Project co-financed by the European Regional Development Fund

CO-EVOLVE

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Promoting the co-evolution of human activities and natural systems for the development of sustainable coastal and maritime tourism

Deliverable 3.5.2-3.5.3

Ecosystem threats from tourism and future trends;

Effects of ecosystem quality

Activity 3.5

Threats co-evolution - Mediterranean scale: Pollution and Ecosystems

WP3

CNR - ISMAR

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The authors are grateful to Alessandro Campanaro for proofreading the report and to Silvia Bellacicco for contributing to the conceptual framework.

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1. Introduction and scope of work

Sea-side recreation is a major driver for the local and regional economy of many touristic areas. On the other hand, coastal touristic activities impinge substantially on the ecological integrity of coastal and marine ecosystems, often depleting their functionality and capability of delivering many other fundamental ecosystem services.

In this context, the objective of the team in charge of 3.5 and 3.9 activities within the project CO-EVOLVE was to assess the most relevant threats and enabling factors (T&EF) impinging on coastal ecosystems, in order to enhance the sustainability of coastal tourism.

In this report only the study associated to threats is presented, while the enabling factors for coastal ecosystem protection are discussed in the deliverables of the Activity 3.9. Furthermore, the T&EF analysis was carried out at two scales: Mediterranean and pilot area. For the assessment at pilot area, refer to the deliverables 3.14 & 3.15.

The main purpose of this deliverable is to report on the current status of threat factors to coastal ecosystems and their services generated from tourism. The deliverable has a special focus on the coastal tourism in the Mediterranean basin, in order to produce a valuable contribution at MED scale to the complex analyses carried out in the CO-EVOLVE project. Moreover, the deliverable shows the achievements produced in the development of proper indicators of threats, presenting also an overview on the main other human activities damaging on coastal ecosystems. Last, we present a proposal for approaching coastal tourism sustainability by guaranteeing ecosystem quality.

The deliverable is structured in this way: after a general overview on the main threats from tourism impinging on coastal ecosystems, particular attention is given to the impacts caused by coastal touristic typologies identified in D3.16.1. Subsequently, the main pressures from Mediterranean coastal tourism are described more in detail, based on both existing studies and also on *ad hoc* analyses. The following section outlines and discusses the proposed indicators and the CO-EVOLVE approach to tourism sustainability.

The findings of this deliverable will be used to frame and downscale the investigation on threat factors to the pilot areas selected in the project.

2. Ecosystem threats and impacts from tourism

Tourist destinations tend to be places characterized by the highest social, cultural, or natural amenities. These destinations, due in part to their high quality, are often in short supply relative to demand. This scarcity leads to the potential for degradation of tourist areas, as they reach and in some cases exceed their carrying capacity (Davies & Cahill 2000).

Tourism was once thought of as a "smokeless" industry with few, if any, environmental impacts. However, recognition of its potential for adverse impacts on the environment is growing. Although in this work only the threats to ecosystems are considered, the impact of tourism to local communities and social system more in general shouldn't be underestimated, due to the tight link between cultural and ecological aspects.

Tourism consists of the activities undertaken during travel from home or work for the pleasure and enjoyment of certain destinations, and the facilities that cater to the needs of the tourist. As such, tourism is responsible for manifold environmental impacts, which might be distinguished in three categories: i) direct impacts, including impacts from the travel to a destination, the tourist activities in and of themselves at that destination, such as hiking or boating, and from the creation, operation and maintenance of facilities that cater to the tourist; ii) "upstream" impacts, those occurring at every point along the supply chain; and iii) "downstream" impacts, where service providers can influence the behaviour or consumption patterns of customers (Davies & Cahill 2000).

Below is reported a general categorization of direct impacts from tourism provided by Davies & Cahill (2000), where the so-called "social" impacts are excluded for the purpose of this report.

- Resource use
    - Energy consumption
    - Water consumption
- Pollution and waste outputs
    - Water quality
    - Air quality
    - Habitat/Ecosystem alteration and Fragmentation
    - Impacts on Wildlife

2.1 Impacts from coastal tourism

Coastal tourism is the most developed form of tourism worldwide and in Europe. 63% of the European holiday makers prefer the coast (EC 1998). The attraction coastal resorts exert on tourists has profoundly altered the natural landscapes; in fact, many coastal roads are built simply to connect resorts and sight-seeing opportunities. Tourist resorts are also generally characterised by extensive car-parking facilities, taking yet more land.
Exponential growth of the use of yachts, pleasure trip vessels and water taxis has fuelled marina and jetty development. Such coastal structures change current systems and often profoundly alter the sand supply to natural beaches (Davenport & Davenport 2006).
Due to the complex range of impacts to coastal ecosystems from coastal and maritime tourism, a refinement and specification of the list proposed by Davies & Cahill 2000 was carried out. The main identified impacts are reported and defined below.

1. Ecosystem fragmentation and degradation - Degradation occurs when ecosystem changes due to human use and results in a reduction in the overall quality of the environment. Ecosystem fragmentation occurs when an intact area of the environment is divided up into smaller patches as a result of human activity (for instance lidos over beaches and dunes). Habitat loss is often a consequence of ecosystem fragmentation, which particularly affects very fragile habitats such as successional vegetation. An example is coastal dune system, formed by mobile and fixed dune habitats.

2. Wildlife disturbance and exploitation - It refers to all those impacts that human interference has on wildlife behaviour, which can have implications for wildlife populations. For example, wildlife may be more vigilant near human disturbance, resulting in decreased forage intake and reduced reproductive success. A direct disturbance of wildlife is exploitation, which reduces population size, but also its vitality and influences wildlife behavioural patterns and fitness.

3. Solid Waste production - A solid waste is any material that is discarded by being abandoned, disposed of, burned, or incinerated. It can also include sludge from a wastewater treatment plants. A peculiar type of solid waste is marine litter, which consists of items that have been deliberately discarded, unintentionally lost, or transported by winds and rivers, into the sea and on beaches. It mainly consists of plastics, wood, metals, glass,

rubber, clothing and paper. Land-based sources such as tourism account for up to 80% of marine litter.

4. Water pollution - Water pollution happens when toxic substances enter water bodies such as lakes, rivers, oceans and so on, getting dissolved in them, lying suspended in the water or depositing on the bed. This degrades the quality of water. Examples of heavy polluting substances are oil and chemical effluents. Water can be also polluted by substances of biological origin, like faecal contamination.

Excessive loads of nutrients, typically compounds containing nitrogen, phosphorus, or both can lead to eutrophication. This process induces excessive growth of plants and algae and, due to biomass load and microbic degradation, may result in oxygen depletion of the water body.

5. Air Pollution - Air pollution can be defined as the presence of toxic chemicals or compounds (including those of biological origin) in the air, at levels that pose a health risk. In an even broader sense, air pollution means the presence of chemicals or compounds in the air which are usually not present and which lower the quality of the air or cause detrimental changes to the quality of life (such as the damaging of the ozone layer or causing global warming).

6. Alien species - Invasive Alien Species are animals and plants that are introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment. Examples of successful invaders are the coastal dune plant *Carpobrotus* spp. and the seaweed *Caulerpa Taxifolia* (Zenetos et al., 2012).

7. Noise pollution - Noise pollution refers to sounds in the environment that are caused by human activities and that threaten the health or welfare of human or animal inhabitants. The most common source of noise pollution by far is motor vehicles. Aircraft and industrial machinery are also major sources. Noise pollution is not easy to measure, because the very definition of noise depends on the context of the sound and the subjective effect it has on the people hearing it. Underwater noise pollution (mainly caused by vessels) is currently under investigation for its effects particularly on cetaceans and other marine animals (Williams et al., 2015). Recreational boating and whale watching boats can be a

considerable source of noise pollution. Although the in-air noise emissions are regulated by EU Recreational Craft Directive 2003/44/EC, no limits are set for underwater noise emission.

8. Light pollution - Light pollution refers to the presence of anthropogenic light sources in the dark sky. Excessive levels, misdirected, or obtrusive lights can alters natural conditions and have serious consequences on animals' physiology and behaviour (Hölker et al., 2012). Besides, anthropogenic light washes out starlight in the night sky, interferes with astronomical research, disrupts ecosystems and wastes energy.

In the CO-EVOLVE project five typologies of coastal tourism were identified (see D3.16.1 for details). They are:

1. Beach/Maritime tourism
2. Urban/Cultural tourism
3. Cruising
4. Recreational boating (Yachting/Marinas)
5. Nature/Ecotourism

Based on the list of impacts presented above, a review of the main impacts from each coastal tourism typology was performed, whose achievements are illustrated in the next paragraphs.

2.2 Direct impacts from Beach/Maritime Tourism

Beach tourism brings apparent economic benefits to the local communities, but environmental costs are associated with them. Such costs can be substantial and unsustainable in the long term, especially for small island resorts.

Ecosystem fragmentation and degradation

Activities pertinent to beach/maritime tourism are not only sunbathing and swimming, but also snorkelling and diving. Unfortunately, many dive sites are in marine protected areas (MPAs). Even if diving and snorkelling themselves may seem harmless, inadvertent related

activities, such as stepping on coral can ruin it. Simple walking on the rocky intertidal produces the same effect, especially because rocks are never replaced in the original position, thus interfering with animal and plant colonization. However, the cumulative nature of the damage is most problematic: one or two tourists may not cause much harm, but hundreds of them over time can do considerable damage to an ecosystem (Gartner 1996). The cumulative impact of tourists on vegetation gradually shifts species composition, because only the most resilient plants can survive in an area under constant pressure from tourist activities. This has been studied in depth in fragile coastal habitats, such as dune systems (Santoro et al. 2012) where damaged dune vegetation is very slow to recover.
Maintenance and cleaning of beaches is a common practice that uses mechanised operations to remove all natural strandlines as well as garbage, and grade the sand. In Europe, the 'Blue Flag' award system requires unsightly natural debris to be removed as well as the rising tide of tourist-generated litter (Davenport & Davenport 2006). Removal of naturally deposited plant debris has been shown to decrease sandy shore biodiversity dramatically (Llewellyn and Shackley, 1996).

Wildlife disturbance and exploitation

Many tourist activities occur in fragile ecosystems, such as coral reefs and sea beds. Snorkelling and diving can cause much damage. Trampling on rocky shore have been shown to mainly result in the decline in the amount of foliose algae and the number of barnacles but also alteration of natural small invertebrates (Casu et al. 2016). Activities such as recreational spear fishing, and crabs, octopus, and lobster collection can cause the decrease in reproductive potential of these species and harsh population decline till extinction of particularly appreciated species in the local cuisine.

Solid Waste

Mass tourism can also harm the ecosystem by littering. Marine litter is a global concern, affecting all the oceans of the world. Every year, millions and millions of tonnes of litter end up in the ocean worldwide, posing environmental, economic, health and aesthetic problems. Littering in natural environments not only contributes to visual pollution, but can also change the nutrient composition of soils and prevent light from reaching plants. This phenomenon is even more alarming in small areas managed by local communities (like islands, for instance), which are not able to assimilate the huge quantity of waste produced daily in beach resorts. It is therefore common in these sites that dumpsites tend to become unsustainable over time, generating soil pollution and diffuse habitat degradation.

2.3 Direct Impacts from Urban/Cultural tourism

Mass tourism in cultural cities is one of the first and most widespread forms of tourism worldwide. Tourists impinge profoundly on the social and environmental assets of a city, often causing unsustainable scenarios in the long term which threaten the attractiveness of the city itself (high costs of living; loss of identity). Mass tourism is related to urbanization, since it can be the engine for further urban sprawl of highly touristic places. Urbanization is correlated with the increase of air temperature, hot days and the decrease of relative humidity, thus having a profound effect on micro and regional climatic conditions (e.g. Cui & Shi 2012).

Solid waste

One of the most important impacts of city tourism is the generation of solid waste. In fact, the quantity of municipal solid waste (MSW) is used as a proxy for calculating the seasonal population of different towns with high amount of tourists (Mateu, 2003). Municipal waste constitutes around 10% of total waste generated; however, it is the waste type most directly related to the consumption patterns, and thus to tourism. In Europe, there are substantial variations between countries in solid waste production. The variation reflects differences in consumption patterns and economic wealth of the countries, but also depends greatly on the organisation of municipal waste collection and management.

Air pollution

Urban tourism is a mass form of touristic activity which, like beach tourism, causes peaks of air pollution during summertime, where people are more likely to travel. Road transport is still the major contributor to pollutant emissions, which have a significant impact on the atmosphere, health and the climate change. High concentrations of heavy metals (Cu, Pb and Zn) derived from traffic pollution can be found in the city centre, residential areas, and along major traffic routes (e.g. Zhang 2006). A key indicator of city air pollutant is particulate matter (PM10 and PM 2.5), for which regular emission reports are due at European level (UNECE Convention on Long-range Transboundary Air Pollution).

Light Pollution

Light pollution is mainly driven by urbanization and it's particularly striking in coastal touristic cities. The sky glow caused by artificial lighting from urban areas disrupts the natural cycles, and has been shown to impact the behaviour of organisms, even many kilometres away from the light sources (Kyba et al. 2011).

2.4 Direct Impacts from Cruising

The cruise industry is the fastest growing segment of the tourism industry; this growth is also reflected in the increase of the number of berths worldwide. Cruise tourism has become significant for a number of ports because cruise tourists are higher yield tourists, spending, on average, much higher amounts per day than other categories of international tourists (Dwyer & Forsyth 1996). The industry has a significant economic impact, and for this reason it is unlikely to slow its growth down over the next decades. Cruise ships produce substantial quantities of garbage, wastewater and sewage that are often discharged untreated into pristine marine habitats.

Solid Waste

As with recreational boats, the amount of solid waste (excluding sewage) generated by the cruise industry is difficult to document. A cruise ship carrying 2,700 passengers can generate at least a ton of garbage per day. An average passenger generates 1kg of dry garbage, 1.5kg of food waste, and disposes of two bottles and two cans (Davies & Cahill 2000). The American National Research Council developed found that cruise ships produce the second most garbage by weight (24% of the total), followed by recreational boaters. It is even more difficult with cruise vessels to determine how much gets tossed overboard. It is nearly impossible to monitor the vessels, and (as with recreational vessels) it is difficult to distinguish shipboard waste from land generated waste once onshore. Evidence of illegal dumping of solid waste must therefore come from passengers on board or other vessels. Some cruise vessels have addressed the waste issue through the use of on-board waste incinerators. However, solid waste is often dumped in landfill sites at tourist destinations, thereby contributing to pollution and habitat loss in highly sensitive environments.

Water pollution

A typical cruise ship discharges around 1 million litres of ‘black water’ (sewage) during a 1-week voyage (United States Environmental Protection Agency, 2000). Very often the discharges are illegal and occur in pristine habitats (Davenport & Davenport 2006). Garbage, wastewater and sewage are generally released untreated.

Air Pollution

The cruise industry has the potential to affect air quality through engine emissions. Most marine fuels are residual fuels with higher concentrations of contaminants such as sulphur. Recent studies have suggested that ocean-going vessels have the potential to affect air quality in coastal regions, port areas, and heavily travelled trade routes where annual sulphur emissions from ships equal or exceed land-based emissions (Capaldo et al. 1999).

Oil and Chemical Effluent

Cruise ships also produce toxic chemicals and hazardous waste from dry-cleaning procedures, used batteries, and paint waste from brush cleaning (Malbin, 1999). Waste oil is produced from normal leakage from the main engines and generators, the cleaning of fuel filters, losses during maintenance, and leaks from hydraulic systems. Fuel oil spillages are a particular problem as heavy fuel oil is more toxic than crude oil (Davenport & Davenport 2006). It is also important to consider the unreported incidents that have an impact on the environment.

Alien Species

The introduction of non-native species through discharge of ballast water is another potential environmental impact of the cruise industry. In the US, the Council on Environmental Quality found that over 130 non-native species have been introduced to the Great Lakes since 1800, with almost a third thought to have been carried by ships. Introduced species cause problems because they can disrupt the food web of the ecosystem and clog the intake pipes of power plants and water treatment facilities.

Ecosystem fragmentation and degradation

Dredging channels for the larger vessels causes increased turbidity that is damaging to both corals and seagrass beds (e.g. Lewis et al., 1985). In the same way, high numbers of snorkelers on a cruise trip can damage marine habitats and disturb wildlife. To date little research has been undertaken to investigate the potential impacts of vessel movements through the generation of waves and propeller-induced turbidity, and ships' wash on marine habitats, although this matter has recently received increasing attention. Ships generate waves which get bigger and more energetic the faster the ship goes relative to its length.

2.5 Direct impacts from Recreational boating

Water pollution

The most significant problem associated with recreational boating and water quality is the discharge of sewage into waterbodies with limited flushing or nearby shellfish beds. Sewage contains pathogens (faecal coliform is used as an indicator of the amount of pathogens contained in the sewage) which can adversely affect human health and contaminate shellfish. Diseases that can be potentially transmitted through human contact with faecal discharge and/or ingestion of contaminated shellfish include typhoid fever, dysentery, infectious hepatitis, and nonspecific gastroenteritis. Significantly higher faecal coliform counts tend to be found in waters with a high recreational boating population during peak usage (summer). In addition to sewage discharges, recreational boats can impact the environment through oil spills.

Solid Waste

Another way that recreational boating can adversely affect water quality is through the discharge of solid waste (garbage). The American National Research Council has listed some of the adverse impacts of marine debris in the environment: (1) aesthetic degradation of surface waters and coastal areas; (2) physical injuries to humans; (3) ecological damage resulting from the interference of plastics with gas exchange between surface waters and deeper waters; (4) alterations in the composition of ecosystems because opportunistic organisms use debris as their environment; (5) entanglements of birds, fish, turtles, and cetaceans; and 6) ingestion of plastic by marine mammals. Although the amount of waste generated on a daily basis is minimal due to the relatively short duration of trips, the cumulative effect has the potential to be significant.

Wildlife disturbance

Recreational boating can cause damage to marine habitat and animals such as coral and seagrass beds by running aground or dragging anchor over the habitat. The noise made by these boat engines and propellers are also thought to interfere with the whales' communications systems.

2.6 Direct impacts from Nature/Ecotourism

Ecotourism attempts to minimize impact on the social, cultural, and physical environment. It can mean the development of tourism facilities in an environmentally responsible manner, recreational programs that promote a greater awareness and appreciation of nature, and a mode of travel that is sensitive to the host community (Yee 1992). Priority areas include waste minimization, energy efficiency, fresh and wastewater management, hazardous substances, transportation, land-use planning and management, and involvement of staff, customers, and communities in environmental issues (Davies & Cahill 2000). Although nature-related coastal tourism is considered as the least impacting form of leisure, even it has a range of impacts on the ecosystems. Ecotourism can adversely impact the environment in the same way as traditional, mass tourism, when performed in a careless way. In addition, if this form of recreation is put in practice in natural areas where no tourism existed before, it will still bring a large number of visitors who will use road, rail and air transport to travel and will disturb wildlife.

Wildlife disturbance

Whale and dolphin watching, coastal estuarine/lagoon bird watching and glass-bottom boat excursions are all increasingly common. Problems are caused by too heavy demand. Ornithologists long ago established that human intrusion reduced hatching and breeding success of a variety of birds by causing disturbance to adults or chicks (Burger, 2002). The movement of tourists' vehicles can also adversely affect wildlife by separating the young from their parents. It is possible for instance that whale-watching boats have this impact because studies have shown that, if young whale calves lose contact with their mothers, they sometimes attach themselves to the side of a ship. There is evidence that the numbers of incidents of ship strike by whale watching boats are a major cause of death and injury to whales (Laist et al. 2001).

Visitor and traffic congestion in some famous national parks have been recorded; overcrowded and noisy natural areas can be indeed seriously affected, as it happens with beach tourism. Furthermore, a dramatic type of damage is the disruption of wildlife when ecotour operators get too close to their habitat to order to satisfy visitors' expectations towards rare and flagship species or habitats.

2.7 Threats from coastal tourism: a summary

From the assessment presented above it became clear that some touristic typologies are more impacting than others on the coastal ecosystems. However, it is worth noting that the availability of reliable information on the five typologies was uneven, with cruise tourism on the top list as to data supply. On the bottom list we can place recreational boating and urban tourism, for which only few studies about their environmental impacts could be found. Such discrepancy must be accounted for, while ranking the five touristic typologies in terms of environmental impact. Table 1 sketches the relative impact of each threat with respect to the five touristic typologies. As done in the empirical analysis carried out in the Deliverable 3.5.1, we assigned an 'X' for low impact, an 'XX' for medium impact and an 'XXX' for high impact. Overall, cruising turned out to be the most impacting touristic typology, followed by beach and urban tourism. On the other hand, ecotourism and recreational boating seem to have lower environmental impact. Cruise, beach, and urban tourism are more responsible for air pollution and solid waste than recreational boating and ecotourism. Cruising also produces highly negative effects on water quality. Light pollution is mainly a consequence of urban tourism, followed by beach tourism and cruising. Its effects are still scarcely studied, especially on marine habitats; for this reason, recreational boating could be as damaging as cruising, although at a much smaller scale. All touristic typologies have a medium environmental impact produced by noise pollution except cruising, for which a high impact was assigned, since it has proven to cause dangerous underwater noise. Alien species are another kind of threat for which data collection is still far from complete. Since there's enough evidence on the heavy role played by cruise vessels in transferring invasive organisms, the highest impact was given to level cruise tourism. Beach tourism is responsible for favouring the invasion of alien organisms through ecosystem degradation and fragmentation. Ecotourism has the lowest total environmental impact, if performed in a respectful way, as already discussed in its dedicated section above.

Table 1: Threat relative impact caused by the five touristic typologies.

THREAT Category	CRUISE	BEACH	URBAN	ECO	BOATING
Air pollution	XXX	XXX	XXX	X	XX
Solid Waste	XXX	XXX	XXX	X	X
Ecosystem degradation and fragmentation	XX	XXX	XX	X	XX
Water pollution	XXX	XX	XX	X	XX
Noise pollution	XXX	XX	XX	XX	XX
Light pollution	XX	XX	XXX	X	X
Wildlife disturbance and exploitation	XX	XX	XX	XX	XX
Alien species	XXX	XX	X	X	X

3. *Ecosystem threats in the Mediterranean Basin*

The Mediterranean Basin, in line with the global statistics, has witnessed a steady increase in international arrivals from the post-war period onwards. It is estimated that by 2020 there will be 350 million tourists visiting the Mediterranean coastal region alone (WTO 2004). In such figure short-distance tourism within countries is not accounted, making the prediction underestimated. Obviously these sheer numbers bring not only economic richness but also environmental impacts which, coupled with climate change effects, can pose a threat to the future of the coastal environment and thus to Mediterranean coastal tourism itself.

The coastal areas of the Mediterranean Sea have been impacted by human presence for millennia and have been affected by deforestation, intensive agriculture, irrigation and the resulting land erosion. However, during the last half century tourism has burgeoned, especially in areas with sandy beaches. Coastal road construction, tourist resorts and car parks have replaced natural habitats with concrete, tarmac and golf courses, while hotel, marina and street lighting now fringe most of the Mediterranean coast and its island systems. Beaches themselves are tramped and occupied by millions of people, while promenades and walkways often replace dune or rocky systems. Ecological effects have been dramatic. Wetlands have disappeared, taking their fauna and flora with them; disturbance and habitat fragmentation have reduced biodiversity; some vulnerable species have been driven close to extinction.

In the majority of coastal regions of the world basic data on tourism and its associated impacts is extremely poor (Orams et al. 1999). Seemingly, quantitative and homogeneous data about threats in the Mediterranean Basin was complex to retrieve since they are often stored in grey literature (i.e. limited-circulation reports and web-disseminated material). Although the evident lack of financial support for rigorous scientific studies on the environmental effects of tourism (Davenport & Davenport 2006), recently EU funded projects and initiatives have been focusing on this topic. The following section is thus based mainly on reports from EU initiatives and projects and on official information available at the various European environmental statistics platforms.

3.1 Noise pollution

The impacts of noise on wildlife have been investigated in depth, as shows the Annotated Bibliography published by Turina and Barber in 2011. Although further studies are needed, noise from vehicles (aircraft, road transportation) seems to be stressful to wildlife. Research on the effects of acoustic overexposure typically reports high variability: though it is impossible to tell, the data so far also suggest there may be considerable species differences in the degree of damage and the time course and extent of recovery.
As outdoor recreation and ecotourism can have negative effects on wildlife species, it is important to determine buffer zones within which activities near critical wildlife areas are limited. To determine buffer size, experiments on water birds were performed, thus detecting considerable variation in flush distances among individuals within the same species and among species in response to different types of vessels. Buffer zones of various sizes were then proposed for each species (Rodgers & Schwikert 2002).

Although the great research efforts in investigating noise pollution effects on wildlife, large scale data for Mediterranean Basin do not exist to date. For this reason, we decided to employ information referred to human health, assuming that it can be valid for wildlife as well. The Directive relating to the assessment and management of environmental noise (the Environmental Noise Directive – END, 2002/49/EC) is the main EU instrument to identify noise pollution levels in EU. The reporting requirements were set to start as from 2005, and the reporting cycle is 5 years, with the exposure data submitted in 2007 and in 2012 afterwards. The database available on the EEA website (https://www.eea.europa.eu/data-and-maps/data/data-on-noise-exposure-2) contains information on the number of people exposed to 5 decibel (dB) bands for two indicators "Lden: 55-59, 60-64, 65-69, 70-74, >75" and "Lnight: 50-54, 55-59, 60-64, 65-69, >70". The database covers the noise sources like major roads, major railways, major airports and urban agglomerations and the corresponding percentage of people exposed to each of the noise sources inside urban areas and outside urban areas. Table 2 shows the values for road noise recorded in 2012 in each NUTS3 region for which information was available. No data was retrieved for the whole Greece. For a better understanding of the data reported, please refer to the relevant map of ecological risk presented in the Deliv. 3.5.4.

Table 2: Percentage of inhabitants exposed to road noise in each NUTS3 region. The percentages are reported for the five road noise Lden bands.

Country	NUTS code	NUTS Name	N. Inhabitants	Area (Km^2)	Lden 55-59	Lden 60-64	Lden 65-69	Lden 70-74	Lden >75
Cyprus	CY000	Nicosia	243254	95	14,1	70,87	6,5	5,3	0,58
Spain	ES511	Baix Llobregat II	191986	73	49,12	34,43	11,98	3,33	0
Spain	ES511	Barcelones II	338851	29	28,24	39,34	28,36	3,66	0,41
Spain	ES511	Valles Occidental II	207483	90	45,02	38,89	14,17	1,88	0
Spain	ES512	Girones	125594	46	18,71	32,57	25,72	21,82	1,27
Spain	ES521	Alicante	328441	47	12,12	6,18	0,67	0,06	0
Spain	ES521	Elche	230454	29	24,6	23,04	16,23	8,37	2,3
Spain	ES522	Castellon de la Plana	181243	107	6,68	30,24	41,22	19,09	0,33
Spain	ES523	Valencia	799188	135	21,71	24,12	14,45	7,55	0,88
Spain	ES611	Almeria	165612	22	28,8	16,06	15,04	4,89	1,81
Spain	ES614	Granada	237929	88	18,53	15,59	13,16	5,8	0,8
Spain	ES617	Malaga	575322	46	20,98	19,66	20,7	8,17	0,57
Spain	ES620	Murcia	442064	886	26,49	14,91	5,34	0,95	0,02
France	FR812	Nimes	148900	221	15,25	34,72	24,78	8,93	0,6
France	FR813	Montpellier	288000	154	10,31	7,29	7,99	4,27	0,21
France	FR815	Perpignan	221400	181	46,28	57,9	26,67	5,1	0,12
France	FR823	Nice	889400	787	13,54	11,91	9,16	2,8	0,56
France	FR824	Marseille	1391400	1422	10,74	9,82	16,36	4,26	0,11
France	FR825	Toulon	519600	713	6,76	7,18	7,66	1,83	0,04
Croatia	HR031	Rijeka	128624	44	11,51	8,86	6,45	2,49	0,08
Croatia	HR035	Split	178192	79	9,65	7,18	1,96	0,06	0
Italy	ITH57	Ravenna	161177	653	28,54	40,45	16,32	1,24	0
Italy	ITH58	Forli	118609	228	10,71	22,01	47,05	9,36	0,76
Italy	ITH59	Rimini	146606	135	38,13	23,19	14,73	1,84	0
Italy	ITI16	Livorno	156150	104	9,73	33,37	32,72	18,57	0,32
Italy	ITF35	Salerno	132608	59	11,99	9,58	17,19	22,47	3,54
Italy	ITF46	Foggia	152747	506	18,4	29,66	21,8	3,67	0
Italy	ITF47	Bari	316532	116	16,18	31,06	21,39	9,29	0
Italy	ITF43	Taranto	191810	247	16,94	26,64	22,63	3,75	0
Italy	ITF48	Andria	100086	399	21,18	39,87	27,08	2,8	0
Italy	ITG25	Sassari	111600	69	32,26	32,8	18,37	7,44	0,18
Italy	ITG27	Cagliari	349962	233	10,54	19,72	37,75	23,75	4,17
Malta	MT001	Valletta	270004	66	6,11	5,33	6,78	2,19	0,33

Anthropogenic underwater noise is now recognized as a world-wide problem, and recent studies have shown a broad range of negative effects in a variety of taxa (e.g. for killer whales, see Erbe 2002). The most commonly measured wildlife responses to noise fall into three main categories: behavioural, acoustic and physiological (OceanCare 2015). These impacts are experienced by fish, crustaceans and cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles and cetaceans (whales, dolphins and porpoises). Underwater noise from shipping is increasingly recognized as a significant and pervasive pollutant with the potential to impact marine ecosystems on a global scale. Underwater noise was first posited as a potential threat to marine fauna fairly recently, in the context of long range communication among baleen whales. From its initially narrow focus on naval applications to the first, prescient suggestion that whales may be affected by ocean noise across very long distances, the literature has taken a more holistic view over time (Williams et al. 2015). In the Mediterranean Sea, the techniques involved to measure underwater noise have greatly developed, thanks to employment of sophisticated techniques like in the case of study based on a "self-organizing maps" method (SOM) carried out in Dalmatia by Rako et al (2013). The overall results of the analysis distinguished two dominant underwater soundscapes, associating them mainly to the seasonal changes in the nautical tourism and fishing activities within the study area and to the wind and wave action. The analysis identified recreational vessels as the dominant anthropogenic source of underwater noise, particularly during the tourist season.

As underwater noise is considered a major threat particularly for cetaceans, the ACCOBAMS Agreement (*The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area*; see Deliverable 3.9.1) has undertaken a work aiming at identifying noise hotspots and areas of potential conflicts with cetacean conservation. Areas accumulating noise-producing activities (noise hotspots) were pointed out, with a focus on zones overlapping with important cetacean habitat as identified by ACCOBAMS Parties. The Figure 1 depicts the major noise hotspots (in red) in the Mediterranean Sea; Veneto and Emilia Romagna coastlines in the North-Central Adriatic Sea and Abruzzi coastlines in the south Adriatic Sea shows the highest values for the Central Mediterranean region. In the Western Mediterranean region instead, Marseille and Nice in France seem to be the highest noise hotspots. The Southern Mediterranean and Eastern Mediterranean regions are characterized by lower values, with Sicily and Tunisia coastlines excluded.

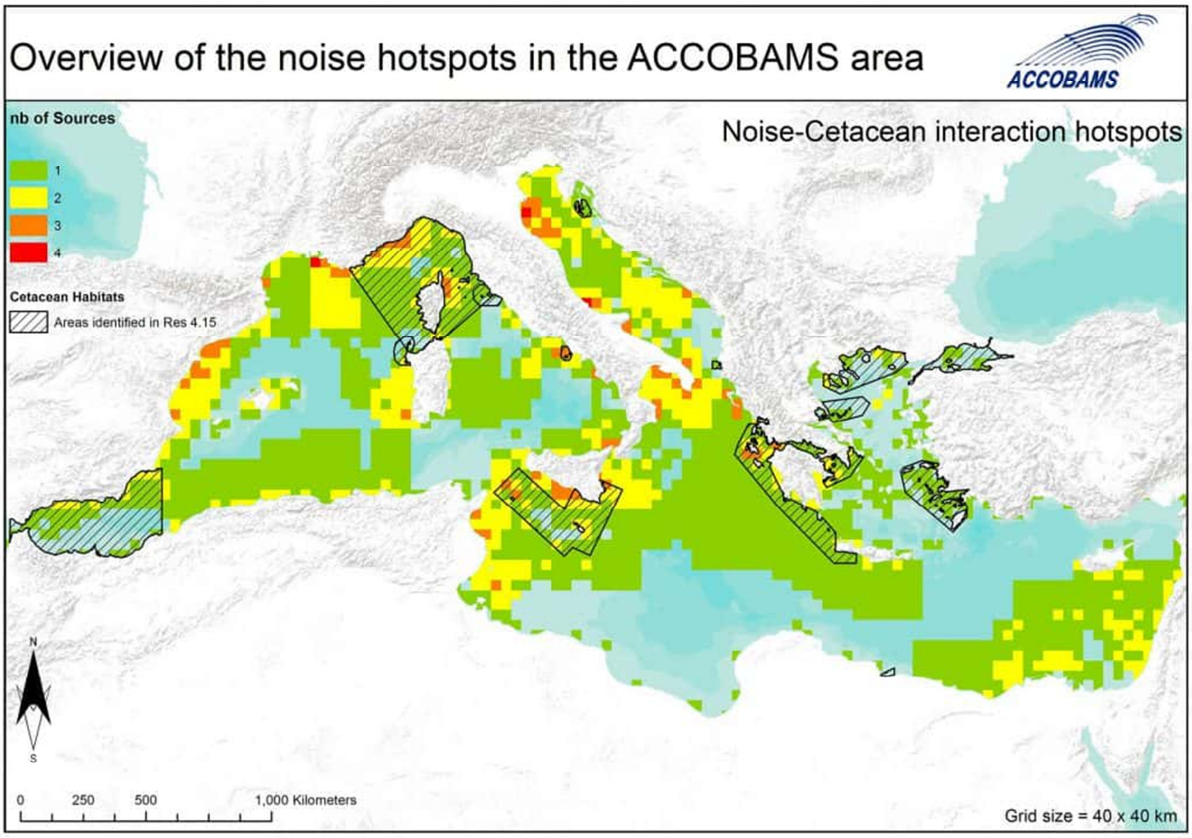

Figure 1: Number of noise-producing human activities over a 40 x 40 km spatial grid (from ACCOBAMS 2016, with kind permission of Dr. Maglio) and interaction with cetacean habitats.

3.2 Air pollution

Human activities release substances into the air, some of which can cause problems for humans, plants, and animals. The most common type of air pollution is the release of particulate matter from burning fossil fuels like petroleum products and coal for energy. Another type of pollution is the release of noxious gases, such as sulphur dioxide, carbon monoxide, nitrogen oxides, and chemical vapours. These can take part in further chemical reactions once they are in the atmosphere, forming smog and acid rain.

Air pollution is produced by transportation and industry. In the case of coastal tourism, cruises, airplanes and road vehicles are likely to be the major vectors of this source of pollution.

Even though the EU has a waterway network of more than 35,000 km covering large to small rivers and canals (INE; Inland Navigation Europe, http://www.inlandnavigation.org/en/factsandfigures.html) and shipping and transport on inland waterways accounted for 465.3 million tonnes of cargo in Europe in 2005 (De La Fuente Layous, L. A.; Eurostat, Ed.; Office for Official Publications of the European Communities, 2006), data on emissions and their impact on air quality is scarce.

A review study by Viana et al. (2014) showed the contribution of maritime transport emissions to coastal air quality in Europe, by collating recent experimental works. Overall in European coastal areas, shipping emissions contribute with 1-7% of ambient air PM_{10} levels, 1-14% of $PM_{2.5}$, and at least 11% of PM_1. In addition, shipping emissions impact not only the levels and composition of particulate and gaseous pollutants, but may also enhance new particle formation processes in urban areas. In the Mediterranean Basin, particularly worrying is the contribution to PM_1 from the ports of Genoa (Mazzei et al. 2008) and Venice (Contini et al. 2011), with the latter contributing to 1% - 8% alone to PM levels (Figure 2). Small islands are also particularly affected by air pollution, like in the case of Lampedusa, where Becagli et al. (2012) calculated a contribution of 30% from SO_2; a 3.9% from PM_{10} and 8% from $PM_{2.5}$.

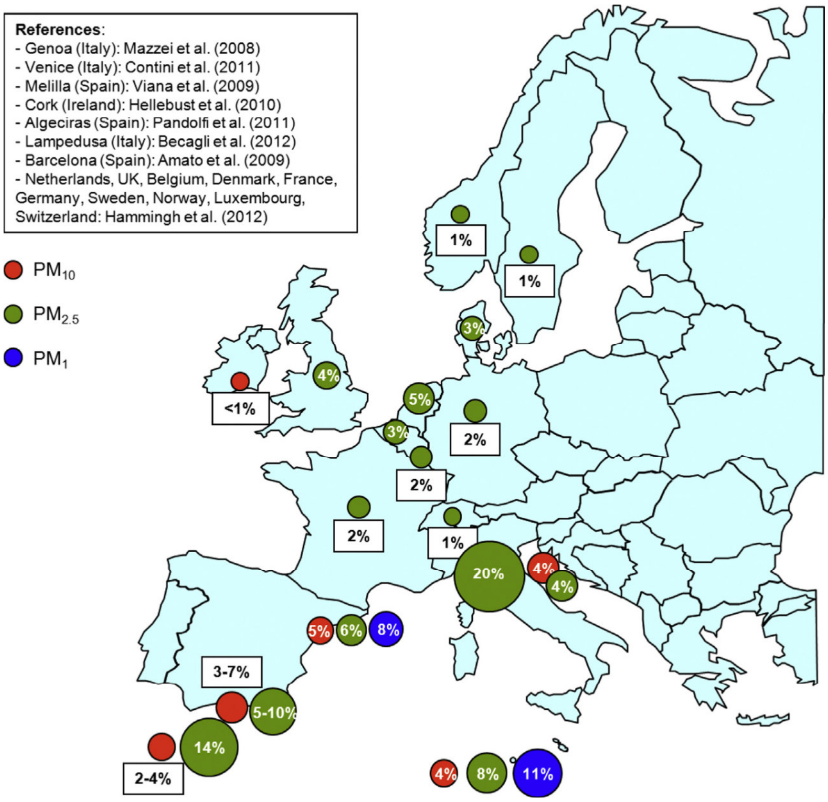

Figure 2: Contribution from shipping emissions to air quality degradation (PM_{10}, $PM_{2.5}$ and PM_1) across Europe (from Viana et al. 2014).

A study by Waked & Afif (2012) compared air quality measurements in three major Mediterranean coastal cities across seasons: Barcelona, Beirut and Athens. The comparison obtained between the three cities showed that emissions per capita for CO and SO_2 are highest in Beirut while emissions of particulate matter were highest in Barcelona. The different patterns between these cities showed that emissions increase in winter in Beirut and Barcelona (11 and 9% respectively) and decreases in the city of Athens by 9%. In summer, an increase of 15% in traffic intensities is observed in Athens while in Beirut and Barcelona, traffic intensities decrease by 10 and 40% respectively (Waked & Afif 2012). Apart from seasonal variation, eastern Mediterranean cities tend to have high PM background levels, which could be attributed to several factors like high population density, low recirculation probability of pollutants because of the geographical setting of the region, frequent dust outbreaks, proximity to the Mediterranean Sea (causing PMs to be rich in sea salt), low precipitation rates, poor vegetal coverage and, in some cases, lack of rules and regulations concerning PM levels (Saliba et al. 2010).

Table 3: Different levels of particulate matter in various Mediterranean countries (from Saliba et al. 2010).

Country	Site	Year	PM2.5	PM10	PM2.5/PM10	Reference
Spain	Barcelona	2003–2004	25.00	39.00	0.64	Pey et al. (2008)
Spain	Tarragona	2001	22.20	37.40	0.59	Moreno et al. (2006)
Spain	Barcelona	1995–2005	26.50	43.00	0.62	(Querol et al. (2008)
	Onda		20.00	28.00	0.71	
	Alcora		24.00	35.00	0.69	
	Cartagena		22.00	46.00	0.48	
	Mallorca		20.00	28.00	0.71	
Greece	Athens	1999–2000	40.20	75.50	0.53	Chaloulakou et al. (2003)
Greece	Akrotiri (Crete)	2004–2006 (PM2.5) 2003–2004 (PM10)	25.40	35.00	0.73	Lazaridis et al. (2008)
Greece	Finokalia	2004–2006	18.2	30.8	0.63	Gerasopoulos et al. (2007)
Egypt	Cairo	1999, 2002	86.24	184.15	0.47	Abu-Allaban et al. (2007)
Israel	Ashod Urb	1999	23.9	48.73	0.49	Peled et al. (2005)
Israel	Ashkelon Urb	1999	24.00	67.10	0.36	Peled et al. (2005)
Israel	Sderot Urb	1999	29.20	52.90	0.55	Peled et al. (2005)
Turkey	Erdemli	2001–2002	9.70	36.40	0.27	Koçak et al. (2007)
Turkey	Izmir (Urban)	2004–2005	64.37	79.98	0.80	Yatkin and Bayram (2008)
	Izmir (Suburban)		24.11	46.9	0.51	
Lebanon	HH	2006–2007	27.63	86.81	0.32	This study
	BH	2004–2005	38.86	103.81	0.37	
	Bliss	2003	40.95	71.34	0.57	
	Seagate	2003–2004		86.90		

As regards the future trends of air pollution generated by ship emissions, there are contrasting hypotheses. On the one hand, a significant improvement in SO_2 emissions has been recorded after the implementation of the EU directive 2005/33/EC, which requires that all ships at berth or anchorage in European harbours use fuels with sulphur content of less than 0.1% by weight while previously, outside of Sulphur Emission Control Areas, up to 4.5% were allowed (Schembari et al. 2012). On the other hand, no strict regulation has been put in place so far for the other heavy air pollutants. Projections of shipping emissions are not reassuring: if total emissions from international navigation for European seas in 2000 were estimated to be approximately 3.3 million tons of NOx, 2.3 million tons of SO_2, and 250000 tons of suspended particles, these figures are expected to increase by 50% in 2020 (Cofala et al., 2007).

3.3 Water pollution

Microbial pollution is related to urban wastewaters. The most important eutrophication hot spots in the Mediterranean often coincide with coliform bacterial hot spots. Pathogenic and other micro-organisms enter the marine environment mainly through municipal waste water discharges. As is the case in other regions, microbiological pollution of the Mediterranean Sea is principally the direct result of the discharge of untreated or partially treated sewage into the immediate coastal zone. Microbial pollution and its effects have been mitigated along the EU Mediterranean coast since the installation of urban wastewater treatment plants in most of the European urban areas. However, the problem elsewhere remains as severe as before. Rivers also add a considerable amount of microbiological pollution, mainly from upstream waste water discharges, but their relative contribution to the pollution of the Mediterranean by micro-organisms (pathogenic and otherwise) has not been assessed in this report. One current area of concern is that of viruses. Those so far isolated in the various matrices of the Mediterranean marine environment are listed in the table. The geographical imbalance in the occurrence of viruses is caused by the difficulty in isolation and quantification. The favourable climatic conditions which lure to the Mediterranean coast one third of the global tourism also provide conditions for relatively long and frequent bathing exposure and beach overcrowding, and thus the area is potentially more conducive to disease transmission and contraction than would be expected in more temperate regions, such as northern Europe (EEA 1999).

The major sources of pollution responsible for faecal bacteria in bathing water are a) Pollution from sewage; b) Water draining from farms and farmland; c) Animals and birds on or near beaches. While the second source is not directly related to coastal tourism, the other two are either caused or affect coastal touristic activities (EEA 2015).

According to the provisions of the EU's revised Bathing Water Directive (2006/7/EC), all EU Member States monitor each year their bathing sites, by defining the length of their bathing season and establishing a monitoring calendar for each bathing water site before the start of the bathing season. During the bathing season, samples from coastal and inland bathing water sites are taken and analysed. Laboratories count the numbers of two microbiological organisms present - intestinal enterococci and *Escherichia coli* (also known as *E. coli*) - which indicate the potential presence of pollution. Local results are usually compiled at national level and, by the end of the bathing season, reported to the European Commission and the EEA (EEA 2015). In 2015, EU Member States reported 14 791 coastal bathing water sites. Coastal sites were monitored in all 23 EU Member States with access to the sea. More than 60 % of these are situated on Mediterranean Sea coasts. Comparing 2014 with 2015 bathing seasons, at least sufficient quality was achieved at 97.1% of EU coastal bathing water sites, representing a 0.3 percentage point improvement. The share of bathing water sites with excellent quality increased from 81.3 % in 2011 to 85.8 % in 2015.

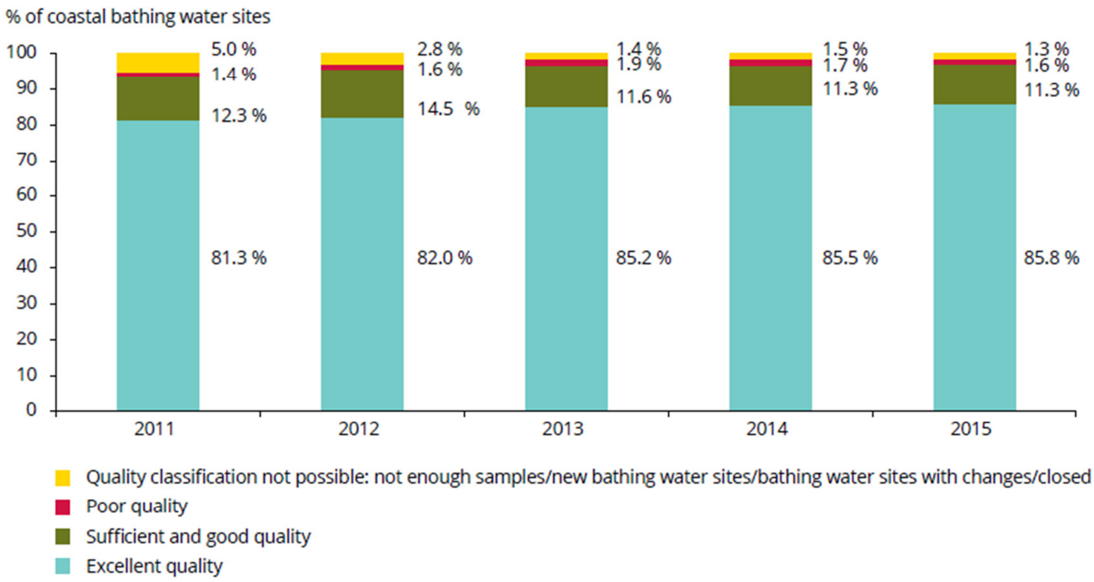

Figure 3: Coastal bathing water quality in the European Union between 2011 and 2015. Source: WISE bathing water quality database (data from annual reports by EU Member States). Detailed data on bathing water quality are available at http://www.eea.europa.eu/data-and-maps/data/bathing-water-directive-status-of-bathing-water-8.

3.4 Eutrophication

Eutrophication results from the increase of nutritional resources to a particular water body and includes the supply of mineral nutrients (nitrogen, phosphorus, silicon, trace elements) as well as organic carbon. Discharges and emissions from land-based sources (industry, households, traffic, and agriculture) provide large inputs of nutrients to coastal waters via rivers, direct discharges, diffuse sources and deposition from the atmosphere. However, eutrophication cannot be defined just in terms of an increase in nutrients concentration, as its manifestations (very often harmful to ecosystems) occur due to the existence of natural conditions, such as high temperatures and calm coastal waters. In the recent past eutrophication has been most pronounced in the developed world, but it has to be expected that it will become more and more important in the developing countries of Asia, Africa and Latin America in the near future.

Additional atmospheric input of inorganic nitrogen has increased significantly to a level where it is already higher than the natural nitrogen supply in the North Atlantic Ocean basin. It is expected that the worldwide production of nitrogen (mainly from fertilizer industry and the burning of fossil fuel) will affect the biogeochemical cycles on a global scale. Unfortunately, the interactive effects of the altering N-cycle on the carbon cycle (including the dynamics of greenhouse gases within both cycles) are poorly understood.

The effects of eutrophication vary from increased growth of phytoplankton, benthos and fish to changed species composition at moderate eutrophication; from blooms of nuisance causing or toxic algae to mass growth of certain species and mortality of others at severe eutrophication, and ultimately to anoxic conditions and mass mortality (fish kills). An algal biomass related phenomenon such as oxygen depletion of the water column and consequent mortality of animals can be prevented by a general reduction of nutrient discharges. At present, mathematical models on ecosystem dynamics are reliable enough to estimate dose-effect relationships. Algal species related harmful effects are less predictable. There is a general consensus that there is a global increase in harmful algal blooms. Also, there are reports which suggest a link between blooms of toxic algae and human activities such as salmon (or fish) farming. Changes in N:P:Si ratios may also cause a shift in species composition. Consequently, alterations in pelagic and benthic communities are to be expected.

Monitoring chlorophyll (Chl) concentration, which is a proxy of phytoplankton biomass, is an efficient tool for recording and understanding the response of the marine ecosystem to human pressures and thus for detecting eutrophication. Colella et al. (2016) have computed Chl trends over the Mediterranean Sea for the period 1998-2009 by using satellite data. Highest Chl concentrations were found in coastal water, in proximity of the river outflow, being conditioned by the nutrient of natural origin carried by rivers (Figure 4). The highest levels of Chl concentration were detected along the Adriatic seaside, along the Nile Delta, and between Tripoli and Sfax along the Tunisian coastline.

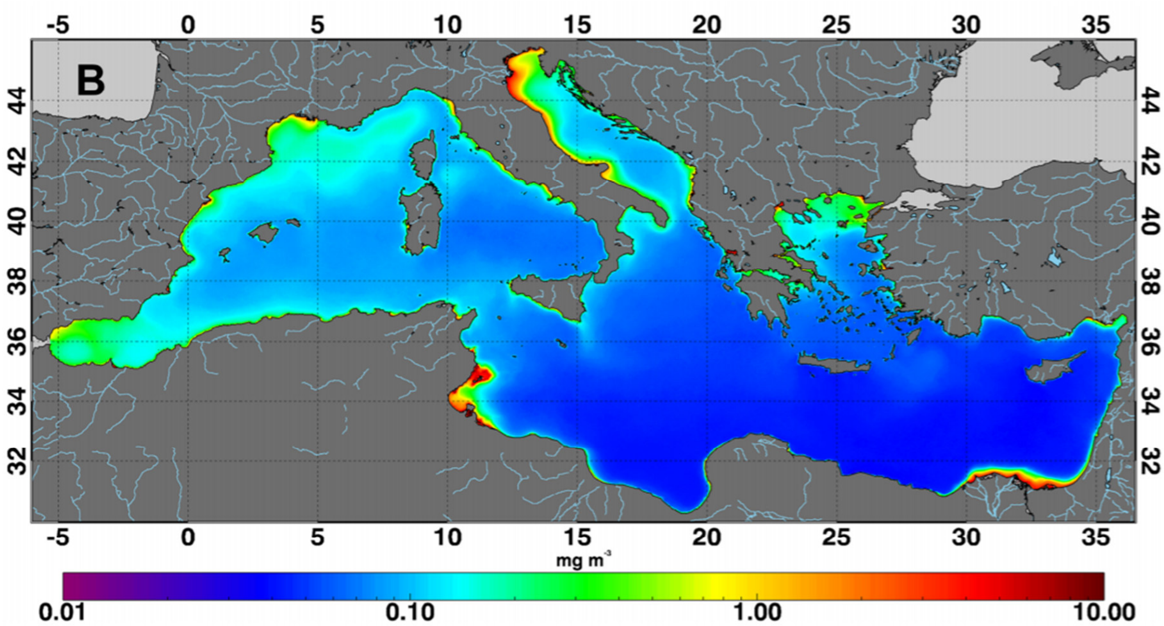

Figure 4: Chl concentration climatology over the Mediterranean Sea relative to 1998–2009 time period (from Colella et al. 2016).

Concerning the future trends, a slight to moderate decrease in eutrophication levels is predicted, when looking at long term scenarios like 2030 or 2050 (Table 4; Campling et al. 2013). Only Cyprus seems to maintain its current eutrophication levels (Table 4).

Table 4: Area (km^2) of ecosystems with nitrogen deposition above critical loads for eutrophication in the Baseline scenario (2005); (from Campling et al. 2013).

Country	2005	2020	2030	2050
Austria	29,403	19,867	17,223	16,075
Belgium	142	28	26	20
Bulgaria	31,492	16,319	14,250	14,429
Cyprus	2,528	2,528	2,528	2,528
Czech Rep.	2,075	1,819	1,696	1,677
Denmark	4,275	4,245	4,234	4,232
Estonia	9,709	4,817	4,421	4,986
Finland	25,607	9,931	7,284	7,840
France	156,660	133,325	124,849	122,825
Germany	64,092	53,327	50,320	48,943
Greece	58,219	55,971	54,671	55,198
Hungary	23,844	21,038	19,168	18,392
Ireland	1,218	644	636	1,162
Italy	99,239	64,519	58,625	59,057
Latvia	32,423	27,882	26,282	27,538
Lithuania	19,277	18,948	18,897	18,933
Luxembourg	1,156	1,126	1,116	1,116
Malta	0	0	0	0
Netherlands	4,172	3,938	3,897	3,885
Poland	71,968	62,580	59,374	60,740
Portugal	32,721	32,618	32,595	32,638
Romania	93,689	89,134	88,213	87,776
Slovakia	22,104	20,043	19,520	19,378
Slovenia	9,383	3,806	2,332	2,055
Spain	211,492	203,678	202,396	204,624
Sweden	82,366	48,596	42,704	46,478
United Kingdom	8,505	4,134	3,908	5,166
Croatia	28,575	25,390	24,524	24,345
EU-28	**1,126,336**	**930,252**	**885,686**	**892,038**
Non-EU	996,153	868,366	853,455	884,838

3.5 Solid waste

Tourism can sustain high levels of employment and income, but the sector is a source of environmental and health impacts. One of the most important is the generation of municipal solid waste (MSW). However, there is a lack of studies which quantify how much solid waste the tourist population produces and how it engages in total and separately collected recyclables. In addition, there is no scientific evidence on whether the proportion of waste generated by the tourist population is the same as that of the resident population, and whether the effect of the tourist population on MSW extends over the following months or not (Mateu-Sbert et al. 2013). Separately collected recyclables (the separation of materials intended for recycling) is particularly necessary in small islands, because they are environmentally more vulnerable to growth in the amount of solid waste and any negative effects on health may spread more quickly (World Health Organization, 1996). In this sense, one of the few studies focused on the specific impact of coastal tourism on solid waste production revealed that there is an increase both in waste production and in separately collected recyclables during touristic season. This study was performed in Menorca (Spain), thus providing a worthy example of environmental impacts of coastal tourism in small Mediterranean islands. In particular, the research showed that a 1% increase in the tourist population in Menorca causes an overall MSW increase of 0.282% and one more tourist in Menorca generates 1.31 kg/day (while one more resident generates 1.48 kg/day).

European statistic datasets provide valuable information on the trend of waste production, although no clear relationship with touristic presence can be done. Municipal waste generation in Europe has slowed down and stabilised at about 520 kg per capita since 2002 (Blumenthal 2011, Figure 5). However, this is not entirely true when looking at single country statistics, especially those in the Mediterranean Basin. Italy, Malta, France and Greece have steady increased their production over time, while Spain has decreased it from 2002. Slovenia’s waste production has increased from 2002 to 2009, while for Croatia, Montenegro and FYROM no data is available, which is not a good sign (Figure 5).

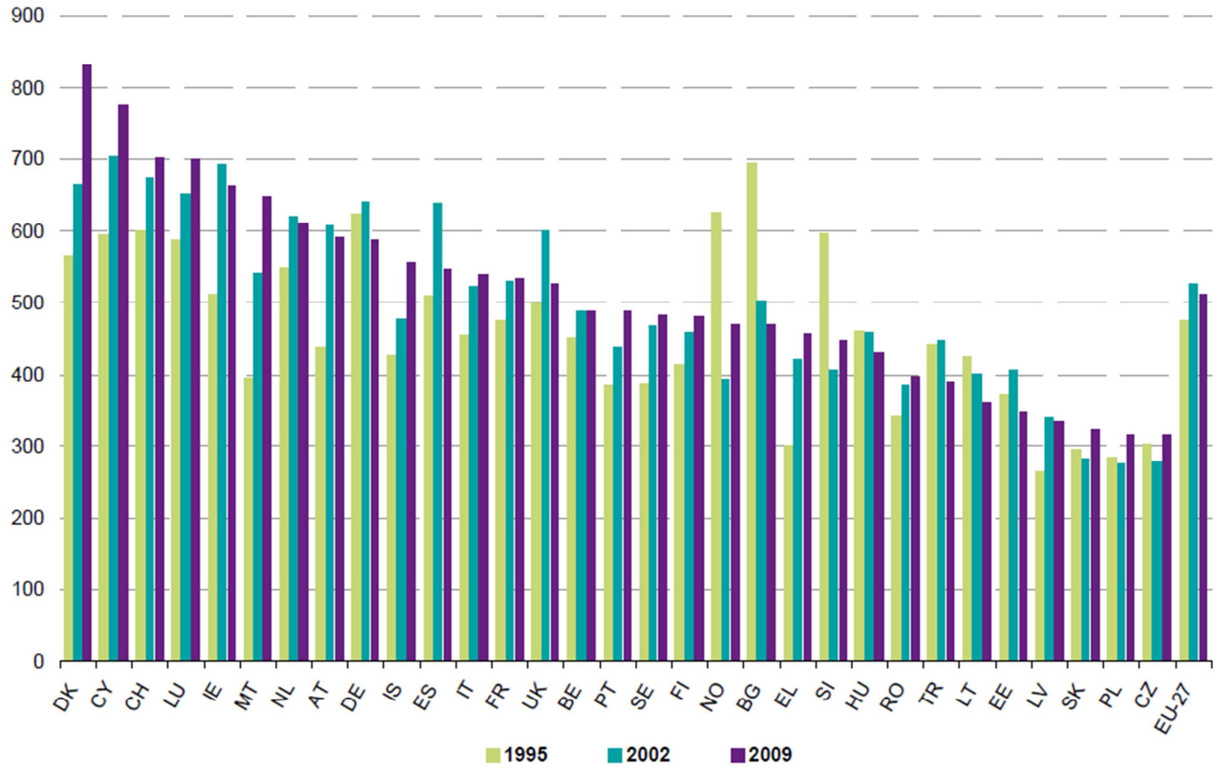

Figure 5: Municipal waste (kg per capita) generated by country in 1995, 2002 and 2009, sorted by 2009 level (from Blumenthal 2011).

3.6 Marine Litter

There is no doubt as to the economic, social and environmental damage caused by coastal and marine litter. It is estimated that 100000 sea mammals are killed each year worldwide by ingesting plastic bags and bottles, or becoming entwined in discarded fishing line. The United Nations Environment Programme reports that over six million tons of litter is dumped in the sea each year. Out of that amount, roughly 15 percent is washed onto beaches, a further 15 percent floats on the surface of the water, and 70 percent sinks to the bottom, often accumulating in so-called ‘dead zones’. Litter from tourism and possibly recreational sailing appears to be on the increase. The challenge is to devise policies and actions that target tourist litter as effectively as they are confronting shipping litter. Local authorities spend millions each year collecting litter from beaches and inshore waters. There are also other economic consequences such as the loss of income from tourism and the damage to ships and fishing gear.

Despite the significance of the issue, data collection in the Mediterranean is not uniform and annual surveys are still dependent largely on the goodwill and enthusiasm of volunteers and NGOs. The most important document produced on the topic is the “Marine Litter Assessment in the Mediterranean” (UNEP/MAP 2015), which stresses how standardized research data concerning the problem of litter in the Mediterranean is still a necessity and information sharing between and among NGOs, research institutes and relevant authorities in the region regarding marine litter related data needs to be improved through a common information sharing system. However, the most relevant outcomes in relation to coastal tourism show that marine litter on beaches in the Mediterranean originates from tourism and recreational activities and is composed mainly of plastics (bottles, bags, caps/lids, etc.), aluminium (cans, pull tabs) and glass (bottles). Regarding marine litter floating in the sea, plastics account for more than 85% and litter densities are generally comparable to those reported from many other coastal areas worldwide.

As to impacts on biota, several studies have investigated the interactions of marine biota with marine litter (mainly plastics) in the Mediterranean basin. These studies unveil a vast array of species that are affected by litter, ranging from invertebrates (polychaetes, ascidians, bryozoans, sponges, etc.), fish and reptiles to cetaceans. Effects from the studies were classified into entanglement, ingestion, colonization and rafting.

Mediterranean countries have not yet drawn up their marine litter monitoring programmes in a coherent manner (if at all) via the use of harmonized monitoring methods across the region. Beach surveys are widely viewed as the simplest and the most cost effective method and therefore are the most frequently performed.

The majority of studies performed to date show a high variability in the density of litter depending the use or characteristics of each beach. For International Coastal Clean-up (Table 5), cigarette butts, plastic bags, fishing equipment, and food and beverage packaging are the most commonly-found items, accounting for over 80% of litter stranded on beaches.

Table 5: Top ten items by country (International Coastal Clean-up, ICC 2014) expressed as number of items/100m of beach

	Number of items per 100 m									
COUNTRY	Cigarette butts	Food wrappers	Beverage bottles (plastic)	Bottle caps (plastic)	Straws Stirrers	Grocery bags (plastic)	Beverage bottles (glass)	Other plastic bags	Paper bags	Beverage cans
Croatia	1540	97	21	86	0	83	34	74	36	22
Egypt	1	2	40	18	1	15	33	6	0	6
Greece	116	6	11	15	13	4	3	3	2	5
Italy	0	0	2	0	0	4	14	0	0	7
Malta	0	15	22	40	13	0	7	3	0	0
Slovenia	21	5	3	6	6	1	1	2	0	2
Spain	79	9	15	23	57	13	5	9	4	8
Turkey	785	14	29	73	22	26	18	4	4	26

For a summary of litter data collected throughout the Mediterranean please refer to UNEP/MAP 2015. The data belong to different periods and were collected by applying different methodologies; therefore no general trends can be elicited.

With regard to seafloor marine litter, Pham et al (2014) performed a large-scale assessment of distribution patterns through 588 videos and trawl surveys across 32 sites in European waters. According to their outcome, the highest litter density occurs in submarine canyons, whilst the lowest density can be found on continental shelves and on ocean ridges. The sites sampled by trawling in the Mediterranean revealed a relatively even distribution of litter but with a higher density on the continental slope, south of Palma de Mallorca (western Mediterranean) with a mean (±SE) of 4.0±1.8 kg of litter ha^{-1} as opposed to densities ranging between 0.7 and 1.8 kg of litter ha^{-1} at the other sites (Figure 6). Other high density Mediterranean hotspots were the area south of Crete and the Central Mediterranean Sea, not far from Italian coastline.

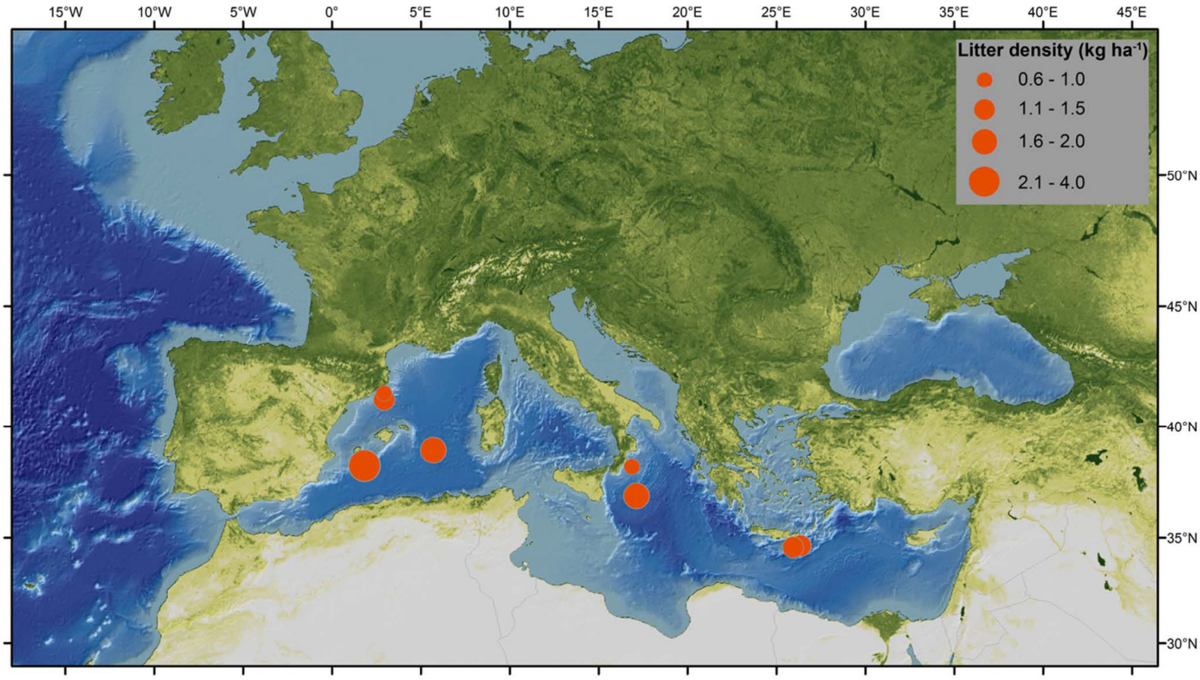

Figure 6: Litter densities (kg/ha) in different locations across the Mediterranean Sea obtained from trawl surveys (from Pham et al. 2014).

3.7 Ecosystem degradation and fragmentation

Habitat destruction is considered the most pervasive threat to the diversity, structure, and functioning of marine coastal ecosystems and to the goods and services they provide (Lotze et al., 2006). The loss of habitat structure generally leads to lower abundances (biomasses) and often to declines in species richness. There is often also a suite of colonizing species that prosper from these transitions (Airoldi et al. 2008). Habitat loss or fragmentation can also exacerbate overfishing by reducing fishable areas or decreasing productivity of marine environments (Newton et al., 2007), and may worsen the effects of global warming, affecting dispersal capacity of many species (Walther et al., 2002). However, there's scarcity of quantitative information about how humans are negatively affecting Mediterranean coastal ecosystems and how these threats can be managed (Claudet & Fraschetti 2010).

Globally, 21.8% of land area has been converted to human dominated uses. Habitat loss has been most extensive in tropical dry forests, temperate broadleaf and mixed forests, temperate grasslands and savannas and Mediterranean forests, woodlands and scrub (Hoekstra et al 2005). Over the centuries, land reclamation, coastal development,

overfishing and pollution have nearly eliminated European wetlands, seagrass meadows, shellfish beds, biogenic reefs and other productive and diverse coastal habitats. It is estimated that every day between 1960 and 1995, a kilometre of European coastline was developed. Most countries have estimated losses of coastal wetlands and seagrasses exceeding 50% of the original area with peaks above 80% for many regions. Conspicuous declines, sometimes to virtual local disappearance of kelps and other complex macro algae, have been observed in several countries. Coastal development and defence have had the greatest known impacts on soft-sediment habitats with a high likelihood that trawling has affected vast areas. In some regions, most estuarine and near-shore coastal habitats were already severely degraded or driven to virtual extinction well before 1900. Native oyster reefs were ecologically extinct by the 1950s along most European coastlines and in many bays well before that. Nowadays less than 15% of the European coastline is considered in ‘good’ condition. Those fragments of native habitats that remain are under continued threat, and their management is not generally informed by adequate knowledge of their distribution and status (Airoldi & Beck 2007).
Habitat fragmentation in meadows of *Posidonia oceanica*, the most important and abundant seagrass in the Mediterranean Sea, was investigated at a region-wide spatial scale using a synthetic ecological index, the Patchiness Index (PI). Results demonstrated that fragmentation in the *P. oceanica* meadows is strongly influenced by the human component, being lower in natural meadows than in anthropized ones, and that it is little influenced by the morphodynamic state of the coast (Montefalcone et al. 2009).

3.8 Wildlife disturbance and exploitation

Coastal tourism causes direct and indirect negative impacts on wildlife, for which there is sound evidence. Sea turtles provide good examples of population crashes due to human disturbance. Two centuries ago there were substantial numbers of green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles within the Mediterranean, all of which sustained breeding populations on the sandy beaches of southern Europe, Mediterranean islands (e.g. Corsica, Sicily, Malta) and North Africa. Green turtle breeding is now limited to Cyprus, while loggerhead populations (declining by as much as 10% per year) are confined to small areas of coastal Greece and Turkey. Leatherback breeding is now virtually unknown, occasional nests being reported in Israel and Syria. Gheskiere et al. (2005) have demonstrated that the upper zone of Mediterranean sandy beaches used by tourists have lower concentrations of organic matter, plus lower densities and diversities of invertebrates by comparison with neighbouring non-tourist beaches.

Apart for indirect impact, overexploitation represents another serious threat to Mediterranean biodiversity. For instance, Mediterranean fisheries resources are in a state of overexploitation driven by rising prices and demand in the past decades. Over-fishing and fishing practices largely account for the impact on natural stocks and habitats:

- Demersal fish stocks (close to the sea bottom) are usually fully exploited, if not over exploited, with a general trend towards smaller individual sizes;
- Small pelagic fish stocks are highly variable in abundance (depending on environmental conditions) and probably not fully exploited except perhaps, for the anchovy resources;
- Large pelagic fish stocks (tuna and swordfish) are overexploited also by international industrial fleets, especially the red tuna for which the Mediterranean is an important spawning area;
- Habitats of high biological significance, such as the *Posidonia oceanica* meadows, are frequently destroyed by trawl-nets operating close to the shore.

Figure 7 represents the hot spots for Mediterranean marine vertebrate species of special conservation concern, based on 110 critically endangered, endangered, vulnerable, or near threatened species. The Gibraltar Strait, Morocco and Tunisia coastlines and the Aegean Sea seem to be the most affected areas (Coll et al. 2010).

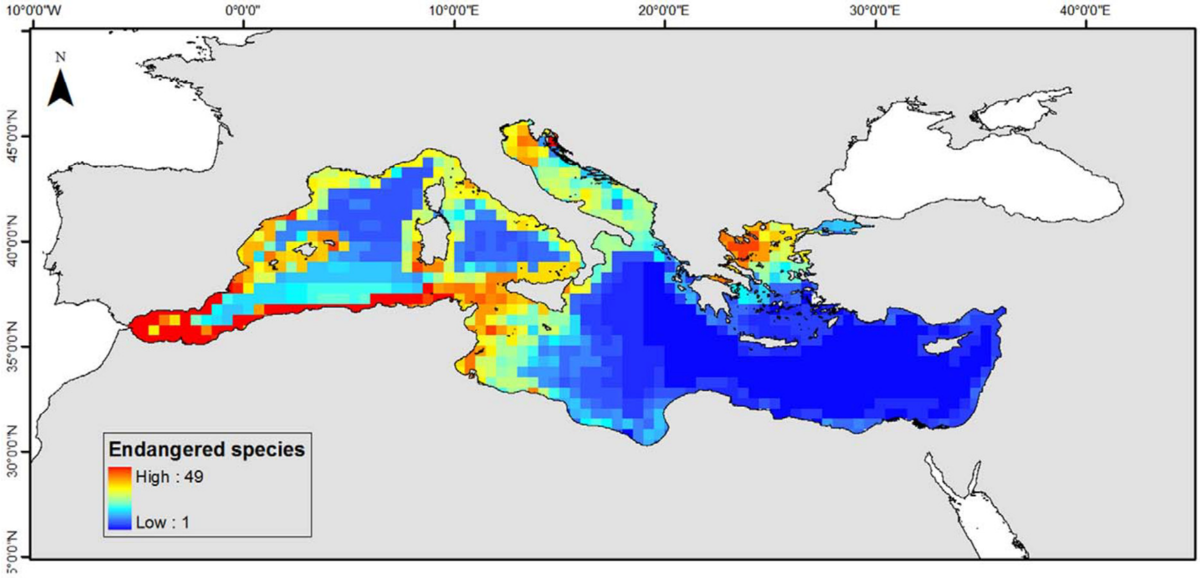

Figure 7: Biodiversity hot spots for Mediterranean vertebrate species of special conservation concern (from Coll et al. 2010)

3.9 Light pollution

Light pollution produces many impacts on the environment and the health of the beings living in it (animals, plants and man). In disrupting ecosystems, light pollution poses a serious threat in particular to nocturnal wildlife, having negative impacts on plant and animal physiology. It can confuse the migratory patterns of animals; it can alter competitive interactions of animals, change predator-prey relations, and cause physiological harm. The rhythm of life is orchestrated by the natural diurnal patterns of light and dark; so disruption to these patterns impacts the ecological dynamics. A large number of scientific studies and reports prove the negative environmental impacts of light pollution; unfortunately, they are still little known because this field of studies has developed since few years (Cinzano et al 2001).

99% of the European Union population lives in areas where the night sky is polluted. Assuming average eye functionality, about half of the European Union population have already lost the possibility of seeing the Milky Way (Cinzano et al. 2001).

Highly developed areas such many Mediterranean coastal cities are hotspots for light pollution, threatening their urban biota; the sky glow caused by artificial lighting from urban areas disrupts natural cycles, and has been shown to impact the behaviour of urban organisms, even many kilometres away from the light sources (Kyba et al. 2011).

The first World Atlas of the zenith artificial night sky brightness at sea level (Cinzano et al. 2001) provides a unconfutable evidence of how worrying is the situation in all developed countries. This first atlas was followed by a second very recent product (Falchi et al. 2016), made with the following methodology: data obtained from the VIIRS Day Night Band were propagated through the atmosphere using the radiative transfer code reported in Cinzano & Falchi (2012). The upward emission function and the radiance calibration are obtained using data from Sky Quality Meters (including data from Duriscoe et al. 2007; Falchi 2010; Kyba et al 2013, 2015 and Zamorano et al. 2016).

Figure 8 shows the hotspots for artificial sky brightness in the Mediterranean Basin (Falchi et al. 2016). The most polluted area coincides with the coastlines, while inland is much less affected by light pollution. This fact is especially true for non EU Mediterranean coastline. The Western EU Mediterranean most threatened coastal areas are: Barcelona, Valencia and Alicante in Spain; Marseille and Nice in France; Venice, Naples and Rome in Italy. On the non EU Mediterranean coastline, the most threatened coastal areas are Arzew and Algeri in Algeria; Tunisi in Tunisia; and Tripoli and Misurata in Lybia. Considering the non EU Eastern Mediterranean coastline, the most polluted areas are the Nile Delta, most of Israeli coast and Istanbul in Turkey. The Eastern EU Mediterranean coastline is less affected by light pollution than the Western one, with Athens and Thessaloniki only as hotspots.

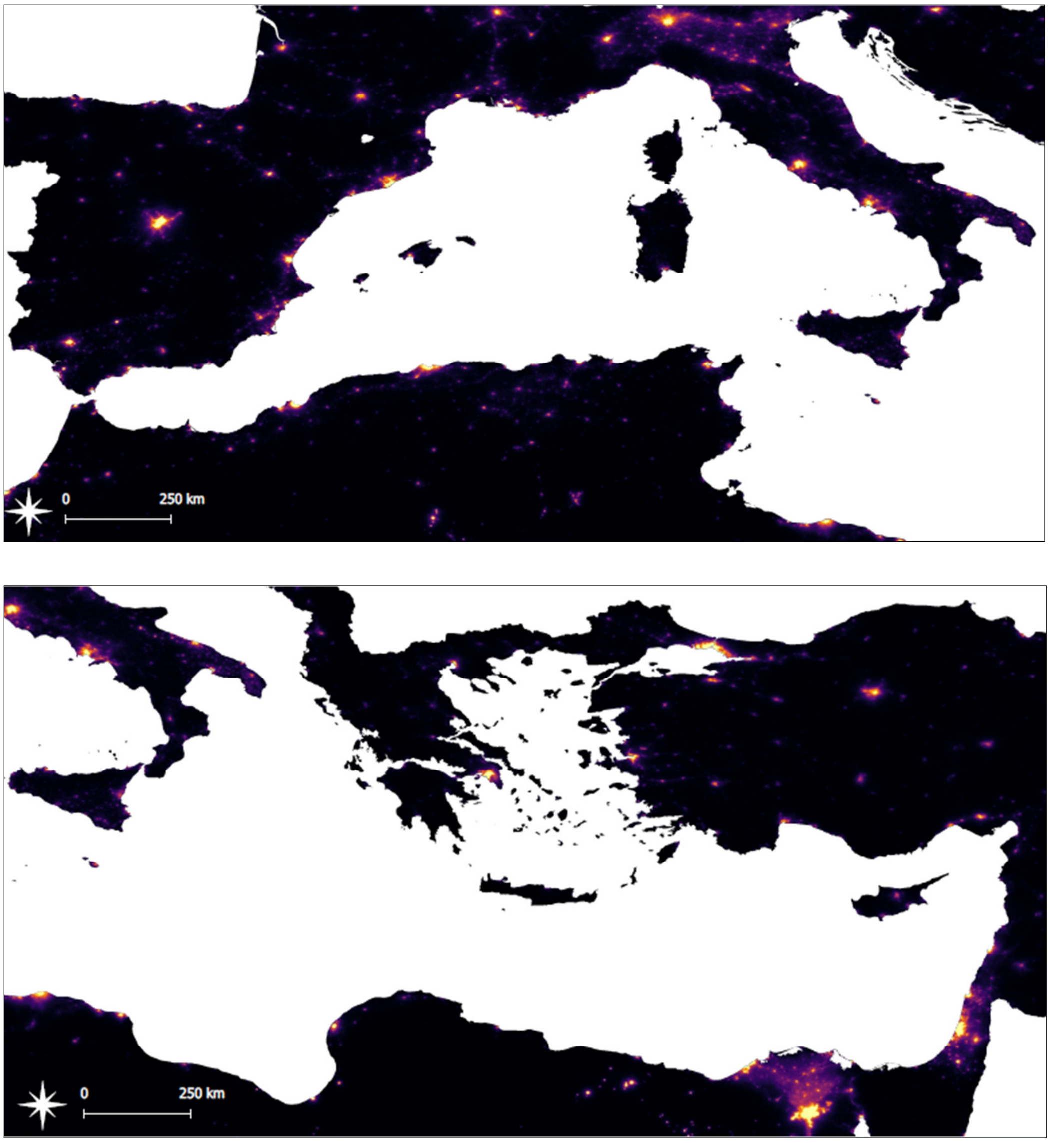

Figure 8: Artificial sky brightness in Western (above) and Eastern (below) Mediterranean Basin. Source: Falchi, Fabio; Cinzano, Pierantonio; Duriscoe, Dan; Kyba, Christopher C. M.; Elvidge, Christopher D.; Baugh, Kimberly; Portnov, Boris; Rybnikova, Nataliya A.; Furgoni, Riccardo (2016): Supplement to: The New World Atlas of Artificial Night Sky Brightness. GFZ Data Services. http://doi.org/10.5880/GFZ.1.4.2016.001

3.10 Invasive species

The invasion by alien species of new regions and territories is a phenomenon of paramount and global importance. It has been estimated that during the last four centuries invasive alien species have contributed to nearly 40% of animal extinctions with known causes. Invasive alien species have affected native biodiversity in almost every type of ecosystem on Earth and consequently, the Mediterranean region too. As one of the greatest drivers of biodiversity loss, second only to habitat loss and fragmentation, they pose a threat to ecosystem integrity and function and, therefore, to human well-being.

Several species are used by humans for commercial reasons but also to provide a number of services. This, in combination with the volume, intensity and range of human activities, has made the Mediterranean with its geographical specificities, exceptionally susceptible to invasions by species throughout history (Figure 9). The pathways and vectors that transport an invasive alien species are important components for a successful invasion. There is no doubt that shipping activities are the most important pathway of alien species in the Mediterranean. Ballast tanks of ships and the fouling on the outside of ships' hulls are significant vectors for marine bio-invasions in the Mediterranean. Aquaculture and mariculture provide pathways for unintentional introductions of alien species including escaped fish species, their parasites and diseases and self-dispersal of larvae and spawn (Figure 9). In addition to the Strait of Gibraltar, which is a well-known access route to the Mediterranean, the opening of the Suez Canal in 1869, has fostered over the years the introduction of alien species of Indo-Pacific and Red Sea origin into the eastern Mediterranean Sea (MIO-ECSDE 2013).

The Mediterranean Sea is considered to be one of the main hotspots of marine alien species invasions on earth and the rate of introductions appears to be steadily increasing. Nearly 1000 species (~ 10-15% of all species inhabiting the Mediterranean Sea) have experienced a successful introduction into the Mediterranean Sea, including species from the Red Sea, the Black Sea and the Atlantic Ocean. Perhaps the most notorious and best studied invasive species in the Mediterranean are a pair of coenocytic chlorophytes *Caulerpa taxifolia* and *Caulerpa racemosa* var. *Cylindracea* (MIO-ECSDE 2013, Zenetos et al. 2012).

The Delivering Alien Invasive Species In Europe (DAISIE) project, funded by the sixth framework programme of the European Commission (Contract Number: SSPI-CT-2003-511202), provides valuable information on biological invasions in Europe, delivered via an international team of leading experts in the field of biological invasions. It aims at creating an inventory of invasive species that threaten European terrestrial, fresh-water and marine environments, and to structure the inventory to provide the basis for prevention and control of biological invasions through the understanding of the environmental, social, economic and other factors involved (http://www.europe-aliens.org). Information is available at country level, but no lower spatial detail exists on this platform.

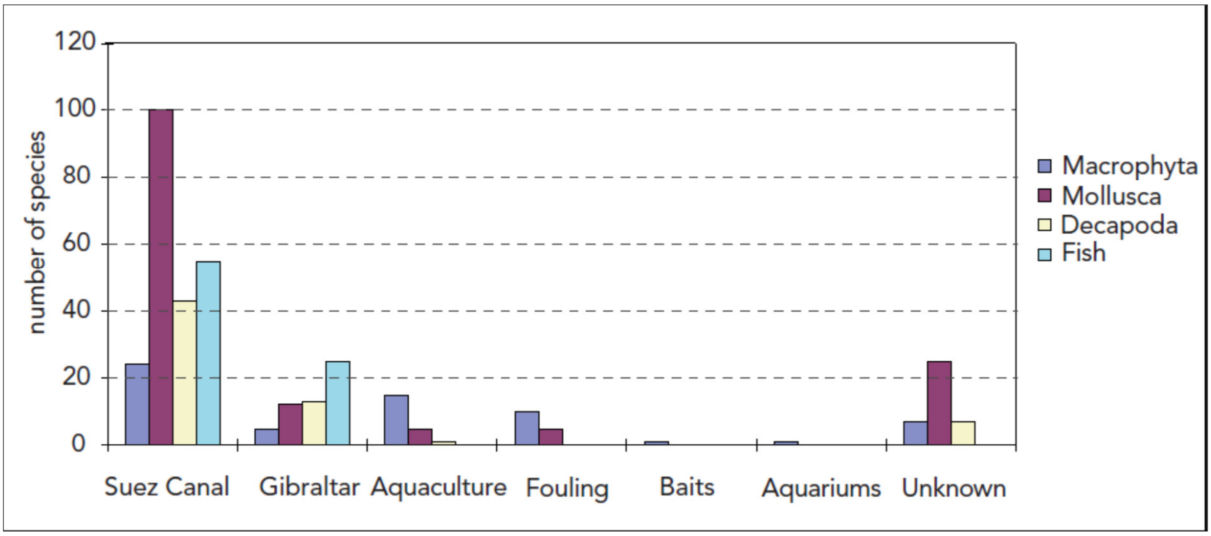

Figure 9: Example of introduction routes for non-indigenous species in the Mediterranean Sea (from ETC/MCE 1999)

The MSFD includes descriptor D2: "Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems" as one out of the eleven qualitative descriptors for determining Good Environmental Status (GES). The two criteria for assessing GES in relation to D2 are: a) abundance and state characterisation of non-indigenous species, in particular invasive species [criterion 2.1], and b) Environmental impact of invasive non-indigenous species [criterion 2.2]. In regards to criterion 2.2 it must be pointed out that the ecological impacts of invasions are often inferred from distribution data under the assumption that the more abundant the alien species, the more severe the impact. Although more than 1300 marine species have been introduced in European Seas, the impact on local ecosystems has been studied only for fewer than 100 species. The Convention on Biological Diversity (CBD) workshop in 2011 has pointed to an indicator for assessing progress towards the implementation of the Strategic Plan for Biodiversity 2011–2020 and achievement of the Aichi biodiversity target 9. "Trend in number of invasive alien species" was proposed as a priority tool to be developed at global level, while 'Trends in invasive alien species pathways management' was proposed for consideration at sub-global level. At this context Zenetos et al. (2012) serves as an updated list of alien species in the Mediterranean (including non EU countries) accommodating recent findings and latest nomenclatural changes, and attempting to assess trends in: 1) temporal occurrence per MSFD area/and introduction rate per major group; and 2) pathways of spreading per MSFD area. Recently a standardized and quantitative method has been developed for mapping cumulative impacts of invasive alien species on marine ecosystems focusing in the Mediterranean area (Katsanevakis et al 2016, see also D3.9.2).

The Marine Alien Invasive Species Strategy for the Mediterranean MPA network aims at giving answers to "actions on all non-native marine species", at several scales: a) at the MPA network scale, that is a scale particularly relevant due to the often very mobile behaviour of many invasive species; b) at the level of each MPA; c) at the general marine scale to create a better understanding and information on the invasive species issue. The method of the strategy is based on MedMIS platform, which provides a searchable gallery for species information with identification factsheets, long-term centralized database on marine alien species, Resource library and alert system Communication Protocol (http://msp-platform.eu/practices/marine-alien-invasive-species-strategy-mediterranean-mpa-network).

Figure 10 reports the number of alien species reported for each MPA involved in MedMIS platform. Although these figures can be biased by the different collection and reporting efforts, they can still give a first overview on the most affected areas. For instance, in Corsica 332 marine alien species have been reported so far, while only eight exist in the Nature Park prirode Lastovsko Otočje, a Dalmatian island.

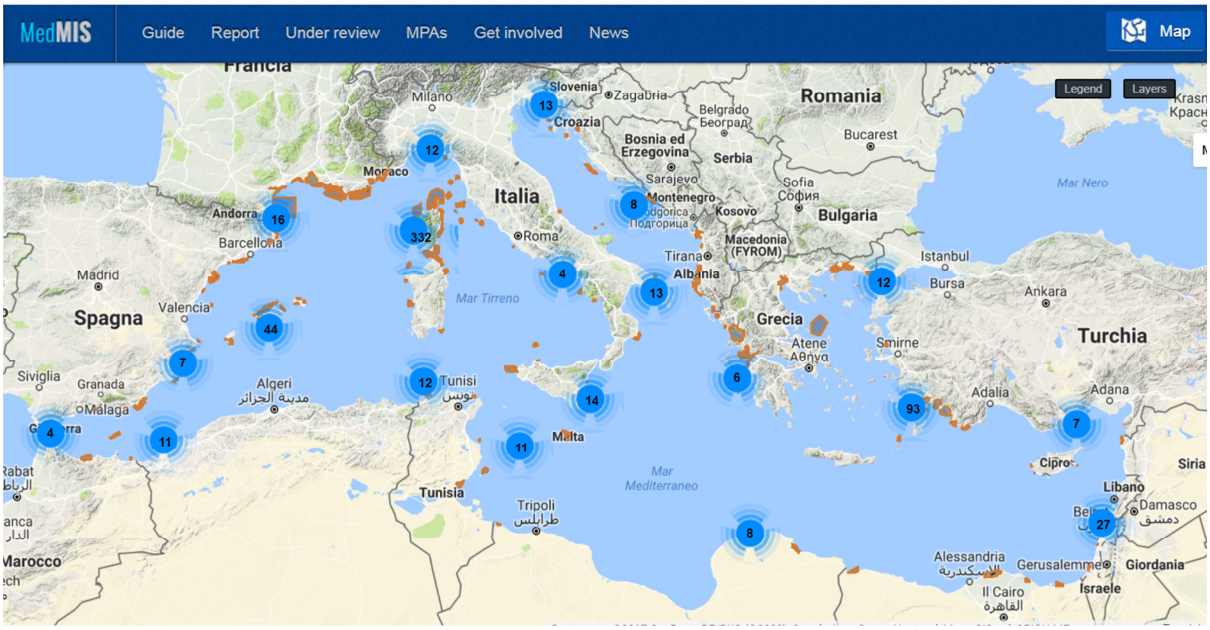

Figure 10: The platform MedMIS gathers a database of marine alien species occurring in the Mediterranean Marine Protected Areas (http://www.iucn-medmis.org).

3.11 Threat indicators in the Mediterranean Basin: the CO-EVOLVE approach

After an analysis of the main tourism-related menaces threating the Mediterranean Basin, a set of threat indicators caused by coastal and maritime tourism is here presented. The assessment focused on the development of appropriate indicators, which could be adequately populated at the selected scale.

Based on the impacts detected and described in the previous Chapter, seven indicators could be populated at NUTS2 or NUTS3 level. Moreover, maps of ecological risks could be built upon such indicators (see Deliv. 3.5.4). Table 2 shows these threat indicators (called *POPULATED* CO-EVOLVE threat indicators) and their relationship with EcAp and ETIS core indicators.

ETIS indicators are a set of 43 indicators covering the fundamental aspects of sustainability monitoring and providing the basis for effective destination management (EC 2016). Through the collective work carried out in CO-EVOLVE, these indicators were refined in order to achieve a “Maritime and Coastal Tourism Sustainability Toolkit” which includes also 5 sets of Supplementary Indicators. These Supplementary Indicators allow touristic destinations to tailor the system to their own particular needs or destination category, e.g. mountain, city, rural, coastal, island and urban areas, as well as coordinated approaches and macro-regional and/or transnational dimensions (EC 2016). For a complete description of the ETIS indicators refer to D3.16.2.

In the case of the indicators specifically addressed to express the main impacts to coastal and maritime ecosystems, a correspondence between ETIS and CO-EVOLVE threat indicators was found for Solid Waste. It is the following:

“Waste production per tourist night compared to general population waste production per person (kg)” vs “Unitary waste production compared to overnight stays” (Table 6).

The difference between the two indicators is that ETIS indicator refers to waste production per tourist night, while CO-EVOLVE indicator employs waste production by inhabitants and compares it with the overnight stays. This is due to the fact that waste production per tourist night can’t be populated, due to lack of data at the required scale.

EcAp indicators are indicators proposed within the Integrated Monitoring and Assessment Programme (IMAP) as part of the Ecosystem Approach (EcAp) adopted in 2008 by the Contracting Parties of the Barcelona Convention, as already presented in the Deliv. 3.9.1.

In our analysis, correspondence between EcAp and CO-EVOLVE indicators was found for Water Pollution. The more comprehensive CO-EVOLVE indicator “Bathing water quality” was proposed instead of the more specific EcAp indicator “Concentration of key harmful contaminants measured in the relevant matrix”, as good spatial information on bathing water quality was available (http://www.eea.europa.eu/data-and-maps/data/bathing-water-directive-status-of-bathing-water-8).

Table 6: Threat indicators populated and mapped within CO-EVOLVE analysis, and their comparison with EcAp and ETIS indicators.

THREAT Category	EcAp indicator	ETIS core indicator	***POPULATED*** CO-EVOLVE threat Indicator
Air pollution	/	/	Artificial land cover surface (airports, roads, industry and urban areas) over total surface
Solid Waste	/	Waste production per tourist night compared to general population waste production per person (kg)	Unitary waste production compared to overnight stays
Ecosystem degradation and fragmentation	/	/	Natural land cover surface over artificial land cover surface
Water pollution	Concentration of key harmful contaminants measured in the relevant matrix	/	Bathing water quality
Noise pollution	/	/	N. people exposed to road noise over 55 dB
Light pollution	/	/	Artificial sky brightness
Eutrophication	/	/	TRIX index

4. Pressures to coastal ecosystems

After an assessment of the main impacts specifically caused by coastal tourism, this section provides a larger overview on the causes of human-made ecosystem degradation, embracing the main drivers impinging on ecosystem integrity.

As already introduced earlier, concentration of populations (resident and non-resident) and human activities around the Mediterranean basin present considerable threats to coastal ecosystems and resources in four major areas:
- On the structure and function of natural ecosystems as a result of the construction and operation of facilities for human activities and the associated urbanisation and activities development;
- on the quality and quantity of natural resources (forests, soils, water, fisheries, beaches, etc.) as a result of increasing concentrations of people and activities adding to the demand for their use and exploitation and subsequent disposal of wastes;
- On the coastal zones as a consequence of the development of different human activities and associated facilities as well as on the competition among conflicting users;
- On the natural and man-made landscape as a result of the changes of activities, and of size and scale of related facilities and associated development.

As shown in Figure 11, the population is projected to increase in future in most of Mediterranean Basin, with the highest numbers foreseen for the non EU Mediterranean countries (especially Turkey and Egypt). Consequently, pressures on the coastal zone are likely to increase in the future, and especially in these countries. In particular, an estimation of a doubling of tourism-related development in the Mediterranean in the next future is foreseen (EEA 1999).

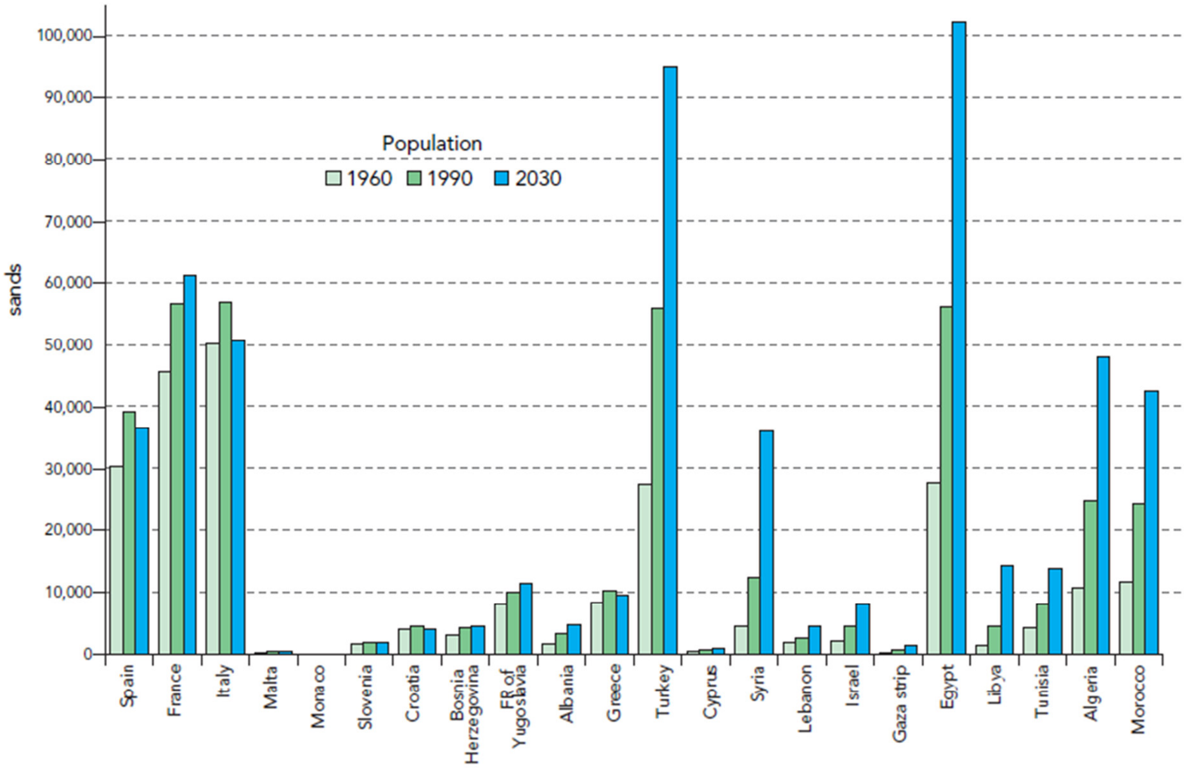

Figure 11: Population increase in the different Mediterranean countries. Source: Blue Plan databases, United Nations, World Population Prospect, the 1994 Revision.

4.1 Human activities along the Mediterranean coastline

Intensive Agriculture

Intense agricultural activity is carried out in the limited coastal plains, often as a result of reclamation of wetlands. The role of agriculture in changing coastal environments of the Mediterranean basin is more indirect than direct and primarily affects the dynamics of wider areas. In most countries, all types of agricultural practices and land use lead to diffuse pollution of water and, hence, are difficult to quantify. Agricultural land is one of the resources on which the pressures of development are the strongest, particularly on the narrow coastal strip bordered by desert regions on the southern coast. Other threats caused by agriculture are soil erosion and nutrient surplus (eutrophication) when excessive fertilisers are applied.

Fisheries & Aquaculture

Mediterranean fisheries exert pressure on the environment as well as on the fish stocks. The overall value of the landings is still high in comparison to the relatively modest tonnage (approximately 1.3 million tonnes) landed. There have been relatively small changes in fishing techniques in the Mediterranean area during recent years. The number of fishing vessels increased from 1980 to 1992 by 19.8 %. Fleet technology in the industrialised EU countries is very high and there has been a shift from labour-intensive to more capital intensive vessels, such as larger trawlers and multi-purpose vessels. The amount of 'passive' fishing by lost fishing nets has generally increased but the number of trawlers has remained steady since 1982.

Marine aquaculture has shown a large expansion in production in a number of Mediterranean countries over recent decades, increasing from 78000 tonnes in 1984 to 248 500 tonnes in 1996 (freshwater aquaculture not considered). Its future development will have to be considered in relation to all other existing and planned activities. The careful selection of sites where aquaculture could be done, with precise definition of their environmental carrying capacity, will contribute to minimisation of nutrient loads on the ecosystem and to reduction of the effects of negative feedback which may eventually affect the production potential of fish-farming activities.

Industry

There is a large range of different industrial activities (from mining to manufactured products) scattered all around the Mediterranean basin, and a number of hot-spots are concentrated mainly in the north-west, generated by heavy industry complexes and big commercial harbours. Discharges and emissions of contaminants from this industry pose an environmental threat especially in the area of the hot-spots. Pressures from industry in the basin include mainly the chemical/petrochemical and metallurgy sectors. Other main industrial sectors in the coastal region are: treatment of wastes and solvent regeneration, surface treatment of metals, production of paper, paints and plastics, dyeing and printing and tanneries.

The export specialisation in each country provides a fairly precise image of the industrial activity which is most important in that country and could primarily cause environmental threats. Three groups of countries can be distinguished:

1. Countries highly specialised in exporting only few products, the rest being imported. This is typical of oil producing countries such as Algeria, Syria, Egypt and Libya;

2. A less specialised group, exporting goods even in a situation of comparative disadvantage with other countries, are Tunisia, Morocco, Turkey, FR Yugoslavia, Cyprus and Malta, exporting goods such as clothes, textiles, and leather. Each one also has more specific productions (chemistry, oils and lubricants in Tunisia; chemistry and fertilisers in Morocco; textile fibres, wool, cotton, paper and cement in Turkey and FR Yugoslavia);

3. A strongly diversified and thus much less specialised group comprises the European Union Member states which account also for the biggest part of the petrochemical industry in the Mediterranean basin.

The impacts of industry on coastal areas can be direct or indirect. Direct impacts deriving from effluents from industry involve pollution problems at the site level (large commercial harbours, heavy industry complexes) that contribute to the creation of hot spots. Indirect impacts are related to the location of industries, ultimately leading to concentration of activities and urban development on the coast. Industry is also a major contributor to air pollution.

Maritime Transport

There are three major passage ways to and from the Mediterranean Sea: the Strait of Çanakkale/Sea of Marmara/ Istanbul Straits, the Strait of Gibraltar and the Suez Canal. The major axis (90 % of the total oil traffic) is from east to west (Egypt-Gibraltar), passing between Sicily and Malta and following closely the coasts of Tunisia, Algeria and Morocco. On average, there are about 60 maritime accidents in the Mediterranean annually, of which about 15 involve ships causing oil and chemical spills. The most accident-prone areas, because of the intense maritime traffic, are: the Strait of Gibraltar and Messina, the Sicilian Channel and the approaches to the Straits of Çanakkale, as well as several ports and their approaches, particularly Genoa, Livorno, Civitavecchia, Venice, Trieste, Piraeus, Limassol/Larnaka, Beirut and Alexandria. The geographical distribution of pollution 'hot spots' is related also to the density of shipping traffic on the various Mediterranean routes. The number of accidents increased in the Mediterranean Sea, with 81 events in 1991 - 1995, compared to 99 events in the previous ten years (1981-1990) (EEA 1999).

4.2 Threats indicators to and from tourism

From the brief review carried out in the previous section it appears clear that coastal tourism is not the only human activity impinging on coastal ecosystems. On the contrary, many other pressures exert their impacts on ecosystems.

In order to better explore the threats *from* and *to* tourism, we performed an expert-based evaluation aiming at assessing which are the main sources of impact causing each threat category. The results are reported in Table 6. Air pollution is mainly caused by industry, road and air transport, and intensive agriculture, but also by beach tourism and urban tourism. However, these two tourism typologies are themselves affected by the impact caused by industry, road and air transport and intensive agriculture. In fact, a resort placed in a polluted beach or city will attract in the long term fewer visitors than a pristine one.

Looking at the threat category “wildlife disturbance and exploitation”, it is directly or indirectly generated by most of the selected human activities. In fact, Aquaculture & Fisheries if performed in an unsustainable way can pose a threat to recreational boating and cruising. In the same way, natural coastline can be fragmented both by intensively cultivated fields (for instance maize) and new industrial settlements, which threaten the coastal touristic potential of the whole area. A third example of the complex dynamics among multiple anthropogenic threats is Light Pollution. We learnt that this threat is generated by urbanization and development (industry), and particularly by beach and urban tourism. However, artificial sky brightness generated by beach and urban tourism can menace the development of more sustainable forms of tourism, such as eco-tourism. In fact, many eco-touristic activities like for instance sea-turtle nesting monitoring can’t be implemented with excessive artificial light.

More in general, we can conclude that:

- When coastal ecosystem integrity is ruined by human activity, many other competing human activities are also impacted;
- Coastal tourism development in particular needs support from integral ecosystems;
- Different coastal tourism typologies can negatively interfere with each other and cumulatively impact the ecosystems.

A further development of this concept (multi-pressure assessment) is part of the Deliverable 3.9.2-3.9.3.

Table 7 summarises the contributions of human activities to the main threat categories previously investigated and also the associated indicators (CO-EVOLVE, EcAp and ETIS), as done in Table 6. However, in this table three new CO-EVOLVE indicators are inserted (those highlighted in light blue), in addition to those that could be populated and mapped. For these three indicators, no data at the required scale could be retrieved. Thus, we propose them in this list in order to stimulate further development in data production by relevant institutions.

Going into details on the proposed indicators, for Marine Litter we propose to adopt the indicator "Annual N. of litter items collected (per NUTS3)" instead of the ETIS indicator "Volume of litter collected per given length of shoreline", since the EU Marine Strategy Framework Directive stresses that for monitoring litter in the marine environment, number of items is mandatory whilst weight is only recommended (Pham et al. 2014). Ideally, both units for litter quantification help understand better trends, but different weights (e.g. heavy clinker vs. light plastic) cannot be compared.

Considering the threat Alien Species, our newly proposed indicator is "N. alien invasive species (per NUTS3)", which simplifies the EcAp indicator "Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas". Although important steps have been taken to tackle at European scale the issue of alien species (see for instance the DAISIE project (http://www.europe-aliens.org), to date no detailed and standardized information exists over their trends in abundance, temporal occurrence, and spatial distribution.

The third newly proposed CO-EVOLVE threat indicator is "N. endangered species (per NUTS3)", for which no correspondent ETIS and EcAp indicators exist. A valuable source of sound data to populate this parameter could be the IUCN Red List factsheets (http://www.iucnredlist.org/), as already mentioned in Paragraph 3.9. However, no information at NUTS3 scale is currently available.

Table 7: List of human activities impinging on each threat category, and correspondent, EcAp, ETIS and CO-EVOLVE indicators. The additional CO-EVOLVE indicators are highlighted in light blue (see Table 5 for comparison). Human activities: Ind= Industry; TR= Transport; IntA= Intensive agriculture; AF= Aquaculture & Fisheries; UT= Urban Tourism; BT= Beach Tourism; ET= Eco-Tourism; RB= Recreational Boating; CT= Cruise Tourism.

Human Activities	THREAT Category	EcAp indicator	ETIS indicator	CO-EVOLVE Threat Indicator
Ind; UT; BT; IntA; TR	Air pollution	/	/	% artificial land cover surface (airports, roads, industry; urban areas) over total surface
UT; BT; ET	Solid Waste	/	Waste production per tourist night compared to general population waste production per person (kg)	Unitary waste production compared to overnight stays
BT; UT; CT; AF; RB	Marine Litter	Trends in the amount of litter washed ashore and/or deposited on coastlines	Volume of litter collected per given length of shoreline	Annual N. of litter items collected (per NUTS3)
BT; UT; CT; AF; RB; IntA; Ind	Ecosystem degradation: wildlife disturbance and exploitation	/	/	N. endangered species (per NUTS3)
CT; AF	Ecosystem degradation: alien species	Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas	/	N. alien invasive species (per NUTS3)
BT; UT; IntA; Ind	Ecosystem degradation: habitat loss and fragmentation	/	/	Natural land cover surface over artificial land cover surface
BT; UT; Industry	Water pollution	Concentration of key harmful contaminants measured in the relevant matrix	/	Bathing water quality
BT; UT; Industry; TR	Noise pollution	/	/	Percentage of people exposed to road noise over 55 dB
BT; UT; Ind	Light pollution	/	/	Artificial sky brightness
IntA; Ind	Eutrophication	/	/	TRIX index

5. Conceptual framework for ecosystem quality and tourism sustainability

In the previous section we gave a comprehensive overview on main threats from and to coastal tourism and described proper indicators for measuring them.
Based on these achievements, this Chapter provides insight over the relationship between ecosystem quality (which is linked to management and protection) and coastal tourism.

5.1 CO-EVOLVE conceptual framework

From the assessment presented in the previous chapters, we understood that coastal tourism impinges on coastal ecosystems through manifold environmental impacts which threaten ecosystem integrity and functionality. We also recognized that, in addition to coastal tourism, many other human pressures disturb coastal ecosystems. Therefore, coastal tourism development is *indirectly* affected by other human activities, as both depend on the same resource. In addition, coastal tourism can be also *directly* damaged by other anthropogenic factors, for instance water pollution generated by intensive agriculture or industry.
It's clear then that only ecosystem integrity maintenance can assure the ecological services ecosystems provide, including the attractiveness for tourists. In other words, only coastal ecosystem services can guarantee the survival of coastal tourism and the other coastal human activities in the long term.
Such integrity maintenance can be achieved through adequate ecosystem protection and management measures, based on environmental policies and good practices, as explained in the Deliverable 3.9.1. The implementation of environmental measures guarantee the delivery of the benefits from those coastal ecosystem services identified and described in the Deliverable 3.5.1 and linked to tourism (especially cultural/aesthetic ecosystem services). These conceptual passages are schematized in Figure 12. On the one hand, multiple pressures to ecosystem and to coastal tourism are highlighted (red arrows); on the other hand, the crucial delivery of benefits from coastal ecosystem services is stressed (blue arrows). The Enabling Factors can protect and support this "supply" in the long term (yellow box).

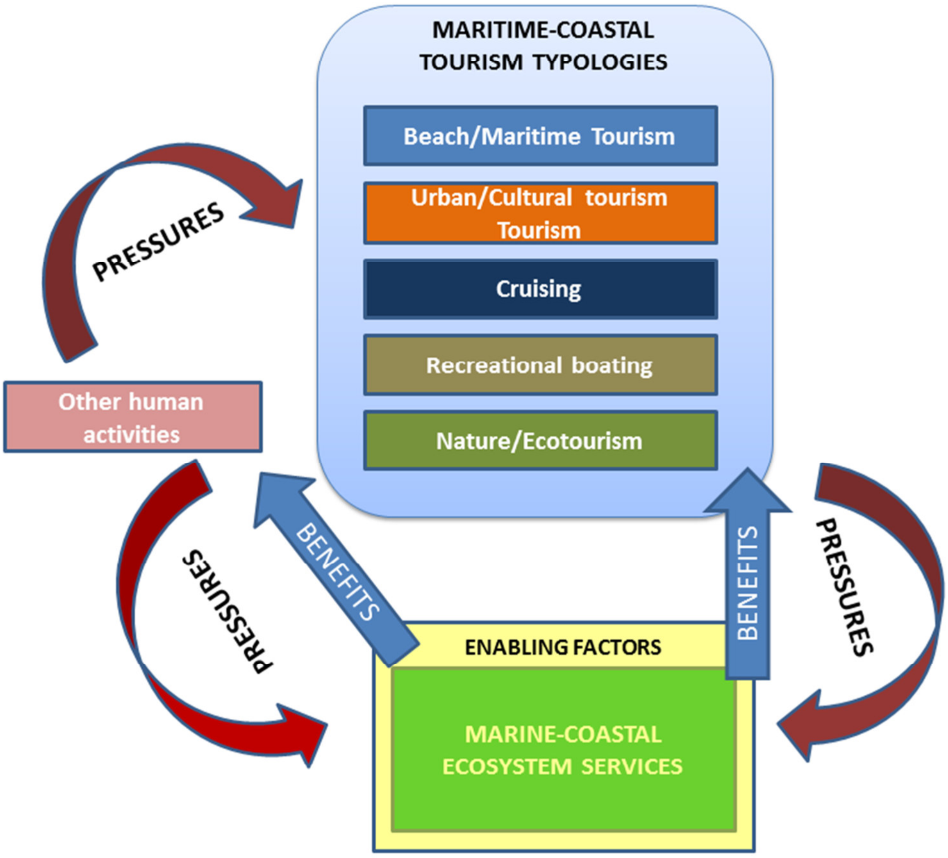

Figure 12: The conceptual framework for connecting coastal tourism typologies and the other human activities with the benefits supported by coastal ecosystems.

In order to better clarify the conceptual framework depicted in Figure 12 we applied it to the CO-EVOLVE tourism typology Recreational Boating. The orange boxes include the activities detected for Recreational Boating in the D3.5.1. Main pressures are listed in the red frames according to each pressure link, while in the blue frames we list three major benefits from coastal and marine ecosystem services (Figure 13).

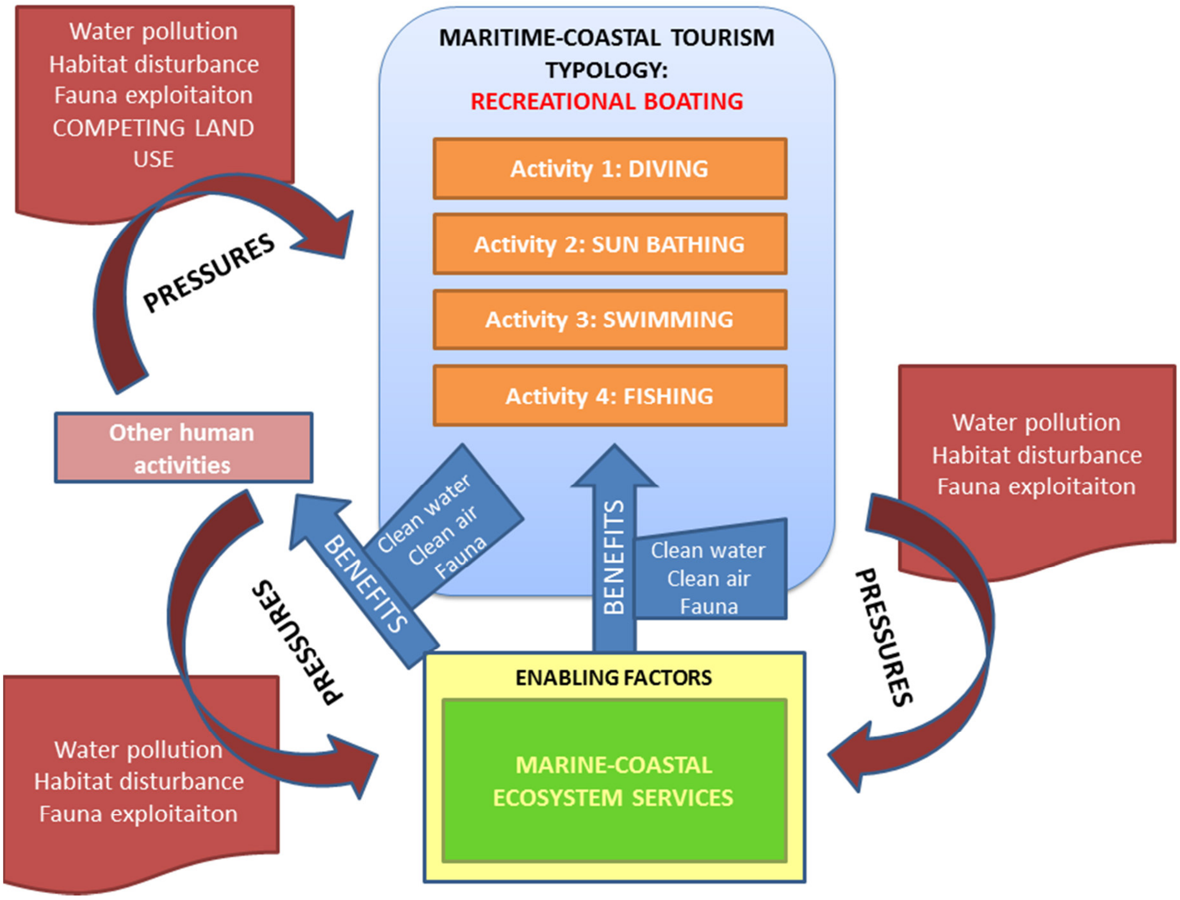

Figure 13: Application of the conceptual framework for connecting coastal tourism typologies and the other human activities with the benefits supported by coastal ecosystems to the tourism typology Recreational Boating.

5.2 Effects of ecosystem quality to coastal tourism

Regardless the crucial relevance of the above-mentioned concepts for sustainable tourism, the effects of ecosystem quality to tourism demand have been analysed very little, especially regarding marine ecosystems.

A very interesting investigation related to water quality change and its effects on human activities is offered by Keeler et al 2012. The authors show how change in water quality generated by different anthropogenic factors negatively affects the final value of recreational human activities as swimming, angling, nature viewing and so on (Figure 14).

Actions considered in the far left column of the Figure 14 include changing land use or land management as well as other drivers of water quality change, such as climate change, invasive species, and atmospheric deposition. Connections between columns are classified as primary or secondary, according to expert opinion.

Although not representative of all possible water quality changes, pathways, and effects on well-being, the figure highlights the most important and often-measured services.

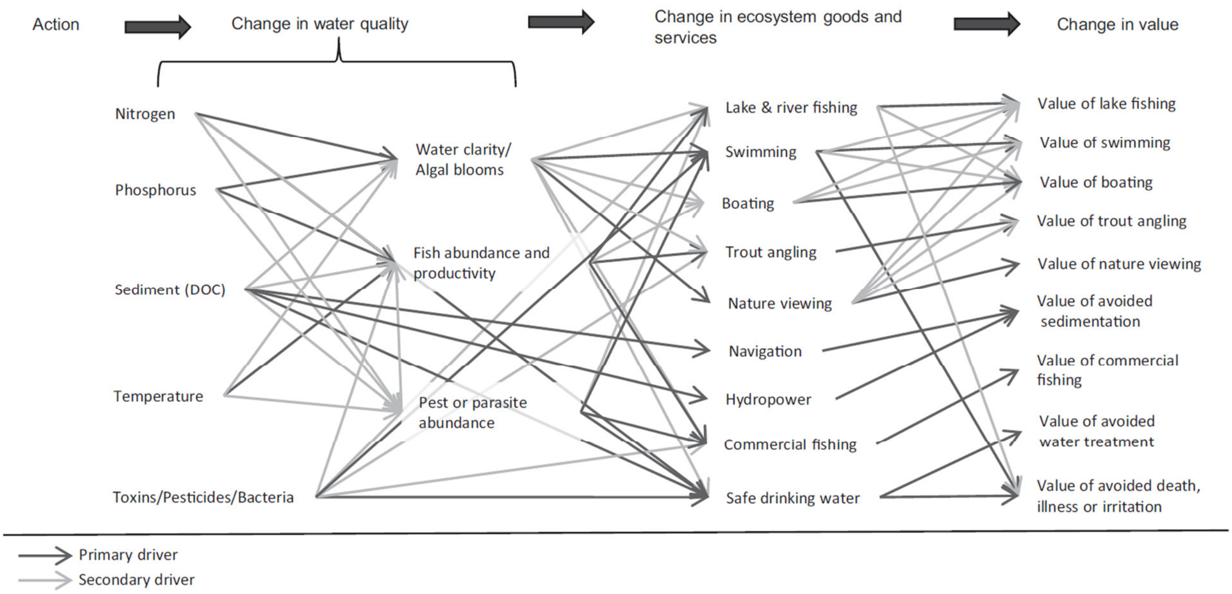

Figure 14: Relationships between water quality change, multiple ecosystem goods and services, and associated changes in values (from Keeler et al. 2012).

A valuable study on the effects of ecosystem quality on tourism sustainability in marine environments is provided by Otrachshenko & Bosello (2017), who use data on MPA and species that are overexploited or collapsed in several countries including the Mediterranean ones as a proxy for marine ecosystem quality. By using autoregressive distributive lag model their study suggested that the deterioration of marine ecosystem quality has a considerable negative impact on inbound coastal tourism. In particular, one percentage change in ecosystem deterioration measured by the suggested overexploitation index, determines 2.6% of tourism expenditure loss over countries analysed. In addition, in the model with the length of stay as the dependent variable, the short-term (current) impact of marine ecosystem quality constitutes only 38% of the overall long-term impact.

This finding suggests that the impact of marine ecosystem quality may be underestimated in a cross-section analysis. Overall, results provided valuable information for policy makers, suggesting that measures enhancing marine ecosystem quality should be considered in addition to conventional tourism policies focused on price. The role of MPAs in guaranteeing ecosystem quality is less straightforward to comment: on the one hand, more protected areas can reduce tourism activity. This was explained by observing that protection indeed imposes some restrictions to the touristic exploitation of an area. On the other hand, developing a richer model specification where MPAs interact with the most important economic variables, MPAs can reinforce the positive effects of GDP from origin countries on tourism demand.

The study by Otrachshenko & Bosello (2017) gives insight on how adequate legal protection of ecosystems can be a tool for sustaining tourism demand. Applying this concept to CO-EVOLVE framework, we obtain the scheme depicted in Figure 15, which can be summarised as the CO-EVOLVE approach to sustainable coastal tourism. The protection levels (good practices, different protection or preservation levels and so forth) of each ecosystem service should be guaranteed by a set of Enabling Factors, in order to achieve sustainability for each coastal touristic typology.
Enabling Factors for ecosystem protection recognized within our overall analysis are conservation policy measures, described in depth in D3.9.1, and cumulative impact tools, described in depth in D3.9.2-3.9.3.

An example of application of the CO-EVOLVE approach to sustainable coastal tourism is presented in Figure 16. This time we chose to represent the tourism typology Beach Tourism. Sustainability holds two pillars: on the left pillar the main ecosystem services supported by sandy shores are listed, while on the right pillar the main activities pertinent to beach tourism are listed (for further details on the touristic activities please see the D3.5.1). Arrows indicate which ecosystem service sustains which activity, following the perspective offered by Keeler et al. 2012. We can see that some activities are supported by more than one ecosystem service, fact that highlights the necessity of an inclusive ecosystem protection level to sustain each touristic activity.

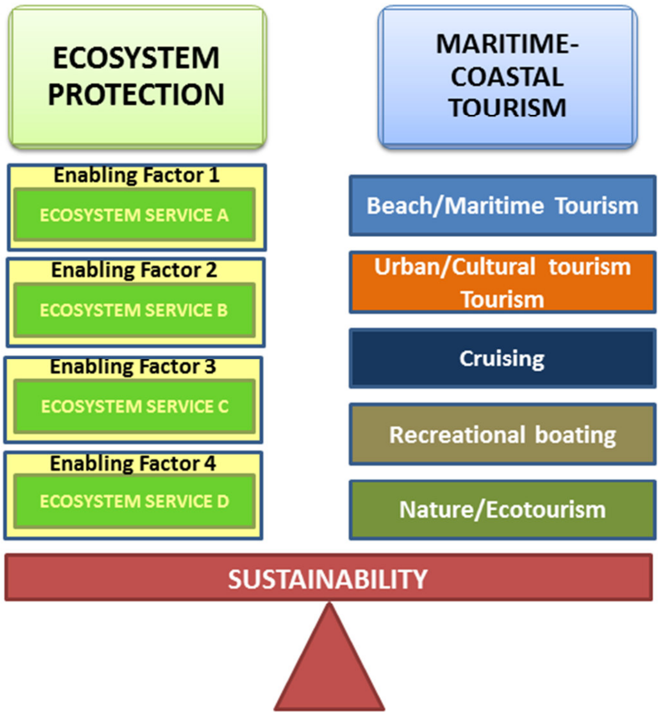

Figure 15: Schematized proposal for CO-EVOLVE approach to sustainable coastal tourism.

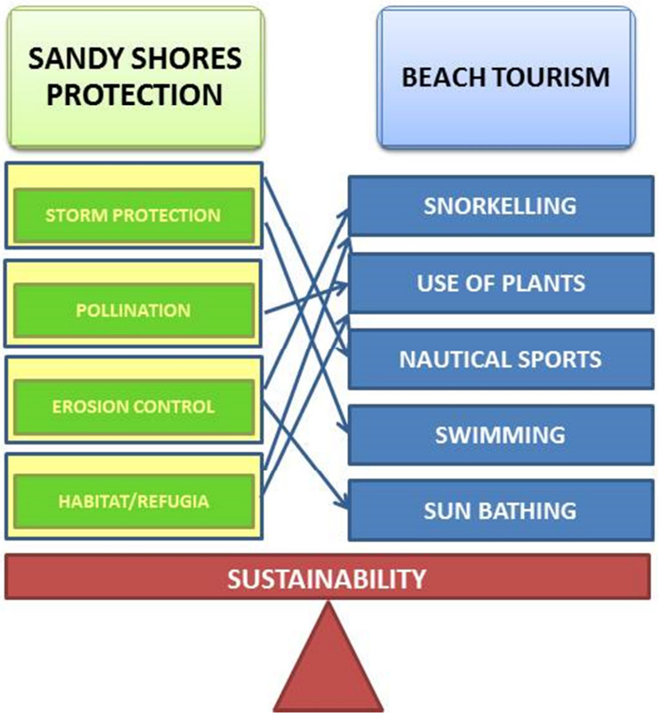

Figure 16: Schematized proposal for CO-EVOLVE approach to sustainable BEACH tourism.

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