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MEDITERRANEAN COASTAL MARINE BIODIVERSITY TRENDS: AN ECOLOGICAL AND SOCIAL ASSESSMENT IN THE NW REGION

MIGUEL MALLO COSTA

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MEDITERRANEAN COASTAL MARINE BIODIVERSITY TRENDS:

AN ECOLOGICAL AND SOCIAL ASSESSMENT IN THE NW REGION

PHD THESIS MIGUEL MALLO COSTA

Supervised by:
VICTORIA REYES-GARCÍA SERGIO ROSSI HERAS PATRIZIA ZIVERI

INSTITUT DE CIÈNCIA I TECNOLOGÍA AMBIENTALS (ICTA)
UNIVERSITAT AUTÒNOMA DE BARCELONA (UAB)

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MEDITERRANEAN COASTAL MARINE BIODIVERSITY TRENDS: AN ECOLOGICAL AND SOCIAL ASSESSMENT IN THE NW REGION

Miguel Mallo Costa

Directors:

Victoria Reyes-García Sergio Rossi Heras Patrizia Ziveri

Tutor:

Victoria Reyes-García

PhD Programme in Environmental Science and Technology

Institut de Ciència i Tecnologia Ambientals

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"*Man's general way of thinking of the totality, i.e. his general world view, is crucial for overall order of the human mind itself. If he thinks of the totality as constituted of independent fragments, then that is how his mind will tend to operate, but if he can include everything coherently and harmoniously in an overall whole that is undivided, unbroken and without border (for every border is a division or break) then his mind will tend to move in a similar way, and from this will flow an orderly action within the whole.*"

David Bohm, *Wholeness and the Implicate Order*, 1980

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To my friends and family. To everyone who directly or indirectly contributed to this work and/or had to put up with me while doing it.

Abstract

The Mediterranean Sea is one of the world's largest biodiversity hotspots, with high biodiversity levels concentrating in the coastal zone of the NW region, overlapping with large anthropogenic pressures. In this work, I use both historical ecological data and human environmental perception to assess changes and trends in the Mediterranean coastal marine habitats.

This manuscript contains four empirical chapters. In the first chapter, I reconstruct the historical ecological trends of Corallium rubrum, a key engineering species of the coralligenous assemblages, which is considered a proxy for the habitat's overall health. Drawing on results from a meta-analysis of previous literature, I calculate yearly average values of C. rubrum basal diameter, height, and weight in the Catalan and Ligurian seas. In both areas, the selected morphometric parameters decreased until the 1990s, a decade marked by the exhaustion of coral harvesting banks and the Mediterranean trawling ban. C. rubrum morphometric parameters increased after the 2000s, reaching levels similar to the 1960s (Ligurian Sea) or 1980s (Catalan Sea). However, such results should be read with caution due to the scarcity of quantitative C. rubrum data before the 1990s, the concentration of research on few marine protected areas (including no-take zones), and the lack of recent data for unprotected colonies.

The other three chapters assess social perceptions of the coastal marine habitats of a NW Mediterranean Marine Protected Area (Cap de Creus, NE Spain) using data collected through semi-structured interviews with local stakeholders and a survey to locals and tourists. The results are discussed considering findings from ecological data in the region. First, I assess social perceptions of the benefits, impacts and threats of coastal marine habitats. Overall, locals and tourists similarly perceived that coastal marine habitats provide valuable regulating services and they assigned less value to the cultural services. The impacts to the local coastal habitats most commonly perceived were marine pollution and climate change, which was also perceived as an important future threat. The harmful impact of people's behaviour towards the coastal habitat was expected to decrease in the future. Some perceptions were in line with the available scientific literature in the area. Cognitive biases (e.g., media influence on respondents' answers) seem to affect people's perceptions of biodiversity trends in coastal marine habitats.

I then assess perceptions of local changes, focusing on environmental changes. Local stakeholders mostly reported economic changes, while environmental changes were less frequently reported. Changes were more often perceived as negative, where decrease in marine life and biodiversity was the most frequently reported trend among respondents. Results from the survey show a general perception of deterioration of the coastal marine habitats, for locals significantly more than for tourists.

Finally, I present results from a survey to scuba divers in which they were asked to qualitatively assess the temporal health status change of Posidonia oceanica and C. rubrum in the region. Results indicate a decreasing trend for both species during the last four decades, especially notable for C. rubrum. Such trends are compared with the available scientific data and their similarities and mismatches are discussed.

Overall, results from this work show the importance of combining ecological and social data in environmental assessments for future habitat management. Ecological data demonstrate an improving trend in protected *C. rubrum*'s health status after having suffered a notable decrease. Social data suggest that people perceive an overall declining trend in the health of NW Mediterranean coastal marine habitats. Combining both types of data allows for a wider and better understanding of biodiversity changes and its potential societal implications, as well as helping define effective adaptation and biodiversity conservation strategies.

Keywords: Anthropogenic impact · Cap de Creus · Coralligenous · Corallium rubrum · Environmental Perception · Global Change · Marine Historical Ecology · Posidonia oceanica

Resumen El Mar Mediterráneo es uno de los mayores puntos calientes de biodiversidad del mundo, con altos niveles de biodiversidad concentrados en la zona costera de la región noroeste que se solapan con grandes presiones antropogénicas. En este trabajo, utilizo tanto datos ecológicos históricos como la percepción ambiental humana para evaluar los cambios y tendencias en los hábitats marinos costeros del Mediterráneo.

Este manuscrito contiene cuatro capítulos empíricos. En el primer capítulo, reconstruyo las tendencias ecológicas históricas de *Corallium rubrum*, una especie ingeniera clave para el coralígeno, la cual se la considera un indicador de la salud general del hábitat. Basándome en los resultados de un meta-análisis de literatura previa, calculo los valores medios anuales del diámetro basal, la altura y el peso de *C. rubrum* en los mares de Cataluña y Liguria. En ambas zonas, los parámetros morfométricos seleccionados disminuyeron hasta los años 90, una década marcada por el agotamiento de los bancos de extracción de coral y la prohibición de la pesca de arrastre en el Mediterráneo. Los parámetros morfométricos de *C. rubrum* aumentaron después de la década de los 2000, alcanzando niveles similares a los de la década de 1960 (mar de Liguria) o de 1980 (mar de Cataluña). Sin embargo, estos resultados deben interpretarse con cautela debido a la escasez de datos cuantitativos de *C. rubrum* antes de la década de 1990, la concentración de la investigación en pocas áreas marinas protegidas (incluidas las zonas de exclusión de pesca), y la falta de datos recientes para las colonias no protegidas.

Los otros tres capítulos evalúan las percepciones sociales de los hábitats marinos costeros de un Área Marina Protegida del Mediterráneo noroccidental (Cap de Creus, noreste de España) utilizando datos recogidos mediante entrevistas semi-estructuradas con participantes locales y una encuesta a gente local y turistas. Los resultados se discuten teniendo en cuenta las conclusiones de los datos ecológicos de la región. En primer lugar, evalúo las percepciones sociales de los beneficios, impactos y amenazas de los hábitats marinos costeros. En general, la población local y los turistas perciben de forma similar que los hábitats marinos costeros proporcionan valiosos servicios de regulación y les asignan menos valor a sus servicios culturales. Los impactos sobre los hábitats costeros locales más percibidos fueron la contaminación marina y el cambio climático, que también se percibió como una importante amenaza futura. También se reportó que el impacto perjudicial del comportamiento de las personas hacia el hábitat costero disminuirá en el futuro. Algunas percepciones coincidían con la literatura científica disponible sobre la zona. Los sesgos cognitivos (p.ej., la influencia de los medios de comunicación en las respuestas de los encuestados) parecen afectar a las percepciones de las personas de este estudio.

A continuación, evalúo las percepciones de los cambios locales, centrándome en los cambios ambientales. Los participantes locales informaron mayoritariamente sobre cambios económicos, mientras que los cambios ambientales fueron los menos frecuentemente señalados. Los cambios se perciben más a menudo como negativos, siendo la disminución de la vida marina y de la biodiversidad la tendencia más señalada por los participantes. Los resultados de la encuesta muestran una percepción general de deterioro de los hábitats marinos costeros, para los locales dicho deterioro es significativamente mayor que para los turistas.

Por último, presento los resultados de una encuesta realizada a buceadores en la que se les pidió que evaluaran cualitativamente el cambio temporal del estado de salud de *Posidonia oceanica* y *C. rubrum* en la región. Los resultados indican una tendencia a la baja para ambas especies durante las últimas cuatro décadas, especialmente notable para *C. rubrum*. Estas tendencias se comparan con los datos científicos disponibles y se discuten sus similitudes y diferencias.

En general, los resultados de este trabajo muestran la importancia de combinar los datos ecológicos y sociales en las evaluaciones ambientales para la futura gestión del hábitat. Los resultados ecológicos demostraron una tendencia a la mejora en la salud del *C. rubrum* protegido tras haber sufrido un notable descenso. Los resultados sociales sugieren que la población percibe una tendencia general a la baja en la salud de los hábitats marinos costeros del noroeste del Mediterráneo. La combinación de ambos tipos de información permite una mayor y mejor comprensión de los cambios en la biodiversidad y sus posibles implicaciones sociales, además de ayudar a definir estrategias eficaces de adaptación y conservación de la biodiversidad.

Palabras clave: Cap de Creus · Coralígeno · *Corallium rubrum* · Ecología histórica marina · Impacto Antropogénico · Percepción ambiental · *Posidonia oceanica*

Resum La Mar Mediterrània és un dels majors punts calents de biodiversitat del món, amb alts nivells de biodiversitat concentrats en la zona costanera de la regió nord-oest que s'encavalquen amb grans pressions antropogèniques. En aquest treball, utilitzo tant dades ecològiques històriques com la percepció ambiental humana per a avaluar els canvis i tendències en els hàbitats marins costaners del Mediterrani.

Aquest manuscrit conté quatre capítols empírics. En el primer capítol, reconstrueixo les tendències ecològiques històriques de *Corallium rubrum*, una espècie enginyera clau per al coral·ligen, la qual se la considera un indicador de la salut general de l'hàbitat. Basant-me en els resultats d'un meta-anàlisi de literatura prèvia, calculo els valors mitjans anuals del diàmetre basal, l'altura i el pes de *C. rubrum* en les mars de Catalunya i Ligúria. En totes dues zones, els paràmetres morfomètrics seleccionats van disminuir fins als anys 90, una dècada marcada per l'esgotament dels bancs d'extracció de coral i la prohibició de la pesca d'arrossegament al Mediterrani. Els paràmetres morfomètrics de *C. rubrum* van augmentar després de la dècada dels 2000, aconseguint nivells similars als de la dècada de 1960 (mar de Ligúria) o de 1980 (mar de Catalunya). No obstant això, aquests resultats han d'interpretar-se amb cautela degut a l'escassetat de dades quantitatives de *C. rubrum* abans de la dècada de 1990, la concentració de la recerca en poques àrees marines protegides (incloses les zones d'exclusió de pesca), i la falta de dades recents per a les colònies no protegides.

Els altres tres capítols avaluen les percepcions socials dels hàbitats marins costaners d'una Àrea Marina Protegida del Mediterrani nord-occidental (Cap de Creus, nord-est d'Espanya) utilitzant dades recollides mitjançant entrevistes semi-estructurades amb participants locals i una enquesta a gent local i turistes. Els resultats es discuteixen tenint en compte les conclusions de les dades ecològiques de la regió. En primer lloc, avaluo les percepcions socials dels beneficis, impactes i amenaces dels hàbitats marins costaners. En general, la població local i els turistes perceben de manera similar que els hàbitats marins costaners proporcionen valuosos serveis de regulació i els assignen menys valor als seus serveis culturals. Els impactes sobre els hàbitats costaners locals més percebuts van ser la contaminació marina i el canvi climàtic, que també es va percebre com una important amenaça futura. També es va reportar que l'impacte perjudicial del comportament de les persones cap a l'hàbitat costaner disminuirà en el futur. Algunes percepcions coincidien amb la literatura científica disponible sobre la zona. Els biaixos cognitius (p. ex., la influència dels mitjans de comunicació en les respostes dels enquestats) semblen afectar les percepcions de les persones d'aquest estudi.

A continuació, avaluo les percepcions dels canvis locals, centrant-me en els canvis ambientals. Els participants locals van informar majoritàriament sobre canvis econòmics, mentre que els canvis ambientals van ser els menys sovint assenyalats. Els canvis es perceben més sovint com a negatius, sent la disminució de la vida marina i de la biodiversitat la tendència més assenyalada pels participants. Els resultats de l'enquesta mostren una percepció general de deterioració dels hàbitats marins costaners, per als locals aquesta deterioració és significativament major que per als turistes.

Finalment, presento els resultats d'una enquesta realitzada a bussejadors en la qual se'ls va demanar que avaluessin qualitativament el canvi temporal de l'estat de salut de *Posidonia oceanica* i *C. rubrum* a la regió. Els resultats indiquen una tendència a la baixa per a totes dues espècies durant les últimes quatre dècades, especialment notable per a *C. rubrum*. Aquestes tendències es comparen amb les dades científiques disponibles i es discuteixen les seves similituds i diferències.

En general, els resultats d'aquest treball mostren la importància de combinar les dades ecològiques i socials en les avaluacions ambientals per a la futura gestió de l'hàbitat. Els resultats ecològics demostren una tendència a la millora en la salut del *C. rubrum* protegit després d'haver sofert un notable descens. Els resultats socials suggereixen que la població percep una tendència general a la baixa en la salut dels hàbitats marins costaners del nord-oest del Mediterrani. La combinació de tots dos tipus d'informació permet una major i millor comprensió dels canvis en la biodiversitat i les seves possibles implicacions socials, a més d'ajudar a definir estratègies eficaces d'adaptació i conservació de la biodiversitat.

Paraules clau: Cap de Creus · Coral·ligen · *Corallium rubrum* · Ecologia històrica marina · Impacte Antropogènic · Percepció ambiental · *Posidonia oceanica*

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1 INTRODUCTION

Research problem

The world is facing a decreasing trend in marine biodiversity (e.g., Pauly et al. 2005; Pandolfi et al. 2003; Lotze and Worm 2009; Lotze et al 2006; Dunic et al. 2021; Jackson et al. 2001; Jackson 1997). Such biodiversity loss includes the decrease of ecosystem's complexity, functionality and health. Maintaining diverse marine habitats (supporting the ecosystem complexity) in good health is crucial to maintain marine essential benefits to humanity and to the rest of the biota. These benefits involve ensuring species endurance, maintaining clean and oxygenated waters, keeping a balanced blue carbon sink and storage for the natural balancing of the carbon cycle, or protecting the coast from erosion and storm damages, among others (United Nations 1992; Balzan et al. 2020). When a high biodiversity-holder habitat regress, it becomes less complex and less mature (with less three-dimensional structures, lower biomass and lower energy and carbon retention on its structure, and less reproductive potential). Consequently, the habitat become less resilient and more prone to physical, chemical and climatic disturbances leading to its functional extinction (Lotze et al. 2011; Rossi 2013; Ruiz et al. 2015).

The Mediterranean Sea is one of the most biodiverse seas of the planet, including a high proportion of endemic species, being a biodiversity hot spot (Bianchi et al. 2012; Lejeusne et al. 2010; Boudouresque 2004). Largely, Mediterranean marine biodiversity is concentrated in shallow water coastal areas (inside the photic zone) and in the NW region, with optimal environmental conditions for numerous communities (Coll et al. 2012; Coll et al. 2010). The main reason for such levels of marine biodiversity in that particular region are the presence of eco-engineering species that hold high biodiversity, especially the *Posidonia oceanica* meadows and the coralligenous habitats (Boudouresque et al. 2016; Boudouresque 2004). The importance of the keystone species living in such areas consist on their capacity of creating and sustaining complex three-dimensional structures that serve as habitat, protection and feeding for several other species. Additionally, they store carbon among other elements derived from the environmental and biological dynamics of the water column, transforming light, CO_2 and organic matter (suspension feeding) into biomass and energy which enables them to keep growing and structure the complexity of such habitats (Rossi 2013; Ruiz et al. 2015; Boudouresque et al. 2016). Thus, maintaining such keystone species and the habitats that they create is crucial to maintain a healthy sea.

The Mediterranean Sea is also one of the highest anthropogenic pressured areas of the world, with high coastal population density and being a major coastal touristic destination (Coll et al. 2010). The habitats of this semi-enclosed sea are facing important anthropogenic impacts like habitat degradation, resource overexploitation, pollution, and eutrophication, especially concentrated on coastal areas (Coll et al. 2012; Navarro et al. 2015). Those impacts add to the climatic drivers of water warming, acidification and sea level rise, threats that are expected to increase in the near future (Coll et al. 2010; Coll et al. 2012). Moreover, given their slow growth rate and limited resilience (Sala and Knowlton 2006; Rossi 2013; Ballesteros 2006), the affectation faced by these habitats degrade them at a faster rate than they can recover.

Document, understand, and interpret the past ecological trends of the seagrass and coralligenous is crucial not only to understand how and why they change, but also how they will be transformed (Rossi 2019; Lotze and Worm 2009; Thurstan et al. 2015; McClenachan et al. 2015). In such context, understanding how local populations perceive these habitats (and the changes they face) is also crucial to better visualize the root problems of their historical regressions. The approach is relevant as human perception is correlated with how humans and society interact with marine habitats and determine their willingness to engage on conservation and restoration actions to improve or maintain the habitat's health status (Shackeroff et al. 2011; Weber and Johnson 2009; Cihar and Stankonva 2006; Pyhälä et al. 2016).

This thesis seeks to gain knowledge of the coastal marine current and historical health status and its trends in the NW Mediterranean Sea, as well as the causes for such trends and health status. For that goal, I focus on key a species of the coralligenous habitat (i.e., *Corallium rubrum*), and secondarily on *P. oceanica* meadows. I assess local perception of present and past changes and health status impacts in the main coastal marine habitats at a Marine Protected Area in the NW Mediterranean Sea.

1.1. Theoretical framework

Before introducing our theoretical framework, I explain the concept of biodiversity, the ways to measure it, and the link between our data and biodiversity, since this work does not measure directly and *per se* the biodiversity of a habitat. Then, I present the two main bodies of knowledge used in this thesis: marine historical ecology and human environmental perception.

In the UN Conference on Environment and Development in Rio 1992, the Convention on Biological Diversity defined biodiversity as: "*The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species and of ecosystems*" (United Nations 1992). Following this definition, marine biodiversity has been also defined as the variety of life in the ocean, from within species level to ecosystems and communities (Sala and Knowlton 2006). Biodiversity within species is named genetic diversity, higher genetic diversity give advantage to a population in front of perturbations, resulting in a higher survival rate of individuals (Gray 1997). Species diversity is the number of species per unit of space, although the measure can also be calculate at phylum, genera or other taxonomic level. Similarly, instead of looking for taxonomic levels, biodiversity can also be assessed in a community or ecosystem level within a known surface or volume. The biodiverisity of an ecosystem will depend on its habitat diversity that will include the coexistence of diverse communities, populations and habitats. Usually a habitat is easier to delimitate than an ecosystem or community since it is defined as the environmental or the ecological area in which an organism inhabits. Functional diversity is defined as the range of functions that can perform the organism in a system (Gray 1997).

Biodiversity can be measured in many different ways and have different units. E.g., a sample within the same habitat (α-diversity), change of diversity between habitats or through time (β-diversity), or diversity of a landscape/seascape or in a regional scale (γ-diversity). Higher levels of biodiversity not always mean healthier communities or ecosystems, as the relation depends on the biodiversity measurement used. To better assess the health status of a habitat, it is necessary to combine different approaches including not only the species diversity but also the habitat temporal dynamics and evenness, species abundance and interaction and functional measures (Walker 1992; Sala and Knowlton 2006; Gray 1997).

Marine benthic species are largely addressed in biodiversity studies and include the organisms that inhabit the benthic zone and are mainly adapted to live on the substrate. The main techniques to study benthic biodiversity nowadays are dredging and grabbing, satellite and aerial

images, underwater visual censuses, and underwater video/picture techniques (Bianchi et al. 2004; Mallet and Pelletier 2014). To assess the health status of a habitat, the measurement of its ecological parameters and extension (including percentage of coverage of a determined area) are frequently used. E.g., for *Posidonia oceanica* the most used measurement is the shoot density (nº shoots/m^2), where absolute standardized value scales are available to classify and compare the health status of the samples. Other analysis require measuring and monitoring through time the depth of the upper and lower position of the meadow, plus describing its typology (Montefalcone 2009). Another example, for *Corallium rubrum* some researchers have used fixed-measure grids to quantify different parameters and extrapolate measures to the total area studied. Parameters used include the height and diameter (with a ruler), the density of colonies (nº of colonies/area), the size structure (observed from the pooling of groups within 1 cm height size range), and the biomass, which can be estimated extrapolating the height and diameter in a power equation available thanks to old registers of dead and poached coral biomass available in the literature (Garrabou et al. 2017). Added to these measures of the population structure and its health status, biodiversity indexes are a useful and simple way to assess the health status of an ecosystem or community; where the complex functioning of those ecosystems does not alter their effectivity. Ecological indices are constructed from fieldwork and/or laboratory data. Examples of biodiversity indices are the Shannon-Wiener diversity index, the Bentix index, or the Conservation index (Simboura and Zenetos 2002; Montefalcone 2009).

In the present thesis, I do not use biodiversity assessment techniques directly to obtain broad biodiversity estimations, but rather, I assess the health status of some key species of the NW Mediterranean coastal marine habitats (CMH). This techniques allows to approximate how much biodiversity (especially functional biodiversity) such habitats hold and have been lost through the time. Specifically, I use an historical ecological assessment of the main studied parameters of *Corallium rubrum*. Additionally, I use information on user's perception of Marine Protected Area (MPA) to assess the relative importance of the impacts and threats that the local CMH suffer at present, and the value of their benefits to humanity (i.e., ecosystem services). I also use human perception (including human memory) to assess how such CMHs have changed during informants' lifetime and how to value in a relative scale the abundance of *P. oceanica* and *C. rubrum* for a determined area. Such methodological techniques, despite not directly measuring biodiversity, are very valid to give an estimation of biodiversity historical trends and present status because they focus on the most biodiversity-holder key engineering species and on the most biodiverse marine habitats of the Mediterranean Sea. In addition, marine historical

ecological and human perception techniques allows us to estimate biodiversity for a wide area in a reasonable amount of time and effort, which could not be feasible using more accurate (but more time and resource-consuming) biodiversity analytical techniques.

1.1.1. Marine historical ecology

Marine historical ecology (MHE) aims to document and interpret long-term changes in marine ecosystems, to characterize and understand the drivers of the changes in community composition and species abundance through time (Lotze and Worm 2009; McClenachan et al. 2015). MHE tries to find historical baselines to solve the shifting baseline syndrome, a common problem especially in fishery science (Pauly 1995) and all the marine life, due to sampling challenge in marine compared to earth systems (Thurstan et al. 2015). To avoid the shifting baseline syndrome, when studying a community or ecosystem, scientists need to understand and quantify its pristine state (reference point) when they begin studying them, or to have, at most, a reference from recent past ecological monitoring studies, that not go further than 50 years ago (Lotze and Worm 2009). Without baselines, scientists can ignore the fact that in the past the marine ecosystems could be more biodiverse or extense, neglecting that their current status can be far from its potential. Thus considering "natural" a long-time degraded ecosystem is a perception problem (Pauly 1995; Jackson 1997). MHE studies help to give a long-term vision of habitats trend, a vision that can be useful for restoration and conservation projects, and to engage stakeholders and influence decision-makers. Such vision can also give insights of what might happen in the modern ecosystems looking at their past variations (Thurstan et al. 2015). The final target of MHE is understanding the potential loss of ecosystem functionality, complexity and the associated trophic interactions.

To accomplish such goals, MHE uses a huge variety of data sources to analyse the past. For example, palaeoceanographic, palaeontological, taxonomical and geochemical records (e.g., isotopes from calcifying organisms preserved in marine sedimentary records, coral geochemistry, shell morphometrics) can cover thousands of years and provide data on the species distributions and dynamics at different climatic temporal scales, making easier to distinguish, by comparison, recent-time human-made changes to the ecosystem. Pre-industrial human alterations on marine abundance of some species in specific sites can be obtained from archaeological records (e.g., bones, shells). Historical records (e.g., logbooks, maps, catch records, restaurant menus) can also be useful to track commercially valuable species from centuries ago. Fisheries data, especially data previous to the onset of large-scale exploitation, are useful to document trends in species of commercial interest. Elder living memory, underwater

photography, and scientific monitoring programs are also useful data sources, although they span shorter timeframes than some of the techniques previously mentioned (Lotze and Worm 2009). Finally, local experts' ecological knowledge can be a useful data source that sometimes goes beyond the knowledge holders' lifetime (Shackeroff et al. 2011).

The available body of literature generated by marine historical ecologists suggest a common pattern in marine trends: large and highly valued species (in nutritional or economic terms) were caught and depleted first. Then, the exploitation moved progressively to less-valued marine resources more difficult to obtain (Lotze and Worm 2009). The decrease of large species allowed the increase of allochthon smaller species at lower trophic levels, changing the ecosystem and food webs functioning (Lotze et al. 2006; Coll et al. 2010). This body of knowledge also documents a spatial expansion and temporal acceleration exploitation trends (Lotze and Worm 2009). Thus, the exploitation of marine resources started in the coast and estuaries and, when resources where turning scarce and the required technology make it feasible, the exploitation in the continental shelf, the continental ridge, the open oceans, and nowadays the deep seas began. Improvements in technology, together with increasing human population, provoke and acceleration in resource exploitation (Lotze and Worm 2009).

Overfishing, mainly the type targeting apex predator species, is one of the main and first-in-time cause of marine species extinction and ecosystem malfunctioning (Jackson et al. 2001; Pauly 1995). Although some high-value species have a long-time track history, most fished species were rarely tracked in past times, for which fisheries data is especially scarce before the 1960s (Lotze and Worm 2009) resulting in a knowledge gap about the state of many marine habitats prior to fishing exploitation and tracking (Thurstan et al. 2015). Moreover, data that comes from fishery sources are biased towards commercial species, and might contain errors from misreporting. Historical data contains some level of uncertainty and suffer from the shifting baseline syndrome, although such biases can be reduced with independent data source techniques or improved research techniques (Thurstan et al. 2015).

MHE studies published so far suffer from some common limitations. First, it is difficult to find a non-altered baseline due to synergy and overlapping, in most cases, of climatic and non-climatic (e.g., exploitation effects on the ecosystems) drivers. Second, for most exploited species there is non-existing data before the human activities affecting marine life started. Finally, there is also a publication bias, as rapid and large declines are more prone to publication that small variations of abundance (Lotze and Worm 2009).

1.1.2. Human environmental perception

Definitions of human environmental perception are quite diverse, including "*the "vision" that every person has of the environment that surrounds it. It is the first step toward the process of knowledge and environmental awareness exercise*" (Fernandes et al. 2006); "*apprehension of the external world through the senses, guided by physical and psychological elements*" (Bell 2001); "*awareness of, or feelings about, the environment, and the act of apprehending the environment by the senses*" (Zube 1999); "*the response of the sense to external stimuli and purposeful activity in which certain phenomena are clearly registered while other recede in the shade or are blocked out*" (Tuan 1974). The diversity of definitions and interpretations of the human environmental perception concept is a reflection of the complexity of such phenomena.

Human environmental perception can be analysed in different steps. When we perceive the surrounding environment, we are doing the following: first, the environment provides a quasi-unlimited amount of information via sensorial inputs that are not specific to any of our sensory channels, which are limited. Such information extends over long time spans and comes from multiple sources. That makes impossible to perceive all the information inputs, for which information needs to be selectively attended, what is called a biological filter (i.e., limited by our physiology). Then, after the biological filter, there are also cultural filters, where the personal psychological factors, judgments, worldview, decisions, choices and life experiences, make individuals to pay attention to certain information and patterns more than others, whereas the remaining sensorial input, although it can be biologically perceived, remain unconscious. Every person has different biological and cultural filters that result in a unique externalization of a limited representation of reality by each human being. In other words, we only have the possibility to subjectively assess a small part of reality (Gärling and Golledge 1989; Ittelson 1973; Tuan 1974; Shafer 1969). A complex, abstract and subjective process like this is also complex to assess (Silva et al. 2016).

To complement historical ecological data, this thesis also relies on human environmental perception (including past perception, i.e. memory) to meet its aims. Human environmental perception has crucial importance as data source. Research in environmental perception can help to seek and understand historical or recent changes on the environment and the drivers that caused such change. Furthermore, it can help designing more accurate and appropriate conservation strategies, sustainable resource exploitation models, assess the health status of a habitat or a whole region, and make projects that embrace the different social views of the inhabitants of a certain area (Silva et al. 2016; Gärling and Golledge 1989). An important fact of

this type of studies is that, often, stakeholders or decision-makers make decisions based on their individual perceptions, rather than on measured criteria (Pyhälä et al. 2016). Environmental perception studies can also provide more recent data of the ecological state of natural habitats than scientific reports and can be useful for designing better conservation models (Shackeroff et al. 2011; Coll et al. 2014). Additionally, this type of information overpasses the descriptive or analytical one obtained from traditional scientific methods in many places (Myers et al. 2013; Yeh 2015; Egan and Mullin 2014). Overall, a people approach to marine historical ecology can improve marine management strategies and avoid delays of certain implementation measures (Shackeroff et al. 2011), as well as gain historical information where data is limited or not available (Coll et al. 2014).

If we assume the actual state of the coastal habitats is largely driven by human behaviour, and that such behaviour arise from our perceptions, we can conclude that more accurate information might change people's perceptions and potentially their behaviour (Weber and Johnson 2009; Vignola et al. 2010; Spence et al. 2011). Generally, when people are asked about the status of marine ecosystems, they perceive them under threat and not well preserved. Such perception might induce a negative behaviour towards them (e.g., "if the ocean is full of garbage, by throwing one more can on it will not change much" or "if the ocean if full of garbage, is meaningless to do a beach cleaning as it will not change much"; Tonin and Lucaroni 2017; Cihar and Stankova 2006). This is especially evident for people that never visit the coast (Jefferson et al. 2014). Such perception towards the marine environment is reflected in less commitment and participation in protection or improvement actions towards marine habitats (Cihar and Stankova 2006). Moreover, marine ecosystems are less experienced and more difficult to be studied in detail, which made them less appreciated overall and can be noted in the public response for marine biodiversity conservation compared with terrestrial one (Gray 1997; Steel et al. 2005). Nevertheless, the same process also happens the other way around, and positive perceptions of marine environment stimulates local people's engagement in conservation and support activities, eco-friendly behaviour, and better policy implementations (Cihar and Stankova 2006; see e.g., Trialfhianty and Suadi 2017). In other words, conservation success highly depends on how people perceive the marine habitats, which can be changed through knowledge acquisition and better-looking marine environments, both of which can result from appropriate policy and conservation measures plus sensitization and visualization campaigns (Dijksterhuis and Bargh 2001; Tonin and Lucaroni 2017; Jacquet and Pauly 2007).

Environmental perception studies suffer, however, from various limitations, many of them being sources of bias in the knowledge-holders providing environmental perceptions. Sometimes is problematic to fit and complement/contrast qualitative data (i.e., from environmental perceptions) with quantitative one (i.e., from ecological assessments), and the legitimacy, validity and reliability of perceptual data (as well as Local Ecological Knowledge data) is strongly discussed in the scientific community (Shackeroff et al., 2011). Perceptual studies can suffer from non-directional errors from the interviewees: lack of memory or knowledge, misremembering, not knowing the answer -which may lead to guesses or imaginations of the knowledge-holder. Another common non-directional error is to generalize between different issues or answer what people says instead of their own experience. Interviewee's ethics or values, interviewee's aims to give a good impression of him or herself (self-esteem effect/audience effect), even truth hiding or false answers also can be a source of bias. Other sources of bias can come from the researchers, if they are conducting interviews (a frequently used method to obtain perceptual knowledge), they can commit bias in the answers due to the question wording or the interview structure. (Newing 2011).

Furthermore, psychological features in the knowledge-holders can affect when perceiving environmental processes, status and changes (Pyhälä et al. 2016). The most common examples of such processes are memory illusions (exaggeration of an ecological change, which can be influenced by the memory of environmental extreme past events; Daw 2010), change blindness (the non-detection of a change, mainly due to desensitization to it; Alessa et al. 2008), and the shifting baseline syndrome (Pauly 1995; Fernández-Llamazares et al. 2015). Cultural values of the local area or of the general globalized society can also influence and shape human environmental perception. The most typical ones being the commodification of nature (Giddings et al. 2002; Martineau and Lafontaine 2020; Keucheyan 2014), and the knowledge coming from external sources like media, government, official agencies, activists, or NGOs (Graziano 2019; Tsfati and Cohen 2013; Bos et al. 2011; Loos 2003; Leonti 2011; Rudiak-Gould 2014).

1.2. Study area

This thesis focuses on the NW Mediterranean region. Concretely chapter 2 focuses on the Catalan Sea and the Ligurian Sea, while chapters 3 to 5 focus on the Cap de Creus Marine Protected Area (MPA) located in Girona (Catalonia, Spain), in the Catalan Sea. This section describes why the Mediterranean Sea is and became a biodiversity hotspot while at the same time is one of the most pressured sea on Earth. Then, I focus on describing the main biodiversity-holder habitats of this sea, why they have this high biodiversity, and what are the impacts and threats they face, causing the reported biodiversity decreasing trend. Finally, I focus on Cap de Creus MPA, highlighting its ecological importance and the impacts and threats it suffers.

1.2.1. Mediterranean Sea: a biodiversity hotspot

The Mediterranean Sea has a surface of approximately 2,500,000 km^2 being the largest semi-enclosed sea on Earth. It is characterized by a vigorous thermohaline and anti-estuarine circulation and is divided into two main basins (western and eastern) with seawater exchange between the two basins at the Strait of Sicily. These basins are composed of different sub-basins due to partial isolation caused by sills that influence water circulation, and by different water properties (Rohling et al. 2015; Rohling et al. 2009). Natural connection with the ocean is through the narrow Strait of Gibraltar, where nutrient-rich Atlantic surface waters enter the Mediterranean and experience an eastward increase of temperature and salinity driven by insolation and evaporation, having a negative hydrological balance (evaporation exceeding precipitation). The Mediterranean becomes increasingly oligotrophic following a north-west to south-east gradient, with the NW region being the richest in nutrients (Rohling et al. 2015).

Although the Mediterranean Sea represents the 0.82% and 0.32% in area and volume of the world ocean respectively (Defant 1961), it accounts for about 4 to 18% of the world total marine species, with a high percentage of endemic species (Bianchi et al. 2012). For this reason is considered a biodiversity hot spot (Lejeusne et al. 2010), only comparable to the species richness found in the southern coast of Australia (Boudouresque 2004).

Nowadays, biodiversity estimations of the Mediterranean have high uncertainties regarding the number of identified marine species (which grow constantly). This is mainly due to a high rate of invasion of alien species and new exploration studies in the deep sea (Boudouresque 2004; Bianchi et al. 2012). Several studies adress the total number of marine species in the Mediterranean Sea. The most recent paper estimates around 15,000 to 20,000 species, one

quarter of them being endemics (Bianchi et al. 2012). Coll et al. (2010) estimated 17,900 species (around 20% endemics) and quantified 626 introduced species, but estimate around 1,000 if unicellular aliens and foraminifera are included. Boudouresque (2004) estimate 12,000 species with greatly more endemism in the west basin than the eastern basin. The most accurate estimate are based only on macroscopic species: 8,500 species (Bianchi and Morri 2000) and 7,000 species (Fredj et al. 1992) are two examples. Microscopic species estimates are less reliable due to the methodological difficulties associated to the accuracy of species identification, problems with the species delimitation, biases of molecular genetics, sampling techniques, and the lack of taxonomists in some species groups. Nevertheless, the development of electronic microscopy is slowly solving most of those issues (Coll et al. 2010).

Researchers have found concrete patterns in Mediterranean species diversity. The eastern basin species composition is more similar with the Indo-Pacific Ocean, while in the western basin, there is a higher similarity with the Atlantic (Coll et al., 2010). Most of the Mediterranean species are of Atlantic origin, 60% of the species coincide with the Portuguese region, and 50% with the Mauritanian region (Boudoresque, 2004). With few exceptions noticed, there is a longitudinal northwest to southeast species richness gradient in the Mediterranean. That gradient relates with the temperature, salinity and productivity inside the basin (Coll et al., 2010). The western basin is the richest in species due to the Atlantic nutrient influx and the wider range of physiochemical conditions inside the basin (Coll et al. 2010; Coll et al. 2012). A vertical gradient also exists, where diversity decreases with depth. The diversity is concentrated in coastal areas and continental shelves, where all the photosynthetic organisms and the fauna associated are found. Such biodiversity concentration goes from the mediolittoral until the bottom limit of the circalittoral area, around 110 m depth in the clearest western Mediterranean waters and until 150 m depth in the eastern basin ones. Bathyal and abyssal species discovered are scarce, as in the Mediterranean are very few areas below 3,000 m depth. In conclusion, the highest species richness is found on the NW Mediterranean coastal areas and continental shelves, where this thesis focuses.

The Mediterranean Sea is a biodiversity hot spot for various reasons: (i) a dynamic geological history, associated with large environmental changes forcing numerous apparitions and extinctions of species. (ii) A very different climatic and hydrographic conditions and physical barriers, having highly diverse biogeographical sectors with their characteristic fauna including a high number of endemism. (iii) Finally, the Mediterranean also has a high invasive species history since ancient times (Gili 2001; Bianchi and Morri 2000). It is important to mention that

the Mediterranean Sea is one of the world's most studied seas and one of the firsts to be studied, where the first available register comes from Aristotle (4th century BP; Voultsiadou et al. 2017), this might contributed to the identification of large number of species compared to other world regions.

1.2.1.1. Geological history and species origin

The Mediterranean Sea experienced large environmental changes during its past associated with species composition, which came from diverse origins. Lejeusne et al. (2010) states that the geologic reasons are the most influent of the actual Mediterranean biodiversity, because it has higher biodiversity than two tropical well studied areas: the Gulf of Mexico and the Caribbean Sea.

The Mediterranean Sea is the result of an active geological history. Thirty Ma ago (Oligocene) the conditions shifted from a large ocean called Tethys (with tropical fauna similar to the fauna found today in the Indo-Pacific Ocean) to a cold-water conditions in a reduced ocean. Ten Ma ago (early Miocene) the Suez Isthmus appeared, separating the Mediterranean with the Indo-Pacific, and the Atlantic connection with the sea was closed 6 Ma ago (last Miocene), becoming an isolated Mediterranean Sea. Extreme conditions derived from the closure of the Gibraltar Strait caused an isolation and partial desiccation of the Mediterranean basin through evaporation with the remained seawater progressively increased in salinity (Messinian salinity crisis). Most of the original Tethys biota became extinct due to the Messinian crisis, remaining an extreme environment with a poor biodiverse desiccated and enclosed basin with remaining high-saline lakes. Five Ma ago (Pliocene), the Strait of Gibraltar re-opened the connection with the Atlantic waters which flowed in and repopulated the Mediterranean with Atlantic biota. In the Quaternary, alternate periods of ice ages and warm interglacials finished shaping the actual Mediterranean biota, with the arrival and proliferation of boreal and subtropical fauna from the Atlantic. Recently, the Indo-Pacific connection, through the Red Sea, was retaken by the opening of the Suez Canal in 1869 (Bianchi et al. 2012; Bianchi and Morri 2000; Gili 2001). These events conform the diversity of origins of the actual Mediterranean marine species, having several types of different biota and in turn a high biodiversity (Bianchi et al. 2012).

1.2.1.2. Biogeographic sectors and endemisms

According to the type of biota and environmental conditions, we can find 13 different biogeographic sectors in the Mediterranean Sea, causing a high biodiversity inside the basin and being prone to numerous endemisms.

Concretely the biogeographic sectors are: Alboran Sea, Algeria and north Tunisia, Tyrrhenian Sea, Balearic Sea to Sardinian Sea, Gulf of Lion and Ligurian Sea, North Adriatic, Central Adriatic, South Adriatic, Ionian Sea, Levant Sea, Souther Aegean Sea, Northern Aegean Sea, and Straits of Messina and Sicily (Bianchi et al. 2012). Regarding endemisms, the latest estimates indicate between 20-25% of Mediterranean species being endemics, one of the highest values worldwide (Bianchi et al. 2012; Coll et al. 2010), although the new findings of Mediterranean species in the close Atlantic is lowering the estimates from past studies (Coll et al. 2010). Most endemism is neoendemic, mostly due to the Messinian crisis (5.6-5.3 Ma ago), and endemism is higher at the species than at the genus level (Boudouresque 2004).

1.2.1.3. Invasive species

Another contributor to the Mediterranean high biodiversity is its high invasive species history. Around 600 alien species were recently estimated, although the real number is probably higher, as bias might exist towards better-known, large and better distinguishable species, and as there is a lack of studies in some areas and a lack of taxonomic expertise (Coll et al. 2010; see also Zenetos et al. 2017; Zenetos et al. 2020).

Around 80% of the Mediterranean alien species are found in the Levantine basin (Coll et al. 2010), most of them being Lessepsian migrants since the Suez Canal opening in 1869 (Boudouresque 2004; Coll et al. 2010). Lessepsian migrants have been notably increasing in the last decade due to the reduction in salinity of the Bitter Lakes (in Egypt; salinity was the reason of keeping away most of the lessepsian migrants; Bianchi and Morri 2003; Coll et al. 2010). In addition, stenohaline migrants spread to the west thanks to the Nile river reduced outflow caused by the construction of the Aswan dam (Bianchi and Morri 2003). Also, much of the lessepsian migrants can easily colonize the Mediterranean Sea since their ancestors were present and subsequently excluded during critical events (i.e. Messinian crisis, ice ages, anoxic crises). Moreover, such facility is helped by the low diversity present in the eastern Mediterranean (Boudouresque 2004).

Most aliens are shallow-water and thermophilic species (Coll et al. 2010; Bianchi and Morri 2003). Warm affinity of most of the alien species is explained in their origin, being 41% from the Indo-Pacific ocean, followed by the Indian Ocean (16%) and the Red Sea (12%). Global warming is supposed to continue favouring those introductions into the Mediterranean (Coll et al. 2010). Mediterranean Sea alien species main sources of introduction are through the Suez Canal (53%), from vessels fouling (22%), and mariculture (10%). In the western Mediterranean,

mariculture accounts as the main source (42%). Other important sources of introduction in the Mediterranean are ballast waters, fishing bait, and aquaria release (Boudouresque 2004; Coll et al. 2010).

Declines in abundance of Mediterranean native species due to alien invasion have been reported (Galil 2009; Francour et al. 2009). Data available focus only on few alien species, from those studies seems that each introduced species constitute a distinct case (Boudouresque 2004). For example, *Caulerpa taxifolia* increases α-diversity in low structural complexity habitats, but homogenizes the habitat and the fauna associated, so in a regional scale lowers β-diversity (Boudouresque 2004; de Villèle and Verlaque 1995; Francour et al. 2009). From the data available, several hypothesis of alien affectation to the new habitat are drawn: (i) zero or slight impact, (ii) changes in the native species abundance, (iii) occupying a similar ecological niche of a native species, displacing it, (iv) displacement of native species towards deeper waters, (v) if the introduced species acts as a key species inside the ecosystem might change of the entire ecosystem functioning, and (vi) progressively set up of a new ecosystem due to the introduced species influence, displacing or disappearing the native ecosystem (Boudouresque 2004).

1.2.2. Mediterranean Sea: a highly pressured Sea

The Mediterranean coastal area is highly populated and is one of the main tourist destinations, being one of the most affected sea by human pressure on Earth (Coll et al. 2010) and with most of its marine habitats being endangered nowadays (Bianchi et al. 2012). Most marine biodiversity impacts are from anthropogenic origin and are concentrated in coastal areas (Gray 1997; Coll et al. 2012). Navarro et al. (2015) stated that the joint effect of environmental, anthropogenic and spatial variables have the largest impact on biodiversity. In fact, the highest biodiversity impacts overlap with the highest biodiversity areas within the Mediterranean Sea, located in the coastal areas of Spain, Gulf of Lions, NE Ligurian Sea, Adriatic Sea, Aegean Sea, SE Turkey, around Nile Delta, and NW Africa (Coll et al. 2012).

The high pressure that affects the Mediterranean Sea, in addition to an overall biodiversity loss, it also slows its species and ecosystem recovery and decreases habitats resilience. Such impacts create a general homogenization pattern in the different marine habitats by either accelerating food webs, and/or causing mass mortalities, and/or facilitating the dominance of invasive species. A homogenized habitat, with loss of structure and biodiversity, becomes more unstable and vulnerable to rapid changes (Bianchi and Morri 2000; Sala and Knowlton 2006; Rossi 2013).

Although many Mediterranean species have suffered large declines in the last decades, no marine species extinction are documented at the basin level but happened at the regional or local scale. The monk seal and the giant limpet are the most critically endangered species of the Mediterranean (Boudouresque 2004). Although there are no records of extinct species, indeed many species (especially the less known and the smallest) may have become extinct without humanity realizing. That includes past and contemporary species not discovered yet. Moreover, although not physically extinct, many species like the ones in the IUCN Red List and the commercially extinct ones, are becoming functionally extinct (meaning that the species is sufficiently rare to accomplish its natural function inside an ecosystem). Functional extinction is an early sign of physical extinction (Sala and Knowlton 2006). The most vulnerable species are the rare ones, the ones with much localized habitats, or the ones with very few individuals, but also common species that in recent years have suffered a steep decline in their populations (Boudouresque 2004).

A part of the decreasing trend, certain species and population might have increased their abundances due to human alteration. This is the case of some invasive species, species that benefit from new, warmer conditions, take advantage of human activities or waste (e.g., seagulls), or species that were predated by species which decreased due to human interventions. Microbial diversity is probably increasing thanks to human pressures, at expenses of speciation decrease of pressured large vertebrates (Sala and Knowlton 2006). An example of predated species that increased their abundance due to human removal of its predator in the Mediterranean is the case of the sea urchins. Large fishes, octopus and other commercially valuable species which predated sea urchins have been overexploited, consequently sea urchin populations have expanded and provoked an intense grazing of seagrasses and algal communities, affecting the species whose lives are dependent of those structural communities (Tomas et al. 2004; Sala and Knowlton 2006). The example shows how the removal of strong interactors alter the food web functioning and the prey increase cause a reduction in structural diversity and consequently in species richness of the habitat. A depletion of prey generally causes a decline in predators (strong interactors) as well (Sala and Knowlton 2006).

1.2.2.1. Main anthropogenic drivers

Drawing on published information and experts' opinion, Coll et al. (2010) identified the following main impacts to biodiversity in the Mediterranean (in order of importance): habitat degradation or loss, exploitation, pollution, climate change, eutrophication, and invasive species. Other impacts identified are maritime traffic and aquaculture. The NW Mediterranean has the

highest concentration of impacts, mainly trawling and dredging, pollution, and exploitation of marine resources. Moreover, the eastern basin is likely to suffer more the potential impacts of climate change (Coll et al. 2012).

Habitat degradation is the main affectation of marine biodiversity loss worldwide (Gray 1997; see also Smith et al. 2017). In the Mediterranean, habitat degradation has been affecting marine life since ancient times, and coastal modification is dated since the Roman period (Coll et al. 2010). Habitat degradation usually starts with fragmentations in small habitat islands, lower immigration rates, and higher extinction rates than the main pool. Marine biota is adapted to natural disturbances, but not to chronic small or intermediate disturbances or to sudden large disturbances that degrade their habitat, like the ones caused directly or indirectly by humanity (Gray 1997).

Resource exploitation is the oldest marine human activity and, together with habitat degradation, a main source of biodiversity loss. Resource exploitation first evidence inside the Mediterranean was reported by Aristotle (4th century BP) and has since then increased largely due to humanity growth and increasing commercialization, supported by technology development that helps to satisfy such demand (Coll et al. 2010). In the Mediterranean, resource exploitation is considered the second source of biodiversity threat (Coll et al. 2010), although historically it accounts as the first one in the north Adriatic (Lotze et al. 2006). Overfishing, especially recent industrial commercial fishing, is the main source of ecosystem degradation and structural and functional change. The decline of commercial important species might induce an increase of less valuable species, altering the food web of an ecosystem and causing declines on species dependent on the exploited ones (e.g., birds or large mammals that feed on overexploited large commercial fishes; Rossi 2019b; Gray 1997; Coll et al. 2010; Tserpes et al. 2006). Other sources of exploitation and habitat loss are trawling and fishing with explosives (Rossi et al. 2017; Gray 1997).

Pollution is especially notable in a semi-enclosed area such as the Mediterranean Sea, with heavy demographic, urban and industrial development. Pollution results in environmental stress for the coastal biota leading to biodiversity loss, and/or reduction in abundance of the dominant species, and/or increased abundance of opportunistic species, which may lead to a shift in species dominance in the community (Bianchi and Morri 2000). Coastal income of heavy metals, mining waste run-off, estuaries debris, and organic chemicals among others are pollutants from anthropogenic origin. The sources of pollution come from industrial and urban (including touristic) litter and sewage plus spilled oil and litter discarded from ships. Plastic litter account

for 75% of the total litter, although it is also usual to find metal, glass, and wood (Gray 1997). Industrial and urban development (e.g., construction of artificial ports and beaches, dams, deforestation, mining activities) alter the coastal natural water-flow, and the patterns of sedimentation and nutrients. Such activities usually transport an unnatural amount of sediments to the sea (Gray 1997).

Eutrophication is another impact to marine biodiversity. Eutrophication is caused by excess of sewage discharged in coastal water, leading to low oxygen concentration and harmful algal blooms that affect the fauna of the area (Gray 1997). Hypoxia conditions in the bottom are a cause of benthic mass mortalities. Eutrophication is also a cause of jellyfish outbreaks (Coll et al. 2010).

1.2.2.2. Climatic drivers

Seawater warming affects the dispersal patterns, behaviour, reproductive success, and in consequence the survival rate of marine species. Seawater warming can also give competitive advantage to one of a pair of niche-sharing species, modify the abundance of prey and/or predators, and modify the water circulation dynamics affecting the dispersal patterns of some species (Bianchi and Morri 2003; Gómez-Gras et al. 2021). The 14/15 ºC Mediterranean mean annual isotherm moved northwards in the last years, creating an expansion of the warm-water species and a contraction of the cold-water ones. The latter are pushed northwards and forced to live in an increasingly smaller remain in the Gulf of Lions and Ligurian Sea, with the impossibility of moving northwards. The situation is also driving an increase of tropical aliens and warm-water indigenous species that can expand northwards since they have a competitive advantage in comparison to the cold-water ones (Bianchi and Morri 1993; Bianchi and Morri 2000; Coll et al. 2010; Bianchi et al. 2012). Species unable to migrate to colder areas in an equal rate as the water warms are likely to be the most affected ones (Coll et al. 2010). Atypical warmer seawater temperatures during summer have been related with mass mortalities of several species, not only directly for not being able to support the temperature, but also because high temperatures trigger pathogen's diseases (Gómez-Gras et al. 2021; Garrabou et al. 2001; Garrabou et al. 2009; Arias-Ortiz et al. 2018; Galli et al. 2017). Moreover, water warming leads coralligenous communities to bleach and subsequent death (Hoegh-Guldberg 1999).

Ongoing anthropogenic climate change is characterized by accelerated increase of CO_2 concentrations in the atmosphere that are partly absorbed by the ocean. The rapid rate of CO_2 absorption in the surface ocean is producing a series of chemical reactions. Main cosequences

are an increase in H^+ that is lowering the seawater pH and decreasing the [CO_3^{-2}], altering the biological marine calcification and reducing the stability of $CaCO_3$, the mineral used by certain organisms to build their skeletons or shells for protection and/or structural purposes (Zeebe 2012). The most affected are likely to be the coralligenous communities and the species that have carbonate structures (Lacoue-Labarthe et al. 2016; Linares et al. 2015; Bianchi et al. 2012; Zunino et al. 2017). Other species, like the seagrasses and brown algae, are likely to have an advantage with increasing atmospheric CO_2 concentration, causing a shift in species abundance in determinate habitats (Zunino et al. 2017; Coll et al. 2010).

Finally, the sea level rise associated to climate change can constitute an important climatic threat for the photosynthetic benthic habitats situated on their bottom limit, which will stop receiving sunlight for its survival (Bianchi et al. 2012).

1.2.3. Keystone Mediterranean marine habitats that hold high biodiversity

The highest biodiversity in the Mediterranean Sea is concentrated in the coastal areas (Coll et al. 2012); among those areas the highest source of diversity is found in the *Posidonia oceanica* meadows followed by the coralligenous habitats (Boudouresque et al. 2006; Boudouresque 2004). The importance of these species reside in that both are ecosystem-engineering species that create and sustain complex 3D structures that serve as habitat, protection, and feeding for several other species. Furthermore, those habitats highly contribute to capture and sink carbon, among other elements of the water column, and transform them to biomass and energy, being a source of increasing biomass and biodiversity as they grow and become more structured and complex. Both habitats reach a high production rate despite low nutrient availability. Both habitats are also capable to modify current flows, and retain water column particles (Rossi 2013; Ruiz et al. 2015; Boudouresque et al. 2006). In conclusion, the biodiversity of the Mediterranean Sea highly depends on the health status of these habitats.

1.2.3.1. *Posidonia oceanica* meadows

P. oceania is considered the most important shallow water habitat in the Mediterranean, where it is endemic, the other actual species of the genus are found all in south Australia (Bianchi et al. 2012). It forms extensive meadows in the infralittoral zone (Coll et al. 2010), being the most characteristic community of that depth (Boudouresque 2004). It is placed, either in soft or hard substrates, between the surface and 25 to 50 m water depth (depending on water turbidity; Boudouresque 2004). In the Catalan Sea, the bottom distribution limit is situated around 25 m depth (Ruiz et al. 2015). *P. oceanica* rhizomes are morphologically and genetically equal between

patches. From the rhizomes a vertical upward growth of the leaves happens (4 to 8 leaves per shoot) and downward we find a root extension (very lignified). Their leaves can overpass 1 m high and 1 cm wide, and they can reach densities superior than 10,000 leaves m^{-2} (1,000 shoots m^{-2}). The vertical rhizomes grow between few mm y^{-1} to several cm y^{-1} and they entwine between each other and the roots to form the matte, characterized by its low decomposition rate due to highly lignification of roots and rhizomes. This matte retains a high quantity of sediments thanks to the leaves that intercept the near bottom currents; such sediments fill clean spaces of the matte and, with time, elevate the seabed depth that helps to attenuate the waves into the coast providing elements to the coastal areas. That particle flux trapped becomes also a sink of carbon and nutrients, and a source of nutrition for several species as well as their shelter and habitat (Ruiz et al. 2015; Boudouresque 2004).

P. oceanica has sexual reproduction through hermaphrodite flowers, but it has a minor importance in the plant extension compared with the clonal rhizome growth (Ruiz et al. 2015). These seagrass meadows have a high primary production (400 to 2,500 g dry weight/m^2/y; 2,000 to 3,000 g dry weight/m^2/y if their autotrophic epiphytes are included) and around 30-40% of it are exported mainly to the circalittoral and bathyal zones. No other marine multicellular photosynthetic organism has the amount of biomass of *P. oceanica*, around 2,100 g dry weight/m^2/y (around 2,200 to 2,500 g dry weight/m^2/year if their autotrophic epiphytes are included; Boudouresque et al. 2006; Boudouresque 2004). *P. oceanica* meadows have a high biomass and primary production rates, particularly if we take into account the very low nutrient concentrations of their environment, being classified as a Low Nutrient High Chlorophyll ecosystem (Boudouresque et al. 2016). It is estimated that around 20% of the species of the Mediterranean Sea are found in this ecosystem (Boudouresque 2004).

P. oceanica is highly valuable for humanity. It has a fishing value, as several commercial species are found there. It decreases coastal erosion by absorption of coastal hydrodynamics and sedimentation and fixation of particulate matter (Ruiz et al. 2015). Its nutrient accumulation, especially nitrogen, prevents eutrophication (Boudouresque et al. 2006). Its carbon sink function, plus the production of oxygen, mitigates global warming, and can reduce coastal contamination by absorption and transformation of toxic substances. Remains of dead *P. oceanica* end accumulated on the beaches preventing sand-removal, acting as shelter, reproduction, and habitat conditions for different species (Ruiz et al. 2015). Mediterranean tourism partly depends on the quality of water and sand of the touristic coastal destination, which is directly dependent of the health status of *P. oceanica* meadows. Finally, another human

value of *P. oceanica* is its bioindicator function, as they are very sensitive to environmental change (Ruiz et al. 2015).

P. oceanica meadows in the Mediterranean Sea are, by far, the most extended and complex of the marine angiosperm meadows, having more biodiversity an ecological niches in their ecosystems than any other meadows (Ruiz et al. 2015). Despite being present all around the Mediterranean coast, the actual surface that the meadows cover is quite small compared with the potential surface that could fill (Boudouresque 2004), covering nowadays around 37,000 km^2, the 1-2% of the Mediterranean seabed (Boudouresque et al. 2006). The main causes of *P. oceanica* meadows degradation are: industrial and urban pollution, water turbidity, boat mooring, trawling and underwater explosives, coastal development, underwater cables and pipes burying, alteration of the sediment flow, displacement by invasive species, epiphytism, sea-urchin grazing, and trampling (Boudouresque et al. 2009; Boudouresque 2004). Some authors state that, a part from the anthropogenic causes of *P. oceanica* regression, there is a natural decline generated by the fact that it is outside its climatic optimum, which is believed that was around the 6,000-2,750 BP (Bianchi 1997). However, natural causes of *P. oceanica* regression are not considered by some authors, as they observe no decline in meadows inside well managed MPAs (Montefalcone et al. 2009). In addition, some authors state that the flowering capacity of *P. oceanica* can improve due to the actual global warming (Montefalcone et al. 2013); although a study in the eastern Ligurian Sea showed that an increase of leaf surface area per shoot was reported without recording a big increase in temperature (Peirano and Bianchi 1995). Interestingly, some authors state that the leave production and rhizome growth on *P. oceanica* will decrease (Mayot et al. 2005), but it is clear that studies with longer periods of monitoring, which lacks considerably, are necessary to corroborate those hypotheses. What is sure is that there is a very slow recovery time of the degraded meadows and recolonization of the once-removed areas, which limits the species resilience (Montefalcone et al. 2010; Ruiz et al. 2015; Boudouresque 2004).

Pollution is closely related with water turbidity and can become toxic to *P. oceanica*. The meadows are affected especially by detergents and nutrients (Boudouresque 2004; Ruiz et al. 2015). Desalination plants sewage cause local shift in salinity that might drastically affect the stenohaline of *P. oceanica* (Ruiz et al. 2015). The highest affectations are seen close to large coastal urban cities (Boudouresque 2004). Most of the highest impacts are concentrated in the NW Mediterranean. For example, the Ligurian Sea meadows lost 30% of their surface area in the 1960s, coinciding with the quick industrial and urban development of that coastal area (Bianchi et al. 2012; Bianchi 1997; Bianchi and Peirano 1995).

Eutrophication caused by urban sewage, aquiculture, contaminated rivers discharge into the sea, runoff waters, and atmospheric pollution affects *P. oceanica* by increasing water turbidity, and promoting massive growth of algae, especially the *P. oceanica* epiphytes, limiting light availability. Also, the increase of nitrogen availability may increase the grazing activity of the herbivores, like sea-urchins, to the meadows and the plant tends to accumulate the nitrogen diminishing its respiratory, photosynthetic and growing function (Ruiz et al. 2015; Ruiz et al. 2001). Water turbidity decreases the depth in which the seagrass meadows receive light for photosynthesis, thus decreasing the deepest parts of the meadows (Montefalcone et al. 2009; Ruiz and Romero 2003).

Trawling causes physical removal and destruction of the meadow and its secondary degradation due to higher sediment and nutrient suspension in the water column reducing light incidence. The higher nutrient suspension also increases the epiphyte presence in *P. oceanica* leaves, which compete for light (Ruiz et al. 2015; Kiparissis et al. 2011). In most Mediterranean countries, trawling is forbidden by law in the areas where the *P. oceanica* is found, but such laws are not fully implemented. For example, 52% of the meadows surface areas have disappeared in Alicante (Spain) due to illegal trawling (Guillén et al. 1994). Boat mooring, done since past times, and underwater explosions (for fishing purposes or during the Second World War) also cause physical destruction and fragmentation of the meadows. Such disturbances suspend bottom sea particles causing the lowering of light availability, thus, slowing *Posidonia*'s growth rate (Boudouresque et al. 2009; Ruiz et al. 2015).

The construction of artificial beaches, ports and other coastal development infrastructures, a part of physically damaging or removing the meadows, may also alter the sediment flow, causing upstream hyper-sedimentation that leads to the burying and then death of the vegetative apexes of the plant, particularly if the sediment input is larger than 5-7 cm/year. Additionally, the downstream shortage of sediment provokes rhizome baring, more vulnerable to trawling and water currents (Boudouresque 2004; Ruiz et al. 2015). For some artificial beaches, the sand was retrieved underwater, removing entire meadow habitats (Ruiz et al. 2015). The burying of pipes and cables in a sea-bottom trench also causes physical destruction of *P. oceanica* (Boudouresque 2004).

1.2.3.2. Coralligenous and *Corallium rubrum*

Coralligenous habitat can be defined as "*hard substratum of biogenic origin that is mainly produced by the accumulation of calcareous encrusting algae growing in dim light conditions*" (Ballesteros 2006).

Coralligenous habitats represent the most characteristic ecosystems of the Mediterranean circalittoral zone (Boudouresque 2004), although these habitats can also develop in the infralittoral zone if there are the adequate light condition for the sciaphilic species that form the coralligenous initial structure from which further species can develop (Ballesteros 2006). The biodiversity in the coralligenous habitats is high but it has not been accurately estimated yet. A recent attempt estimated 1,666 species, the real number probably being much higher (Ballesteros 2006). Coralligenous habitats are found along the entire Mediterranean coast with possible exception of Israel and Lebanon. The best developed habitats are found in the Aegean Sea and the NW Mediterranean, where the majority of studies of these formations are found (Ballesteros 2006). The coralligenous can grow forming banks or rims, either in horizontal or vertical surfaces as well as in overhangs, holes, or tier shapes (Boudouresque 2004; Ballesteros 2006). The complexity of the coralligenous allows the development of huge diversity of species and contains many microenvironments where irradiance, water motion, nutrient availability, and other environmental factors highly vary, allowing many different ecological niches situated very close from each other. Very low dynamism and seasonality is observed in those communities, especially notable in the deeper ones (Ballesteros 2006).

Coralligenous distribution completely depends on light intensity as such habitats need light for the growth and development of their main engineering species but until a limit, as light excess cannot be supported by those organisms. Due to its morphology, the coralligenous light levels can highly vary, e.g., a horizontal exposed surface receive much more irradiance than crevices and small holes on their structure. A similar situation happens with the water movement in the coralligenous community (Ballesteros 2006). The light levels mark its bathymetric distribution, which range around 10 to 130 m depth (Gili 2001; Boudouresque 2004; Ballesteros 2006). The shallower coralligenous communities are dominated by algal builders (mainly *Mesophyllum alternans*) and they are mostly covered by green algae reaching high densities. Coralline algae, green algae, species diversity, and covered space in the coralligenous decreases with depth. But among the shallow algae-dominated coralligenous, the highest diversity is often found in the crevices, holes and cavities of the coralligenous, where algae are usually scarce or absent due to limited irradiance. Indeed, this microhabitat is the only shallow potential habitat of *C. rubrum* (Ballesteros 2006).

In the coralligenous, suspension feeders are the dominant organisms (Gili and Coma 1998; Gili 2001). We find the engineering species that create the initial structure through their calcareous skeletons, these builders are commonly coralligenous macroalgae (mainly *Mesophyllum* and

Lithopyllum), but there are also animal builders, mainly Bryozoa (Boudouresque 2004; Ballesteros 2006). Then, building on this initial structure, we find different types of organisms. We find fauna that helps with the building of the structure, which represent around 24% of the total species number (red coral is included among those). We also find fauna that colonize and live in the microhabitats of the coralligenous (small holes, crevices…), which represents around 7% of the total species. We find the fauna living over the coralligenous concretions (epifauna) and inside them mainly in the sediments that coralligenous retain (endofauna), which represents the 67% of the total species. Finally, eroding species account for 1% of the total (Hong 1982; Ballesteros 2006).

Between the coralligenous species, epibiosis and commensalism are the most common relations; mutualism and parasitism have been reported as well. Most epibionts are non-selective, as most of the space of a coralligenous community is already occupied by other species, so the new ones settle on the previously living ones. Most of the sessile species in the coralligenous are epibionts. Some basibionts have antifouling defences to avoid proliferation of epibionts (Ballesteros 2006). Most species forming part of the coralligenous structure are well protected against predation, some due to its strong skeletons, and others due to chemical defences; these chemical substances also serve for space competition in the coralligenous. The main feeding way is through the pelagic biota and not in the sessile companions. So, in an environment dominated by suspension feeders, little space is given for herbivory and carnivory, although some species depend on these feeding strategies. The sea urchin *Sphaerechinus granularis* is the main herbivore (sea urchin effects account for 95% of the total $CaCO_3$ eroded), and the fishes that develop on these habitats are the main carnivores together with echinoderms and crustaceans. Most of the feeders are non-selective in prey (Ballesteros 2006).

Corallium rubrum is an engineer species found in the coralligenous communities dominated by animal builders (Garrabou et al. 2017; Ballesteros 2006), commonly in *Paramuricea clavata*-dominated communities, usually in vertical rocky cliffs. Also, it is common to find this species together with Bryozoa, Porifera, and Annelida (True 1970). *C. rubrum* is found in deeper coralligenous or in shallower ones, if there is very dim light. The species can also be found in crevices, holes and caves; it can be located very shallow, if irradiance is very low inside those physical features (Garrabou et al. 2017; Tsounis et al. 2010). Geographically speaking, *C. rubrum* is found mostly in the western basin, especially in the north-west, although it is also found in some areas of the eastern Mediterranean (Ballesteros 2006; Garrabou et al. 2017). Its bathymetric range goes from 5 to around 1000 m depth (Garrabou et al. 2017; Knittweis et al.

2016; Rossi et al. 2008). Red coral is a sessile and aposymbiotic cnidarian who reaches sexual maturity between 7 and 10 years; it has a limited larval dispersal effect, supported by its low population dynamics and genetic mixing. It can live from several decades to centuries. It has a small size (25 mm height, 3.6 mm diameter) and very slow growth rate (0.24-0.26 mm y^{-1}; Garrabou et al. 2017; Garrabou and Harmelin 2002). Red coral key roles inside the habitat reside on its capacity of increasing its 3D complexity, plus its storage and bioremoval function of carbon from the sea, which is used to form its $CaCO_3$ skeleton and its sclerites (Picciano and Ferrier-Pagès 2007; Vielzeuf et al. 2008). Its tree-like structure also is used for protection by several species (Tsounis et al. 2010).

Due to the impacts they suffer, the coralligenous habitats tendence is to build smaller colonies and smaller benthic organisms in it, with lower biomass of the ancient organisms that form and shape its structure, and a lower capacity of retaining energy. In other words, biodiversity is decreasing and the 3D structure is in a flattening trend (Rossi 2013). Red coral, despite thousands of years of being exploited, is commonly observed thanks to its high survival rate and growth capacity after a partial breakage if it remains attached to the substratum. But its recovery is very slow (from several decades to centuries), making most of the actual colonies small in size (Garrabou and Harmelin 2002; Tsounis et al. 2006; Garrabou et al. 2017; Bavestrello et al. 2015; Rossi 2019). These changes result in a generalized shifting baseline syndrome, as a large long-lived non-perturbed colony seems an exception, when it actually was the normal state in the past (Garrabou et al. 2017). Anthropogenic or natural perturbations that cause the complete separation of the whole population of red coral from its substratum, lead to the cnidarian extinction (Garrabou et al. 2017).

The species living on the coralligenous habitat are very sensitive to pollution and high sedimentation rates. Sixteen macroalgae species have been reported as endangered (Ballesteros 2006). Local to regional extinction is the first sign of physical extinction, and those might have already occurred for some species. Most of the endangered species related to coralligenous communities are scarce due to their commercial value, as it is the case for *C. rubrum* (Ballesteros 2006; Tsounis et al. 2010). Red coral high decrease, especially in shallow communities, due to its commercial exploitation in almost all the Mediterranean countries, added to its slow recovery rates, made it to be considered as functionally extinct (Tsouinis et al. 2010; Garrabou et al. 2017).

Most of the species living in the coralligenous habitats support the seasonal temperature variabilities, ranging around 10 to 23 ºC, but some organisms are only found in deep coralligenous due its stenothermal behaviour (Ballesteros 2006). The main risk for these species,

especially reported for the benthic suspension feeders, is when very warm summer temperatures last longer than usual and are accompanied by a long period of low nutrient mixing due to water column stability. This situation provokes physiological stress to many organisms and can provoke and sudden increase in pathogenic diseases, causing episodes of mass mortalities (Garrabou et al. 2001; Gómez-Gras et al. 2021). Red coral populations above 30 m have reportedly been affected by high temperature anomalies (Garrabou et al. 2001; Cerrano et al. 2002). Climate change trends leading to a warmer Mediterranean will likely increase the frequency and effect of these episodes. Furthermore, calcareous coral is expected to be increasingly affected by ocean acidification due to the reduction of $CaCO_3$ calcification rate. Sea level rise is expected to reduce light availability for the deep bottom communities jeopardizing its photosynthesis function and growth (Rossi 2013; Crisci et al. 2011; Zunino et al. 2019).

Trawling is the most destructive non-selective harvesting method for coralligenous. A part of the physical damage it entails, it also increases turbidity of the seawater and sedimentation, decreasing the growth of communities. This leads to fragmentation, biodiversity loss and affectation to trophic webs in the coralligenous habitats (Ferrigno et al. 2021; Rossi 2013; Ballesteros 2006). The St. Andrew's Cross is a wooden dredging device made specially to catch red coral but it is non-selective and highly destructive. It is used since the 4th century BC, peaking in the 1800s. Technological advance made motor-boats use a derivation of the St. Andrew's cross, but it made with metal: ingegno, causing higher impact. The method was banned from the entire Mediterranean in 1994 (Cattaneo-Vietti et al. 2017; Cattaneo-Vietti et al. 2016; Rossi 2019; Garrabou et al. 2017).

Nowadays scuba diving is the only legal way to harvest coral, and where the law limits or prohibits coral harvest, poaching and irregular harvesting happens in some degree (Rossi 2013). Scuba diving began in the 1950s, resulting in the increased impact of corals impossible to reach by trawling and dredging mechanisms (i.e. in caves, crevices and holes) (Cattaneo-Vietti et al. 2016; Garrabou et al. 2017). With diving bottles, divers can reach deep corals around 140 m depth (Garrabou et al. 2017). Populations of coralligenous in frequented diving places where reported with lower density, and smaller diameter and height compared to populations in unfrequented places. High frequented diving coastal areas cause erosion and non-intentional coral breakage in a quicker rate that its recovery (Betti et al. 2019; Sala et al. 1996; Garrabou et al. 1998; Linares et al. 2010; Ballesteros 2006). Harvest of red coral, mainly used for jewellery, is a main source of disturbance. For the jewellery industry, the most valuable red corals are the

tallest and more branched individuals, which also are the ones with higher reproductive potential (Tsounis 2009; Tsounis et al. 2010).

Pollution, especially from waste water, is a cause of biodiversity decrease in coralligenous communities and one of its main threats (Boudouresque 2004; Coll et al. 2010; Hong 1983). It causes a shift in species abundance, with some decreasing and others increasing. Usually engineer species are substituted by others with lower building capacity, and bioeroders gain abundance, causing an increase in coralline destruction and a decrease in construction (Ballesteros 2006). Pollution also increases water turbidity, affecting light irradiance to the autotrophic species (Boudouresque 2004).

Algal species are the only invasive reported for coralligenous, the most dangerous is *Womersleyella setacea*, a red algae that colonized most of the Mediterranean. It grows on calcareous corallines covering them by a 1-2 cm thick layer, decreasing the light availability, and therefore their growth, increasing sediment trapping, impeding recruitment of other species and displacing other macroalgae. Altogether, the presence of this species results in a decrease of species richness and a homogenization of the community (Ballesteros 2006). Intensive aquaculture, mining extractions (especially petroleum, gas, and cobalt), and coastal development most of the times related to tourism with the consequent increase in boat anchoring, trampling, sewage and other pollution, are other factors that largely affects the coralligenous communities (Rossi 2013; Coll et al. 2010).

1.2.4. Cap de Creus Marine Protected Area

Cap de Creus region (north Catalonia, Spain) was included inside the Pla d'Espais d'Interès Natural (PEIN; in English: Natural Interest Spaces Plan) by the Decret 328/1992 of the law 12/1085 the 3rd of June. Then became a Natural Park and a MPA in the 12th of March 1998 by the law 4/1998, comprising 3,073 ha. Furthermore, Cap de Creus offshore space is a Site of Community Interest since 2006 and is included in the Natura 2000 network (Generalitat de Catalunya 2021). This canyon has high biodiversity habitats with high endemism, having a mayor importance in the entire region as it has several benthic engineer species, very sensitive to impacts (Orejas et al. 2009; Gili et al. 2011). The current MPA contains three Partial Natural Reserves and one Integral Natural Reserve. On the Partial Natural Reserves, submarine fishing is not allowed, while traditional fishing can be done with certain limitations. The Integral Natural Reserve is a no-take zone, where all extractive and recreational activities are prohibited

(extracting resources, sailing, immersion…), with the exceptions of scientific immersions with previous permission from the Natural Park.

Climatological conditions in the area are mild, with moderate annual temperatures and precipitations. This coastal region is one of the most nutrient-rich and productive of the Mediterranean Sea thanks to nutrient input from close rivers (Muga, Fluvià, and Rhône) and from an important water-column mixing generated by strong cold winds in winter producing intense currents at the coast (Gili et al. 2011; Rohling et al. 2015). Coastal marine flora and fauna of the region lay either on sandy or on rocky bottoms, where the most biodiverse-holder habitats of the Mediterranean Sea develop. Sandy bottoms are dominated by *P. oceanica* meadows (182.1 ha). The seagrasses *Cymodocea nodosa* and *Zostera noltii* are also found, but in lower extension (Ruiz et al. 2015; Sardà et al. 2012). Coralligenous habitat dominate in the rocky bottoms of the MPA. The coralligenous composition found in the infralittoral zone is mainly composed by photosynthetic algae (617.8 ha), or dominated by *Eunicella* spp. or *Codium* spp. In the circalittoral zone, *Axinella* spp. and *Paramuricea* spp. are the dominant species of the coralligenous, habitats in which *C. rubrum* develops (Sardà et al. 2012; Gili et al. 2011; Gori et al. 2011; Linares et al. 2018).

The municipalities with marine land inside the Cap de Creus MPA are Roses, Cadaqués and Port de la Selva. The traditional occupations of the inhabitants of such municipalities mainly focused on the fishery industry, with a small and artisanal fishery for the inhabitants subsistence (Gómez et al. 2006). Agriculture was also an important occupation, concretely in vineyards and olive crops. Apart of those, in Cadaqués the salting industry also was important and Roses had a strategic military spot and was a notable commercial centre. Such picture changed from the 1960s, when a touristic boom started on the area, tourism becoming the main economic activity. The tree municipalities became tourist-oriented and started transforming the town's infrastructure and the coastline to meet the touristic demand, although the traditional activities remain in the area with less relative importance. Nowadays, tourism is the main source of income for these municipalities, e.g., Girona province had 5.7, 7.8 and 7.9 million tourists and 22.9, 25.5 and 25.8 million overnight stays during 2017, 2018 and 2019 respectively (Newsletter Costa Brava 2019). Within the Girona province, the Costa Brava and Cap de Creus are the main tourism attractors.

1.2.4.1. Impacts and threats in Cap de Creus MPA

Since the establishment of the MPA in 1998, in Cap de Creus resource exploitation and the recreational and touristic activities (e.g., recreational boating and fishing, shellfish collection, spearfishing, scuba diving, artisanal fishery) coexist. In the area, there is a delicate equilibrium with conservation and regulation measures of protection of natural habitats along with sensibilization campaigns, illegal exploitation activity and fines for breach the established norms. In fact, recreational and touristic use have been often prioritized over nature conservation, and particularly in summer, at the peak of the touristic season (Hereu et al. 2018; Corrales et al. 2020; Vilas et al. 2020; Font and Lloret 2011; Lloret and Riera 2008).

During the last decades, some vulnerable exploited species (included in annex III of the conventions of Barcelona and/or Bern or in the IUCN Red List) decreased their landings in Cap de Creus, being this a probable sign of overfishing (Lloret and Riera 2008). Artisanal fishermen notice and state that situation (Gómez et al. 2006). Reports of vulnerable species catch like *Pagrus pagrus* and *Epinephelus marginatus* are documented in the literature (Corrales et al. 2020; Font and Lloret 2011; Lloret et al. 2008; Lloret et al. 2008b).

The number of species catched and the estimaties of total tons/y of catches for most of the fishing activities happening in Cap de Creus are reported in the literature. Commercial small-scale artisanal fishing catches a large, but unreported, number of species although in terms of yield only around 15 species are important. This fishing activity contributes to 50 tons/y of catches and declined in the last decades (Gómez et al. 2006). Recreational boat fishing, which constitutes a major activity in the park with an estimated average of 193 fishing hours/person and a 30% of the total harvest in the park, catches 33 fishing species and 20 tons/y (Lloret et al. 2008b). Recreational and small-scale fisheries had the largest negative effect on the MPA as they usually fish inside the protected area's waters or in the vicinity, probably due to a high fishing pressure and the lack of regulation reinforcement in the MPA (Corrales et al. 2020; Vilas et al. 2020; Lloret et al. 2008b). The total catches of these fisheries are higher than in the two closest MPAs: Medes and Cerbèrbe-Banyuls (Corrales et al. 2020) and they had the lowest biomass and average length (Vilas et al. 2020).

Spearfishers are reported to catch 21 different species in Cap de Creus, with an estimate of 19 tons/y of catch. Due to its great ability to fish for a specific target, spearfishing is an important cause of decline of long lived, slow growing species with a low reproductive potential and high trophic level, most of them with high degrees of vulnerability (Lloret et al. 2008). Recreational

shore angling catches 25 species and 3 tons/year including an important weight of vulnerable top predators (Font and Lloret 2011). Recreational and small-scale commercial fishing is allowed in all areas of the MPA except for the 21 ha of integral reserve where no fishing is allowed. Spearfishing and shellfish collection are also prohibited in the partial reserve. Also, fishing in Cap de Creus is subjected to other regulations like a minimum landing size. Despite such regulations, 30% of recreational boat fishers had no fishing license, some spearfishers did not had a license either (Lloret et al. 2008; Lloret et al. 2008b). Minimum legal landing size was not respected by some boat fishers and shore anglers (e.g., seven targeted species by shore anglers did not respect that, with the most distinct case of 90% of the *Diplodus vulgaris* reported being undersized; Font and Lloret 2011; Lloret et al. 2008b). Furthermore, 47% of shore anglers were using more than the two permitted fishing rods at the same time and only 3% of the interviewed sample discarded the unwanted species (Font and Lloret 2011). Finally, illegal fishing is reported in the MPA, e.g., spearfishing inside the partial reserve or gillnets found in the integral reserve (Hereu et al. 2018; Purroy et al. 2014; Lloret et al. 2008).

Most of the sea pollution in the study area comes from the land directly or indirectly through wind and rain, although a part of it comes from the sea (e.g., from shipping traffic; Bas 2009). Specific literature for the Cap de Creus region documents the density of floating marine macro-litter, calculated as 16.7 (±22.3) items/km^2 (Garcia-Garin et al. 2020). Human litter was present in more than 3,000 m of the areas' coastal bottom (10.1% of the videos filmed with a ROV), mostly related with fishing and recreative sea activities (Sardà et al. 2012). Furthermore, Purroy et al. (2014) stated that 70% of the 90,000 ha of Cap de Creus were affected by at least one type of fishing gear. Additionally, De Haan et al. (2019) found an average of 0.19 ±0.16 microplastics/m^2 during a north Catalan transect that included Cap de Creus.

The available literature for Cap de Creus reports the presence of species affected by climate change. The study by Hereu et al. (2018) reported mortality through bleaching of all the observed encrusting calcifying algae, reaching 30% of the observed individuals in some stations. Also the gorgonians *Eunicella singularis* and *Paramuricea clavata* among others were greatly affected by the seawater warming (the latter overpassing 50% in some stations). They also observed species mortality in bivalve mollusks, briozoans, and sponges. Finally, the authors expect that each year mortalities rise. Additionally, an oceanographic station located at l'Estartit (less than 50 km away from Cap de Creus) measured an increase of the mean temperature of 1.1 ºC in the upper 50 m of the water column from 1974 until 2010. The same station also measured the sea level rise since 1990, which has rise an average of 3.4 mm y^{-1} until 2010 (Calvo et al. 2011). The

thermophilic species *Epinephelus marginatus* increased its landings in Cap de Creus, probably because of the rise in water temperature (Lloret and Riera 2008; Gómez et al. 2006).

The northwestern region is the Mediterranean area with the highest native marine species biodiversity and the lowest alien species numbers (Katsanevakis et al. 2014). The presence of marine invasive species at the MPA of Cap de Creus is very recent and is not yet captured on the scientific literature. In autumn 2019, a marine biologist of the Marine Support Group of the Rural Agents Corps confirmed the presence of the algae *Caulerpa cylindracea* in the MPA (Rodríguez 2019). The last published reports where they search for alien species in the area did not report any (Hereu et al. 2018; Hereu et al. 2016). Despite not seeing them, they were expecting their presence soon. Additionally, Font and Lloret (2011) reported that 41% of the recreational shore anglers in Cap de Creus used alien alive baits, which can be a potential threat of alien species introduction; dumping in the sea the seaweed used for packing the baits too.

1.3. Aims and structure

This thesis is structured in six chapters: the first introductory chapter, four empirical chapters written with the structure of scientific articles (chapters 2 to 5), and the overall conclusions (chapter 6). Chapter 2 has been already published in a peer-reviewed journal and chapter 3 is presently under review. Both chapters maintain the original content of their publication and submission respectively. Chapter 4 and 5 have not been submitted to any journal yet. Because chapters 2 to 5 are written as independent scientific articles, there is some duplicated information through the chapters (e.g. background and methods). Also, every chapter has its own reference and supplementary material (cited as SM in the text) sections.

The overarching aim of the thesis is to contribute to the understanding of the trends of coastal marine biodiversity loss in the NW Mediterranean Sea region. The importance of anthropogenic and climatic pressures in explaining these trends are addressed, with a special emphasis on the dominant and largest biodiversity-holder habitats of the Mediterranean Sea: the coralligenous and the seagrass meadows. The thesis also aims to understand how local populations perceive such trends and their related impacts.

Chapter 2 main theoretical framework comes from MHE and seeks to reconstruct the temporal trends of the most reported *C. rubrum* population parameters in the NW Mediterranean Sea and to assess their temporal changes in total carbon sequestration. We found few studies assessing

the historical *C. rubrum* health status and population structure through time, even more scarce for large time periods and extensive areas. The MHE approach used in this chapter can help trace and interpret the changes between ancient and current *C. rubrum* populations and the potential drivers for such changes. This study, covering a large time-span and a wide region, contribute to know better the *C. rubrum* trends and understand associated loss of its ecosystem function including their carbon sink capability. To achieve that aim, we did a meta-analysis of peer-reviewed and grey literature, including documents that provide qualitative assessments. From those documents we selected the ones with information about red coral most reported biometric parameters: basal diameter, height and weight, and we obtained their yearly averages and estimate their biomass, carbon flux and carbon fixation.

Chapters 3 to 5 assess local perceptions of the same trends, also relaying in human memory as a source of knowledge. Those chapters use the same methodological approach, consisting in qualitative exploratory semi-structured interviews and a quantitative survey. They also refer to the same study area (Cap de Creus). In particular, the chapters rely on information from semi-structured interviews to specific local stakeholders (that is: owners and managers of tourist accommodations, fresh seafood restaurants and scuba diving centres), which are people dependent on some degree on the CMHs health status for their income. On such interviews we asked participants to list the changes perceived in the area since they had begun working there (chapters 3 and 4). The survey sample included a broader sample of adults found in the study area and has four parts. The first part consisted in sociodemographic data of the respondent, the second part consisted in raking a list of benefits, impacts and threats from/to the CMHs of the region regarding the importance they had for the respondents (chapter 3). The third part of the survey consisted in knowing the agreement degree of the respondents to sentences, which describe past vs. present situations (e.g. "*in comparison with the past, today exists more boat transit and boat anchoring; this increases the negative impacts on marine life*"; chapter 4). The fourth part was addressed to recreative scuba divers, they had to do a qualitative estimate of the overall abundance and health status of *P. oceanica* and *C. rubrum* seen in their dives during the different decades they have been diving in the region (chapter 5).

Chapter 3 aims to understand how the users of Cap de Creus MPA perceive the benefits, impacts and threats of CMHs in order to obtain information on the awareness of the users' perceptions, that can help to improve effective marine life conservation and management policies of coastal areas. Chapter 4 aims to know how Cap de Creus MPA users perceive temporal environmental trends in the local CMHs, contributing to the scarce literature that

assess a wide range of environmental temporal changes for different typologies of people in a concrete area. Finally, chapter 5 addresses how scuba divers perceive temporal change on the health status of *P. oceanica* and *C. rubrum* in Cap de Creus MPA and compare their perceptual trends with the available ecological data. The results contribute to understand the functional transformation of these biodiverse-holder habitats.

1.4. References

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2 HISTORICAL RECORD OF *CORALLIUM RUBRUM* AND ITS CHANGING CARBON SEQUESTRATION CAPACITY: A META-ANALYSIS FROM THE NORTH WESTERN MEDITERRANEAN

This chapter corresponds to a published scientific article:

Mallo M, Ziveri P, Reyes-García V, Rossi S (2019) Historical record of Corallium rubrum and its changing carbon sequestration capacity: A meta-analysis from the North Western Mediterranean. PLoS One 14:1–20. https://doi.org/10.1371/journal.pone.0223802.

Abstract

Background: There is a scarcity of long time-span and geographically wide research on the health status of *Corallium rubrum*, including limited research on its historical ecology and carbon sequestration capacity.

Objectives: To reconstruct the temporal trends of the most reported *C. rubrum* population parameters in the Northwestern Mediterranean Sea and to determine the changes in total carbon sequestration by this species.

Data sources: Quantitative and qualitative, academic and grey documents were collected from scientific web browsers, scientific libraries, and requests to scientists.

Study eligibility criteria: Documents with original information of basal diameter, height and/or weight per colony, with a depth limit of 60 m in the Catalan and Ligurian Seas were analysed.

Synthesis methods: We calculated yearly average values of *C. rubrum* biometric parameters, as well as estimated total weight, carbon flux, and carbon fixation in the structures of *C. rubrum*'s colonies.

Results: In both study areas, the values of the selected morphometric parameters for *C. rubrum* decreased until the 1990s, then increased from the 2000s, with average values surpassing the levels of the 1960s (Ligurian Sea) or reaching levels slightly lower than those of the 1980s (Catalan Sea). The difference in carbon sequestered between the oldest (1960s: Ligurian Sea; 1970s: Catalan Sea) and the lowest (1990s) biomass value of colonies is nearly double.

Limitations: Quantitative data previous to the 1990s are very limited. Information on recent recovery trends in *C. rubrum* parameters is concentrated in a few areas and biased towards colonies in marine protected areas, with scarce quantitative information from colonies in other areas.

Conclusions: The halt in the *C. rubrum* decreasing trend coincided with the exhaustion of tree-like colonies and the first recovery response due to effective protection measures in some areas. Nevertheless, *C. rubrum* climate change mitigation capacity through carbon sequestration can be drastically reduced from its potential in only a few decades.

2.1. Introduction

The coralligenous is one of the most biodiverse habitats of the Mediterranean Sea (Boudouresque et al. 2017; Boudouresque 2004). This community forms a complex 3D structure that serves as habitat, protection, and feeding area for several species. Moreover, the community is dominated by benthic suspension feeders (Ballesteros 2006) that strain suspended matter and food particles and fix the suspended particles into long-lived structures, acting thus as carbon sinks (Rossi et al. 2012). The coralligenous' structural complexity and the different architecture of the ecosystem-engineering species allow for the development of a large number of highly biodiverse systems that take advantage of the microenvironmental heterogeneity, in which irradiance, water motion, nutrient availability, and other environmental factors highly vary (Boudouresque et al. 2017; Ballesteros 2006). However, several factors are threatening this habitat, resulting in some suspension feeding communities losing individuals or colonies (Montefalcone et al. 2017; Roghi et al. 2010; Coma et al. 2004; Linares et al. 2005). Moreover, compared to larger specimens, the younger (and smaller) ones possibly retain less carbon in their structures (Rossi et al. 2021; Rossi 2013). Biodiversity in this community is also decreasing; the habitat becomes more homogenous and the 3D structures less common (Rossi 2013; Betti et al. 2017), and thus less resilient to environmental changes (Bianchi and Morri 2000; Sala and Knowlton 2006).

One of the most emblematic species in the coralligenous community is the red coral, *Corallium rubrum* (CR) (Ballesteros 2006; Tsounis et al. 2010). Red coral is a long-living, slow-growing, sciaphilous, and heterotrophic cnidarian that increases the 3D complexity of its habitat. The arborescent structure of red coral may serve as refuge for several organisms (Tsounis et al. 2010). This anthozoan lives in cracks, crevices, overhangs, and boulders between 7 and 1016 m depth (Rossi et al. 2008; Tsounis et al. 2006a; Knittweis et al. 2016). A main feature of this passive benthic suspension feeder is its calcium carbonate ($CaCO_3$) skeleton, composed of annual growth bands with an organic skeleton matrix (Marschal et al. 2004). The red coral captures detrital particulate organic carbon (POC) and nano-, phyto- and zoo-plankton from the water column, from which it obtains carbon and other nutrients. The biomineralization forms an axial skeleton and the sclerites made of $CaCO_3$ crystallize in the form of high-magnesium calcite and organic matter (Vielzeuf et al. 2008). This process contributes to the storage and biological removal of carbon from seawater (Picciano and Ferrier-Pagès 2007).

Red coral has been harvested since ancient times, mainly for jewellery (Tsounis et al. 2010; Cattaneo-Vietti et al. 2016; Tescione 1968). For the jewellery industry, the most valuable pieces are the largest and more branched colonies, which are also the ones with higher reproductive potential [Ballesteros 2006; Rossi 2013; Rossi et al. 2008; Santangelo et al. 2003). Reproduction in this organism is limited, as CR is a gonochoric internal brooder with low reproductive rates and limited dispersal of its larvae, resulting in low genetic mixing (Costantini et al. 2007; Costantini et al. 2011). Such facts, added to its slow recovery after a perturbation (the recovery process can last from several decades to centuries), has resulted in most of the actual CR colonies being small in size (Garrabou and Harmelin 2002; Bramanti et al. 2009; Garrabou et al. 2017a). Moreover, in several regions this species is considered 'ecologically extinct' (unable to make its function in the eco- system) (Tsounis et al. 2010; Pandolfi et al. 2003), the discovery of large long-lived non-perturbed colonies being nowadays an exception (Garrabou et al. 2017b; Cau et al. 2016). The extinction of red coral is of concern not only for the species itself, but also for the potential effects on the entire habitat (Tsounis et al. 2010).

Very few studies have assessed the historical CR population structure and health status (defined as the normal demographical, physiological and reproductive conditions of a population that would allow perpetuation of future generations, avoiding local extinction; Rossi et al. 2017b) through time. Moreover, the comparison of CR population structure and health status between different areas and large periods of time remains scarcely reported (Garrabou and Harmelin 2002; Linares et al. 2011; Bavestrello et al. 2015b; Boavida et al. 2016). Historical ecology can help trace and interpret the changes between ancient and current populations and ecosystems and the potential drivers of these changes (e.g., biodiversity loss, acceleration of biogeochemical cycles, presence of eutrophic areas, and loss of carbon retention in long-lived structures) (Thurstan et al. 2017). Studies covering wide regions and a large time-span (like those done with other species and ecosystems, e.g., Gatti et al. 2015; Marbà et al. 2014; Lotze et al. 2011; Holon et al. 2015; Ferretti et al. 2008; Ardizzone et al. 2006; Jackson 1997) can shed light on CR's temporal trends, which in turn, may help us understand not only the species health status trends, but also the associated loss of ecosystem services, including CR's role as a carbon sink or as a habitat-forming species (Tsounis et al. 2010).

In this study, we use historical data on CR biometric and population structure from two different NW Mediterranean regions, Catalan Sea and Ligurian Sea, to quantify CR population changes. The analysis of temporal patterns in CR distribution and biometric parameters is then used to provide an estimate of CR populations as potential carbon sinks.

2.2. Methodology

An extensive literature review was performed regarding the presence, demography, and biometrics of CR in the Catalan Sea (including Côte Vermeille) and the Ligurian Sea regions. Demographic and biometric parameters describe the characteristics of a population and serve to determine the species' health status. Our search included grey and academic literature and documents that offered both quantitative and qualitative descriptions of CR's health status. Specifically, we did a research in the fields "Topic" (Web of Science) and "In the Title" (Google Scholar) using the following keywords: "Corallium rubrum" OR "red coral" OR "coralligenous" AND "Mediterranean" OR "Catalunya" OR "Catalonia" OR "Catalan" OR "Liguria". Additionally, a systematic review of two scientific libraries, plus punctual research in several others, was realized. Additional documents were obtained from our network of scientists working on the topic. Finally, references cited in previously selected documents were also reviewed. Documents were reviewed if written in Catalan, Spanish, English, French, Italian, or Latin. The bibliographic research was not limited regarding the antiquity of a document and we considered documents published up until September 2018. The oldest document found describes CR from the 3rd century BP (Julius Solinus 1895).

From a total of 84 pre-selected documents, 65 contained original data (new scientific knowledge) on CR health status (Fig 1; SM 1), 22 of them providing only qualitative descriptions. The documents providing quantitative information on the most commonly studied parameters (i.e., basal diameter, height, and dry weight) were reviewed, resulting in 28 documents that included information on at least one of these parameters. Finally, 24 documents with comparable information were included in the meta-analysis (Fig 1). The number of documents selected during the various stages of the meta-analysis is shown in Fig 2.

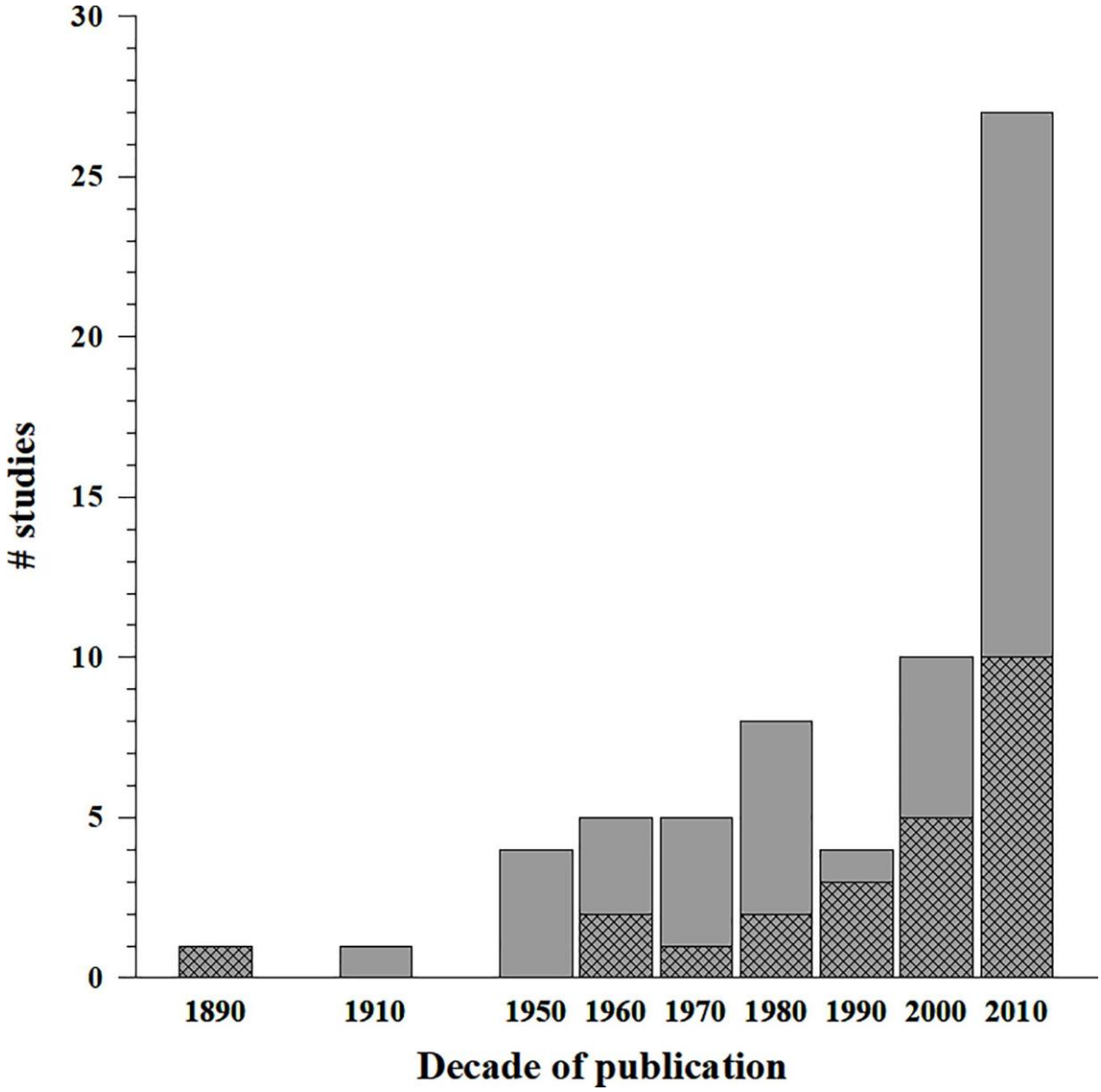

Figure 1. *Publication date and number of documents with original data on Corallium rubrum health status, by decade and study site. In grey the number of documents in the Catalan Sea (including Côte Vermeille) and the Ligurian Sea: n = 65; in cross grids the documents selected for the analysis: n = 24.*

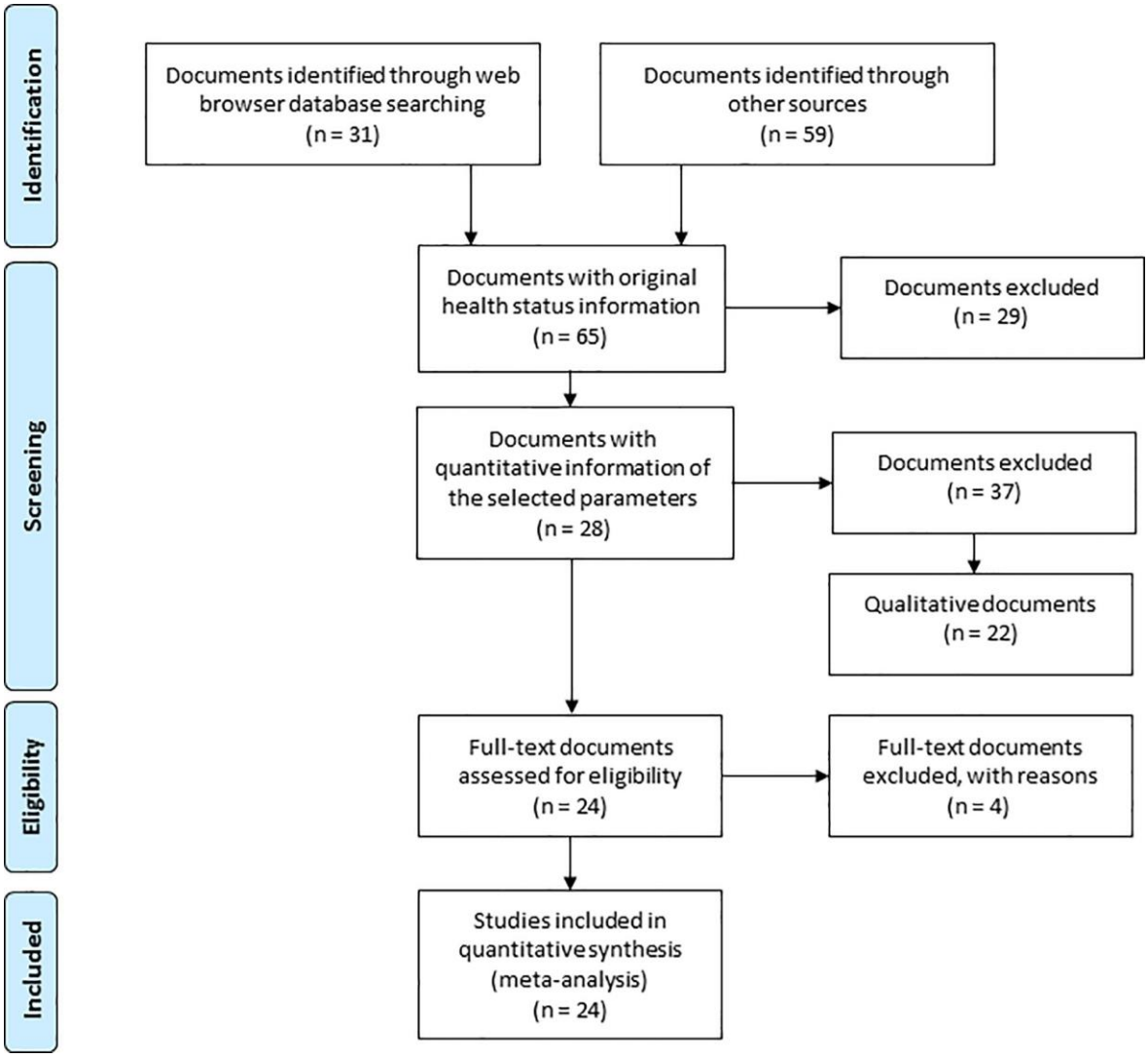

Figure 2. *Selection of documents for inclusion in the meta-analysis.*

We used the colony patch as sampling unit for this work. We consider a patch of red coral as a distinct group of colonies, where the distance of colonies within the patch is substantially lower than the distance of colonies between patches (CR usually follows a patchy distribution; Rossi et al. 2008). When the colony patch sampling unit was not possible, the nearest higher-resolution available was used. For a given parameter, the yearly mean value was taken as the average of the values for all the colony patches (or higher resolution) sampled in the same year. The maximum depth of CR used is 60 m, as the studies made below this depth are very scarce and sparse, decreasing the consistency and precision of statistical comparisons (Rossi et al. 2008; García-Rodríguez and Massò 1986; Cattaneo-Vietti et al. 1995; Bavestrello et al. 2010; Bavestrello et al. 2015a). Some documents (25%) did not indicate the sampling year, so we assumed collection

was done one year before the publication date. If the parameter was obtained during various years and only an average value was provided, we assigned the result to the last year when samples were reportedly collected (e.g., Tsounis et al. 2006a; Gili and Sardà 1980). Number of colonies used to estimate each parameter can be found in SM 2.

Results obtained from random sampling were considered comparable, irrespectively of whether data were obtained from quadrants or stations (e.g., Linares et al. 2011; Bramanti et al. 2014), transect lines (e.g., Tsounis et al. 2006a; Cattaneo-Vietti et al. 1995), or covered the whole area (e.g., Gili and Sardà 1980). Studies excluding colonies < 2 mm basal diameter or < 2 cm height were also considered comparable (e.g., Bavestrello et al. 2015b), as it is usually hard to do reliable analysis with such small sizes. Samples obtained through poaching were discarded from the analysis (Linares et al. 2011; Montero-Serra et al. 2017; Descamp and Carteron 2004; Hereu et al. 2000), since it is unknown whether they represent the natural population accurately. Commercial samples were also discarded as they usually only include the largest individuals (e.g., García-Rodríguez and Massò 1986; García-Rodríguez and Massò 1986b), and therefore are not representative.

We used all the available data in the literature from our study regions, plus off the Tuscany region, to calculate additional parameters than those found in the literature. The additional values were obtained using regression analysis for each pair of parameters previously selected (Fig 3; See SM 3, SM 1, and SM 4). The following equations resulted from those regressions:

$$y = 0.875x - 0.655 \quad (1)$$

y = height (cm), x = basal diameter (mm), $r^2 = 0.651$

$$y = 0.453x + 2.484 \quad (2)$$

y = height (cm), x = weight (g), $r^2 = 0.552$

$$y = 1.808x - 5.582 \quad (3)$$

y = weight (g), x = basal diameter (mm), $r^2 = 0.828$

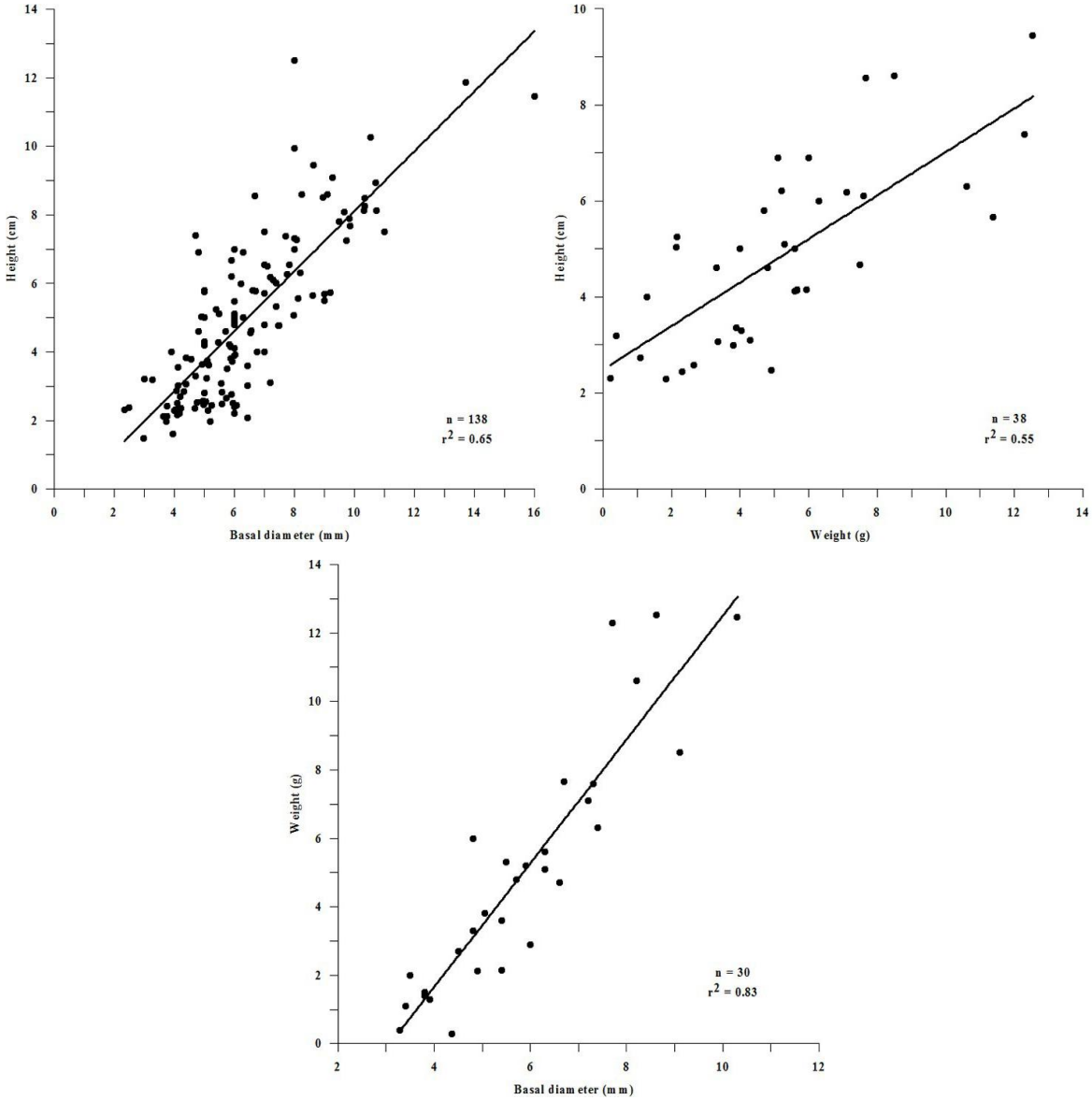

Figure 3. *Scatter plots of C. rubrum physiological parameters. Regression line equations: (1) height vs basal diameter, (2) height vs weight, and (3) weight vs basal diameter. See SM 1 and SM 3 for the data source.*

To test the percentage of error of the linear regression Eqs (1–3), we compared the parameter values resulting from our calculations with experimental values obtained from the previous literature research. We used the following formula:

$$\%\ error = \left|\frac{calculated\ value - literature\ value}{literature\ value}\right| \times 100 \quad (4)$$

Formulas (1–3) have 26%, 24% and 47% of error respectively. The data points obtained through formulas represent 40% of the total values used in this study.

To estimate CR biomass, we used the average dry weight values of each year multiplied by a fixed and robust value of density in each region (the data with more replicates and statistically sounder). The density values used are 114.68 colonies/m^2 from the Catalan Sea (Rossi et al. 2008) and 216.65 colonies/m^2 from the Ligurian Sea (Bavestrello et al. 2006). We used a fixed density value as the values obtained from the literature presented a high variability (SM 5), presumably from the use of different methodologies and very diverse sample sizes, resulting in incomparable results. The use of a mean fixed density value involves an estimate of the CR biomass for the selected sites, as we do not take into account the spatial and temporal variability of CR's density (Cau et al. 2016; Linares et al. 2011).

The potential area where CR can live was estimated from the literature. We define "potential area" as the surface suitable for CR growth even if is not currently present in the area. In both regions, we limited the extension of the potential areas to the locations where most CR is found. For the Catalan Sea we used data from the three marine protected areas (MPAs): Cap de Creus (Sardà et al. 2012), Medes i Montgrí (Hereu et al. 2013), and Cerbère-Banyuls (Payrot et al. 2014). For the Ligurian Sea we used the data from Portofino (MPA since 1998) by Cánovas-Molina et al. (2016).

To calculate the potential for carbon sequestration, we obtained the CR carbon ingestion rate of detrital POC and phyto- and zoo-plankton from Tsounis et al. (2006b). The carbon ingestion from bacterioplankton was extracted from Picciano and Ferrier-Pagès (2007). Oxygen consumption at 16°C was obtained from Previati et al. (2010). The value was converted into respired carbon equivalents using the conversion factor 0.281 (McCloskey et al. 1978). The estimation of the number of polyps in a colony was done using the results of Santangelo et al. (2003). The CR's basal diameter growth rate was obtained from Bramanti et al. (2014), using 0.241 and 0.237 mm y^{-1} for the Ligurian and Catalan Sea, respectively. We draw upon Coppari (2015) and use a relation of 5.82 mg cm^{-1} to convert the increase of growth to weight. Like we did for the biometric parameters, we use the same fixed density values, not taking into account the CR's self-thinning processes (Cau et al. 2016). To estimate the potential for carbon fixation we only take into account the basal diameter growth. Due to lack of conclusive studies on the topic, we do not consider the increase of total height in the colony, nor the branches. For that reason, our results of carbon retention are expected to be underestimated.

2.3. Results

2.3.1. Biometric parameters analysis

Twelve documents provide qualitative information about CR's health status for the Catalan Sea: ten documents contain information about CR's abundance, nine about location (geographical and/or bathymetric), two about size, one about diameter, and five about other parameters. For the Ligurian Sea, ten documents providing qualitative information were found. Size was reported in nine documents, location in nine, abundance in eight, weight in two, and other parameters in four (SM 6).

The qualitative data gathered during the literature review show that CR was exploited since ancient times and from very shallow depths. For example, the illustrations of Tescione (1968) show people harvesting coral in apnea in the 18th century, suggesting that large branches of CR were available at few meters depth in the Gulf of Naples. The text provided by Tescione also shows that, as early as the 14th century there was a real concern about the use of the ingegno and the intensive harvesting of the species. The following texts illustrate this concern:

"*. . .the fear that coral reefs would soon be exhausted, since, by a royal edict of 1332–33, the prohibition to fish for coral without the King's permission between Cape Minerva and Capri, a place very rich in coral, was renewed.*"

"*To face the threat of impoverishment of the sea-bot- toms, because of the devastating action of the devices that were being used, the French tried very hard to find better means of fishing, and the Academy of Marseilles, in 1876, announced a useless competition with a prize for the inventor of a less ravaging device.*"
(Tescione 1968) (SM 6).

The reviewed literature also suggests that CR was more abundant before the publication of the first studies with occupancy data. This is evident in the following texts:

"*. . .fishermen that keep the ones that casually extract with the fish.*"
(Instrucción modo recoger mariscos, caracoles, conchas, corales…, n.d.)

"*. . .at the beach, thrown by the waves, especially after storms. . .*"
(Maluquer 1917)

"*. . .the visions all the coral harvesters remember are about all the rocky walls and caves completely crowded of flowered coral with its white polyps, and from the big and abundant quantity and variety of fishes and lobsters,*

it is an inexplicable wonder. . ."

(Pons 1989)

"*. . .rapidly plunging into the water pulled out corals.*"

(Tescione 1968) (SM 6).

Regarding quantitative data, 29% of the documents included in this study yield data coming from grey literature, 37% from the scientific web browsers search, 46% from the scientific libraries and the network of scientists, and 21% from the references in the pre-selected literature. The most represented region is the Catalan Sea, with 58% of the documents referring to this area. The Ligurian Sea accounts for 50% of the documents. Two documents provide information from both sides (SM 1). All the studies from the Ligurian Sea were sampled in Portofino, with the exception of the roman writer Gaius Julius Solinus (1895), a document in which the most specific location stated is "*Liguria*". One third of the samples for the Catalan Sea come from Cap de Creus, another third from Medes Islands and the Montgrí Coast, and almost all the remainder from the Côte Vermeille. One study also includes samples from Begur coast (SM 1).

For both regions and for all parameters analysed, we find a "U" shaped distribution of the data across time, best fitted by a 2nd degree polynomic function (Fig 4, SM 2). The Catalan Sea region contains more data points per year and more years of data than the Ligurian Sea. In both regions, however, the 1990s mark a clear difference in the amount of data available, with most of the data points belonging to the period 1990–2005. Overall, data for the analysed parameters have increased more in the Ligurian Sea than in the Catalan Sea. The Ligurian Sea also contains older data with several studies conducted during the first half of the 1960s. In contrast, the first study for the Catalan Sea was conducted in the late-1970s.

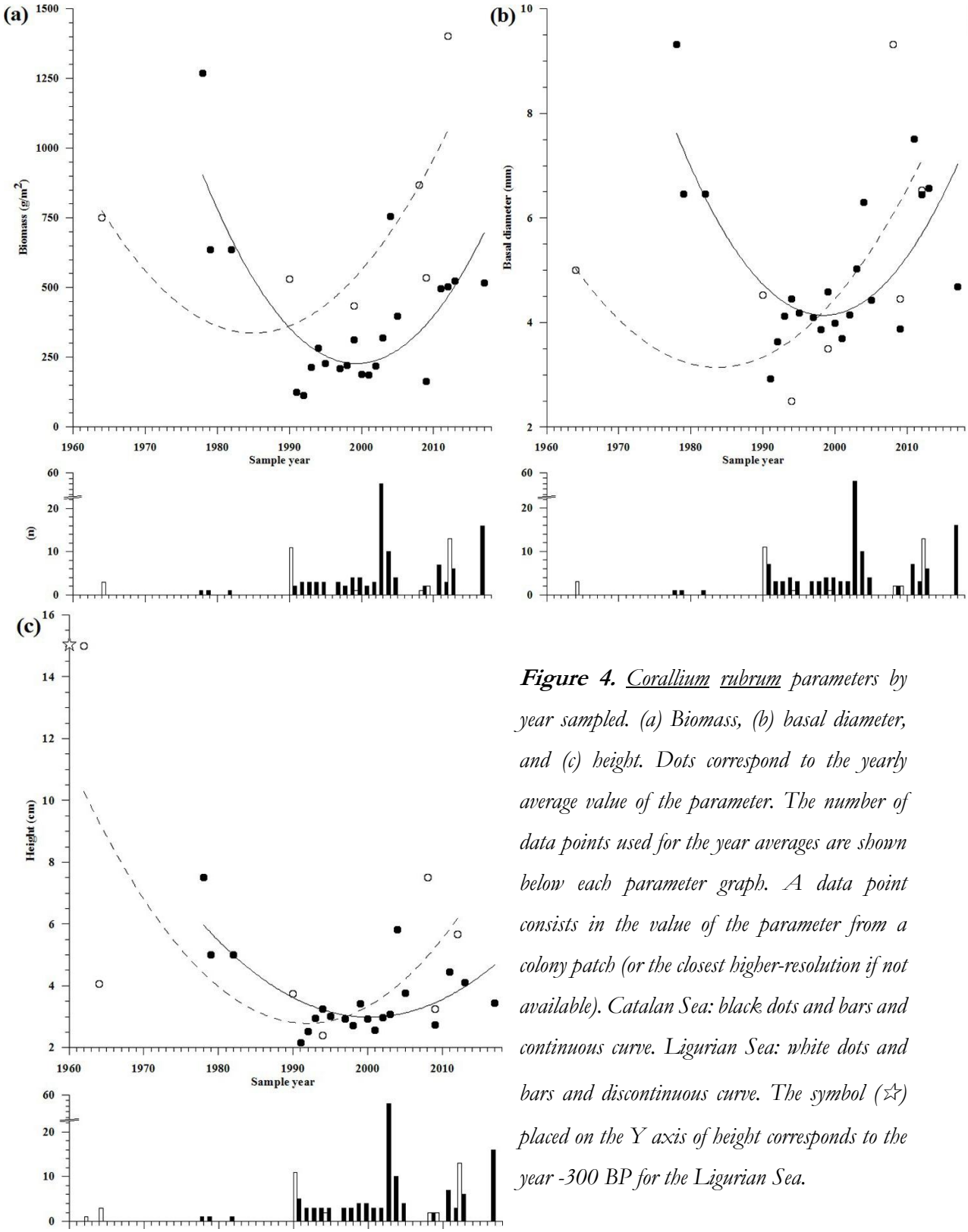

Figure 4. *<u>Corallium</u> <u>rubrum</u> parameters by year sampled. (a) Biomass, (b) basal diameter, and (c) height. Dots correspond to the yearly average value of the parameter. The number of data points used for the year averages are shown below each parameter graph. A data point consists in the value of the parameter from a colony patch (or the closest higher-resolution if not available). Catalan Sea: black dots and bars and continuous curve. Ligurian Sea: white dots and bars and discontinuous curve. The symbol (☆) placed on the Y axis of height corresponds to the year -300 BP for the Ligurian Sea.*

In the Catalan Sea, the values of the parameters observed experienced a decrease until the 1990s. These values remained low until the mid-2000s. After the mid-2000s, values started rising until the 2010s, when the value of the basal diameter reached the level of 1980s and the values of biomass and height reached levels slightly lower than those found in the 1980s. In the case of the Ligurian Sea, we observe a decrease of the values of the parameters until the mid-1990s-2000s with a later increase, in which biomass and basal diameter values surpassed the values found in the 1960s, as well as some of the height measures found in the 1960s.

In 2009, the CR biomass from the Ligurian Sea reached 1401 g/m^2, a value double that reported in 1964 (749 g/m^2). The CR biomass showed its lowest value in 1999: 433 g/m^2. In the Catalan Sea, biomass ranges from 1269 g/m^2 in 1978 to an order of magnitude less, 113 g/m^2 in 1992. From the 1990s, CR biomass levels in the Catalan Sea rise again reaching 503 g/m^2 in 2013, although the value remains lower than the 1980s value: 636 g/m^2 (Fig 4a).

In the studies of the Ligurian Sea, the values reported for basal diameter decrease from 5 mm in 1964 to 2.5 mm in 1994, then increasing and reaching a peak in 2008 (9.32 mm). The most recent measure for basal diameter in the region dates from 2012 and is 6.53 mm, higher than the values reported for the 1960s. However, with the exception of the value from 2008, all other values for basal diameter remain below 7 mm. In the Catalan Sea, basal diameter values decreased from 9.32 mm in 1978 to 2.92 mm in 1991 and then increased to the peak of 7.51 mm in 2011, thus reaching values similar to those found in the late-1970s1980s, with the exception of the peak measured in 1978 (Fig 4b).

The oldest value for CR height from the Ligurian Sea dates from the 3rd century BP (Julius Solinus 1895), when its reported value was 15 cm. CR height values in the Ligurian Sea from the 1960s are very variable (1962: 15 cm, 1964: 5.64, 4.88, and 4.77 cm), although there is an overall decreasing trend, with a minimum value of 2.38 cm in 1994, and then a rise until the peak of 2008: 7.5 cm. Again, the most recent value is from 2012: 5.67 cm, higher than some of the 1960s values. In the Catalan Sea, CR height also decreases from 7.5 cm in 1978 to 2.16 cm in 1991. CR height value then increased to a peak of 4.44 cm in 2011. During the last decade, CR height values were larger than the values reported for the 1990s (2.16–3.41 cm), but smaller than the values reported at the end of 1970s1980s (Fig 4c).

2.3.2. Carbon sequestration capacity

The three MPAs in the Catalan Sea contain 173.34 ha potentially suitable for CR, which would represent $1.99 \cdot 10^8$ colonies. The estimated carbon sink (carbon invested for growth) of those

colonies is 27,419 g C y^{-1}, corresponding to 158 g C ha^{-1} y^{-1}. For 2017, we estimate 8.94 105 kg of CR with a carbon flux of 0.0135 kg C ha^{-1} y^{-1} (C flux = C ingestion–C respiration). The oldest data available for the region, corresponding to 1978, estimate 2.20 106 kg of CR and 0.0129 kg C ha^{-1} y^{-1} of carbon flux. The year with the lowest biomass value, 1992, CR would have $1.95 \cdot 10^5$ kg in the region and a flux of 0.0071 kg C ha^{-1} y^{-1}.

In the Ligurian Sea, the potential CR occupies 23.8 ha with $5.16 \cdot 10^7$ colonies. The potential colonies C sink accounts for 7,232 g C y^{-1}, corresponding to 304 g C ha^{-1} y^{-1}. The newest data available from the Ligurian Sea, for 2012, result in the estimation of $3.33 \cdot 10^5$ kg of CR, with a carbon flux of 0.0035 kg C ha^{-1} y^{-1}. The oldest data available (1964) and the lowest value (1999) result in $1.78 \cdot 10^5$ and $1.03 \cdot 10^5$ kg of coral, and a carbon flux of 0.0035 and 0.0018 kg C ha^{-1} y^{-1} respectively.

2.4. Discussion

Our analyses indicate that variability in CR health status is mainly driven by the harvest intensity and the presence of protection measures. These results, however, should be taken with caution as data from the last two decades might be biased since they mainly come from protected areas, leaving the recent CR health status in unprotected regions understudied. This bias emphasizes the limitation in unravelling the detailed status of the living communities. Furthermore, the low availability of quantitative pre-1990s data suggest caution in interpreting trends during this time period.

2.4.1. Biometric parameters analysis

In the Mediterranean region, habitat degradation and exploitation are the main sources of biodiversity loss (Coll et al. 2010). These impacts have been occurring since ancient times. For example, coastal modification dates back to the Roman period and coastal exploitation was evidenced by Aristotle (4th Century BP). Over the course of history, the Mediterranean Sea has faced an increasing use of resources, as population living in its coastal areas has grown, maritime trade has intensified, and the commercialization of sea-related products increased (Coll et al. 2010; Goffredo and Dubinsky 2014; Lotze et al. 2011). Thus, the shallow water environment where CR can grow has been under pressure, with continuous exploitation since antique periods (Tsounis et al. 2010; Tescione 1968). Moreover, both chronic and small or intermediate

disturbances, as well as sudden large disturbances, have gradually degraded this habitat (Gray 1997).

In conclusion, CR pristine status before anthropogenic pressure is unknown, as the oldest data available about CR's health status in the Mediterranean Sea was recorded after the human exploitation of the resource had already started, around 30,000 years ago (Tescione 1968, Ascione 1993). We can only guess how the "red forests" of the Mediterranean were: possibly large spaces monopolized by CR (Rossi 2019), a slow-growing but very competitive species in terms of space occupation (Giannini et al. 2003).

In this study, the oldest quantitative data available regarding CR status, in the two study regions (Tortonese 1963: Weinberg 1979), report an ecosystem already affected by human uses (e.g., trawling, harvesting with devices like the St. Andrew's Cross or the ingegno, and/or selective harvesting by divers: Rossi 2013; Tsounis et al. 2010; Tescione 1968; Pons 1989; Lastras et al. 2016; Purpura 2006; Plujà 1999; Torntore 2002; Lleonart and Camarasa 1988; Ortíz et al. 1986; Audivert 1971; Roghi 1966; Ghidiglia 1892). Some older quantitative information is available for areas not analysed in this study and/or for other health status parameters (e.g. Julius Solinus 1895; Mazzarelli 1915; Bini and Maldura 1938). Data for the regions and the parameters specifically selected in this study are more abundant, and probably more reliable, since the 1990s. Researchers have argued that data on CR harvesting is only reliable from the late-1980s and early-1990s, given that the number of studies prior to these decades is scarce and the oldest techniques to analyse the parameters might be less accurate (Tsounis et al. 2013).

Despite the absence of quantitative data, the qualitative data collected in this work suggests that CR was larger, thicker, and had a greater biomass before the 1960s, since when quantitative data became available. Our finding is in line with data from the FAO, which show a sharp decline of 2/3 of the biomass harvested in only few years in the late-1970s (Tsounis et al. 2013). Our result is also consistent with information from the older commercial samples, which usually contain data of the biggest, oldest and less perturbed specimens found in a coral population of a concrete area, as the harvesters seek for the best quality coral, with higher commercial value (Pons 1989; Torntore 2002; Ghidiglia 1892; Tsounis 2009; Bini and Maldura 1938). Indeed, such samples show the potential status of CR populations if they remain unperturbed from decades to centuries (Garrabou et al. 2017b). For the Catalan Sea, a commercial sample collected in 1962, at a depth between 25 to 35 m, and with an average of 16 mm in basal diameter and 11.45 cm in height has been documented while the biggest specimens measured in that sample were 15.5 cm tall, and with a basal diameter of 45 mm (Garrabou and Harmelin 2002).

In the 1990s, in the two studied regions, the decreasing trend in CR basal diameter, height and biomass stopped. Several reasons explain this shift: as commercial CR banks get exhausted, the CR fishing decreased relative to previous decades and became stable (Bini and Maldura 1938; Santangelo and Abbiati 2001). The number of harvesting licenses given during this time also decreased (Garrabou et al. 2017a; FAO 1988). Harvesting of CR was banned in Medes in 1963, and in Cerbère-Banyuls areas where CR cannot be extracted were established in 1974, although they were only effectively implemented after 1981 (Fuchs 1990).

Moreover, CR health status parameters compiled in this study rise again in the 2000s, always a bit earlier in the Ligurian Sea compared with the Catalan Sea. However, the CR recovery documented should be interpreted with caution, as it only reflects the community living at a maximum water depth of 60 m in two NW Mediterranean regions. But most importantly, the majority of the data reported in this study comes from MPAs, where different levels of protection measures might positively affect the species' health status. In Portofino, where all the data of Liguria comes from, CR harvest was banned in 1999 (Salmona and Verardi 2001); in Medes islands CR cannot be extracted since 1983, a ban that was then extended to the Montgrí Coast in 1992; Cap de Creus has CR protected since 1998 for the partial and integral protected areas (Linares et al. 2018); in the Cerbère-Banyuls MPA the CR extraction is also banned since 1979 (Environnement Septentrion 2015). Therefore, the results presented here largely illustrate the health status of CR in areas protected since approximately two decades ago, but they cannot be extended to non-protected areas.

However, despite protection, there is evidence that CR poaching has continued regularly in the Catalan Sea (Tsounis et al. 2006a; Garrabou et al. 2017a; Montero-Serra et al. 2017; Descamp and Carteron 2004; Hereu et al. 2000). Poaching in Liguria seems more sporadic (Bavestrello et al. 2015b), and the harvesting pre-protection less intense (Bramanti et al. 2014). This seems logical as the Catalan Sea has CR of higher quality for the jewellery industry, while that from Liguria is substantially affected by boring sponges (Cattaneo-Vietti et al. 1995; Pons 1989; Torntore 2002; Audivert 1971; Calcinai et al. 2000; Senes et al. 2000; Cattaneo-Vietti et al. 1993). In sum, the poaching history and the coral quality might explain why the biometric parameters of the Ligurian CR reached higher values than the ones documented in the 1960s. Probably, the CR status reported in Portofino in the 2010s is similar to how it was in the 1950s, just when intensive harvesting by scuba diving was about to increase (Bavestrello et al. 2015b).

The literature suggests that CR from unprotected areas shows worse health status than the CR in protected areas (Tsounis et al. 2006a; Linares et al. 2017; Environnement Septentrion 2015).

Despite such evidence, quantitative studies in non-protected areas still remain scarce and are focused in a few places, although CR presence is known in several other locations such as Llancà (Plujà 1999), l'Escala (Maluquer 1916), Llafranch (Tur and Godall 1982), Illes Formigues (Pons 1989), Blanes, Ametlla de Mar (Programa-Bentos 1973), Genoa Bay (Tortonese 1963; Carus 1885), and La Spezia (Carus 1885).

Even though available data is not enough to provide a full picture of the health status of CR found deeper than 60 m, we can still hint at its actual ecological trend. The pioneering studies with quantitative data from deep CR are García-Rodríguez and Massó in 1986 and Cattaneo-Vietti et al. in 1994, in the Catalan and Ligurian Seas respectively, both reaching up to 90 m depth. As the study in the Catalan Sea came from a commercial sample, we compare its results with those from a study in the same area in 2002–2003 (Rossi et al. 2008), only counting the specimens ≥ 7 mm of basal diameter and ≥ 6 cm of height of the 2003 sample. A basal diameter of 13.7 (1984) and 8.07, 10.31, and 10.34 mm (2003), and a height of 11.86 (1984) vs 8.11, 8.48, and 7.28 cm (2003) were recorded. The study of Liguria described samples of 7–9 mm basal width and 10-15 cm tall, meanwhile 2012 samples in the same location had 8, 3, and 6 mm basal diameter and 7, 2.5, 3.2, and 5.1 cm of height (Bavestrello et al. 2015b). These data, while scarce, seem to suggest that deep corals have been suffering deterioration in recent decades. Such regression is understandable as scuba diving technology improved, allowing deeper harvesting (Tsounis et al. 2010; Boavida et al. 2016; Pons 1989; Tsounis et al. 2013), and deep corals remain unprotected by law. Deep coral banks have been historically affected by trawling and trammel nets, but pristine status coral might still exist. Mazzarelli (1915) found CR up to 19 cm tall and 22 mm of basal diameter width in the deep coral banks off Sardinia in 1913 (Mazzarelli 1915). How close to the pristine size those measurements are will remain unknown.

2.4.2. Carbon sequestration capacity

Studies like the one presented here are essential to highlight the importance of marine carbon sinks, especially those represented by the animal forests of the seas (Rossi et al. 2012). The destruction of the living 3D structures in the benthos diminishes their carbon sequestration capacity by the lack of sessile organisms capable to store it; this implies a loss of mitigation capacity against climate change (Marbà et al. 2014; Coppari 2015; Arias-Ortiz et al. 2018; Rossi et al. 2017a; Duarte et al. 2010), which in turn will wreak future havoc on these habitats (Rossi et al. 2017a; Hughes et al. 2003; Calvo et al. 2011; Bianchi 1997). A drastic change in some coastal communities may be part of the positive feedback resulting in climate change acceleration, organic pollution, or biodiversity loss (Thurstan et al. 2017). CR has proved to be

vulnerable to climate change and ocean acidification. For example, in shallow areas (0–40 m depth), CR has been affected by heat waves (Galli et al. 2017; Galli et al. 2016; Garrabou et al. 2009; Torrents et al. 2008; Garrabou et al. 2001; Perez et al. 2000), and can be potentially affected by ocean acidification, which affects the capacity to build its skeleton (Le Goff et al. 2017; Bramanti et al. 2013).

In the present study, CR carbon retention capacity was estimated based on the CR data available at different time periods from each study area. Calculations were done assuming that CR extension coincides with the potential habitats it can grow from the locations where practically all the data comes from (Cap de Creus, Medes & Montgrí, Cebère-Banyuls, and Portofino). Furthermore, we assumed a fixed density value despite the fact that density can change in space (location and depth), time, and due to its relation with colony size (self-thinning process; Cau et al. 2016; Linares et al. 2011). According to our calculations, since the 1990s until today, the potential carbon retention capacity of CR has nearly doubled. Larger colonies have a larger gonadal output (Rossi 2013; Rossi et al. 2008; Santangelo et al. 2003), a higher potential recruitment and a higher population stability in the face of perturbations (Bramanti et al. 2014).

However, as mentioned, our results are biased towards protected areas, and are hardly transferable to a wider context. For example, a similar calculation of the carbon retained by *Posidonia oceanica* shows a 62 to 87% decrease with respect to data obtained before the 1960s (Marbà et al. 2014), a scenario that might reflect better the reality of the Mediterranean marine ecosystems. Moreover, for our calculations, we decided to be conservative and only consider the CR diameter growth of its base (i.e. the sequestered carbon in the growing rings of its main trunk), based on the mean values observed in both areas (Bramanti et al. 2014). CR branches grow much faster (linear growth 1.5–2.5 mm y^{-1}; Bramanti et al. 2005), for which the inclusion of the carbon stored in each branch in our calculations might have resulted in a higher carbon storage result. If we consider that an ancient red coral may had dozens of branches per colony, the number of sequestered carbon may be exponentially higher compared to the present results.

Results from this work might suggest that CR experienced a dramatic decrease in a short time period until the 1990s, when its carbon retention capacity reached its lowest point. The potential coral weight and the carbon flux decreased nearly two-fold between the oldest and the lowest biomass values separated only by 14 and 35 years in the Catalan and Ligurian Seas, respectively. Such statement needs to be treated with caution due to the low availability of pre- 1990s data. CR carbon storage capacity is disrupted by the reduction of its distribution, size and complexity (corals in the past having more branches and polyps and therefore larger capacity to capture

carbon and retain it as a structure). An example illustrates the importance of CR distribution for carbon storage: the potential area where CR can grow in the entire Ligurian Sea accounts for 130.9 ha, whereas the actual CR specimens have an extension of 6.31 ha, only found in Portofino MPA (Cánovas-Molina et al. 2016). This would account for a C flux of 0.0009 kg C ha^{-1} y^{-1} in 2012, notably smaller than the value extrapolated for the entire Ligurian Sea's potential area (0.0190 kg C ha^{-1} y^{-1}).

These kinds of estimates of carbon flux and carbon sink are available in the literature for different benthic systems, but they are still scarce for CR. For example, estimates for seagrass meadows carbon sink gives 6,700 kg C ha^{-1} y^{-1} (Duarte et al. 2010), for *Paramuricea clavata* and *Eunicella singularis* 2,000 kg C ha^{-1} y^{-1} both, and for *Leptogorgia sarmentosa* 0.008 kg C ha^{-1} y^{-1} (Coppari et al. 2019), all of them substantially higher than our results (158 and 304 g C ha^{-1} y^{-1}). Again, the difference might be due to the fact that we only considered basal diameter growth. Regarding the C flux, Coppari et al. (2019) calculated 1,000 kg C ha^{-1} for *P. clavata* and *E. singularis*, and 0.02 kg C ha^{-1} for *L. sarmentosa*, which is the closest species to CR in C flux magnitude (0.0135 and 0.0035 kg C ha^{-1} in this study).

2.5. Conclusions

This article provides a spatial and temporal assessment of CR's health status, presenting new understanding of past changes and its carbon sequestration capacity. The CR biometric parameters, and therefore, the species' health status is conditioned by its harvesting pressure and protection measures that impacted its ecological history. In only two to three decades after the establishment of the protected areas, CR reached levels of health similar to those documented in the 1960s (Ligurian Sea) or 1980s (Catalan Sea), suggesting that this protection measures are effective. However, the majority of CR locations remain unprotected and unstudied, leaving no evidence of what would be the actual health status of such colonies. Therefore, to be able to calculate Mediterranean-wide estimates, more quantitative studies about CR demographic and biometric parameters are needed, especially in unstudied locations where CR did not benefit from protective measures. Regarding older CR biometric information, the French Mediterranean coast has an important amount of pre-1990s data (e.g., Dantan 1928; Marsili 1707; Marsili 1725; de Lacaze-Duthiers 1862; de Lacaze-Duthiers 1864; True 1970; Carpine and Grasshoff 1975; Marin and Reynal de Saint-Michel 1981) with several pioneering studies on coralligenous systems (e.g., Marion 1883; Gilet 1954; Peres and Picard 1956; Gautier

1957; Laborel et al. 1961; Vaissière 1964; Peres and Picard 1964; Picard 1965). Meta-analyses of these data could add to the CR trends obtained in this study and shed further light on its ecological history.

The CR size and abundance conditionates its carbon sequestration capacity. Our results suggest that both characteristics can be reduced within a few decades. Further studies on the capacity of carbon retention of the different species present in the coralligenous and other habitats (continental platform, deep water corals . . .) will help to assess the degree of importance of this Mediterranean habitat in the carbon cycle and its climate change mitigation capacity. A more accurate estimation of CR retention (considering the increase of total height and branch lengths) is urgently needed to understand the importance of the marine animal forests as carbon sinks. The knowledge of their longer ecological trends also related to climate change mitigation and biodiversity conservation should improve a decision-making strategy for the species conservation.

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2.7. Supplementary material

Supplementary material 1. List of publications of *Corallium rubrum* with demographic, biometric, and location information from the Catalan Sea, Ligurian Sea and off Tuscany. The table shows the main characteristics and parameters described of the publications included in the meta-analysis, plus the publications excluded. The publications come from an extensive literature review in the three regions studied (further information on SM 3).

Reference Code	Publication year	Class	Type	Data type	Data collection year	Region	Location	Depth range	Sampling method	Sample type	Health status parameters
Included in the meta-analysis of this study											
1	2018	G	Book section	QT	2017	Cat	Cap Creus, Medes & Montgrí	15-47	Photo	Random	ρ, H, B, % harvested, % necrosis
2	2015	G	Report	QT	2013	Cat	Côte Vermeille	30	Photo	Random	ρ, Nº Br, H, Ø
3	2015	A	Journal	QT	2012	Lig	Portofino	25-40	Physical	Random	ρ, H, Ø, B, W, Nº Br
4	2015	A	Conference Proceeding	QT	2012	Lig, Tus	Portofino, Tuscan Archipelago	40-230	ROV	Random	ρ, H, Ø, Occ (%), Fishing impact (%)
5	2014	A	Journal	QT	2009	Cat, Lig	Cap Creus, Portofino	30-35	Photo, Physical	Random	ρ, Rρ, Ø, A/J, Gr, Age, Fecundity, Fertility, M/F, Bored colonies (%)
6	2012	G	Report	QT	2011	Cat	Côte Vermeille	27-40	Photo	Random	H, Ø, ρ, Nº Br
7	2011	A	Journal	QT	1992-95, 1997-03, 2005	Cat	Medes & Montgrí	15-40	Photo, Physical	Random & Poached	H, Ø, ρ, Rρ, Gr, B
8	2010	A	Journal	QT	2005	Cat	Cerbère-Banyuls	23-25	Photo	Random	ρ, Ø, H, Nº Br
9	2010	A	Conference Proceeding	QT	2008	Lig	Portofino	30-70	Photo	Random	ρ, Ø, H, W, B
10	2010	A	Conference Proceeding	QT	2009*	Cat, Lig	Cap Creus, Portofino		Physical	Random	Ø, Age, Gr
11	2008	A	Journal	QT	2002, 03, 05, 06	Cat	Cap Creus, Cap Creus Canyon	50-230	ROV	Random	Patch ρ, ρ, H, Ø, Nº 1ary Br
12	2006	A	Journal	QT	2002-03	Cat	Cap Creus, Medes & Montgrí, Begur	7-49	Photo, SD	Random	ρ, Occ, Patch ρ, Ø, H, Nº Br, Age
13	2004	G	Report	QT	2004	Cat	Côte Vermeille	17-52	Photo, SD	Random, Poached	ρ, Ø, H, Nº Br, Cover (%), Necrosis, Epibiosis
14	2002	G	Report	QT	1991-95, 1997-02	Cat	Medes & Montgrí	15-40	Photo	Random	ρ, Rρ, Ø, Mortality (%)
15	2000	A	Journal	QT	1999*	Lig	Portofino	20-42	SD	Random	ρ, Ø, W, Boring (%)
16	1997	A	Book section	QT	1990, 1994	Lig	Portofino	37	Photo, Physical	Random	ρ, Ø, H, H/Apex ratio
17	1995	A	Book section	QT	1994	Lig	Portofino	58-90	ROV	Random	ρ, H, Ø
18	1993	A	Book section	QT, QL	1990	Lig	Portofino	34-42	Photo, Physical	Random	ρ, H, Ø, W, B, H/Apex ratio
19	1986	A	PhD Thesis	QT, QL	1972-74, 1977-82	Cat	Medes, Estartit	5-55	Photo, Physical	Random	H, Br Ø, Width, Organic Matter
20	1980	G	TFG	QT	1977-79	Cat	Medes	2-48	Photo, Physical, SD	Random	Vol, H, Width, Shannon Biodiversity Index
21	1979	A	Journal	QT	1978*	Cat	Banyuls	23-26	SD	Random	H, ρ
22	1965	A	Journal	QT	1964*	Lig	Portofino		Physical	Random	ρ, B
23	1963	G	Magazine	QT, QL	1962*	Lig	Genoa Bay, Portofino	20-200	Physical	Random	H
24	1895	G	Book	QT, QL	-300	Lig				Random	H
Other studies with original health status information not included in the meta-analysis (including Tuscany)											
25	2017	A	Journal	QT	2011, 2015	Cat	Medes & Montgrí	15-17	Photo, Physical	Poached	H, Survival rate (%), Fecundity, Fertility (%)
26	2016	A	Journal	QT	2009, 2010	Cat	La Fonera Canyon head	101-297	Echo, ROV	Random	Occ
27	2016	A	Journal	QT	2010-12	Cat	Cap Creus	25-30	Physical	Bias larger	H, Ø, Fecundity, Organic matter (%)
28	2016	A	Journal	QT	2007, 2013	Cat	Medes	15-30	Photo	Random	ρ, Cover (%), Diversity indices (coralligenous), Patch size, Patch nº
29	2016	A	Journal	QT	2008, 2009	Cat, Lig	Medes, Portofino	18, 50	Physical		Ø, Gr, Age
30	2016	A	Journal	QT		Lig, Tus	Livorno, Vada, Argentario, Portofino	30-40	Photo	Random	Cover (%)
31	2016	A	Journal	QT		Lig	Portofino	11-84	Echo, ROV, SD	Random	Cover
32	2016	A	Journal	QT	2010	Tus	Elba, Pianosa	50-130	Echo, ROV, Physical	Random	Ø, H, Age, Gr, Nº Br, Br order, Age 1st Br
33	2015	A	Conference Proceeding	QT		Cat	Medes, Cerbère-Banyuls	15-25	Photo	Random	ρ, Rρ
34	2015	A	Conference Proceeding	QT		Cat	Cerbère-Banyuls		Photo		H
35	2015	A	Conference Proceeding	QT	2012	Tus, Lig	Isuela, Montecristo, Tuna	28-108	Echo, ROV	Random	ρ
36	2015	A	PhD Thesis	QT	2002-03, 05, 06	Cat	Cap Creus	20-80	ROV	Random	Nº colonies, B, Carbon retention
37	2015	A	PhD Thesis	QT	2010-11	Cat	Cap Creus	25-30	Physical	Random	Fecundity, Gonads (nº, Ø, Vol.), Organic matter, Lipids, Fatty acids
38	2015	A	Journal	QT	2010	Tus	Elba, Pianosa	60-94	Echo, ROV, Physical	Random	Ø, H, Age, Gr, Nº Br, Age 1st Br
39	2015	A	Journal	QT	2010	Tus	Elba	85-90	Physical	Random	Ø, Fecundity, M/F, Predation (%)
40	2013	A	Journal	QT	2002	Cat	Medes	20	Physical		Gr
41	2013	A	Journal	QT	2010	Tus	Elba	50-130	Echo, ROV, Physical	Random	Occ, M/F, Fecundity, Ø, H, Br order, W, Gr, Age, ρ

42	2012	A	Journal	QT	2003-07	Tus, Cat	Calafuria, Elba, Medes	34-36	Photo, Physical	Recruits in artificial substrate	Rρ, Gr, Recruitment, Mortality, W, Epibiosis (%)
43	2012	G	MS Thesis	QL		Cat	Medes, Montrgí, Golf Pals				See SM 6
44	2011	A	Journal	QT	2006, 2007	Cat	Medes	14-20	Photo, Physical	Random	nº species/area
45	2007	A	Journal	QT	2003, 2004	Tus, Cat	Calafuria, Elba, Medes		Photo	Recruits in artificial substrate	Mortality, Rρ
46	2007	A	Journal	QT		Tus	Livorno	25-45	Physical, Photo	Recruits in artificial substrate	Ø, Gr, Age
47	2006	A	Journal	QT	2002-03	Cat	Cap Creus, Medes & Montgrí	16-45	Physical	Random	H, M/F, Fertility, Fecundity
48	2006	A	Journal	QT	1995-96, 1997-98	Tus	Livorno	25	Photo	Random	ρ
49	2005	A	Journal	QT	1998-02	Tus	Livorno	24-36	Photo, Physical	Recruits in artificial substrate	Rρ, Ø, H, Mortality, Gr, Nº polyps
50	2004	A	Journal	QT	2002	Cat	Medes	30	Physical		Ø, Gr
51	2004	A	Journal	QT	1992, 1997	Tus	Livorno	25-40	Physical		M/F, Fecundity, Fertility, Mortality, Survival, ρ, Rρ
52	2003	A	Journal	QT		Cat	Medes	13-35	Photo	Random	Cover (%)
53	2003	A	Journal	QT	1998-99	Tus	Livorno	24-36	Physical		M/F, Fertility, Fecundity
54	2003	A	Journal	QT		Tus	Livorno	25-35	Photo	Random	Rρ
55	2003	A	Journal	QT	1998-00	Tus	Livorno	24-36	Photo	Recruits in artificial substrate	Rρ
56	2002	A	Journal	QT	1962	Cat	Cap Creus	25-35	Physical	Bias larger	Ø, H
57	1999	G	Magazine	QL		Cat	Costa Brava	5	150		See SM 6
58	1997	A	Book section	QT		Tus	Livorno (shallow), Tuscan Archipelago (deep)	33-36 (shallow), 80 (deep)	Photo (shallow), Physical (deep)	Random (shallow); Bias larger (deep)	Shallow: Rρ, ρ, W, B; Deep: Ø, W
59	1993	A	Book section	QT	1990-91	Tus	Livorno, Elba	30-50	Physical		Ø
60	1993	A	Book section	QT		Tus	Livorno	31-36	Physical		ρ, Rρ, H, Ø, W
61	1992	A	Journal	QT	1987	Tus	Livorno	30-50	Physical	Random	ρ, Rρ, Ø, W, B
62	1989	G	Magazine	QL	1389, 1959-61, ...	Cat	Costa Brava				See SM 6
63	1988	G	Report	QL		Lig	Portofino	16-?	Physical, SD		See SM 6

64	1988	G	Report	QT		Tus	Livorno	31-36	Physical	Random	ρ, H, Ø, W, Recruitment (%), Dead colonies (%)
65	1988	A	Journal	QT		Tus	Livorno	31-36	Physical	Random	ρ, H, Ø, W
66	1986	A	Journal	QT	1984	Cat	Costa Brava	0-90	Physical	Bias larger	Ø, H, W
67	1986	A	Journal	QT		Cat	Cap Creus	60	Physical	Bias larger	Ø, H, W
68	1984	G	Report	QT, QL		Cat	Cap Begur to Palamós, Port de la Selva to Punta Falconera	20-50	Echo, ROV, SD, Photo, Physical	Random	B , Area, See SM 6
69	1982	A	Journal	QL	1979, 1980	Cat	Llafranch	30-52	SD, Physical		See SM 6
70	1978	A	Journal	QT		Cat	Banyuls	23-36	SD	Random	ρ
71	1975	A	Journal	QT, QL	1973-74	Cat	Banyuls	36	SD	Random	ρ
72	1971	G	Book section	QL	1800s-1970	Cat	Estartit, Begur, Escala, Cap Creus				See SM 6
73	1971	A	Journal	QL	1960-61	Cat	Lacaze-Duthiers Canyon, Cap Creus Canyon	280	Physical, SDsub		See SM 6
74	1968	A	Journal	QL	1967	Tus	Elba	26-50	SD, Echo	Random	ρ (QL), Cover (QL), Commercial value (QL)
75	1968	G	Book	QL		Lig, Tus					See SM 6
76	1965	A	PhD Thesis	QL		Cat	Côte Vermeille	20	Physical, SD		See SM 6
77	1961	A	Journal	QL	1959, 1960	Lig	Portofino	20-40	Physical	Random	See SM 6
78	1959	A	Journal	QL	1959	Lig	Portofino	25-58	Physical	Random	See SM 6
79	1958	A	Journal	QL	1955, 1957	Lig	Portofino	10-40	Physical	Random	See SM 6
80	1958	A	Journal	QL	1958	Tus	Elba	40	Physical	Random	See SM 6
81	1957	A	Journal	QL	1957	Lig	Portofino	20-45	Physical	Random	See SM 6
82	1956	A	Journal	QL		Lig	Portofino		Physical	Random	See SM 6
83	1917	G	Book	QL	1917	Cat					See SM 6
84	Unknown	G	Generic	QL	Unknown (Within 1809-1898?)						See SM 6
Studies with location information (including Tuscany)											
85	2016	A	Journal	Loc	1861-2014	Lig, Tus					
86	1985	A	Journal	Loc	1977-81	Cat	Medes		Echo, Photo, SD, Physical	Random	
87	1980	A	Journal	Loc	1972-74	Cat	Cadaqués, Estartit, Blanes, Ametlla de Mar, Sa Tuna (Cap Begur)	0-20; 0-40	Photo, Physical	Random	

88	1973	G	Report	Loc	1972-74	Cat	Cadaqués, Estartit, Blanes, Ametlla de Mar, Sa Tuna (Cap Begur)	0-45	Physical		
89	1964	G	Book	Loc		Cat	Cap Creus	15-35			
90	1962	A	Journal	Loc		Cat	Cap Creus	25-30	Physical, SD		
91	1962	A	Conference Proceeding	Loc		Lig	Portofino	10-40			
92	1916	A	Book	Loc	1916	Cat	Cadaqués, L'Escala	15-30	Physical		
93	1895	A	Journal	Loc		Cat	Banyuls, Cap Creus, Lacaze-Duthiers Canyon	25-40; >40 (Canyon)	Physical		
94	1885	G	Book	Loc		Lig, Tus	Genova, La Spezia, Tuscan Seas				

Studies with no original information (including Tuscany)

95	2017	G	Report	QT		Cat			Literature		
96	2016	A	PhD Thesis	QT	2006, 07, 13	Cat	Medes	14-30	Photo, Physical	Random	See References 28 and 44
97	2015	A	Journal	QT	1993-2012	Tus, Cat, Lig	Calafuria, Elba, Medes, La Spezia, Portofino		Physical, Photo, ROV		
98	2009	A	Conference Proceeding	QT	2008	Lig	Portofino	30-70	Photo	Random	ρ, B, W, H
99	2009	A	Journal	QT		Tus	Livorno		Literature		
100	2007	A	Journal	QT	1993-05	Cat			Literature		
101	2005	A	PhD Thesis	QT	2002-03	Cat	Cap Creus, Medes & Montgrí, Begur	7-49	Photo, SD, Physical	Random	See References 12 and 47
102	2001	G	Report	QT	1991-95, 1997-00	Cat	Medes & Montgrí	18-40	Photo	Random	ρ, Rρ, Ø
103	2000	G	Report	QT	1991-95, 1997-99	Cat	Medes & Montgrí	18-40	Photo	Random	ρ, Rρ, Ø
104	2000	G	Report	QT	2000	Cat	Medes	20-30	Photo, Physical	Random: & Poached	Ø, B + Poached: H, W, Lenght, Ø, Br Ø, Area, Vol.
105	1997	A	Journal	QT		Tus	Livorno	33-37	Photo, Physical	Random	ρ, Rρ, B, Survival

106	1995	A	Book section	QT		Tus	Livorno (shallow), Tuscan Archipelago (deep)	33-36 (shallow), 80 (deep)	Photo (shallow), Physical (deep)	Random (shallow); Bias larger (deep)	Shallow: Rρ, ρ, W, B; Deep: Ø, W
107	1995	G	Report	QT	1992-95	Cat	Medes & Montgrí	12-50	Photo	Random	Ø
108	1994	A	Journal	QT	1990	Lig	Portofino	38	Photo	Random	ρ, H, Ø, W, H/Apex ratio
109	1994	A	Journal	QT	1990	Lig	Portofino	34-42	Photo, Physical	Random	ρ, Ø, W, B
110	1982	A	Book	QT	1977-79	Cat	Medes	10-48	Physical, Photo, SD	Random	Vol, H, Width
111	1978	A	Journal	QT		Cat	Banyuls	23-26	SD	Random	ρ
112	1964	A	Journal	Loc	1960-61	Cat	Lacaze-Duthiers Canyon	280	Echo, Photo, Physical, SDsub		

See the reference of each document in the list below through its reference code. Class: A = academic, G = grey literature.
Data type: QT = quantitative, QL = qualitative, Loc = location: a location document provides information about the presence of *C. rubrum* in a determinate place (depth and/or geographical situation) but does not give information about its health status.
Region: Cat = Catalan Sea, Lig = off Liguria, Tus = off Tuscany.
Sampling method: Photo = underwater photography and/or photogrammetry, Physical = physical samples (e.g. scraped), Echo = echosounder, ROV = Remote Operated Vehicle, SD = scuba diving observations, underwater visual census, SDsub = visual observations with submarine.
Health status parameters: Ø = basal diameter, ρ = density, Rρ = recruits density, H = height, B = biomass, W = weight, Gr = growth rate, Age: we excluded the age data obtained with the petrographic method, Nº Br = number of branches, Br order = branching order, Age 1st Br = age of first branching, Nº 1ary Br = number of primary branches, Occ = occupancy, Vol = volume, A/J = adult/juvenile ratio, M/F = male/female ratio. % = when data of the parameter is showed in relative values.

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Supplementary material 2. *Corallium rubrum* values of its most studied parameters and number of colonies sampled for obtaining them. These values are used as data points for the yearly averages in Fig 4. Weight values are multiplied by a fixed density value to show biomass values in Fig 4.

Data

collection year	Ref. Code	# colonies	Ø (mm)	SD	H (cm)	SD	W (g)	SD
Catalan Sea								
1978*	21	Unknown	9.32†	2.43	7.50		11.07⦇	2.69
1979	20	56	6.46†	1.68	5.00		5.55⦇	1.35
1982	19	56	6.46†	1.68	5.00		5.55⦇	1.35
1991	14	150	2.57		1.60†	0.42		
		150	2.13					
		150	3.13		2.09†	0.54		
		150	2.21					
		150	2.98		1.96†	0.51		
		150	3.66		2.55†	0.66	1.03⦇	0.48
		150	3.71		2.59†	0.68	1.13⦇	0.53
1992	7	150	3.91	0.83	2.77†	0.72	1.49⦇	0.70
		150	3.33	0.51	2.26†	0.59	0.44⦇	0.21
		150	3.65	0.60	2.54†	0.66	1.02⦇	0.48
1993		150	4.72	0.81	3.48†	0.91	2.95⦇	1.38
		150	3.72	0.53	2.60†	0.68	1.15⦇	0.54
		150	3.91	0.46	2.77†	0.72	1.49⦇	0.70
1994		150	5.11	0.90	3.82†	0.99	3.66⦇	1.71
		150	3.97	0.49	2.82†	0.73	1.60⦇	0.75
		150	4.26	0.58	3.07†	0.80	2.12⦇	0.99
1995		150	4.88	0.72	3.62†	0.94	3.24⦇	1.52
		150	3.56	0.69	2.46†	0.64	0.86⦇	0.40
		150	4.11	0.63	2.94†	0.77	1.85⦇	0.87
1997		150	4.54	1.19	3.32†	0.86	2.63⦇	1.23
		150	3.47	0.54	2.38†	0.62	0.69⦇	0.33
		150	4.26	0.78	3.07†	0.80	2.12⦇	0.99
1998		150	4.46	0.84	3.25†	0.85	2.48⦇	1.16
		150	3.27	0.47	2.21†	0.57		
		150	3.85	0.57	2.71†	0.71	1.38⦇	0.65
1999		150	4.14	0.96	2.97†	0.77	1.91⦇	0.89
		150	3.44	0.64	2.36†	0.61	0.64⦇	0.30
		150	3.67	0.62	2.56†	0.67	1.06⦇	0.49
		150	7.10⦇	3.33	5.78⦇	1.40	7.26	
2000		150	4.45	0.97	3.24†	0.84	2.47⦇	1.16
		150	3.28	0.58	2.22†	0.58	0.35⦇	0.16
		150	3.63	0.62	2.52†	0.66	0.98⦇	0.46
		133	4.62⦇	2.16	3.74⦇	0.91	2.77	
2001		150	4.52	0.93	3.3†	0.86	2.59⦇	1.21
		150	3.09	0.77	2.05†	0.53		
		150	3.45	0.63	2.36†	0.62	0.66⦇	0.31
2002		150	5.20	1.11	3.90†	1.01	3.82⦇	1.79
		150	3.44	0.73	2.36†	0.61	0.64⦇	0.30
		150	3.77	0.97	2.64†	0.69	1.24⦇	0.58
2003		150	4.90	1.24	3.63†	0.95	3.28⦇	1.54
		150	3.36	0.71	2.29†	0.60	0.49⦇.	0.23
		150	3.58	0.82	2.48†	0.65	0.89⦇	0.42
	12	1677 overall	6.55	3.16	4.61	2.90	4.68⦇	1.14
			4.96	1.96	2.57	1.56	3.38⦇	1.58
			5.73	1.98	2.65	1.57	0.37⦇	0.09
			4.12	1.85	3.02	1.60	1.19⦇	0.29
			4.07	1.66	2.86	1.72	0.82⦇	0.20
			8.13	2.96	5.56	2.87	6.78⦇	1.65
			4.71	2.20	3.30	1.62	1.81⦇	0.44
			5.77	1.94	3.50	1.42	2.24⦇	0.54
			4.18	1.63	2.20	1.13	1.98⦇	0.93
		1722 overall	5.92	2.66	3.72	1.70	2.72⦇	0.66
			4.09	1.31	2.49	1.34	1.82⦇	0.85
			4.39	1.64	3.82	2.03	2.94⦇	0.72
			4.12	1.66	3.55	1.84	2.34⦇	0.57
			5.14	1.81	3.60	1.28	2.47⦇	0.60
			4.19	1.26	2.70	1.26	0.48⦇	0.12
			3.63	1.61	2.12	1.07	0.99⦇	0.46
			4.93	1.71	3.63	1.67	2.53⦇	0.61
			5.47	2.61	4.27	2.11	3.94⦇	0.96
			5.10	1.88	3.75	2.16	2.80⦇	0.68
			6.22	1.39	5.98	2.84	7.71⦇	1.87
			4.10	1.46	2.16	1.14	1.84⦇	0.86
			5.05	1.55	2.54	1.29	3.55⦇	1.66
			3.76	1.14	2.41	1.21	1.22⦇	0.57
			3.74	1.23	1.98	1.06	1.17⦇	0.55
			4.00	1.78	2.29	1.09	1.65⦇	0.77
			4.31	2.63	2.85	1.49	0.82⦇	0.20
			4.56	2.05	3.78	1.59	2.86⦇	0.69

Data collection year	Ref. Code	# colonies	Ø (mm)	SD	H (cm)	SD	W (g)	SD
2003	12	1632 overall	4.98	2.52	2.47	1.51	3.43⦇	1.61
			5.20	2.05	1.97	1.36	3.82⦇	1.79
			5.25	1.81	2.43	1.67	3.91⦇	1.83
			4.69	1.77	2.36	1.32	2.89⦇	1.35
			2.97	1.43	1.47	1.04		
		819 overall	4.75	1.72	2.52	1.45	3.02⦇	1.41
			7.00	2.81	6.54	3.63	8.95⦇	2.17
			6.44	1.97	3.59	1.02	2.44⦇	0.59
			5.84	2.10	4.21	2.18	3.82⦇	0.93
			5.88	2.05	4.15	2.23	3.68⦇	0.90
			6.53	1.91	4.56	3.01	4.57⦇	1.11
			6.75	1.95	4.00	1.68	3.34⦇	0.81
			6.08	2.27	2.45	1.02	5.41⦇	2.53
			6.45	2.79	3.02	1.86	1.18⦇	0.29
			6.00	2.17	2.39	1.41	5.27⦇	2.47
			6.01	1.96	3.91	1.41	3.16⦇	0.77
		695 overall	4.02	1.22	2.32	1.09	1.68⦇	0.79
			5.58	2.57	2.48	1.43	4.5⦇	2.11
			6.43	4.32	2.07	1.24	6.06⦇	2.84
			4.39	1.70	3.07	1.69	1.29⦇	0.31
			5.58	3.71	2.82	1.44	0.73⦇	0.18
			3.75	1.31	2.13	1.15	1.19⦇	0.56
			5.13	2.17	2.29	1.33	3.7⦇	1.73
		1051 overall	4.17	1.08	2.24	1.04	1.96⦇	0.92
			4.23	1.42	2.36	1.15	2.06⦇	0.97
			5.07	1.77	3.23	1.74	1.63⦇	0.40
			3.95	1.45	1.61	0.98	1.56⦇	0.73
2004	13	625 overall	6.00		4.80		5.11⦇	1.24
			5.00		4.30		4.01⦇	0.97
			6.00		4.10		3.56⦇	0.87
			5.00		5.00		5.55⦇	1.35
			5.00		5.75		7.2⦇	1.75
			5.00		4.20		3.79⦇	0.92
			6.00		5.48		6.61⦇	1.61
			11.00		7.50		11.07⦇	2.69
			6.00		7.00		9.96⦇	2.42
			8.00		9.95		8.89⦇	4.16
2005	7	150	4.90	1.25	3.63†	0.95	3.28⦇	1.54
		150	3.36	0.70	2.29†	0.60	0.49⦇	0.23
		150	3.57	0.84	2.47†	0.64	0.87⦇	0.41
	8	109	5.90	3.10	6.67	3.76	9.23⦇	2.24
2009	5	143	4.08	1.24	2.92†	0.76	1.80⦇	0.84
2009*	10	36	3.67	0.78	2.56†	0.67	1.06⦇	0.50
2011	2	280	5.56		3.08		1.31⦇	0.32
		181	7.98		5.08		5.72⦇	1.39
		251	9.01		5.69		7.07⦇	1.72
	6	201 (Ø); 475	9.20	3.40	5.72	2.46	7.14⦇	1.74
		(H) overall	8.60	3.70	5.64	2.69	6.96⦇	1.69
			7.20	2.80	3.11	1.56	1.38⦇	0.34
			5.00	1.40	2.80	1.67	0.70⦇	0.17
2012	2	227	5.96		2.51		5.20⦇	2.44
		99	5.88		3.81		2.93⦇	0.71
		162	7.47		4.76		5.02⦇	1.22
2013		95	5.90		2.76		0.61⦇	0.15
		42	7.40		5.32		6.26⦇	1.52
		78	6.00		2.20		5.27⦇	2.47
		132	5.90		3.81		2.92⦇	0.71
		31	6.70		5.77		7.25⦇	1.76
		251	7.50		4.76		5.02⦇	1.22
2017	1	140	5.49†	1.43	4.15	0.15	5.94	
		149	6.07†	1.58	4.66	0.20	7.49	
		109	5.44†	1.42	4.11	0.13	5.60	
		192	3.69†	0.96	2.57	0.13	2.65	
		112	5.49†	1.43	4.15	0.15	5.66	
		151	5.47†	1.42	4.13	0.13	5.66	
		110	4.51†	1.17	3.29	0.15	4.03	
		119	4.59†	1.19	3.36	0.13	3.88	
		30	7.22†	1.88	5.66	0.49	11.37	
		181	4.28†	1.11	3.09	0.25	4.28	
		130	3.86†	1.00	2.72	0.13	1.10	
		34	3.57†	0.93	2.47	0.13	4.92	
		100	3.53†	0.92	2.43	0.14	2.30	
		143	4.15†	1.08	2.98	0.17	3.81	
		52	4.24†	1.11	3.06	0.22	3.35	
		75	3.35†	0.87	2.28	0.12	1.83	

Data collection year	Ref. Code	# colonies	Ø (mm)	SD	H (cm)	SD	W (g)	SD
Ligurian Sea								
-300	24	Unknown			15.00			
1962*	23	Unknown			15.00			
1964*	22	< 100	5.64⦇	2.64	4.58⦇	1.11	4.63	
1964	3	Unknown	4.88⦇	2.29	3.96⦇	0.96	3.25	0.93
	9	< 100	4.47⦇	2.09	3.62⦇	0.88	2.50	0.40
1990	3	Unknown	2.40	0.30	3.46⦇	0.84	2.15	0.34
	9	Unknown	5.02⦇	2.35	4.07⦇	0.99	3.50	0.40
	18	Unknown	5.40		4.07†	1.06	3.60	
			3.80		2.67†	0.70	1.50	
			4.50		3.28†	0.85	2.70	
			6.00		4.60†	1.20	2.90	
			3.40		2.32†	0.60	1.10	
			3.80		2.67†	0.70	1.40	
			5.05		3.76†	0.98	3.80	
			4.90	1.30	5.03	1.48	2.13	1.30
			5.40	1.60	5.24	1.44	2.15	1.40
1994	16	Unknown	2.50	0.90	2.38	1.23		
1999*	15	Unknown	3.50		2.41†	0.63	2.00	
2008	9	Unknown	6.46†	1.68	5.00	1.60	4.00	0.50
			12.17†	3.17	10.00	2.00		
2009	5	477	4.42	1.69	3.21†	0.84	2.41⦇	1.13
2009*	10	75	4.48	1.45	3.27†	0.85	2.52⦇	1.18
2012	3	368 overall	8.20	0.70	6.30	0.30	10.60	1.80
			9.10	0.90	8.60	1.30	8.50	0.90
			6.30	1.10	6.90	0.80	5.10	0.90
			7.40	1.30	6.00	0.40	6.30	1.10
			4.80	0.30	6.90	0.40	6.00	1.30
			6.60	0.80	5.80	0.60	4.70	0.70
			6.30	0.60	5.00	0.50	5.60	1.10
			5.50	0.60	5.10	0.40	5.30	1.00
			7.30	0.50	6.10	0.30	7.60	0.90
			5.90	0.30	6.20	0.43	5.20	0.50
			5.70	0.60	4.60	0.30	4.80	0.20
			4.80	0.20	4.60	0.50	3.30	0.39
	4	Unknown	7.00	2.00	7.50	5.00	11.07⦇	2.69

See the reference of each document in the S1 Table reference list through its reference code.

colonies "overall" are stated when no # per value is available and represents the sample size containing all the values comprised until the next # shown in the table. SD: Standard deviation.

Ø: Basal diameter. H: Height. W: Weigh.

Values obtained through formulas (See Fig. 3) are marked with signs: (†): with formula (1), (⦇) with formula (2), and (⦇) with formula (3).

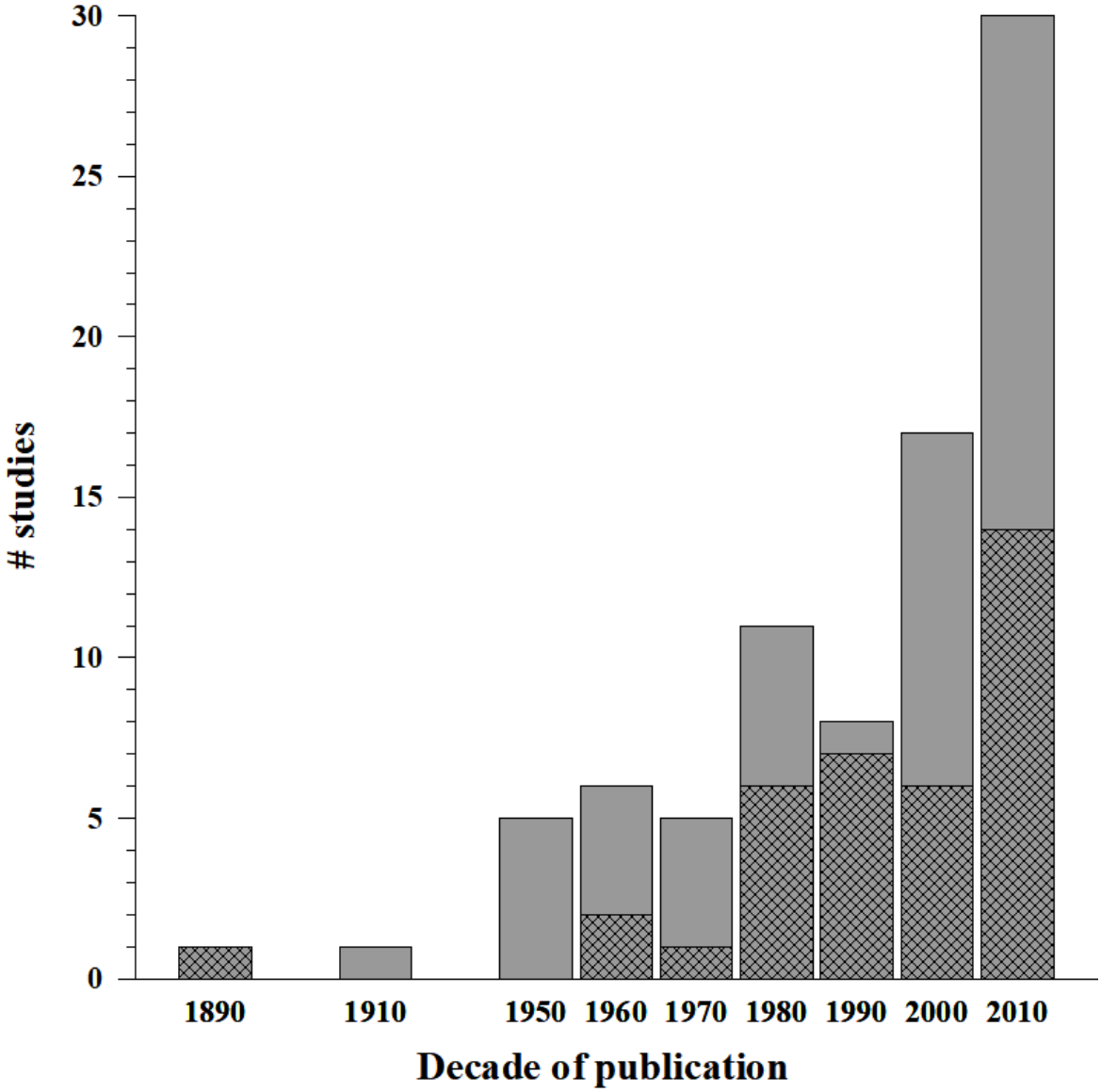
Supplementary material 3. Supporting information methodology. This article was elaborated through a simplification of an original literature review. The methodology of such review is explained here, as well as the source of Fig 3, SM 1, SM 4, and SM 5.

We performed an extensive literature review about the health status of *Corallium rubrum* (CR) within the Catalan Sea (including Côte Vermeille), Ligurian Sea and off Tuscany regions. We included grey literature and qualitative documents. We did a scientific web browser research in "Topic" (Web of Science) and "In the Title" (Google Scholar) using the keywords: "Corallium rubrum" OR "red coral" OR "coralligenous" AND "Mediterranean" OR "Catalunya" OR "Catalonia" OR "Catalan" OR "Tuscany" OR "Tuscan" OR "Liguria". Additionally, we realized an in-depth methodical review of two libraries: Biblioteca Carles Bas i Peired (CSIC-CMIMA; Barcelona) and Bibliothèque du Laboratoire Arago (BUPMC; Banyuls-sur-mer); we also researched punctually in other libraries and we obtained documents from scientists. We also reviewed references inside the selected documents. We included documents written in Catalan, Spanish, English, French, Italian, or Latin. The research time span finished in September 2018.

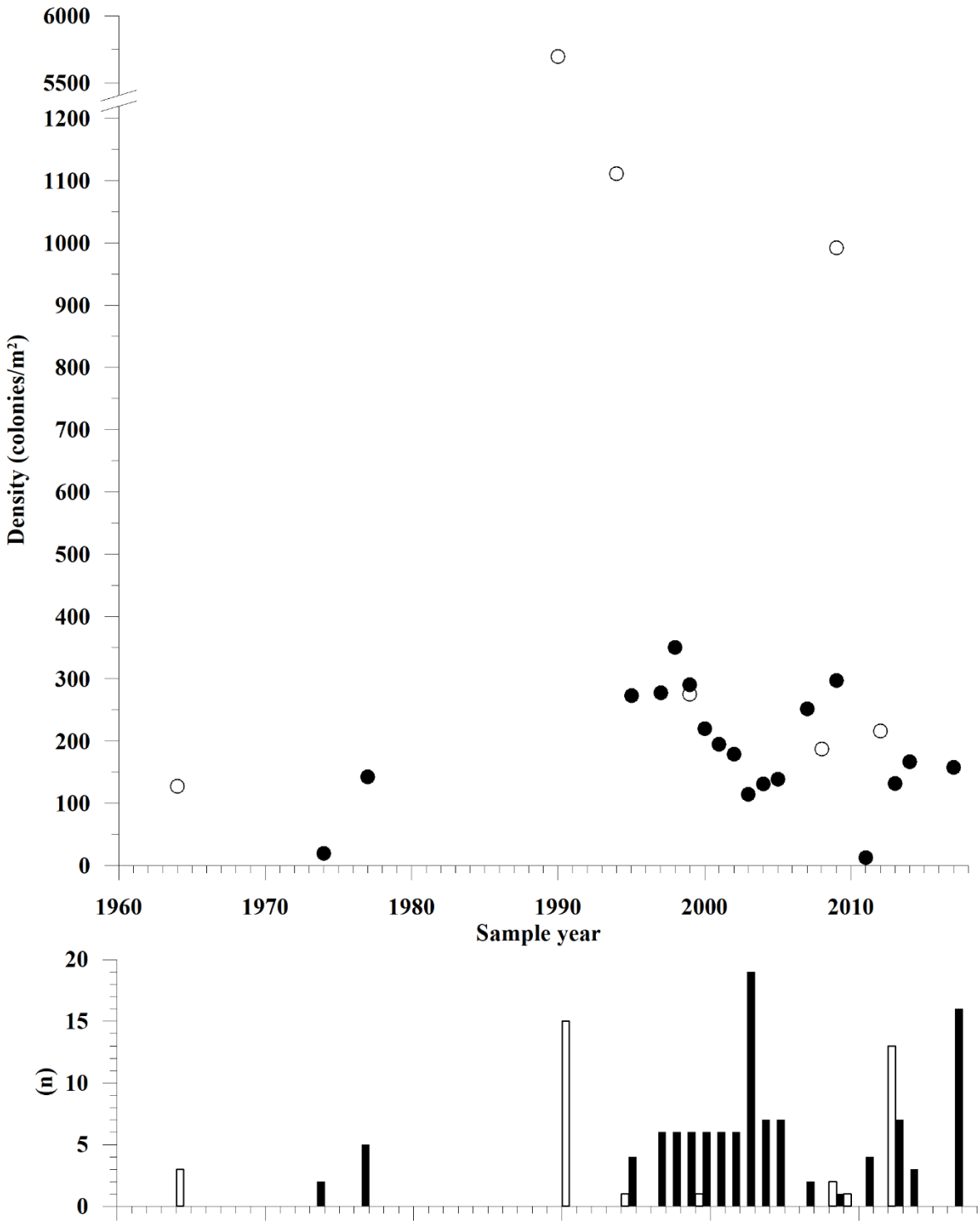
From this search we found 102 documents describing quantitatively and/or qualitatively some parameter of CR's health status. Additionally, we found ten location documents (SM 1). A location document provides information about the presence of CR in a definitive place (depth and/or geographical situation) but does not give information about its health status. From the original 102 documents, 84 include original information about CR's health status (SM 4). Among these 84 documents, we used the ones with basal diameter, height, and weight data to make Fig 3.

The documents with CR health status information (n = 84) are comprised by 80% of academic and 20% of grey literature. The documents with quantitative information represent the 79% and the qualitative ones 29% (SM 6). The Catalan Sea is the most represented region, appearing in 52% of the articles, followed by Tuscany with 30% and Liguria with 27% (SM 1).

Supplementary material 4. In grey the number of documents published per decade with original demographic and biometric information of *Corallium rubrum* (CR) within the Catalan Sea (including Côte Vermeille), Ligurian Sea, and off Tuscany regions: n = 84. The documents that provide qualitative information represent 29% of the total. In cross grids the proportion of documents containing original data about CR basal diameter, height and/or weight: n = 37.



Supplementary material 5. *Corallium rubrum* density values by year sampled. Dots correspond to the yearly average value of density. The number of data points used for the year averages are shown below. Catalan Sea: black dots and bars. Ligurian Sea: white dots and bars.



Supplementary material 6. Qualitative information related with the health status of *Corallium rubrum* from the Catalan Sea, Ligurian Sea and off Tuscany. The information comprises notes or text extractions from the original documents. For the full reference of each code at the beginning of the text, see the list of references of SM 1.

Catalan Sea

19. Shrub-like colonies, small, hard and with an irregular branching. Very variable diameter, that in the branches goes from 1 to 3 mm. Branches are located in all directions, although they tend to locate in a single level.

43. Scuba divers perceive red coral is in regression (lower density, shorter branches). Also, they perceive that high scuba diving frequency is affecting directly or indirectly the red coral.

57. To grow 0.8 mm needs a year regarding some biologists, opinion I do not share at all, as the appreciated observations in some stretches surpass more than 1 cm.

The red gold lives in fretworks between 5 and 150 m in semi-dark environments of caves, balms, and cliffs.

In Catalonia, is abundant at the nord end of Girona, especially in Medes, Escala, and Cap de Creus. In Llançà is missing, only is present in a testimonial way outside Cap Ras and in Pou d'en Porret, where a coral fishing device remains from some ancestor from the area. But the little coral existant was of an excellent height and quality, not always was like that.

62. Coral growth from 6-10 m depth.

Coral quantity per day per ship it was not usually very abundant.

1959: Work between 30 and 40 m. The visions all the coral harvesters remember are about all the rocky walls and caves completely crowded of flowered coral with its white polips, and from the big and abundant quantity and variety of fishes and lobsters, its an inexplicable wonder, at least I can not explain it.

Explained by Mr. Costas Contos: Coral was different from one area to another. The one from Begur and Cap de Creus was the best in color and without pores, but from 30 braces (~ 50 m) almost all was first quality coral, and sometimes they worked until 47 braces (~ 85 m).

68. Illes Formigues: traditional area of coral harvesting between 32-40 m. Actually present in very low densities. Sponges are observed as the main cause of polyp mortality.

Red coral places: Ullastre, Formigues, Tamariu, Galladera, Encalladora, Portaló, Massina, Fornells, and Agullas: appearance of a bacterial veil covering the colonies.

69. Els Ullastres (Llafranch) at Winter 1979, spring and summer 1980: Closer to the 52 m depth increase the nº of colonies observed (they apear at approximately 30 m). Red coral has an habitual presence at coralligenous and semi-dark caves, in all kinds of hard subtrate inclination.

71. Port-Vendres: Found in low numbers at obscure locations.

72. High quality coral with big abundances was always bred in the submarine caves and potholes of Medes.

Haversting places: Medes, Estartit, Escala, Cap de Creus, Begur; outside Costa Brava: Côte Bleue, Corsica, Livorno, Napoli, Genoa, Tunisia, Algeria, Morocco, until Cape Verde.

Coral extraction almost uninterrupted since the beginning of the 1800s. In 1870-75 the first classic divers could reach 40-50 m depth. Fishing testimony in Illa Petita (Medes).

1954: first scuba divers in Costa Brava. They accessed to the most hidden places. Harvesting magnificent coraliferous trees specimens of a massive constitution and beauty that never could be dreamt.

73. Found just at 280 m with small branches showing on the horizontal facies.

76. From about 20 m on the sciaphilic overhangs, in dense colonies.

Common in Cap Abeille. Rare in Cap Oullestreil.

83. Predominant animals: at the beach, throwed by the waves, especially after storms, some cnidarians are found, especially corals.

84. In the countries where coral is still abundant, there are people that are dedicated to catch them, it is very easy to adquire samples from it and from other species. But it does not appear where it is not abundant or where lacks its industry, there is no other way to catch it that order the fishermen that keep the ones that casually extract sometimes with the fish, and catch the other species, that being lighter, the waves throw to the shore in the seas where they are abundant.

The document has no date and authorship. It is believed that was done by Mariano de la Paz Graells as a guide to scientific recollection of samples by the Spanish Navy officers. M. P. Graells lived during 1809-1898 [Pérez-Rubín Feigl J. Oceanografía, biología y ordenación pesqueras en la armada española (1890-1925). In: X Congreso de la Sociedad Española de Historia de las Ciencias y de las Técnicas. Encuentro internacional Europeo-Americano 2008. Editors: Cobos Bueno JM, Pulgarín Guerrero A, Ausejo E. Badajoz, Spain. 2011;269-287].

Ligurian Sea

18. Punta Torreta: As in the earlier studies (Marchetti, 1965: Ref. 22; Tortonese, 1958; Ref. 79), we found the first red coral colonies at about 30 m.

Punta Carega: Marchetti (Ref. 22) recorded small red coral colonies from a depth of 27 m, while Tortonese reported colonies only in the 1961 paper (Ref. 77). Today red coral starts to appear at 30 m.

Marcante Cave: Tortonese (Ref. 79) mentioned the cave without entering into detail. Not examined by Marchetti (Ref. 22). Today there is a well-structured red coral population from the entrace to the cave reaching back 5.5 m.

Punta del Faro: Marchetti (Ref. 22) recorded many small colonies, starting from a depht of 21 m. Today the first colonies appear at about 25 m, and the population is characterized by a high density of small colonies.

This study: Around the southern cliff of the Portofino Promontory the first red coral colonies, generally quite small, start to appear at about a depth of 20-25 m and they are low in density. The average density values tend to increase with depth to reach a maximum at 30-40 m.

A comparison between our data and those of Marchetti 1965 (Ref. 22) revealed differences in the density. In 1965, this value varied from 100-300 col/m2 with a weight between 650 and 1200 g/m2. Therefore, in 30 years there has been an increase in density and a reduction in the mean size of single colonies. The higher density is probably due to a reduction in fishing by amateur divers, while the weight, which has remained unchanged, indicates that the increased density has led to a greater intraspecific competition. This was confirmed by the finding that colonies with the greater basal diameter occurred in stations with a lower density.

23. The colonies are usually 4 to 8 inches high (~ 10-20 cm) but may grow larger, especially in the depths.

Red coral lives attached to rocky bottoms, between 65 and 650 feet (~ 20-200 m) along the coasts. Colonies are first found at about 65 feet but become more numerous and better deveoloped at greater depths. They are often found in remarkable numbers in the submerged and dark caves. At upper levels they are scarce and as a whole the corals are smaller and do not form dense populations. At greater depths these creatures grow on hard surfaces, forming veritable banks.

The existence of red coral in the bay of Genoa was noticed long ago. However, this species was cosidered quite rare until 1955, when some skin divers found a number of colonies along the rocky coasts of the Portofino promontory.

24. Ligurian Sea produces branches of coral that are soft and fleshy in deep waters, while become stony when they are collected from the place where they are born. Not only its condition is modified, also the colour, as immediately they turn scarlet.

63. Location: from east of Seno de S. Fruttuoso until the head of the Portofino lighthouse.

Coral found in vertical rock walls with overhangs and deep crevices (the closest from S. Fruttuoso Bay): red coral colonies set easily in all the crevices of the rock. Found at low depth (16m). Also, red coral is found in rocky landslides of different sizes (more frequent than the other environment).

Marchetti (1965; Ref. 22) said red coral was absent in stations facing Cala degli Inglesi (in this study only appeared in an artificial sunken cargo boat) and the one closer to Punta del Faro di Portofino (present in this study). In this study red coral appeared with an uninterrupted distribution along all the coast studied.

In some stations red coral appeared at shallower or deeper depths than Marchetti (1965). The stations that are found deeper now are the ones that are highly frequented by scuba divers where the collection even of small red coral had become an extended practice. The presence of many broken colonies and even partially fixed to the substrate as well as only the basis fixed to the substrate confirm this observation.

The stations that red coral is found at shallower depths than Marchetti (1965) are the ones little frequented by divers, the approximation is difficult, the currents are strong; despite the navigation is intense vertically from the immersion areas.

Seventy-five % of colonies are parasitized, the population is massively damaged by Clionidae.

Red coral colonies inside the wreck cargo boat are the biggest of the study and the colonies have the typical “bush tree” form where the ramifications develop in radius with respect to the central axis. Growth rate (at artificial cargo ship wrecked station only): 7-8 mm (new colonies, very young).

75. Its beautiful calcium carbonate skeleton has been used as jewellery, currency, and religious talismans as early as 30,000 years ago.

First gathered in the form of fragments of natural branches thrown from the sea to the beaches. Later, in the Palaeolithic Age, a characteristic of primitive fishing, pulled away by force by divers using their hands or stones, to be then, in the Iron Age, cut with a metal device in the anfractuosities of the caves and reefs, where water was not too deep. The first fishing system is, in a certain way, confirmed by Orpheus himself, when he tells us, in narrating the already mentioned original mystery of its petrification, how coral is born far away in the sea and he dwells upon explaining to us the phenomenon of its branches swarming on the coastal gravel. The following lines would prove, furthermore, that in this sea phenomenon not only small fragments but even bigger pieces were thrown on to the beach: "Meanwhile the plant's root remain in its position, its branches bloom towards unpredictable places".

At first, large coral branches were collected after being washed up on the beach after stroms. But soon fishermen on Greek islands started to harvest colonies from shallow water by the use of hooks on long wooden poles, and later by breath-hold diving while using Japanese goggles.

Gathering coral on the beach with an expert hand or in the maze of the sea bottoms, where the largest and most beautiful branches were picked.

In the XIV Century, was the time when Fazio degli Uberti sang in his gentle poem: "The Ligurian Sea produces coral, at its bottom, in the shape of a small tree: the pale coloured branch between white and yellow breaks like glass, when it is caught, and the bigger it is and with more branches, the more beautiful...".

To face the threat of impoverishment of the sea-bottoms, because of the devastating action of the devices that were being used, the Frenchs tried very hard to find better means of fishing; and the Academy of Marseilles, in 1876, announced a useless competition with a prize for the inventor of a less ravaging device.

The favourable conditions granted by the Angevins must probably have aroused, at certain moments, the fear that coral reefs would soon be exhausted, since, by a royal edict of 1332-33,

the prohibition to fish for coral without the King's permission between Cape Minerva and Capri, a place very rich in coral, was renewed.

In the inventory of the possessions of Guglielmo Monaco, an inventory written immediately after his death, on the 28 of September 1498, there is "a pair of paternostri of two hundred and eight big corals with a big silver gilded button all weighing one pound, one and a half ounces" (~ 500 g).

77. Punta Carega (San Fruttuoso): 20-30m: scarce and small colonies (wall), presence in crevices. At 30-40m: abundant. Numerous colonies but of small stature (walls and crevices).

78. Punta del faro di Portofino (25-58m depth): very few and small specimens. In turn, its common in all Portofino promontory.

79. Red coral locations: Punta Torretta (30-40 m): boring, competition for space. Between S. Fruttuoso and Punta Carega at 10-12 m : red coral among the most visible exponent of the fauna, at 20-40 m also present. Portofino at 20-40 m.

In 1955, D. Marcante, during his dives, discovered the great abundance of red coral in the underwater caves near San Fruttuoso.

81. From Punta Chiappa until the East of San Fruttuoso: red coral has been emphasized by the great abundance in the caves near San Fruttuoso. The coral appears in small, low-developed colonies already at about 20 m of depth, but it is at 40-45 m that becomes dominant with taller, larger and more ramified colonies.

82. Punta Chiappa, Bay of San Fruttuoso: Substantial population of red coral, the great abundance contributes to a considerable extent (D. Marcante) although the presence of this species has been known for a long time in several localities of Liguria, including Portofino, only in 1955 Mr. D. Marcante revealed its great abundance in the caves near S. Fruttuoso.

Deeper than 15m the coral gradually takes over and between 35-45 m becomes dominant in turn.

Coral colonies appear already at 20-22 m in small numbers, and are characterized by a lesser stature, a weaker branching and a longer basal trunk. They can contrast with the larger, slimmer, more ramified ones that were encountered at 45m.

Big abundance of red coral in the typical cold Mediterranean facies.

Tuscany

74. Capo Fonza (Elba): red coral first apparance at 26 m with not very wide banks. Very dense banks, with very poorly developed branches, and with low commercial value.

The branches of greatest commercial interest are those taken at greater depths by populations formed by colonies grown under these conditions.

80. Red coral at 40 m depth: covers the ceiling of small and large caves or the fissures of the coralligenous. Of excellent quality and color, although of medium thickness, the coral is surrounded by huge quantities of yellow sponges, in clusters, similar to helmets of bananas.

3 LOCAL AND TOURIST PERCEPTIONS OF COASTAL MARINE HABITATS IN CAP DE CREUS (NE SPAIN)

This chapter corresponds to a submitted scientific article to the journal *Regional Environmental Change*, which in the thesis submission date is found under review. The version appearing here is the submitted article without any reviewer's input on it.

Abstract

Direct human pressure on Marine Protected Areas (MPAs) adds to climate change impacts on marine habitats, especially in coastal biodiversity hot spots. Understanding MPA users perception towards the Coastal Marine Habitats (CMHs) could improve awareness of the challenges that such areas have to face, eventually providing insights for the design of conservation and tourism management plans. We studied perception of benefits, impacts and threats of CMHs by locals and tourists (n = 624) of Cap de Creus MPA (NW Mediterranean Sea). Overall, we found that perceptions of tourists and locals are similar. Respondents perceived that CMHs provide valuable regulating services, and they assigned less value to cultural services. Locals valued the food provision benefit of CMHs significantly more than tourists, probably because of the historical importance of fisheries for subsistence. Respondents ranked marine pollution of inland origin, climate change, and people's behaviour towards nature as the most impactful and threatening to CMHs, and invasive marine species as the least. Respondents also perceived that climate change impacts would increase soon, while the impact of people's behaviour towards nature would decrease. Tourists perceived mass tourism as significantly more impactful and threatening to CMHs than locals did. Overall, our study shows that conservation of CMHs is highly valued, so more effort need to be directed toward this goal.

3.1. Introduction

The Mediterranean Sea, despite representing only 0.8% of the surface world's ocean and 0.32% of its volume (Defant 1961), is a biodiversity hotspot (Lejeusne et al. 2010), where 4 to 18% of the world's marine species live, including a high percentage of endemic species (Bianchi et al. 2012). Mediterranean marine species range from 12,000 to 20,000 in number, a diversity only comparable with the southern coast of Australia (Coll et al. 2010; Bianchi et al. 2012; Boudouresque 2004). In the Mediterranean basin, biodiversity is mostly concentrated in coastal and continental shelves. The habitats distributed in these areas have higher biodiversity in the northwestern basin, where the uppermost seawater is relatively colder, fresher, and more productive than in the rest of the Mediterranean Sea (Coll et al. 2010; Coll et al. 2012).

Northwestern coastal marine habitats (CMHs) play a crucial role in maintaining Mediterranean biodiversity, as a high number of species feed, nurse and are protected there, especially in the seagrass meadows (Duffy 2006; Boudouresque et al. 2004) and the coralligenous (Valisano et al. 2019; Casas-Güell et al. 2015; Kipson et al. 2011). These CMHs also provide numerous contributions to people, including food provision, control of pollutants, oxygen release, biological and climate regulation, coastal protection, ocean nourishment, recreation, and symbolic and aesthetic values (Liquete et al. 2013; Barbier et al. 2011; Lloret 2010). As blue carbon sinks, CMHs also contribute to carbon sequestration (Mallo et al. 2019; Coppari et al. 2019; Krause-Jensen and Duarte 2016; Duarte et al. 2010).

As the coasts of the Mediterranean are highly populated (UNEP/MAP 2012) and the region is a major world tourist destination (Weston et al 2019), the Mediterranean faces enormous human pressure, and it is the sea with the greatest anthropogenic impacts on Earth (Claudet et al. 2020; Coll et al. 2010). Anthropogenic impacts (e.g., pollution, hypoxia, invasive species, or bottom trawling; Coll et al 2012; Claudet and Fraschetti 2010) are particularly concentrated in coastal areas (Gray 1997), especially in the northwestern region (Coll et al. 2012). These stressors affect CMHs by decreasing their complexity, sometimes through fragmentation and patchiness, lowering water quality, decreasing biodiversity, altering food chains, and decreasing their carbon sequestration potential. These changes, in turn, imply less habitat resilience to perturbations, less ability to mitigate climate change, and a lower capacity for sustaining biodiversity (e.g.: Rossi 2019; Montefalcone et al. 2017; Rossi et al. 2017; Deudero and Alomar 2015; Micheli et al. 2013; Lacoue-Labarthe et al. 2016). From a social point of view, a habitat's low health status decreases the area's tourism attraction potential, affecting the local economy and livelihoods (Krelling et

al. 2017; Rodrigues et al. 2015; Kirillova et al. 2014; Van der Merwe et al. 2011; Petrosillo et al. 2007; Liu et al. 1987).

In this article, we explore the benefits, impacts (including stressors), and threats of CMHs in Cap de Creus (NE Spain) as perceived by the local population and tourists visiting the area. Understanding how the users of coastal marine areas perceive the benefits, impacts, and threats of CMHs would be a step forward towards effective marine life conservation and management policies of coastal areas, as awareness of the problems are a key step for proposing new conservation measures or maintaining the existing ones, including a better design of a sustainable tourism model (e.g., Llausàs et al. 2019).

3.2. Methods

3.2.1. Study area

We conducted research in the Cap de Creus peninsula (42º 33'N; 03º19'E), Costa Brava (Girona, Spain). Specifically, we collected data in Port de la Selva, Cadaqués and Roses, the three municipalities with marine jurisdiction in the 3,073 ha of the Cap de Creus Natural Park, which was established in 1998 (Fig. 1). For this work, we focus on the three municipalities neigbouring a Marine Protected Area (MPA), the Natural Park of Cap de Creus, where the quality of the natural habitat plays a major role as tourist attractor.

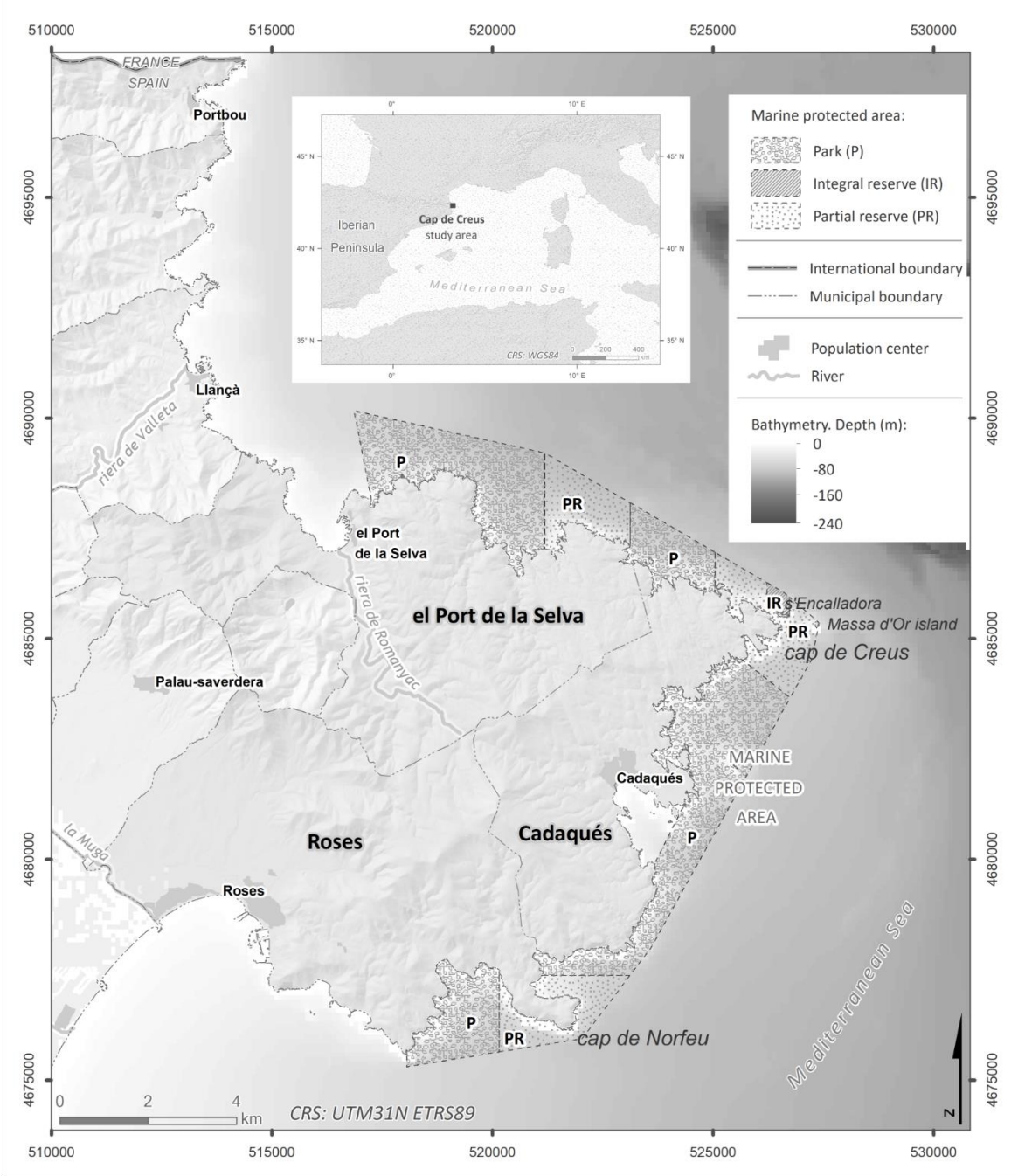


Figure 1. *Map of the study area.*

The study area has a mild climate, characterized by moderate annual precipitations and temperatures. The coastal marine environment is influenced by an important river runoff from the Rhône, the Fluvià and the Muga, and a intense vertical mixing in winter due to typical dry, cold and strong winds, causing strong coastal currents (Rohling et al. 2015; Gili et al. 2011). Such features make the Cap de Creus coastal and offshore system one of the most productive

marine areas of the Mediterranean Sea (Gili et al. 2011). Sandy bottoms characterize the marine vegetation in this system where seagrass meadows, especially *Posidonia oceanica*, dominate (Ruiz et al. 2015; Sardà et al. 2012). The shallow and deep rocky bottoms are dominated by coralligenous species, like *Paramuricea clavata*, *Eunicella* spp., *Axinella* spp. and *Corallium rubrum* (Sardà et al. 2012; Gili et al. 2011; Gori et al. 2011; Linares et al. 2018).

Traditionally, the main source of income in Roses, Cadaqués and El Port de la Selva were fisheries and agriculture. However, since the 1960s, these villages became strong tourist attractions, and today, tourism is the main source of income for the local population (Newsletter Costa Brava 2019). Recreational activities with potential impacts on the Cap de Creus Natural Park include recreational boating (anchoring), artisanal fishery, recreational fishing, non-regulated shellfish collection, spearfishing, and inappropriate recreational scuba diving. Most of these activities happen during the summer months, affecting the seagrass meadows, the coralligenous, and the infralittoral algal habitats (e.g., Hereu et al. 2018; Corrales et al. 2020; Vilas et al. 2020; Font and Lloret 2011; Lloret and Riera 2008).

3.2.2. Data collection

We conducted research in two phases combining qualitative and quantitative data collection methods. During December 2017 and July 2018, we performed exploratory semi-structured interviews. We used information from these interviews to design a survey to collect data during July and August 2019. Participation in our research was voluntary, and the Ethics Committee on Animal and Human Experimentation of the Autonomous University of Barcelona approved the research protocol (CEEAH 4792).

3.2.2.1. Semi-structured interviews

We used semi-structured interviews to assess how people who are directly or indirectly dependent on the CMHs for their income perceive environmental changes and their impacts. The sample for semi-structured interviews included owners and managers of tourist accommodations, fresh seafood restaurants, and scuba diving centres. To select the target sample, we first compiled a list of local businesses. We contacted the 93 potential candidates in our list, from which 40 (43%) agreed to be interviewed (see SM 1).

We asked informants to list the changes perceived in the area since they had begun work there. We highlighted that we were interested in changes affecting them and/or other local inhabitants.

Responses to our question included impacts, drivers and/or stressors (all named as 'impacts' hereafter). We handwrote responses referring to environmental changes.

3.2.2.2. Survey

In the second phase of the research, we conducted a survey to assess people's perceptions of the benefits provided by the local CMH, as well as the impacts and threats affecting it (SM 2). To select survey respondents, we used convenience sampling. Our sample included adults found in the three municipalities of the study area, regardless of their place of residence (i.e., including tourists). We approached 1227 people, from which 624 (51%) agreed to respond to the survey (see SM 1).

The survey collected information on respondent's sociodemographic status and perceptions of Cap de Creus CMH benefits, impacts, and threats (SM 2; SM 3). To form a list of CMH benefits, we used published literature to, select the six more relevant and easy to identify benefits provided by a CMH (Liquete et al. 2013). In our survey, we asked respondents to rank the six listed benefits from the most (=1) to the least (=6) relevant. Respondents could put an "x" if they perceived that some benefit(s) in our list were not relevant in the area.

To examine perceptions of the main impacts on local CMHs, we selected the eight negative environmental changes most frequently reported in the semi-structured interviews (SM 4). We asked respondents to rank the selected impacts from the most (=1) to the least (=8) impactful. Respondents could also indicate that some elements in the list did not affect local CMHs (=x). To examine perceptions of the main threats affecting CMHs, we used the same procedure, but asked respondents to speculate how important would be the same eight selected impacts in 2050.

3.2.3. Data analysis

We calculated the mean and median value of each benefit, impact, and threat, considering the rank assigned by our pool of respondents. Given our scales, higher values account for less beneficial, less impactful, and less threatening items than lower values. We then conducted three analyses for each element in our list: we compared the mean and median values of (i) the full sample, (ii) tourists vs. locals, and (iii) tourists vs. locals but disaggregating the sample according to other sociodemographic characteristics of informants (Table 1). We considered respondents were local if they resided in the study area or the closest neighbouring towns (listed in Table 1), and tourists if they lived 120 km or further from the study area.

Table 1. *Sociodemographic variables used for the statistical analysis. The question(s) we took them from, how we refer this variable in the article, what methods we used to group them, and which categories we considered for the analysis.*

Question at the survey questionnaire (Online Resource 2)	**Referred in the article as**	**Grouped as/ Named as**	**Grouping method**	**Discarded for the statistical analysis**
Town/city of residence	Local / tourist	Local, tourist	Locals are from: Roses, Cadaqués, El Port de la Selva, Cala Jòncols, Castelló d'Empuries, Empuriabrava, Llançà, Selva de Mar, and Vilajuïga. Tourists: the ones living more than 120 km away from the area. The respondents that lived closer than this distance but were not locals are not included in this study.	
Town/city of residence	Residence respect sea proximity	Coastal, Near coast, Inland	Coastal = the town/city of residence limits with the sea. Near coast = it takes less than one hour to arrive to the closest coast by car (calculated with © Google Maps). Inland = it takes more than one hour to arrive to the closest coast.	Near coast locals due to low sample size
How often do you visit this area? AND What was the decade of your first visit?	Frequency & antiquity	Born locals, Not born locals, Frequent, Infrequent, First timers	Born locals = Locals born in the study area. Not born locals = Locals not born on the study area but living there for more than a decade. Frequent = Tourists that visit the study area since more than a decade, either frequently or once per year. Infrequent = Locals not born on the study area with less than a decade living there, or tourists that visit the study area since less than a decade (either frequently or once per year), or tourists that visit the study area infrequently. First timers = Tourists that visit the study area for the first time.	Not born locals and Infrequent locals due to low sample size
To what extent do you think you depend on the marine environment in your daily life, either for your work and/or income or for your leisure activities?	Affinity / dependance	Depend, Joy, Indifferent, Avoid	We grouped the first two answers into one category: Depend = "Strongly. I need it frequently" and "I need it once in a while, I cannot spend too much time without it". Joy = "I enjoy it, but I do not depend on it". Indifferent = "Indifferent. It has nothing to do with me". Avoid = "I avoid it".	Indifferent and Avoid (locals and tourists) due to low sample size
Age group	Age group	Young, Middle, Older	Young = 18-29 years. Middle = 30-49 years (30-39 and 40-49 grouped). Older = > 50 years (50-59, 60-69, 70-79, 80-89, >90 grouped).	
What is the highest level of education that you have completed?	Education level	Low, Medium, High	Low = "No schooling completed", "Primary school" and "Middle school" grouped. Medium = "High school" and "Professional degree/technical school training" grouped. High = "University", "Master, post-graduate" and "Doctorate/PhD" grouped.	
Choose one of the following that best indicate your average yearly income. If you are retired think in your income when you were working.	Income	Low, Mid, High	Low = < 14,000 €/year. Mid = 14-35,000 €/year. High = > 35,000 €/year (35-56,000 and > 56,000 €/year grouped).	No income (locals and tourists) due to low sample size

Ordinal answers of benefits, impacts and threats questions have a non-normal and homoscedastic distribution according to the Shapiro-Wilk normality test (Shapiro and Wilk 1965) and the Levene's test for homogeneity of variance (Levene 1960) respectively. To know if the difference in average values of the different benefits, impacts and threats across the two groups (e.g., local and tourist) was statistically significant, we did a Kruskal-Wallis rank-sum test (Kruskal and Wallis 1952) establishing an alpha of 0.05. Subsequently, we used the Dunn test (Dunn 1964) with p-values adjusted with the Holm method (Holm 1979) as a post-hoc test to know which groups were statistically different between them. We performed all the analyses with the software program R-Studio v1.2.5033 © 2009-2019 Rstudio, Inc.

3.2.4. Limitations

We acknowledge that, as other research based on survey data, the results presented here might be potentially affected by several types of biases including omitted variable bias (e.g., informants' identity or profession), complacency bias (e.g., when respondents answer what they think is socially correct rather than their own perception), or respondent's fatigue. A potential source of bias specific to this work is that, although we asked participants to provide responses in relation to the Cap de Creus Natural Park, their responses might have been conditioned by experiences in other coastal areas. Finally, our questionnaire might not have captured sensitive information with the same precision than more qualitative methods could do. For example, we asked respondents to rank elements in a predetermined list of benefits, impacts and threats, which might not have fully captured the informants' complex perceptions of all the processes influencing the local CMH.

3.3. Results

3.3.1. Semi-structured interviews

The average age of semi-structured interview respondents was 51 years (±12) and they had been running their businesses for 31 years (±14) on average. Fourteen (37%) interviewees did not mention any environmental negative change, while the remaining interviewees reported 12 different types of changes. We used the list of the most reported changes to select the eight impacts used in the survey (SM 4).

3.3.2. Survey

Survey respondents were quite homogeneously distributed across the three study sites: Cadaqués (34.1%), El Port de la Selva (33.8%), and Roses (32.1%). Most respondents had Spanish nationality (67.8%), followed by French (19.7%). The rest of the sample belonged to 28 other countries, each representing less than 2% of the sample. Local people represented 34.3% of the sample and tourists 65.7%, which should be taken into account when interpreting survey results (SM 3).

While almost all local respondents lived in coastal areas, only 31% of tourists did (Fig. 2a). Overall, our sample had a balanced distribution regarding frequency and antiquity visiting the area (Fig. 2b) and dependence on CMHs for their living or wellbeing (Fig. 2c; Table 1). A higher percentage of locals (61%) than of tourists (40%) considered themselves dependent on CMHs (Fig. 2c). The distribution of the sample is less balanced regarding age, education, and income level. The youngest age group (18-29 years) is the most represented in our sample (30.5%), while the oldest age group (≥80 years) is the least represented (2%; Fig 2d). The share of tourists in the group with highest education level was higher than that of locals (Fig. 2e) and, while most of our respondents (67%) earn less than 35,000 €/year, the share of tourists in high income categories was larger than the share of locals (Fig. 2f).

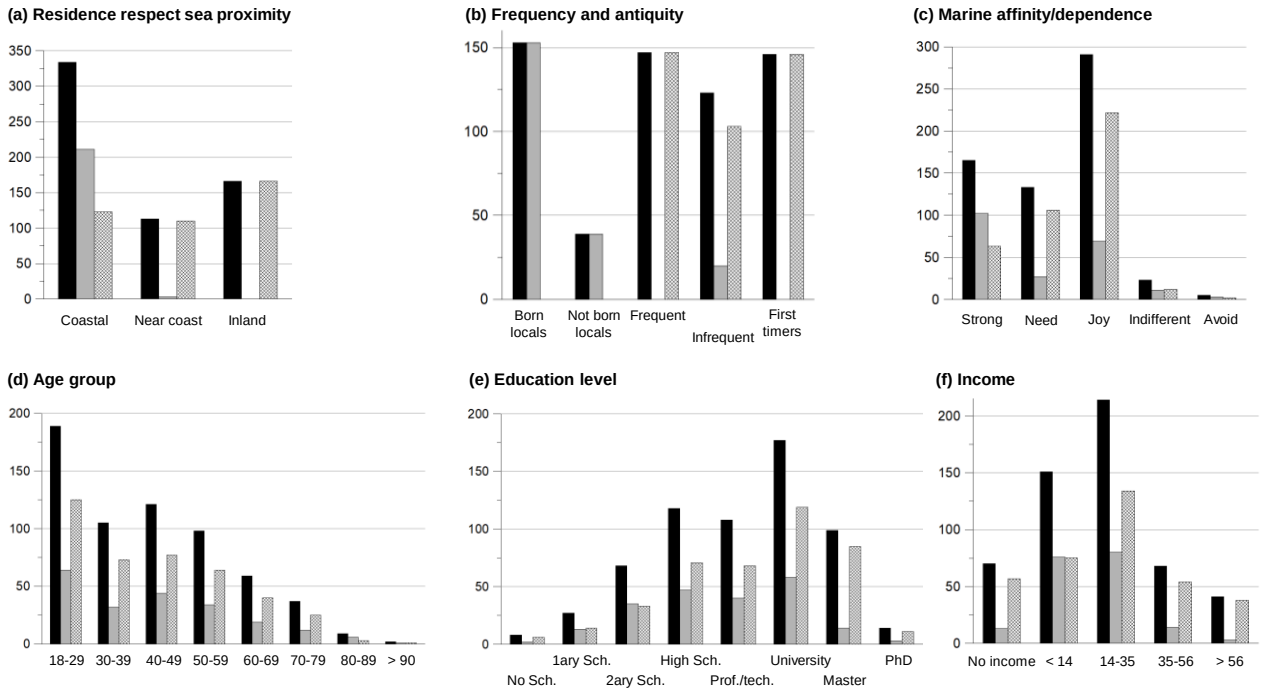


Figure 2. *Sample distribution across sociodemographic characteristics. Black boxes: total sample. Grey boxes: locals. Crossed boxes: tourists.*

Finally, we noted that only a minority of respondents used the "x" option (17%) when ranking, and some misunderstood the use of "x" and used it like "N/A", therefore we did not take into account these responses in the analysis.

3.3.2.1. Perceived benefits

The question on the benefits of the CMH was answered by 98.1% of respondents. On average, respondents ranked biodiversity protection and preservation (mean 2.45) and climate regulation (2.81) as the most important benefits provided by the local CMH. Conversely, aesthetic (4.25) and recreation (4.81) were ranked as the least important benefits (Fig. 3a).

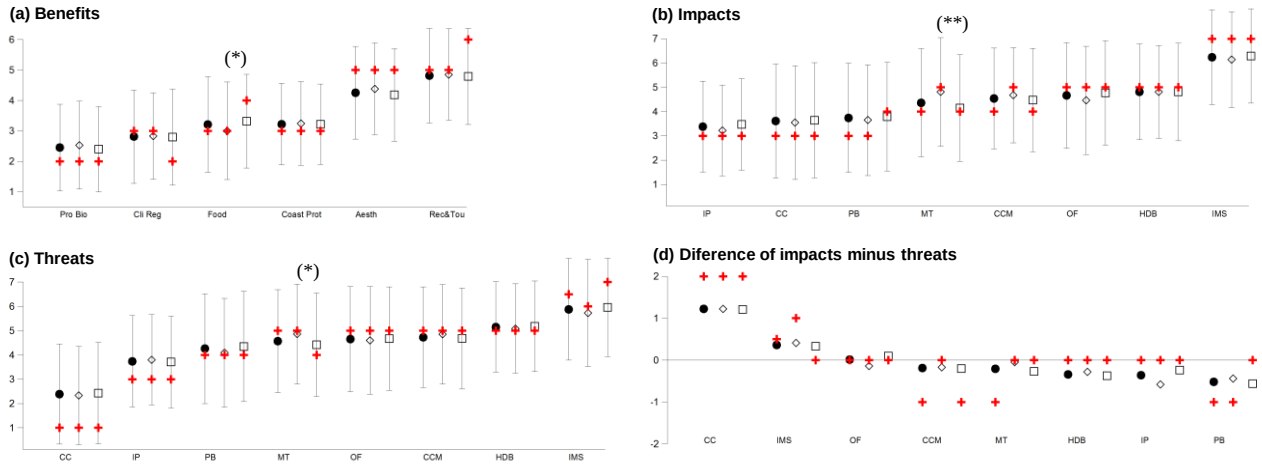


Figure 3. *Average rank values for (a) benefits, (b) impacts, and (c) threats. The difference between (b) and (c) is shown in (d). Benefits range from 1 to 6 and impacts and threats range from 1 to 8. A number closer to "1" in (a, b, and c) means more beneficial/impactful/threatening than higher values. In graph (d), zero represents no change, positive numbers are the ones with a lower average in threats than impacts, while the negative values mean the opposite. Average = black circles (total sample), diamonds (locals) and squares (tourists). Median = red crosses. Standard deviation is shown in vertical bars. Significant p-values from the Kruskal-Wallis rank-sum test within locals and tourists: (*) = p < 0.05, (**) = p < 0.01. Pro Bio: protection and preservation of biodiversity. Cli Reg: climate regulation. Food: food provision, Coast Prot: coastal protection. Aesth: aesthetic value. Rec&Tou: recreation and tourism. IP: inland pollution discharging in the sea, CC: climate change, PB: people's irresponsible behaviour, MT: mass tourism, CCM: coastal construction and modification, OF: overfishing, HDB: habitat degradation due to boat transit and anchoring, IMS: invasive marine species.*

The only significant difference between tourists and locals regarding their ranking of CMH benefits was that locals valued the food provision benefit more than tourists did (p = 0.017; Fig. 3a). Other less important differences between the two groups refer to biodiversity protection and aesthetic value. Thus, although the biodiversity protection benefit was generally valued by all people in the sample, locals with a high education level value it more (2.32) than tourists with a low education level (3.02). Additionally, while aesthetics was one of the lesser valued benefits provided by CMHs, tourists who came frequently to the study area ranked this benefit higher (4.00) than locals born there (4.51, Table 2; SM 5).

Table 2. *p-values from the Kruskal-Wallis rank sum test from crossing the parameter 'Local/Tourist' with the six sociodemographic parameters that give title to the columns and with the dependent variables (benefits, impacts, threats). Significantly different values are shown with asterisks: (*) p < 0.05, (**) p < 0.01. Significant values in bold are the ones that, after a post-hoc Dunn test, a significant difference is found between at least one subgroup of locals and tourists (see Online Resource 5 for more detail).*

	Local/tourist X Residence respect sea proximity	**Local/tourist X Frequency and antiquity**	**Local/tourist X Affinity/dependence**	**Local/tourist X Education level**	**Local/tourist X Income**	**Local/tourist X Age group**
Benefits						
Food provision	**0.007****	0.186	0.111	0.027*	**0.003****	**0.000****
Coastal protection	0.963	0.946	0.823	0.932	0.125	0.338
Climate regulation	0.045*	0.084	0.648	0.257	0.054	**0.003****
Protection and preservation of biodiversity	0.187	0.229	0.92	**0.002****	**0.023***	**0.025***
Aesthetic value	0.241	**0.024***	0.321	0.082	0.468	0.9
Recreation and tourism	0.76	0.814	0.972	0.409	0.061	0.095
Impacts						
Climate change	0.556	0.813	0.325	**0.000****	0.628	0.385
Overfishing	0.26	0.032*	0.328	0.409	0.334	0.072
Invasive marine species	0.279	0.748	0.772	**0.000****	0.946	**0.011***
Habitat degradation due to boat transit and anchoring	0.005**	0.302	0.998	0.562	0.247	0.737
Inland pollution that ends up in the sea	0.033*	0.234	0.25	0.248	0.766	0.495
Coastal construction and modification	0.49	0.253	0.431	0.15	0.509	0.843
Mass tourism	**0.005****	**0.002****	**0.001****	**0.001****	**0.004****	0.024*
People's irresponsible behaviour/lack of respect towards nature	0.833	0.55	0.245	0.482	0.335	0.368
Threats						
Climate change	0.211	0.574	0.1	0.834	0.366	0.965
Overfishing	0.359	0.639	0.835	0.618	0.509	0.214
Invasive marine species	0.208	0.1	0.963	0.143	0.114	0.02*
Habitat degradation due to boat transit and anchoring	0.011*	0.938	0.514	0.503	0.315	0.51
Inland pollution that ends up in the sea	0.023*	0.642	0.889	0.063	0.833	0.987
Coastal construction and modification	0.386	0.319	0.064	0.712	0.263	0.808
Mass tourism	**0.042***	0.258	**0.004****	0.065	0.171	0.247
People's irresponsible behaviour/lack of respect towards nature	0.53	0.442	0.006**	0.282	0.708	**0.004****

3.3.2.2. Perceived impacts and threats

The questions on impacts and threats were answered by 96.3% and 84.1% of the respondents, respectively. We found that 147 respondents (28%) provided the same responses to the impacts and threats questions, which calls for caution in the interpretation of these results.

Overall, inland pollution discharging into the sea was the highest ranked impact on the CMH (mean 3.38), followed by climate change, (3.61) and people's irresponsible behaviour towards nature (3.74; Fig. 3b). These three impacts were also considered as the greatest threats, although the order was different, with climate change receiving the highest rank as a threat (2.39; Fig. 3c). Indeed, the average ranking of climate change from impact to threat increased by 1.22 and its median by 2 points in our scale (Fig. 3d). On the other side of the scale, invasive marine species had the lowest ranking as an impact (6.24; Fig. 3b), and also received the lowest rank as threat by 2050, although with a lower mean (5.88; Fig. 3c). Indeed, after climate change, invasive marine species was the element with the largest ranking increase (+0.36; i.e., getting more threatening), whereas people's irresponsible behaviour towards nature was the element with the largest ranking decrease (-0.52; Fig. 3d).

Overall, tourists and locals share similar perceptions regarding the importance of current impacts and future threats on CMHs, with one significant exception: locals perceive mass tourism as less impactful ($p = 0.001$; Fig.3b) and less threatening ($p = 0.028$; Fig. 3c) to the local CMH than tourists do. However, this overall similarity between local and tourist perceptions of the impacts and threats to the local CMH hides some subsample differences, mostly related to age and education level. Thus, when asked about future threats, locals over 50 years of age ranked people's behaviour higher than tourists of the same age category and than the youngest respondents (Table 2; SM 5). Additionally, climate change was perceived as more impactful by respondents with low education levels, while respondents with the highest education level perceive it as less impactful. This difference was significant for both local and tourist education level subgroups. In addition, elder locals and locals with low education levels considered invasive marine species as more impactful than younger tourists and tourists with medium and high education levels.

3.4. Discussion

Results from this work suggest that locals and tourists have similar perceptions regarding the benefits, impacts, and threats of the Cap de Creus CMH, with three exceptions (food provision benefit, and mass tourism impact and threat). In this discussion, we comment on the overall ranking of CMH benefits, impacts and threats, and discuss differences between locals and tourists.

3.4.1. Benefits

Results from our survey show that the most valued CMH benefits perceived by our informants were biodiversity protection and preservation, and climate regulation (regulating services), while the least valued benefits were aesthetics, and recreation and tourism (cultural services). These results are in line with results from previous studies in other coastal areas (Blayac et al. 2014; Ursi and Towata 2018; Cárcamo et al. 2014; Blasiak et al. 2015). For example, regulating services were the most important services for pond fish farmers and other users in Lorraine, France (Blayac et al. 2014), and cultural services were the least prioritized services by local stakeholders of three Pacific Chilean islands (Cárcamo et al. 2014). Our results add to a growing body of literature suggesting that users of coastal marine areas value the regulatory services these areas provide more than their provision and cultural services.

As seen in previous studies, our results also suggest that valuations vary within the group of respondents. For example, Blayac et al. (2014) found that highly educated respondents prioritize the regulating over the provisioning benefits. Our results about protection and preservation of biodiversity, where respondents with a higher education level valued this benefit more than respondents with a lower education level, are in line with these previous findings. However, we do not find the same trend on the other two regulating services (climate regulation and coastal protection; SM 5).

An interesting element in CMH perception refers to the different valuation of the food provision service assigned by locals and tourists, with locals' valuing CMH food provision benefits significantly more than tourists. This is particularly the case for older locals, who ranked the food provision service higher than middle-aged and young tourists. We explain this result within the context of the past relevance of Cap de Creus fisheries, before the tourist boom of the 1960s, when fisheries were the main source of income and food provision in the area (Gómez and Riera 2007). Indeed, the local population continues to maintain strong ties with fishing activities (including recreational fishing). A similar interpretation has been provided in

other studies that have also found that elders valued significantly more the provisioning function than younger informants (e.g., Blayac et al. 2014), and that artisanal fishermen perceive the food provision service as essential both economicaly and socially (Queiroz et al. 2020; Hussain and Badola 2010).

Our survey also provided some previously unreported results. We found that tourists with a low education level ranked the biodiversity protection and preservation benefit lower than locals with a high education level. This could be due to the fact that formal education emphasizes the importance of species preservation for the well functioning of a habitat, which gains even more importance when related to the respondent's home area. We also found that locals do not value the beauty of their surroundings as much as visitors do, perhaps because they have always known the landscape and therefore it provides no novelty effect for them.

3.4.2. Impacts and threats

The impacts receiving the highest ranking in our survey were, in order, inland pollution discharging on the sea, climate change, and people's behaviour towards nature. The impact receiving a lowest ranking was invasive marine species. A similar ranking was found among threats, although climate change received the highest ranking as threat. When substracting the averages of impacts minus threats of each item, the values of climate change and invasive marine species increased most, whereas people's behaviour towards nature decreased. Tourists and locals ranked impacts and threats similarly, with the exception of mass tourism.

3.4.2.1. Marine pollution

Using a combination of a literature review and expert opinions, Coll et al. (2010) ranks pollution as the third most important impact on Mediterranean marine life. Marine pollution is generally associated with human concentration on the adjacent coast (Kocasoy 1995; Kocasoy 1989). Although this is not the case in Cap de Creus, which displays a lower population density than other areas of the region (Statistical Institute of Catalonia 2020), respondents' perceptions of the high impact of pollution on the local CMH find echoes in the literature analysing pollution levels on Cap de Creus' CMH. Previous studies conducted in the area have documented sea pollution derived from macro-litter, microplastics and fishing gears (Garcia-Garin et al. 2020; Sardà et al. 2012; de Haan et al. 2019; Purroy et al. 2014). For example, fishing gears are reported to affect 70% of the Cap de Creus MPA and were present in all the P. oceanica beds of the area (Purroy et al. 2014).

The importance of pollution has been also reported in surveys conducted elsewhere. For example, a survey in the UK reported that litter was the main element of an unhealthy marine environment (reaching 60% of reports; Jefferson et al. 2014). The authors of the previous study argued that litter is easier to spot by non-experts than other drivers of change, which is also the case in our study area (e.g., Garcia-Garin et al. 2020; Purroy et al. 2014), which may explain why pollution received the highest rank as a CMH impact.

3.4.2.2. Climate change

Climate change received the second highest rank as an impact and the highest as a threat, a finding which is generally in line with expert opinions. According to Coll et al. (2010), experts expected climate change effects on marine taxa would grew by 10.8% in a decade. Similarly, our respondents expected that the threat would growth by 66.2% in 30 years. The tourists are indeed willing to to ameliorate the CMH, being climate change one of the main concerns for the near future (Rodrigues et al. 2015). We suggest that the overall perception of the importance of climate change as an impact and threat to the CMH reflect both personal observations and mass media information.

Some people in the sample could have directly observed climate change impacts through their direct interactions with the local environment (e.g., scuba diving, fishing, snorkelling). For example, informants might have observed thermophilic species increasing their landings on the MPA (Lloret and Riera 2008; Gómez et al. 2006), or benthic species increasingly dying (Hereu et al. 2018) due to increasing warm waters (Calvo et al. 2011). Indeed, during data collection, some informants reported that summer seasons are now hotter and longer than they used to be and some respondents recalled an increase of weather extreme events, especially storms.

The effects of climate change, however, might be manifested slowly (decadal or multi-decadal scale) and gradualy and are expressed in multiple processes that can not always be detected through personal observations (Weber 2016; Weber 2010). Moreover, complex ongoing ecosystem transformations and community shifts may not always result in dramatic changes, so they are perceived as part of the natural adaptation to current social and economic needs (Bearzi 2009). This is why we argue that the high rank received by climate change as an important CMH impact is also a result of the fact that climate change and its impacts on the marine environment have been heavily reported by the media (Weber 2016; Weber 2010). Indeed, previous work shows that mass media communication shapes perceptions of the importance of climate change (e.g., Graziano 2019; Tsfati and Cohen 2013; Bos et al. 2011; Loos 2003).

One additional finding deserves attention. We found that climate change received a higher ranking among informants with low levels of education compared with higher-schooled respondents (SM 5). The finding is not knew, as previous work has shown that highly educated people have a lower climate risk perception, typically because they are less involved in primary works and are less dependent on natural resources and natural fluctuations (like droughts or floods) for their livelihoods (O'Connor et al 1999; Bearzi 2020; García-del-Amo et al. 2021). The finding, however, emphasizes the importance of being connected to nature to understand how it changes.

3.4.2.3. Invasive marine species

The literature also provides support to the importance given by our respondents' regarding the relatively low impact of invasive marine species. Indeed, research shows that the northwestern Mediterranean region is the area with the highest native marine species biodiversity and lowest incidence of marine alien species (Katsanevakis et al. 2014). The presence of marine invasive species at the MPA of Cap de Creus is very recent (Rodríguez 2019), as the last reports investigating the presence of invasive marine species did not find any (Hereu et al. 2018; Hereu et al. 2016).

Interestingly, although the presence of alien species in Cap de Creus is low and recent (Rodríguez 2019), 90% of people in our sample ranked them as having some impact. It is possible that this is because some respondents mistake rare native species with alien species. It is also possible that, as for climate change, people's perception of invasive marine species is shaped by media communications on the importance and effects of invasive marine species (e.g., Piazzi et al. 2016; Zenetos and Galanidi 2020). Finally, we argue that it is also possible that local people in the sample report on invasive alien species because they have noted their presence, even if this has not been reported in the literature, as it has been the case elsewhere (e.g., Coll et al. 2014; Reyes-García et al. 2019; Reyes-García et al. 2016; Aswani and Lauer 2014). Particularly, elders and locals working in direct contact with nature (e.g., fishermen) are in a suitable position to detect changes in marine fauna, which indeed dovetails with our empirical result that older locals and locals with low education levels rank invasive marine species as significantly more impactful than young and higher educated tourists (SM 5). Another issue that could be noticed by some locals is the use of non-native species as live bait, and the dumping of their packing composed of live seaweed by recreational shore anglers in the area, which might settle invasives in the marine habitat (Font and Lloret, 2011).

Finally, although invasive marine species does not rank high as a threat, its ranking did increase. Again, the finding is in line with the scientific literature suggesting that the accelerated Mediterranean Sea warming (i.e., Mediterranean tropicalization; Bianchi 2007) provides an advantange to the thermophilic invasive species over the Mediterranean biota, helping them to expand and establish themselves (Zenetos and Galanidi 2020). Our survey, however, did not allow us to test to what extent respondents were aware of this threat.

3.4.2.4. People's irresponsible behaviour/lack of respect towards nature

Overall, survey respondents considered that people's behaviour towards nature would become less impactful in the future. The result shows an optimistic view of how humans relate to nature, arguably because of the effect of sensibilization campaings (e.g., Jacquet and Pauly 2007), especially incident in natural parks (Petrosillo et al. 2007). Interestingly, older locals consider people's irresponsible behaviour as more threatening than other groups (SM 5). Older locals might feel more rooted to their traditions and the socio-cultural frame of their area, thus feeling more threatened by the increasing tourism phenomena in the area and the potential impact of tourist behaviour on the CMH.

3.4.2.5. Mass tourism

Irrespective of other socio-demographic characteristics, tourists consider mass tourism in Cap de Creus significally more impactful and threatening for the CMH than locals do. This finding is in line with findings from other studies showing that tourists perceive themselves as more impactful than locals (Priskin 2003; Petrosillo et al. 2007), and those locals perceive themselves as partly responsible for impacts to their surroundings (Liu et al. 1987). Other factors could have affected the answers of locals regarding the impact of tourism to the CMH: the economic benefit of the tourism industry for the local inhabitants (Perdue et al. 1990), and/or the maintenance and improvement of recreational and public facilities to maintain a strong attractiveness for tourism in the area (Liu et al. 1987).

3.5. Conclusion

Overall, our study shows that conservation of CMHs is highly valued both by local and tourist. People in our sample acknowledge that the Cap de Creus CMH provides important benefits, with the regulating services of the CMH being valued the most. Respondents also acknowledge that the CMH is impacted and threatened by different processes, mainly pollution and climate

change. To a greater extend than locals, tourists in the sample consider mass tourism an important impact. The only impact percieved to improve in the future is people's respect towards nature. From these results, we conclude that more efforts toward conservation of the area need to be developed.

Assesing the different perceptions of inhabitants and visitors of locations where the protection and use of nature are confronted, such as key natural areas where tourism is economically important, is crucial to design more adjusted and realistic conservation and management policies inline with user perception. Such reserach is also crucial for providing information that can improve the sustainability of the tourism model. Our study contributes towards this path.

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3.7. Supplementary material

Supplementary material 1. List of potential and final informants of the semi-structured interviews and the survey, including the motives of no answer.

Semi-structured interviews					**Motive of no answer**				
Interviewed (Potential interviewees)	**Roses**	**Cadaqués**	**Port de la Selva**	**Total**	**Lack of time**	**Unwill**	**< 10 years**	**N/A**	**Total**
Fresh seafood restaurants	5 (12)	5 (14)	4 (5)	14 (31)	8	4	3	2	17
Coastal hotels and hostels	10 (30)	8 (17)	3 (4)	21 (51)	6	7	6	11	30
Diving centres	1 (5)	3 (4)	1 (2)	5 (11)	2	0	0	4	6
Total	16 (47)	16 (35)	8 (11)	40 (93)	16	11	9	17	53

Survey	**Total**	**Female**	**Male**	**Motive of no answer**					
Respondants	624	363	261	**Lack of time**		**Unwill**		**Language barrier**	**Other**
Non respondants	603	323	280	178			359	36	30
				Due to work	Due to appointment	Unknown			
				75	41	62			

Semi-structured interviews: The establishments that closed and the new ones that opened after the elaboration of the potential list of interviewees (winter 2017) were not counted nor considered for interview. The restaurants that in the moment of the interview said that they did not serve fresh seafood were not counted in the list as well. The owners or managers of more than one type of establishment (e.g. owner of two hotels) where counted only as one in the list of potential interviewees; this happened six times. The people that own two different establishments (e.g. and hostel and a restaurant) where counted as two despite a single interview was realized; these happened two times. We excluded people with less than ten years working or diving in the area ("< 10 years" category). For the particular case of fresh seafood restaurants in Roses, in order to avoid a long and time-consuming list of restaurants, we decided to include in the list of potential interviewees only the fresh seafood restaurants that appeared in the "Suquet de Peix" (Fish Suquet) catalogue handed to us by the office of tourism in winter 2017. An actualized version of such catalogue can be consulted online (http://en.visit.roses.cat/plan/restaurants/).

Survey: Before answering the questionnaire, the interviewer introduced itself, the institution that was working from (ICTA-UAB) and its position (doctoral student, fieldwork assistant, researcher) and explained the project and the objective of this questionnaire to the interviewees. We also reminded them that they will remain anonymous and that we disposed of a text-version of the informed consent expressed beforehand orally. The researcher helped to clarify any doubt the respondent had in a neutral way, i.e., such help never implied conditioning the answer of the respondent. We had translated the survey to the four most common languages spoken by residents and tourists in the area: Spanish, Catalan, English, and French. We counted the people who did not understand any of those languages as non-respondents, inside the category of "Language barrier".

Supplementary material 2. English version of the survey questionnaire.

Universitat Autònoma de Barcelona

ICTA Institut de Ciència i Tecnologia Ambientals-UAB

EXCELENCIA MARÍA DE MAEZTU

Date (dd/mm/yy):_____/_____/_____ **Code#:**_____(leave this blank)

ENGLISH

Gender: Female Male Other:_____

Town/city of residence:_____ **Country:** _____

Where are you hosted? (answer only if you do not live here)**:** Port de la Selva Roses Cadaqués

How often do you visit this area? (select one box only)

I live here all year round → Since what decade?:_____ or Since birth

Once every year → What was the decade of your first visit? _____
Frequently → What was the decade of your first visit? _____
Infrequently → What was the decade of your first visit? _____
This is my first time

From what you know, indicate the following impacts/threats in order of importance according to its effect to the coastal marine life in this area. Consider current impacts, and future threats (in 30 years, by 2050). Number them from 1 to 8, where (1) is the one with most impact and (8) the one with least impact. If you think that a particular impact/threat does not or will not affect the coastal marine life in this area mark it with a (X).

Impacts (nowadays)		Threats (in 30 years)
Climate change	( )	( )
Overfishing	( )	( )
Invasive marine species	( )	( )
Habitat degradation due to boat transit and anchoring	( )	( )
Inland pollution that ends up in the sea	( )	( )
Coastal construction and modification	( )	( )
Mass tourism	( )	( )
People's irresponsible behaviour/lack of respect towards nature	( )	( )

Coastal marine life provides different benefits to society. Which benefits do you value the most? Prioritize them from 1 to 6 where (1) = most valued, and (6) = least valued. If you think that a particular value is not a real benefit mark it with a (X).

( ) Food provision: fishing & aquaculture

( ) Coastal protection: the coast line protects against inundation and coastal erosion from waves and storms

( ) Climate regulation: sequestration and storage of carbon dioxide (CO_2) and other greenhouse gases

( ) Protect and preserve biodiversity: seagrass beds, coral reefs and other habitats that provide an environment that facilitates the health and reproduction of other species that live in it.

( ) Aesthetic value: Pleasure or positive feelings and/or emotions caused from enjoying the coastal and marine landscapes, habitats or species.

( ) Recreation and tourism: marine and/or beach sports and activities like sunbathing, swimming, scuba diving, snorkelling, sailing, recreational fishing…

To what extent do you think you depend on the marine environment in your daily life, either for your work and/or income or for your leisure activities? (select one box only)

For example, you might be strongly dependent if your work is highly based on the sea, like fishermen, whale watching, lifeguard… or your hobby, like surfing, swimming, diving… or simply the need of going to visit the coastline.

Strongly. I need it frequently
I need it once in a while, I cannot spend too much time without it
I enjoy it, but I do not depend on it
Indifferent. It has nothing to do with me
I avoid it

Age group: (select one box only)

- ☐ 18 – 29
- ☐ 30 – 39
- ☐ 40 – 49
- ☐ 50 – 59
- ☐ 60 – 69
- ☐ 70 – 79
- ☐ 80 – 89
- ☐ ≥ 90

What is the highest level of education that you have completed?: (select one box only)

No schooling completed
Primary school
Middle school
High school
Professional degree/technical school training
University
Master, post-graduate
Doctorate/PhD

What is your profession? _____

Choose one of the following that best indicate your average yearly income. If you are retired think in your income when you were working:
(select only one box and the one in your currency)

Euros (€)	**Dollars ($)**	**Pound sterling (£)**
☐ No income/unemployed	☐ No income/unemployed	☐ No income/unemployed
☐ < 14,000 €	☐ < 15,000 $	☐ < 12,000 £
☐ 14,000 – 35,000 €	☐ 15,000 – 40,000 $	☐ 12,000 – 30,000 £
☐ 35,000 – 56,000 €	☐ 40,000 – 60,000 $	☐ 30,000 – 50,000 £
☐ > 56,000 €	☐ > 60,000 $	☐ > 50,000 £

Supplementary material 3. Survey responses. Country: Abbreviated by ISO alpha-3 coding. Town/city of residence and profession not shown to respect anonymity. See the coding of sociodemographic variables in Table 1.

				Sociodemographic parameters							Benefits						Impacts								Threats							
Code	Place of interview	Gender	Country	Residence Local / Tourist	respect sea proximity	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Food provision	Coastal protection	Climate regulation	Protect preserve biodiversity	Aesthetic value	Recreation & tourism	Climate change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour	Climate Change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour
SC15	Cadaqués	Male	AUS	Tourist	Coastal	First timer	Need	18-29	Master	14-35	3	2	1	5	4	6	1	5	7	3	2	4	6	8	1	2	7	6	4	5	3	8
SC14	Cadaqués	Female	FRA	Tourist	Inland		Joy	70-79	No Sch.	14-35	5	6	4	3	1	2	6	5	2	4	1	3	8	7	5	4	2	3	1	6	8	7
SC13	Cadaqués	Female	GBR	Tourist	Near coast	First timer	Need	18-29	Master	14-35	6	3	1	2	5	4	1	3	2	6	4	8	7	5	1	2	3	5	4	8	7	6
SC12	Cadaqués	Female	FRA	Tourist	Near coast	First timer	Joy	60-69	Middle Sch.	14-35	3	4	1	2	5	6	1	7	6	4	2	8	5	3	2	7	8	6	1	3	4	5
SC11	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Joy	50-59	High Sch.	14-35	1	4	3	2	5	6	6	8	7	3	1	2	4	5								
SC10	Cadaqués	Female	IRL	Tourist	Coastal	First timer	Need	30-39	Master	14-35	4	3	2	1	5	6	1	2	3	7	4	8	6	5	1	2	3	5	4	8	7	6
SC09	Cadaqués	Male	FRA	Tourist	Inland	First timer	Strong	18-29	University	No income	3	4	1	2	5	6	1	2	5	6	3	7	8	4	1	2	5	6	3	7	8	4
SC07	Cadaqués	Male	NLD	Tourist	Coastal	Frequent	Joy	18-29	High Sch.	14-35	4	3	2	1	5	6	5	4	6	8	1	7	2	3	4	2	7	8	3	6	1	5
SC06	Cadaqués	Male	NLD	Tourist	Coastal	Frequent	Joy	18-29	Master	35-56	4	2	3	1	5	6	3	6	8	7	4	1	2	5	2	4	8	7	6	3	1	5
SC02	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Joy	80-89	No Sch.	14-35	3	2	1	4	5	6	1	2	3	5	6	8	4	7	1	2	3	5	6	8	4	7
SC03	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	60-69	Middle Sch.	14-35	3	6	5	4	1	2	1	2	5	3	4	8	6	7	1	6	3	2	4	7	2	8
SC01	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	70-79	Primary Sch.	14-35	3	2	1	4	5	6	1	2	3	5	6	8	4	7	1	2	5	3	7	8	4	6
SC04	Cadaqués	Female	ESP	Tourist	Near coast		Strong	40-49	Prof./Tech.	14-35	3	4	5	6	2	1	1	2	8	6	3	5	7	4	4	5	6	7	3	2	8	1
AR12	Roses	Male	FRA	Tourist	Inland	First timer	Joy	40-49	University	14-35	5	2	4	1	3	6																
AR11	Roses	Female	FRA	Tourist	Inland		Joy	50-59	Prof./Tech.	14-35	1	2	3	4	5	6	1	6	5	7	2	8	4	3								
AR10	Roses	Male	ROU	Tourist	Inland	Frequent	Joy	18-29	High Sch.	14-35	3	1	6	2	4	5	1	4	5	8	2	7	3	6	1	4	5	8	2	7	3	6
AR08	Roses	Male	ESP	Local	Coastal	Infrequent					6	5	3	2	1	4	2	8	3	5	6	4	1	7								
AR07	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	18-29	University	<14	3	1	4	2	5	6	6	3	7	4	1	8	2	5	4	1	6	7	5	2	3	8
AR06	Roses	Male	ESP	Local	Coastal	Born local	Joy	40-49	High Sch.	14-35	1	4	3	6	2	5	7	4	2	5	1	3	6	8								
AR04	Roses	Female	ESP	Local	Coastal	Born local	Joy	30-39	Prof./Tech.	14-35	6	5	3	4	1	2	1	2	6	7	3	4	8	5	1	2	6	7	3	4	8	5
AR02	Roses	Male	FRA	Tourist	Inland	Infrequent	Indifferent	18-29	University	14-35	1	3	4	5	6	2	1	2	5	4	3	7	8	6	1	2	5	4	3	7	8	6
AR01	Roses	Male	BEL	Tourist	Inland	Frequent	Joy	50-59	University		1	4	3	2	5	6	1	2	5	6	3	8	7	4	1	3	6	5	2	8	7	4
WP07	Port Selva	Male	ESP	Local	Coastal	Born local	Joy	70-79	High Sch.		1	3	4	2	5	6	3	1						2	3	1						2
WP08	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	70-79	Middle Sch.				4	3	1	2	1	2	3	5	4				1	2	3	4	5			
WP09	Port Selva	Female	LVA	Tourist	Coastal	First timer	Joy	40-49	Master	14-35	2	3	4	1	5	6	5	6	7	3	1	8	4	2	5	6	7	3	1	8	4	2
WP10	Port Selva	Female	ESP	Tourist	Coastal	First timer	Joy	18-29	Master	14-35	1	4	3	2	5	6	3	1	8	2	5	4	7	6	1	6	5	2	3	4	7	8
WP11	Port Selva	Male	LUX	Tourist	Inland	Frequent	Joy	50-59	University	>56	4	3	5	6	2	1	8	7	6	4	2	1	3	5	8	7	6	4	2	1	3	5
WP13	Port Selva	Female	FRA	Tourist	Inland	Frequent	Joy	40-49	PhD	>56	3				1	2	1	2	7		6	4	3	5	1	2	7		6	4	3	5
WP14	Port Selva	Male	FRA	Tourist	Inland	Frequent	Joy	40-49	Master	>56	3	2	4	1	5	6	1	5	7	8	2	3	6	4	1	5	7	8	2	3	6	4
WP15	Port Selva	Male	FRA	Tourist		Frequent	Need	50-59	Master	35-56	6	5	4	1	3	2	4	8	7	6	5	3	2	1	1	8	7	6	5	4	2	3
WP16	Port Selva	Female	FRA	Tourist		Frequent	Joy	30-39	Master	35-56	1	3	6	2	4	5	5	6	8	7	3	4	2	1	2	6	8	7	5	3	4	1
WP17	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	90	Master		3	4	2	1	5	6	2	4	8	7	1	6	3	5	1	4	3	8	2	7	5	6
WP18	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	60-69	Primary Sch.		1	2	3	4	5		1			2	3				1			2	3			
WP19	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	18-29	Middle Sch.	<14	5	2	3	1	4	6	2	3	8	6	1	5	7	4	5	6	8	7	3	1	2	4
AP13	Port Selva	Male	ESP	Tourist	Coastal	Frequent		60-69	Prof./Tech.	14-35	4	3	2	1	5	6																
AP14	Port Selva	Male	AND	Tourist	Inland		Need	60-69	University	>56	3	6	2	1	5	4	6	4	7	8	2	5	3	1	3	2	8	7	6	5	4	1
AP16	Port Selva	Female	CHE	Tourist	Inland	Frequent	Joy	50-59	University	>56	5	6	3	4	2	1	3	4	1	2	7	6		5	6	5	3	2	4	1		7
AP17	Port Selva	Female	FRA	Tourist	Inland	Frequent	Joy	50-59	University	14-35	3	1	4	2	5		1	5	8	7	4	6	2	3	1	5	8	7	4	6	2	3
AP19	Port Selva	Male	ESP	Tourist	Coastal	First timer	Joy	30-39	Prof./Tech.	14-35	4	2	3	1	5	6	1	6	5	2	3	7	4	8	1	6	5	2	3	7	4	8
AP20	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	60-69	Middle Sch.	14-35	2	6	5	4	3	1	1	7	6	4	2	3	5	8	1	7	6	4	2	3	5	8
AP21	Port Selva	Female	ESP	Tourist	Coastal	First timer	Joy	18-29	High Sch.		6	4	5	3	1	2	7	4	8	5	6	3	2	1	7	4	8	5	6	3	2	1
AP22	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	30-39	Prof./Tech.		1	3	2	4	6	5	1	5	8	7	6	4	3	2	1	5	8	7	6	4	3	2
AP23	Port Selva	Female	ESP	Local	Coastal	Infrequent	Joy	18-29	Prof./Tech.	<14	4	3	2	1	6	5	2	6	7	4	5	3	8	1	2	7	5	6	3	4	8	1
AP24	Port Selva	Female	FRA	Tourist	Inland	Frequent	Joy	18-29	Middle Sch.	No income	3	5	4	6	2	1																
AP25	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	18-29	High Sch.	<14	3	2	4	6	5	2	5	8	1	6	2	4	7	3	5	7	4	8	3	6	7	2
AP26	Port Selva	Male	ESP	Local	Coastal	Born local	Need	50-59	Prof./Tech.	14-35	3	1	6	5	4	3																
SP67	Port Selva	Male	BEL	Tourist	Inland	Frequent	Need	60-69	High Sch.	14-35	4	5	3	1	2	6	5	1	2	4	3	8	6	7	5	1	2	4	3	8	6	7
SP51	Port Selva	Male	ESP	Local	Coastal	Born local	Joy	80-89	Primary Sch.	14-35	1	3	2	4	5	6	1	2	3	4	5	7	8	6	1	2	3	4	5	7	8	6
SP50	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	18-29	Prof./Tech.	<14	4	3	2	1		5	1	4	8	7	2	5	6	3	1	6	8	7	2	5	3	4
SP52	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Joy	18-29	Master	<14							1	6	8	7	3	5	2	4	1	6	8	7	3	5	2	4
SP53	Port Selva	Female	ESP	Tourist	Coastal	First timer	Need	18-29	Master	<14	3	4	2	1	5	6	7	8	6	4	3	2	1	5	1	2	7	5	6	3	4	8
SP55	Port Selva	Male	ESP	Local	Coastal	Born local	Need	80-89	Middle Sch.	14-35	2	3	4	5	6	1	5	4	3	7	1	8	6	2	1		5		2	6	4	3
SP57	Port Selva	Female	FRA	Tourist	Coastal	Infrequent	Joy	60-69	Prof./Tech.		4	3	1	2	5	6	4	1	7	8	2	5	6	3	1	4	7	8	2	5	6	3
SP63	Port Selva	Female	ESP	Tourist	Near coast	First timer	Joy	18-29	High Sch.	<14	2	4	1	3	5	6	1	2	8	4	5	7	3	6	1	2	8	4	6	7	3	5
SP62	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Joy	18-29	High Sch.	No income	5	3	2	1	4	6	1	4	8	3	5	7	2	6	1	5	8	7	3	6	2	4
SP61	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	18-29	High Sch.	No income	5	4	3	1	2	6	1	7	8	6	4	2	3	5	5	6	2	3	7	1	4	8
SP60	Port Selva	Male	ESP	Tourist	Near coast	First timer	Need	18-29	High Sch.	No income		3	1	2	4		1	5	2	7	3	8	6	4	1	2	3	8	6	7	5	4
SP59	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Joy	18-29	High Sch.	No income		3	1	2	4	5	1	8	6	7	5	4	2	3	1	2	8	6	4	5	3	7
SP58	Port Selva	Male	ESP	Tourist	Near coast	Infrequent	Strong	18-29	High Sch.	No income	6	3	1	2	4	5	1	2	8	4	3	6	5	7	1	6	8	3	2	4	7	5
SP57	Port Selva	Male	ESP	Tourist	Coastal	First timer	Joy	30-39	Middle Sch.	<14	5	6	4	3	1	2	8	7	6	5	3	4	1	2	1			5	2		4	3
SP66	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Joy	18-29	University	No income	3	2	5	1	4	6	4	6	7	5	2	1	3	8	1	7	6	5	4	2	3	8
SP65	Port Selva	Male	ESP	Tourist	Coastal	Infrequent	Need	18-29	High Sch.	No income	2	4	3	1	5	6	4	6	8	5	2	1	7	3	1	7	6	5	4	2	3	8
SP66b	Port Selva	Male	ESP	Local	Coastal	Born local	Joy	18-29	High Sch.	<14	1	3	4	2	5	6	6	1	2	5	7	8	3	4	8	2	5	6	7	3	1	4
MR23	Roses	Female	ESP	Local	Coastal	Born local	Strong	50-59	High Sch.	<14	3	4	2	1	6	5	2	5		7	3	4	6	1	2	5		7	3	4	6	1
MR28	Roses	Female	ESP	Local	Coastal	Born local	Need	18-29	University	<14		3	1	2	5	4	1	3	5	7	2	6	4	8	1	3	8	7	4	2	5	6
MR29	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	High Sch.	No income	5	3	6	1	2	4	3	1	7	2	8	4	5	6	1	6	3	2	4	7	8	5
MR32	Roses	Female	ESP	Local	Coastal	Born local	Need	18-29	Middle Sch.	<14	6	3	2	1	4	5	1	4		7	3	6	2	5	1	6	8	7	4	3	2	5
MR33	Roses	Male	ESP	Local	Coastal	Born local	Need	30-39	University	14-35	2	3	1	4	5	6	1	2	3	4	5	6	8	7	1	2	3	4	5	6	8	7
SR27	Roses	Female	ESP	Local	Coastal	Born local	Strong	40-49	Prof./Tech.	14-35	3	1	2	4	5	6	4	3	5	2	1	6	7	8	1	4	5	3	2	6	7	8
SR28	Roses	Female	ESP	Local	Coastal	Born local	Need	40-49	Middle Sch.	14-35	3	2	4	1	5	6	6	7	8	5	1	4	3	2	1	8	7	6	2	4	3	5
SR27	Roses	Male	FRA	Tourist	Inland	Infrequent	Joy	18-29			2	5	3	4	1	6																
SR30	Roses	Male	ESP	Tourist	Near coast	Frequent	Joy	40-49	University	35-56	1	6	4	5	2	3	4	2	3	8	5	7	1	6	4	2	3	8	5	7	1	6
SR31	Roses	Male	FRA	Tourist	Inland	Frequent	Joy	60-69	Middle Sch.	<14	2	5	1	6	3	4	1	3	2	6	8	5	7	4	1	3	2	6	8	5	7	4
SR32	Roses	Female	CHE	Tourist	Inland	Infrequent	Joy	30-39	Master	>56	4	3	2	1	5	6	5	7	6	8	1	2	4	3	1	6	7	8	2	3	5	4
SR34	Roses	Male	CHE	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	>56	4	3	2	1	5	6	7	5	8	6	3	4	1	2	8	7	6	5	1	3	4	2
SR35	Roses	Male	ESH	Tourist	Near coast	First timer	Joy	30-39	Primary Sch.	<14	2	4	1	3	6	5	1	2	6	3	5	4	7	8	4	5	8	6	7	1	2	3
SR36	Roses	Male	FRA	Tourist	Inland	Frequent	Indifferent	60-69	Middle Sch.	14-35	6	5	4	2	1	3	1	2	6	4	3	5	7	8	1			2	5	8	3	4
SR37	Roses	Female	ESP	Tourist	Inland	Infrequent	Joy	60-69	Primary Sch.	14-35	4	2	1	6	3	5	1	2	8	3	5	6	4	7	5	6	7	2	1	8	3	4
SR38	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	University	<14	4	3	1	2	6	5	6	3	8	5	1	4	7	2	5	4	1	3	7	2	6	8
SR39	Roses	Female	ESP	Local	Coastal	Not born loca	Need	18-29	Middle Sch.		3	2	1	4	5	6																
SR40	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	University	<14	4	2	1	3	6	5	1	6	7	8	2	5	4	3	1	4	8	7	5	6	2	3
SR41	Roses	Female	ESP	Local	Coastal	Born local	Strong	50-59	Prof./Tech.	<14	5	6	1	3	2	4	1	5	6	8	2	3	7	4	1	7	2	4	3	8	6	5
SR42	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	University	<14	3	4	1	2	6	5	1	3	8	7	4	5	6	2	1	3	8	7	4	5	6	2
SR43	Roses	Female	CAN	Tourist	Inland	Frequent	Need	50-59	Prof./Tech.	14-35	1	2	4	3	5	6	1	2	7	4	3	5	6	8	1	2	7	4	5	3	6	8
SR44	Roses	Male	CAN	Tourist	Inland	Frequent	Joy	50-59	Middle Sch.	35-56	1	2	4	3	5	6	1	2	6	8	3	7	5	4	1	2	6	8	3	7	5	4
SR45	Roses	Male	ESP	Tourist	Inland	Frequent	Joy	30-39	University	14-35	3	1	2	5	6	3	1	6	2	5	8	4	3	7	3	7	6	4	1	5	2	3
SR46	Roses	Female	ESP	Tourist	Inland	Infrequent	Joy	30-39	University	35-56	4	3	2	1	6	5	1	3	4	8	5	6	7	2	1	2	4	5	3	6	7	8
SR47	Roses	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	Primary Sch.	<14	2	4	5	3	1	6	6	7	4	6	2	3	1	5	8	7	2	3	1	4	6	5
SR48	Roses	Male	ESP	Local	Coastal	Born local	Joy	18-29	High Sch.	<14	4	3	2	1	6	5	5	6	8	7	3	4	1	2	2	5	8	7	6	4	3	1
SR49	Roses	Female	ESP	Local	Coastal	Infrequent	Joy	18-29	Prof./Tech.	14-35	3	5	4	2	1	6	1	2	5	4	6	3	8	7	1	2	5	4	6	3	8	7
AC182	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	30-39	Master	14-35	1	4	2	3	6	5	1	5	7	4	3	6	8	2	1	5	7	4	3	6	8	2
AC183	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	18-29	University	<14	6	5	3	1	4	2	2	4	7	6	3	5	8	1	2	4	7	6	3	5	8	1
AC184	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	40-49	Master	14-35	5	4	2	1	3	6	2	1	8	3	6	7	4	5	1	5	6	4	3	7	2	8
ZC09	Cadaqués	Male	ESP	Local	Coastal	Not born loca	Joy	40-49	University	<14	4	2	3	1	5	6	7	5	4	6	8	1	2	3	1	6	5	8	4	7	3	2
ZC10	Cadaqués	Male	ESP	Tourist	Coastal	First timer	Need	18-29	High Sch.	<14	2	4	1	3	6	5	2	1	7	3	5	8	4	6	1	2	8	4	5	3	6	7
ZC11	Cadaqués	Female	ESP	Tourist	Inland	First timer	Joy	50-59	High Sch.	35-56	4	3	2	1	5	6	3			4		1	2	5	1	2	7	6	5	3	4	8
ZC12	Cadaqués	Male	ESP	Tourist	Inland	First timer		50-59	University	35-56	4	3	2	1	5	6	5	4	6	7	3	1	2	8	4	5	6	7	3	1	2	8
ZC13	Cadaqués	Female	ESP	Tourist	Coastal	Infrequent	Joy	18-29	Prof./Tech.	<14	4	3	2	1	6	5	1		5	4	7	3	2	1	3	6	7	8	5	4	2	1
ZC14	Cadaqués	Male	ESP	Tourist	Near coast	First timer	Indifferent	18-29	Prof./Tech.	14-35	4	3	1	2	5	6	8	5	2	3	7	1	4	6	8	2	4	7	6	3	1	5
ZC15	Cadaqués	Male	POL	Tourist	Inland	First timer	Joy	30-39	Master	14-35	6	4	1	2	3	5	7	6	8	1	4	2	5	3	2	6	8	1	5	3	7	4
ZC16	Cadaqués	Female	POL	Tourist	Inland	First timer	Joy	30-39	Master	<14	5	3	1	2	4	6	7	6	8	1	2	5	4	3	1	5	7	6	2	8	4	3
ZC17	Cadaqués	Female	ESP	Local	Coastal	Not born loca	Strong	70-79	High Sch.	<14	6	2	5	3	1	4	5				3	2	4	1						2		1
ZC19	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Strong	40-49	Master	<14	4	3	1	2	5		6	7	8	4	5	1	3	2	3	8	4	1	2	6	7	5
ZC22	Cadaqués	Male	ESP	Local	Coastal	Not born loca	Strong	50-59	Middle Sch.		2	1	3	4	5		1	2	3	4	5	6	7	8	1	8	3	4	6	7	2	5
MC187	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	30-39	University	14-35							5	3	8	4	1	2	7	6	1	4	8	5	2	3	6	7
MC180	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	18-29	University	<14	2	3	1	4	5	6																
MC182	Cadaqués	Female	ESP	Tourist	Inland	Frequent	Joy	18-29	Middle Sch.	No income	4	5	1	2	3	6	1	7	6	8	2	3	4	5	1	5	6	7	2	3	8	4
MC185	Cadaqués	Female	ESP	Local	Coastal	Born local	Joy	18-29	Middle Sch.	No income	4	3	2	1	5	6	2	7	6	5	8	1	3	4	2	7	6	5	8	1	3	4
MC186	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	40-49	University	14-35	2	1	3	4	6	5	5	2	7	6	1	4	3	8	1	6	2	8	7	3	5	4
MC188	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	18-29	University	<14	5	3	2	1	4	6	4	2	3	6	5	8	7	1	1	3	2	7	6	8	5	4
MC189	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	50-59	Master	35-56	4	3	2	1	6	5	5	4	6	1	7	8	2	3	1	5	2	4	7	8	3	6
MC192	Cadaqués	Male	ESP	Tourist	Near coast	Infrequent	Strong	18-29	Prof./Tech.	<14	2	4	6	1	3	5	2	7	6	8	3	4	5	1	1	6	8	7	5	4	3	2
MC193	Cadaqués	Female	ESP	Tourist	Near coast	First timer	Joy	18-29	University	No income	1	4	3	2	5	6	7	5	8	3	1	2	6	4	7	5	8	3	1	2	6	4
MC190	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Need	30-39	University	14-35	5	3	2	1	4	6	4	7	6	8	5	2	3	1	2	7	6	8	5	4	3	1
MC191	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Strong	40-49	Prof./Tech.	14-35	4	3	1	2	5	6	6	5	8	7	2	3	4	1	2	5	6	8	3	4	7	1
MC194	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	50-59	University	35-56	4	3	1	2	5	6	8	7	6	5	4	1	2	3	2	4	1	3	5	6	7	8
ZP01	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	60-69	Master	35-56	5	2	6	1	3	4						1	2	3						1	2	3
ZP02	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	18-29	Primary Sch.	14-35	5	3	6	1	4	2								1								1
UR21	Roses	Male	ESP	Local	Coastal	Not born loca	Joy	30-39	High Sch.	14-35	1	5	2	3	6	4	2	7	8	6	3	4	5	1	2	7	8	6	3	4	5	1
UR20	Roses	Male	FRA	Tourist	Inland	Frequent	Strong	60-69	Prof./Tech.	14-35	2	1	4	3	5	6	5	6		2	1	4	7	3								
UR18	Roses	Female	FRA	Tourist	Inland	Infrequent	Need	60-69	Middle Sch.	35-56	3	6	5	4	1	2	3		4		5		2	1								
MC231	Cadaqués	Female	ESP	Local	Coastal	Infrequent	Strong	30-39	University	<14	4	5	3	1	6	2	4	8	5	3	7	2	1	6	1	3	7	2	4	5	6	8
MC232	Cadaqués	Female	ESP	Local	Coastal	Not born loca	Strong	50-59	University	<14	5	3	2	1	4	6	5	6	7	2	3	1	4	8	7	6	8	3	2	1	4	5
MC228	Cadaqués	Female	FRA	Tourist	Inland	Infrequent	Need	18-29	High Sch.	No income	1	2	3	4	5	6	3	7	5	8	1	2	4	6	2	4	3	6	1	2	5	7
MC226	Cadaqués	Female	FRA	Tourist	Inland	First timer	Indifferent	18-29	High Sch.	No income	4	3	2	1	5	6	5	7	4	1	6	3	2	8	1	2	7	4	3	5	6	8
MC227	Cadaqués	Male	FRA	Tourist	Inland	First timer	Joy	18-29	High Sch.	<14	1	6	5	4	2	3	3	6	5	7	4	8	2	1	1	4	3	7	5	8	6	2
MC230	Cadaqués	Female	ESP	Local	Coastal	Not born loca	Strong	40-49	Master	<14	6	5	2	1	3	4	6	7	8	5	2	3	4	1	1			4	6	3	7	5
AP201	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	40-49	Master	14-35	1	3	4	2	5	6	1	2	3	5	6	8	7	4	1	2	3	5	4	8	7	6
AP202	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	50-59	Prof./Tech.	14-35	1	3	4	2	5	6	2	1	8	4	3	7	5	6	1	2	8	4	3	7	5	6
AP203	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	30-39	Master		4	1	3	2	6	5	4	8	5	3	6	7	2	1	4	8	5	3	6	7	2	1
AP204	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	30-39	Master	35-56	3	5	6	4	1	2	2			1	4	3	5	6								
AP205	Port Selva	Female	FRA	Tourist	Inland	First timer	Strong	60-69	Primary Sch.		6	2	1	3	5	4																
AP206	Port Selva	Female	ESP	Tourist	Inland	Frequent	Joy	50-59	Middle Sch.		2		1		4	3					2			1					2			1
AP208	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Need	18-29	University	No income	5	3	2	1	4	6	6	5	7	4	3		1	2	6	5	7	4	3		1	2
AP209	Port Selva	Female	FRA	Tourist	Inland	Frequent	Need	40-49	Master	35-56	5	2	3	1	4	6																
AP2010	Port Selva	Female	FRA	Tourist	Inland		Joy	60-69	Prof./Tech.	<14	3	4	1	2	5	6	4	1	8	7	3	6	5	2	4	1	8	7	3	6	5	2
AP211	Port Selva	Female	ESP	Tourist	Coastal	First timer	Need	40-49	Prof./Tech.	14-35	6	3	2	1	4	5	6	2	1	7	8	4	5	3	8	1	2	4	7	5	6	3
AP212	Port Selva	Female	SLV	Tourist	Near coast	First timer	Joy	30-39	Prof./Tech.	<14	4	3	1	2	5	6	1	6	7	5	2	3		4	1	6	7	5	2	3		4
AR187	Roses	Female	PRT	Tourist		First timer	Need	30-39	Prof./Tech.	<14	4	3	2	1	6	5	1	7	8	4	2	5	6	3	1	7	8	4	2	5	6	3
AR188	Roses	Female	NLD	Tourist	Near coast	First timer	Strong	40-49	Prof./Tech.		2	1	3	4	5	6	2	3	8	6	5	7	4	1	2	5	8	6	4	7	3	1
AR190	Roses	Male	ESP	Tourist	Near coast	Infrequent	Joy	50-59	High Sch.	35-56	1	3	4	2	5	6	3	4	2	1	5	6	7	8	3	4	1	7	8	6	5	2
AR191	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	80-89	Primary Sch.		4	6	5	3	2	1	3	2	5	7	1	6	8	4								
AR194	Roses	Female	ESP	Local	Coastal	Infrequent	Strong	30-39	University	<14	4	3	2	1	5	6	2	7	6	4	3	8	5	1	4	3	8	7	6	5	2	1
AR195	Roses	Female	FRA	Tourist	Inland	First timer	Joy	30-39	University	14-35	1	3	5	2	6	4	3	4	7	5	2	6	8	1	3	4	7	5	2	6	8	1
AR196	Roses	Female	ESP	Tourist	Inland	First timer	Joy	50-59	PhD		3	2	1	4	5	6	6	8	5	7	2	1	3	4	6	8	5	7	2	1	3	4
AR197	Roses	Male	FRA	Tourist	Near coast	First timer	Joy	60-69	Prof./Tech.	35-56	2	4	5	6	3	1	1	3	4	2	6	7	8	5	4	2	1	6	5	8	7	3
AR198	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	40-49	University	35-56	4	3	2	1	6	5	1	5	6	7	4	8	3	2	1	5	6	7	4	8	3	2
AR199	Roses	Female	FRA	Tourist	Inland	Infrequent	Indifferent	18-29	High Sch.	<14	6	4	3	5	2	1	7	5	8	6	1	2	3	4	5	7	8	6	1	3	2	4
AR200	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	14-35	6	3	2	1	4	5	7	6	8	3	1	2	4	5	1	8	7	5	6	4	2	3
MR195	Roses	Female	ESP	Local	Coastal	Born local	Strong	30-39	High Sch.	<14	2	3	1	4	5	6	3	4	7	5	1	6	8	2	2	3	8	4	1	6	7	5
MR196	Roses	Female	ESP	Local	Coastal	Not born loca	Strong	50-59	High Sch.	14-35	5	6	3	2	1	4	3	8	4	5	1	7	6	2	1	7	2	6	3	8	5	4
MR197	Roses	Female	ESP	Tourist	Coastal	Frequent	Strong	30-39	Master	35-56	6	1	2	3	5	4	6	5	7	3	1	4	8	2	3	6	7	5	1	4	8	2
MR198	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	Master	14-35	3	4	6	5	1	2	4	7	8	6	2	3	5	1	3	8	5	7	6	2	4	1
MR200	Roses	Female	ESP	Local	Coastal	Born local	Strong	50-59	High Sch.	14-35	4	2	1	3	6	5	4	5	8	1	3	6	2	7	1	6	4	3	2	7	8	5
MR201	Roses	Male	FRA	Tourist	Inland	Frequent	Joy	50-59	Master	35-56	3	4	2	1	5	6	3	1	4	6	2	8	7	5	1	2	3	7	4	8	6	5
MR202	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	Middle Sch.	No income	4	2	1	3	6	5	2	1	3	8	6	5	7	4	3	1	2	7	4	5	6	8
MR206	Roses	Female	FRA	Tourist	Near coast	Infrequent	Joy	40-49	High Sch.	14-35	3	5	4	1	2	6	3	5	7	8	1	4	6	2	3	1	7	8	2	6	5	4
AC173	Cadaqués	Male	ESP	Tourist	Coastal	First timer	Strong	18-29	Prof./Tech.	14-35	6	3	4	1	2	5	6	8	7	5	3	4	2	1	6	8	7	5	3	1	2	4
AC176	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	40-49	Master	>56	1	4	3	2	5	6	8	1	7	5	4	3	6	2	1	6	2	4	3	6	7	8
AC177	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	40-49	High Sch.	14-35	1	5	4	2	3	6	5	4	8	7	1	2	6	3	1	6	3	7	2	4	5	8
AC178	Cadaqués	Female	FRA	Tourist	Near coast	First timer	Joy	18-29	High Sch.	<14	1	6	2	3	5	4	1	7	6	5	2	8	3	4	1	8	7	6	5	4	3	2
AC179	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Need	18-29	Master	<14	4	6	5	2	1	3	6	8	7	3	2	4	1	5								
AC180	Cadaqués	Male	ESP	Tourist	Coastal	Infrequent	Strong	40-49	Middle Sch.		6	5	4	3	2	1	1	7	6	8	2	5	4	3								
AC181	Cadaqués	Female	ESP	Local	Coastal	Born local	Joy	50-59	Prof./Tech.	14-35	1	4	2	3	6	5	4	3	5	1	8	7	6	2	1	3	7	6	4	5	8	2
MP243	Port Selva	Male	FRA	Tourist	Inland		Joy	40-49	University	14-35	3	4	2	1	5	6	3	6	8	5	1	4	7	2	1	2	8	3	6	5	7	4
MP245	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	30-39	Middle Sch.	14-35	5	3	2	1	6	4	4	2	6	5	1	7	8	3	2	1	8	7	3	4	6	5
MP246	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	50-59	Prof./Tech.	14-35	2	4	3	1	5	6	2	1	8	4	5	6	7	3	1	2	8	4	5	6	7	3
MP247	Port Selva	Male	FRA	Tourist	Inland	Infrequent	Need	50-59	Master	35-56	3	2	4	1	5	6	5	4	8	6	2	3	7	1	2	3	8	7	1	6	5	4
MP248	Port Selva	Male	FRA	Tourist	Inland	Frequent	Joy	40-49	Master	>56	2	3	4	5	1		3	5	8	7	6	2	1	4	1	2	5	7	6	8	3	4
MP249	Port Selva	Male	ESP	Tourist	Coastal	Infrequent	Joy	18-29	High Sch.	<14	4	3	2	1	6	5	1	5	3	7	2	4	8	6	3	5	4	2	6	8	1	7
MP150	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	60-69	Master	35-56	2	3	1	4	5	6	4	7	8	6	5	3	2	1								
MP252	Port Selva	Female	CHE	Tourist	Inland	Frequent	Need	18-29	High Sch.	No income	3	5	2	1	4	6	8	6	4	2	5	7	3	1	2	6	1	8	5	7	4	3
MP253	Port Selva	Female	CHE	Tourist	Inland	Infrequent	Joy	18-29	Middle Sch.	<14	5	4	3	1	2	6	5	2	6	4	3	7	8	1	1	2	8	6	3	5	4	7
MP254	Port Selva	Female	CHE	Tourist	Inland	Infrequent	Joy	18-29	Prof./Tech.	<14	4	2	3	1	5		4	4	5	8	2	3	7	6	1	2	5	8	3	6	7	4	1
MP256	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	18-29	High Sch.	No income	4	3	2	1	6	5	4	7	8	6	2	3	5	1	1	7	8	6	5	2	3	4
MP255	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	High Sch.	No income	4	2	1	3	5	6	3	7	8	4	2	1	6	5	1	5	7	6	2	4	8	3
UC12	Cadaqués	Female	ESP	Local	Coastal	Infrequent	Need	30-39	University	14-35	1	5	6	4	2	3	5	4	7	2	3	8	6	1								
UC12B	Cadaqués	Male	ESP	Local	Coastal	Not born loca	Strong	60-69	PhD	>56	3	6	1	2	4	5	1	7	8	6	2	4	3	5	1	7	8	6	2	4	3	5
UC13	Cadaqués	Male	FRA	Tourist	Inland	First timer	Strong	40-49	University	14-35	6	3	1	2	5	4	1	2	4	8	3	6	7	5	1	2	4	7	3	5	6	8
UC15	Cadaqués	Female	ESP	Tourist	Coastal	First timer	Strong	18-29	University	No income	5	4	3	1	2	6	7	6	8	5	3	1	2	4	1	6	7	5	2	4	3	8
UC14	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	University	No income	5	4	2	1	3	6	5	7	8	4	2	3	1	6	2	7	8	5	4	3	1	6
UC16	Cadaqués	Male	ESP	Local	Coastal	Not born loca	Need	50-59	University	No income	6	5	3	4	2	1	3	8	7	1	4	5	6	2	3	8	7	1	4	5	6	2
UC16B	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Need	40-49	University	>56	3	4	2	1	5	6	1	7	8	3	2	4	5	6	1	7	8	3	2	4	5	6
UC11B	Cadaqués	Male	ESP	Local	Coastal	Not born loca	Strong	18-29	Middle Sch.	14-35	1	5	3	2	4	6	6	7	8	4	5	2	1	3	6	7	8	5	3	4	1	2
UC11	Cadaqués	Female	FRA	Tourist	Coastal	Infrequent	Strong	30-39	Master	14-35	4	2	1	3	6	5	8	6	7	1	2	4	5	3								
MP211	Port Selva	Female	ESP	Tourist	Coastal	First timer	Joy	18-29	Master	14-35	3	4	1	2	5	6	6	7	8	5	3	4	1	2	3	7	8	5	3	4	1	2
MP215	Port Selva	Female	ESP	Tourist	Coastal	First timer	Joy	18-29	Master	<14	6	2	1	3	5	4	1	6	7	3	5	8	4	2	1	6	8	7	5	4	3	2
MC220	Cadaqués	Male	ESP	Local	Coastal	Not born loca	Need	50-59	Middle Sch.	No income	2	5	3	6	1	4		5	6	4	1	7	2	3	1	8	6	3	5	7	4	2
MC221	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	30-39	High Sch.	14-35	3	2	1	4	5	6	6	1	4	2	3	5	7	8	1	2	3	4	5	6	7	8

				Sociodemographic parameters							Benefits						Impacts								Threats							
Code	Place of interview	Gender	Country	Local / Tourist	Residence respect sea proximity	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Food provision	Coastal protection	Climate regulation	Protect preserve biodiversity	Aesthetic value	Recreation & tourism	Climate change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour	Climate Change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour
MC222	Cadaqués	Female	ITA	Tourist	Inland	First timer	Strong	40-49	University	>56	4	1	2	3	5	6	7	6	8	5	2	1	4	3	1	6	8	5	7	2	3	4
MP212	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	Master	No income	4	3	2	1	6	5	5	6	8	1	2	7	3	4	3	4	7	5	8	2	1	6
MP210	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	60-69	High Sch.		1	3	4	2	5	6	6	2	7	3	5		4	1								
MP213	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Strong	18-29	Master	14-35	4	2	1	3	6	5	4	8	7	6	3	2	1	5	2	3	5	4	6	1	7	8
MC223	Cadaqués	Male	ITA	Tourist	Inland	Infrequent	Need	30-39	High Sch.	14-35		3	2	1	5	6	1	7	5	8	6	4	2	3	1	7	6	8	5	4	2	3
UC01	Cadaqués	Female	ESP	Tourist	Near coast	Infrequent	Joy	50-59	High Sch.	<14	1	6	3	4	5	2	4	2	5	3	6	7	8	1								
UC02	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	70-79	Prof./Tech.		5	2	1	3	6	4	5	7	8	3	2	4	6	1	4	7	8	3	1	5	6	2
UC03	Cadaqués	Female	FRA	Tourist	Coastal	First timer	Joy	30-39	University	35-56	1	5	6	2	3	4	5	6	7	4	8	3	1	2	1	5	6	7	8	4	2	3
UC04	Cadaqués	Male	FRA	Tourist	Inland	Frequent	Joy	60-69	University	14-35	1	4	5	2	3	6	4					2	1	3	1				2	3	4	5
UC05	Cadaqués	Male	GBR	Tourist	Inland	First timer	Indifferent	30-39	Master	>56	1	6	5	2	3	4	8	5	3	4	2	6	7	1	1	4	2	5	3	7	8	6
UC06	Cadaqués	Female	GBR	Tourist	Inland	First timer	Need	30-39	PhD	>56	4	3	2	1	5	6	4	6	7	5	3	8	2	1	2	7	8	6	4	5	3	1
UC07	Cadaqués	Female	FRA	Tourist	Inland	Infrequent	Joy	50-59	Master	14-35	2	4	5	1	3	6	4	6	7	3	8	2	1	5	2	6	7	8	3	4	1	5
UC09	Cadaqués	Female	BRA	Tourist	Inland	First timer	Joy	18-29	University	>56	2	4	3	1	5	6	6	5	8	4	1	7	3	2	4	5	8	7	1	6	3	2
MR240	Roses	Male	ESP	Local	Coastal	Born local	Joy	60-69	High Sch.	14-35	3	4	2	1	6	5	8	7	6	5	1	2	3	4	8	7	6	5	3	2	1	4
MR241	Roses	Female	ESP	Local	Coastal	Not born loca	Strong	18-29	Prof./Tech.	14-35	2	6	5	4	1	3	6	7	8	4	5	3	2	1	6	8	7	2	4	3	5	1
UR31	Roses	Female	FRA	Tourist	Inland	Frequent	Need	70-79	Middle Sch.	35-56	2	1	5	6	4	3	6	5	8	7	1	2	3	4								
UR30	Roses	Male	FRA	Tourist	Inland	First timer	Indifferent	60-69	Primary Sch.	14-35		2	3	1	4		1	7	6	3	4	5	8	2								
UR29	Roses	Female	FRA	Tourist	Inland	First timer	Indifferent	18-29	High Sch.	No income	1					2	1				2		3	4	1				2		3	4
UR17	Roses	Male	FRA	Tourist	Inland	First timer		70-79	Middle Sch.	14-35							1				4	3	2									
UR28	Roses	Male	FRA	Tourist	Inland	First timer	Joy	50-59	Middle Sch.	14-35	4	3		1	2		8	7	6	4	3	2	5	1								
UR27	Roses	Male	FRA	Tourist	Inland	Frequent	Strong	50-59	High Sch.	>56	4	1	2	3	5	6	7	1	8	6	5	2	3	4	6	1	2	3	4	7	5	8
UR26	Roses	Male	ESP	Local	Coastal	Born local	Joy	60-69	High Sch.	14-35	1	4	5	6	2	3	4	5	8	7	3	6	2	1	1	6	7	8	2	3	5	4
UR25	Roses	Female	FRA	Tourist	Near coast	Infrequent	Need	30-39	Middle Sch.	14-35	4	2	3	1	5	6	2	5	4	6	1	3	8	7	1	4	5	6	2	3	8	7
UR24	Roses	Male	FRA	Tourist	Near coast	Infrequent	Joy	18-29	University	No income	3	4	2	1	6	5	5	3	8	6	2	4	7	1	1	6	8	7	4	3	5	2
UR23	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	40-49	University	14-35	1	5	2	3	6	4	8	5	7	2	1	4	6	3	2	1	3	4	7	6	5	8
MC16	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	40-49	University	14-35	1	4	3	5	2	6	1	7	3	6	4	8	2	5	1	7	3	6	4	8	2	5
MC19	Cadaqués	Male	BOL	Tourist	Inland	Infrequent	Joy	30-39	Prof./Tech.	<14							4	1	7	5	3	8	6	2								
MC20	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	18-29	Middle Sch.	<14	1	6	4	2	3	5																
MC21	Cadaqués	Female	POL	Tourist	Inland	Infrequent	Joy	18-29	High Sch.	<14	4	3	2	1	6	5	2	8	7	5	6	3	4	1	2	8	7	4	5	1	6	3
MC22	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	18-29	University	<14	3	2	4	1	5	6	2		5	4	1	8	6	3	1	7	5	2	3	8	6	4
MC18	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	40-49	Master	14-35	2	3	1	4	5	6																
MP257	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	50-59	Primary Sch.		1	2	5	3	4	6	2	1	5	4	3	7	8	6	1	8	4	5	6	3	7	2
MP258	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	50-59	Prof./Tech.	<14		3	1	2	4	5	4	2	7	5	1	8	6	3								
MP251	Port Selva	Female	ESP	Local	Coastal	Infrequent	Strong	30-39	University	<14	5	1	2	3	4	6	7	6	8	5	1	4	2	3	2	8	5	3	7	1	4	6
MP259	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	40-49	University	14-35	1	2	4	3	6	5	2			1		4	3	5	1			3			2	4
UP40	Port Selva	Male	FRA	Tourist	Inland	First timer	Joy	50-59	PhD	35-56	1	2	6	3	5	4	3	1	2	6	4	8	5	7	3	1	2	6	4	8	5	7
UP41	Port Selva	Male	FRA	Tourist	Coastal	Frequent	Joy	30-39	High Sch.	14-35	6	3	5	1	4	2	1	8	7	6	4	5	3	2	1	5	7	6	4	8	3	2
UP42	Port Selva	Male	FRA	Tourist	Inland	First timer	Joy	40-49	Primary Sch.		4	5		3	1	2																
UP42	Port Selva	Male	ESP	Tourist	Near coast	First timer	Joy	30-39	University	14-35	2	3	1	4	5	6	2	5	7	8	3	6	4	1	2	5	7	8	3	6	4	1
UP44	Port Selva	Male	ESP	Tourist	Near coast	First timer	Need	50-59	Middle Sch.		1	4	2	3	5	6	1	7	8	3	5	2	6	4	1	7	8	3	5	2	6	4
UP45	Port Selva	Male	ESP	Local	Coastal	Not born loca	Strong	80-89	Prof./Tech.									2	4	3		5		1								
UP46	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Strong	40-49	University	>56	4	1	2	3	5	6	2	7	8	3	1	6	5	4	2	7	8	3	1	6	5	4
UP47	Port Selva	Male	ESP	Tourist	Inland	First timer	Joy	60-69	No Sch.	14-35	3	2		1	4	5	5	2		4	6	3	7	1	5	2		4	6	3	7	1
UP48	Port Selva	Female	FRA	Tourist	Inland	First timer	Joy	50-59	Master	14-35	2	3	5	1	4	6				5	4	3	1	2				5	4	3	1	2
UP49	Port Selva	Female	FRA	Tourist	Inland	First timer	Joy	60-69	University		4	2	1	3	5	6	1	2	4	6	3	8	7	5	1	2	4	6	3	8	7	5
UP50	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	50-59	High Sch.		1	2	3	4	5	6	6	7	8	5	2	3	4	1	6	7	8	5	2	3	4	1
UP51	Port Selva	Male	FRA	Tourist	Inland	First timer	Strong	70-79	PhD	>56	3	2	5	1	6	4	1	3	6	4	2	7	5	8	1	2	5	4	3	6	7	8
UP52	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	60-69	Master	>56	3	4	2	1	5	6	2	7	8	6	1	3	5	4	1	7	8	6	2	3	4	5
UP53	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	University	14-35	4	2	3	1	5	6	1	8	3	5	4	6	7	2	1	8	3	5	4	6	7	2
UP54	Port Selva	Female	ESP	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	14-35	4	3	2	1	5	6	5			6	3	4	1	2								
UP55	Port Selva	Female	ESP	Local	Coastal	Infrequent		18-29	Middle Sch.	<14	3	1	2	4	5	6	1	2	3	4	5	6	7	8								
UP56	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	40-49	Prof./Tech.	14-35							1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2
UP57	Port Selva	Male	FRA	Tourist	Near coast	First timer	Need	40-49	Prof./Tech.	14-35	1	3	6	4	5	2	4	3	8	7	2	5	6	1	1	2	8	7	6	5	3	4
UP58	Port Selva	Male	ESP	Local	Coastal	Not born loca	Need	40-49	University	35-56	2	3	1	4	5	6	8	4	7	6	1	5	3	2								
UP59	Port Selva	Male	BEL	Tourist	Inland	Frequent	Strong	40-49	Middle Sch.		3	5	1	2	4	6	4	3	1	7	2	6	8	5								
MP242	Port Selva	Male	FRA	Tourist	Inland	Infrequent	Need	70-79	Master	>56	4	2	3	1	5	6	2	1	7	4	3	6	8	5	1	3	2	4	5	6	8	7
ZP03	Port Selva	Female	USA	Tourist	Coastal	Frequent	Joy	70-79	Master	>56	4	3	2	1	5	6	2	4	6	8	1	7	3	5	1	3	2	8	6	7	4	5
ZP04	Port Selva	Female	ESP	Local	Coastal	Born local	Need	40-49	Master	14-35	2	4	3	1	5	6	3	1	7	4	5	6	8	2	2	1	5	4	6	7	8	3
ZP05	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	30-39	Prof./Tech.		3	1	4	2	5	6	6	7	8	4	3	1	5	2	1	2	8	3	4	5	7	6
ZP06	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	80-89	High Sch.		5	4	3	2	1	6																
ZP07	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	40-49	Master	>56	5	6	2	1	3	4	1	4		5	3	6	7	2	1	5	6	4	2			3
ZP08	Port Selva	Male	ESP	Local	Coastal	Not born loca	Strong	40-49	High Sch.	14-35	1	6	5	4	2	3	3	4	5	6	1	7	2	8	1	3	2	8	4	5	6	7
MP170	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	70-79	Middle Sch.		1	3	2	4				1		3			2									
MP172	Port Selva	Male	CHE	Tourist	Inland	First timer	Joy	50-59	Prof./Tech.	>56	5	1	2	4	3	6	3	4	8	7	2	5	6	1	1	4	8	7	3	5	6	2
MP173	Port Selva	Male	CHE	Tourist	Inland	First timer	Joy	18-29	Prof./Tech.	<14	4	3	1	2	5	6	1	8	7	6	3	5	4	2	1	3	8	4	2	5	7	6
MP174	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	18-29	University	<14	4	3	1	2	5	6	2	5	8	6	1	4	7	3	1	5	7	8	2	4	6	3
MP175	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	40-49	University	<14							7	6		5	4	3	2	8	8	4	6	5	7	3	2	1
MP176	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	18-29	University	14-35	3	2	4	1	5	6	1	2	8	6	4	5	7	3	1	4	8	6	3	5	7	2
MP177	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	18-29	University	14-35	6	3	4	5	2	1	6	7		2	4	5	3	1	6	1		7	4	5	3	2
AP164	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	70-79	Prof./Tech.	14-35	6	1		2	3	4	4	1	5	3	6	2	7	8	4	1	5	3	6	2	7	8
AP165	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Strong	70-79	University		3	4	5	6	2	1	5	1		2	4	3	7	6								
AP166	Port Selva	Female	FRA	Tourist	Inland	Infrequent	Joy	18-29	University	No income	3	5	2	1	4	6	1	3	7	8	4	6	2	5	1	4	7	8	2	6	3	5
AP167	Port Selva	Female	DEU	Tourist	Inland	First timer	Need	18-29	University	<14	2	1	6	5	3	4																
AP168	Port Selva	Male	DEU	Tourist	Inland	First timer	Joy	18-29	Master	35-56	3	1	2	4	5	6	6	5	1	3	8	2	4	7	2	5	8	7	3	6	4	1
AP170	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	40-49	High Sch.	<14	2	4	1	3	6	5	5	4	8	7	6	2	3	1	5	4	8	7	6	2	3	1
AP171	Port Selva	Male	ESP	Tourist	Coastal	Infrequent	Joy	30-39	University	14-35				3	2	1	6	1	7	2	5	3	8	4								
AR141	Roses	Female	FRA	Tourist	Near coast	First timer	Need	30-39	University	No income	3	2	4	1	6	5	4	2	3	8	5	7	6	1	4	2	3	8	5	7	6	1
AR142	Roses	Female	FRA	Tourist	Inland	Infrequent	Need	50-59	High Sch.	14-35	5	2	1	3	6	4	1	3	6	7	5	4	8	2	1	3	6	7	5	4	8	2
AR143	Roses	Male	DEU	Tourist	Inland	First timer	Joy	50-59	Master		5	3	1	2	4	6	1	5	6		2		4	3	1	5	6		2		4	3
AR144	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	Prof./Tech.	<14	4	1	2	3	5	6	1	5	8	4	2	3	6	7	1			3	2		4	5
AR145	Roses	Female	ESP	Local	Coastal	Born local	Joy	30-39	Prof./Tech.	14-35	3		2	1	4	5	1	2	8	4	3	5	6	7			4			1	2	3
AR146	Roses	Female	ESP	Local	Coastal	Born local	Need	30-39	Prof./Tech.	<14	4	2	3	1	6	5	3	7	6	4	2	5	8	1	3	7	6	4	2	5	8	1
AR147	Roses	Female	ESP	Local	Coastal	Born local	Joy	40-49	Middle Sch.	14-35	1	2	5	6	4	3	1				2		4	3	1				2		4	3
AR148	Roses	Female	ARE	Tourist	Coastal	First timer	Joy	18-29	High Sch.	No income	5	2	1	3	6	4	3	6	5	4	1	8	7	2	2	5	6	7	1	8	4	3
AR149	Roses	Female	FRA	Tourist	Inland		Joy	70-79	Middle Sch.	<14	5	3	1	2		4	4					2	1	3	4					2	1	3
AR150	Roses	Male	FRA	Tourist	Near coast	First timer	Joy	30-39	Prof./Tech.	35-56	4	2	3	1	6	5	4	5	6	8	3	7	2	1	1	7	6	8	4	5	3	2
AR151	Roses	Female	FRA	Tourist	Inland	First timer	Joy	50-59	Master	35-56	3	4	1	2	5	6	5	6	7	8	3	4	2	1	1	2	3	8	4	5	6	7
AR152	Roses	Male	FRA	Tourist	Coastal	Infrequent	Joy	60-69	University	<14		4	3		2	1				2			3	1				2			3	1
AR153	Roses	Male	ESP	Local	Coastal	Born local	Need	18-29	Primary Sch.	14-35										3	2		4	1				3	2		4	1
AR154	Roses	Male	BEL	Tourist	Inland	First timer	Joy	30-39	Prof./Tech.	14-35	6	4	5	1	2	3	8	5	7	6	2	1	3	4	8	5	7	6	2	1	3	4
SC16	Cadaqués	Male	ESP	Tourist	Coastal	First timer	Joy	60-69	PhD	>56	4	3	1	2	5	6	1	7	4	8	2	3	5	6	1	2	4	5	3	7	6	8
SC17	Cadaqués	Male	FRA	Tourist	Near coast		Joy	70-79	Middle Sch.	14-35	2	1	3	4	5		1	5	3	8	2	6	7	4	1	3	6	7	2	4	5	8
SC18	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Joy	40-49	University	<14	1	5	4	2	6	3	8	4	6	5	3	7	1	2	1	4	5	6	7	3	2	8
SC19	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Need	40-49	University	14-35	5	4	6	1	2	3	7	1	8	3	2	4	5	6	1	2	8	4	3	5	6	7
SC20	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Need	50-59	High Sch.	35-56	2	3	6	1	5	4	8	6	3	7	1	4	5	2	6	5	4	7	1	8	2	3
SC21	Cadaqués	Male	MAR	Tourist	Coastal		Strong	50-59	Primary Sch.	<14	2	5	1	4	6	3	3	2	1	7	4	6	5	8	1	7	8	2	3	6	5	4
SC22	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Need	50-59	Prof./Tech.		1	2	4	3	5	6	2	7	8	6	3	4	5	1	1	7	8	6	4	5	2	3
SC23	Cadaqués	Female	GBR	Tourist	Coastal		Joy	40-49	University	>56	3	4	1	5	6	2	8	3	7	4	2	6	5	1	1	8	2	5	3	7	6	4
SC24	Cadaqués	Female	AUS	Tourist	Coastal	First timer	Need	18-29	University	<14	1	3	2	4	5	6	2	1	4	5	6	7	3	8	1	7	6	5	3	4	2	8
SC25	Cadaqués	Female	ESP	Local	Coastal	Born local	Indifferent	70-79	Primary Sch.	14-35	1	3	6	2	4	5	2	7	3	8	4	6	5	1	3	8	2	6	4	5	7	1
SC26	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	80-89	Primary Sch.	14-35	4	3	6	5	2	1	2	7	3	8	4	6	5	1	3	8	2	6	4	5	7	1
MC02	Cadaqués	Female	FRA	Tourist			Joy	40-49	Master	14-35	4	3	1	2	6	5	1	7	6	8	2	4	5	3	1	3	2	5	4	6	7	8
MC03	Cadaqués	Female	ESP	Tourist	Coastal	First timer	Strong	18-29	Middle Sch.	No income	2	4	1	3	5	6	6	4	7	5	2	8	1	3	1	7	2	4	3	8	6	5
MC04	Cadaqués	Female	ESP	Tourist	Inland	First timer	Need	18-29	Middle Sch.	No income	2	3	1	4	5	6	6	2	8	7	5	4	1	2	2	4	3	7	1	8	5	6
MC05	Cadaqués	Female	ESP	Local	Coastal	Born local	Indifferent	18-29	High Sch.	No income		1	3	2	4		6	7	8	5	3	4	2	1	6	7	8	5	3	4	2	1
MC06	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	50-59	University	35-56	3	2	1	6	5	4	6	7	8	5	1	2	3	4	1	8	3	7	2	4	5	6
MC08	Cadaqués	Female	ESP	Local	Coastal	Born local	Joy	40-49	University		3	2	5	1	6	4	3	5	8	4	1	2	6	7	3	5	8	4	1	2	6	7
MC07	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Joy	50-59	University	>56	4	3	1	2	5	6	6	8	7	4	5	2	1	3	6	8	7	4	5	2	1	3
MC09	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	60-69	High Sch.	<14	1	2	3	4	5	6	4	3	8	5	6	7	2	1	4	3	8	5	6	7	2	1
MC10	Cadaqués	Female	ESP	Local	Coastal	Born local	Joy	60-69	University	<14	4	2	3	1	6	5	6	5	8	4	3	1	2	7	1	6	3	5	2	4	7	8
MC11	Cadaqués	Female	ARG	Tourist	Coastal	Infrequent	Strong	30-39	University	<14	4	3	1	2	5	6	6	3	8	2	1	4	7	5	1	6	7	2	3	4	5	8
MC12	Cadaqués	Female	ARG	Tourist	Coastal	First timer	Joy	18-29	Middle Sch.	<14		5	4	2	1	3	6	7		2	1	5	3	4	2	3		7	4	6	1	5
MC13	Cadaqués	Female	ESP	Local	Coastal	Infrequent	Indifferent	30-39	University	14-35	1	3	4	2	5	6	8	2	1	3	6	7	5	4	7	5	1	2	4	8	3	6
AR155	Roses	Female	FRA	Tourist	Inland	First timer	Joy	18-29	University	No income	1	3	2	4	5	6	1	2	7	8	5	6	4	3	1	2	8	7	3	4	6	5
AR157	Roses	Female	FRA	Tourist	Inland	Infrequent	Need	40-49	Middle Sch.	<14	6	4	5	3	2	1							2	1						1		
AR158	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	High Sch.	<14	5	1	6	4	3	2	1	2	6	8	3	5	7	4	1	2	6	7	3	8	4	5
AR160	Roses	Female	FRA	Tourist	Near coast	First timer	Joy	40-49	Prof./Tech.		1	2	3	4			8	3	7	4	6	5	2	1	8	3	7	4	6	5	2	1
AR161	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	30-39	University	>56	1	2	6	3	5	4				3	2		1		2		3		1		4	
AR162	Roses	Female	FRA	Tourist	Coastal	Frequent	Joy	70-79	No Sch.								1	2			3	4	6	5	1	2			3	4	6	5
AR163	Roses	Male	ESP	Tourist	Near coast	First timer	Joy	18-29	University	No income	6	4	2	1	3	5	2	7	8	5	4	6	3	1	2	7	6	5	4	8	3	1
AP125	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	70-79	PhD	14-35	1	5	6	2	3	4	5	2	8	6	7	1	3	4								
AP127	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	University		3	4	5	6	2	1	1	7		6	5	4	3	2								
AP128	Port Selva	Female	ESP	Local	Coastal		Indifferent	18-29	High Sch.	<14	4	1	2	3	5	6	1	6	8	4	3	7	5	2	2	4	6	5	1	7	8	3
AP129	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	18-29	High Sch.	14-35	3	4	2	1	5	6	3	7	8	5	1	6	4	2								
AP130	Port Selva	Male	ESP	Tourist	Coastal	First timer	Joy	18-29	Prof./Tech.	No income	3	5	1	2	4	6	3	4	8	5	1	6	7	2	1	3	4	6	2	5	8	7
AP131	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	Master		3				1	2							1	2								
AP132	Port Selva	Female	ESP	Tourist	Coastal	First timer	Strong	18-29	Master	14-35	4	2	3	1	5	6	6	5	8	1	2	3	4	7	3	5	8	4	1	7	6	2
AP133	Port Selva	Male	ESP	Tourist	Coastal	First timer	Joy	18-29	Master	<14	4	3	2	1	6	5	5	8	7	4	3	2	6	1	3	8	6	7	5	4	2	1
AP135	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	50-59	High Sch.	35-56	4	6	1	2	5	3	5	8	7	6	1	3	2	4	2	8	5	7	3	1	4	6
AP136	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Strong	30-39	High Sch.		3	5	6	1	2	4	3	6	7	2	5	4	8	1	1	6	7	3	5	4	8	2
AP137	Port Selva	Female	ESP	Tourist	Near coast	First timer	Joy	50-59	University	14-35	4	2	3	1	6	5	6	2	7	5	4	1	3	8								
AP138	Port Selva	Male	ESP	Tourist	Coastal	First timer	Joy	18-29	Primary Sch.	No income	4	3	1	2	6	5	2	4	7	3	5	6	8	1								
AP139	Port Selva	Male	ESP	Local	Coastal	Born local	Joy		Prof./Tech.	14-35	5	2	3	1	4	6	4	1	6	2	5			3	1	2	6	3	5	7		4
AP140	Port Selva	Female	ESP	Tourist	Inland	Frequent	Strong	40-49	University	14-35	3	4	5	1	2	6	5	7	8	6	2	4	3	1								
AR105	Roses	Male	FRA	Tourist	Inland	First timer	Joy	70-79	Middle Sch.	14-35	4	2	1	3	5	6				3		4	1	2				3		4	1	2
AR106	Roses	Female	FRA	Tourist		Frequent					1	2	3	4	5	6				1		2						1		2		
AR107	Roses	Female	DEU	Tourist	Inland	First timer	Strong	18-29	High Sch.	No income	5	3	1	4	6	2	1	6	8	4	3	7	5	2	1	6	8	4	3	7	5	2
AR108	Roses	Male	ESP	Local	Coastal	Born local	Indifferent	60-69	University	35-56		3	1	2							1			2					1			2
AR109	Roses	Female	ESP	Tourist	Inland	Infrequent	Strong	70-79	No Sch.		1	3	6	4	2	5	5		4	3	1		2	6	5		4	3	1		2	6
MP144	Port Selva	Female	ESP	Tourist	Near coast	First timer	Joy	18-29	High Sch.	No income		3	2	1	4	5	1	7	8	3	5	6	4	2	1	7	8	5	2	6	3	4
MP145	Port Selva	Male	ESP	Tourist	Near coast	Infrequent	Joy	18-29	Prof./Tech.	No income	3	5	4	6	2	1	1	2	8	3	5	6	4	7	8	7	6	4	5	3	2	1
MP146	Port Selva	Female	POL	Tourist	Inland	Infrequent	Joy	18-29	High Sch.	No income	1	4	3	2	5	6	6	7	8	5	1	3	4	2	5	4	8	7	1	3	6	2
MP147	Port Selva	Female	POL	Tourist	Inland	First timer	Joy	18-29	High Sch.	No income	5	6	1	2	4	3	1	4	8	3	2	7	6	5	2	4	7	3	1	5	8	6
MP148	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Joy	18-29	High Sch.	<14	1	4	3	2	5	6	5	7	8	4	1	6	3	2								
WP101	Port Selva	Male	ESP	Tourist	Near coast	Infrequent	Joy	30-39	University	14-35	1	2	4	3	5	6	8	6	7	5	4	1	2	3	8	6	7	5	4	1	2	3
WP102	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Joy	30-39	University	14-35	4	2	3	1	5	6	8	4	7	3	1	2	6	5	8	7	6	5	4	1	3	2
WP103	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	40-49	Prof./Tech.	14-35	6	5	1	3	2	4	5	7	8	4	1	2	3	6	4	7	8	5	2	1	3	6
WP104	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong		Master	14-35	6	3	2	1	4	5	5	1	8	6	7	3	2	4	5	1	8	7	6	3	2	4
WP105	Port Selva	Female	FRA	Tourist	Inland	Infrequent	Indifferent	30-39	University	>56	5	3	2	1	4	6	4	6	3	1	5	2	7	8	8	5	6	1	4	3	7	2
WP106	Port Selva	Male	GBR	Tourist	Inland	Infrequent	Joy	40-49	Master	>56	4	1	3	2	5	6	4	2	3	8	1	7	5	6	1	2	5	8	3	7	4	6
WP107	Port Selva	Female	DNK	Tourist	Near coast	First timer	Strong	18-29	High Sch.	No income	1	4	5	2	3	6	2	1	7	4	3	5	6	8	1	2	7	4	3	5	6	8
WP110	Port Selva	Male	FRA	Tourist	Inland	Infrequent	Need	40-49	University	14-35	1	6	3	2	4	5	8	5	6	2	1	3	4	7	1	5	3	4	2	6	7	8
WP111	Port Selva	Female	FRA	Tourist	Inland	Infrequent	Need	60-69	Master	14-35	4	2	5	3	1	6	3	2		7	5	4	6	1	3	2		7	5	4	6	1
WP112	Port Selva	Female	ESP	Local	Near coast	Not born loca	Joy	50-59	High Sch.		4	3	2	1	5	6	5				3	2	4	1	5				3	2	4	1
WP113	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	60-69	PhD	14-35	2	4	1	3	5	6	3	1	8	4	5	2	6	7	3	1		4	5	2	6	7
WP114	Port Selva	Female	ESP	Tourist	Near coast	First timer	Joy	18-29	University	<14	3	4	6	5	2	1	8	6	7	5	4	3	2	1	3	8	4	2	5	1	6	7
WP115	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Joy	18-29	High Sch.	No income	4	1	3	2	5	6	4	3	8	5	6	1	2	7	1	4	3	5		2	6	8
WP116	Port Selva	Male	ESP	Tourist	Coastal	Infrequent	Need	18-29	University	<14	1	3	4	2	5	6	5	7	6	1	3	2	4	8	2	5	7	1	6	4	3	8
WP117	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Need	30-39	PhD	<14	4	3	2	1	6	5	1	2	3	6	5	4	8	7	2	4	1	3	5	8	6	7
AR104	Roses	Male	ESP	Tourist	Near coast	First timer	Joy	40-49	PhD	35-56	6	5	4	3	1	2	2			5	6	4	3	1	1			3	2	5	4	6
MR160	Roses	Female	AUS	Tourist	Coastal	First timer	Need	60-69	University	>56	6	4	5	3	1	2	2	7	8	3	1	6	5	4	3	6	7	4	5	2	1	8
MR161	Roses	Female	ESP	Tourist	Coastal	First timer	Need	30-39	Master	No income	6	2	3	1	4	5	6	2	4	5	7	1	3	8	1	3	2	6	8	5	4	7
MR162	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	40-49	Master	35-56	4	3	2	1	5	6	4	3	5	2	6	7	1	8	1	5	4	3	6	8	2	7
MR163	Roses	Male	ESP	Local	Coastal	Born local	Strong	30-39	Prof./Tech.	14-35	4	3	2	1	5	6																
MR164	Roses	Male	BEL	Tourist	Coastal	Frequent	Joy	30-39	Middle Sch.	>56	3	1	5	2	6	4	1	4	8	7	6	2	3	5								
MR165	Roses	Female	ESP	Tourist	Inland	Frequent	Joy	50-59	Primary Sch.	14-35	2	5	1	3	4	6	1	5		4	2			3								
MR166	Roses	Male	ESP	Tourist	Inland	Frequent	Joy	50-59	Primary Sch.	14-35	2	4	1	3	4	6	1	5		4		2		3								
MP130	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	70-79	Middle Sch.	35-56	3	2	1	4	5	6	2	5	6	7	8	4	3	1	1	2	7	3	8	6	4	5
MP131	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	40-49	University	35-56	1	3	2	4	5	6	6	7	8	5	4	3	2	1	1	2	5	6	7	8	4	3
MP132	Port Selva	Female	ESP	Local	Coastal	Not born loca	Strong	50-59	Prof./Tech.	14-35	2	3	4	1	5	6	3	7	5	8	6	4	1	2	1	2	3	6	4	8	7	5
MP133	Port Selva	Female	ESP	Tourist	Inland	First timer	Strong	18-29	University	14-35	3	4	1	2	6	5	1	7	8	4	3	5	6	2	1	5	8	7	3	4	2	6
MP134	Port Selva	Male	ESP	Local	Coastal	Born local	Strong	18-29	Master	<14	2	5	3	1	4	6	1	2	3	8	5	7	6	4	1	2	3	8	5	7	6	4
MP137	Port Selva	Female	FRA	Tourist	Inland	First timer	Joy	18-29	University	No income	4	5	1	2	3	6	5	7	8	6	2	3	1	4	2	8	7	6	1	4	3	5
MP138	Port Selva	Female	ESP	Local	Coastal	Infrequent	Joy	30-39	Middle Sch.	<14	3	4	1	2	6	5	2	5	7	3	4	6	8	1	4	6	7	5	2	3	8	1
MP140	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	50-59	Prof./Tech.	<14	1	4	3	2	5	6	4	7	3	1	2	6	8	5								
MP141	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	30-39	University		4	3	2	1	5	6	7	4	8	6	3	5	1	2	7	2	8	6	1	5	4	3
MP142	Port Selva	Male	ESP	Local	Coastal	Born local	Indifferent	50-59	University	14-35	4	1	2	5	3	6																
MP143	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	18-29	University	14-35	3	1	2	4	6	5	6	1	7	5	4	3	8	2	1	2	3	7	4	5	6	8
MP144	Port Selva	Female	ESP	Tourist	Coastal		Strong	30-39	Prof./Tech.	<14	4	2	3	1	5	6	1	2	3	4	8	5	7	6	1	2	3	4	5	8	7	6
ZC24	Cadaqués	Female	ESP	Local	Coastal	Not born loca	Need	18-29	High Sch.	No income	3	1	2	4	6	5	4	7	8	2	1	5	6	3	1	6	8	4	3	2	7	5
ZC25	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Joy	18-29	Master	<14	3	4	1	2	6	5	1	4	6	8	2	3	5	7	1	4	6	8	2	3	5	7
ZC26	Cadaqués	Male	ESP	Local	Coastal	Not born loca	Strong	18-29	Prof./Tech.	<14	1	4	2	3	5	6	8	6	5	7	3	2	1	4	3	2	1	6	8	7	4	5
ZC27	Cadaqués	Female	ESP	Local	Coastal	Infrequent	Joy	50-59	Master	35-56	4	1	3	2	5	6	5	7	8	4	2	3	6	1	1	7	8	6	3	2	5	4
ZC29	Cadaqués	Female	CHL	Tourist	Inland	First timer	Need	18-29	University	No income	4	5	6	3	1	2	2	7	8	5	1	4	6	3	1	7	8	4	6	2	5	3
ZC30	Cadaqués	Male	ESP	Tourist	Inland	First timer	Need	40-49	University	>56	3	5	2	1	6	4	2	6	7	8	1	4	5	3	1	7	6	8	3	5	4	2
ZC31	Cadaqués	Male	FRA	Tourist	Inland	First timer	Joy	40-49	University	>56	3	2	1	4	5	6	1	6	8	7	5	4	3	2	1	6	7	8	5	4	2	3
ZC32	Cadaqués	Male	ESP	Tourist	Near coast	Infrequent	Need	30-39	Master	35-56	3	6	4	5	1	2	4	7	8	1	6	5	2	3	1	2	8	3	5	4	6	7
ZC33	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Need	70-79	High Sch.	>56	4	2	1	3	5	6	1	7	8	6	4	5	3	2	1	3	8	7	2	6	4	5
ZC34	Cadaqués	Female	ESP	Tourist	Near coast	Infrequent	Need	30-39	Master	14-35	4	6	5	3	2	1	5	8	7	1	6	3	4	2	1	4	6	3	5	2	7	8
ZC35	Cadaqués	Male	ESP	Tourist	Near coast	First timer	Strong	30-39	Middle Sch.	14-35	4	2	1	3	5	6	2	3	8	1	5	4	6	7	1	4	8	2	5	3	7	6
ZC36	Cadaqués	Male	ESP	Tourist	Near coast	First timer	Strong	18-29	Prof./Tech.	14-35	5	3	4	1	6	2	6	5	8	1	3	4	7	2	3	2	5	4	1	6	8	7

				Sociodemographic parameters							Benefits						Impacts								Threats							
Code	Place of interview	Gender	Country	Local / Tourist	Residence respect sea proximity	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Food provision	Coastal protection	Climate regulation	Protect preserve biodiversity	Aesthetic value	Recreation & tourism	Climate change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour	Climate Change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour
UC75	Cadaqués	Male	ESP	Tourist	Coastal	First timer	Need	18-29	University	<14	4	6	3	5	1	2	4	7	8	5	2	6	3	1	4	7	8	5	3	6	1	2
UC60	Cadaqués	Male	GBR	Tourist		First timer	Need	40-49	High Sch.	35-56							2	6	7	3	1	4	5	8								
UC61	Cadaqués	Male	ESP	Tourist	Near coast	Infrequent	Strong	18-29	Master	14-35	3	5	1	2	6	4	6	7	8	4	3	5	1	2	2	7	8	5	1	6	3	4
UC62	Cadaqués	Male	ESP	Tourist	Coastal	Infrequent	Joy	30-39	University	No income	5	3	2	1	4	6	5	8	6	1	2	3	4	7	1	7	8	2	6	5	3	4
UC63	Cadaqués	Female	ESP	Tourist	Near coast	Infrequent	Need	18-29	High Sch.	<14	6	5	3	2	1	4	2	5	8	7	4	6	3	1								
UC65	Cadaqués	Female	ARG	Tourist		Infrequent	Need	18-29	Middle Sch.	No income	6	3	2	1	4	5	5	7	8	6	1	3	2	4	2	6	8	5	1	3	7	4
UC68	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Need	40-49	University	14-35	2	3	4	1				6	7	1	5	4	3	2		6	7	1	5	4	3	2
UC69	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	30-39	Prof./Tech.	14-35	2	4	3	5	1	6	6	7		5	2	1	4	3	6	7		5	2	1	4	3
UC70	Cadaqués	Female	FRA	Tourist	Inland	First timer	Joy	30-39	Prof./Tech.	14-35	4	3	1	2	5	6	1	7	8	5	4	6	2	3								
UC73	Cadaqués	Male	DNK	Tourist	Coastal	First timer	Joy	30-39	Master	>56	6	5	4	3	1	2	6	8	7	5	3	4	2	1	2	7	6	3	8	5	4	1
UC74	Cadaqués	Female	DNK	Tourist	Coastal	First timer	Joy	40-49	Master	35-56	1	3	4	2	6	5	3	7		4	1	6	2	5								
UC71	Cadaqués	Male	FRA	Tourist	Inland	First timer	Joy	30-39	Master	14-35	1	3	2	4	6	5	7	3	8	2	6	4	1	5								
MC260	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	18-29	High Sch.	No income		2	3	1	4		1	3	4	2	6	7	8	5	1	2	3	4	6	7	8	5
MC261	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	30-39	Master	14-35	4	3	1	2	5	6	7	1	2	6	3	4	5	8	1	3	2	7	4	5	6	8
MC262	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	30-39	Prof./Tech.	14-35	4	3	1	2	5	6	7	1	8	2	4	6	3	5	2	1	8	7	3	6	4	5
MC263	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	30-39	High Sch.	<14	6	3	2	1	5	4	6	7	8	5	1	2	4	3	1	2	4	3	5	8	7	6
MC264	Cadaqués	Male	ESP	Local	Coastal	Born local	Need	30-39	High Sch.	35-56	4	5	1	2	6	3	1	6	2	4	3	8	5	7	1	6	2	4	3	8	5	7
MC265	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	40-49	Middle Sch.	<14	3	1	4	2	6	5	1	7	3	8	2	4	5	6	1	7	2	8	3	4	5	6
MC267	Cadaqués	Male	ESP	Local	Coastal	Born local	Joy	18-29	Middle Sch.	14-35	3	4	2	1	6	5	1	5	7	4	2	3	8	6	1	5	6	7	4	2	8	3
MC268	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	University	<14	2	3	5	1	4	6	1	3	4	7	6	3	2	8	1	3	6	7	8	3	2	4
MC269	Cadaqués	Female	ESP	Tourist	Coastal	Infrequent	Joy	18-29	University	<14	4	3	2	1			8	6	7	3	2	1	4	5	7	6	8	4	2	3	1	5
WC75	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	50-59	University	14-35	6	4	2	1	3	5	5	7	8	4	6	3	2	1	5	7	8	4	6	3	2	1
WC76	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Need	70-79	High Sch.		4	2	1	3	5	6	6	2	8	5	1	3	7	4	6	2	8	5	1	3	7	4
WC77	Cadaqués	Female	FRA	Tourist	Inland	Infrequent	Need	40-49	University	35-56	6	5	4	1	2	3	2	3	8	7	1	5	6	4	1	2	8	7	3	6	5	4
WC78	Cadaqués	Male	FRA	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	14-35	1	3	6	2	4	5	6	2	7	8	4	5	3	1	2	3	7	8	5	6	4	1
WC79	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Joy	60-69	High Sch.	14-35	5	2	3	1	4	6	4	6	7	8	1	2	5	3	4	6	7	8	1	2	5	3
MC100	Cadaqués	Male	ESP	Local	Coastal	Born local	Avoid	40-49	Primary Sch.					1				3				1	2	4								
MC102	Cadaqués	Female	ESP	Local	Coastal	Infrequent	Strong	30-39	University	<14	3	2	1	4	5	6	8	6	7	5	3	1	2	4	4	8	7	6	3	2	1	5
MC101	Cadaqués	Female	ESP	Local	Coastal	Born local	Need	18-29	University	<14	4		2	1	3	5	8	6	7	5	3	2	1	4								
MC103	Cadaqués	Female	ESP	Tourist	Near coast	First timer	Joy	18-29	Master	<14	4	3	1	2	5	6	7	3	8	1	4	6	2	5	7	5	8	2	4	6	3	1
MC104	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Need	40-49	High Sch.	14-35	4	2	1	3	5	6	2	3	1	5	4	8	6	7	1	2	3	4	5	8	6	7
MC106	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Strong	18-29	University		2	4	3	1	5	6	3	1	2	7	4	8	5	6	1	2	3	7	4	6	5	8
MC107	Cadaqués	Female	ESP	Local	Coastal	Not born loca	Need	40-49	Prof./Tech.	<14	3	2	4	1	6	5	6	7	8	2	1	4	5	3	1	7		4	3	2	5	6
MC108	Cadaqués	Male	ESP	Local	Coastal	Infrequent	Strong	18-29	University	<14	6	3	2	1	5	4	6	1	8	5	2	3	7	4	3	1	8	4	2	5	7	6
MC110	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	50-59	University	35-56	4	3	2	1	5	6																
MC112	Cadaqués	Male	ISR	Tourist	Near coast	First timer	Strong	18-29	University	<14	3	4	5	1	2	6	5	6	8	4	2	3	7	1	3	7	8	6	2	4	5	1
MC113	Cadaqués	Female	ESP	Local	Coastal	Infrequent	Strong	18-29	University	<14	5	4	2	1	3	6	3	7	8	6	5	2	1	4	1	7	8	6	5	3	2	4
MC114	Cadaqués	Male	ISR	Tourist	Coastal	First timer	Need	18-29	High Sch.	No income	5	3	1	2	4	6	6	7	8	4	3	1	2	5	1	7	8	5	4	2	3	6
WP54	Port Selva	Female	GBR	Tourist	Near coast	Frequent	Joy	30-39	PhD		4	1	2	3	5	6	7	6	5	2	4	3	1	8	4	7	3	5	6	2	1	8
WP55	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Need	40-49	University	<14	1	4	3	2			1	4	3	2	5	8	7	6	1	6	5	2	3	7	8	4
WP56	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Need	50-59	Master		4	3	1	2	5	6	1	2	8	6	5	3	4	7	1	2	8	6	5	3	4	7
WP57	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Need	40-49	University	35-56	1	6	4	5	2	3	6	5	7	2	3	8	4	1	2	6	7	3	5	8	4	1
WP58	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Need	50-59	University	35-56	3	2	1	4	5	6	7	6	8	3	5	4	2	1	1	2	3	6	4	5	7	8
WP59	Port Selva	Female	RUS	Tourist	Inland	Infrequent	Need	30-39	University		1	2	3	4	5	6	1	8	4	6	5	2	7	3	1	8	4	6	5	2	7	3
WP60	Port Selva	Female	ESP	Tourist	Inland	Infrequent	Need	18-29	University	<14	1	4	3	2	5	6	3	5	7	6	1	2	8	4	1	4	6	3	2	7	8	5
WP61	Port Selva	Female	ESP	Tourist	Inland	Frequent	Need	18-29	University	<14	4	3	1	2	5	6	4	3	6	1	5	7	2	8	1	2	3	7	8	4	6	5
WP66	Port Selva	Female	DEU	Tourist	Inland	Infrequent	Joy	50-59	University	<14	4	3	2	1	6	5	1	2	8	7	4	3	5	6	1	2	4	7	3	8	5	6
WP67	Port Selva	Male	ESP	Tourist	Coastal	Infrequent	Joy	40-49	University		4	3	1	2	6	5	1	3	8	6	7	5	2	4	1	3	8	6	7	5	2	4
WP68	Port Selva	Female	FRA	Tourist	Coastal	Frequent	Need	40-49	Master		1	2	3	4	5		5	8	6	3	4	7	1	2	2	5	3	4	1	8	6	7
WP69	Port Selva	Male	FRA	Tourist	Inland	Frequent	Joy	40-49	Prof./Tech.	35-56	4	3	1	2	6	5	5	6	7	3	8	4	1	2	1	2	7	6	8	5	3	4
WP70	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Joy	50-59	High Sch.		1	3	4	2	5	6	2	7	8	3	1	5	6	4	2	7	8	3	1	5	6	4
MP90	Port Selva	Male	ESP	Local	Coastal	Born local	Need	70-79	Middle Sch.	<14	1		5	3	2	4	3	4			1			2								
MP91	Port Selva	Male	ESP	Local	Coastal	Not born loca	Strong	60-69	Prof./Tech.		1	4	3	2	5	6	2	3	5	8	1	6	7	4	1		5	6	2	4	7	3
MP92	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	40-49	Prof./Tech.		1	4	3	2	5	6	1	7	8	4	2	6	5	3	1	7	8	4	2	6	5	3
MP93	Port Selva	Male	FRA	Tourist	Inland		Avoid	50-59	University	<14	6	4	1	2	3	5	1	3	7	8	5	4	6	2								
MP94	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	40-49	Prof./Tech.	14-35	3	4	2	1	6	5	2	1	8	3	4	5	7	6	1	2	8	3	4	5	7	6
AP75	Port Selva	Male	ESP	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	14-35	4	3	2	1	5	6	1	4	2	5	3	8	7	6	8	3	2	4	1	5	6	7
AP76	Port Selva	Male	FRA	Tourist	Inland	Frequent	Indifferent	40-49	PhD	35-56	6	5	3	4	2	1	5	8	4	6	3	7	2	1	3	8	4	6	5	7	2	1
AP77	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Avoid	40-49	Prof./Tech.	14-35	6	2	5	1	3	4	1	5	8	3	4	2	7	6	1	5	8	3	4	2	7	6
AP78	Port Selva	Male	ESP	Local	Coastal	Born local	Avoid	70-79	Primary Sch.								2	5	6	8	1	4	3	7	2	5	6	8	1	4	3	7
AP79	Port Selva	Female	ESP	Tourist	Near coast	Frequent		60-69			4	2	6	3	1	5	1	3	8	4	5	7	6	2	1	3	8	4	5	7	6	2
AAP80	Port Selva	Male	ESP	Local	Coastal	Not born loca	Indifferent	50-59	Prof./Tech.	No income	1	2	3	6	4	5	2	1	5	3	4	6	7	8	2	1	5	3	4	6	7	8
AP81	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	80-89	Middle Sch.	35-56	1	2	5	4	3	6	1	4	7	2	3	5	8	6	1	4	7	2	3	5	8	6
AP85	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	18-29	Prof./Tech.	<14	4	3	2	1	5	6	1	7	8	4	2	5	6	3	1	7	8	4	2	5	6	3
AP86	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Joy	18-29	High Sch.	No income	3	4	2	1	5	6	6	7	8	5	3	2	1	4	6	7	8	5	3	2	1	4
AP87	Port Selva	Female	ESP	Tourist	Near coast	First timer	Joy	18-29	University	14-35	3	2	1	4	6	5	1	6	7	8	3	5	4	2	1	3	7	8	2	4	5	6
AP88	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	18-29	University	14-35	3	4	2	1	6	5	7	5	8	1	2	6	4	3	8	5	7	1	2	6	4	3
AP91	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	70-79	University	35-56	5	1	2	3	4	6	2	6	5	4	7	3	1	8	1	3	7	2	4	5	6	8
AP92	Port Selva	Male	ESP	Tourist	Inland	First timer	Joy	18-29	High Sch.	No income	6	3	1	2	4	5	5			2	6	1	3	4	1			4	6	2	3	5
AP93	Port Selva	Female	ESP	Tourist	Coastal		Strong	18-29	University	No income	4	1	3	2	5	6	4	8	7	6	5	1	2	3	2	8	7	6	5	4	1	3
AP94	Port Selva	Male	ESP	Tourist	Inland	Infrequent	Joy	30-39	University		4	3	2	1	5	6	7	6	8	3	4	1	2	5	1	7	8	4	5	2	3	6
AP95	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Need	50-59	Master	>56	2	6	1	5	3	4	2	1	5	6	7	3	4	8	1	2	7	8	5	4	3	6
MR70	Roses	Female	ESP	Local	Coastal	Infrequent	Joy	50-59	No Sch.	<14	2	6	5	4	3	1	1	8	5	6	2	4	3	7								
MR72	Roses	Female	ESP	Local	Coastal	Born local	Strong	50-59	Middle Sch.	14-35	1	4	2	3	5	6	1	3	8	7	6	5	4	2	1	3	8	7	6	5	4	2
WR90	Roses	Female	FRA	Tourist	Inland	First timer	Joy	18-29	University	<14	4	3	2	1	5	6	1	6	8	7	5	2	3	4	1	2	3	7	6	8	5	4
WR91	Roses	Male	FRA	Tourist	Inland	Infrequent	Joy	18-29	Master	14-35	3	4	2	1	5	6	2	3	5	4	6	8	7	1	1	2	4	6	3	8	7	5
WR92	Roses	Male	FRA	Tourist	Near coast	First timer	Joy	30-39	Master	14-35	1	4	5	3	2	6	4	6	5	7	8	3	2	1	2	6	5	7	8	3	4	1
WR93	Roses	Female	ESP	Local	Coastal	Not born loca	Joy	50-59	University	14-35	1	4	6	5	2	3	6	2	8	3	1	4	7	5	1	3	4	5	6	2	8	7
WR93	Roses	Male	RUS	Tourist	Coastal	First timer	Joy	40-49	University	14-35	5	1	2	3	4	6	1	3	7	6	2	5	8	4	1	7	8	5	3	4	6	2
WR95	Roses	Female	ESP	Local	Coastal	Born local	Strong	60-69	University		1	5	4	3	2	6	1	7	8	6	2	3	5	4	1	7	8	6	2	3	5	4
WR97	Roses	Female	ESP	Local	Near coast	Born local	Joy	30-39	University		3	4	1	2			6	2	8	7	4	1	3	5	6	2	8	7	4	1	3	5
WR98	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	High Sch.	<14	4	2	1	3	5	6	8	5	6	4	7	3	2	1	8	3	2	1	4	5	7	6
WR99	Roses	Female	ESP	Local	Coastal	Born local	Joy	30-39	Primary Sch.	<14	4	3	2	1	5	6	5	1	2	3	4	7	8	6	5	8	1	4	3	6	2	7
MR115	Roses	Female	ESP	Local	Coastal	Born local	Strong	50-59	High Sch.	>56	4	3	1	2	5	6	1	5	6	7	4	8	3	2	1	6	5	8	3	7	4	2
MR116	Roses	Female	ESP	Local	Coastal	Born local	Need	50-59	Prof./Tech.	14-35	1	2	4	3	5	6																
MR118	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	University	14-35	4	3	2	1	5	6	3	4	5	2	1	7	8	6								
MR119	Roses	Female	ESP	Local	Coastal	Born local	Need	18-29	University	<14	3	4	2	1	5	6	3	4	5	2	1	7	8	6								
MR124	Roses	Female	DEU	Tourist	Near coast	First timer	Joy	18-29	Prof./Tech.	<14	4	1	2	3	6	5	7	6	8	5	2	4	3	1	3	7	8	6	2	5	4	1
MR123	Roses	Male	DEU	Tourist	Near coast	First timer	Joy	30-39	Prof./Tech.	14-35	2	4	1	3	6	5	2	5	8	6	1	7	4	3	1	3	8	7	2	6	5	4
MR125	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	Prof./Tech.	<14	2	3	1	4	6	5	6	4	8	5	1	3	7	2	6	3	8	7	1	2	4	5
MR124	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	Middle Sch.	<14	1	4	2	3	5	6	6	1	4	2	5	3	7	8	3	1	4	2	6	5	7	8
MR125	Roses	Female	ESP	Local	Coastal	Not born loca	Joy	60-69	Primary Sch.	14-35	1	2	3	4	5	6	1	8	2	7	6	3	4	5	7	6	8	1	3	5	4	2
MR122	Roses	Male	ESP	Local	Coastal	Infrequent	Joy	18-29	High Sch.	<14	4	3	2	1	5	6	2	3	5	6	1	8	7	4	2	3	5	4	1	7	6	8
MR127	Roses	Male	ESP	Local	Coastal	Born local	Need	30-39	University	14-35	4	5	1	2	3	6	1	2	5	4	3	7	8	6	1	2	4	5	3	7	8	6
MR128	Roses	Male	ESP	Tourist	Near coast	First timer	Need	30-39	Prof./Tech.	14-35	1	2	3	4	6	5	1	4	3	5	2	6	7	8	1	5	7	4	3	2	6	8
MR129	Roses	Female	ESP	Tourist	Near coast	First timer	Joy	30-39	University	35-56	4	2	3	1	5	6	6	7	5	4	8	3	2	1	6	7	5	4	8	3	2	1
WC71	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	40-49	Prof./Tech.	<14	1	2	4	3	6	5	8	5	7	6	4	1	2	3	5	4	8	7	6	2	1	3
WC72	Cadaqués	Female	ESP	Tourist	Near coast	Infrequent	Need	60-69	High Sch.		3	2	4	5	1	6	1	8	7	3	2	6	5	4	1	8	7	3	2	6	5	4
WC73	Cadaqués	Female	ESP	Local	Coastal	Born local	Joy	40-49	University	<14	3	1	6	2	4	5	1	6	8	2	3	4	5	7	1	2	8	3	7	4	5	6
WC74	Cadaqués	Female	ESP	Tourist	Coastal	Infrequent	Need	18-29	High Sch.	<14	1	4	2	3	5	6	8	4	7	3	6	5	2	1	3	2	5	4	1	6	7	8
ZR45	Roses	Female	ESP	Tourist	Coastal	First timer	Need	30-39	University	<14	6	3	2	1	4	5	6	7	8	2	4	5	3	1	1	7	6	4	5	8	3	2
ZR37	Roses	Female	FRA	Tourist	Inland	Frequent	Joy	40-49	University	14-35	3	4		5	2	1	4	7	8	6	3	2	5	1	4	6	8	7	3	2	5	1
ZR38	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	70-79	University	14-35	1	2	3	4	5	6	1			4	3			2	1			4	3			2
ZR39	Roses	Female	FRA	Tourist	Inland	First timer	Joy	40-49	Prof./Tech.	<14	4	5	1	6	2	3	2	5	3	4	1	6	7	8	2	5	3	4	1	6	7	8
ZR40	Roses	Female	FRA	Tourist	Near coast	Infrequent	Need	50-59	High Sch.	<14	2	1	3	4	5	6	1	2	8	5	6	7	4	3	2	3	8	4	5	7	6	1
ZR42	Roses	Female	FRA	Tourist	Inland	Frequent	Need	50-59	University	14-35	4	1	3	2	5	6	4	2	7	8	3	6	5	1	4	3	6	5	2			1
ZR43	Roses	Male	ESP	Tourist	Inland	First timer	Joy	18-29	University	14-35	3	5	4	6	1	2	5	2	1	3	6	7	4	8	8	1	5	4	6	2	3	7
ZR44	Roses	Female	ESP	Tourist	Inland	First timer	Joy	18-29	Master	35-56	4	3	2	1	5	6	2	3	8	7	5	1	4	6	1	3	8	7	5	2	4	6
MR270	Roses	Male	ESP	Local	Coastal	Born local	Strong	18-29	Prof./Tech.	<14	4	3	6	5	1	2	1	2	7	6	4	8	5	3	1	2	7	6	4	8	3	5
MR271	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	50-59	Prof./Tech.	<14	4	3	2	1	6	5	1	4	7	6	8	5	3	2	1	4	7	6	8	5	3	2
MR272	Roses	Female	ESP	Tourist	Coastal	First timer	Strong	18-29	High Sch.	<14	4	6	2	1	3	5	5	4	8	2	6	3	7	1	1	3	8	4	7	5	6	2
AR110	Roses	Male	FRA	Tourist	Coastal	Infrequent	Joy	60-69	High Sch.	14-35	4	2	1	3	5	6	6	4	7	3	5	8	1	2	1	5	4	6	8	7	2	3
AR111	Roses	Male	DEU	Tourist	Inland	Frequent	Joy	50-59	University		4	2	3	1	5	6	8	7	6	3	4	2	1	5	8	7	6	3	4	2	1	5
AR112	Roses	Female	FRA	Tourist	Near coast	Infrequent	Strong	18-29	Prof./Tech.	<14	1	3	4	6	5	2	5	4	8	6	3	7	2	1	5	4	8	6	3	7	2	1
AR113	Roses	Female	CHE	Tourist	Inland	Frequent	Joy	30-39	Prof./Tech.	<14	1	3	5	4	6	2	4	7	8	2	3	6	5	1	2	7	8	6	1	5	3	4
AR114	Roses	Female	ESP	Local	Coastal	Born local	Strong	18-29	University	<14	2	5	4	3	6	1	1	5	7	6	2	8	4	3	1	5	7	6	2	8	4	3
AR115	Roses	Female	ESP	Local	Coastal	Born local	Strong	60-69	High Sch.	14-35	2	3	4	5	6	1																
AR116	Roses	Male	ESP	Local	Coastal	Born local	Joy	30-39	Prof./Tech.	14-35	3	4	1	2	5	6	2	6	8	3	1	4	7	5	2	6	8	3	1	4	7	5
AR117	Roses	Female	FRA	Tourist		First timer	Joy	18-29	University	14-35	1	2	6	4	5	3	8	3	2	4	5	7	6	1	8	3	2	4	5	7	6	1
AR119	Roses	Female	FRA	Tourist	Inland	First timer	Joy	18-29	Master	14-35	1	3	2	4	5	6	5	6	8	4	1	3	7	2	5	6	8	4	1	3	7	2
AR120	Roses	Male	FRA	Tourist	Inland	Frequent	Need	50-59	University	35-56	1	4	5	2	3	6	6	5			3	1	2	4								
AR121	Roses	Male	FRA	Tourist	Inland	Frequent	Need	70-79	Middle Sch.	14-35	3	4	2	1	5	6	7	6	5	8	3	4	2	1								
AR123	Roses	Female	ESP	Local	Coastal	Infrequent	Avoid	50-59	University	14-35	3	4	5	6	2	1	7	8	6	4	3	5	2	1	7	8	6	4	3	5	2	1
AC96	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Indifferent	40-49	High Sch.	35-56	6	4	5	3	1	2	8	6	7	3	4	5	1	2	5	6	7	3	4	8	1	2
AC97	Cadaqués	Female	ESP	Tourist	Near coast	First timer	Joy	40-49	University	14-35					1	2	6			2	3	4	1	5	6			2	3	4	1	5
AC98	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	60-69	Master	14-35	2	5	3	1	4	6	1			6	5	3	4	2	1			6	5	3	4	2
AC99	Cadaqués	Female	BEL	Tourist		Infrequent	Strong	30-39	High Sch.	35-56	2	3	5	1	6	4	4	6	5	8	3	7	1	2	4	6	5	8	3	7	1	2
AC100	Cadaqués	Female	ESP	Tourist	Coastal	Infrequent	Joy	50-59	University		1	3	4	2	5	6	1	7	8	6	3	2	5	4	1	7	8	6	3	2	5	4
AC101	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	30-39	University	14-35	4	3	2	1	5	6	3	8	4	5	3	1	2	6	3	8	4	5	3	1	2	6
AC102	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Need	40-49	Master	14-35	6	4	3	1	2	5	1	4	5	8	2	7	6	3	1	4	5	8	2	7	6	3
AC103	Cadaqués	Female	ESP	Tourist	Inland	Frequent	Joy	60-69	University		4	5	6	1	2	3					4	3	1	2					4	2	1	3
WR80	Roses	Female	ESP	Local	Coastal	Born local	Joy	50-59	Middle Sch.	14-35	1	3	2	4	6	5	1	4	8	5	2	3	6	7	1	3	8	2	4	5	7	6
WR81	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	<14	4	1	2	3	5	6	1	4	5	6	2	7	8	3	2	8	5	6	4	1	7	3
WR82	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	30-39	University	35-56	2	6	1	4	5	3	6	5	7	5	1	4	2	3	6	5	7	5	1	4	2	3
WR83	Roses	Male	FRA	Tourist	Inland	Infrequent	Need	40-49	High Sch.	35-56	5	1	3	4	2	6	3	8	7	5	1	2	6	4	3	8	7	5	1	2	6	4
WR84	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	40-49	Master	35-56		2	3	1	4		7	6	5		4	2	3	1	7	6	5		4	2	3	1
WR85	Roses	Female	ESP	Local	Coastal	Born local	Strong	30-39	Middle Sch.	<14	4	6	5	1	2	3	1				2			3	1				2			3
WR86	Roses	Male	ESP	Local	Coastal	Infrequent	Joy	18-29	Middle Sch.		4	3	2	1	5	6	1	8	7	5	2	4	6	3	1	8	7	6	2	3	4	5
WR87	Roses	Male	CHE	Tourist	Inland	First timer	Joy	18-29	Prof./Tech.		1	2	3	5	6	4	1	4	8	5	2	7	3	6	1	4		5	2	7	3	6
WR88	Roses	Female	ESP	Tourist	Inland	First timer	Strong	30-39	University	No income	4	1	2	3	6	5	1	2	6	8	3	5	4	7	1	2	6	8	3	5	4	7
WR89	Roses	Male	FRA	Tourist	Inland	Frequent	Need	70-79	Prof./Tech.			3	1	2	4	5	1	4	5	8	3	6	2	7	1	4	5	8	3	6	2	7
MR79	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	High Sch.	<14	5	6	3	1	2	4																
MR75	Roses	Male	ESP	Local	Coastal	Born local	Strong	60-69		35-56	2	3	1	4	5	6	8	5	4	6	3	7	1	2	7	6	2	8	1	4	5	3
MR77	Roses	Female	ESP	Local	Coastal	Born local	Strong	40-49	Prof./Tech.	14-35	1	4	2	3	6	5	4	5	3	8	1	6	7	2	3	5	1	8	2	7	6	4
MR78	Roses	Female	ESP	Local	Coastal	Born local	Strong	40-49	University	35-56	3	2	1	4	6	5	3	6	8	5	1	7	2	4	3	5	7	4	1	8	2	6
MR80	Roses	Male	ESP	Local	Coastal	Born local	Strong	40-49	High Sch.	14-35	1	6	5	4	3	2	4	3		5	2	6	7	1								
MR81	Roses	Female	ESP	Local	Coastal	Born local	Strong	40-49	High Sch.	14-35	3	2	4	1	6	5	3	5	4	8	1	7	6	2	1	6	4	5	3	8	7	2
MR82	Roses	Male	ESP	Tourist	Coastal	Infrequent	Need	18-29	Master	14-35	6	5	2	1	3	4	8	1	7	4	5	6	3	2	3	7	4	2	5	8	1	6
MR83	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	60-69	Prof./Tech.	14-35	2	3	6	1	4	5	1	7	6	2	3	5	8	4								
MR84	Roses	Female	ESP	Local	Coastal	Born local	Need	18-29	Master	14-35	4	3	1	2	5	6	2	4	8	6	3	7	5	1	1	4	8	6	3	7	5	2
MR85	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	High Sch.	No income	3	4	2	1	5	6	2	7	8	5	4	6	3	1	1	7	8	4	5	6	3	2
MR89	Roses	Female	ESP	Local	Coastal	Born local	Joy	40-49	High Sch.	<14	5	3	1	2	4	6																
AR56	Roses	Female	ESP	Local	Coastal	Born local	Strong	40-49	Prof./Tech.		5	6	3	1	4	2	3	5	8	6	1	4	7	2	3	5	8	6	1	4	7	2
AR57	Roses	Male	ESP	Tourist	Near coast	Infrequent	Joy	30-39	Primary Sch.	<14	4	1	6	3	5	2	5	6	8	7	3	4	2	1	5	6	8	7	3	4	2	1
AR58	Roses	Male	ESP	Local	Coastal	Born local	Strong	18-29	Prof./Tech.	<14	4	3	2	1	6	5	1	3	8	6	4	5	7	2	1	3	8	6	4	5	7	2
AR59	Roses	Female	FRA	Tourist		First timer	Need	18-29	No Sch.	No income	2	3	1	4	6	5	1	2	6	7	5	8	3	4	1	2	6	7	5	8	3	4
AR60	Roses	Male	ESP	Local	Coastal	Born local	Strong	18-29	Prof./Tech.	<14	1	5	2	3	4	6	2	2	4	8	7	3	6	1	5	1	3	8	6	2	5	7	4
AR64	Roses	Female	ESP	Tourist	Inland	Infrequent	Joy	18-29	University	No income	4	3	2	1	6	5	2	2	7	8	6	1	5	3	4	1	7	8	6	2	5	3	4
AR65	Roses	Female	ESP	Tourist	Coastal	First timer	Need	18-29	High Sch.	No income	2	3	1	4	5	6	2	5	7	3	6	4	8	1	1	6	5	4	2	3	8	7
AR66	Roses	Male	ESP	Tourist	Inland	First timer	Need	18-29	High Sch.	No income	6	4	1	2	5	3	8	3	4	2	1	5	7	6	8	6	2	7	1	5	4	3
AR67	Roses	Male	FRA	Tourist	Inland	Infrequent	Need	40-49	University	>56	6	5	3	4	1	2	5	6			1	4	2	3	1	6			2	5	3	4
AR68	Roses	Female	ESP	Local	Coastal	Born local	Joy	40-49	High Sch.	<14	6	5	4	3	2	1	1	4	8	5	3	6	7	2								
AR69	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	50-59	High Sch.	14-35	1	2	3	4	5	6	8	5	7	4	3	2	6	1	8	5	7	4	3	2	6	1
AR70	Roses	Female	ESP	Local	Coastal	Born local	Strong	50-59	Middle Sch.	14-35	4	1	2	3	6	5	8	7	6	5	2	4	3	1	8	7	6	5	2	4	3	1
AR71	Roses	Female	ESP	Local	Coastal	Not born loca	Joy	70-79	No Sch.	No income	1	3	4	2	6	5	3	2	5	4	1	6	8	7	3	2	5	4	1	6	8	7
AR72	Roses	Female	ESP	Tourist	Coastal	Frequent	Strong	50-59	Prof./Tech.	35-56	2	4	1	2	3	5	4	7	5	6	2	8	1	3	1	7	6	4	3	8	2	5
MP40	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	18-29	Middle Sch.	No income	1	2	3	4	6	5	1	5	4	6	2	8	7	3	1	8	7	6	3	5	4	2
MP41	Port Selva	Female	ESP	Local	Near coast	Born local	Strong	50-59	PhD	14-35	4	1	2	3	5	6	8	6	7	3	4	5	2	1	3	4	8	5	7	6	2	1
MP42	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	40-49	Prof./Tech.	14-35	6	1	2	3	4	5	7	1	8	6	5	4	3	2	5	2	8	6	7	3	1	4
MP43	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	18-29	High Sch.	<14	4	2	3	1	6	5	4	3	6	1	5	2	8	7								
MP44	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	40-49	Prof./Tech.	<14	2	1	4	3	5	6	4	5	6	3	1			2	1	5	6	4	3	7		2
MP46	Port Selva	Female	ESP	Local	Coastal	Born local	Need	90	University	14-35							2	1	3	4			5									
MP47	Port Selva	Female	ESP	Local	Coastal	Born local	Joy	18-29	Master	<14	4	3	2	1	5	6	6	7	8	5	3	4	1	2	1	7	8	6	5	4	2	3
MP48	Port Selva	Female	ESP	Local	Coastal	Infrequent	Joy	30-39	Middle Sch.	<14	2	1	3	4	5	6	1	5	3	6	2			4	1		4		2			3
MP51	Port Selva	Female	ESP	Local	Coastal	Born local	Strong	40-49	Middle Sch.	14-35	2	4	3	1	6	5	1	2	8	3	6	7	4	5	1	2	3	4	7	8	5	6
MP52	Port Selva	Female	ESP	Tourist	Coastal	First timer	Joy	50-59	University	35-56	3	4	6	5	2	1	8	7	4	3	5	2	6	1	8	7	4	3	5	2	6	1
MP53	Port Selva	Female	ESP	Tourist	Inland	Frequent	Strong	40-49	Master	>56	4	1	2	3	5	6	1	2	5	3	4	6	7	8	1	2	6	7	3	4	8	5
MC50b	Cadaqués	Female	ESP	Local	Coastal	Born local	Strong	30-39	High Sch.	14-35	1	4	2	3	5	6	2	3	8	7	5	6	4	1	2	5	8	7	3	4	6	1
MC52b	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	40-49	University	14-35	3	4	2	1	6	5	4	2	7	3	5	8	6	1	3	2	7	4	5	8	3	1
MC53b	Cadaqués	Female	ESP	Tourist	Coastal	First timer	Strong	18-29	University	No income	5	2	1	3	4	6	3	1	8	5	6	7	2	4	2	1	8	4	7	5	3	6
MC56	Cadaqués	Female	ESP	Local	Coastal	Not born loca	Strong	60-69	University	14-35	5	4	2	1	3	6	6	7	8	4	3	5	2	1	4	5	6	3	7	8	2	1
MC57	Cadaqués	Male	ESP	Local	Coastal	Infrequent	Need	40-49	Middle Sch.	<14	4		2	3	1	5	3	5	8	2	1	6	7	4	3	5	8	2	1	6	7	4
MC58	Cadaqués	Male	ESP	Local	Coastal	Born local	Strong	40-49	University	35-56	5	3	2	1	4	6	4	7	8	6	5	2	3	1	1	2	8	7	3	6	4	5
MC59	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Need	30-39	Master	<14	2		3	1	5	4	8	7	6	5	4	1	3	2	8	7	6	4	5	1	3	2
MC60	Cadaqués	Male	ESP	Tourist	Inland	Frequent	Need	30-39	Master	<14	3	2	1	4	6	5	3	3	4	6	5	7	1	2	8	1	3	5	6	2	4	8	7
MC61	Cadaqués	Male	ESP	Local	Coastal	Born local	Indifferent	18-29	Middle Sch.	No income	3	5	1	6	4	2	3	2	7	5	1	4	8	6	2	4	6	7	1	8	5	3
MC62	Cadaqués	Female	ESP	Local	Coastal	Born local	Joy	18-29	High Sch.	No income	4	3	2	1	6	5	1	4	6	8	2	3	5	7	1	4	5	2	6	3	7	8
WP01	Port Selva	Male	ESP	Local	Coastal	Born local	Joy	70-79	Master	35-56	5	3	4	1	2	6	8	6	7	1	2	3	4	5	1	2	6	4	5	7	3	8
WP04	Port Selva	Female	FRA	Tourist	Inland	First timer	Joy	40-49	Master	14-35	4	3	5	6	2	1	5	7	1	2	6	4	3	8	8	5	6	1	7	4	3	2
WP05	Port Selva	Male	GBR	Tourist	Near coast	Frequent	Joy	30-39	Prof./Tech.	14-35	4	5	6	1	2	3	1	2	7	8	4	5	3	6	1	2	7	8	4	5	3	6
WP06	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	70-79	Master	35-56	4	3	2	1	6	5																

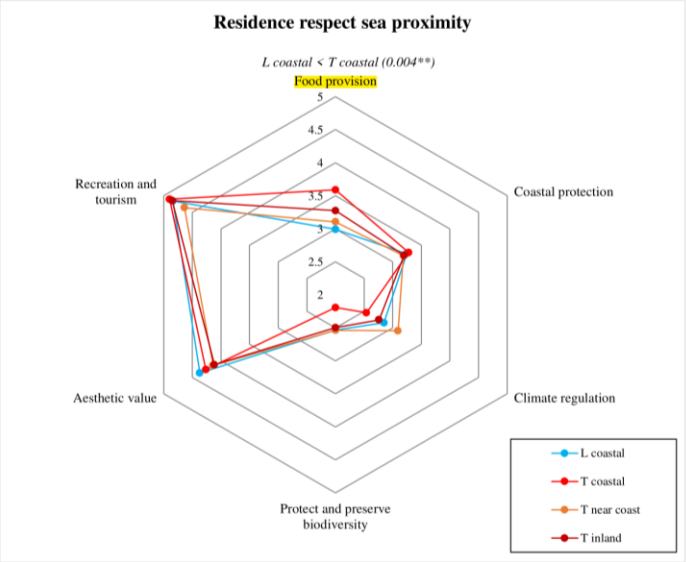
				Sociodemographic parameters								Benefits						Impacts								Threats							
Code	Place of interview	Gender	Country	Residence Local / Tourist	respect sea & proximity	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Food provision	Coastal protection	Climate regulation	Protect preserve biodiversity	Aesthetic value	Recreation & tourism	Climate change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour	Climate Change	Overfishing	Invasive marine species	Boat transit & anchoring	Inland pollution to the sea	Coastal construction & modification	Mass Tourism	People's behaviour
WR40	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	50-59	High Sch.	<14	1	4	5	3	6	2	1	6	8	4	2	5	7	3	1	6	8	4	2	5	7	3
WR41	Roses	Female	ESP	Tourist	Near coast	First timer	Joy	50-59	Prof./Tech.	<14	3	4	5	1	6	2	5	6	4	3	2			1	5	6	4	3	2			1
WR42	Roses	Male	ESP	Local	Coastal	Not born loca	Indifferent	30-39	Middle Sch.		6	1	3	2	4	5	2	3	4	8	5	6	7	1	1	4	5	7	8	3	6	2
WR43	Roses	Female	ESP	Local	Coastal	Not born loca	Joy	40-49	Prof./Tech.		1	3	4	2	5	6	1	5		7	2	6	3	4	1	5		7	2	6	3	4
WR45	Roses	Male	FRA	Tourist	Inland	Frequent	Joy	50-59	Prof./Tech.	14-35	1	5	4	2	3		1	8	7	6	2	3	4	5	1	8	5	3	4	6	2	7
WR46	Roses	Male	ESP	Local	Coastal	Born local	Strong	18-29	High Sch.	14-35	3	4	2	1	5	6	6	1	8	4	3	5	2	7	1	5	8	3	2	7	4	6
WR47	Roses	Female	ESP	Local	Coastal	Born local	Need	50-59	Middle Sch.		1	5	3	2	4	6	5	4	6	1	7	2		3	5	4	6	1	7	2		3
WR48	Roses	Female	ESP	Tourist	Coastal	Frequent	Need	18-29	Master	14-35	4	1	5	3	2	6	4	7	5	8	3	1	2	6	1	7	4	8	3	5	6	2
WR49	Roses	Female	ESP	Local	Coastal	Born local	Joy	18-29	University	<14	3	2	6	1	3	4	6	1	8	5	7	4	2	3	2	1	8	5	7	4	3	6
WR50	Roses	Male	ESP	Tourist	Near coast	Frequent	Joy	40-49	Master	14-35	4	2	3	1	5	6	2	5	7	4	1	8	6	3	2	4	5	7	1	8	6	3
WR51	Roses	Female	ESP	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	14-35	3	4	1	2	5	6	2	3	7	5	1	6	8	4	1	6	7	5	3	4	8	2
WR52	Roses	Male	ESP	Local	Coastal	Not born loca	Strong	60-69	High Sch.		2	3	4	1	5	6	1	2	7	8	5	6		4	1	2	7	8	5	6		4
AC29	Cadaquès	Male	GBR	Tourist	Inland	First timer	Joy	18-29	High Sch.	No income	4	6	3	5	1	2	8	4	5	6	7	2	1	3	2	5	6	7	8	4	1	3
AC31	Cadaquès	Female	GBR	Tourist	Near coast	Infrequent	Need	50-59	University		1	2	6	3	4	5	8	2	4	5	7	6	5	8	7	2	4	5	7	6	2	8
AC32	Cadaquès	Female	BEL	Tourist	Near coast	Frequent	Need	18-29	Prof./Tech.	14-35	1	3	2	4	5	6	3	2	1	4	6	8	7	5								
AC33	Cadaquès	Male	USA	Tourist	Inland	First timer	Joy	70-79	University	>56	2	3	4	1	5	6	1	2	4	5	3	6	8	7								
AC34	Cadaquès	Male	FRA	Tourist	Inland	First timer	Joy	40-49	Master	<14	3	1	2	4	5	6	8	7	6	5	2	4	3	1	1	8	7	6	3	5	4	2
AC35	Cadaquès	Female	ESP	Local	Coastal	Born local	Joy	60-69	University	35-56	6	5	3	2	1	4	1	5	2	4	3	6	8	7								
AC36	Cadaquès	Female	FRA	Tourist	Inland	Frequent	Indifferent	70-79	University	14-35	1	5	6	2	3	4	8	1	4	5	2	6	7	3	1	4	5	6	2	3	7	8
AC37	Cadaquès	Male	ESP	Tourist	Coastal	Frequent	Need	70-79	University	14-35	4	5	6	3	1	2	7	1	2	6	3	8	4	5	7	1	2	6	3	8	4	5
AC38	Cadaquès	Female	ESP	Tourist	Near coast	First timer	Joy	30-39	Prof./Tech.	14-35	2	5	6	1	3	4	4	6	8	3	2	5	1	7	6	2	8	5	3	4	1	7
AC39	Cadaquès	Male	ESP	Tourist	Near coast	First timer	Need	40-49	University	14-35	4	3	1	2	5	6	6	7	8	4	3	2	1	5	1	6	8	5	3	4	2	7
AC40	Cadaquès	Female	ESP	Local	Coastal	Born local	Joy	50-59	University	14-35	6	5	4	3	1	2	7	8	6	1	3	2	5	4	1	4	5	7	3	2	6	8
AC41	Cadaquès	Female	ESP	Local	Coastal	Born local	Joy	40-49	Primary Sch.		2	4	3	1	5	6	4	1	2	8	7	6	3	5	4	1	2	8	7	6	3	5
AC42	Cadaquès	Female	ESP	Local	Coastal	Born local	Strong	18-29	University	<14	4	3	1	2	5	6	1	2	6	7	3	4	5	8	1	2	7	6	4	3	5	8
AC43	Cadaquès	Female	GBR	Tourist	Inland	First timer	Need	18-29	High Sch.	No income	2	4	1	5	3	6	3	4	8	2	1	6	5	7	1	3	8	2	4	6	5	7
AC45	Cadaquès	Male	ESP	Tourist	Near coast	Frequent	Need	30-39	Master	35-56	6	4	3	1	2	5	7	5	8	4	6	2	1	3	1	8	3	7	6	4	2	5
AC46	Cadaquès	Female	ESP	Tourist	Coastal	Infrequent	Strong	18-29	Master	No income	4	2	3	1	5	6	4	3	5	8	2	1	7	6	1	4	6	7	3	2	8	5
AC47	Cadaquès	Male	ESP	Tourist	Near coast	First timer	Joy	40-49	Master	35-56	1	2	3	4	5	6	6	5	4	3	2	7	8	1	7	6	5	4	3	2	8	1
AC48	Cadaquès	Female	ESP	Tourist	Inland	First timer	Joy	50-59	Middle Sch.		1	2	3	4	5	6	6	7	8	5	4	2	1	3	6	7	8	5	4	2	1	3
AC49	Cadaquès	Female	ESP	Tourist	Near coast	Frequent	Joy	50-59	University	14-35	4	3	2	1	5	6	3	7	4	1	5	6	2	8	1	5	3	2	6	8	7	4
AC50	Cadaquès	Female	FRA	Tourist	Near coast	First timer	Joy	50-59	High Sch.	14-35	4	1	2	3	5	6																
AC51	Cadaquès	Male	ESP	Local	Coastal	Born local	Indifferent	40-49	High Sch.	14-35	2	1	3	4	5	6	1	8	7	2	3	4	5	6	1	8	7	2	3	4	5	6
AC52	Cadaquès	Male	ESP	Tourist	Near coast	First timer	Need	30-39	Prof./Tech.	<14	3	4	6	2	5	1																
AC54	Cadaquès	Female	FRA	Tourist		First timer	Need	30-39	University	<14	6	4	5	1	2	3	1	7	5	6	2	3	8	4	1	7	5	6	2	3	8	4
AC55	Cadaquès	Female	ESP	Local	Coastal	Born local	Need	60-69	University		1	2		3	4	5	5	7	6	8	4	3	1	2	4	5	7	8	6	3	1	2
WC20	Cadaquès	Female	FRA	Tourist	Inland	Frequent	Joy	60-69	Middle Sch.	14-35	2	1	4	3	5	6	1	8	7	6	2	3	5	4	1	8	7	6	2	3	5	4
WC21	Cadaquès	Female	FRA	Tourist	Inland	Infrequent	Strong	50-59	High Sch.	14-35	1	2	4	3	5	6	1	7	8	6	2	3	4	5	1	5	8	7	2	6	3	4
WC22	Cadaquès	Male	FRA	Tourist	Inland	Infrequent	Strong	50-59	Prof./Tech.	14-35	2	3	4	1	6	5	6	2	8	7	1	5	3	4	6	2	8	7	1	5	3	4
WC23	Cadaquès	Female	ESP	Tourist	Near coast	First timer	Need	30-39	University	14-35	3	4	6	1	5	2	7	6	8	3	2	1	4	5	7	6	8	3	1	2	5	4
WC24	Cadaquès	Female	ESP	Tourist	Near coast	First timer	Joy	30-39	Master	<14	3	4	5	1	6	2	4	2	1	3	8	7	5	6	6	2	1	3	8	7	4	5
WC25	Cadaquès	Female	FRA	Tourist	Inland	Infrequent	Joy	60-69	Prof./Tech.	14-35	4	2	3	1	5	6	3	5	8	6	1	4	2	7	5	4	6	2	8	1	3	7
WC26	Cadaquès	Female	FRA	Tourist	Inland	First timer	Joy	40-49	University		5	3	1	2	4	6	1	6	8	7	5	4	2	3	3	4	7	8	6	5	2	1
WC27	Cadaquès	Male	NLD	Tourist	Near coast	Frequent	Joy	60-69	Prof./Tech.	>56	4	2	1	3	6	5	2	3	5	4	7	6	8	1	2	3	5	4	7	6	8	1
WC28	Cadaquès	Male	HUN	Tourist	Inland	First timer	Joy	50-59	Master	14-35	4	3	1	2	5	6	1	3	7	8	6	5	4	2	1	7	5	6	2	3	8	4
WC30	Cadaquès	Female	ESP	Tourist	Near coast	Infrequent	Joy	50-59	Master	14-35	4	3	1	2	5	6	5	3	6	4	7	2	1	8	1	2	4	5	3	6	7	8
WC31	Cadaquès	Male	FRA	Tourist	Near coast	First timer	Joy	40-49	Master		1	5	2	4	3	6	2	3	7	8	4	5	6	1	1	3	7	6	2	5	8	4
WC33	Cadaquès	Female	ESP	Local	Coastal	Born local	Strong	30-39	University		2	3	4	1	5	6	6	5	8	2	3	7	4	1	1	6	8	2	4	7	5	3
WC34	Cadaquès	Female	ESP	Local	Coastal	Born local	Joy	80-89	Primary Sch.		1		2	3		4	3				4	2		1	3				4	2		1
WC35	Cadaquès	Male	ESP	Local	Coastal	Born local	Indifferent	70-79	Primary Sch.	35-56	6	2	3	1	5	4	3		2	4				1	1		2	4				3
WC37	Cadaquès	Male	ESP	Local	Coastal		Joy	60-69	High Sch.	<14	1	5	4	2	3	6	2	3	7	5	1	8	6	4	1	3	7	5	2	8	6	4

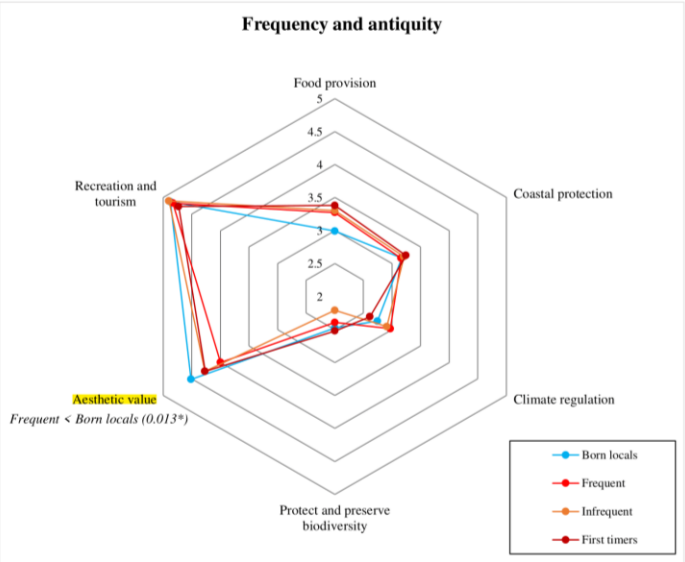
Supplementary material 4. Answers of the semi-structured interviews corresponding to negative environmental impacts. Rows refer to impacts and columns to informants.

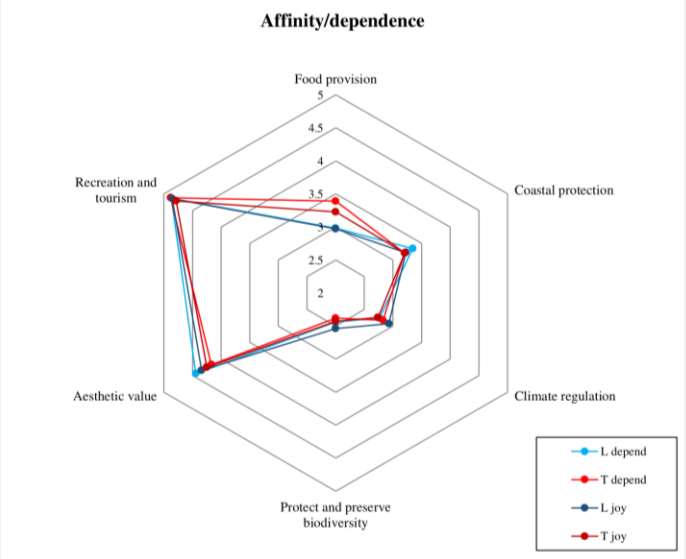
		Interview #																																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Total	Impact/threat in the survey
Type of change (now compared with the past, except contradicted)	Weather and/or climate changed. Climate extreme events affectation		x		x					x				x																		x		x						6	Climate change
	Past nostalgia of aesthetic value of nature		x																x													x								3	*(type of change without an impact related)*
	More invasive species				x															x							x			x				x						5	Invasive marine species
	Overfishing		x		x								x															x	x	x										6	Overfishing
	Increase marine contamination														x																									1	Inland pollution that ends up in the sea
	Beach and/or coast construction and/or lack of maintenance					x					x								x									x				x								5	Coastal construction and modification
	Species decrease and depletion		x		x								x	x	x	x	x		x								x	x	x	x		x		x		x		x		16	*(type of change without an impact related)*
	Tourism affecting nature					x	x				x							x														x				x				6	Mass tourism
	More vessel transit and/or more anchoring						x						x		x												x							x						5	Habitat degradation due to boat transitand anchoring
	Lack of environmental awareness and damaging environmental behaviour										x		x													x	x	5	x			x				x		x		9	People's irresponsible behaviour/lack ofrespect towards nature
	Ineffective management of the Natural Park		x		x													x									5				x			x						6	*(type of change without an impact related)*
	Species sickness		x																															x						2	*(type of change without an impact related)*
	Quantity of changes reported per interview		6		5	2	2			1	3		4	2	3	1	1	2	3	1						1	5	4	3	3	1	6		6		3		2		70	

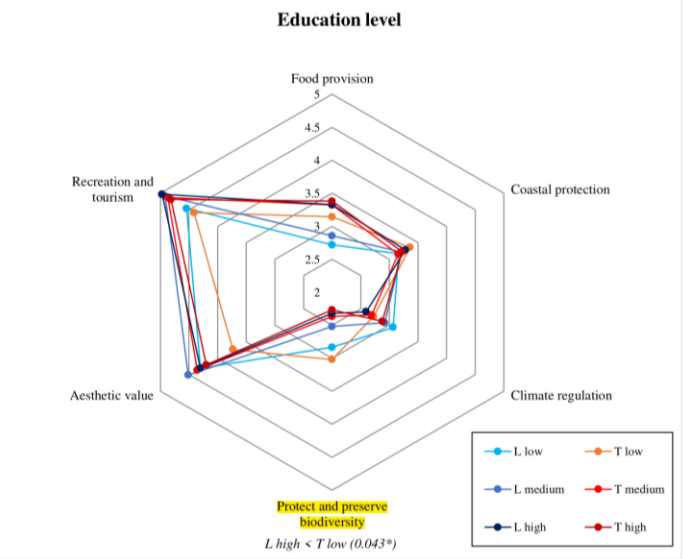
Supplementary material 5. Average rank values for locals and tourist subgroups with different socio-demographic characteristics. Concentric polygons represent the axis of the average values, where proximity to the centre means lower values, thus more beneficial/impactful/threatening and vice-versa. Each spike represents an item from the benefits, impacts, and threats questions. Items highlighted in yellow show significant differences between at least one local and tourist subgroup in the Kruskal-Wallis rank sum test (see Table 2). Close to the highlighted area, in italics, is written the local vs tourist subgroups that show significant differences between them as shown by a post-hoc Dunn test (p-value inside parenthesis: (*) $p < 0.05$, (**) $p < 0.01$). T = tourist (red range colours), L = local (blue range colours).

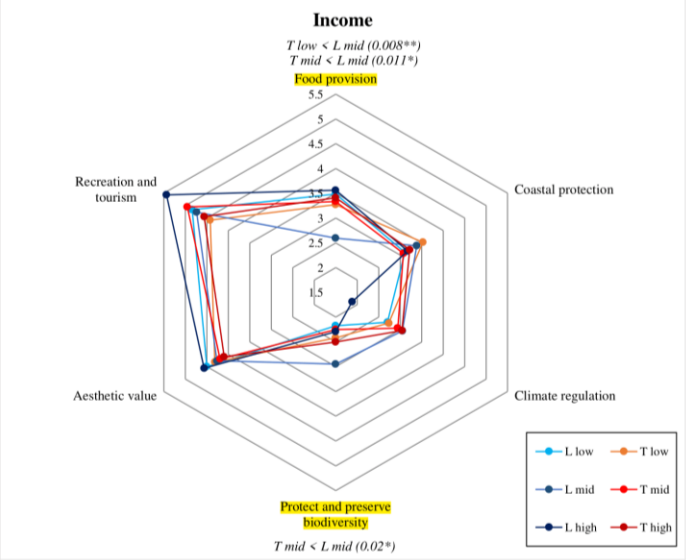
Benefits

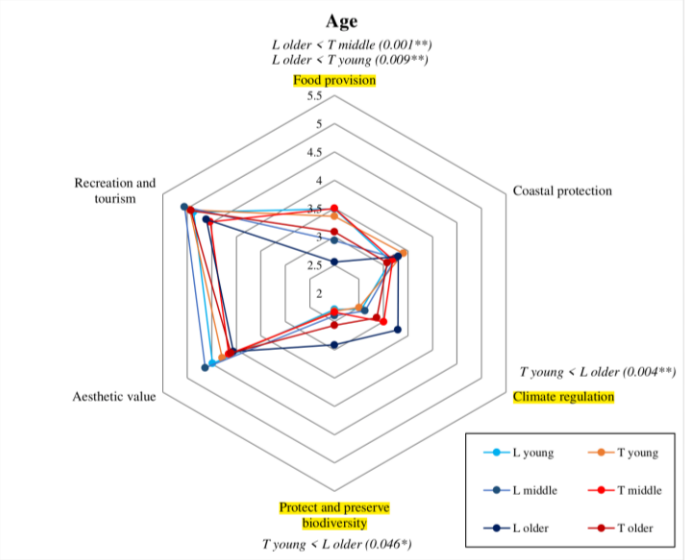

Residence respect sea proximity
L coastal < T coastal (0.004**)
Food provision
Coastal protection
Climate regulation
Protect and preserve biodiversity
Aesthetic value
Recreation and tourism
L coastal
T coastal
T near coast
T inland


Frequency and antiquity
Food provision
Coastal protection
Climate regulation
Protect and preserve biodiversity
Aesthetic value
Frequent < Born locals (0.013*)
Recreation and tourism
Born locals
Frequent
Infrequent
First timers

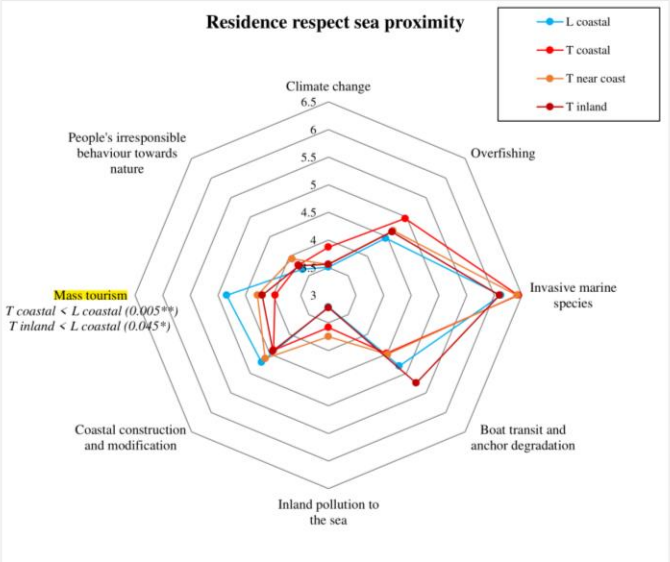

Affinity/dependence
Food provision
Coastal protection
Climate regulation
Protect and preserve biodiversity
Aesthetic value
Recreation and tourism
L depend
T depend
L joy
T joy

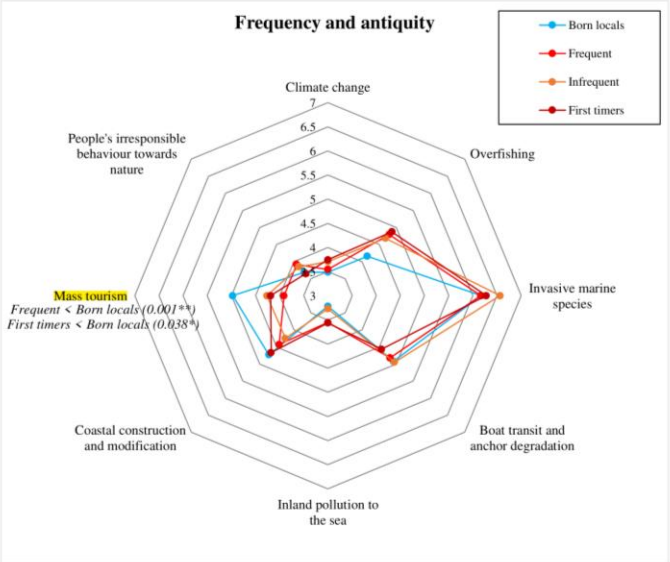

Education level
Food provision
Coastal protection
Climate regulation
Protect and preserve biodiversity
L high < T low (0.043*)
Aesthetic value
Recreation and tourism
L low
T low
L medium
T medium
L high
T high

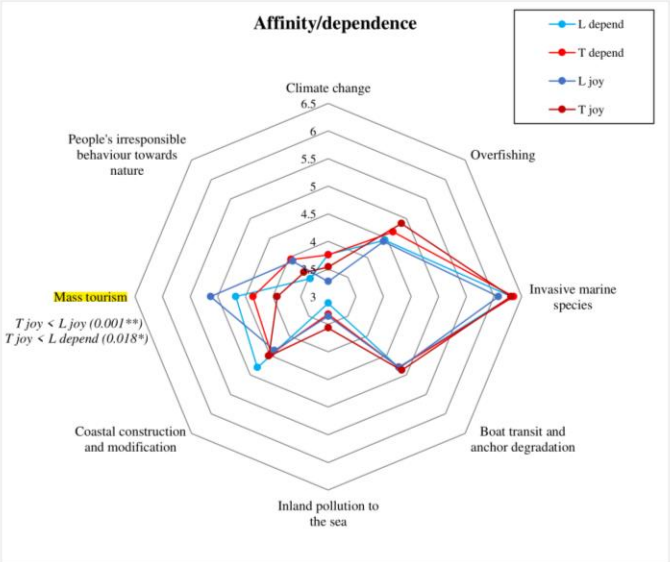

Income
T low < L mid (0.008**)
T mid < L mid (0.011*)
Food provision
Coastal protection
Climate regulation
Protect and preserve biodiversity
T mid < L mid (0.02*)
Aesthetic value
Recreation and tourism
L low
T low
L mid
T mid
L high
T high


Age
L older < T middle (0.001**)
L older < T young (0.009**)
Food provision
Coastal protection
T young < L older (0.004**)
Climate regulation
Protect and preserve biodiversity
T young < L older (0.046*)
Aesthetic value
Recreation and tourism
L young
T young
L middle
T middle
L older
T older

Impacts







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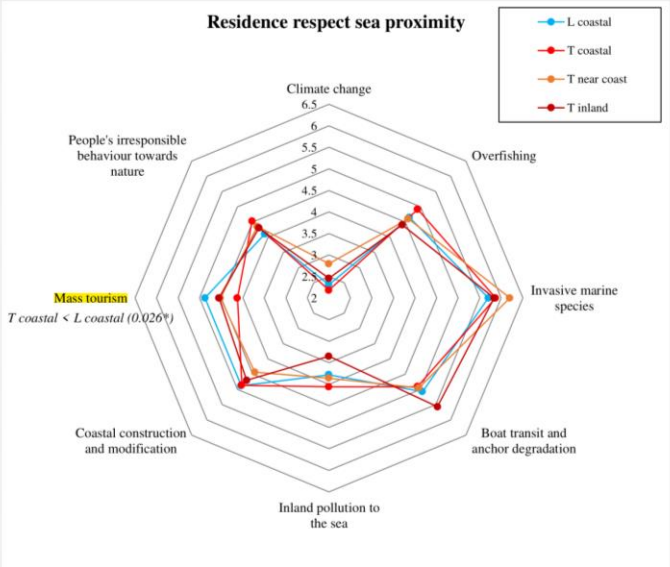

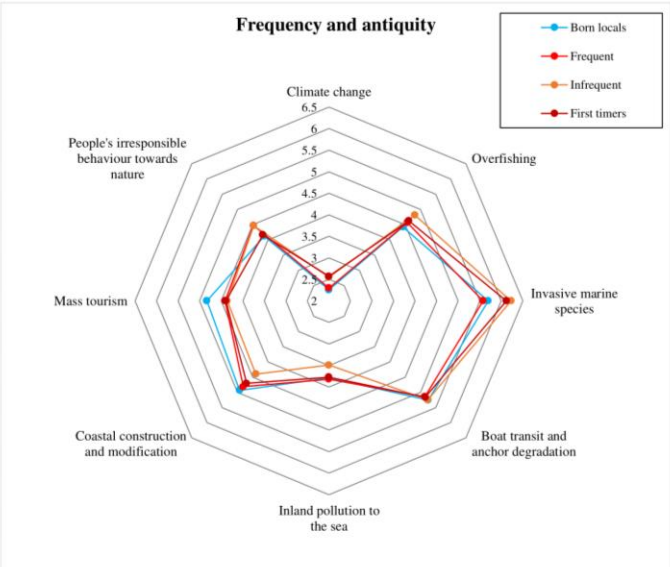

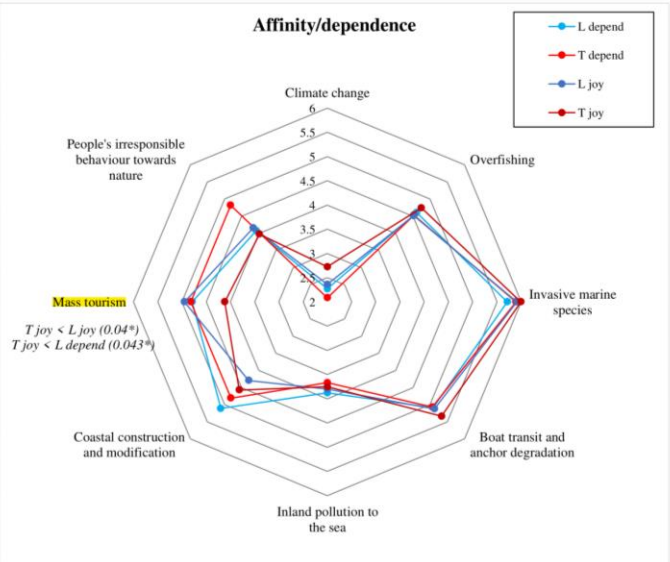

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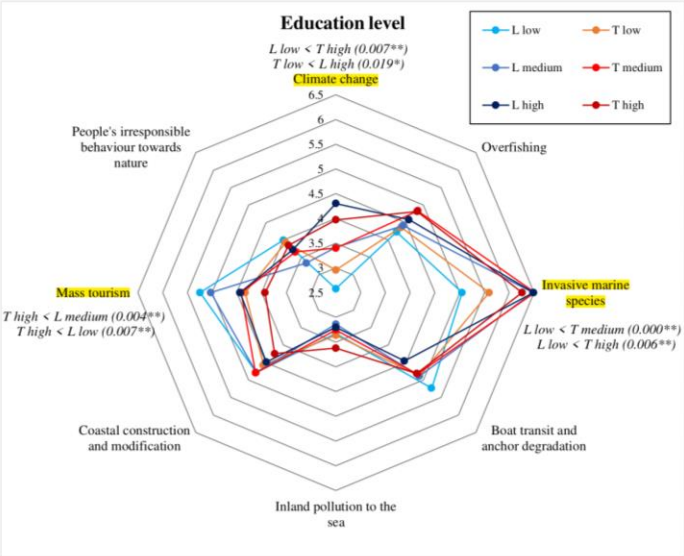

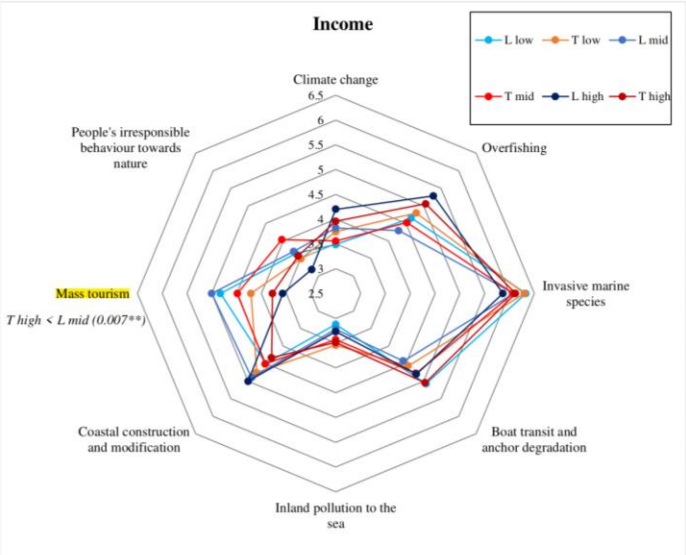

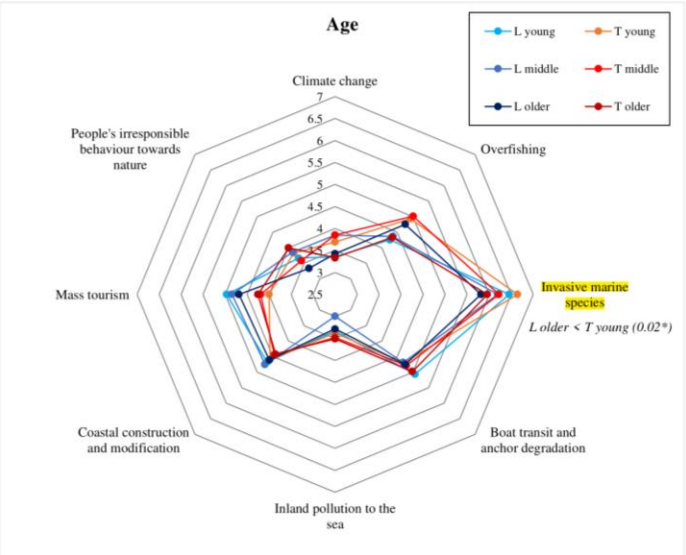

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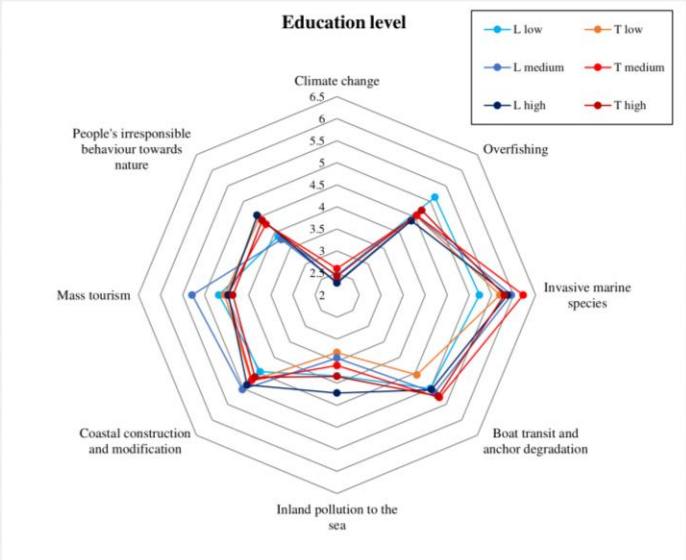

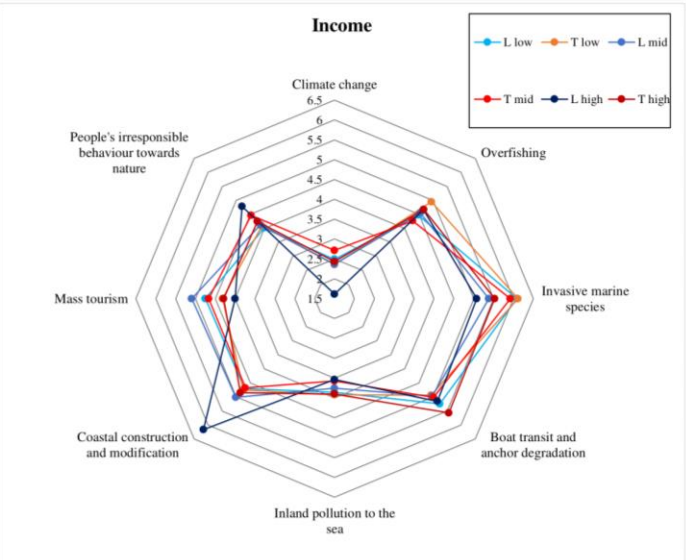

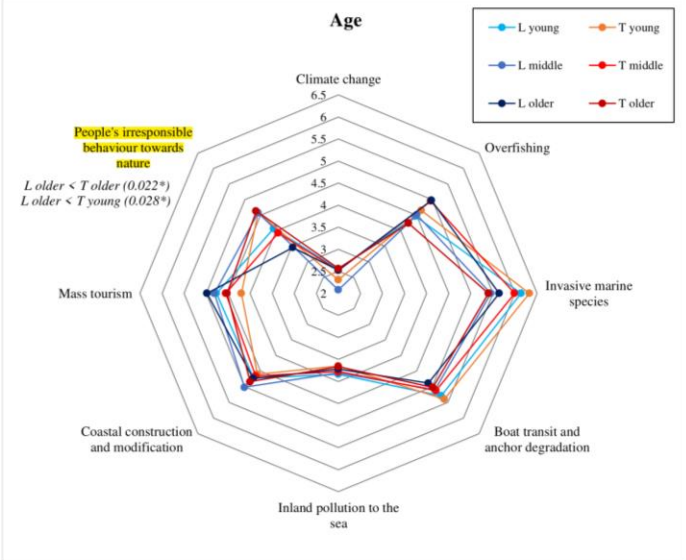

4 COASTAL MARINE HABITATS DETERIORATE IN CAP DE CREUS MARINE PROTECTED AREA (NE SPAIN) AS PERCEIVED BY THEIR USERS

At the time of the thesis submission, this chapter is not submitted nor published in a scientific journal.

Abstract

Assessing how different users of a Marine Protected Area (MPA) perceive local environmental changes can lead to more adequate conservation and management strategies. Individual perceptions of marine habitats is related with a person's willingness to engage or support conservation activities and respectful attitudes towards nature. We assess how local and foreign users of the Cap de Creus MPA perceive environmental changes of the coastal marine habitats. To reach that goal we carried out semi-structured interviews to local stakeholders (n = 38), where they listed perceived changes in the area trough time, and a survey to diverse MPA users (n = 427), where they confirmed the degree of agreement to statements related with past vs. present coastal marine habitat status. The interview results show that economic changes are the most reported, in contrast with the environmental changes, which are the least reported, probably because of society's paradigm based on the commodification and reification of nature plus the importance of economic changes generated through the tourism industry in the area. Our results also show that negative reports (i.e., worsening status) clearly dominate, and the overall trend in the survey responses shows an agreement towards deterioration over time of the coastal marine environment. Such results agree with regional and local scientific ecological data available. Finally, local inhabitants perceive a more acute deterioration of the coastal marine environment than tourists, probably because most local respondents seem to be more connected with nature (as reported in their sociodemographic data) and care more of their natural surroundings than tourists. Taking into account that Cap de Creus has been an MPA for more than two decades (1998), the results of this study raise concerns regarding the overall negative trends in coastal marine habitat health status, and with the ever-increasing human disconnection with nature.

4.1. Introduction

Human perception of the surrounding environment is a complex process. Indeed, through our senses, we only process a small fraction of all the stimuli around, which we internally interpret judging their relevance, resulting in a subjective and limited representation of reality (Silva et al. 2016; Gärling and Golledge 1989; Ittelson 1973). In that sense, environmental perception, defined by Bell (2001) as the « *apprehension of the external world through the senses, guided by physical and psychological elements* », is of abstract nature and influenced by many factors. Research shows that individuals' physiological and biological characteristics (e.g., age, gender, height, weight, health status), socio-economic characteristics (e.g., income, social status, access to information), and psychological characteristics (e.g., beliefs and preconceptions, shifting baseline syndrome, change blindness, memory illusions) are important in determining how a person perceives the environment (Pyhälä et al. 2016; Silva et al. 2016; Howe and Leiserowitz 2013).

A good understanding of the factors that shape human environmental perceptions is important for several reasons. Such knowledge can lead to more specific and accurate conservation decisions, to a better design of a conservation model for a natural environment, or to novel data of the health status of a habitat (Silva et al. 2016; Gärling and Golledge 1989; Shackeroff et al. 2011; Pyhälä et al. 2016). For example, a study in Permuteran (Indonesia) identified that the people that were more prone to contribute to a coral reef restoration project were the ones interacting more with the sea and the project's location, i.e., the inhabitants that felt that they will gain more personal benefit from the project (such as increased seascape beauty and tourism income). Additionally, the study identified a local spiritual group as the biggest source for raising awareness of the project benefits within the community and for motivating its inhabitants to participate, as they had the community's trust and attention (Trialfhianty and Suadi 2017).

Assessing how people with different characteristics and backgrounds perceive the same environment can contribute to improve environmental management, particularly in highly touristic settings, where two worldviews are often confronted (e.g., Llausàs et al. 2019; Perdue et al. 1990). Furthermore, the assessment of variation in environmental perceptions can help to understand behavioural differences in how people relate to the environment (Weber and Johnson 2009; Spence et al. 2011). For example, young tourists perceived almost all recreational activities on a coastal region of Australia as more harmful than older tourists (Priskin et al. 2003), and young beach users of Asturias (Spain) are the age group that perceive most litter at the beach (Rayón-Viña et al. 2018). A more acute perception of environmental deterioration by the

youngest generation seem to be a global trend caused by more environmental education addressed to youngsters, which seem to be more aware of the human impact on natural regions (Priskin et al. 2003; Rayón-Viña et al. 2018).

Given that our environmental perception is partly based in the apprehension of the external world through the senses, and given that marine ecosystems are less viewed, experienced, studied, understood, and appreciated than terrestrial ones (Gray 1997; Steel et al. 2005), there is a lack of research on how people perceive marine environments. For example, Tonin and Lucaroni (2017) reported that 58% of their sample (representative lay people of major Italian cities) had never heard about biodiversity on the coralligenous habitats, and very few had directly experienced being close to the coralligenous. This is important for the management of marine habitats, as people who has never visited coastal marine habitats are, generally, less interested in their maintenance, including their disposition to collaborate in its conservation (Jefferson et al. 2014; Trialfhianty and Suadi 2017). Moreover, people who have negative perceptions of marine habitats (e.g., see them as holding low diversity or high levels of pollution) typically do not engage or support marine habitats conservation activities, neither have a respectful behaviour towards these ecosystems (Cihar and Stankova 2006; Tonin and Lucaroni 2017). Conversely, healthier marine habitats have the potential to change people's perceptions of them positively, which can stimulate environment-friendly behaviours and higher disposition to engage in conservation activities by their users (Cihar and Stankova 2006; Tonin and Lucaroni 2017; Dijksterhuis and Bargh 2001).

We find different typologies of studies on the perception of coastal marine habitats in the literature. An important part of such literature focuses on the perception of beach litter and dirtiness, in some cases including locals' perceptions of tourism as a contributing cause of beach status (e.g., Marin et al. 2009; Garcés-Ordóñez et al. 2020; Hayati et al. 2020; Rayon-Viña et al. 2018). Another noteworthy part of the literature focuses on the perception of inhabitants or visitors about the effectiveness of conservation measures of a protected area and/or how such measures affect the local population (e.g., Kaida and Dang 2016; Bennet and Dearden 2014; Leleu et al. 2012; Engel et al. 2014). We find also articles dealing with users' perceptions of ecosystem services or benefits that coastal marine habitats (CMHs) provide to society (e.g., Blayac et al. 2014; Cárcamo et al. 2014; Blasiak et al. 2015; Ursi and Towata 2018), or users' perception of the health status of the CMH as well as their assessment about present-time impacts and future threats that might face (e.g., Foster et al. 2011; Trenouth et al. 2012; Jefferson et al. 2014).

In the last decades, interest has also grew for assessing peoples' past memory of coastal marine habitats, with the intention to be one more source of knowledge to assess temporal ecological trends inside the frame of historical ecology (Lotze and Worm 2009; Shackeroff et al. 2011; Thurstan et al. 2015). In that sense, most of the literature on marine environmental perceptions have focused on changes or temporal trends in specific issues, like commercial or representative species (e.g., Coll et al. 2014; Azzurro et al. 2011; Maynou et al. 2011; Pita et al. 2013), plastic pollution (Arulnayagam 2020), physical coastal change from environmental phenomena (Boyer-Villemarie et al. 2014), or the change of the 'sense of place' for inhabitants (Rogan et al. 2005). Few studies have assessed a wide range of environmental temporal changes for different typologies of people (Abecasis et al. 2013; Tran et al. 2002). This study seeks to contribute to this body of knowledge.

Specifically, the aim of this article is to study how inhabitants and visitors of the Cap de Creus Marine Protected Area (MPA) in NE Spain perceive temporal environmental trends in local CMHs. We focus on a NW Mediterranean region because is one of the world's highest biodiversity holders, while at the same time suffers the highest anthropogenic pressures (Lejeusne et al. 2010; Bianchi et al. 2012; Coll et al. 2010; Coll et al. 2012; Claudet et al. 2020). Concretely, we focus in Cap de Creus MPA, which provides a good example of the confrontation of marine biodiversity conservation and use of the habitat for fisheries and recreation activities (Corrales et al. 2020).

4.2. Methods

4.2.1. Study area

The research area comprises three municipalities of the Alt Empordà (Girona, NE Spain): Roses, Cadaqués, and El Port de la Selva. Since 1998, when the MPA was created, the three municipalities neighbour the Cap de Creus Natural Park (Fig. 1). The MPA is located in one of the most productive coastal region of the Mediterranean Sea thanks to river runoffs and strong wind-induced seawater vertical mixing and surface sea fertilization (Gili et al. 2011; Rohling et al. 2015). Cap de Creus' CMHs lay mostly on sandy or rocky terrains, where seagrass meadows and coralligenous develop respectively (Sardà et al. 2012). Both habitats, if healthy, are hotspots of marine biodiversity (Duffy 2006; Valisano et al. 2019).

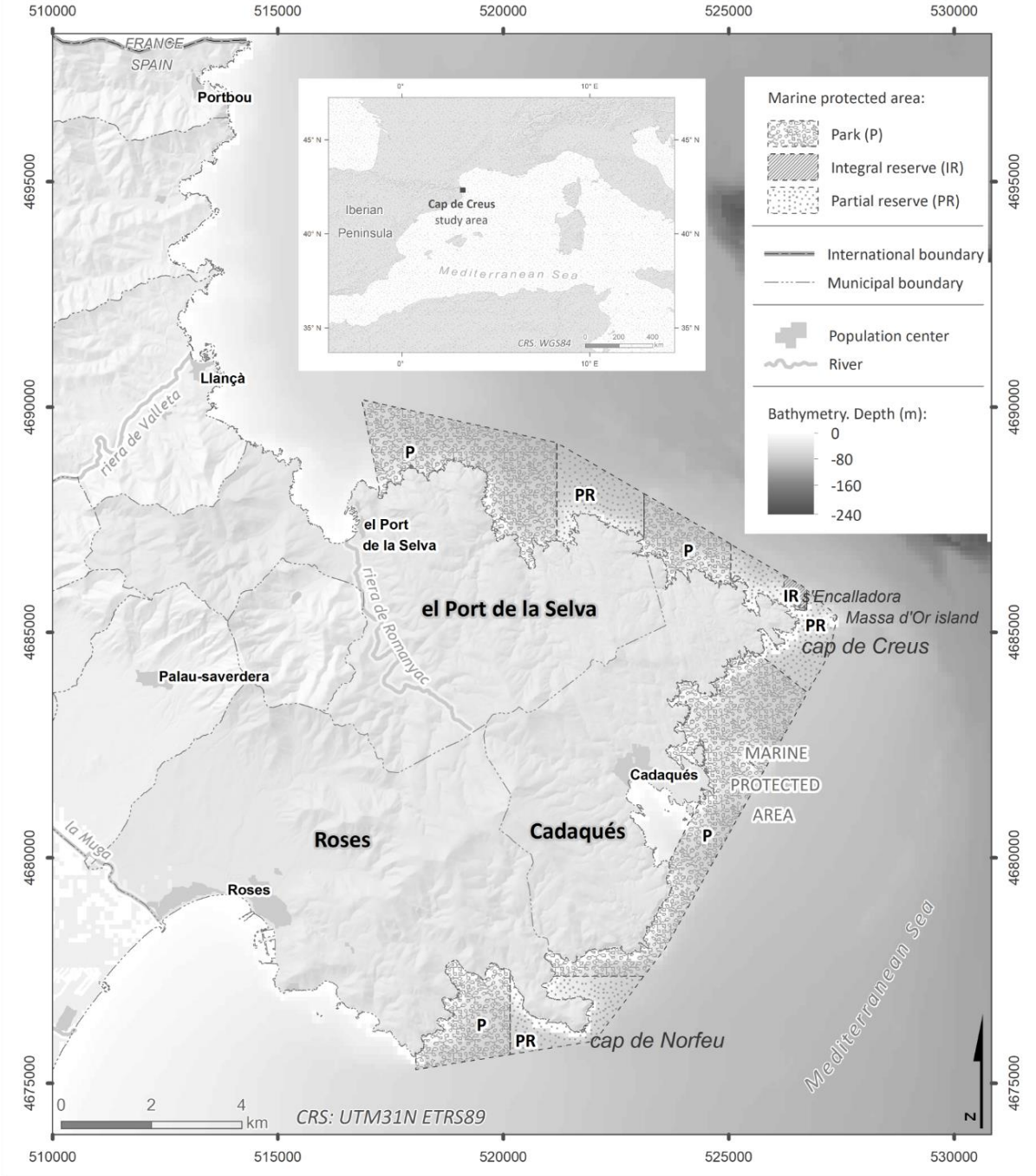

Figure 1. *Map of the study area.*

The Costa Brava (including Cap de Creus) became an important touristic destination since the 1960s. Before that period, the main economic activities of the area were artisanal and small scale fisheries and agriculture (Gómez et al. 2006). Roses is the biggest and most densely populated municipality of the study site. Historically, Roses was an important commercial centre and a strategic military post. Since the 1960s, it became a largely tourism-oriented municipality, with

numerous touristic infrastructures and services including a marina. The so-called 'sun-and-beach' tourism and family tourism are Roses main source of income and town development, although fishery and agriculture (olive and vineyard) continue to be present in the area. Cadaqués was traditionally a fishing town, also specialized in the salt industry. Olive crop was a significant economic activity in Cadaqués too. Due to its gastronomy and architecture, and to the presence of several recognized artists, especially during the 20th century, Cadaqués largely attracts cultural tourism. Among the three studied towns, El Port de la Selva is the one with the lowest population density and with two degrees of magnitude less inhabitants than Roses. As the other two municipalities, El Port de la Selva had an important fishing tradition until the 1960s, when the economic activity of the area started to be dominated by the tourism industry. The other main economic activities in this town are oil and vineyard crops.

4.2.2. Data collection

We used a mixed-method approach to collect data. We first collected qualitative data using semi-structured interviews during December 2017 and July 2018. We then used the outputs of these interviews to design a survey that was applied during July and August 2019. The ethics committee of the Autonomous University of Barcelona approved our sampling procedure and data collection methods (CEEAH 4792).

4.2.2.1. Semi-structured interviews

We conducted semi-structured interviews, to evaluate (i) the main temporal changes in the study area as perceived by stakeholders economically dependent on the local CMHs and (ii) the relative importance of the perceived environmental changes, as compared to social and economic changes. To select participants, we gathered a list of owners and managers of touristic accommodations, fresh seafood restaurants, and scuba diving centres from the tourism centres of each municipality. We contacted all business listed (n=93) and obtained an answer rate of 43% (n = 38; SM 1).

We conducted the semi-structured interviews using two open questions. We first asked: « *What do you think has changed negatively/to worst since you started doing your activity in this area until today? Consider things that have affected both you and other town citizens* ». We then asked the opposite, i.e., using the same question but changing « *negatively/to worst* » by « *positively/to better* ». We hand-noted answers and later classified changes as negative or positive, and as social, economic or environmental. From these data, we compiled a list of different changes ('types of change') and the number of interviewees reporting a change ('frequency of change').

4.2.2.2. Survey

We collected survey data to assess perceptions of Cap de Creus' CMHs environmental changes from a broad sample, including locals and tourists. We used a convenient sampling strategy and approached adults in the streets of Roses, Cadaqués and El Port de la Selva. The only prerequisite to be interviewed was to know the area for at least 10 years, to ensure that respondents could have perception of temporal change. We approached 1227 people, 65% of them declined to be interviewed or did not pass the prerequisite, for which our final sample is of 427 people (Online Resource 1).

In the survey, we collected respondent's sociodemographic information and degree of agreement to ten statements in a five-level Likert scale. We select the statements based on the environmental changes most frequently reported during semi-structured interviews. As a baseline reference point, we asked respondents to consider their first visit to the area in the case of tourists and nonnatives, and their childhood in the case of natives. Then we asked informants to indicate their level of agreement (0 = N/A, 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree; SM 2) with each of the statements.

4.2.2.3. Survey data analysis

To analyse data, we first recoded the Likert scale responses. We transformed responses on "N/A" (= 0) to "Neither agree nor disagree" (= 3), as many informants misunderstood these categories, making impossible their differentiation. To avoid respondents' automation of responses, in the survey we did not present the statements in the same alignment. So, before analysing the data we homogenized answers from the third, fourth, and fifth statements to align all statements to the highest value ("5") towards strong agreement with worse status of the CMHs as compared to the past (SM 2).

We use Likert scale results to analyse perceptions of (i) the whole sample, (ii) local inhabitants vs. tourists, and (iii) subcategories of local inhabitants vs. tourists considering other sociodemographic characteristics. To conduct the analysis, we treated the Likert scale statements as numerical (1 to 5). We also compared the aggregated mean of the ten statements. A value closer to 5 always represents a higher negative affectation of local CMHs than in past times, and vice-versa. We classified as "locals", people who reside on the study area or nearby towns (see Table 1); and we classified as "tourists" people who live at least 120 km away from the study area.

In the last part of the analysis, we also considered the following sociodemographic characteristics of informants: (i) residence-to-sea distance, (ii) affinity and/or dependence from CMHs, (iii) age, (iv) formal education, (v) income, and (vi) baseline of reference (i.e., respondents' point of reference to evaluate changes). For nonnatives, such baseline coincide with their first visit to the area, as reported in the survey. For natives, we assigned the baseline to the decade when they were ten years old. We grouped these sociodemographic characteristics; see Table 1 to see exactly how we create the variables that define the different subgroups.

Table 1. *Sociodemographic variables used for statistical analysis. The table includes survey question(s) used to make the category, variable name, and categorization.*

Survey question (Online Resource 2)	Town/city of residence	Town/city of residence	To what extent do you think you depend on the marine environment in your daily life, either for your work and/or income or for your leisure activities?	Age group	What is the highest level of education that you have completed?	Choose one of the following that best indicate your average yearly income. If you are retired think in your income when you were working.	What was the decade of your first visit? / Since what decade? / Age group (for natives)
Referred in the article as	Local, tourist	Residence-to-sea distance	Affinity / dependence	Age group	Education level	Income	Baseline decade
Variable name	Local, tourist	Coastal, Near coast, Inland	Depend, Joy, Indifferent, Avoid	Young, Middle, Older	Low, Medium, High	Low, Mid, High	Recent, Mid-term, Distant
Categories definition	Locals are people living in Roses, Cadaqués, El Port de la Selva, Cala Jòncols, Castelló d'Empuries, Empuriabrava, Llançà, Selva de Mar, and Vilajuïga. Tourists: are people living more than 120 km away from the area. Respondents living <120km but who are not locals are excluded from the study.	Coastal: the town/city of residence limits with the sea. Near coast: it takes less than one hour by car to arrive to the closest coast (calculated with © Google Maps). Inland = it takes more than one hour by car to arrive to the closest coast.	Respondents had to choose among categories Depend = "Strongly. I need it frequently" and "I need it once in a while, I cannot spend too much time without it". Joy = "I enjoy it, but I do not depend on it". Indifferent = "Indifferent. It has nothing to do with me". Avoid = "I avoid it".	Young = 18-29 years. Middle = 30-49 years (30-39 and 40-49 grouped). Older = > 50 years (50-59, 60-69, 70-79, 80-89, >90 grouped).	Low = "No schooling completed", "Primary school" and "Middle school" grouped. Medium = "High school" and "Professional degree/technical school training" grouped. High = "University", "Master, post-graduate" and "Doctorate/PhD" grouped.	Low = < 14,000 €/year. Mid = 14-35,000 €/year. High = > 35,000 €/year (35-56,000 and > 56,000 €/year grouped).	Recent = baseline decades from 2000s and 1990s. Mid-term = 1980s and 1970s. Distant = from 1960s and older.
Categories omitted in the statistical analysis		Near coast locals due to low sample size	Indifferent and Avoid (locals and tourists) due to low sample size			No income (locals and tourists) due to low sample size	

To test whether there are statistically significant differences between locals' and tourists' perceptions of CMH environmental trends, while also considering other sociodemographic characteristics, we used a Kruskal-Wallis rank-sum test (Kruskal and Wallis 1952; $\alpha = 0.05$) and a post-hoc Dunn test with the Holm method for p-values adjustment (Dunn 1964; Holm 1979). We used R-Studio v1.2.5033 to run all analyses.

4.2.3. Limitations

We acknowledge that our results suffer from several limitations, for which they should be interpreted with caution. First, participants' perceptions can be shaped by many factors not included in our survey. These factors include, for example, survey context, participant's profession, mood, mental disposition at the time of answering, political bias or interferences from perceptions of other coastal areas known to them. This omitted variable bias can affect our results in unknown magnitude and direction. Second, survey responses can also be affected by complacency bias, or informants' tendency to reply according to what they think the surveyor wants to hear. However, since this bias might affect all informants on the same level, we do not expect differences between different categories of respondents. Furthermore, our data collection methods do not fully capture all the issues that can influence the CMHs, but rather only capture a limited view of a high complex reality. For example, we classified answers to the semi-structured interviews into three dimensions, although all three are interconnected and interdependent (Giddings et al. 2002). In that sense, our data represents a fragmented view of what informants might understand as a complex network.

Despite the inherent subjectivity of human perceptions, we have a representative sample for a small specific area and a reliable simplification of reality based local stakeholders' reports. Our respondents for the semi-structured interviews depend in some degree of the quality of the local CMHs for their livelihoods. This fact was particularly evident for the scuba diving centres, where the quality of local CMH play a major role in fidelizing tourism (32% of interviewees reported to us faithful clients during time), and in coastal hotels, where clients are attracted by the immediate coastline and seascape scenery (Kirillova et al. 2014; Van der Merwe et al. 2011). Therefore, and despite potential bias in responses, we consider that respondents' answers are a valid proxy to assess changes that happened on this area.

4.3. Results

4.3.1. Semi-structured interviews

Our sample for semi-structured interviews was unbalanced towards men (64%) and respondents had an average of 51 (±12) years of age. Respondents had been working in the area for an average of 31 (±14) years (SM 3).

4.3.1.1. Main changes reported

Respondents reported 63 different types of changes in Cap de Creus: 24 of the reported changes were perceived as positive and 39 as negative. Most changes referred to economic aspects (41%), followed by social (30%), and environmental aspects (29%). The frequency of changes reported as negative (75% of all reported changes; 7.2 per interview) is higher than the frequency of changes reported as positive (25%; 2.4 per interview). The distribution is similar, both when all the changes are pooled and when considering their classification as economic, social, and environmental changes. When looking at the number of interviewees reporting changes, economic changes were most frequently reported (47%), followed by social (29%) and environmental ones (24%; Table 2; SM 4).

Table 2. *Number and frequency of changes reported in semi-structured interviews (n = 38), differentiating among economic, social, and environmental changes.*

	Total			**Economic**			**Social**			**Environmental**		
	Both	(+)	(-)	Both	(+)	(-)	Both	(+)	(-)	Both	(+)	(-)
Types of change												
n	63	24	39	26	11	15	19	7	12	18	6	12
% respect total	100	38	62	41	17	24	30	11	19	29	10	19
% respect (+)		100			46			29			25	
% respect (-)			100			38			31			31
Frequency of changes												
n	365	93	272	171	54	117	106	21	85	88	18	70
Average/interview	9.6	2.4	7.2	4.5	1.4	3.1	2.8	0.6	2.2	2.3	0.5	1.8
% respect total	100	25	75	47	15	32	29	6	23	24	5	19
% respect (+)		100			58			23			19	
% respect (-)			100			43			31			26

4.3.1.2. Environmental changes

Semi-structured interview respondents reported 88 instances of environmental changes that we classified in 18 different types, 12 were perceived as negative and six as positive. Twelve respondents (31.6%) did not report any environmental change. Negative environmental change reports dominate, representing 70 of the 88 mentions (79.5%; 1.8 per interview). The two negative environmental changes most often reported were 'less biodiverse' with 16 reports, and 'more disrespectful users', with nine reports. Respondents reported 18 times positive environmental changes (0.5 per interview), with 24 respondents (63.2%) not reporting any positive environmental change. The positive environmental change most often reported was 'more biodiversity' with eight reports (Fig. 2, Table 2, SM 4).

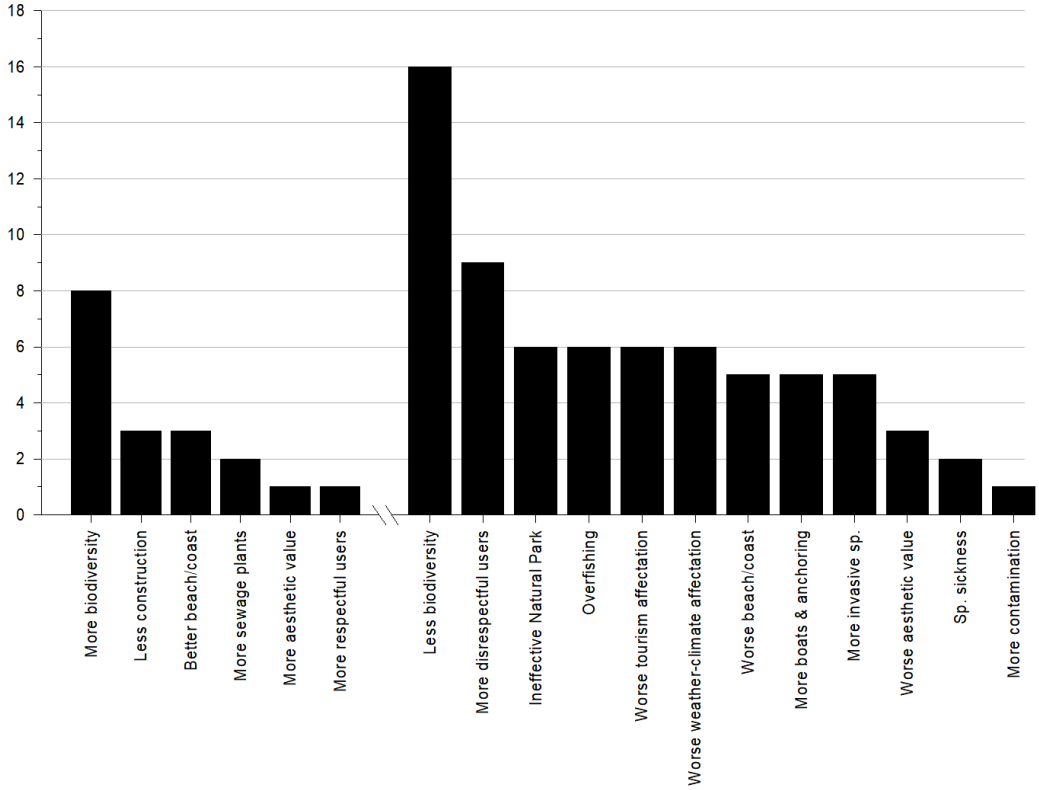

Figure 2. *Answers of the semi-structured interview for the environmental aspect. The horizontal axis show the different types of change reported, the positive ones on the left, and the negative ones after the axis breaks. The bars represent the quantity of changes reported.*

4.3.2. Survey

Following our sampling design, the survey sample (n = 427) was homogeneously distributed across the three municipalities (Cadaqués 33.7%, El Port de la Selva 33.7%, and Roses 32.6%) and between locals (52%) and tourists (48%; SM 5).

Most people in our sample live in coastal areas, although the distribution was biased among locals (who almost unanimely live in coastal areas) and tourists who reside in similar proportions in coastal, near coast, and inland areas (Fig. 3a). Regarding the type of relation to CMHs, most locals have a strong affinity and/or dependence on CMHs, while most tourists state that their relation with CMHs correspond to the 'joy' and 'need' categories (Fig. 3b). People who had completed university studies predominate in our sample, although education levels were lower among locals than among tourists (Fig. 3c). Most people in the sample had an income between 14,000 and 35,000 €/year (43.6%). Tourists dominate in the higher income categories (>35,000 €/year), whereas locals dominate in the categories under 35,000 €/year (Fig. 3d). The largest age group in our sample correspond to informants between 18 and 29 years, dominated by locals, while tourists slightly dominate from 50 years onwards (Fig. 3e). Finally, there is a predominance of people with a reference baseline on the 2000s, and a lower proportion of the sample have a reference baseline on the 1970s and older (Fig. 3f).

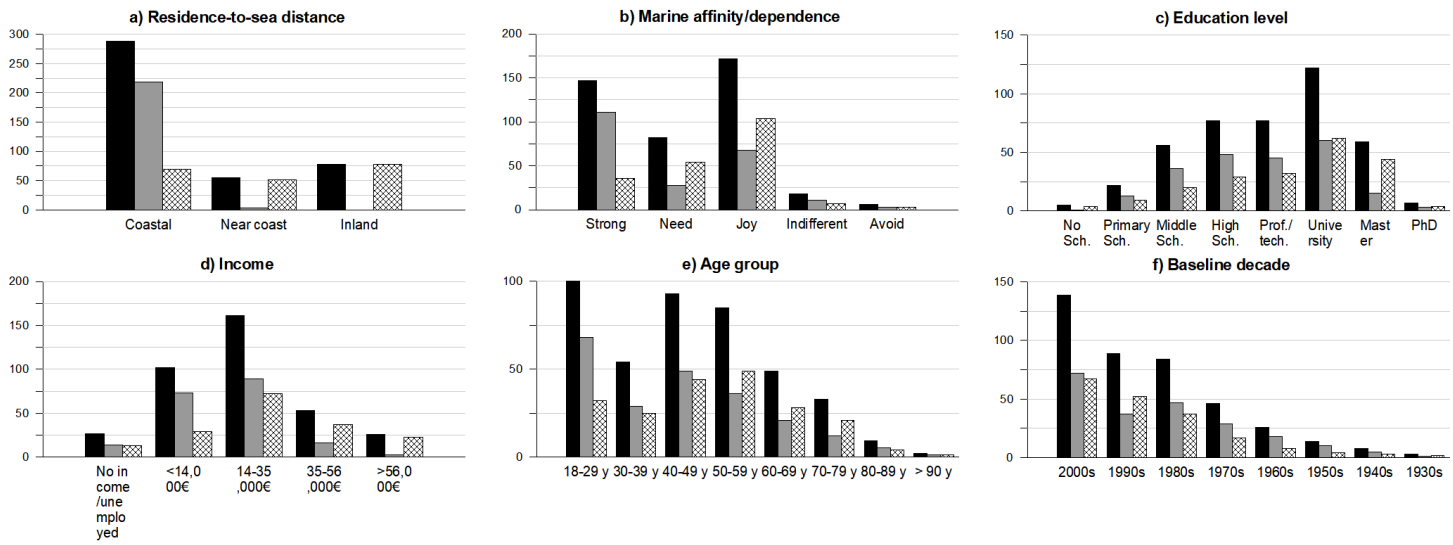

Figure 3. *Survey answers of the sociodemographic parameters chosen for analysis. Black bars: total sample. Grey bars: locals. Crossed bars: tourists. Note the different Y axis in the graphs.*

4.3.2.1. Perception of change

When looking at the aggregated sample, the statements for which most respondents "strongly agree" are the ones referring to the fact that there is 'less marine life' (56.4%), 'more marine pollution' (45%), and 'more boat transit and anchor' (41.9%) now than in the past (Fig. 4a-c).

Most people in our sample "agree" that now there is 'more tourism impact' (37%), 'nostalgia of a more beautiful sea' (33.7%), 'overfishing' (35.8%) and 'hotter temperatures' (35%; Fig. 4d-f, h). The most frequent option for the statement that there are 'more invasive species' (40.8%) is "Neither agree nor disagree" (Fig. 4g). Finally, most informants "disagree" that there is 'less respect towards nature' (31.1%) and 'less clean coasts' (31.4%; Fig. 4i, j).

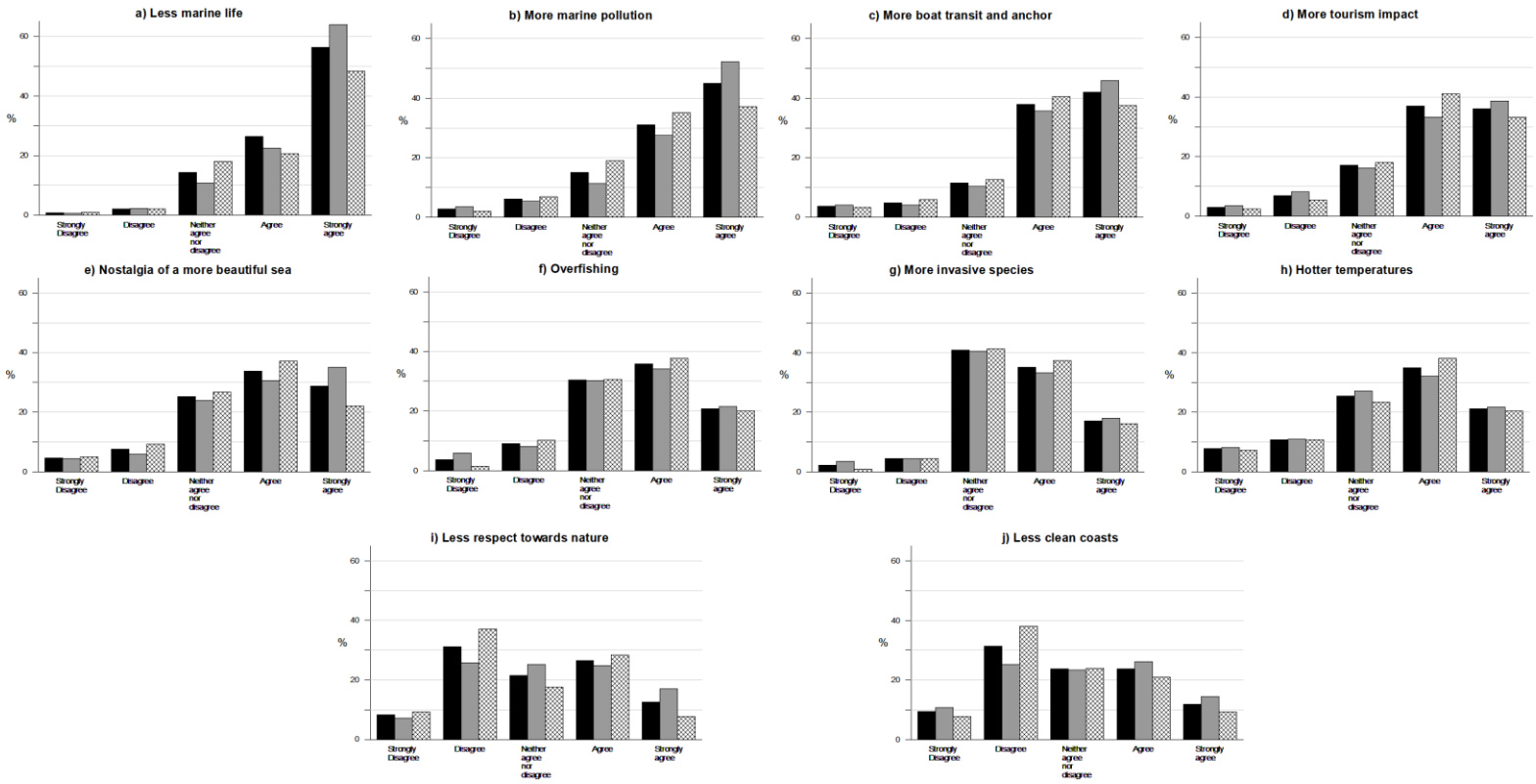

Figure 4. *Survey results of the statements Likert table in percentages. Black bars: total sample. Grey bars: locals. Crossed bars: tourists.*

The average of the numerical value of the ten Likert-statements suggests that survey participants slightly agree with an increase of environmental affectation on the CMHs of Cap de Creus (i.e., worse status of CMHs compared with the past; 3.7 ±0.51, between "agree = 4" and "neither agree nor disagree = 3"; Fig. 5).

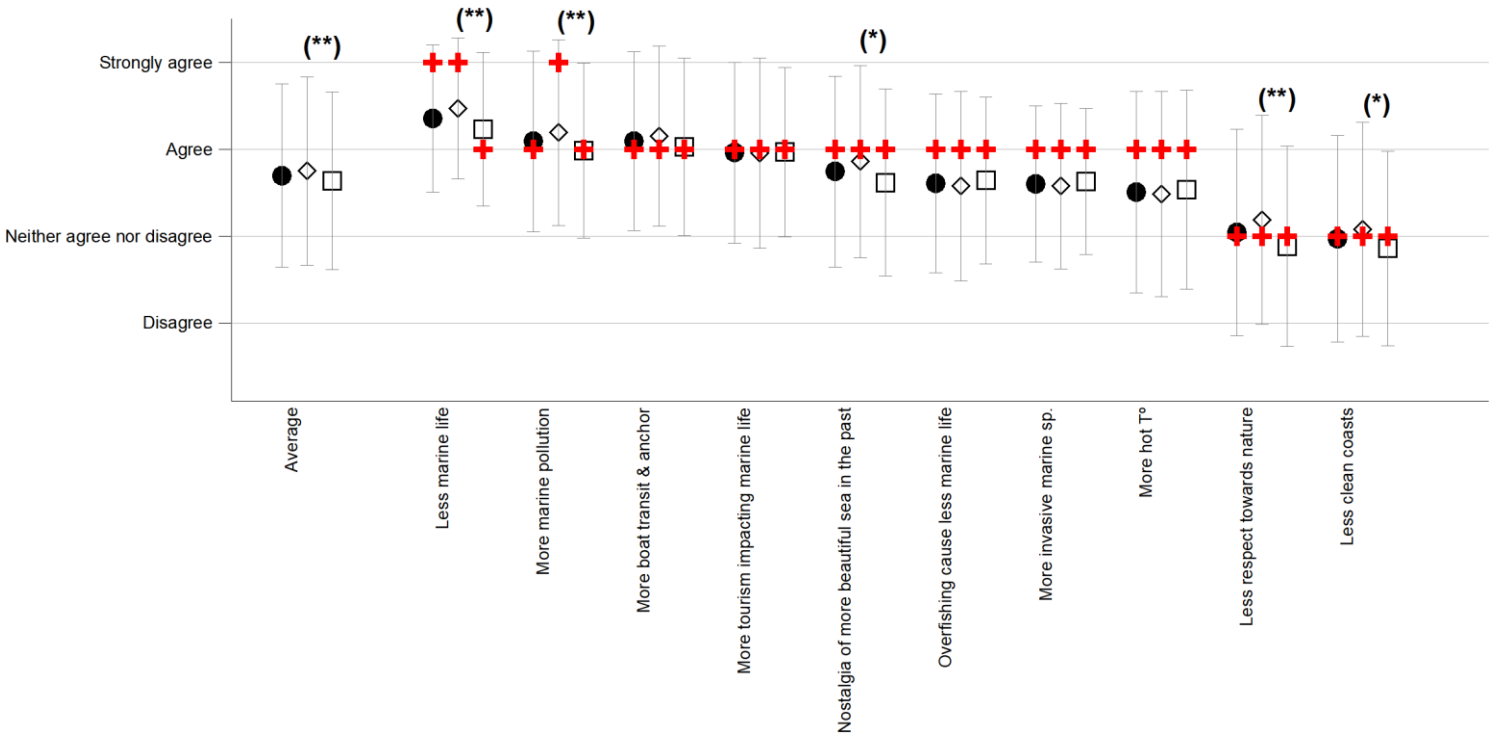

Figure 5. *Survey results of the Likert-scale statements. Median = red cross. Average = black circles (total sample), diamonds (locals), and squares (tourists). Standard deviation = vertical bars. Significant p-values from the Kruskal-Wallis rank-sum test within locals and tourists: (*) = $p < 0.05$, (**) = $p < 0.01$.*

The statement for which there was highest agreement is the one referring to the current presence of 'less marine life' in the local CMHs (on average situated above "agree": 4.358 ±0.85). Three other statements have an average around "agree": 'more marine pollution' (4.094 ±1.04), 'more boat transit and anchor' (4.094 ±1.03), and 'more tourism impact' (3.963 ±1.04). Four statements have averages a little under "agree": 'nostalgia of a more beautiful sea' (3.745 ±1.1), 'overfishing' (3.069 ±1.03), 'more invasive species' (3.603 ±0.9), and 'hotter temperatures' (3.509 ±1.16). Finally, two statements have averages that would correspond to the "neither agree nor disagree" category: 'less respect towards nature' (3.042 ±1.19) and 'less clean coasts' (2.974 ±1.19; Fig. 5).

Results of the Kruskal-Wallis rank-sum test show that, overall, local inhabitants perceive significantly more increase in the environmental affectation of CMHs (3.755 ±0.524) than tourists do (3.639 ±0.483; $p = 0.009$). Indeed, for five of the ten statements in the survey, locals perceived a higher present-time impact than tourists did, the difference being statistically significant (Fig. 5). Thus, for the 'less marine life' statement ($p = 0.001$), 64% of locals marked "strongly agree" and only 13.1% marked a neutral or disagreement option, whereas 48.3% of tourists "strongly agree" with the statement, but 21% went for a neutral or disagree answer (Fig. 4a). A similar trend is found for 'more marine pollution' ($p = 0.005$), although in this case, tourists more frequently selected the "agree" option than locals did (Fig. 4b).

Locals have significantly more 'nostalgia of a more beautiful sea' than tourists do, as more locals (35.1%) than tourists (22%; $p = 0.012$; Fig. 4e) answered that they "strongly agree" with the statement. The same pattern happened in 'respect towards nature' ($p = 0.008$), and 'less clean coasts' ($p = 0.045$), but in these two statements tourists most frequently selected the "disagree" option (37.1% and 38% respectively; Fig. 4i-j).

The last part of the analysis consisted in seeking differences between locals and tourists taking into account other sociodemographic characteristics. The sociodemographic characteristics showing more differences between locals and tourists subcategories are age and affinity/dependence. Education level is the only category for which we did not find significant differences between local and tourist perceptions (Table 3).

Table 3. *p-values from the Kruskal-Wallis rank sum test from crossing the parameter 'Local/tourist' with the six sociodemographic variables, by statements in the Likert scale. Significant different values are shown with asterisks: (*) p < 0.05, (**) p < 0.01. Significant values in bold are the ones that, after a post-hoc Dunn test, a significant difference is found between at least one subgroup of locals and tourists (see SM 6 for more detail).*

Statements	**Local/tourist X Residence-to-sea distance**	**Local/tourist X Affinity/dependence**	**Local/tourist X Education level**	**Local/tourist X Income**	**Local/tourist X Age**	**Local/tourist X Baseline decade**
Less marine life	**0.02***	**0.000****	0.035*	0.069	**0.001****	**0.001****
More marine pollution	**0.008****	**0.006****	0.03*	0.155	**0.021***	0.125
More boat transit and anchor	0.038*	**0.003****	0.31	0.086	0.302	0.149
More tourism impact	0.142	**0.003****	0.03*	0.081	0.037*	0.047*
Nostalgia of a more beautiful sea	**0.005****	**0.001****	0.052	0.155	**0.007****	0.099
Overfishing	0.98	0.103	0.642	0.912	0.644	0.603
More invasive species	0.942	**0.000****	0.917	0.086	0.236	0.761
Hotter temperatures	0.292	0.965	0.382	0.344	**0.013***	0.745
Less respect towards nature	0.071	0.137	0.206	0.069	**0.031***	0.19
Less clean coasts	0.128	0.205	0.07	**0.004****	**0.000****	**0.000****
Average	**0.006****	**0.001****	0.096	**0.036***	**0.001****	**0.032***

When looking at the average answer of the ten Likert-scale statements for each subgroup (Table 4), we notice that some sociodemographic variables account for a perception of more negative affectation in present CMHs (i.e. the averages closer to 5). The characteristics that are associated with a more negative perception of CMHs health status nowadays, as compared to the past, include residency on a coastal area (vs. residency inland), being dependent and/or strongly affine to the CMHs (vs., people who consider that they do not depend on them), low income (vs. high income), and being younger than 30 years of age (vs. being older than 30 years). The education level and reference baseline categories do not show a clear pattern nor significant differences between groups (Table 4).

Table 4. *Average answer to the ten Likert-scale statements of the survey for each subcategory of locals (L) and tourists (T) ordered from highest to lowest value. In the last column, the subcategories that are statistically significant between them are linked with the p-value obtained from the post-hoc Dunn test with the Holm method for p-values adjustment. (*) p < 0.05, (**) p < 0.01.*

Sociodemographic categories	$\bar{x}$	σ	Significant differences (p-value)
Residence-to-sea distance			
L coastal	3.754	0.562	
T coastal	3.744	0.487	0.004**
T near coast	3.656	0.484	0.049*
T inland	3.569	0.457	
Affinity/dependence			
L depend	3.818	0.480	
T depend	3.773	0.432	0.000**
L joy	3.629	0.559	0.003**
T joy	3.530	0.499	
Education level			
L medium	3.770	0.516	
L high	3.785	0.529	
L low	3.684	0.546	
T high	3.652	0.497	
T low	3.648	0.468	
T medium	3.603	0.468	
Income			
L low	3.848	0.456	
T low	3.744	0.426	
L mid	3.706	0.554	0.046*
T mid	3.637	0.478	
L high	3.621	0.410	
T high	3.583	0.498	
Age			
L young	3.869	0.433	
T young	3.841	0.441	0.033*
L older	3.704	0.573	0.001**
L middle	3.700	0.541	
T middle	3.607	0.510	
T older	3.590	0.458	
Baseline			
L recent	3.834	0.477	
T distant	3.747	0.494	
L mid-term	3.711	0.530	
T recent	3.647	0.465	
L distant	3.632	0.623	
T mid-term	3.604	0.538	

The average value for the ten Likert-scale statements calculated by subsample show that the subsamples that perceive a higher decrease in CMHs health are most often from the local respondents. Again, affinity/dependence and age are the sociodemographic variables that have most statistical differences between tourists and locals, while the education level has none (SM 6).

Our analysis of subsamples show that locals living by the sea perceive less marine life (average: 4.48), more marine pollution (4.19) and have more nostalgia of a more beautiful sea (3.86) than in past times compared with tourists that have their residence inland (4.19, p = 0.026; 3.91, p=

0.04; and 3.53 p= 0.045 respectively). The same issue happens to locals that are dependent or strongly affine with the CMHs (marine life: 4.6, marine pollution: 4.29, nostalgia: 3.89) compared with tourists that enjoy but do not depend on it (4.1, p = 0.000; 3.98, p= 0.026, and 3.39, p=0.001 respectively), with the addition that locals also perceive more affectation from boat transit and anchor (locals: 4.3, tourists: 3.91, p = 0.005) and from tourism (4.07, 3.77, p = 0.026). Low income locals are the ones that perceive that coasts went less cleaner in recent times, in opposition with high income tourists (3.41, 2.78, p = 0.035). Young locals perceive a lower respect towards nature (3.37), less clean coasts (3.56) and more marine pollution (4.35) than in the past compared with the older category of tourists (2.75, p = 0.01; 2.6, p= 0.016, and 3.95 p= 0.016 respectively). Distant and mid-term baseline locals perceive less marine life in the present than tourists with a recent baseline (recent tourists: 4.14, distant locals: 4.77; p = 0.001, mid-term locals: 4.49; p = 0.023; SM 6).

4.4. Discussion

Three main findings steam out from our results. Based on responses to semi-structured interviews, the first result of this study is that environmental changes are the least reported in interviews; economic and social changes having a largest frequency of report. Second, our data also show that reports of negative environmental changes clearly dominate over reports of positive environmental changes, and the overall survey participants perceived that the health status of the local environment declined overtime. Finally, our data also show that local inhabitants have a more acute perception of negative environmental trends in local CMH than tourists.

The first important finding of this work is that informants reported less types of environmental changes and with less frequency than they report economic and social changes. Moreover, an important percentage of respondents did not report any environmental change, and mostly focused on the report of economic changes. We can think of two non-excluding explainations for our findings. On the one side, such results can be explained by the cultural context of Western society, where nature and human relations are often described in economic terms or commodified (e.g., natural capital, ecosystem services), viewing nature as a resource or a good that can be traded at a market (Giddings et al. 2002; Martineau and Lafontaine 2020; Keucheyan 2014). In this context, economic considerations dominate the environmental and social decisions made by governments, global companies and organizations, big corporations,

international forums, think thanks, and the like (Giddings et al. 2002; Korten 1996). This conceptualization of nature, with time and repetition, has become a cultural paradigm, not only to decision-makers but also to the majority of society. Such paradigm influence the subjective reality of individuals, potentially causing the predominant habit of looking at nature with an utilitarian viewpoint, forgetting the non-quantifiable aspects like emotional bindings, or seeing nature as a singular entity itself (i.e. reification of nature; Martineau and Lafontaine 2020; Lukács 1971). This dominant cultural paradigm might partly explain the dominance of responses referring to economic versus environmental changes.

Furthermore, the predominance of economic factors in informants' responses might also be explained by the dramatic economic changes occurring in the area over the last decades. In particular, tourism has become the main source of income for the local stakeholders' livelihood, with a predominance of seasonal tourism, which (in many areas) has negative environmental impacts associated (Zahedi 2008; Sunlu 2003). Several studies report that local people is aware of tourism environmental impacts, including marine pollution and beach littering (e.g., Garcés-Ordóñez et al. 2020; Lopes da Silva et al. 2018; Asensio-Montesinos et al. 2019), with tourists themselves being also aware of this problem (e.g., Hayati et al. 2020; Krelling et al. 2017; Priskin 2003). This finding is also reflected in our survey results, where most respondents (independently of being locals or tourists) "agree" or "strongly agree" to 'more tourism impact' (note that we surveyed during the touristic peak) and reported 'more tourism impacting marine life' as one of the main environmental changes suffered in the region.

Beyond environmental impacts, seasonal tourism overcrowding also affects local stakeholders socially (the second social factor most frequently reported) and economically (with 'low quality tourism, reduction of purchasing power and/or will to spend little'; 'tourists stay less time' being the two main economic changes reported). Our results are in line with other findings reported in the literature. Interestingly, research has shown that, when people benefit less from tourism, they also report more environmental and social impacts coming from this activity than when they derive a high profit from it (Ap 1992; Perdue et al. 1990). The explaination migh be valid for our case study, as stakeholders reported that tourists now stay less time and spend less money than before, and that there is 'more competence in tourist destinations'. Such statements can be interpreted as people reporting higher environmental impacts for the actual tourism compared with the past.

The second main finding of this work is that there is a clear dominance of reports of negative over positive changes. This pattern was found in relation to economic, social, and environmental

changes and in relation to the type and quantity of reports. Such pattern is also found in our survey results, as our sample leans towards an agreement of more present environmental affectation of nature compared with past times. The dominance of negative trends when examining environmental change perceptions is in line with findings from other works examining marine environmental changes, in which an overall perception of the worsening of marine habitats (e.g., Tonin and Lucaroni 2017; Jefferson et al. 2014; Forster et al. 2011) and an increase in marine habitats affectation dominates (Arulnayagam 2020; Abecasis et al. 2013; Pita et al. 2013; Tran et al. 2012). It is possible that negativity biases, or human propensity to focus more on negative aspects, contribute to such trend (Rozin and Royzman 2001; Vaish et al. 2008). Negativity biases are important because they affect in a damaging way how the users interact with a natural space, also affecting their commitment to conservation of the marine habitats (Cihar and Stankova 2006; Steel et al. 2005). In that sense, inappropriate interaction with Cap de Creus natural areas has been reported by our local respondents. In the interviews 'more disrespectful users' was highly reported, and in the survey locals displayed more agreement towards 'less respect towards nature' as a source of environmental deterioration.

However, it is also likely that our findings indicate a real deterioration of the environmental quality of the area. Indeed, such deterioration is well reported in Mediterranean CMHs. To mention some, an assessment of temporal studies of *Posidonia oceanica* discovered a loss of 7277 ha in 170 years approximately (Marbà et al. 2014; see also Dunic et al. 2021). Reports also show that most commercial marine species have decreased in abundance. The same is true for eco-engineering species (Lotze et al. 2011; Lotze and Worm 2009), especially large predators like sharks which have decreased more than 90% since the first fishery records are available until present (Ferreti et al. 2008). Studies have also reported an intense depletion and decrease of red coral (Cattaneo-Vietti et al. 2016; Bavestrello et al. 2015; Santangelo et al. 1993). Literature also documents the same trends in other Mediterranean specific locations, e.g., a habitat dominated by sponges have seen how the sponges fade off in La Strea Bay, Italy (Gravina et al. 2020). Other study report structural homogenization of a submarine cave due to the decline in benthic 3D organisms for three decades in Bergeggi, Italy (Montefalcone et al. 2018), among many others (e.g., Betti et al. 2017; Gatti et al. 2015; Bourcier 1996).

Therefore, overall, the negative trends reported in our survey could just reflect negative trends on the health status of the Mediterranean biodiversity. Indeed, despite being an MPA and contributing to the recovery of some key species and habitats (e.g. Mallo et al. 2019; Hereu et al. 2018), Cap de Creus has documented trends of biodiversity loss and environmental quality

worsening. Overfishing is an important driver that has contributed to such regressive biodiversity trend and that could be noticed by the MPA users. For example, local artisanal fishermen notice a decrease in vulnerable species landings (Gómez et al. 2006) and catches (Corrales et al. 2020; Font and Lloret 2011). Cap de Creus also suffers a decline in commercial species catches (Gómez et al. 2006), which have less average weight and length, a sign of overfishing (Vilas et al. 2020). The situation is aggravated due to illegal fishing in restricted areas and breaching of other MPA measures, like the minimum landing size of catches (Hereu et al. 2018; Lloret et al. 2008). The area also suffers from other affectations contributing to biodiversity loss like sea litter and pollution (e.g., Sardà et al. 2012; Purroy et al. 2014) and climate change (Hereu et al. 2018), which likely justify participants' responses. Given the scientific evidence, it is then not surprising that local stakeholders identified 'less biodiversity' as the main negative change in the area, or that the most strongly agreed statement of our survey was that there is 'less marine life' now than in the past.

The third important finding of this work is that local inhabitants have a more acute perception of negative environmental changes than tourist do, at least for five of the ten statements of the Likert-scale table. Based in results of the analysis of differences between the two subsamples, we argue that a key reason for such difference could be the socio-demographic factors that differentiate locals and tourists. In particular, we found that respondents with a more acute perception of change are people living close to the sea, those who are more affine/dependent of the CMHs, those with low income, and younger respondents. People living close to the sea and those who are more affine/dependent of the CMHs might have higher contact with nature (coastal marine nature in our case), which has been shown to shape environmental change perceptions (Mayer and Frantz 2004; Cihar and Stankova 2006; García-del-Amo et al. 2021). For example, fishermen or scuba divers may perceive changes because they have less captures or see the complexity deterioration of the habitats. A sense of higher nature connexion imply higher concern for it, thus, the perception of our local inhabitants might have been amplified against negative changes (Mayer and Frantz 2004; Vining et al. 2008). In fact, that locals use to care more about their surrounding environment than strangers is a trend previously reported in the literature when assessing the Not In My Back Yard (NIMBY) and Locally Unwanted Land Use (LULU) phenomena (e.g., Schively 2007; Dear 2007). We do not have a clear explaination of why people with low income might have a more acute perception of environmental change, other than an important part of low income jobs are primary works, thus, in direct contact with natural resources, for which this variable might actually be measuring contact with nature, as it

has been reported in other areas of Spain (García-del-Amo et al. 2021). Finaly, it is possible that younger participants perceive more environmental change due to the fact that they have been born in a time where the protection of the environment and the ecological values are higher than ever in the society, and with the existence of more sensitization campaigns (Jacquet and Pauly 2007).

4.5. Conclusion

The main result of this work is that local users's perception of habitat deterioration and the scientific quantification of such transformation are in line. This study adds to previous work on users' perception of environmental change, focusing on the health status of coastal marine environments, which are the most neglected ones. We found that, in the case of Cap de Creus (NE Spain), users perceive a decline of nature status, with a clear consensus on the deterioration of the local coastal marine environment. The reported negative environmental trend is particularly worrying since the area has been a MPA for more than 20 years. Furthermore, environmental changes do not seem to be the main concern of the local stakeholders. We suggest that the increasing disconnection of people with nature and the generalized loss of environmental awarness and knowledge is an important contributing driver of the historical worldwide decline of natural assets (perceptual and factual; Kesebir and Kesebir 2017; Vining et al. 2008; Balmford et al. 2002). We argue that a human behavioural change towards nature is necessary in order to increase a societal environmental concern, with a consequent rise of eco-friendly behaviours and actions like the participation in nature restoration and conservation activities (Mayer and Frantz 2004; Trialfhianty and Suadi 2017; Cihar and Stankova 2006).

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4.7. Supplementary material

Supplementary material 1. List of potential and final interviewees of the semi-structured interviews for the three municipalities of the study. The table includes information on the number of people approached and interviewed, the gendered distribution, and the reasons for not being included in the final sample.

Semi-structured interviews					**Motive of no answer**				
Interviewed (Potential interviewees)	**Roses**	**Cadaqués**	**Port de la Selva**	**Total**	**Lack of time**	**Unwill**	**< 10 years**	**N/A**	**Total**
Fresh seafood restaurants	5 (12)	5 (14)	4 (5)	14 (31)	8	4	3	2	17
Coastal hotels and hostels	10 (30)	8 (17)	3 (4)	21 (51)	6	7	6	11	30
Diving centres	1 (5)	3 (4)	1 (2)	5 (11)	2	0	0	4	6
Total	16 (47)	16 (35)	8 (11)	40 (93)	16	11	9	17	53

Survey	**Total**	**Female**	**Male**	**Motive of no answer**						
Respondants	427	245	182	**Lack of time**			**Unwill**	**Language barrier**	**< 10 years**	**Other**
Non respondants	800	449	351	178			359	36	197	30
				Due to work	Due to appointment	Unknown				
				75	41	62				

Semi-structured interviews: The establishments that closed and the new ones that opened after the elaboration of the potential list of interviewees (winter 2017) were not counted nor considered for interview. The restaurants that in the moment of the interview said that they did not serve fresh seafood were not counted in the list as well. The owners or managers of more than one type of establishment (e.g. owner of two hotels) where counted only as one in the list of potential interviewees; this happened six times. The people that own two different establishments (e.g. and hostel and a restaurant) where counted as two despite a single interview was realized; these happened two times. We excluded people with less than ten years working or diving in the area ("< 10 years" category). For the particular case of fresh seafood restaurants in Roses, in order to avoid a long and time-consuming list of restaurants, we decided to include in the list of potential interviewees only the fresh seafood restaurants that appeared in the "Suquet de Peix" (Fish Suquet) catalogue handed to us by the office of tourism in winter 2017. An actualized version of such catalogue can be consulted online (http://en.visit.roses.cat/plan/restaurants/).

Survey: Before answering the questionnaire, the interviewer introduced itself, the institution that was working from (ICTA-UAB) and its position (doctoral student, fieldwork assistant, researcher) and explained the project and the objective of this questionnaire to the interviewees. We also reminded them that they will remain anonymous and that we disposed of a text-version of the informed consent expressed beforehand orally. The researcher helped to clarify any doubt the respondent had in a neutral way, i.e., such help never implied conditioning the answer of the respondent. We had translated the survey to the four most common languages spoken by residents and tourists in the area: Spanish, Catalan, English, and French. We counted the people who did not understand any of those languages as non-respondents, inside the category of "Language barrier". We excluded people that visited or lived in the area for less than ten years "< 10 years".

Supplementary material 2. English version of the survey questions. At the end, we include a table with the original statements used in the questionnaire, the ones that we twisted their answers' value for the data analysis, and the two different abbreviations of the statements used inside the article.

Date (dd/mm/yy):_____/_____/_____ **Code#:**_____ (leave this blank) **ENGLISH**

Gender: Female Male Other:_____

Town/city of residence:_____ **Country:** _____

Where are you hosted? (answer only if you do not live here)**:** Port de la Selva Roses Cadaqués

How often do you visit this area? (select one box only)

- ☐ I live here all year round → Since what decade?:_____ or Since birth
- ☐ Once every year → What was the decade of your first visit? _____
- ☐ Frequently → What was the decade of your first visit? _____
- ☐ Infrequently → What was the decade of your first visit? _____
- ☐ This is my first time

⚠ ***If you visited this area <u>for the first time</u> you do not have to answer this table.***

How much do you agree with the following statements? Always refer your answers to <u>this area</u> (Cap de Creus). Note that some sentences are comprised of more than one statement; your answer must take into account the full sentence and not only one part. When the statements mention "in the past" refer to your first visit to the area or, if you are born here, since your childhood.

Statement	N/A	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
In comparison with today, in the past there were less long-lasting hot temperatures. In other words, summers were shorter.	0	1	2	3	4	5
In comparison with today, in the past more fishes and other marine species were visible in the sea.	0	1	2	3	4	5
In comparison with the past, people are today more aware of the importance of respecting the natural areas they are visiting (for example, not littering, not stepping on marine life or collecting plants or animal souvenirs…).	0	1	2	3	4	5
In comparison with the past, today the coast (including beaches) remains cleaner and better taken care of.	0	1	2	3	4	5
In the past the sea was more polluted than today.	0	1	2	3	4	5
In comparison with the past, today there exists more boat transit and boat anchoring; this increases the negative impacts on marine life.	0	1	2	3	4	5
In comparison with the past, today there are more invasive marine species that come from outside and negatively affect the local marine life.	0	1	2	3	4	5
Overfishing is the main cause of marine life decrease.	0	1	2	3	4	5
People feel nostalgia about how beautiful the sea used to be and complain that the younger generation never saw it like they did.	0	1	2	3	4	5
This area receives increasingly tourism, which has a growing negative impact on marine life.	0	1	2	3	4	5

To what extent do you think you depend on the marine environment in your daily life, either for your work and/or income or for your leisure activities? (select one box only)

For example, you might be strongly dependent if your work is highly based on the sea, like fishermen, whale watching, lifeguard… or your hobby, like surfing, swimming, diving… or simply the need of going to visit the coastline.

- ☐ Strongly. I need it frequently
- ☐ I need it once in a while, I cannot spend too much time without it
- ☐ I enjoy it, but I do not depend on it
- ☐ Indifferent. It has nothing to do with me
- ☐ I avoid it

Age group: (select one box only)

- ☐ 18 – 29
- ☐ 30 – 39
- ☐ 40 – 49
- ☐ 50 – 59
- ☐ 60 – 69
- ☐ 70 – 79
- ☐ 80 – 89
- ☐ ≥ 90

What is the highest level of education that you have completed?: (select one box only)

- ☐ No schooling completed
- ☐ Primary school
- ☐ Middle school
- ☐ High school
- ☐ Professional degree/technical school training
- ☐ University
- ☐ Master, post-graduate
- ☐ Doctorate/PhD

What is your profession? _____

Choose one of the following that best indicate your average yearly income. If you are retired think in your income when you were working:
(select only one box and the one in your currency)

Euros (€)

- ☐ No income/unemployed
- ☐ < 14,000 €
- ☐ 14,000 – 35,000 €
- ☐ 35,000 – 56,000 €
- ☐ > 56,000 €

Dollars ($)

- ☐ No income/unemployed
- ☐ < 15,000 $
- ☐ 15,000 – 40,000 $
- ☐ 40,000 – 60,000 $
- ☐ > 60,000 $

Pound sterling (£)

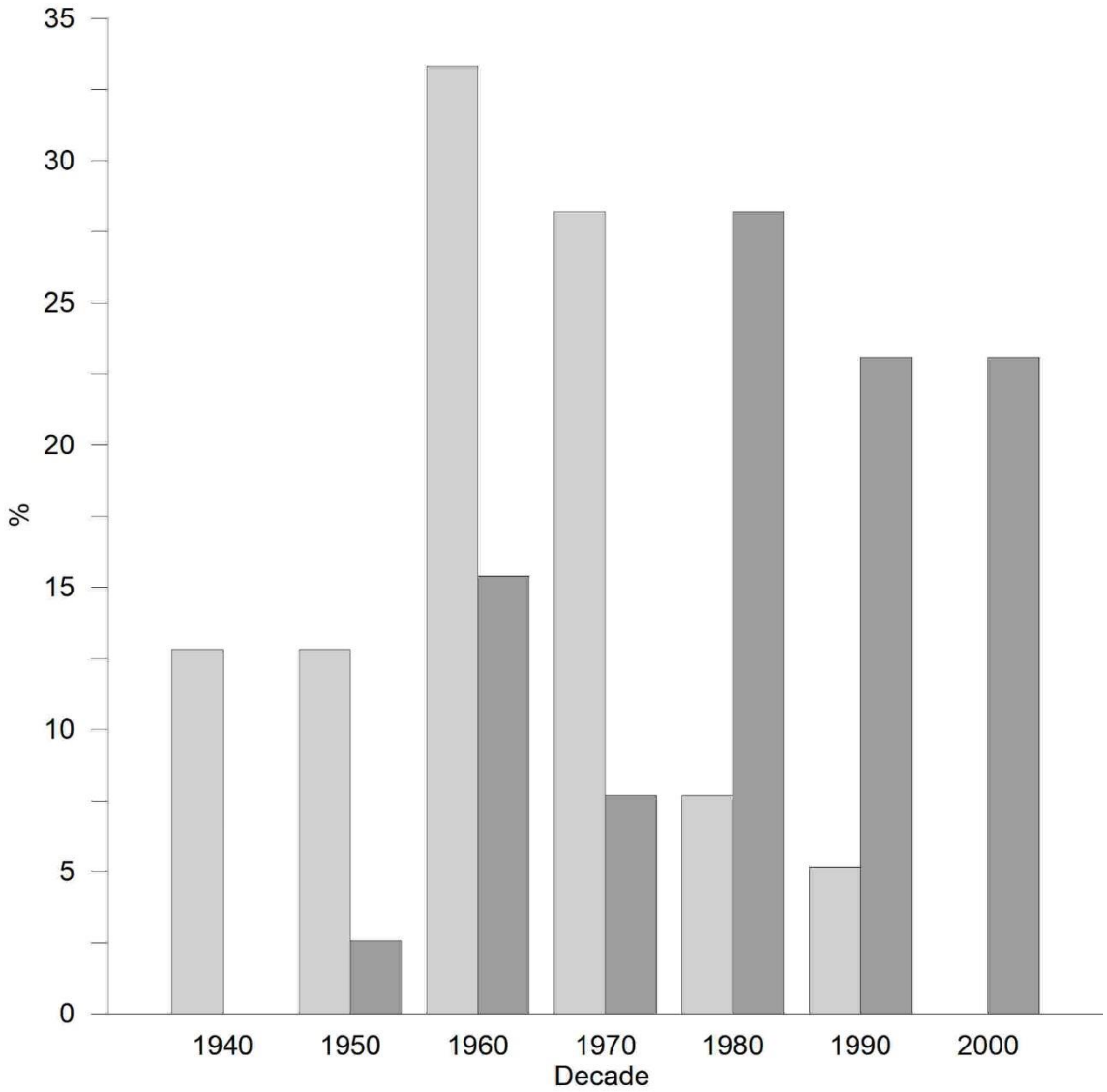
- ☐ No income/unemployed
- ☐ < 12,000 £
- ☐ 12,000 – 30,000 £
- ☐ 30,000 – 50,000 £
- ☐ > 50,000 £

[*Not part of the questionnaire*]

Original statements used in the questionnaire, the ones that we twisted their answers' value for the data analysis, and the two different abbreviations of the statements used inside the article.

Original Statement	Twisted order?	Abbreviation	Abbreviation 2
In comparison with today, in the past there were less long-lasting hot temperatures. In other words, summers were shorter.		Hotter temperatures	Hot Tº
In comparison with today, in the past more fishes and other marine species were visible in the sea		Less marine life	Marine life
In comparison with the past, people are today more aware of the importance of respecting the natural areas they are visiting (for example, not littering, not stepping on marine life or collecting plants or animal souvenirs…)	Yes	Less respect towards nature	Respect towards nature
In comparison with the past, today the coast (including beaches) remains cleaner and better taken care of	Yes	Less clean coasts	Clean coasts
In the past the sea was more polluted than today	Yes	More marine pollution	Marine pollution
In comparison with the past, today there exists more boat transit and boat anchoring; this increases the negative impacts on marine life		More boat transit and anchor	Boat transit and anchor
In comparison with the past, today there are more invasive marine species that come from outside and negatively affect the local marine life		More invasive species	Invasive species
Overfishing is the main cause of marine life decrease		Overfishing	Overfish
People feel nostalgia about how beautiful the sea used to be and complain that the younger generation never saw it like they did		Nostalgia of a more beautiful sea	Nostalgia
This area receives increasingly tourism, which has a growing negative impact on marine life		More tourism impact	Tourism

Supplementary material 3. Frequency distribution of semi-structured interview respondent's (n = 38) decade of birth (light grey) and decade starting the activity in the area (dark grey).



Supplementary material 4. Changes (rows) and frequency of changes (cells) reported in semi-structured interviews, by aspect (social, economic, environmental) and direction (positive, negative). Columns represent interviewees.

Dimension	Direction	Types of change (article name)	Types of change (longer name) (now compared with before, except where contradicted)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Frequency of changes
Social	Positive		Better town and/or home infrastructure					1		1				1						1	1		1									1		1				1		1	1	11
			More competence = better service													1							1									1								1		4
			Better legislation and/or regulations													1																								1		2
			Search and appreciation of a good service																																					1		1
			Internet visibility = more information								1																															1
			Increase social and/or cultural richness																		1																					1
			Less alcohol consumption, more consciousness of alcohol dangers				1																																			1
	Negative		Client exigencies, impatience, problems and/or behaviour						1	1		1	1		1	1		1	1			1					1	1		1							1	1	1		1	16
			Summer overcrowding of tourism					1	1							1			1		1							1	1	1	1	1			1	1		1	1			14
			Deficient and bad practices in town infrastructure, services and/or regulations (for locals and/or tourists)										1			1	1			1						1	1	1			1			1	1	1		1		1		13
			Loss of town essence, good feeling, familiarity. Past nostalgia					1										1			1		1			1		1	1		1	1										9
			No appreciation and/or knowledge of good food and/or fresh fish	1	1		1			1						1					1							1			1											8
			Physical and psychological effects due overwork and/or social media feedback						1			1				1		1									1			1												1	7
			Loss of traditional practices and culture		1														1												1	1		1								5
			Bad and/or unfair management of the Natural Park		1																							1				1	1		1							5
			Foreign not appreciated. Advantageous helps for foreign compared to locals					1					1	1							1																					4
			Bad perspectives for future generations															1													1											2
			Low sea pedagogy and/or knowledge												1																											1
			Decrease of local fix young population														1																									1
Economic	Positive		Town infrastructure attracts tourism					1	1			1									1		1				1				1	1					1	1			1	11
			Out of season tourism increased. Alternative tourism increased (not sun and beach)					1				1										1										1		1	1			1			1	8
			Tourism increased				1															1	1						1		1				1		1					7
			Internet visibility								1	1												1	1		1					1			1							7
			Natural Park conservation = economic gains		1			1				1			1																				1							5
			Town initiatives = higher income			1							1										1				1															4
			Tº/heat duration increased = more work time				1					1										1					1															4
			Higher price fresh fish as a benefit	1		1																															1					3
			In the past tourism was beneficial for the town	1																														1								2
			Tourists come more frequently									1				1																										2
			Competitive alcohol price	1																																						1
	Negative		Low quality tourism, reduction of purchasing power and/or will to spend little				1	1		1		1	1				1	1		1	1		1	1	1	1				1	1	1		1			1		1	1		20
			Tourists stay less time					1				1	1	1		1		1				1	1	1			1					1				1			1		1	14
			More competence inside the town										1	1				1					1	1	1	1	1	1		1						1	1			1		13
			Big seasonality. Shorter summer working season						1			1	1	1		1	1	1		1						1	1								1							11
			Higher price fresh fish as a prejudice	1	1	1	1			1	1					1			1		1																			1		10
			Increase of cheap low quality food and/or fish		1		1			1						1			1									1			1						1			1		9
			More competence in tourist destinations	1				1	1				1											1		1					1	1							1			9
			Tourism and/or clients decreased				1							1						1	1			1				1									1		1			8
			Administrative requisites and/or taxes	1					1			1						1								1	1															6
			Difficult to park the car. Need for parking									1	1	1																								1	1			5
			Traditional fishery income not enough for a living		1											1			1																						3
			Restoration depleted commercial species		1		1													1																						3
			City not designed for night leisure and/or for the youth										1	1																												2
			Internet visibility = clients social media feedback						1																		1															2
			Difficulty to contract trained personal due to short season													1																			1							2
Environmental	Positive	More biodiversity	Biodiversity, nature, and/or conservation increase and species increase and/or recover		1										1						1								1		1		1		1	1						8
		Less construction	Construction decreased																1						1										1							3
		Better beach/coast	Beaches and/or coast preservation improved															1	1											1												3
		More sewage plants	Sewage treatment plants					1																										1								2
		More aesthetic value	Aesthetic value of nature												1																											1
		More respectful users	More respectful users of nature, higher awareness												1																											1
	Negative	Less biodiversity	Species depletion and decrease		1		1								1	1	1	1	1		1								1	1	1	1		1		1		1		1		16
		More disrespectful users	Bad ecologic behaviour, lack of awareness										1		1													1	1	1	1			1				1		1		9
		Worse wather-climate affectation	Weather and/or climate changed. Climate extreme events affectation		1		1					1				1																		1		1						6
		Overfishing	Overfishing		1		1								1															1	1	1										6
		Worse tourism affectation	Tourism affecting nature					1	1				1							1														1				1				6
		Ineffective Natural Park	Ineffective management of the Natural Park		1		1													1									1				1			1						6
		More boats & anchoring	More vessel transit and/or more anchoring						1						1		1												1							1							5
		More invasive sp.	More invasive species				1															1							1			1				1						5
		Worse beach/coast	Beach and/or coast construction and/or lack of maintenance					1					1								1									1				1								5
		Worse aesthetic value	Past nostalgia of aesthetic value of nature		1																1													1								3
		Sp. sickness	Species sickness		1																															1						2
		More contamination	Increase marine contamination														1																									1
			Frequency of changes reported per interview	7	16	7	9	11	14	3	15	9	14	7	11	6	9	12	10	14	11	7	6	11	13	3	14	6	3	14	13	10	14	14	8	8	6	4	7	9	10	365

Supplementary material 5. Answers of the survey (SM 2). Country: Abbreviated by ISO alpha-3 coding. Town/city of residence and profession answers are not shown due to anonymity reasons. See the meanings of the sociodemographic columns in Table 1.

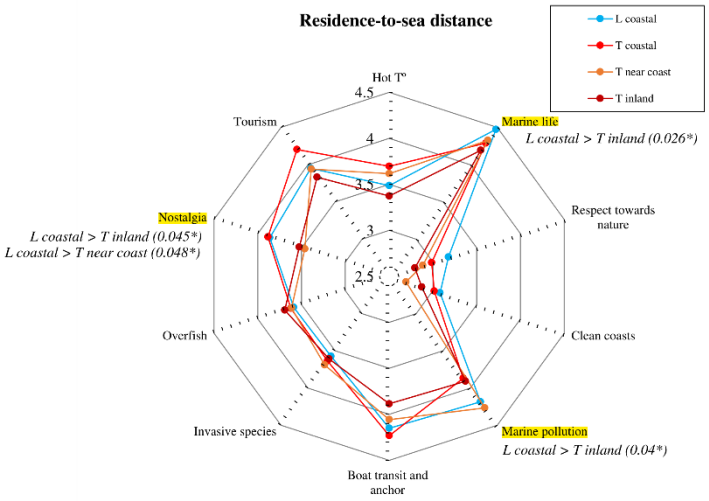
				Sociodemographic parameters								Statements (See SM 2 for the entire statement)										
Code	Place of interview	Gender	Country	Local / Tourist	Residence-to-sea distance	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Baseline decade	Hot T°	Marine life	Respect towards nature	Clean coasts	Marine pollution	Boat transit & anchor	Invasive species	Overfish	Nostalgia	Tourism	Average
SC14	Cadaqués	Female	FRA	Tourist	Inland		Joy	70-79	No Sch.	14-35		4	3	2	2	2	4	3	5	3	4	3.2
SC11	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Joy	50-59	High Sch.	14-35	2000s	3	5	5	5	5	5	3	4	4	4	4.3
SC07	Cadaqués	Male	NLD	Tourist	Coastal	Frequent	Joy	18-29	High Sch.	14-35	2000s	4	5	2	3	5	5	3	3	5	5	4.0
SC06	Cadaqués	Male	NLD	Tourist	Coastal	Frequent	Joy	18-29	Master	35-56	1990s	4	3	3	2	2	3	3	3	4	3	3.0
SC05	Cadaqués	Male	FRA	Tourist	Near coast	Frequent	Joy	50-59	University	35-56	1980s	1	5	4	1	5	5	4	3	4	4	3.6
SC02	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Joy	80-89	No Sch.	14-35	1980s	5	5	5	1	5	2	4	4	5	3	3.9
SC03	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	60-69	Middle Sch.	14-35	1980s	5	5	5	4	5	5	4	4	5	5	4.7
SC01	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	70-79	Primary Sch.	14-35	1970s	5	5	5	1	5	2	4	4	5	3	3.9
SC04	Cadaqués	Female	ESP	Tourist	Near coast		Strong	40-49	Prof./Tech.	14-35		5	5	4	4	4	4	4	4	2	4	4.0
AR11	Roses	Female	FRA	Tourist	Inland		Joy	50-59	Prof./Tech.	14-35		2	5	1	4	3	4	4	4	5	4	3.6
AR10	Roses	Male	ROU	Tourist	Inland	Frequent	Joy	18-29	High Sch.	14-35	2000s	4	5	2	4	5	3	1	3	1	3	3.1
AR06	Roses	Male	ESP	Local	Coastal	Native	Joy	40-49	High Sch.	14-35	1980s	3	5	3	3	3	4	3	3	5	5	3.7
AR05	Roses	Female	ESP	Local	Coastal	Native	Strong	40-49	University	<14	1980s		5	5	4	4	5	5	5	5	5	4.8
AR04	Roses	Female	ESP	Local	Coastal	Native	Joy	30-39	Prof./Tech.	14-35	1990s	2	4	4	4	4	4	3	4	2	4	3.5
AR01	Roses	Male	BEL	Tourist	Inland	Frequent	Joy	50-59	University		1990s	4	5	2	2	2	3	3	5	3	4	3.3
WP07	Port Selva	Male	ESP	Local	Coastal	Native	Joy	70-79	High Sch.		1950s	4	5	3	4	4	4	5	5	4	4	4.2
WP08	Port Selva	Male	ESP	Local	Coastal	Native	Strong	70-79	Middle Sch.		1950s	5	5	3	2	5	3	5	1	1	1	3.1
WP11	Port Selva	Male	LUX	Tourist	Inland	Frequent	Joy	50-59	University	>56	1970s	4	5	3	4	5	4	4	3	5	3	4.0
WP12	Port Selva	Female	LUX	Tourist	Inland	Frequent	Joy	50-59	Prof./Tech.	>56	2000s	4	5	3	2	4	3	3	5	4	4	3.7
WP13	Port Selva	Female	FRA	Tourist	Inland	Frequent	Joy	40-49	PhD	>56	1970s	3	5	3	2	5	5	5	3	3	4	3.8
WP14	Port Selva	Male	FRA	Tourist	Inland	Frequent	Joy	40-49	Master	>56	2000s	3	5	3	3	5	4	4	3	4	4	3.8
WP15	Port Selva	Male	FRA	Tourist		Frequent	Need	50-59	Master	35-56	2000s	3	4	4	2	4	4	2	5	5	4	3.7
WP16	Port Selva	Female	FRA	Tourist		Frequent	Joy	30-39	Master	35-56	1990s	4	3	2	2	3	3	3	2	2	3	2.7
WP17	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	>90	Master		1930s	5	5	4	3	5	5	5	4	5	5	4.6
WP18	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	60-69	Primary Sch.		1970s	2	4	2	2	5	5	4	4	3	2	3.3
WP19	Port Selva	Female	ESP	Local	Coastal	Native	Strong	18-29	Middle Sch.	<14	2000s	4	5	5	3	5	3	4	5	5	5	4.4
AP14	Port Selva	Male	AND	Tourist	Inland		Need	60-69	University	>56		2	5	1	3	5	5	5	2	5	2	3.5
AP15	Port Selva	Female	DEU	Tourist		Frequent	Joy	60-69	High Sch.	14-35	1980s	3	3	2	2	3	3	3	3	4	3	2.9
AP16	Port Selva	Female	CHE	Tourist	Inland	Frequent	Joy	50-59	University	>56	1990s	4	4	2	2	4	3	3	4	3	2	3.1
AP17	Port Selva	Female	FRA	Tourist	Inland	Frequent	Joy	50-59	University	14-35	1970s	2	5	2	2	4	2	3	4	4	4	3.2
AP18	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Avoid	70-79	Primary Sch.	<14	1940s	4	5	1	1	3	5	3	1	4	5	3.2
AP20	Port Selva	Female	ESP	Local	Coastal	Native	Joy	60-69	Middle Sch.	14-35	1960s	5	5	1	1	3	2	1	2	4	4	2.8
AP22	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	30-39	Prof./Tech.		2000s	4	3	3	4	2	3	4	3	3	4	3.3
AP24	Port Selva	Female	FRA	Tourist	Inland	Frequent	Joy	18-29	Middle Sch.	No income	2000s	4	4	1	3	4	3	2	5	3	3	3.2
AP25	Port Selva	Female	ESP	Local	Coastal	Native	Strong	18-29	High Sch.	<14	2000s	5	5	4	4	5	5	3	5	5	5	4.6
AP26	Port Selva	Male	ESP	Local	Coastal	Native	Need	50-59	Prof./Tech.	14-35	1970s	4	5	3	2	4	4	3	3	4	3	3.5
SP67	Port Selva	Male	BEL	Tourist	Inland	Frequent	Need	60-69	High Sch.	14-35	1960s	3	4	4	4	4	4	3	2	2	3	3.3
SP51	Port Selva	Male	ESP	Local	Coastal	Native	Joy	80-89	Primary Sch.	14-35	1940s	5	5	5	1	4	3	4	3	5	3	3.8
SP50	Port Selva	Male	ESP	Local	Coastal	Native	Strong	18-29	Prof./Tech.	<14	2000s	4	5	2	2	3	5	3	3	5	5	3.7
SP52	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Joy	18-29	Master	<14	2000s	3	4	3	3	3	4	3	2	1	4	3.0
SP55	Port Selva	Male	ESP	Local	Coastal	Native	Need	80-89	Middle Sch.	14-35	1940s	4	5	4	2	4	4	4	4	4	4	3.9
SP61	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	18-29	High Sch.	No income	2000s	5	3	4	3	5	5	5	3	4	5	4.2
SP66b	Port Selva	Male	ESP	Local	Coastal	Native	Joy	18-29	High Sch.	<14	2000s	3	4	5	4	5	4	4	3	3	2	3.7
MR23	Roses	Female	ESP	Local	Coastal	Native	Strong	50-59	High Sch.	<14	1970s	3	4	4	4	4	4	3	4	4	5	3.9
MR28	Roses	Female	ESP	Local	Coastal	Native	Need	18-29	University	<14	2000s	4	4	4	5	5	4	4	3	4	5	4.2
MR29	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	High Sch.	No income	2000s	4	4	3	3	4	5	3	2	4	2	3.4
MR32	Roses	Female	ESP	Local	Coastal	Native	Need	18-29	Middle Sch.	<14	2000s	4	5	4	5	5	5	2	5	4	5	4.4
MR33	Roses	Male	ESP	Local	Coastal	Native	Need	30-39	University	14-35	1990s	3	5	1	1	2	4	3	3	1	2	2.5
SR27	Roses	Female	ESP	Local	Coastal	Native	Strong	40-49	Prof./Tech.	14-35	1980s	2	5	3	2	4	4	3	5	5	5	3.8
SR28	Roses	Female	ESP	Local	Coastal	Native	Need	40-49	Middle Sch.	14-35	1980s	3	5	3	3	4	4	4	5	5	4	4.0
SR30	Roses	Male	ESP	Tourist	Near coast	Frequent	Joy	40-49	University	35-56	1980s	1	5	1	1	4	5	3	5	2	4	3.1
SR31	Roses	Male	FRA	Tourist	Inland	Frequent	Joy	60-69	Middle Sch.	<14	2000s	2	5	2	3	5	4	2	5	3	3	3.4
SR33	Roses	Female	FRA	Tourist	Inland	Frequent	Need	50-59	Middle Sch.	<14	1990s	3	5	3	2	4	5	3	5	5	5	4.0
SR36	Roses	Male	FRA	Tourist	Inland	Frequent	Indifferent	60-69	Middle Sch.	14-35	1990s	5	4	3	3	4	4	4	2	5	4	3.8
SR37	Roses	Female	ESP	Tourist	Inland	Infrequent	Joy	60-69	Primary Sch.	14-35	1990s	5	4	2	2	3	4	4	4	4	4	3.6
SR38	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	University	<14	2000s	4	3	4	2	5	4	4	2	3	3	3.4
SR39	Roses	Female	ESP	Local	Coastal	Non-native	Need	18-29	Middle Sch.		1990s	2	4	1	2	3	4	3	3	3	4	2.9
SR40	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	University	<14	2000s	5	5	4	4	5	4	2	2	5	5	4.1
SR41	Roses	Female	ESP	Local	Coastal	Native	Strong	50-59	Prof./Tech.	<14	1970s	5	5	3	3	3	2	4	3	4	3	3.5
SR42	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	University	<14	2000s	3	5	2	5	3	5	3	4	5	1	3.6
SR43	Roses	Female	CAN	Tourist	Inland	Frequent	Need	50-59	Prof./Tech.	14-35	2000s	3	4	3	2	4	3	4	4	2	2	3.1
SR44	Roses	Male	CAN	Tourist	Inland	Frequent	Joy	50-59	Middle Sch.	35-56	2000s	4	3	1	3	5	3	4	5	3	1	3.2
SR45	Roses	Male	ESP	Tourist	Inland	Frequent	Joy	30-39	University	14-35	2000s	3	3	5	5	5	1	3	3	1	1	3.0
SR46	Roses	Female	ESP	Tourist	Inland	Infrequent	Joy	30-39	University	35-56	1980s	4	5	3	3	5	5	4	4	4	4	4.1
SR47	Roses	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	Primary Sch.	<14	1980s	5	3	4	1	5	5	5	2	4	5	3.9
SR48	Roses	Male	ESP	Local	Coastal	Native	Joy	18-29	High Sch.	<14	2000s	5	3	4	4	5	4	4	5	5	5	4.4
AC182	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	30-39	Master	14-35	1990s	4	3	3	4	3	4	4	4	3	4	3.6
AC183	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	18-29	University	<14	2000s	3	3	2	3	3	4	3	3	3	4	3.1
AC184	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	40-49	Master	14-35	1980s	2	4	2	3	4	5	4	4	3	4	3.5
ZC09	Cadaqués	Male	ESP	Local	Coastal	Non-native	Joy	40-49	University	<14	2000s	5	3	4	4	5	5	3	3	5	5	4.2
ZC17	Cadaqués	Female	ESP	Local	Coastal	Non-native	Strong	70-79	High Sch.	<14	1940s	5	5	5	1	2	5	1	1	2	2	2.9
ZC19	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Strong	40-49	Master	<14	1990s	3	3	3	2	4	4	3	3	4	5	3.4
ZC22	Cadaqués	Male	ESP	Local	Coastal	Non-native	Strong	50-59	Middle Sch.		1960s	1	5	5	5	5	5	3	5	5	5	4.4
MC187	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	30-39	University	14-35	1990s	4	5	3	3	5	5	5	3	5	5	4.3
MC180	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	18-29	University	<14	2000s	4	5	4	4	5	4	4	4	3	4	4.1
MC181	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	40-49	Prof./Tech.	14-35	1980s	4	5	4	4	5	5	4	4	4	3	4.2
MC182	Cadaqués	Female	ESP	Tourist	Inland	Frequent	Joy	18-29	Middle Sch.	No income	2000s	3	5	4	4	5	3	5	3	5	5	4.2
MC183	Cadaqués	Male	ESP	Local	Coastal	Native	Need	50-59	University	35-56	1970s	1	5	5	5	5	5	4	4	5	5	4.4
MC184	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	60-69	University	14-35	1960s	2	5	1	5	5	5	5	4	5	5	4.2
MC185	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	18-29	Middle Sch.	No income	2000s	4	3	2	1	5	5	4	4	4	4	3.6
MC186	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	40-49	University	14-35	1980s	2	4	4	4	4	4	4	4	4	2	3.6
MC188	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	18-29	University	<14	2000s	5	5	2	2	5	3	4	3	5	4	3.8
MC189	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	50-59	Master	35-56	1960s	3	4	1	2	4	4	4	4	4	4	3.4
MC190	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Need	30-39	University	14-35	2000s	3	4	4	4	5	4	3	3	4	4	3.8
MC191	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Strong	40-49	Prof./Tech.	14-35	1990s	4	5	4	4	5	5	3	4	5	5	4.4
MC194	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	50-59	University	35-56	1980s	4	5	4	4	4	5	5	2	4	4	4.1
ZP01	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	60-69	Master	35-56	2000s	1	3	2	1	5	4	3	4	4	4	3.1
ZP02	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	18-29	Primary Sch.	14-35	1990s	5	5	1	1	5	5	5	5	5	1	3.8
UR21	Roses	Male	ESP	Local	Coastal	Non-native	Joy	30-39	High Sch.	14-35	2000s	4	5	2	1	5	2	3	1	5	1	2.9
UR20	Roses	Male	FRA	Tourist	Inland	Frequent	Strong	60-69	Prof./Tech.	14-35	1990s	1	5	4	1	5	5	2	5	5	5	3.8
MC232	Cadaqués	Female	ESP	Local	Coastal	Non-native	Strong	50-59	University	<14	2000s	3	5	3	3	4	5	4	3	4	4	3.8
MC230	Cadaqués	Female	ESP	Local	Coastal	Non-native	Strong	40-49	Master	<14	2000s	5	5	4	5	5	5	3	3	5	5	4.5
AP201	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	40-49	Master	14-35	2000s	3	4	4	4	5	3	4	4	3	4	3.8
AP202	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	50-59	Prof./Tech.	14-35	2000s	2	5	4	3	4	2	4	5	4	3	3.6
AP203	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	30-39	Master		2000s	4	4	5	5	3	4	4	2	3	4	3.8
AP204	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	30-39	Master	35-56	2000s	3	4	4	4	5	4	3	3	4	4	3.8
AP206	Port Selva	Female	ESP	Tourist	Inland	Frequent	Joy	50-59	Middle Sch.		1970s	4	3	4	4	4	4	3	3	4	4	3.7
AP208	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Need	18-29	University	No income	2000s	4	3	4	4	4	4	4	4	4	5	4.0
AP209	Port Selva	Female	FRA	Tourist	Inland	Frequent	Need	40-49	Master	35-56	1970s	4	4	4	5	5	5	5	5	5	5	4.7
AR186	Roses	Female	GBR	Tourist	Inland	Frequent	Joy	80-89	High Sch.	<14	1980s	1	4	4	3	1	3	5	4	3	4	3.2
AR190	Roses	Male	ESP	Tourist	Near coast	Infrequent	Joy	50-59	High Sch.	35-56	1960s	4	4	2	3	5	4	4	2	4	3	3.5
AR191	Roses	Male	ESP	Local	Coastal	Non-native	Strong	80-89	Primary Sch.		1960s	4	5	2	2	5	4	4	4	3	4	3.7
AR192	Roses	Male	BEL	Tourist	Inland	Frequent	Need	50-59	Middle Sch.	14-35	1990s	4	4	2	4	4	5	4	4	4	4	3.9
AR193	Roses	Female	FRA	Tourist		Frequent	Need	50-59	Master	35-56	1970s	3	5	3	2	4	4	4	3	3	4	3.5
AR198	Roses	Female	FRA	Tourist	Inland	Infrequent	Joy	40-49	University	35-56	2000s	4	5	4	3	5	5	4	3	3	5	4.1

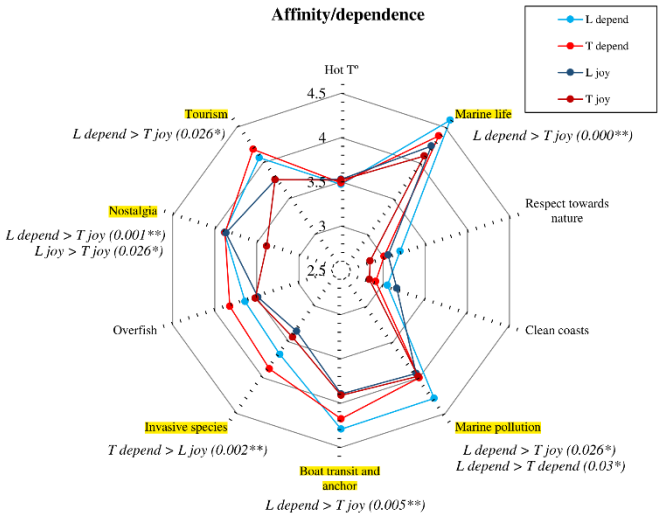
				Sociodemographic parameters								Statements (See SM 2 for the entire statement)										
Code	Place of interview	Gender	Country	Local / Tourist	Residence-to-sea distance	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Baseline decade	Hot T°	Marine life	Respect towards nature	Clean coasts	Marine pollution	Boat transit & anchor	Invasive species	Overfish	Nostalgia	Tourism	Average
MR195	Roses	Female	ESP	Local	Coastal	Native	Strong	30-39	High Sch.	<14	1990s	4	5	3	2	4	4	3	3	4	2	3.4
MR196	Roses	Female	ESP	Local	Coastal	Non-native	Strong	50-59	High Sch.	14-35	1980s	2	3	2	4	4	4	4	3	3	4	3.3
MR197	Roses	Female	ESP	Tourist	Coastal	Frequent	Strong	30-39	Master	35-56	2000s	1	5	4	3	5	5	3	4	3	3	3.6
MR198	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	Master	14-35	2000s	4	5	3	3	3	4	4	3	3	5	3.7
MR200	Roses	Female	ESP	Local	Coastal	Native	Strong	50-59	High Sch.	14-35	1970s	4	5	4	2	5	5	5	3	5	5	4.3
MR201	Roses	Male	FRA	Tourist	Inland	Frequent	Joy	50-59	Master	35-56	1990s	4	1	2	3	4	3	5	4	2	4	3.2
MR202	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	Middle Sch.	No income	2000s	3	2	2	2	1	3	5	5	3	3	2.9
MR205	Roses	Male	ESP	Local	Coastal	Native	Joy	30-39	Prof./Tech.	<14	1990s	4	4	1	4	4	5	4	4	4	4	3.8
AC172	Cadaqués	Male	FRA	Tourist	Inland	Infrequent	Need	40-49	University	14-35	1990s	4	5	4	2	4	4	3	3	4	4	3.7
AC176	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	40-49	Master	>56	1980s	3	4	4	1	5	2	5	3	2	1	3.0
AC177	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	40-49	High Sch.	14-35	1980s	3	4	2	3	4	4	4	3	3	3	3.3
AC179	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Need	18-29	Master	<14	1990s	5	5	2	2	5	5	4	5	3	5	4.1
AC181	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	50-59	Prof./Tech.	14-35	1970s	4	3	3	4	3	4	4	4	3	4	3.6
MP243	Port Selva	Male	FRA	Tourist	Inland		Joy	40-49	University	14-35		5	5	2	3	3	4	3	3	2	3	3.3
MP244	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Strong	60-69	University	35-56	1970s	4	5	2	2	5	3	3	5	3	2	3.4
MP245	Port Selva	Male	ESP	Local	Coastal	Native	Strong	30-39	Middle Sch.	14-35	1990s	4	5	2	5	5	5	5	5	4	4	4.4
MP246	Port Selva	Female	ESP	Local	Coastal	Native	Strong	50-59	Prof./Tech.	14-35	1970s	4	5	2	2	5	4	4	2	3	4	3.5
MP248	Port Selva	Male	FRA	Tourist	Inland	Frequent	Joy	40-49	Master	>56	2000s	1	3	2	2	3	4	2	4	2	4	2.7
MP249	Port Selva	Male	ESP	Tourist	Coastal	Infrequent	Joy	18-29	High Sch.	<14	1990s	4	3	1	2	5	5	4	3	3	3	3.3
MP150	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	60-69	Master	35-56	1990s	2	3	2	2	2	4	4	4	3	3	2.9
MP252	Port Selva	Female	CHE	Tourist	Inland	Frequent	Need	18-29	High Sch.	No income	2000s	3	5	2	3	4	3	5	4	4	5	3.8
MP256	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	18-29	High Sch.	No income	2000s	4	5	3	2	5	4	3	3	3	5	3.7
MP255	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	High Sch.	No income	2000s	5	5	4	4	3	4	3	4	4	5	4.1
UC12B	Cadaqués	Male	ESP	Local	Coastal	Non-native	Strong	60-69	PhD	>56	1970s	5	5	1	3	5	5	4	2	4	5	3.9
UC14	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	University	No income	1990s	3	5	2	2	5	4	3	2	5	5	3.6
UC16	Cadaqués	Male	ESP	Local	Coastal	Non-native	Need	50-59	University	No income	1990s	1	5	2	5	5	5	3	1	1	5	3.3
UC16B	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Need	40-49	University	>56	2000s	2	3	3	2	2	4	3	2	2	4	2.7
UC11B	Cadaqués	Male	ESP	Local	Coastal	Non-native	Strong	18-29	Middle Sch.	14-35	2000s	3	5	5	4	1	5	5	3	4	4	3.9
UC11	Cadaqués	Female	FRA	Tourist	Coastal	Infrequent	Strong	30-39	Master	14-35	2000s	2	4	2	2	3	4	4	4	4	4	3.3
MC220	Cadaqués	Male	ESP	Local	Coastal	Non-native	Need	50-59	Middle Sch.	No income	1980s	2	5	5	5	4	5	4	4	5	2	4.1
MC221	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	30-39	High Sch.	14-35	1990s	4	5	2	3	5	5	5	3	3	4	3.9
MP212	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	Master	No income	1990s	4	5	4	3	5	4	3	5	5	4	4.2
MP210	Port Selva	Male	ESP	Local	Coastal	Native	Strong	60-69	High Sch.		1960s	5	5	5	5	5	5	5	5	5	5	5.0
MC223	Cadaqués	Male	ITA	Tourist	Inland	Infrequent	Need	30-39	High Sch.	14-35	2000s	3	3	3	1	3	2	4	3	3	3	2.8
UC01	Cadaqués	Female	ESP	Tourist	Near coast	Infrequent	Joy	50-59	High Sch.	<14	1980s	5	5	5	1	4	5	5	5	5	5	4.5
UC02	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	70-79	Prof./Tech.		1980s	3	5	1	2	5	3	2	1	4	3	2.9
UC04	Cadaqués	Male	FRA	Tourist	Inland	Frequent	Joy	60-69	University	14-35	1980s	4	5	1	1	4	3	3	3	5	5	3.4
UC07	Cadaqués	Female	FRA	Tourist	Inland	Infrequent	Joy	50-59	Master	14-35	2000s	4	3	4	2	4	4	4	3	3	4	3.5
MC105	Cadaqués	Female	ESP	Local	Coastal	Native		40-49	University	14-35	1980s	3	5	5	3	4	4	3	4	5	3	3.9
MR240	Roses	Male	ESP	Local	Coastal	Native	Joy	60-69	High Sch.	14-35	1960s	3	4	2	1	2	3	4	3	2	2	2.6
MR241	Roses	Female	ESP	Local	Coastal	Non-native	Strong	18-29	Prof./Tech.	14-35	1990s	2	4	3	3	4	4	4	3	4	4	3.5
UR31	Roses	Female	FRA	Tourist	Inland	Frequent	Need	70-79	Middle Sch.	35-56	1970s	3	4	2	2	4	4	3	2	3	4	3.1
UR27	Roses	Male	FRA	Tourist	Inland	Frequent	Strong	50-59	High Sch.	>56	2000s	1	4	2	2	4	2	4	5	3	3	3.0
UR26	Roses	Male	ESP	Local	Coastal	Native	Joy	60-69	High Sch.	14-35	1960s	4	3	1	1	2	2	3	2	3	3	2.4
UR23	Roses	Male	ESP	Local	Coastal	Non-native	Strong	40-49	University	14-35	1990s	2	4	3	2	4	5	5	5	4	5	3.9
WP999	Port Selva	Female	ITA	Tourist	Near coast	Frequent	Joy	70-79	University	>56	1950s	2	4	2	2	4	4	4	4	2	2	3.0
MC16	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	40-49	University	14-35	1980s	1	3	3	2	3	1	3	1	1	1	1.9
MC20	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	18-29	Middle Sch.	<14	2000s	1	2	5	2	3	4	2	3	2	3	2.7
MC22	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	18-29	University	<14	2000s	3	5	4	2	5	4	3	3	4	4	3.7
MC18	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	40-49	Master	14-35	1980s	3	5	2	3	4	5	4	5	4	5	4.0
MP257	Port Selva	Female	ESP	Local	Coastal	Native	Joy	50-59	Primary Sch.		1970s	4	5	4	4	4	5	3	5	4	3	4.1
MP258	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	50-59	Prof./Tech.	<14	1960s	3	5	3	3	4	5	4	5	4	5	4.1
MP259	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	40-49	University	14-35	1990s	4	4	2	2	4	4	4	4	3	4	3.5
UP41	Port Selva	Male	FRA	Tourist	Coastal	Frequent	Joy	30-39	High Sch.	14-35	1980s	2	5	2	1	5	1	3	3	1	3	2.6
UP46	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Strong	40-49	University	>56	1990s	5	4	2	1	4	5	5	5	4	5	4.0
UP50	Port Selva	Female	ESP	Local	Coastal	Native	Strong	50-59	High Sch.		1970s	4	4	2	4	4	5	3	1	2	3	3.2
UP52	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	60-69	Master	>56	1990s	4	5	1	2	1	4	5	4	4	5	3.5
UP53	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	University	14-35	1990s	5	5	1	1	4	4	5	3	4	3	3.5
UP56	Port Selva	Male	ESP	Local	Coastal	Native	Strong	40-49	Prof./Tech.	14-35	1980s	5	5	1	1	5	5	5	3	5	4	3.9
UP58	Port Selva	Male	ESP	Local	Coastal	Non-native	Need	40-49	University	35-56	1990s	3	5	2	3	5	3	3	5	1	5	3.5
UP59	Port Selva	Male	BEL	Tourist	Inland	Frequent	Strong	40-49	Middle Sch.		1990s	1	5	4	3	5	1	4	5	4	3	3.5
ZP03	Port Selva	Female	USA	Tourist	Coastal	Frequent	Joy	70-79	Master	>56	1980s	2	5	3	5	5	5	5	5	5	5	4.5
ZP04	Port Selva	Female	ESP	Local	Coastal	Native	Need	40-49	Master	14-35	1980s	2	5	2	1	5	3	4	4	2	2	3.0
ZP05	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Need	30-39	Prof./Tech.		1980s	2	4	4	4	4	4	4	4	4	4	3.8
ZP06	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	80-89	High Sch.		1950s	4	4	2	2	4	4	4	4	4	4	3.6
ZP07	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	40-49	Master	>56	1980s	4	5	4	4	5	5	3	3	4	2	3.9
ZP08	Port Selva	Male	ESP	Local	Coastal	Non-native	Strong	40-49	High Sch.	14-35	1970s	2	5	3	1	1	5	5	5	3	3	3.3
MP170	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Strong	70-79	Middle Sch.		1990s	3	5	3	3	5	5	3	5	5	4	4.1
MP171	Port Selva	Male	ESP	Local	Coastal	Non-native	Strong	18-29	Middle Sch.	<14	2000s	3	4	4	4	5	3	1	4	3	5	3.6
MP174	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	18-29	University	<14	1990s	3	5	3	2	5	4	3	3	4	3	3.5
MP175	Port Selva	Female	ESP	Local	Coastal	Native	Strong	40-49	University	<14	1980s	3	5	2	1	4	4	3	4	3	3	3.2
MP176	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	18-29	University	14-35	2000s	4	5	2	2	4	4	3	4	4	4	3.6
MP177	Port Selva	Male	ESP	Local	Coastal	Native	Strong	18-29	University	14-35	2000s	5	5	4	4	5	5	2	2	1	4	3.7
AP164	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	70-79	Prof./Tech.	14-35	1940s	4	3	2	2	4	4	2	5	4	3	3.3
AP165	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Strong	70-79	University		1960s	2	4	2	2	4	5	3	4	3	4	3.3
AP170	Port Selva	Female	ESP	Local	Coastal	Native	Strong	40-49	High Sch.	<14	1980s	2	5	4	3	5	4	2	4	3	3	3.5
AR144	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	Prof./Tech.	<14	2000s	4	3	2	4	5	3	3	2	3	4	3.3
AR145	Roses	Female	ESP	Local	Coastal	Native	Joy	30-39	Prof./Tech.	14-35	1990s	1	3	3	2	3	3	3	5	3	2	2.8
AR146	Roses	Female	ESP	Local	Coastal	Native	Need	30-39	Prof./Tech.	<14	1990s	3	5	3	3	3	5	4	4	5	4	3.9
AR147	Roses	Female	ESP	Local	Coastal	Native	Joy	40-49	Middle Sch.	14-35	1980s	1	3	2	2	5	4	4	1	3	3	2.8
AR149	Roses	Female	FRA	Tourist	Inland		Joy	70-79	Middle Sch.	<14		3	4	2	2	4	4	4	4	4	4	3.5
AR153	Roses	Male	ESP	Local	Coastal	Native	Need	18-29	Primary Sch.	14-35	2000s	4	4	3	2	5	4	3	4	4	4	3.7
SC17	Cadaqués	Male	FRA	Tourist	Near coast		Joy	70-79	Middle Sch.	14-35		4	4	3	2	3	5	4	3	4	3	3.5
SC18	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Joy	40-49	University	<14	1990s	4	4	4	3	4	4	3	4	4	4	3.8
SC19	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Need	40-49	University	14-35	1990s	5	4	5	2	5	5	5	4	3	4	4.2
SC20	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Need	50-59	High Sch.	35-56	1990s	3	4	4	2	3	4	4	3	4	4	3.5
SC21	Cadaqués	Male	MAR	Tourist	Coastal		Strong	50-59	Primary Sch.	<14		5	5	2	2	5	1	5	5	5	4	3.9
SC22	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Need	50-59	Prof./Tech.		1990s	2	4	3	4	4	4	4	4	4	4	3.7
SC23	Cadaqués	Female	GBR	Tourist	Coastal		Joy	40-49	University	>56		4	4	1	4	1	5	3	4	4	4	3.4
SC25	Cadaqués	Female	ESP	Local	Coastal	Native	Indifferent	70-79	Primary Sch.	14-35	1950s	5	5	2	1	5	5	5	1	4	2	3.5
SC26	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	80-89	Primary Sch.	14-35	1940s	5	5	2	1	4	4	5	3	3	2	3.4
MC02	Cadaqués	Female	FRA	Tourist			Joy	40-49	Master	14-35		4	4	2	2	4	2	3	3	2	2	2.8
MC05	Cadaqués	Female	ESP	Local	Coastal	Native	Indifferent	18-29	High Sch.	No income	2000s	4	5	4	3	5	4	3	4	5	5	4.2
MC06	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	50-59	University	35-56	1970s	4	4	4	4	3	4	4	5	3	5	4.0
MC08	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	40-49	University		1980s	3	5	3	3	4	5	4	5	5	4	4.1
MC07	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Joy	50-59	University	>56	1980s	4	4	4	4	4	4	3	3	4	5	3.9
MC09	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	60-69	High Sch.	<14	1960s	5	5	4	4	4	5	4	5	3	5	4.4
MC10	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	60-69	University	<14	1960s	5	5	3	4	4	5	3	3	5	4	4.1
MC11	Cadaqués	Female	ARG	Tourist	Coastal	Infrequent	Strong	30-39	University	<14	2000s	3	4	2	3	4	5	3	3	4	5	3.6
MC15	Cadaqués	Male	ESP	Local	Coastal	Native	Need	18-29	Prof./Tech.	14-35	2000s	2	5	4	3	5	5	3	3	4	3	3.7
AR158	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	High Sch.	<14	2000s	3	4	4	5	5	3	3	3	5	5	4.0
AR162	Roses	Female	FRA	Tourist	Coastal	Frequent	Joy	70-79	No Sch.		1970s	5	5	2	2	3	5	4	5	5	5	4.1
AP125	Port Selva	Male	ESP	Local	Coastal	Native	Strong	70-79	PhD	14-35	1950s	4	5	2	2	4	4	3	4	4	4	3.6
AP126	Port Selva	Female	FRA	Tourist	Near coast	Frequent	Indifferent	60-69	No Sch.		1990s	4	4	2	2	5	1	4	4	4	3	3.3
AP127	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	University		1980s	4	3	2	2	4	2	3	2	2	2	2.6
AP128	Port Selva	Female	ESP	Local	Coastal		Indifferent	18-29	High Sch.	<14		4	5	3	2	5	4	2	3	1	2	3.1
AP129	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	18-29	High Sch.	14-35	2000s	3	5	4	5	3	5	3	5	4	5	4.2

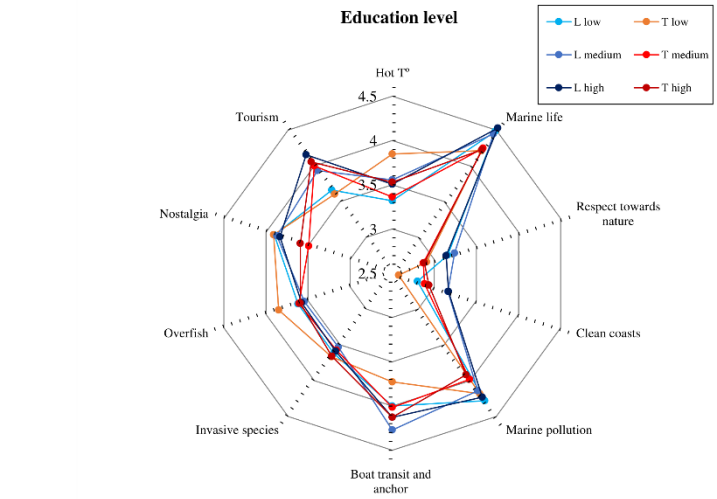
				Sociodemographic parameters								Statements (See SM 2 for the entire statement)										
Code	Place of interview	Gender	Country	Local / Tourist	Residence-to-sea distance	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Baseline decade	Hot T°	Marine life	Respect towards nature	Clean coasts	Marine pollution	Boat transit & anchor	Invasive species	Overfish	Nostalgia	Tourism	Average
AP131	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Joy	60-69	Master		2000s	4	3	2	2	3	1	3	3	1	1	2.3
AP135	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	50-59	High Sch.	35-56	1990s	4	4	4	3	4	5	4	3	3	5	3.9
AP139	Port Selva	Male	ESP	Local	Coastal	Native	Joy		Prof./Tech.	14-35		1	2	5	4	5	5	5	5	3	4	3.9
AP140	Port Selva	Female	ESP	Tourist	Inland	Frequent	Strong	40-49	University	14-35	2000s	4	5	3	3	5	5	5	4	5	5	4.4
AR108	Roses	Male	ESP	Local	Coastal	Native	Indifferent	60-69	University	35-56	1960s	2	5	5	2	4	4	3	3	4	4	3.6
WP103	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	40-49	Prof./Tech.	14-35	1980s	1	2	4	4	4	4	3	2	2	3	2.9
WP104	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong		Master	14-35	2000s	4	5	5	5	1	5	5	5	5	5	4.5
WP105	Port Selva	Female	FRA	Tourist	Inland	Infrequent	Indifferent	30-39	University	>56	2000s	3	5	2	3	3	3	3	4	5	4	3.5
WP106	Port Selva	Male	GBR	Tourist	Inland	Infrequent	Joy	40-49	Master	>56	2000s	5	5	3	3	4	5	5	5	4	4	4.3
WP112	Port Selva	Female	ESP	Local	Near coast	Non-native	Joy	50-59	High Sch.		1960s	3	5	4	3	5	4	4	1	3	4	3.6
WP113	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	60-69	PhD	14-35	1970s	3	5	1	3	4	5	4	4	3	4	3.6
WP116	Port Selva	Male	ESP	Tourist	Coastal	Infrequent	Need	18-29	University	<14	2000s	4	5	1	2	4	5	3	3	5	5	3.7
MR162	Roses	Male	ESP	Local	Coastal	Non-native	Strong	40-49	Master	35-56	1990s	4	5	3	2	5	4	4	4	4	5	4.0
MR163	Roses	Male	ESP	Local	Coastal	Native	Strong	30-39	Prof./Tech.	14-35	1990s	1	5	4	5	5	5	3	2	5	3	3.8
MR165	Roses	Male	BEL	Tourist	Coastal	Frequent	Joy	40-49	Prof./Tech.		1980s	3	2	2	3	3	4	3	3	3	3	2.9
MR164	Roses	Male	BEL	Tourist	Coastal	Frequent	Joy	30-39	Middle Sch.	>56	2000s	2	2	2	3	3	4	3	3	3	3	2.8
MR165	Roses	Female	ESP	Tourist	Inland	Frequent	Joy	50-59	Primary Sch.	14-35	1980s	5	5	4	5	5	1	1	2	1	1	3.0
MR166	Roses	Male	ESP	Tourist	Inland	Frequent	Joy	50-59	Primary Sch.	14-35	1980s	5	5	5	4	5	5	5	4	5	4	4.7
MP130	Port Selva	Male	ESP	Local	Coastal	Native	Strong	70-79	Middle Sch.	35-56	1950s	4	5	4	2	5	5	3	4	5	4	4.1
MP131	Port Selva	Female	ESP	Local	Coastal	Native	Strong	40-49	University	35-56	1980s	1	4	2	2	5	4	3	4	4	4	3.3
MP132	Port Selva	Female	ESP	Local	Coastal	Non-native	Strong	50-59	Prof./Tech.	14-35	1990s	5	5	5	2	5	5	5	3	5	5	4.5
MP134	Port Selva	Male	ESP	Local	Coastal	Native	Strong	18-29	Master	<14	2000s	4	5	4	5	5	3	3	3	4	3	3.9
MP140	Port Selva	Female	ESP	Local	Coastal	Native	Strong	50-59	Prof./Tech.	<14	1970s	4	4	3	2	3	4	4	4	4	3	3.5
MP141	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Joy	30-39	University		1980s	4	3	5	5	5	5	3	3	1	4	3.8
MP142	Port Selva	Male	ESP	Local	Coastal	Native	Indifferent	50-59	University	14-35	1970s	5	3	4	3	5	4	4	4	4	4	4.0
MP143	Port Selva	Female	ESP	Local	Coastal	Native	Joy	18-29	University	14-35	2000s	5	5	4	3	5	4	4	4	3	5	4.2
MP144	Port Selva	Female	ESP	Tourist	Coastal		Strong	30-39	Prof./Tech.	<14		5	5	5	3	3	5	3	5	5	4	4.3
ZC24	Cadaqués	Female	ESP	Local	Coastal	Non-native	Need	18-29	High Sch.	No income	2000s	3	5	5	4	4	5	3	3	5	5	4.2
ZC25	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Joy	18-29	Master	<14	1990s	2	5	2	5	5	5	3	4	4	5	4.0
ZC26	Cadaqués	Male	ESP	Local	Coastal	Non-native	Strong	18-29	Prof./Tech.	<14	2000s	4	5	5	3	5	5	5	5	5	5	4.7
ZC27	Cadaqués	Female	ESP	Local	Coastal	Non-native	Joy	50-59	Master	35-56	1980s	4	4	2	2	3	4	3	3	3	4	3.2
ZC33	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Need	70-79	High Sch.	>56	1990s	5	5	5	2	3	5	3	4	4	5	4.1
UC68	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Need	40-49	University	14-35	1990s	3	5	2	4	5	5	3	5	5	5	4.2
UC69	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	30-39	Prof./Tech.	14-35	1990s	4	5	4	3	5	5	3	2	4	5	4.0
MC260	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	18-29	High Sch.	No income	1990s	4	3	4	4	4	5	4	5	2	5	4.0
MC261	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	30-39	Master	14-35	1990s	4	5	3	5	5	5	5	5	5	5	4.7
MC262	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	30-39	Prof./Tech.	14-35	1990s	3	5	5	4	5	5	4	3	5	5	4.4
MC263	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	30-39	High Sch.	<14	1990s	3	5	2	4	5	5	4	5	5	5	4.3
MC264	Cadaqués	Male	ESP	Local	Coastal	Native	Need	30-39	High Sch.	35-56	1990s	3	4	3	2	4	4	4	3	4	5	3.6
MC265	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	40-49	Middle Sch.	<14	1980s	3	5	4	2	5	5	5	4	5	3	4.1
MC266	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	18-29	Middle Sch.	No income	2000s	5	4	3	5	5	5	5	5	3	3	4.3
MC267	Cadaqués	Male	ESP	Local	Coastal	Native	Joy	18-29	Middle Sch.	14-35	2000s	3	5	5	5	5	5	3	5	5	5	4.6
MC268	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Strong	18-29	University	<14	2000s	5	5	4	4	4	4	4	4	5	5	4.4
WC75	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	50-59	University	14-35	1970s	2	3	4	4	4	4	3	2	3	4	3.3
WC76	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Need	70-79	High Sch.		1940s	3	5	2	4	4	4	4	3	3	4	3.6
WC77	Cadaqués	Female	FRA	Tourist	Inland	Infrequent	Need	40-49	University	35-56	2000s	3	4	1	2	3	3	3	4	4	3	3.0
WC78	Cadaqués	Male	FRA	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	14-35	2000s	3	4	2	3	3	4	3	4	4	4	3.4
WC79	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Joy	60-69	High Sch.	14-35	2000s	4	5	2	5	5	5	3	2	4	4	3.9
MC100	Cadaqués	Male	ESP	Local	Coastal	Native	Avoid	40-49	Primary Sch.		1980s	3	5	5	5	5	5	3	2	5	5	4.3
MC101	Cadaqués	Female	ESP	Local	Coastal	Native	Need	18-29	University	<14	2000s	4	5	5	4	5	5	3	3	4	5	4.3
MC104	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Need	40-49	High Sch.	14-35	1980s	4	5	3	2	4	5	5	3	3	3	3.7
MC106	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Strong	18-29	University		1990s	5	3	2	4	3	4	5	4	5	5	4.0
MC107	Cadaqués	Female	ESP	Local	Coastal	Non-native	Need	40-49	Prof./Tech.	<14	1990s	3	4	2	3	4	4	3	3	4	5	3.5
MC110	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	50-59	University	35-56	1970s	1	3	2	4	5	1	1	5	2	3	2.7
MC111	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	18-29	Prof./Tech.	<14	2000s	2	4	3	5	5	5	3	3	5	5	4.0
WP54	Port Selva	Female	GBR	Tourist	Near coast	Frequent	Joy	30-39	PhD		2000s	3	5	2	2	3	4	3	3	4	5	3.4
WP55	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Need	40-49	University	<14	1970s	3	5	2	4	3	4	4	4	4	4	3.7
WP56	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Need	50-59	Master		1990s	1	4	3	3	4	5	3	5	4	5	3.7
WP57	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Need	40-49	University	35-56	1980s	4	5	4	3	2	5	3	4	5	5	4.0
WP58	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Need	50-59	University	35-56	1990s	4	5	3	3	4	5	4	3	4	5	4.0
WP60	Port Selva	Female	ESP	Tourist	Inland	Infrequent	Need	18-29	University	<14	1990s	5	5	4	5	5	5	5	3	3	4	4.4
WP61	Port Selva	Female	ESP	Tourist	Inland	Frequent	Need	18-29	University	<14	2000s	5	4	4	5	4	5	5	4	5	5	4.6
WP66	Port Selva	Female	DEU	Tourist	Inland	Infrequent	Joy	50-59	University	<14	1990s	3	3	4	4	3	4	3	4	3	3	3.4
WP68	Port Selva	Female	FRA	Tourist	Coastal	Frequent	Need	40-49	Master		1980s	1	5	2	2	4	5	5	4	1	4	3.3
WP69	Port Selva	Male	FRA	Tourist	Inland	Frequent	Joy	40-49	Prof./Tech.	35-56	1980s	3	4	2	3	4	5	4	4	4	4	3.7
WP70	Port Selva	Female	ESP	Tourist	Near coast	Infrequent	Joy	50-59	High Sch.		1980s	4	3	2	2	2	4	3	3	2	2	2.7
MP90	Port Selva	Male	ESP	Local	Coastal	Native	Need	70-79	Middle Sch.	<14	1950s	3	5	2	1	5	2	3	4	4	5	3.4
MP91	Port Selva	Male	ESP	Local	Coastal	Non-native	Strong	60-69	Prof./Tech.		1970s	5	5	5	5	5	4	4	2	3	1	3.9
MP92	Port Selva	Female	ESP	Local	Coastal	Native	Strong	40-49	Prof./Tech.		1980s	4	5	5	4	5	5	4	3	5	4	4.4
MP93	Port Selva	Male	FRA	Tourist	Inland		Avoid	50-59	University	<14		3	5	2	2	5	4	4	4	2	2	3.3
MP94	Port Selva	Female	ESP	Tourist	Coastal	Frequent	Strong	40-49	Prof./Tech.	14-35	2000s	4	3	2	2	5	5	3	4	3	3	3.4
AP75	Port Selva	Male	ESP	Tourist	Inland	Infrequent	Joy	40-49	Prof./Tech.	14-35	2000s	3	4	4	4	5	4	3	4	3	4	3.8
AP76	Port Selva	Male	FRA	Tourist	Inland	Frequent	Indifferent	40-49	PhD	35-56	1980s	3	2	2	1	2	5	3	3	3	3	2.7
AP77	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Avoid	40-49	Prof./Tech.	14-35	2000s	4	5	2	3	3	5	5	4	5	5	4.1
AP78	Port Selva	Male	ESP	Local	Coastal	Native	Avoid	70-79	Primary Sch.		1950s	1	5	1	1	5	3	3	3	2	3	2.7
AP79	Port Selva	Female	ESP	Tourist	Near coast	Frequent		60-69			1930s	5	5	3	2	5	4	3	5	5	5	4.2
AAP80	Port Selva	Male	ESP	Local	Coastal	Non-native	Indifferent	50-59	Prof./Tech.	No income	1970s	5	5	5	5	5	5	5	5	3	5	4.8
AP81	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Need	80-89	Middle Sch.	35-56	1950s	4	4	5	5	5	4	3	4	5	4	4.3
AP85	Port Selva	Female	ESP	Local	Coastal	Native	Joy	18-29	Prof./Tech.	<14	2000s	5	4	3	2	4	4	3	5	5	4	3.9
AP88	Port Selva	Female	ESP	Local	Coastal	Native	Strong	18-29	University	14-35	2000s	3	5	2	4	4	4	3	4	5	5	3.9
AP91	Port Selva	Male	ESP	Tourist	Near coast	Frequent	Joy	70-79	University	35-56	1960s	5	5	2	3	5	4	4	3	4	5	4.0
AP93	Port Selva	Female	ESP	Tourist	Coastal		Strong	18-29	University	No income		5	5	5	5	3	5	4	3	5	4	4.4
AP95	Port Selva	Female	ESP	Tourist	Coastal	Infrequent	Need	50-59	Master	>56		2	4	2	4	4	2	4	4	4	5	3.5
MR71	Roses	Female	ESP	Local	Coastal	Native	Avoid	18-29	University	<14	2000s	5	5	2	4	4	4	5	4	5	4	4.2
MR72	Roses	Female	ESP	Local	Coastal	Native	Strong	50-59	Middle Sch.	14-35	1970s	4	5	3	2	4	5	5	4	3	4	3.9
MR73	Roses	Male	ESP	Local	Coastal	Native	Strong	30-39	Middle Sch.	14-35	1990s	2	5	3	1	5	5	3	4	1	4	3.3
WR91	Roses	Male	FRA	Tourist	Inland	Infrequent	Joy	18-29	Master	14-35	2000s	4	4	4	4	5	4	3	3	4	5	4.0
WR93	Roses	Female	ESP	Local	Coastal	Non-native	Joy	50-59	University	14-35	2000s	2	4	1	1	2	5	3	4	3	3	2.8
WR95	Roses	Female	ESP	Local	Coastal	Native	Strong	60-69	University		1960s	5	5	4	3	5	5	3	1	3	4	3.8
WR96	Roses	Female	ESP	Local	Coastal	Native	Need	40-49	University	14-35	1980s	3	5	4	4	4	5	4	4	4	4	4.1
WR97	Roses	Female	ESP	Local	Near coast	Native	Joy	30-39	University		1990s	3	3	3	3	4	4	3	3	4	4	3.4
WR98	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	High Sch.	<14	2000s	4	5	5	5	5	4	3	3	5	5	4.4
WR99	Roses	Female	ESP	Local	Coastal	Native	Joy	30-39	Primary Sch.	<14	1990s	1	4	5	3	3	1	4	4	4	3	3.2
MR115	Roses	Female	ESP	Local	Coastal	Native	Strong	50-59	High Sch.	>56	1970s	3	5	4	1	5	4	2	4	4	5	3.7
MR116	Roses	Female	ESP	Local	Coastal	Native	Need	50-59	Prof./Tech.	14-35	1970s	5	5	2	3	5	5	3	5	5	5	4.3
MR117	Roses	Male	ESP	Local	Coastal	Native	Strong	30-39	Master	35-56	1990s	5	5	1	5	5	3	3	4	3	5	3.9
MR118	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	University	14-35	2000s	4	4	4	3	4	5	5	3	3	5	4.0
MR119	Roses	Female	ESP	Local	Coastal	Native	Need	18-29	University	<14	2000s	4	4	4	3	4	5	5	3	3	5	4.0
MR120	Roses	Male	BEL	Tourist	Inland	Frequent	Joy	40-49	Middle Sch.	35-56	1990s	4	3	2	2	2	3	4	4	3	3	3.0
MR121	Roses	Male	ESP	Local	Coastal	Native	Strong	50-59	Middle Sch.	14-35	1970s	5	5	2	1	5	5	5	4	5	5	4.2
MR125	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	Prof./Tech.	<14	2000s	4	5	1	4	5	5	3	4	4	4	3.9
MR124	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	Middle Sch.	<14	2000s	5	5	3	2	4	4	4	5	5	4	4.1
MR125	Roses	Female	ESP	Local	Coastal	Non-native	Joy	60-69	Primary Sch.	14-35	1980s	4	5	4	3	3	1	4	4	4	4	3.6
MR127	Roses	Male	ESP	Local	Coastal	Native	Need	30-39	University	14-35	1990s	4	4	2	2	2	5	5	4	5	5	3.8
WC71	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	40-49	Prof./Tech.	<14	1980s	4	2	1	1	1	5	5	5	5	5	3.4
WC73	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	40-49	University	<14	1980s	4	5	5	5	4	5	3	5	3	5	4.4
ZR37	Roses	Female	FRA	Tourist	Inland	Frequent	Joy	40-49	University	14-35	2000s	2	3	4	2	4	5	3	2	2	5	3.2

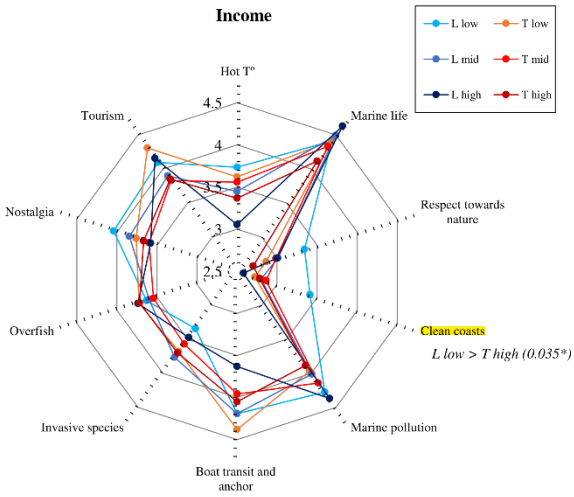
				Sociodemographic parameters								Statements (See SM 2 for the entire statement)										
Code	Place of interview	Gender	Country	Local / Tourist	Residence-to-sea distance	Frequency & Antiquity	Marine affinity/ dependence	Age group	Education level	Income	Baseline decade	Hot T°	Marine life	Respect towards nature	Clean coasts	Marine pollution	Boat transit & anchor	Invasive species	Overfish	Nostalgia	Tourism	Average
ZR38	Roses	Male	ESP	Local	Coastal	Non-native	Strong	70-79	University	14-35	1950s	1	4	2	2	4	4	3	4	4	4	3.2
ZR42	Roses	Female	FRA	Tourist	Inland	Frequent	Need	50-59	University	14-35	1980s	1	4	4	2	4	3	4	4	3	3	3.2
MR270	Roses	Male	ESP	Local	Coastal	Native	Strong	18-29	Prof./Tech.	<14	2000s	5	5	3	4	5	5	4	4	4	5	4.4
MR271	Roses	Male	ESP	Local	Coastal	Non-native	Strong	50-59	Prof./Tech.	<14	1970s	3	3	2	3	2	5	5	4	3	5	3.5
AR111	Roses	Male	DEU	Tourist	Inland	Frequent	Joy	50-59	University		2000s	4	3	4	4	3	5	2	2	3	4	3.4
AR113	Roses	Female	CHE	Tourist	Inland	Frequent	Joy	30-39	Prof./Tech.	<14	2000s	4	4	3	2	4	4	4	3	3	4	3.5
AR114	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	University	<14	2000s	5	5	4	2	5	5	3	5	5	5	4.4
AR115	Roses	Female	ESP	Local	Coastal	Native	Strong	60-69	High Sch.	14-35	1960s	5	5	3	2	5	5	3	4	5	5	4.2
AR116	Roses	Male	ESP	Local	Coastal	Native	Joy	30-39	Prof./Tech.	14-35	1990s	5	5	3	4	5	5	4	4	4	5	4.4
AR120	Roses	Male	FRA	Tourist	Inland	Frequent	Need	50-59	University	35-56	1990s	4	5	2	2	2	4	4	4	4	4	3.5
AR121	Roses	Male	FRA	Tourist	Inland	Frequent	Need	70-79	Middle Sch.	14-35	1980s	4	4	4	2	2	4	4	4	4	4	3.6
AC96	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Indifferent	40-49	High Sch.	35-56	1980s	5	5	2	5	5	5	3	3	4	5	4.2
AC98	Cadaqués	Female	ESP	Tourist	Coastal	Frequent	Joy	60-69	Master	14-35	1970s	4	4	3	3	5	5	4	4	4	4	4.0
AC99	Cadaqués	Female	BEL	Tourist		Infrequent	Strong	30-39	High Sch.	35-56	1990s	2	1	4	4	5	4	5	5	3	4	3.7
AC100	Cadaqués	Female	ESP	Tourist	Coastal	Infrequent	Joy	50-59	University		2000s	5	4	2	3	3	4	3	3	4	5	3.6
AC101	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	30-39	University	14-35	1990s	5	5	3	2	4	5	3	3	5	5	4.0
AC102	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Need	40-49	Master	14-35	2000s	4	5	2	4	4	5	4	4	5	5	4.2
AC103	Cadaqués	Female	ESP	Tourist	Inland	Frequent	Joy	60-69	University		1990s	5	3	4	2	2	3	3	4	2	5	3.3
WR80	Roses	Female	ESP	Local	Coastal	Native	Joy	50-59	Middle Sch.	14-35	1970s	3	5	2	3	5	4	3	3	4	3	3.5
WR85	Roses	Female	ESP	Local	Coastal	Native	Strong	30-39	Middle Sch.	<14	1990s	4	4	2	3	4	4	3	3	4	2	3.3
WR89	Roses	Male	FRA	Tourist	Inland	Frequent	Need	70-79	Prof./Tech.		1960s	5	4	2	2	3	5	4	3	3	5	3.6
MR79	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	High Sch.	<14	2000s	4	4	3	3	1	5	5	4	4	5	3.8
MR75	Roses	Male	ESP	Local	Coastal	Native	Strong	60-69		35-56	1960s	3	4	4	2	3	3	4	4	4	5	3.6
MR76	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	High Sch.	<14	2000s	3	5	2	4	5	5	4	4	4	4	4.0
MR77	Roses	Female	ESP	Local	Coastal	Native	Strong	40-49	Prof./Tech.	14-35	1980s	3	1	5	3	4	4	4	4	4	4	3.6
MR78	Roses	Female	ESP	Local	Coastal	Native	Strong	40-49	University	35-56	1980s	4	5	2	2	4	4	4	4	3	4	3.6
MR79	Roses	Male	ESP	Local	Coastal	Native	Strong	30-39	Prof./Tech.	14-35	1990s	4	4	2	2	3	5	3	5	2	4	3.4
MR80	Roses	Male	ESP	Local	Coastal	Native	Strong	40-49	High Sch.	14-35	1980s	4	5	4	4	4	4	2	4	4	4	3.9
MR81	Roses	Female	ESP	Local	Coastal	Native	Strong	40-49	High Sch.	14-35	1980s	3	5	2	2	5	4	4	3	3	3	3.4
MR83	Roses	Male	ESP	Local	Coastal	Non-native	Strong	60-69	Prof./Tech.	14-35	2000s	5	5	2	5	5	5	3	3	3	4	4.0
MR84	Roses	Female	ESP	Local	Coastal	Native	Need	18-29	Master	14-35	2000s	3	5	3	3	3	4	4	4	4	4	3.7
MR85	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	High Sch.	No income	2000s	5	4	4	4	3	4	3	4	4	5	4.0
MR86	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	University	<14	2000s	3	4	3	4	5	4	4	4	5	5	4.1
MR87	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	High Sch.	<14	2000s	3	4	2	3	5	4	2	4	2	4	3.3
MR88	Roses	Female	ESP	Local	Coastal	Native	Strong	18-29	Prof./Tech.		2000s	3	5	2	3	5	5	4	5	5	4	4.1
MR89	Roses	Female	ESP	Local	Coastal	Native	Joy	40-49	High Sch.	<14	1980s	4	5	4	4	5	1	3	3	5	5	3.9
MR90	Roses	Female	ESP	Local	Coastal	Native	Joy	40-49	University	14-35	1980s	4	3	4	3	4	4	3	3	3	5	3.6
AR56	Roses	Female	ESP	Local	Coastal	Native	Strong	40-49	Prof./Tech.		1980s	3	5	3	3	5	3	3	3	3	3	3.4
AR58	Roses	Male	ESP	Local	Coastal	Native	Strong	18-29	Prof./Tech.	<14	2000s	4	3	3	5	5	4	3	4	3	4	3.8
AR60	Roses	Male	ESP	Local	Coastal	Native	Strong	18-29	Prof./Tech.	<14	2000s	5	5	5	5	5	5	2	5	5	4	4.6
AR61	Roses	Male	ESP	Local	Coastal	Native	Joy	18-29	Prof./Tech.	<14	2000s	4	4	3	5	5	4	4	5	4	5	4.3
AR64	Roses	Female	ESP	Tourist	Inland	Infrequent	Joy	18-29	University	No income	1990s	4	4	4	4	4	4	4	4	4	5	4.1
AR68	Roses	Female	ESP	Local	Coastal	Native	Joy	40-49	High Sch.	<14	1980s	5	5	4	3	4	4	3	3	4	3	3.8
AR69	Roses	Male	ESP	Local	Coastal	Non-native	Strong	50-59	High Sch.	14-35	1970s	1	5	3	2	4	5	4	3	3	4	3.4
AR70	Roses	Female	ESP	Local	Coastal	Native	Strong	50-59	Middle Sch.	14-35	1970s	4	5	4	4	5	4	4	4	5	5	4.4
AR71	Roses	Female	ESP	Local	Coastal	Non-native	Joy	70-79	No Sch.	No income	1960s	2	4	3	2	2	4	3	4	4	2	3.0
AR72	Roses	Female	ESP	Tourist	Coastal	Frequent	Strong	50-59	Prof./Tech.	35-56	1980s	5	4	2	3	2	2	4	4	5	5	3.6
MP40	Port Selva	Female	ESP	Local	Coastal	Native	Joy	18-29	Middle Sch.	No income	2000s	4	4	3	4	4	3	3	3	4	2	3.4
MP41	Port Selva	Female	ESP	Local	Near coast	Native	Strong	50-59	PhD	14-35	1970s	4	5	5	3	5	5	4	4	4	5	4.4
MP42	Port Selva	Female	ESP	Local	Coastal	Native	Joy	40-49	Prof./Tech.	14-35	1980s	3	4	4	5	2	4	4	5	3	4	3.8
MP44	Port Selva	Female	ESP	Local	Coastal	Native	Joy	40-49	Prof./Tech.	<14	1980s	4	5	3	4	5	5	1	1	5	5	3.8
MP45	Port Selva	Female	ESP	Local	Coastal	Native	Strong	50-59	University	14-35	1970s	4	5	4	3	1	1	3	4	5	5	3.5
MP46	Port Selva	Female	ESP	Local	Coastal	Native	Need	>90	University	14-35	1930s	3	5	4	2	5	2	4	4	5	4	3.8
MP47	Port Selva	Female	ESP	Local	Coastal	Native	Joy	18-29	Master	<14	2000s	3	4	2	3	4	5	3	3	4	4	3.5
MP49	Port Selva	Female	ESP	Tourist	Near coast	Frequent	Indifferent	18-29	Middle Sch.	No income	2000s	4	5	4	3	5	3	4	4	1	5	3.8
MP50	Port Selva	Male	ESP	Local	Coastal	Native	Strong	18-29	Prof./Tech.	<14	2000s	2	5	4	4	5	3	4	1	4	3	3.5
MP51	Port Selva	Female	ESP	Local	Coastal	Native	Strong	40-49	Middle Sch.	14-35	1980s	5	3	2	2	1	4	4	3	5	2	3.1
MP53	Port Selva	Female	ESP	Tourist	Inland	Frequent	Strong	40-49	Master	>56	1990s	5	4	3	5	5	4	4	3	4	4	4.1
MC50b	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	30-39	High Sch.	14-35	1990s	3	5	4	2	3	5	4	4	4	5	3.9
MC51b	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	18-29	Middle Sch.	<14	2000s	2	4	5	5	5	5	3	2	3	4	3.8
MC52b	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	40-49	University	14-35	1980s	4	4	2	4	4	5	3	4	5	4	3.9
MC54	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	50-59	Middle Sch.	14-35	1970s	4	5	3	4	5	5	5	5	5	5	4.6
MC55	Cadaqués	Female	ESP	Local	Coastal	Native	Indifferent	60-69	High Sch.		1960s	3	5	5	5	5	5	5	5	3	5	4.6
MC56	Cadaqués	Female	ESP	Local	Coastal	Non-native	Strong	60-69	University	14-35	1980s	5	5	2	4	5	5	4	5	4	5	4.4
MC58	Cadaqués	Male	ESP	Local	Coastal	Native	Strong	40-49	University	35-56	1980s	3	5	4	3	3	3	5	5	5	5	4.1
MC59	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Need	30-39	Master	<14	2000s	3	3	4	3	3	4	4	3	3	5	3.5
MC60	Cadaqués	Male	ESP	Tourist	Inland	Frequent	Need	30-39	Master	<14	2000s	4	5	3	3	3	5		3	3	5	3.8
MC61	Cadaqués	Male	ESP	Local	Coastal	Native	Indifferent	18-29	Middle Sch.	No income	2000s	3	2	3	4	4	3	4	3	2	5	3.3
MC62	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	18-29	High Sch.	No income	2000s	4	4	3	4	2	5	3	3	4	5	3.7
WP01	Port Selva	Male	ESP	Local	Coastal	Native	Joy	70-79	Master	35-56	1950s	3	5	2	2	2	5	3	3	5	4	3.4
WP02	Port Selva	Male	FRA	Tourist	Inland		Joy	60-69	Prof./Tech.	<14		3	5	1	2	4	5	2	5	4	5	3.6
WP05	Port Selva	Male	GBR	Tourist	Near coast	Frequent	Joy	30-39	Prof./Tech.	14-35	1980s	4	4	3	2	5	3	3	2	3	4	3.3
WP06	Port Selva	Male	ESP	Tourist	Coastal	Frequent	Joy	70-79	Master	35-56	1950s	5	5	5	3	5	4	4	5	5	4	4.5
WR38	Roses	Male	ESP	Local	Coastal	Non-native	Joy	18-29	Middle Sch.	<14	2000s	2	5	1	4	5	4	3	4	5	3	3.6
WR40	Roses	Male	ESP	Local	Coastal	Non-native	Strong	50-59	High Sch.	<14	1990s	3	3	5	2	3	4	4	3	4	4	3.5
WR42	Roses	Male	ESP	Local	Coastal	Non-native	Indifferent	30-39	Middle Sch.		1990s	3	3	5	3	5	4	4	3	5	5	4.0
WR43	Roses	Female	ESP	Local	Coastal	Non-native	Joy	40-49	Prof./Tech.		1980s	2	5	4	2	5	3	3	4	5	3	3.6
WR45	Roses	Male	FRA	Tourist	Inland	Frequent	Joy	50-59	Prof./Tech.	14-35	1980s	1	5	2	2	3	4	4	4	4	4	3.3
WR46	Roses	Male	ESP	Local	Coastal	Native	Strong	18-29	High Sch.	14-35	2000s	4	5	3	4	5	5	3	4	3	4	4.0
WR47	Roses	Female	ESP	Local	Coastal	Native	Need	50-59	Middle Sch.		1970s	5	5	3	1	5	1	1	1	5	5	3.2
WR48	Roses	Female	ESP	Tourist	Coastal	Frequent	Need	18-29	Master	14-35	1990s	5	3	4	4	4	2	4	3	5	5	3.9
WR49	Roses	Female	ESP	Local	Coastal	Native	Joy	18-29	University	<14	2000s	3	5	5	4	4	4	3	5	3	4	4.0
WR50	Roses	Male	ESP	Tourist	Near coast	Frequent	Joy	40-49	Master	14-35	1980s	4	5	4	5	5	5	3	3	3	4	4.1
WR52	Roses	Male	ESP	Local	Coastal	Non-native	Strong	60-69	High Sch.		2000s	1	5	1	1	4	5	5	5	1	1	2.9
AC32	Cadaqués	Female	BEL	Tourist	Near coast	Frequent	Need	18-29	Prof./Tech.	14-35	1990s	3	5	2	2	4	4	4	1	1	4	3.0
AC35	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	60-69	University	35-56	1960s	5	5	5	4	5	1	3	2	5	3	3.8
AC36	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Indifferent	70-79	University	14-35	2000s	5	3	1	4	3	4	3	3	3	4	3.3
AC37	Cadaqués	Male	ESP	Tourist	Coastal	Frequent	Need	70-79	University	14-35	1960s	5	5	2	2	4	5	5	5	4	5	4.2
AC40	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	50-59	University	14-35	1970s	5	5	2	3	5	5	5	5	5	5	4.5
AC41	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	40-49	Primary Sch.		1980s	2	5	2	3	5	5	1	2	5	2	3.2
AC42	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	18-29	University	<14	2000s	5	4	3	4	5	5	3	4	4	4	4.1
AC44	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	30-39	University	14-35	1990s	3	5	5	5	5	5	3	4	4	5	4.4
AC45	Cadaqués	Male	ESP	Tourist	Near coast	Frequent	Need	30-39	Master	35-56	1980s	4	4	2	3	5	4	3	4	3	4	3.6
AC49	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Joy	50-59	University	14-35	1970s	4	4	3	2	3	4	3	3	3	5	3.4
AC51	Cadaqués	Male	ESP	Local	Coastal	Native	Indifferent	40-49	High Sch.	14-35	1980s	4	3	4	2	1	1	1	2	5	1	2.4
AC53	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	40-49	University	14-35	1980s	4	4	2	2	4	2	3	2	5	3	3.1
AC55	Cadaqués	Female	ESP	Local	Coastal	Native	Need	60-69	University		1960s	1	3	4	2	4	2	4	2	2	4	2.8
WC20	Cadaqués	Female	FRA	Tourist	Inland	Frequent	Joy	60-69	Middle Sch.	14-35	2000s	2	3	3	2	4	5	3	4	3	4	3.3
WC21	Cadaqués	Female	FRA	Tourist	Inland	Infrequent	Strong	50-59	High Sch.	14-35	2000s	4	5	3	5	5	4	5	4	5	5	4.5
WC22	Cadaqués	Male	FRA	Tourist	Inland	Infrequent	Strong	50-59	Prof./Tech.	14-35	2000s	3	5	2	2	5	4	4	5	4	4	3.8
WC25	Cadaqués	Female	FRA	Tourist	Inland	Infrequent	Joy	60-69	Prof./Tech.	14-35	2000s	1	5	2	2	5	5	4	3	2	3	3.2
WC27	Cadaqués	Male	NLD	Tourist	Near coast	Frequent	Joy	60-69	Prof./Tech.	>56	2000s	4	4	2	2	4	2	3	4	3	4	3.2
WC29	Cadaqués	Female	ESP	Tourist	Near coast	Frequent	Joy	40-49	University		1990s	5	5	4	4	4	5	5	5	4	5	4.6
WC30	Cadaqués	Female	ESP	Tourist	Near coast	Infrequent	Joy	50-59	Master	14-35	1990s	3	4	2	2	5	4	4	3	5	4	3.6
WC33	Cadaqués	Female	ESP	Local	Coastal	Native	Strong	30-39	University		1990s	5	5	5	4	5	5	4	4	5	5	4.7
WC34	Cadaqués	Female	ESP	Local	Coastal	Native	Joy	80-89	Primary Sch.		1940s	3	5	3	4	5	5	5	5	5	5	4.5
WC35	Cadaqués	Male	ESP	Local	Coastal	Native	Indifferent	70-79	Primary Sch.	35-56	1950s	1	5	2	2	5	5	5	5	1	3	3.4
WC37	Cadaqués	Male	ESP	Local	Coastal		Joy	60-69	High Sch.	<14		4	4	1	2	2	3	3	4	3	4	3.0

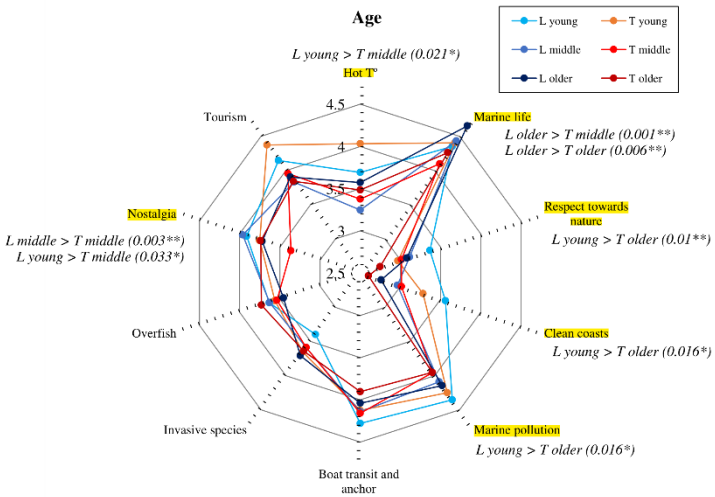
Supplementary material 6. Average values of each subcategory inside each sociodemographic parameter, differentiating between locals and tourists. Concentric polygons represent the axis of the average values, where 1 = "strongly disagree", 2 = "disagree", 3 = "neither agree nor disagree", 4 = "agree", and 5 = "strongly agree". Each spike represents an abbreviation of each statement in the Likert table (see SM 2). The names of the statements highlighted in yellow are the significant ones between local and tourist subgroups regarding a Kruskal-Wallis rank sum test (see Table 3). Close to the highlighted area, in italics, are written the local vs tourist subgroups that show significant differences between them regarding a post-hoc Dunn test (p-value inside parenthesis; (*) $p < 0.05$, (**) $p < 0.01$). T = tourist (red range colours), L = local (blue range colours).

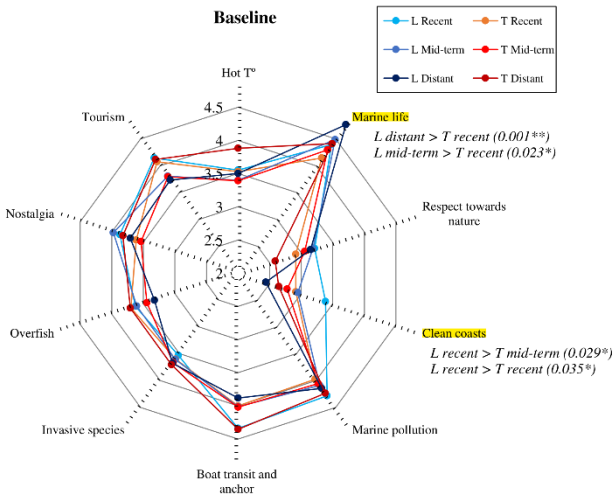

Residence-to-sea distance
L coastal
T coastal
T near coast
T inland
Hot Tº
Marine life
L coastal > T inland (0.026*)
Respect towards nature
Clean coasts
Marine pollution
L coastal > T inland (0.04*)
Boat transit and anchor
Invasive species
Overfish
Nostalgia
L coastal > T inland (0.045*)
L coastal > T near coast (0.048*)
Tourism
4.5
4
3.5
3
2.5


Affinity/dependence
L depend
T depend
L joy
T joy
Hot Tº
Marine life
L depend > T joy (0.000**)
Respect towards nature
Clean coasts
Marine pollution
L depend > T joy (0.026*)
L depend > T depend (0.03*)
Boat transit and anchor
L depend > T joy (0.005**)
Invasive species
T depend > L joy (0.002**)
Overfish
Nostalgia
L depend > T joy (0.001**)
L joy > T joy (0.026*)
Tourism
L depend > T joy (0.026*)
4.5
4
3.5
3
2.5


Education level
L low
T low
L medium
T medium
L high
T high
Hot Tº
Marine life
Respect towards nature
Clean coasts
Marine pollution
Boat transit and anchor
Invasive species
Overfish
Nostalgia
Tourism
4.5
4
3.5
3
2.5


Income
L low
T low
L mid
T mid
L high
T high
Hot Tº
Marine life
Respect towards nature
Clean coasts
L low > T high (0.035*)
Marine pollution
Boat transit and anchor
Invasive species
Overfish
Nostalgia
Tourism
4.5
4
3.5
3
2.5


Age
L young
T young
L middle
T middle
L older
T older
L young > T middle (0.021*)
Hot Tº
Marine life
L older > T middle (0.001**)
L older > T older (0.006**)
Respect towards nature
L young > T older (0.01**)
Clean coasts
L young > T older (0.016*)
Marine pollution
L young > T older (0.016*)
Boat transit and anchor
Invasive species
Overfish
Nostalgia
L middle > T middle (0.003**)
L young > T middle (0.033*)
Tourism
4.5
4
3.5
3
2.5


Baseline
L Recent
T Recent
L Mid-term
T Mid-term
L Distant
T Distant
Hot Tº
Marine life
L distant > T recent (0.001**)
L mid-term > T recent (0.023*)
Respect towards nature
Clean coasts
L recent > T mid-term (0.029*)
L recent > T recent (0.035*)
Marine pollution
Boat transit and anchor
Invasive species
Overfish
Nostalgia
Tourism
4.5
4
3.5
3
2.5
2

5 TEMPORAL SHIFTS OF *POSIDONIA OCEANICA* AND *CORALLIUM RUBRUM* IN CAP DE CREUS (NE SPAIN): AN ASSESSMENT BY RECREATIONAL SCUBA DIVERS

At the time of the thesis submission, this chapter is not submitted nor published in a scientific journal.

Abstract

Temporal trends of the main Mediterranean benthic coastal marine habitats point to an overall regression of their distribution and health status. Understanding such regressions is important as they lead to a loss of complexity and biodiversity and a lower resilience against perturbations, making the habitats more prone to dysfunctions. This study is based on scuba diver perceptions of temporal change on the health status of two key ecosystem engineering species in the Cap de Creus Marine Protected Area: *Corallium rubrum* (red coral) and *Posidonia oceanica*. To qualitatively assess the health status of both species for the past four decades, we conducted semi-structure interviews with managers of scuba diving centres and a survey to recreational scuba divers of the area and compared responses with trends obtained with ecological data. Scuba divers reported a decreasing trend for both species, especially notable for *C. rubrum*, while for *P. oceanica* responses indicate only a slight decrease in the average abundance, with dominance of decadal stable reports. Ecological comparable data in the area is only available for the last two decades and suggest stability in the health status of both species. Available ecological data for red coral are not sufficient to define a robust systematic trend, although the seemingly stable tendency found does not match with divers' reports of a decreasing trend. We explain the mismatch arguing that both data sources sample different areas: while ecological data mainly focuses on no-take areas inside Cap de Creus, the divers might mainly visit areas where red coral colonies are unprotected. For *Posidonia*, stability trends in the last two decades dominate in both approaches, ecological data and divers' responses, suggesting that this habitat did not suffer major regressions in that time period. We argue that local expert knowledge (i.e., divers' knowledge) is an untapped source of information that could contribute to increase the knowledge of these key species historical ecological trends, helping to predict how they can evolve in the recent future.

5.1. Introduction

The Mediterranean Sea, and especially the coastal NW region, is considered a biodiversity hotspot (Lejeusne et al. 2010; Coll et al. 2012). Benthic habitats like the *Posidonia oceanica* meadows and coralligenous contribute to high concentration of different species, resulting in one of the highest biodiversity-holder areas of the region (Boudouresque 2004; Ballesteros 2006; Bouderesque et al. 2017). A key species in the coralligenousis is the octocoral *Corallium rubrum* (red coral), a cnidarian engineering species that increases the complexity of the habitat, serving as refuge for several species, and contributing to carbon capture (Tsounis et al. 2010; Picciano et al. 2007; Mallo et al. 2019; Rossi and Rizzo 2020). Benthic habitats have been deeply transformed during centuries mainly by human activities, but is during the last four-five decades when their degradation has been more evident, particularly in certain areas (Kiparissis et al. 2011; Rossi 2019).

The analysis of temporal trends of benthic habitats shows that the coastal marine Mediterranean region has faced large anthropogenic impacts that tamper the health status and distribution of the benthic ecosystems (Claudet and Fraschetti 2010), even in Marine Protected Areas (MPA; Claudet et al. 2020). However, a clear understanding of the multiple environmental drivers of change on the coastal benthic systems is lacking. One of the most effective and direct way to assess the health status of coastal marine habitats is through scientific scuba diving (Cattaneo-Vietti and Mojetta 2021). However, when logistics and financing is limited, recreational scuba diving, providing perceptual and/or photographic information, can be a good alternative. In fact, the aggregated perception of many visitors can provide a complete qualitative map through scuba diving centres or free diving (e.g., Marrocco et al. 2019). To date, recreative scuba diving has been used for monitoring the Mediterranean coralligenous (e.g., Gerovasileiou et al. 2016; Turicchia et al. 2021), and specifically *C. rubrum* (Bramanti et al. 2011), and *Posidonia* meadows (e.g., Montefalcone et al. 2006; de Virgilio et al. 2020), and a few studies have also relied on this method of data collection to reflect on changes over time, i.e., tapping on the memory of divers' past immersions (e.g., Jiménez-López 2012 in Medes Islands MPA).

This work seeks to know how scuba divers perceive temporal change on the health status of *P. oceanica* and *C. rubrum* in the Cap de Creus MPA (NE Spain). Past observations are key to understand the ecosystem transformation through time and how their functioning has changed during the last decades to centuries (Thurstan et al. 2017; Rossi 2019). In the case of the red coral, these changes have been dramatic especially in the NW Mediterranean Sea, where it is

considered that the octocoral population passed from a 'tree forest' to a 'grassland' (Mallo et al. 2019; Rossi 2019). Our study addresses changes during the past four decades in an emblematic coastal area of the NW Mediterranean Sea. We compare such perceptual trends with ecological data to detect differences between both data collection methods. The aim of this study is to contribute to a better understanding of the functional transformation of these biodiversity hotspots through time and support the idea that losing complexity is related with a poorer functionality of the ecosystems.

5.2. Methods

We collected data in three municipalities (Port de la Selva, Cadaqués, and Roses) around the Cap de Creus Marine Protected Area (MPA), NE Spain. The marine reserve was established in 1998 and its dominant marine habitats include seagrass meadows on sandy bottoms, where *P. oceanica* dominates, and coralligenous on rocky bottoms (Sardà et al. 2012). We conducted semi-structured interviews with managers of scuba diving centres (December 2017 and July 2018) and a survey to recreational scuba divers (July and August 2019).

Our first method of data collection was the semi-structured interviews. We showed managers of the scuba diving centres a map of Cap de Creus and photo-cards of different levels of abundance of *C. rubrum* and *P. oceanica*: "Much", "Medium", "Low", and "Absent" (SM 1). The respondents had to interpret the level of abundance of both species in large areas of Cap de Creus and for different decades (i.e., since they started diving in the area to date). When interviewees reported having observed different abundances of a species in a particular area, we asked them to estimate the average abundance. In addition, we asked interviewees to report information only for areas they knew well. When an interviewee reported a change of abundance in a species of an area from a decade to another, we further asked about the driver(s) of such change.

Our second method of data collection was a survey. The respondents were scuba divers who had dived in the area for at least a decade. Before responding to the survey, we asked whether they were aware of *C. rubrum* and *P. oceanica* during their dives. If the answer was positive, they had to provide a qualitative estimate of the overall species abundance and health status (i.e., for all the places they visited) within the qualitative categories: "Much", "Medium", "Little", "Absent" for each decade they dived in the study area. They had visual references for each

category. Finally, we also asked survey participants to foresee how the species abundance and health would be by 2050 (SM 2).

In both methodologies, we assigned a numeric value to the qualitative answers: "Much" = 3, "Medium" = 2, "Little" = 1, "Absent" = 0 and we calculated the average value and their respective standard deviation for each decade. Then, a linear regression between all decades was applied to show the overall trend in time. Also for both methodologies, we noted answers' overall and decadal variations, which are "increase" (e.g. when in the 1990s is "Medium" and in the 2000s "Much"), "stable", or "decrease" to compare the subjective categorization between our respondents.

We acknowledge the numerous limitations of our approach. First, our study has a low sample size, although is potentially compensated by the informants' specific expertise, we also acknowledge that our results are only a way to reflect broad overall trends and not a comparison within areas in the Cap de Creus region. Second, we acknowledge that the data collection methods do not reflect the complexity of the reality, as it is addressing the abundance of two eco-engineering species in the study area, but not taking into account other factors that might compromise their health status. However, the target species visual abundance can be considered the first indicator of their health status. Third, a subjective interpretation of the four categories of abundance and size (Much, Medium, Little, Absent) might have happened. We tried to minimize this bias by providing visual references, although we cannot discard that, for example, some respondents might value more the size of big corals and others their density. Such subjectivity can be magnified when respondents try to give an average of all their decadal sights and for all the different locations they dived. Finally, the method is subject to memory bias and change blindness, which potentially affect responses in unknown magnitude and direction.

5.3. Results

Semi-structured interviews to managers from five scuba diving centres covered 45% of the potential sample (n = 5), from which we obtained 20 reports for *C. rubrum* and 22 for *P. oceanica* (Table 1). A report was defined as each assessment of the abundance and health of the species for an area (i.e., a card placement on the map; SM 1). Interviewees' reports never covered the entire Cap de Creus MPA, but usually the area closer to their diving centre. In some cases they mentioned a species change and its cause, but they consider not that the magnitude of the change was not enough to change the card category.

Table 1. *Answers of the semi-structured interviews (n = 5). Absent = 0, Little = 1, Medium = 2, Much = 3.*

Interview #	Approximate location	Abundance category 2017-18	2010s	2000s	1990s	1980s	Overall trend	Drivers of change
Corallium rubrum								
1	Falconera	1	1	1	1	2	decrease	Overharvesting (including poachers)
	Cap Norfeu	2	2	2	2	3	decrease	
	Santa Eulalia de la Peña - Sud Cadaqués	1	1	1	1	2	decrease	
2	Cap Norfeu - Santa Eulalia de la Peña	1	1	1			stable	Overharvesting
	Cadaqués Bay Surroundings - Port Lligat - Guillola Bay	0	0	1			decrease	
	Cap de Creus	1	1	2			decrease	
	Culip - Tres Frares	2	2	2			stable	
	El Golfet	2	2	3			decrease	
3	Cap Norfeu - Santa Eulalia de la Peña	1	1				stable	Poaching. Lack of vigilance MPA
	Cadaqués Bay Surroundings - Port Lligat - Guillola Bay	1	1				stable	
	Cap de Creus	2	3				decrease	
	Culip - Tres Frares	1	2				decrease	
	El Golfet	1	1				stable	
4	Culip - Tres Frares	1	1	2	3		decrease	Overharvesting
	El Golfet	1	1	2	3		decrease	
5	Cap Norfeu - Santa Eulalia de la Peña	0	1	1	3		decrease	Overharvesting (especially Poachers). Lack of vigilance MPA
	Cadaqués Bay Surroundings - Port Lligat	0	1	1	1		decrease	
	Guillola - Jugadora	0	-	-	3		decrease	
	Culip - Tres Frares	0	1	1	3		decrease	
	El Golfet	0	1	1	3		decrease	
Posidonia oceanica								
1	Palangres - Falconera	3	3	3	3	3	stable	Decrease: 80s-90s: pollution. From 90s: Anchoring. Increase: from 90s: people awareness
	Falconera - Cap Norfeu	3	3	3	3	3	stable	
	Cap Norfeu - Santa Eulalia de la Peña	2	2	2	2	2	stable	
2	Montjoi - Cap Norfeu	3	3	2			increase	Decrease: Anchoring. Increase: mainly people awareness, partly vigilance MPA
	Cap Norfeu - Santa Eulalia de la Peña	3	3	2			increase	
	Santa Eulalia de la Peña - Sud Cadaqués	3	3	3			stable	
	Cadaqués Bay Surroundings - Port Lligat	2	2	2			stable	
	Guillola - Cap Creus	3	3	3			stable	
	Culip - Tres Frares	3	3	3			stable	
3	Falconera - Cap Norfeu	1	1				stable	
	Cap Norfeu - Santa Eulalia de la Peña	2	2				stable	
	Cadaqués Bay Surroundings - Port Lligat - Guillola Bay	3	3				stable	
	Cap Creus	2	2				stable	
	Culip - Tres Frares	1	1				stable	
	Punta de la Creu - Cala Tavallera	0	0				stable	
4	Culip - Tres Frares	3	3	3	3		stable	
	El Golfet	3	3	3	3		stable	
	Badia Port Selva	3	3	3	3		stable	
5	Cap Norfeu - Santa Eulalia de la Peña	3	3	3	3		stable	Anchoring. Lack of vigilance MPA
	Cadaqués Bay Surroundings - Port Lligat - Guillola Bay	2	2	2	2		stable	
	Culip - Tres Frares	2	3	3	3		decrease	
	El Golfet	3	3	3	2		increase	

The number of semi-structured interview reports was lower for past than for more contemporary events, with a higher number of reports for recent years (2017-18), and only a few in the 1970s. The calculated average abundance per decade suggests an overall decreasing trend for both species (Fig. 1a), more notable in *C. rubrum*, which had an average between the "Medium"-to-"Much" category in the 1980s and 1990s decreasing until the "Little" category at the present. The largest decrease in *C. rubrum* occurred from the 1990s to the 2000s. Despite a slight overall decrease, *P. oceanica* remained stable between the "Much"-to-"Medium" categories across decades.

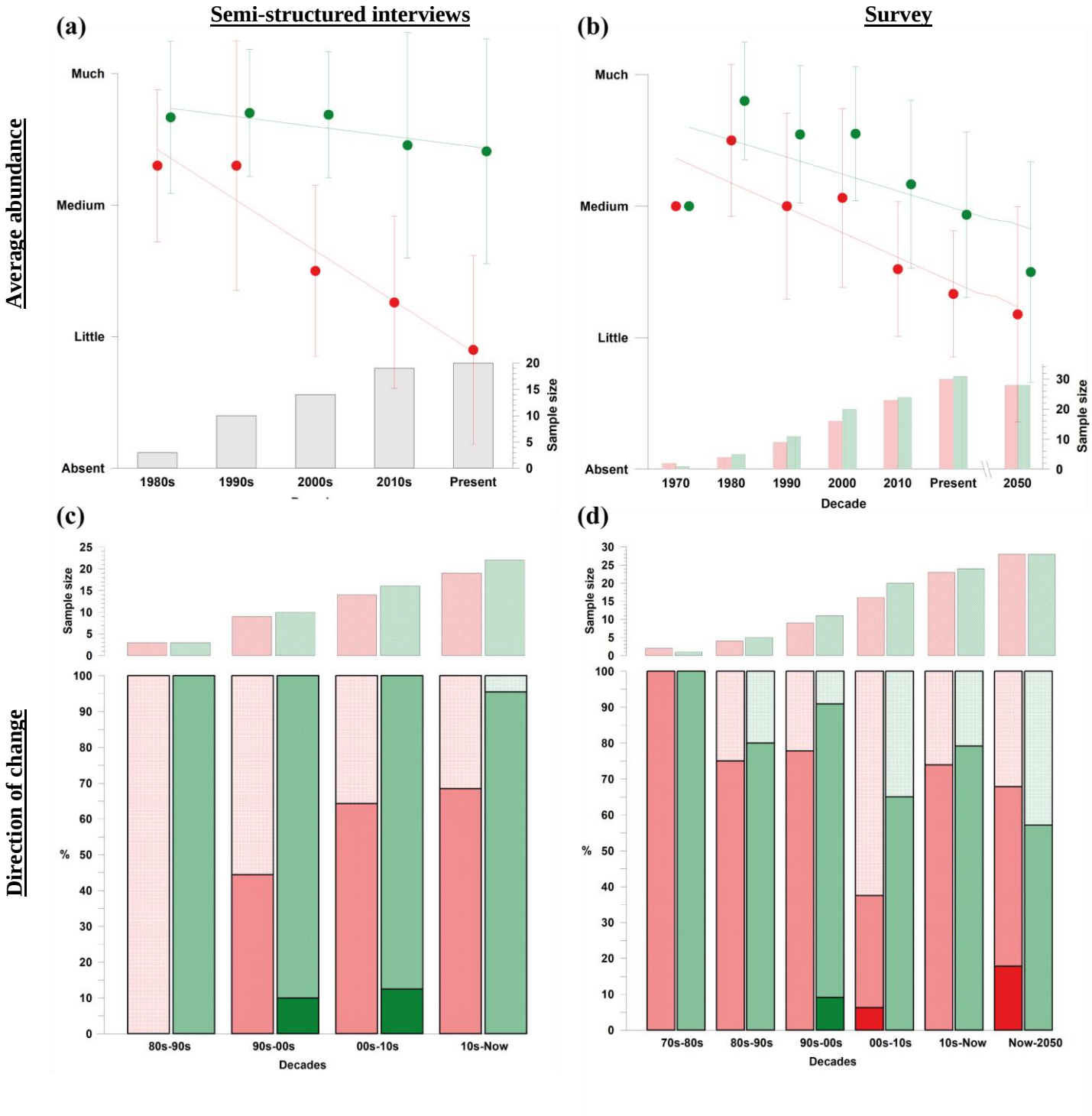


Figure 1. (a, c) *Semi-structured interview results.* ***(b, d)*** *Survey results.* ***(a, b)*** *Average abundance per decade for each category of Corallium rubrum (red) and Posidonia oceanica (green) with standard deviation error bars and linear regressions. Bottom bars represent the number of reports for each species.* ***(c, d)*** *The direction of change in respondents' answers for each decade (shown in %). Solid colour meaning "increase", medium-transparent colour "stable", and the high-transparent "decrease". Upper bars represent the number of reports for each species.*

Thirty-two scuba divers answered the survey (Table 2). Almost all of them were aware of the status of *C. rubrum* and *P. oceanica* during their dives (30 of *C. rubrum*, 31 of *P. oceanica*). Like in the interviews, the number of reports was lower for past events, as most respondents dived in the recent years (2019), only a few reached the decade of the 1980s, and two had dived in the 1970s. Also similarly as in semi-structured interviews, results indicate an overall decreasing trend in the abundance of the two studied species (Fig. 2b): the average abundance of *C. rubrum* changed from a "Much-to-Medium" (1980s) towards the "Little" category (2019). With this method, the largest decrease appears between the 2000s towards the 2010s; slightly increasing the previous decade (1990-2000; a decade that showed the highest decrease in the semi-structured interviews). Responses to the survey show a more pronounced decrease in *P. oceanica* than in the semi-structured interview's answers, changing from close to "Much" category in the 1980s towards "Medium" in the present. Finally, respondents considered that by 2050 both species will continue decreasing, but such perception is especially evident for *P. oceanica*.

Table 2. *Survey answers. The years on the top columns represent the decades, except 2019 that represents the time of the interview. Obs. = Have you seen and observed any red coral/Posidonia during your dives in this area? Y = Yes, N = No. 3 = Much, 2 = Medium, 1 = Little, 0 = Absent. N/A = No answer.*

Intreview #	***Corallium rubrum***								***Posidonia oceanica***							
	Obs.	2019	2010	2000	1990	1980	1970	2050	Obs.	2019	2010	2000	1990	1980	1970	2050
1	Y	1						1	Y	2						N/A
2	Y	1	1	2	2			3	Y	3	3	3	3			3
3	Y	1	1					2	Y	3	3	3				3
4	Y	1	1	2	2			1	Y	2	2	3	3	3		2
5	Y	1	1	2	2			1	Y	2	2	2	2			2
6	Y	1	1					0	Y	3	3					2
7	Y	1	2	3	3	3		N/A	Y	1	2	3	3	3		0
8	Y	1	1	1	1	2	2	1	Y	2	3	3	2	2	2	2
9	Y	1	2					1	Y	2	2					2
10	Y	1	2	2	3	3		0	Y	2	2	3	3	3		1
11	Y	1	1	1	1			1	Y	2	2	2	2			1
12	Y	1	2	3				1	Y	2	2	2				1
13	Y	2						0	Y	2						N/A
14	Y	1	1					1	Y	1	1					1
15	Y	2	2	2				2	Y	2	2	2				2
16	Y	2	2	2				2	Y	2	2	2				2
17	Y	2	2					1	Y	2	2	3	3			1
18	Y	1	1	2				2	Y	0	1	2	3			0
19	N								Y	2	2	2				1
20	Y	2	2					1	Y	2	2					1
21	N								N							
22	Y	1						1	Y	2						1
23	Y	2						N/A	Y	2						1
24	Y	1						0	Y	1						0
25	Y	1	2	3				0	Y	3	3	3				3
26	Y	1	2	3				2	Y	2	3	3				N/A
27	Y	1	1	2	2			0	Y	1	1	2	2			1
28	Y	1	1	2				2	Y	2	3	3				2
29	Y	2	2	1	2	2	2	2	Y	2	2	2	2	3		2
30	Y	2						2	Y	2						2
31	Y	2	2					2	Y	2	2	3				2
32	Y	2						1	Y	2						1

We focus now on the decadal variations of answers within each respondent (i.e. "decrease", "stable", or "increase"; Fig. 1c, d). In the semi-structured interviews (Fig. 1c) we did not obtain any report of increase for *C. rubrum*. Reports of the decrease of the species dominate until the 2000s, while the stable population reports dominate in the period 2000-2019. Additionally, in the survey (Fig. 1d) we observe a dominance of answers related to stable reports instead of decreasing ones (except in 2000s-2010s). By 2050, the three possibilities (stable, increase, decrease) are well represented for red coral. Looking at the results of *P. oceanica*, reports of a stable population related dominate (Fig. 1c). The same trend is found with survey results (Fig. 1d), although survey respondents provided further reports of decrease, especially from the 2000s. For 2050, respondents have a divided opinion between stable and decrease. Unlike with *C. rubrum*, none of the respondents thinks *P. oceanica* will increase in abundance by 2050.

Finally, according to responses from semi-structured interviews, the drivers of the decreasing abundance of *C. rubrum* are overharvesting (reported by 4 respondents), poaching (3), and a lack of vigilance on the MPA, which can be related with the previous answers (2; Table 1). For *P. oceanica*, the perceived drivers of the decreasing abundance are boat anchoring (3), pollution (1; only in the 1980s-1990s), and lack of vigilance of the MPA (1). The perceived drivers that explain the increasing abundance in *P. oceanica* are the increase of people's awareness (2) and the vigilance of the Natural Park (1).

5.4. Discussion

In this section, we compare our results with ecological data from the Cap de Creus region and from a wider area and discuss reported drivers of change and threats that might shape the future health of benthic habitats. Due to the approach limitations, the results and conclusions derived from this study should be taken as an insight that can serve as motivation to future studies with larger sample size.

Comparable quantitative results of red coral morphometric parameters, which would provide information of their health status, are not common on the Cap de Creus area and the available records cover only the last two decades (SM 3; Tsounis et al. 2006; Bramanti et al. 2014; Vielmini et al. 2010; Linares et al. 2018). Previous samples quantitatively studied in this area exist, but they are not representative of the natural population as they are commercial catches, which are usually biased towards the largest specimens (García-Rodríguez and Massò 1986; García-Rodríguez and Massò 1986b). There are, however, quantitative records of red coral in other

regions of the Catalan Sea: the Medes Islands and the Banyuls-Cerbère MPAs covering longer time-spans than the ones for Cap de Creus (Mallo et al. 2019).

Ecological data reporting red coral abundance in Cap de Creus from the 2000s onwards suggest their stable conditions (due to the large standard deviation bars; SM 3). Such trend is in line with most of the decadal variations reported by our participants (Fig. 1c, d), although the stable trend does not match with the average answers, which show a decrease in abundance for the same decades (Fig. 1a, b). Remarkably, when comparing our results (Fig. 1b) with the available data from the Catalan Sea (See Fig. 4 in Mallo et al. 2019), we find that both sources of information suggest a decrease in the abundance of red coral in the decades 1980s to 1990s and a stabilization in 1990s to 2000s. Both data sources differ on the trend reported for the period from 2000s up to now, as scuba divers of this study perceive a decrease in abundance (for Cap de Creus), whereas ecological data show a recovery (for the Catalan Sea overall; Mallo et al. 2019).

We argue that our respondents possibly identify a true local decrease in abundance of red coral from 2000s onwards in the overall Cap de Creus region. We base our argument on the fact that the available ecological data from the last decades, where we see red coral improving, are mainly focused on no-take zones within the MPAs (Mallo et al. 2019), although several areas of Cap de Creus have no restriction and, as managers of scuba diving centres reported, this resulted in the colonies suffering several harvesting and poaching episodes (see also Garrabou et al. 2017). Such events, added to a deficient surveillance from the MPA (also reported by an interviewee), could explain that most red coral patches visited by our participants experience a decrease in abundance. A similar situation happens in the Medes Islands (a Catalan MPA where since 1983 is forbidden to extract red coral), where recreative scuba divers reported a decrease of red coral abundance outside no-take zones, while inside such zones they reported as red coral was improving (Jiménez-López 2012).

Comparable quantitative data about the health status of *P. oceanica* in Cap de Creus are available mainly for the last decade (2010s), although some data are also comparable from the 2000s (Romero et al. 2020; Romero et al. 2016). These data show that the shoot density and cover of *Posidonia* has been stable in Cap de Creus from 2008 up to now. Regarding the *Posidonia* depth limit, a generalized regression was recorded between the 2000s and 2014, followed by an overall stability for this depth limit (Romero et al. 2020; Romero et al. 2016). The stability of *Posidonia* observed in the last two decades with ecological data matches information provided by divers. The slight decrease reported in the survey between 2000s-2010s may have many explanations, including the fact that our respondents noticed the depth limit regression recorded on the

ecological values (i.e. clearings or dead *Posidonia* on its border), that they noticed more boat anchoring than in the past due to the increase in frequentation after being established as a MPA, or that they dived mostly in the most impacted areas where the minority regressing meadows are found, among other possibilities. We also highlight that Romero et al. (2020), after establishing reference values for their measures, classified the overall present state of *Posidonia* meadows in Cap de Creus as 62% "Good" and 38% "Moderate" which can be related with our survey results for the present moment: "Medium" (Fig. 1b).

We need to refer to overall Mediterranean trends to use older data about the health status of *P. oceanica*. Thanks to old maps of *Posidonia* distribution, we know that its abundance has decreased since at least 1842, the change being especially notable from the 1960s onwards. From 1962 onwards, *Posidonia* temporal changes started being scientifically assessed, and from the 1990s began to be notably studied (Marbà et al. 2014; Dunic et al. 2021). Despite the overall decreasing abundance in absolute numbers, the study of Marbà et al. (2014) found a relatively large percentage of studied meadows with a steady or even increasing state (38% of the studied meadows were steady or increasing in areal extent, 18% in shallow limit, 11% in deep limit, 50% in cover percentage, and 57% in absolute density). Like in other places of the Mediterranean, in Cap de Creus, *Posidonia* meadows could have remained stable or only suffering a slight decrease in their health status for more than two decades away, as our results glimpse.

The difference in trends found between the two species can be explained by the fact that they are affected by different drivers of change and with different intensity. Overharvesting and poaching was reported by managers of scuba diving centres as the main driver of change that caused the decrease of *C. rubrum* in Cap de Creus (Table 1). Such reports dovetail with scientific literature (Tsounis et al. 2006; Linares et al. 2018; Bramanti et al. 2014; Garrabou et al. 2017). For older times, qualitative information reports a heavy exploitation in the Costa Brava region emphasizing either how abundant red coral was in the past, how easy was to obtain it, or the continuous extraction it suffered (e.g., Pons 1989; Audivert 1971; Maluquer 1917; Mallo et al. 2019).

According to the reports of our interviewed managers of scuba diving centres, the main pressure affecting *P. oceanica* in Cap de Creus nowadays is boat anchoring (and the structures built for it; Table 1), coinciding with the scientific reports in the area (Romero et al. 2020). Other impacts affecting Cap de Creus meadows are oils and antifouling derived from boat transit and sunscreens (Romero et al. 2020). Those impacts are mostly avoidable by changing users' behaviour, either by imposing measures (better vigilance from the MPA) or self-consciously

(increase of people awareness). In fact, both measures (better MPA vigilance and increase awareness) has been reported by our interviewees as the cause underlying a decadal increase in *Posidonia* health (Table 1).

Expectations from our surveyed scuba divers regarding the health status of both species by 2050 were not optimistic. Although stable reports dominate, it is worrying that "increase" reports are a minority and only for red coral (Fig. 1b, d). Unfortunately, the reasons for this predicted change were not asked in the survey, so we can only hypothesize. One reason can be that some of our respondents do not have expectations of a long-term effectivity of the MPA protection measures, and they expect that red coral poaching or boat anchoring on the meadows will continue happening. Another reason can be their concern about climate change threats in these habitats, as it is unlikely that MPA measures can directly protect the studied species against climate change negative impacts. The effects that climate change can have on *C. rubrum* (e.g., Galli et al. 2016; Garrabou et al. 2009; Bramanti et al. 2013) and *P. oceanica* (e.g., Pergent et al. 2014; Marbà and Duarte 2010) are well known, so it is reasonable that our respondents expect a future decrease of these species in the area. Furthermore, the decrease of emblematic and endemic species like red coral will most probably negatively impact local economies, as the presence of these species in a healthy state attract scuba diving tourism and directly or indirectly modulate the resources for other species supporting the overall ecosystem functioning (Bramanti et al. 2011; Duffus and Dearden 1990). This fact is exemplified in the neighbouring Medes Islands MPA, where recreative scuba divers noticed a decrease in the attractiveness of the coralligenous areas because of climate change, reducing their willingness to pay for the experience while expecting economic losses in the region (Rodrigues et al. 2015).

5.5. Conclusion

Using the memory and perception of recreative scuba divers, in this work we gathered data of the health status of *C. rubrum* and *P. oceanica* of Cap de Creus as old as the 1970s. Our information complements available ecological data which, albeit being more precise, it only span the last two decades. We argue that these data can complement our knowledge of historical ecological trends of the studied marine habitats and their drivers, thus having more information on how these habitats can behave and evolve in the close future (Thurstan et al. 2015; Lotze and Worm 2009). A potential application of this findings refers to the use of Citizen Science projects involving

long-time scuba divers to understand trends in marine habitats health (scuba divers being the largest group of volunteers in marine Citizen Science projects; Hermoso et al. 2020).

We should stimulate studies collecting local information on species trends, as they provide qualitative interesting information vital in places where other types of information lacks. The benefits of this kind of studies is that they have the ability to cover extensive areas with lower sampling costs than conventional methods and that they stimulate social participation on conservative actions while bridging the gap between science and society (Marrocco et al. 2019; Zorrilla-Pujana et al. 2020). Concretely for Cap de Creus, a more detailed study with a larger sample could be used for not only red coral and *Posidonia*, but other key habitat-engineering species like *Zostera noltii*, *Cymodocea nodosa* or *Paramuricea clavata*, or the recent invader *Caulerpa cylindracea* detected in the area, or the state of the last remains of *Pinna nobilis* (Romero et al. 2020). Furthermore, for the *Posidonia* of Cap de Creus, a study focused on old and quantifiable data sources (e.g., old photographs, satellite images…) would shed more light on its historical ecological trend, giving clues for a future restoration plan if needed.

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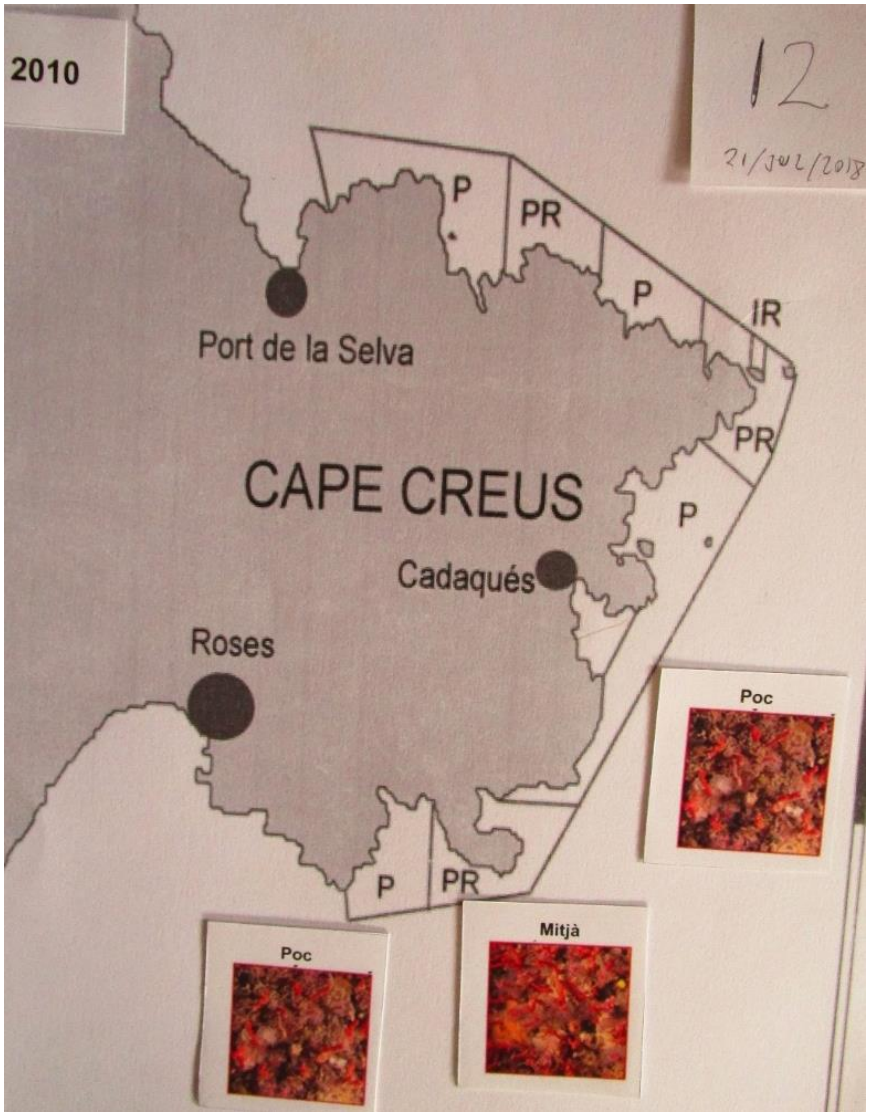
5.7. Supplementary material

Supplementary material 1. Example of an answer of the semi-qualitative interviews realized to scuba diving centres managers.



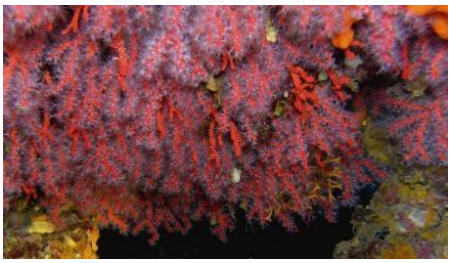
Supplementary material 2. English version of the questionnaire.

⚠ *Only answer this section if you scuba dive frequently in the area.*

ENGLISH

Have you seen and observed any red coral during your dives in this area? Yes No

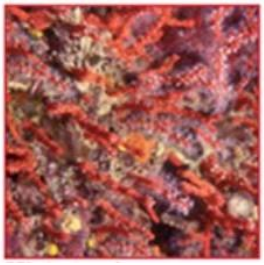
Red coral (*Corallium rubrum*)



If you answered "Yes" the question above, mark with an " X " how much Red coral (*Corallium rubrum*) in general you consider was present in the area during each decade (one " X " per decade only). Consider both, quantity and size. Leave blank the decades that you did not dive in the area.

– think in a general way for all the areas that you saw red coral and make a broad estimate

Much



Medium

Little

Absent

Decade	Much	Medium	Little	Absent	Decade	Much	Medium	Little	Absent
Today (2019)					1970s				
2010s					1960s				
2000s					1950s				
1990s					1940s				
1980s					1930s				

How much red coral do you think there will be in 30 years (by 2050)?: Much Medium Little Absent

Have you seen and observed any *Posidonia* during your dives in this area? Yes No

***Posidonia*, Neptune grass, Mediterranean tapeweed (*Posidonia oceanica*)**

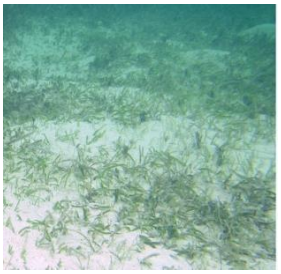
If you answered "Yes" the question above, mark with an " X " how much *Posidonia* in general you consider was present in the area during each decade (one " X " per decade only). Leave blank the decades that you did not dive or not observe *Posidonia* in the area.

– think in a general way for all the areas that you saw *Posidonia* and make a broad estimate

Much

Medium

Little



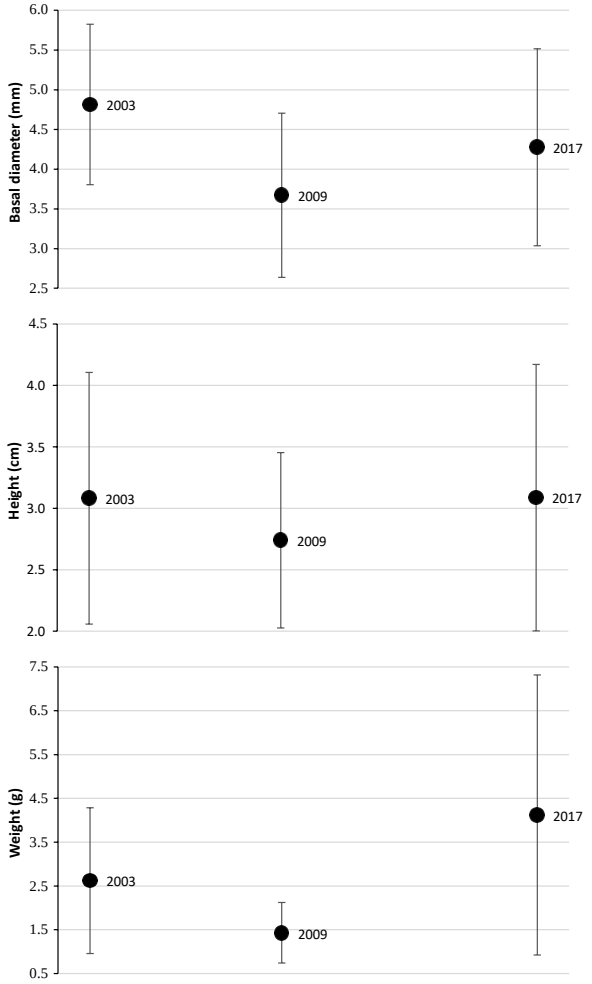
Absent

Decade	Much	Medium	Little	Absent	Decade	Much	Medium	Little	Absent
Today (2019)					1970s				
2010s					1960s				
2000s					1950s				
1990s					1940s				
1980s					1930s				

How much *Posidonia* do you think there will be in 30 years (by 2050)?: Much Medium Little Absent

Supplementary material 3. On the left, *Corallium rubrum* values of its most studied parameters and number of colonies sampled for obtaining them. On the right, the yearly averages and their respective standard deviations of those parameters. This material is modified from Figure 4 and S4 Table in Mallo et al. (2019), *PLOS ONE*.

Data collection year	Ref. Code	# colonies	Ø (mm)	SD	H (cm)	SD	W (g)	SD
2003	(i)	1677 overall	6.55	3.16	4.61	2.90	4.68⸮	1.14
			4.96	1.96	2.57	1.56	3.38‡	1.58
			5.73	1.98	2.65	1.57	0.37⸮	0.09
			4.12	1.85	3.02	1.60	1.19⸮	0.29
			4.07	1.66	2.86	1.72	0.82⸮	0.20
			8.13	2.96	5.56	2.87	6.78⸮	1.65
			4.71	2.20	3.30	1.62	1.81⸮	0.44
			5.77	1.94	3.50	1.42	2.24⸮	0.54
			4.18	1.63	2.20	1.13	1.98‡	0.93
		1722 overall	5.92	2.66	3.72	1.70	2.72⸮	0.66
			4.09	1.31	2.49	1.34	1.82‡	0.85
			4.39	1.64	3.82	2.03	2.94⸮	0.72
			4.12	1.66	3.55	1.84	2.34⸮	0.57
			5.14	1.81	3.60	1.28	2.47⸮	0.60
			4.19	1.26	2.70	1.26	0.48⸮	0.12
			3.63	1.61	2.12	1.07	0.99‡	0.46
			4.93	1.71	3.63	1.67	2.53⸮	0.61
			5.47	2.61	4.27	2.11	3.94⸮	0.96
			5.10	1.88	3.75	2.16	2.80⸮	0.68
			6.22	1.39	5.98	2.84	7.71⸮	1.87
			4.10	1.46	2.16	1.14	1.84‡	0.86
			5.05	1.55	2.54	1.29	3.55‡	1.66
			3.76	1.14	2.41	1.21	1.22‡	0.57
			3.74	1.23	1.98	1.06	1.17‡	0.55
			4.00	1.78	2.29	1.09	1.65‡	0.77
			4.31	2.63	2.85	1.49	0.82⸮	0.20
			4.56	2.05	3.78	1.59	2.86⸮	0.69
		1632 overall	4.98	2.52	2.47	1.51	3.43‡	1.61
			5.20	2.05	1.97	1.36	3.82‡	1.79
			5.25	1.81	2.43	1.67	3.91‡	1.83
			4.69	1.77	2.36	1.32	2.89‡	1.35
			2.97	1.43	1.47	1.04		
2009	(ii)	143	4.08	1.24	2.92†	0.76	1.80‡	0.84
2009*	(iii)	36	3.67	0.78	2.56†	0.67	1.06‡	0.50
2017	(iv)	30	7.22†	1.88	5.66	0.49	11.37	
		181	4.28†	1.11	3.09	0.25	4.28	
		130	3.86†	1.00	2.72	0.13	1.10	
		34	3.57†	0.93	2.47	0.13	4.92	
		100	3.53†	0.92	2.43	0.14	2.30	
		143	4.15†	1.08	2.98	0.17	3.81	
		52	4.24†	1.11	3.06	0.22	3.35	
		75	3.35†	0.87	2.28	0.12	1.83	



colonies "overall" are stated when no # per station is available and represents the sample size containing all the stations comprised until the next # shown in the table.

(*) after the year means that the publication did not indicate the sampling year, so we assumed collection was done one year before the publication date.

SD: Standard deviation. Ø: Basal diameter. H: Height. W: Weigh.

Values obtained through formulas (See Mallo et al. 2019; Fig. 3) are marked with signs: (†): with formula (1), (⸮) with formula (2), and (‡) with formula (3).

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6 CONCLUSIONS

In this section, I start by presenting the main theoretical and methodological contributions that this thesis has provided to the body of knowledge related with marine historical ecology and with human environmental perception. I organize the different subsections starting with a discussion of the general contribution and then going through the contributions of the different chapters of this thesis. In the second section, I discuss possible policy implications of this work, before ending with a section suggesting potential future research lines.

6.1. Theoretical and methodological contributions

Overall, this thesis constitutes an example of a multidisciplinary approach to tackle socio-ecological complex environmental issues. It combines ecological and social data for the environmental assessment of coastal marine habitats of the NW Mediterranean region. More concretely, it produces knowledge from a historical ecological approach and from human environmental perception to seek current and historical trends in the health status of the main biodiversity-holder habitats of the region.

The ecological approach is based on a meta-analysis of quantitative data previously reported in the literature and complemented with qualitative descriptions. I use these data to examine historical trends of *Corallium rubrum* in the NW region of the Mediterranean. The analysis suggest that, despite a historical decreasing trend, in recent decades *Corallium rubrum* seem to be recovering in Marine Protected Areas (MPAs). Importantly, the status of *C. rubrum* is unknown in non-protected areas, as such data is not reported in the scientific literature. Using information provided by scuba divers, this work shows that *C. rubrum* colonies continue to decline in Cap de Creus MPA, a finding that can possibly be extrapolated to other unprotected colonies, which are more abundant than the protected ones. Results from this work also show that MPA users' also perceive declining trends in the overall marine biodiversity and a general deterioration of marine costal habitats. Together, these findings point towards a continued decline in coastal marine biodiversity (even when looking at a MPA; see also Claudet et al. 2020), as several studies suggest for other marine habitats worldwide (e.g., Dunic et al. 2021; Rossi 2019; Rossi 2019b; Thurstan et al. 2015; Jackson 1997). The finding is important, as it has been shown that loss of marine biodiversity leads to a homogenization and simplification of the habitats' structure, making marine habitats less resilient to environmental changes, with a lower capacity of holding biodiversity and of providing benefits to humanity (Rossi 2013; Betti et al. 2017; Sala and Knowlton 2006).

In chapter 2, I assessed *Corallium rubrum*'s health status in the NW Mediterranean region (Catalan Sea and Ligurian Sea) for a long time period (60 years quantitatively, but with the first qualitative data coming from the 3rd Century BP; Julius Solinus 1895). This work is the first assessment for that species spanning such a long period and such wide geographical extension. Moreover, assessments similar to this one are rare in the literature of red coral, even for smaller areas and shorter time frames (see e.g., Garrabou and Harmelin 2002; Linares et al. 2011; Bavestrello et al. 2015; Boavida et al. 2016).

The main conclusion of Chapter 2 is that trends on the health status of *C. rubrum* mainly depend on harvest intensity, and more recently on protection measures. It is important to note that we do not have a clear knowledge of the pristine status of a coralligenous habitat dominated by red coral, as the oldest documented records are from after the start of harvest of the species in the study area (Tortonese 1963; Weinberg 1979; Tescione 1968; Ascione 1993). Even the largest specimens reported in the literature (e.g., Garrabou et al. 2017) have been affected by some kind of anthropogenic impact or exploitation. Qualitative data gathered in this study show that red coral was more abundant and healthier before the first quantitative data available in the 1960s (e.g., Tescione 1968; Pons 1989; Palmulli 1988; Audivert 1971). Then, red coral abundance declined until the 1990s, when the abundance of red coral stabilized, coinciding with the exhaustion of commercial red coral banks and the ban on red coral extraction in some Catalan MPAs (Bini and Maldura 1938; Santangelo and Abbiati 2001; Fuchs 1990). A decade after (2000s), several studies show that the health status indicator parameters of red coral started to improve, a trend that continues until nowadays (i.e., thicker, heavier and taller colonies). After one-to-two decades of protection, red coral health status became similar to the one from the 1980s (in the Catalan Sea) and from the one of the 1960s (Ligurian Sea). However, it should be noticed that in the last two decades, scientific studies on red coral are clearly biased towards colonies found in protected areas (which might comprise a minority of the total number of colonies), an particularly towards colonies found in no-take zones. This bias leaves the unprotected colonies mostly unstudied. Therefore, the trend indicating an improvement of the health status of *C. rubrum* found in this study might be interpreted as the effectiveness of the species' conservation efforts in MPAs. It also highlight the relatively quick recovery (particularly taking into account that red coral is a slow growing species).

Although this study focused on red coral found in the first 60 m water column depth, we collected data that suggest that deep corals have been suffering a decreasing trend in recent times (Bavestrello et al. 2015; Rossi et al. 2008). This suggestion is based on reported older deep samples that were taller and thicker (Mazzarelli 1915; García-Rodríguez and Massó 1984; Cattaneo-Vietti et al. 1994). The trend is probably driven by coral historical destruction with trawling and more recent scuba diving deep harvest, which is now possible thanks to technological improvement (Tsounis et al. 2010; Boavida et al. 2016).

In chapter 2, I also made a broad estimate of the carbon retention capacity of *C. rubrum*. The calculation was done for all the potential places in the study area where it can grow considering different periods of time. The calculation included the estimaties of the total number of colonies

and the total biomass. Such estimates exist in the literature for different benthic species, but remain scarce for red coral (Coppari et al. 2019; Duarte et al. 2010). The estimates show that in approximately two decades, *C. rubrum* carbon retention capacity could either double or be reduced to half, depending on management. This finding highlights the importance of healthy and abundant colonies for its blue carbon sink function that mitigates climate change effects.

The remaining chapters of the thesis are based on interview and survey data collected in the municipalities surrounding the Cap de Creus MPA (chapters 3 to 5). I used free-listings (a common technique used in social sciences; e.g., Triguero-Mas et al. 2010; Queiroz et al. 2017) to obtain a wide understanding of all the positive and negative changes that local stakeholders perceive in the area. Then, I used the most frequently reported negative environmental changes to design survey questions about perceived impacts and threats to coastal marine habitats (used in the analysis presented in chapter 3) and the Likert-scale statements on changes on coastal marine habitats change (used in the analysis presented in chapter 4). The use of information from semi-structured interview for the design of the survey helped to prepare a locally-attuned questionnaire for the MPA users.

I derive several conclusions from the work presented in chapters 3 and 4. First, there is an overall homogeneous trend regarding present-time perception of threats, impacts, and benefits. However, despite this general trend, I also found that the same environment is differently perceived by different people, perceptions being shaped by individual sociodemographic characteristics. For example, locals perceive local coastal marine habitat deterioration more than tourists do. Such differences in perception are probably related to the fact that most locals seem to be more in contact with their surrounding nature as inferred by their sociodemographic characteristics (i.e., affine and/or dependent of the coastal marine habitats (CMHs), residing close to the sea, and probably, having more primary jobs in direct contact with natural resources). Second, irrespectively of their sociodemographic characteristics, survey respondents valued the conservation of the MPA's. This is demonstrated by the fact that respondents gave higher values to regulating services provided by the CMHs than to services related with their use (for joy or exploitation). Third, when assessing temporal changes in the area, environmental changes where the least reported (vs. economic and social changes), probably due to the importance of economic changes made through the tourism sector since Cap de Creus municipalities became high-tourism oriented from the 1960s. In addition, nature's commodification and reification could influence such perceptions. Finally, results point to a dominance of negative environmental changes reports and to an overall perception of

environmental deterioration in the area. Such perceptions are in line with regional and local ecological literature. Documenting those negative perceptions is important because they influence how users interact with the environment. For example, it has been documented that people with negative environmental perceptions are less likely to have eco-friendly behaviours and commit to conservation activities (Cihar and Stankova 2006; Mayer and Frantz 2004).

Information provided by scuba divers and reported in chapter 5 are based on their memory and perceptions. Through these methods, this work assesses the temporal trends for the last 40 years of two keystone species in the most biodiverse habitats of the Mediterranean Sea. Differently from the historical-ecological assessment conducted in chapter 2, the source of data used in this chapter lacks analytical precision, although such precision is not necessary for getting a general idea of the overall trends. Moreover, the method used in this chapter has the advantage of being less biased, as scuba divers' reports of status of red coral colonies are probably less biased towards protected colonies than scientific assessments, for which they provide a more realistic assessment of the whole red coral status. Furthermore, this method is also less time-consuming, involve less logistics, and requires les financial resources than standard ecological assessments (Marrocco et al. 2019). Furthermore, the method allows the possibility of having additional information on potential drivers of change. For example, in our case study the scuba diving centres' managers provided their vision of what were the drivers of change that caused those species improve or decline in a determinate time period.

The trends of *Posidonia* and red coral obtained with scuba divers' reports improve the knowledge of the historical trends in the area. The main conclusions from this chapter are (i) that almost every scuba diver participating in the survey had knowledge of the health status of the two species and (ii) that they mostly report an overall decreasing trend for both species. An important conclusion of Chapter 2 was that the available ecological data for Cap de Creus during the last two was scarce and not robust enough to find a clear trend. However, if we assume that scuba divers reports can be extrapolated to all the Catalan Sea, then the trends reported in chapter 2 match with the scuba diver perceptions until the 2000s, when ecological data indicate an increasing trend in red coral health status, while scuba divers' perception is the opposite. As stated above, we argue that scuba divers are probably less biased (although also less accurate), as they do not report on the status of coral in protected colonies only, for which the overall red coral health status of Cap de Creus probably is closer to trends reported in chapter 5, rather than to trends reported in chapter 2. Regarding *Posidonia*, scientific data for the last decade show a stable trend for the area. While our average data show a slight decrease (2010s-Present), most

reports of our participants were "stable". Thus, we can say that more or less, participants' perceptions matched with scientific ecological data for this species.

6.2. Policy implications

Findings from this thesis have important policy implications. First, results suggest that the protection measures applied to red coral in MPAs (especially in no-take zones) seem to be functioning well, as red coral is recovering. Such type of measures should then continue to be promoted in the area and expanded. Second, despite the success in MPA, the recovery of coral under protection represents a small fraction of the Mediterranean colonies, and we practically have no data of the present health status of unprotected red coral. Unprotected red coral has proven to be in worse status than the protected one, according to ecological assessments (Tsounis et al. 2006; Septentrion 2015) and to divers' memory and perception (Jiménez-López 2012; also confirmed in chapter 5 of this thesis). Such trends can possibly be extrapolated to other key benthic species of the Mediterranean coralligenous like *Paramuricea clavata* and *Eunicella singularis*. The implication of this finding is that the MPAs need to increase in number and extension in the Mediterranean Sea, especially where biodiversity concentrates (Francour et al. 2001). Third, having a better understanding of how red coral health status could change in the recent future in response to different drivers of change (thanks to knowing long-time ecological trends of the species) could help to improve their conservation strategy. Concretely, is crucial to acknowledge that red coral is an endangered species, according to IUCN criteria, particularly as most coral in the Mediterranean sea is now under the minimum harvest size (7 mm of basal diameter) and close if not completely functionally extinct (Rossi 2013; Garrabou et al. 2017b). Specific measures that could help in the protection of this fragile species include the removal of red coral fishing licenses and ensuring that poaching episodes do not happen in protected areas (Garrabou et al. 2017b; Arafeh-Dalmau et al. 2019; Linares et al. 2011).

A better understanding of users' perception of coastal marine areas, including MPAs, and a better understanding of historical environmental changes of the CMHs as perceived by users, can contribute to the design of more efficient management and conservation policies for natural resources, species and habitats. This is so because being aware of social perceptions facilitates empathy in policy design and understanding of the different typologies of users, which can result in the design of more locally attuned conservation projects and proposals (Llausàs et al. 2019; Shackeroff et al. 2011; Gärling and Golledge 1989). Finally, the promotion, elaboration and

facilitation by the governmental bodies, of projects involving long-time scuba divers, as well as other Citizen Science projects that impulse and encourage the local population towards a conservation or restoration project, would help bridging the science-society gap along with an improvement of the local natural environment (Zorrilla-Pujana et al. 2020; Trialfhianty and Suadi 2017).

6.3. Future research

An important line of future research regarding *C. rubrum* is to continue studying its ecological history with studies covering long time spans. Such studies could help better understand the actual health status of the species and model its potential future trends, as well as its role as engineering species in the coralligenous and its blue carbon sink function. A natural place to conduct such research, for example with a meta-analysis like the one realized in this thesis, is the French Mediterranean coast. This particular area was one of the pioneer in benthic marine studies (Marion 1883; Gilet 1954; Peres and Picard 1956) and has several old and valuable data of the species (Dantan 1928; Marsili 1707; Marsili 1725; True 1970; Carpine and Grasshoff 1975; Marin and Reynal de Saint-Michel 1981). After a study like that, the entire NW Mediterranean region would be covered for this species.

Additionally, is crucial to locate and study unprotected *C. rubrum* colonies in the area to complete the species' health status. Such data would also provide a reliable approximation of the percentage of the existing colonies in the Mediterranean (and outside it, as it is a semi-endemic; Boavida et al. 2016). Of course, mapping red coral also includes deep-coral, which will provide a better understanding of which deep coral colonies have been impacted by trawling and maybe even to discover some colonies close to its pristine status (Lastras et al. 2016; Giusti et al. 2019; Mazzarelli 1915; Garrabou et al. 2017). In addition, such work and efforts can be extrapolated to all the important biodiversity-holder species of the sea (e.g., Marbà et al. 2014; Dunic et al. 2021; Di Iorio et al. 2021; Valisano et al. 2019).

A method that could help materialize these research lines is the use of scuba diver perception and memory for obtaining historical ecological trends, as this method is efficient when time, logistics and resources (including funding) is limited. Furthermore, the method allows to sample large areas and scuba divers are usually very committed to participate in conservation and scientific projects, being one of the largest group of volunteers (Hermoso et al. 2020; Marrocco et al. 2019). Thus, more studies like the one presented in chapter 5 of this thesis could be useful

to have a broad idea of the status of an species or an habitat. As one of the main limitations of chapter 5 is the low sample size, a study with larger sample would be a good starting point for future research. Furthermore, such studies could also take a multi-species approach, including other key species of the Mediterranean habitats, tracking invader species and their effects on native populations, or checking the health and abundance of endangered species (e.g. *Pinna nobilis*).

After studying the perceptions of Cap de Creus users and the ecological trends of its CMHs, I conclude that Cap de Creus needs more efforts towards conservation actions. It is concerning that a MPA since 1998 has reports of deteriorating marine life from their users and in ecological literature. For the part implying research, further research has to be done in finding the right equilibrium between conservation and exploitation activities in the area. This will probably imply that all type of users' perceptions and wills should be better understood in order to be able to implement proposals (Pendelton et al. 2018; as mentioned above, Citizen Science projects could be a good option).

6.4. References

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