Science of the Total Environment 652 (2019) 1302–1317

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Tackling challenges for Mediterranean sustainable coastal tourism: An ecosystem service perspective

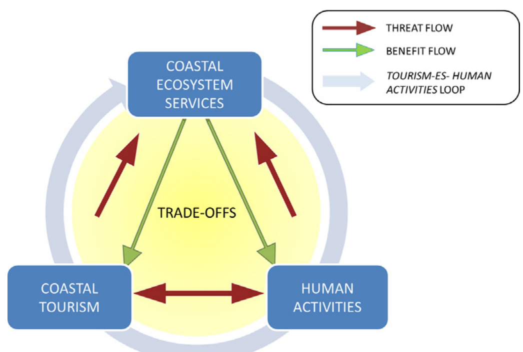
Mita Drius [a,*], Lucia Bongiorni [a], Daniel Depellegrin [a], Stefano Menegon [a], Alessandra Pugnetti [a], Simon Stifter [b]

[a] ISMAR-CNR, Institute of Marine Sciences, National Research Council, Arsenale - Tesa 104, Castello 2737/F, 30122 Venice, Italy
[b] Schloss-Schöneck 4, 39030 Falzes, Italy

HIGHLIGHTS

- A "threats - ecosystem services - tourism" conceptual framework is provided.
- Relations between coastal tourism and cultural services are qualitatively assessed.
- Coastal tourism industry can damage itself through ecosystem services' impairment.
- Impacts from other human activities to ecosystem services affect coastal tourism.
- Multiple threat analysis provides insight for sustainable tourism development.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 31 July 2018
Received in revised form 8 October 2018
Accepted 9 October 2018
Available online 11 October 2018

Editor: Damia Barcelo

Keywords:
Coastal recreation
Multiple threats
Cultural services
Geospatial modelling
Coastal ecosystems

ABSTRACT

Coastal tourism is a growing industry sector in the Mediterranean Basin. This and the other human activities occurring along the coastline share space and resources, leading to conflicts for divergent uses. Moreover, the overexploitation of natural resources degrades and depletes coastal habitats, with negative feedback effects for all human activities. Hence, both tourism and the other human activities have to consider their dependence on coastal ecosystem services, and act at technical and policy level to reach a compromise that preserves natural resources in the long term. Here we provide a conceptual framework illustrating the complex relationships and trade-offs among threats from coastal tourism and from other human activities and coastal ecosystem services, with a focus on cultural ones. We discuss the negative feedbacks on tourism development and provide examples of geospatial analysis on cumulative threats generated by other human activities and affecting tourism itself. The proposed conceptual framework and the threat analysis aim at highlighting the negative feedback effects of human driven threats on the development of Mediterranean coastal tourism, through an ecosystem service perspective. Both tools provide valuable insight for supporting decision makers and planners in achieving integrated coastal management, with a focus on sustainable tourism.

1. Introduction

The Mediterranean Basin is the preferred destination for more than 30% of the international tourists worldwide, especially during summer months (Piante and Ody, 2015), and studies forecast that international arrivals will amount to 500 million in 2030, with an average increasing

* Corresponding author.
E-mail addresses: mita.drius@ve.ismar.cnr.it (M. Drius), lucia.bongiorni@ismar.cnr.it (L. Bongiorni), daniel.depellegrin@ve.ismar.cnr.it (D. Depellegrin), stefano.menegon@ismar.cnr.it (S. Menegon), alessandra.pugnetti@ismar.cnr.it (A. Pugnetti), simstifter@gmail.com (S. Stifter).

https://doi.org/10.1016/j.scitotenv.2018.10.121

annual rate of 2.6% (Plan Blue, 2016 and literature therein; UNEP/MAP, 2012). Spain, France and Italy have a leading role in the distribution of tourist arrivals, with total market share over 60%, followed by the rapid growth rates of the Southern and Eastern EU Mediterranean countries (Piante and Ody, 2015; Satta, 2004). Coastal areas are those most visited by tourists, so that coastal tourism often represents a major economic driver and employment producer for these countries. Coastal tourism has actually been identified as one of the five priorities of the EU Blue Growth Strategy (EU Commission, 2017).

While it is unquestionable that tourism plays a crucial role in the economic development of the Mediterranean region, it is undoubtedly true that its continuous growth will exert increasing pressures on the environmental resources of coastal zones. The massive fluxes of tourists, which often concentrate in relatively small areas, may have a huge environmental impact on Mediterranean ecosystems and their functionality, intensifying and cumulating with other human impacts of the local population activities (e.g. waste, water consumption, and pollution). In fact, more than one third of today's Mediterranean population live on coastal areas exerting strong pressures on coastal ecosystems, with increasing impacts in the last decades (Coll et al., 2012; UNEP/MAP, 2012). Habitat loss and degradation, pollution, alien species introduction, overexploitation of marine resources, and climate change are among the most important threats in the region (Coll et al., 2010; Costello et al., 2010). The Mediterranean Basin is at the same time a recognized hot spot of terrestrial and marine biodiversity (Bianchi, 2007; Bianchi and Morri, 2000; Coll et al., 2010; Myers et al., 2000), hosting high percentages of endemisms and emblematic species of conservation concern, and thus highly vulnerable to human-driven threats. On the other hand, the diversity of species and the complex mosaic of habitats and landscapes lie at the heart of many tourist attractions in the Mediterranean and the good functionality of coastal ecosystems is a prerequisite for coastal tourism and related economic activities to persist in the long term. Hence, at least in principle, the maintenance of essential ecological processes and the conservation of natural heritage and biodiversity should coexist with sustainable tourism development.

The concept of "sustainable tourism" (sensu UNEP, 2005) has appeared in the last decade in order to tackle a variety of problems, such as ecological degradation, loss of cultural heritage and economic dependence, originating from coastal tourism (UNWTO, 2013). Sustainable tourism aims to meet the needs of tourists (e.g. infrastructures, but also beauty and natural perceptions of recreational sites), taking into account the local population needs, the accommodation capacity and the environment (Simpson, 2008). Ecosystem services (ES; Haines-Young and Potschin, 2013; Kumar, 2010; MEA, 2005), i.e. the benefits people obtain from ecosystems, are explicitly or implicitly used to evaluate the progress towards sustainable development and they represent an important integrated framework in sustainability science (Griggs et al., 2013; Liu et al., 2015; Wu, 2013). The assessment of ES helps bridge the conceptual gap between the ecological and social sciences, by linking the state of ecosystems with human well-being and activities (Böhnke-Henrichs et al., 2013).

The ES approach has started to appear also in environmental policies addressing the sustainable development and management of coastal zones, such as the Water Framework Directive (WFD, 2000/60/EC), the Marine Strategy Framework Directive (MSFD; EC, 2008), the Integrated Coastal Zone Management protocol (ICZM; EC, 2002), and the Maritime Spatial Planning Directive (MSP, 2014/89/EC; Drakou et al., 2017 and literature therein). Similar principles are expressed in the Ecosystem Approach (EcAp), the overarching pillar of UNEP/MAP, in the European Biodiversity Strategy to 2020, which fully acknowledges the central role of ES for our society, and in the Mediterranean Strategy for Sustainable Development 2016–2025 (UNEP/MAP, 2016).

Despite the emergence of the ES concept in EU and Mediterranean policy in support of the sustainable development and management of coastal areas, the current growth paradigm of the Mediterranean tourism sector still exerts pressures on environmental resources, which may interact with other human activities and cause complex cumulative effects on the marine and coastal environment and their services (Halpern et al., 2008; Micheli et al., 2013). Coastal tourism itself can be identified both as cultural service (e.g. Daniel et al., 2012; de Groot et al., 2010; MEA, 2005), producing benefits for humans, and as driver of ecosystem change (Church et al., 2017) and it is inextricably entangled with regulating and provisioning services (Chan et al., 2012).

In this context any ES assessment of modelling in support of spatial planning must take into consideration the interdependencies of ES (the use of one may affect the provision of others), and their potential trade-offs (the optimization of a single service often lead to reductions or losses of other services), since they are the product of complex ecological systems (Böhnke-Henrichs et al., 2013; Rodríguez et al., 2006).

The multifaceted interactions among ES and the human activities need to be analysed thoroughly and urgently. Conceptual frameworks disentangling these multiple links have started being developed in the 2000s, for instance in agriculture (e.g. Ribaudo et al., 2010), in fisheries (e.g. Lopes et al., 2015) and in inland water management (e.g. Keeler et al., 2012), whereas studies specifically investigating the major threats from coastal tourism and their interaction with other human activities impinging on ecosystems, along with their implications for the long term delivery of ES, are still lacking (Arkema et al., 2015; Papageorgiou, 2016).

A valuable opportunity to explore the multiple links among Mediterranean coastal tourism, ES and the other human activities was provided by the MED project CO-EVOLVE (2016–2019; https://co-evolve.interreg-med.eu/), which aims at analysing and promoting the co-evolution of human activities and natural systems in Mediterranean touristic coastal areas. This project gave the possibility to rapidly share and cross-validate the produced information and frameworks among the EU partners involved (Spain, France, Italy, Croatia, and Greece) and to benefit from their expert-based assessment.

The aim of this study is to develop, test and discuss a conceptual framework, which characterizes the Mediterranean coastal ecosystems and their services; the coastal tourism typologies and their relation with cultural services; the threats generated by coastal tourism and by other human activities on ES; and their negative feedback effects in terms of attractiveness to the coastal tourism industry itself. The framework is shaped on the five CO-EVOLVE countries, but it can be generalized to any coastal and marine area of the Mediterranean Basin and beyond.

The study is structured as follows: first, we illustrate the main coastal ES occurring in the Mediterranean Basin, according to the prevalent ecosystem types. Second, we characterize the main coastal tourism typologies and recreational activities. Third, we define the main threats from tourism to coastal ecosystems, and those from other human activities to tourism. Then, with the aid of the identified conceptual framework, we present and discuss a case study for the Italian Northern Adriatic coast showing geospatial tourism threat analysis exerted by (i) a single tourism typology (recreational boating) and by (ii) multiple human activities to beach tourism. Findings are discussed for their relevance in support of the conceptual framework and in relation to its contribution to the sustainable development of coastal tourism in the Mediterranean.

2. Materials and methods

2.1. Linking tourism and ES to other human activities: a conceptual framework

Conceptual frameworks in the forms of cascade models are used, in the context of ES, to better represent the transdisciplinary nature of the 'ES paradigm' (IPBES, 2012). The cascade model provides a useful setting to schematically visualize the benefits arising from ES, their effects on human well-being, and the way institutional and social responses may influence the state of the ecosystems and, therefore, their potential to deliver further services (Haines-Young and Potschin,

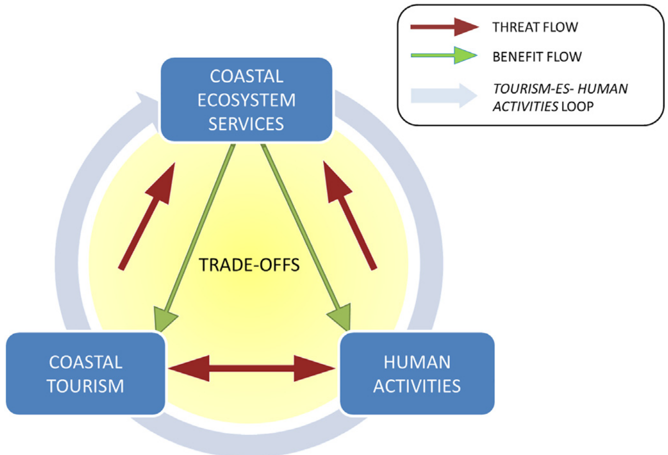


Fig. 1. The three components (coastal tourism, other human activities and coastal ES) of the conceptual framework, the TEO (Tourism-ES-Other human activities) loop and their flows. Red arrows represent the threat flows, while green arrows represent the benefit flows. The light grey loop arrow indicates the TEO loop. The yellow area represents the trade-offs among the three components. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2010). The conceptual framework adopted in this study is outlined in Fig. 1. The aim of the framework is to schematically characterize the complex relationships among coastal tourism (CT), the other human activities (HA) and coastal ES (CES). Basically, we concentrated on two types of relationships (benefits and threats) linking CES, CT and HA. The red and green arrows represent the threat and the benefit flows respectively. CES produce two unidirectional benefit flows towards CT and HA, whereas they receive two unidirectional threat flows from CT and HA. For example, while CES produce benefits to CT and HA such as ensuring clean bathing water and supplying seafood, they are impacted by threat factors generated from both components (e.g. water pollution and fish overexploitation, respectively). Moreover, between CT and HA a bidirectional threat flow exist. For instance, industry (HA) can damage CT through noise pollution, whereas CT can favour alien species introduction, which impair the development of aquaculture (HA).

The threat flows produced by CT and by HA on CES ultimately produce feedback effects to CT itself, generating the "Tourism-ES-Other human activities" (TEO) loop. In Fig. 1 the TEO loop is represented with a light grey arrow originating from CES, encompassing HA and CT, and ending in CES. The loop basically expresses two main concepts: (i) CES are the fundamental components of the loop, as no CT or HA may exist if benefits from CES are no longer provided, and (ii) the threats generated from HA and CT on CES ultimately negatively impact on HA and CT themselves.

Possible trade-offs exist between CT and HA, which rely on interdependent CES, and among all the three components. In fact, trade-offs among different activities imply trade-offs among CES.

The components and the relationships making up the TEO loop are described and commented in detail in the following paragraphs.

2.2. Characterization of coastal ecosystems and their services in the Mediterranean

In order to define the main Mediterranean CES, the first component of the TEO loop, we started with the characterization of the Mediterranean coastal ecosystems. We performed a literature research on the main ecosystem type classifications. Taking into consideration the purpose and scale of our analysis, we adopted the global ecosystem types classification proposed by the World Resource Institute (Burke et al., 2001). Although this ecosystem type classification is coarse, it is suitable to be connected to the associated CES typologies. The global ecosystems classification was then applied to the Mediterranean coastal and marine systems through a survey conducted among the CO-EVOLVE consortium, where each partner was requested to select from the global classification the ecosystem types prevalently occurring along their coasts. Project partners represent different relevant sectors (coastal managers, researchers, regional authorities) and have long-term experience in Mediterranean coastal management.

Similarly to the methodology adopted for defining coastal ecosystems, we performed a literature review on the main CES classifications to characterize those provided by Mediterranean coastal ecosystems. We adopted and modified the classification schemes proposed by Martínez et al. (2007) and Liquete et al. (2013), which appeared the most appropriate for our purposes and which also take already into account former classifications, such as the Millennium Ecosystem Assessment (MEA, 2005), The Economics of Ecosystems and Biodiversity - TEEB (Kumar, 2010), and the EU Common International Classification of Ecosystem Services - CICES (Haines-Young and Potschin, 2013).

According to this classification, we attributed the main CES to each of the ecosystem typologies selected in the Mediterranean area, using a threefold ES framework: (i) provisioning (all the products from ecosystems, including food, materials, genetic resources and habitat), (ii) regulation and maintenance (all the functions of ecosystems, which sustain maintenance and regulation, including, e.g., air and water quality, climate regulation and natural hazards), and (iii) cultural (the non-material benefits people obtain from ecosystems, including recreation, cognitive development and aesthetic experiences).

2.3. Characterization of coastal tourism typologies and recreational activities

The second component in the TEO loop is coastal tourism (CT). Due to the close interaction between coastal and maritime recreational activities, in this study CT comprises both tourism forms. The coastal one refers to the beach-based (e.g. swimming, surfing, sun bathing) and land-based recreation (all the other activities that take place in the coastal area for which the proximity of the sea is a requisite), as well as the associated supplies and manufacturing industries (Ecorys, 2013). Sea-based activities, such as boating, yachting, cruising, and nautical sports, as well as the required landside facilities and manufacturing, belong to maritime tourism (Ecorys, 2013).

Five main CT typologies were selected within the CO-EVOLVE partnership and adapted to the Mediterranean Basin: (i) beach tourism, which includes all beach-based activities and nautical sports dependent on beach facilities; (ii) urban tourism, which refers to visiting of coastal villages and towns; (iii) cruise tourism, which includes cruising activities occurring near the coastline, such as embark/disembark facilities and coastal navigation; (iv) recreational boating, which includes yachting; and (v) ecotourism, which involves environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature. The main coastal recreational activities related to these five CT typologies were identified through literature research (Davenport and Davenport, 2006; Fish et al., 2016; Ghermandi et al., 2010; Liquete et al., 2013) and CO-EVOLVE experts' consultation, in order to adapt the obtained list to the specificities of the Mediterranean. They were then organized according to Fish et al. (2016) (Fig. 2) into four, often interrelated, groups of recreational activities: (i) playing and exercising, which engage informal and physical interactions between people and the natural environment, such as walking, bathing, running, cycling, sitting, looking, and listening; (ii) creating and expressing, which include activities inspired by natural environment; (iii) producing and caring, which comprise activities of engagements with the natural environment, such as environmental volunteering, citizen science; and (iv) gathering and consuming, which involve passive and active engagements with the natural world,

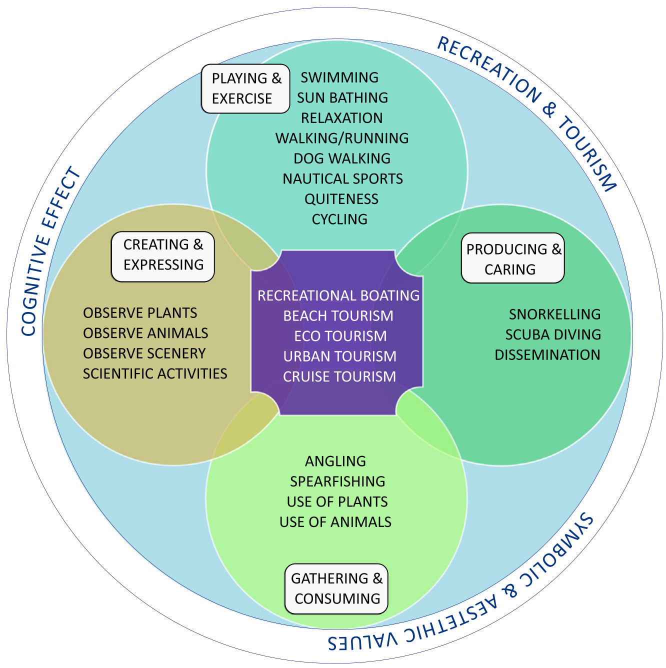


Fig. 2. Recreational activities related to the five CT typologies. Activities are organized in four recreational groups (coloured circles) on the base of Fish et al. (2016) classification. Groups of activities are further enclosed into the three cultural CES categories defined by Liquete et al. (2013) and placed in the outer circle of the figure. CT typologies are depicted in the middle, partially overlapping with the four recreational activities groups, as each CT typology includes various combinations of activities. This graphical expedient expresses the impossibility of univocally relating each recreational activity to a single cultural ES category and to a single CT typology. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

such as collecting wild food, fibre and ornaments. The four clusters can be embedded into the three broader cultural CES categories (Fig. 2), according to the scheme proposed in Liquete et al. (2013): (i) recreation and tourism, (ii) symbolic and aesthetic values, and (iii) cognitive effect. However, it is worth noting that the resulting categorization scheme (Fig. 2) cannot be rigid as each CT typology includes various combinations of activities and the same activity can be categorized in more than one of the four groups.

Project partners were asked, by means of a structured interview, to indicate the coastal recreational activities occurring in their country and to rank, from 1 (low) to 3 (high), the importance of each activity at the country level. Structured interviews were preferred over other research methods because they allowed ranking the different recreational activities by providing the interviewees with univocal options, and also because they allowed a clear comparison among countries. We adopted a simplified evaluation scheme, which considered only three broad categories (low, medium and high) in order to limit the arbitrariness in ranking.

2.4. Threats from coastal tourism and other human activities

The third components of the TEO loop are the other human activities (HA). We detected five main HA, based on Piante and Ody (2015): urbanization (coastal artificialization and development), industry, transport (including shipping), intensive agriculture, and fisheries and aquaculture. Climate change was not specifically addressed in our analysis, as it is considered a result of complex interactions between natural variability and human activities and thus not directly related to a single activity.

Both CT and HA generate a threat flow to CES and ultimately to CT, closing the TEO loop. The term “threat” can be viewed as the risk of ES reduction, partial or permanent loss of provision or impairment of their use, due to a single or multiple anthropogenic effects (Maron et al., 2017; Worm et al., 2006). In this study, threats include the ideas of “pressures” and “impacts” conceptualized in the DPSIR (Driver-Pressure-State-Impact-Response) framework adopted by the European Environment Agency (Patrício et al., 2016). “Pressures” are defined as a result of a driver-initiated mechanism (human activity/natural process) causing an effect on any part of an ecosystem that may alter the environmental state, while “impacts” indicate the consequences of environmental state changes in terms of substantial environmental and/or socio-economic effects (Oesterwind et al., 2016).

We reviewed threats generated from CT through a specific classification, here named “CO-EVOLVE threat”, which integrates impacts produced from tourism, as reported by Davies and Cahill (2000), and pressures listed in the MSFD. We focused only on what Davies and Cahill (2000) define as “direct impacts” exerted by tourism, i.e. those that are more easily and directly related to the tourism activity itself: (i) travelling to a destination, (ii) from the recreational activities themselves at a destination, and (iii) from the creation, operation and maintenance of touristic facilities.

The literature review we conducted allowed us performing a ranking of the five CT typologies (see Section 2.3) in relation to CO-EVOLVE threats. Specifically, we qualitatively assessed to what extent each CO-EVOLVE typology (i) produces each CO-EVOLVE threat (“threats from tourism”), and (ii) is targeted by each CO-EVOLVE threat (“threats to tourism”). In order to limit arbitrariness in the evaluation, CT typologies were ranked using a simplified system with three levels of concern (low, medium or high), as done for the recreational activities.

2.5. Geospatial modelling of threats from and to CT: the Northern Adriatic Sea case study

In order to test how the above mentioned HA interact with CT and the implications for CT itself, we developed a case study focused on two CT typologies: beach tourism and recreational boating. While the former is an established form of mass tourism in the Mediterranean, the latter is currently experiencing an increasing popularity, as reflected by the manifold new marinas development and increasing leisure boat industry (Nautica Report, 2016; Plan Bleu, 2011).

2.5.1. Study area

The case study area is located along the Italian coasts of the Northern Adriatic Sea (NAS, Fig. 3) totalling about 372 km of coastline. The area includes three administrative regions, Friuli-Venezia Giulia (93 km), Veneto (139 km) and Emilia-Romagna (140 km), and 36 municipalities. The case study area was selected due to its popularity as recreational area at national level (EC, 2017) and at the Mediterranean Basin level. In addition, the NAS belongs to the most crowded marine areas of the Mediterranean, where a multitude of sea uses (e.g. maritime traffic, aquaculture, commercial fishery, oil and gas extraction) coexists with intense recreational activities (Barbanti et al., 2017; Menegon et al., 2018b). In the NAS important coastal tourism resorts are Rimini (1.6 million arrivals per year; Regione Emilia Romagna, 2016), Jesolo (over 1 million arrivals per year; Turismo Venezia, 2018), and Caorle (over 600 thousands arrivals per year; Turismo Venezia, 2018). Regarding Venice municipality, only 5% of total arrivals are connected to beach tourism and recreational boating, according to regional statistics (over 200 thousands arrivals per year recorded in the Lido of Venice; Turismo Venezia, 2018). In the appendix (Fig. A1) arrivals for all the coastal municipalities in the NAS are provided.

2.5.2. Dataset

The geospatial datasets applied for the analysis include locations of marinas, retrieved from Tools4MSP Geoplatform (2018), and annual statistics

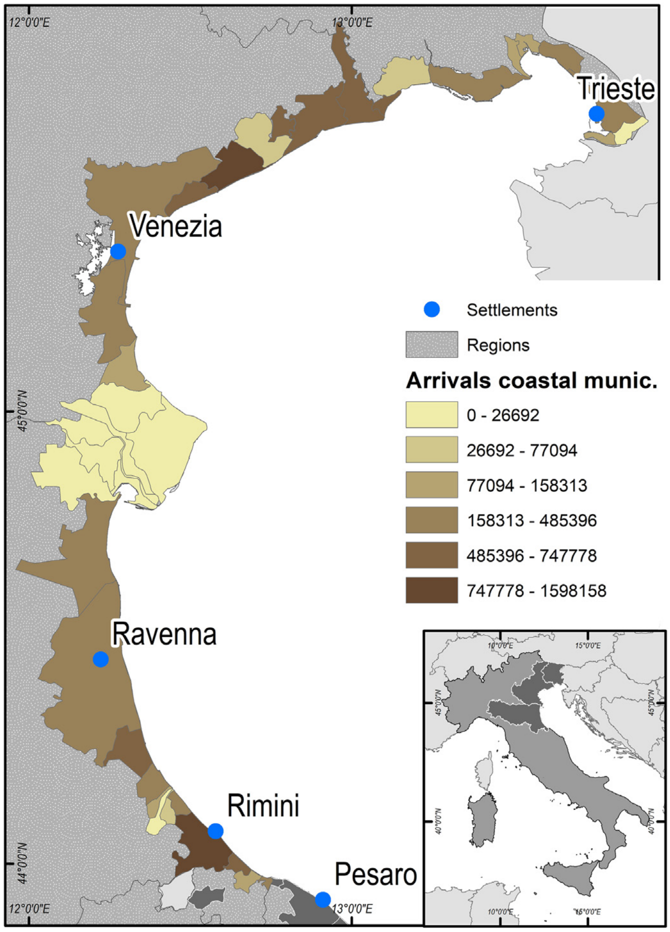


Fig. 3. Case study area in the Italian Northern Adriatic Sea (NAS) and arrivals per year by coastal municipality. Note: for Venice municipality only arrivals to Lido of Venice were considered (Turismo Venezia, 2018).

for the tourism arrivals at municipality level for Friuli-Venezia Giulia (Regione Friuli-Venezia Giulia, 2015), Veneto (Turismo Venezia, 2018) and Emilia-Romagna (Regione Emilia-Romagna, 2016). Datasets on different coastal human activities were retrieved from the Tools4MSP Geoplatform (2018; Table 1) and can be downloaded from Menegon et al. (2018c).

2.5.3. Cumulative pressure and tourism threat analysis

Threat analysis is based on tourism-oriented specification of the Tools4MSP modelling framework (Menegon et al., 2018b and 2018d). The framework provides geospatial modelling tools oriented to MSP and ICZM, including cumulative effects assessment (CEA), which have been applied in different macro-regional, national and regional contexts (Barbanti et al., 2017; Depellegrin et al., 2017). In the case study, threats to and from tourism are based on a cumulative pressure (CP) index applied within a buffer of 3 nm, which is considered as area of most intense interaction among touristic activities (Barbanti et al., 2017).

Two cases of tourism-oriented threat analysis were tested: (i) Threats from tourism to tourism (*Th from CT*): geospatial analysis of CP exerted by recreational boating on beach tourism sites; and (ii) Threats from cumulative human activities to tourism (*Th to CT*): geospatial analysis of CP exerted by multiple human activities on beach tourism sites. The threat to the cultural service “Recreation and tourism” is tested using the number of arrivals per municipality as proxy for the societal demand for coastal recreation (Böhnke-Henrichs et al., 2013).

The algorithm applied for cumulative pressure analysis in coastal area is adopted from Menegon et al. (2018c) and can be defined as follows:

$$CP = \sum_{j=1}^{m} P_j$$

where

$$P_j = \sum_{i=1}^{l} w_{i,j}\left(D(U_i) * M_{i,j}\right) \tag{1}$$

whereas:

$U =$ i-th human activity
$P =$ j-th pressures derived from the MSFD
$w_{i,j} =$ use-specific relative pressure weight
$D(U_i) =$ intensity or presence/absence of i-th activity over the region of analysis
$M_{i,j} =$ 2D gaussian kernel function used for pressure dispersion
$* =$ convolution operator

Table 1
Dataset of human activities adopted from Piante and Ody (2015) and implemented in the NAS case study area. Note: P/A – presence/absence; I – intensity.

Human activities	Uses	Indicator
Aquaculture	Aquaculture[a,b]	P/A
Fisheries	Trawling[c]	I – hours of activities calculated through Vessel Monitoring System (VMS)
	Small scale fishery[g]	I – fishing effort expressed in 5 classes of intensity: from very low to high
Industry	Off-shore sand deposit[a,g,h,i,j]	P/A
	Liquefied natural gas terminal (LNG)[f]	P/A
	Oil and gas extraction[b,k,l,m,n], oil and gas research[b,k,l,m,n]	P/A
	Renewable energy facilities (offshore wind farms)[c,f]	P/A
Tourism	Marinas[o]	I/PR – distance from the marinas and number of boats/marinas
Transport	Naval based activities[o]	I/PR – distance from the cargo ports and port capacity
Urbanization and intensive agriculture	River and coastal urban areas[o]	I – modelled nutrient input (Nitrogen and Phosphorus)
Other	Cables and pipelines[b,d]	P/A
	Coastal defense work[b,e]	P/A
	Dumping area for dredging[b]	P/A
	Military areas[b,h]	P/A

[a] Veneto Region (www.regione.veneto.it).
[b] SHAPE-Shaping a Holistic Approach to Protect the Adriatic Environment between coast and sea (www.shape-ipaproject.eu).
[c] Blue Hub, JRC in-house platform to exploit big data in the maritime domain (www.bluehub.jrc.ec.europa.eu).
[d] OTE S.A. – Hellenic Telecommunication Organization (www.ripe.net).
[e] SIT-Apulia Region (www.sit.puglia.it).
[f] OGS-Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (www.ogs.trieste.it).
[g] CNR-ISMAR-Italian National Research Council-Institute of Marine Sciences (www.cnr-ismar.it).
[h] MIPAAF-Italian Ministry of Agriculture, Food and Forests (www.politicheagricole.it).
[i] Emilia Romagna Region (www.regione.emilia-romagna.it).
[j] Arenaria S.r.l. (www.arenariasabbie.com).
[k] MEDTRENDS-The Mediterranean Sea: Trends, Threats and Recommendations (www.medtrends.org).
[l] MESMGR-Ministry of Economy, Sector for Mining and Geological Research (www.petroleum.me).
[m] CHA – Croatian Hydrocarbons Agency (www.azu.hr).
[n] MISE-Italian Ministry for Economic Development (www.sviluppoeconomico.gov.it).
[o] Modelled.

U defines the 15 most relevant human activities in the study area (Table 1); P are the seven environmental pressures defined according to the MSFD: marine litter, significant changes in thermal regime, introduction of synthetic compounds, introduction of non-synthetic substances and compounds, introduction of other substances, inputs of fertilisers and other nitrogen and phosphorus-rich substances and inputs of organic matter; $w_{i,j}$ is an expert-based weighting factor (from 0 to 1) defining the contribution of the use i in generating pressure j; $D(U_i)$ is the normalized score of the geospatial datasets of U (Table 1), representing the intensity (score 0 to 1) of an activity or defining its presence-absence (score 0 or 1). The full geospatial dataset is available within the Tools4MSP Geoplatform (www.tools4msp.eu) or under Menegon et al. (2018c). The function $M_{i,j}$ models the pressure propagation using the Tools4MSP modelling framework. For further details on the dispersion function we refer to Menegon et al. (2018a and 2018b). The algorithm for tourism threat (T_{Threat}) analysis is presented in Eq. (2):

$$T_{Threat} = CP_{Th\ to/from\ CT} \times CT \tag{2}$$

whereas CP is the cumulative pressure as described in Eq. (1) and CT refers to coastal tourism expressed as the normalized value of tourism arrivals within the coastal municipalities of the study area (Fig. 3). The CP can be applied flexibly to identify threats to tourism ($CP_{Th\ to\ CT}$) and for the analysis of threats from tourism ($CP_{Th\ from\ CT}$).

3. Results and discussion

3.1. Coastal ecosystems and their services in the Mediterranean area

Eleven coastal ecosystem types were identified in this study, and the main Mediterranean CES for each of them are shown in Table 2.

CES provided by the different ecosystem types include a large variety of ecosystem processes and functions as well as controlling components, which have been analysed in the literature only partially and prevalently from a qualitative point of view (Liquete et al., 2013; Salomidi et al., 2012). The provision of CES is strongly linked to the distribution, size and conservation status of the different natural habitats (Dobson et al., 2006; Maes et al., 2012). According to the reviews by

Table 2
List of coastal ecosystems and main associated CES.
Modified after Martínez et al. (2007) and Liquete et al. (2013).

Coastal ecosystem types	Coastal ecosystem services		
	Provisioning	Regulation and maintenance	Cultural
Sandy shores	Habitat/refugia Raw material	Disturbance regulation Pollination Erosion control Storm protection	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Estuaries	Habitat/refugia Food production Raw material	Disturbance regulation Nutrient cycling Biological control Storm protection	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Coastal shelf	Food production Raw material	Nutrient cycling Biological control	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Evergreen needle leaf forests	Food production Raw material	Climate regulation Waste treatment Biological control	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Evergreen broad leaf forests	Water supply Food production Raw material Genetic resources	Climate regulation Disturbance regulation Water regulation Erosion control Nutrient cycling Waste treatment	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Shrublands	Food production Raw material Genetic resources	Pollination Gas regulation Waste treatment Biological control	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Permanent wetlands	Water supply Food production Habitat/refugia Raw material	Gas regulation Disturbance regulation Waste treatment Storm protection	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Coralligenous habitats	Habitat/refugia Food production Raw material	Disturbance regulation Waste treatment Biological control Storm protection	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Sea grass	Raw material	Nutrient cycling Storm protection	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Swamps-floodplains	Habitat/refugia Raw material Food production	Gas regulation Disturbance regulation Water regulation Water supply Waste treatment	Recreation and tourism Symbolic and aesthetic values Cognitive effect
Grasslands	Food production Raw material Genetic resources	Gas regulation Climate regulation Water regulation Erosion control Waste treatment Biological control Pollination Storm protection	Recreation and tourism Symbolic and aesthetic values Cognitive effect

Barbier et al. (2011) and Liquete et al. (2013), most information worldwide is found for intertidal areas such as coastal wetlands, beach and dune systems, where water purification, coastal protection, climate regulation and life cycle maintenance are the most commonly CES assessed (Everard et al., 2010; Tomlinson et al., 2011). Subtidal areas, such as coralligenous habitats and seagrass meadows, are also well studied, mostly for their provision of habitat, spawning and nursery grounds for commercial fish species, for coastal protection from storms and erosion and for carbon storage (Bos et al., 2007; Harris et al., 2010; Hicks, 2011).

In the Mediterranean, data and methods to assess the provision of coastal ecosystem services are much more limited when compared to inland ones. However, according to Mangos et al. (2010), the Mediterranean Basin is able to deliver an immense richness to its inhabitants and visitors, economically translated into 26 billion € per year. This impressive figure arose from an economic valuation based on five CES (food production, recreation and tourism, climate regulation, disturbance regulation, and waste treatment) in five Mediterranean ecosystems (sea grass meadows, coralligenous habitats, hard substrate areas with photophilic algae, soft substrate areas, and the open sea). Regarding Mediterranean lagoons and estuaries, useful indications on the main CES supplied can be retrieved from a recent Pan-European review, which analysed 14 case studies, three of which in the Mediterranean, where CES were identified and their relative importance assessed (Lillebø et al., 2016). A wide range of CES was identified specifically for the Mediterranean sites, both in the provisioning (e.g.: wild animals and their outputs, animals from in situ aquaculture, fibres and other materials from plants, algae and animals, genetic materials from all biota, surface water, and ground water) and regulating categories (e.g. bioremediation and filtration/sequestration/storage by micro-organisms, algae, plants, animals, control of erosion rates, flood protection, maintaining nursery populations and habitats, pest control, decomposition and fixing processes, and global climate regulation by reduction of greenhouse gas concentrations). Little quantitative information exists to date for the CES capacity of Mediterranean coastal dunes. Studies focussed mainly on carbon storage potential and habitat provision of dunes along the Adriatic Sea coastline (Drius et al., 2016). A comprehensive review on coastal dunes at European level (Everard et al., 2010) provides a large list of CES supplied by dunes, including sand extraction, climate and water regulation, storm protection, water purification and waste treatment, habitat provision, and recreation.

Cultural CES remain less explored than the other CES categories (Rodrigues, 2015) and somehow more difficult to address (Drakou et al., 2017): beaches, intertidal mudflats, and dunes are the best assessed coastal habitats as regards their importance in providing opportunities for recreation and leisure (de Oliveira and Berkes, 2014; Everard et al., 2010; Garcia Rodrigues et al., 2017). Investigations on cultural CES evidence their links with ecological integrity and, in particular, the positive effect of biodiversity, which sustains a larger number of recreational activities (Chung et al., 2015) and represents a determining factor for diving locations (Ruiz-Frau et al., 2013). Coastal communities have always shown strong bonds to the sea due to the local identity and natural and cultural sites, linked to traditions and religion, which are numerous in the coastal zone. Both coastal and inland societies value the existence and beauty of charismatic habitats and species such as coralligenous habitats or marine mammals. Moreover, the appeal of coastal ecosystems is usually linked to wilderness, sports, or iconic landscapes and species.

Recreation and tourism are clumped together and generally included in the cultural ES (e.g. de Groot et al., 2010; MEA, 2005), among the benefits gained by humans from interactions with nature, since they supply the society with crucial values, such as physical exercise, aesthetic experiences, intellectual stimulation, inspiration, and other contributions to physical and psychological well-being (Daniel et al., 2012). Sometimes their role is even overemphasised, being considered as the chief representative of the cultural ES (Milcu et al., 2013). In practical terms it is difficult to disentangle touristic from local recreation outdoor activities, even though they have distinct economic consequences in terms of spatial (i.e. tourists tend to gather in better known areas and facilities) and expenditure patterns (i.e. tourists make a greatest use of accommodation and transport).

Some authors claim that tourism should be instead considered among the provisioning services (Abson and Termansen, 2011), in particular when a strict economic dependence on this service for the communities exists (Daw et al., 2011; Rounsevell et al., 2010). Others (Kumar, 2010; de Groot et al., 2013) criticize the inclusion of tourism as a cultural service, since it should not be considered as a service, but rather as an outcome. Whatever the view, tourism is anyway based on the resource dependencies across the full range of ES, representing a driver of their change, both in a positive and negative way (Church et al., 2017). On the one hand, certain forms of tourism, such as ecotourism, are tightly connected with the values people assign to the natural resources and may influence positively the way ecosystems are maintained and managed. On the other hand, mass tourism may represent a threat for coastal ecosystems, leading to the degradation of the terrestrial and marine environment and of their ability to support all the service categories (Church et al., 2017).

Cultural CES can generate synergies and trade-offs among them and with other ES categories. Focusing on recreation and tourism, such CES is considered in synergies with aesthetic and cultural heritage, while it trades off in particular with the CES habitat/refugia, with some kind of food production (e.g. in situ aquaculture), and with energy production (Garcia Rodrigues et al., 2017).

3.2. Main Mediterranean coastal recreational activities

Twenty-one coastal recreational activities were identified for the Mediterranean area (Table 3). Overall they belong to the five detected CT typologies, although some activities are more related to certain typologies than others (see Section 2.3 and Fig. 2).

The analysis based on the CO-EVOLVE partners' survey showed that swimming and sun bathing are the most relevant coastal recreational activities in all countries. The French and Croatian partners assigned a higher importance score to sports like sailing, kayaking and walking compared to the other partners. On the other hand, little or medium importance was assigned to more nature-related activities, such as observation of animals (insects and birds) or plants and snorkelling and to the utilization of natural resources. Italy, France and Greece regarded the use of molluscs/crustaceans very important. In general, low importance was assigned to plants if compared to animals (birds). All partners but Spain considered relaxation very relevant. Croatia was the only country acknowledging the high relevance of quietness. Lastly, activities such as scientific and dissemination initiatives were regarded as of relatively scarce relevance.

The results stress that relaxation is a very relevant benefit provided by coastal ecosystems. Relaxation is beneficial in particular to those individuals coming or normally living in an urban context, where daily stress and loss of identity are more likely to occur (Daniel et al., 2012). Moreover, since in most people's mind coastal systems are associated to great natural sceneries and a deep sense of wellness, recreational activities like nautical sports or nature observation may play a relevant role in connecting people with nature, reducing alienation from the ecosystems and the resources they provide. Coastal ecosystems are highly correlated with restorative experiences and positive emotions (Ashbullby et al., 2013; White et al., 2010, 2013; Willis, 2015), and they provide inspiration for arts, material for ecological research and education, information and awareness (Liquete et al., 2013). According to our results, dissemination and scientific activities were considered of much lower importance, compared to the other identified activities, showing that the educational value of coastal ecosystems shall be further acknowledged.

Table 3
Main coastal recreational activities in the Mediterranean Basin, and their relative importance per country. Activities' importance was assessed based on CO-EVOLVE partners' expertise. Symbols: white - low importance; pale green - medium importance; green - high importance.

Recreational activities	Italy	France	Croatia	Spain	Greece
Observe birds					
Observe fish and cetaceans					
Observe scenery					
Observe other animals/insects					
Observe plants					
Swimming					
Sun bathing					
Cycling					
Running					
Dog walking					
Walking					
Snorkelling, scuba diving					
Angling, spearfishing					
Nautical sports (sailing, water-skiing, kayaking)					
Ornamental use of plants (e.g. *Limonium* spp.)					
Use of birds (hunting included)					
Use of molluscs/crustaceans					
Quietness (for example through natural sounds)					
Relaxation					
Scientific activities					
Dissemination activities (e.g. nature guided tours, exhibitions in visitor centres)					

3.3. Threats from and to coastal tourism in the Mediterranean

The integrated classification of CO-EVOLVE threats includes nine categories, which have the advantage to integrate the main impacts and pressures from and to CT in a single combined framework (Table 4). The list of CO-EVOLVE threats includes well-established pressures such as solid waste and water pollution and emerging ones such as light pollution. Three new threat categories are added, in comparison to Davies and Cahill's (2000) scheme: alien species, noise pollution and light pollution. While threats from tourism are well documented (Bellan and Bellan-Santini, 2001; Davenport and Davenport, 2006; Hall, 2001; Piante and Ody, 2015; Plan Bleu, 2016), information on negative feedbacks effect to tourism itself are mainly qualitative and have been mostly extrapolated from socio-economic and management studies (e.g. Balance et al., 2000; Keeler et al., 2012).

Solid waste production (which includes above all plastics items and debris), air and water pollution, mass consumption of resources and energy (mostly due to accommodation), and onsite activities and transportation are all threats generated by tourism (Pan Bleu, 2016). In the Mediterranean, tourism and in particular beach tourism and cruising are considered to be predominant sources of land-based litter (e.g. Cappato, 2011; EU Report, 2011; Ivar do Sul et al., 2011). A study conducted on 13 beaches in the Mediterranean Sea found that the quantity of litter on a beach is inversely related to its geographical distance to a population centre and directly related to the number of visitors (Gabrielides et al., 1991). Urban tourism can also significantly contribute to total waste, to the extent that the amount of municipal waste can be used as a proxy to calculate seasonal tourism trend in towns (Mateu, 2003). Moreover, marine litter from tourism and non-touristic activities can spread very easily to other coastal destinations, leading to aesthetic deterioration. Natural resources overuse is a major threat for the Mediterranean coasts, especially considering water scarcity in combination with the projected effects of climate change. Water use by coastal resorts for swimming pools, laundry, golf courses, showers, gardens, toilets and kitchens can be excessive, putting at risk the vitality of a destination in the long term (Honey and Krantz, 2007). Several activities related to CT (particularly linked to cruising and to a lesser extent to beach, recreational boating and urban tourism) can

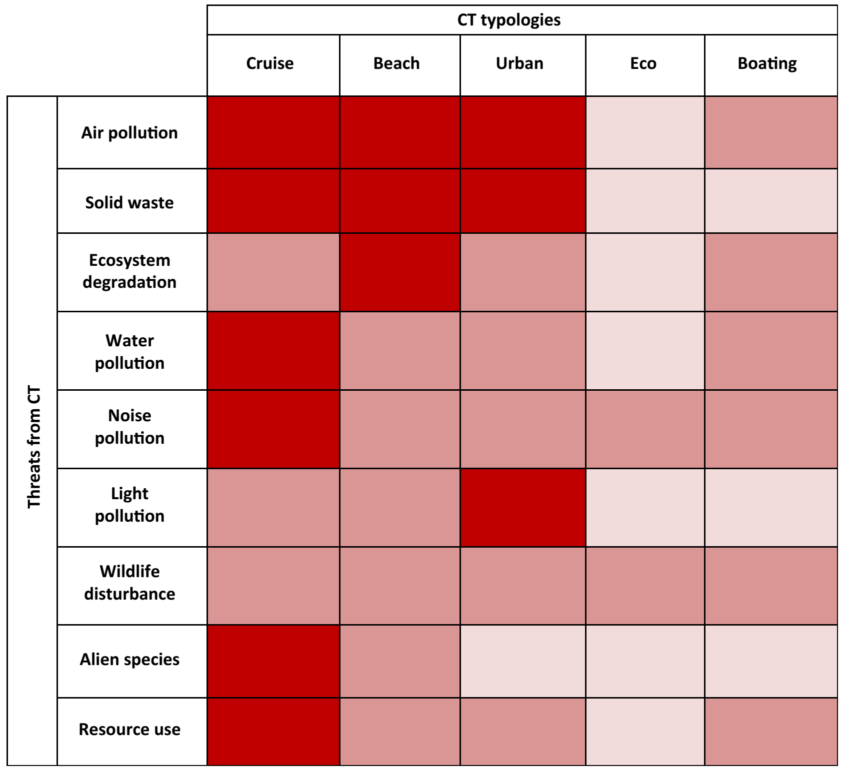
Table 4
Comparison among environmental pressures (MSFD), impacts from CT according to Davies and Cahill (2000), and CO-EVOLVE threats. Examples of CO-EVOLVE threats and of their negative feedback effects to CT are provided.

MSFD pressures	Impacts from CT	CO-EVOLVE threats	Examples of CO-EVOLVE threats	Examples of negative feedbacks to CT
Input of litter (solid waste, including micro-sized litter)	Waste pollution	Solid waste	Marine debris produced by crowded beaches can directly damage the coastal flora and fauna and change the structure of the seabed.	Destinations hosting polluted habitats lose attractiveness, especially for ecotourism.
Input of nutrients (fertilisers and other nitrogen and phosphorus-rich substances) Input of synthetic and non-synthetic substances and compounds	Water pollution	Water pollution	Pressure on existing sewage treatment plants can lead to overflows during peak tourist season. During peak usage (summer) significantly high faecal coliform counts tend to be found in waters with high recreational boating activity.	Seaside resorts whose water bathing quality decreases are no longer competitive
	Air pollution	Air pollution	Gas emission due to leisure travels by cars and planes.	Breathing problems, nuisance, loss of attractiveness, climate instability.
	Resource use	Resource use	Excessive water comsumption in touristic structures relevant in regions facing water scarcity.	Destinations affected by water scarcity cannot thrive in the long term.
Physical disturbance to seabed, change of seabed substrate or morphology, extraction of material	Habitat/Ecosystem alteration and fragmentation	Ecosystem degradation and fragmentation	Land cover changes due to touristic infrastructure development. Recreational boating can cause damage to marine habitats such as seagrass beds through propellers or by dragging anchors over the seafloor. Littering and trampling on seabed.	Destinations hosting degraded habitats lose attractiveness.
Extraction of, or mortality/injury, to wild species (by recreational fishing and other human activities) Disturbance of species (e.g. where they breed, rest, and feed)	Impacts on wildlife	Wildlife disturbance and exploitation	Recreational spearfishing and fauna and flora collection reduce population size and its vitality and they influence wildlife behavioural patterns and fitness.	Destinations whose economy is based on seafood resources can't sustain demand in the long term.
Input or spread of non-indigenous species		Alien species	Release of non-native species through discharge of ballast water by cruise ships can alter communities and coastal food webs.	Alien species can clog water treatment facilities, compromising bathing in coastal waters.
Input of anthropogenic sound		Noise pollution	The noise made by boat engines and propellers interferes with sea mammals communication systems.	Popular ecotouristic activities such as whale watching are negatively affected.
Input of other form of energy (light, electromagnetic fields, and heat)		Light pollution	Artificial light from coastal touristic infrastructures alters wildlife reproduction and nesting (e.g. sea turtles).	Wildlife observation spots lose value; view of the Milky Way loses attractiveness.

significantly contribute to water pollution through introduction of wastewater nutrients, faecal pathogens, oils and antifouling. Keeler et al. (2012) interlinked changes in water quality (water clarity, fish abundance, noxious algal blooms and the like) to change in the providing cultural ES (including several recreational activities, like bathing, swimming, angling and nature viewing) and associated these to changes in values of such activities (e.g. diminished recreational opportunities).

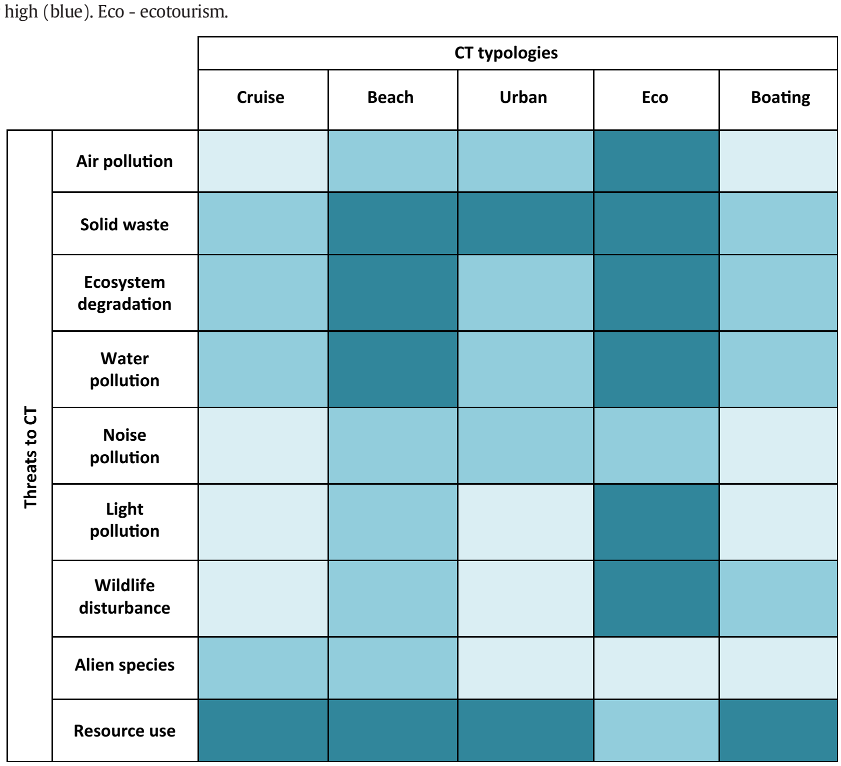
The impact level of each threat generated by CT (Table 5) suggested that some of the CT typologies are more impacting than others on the coastal ecosystems. However, it is worth noting that the availability of reliable information on the five CT typologies was uneven, with cruise tourism on the top list as to data availability (Cappato, 2011 and literature therein). On the bottom list, we could place urban tourism, for which few studies dealing with its environmental impact could be found (Ashworth and Page, 2011; Lloret et al., 2008). Such discrepancy must be accounted for while ranking the five CT typologies in terms of environmental impact. Overall, cruising, an increasing touristic activity in the Mediterranean (MedCruise Association, 2014; Perseus, 2013), turned out to be the most impacting CT typology, followed by beach and urban tourism. On the other hand, ecotourism has the lowest environmental impact. Cruise, beach, and urban tourism resulted the most responsible for air and water pollution and solid waste in comparison to recreational boating and ecotourism, although recreational boating could be as damaging as cruising if considering small spatial scale (e.g. Albanis et al., 2002; Diez et al., 2002). Previous studies have suggested that vessels have the potential to affect air quality in coastal regions and in ports, with air sulphur emission equal or exceeding land based emission (Capaldo et al., 1999). Especially during summer time, also urban and beach tourism may contribute to peaks of air pollution due to intense transports to reach such destinations. All CT typologies but ecotourism generate water pollution due to the release of sewage discharge (faecal contamination), detergents, antifouling paintings, and leakage of oil from engines. Such discharges are often illegal and they can occur in pristine areas (Davenport and Davenport, 2006). Eutrophication can also be a direct consequence of CT: poor run-off control during touristic infrastructure construction and afterwards can lead to high sediment concentrations and nitrification in seagrass beds and in coralligenous habitats (Honey and Krantz, 2007). Light pollution can be assumed to be mainly a consequence of urban tourism, followed by beach tourism and cruising (mainly artificial lighting of coastlines, tourist resorts, marinas, and cruise ships, see e.g. Davies et al., 2014; Kyba et al., 2011). Although the best-known impact of artificial light is the disorientation experienced by sea turtles hatchlings (Chepesiuk, 2009; Lutcavage et al., 2017; Witherington and Martin, 2000), light pollution effects are still not adequately studied, especially on marine habitats (Davies et al., 2014 and literature therein) and in particular in relation to touristic activities. However, a new form of ecotourism, the “dark sky nature tourism” is on the rise, proving an interest for the issue (Smith, 2008). All CT typologies but cruising and recreational boating have medium environmental impact in terms of noise pollution. Cruise ships and recreational boats have a high one (Racko et al., 2013): underwater noise, in fact, has proven to interfere with sea mammals' means of communication (e.g. ACCOBAMS, 2016; Erbe, 2002). Alien species are another kind of threat for which data collection is still far from being complete. Since there is enough evidence on the heavy role played by cruise vessels in transferring invasive organisms, the highest impact can be assigned to cruise tourism, and to activities linked to ecotourism and recreational boating (boat anchors, SCUBA equipment, ballast and bilge water, and fouled hulls; Anderson et al., 2015 and literature

Table 5
Ranking, based on literature review, of the five CT typologies according to the CO-EVOLVE threats from CT. The level of concern of each threat produced by each CT is ranked as low (light pink), medium (dark pink) or high (red). Eco - ecotourism.



therein), while beach tourism is likely responsible for weakening resistance to invasions through ecosystem degradation and fragmentation (e.g. Stachowicz et al., 2002). Wildlife can be disturbed by all CT typologies at medium level. Ecotourism boats for instance have proved to interfere with cetaceans' behaviour (Blane and Jaakson, 1994), while beach tourism, recreational boating and cruise tourism have largely

Table 6
Ranking, based on literature review, of the five CT typologies according to the CO-EVOLVE threats to CT. The level of concern of each threat impinging on each CT typology is ranked as low (light blue), medium (turquoise) or high (blue). Eco - ecotourism.



contributed to the decline of endangered species such as the monk seal *Monachus monachus* through disturbance and habitat deterioration (Johnson and Lavigne, 1999).

The ranking on the level of concern of CO-EVOLVE threats towards CT (Table 6) showed that solid waste, ecosystem fragmentation and degradation and water pollution are the ones most affecting CT typologies (in particular beach and ecotourism). Impacts here should be considered as those affecting benefits and development of the coastal tourism industry, for instance by decreasing landscape attractiveness for tourists (in terms of perception of naturalness and cleanliness of beaches and dunes) and by compromising their wellness perception (examples are disgraceful odours and difficulties in breathing). The analysis showed also that some CO-EVOLVE threats mainly target specific CT typologies. For instance, light pollution targets in particular ecotourists interested in observing nocturnal fauna (Longcore and Rich, 2004), whereas water pollution and ecosystem degradation and fragmentation affect mainly ecotourism and beach tourism (Pendleton et al., 2001), by compromising both recreational (bathing, snorkelling, walking on beaches and sand dunes) and non-material activities, like observation of natural scenery, sense of identity and inspiration.

3.4. Geospatial analysis of multiple threats to and from coastal tourism: a case study

Fig. 4a illustrates cumulative pressures from human activities on beach tourism. The areas with the highest pressure are located in the proximity of (i) municipalities that experience high level of urbanization, such as Muggia (CP = 6.5), Trieste (CP = 4.0) and Ravenna (CP = 5.6), of (ii) coastal municipalities influenced by transitional water (in front of Venice lagoon), and of (iii) those influenced by fluvial discharge such as the Adige River and in the south of the Po River outlet, like Codigoro (CP = 4.3). In terms of threats to tourism, potentially very highly affected coastal municipalities are located in Emilia-Romagna (e.g. Rimini, Cervia) and Veneto Region (Jesolo).

In Fig. 4b results for the CP from recreational boating illustrate that coastal areas at highest CP (3.6) are located in the Gulf of Trieste and in the proximity of Venice Lagoon outlets (CP = 3.8). In contrast, coastal areas of Emilia-Romagna region show lower pressures from recreational boating. Coastal municipalities subjected to the highest threat from recreational boating are located in Veneto (Jesolo, Cavallino-Treporti and S. Michele al Tagliamento) and Friuli-Venezia Giulia (Duino-Aurisina, Monfalcone, and Lignano Sabbiadoro).

The case study illustrates the flexibility of the proposed modelling approach in taking into account the tourism threat analysis in the frame of the TEO loop. The integrated analysis of CT threats is particularly relevant for coastal planning, as it takes into consideration how co-existing CT typologies (in the case study beach tourism and recreational boating) may negatively interact among each other, by generating threats such as, for instance, waste production (e.g. nutrient load, marine litter) and water pollution (e.g. introduction of synthetic and non-synthetic compounds). These threats impair coastal ecosystems and their services, with negative effects for the development of both CT typologies. Similarly, proximity of recreational boating facilities and boats density along coastal areas have relevant effects on the distribution of pressures and ultimately on the recreational value of beach tourism. Moreover, the results produced in the tested case study can be relevant to assess coastal areas that require highest management priority, due to the presence of intensive human activities. A better

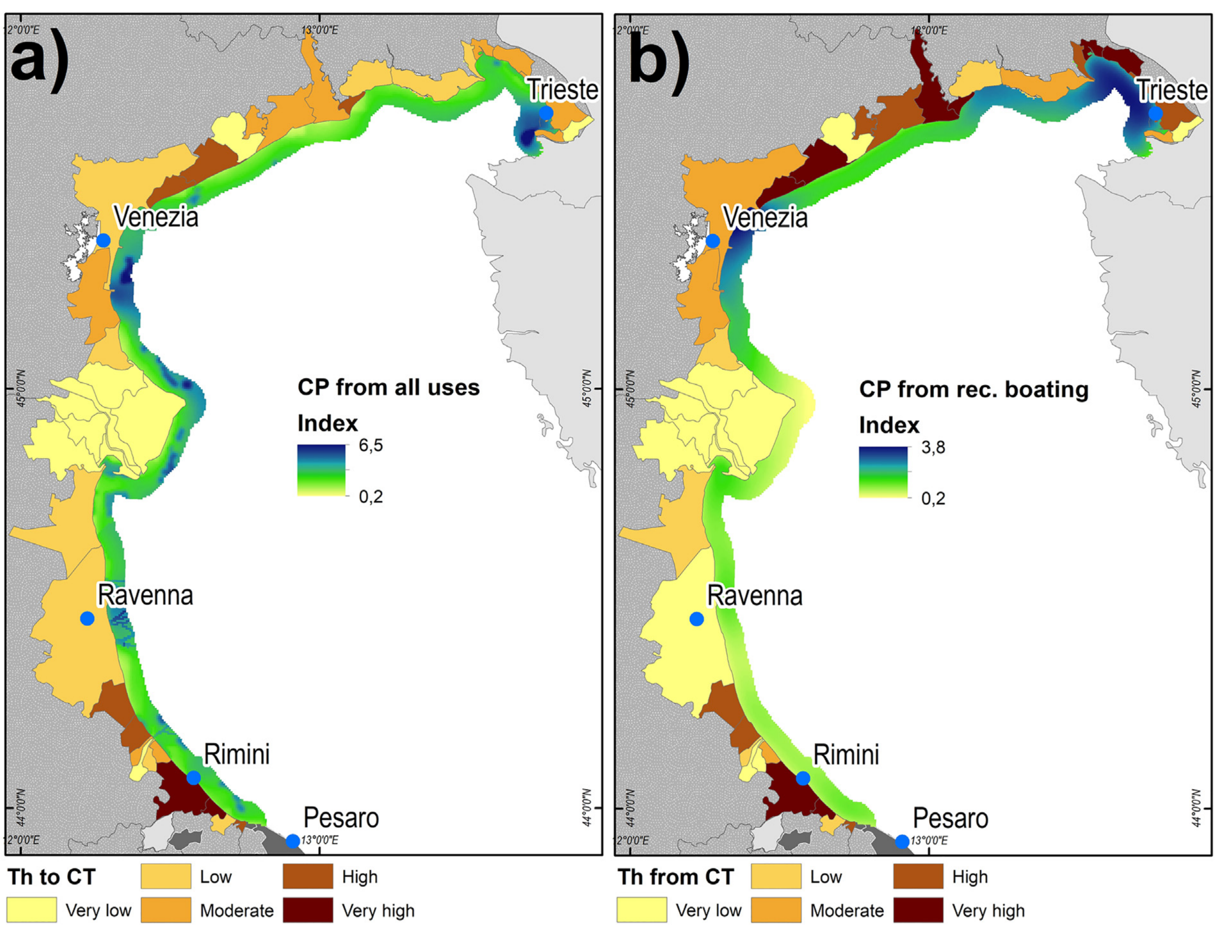


Fig. 4. a) Threats to tourism: CP from all activities on coastal areas and threats to touristic (Th to CT) coastal municipalities; b) Threats from tourism to tourism: CP scores generated by recreational boating and threats from tourism (Th from CT) on coastal municipalities (beach tourism).

prioritization of management actions requires further knowledge on the type of touristic activities in coastal municipalities, and the available infrastructure (e.g. number of beaches, overnight stay facilities, etc.) ideally supported by field surveys on the socio-economic value of recreational areas, such as travel cost assessment (Depellegrin and Blažauskas, 2013) or contingency valuation methods (Jala and Nandagiri, 2015).

Although the presented model incorporates seven threats, additional pressures need to be considered in future applications. This includes visual impacts that can have considerable effect on coastal tourism (Depellegrin et al., 2014; Griffin et al., 2015) or light pollution effects on leisure relevant marine species such as turtles (Kamrowski et al., 2012; Truscott et al., 2017). Model outputs also suggest the need of an integrated management of the coastal area, taking into account human activities that may generate potential pressure with long distance effects (e.g. synthetic compounds or marine litter; Kenny et al., 2017).

3.5. From coastal tourism to coastal tourism: an ecosystem service perspective

The abovementioned complex trade-offs between threats generated from and directed to CT, and the implications for CT development are schematized in Fig. 5. The diagram represents an in-depth visual analysis of the TEO loop, where each component is further expanded based on the study outcomes. By means of multiple connecting arrows, the diagram shows (i) how CT and the other HA impinge on CES through CO-EVOLVE threats; (ii) how CO-EVOLVE threats affect CES impairment; and (iii) how such reduction in CES supply affects the development of CT. The effects generated by the other HA on coastal activities are not highlighted in the diagram, to enhance its readability. The CT loop is represented through thin red arrows, which flow from the CT industry through CO-EVOLVE threats and CES, till the negative effects for CT development. A thick red arrow reconnects the negative effects generated by the reduction in CES supply to the CT industry, closing the loop. Going into details, CO-EVOLVE threats produce a flow of impacts that impinge on the supply of CES, particularly on regulating (turquoise boxes) and provisioning (blue boxes) CES. The multiple effects produced by the impairment of the CES have a cascade negative effect on several aspects that determine CT success: bathing water quality, water supply, food availability, air quality, landscape integrity, climatic stability, coastal protection, and the perception of biodiversity value. A deterioration in these aspects generates a decrease in the value of coastal recreational activities (brown box), which in turn depend on cultural CES integrity (highlighted in purple). However, as the diagram clearly shows, coastal recreational activities lose value due to the impairment of cultural, regulating and provisioning CES.

It's also worth noting that while each threat targets a specific CES, reducing its supply, the generated cumulative negative effects from the CO-EVOLVE threats impinge on several aspects crucial for the CT industry, such as bathing water quality, coastal protection, perception of biodiversity value, seafood availability and so on. An example can better clarify such complex flow. The CT cruise industry pollutes the coastal waters of a beach resort; water pollution (CO-EVOLVE threat) negatively affects coastal water nutrient cycling (regulating CES), fact that, in the long term, provokes a decrease in bathing water quality in the

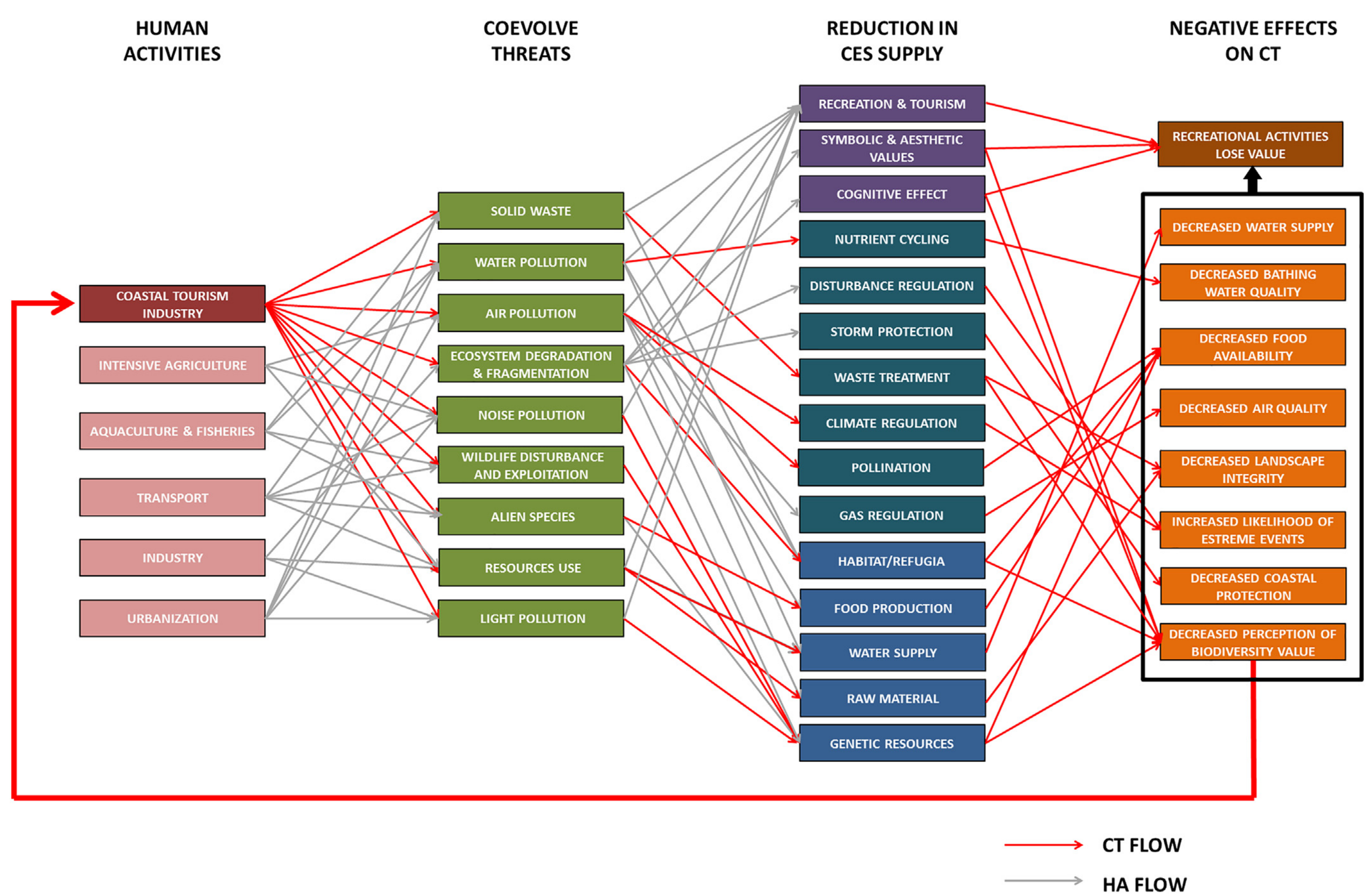


Fig. 5. Expanded TEO loop conceptual framework, highlighting the implications of the threats from and to CT for CT development. Thin red arrows indicate the negative effects generated by CT and its threats to CES and thus to recreational activities. Thin grey arrows represent the negative effects pathways generated by the other HA. CES categories are evidenced with different colours: purple (cultural), turquoise (regulation and maintenance), and blue (provisioning). The black frame indicates the dependence of the recreational activities on a set of negative effects (orange boxes) produced by a reduced supply in CES. The thick red arrow at the bottom of the diagram shows the effects of the impairment in CT assets for the development of CT industry. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

resort (negative effect on CT). Indeed, a satisfactory bathing water quality is crucial for most of coastal recreational activities, such as swimming, snorkelling, spearfishing, and nautical sports. Therefore, a coastal resort whose bathing water quality is poor is likely to lose attractiveness and ultimately to decline.

Although the focus of the expanded conceptual framework is on CT, the other HA generate a flow as well, represented in Fig. 5 through thin grey arrows. Threats from HA have themselves multiple effects on all CES, and eventually on recreational activities that are the core element for CT development. For instance, intensive agriculture can generate the threat "water pollution", whose negative effects range from decreased seafood production (provisioning CES) to reduced integrity of coastal habitats (provisioning CES), eventually lowering the value of recreation and tourism (cultural CES). Therefore, not only tourism itself but also other HA can damage the CT industry. Negative feedback effects for tourism development can be primarily tracked through the loss of cultural benefits such as leisure, relaxation, inspiration, wellness, and aesthetic attractiveness, but also through the loss of provisioning and regulating CES (for example climate regulation and coastal protection).

The expanded framework depicted in Fig. 5 emphasizes the role of CES as central pillar to guarantee the survival of CT and to guide the management of conflicts among HA in the long term. Among CES, cultural ones are of outmost importance in this process, as the contribution to human well-being coming from the interactions, at different level, with nature represents the main link with the non-material benefits of cultural CES and it highlights the need of a holistic sustainable management, which should consider the ways in which nature impacts on humans as much as how humans impact on nature (Willis, 2015).

4. Conclusions

This study provides an original conceptual framework, which was conceived in the context of the cascade models, whose main purpose is, on one hand, to link the benefits arising from ES with their effects on human well-being, and, on the other hand, to show how human activities may negatively influence ES capacity to deliver further services (Haines-Young and Potschin, 2010). In particular, our framework aimed at characterizing CES, CT and the other HA in the Mediterranean, and at disentangling the complex interactions among these three components. Threats from CT and to CT are based on a newly proposed classification, which integrates the main impacts and pressures from CT in a single combined framework, and proposes novel threat categories like for instance light pollution. Such classification can be applied to other coastal areas of European Seas. Cumulative threats models supported by the conceptual framework and applied to beach tourism and recreational boating offered a tool to address trade-offs between CT and the other HA. This tool proved valuable in supporting the identification of areas at highest trade-off to beach tourism, and effective in conveying coastal management and planning information to decision-makers and authorities at different administrative levels (regional and local). In future the conceptual framework can be further coupled with socioeconomic indicators, to better understand the value of the coastal resource for recreation. In this frame, MSP and ICZM can play an essential role in promoting sustainable development of CT, by creating synergies with other coastal and maritime activities.

This study contributed to a better definition of the components in need of attention while addressing coastal sustainability, and also provided a concrete test whose methodology and results are transferrable to other touristic coastal regions. In order to enable CT to contribute in a positive manner to socioeconomic well-being and even to be a positive force for nature conservation, pathways to sustainability need to require a secure supply of all CES. The study embraces such vision, by mainstreaming CES as central component of the conceptual framework.

Acknowledgements

This study was co-financed by the Interreg MED Programme 2014-2020, modular project CO-EVOLVE (1MED15_3.1_M12_277).

Appendix A

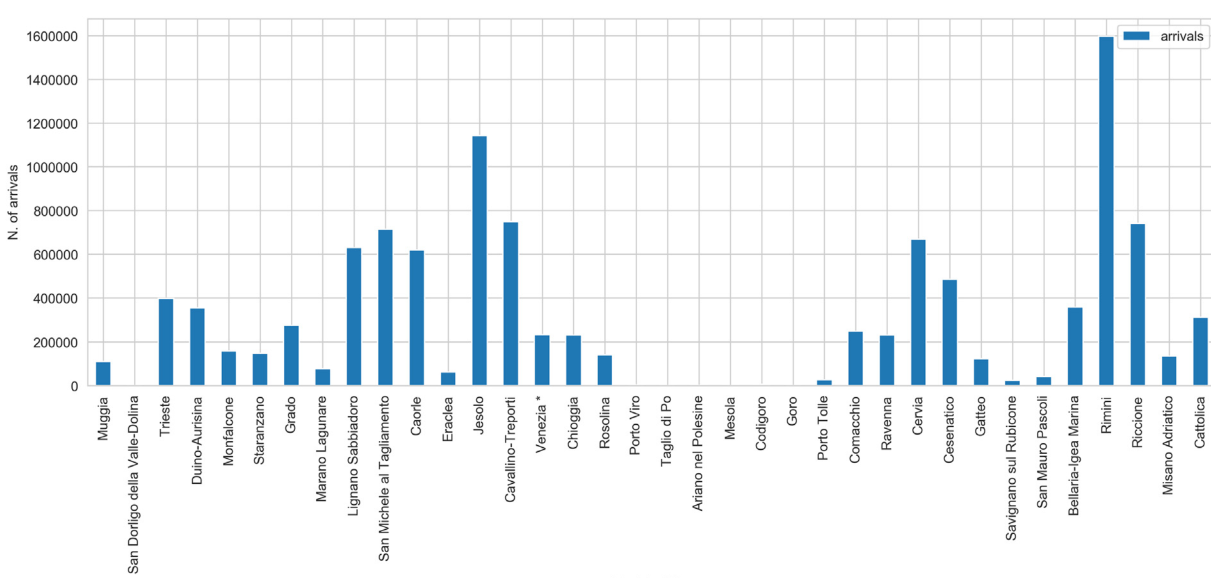


Fig. A1. Arrivals by coastal municipality of the Italian Northern Adriatic Sea. Datasets for arrivals refer to 2017 (Veneto Region; Turismo Venezia, 2018), 2016 (Emilia-Romagna Region) and 2015 (Friuli-Venezia Giulia Region). *Refers only to the arrivals recorded in Lido of Venice.

References

Abson, D.J., Termansen, M., 2011. Valuing ecosystem services in terms of ecological risks and returns. Conserv. Biol. 25 (2), 250–258. https://doi.org/10.1111/j.1523-1739.2010.01623.

ACCOBAMS, 2016. Overview of the Noise Hotspots in the ACCOBAMS Area. Part I – Mediterranean Sea. Final Report by Maglio A., Pavan G., Castellote M., Frey S.

Albanis, T.A., Lambropoulou, D.A., Sakkas, V.A., Konstantinou, I.K., 2002. Antifouling paint booster biocide contamination in Greek marine sediments. Chemosphere 48 (5), 475–485.

Anderson, L.G., Rocliffe, S., Haddaway, N.R., Dunn, A.M., 2015. The role of tourism and recreation in the spread of non-native species: a systematic review and meta-analysis. PLoS ONE 10 (10), e0140833. https://doi.org/10.1371/journal.pone.0140833.

Arkema, K.K., Verutes, G.M., Wood, S.A., Clarke-Samuels, C., Rosado, S., Canto, M., et al., 2015. Embedding ecosystem services in coastal planning leads to better outcomes for people and nature. Proc. Natl. Acad. Sci. U. S. A. 112, 7390–7395.

Ashbullby, K.J., Pahl, S., Webley, P., White, M.P., 2013. The beach as a setting for families' health promotion: a qualitative study with parents and children living in coastal regions in Southwest England. Health Place 23, 138–147. https://doi.org/10.1016/j.healthplace.2013.06.005.

Ashworth, G., Page, S.J., 2011. Urban tourism research: recent progress and current paradoxes. Tour. Manag. 32 (1), 1–15.

Balance, A., Ryan, P., Turpie, J.K., 2000. How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa. S. Afr. J. Sci. 96, 210–213.

Barbanti, A., Sarretta, A., Venier, C., Bellacicco, S., Depellegrin, D., Farella, G., Menegon, S., Lorito, S., Grati, F., Bolognini, L., Perini, L., 2017. Sviluppo ed analisi di proposte di ICZM-MSP in aree specifiche: costa emiliano-romagnola. Zenodo (Volume 1: https://doi.org/10.5281/zenodo.1116737, Volume 2: https://doi.org/10.5281/zenodo.1116740).

Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C., Silliman, B.R., 2011. The value of estuarine and coastal ecosystem services. Ecol. Monogr. 81 (2), 169–193.

Bellan, G.L., Bellan-Santini, D.R., 2001. A review of littoral tourism, sport and leisure activities: consequences on marine flora and fauna. Aquat. Conserv. Mar. Freshwat. Ecosyst. 11 (4), 325–333.

Bianchi, C.N., 2007. Biodiversity issues for the forthcoming tropical Mediterranean Sea. Hydrobiologia 580, 7–21. https://doi.org/10.1007/s10750-006-0469-5.

Bianchi, C.N., Morri, C., 2000. Marine biodiversity of the Mediterranean Sea: situation, problems and prospects for future research. Mar. Pollut. Bull. 40 (5), 367-337.

Blane, J.M., Jaakson, R., 1994. The impact of ecotourism boats on the St Lawrence beluga whales. Environ. Conserv. 21 (3), 267–269.

Böhnke-Henrichs, A., Baulcomb, C., Koss, R., Salman Hussain, S.S., de Groot, R.S., 2013. Typology and indicators of ecosystem services for marine spatial planning and management. J. Environ. Manag. 130, 135–145.

Bos, A.R., Bouma, T.J., De Kort, G.L.J., Van Katwijk, M.M., 2007. Ecosystem engineering by annual intertidal seagrass beds: sediment accretion and modification. Estuar. Coast. Shelf Sci. 74, 344–348.

Burke, L., Kura, Y., Kasem, K., Revenga, C., Spalding, M., McAllister, D., 2001. Coastal Ecosystems. World Resources Institute, Washington DC.

Capaldo, K., Corbett, J.J., Kasibhatla, P., Fischbeck, P., Pandis, S.N., 1999. Effects of ship emissions on sulphur cycling and radiative climate forcing over the ocean. Nature 400, 743–746.

Cappato, A., 2011. Cruises and Recreational Boating in the Mediterranean. Pan Bleu UNEP/MAP Regional Activity Center.

Chan, K.M.A., Guerry, A.D., Balvanera, P., Klain, S., Satterfield, T., Bostrom, A., et al., 2012. Where are cultural and social in ecosystem services? A framework for constructive engagement. Bioscience 62 (8), 744–756. https://doi.org/10.1525/bio.2012.62.8.7.

Chepesiuk, R., 2009. Missing the dark: health effects of light pollution. Environ. Health Perspect. 117 (1), A20–A27. https://doi.org/10.1289/ehp.117-a20.

Chung, M.G., Kang, H., Choi, S.-U., 2015. Assessment of coastal ecosystem services for conservation strategies in South Korea. PLoS ONE 10 (7), e0133856. https://doi.org/10.1371/journal.pone.0133856.

Church, A., Coles, T., Fish, R., 2017. Tourism in sub-global assessments of ecosystem services. J. Sustain. Tour. 25 (11), 1529–1546. https://doi.org/10.1080/09669582.2017.1291649.

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Ben Rais Lasram, F., et al., 2010. The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. PLoS ONE 5 (8), e11842. https://doi.org/10.1371/journal.pone.0011842.

Coll, M., Piroddi, C., Albouy, C., Ben Rais Lasram, F., Cheung, W.W., Christensen, V., Palomares, M.L., Steenbeek, J., Trujillo, P., Watson, R., Pauly, D., 2012. The Mediterranean Sea under siege: spatial overlap between marine biodiversity, cumulative threats and marine reserves. Glob. Ecol. Biogeogr. 21 (4), 465–480.

Costello, M.J., Coll, M., Danovaro, R., Halpin, P., Ojaveer, H., Miloslavich, P., 2010. A census of marine biodiversity knowledge, resources, and future challenges. PLoS One 5 (8), e12110.

Daniel, T.C., Muhar, A., Arnberger, A., Aznar, O., Boyd, J.W., Chan, K.M., Grêt-Regamey, A., 2012. Contributions of cultural services to the ecosystem services agenda. Proc. Natl. Acad. Sci. 109 (23), 8812–8819.

Davenport, J., Davenport, J.L., 2006. The impact of tourism and personal leisure transport on coastal environments: a review. Estuar. Coast. Shelf Sci. 67, 280–292. https://doi.org/10.1016/j.ecss.2005.11.026.

Davies, T., Cahill, S., 2000. Environmental Implications of the Tourism Industry. Discussion Paper 00-14.

Davies, T.V., Duffy, J.P., Bennie, J., Gaston, K.J., 2014. The nature, extent, and ecological implications of marine light pollution. Front. Ecol. Environ. 12 (6), 347–355.

Daw, T., Brown, K., Rosendo, S., Pomeroy, R., 2011. Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being. Environ. Conserv. 38, 370–379.

de Groot, R.S., Fisher, B., Christie, M., Aronson, J., Braat, L.C., Haines-Young, R., Gowdy, J., Maltby, E., Neuville, A., Polasky, S., Portela, R., Ring, I., 2010. Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. In: Kumar, P. (Ed.), TEEB Foundations 2010. The Economics of Ecosystems and Biodiversity (TEEB): Ecological and Economic Foundations. Earthscan, London, pp. 9–40.

de Groot, R.S., Blignaut, J., Van Der Ploegs Aronson, J., Elmqvist, T., Farley, J., 2013. Benefits of investing in ecosystem restoration. Conserv. Biol. 27 (6), 1286–1293.

de Oliveira, L.E.C., Berkes, F., 2014. What value São Pedro's procession? Ecosystem services from local people's perceptions. Ecol. Econ. 107, 114–121. https://doi.org/10.1016/j.ecolecon.2014.08.008.

Depellegrin, D., Blažauskas, N., 2013. Integrating ecosystem service values into oil spill impact assessment. J. Coast. Res. 29 (4), 836–846.

Depellegrin, D., Blažauskas, N., Egarter Vigl, L., 2014. An integrated visual impact assessment model for offshore windfarm development. Ocean Coast. Manag. 98, 95–110.

Depellegrin, D., Menegon, S., Farella, G., Ghezzo, M., Gissi, E., Sarretta, A., Venier, C., Barbanti, A., 2017. Multi-objective spatial tools to inform maritime spatial planning in the Adriatic Sea. Sci. Total Environ. https://doi.org/10.1016/j.scitotenv.2017.07.264.

Diez, S., Abalos, M., Bayona, J.M., 2002. Organotin contamination in sediments from the western Mediterranean enclosures following 10 years of TBT regulation. Water Res. 36, 905–918.

Dobson, A., Lodge, D., Alder, J., Cumming, G.S., Keymer, J., McGlade, J., Mooney, H., Rusak, J.A., Sala, O., Wolters, V., Wall, D., Winfree, R., Xenopoulos, M.A., 2006. Habitat loss, trophic collapse, and the decline of ecosystem services. Ecology 87 (8), 1915–1924. https://doi.org/10.1890/0012-9658(2006)87[1915:HLTCAT]2.0.CO;2.

Drakou, E.G., Kermagoret, C., Liquete, C., et al., 2017. Marine and coastal ecosystem services on the science–policy–practice nexus: challenges and opportunities from 11 European case studies. Int. J. Biodivers. Sci. Ecosyst. Serv. Manag. 13 (3), 51–67.

Drius, M., Carranza, M.L., Stanisci, A., Jones, L., 2016. The role of Italian Natura 2000 coastal dunes as carbon sinks and diversity sources. A multi-service perspective. Appl. Geogr. 75, 127–136.

EC, 2002. Recommendation of the European Parliament and of the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe.

EC, 2008. Directive 2008/56/EC of the European Parliament of the Council of 17 June 2008 Establishing a Framework for Community Action in the Field of Marine Environmental Policy (Marine Strategy Framework Directive).

EC, 2017. Tourism Statistics at Regional Level. Web. http://ec.europa.eu/eurostat/statistics-explained/index.php/Tourism_statistics_at_regional_level, Accessed date: 15 July 2018.

Ecorys, 2013. Study in support of policy measures for maritime and coastal tourism at EU level. http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/study-maritime-and-coastal-tourism_en.pdf.

Erbe, C., 2002. Underwater noise of whale watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Mar. Mamm. Sci. 18 (29), 394–418.

EU Commission, 2017. Report on the Blue Growth Strategy. Towards more sustainable growth and jobs in the blue economy. Commission Staff Working Document on Blue Growth 2013–2016 https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/swd-2017-128_en.pdf, Accessed date: 5 May 2018.

EU Report, 2011. EU Science for Environment Policy|In-depth Reports|Plastic Waste: Ecological and Human Health Impacts November 2011.

Everard, M., Laurence, J., Watts, B., 2010. Have we neglected the societal importance of sand dunes? An ecosystem services perspective. Aquat. Conserv. Mar. Freshwat. Ecosyst. 20, 476–487.

Fish, R., Church, A., Winter, M., 2016. Conceptualising cultural ecosystem services: a novel framework for research and critical engagement. Ecosyst. Serv. 21, 208–217. https://doi.org/10.1016/j.ecoser.2016.09.002.

Gabrielides, G.P., Golik, A., Loizides, L., Marino, M.G., Bingel, F., Torregrossa, M.V., 1991. Man-made garbage pollution on the Mediterranean coastline. Mar. Pollut. Bull. 23, 437–441.

Garcia Rodrigues, J., Conides, A., Rivero Rodriguez, S., Raicevich, S., Pita, P., Kleisner, K., Pita, C., Lopes, P., Alonso Roldán, V., Ramos, S., Klaoudatos, D., Outeiro, L., Armstrong, C., Teneva, L., Stefanski, S., Böhnke-Henrichs, A., Kruse, M., Lillebø, A., Bennett, E., Belgrano, A., Murillas, A., Sousa Pinto, I., Burkhard, B., Villasante, S., 2017. Marine and coastal cultural ecosystem services: knowledge gaps and research priorities. One Ecosyst. 2, e12290. https://doi.org/10.3897/oneeco.2.e12290.

Ghermandi, A., Nunes, P.A.L.D, Portela, R., Nalini, R., Teelucksingh, S.S., 2010. Recreational, cultural and aesthetic services from estuarine and coastal ecosystems. FEEM Working Paper No. 121.2009 https://doi.org/10.2139/ssrn.1532803.

Griffin, R., Chaumont, N., Denu, D., Guerry, A., Choong-Ki, C.-K., Mary Ruckelshaus, M., 2015. Incorporating the visibility of coastal energy infrastructure into multi-criteria siting decisions. Mar. Policy 62, 218–223.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., Noble, I., 2013. Policy: sustainable development goals for people and planet. Nature 495, 305–307. https://doi.org/10.1038/495305a.

Haines-Young, R.H., Potschin, M.P., 2010. The links between biodiversity, ecosystem services and human well-being. In: Raffaelli, D.G., Frid, C.L.J. (Eds.), Ecosystem Ecology: A New Synthesis. Cambridge: BES Ecological Reviews Series. Cambridge University Press, pp. 110–139.

Haines-Young, R., Potschin, M., 2013. CICES V4.3-Report Prepared Following Consultation 440 on CICES Version 4, August–December 2012. EEA Framework Contract No. 441 EEA/IEA/09/003.

Hall, C.M., 2001. Trends in ocean and coastal tourism: the end of the last frontier? Ocean Coast. Manag. 44 (9–10), 601–618.

Halpern, B.S., McLeod, K.L., Rosenberg, A.A., Crowder, L.B., 2008. Managing for cumulative impacts in ecosystem-based management through ocean zoning. Ocean Coast. Manag. 51 (3), 203–211.

Harris, A., Manahira, G., Sheppard, A., Gough, C., Sheppard, C., 2010. Demise of Madagascar's once great barrier reef-change in coral reef condition over 40 years. Atoll Res. Bull. 1–16.

Hicks, C.C., 2011. How do we value our reefs? Risks and tradeoffs across scales in "biomass-based" economies. Coast. Manag. 39, 358–376. https://doi.org/10.1080/08920753.2011.589219.

Honey, M., Krantz, D., 2007. Global Trends in Coastal Tourism. Center on Ecotourism and Sustainable Development.

IPBES, 2012. Outcome of an Informal Expert Workshop on Main Issues Relating to the Development of a Conceptual Framework for the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Ivar do Sul, J.A., Santos, I.R., Friedrich, A.C., et al., 2011. Plastic pollution at a sea turtle conservation area in NE Brazil: contrasting developed and undeveloped beaches. Estuar. Coasts 34, 814–823.

Jala, A., Nandagiri, L., 2015. Evaluation of economic value of Pilikula Lake using travel cost and contingent valuation methods. International conference on water resources, coastal and ocean engineering (ICWRCOE 2015). Aquat. Procedia 4, 1315–1321.

Johnson, W.M., Lavigne, D.M., 1999. Mass tourism and the Mediterranean monk seal. The Monachus Guardian 2 (2).

Kamrowski, R.L., Limpus, C., Moloney, J., Hamann, M., 2012. Coastal light pollution and marine turtles: assessing the magnitude of the problem. Endanger. Species Res. 19, 85–98. https://doi.org/10.3354/esr00462.

Keeler, B.L., Polasky, S., Brauman, K.A., Johnson, K.A., Finlay, J.C., O'Neill, A., Kovacs, K., Dalzell, B., 2012. Linking water quality and well-being for improved assessment and valuation of ecosystem services. Proc. Natl. Acad. Sci. 109 (45), 18619–18624.

Kenny, M., Jenkins, A.J., Wood, C.D., Bolam, S.G., Mitchell, P., Scougal, C., Judd, A., 2017. Assessing cumulative human activities, pressures, and impacts on North Sea benthic habitats using a biological traits approach. ICES J. Mar. Sci. https://doi.org/10.1093/icesjms/fsx205.

Kumar, P., 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. The Economics of Ecosystems and Biodiversity (TEEB), United Nations Environment Programme, Geneva, Switzerland.

Kyba, C.C., Ruhtz, T., Fischer, J., Hölker, F., 2011. Cloud coverage acts as an amplifier for ecological light pollution in urban ecosystems. PLoS ONE 6 (3), e17307.

Lillebø, A.I., Somma, F., Norén, K., Gonçalves, J., Alves, M.F., Ballarini, E., Bentes, L., Bielecka, M., Chubarenk, B.V., Heise, S., Khokhlov, V., Klaoudatos, D., Lloret, J., Margonski, P., Marín, A., Matczak, M., Oen, A.M.P., Palmieri, M.G., Przedrzymirska, J., Różyński, G., Sousa, A.I., Sousa, L.P., Tuchkovenko, Y., Zaucha, J., 2016. Assessment of marine ecosystem services indicators: experiences and lessons learned from 14 European case studies. Integr. Environ. Assess. Manag. 12 (4), 726–734.

Liquete, C., Piroddi, C., Drakou, E.G., Gurney, L., Katsanevakis, S., Charef, A., Egoh, B., 2013. Current status and future prospects for the assessment of marine and coastal ecosystem services: a systematic review. PLoS One 8 (7), e67737.

Liu, J., Mooney, H., Hull, V., Davis, S.J., Gaskell, J., Hertel, T., Lubchenco, J., Seto, K.C., Gleick, P., Kremen, C., Li, S., 2015. Systems integration for global sustainability. Science 347 (6225), 1258832. https://doi.org/10.1126/science.1258832.

Lloret, J., Zaragoza, N., Caballero, D., Font, T., Casadevall, M., Riera, V., 2008. Spearfishing pressure on fish communities in rocky coastal habitats in a Mediterranean marine protected area. Fish. Res. 94, 84–91.

Longcore, T., Rich, C., 2004. Ecological light pollution. Front. Ecol. Environ. 2, 191–198. https://doi.org/10.1890/1540-9295(2004)002[0191:ELP]2.0.CO;2.

Lopes, P.F., Pacheco, S., Clauzet, M., Silvano, R.A., Begossi, A., 2015. Fisheries, tourism, and marine protected areas: conflicting or synergistic interactions? Ecosyst. Serv. 16, 333–340.

Lutcavage, M.E., Plotkin, P., Witherington, B., Lutz, P.L., 2017. 15 human impacts on sea turtle survival. The Biology of Sea Turtles. vol. 1, p. 45.

Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schägner, J.P., Grizzetti, B., Drakou, E.G., La Notte, A., Zulian, G., et al., 2012. Mapping ecosystem services for policy support and decision making in the European Union. Ecosyst. Serv. 1, 31–39.

Mangos, A., Bassino, J.-P., Sauzade, D., 2010. The economic value of sustainable benefits rendered by the Mediterranean marine ecosystems. Blue Plan Papers 8. Plan Bleu, Valbonne.

Maron, M., Mitchell, M.G.E., Runting, R.K., Rhodes, J.R., Mace, G.M., Keith, D.A., Watson, J.E.M., 2017. Towards a threat assessment framework for ecosystem services. Trends Ecol. Evol. 32, 240–248. https://doi.org/10.1016/j.tree.2016.12.011.

Martínez, M.L., Intralawan, A., Vázquez, G., Pérez-Maqueo, O., Sutton, P., Landgrave, R., 2007. The coasts of our world: ecological, economic and social importance. Ecol. Econ. 63 (2), 254–272.

Mateu, J., 2003. Turismo residencial y dispersión urbana en Mallorca (Illes Balears). Un ensayo metodológico en el municipio de Pollença. Estudios Turísticos 155–156, 197–218.

MEA, 2005. Ecosystems and Human Well-Being: Biodiversity Synthesis. Millennium Ecosystem Assessment. World Resources Institute, Washington, D.C. (USA).

MedCruise Association, 2014. Cruise Activities in MedCruise Ports: Statistics 2013, Piraeus, Greece.

Menegon, S., Depellegrin, D., Farella, G., Gissi, E., Ghezzo, M., Sarretta, A., Venier, C., Barbanti, A., 2018a. A modelling framework for MSP-oriented cumulative effect assessment. Ecol. Indic. 91, 171–181.

Menegon, S., Depellegrin, D., Farella, G., Sarretta, A., Venier, C., Barbanti, A., 2018b. Addressing cumulative effects, maritime conflicts and ecosystem services threats through MSP-oriented geospatial webtools. Ocean Coast. Manage. 163, 417–436. https://doi.org/10.1016/j.ocecoaman.2018.07.009.

Menegon, S., Depellegrin, D., Venier, C., 2018c. Geospatial Dataset for Cumulative Effects Assessment in the Italian Adriatic Sea [WWW Document]. https://doi.org/10.5281/zenodo.1173764, Accessed date: 5 February 2018.

Menegon, S., Sarretta, A., Depellegrin, D., Farella, G., Venier, C., Barbanti, A., 2018d. Tools4MSP: an open source software package to support maritime spatial planning. PeerJ Comput. Sci. https://doi.org/10.7717/peerj-cs.165.

Micheli, F., Halpern, B.S., Walbridge, S., Ciriaco, S., Ferretti, F., Fraschetti, S., Lewison, R., Nykjaer, L., Rosenberg, A.A., 2013. Cumulative human impacts on Mediterranean and Black Sea marine ecosystems: assessing current pressures and opportunities. PLoS ONE 8 (12), e79889.

Milcu, A.I., Hanspach, J., Abson, D., Fischer, J., 2013. Cultural ecosystem services: a literature review and prospects for future research. Ecol. Soc. 18 (3), 44. https://doi.org/10.5751/ES-05790-180344.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.

Nautica Report, 2016. Adriatic Sea Tourism Report. 2016 edition. Web. https://www.nauticareport.it/public/RisposteTurismo_AdriaticSeaTourismReport2016_ExecutiveSummary.pdf, Accessed date: 22 July 2018.

Oesterwind, D., Rau, A., Zaiko, A., 2016. Drivers and pressures–untangling the terms commonly used in marine science and policy. J. Environ. Manag. 181, 8–15.

Papageorgiou, M., 2016. Coastal and marine tourism: a challenging factor in marine spatial planning. Ocean Coast. Manag. 129, 44–48.

Patrício, J., Elliott, M., Mazik, K., Papadopoulou, K.N., Smith, C.J., 2016. DPSIR - two decades of trying to develop a unifying framework for marine environmental management? Front. Mar. Sci. 3 (177). https://doi.org/10.3389/fmars.2016.00177.

Pendleton, L., Martin, N., Webster, D.G., 2001. Public perceptions of environmental quality: a survey study of beach use and perceptions in Los Angeles County. Mar. Pollut. Bull. 42, 1155–1160.

Perseus, 2013. Preliminary identification of pressure of the coastal seas in socio-economic term. Gap Analysis on Data and Knowledge. Deliverable Nr. 2.2.

Piante, C., Ody, D., 2015. Blue Growth in the Mediterranean Sea: The Challenge of Good Environmental Status. MedTrends Project. WWF, France.

Plan Bleu, 2011. Cruises and Recreational Boating in the Mediterranean. Plan Bleu UNEP/MAP Regional Activity Centre, Valbonne.

Plan Bleu, 2016. Tourism and Sustainability in the Mediterranean: Key Facts and Trends. Plan Blue. Regional Activity Centre, Valbonne.

Racko, N., Vilibić, I., Mihanovi, H., 2013. Mapping underwater sound noise and assessing its sources by using a self-organizing maps method. J. Acoust. Soc. Am. 133 (3), 1368–1376.

Regione Emilia-Romagna, 2016. Analisi territoriale dell'offerta turistica. Dati definitivi 2016. Web. http://statistica.regione.emilia-romagna.it/turismo/dati-preliminari/tur_2016/analisi-territoriale-dellofferta-turistica, Accessed date: 5 May 2018.

Regione Friuli-Venezia Giulia, 2015. Flussi turistici della Regione 2015. Movimento clienti nelle strutture ricettive anno 2015 Web. https://www.dati.friuliveneziagiulia.it/Turismo/Flussi-turistici-della-Regione-2015/7z56-5r62, Accessed date: 5 May 2018.

Ribaudo, M., Greene, C., Hansen, L., Hellerstein, D., 2010. Ecosystem services from agriculture: steps for expanding markets (special section—payments for ecosystem services: from local to global). Ecol. Econ. 69, 2085–2092. https://doi.org/10.1016/j.ecolecon.2010.02.004.

Rodrigues, J.M.G., 2015. Cultural services in aquatic ecosystems. In: Chicharo, L., Müller, F., Fohrer, N. (Eds.), Ecosystem Services and River Basin Ecohydrology. Springer, Dordrecht.

Rodríguez, J.P., Beard Jr., T.D., Bennett, E.M., Cumming, G.S., Cork, S., Agard, J., Dobson, A.P., Peterson, G.D., 2006. Trade-offs across space, time, and ecosystem services. Ecol. Soc. 11 (1), 28.

Rounsevell, M.D.A., Dawson, T.P., Harrison, P.A., 2010. A conceptual framework to assess the effects of environmental change on ecosystem services. Biodivers. Conserv. 19, 2823–2842. https://doi.org/10.1007/s10531-010-9838-5.

Ruiz-Frau, A., Hinz, H., Edwards-Jones, G., Kaiser, M.J., 2013. Spatially explicit economic assessment of cultural ecosystem services: non-extractive recreational uses of the coastal environment related to marine biodiversity. Mar. Policy 38, 90–98.

Salomidi, M., Katsanevakis, S., Borja, Á., Braeckman, U., Damalas, D., Galparsoro, I., Mifsud, R., Mirto, S., Pascual, M., Rabaut, M., 2012. Assessment of goods and services, vulnerability, and conservation status of European seabed biotopes: a stepping stone towards ecosystem-based marine spatial management. Mediterr. Mar. Sci. 13 (1), 49–88.

Satta, A., 2004. Tourism in the Mediterranean: processes and impacts on the coastal environment. Forum on Integrated Coastal Management in the Mediterranean: Towards Regional Protocol. United Nations Environment Programme, Mediterranean Action Plan. Cagliari, pp. 59–73.

Simpson, M.C., 2008. Community benefit tourism initiatives - a conceptual oxymoron? Tour. Manag. 29 (1), 1–18.

Smith, M., 2008. Time to turn off the lights. Nature 457 (7225), 27.

Stachowicz, J.J., Fried, H., Osman, R.W., Whitlatch, R.B., 2002. Biodiversity, invasion resistance, and marine ecosystem function: reconciling pattern and process. Ecology 83, 2575–2590.

Tomlinson, B., Sastre, S., Blasco, D., Guille, J., 2011. The systems approach framework as a complementary methodology of adaptive management: a case study in the urban beaches of Barcelona. Ecol. Soc. 16 (4), 28–40.

Tools4MSP Geoplatform, June 2018. Web. www.tools4msp.eu.

Truscott, Z., Booth, D.T., Limpus, C.J., 2017. The effect of on-shore light pollution on sea-turtle hatchlings commencing their off-shore swim. Wildl. Res. 44 (2), 127–134. https://doi.org/10.1071/WR16143.

Turismo Venezia, 2018. Web. http://www.turismovenezia.it/Statistiche-2015-485193.html, Accessed date: 15 July 2018.

UNEP, Division of Technology, 2005. Making Tourism More Sustainable: A Guide for Policy Makers. World Tourism Organization Publications.
UNEP/MAP, 2012. State of the Mediterranean marine and coastal environment. UNEP/MAP – Barcelona Convention. Athens.
UNEP/MAP, 2016. Mediterranean Strategy for Sustainable Development 2016–2025. Plan Bleu, Regional Activity Centre, Valbonne.
UNWTO, 2013. Sustainable Tourism for Development Guidebook. http://cf.cdn.unwto.org/sites/all/files/docpdf/devcoengfinal.pdf, Accessed date: 5 July 2018.
White, M., Smith, A., Humphryes, K., Pahl, S., Snelling, D., Depledge, M., 2010. Blue space: the importance of water for preference, affect, and restorativeness ratings of natural and built scenes. J. Environ. Psychol. 30 (4), 482–493. https://doi.org/10.1016/j.jenvp.2010.04.004.
White, M.P., Alcock, I., Wheeler, B.W., Depledge, M.H., 2013. Coastal proximity, health and well-being: results from a longitudinal panel survey. Health Place 23, 97–103. https://doi.org/10.1016/j.healthplace.2013.05.006.
Willis, C., 2015. The contribution of cultural ecosystem services to understanding the tourism–nature–wellbeing nexus. J. Outdoor Recreat. Tour. 10, 38–43. https://doi.org/10.1016/j.jort.2015.06.002.
Witherington, B.E., Martin, R.E., 2000. Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches. Technical Report, TR-2. Marine Research Institute, St. Petersburg, FL, Florida.
Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J., Watson, R., 2006. Impacts of biodiversity loss on ocean ecosystem services. Science 314, 787–790. https://doi.org/10.1126/science.1132294.
Wu, J., 2013. Landscape sustainability science: ecosystem services and human well-being in changing landscapes. Landsc. Ecol. 28, 999–1023.