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Abstract: Emergy analysis was applied to three municipalities (Portofino, Santa Margherita Ligure, Rapallo) of Liguria Region coast where tourism and cruise tourism are thriving. Results were compared with traditional economic indices. The territorial assessment of the municipalities was analysed from an environmental and economic perspective, focusing on tourism and cruise tourism. Similarities and differences among case studies emerged. The three economies resulted driven by tertiary sector but consequences from the different development strategies come to light. Portofino developed an elite type tourism with a greater attention devoted to the environment. This is mirrored by a sort of safeguarding of tourism and natural resources and by the detriment of the productive sector flourishing, on the contrary, in Rapallo. Santa Margherita lays in a boundary condition. Cruise tourism sector was analysed in these contexts. Ecological and economic impacts of cruise sector revealed to be significant only in Portofino being less than 1% in Rapallo and Santa Margherita. Load imposed to local environment by cruise ships tourism was calculated and Portofino showed a limit condition, Santa Margherita and Rapallo exceeded the local carrying capacity. This is due to the different management approaches pursued: only in Portofino the territory results more able to absorb impact, even if the limit is currently reached. As a consequence it appears evident that such phenomena as cruise tourism is, even if economically promising in the short term, should be managed with a long term perspective, integrating them in the local context and setting up strategies for impacts reduction or mitigation.

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Paolo Vassallo

Genoa, 22/02/2016

Dear Editor,

please find enclosed the manuscript titled:

**“The economic revenues and the ecological cost of cruise tourism”** by Chiara Paoli, Paolo Vassallo, Giorgio Fanciulli, Francesco Massa, Giulia Dapuetto, Sara Venturini, Paolo Povero.

The research article deals with the issue of cruise tourism impacts from both an environmental and economic perspective. In particular we analysed the economies of three tourism oriented coastal municipalities in the Liguria Region (north-west of Italy) through emergy analysis. Basing on the methodology applied in a previous research of us (Vassallo et al., 2009), we assessed the entire economic structure of the studied municipalities, their tourism sector and then we focused on cruise ship tourism.

Results allowed the comparison of environmental and economic parameters both expressed in monetary units and the identification of critical sector in both perspectives. The employment of monetary units makes results immediately intelligible not only to scientists but also to territorial managers or even general public and can be useful in order to make manifest the value of environment often shaded or to facilitate the introduction of management policy aimed not only at boosting economy but also at preserve environment.

Moreover we assessed the load imposed to local environment by cruise ships tourism, we estimated the local carrying capacity and we compared them in order to evaluate the ability of territories to absorb impacts.

This kind of approach can be exported and applied to whatever process or system.

In our opinion, and also following our conversation with Dr. Huisingh in Beijing at the World Summit for Environmental Accounting 2016, the addressed topics should fit with Journal of Cleaner Production aims and topics, being related to the domains of interest such as environmental and sustainability assessment, sustainable development and sustainability, sustainable consumption, governance, legislation, and policy for sustainability.

We hope you will appreciate our research taking it into account for publication.

All the best

Paolo Vassallo

## The economic revenues and the ecological cost of cruise tourism.

2 Paoli C., Vassallo P., Dapueto G., Fanciulli G., Massa F., Venturini S., Povero P.

### Abstract

4 Energy analysis was applied to three municipalities (Portofino, Santa Margherita Ligure,  
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6 compared with traditional economic indices. The territorial assessment of the municipalities was  
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integrating them in the local context and setting up strategies for impacts reduction or mitigation.

22

Keywords: Energy analysis, carrying capacity, Ligurian Sea, Tigullio gulf, willingness to pay,

24 PES

### 26 Introduction

Cruise tourism has encountered a phenomenal growth in the last four decades, most of all in  
28 terms of passengers number, becoming a mobile edition of land-based tourism competitors  
(Lumsdon and Page, 2007). In the 1970s the average capacity of a cruise ship was 800  
30 passengers, 30 years later it reached 1900 passengers and currently main companies are investing

in ships which can accommodate 6000 people (Stefanidaki and Lekakou, 2014). From 2003 to  
2 2014 demand for cruising worldwide has increased from 12.0 to 21.6 million passengers, with  
410 cruise ships and \$37.1 billion in revenues (Sun et al., 2011, CLIA, 2014). Nowadays  
4 revenues of cruise corporations represent a modest share of the total international tourism  
receipts, equal to the 3%. Nonetheless the sector is the fastest growing segment in the travel  
6 industry with an increase at almost twice the rate of other land based tourism's sectors (Kester,  
2002).

8 In 2013 the European cruise ships market played a significant role in the global cruise scenario:  
the 30% of total passengers are Europeans, while the European industry engendered 31.2 million  
10 passengers visits in 250 European port cities, in both the Mediterranean and in the Baltic Sea.  
This generates a significant impact on European economy consisting in a direct expenditure of  
12 €16.2 billion linked with European cruise industry (almost the 25% of which due to crew and  
passengers spending) and 339'417 (CLIA, 2014) jobs generated. With more detail, the  
14 Mediterranean European fleet is composed by 166 cruise ships carrying 3.86 million passengers,  
equal to over the 20% of total passengers with a 10% increase from 1998 (Dwyer and Forsyth,  
16 1998; CLIA, 2014; Stefanidaki, and Lekakou, 2014). In this context, Italian ports play a central  
role, with five ports (Civitavecchia, Venice, Naples, Genoa and Savona) included in the  
18 Mediterranean top ten for embarked, disembarked and visiting passengers, four of which  
included within major ports for revenue passengers and representing the country with greater  
20 direct expenditures in Europe (CLIA, 2014).

It is at present generally accepted that the globalized cruise tourism affects locality but it is not  
22 totally definite how (Stefanidaki, and Lekakou, 2014). The great part of studies about cruise  
tourism addresses economic issue or analyse passengers' profiles and behaviour. The economic  
24 contribution of cruise industry on destination economies has been widely investigated in different  
areas even if the real economic fall on local economies has been rarely analysed (Field et al.,  
26 1985; Marti 1986; Dwyer and Forsyth, 1998; De la Vina and Ford, 1999; Gabe et al., 2003; Seidl  
et al., 2007; BREA, 2012; BREA 2014 a,b,c; CLIA, 2014; World Bank Group, DFAT-Australia,  
28 and Carnival Australia, 2014; Chua et al., 2015; De Cantis et al., 2016).

On the contrary environmental and social impacts have been scarcely quantified and  
30 consequently managed (Maragkogianni and Papaefthimiou, 2015). When environmental impacts

1 have been taken into account, it appears evident that they can not be neglected. Cruise ships have  
2 been defined “floating cities” mimicking their land-based luxurious resorts counterpart with a  
3 variety of facilities on board, from restaurants to shopping centres. As a consequence they  
4 constitute one of the most energy intense forms of tourist activities generating a huge quantity of  
5 emissions and waste (Eijgelaar et al., 2010, Brida et al., 2013). It has been evaluated that carbon  
6 emissions per cruise passenger are four times greater than economy class aviation and about five  
7 times higher than the average energy use for luxurious hotels per visitor night (Howitt et al.,  
8 2010).

9  
10 These harmful substances do not affect only open water ecosystems since from one hand part of  
11 them, such as solid wastes, are stocked during navigation to be landed mainly in home ports and  
12 from the other hand some others are generated by activities carried on at mooring. As a  
13 consequence these impacts relapse in part on ports, both on home ports, from which ships begin  
14 and end, and, less heavily, on ports of call, that are intermediate stops (Brida et al., 2013).  
15 Maritime activity influences port cities, generating pollution that cruise ships can contribute to  
16 intensify. In particular emissions can affect local air quality, also considering that around 6% of  
17 fuel consumption from ships is consumed during in-port operations (Cooper, 2003; Isakson et al.,  
18 2001; Miola et al., 2009; McArthur and Osland, 2013). Moreover, destinations frequently suffer  
19 overcrowding and have to face sudden population's increases with a great load imposed to the  
20 public service system in terms of transports and provisioning of resources and goods. In this  
21 context it should be considered that tourism is intrinsically dependent on natural resources. It is  
22 said that “Tourism contains the seed of its own destruction” since it can lead to the destruction of  
23 environmental features that attract visitors (Glasson et al., 1995). This is why recently the  
24 dominant perception of cruise tourism as an income generator is contested since an accurate  
25 balance between benefits and costs should be carried out. In particular nature provides a service  
26 to humans, namely an “ecosystem service” (MA, 2005), giving them the opportunity of enjoying  
27 of certain natural characteristics. Ecosystem goods and services are the benefits people obtain  
28 from ecosystems that arise from the stock of resources collected in ecosystem (such as soil,  
29 water, atmosphere or living organisms) defined as natural capital (De Groot et al., 2002). The  
30 possibility to access to a service generates benefits and costs not always recorded in market  
values.

Food, fibres and fuel provision as well as the recreational services such as landscapes enjoyment

are perceived by humans and some of them have explicit prices. Other services, such as climate regulation or nutrient cycling, on the contrary, are not so well known as well as their value (DEFRA, 2007).

4 Usually economists identify two main categories of values: use and non-use.

Use values arise from the an interaction of humans with natural resources and are split among direct and indirect.

The former (direct) are related with the physical exploitation of ecosystem, while the second (indirect) are linked with the ability of ecosystem to support humans or what humans directly use.

Direct values are moreover divided between consumptive (if a component of the ecosystem is extracted for an anthropocentric purpose, such as fishes) and non-consumptive (if the component is enjoyment of an ecosystem component, such as recreation). Use values, such as for example those associated with waste assimilation or climate regulation, allow the existence of direct use ones.

14 Non-use values are mainly connected with the existence of environments themselves: even if people do not use them but anyway wish to see them preserved (Hawkins, 2003).

16 Even if generally only services having direct use consumptive value are traded in market, the total value (and than the total benefit) of a service is given by both use and non-use values.

18 Moreover the exploitation of a certain service can potentially impose the deterioration of the ecosystem service itself or of other ecosystem services: consumptive use can generate a quantity reduction of the ecosystem service, non-consumptive a quality reduction through, for example, pollution. This a cost humans inflict to nature (and consequently to themselves potentially compromising the possibility to enjoy of natural resources) that economy is often unable to measure.

24 The study is focused on the estimate of both economic benefits and environmental costs of cruise tourism in the Gulf of Tigullio, Liguria Region, western part of Italy. The area, despite its narrow extension, is globally recognized as a high natural value tourist attraction, and it includes a Marine Protected Area. In the Gulf, three ports of call (Portofino, Santa Margherita, Rapallo) for cruise ships are present, attracting overall over 37'000 passenger in 2014. The three ports display different characteristics in terms of size of ships accommodated, passengers received,

demographic, economic and environmental patterns and are then suitable for comparisons and  
2 evaluations. Moreover in Portofino, following the promulgation of a national decree, cruise ships  
can only anchor at a 0.7 miles from coast, with repercussions on the three municipalities. Given  
4 this specific mooring procedure impacts on three ports are quite limited and restricted to  
atmospheric emissions and outcomes linked to passengers when landed.

6 A multidisciplinary approach, based on economic and environmental techniques, is here  
proposed. For the economic analysis direct impacts on local economies have been evaluated both  
8 in term of passengers and crew expenditures and added value generation. Expenditures have been  
evaluated by means of an appropriate questionnaire aimed also at taking information about  
10 passengers' profile. Simultaneously, passengers have been asked about the value they ascribe to  
MPA in order to obtain an economic valuation of non-use values of the area. The environmental  
12 analysis has been performed by means of emergy analysis (Odum, 1996), a system methodology,  
able to quantify whatever resource, good or service in the same unit of measure and to later  
14 translate them in monetary terms. By means of emergy analysis costs supported by nature to  
absorb pollution from cruise ships presence in the area can be quantified in ecological and then  
16 economic terms.

## **Materials and methods**

### **18 Study area**

The Gulf of Tigullio (also called “Gulf Marconi”) is an area that spreads over the Ligurian Sea  
20 (Northern Italy), from “Punta di Portofino” at Northwest to “Punta Manara” at south-east.

The Gulf includes seven coastal municipalities, three of which (Portofino, Santa Margherita  
22 Ligure and Rapallo) are ports of call for cruise tourism and consequently have been analysed  
within this study.

24 In the Gulf, after World War II, coastal tourist activities associated with these municipalities  
developed. Ports in the area, formerly devoted to small fishing activities, turned into marinas and  
26 yachting, and became one of the principal recreational activities. Nowadays, the area maintains  
the characteristics of a prosperous tourist resort with an economy almost exclusively based on  
28 onshore and offshore tourism (Salmona and Verardi, 2001). Water and beaches' quality and the  
integrity of coastal and marine ecosystem are then essential elements for the sustainable  
30 development of the area, from both an environmental and an economic point of view.

For this reason in 1999, the Marine Protected Area (MPA) of Portofino was established in the north-western part of the Gulf of Tigullio, with a law from the Department of the Environment.

*Figure 1 should be placed here*

The MPA borders include the totality of Portofino municipality coast and a fraction of Santa Margherita Ligure coast (13%). Rapallo is outside the MPA even if adjacent with Santa Margherita Ligure (Figure 1). The MPA is widely recognised as an high natural value area, worldwide known for its emerged and submerged landscape as well as for the rich biodiversity the MPA hosts with endemisms and endangered species. The MPA of Portofino is included in the European Natura 2000 Network as Site of Community Importance (SCI IT1332674: Fondali monte di Portofino).

Since 2005 the Portofino MPA is a SPAMI (Specially Protected Area of Mediterranean Interest) according to the decision of the RAC/SPA Office (UNEP, 2005).

Within the MPA many activities such as diving, fishing and also recreational boating are regulated with different protection levels, from more severe in A zone to less severe in C zone.

Anyway the access into the MPA is forbidden to the ships longer than 24 meters. Nevertheless activities, mainly tourism oriented, are very common and pressure on local environment is very high (recreational boating reaching maximum in august with about 200 units per days (Venturini et al., 2016); diving activities count at present over 30'000 annual dives.

Following the accident of the Costa Concordia that in 2012 collided with a submerged rock close to the Giglio Island (Tuscany, Italy), causing 32 victims (Regoli et al., 2014), in Italy it has been issued the Ministerial Decree (D.M.) 07/03/2012 "General provisions to limit or prohibit the transit of ships for the protection of sensitive areas and to protect the territorial sea". In the particular case of Portofino, is enacted the ordinance n.56/2012 by the District Maritime (Coast Guard) of Santa Margherita Ligure, amended by Ordinance N. 223/2012, where the anchor zone for the cruise ships in front of Portofino municipality is moved from 0.3 miles to 0.7 miles from coast. Basic statistics about the three considered municipalities are reported in Table 1.

		<i>Portofino</i>	<i>Santa Margherita</i>	<i>Rapallo</i>
<b>Land area</b>	m <sup>2</sup>	2.55E+06	9.82E+06	3.40E+07
<b>Coast length</b>	m	5.25E+03	4.40E+03	5.35E+03
<b>Urbanized area</b>	m <sup>2</sup>	8.16E+04	1.72E+06	3.70E+06
<b>Cultivated area</b>	m <sup>2</sup>	5.69E+05	3.89E+06	6.35E+06
<b>Population</b>	number	4.37E+02	9.62E+03	2.92E+04
<b>Population density</b>	pop/m <sup>2</sup>	1.71E+02	9.80E+02	8.59E+02
<b>Employees</b>	number			
Industry		2.20E+01	4.45E+02	1.76E+03
Agriculture		8.00E+00	5.60E+01	1.60E+01
Tourism		2.15E+01	1.88E+02	3.49E+02
Other tertiary		1.87E+02	1.87E+03	4.77E+03
<b>Water consumption</b>	g	4.35E+11	2.46E+12	5.63E+12
<b>Vehicles in circulation</b>	number	2.32E+02	4.54E+03	1.40E+04
<b>Tourists presences</b>	number			
Accommodation facilities		4.34E+04	2.78E+05	2.78E+05
Second houses (estimate)		4.98E+05	2.72E+06	4.43E+06
<b>Cruise tourists arrivals</b>	number	2.17E+04	1.50E+04	1.00E+03
<b>Average hours spent by cruise tourists</b>	hours	9.96E+00	1.37E+01	9.97E+00

*Table 1: basic statistics of considered municipalities from local and national statistical services (National Institute of Statistics (ISTAT), Liguria region annual statistics, Chamber of Commerce)*

## 2 Economic analysis

### *Questionnaire survey*

- 4 Even if researches regarding the cruise tourism sector are scarce and fragmented, the evaluation of cruise ships tourists expenditures has been generally employed in the last two decades in order
- 6 to assess the economic impact of cruise ships on destinations (Dwyer and Forsyth, 1998; Larsen et al., 2013). Cruise tourists expenditures have direct and indirect effects on local economies.
- 8 The direct effects is on suppliers and retailers who sell goods and services (e.g. food, beverage,

fuel, night stays) to cruise tourists and operators. Indirect effects are related with the augmentation of value added associated with the increase of employees and profits (Dwyer and Forsyth, 1998).

In order to obtain information about the behaviour of cruise tourists in the three considered ports a traditional questionnaire-based survey was performed. The employed questionnaire, appropriately created by the University of Genoa research team together with MPA staff, was a one page long and it was translated in 5 languages (Italian, Spanish, English, French, German). Two trained interviewers and a supervisor realized face-to-face interviews to cruise tourists and operators. Each interview took about 15-20 minutes and was realized at dock before boarding.

The questionnaire included, after date and place, 2 questions about the ship (name and other ports of call), 2 questions about the journey (if they visited the surroundings and if it was their first time in the resort), 5 questions about personal data (nationality, city, age, sex, job), 6 questions regarding the enjoyment level of the municipalities services and natural environment (Table 2).

Finally the last part of the questionnaire was specifically addressed to the estimation of direct expenditures and assessment of contingent valuation.

	disagreement			Indifferent	agreement		
I think that this town is very well cared	-3	-2	-1	0	1	2	3
I am glad I have decided to come here	-3	-2	-1	0	1	2	3
I will return in this town	-3	-2	-1	0	1	2	3
I will tell my friends about this holiday village	-3	-2	-1	0	1	2	3
I found the locals friendly and kind	-3	-2	-1	0	1	2	3
In this city you respect the natural environment	-3	-2	-1	0	1	2	3

Table 2: questions about enjoyment level ( -3 complete disagreement, 3 complete agreement)

16

*Direct expenditures*

People were first asked if they made some purchases (yes or no option) and then to detail expenses split in these categories: food, souvenirs, clothes, other.

20 *Contingent valuation*

People were initially asked if they were aware about the existence of Marine Protected Area, later

1 they were asked if, given that marine protected areas must protect coastal and marine  
2 environments, protect cultural, economic and environmental assets (especially with regard to  
3 flora and fauna), they judged the establishment of these areas as a priority, important, not very  
4 important, irrelevant. Finally they were asked how much would they be willing to pay to protect  
5 and save the area (€ per year).

6

### *Value added*

8 In order to investigate the weight of tourism sector and cruise tourism on local economies data  
9 about the value added were examined. Nonetheless national and regional institute of statistics do  
10 not provide these information at municipal level. As a consequence required data were obtained  
11 as follow.

#### 12 *Value added of municipalities*

13 Data about value added were available, at local level and from the Italian National Institute of  
14 Statistics (ISTAT), for the year 2005 and for the local market area (LMA, see  
15 <http://www.istat.it/en/archive/142790> for more detail). These are sub-regional geographical areas  
16 where the bulk of the labour force lives and works, and where establishments can find the largest  
17 amount of the labour force necessary to occupy the offered jobs. They respond to the need for  
18 meaningfully comparable sub-regional labour market areas for the reporting and analysis of  
19 statistics. In particular, the Rapallo LMA is composed by 5 municipalities, including the three  
20 municipalities analysed: Rapallo, Santa Margherita and Portofino.

21 Data of value added were available for different economic sectors (namely: agriculture, industry,  
22 service industry) at current prices updated to 2014 prices. The value added of each municipality  
23 has been calculated as valued for employee for each sector multiplied by the number of employee  
24 per sector within each municipality.

#### *Value added of tourism and cruise sector*

26 The value added of tourism in the considered municipalities was calculated as multiplication of a  
27 value added coefficient per tourist presence, calculated by regional authority (Osservatorio  
28 Turistico della Liguria, 2013), and tourist presences. The applied coefficient for accommodation  
facilities is equal to 29€ without taxes while for second houses it values 19€.

1 The share of valued added ascribable to cruise tourism has been calculated as an average using  
2 two calculation methods (Osservatorio Turistico della Liguria, 2013):

3 1. Value added activated per hour spent by cruise tourists multiplied by average number of hours  
4 spent at each municipality and total number of cruise tourists arrivals at each municipality

5 The hourly coefficient has been calculated as a share of accommodation facilities coefficient and  
6 as the percentage of sector activated by cruise tourists; the coefficient is equal to 0.86 €/hour

7 2. Valued added activated per € spent multiplied by average expense per cruise tourist at each  
8 municipality and total number of cruise tourists arrivals at each municipality; the coefficient is  
equal to 0.27€.

10

### **Ecologic analysis**

#### 12 ***Emergy analysis***

13 Emergy analysis is a thermodynamic based methodology introduced during '80s by Howard  
14 Odum and it is a technique of quantitative analysis which standardizes the values of non-moned  
and monied resources, services and commodities in a sole common unit (Brown and Herenden,  
16 1996). This makes emergy a very versatile technique that can be applied to whatever natural or  
human systems or to a mix of two.

18 Emergy theory is defined by two key concepts: solar emergy itself and solar transformity.

19 Solar emergy is identified by the quantity of solar energy required, directly or not, to provide a  
20 given flow or storage of energy or matter (Odum, 1996). Emergy is expressed in solar Emergy  
Joule (seJ) and usually calculated on an annual scale.

21 Transformity measures the input of emergy per unit output and it is calculated as the ratio of the  
22 Emergy necessary to produce a flow or a storage to the actual energy of that flow or storage  
23 (Ulgiati and Brown, 2002). The transformity is expressed in solar emergy Joule per Joule of  
24 output flow (seJ/J). For certain products or flows easily quantifiable in units of mass or money a  
25 conversion value expressed in seJ/g or seJ/€ can be used (Paoli et al., 2008).

26 These coefficients are respectively named specific emergy and emergy per unit money;  
27 transformity, specific emergy and emergy per unit money, can be gathered under the locution  
28 Unit Emergy Value (UEV hereinafter, Amponsah et al., 2011)

1 Energy accounting is organized as a top-down approach (Ulgiati and Brown, 2002) leading to  
2 the conversion of all inputs to the system into their energy content. Tables of the actual flows are  
constructed: the different units for each flow are multiplied by appropriated UEV to convert them  
4 into solar energy. Comparison between flows of different materials and energies are possible  
once expressed in energy units.

6 As a consequence energy is indicated as an environmental sustainability indicator that allows  
evaluating the quality of resources employed in a process as well as the quantity: the greater the  
8 energy flow necessary to sustain a process, the greater the quantity of solar energy consumed or,  
in other words, the greater the environmental cost (Vassallo et al., 2006).

10 In such a way energy is able to provide an objective valuation based on the effort made by nature  
to supply energy and material flows that allows the production of a certain good or service.

12 The environmental cost calculated in energy units and then in ecological terms can be translated  
in monetary terms by the employment of a particular index that is a combination of energy and  
14 economic value, called “Energy-to-money ratio”. It is calculated as ratio of the energy flow to a  
nation to its GDP (Gross Domestic Product). It is expressed in seJ/currency, (seJ/€ in our case)  
16 and represents energy purchasing power since it values how much energy corresponds, on  
average, to one unit of money produced by the national economy (Odum, 1996). Pulselli et al.  
18 (2011) calculated it for Europe and its value equals to 1.71E+12 seJ/€. The ratio between an  
energy flow and energy money ratio gives an estimate of the economic value of a service or  
20 good generated by humans or by nature.

The energy approach has been applied in order to evaluate the environmental costs associated  
22 with the sustenance of:

- the economies of studied municipalities
- 24 • tourism sector in the context of each municipalities
- the environmental impact of cruise tourism in the context of each municipality and local  
26 environment

## 28 **Emergy of municipalities and tourism sector**

The emergy calculation of municipalities and tourism sector have been performed following the  
30 approach applied in Vassallo et al. (2009), suited for a typical Liguria Region coastal resorts.  
Main inputs that support the system have been identified and then quantified.

Each item's energy, mass or money value has been obtained from either direct survey or statistical  
2 collections. Statistics have been gathered from different sources including Ligurian Region  
statistics (<http://www.regione.liguria.it>) and the Italian institute for statistical production  
4 (<http://www.istat.it>). Emergy values for each item have been calculated by means of UEV  
multiplication.

6 Consumptions of resources by tourists have been calculated considering them as equivalent  
residents when direct data were not available (Vassallo et al., 2009).

8

### **Emergy of cruise tourism impact**

10 Cruise tourism environmental impact has been calculated as sum of three components:

- emergy of natural inputs enjoyed during the stay
- 12 • emergy of human labour required for cruise tourists' expenses
- emergy of imports for cruise tourists' expenses

14 For each passenger interviewed the three components were calculated to get an average emergy  
value per passenger then ascribed to total cruise arrivals in the three municipalities.

16 Natural inputs (rain, geothermal heat, tides, waves) have been allocated calculating the equivalent  
residents corresponding to the total amount of hours spent by cruise tourists in the municipality.

18 Following, an hourly share of each natural input, calculated as ratio between availability and the  
hours spent in the municipality by residents, tourist and cruise tourists, has been ascribed to each  
20 tourist and multiplied by hours spent in the municipality.

Each passenger was asked about money spent for food, souvenirs, clothes and other goods.

22 From a local report on tourism (Osservatorio Turistico della Liguria, 2013) it results that 5.65 full  
time workers and 0.74€ of imports per each Euro of expenses are activated locally for a million  
24 of Euros of expenses.

At each passenger a share of human labour and imports has been then ascribed according to  
26 declared expenses.

As further elaboration the amount of natural resources required to absorb emissions generated by  
28 cruise ships has been assessed to be compared with natural resources availability.

A this purpose, emissions of greenhouse gases per passenger from in-port ships activity have  
30 been calculated.

Emissions per passenger have been quantified according to the methodology proposed by

McArthur and Osland (2013) for valuation of atmospheric emissions of ships at berth.

2 In particular the following equation was applied for each gas emissions:

$$E_{Pi} = FC * LF * E_{Fi}$$

4 where

$E_{Pi}$  = Emissions in kg of atmospheric pollutant i

6  $FC$  = fuel consumption per passenger at full power

$LF$  = load factor to estimate the fuel consumption of the auxiliary engines when the ship is at

8 berth in comparison with consumption at full power

$E_{Fi}$  = Emissions factor of atmospheric pollutant i

10  $FC$  is calculated according the equation proposed to McArthur and Osland (2013)

$$16.904 + 0.00198 * GTP / 24 * H$$

12 where  $GTP$  is the gross tonnage per passenger ratio and  $H$  the number of hours passed by the ship in port. Data about gross tonnage and passengers have been provided by local port authority.

14  $LF$  is considered equal to 0.2 following Dalsøren et al. (2009). Applied  $E_{Fi}$  are reported in Table 3 according to McArthur and Osland (2013).

Pollutant	Emission factor (kg/t)	Limit value (mg/m <sup>3</sup> )
NO <sub>x</sub>	53.4	30
SO <sub>x</sub>	1.562	20
PM 10	0.7	40
PM 2.5	0.665	25

Table 3: Emission factors for marine diesel/gas oil and limit values of considered pollutants

16 Once emissions of different pollutants are calculated the effort demanded to environment to absorb this impact has been calculated by estimating the kinetic energy by wind required to keep  
18 concentration within the limits considered as not dangerous for human health and vegetation by national laws (namely Legislative decree 155/2010); limit values are reported in Table 3.

20 The air mass required to dilute emissions by ships at mooring has been calculated as follows:

$$MA_i = E_{Pi} / LV_i * D$$

22 where  $MA_i$  = mass air to dilute pollutant;  $LV_i$  = limit value for pollutant I;  $D$  = air density

The greater MAi among those calculated has been selected and employed to quantify kinetic  
2 energy to dilute pollutants.

4

## Results

### 2 Economic analysis

#### Questionnaire survey: direct expenditures and contingent valuation

4 A total of 618 cruise passengers from 15 ships were interviewed in 23 sampling days (Table 4).

Ship code	Sampling days	Municipality	Ship length	Gross tonnage	Passengers	Crew	Interviews
S1	4	Rapallo	249	54763	1500	600	127
S2	2	Portofino	162	14983	372	200	54
S3	3	Portofino	240	66084	1250	800	50
S4	2	Portofino	180	30000	684	400	17
S5	3	Portofino	225	28890	516	370	53
S6	2	Portofino	215	48075	700	445	35
S7	1	Portofino	250	68870	1080	655	31
S8	1	Portofino	180	30227	688	373	20
S9	1	Rapallo	215	3500	170	70	11
S10	1	Portofino	104	5000	110	89	14
S11	1	Portofino	187	14983	312	190	20
S12	1	Portofino	154	16900	296	212	25
S13	2	S.Margherita L. and Portofino	180	30300	866	390	99
S14	1	S.Margherita L.	60	3100	50	21	8
S15	1	S.Margherita L.	181	30277	866	390	21
S16	1	Portofino	240	66884	1258	780	31

Table 4: Main characteristics of ships where passengers were interviewed and number of interviews realised per ship

Questionnaires were distributed in three municipality as shown in Figure 2.

Over 60% of questionnaires have been distributed in Portofino since this is the municipality accommodating the majority of cruise tourists: a number equal to 1.5 times those welcomed in Santa Margherita and 21 times in Rapallo. The 64% of people interviewed were women, the greatest part (79%) are over 40 years old with a 41% comprised in the 40-60 age category.

*Figure 2 should be placed here*

Passengers were also asked about their enjoyment level, average score per question is reported in Table 5, enjoyment level score is obtained as average of the sum of scores given by each passenger to each question.

Portofino shows the highest scores for all questions, excluded that about the welcome by locals and the respect of natural environment (even if the value is almost equal to the greatest one showed by Santa Margherita).

	Town care	Glad about the stay	Inclined to return	Inclined to tell to friends	Welcome by locals	Respect of natural environment	Enjoyment level score
Portofino	2.61	2.72	2.21	2.68	2.41	2.58	15.14
Santa Margherita Ligure	2.44	2.58	1.81	2.50	2.39	2.59	14.30
Rapallo	2.40	2.67	2.01	2.55	2.57	2.51	14.71

*Table 5: average score of replies to questions about enjoyment*

4

Concerning direct expenditure the 69% of respondent declared to purchase something in the municipality where they were interviewed. On average cruise tourists spend 42€ per passenger, for the 40% in clothes. Cruise tourist spend a greater average amount per landing (53€) in Portofino, mainly (44%) for clothes, while in Santa Margherita and Rapallo expenses are lower (28 and 23 € respectively) and for over the 40% for food (Figure 3).

*Figure 3 should be placed here*

10 The bulk of cruise tourists are not aware about the presence of the MPA (62%) but they judged its establishment as a priority or important (Figure 4), only the 1.46% estimated the MPA, not important or did not replied.

*Figure 4 should be placed here*

When asked about their willingness to pay (WTP) to protect and save the area, cruise tourists declared to be on average available to pay an amount equal to 82€ per year.

16 If different municipalities are considered, the greater WTP is recorded in Portofino (102€ per year), followed by Rapallo (76€ per year) while Santa Margherita displays a value significantly lower (31€ per year)

### **Value added of municipalities, tourism sector and cruise tourism**

Results about the calculation of value added of municipalities (together with the percentage contribution of different economic sectors to the total value), of tourism sector and of cruise tourism are reported in Table 6.

<b>Total municipality</b>	Agriculture	Industry	Tertiary	<b>Tourism sector</b>	<b>Cruise tourism</b>
<b>16.39</b>	2.49%	7.19%	90.32%	<b>10.50</b>	<b>0.27</b>
<b>172.39</b>	1.66%	13.82%	84.52%	<b>58.58</b>	<b>0.16</b>
<b>458.16</b>	0.18%	20.62%	79.21%	<b>90.27</b>	<b>0.01</b>

*Table 6: Values added of municipalities (with percentage contribution of different economic sectors) their tourism sector and cruise tourism*

4 The economies of the three municipalities are dominated by the tertiary sector (79-90% of the value added). Nonetheless the industrial sector contribute for the 21% to the value added in  
6 Rapallo. Agriculture is not relevant from an economic perspective in the three municipalities.

### **Emergy of municipalities**

8 Results from the application of emergy analysis to the three considered municipalities are reported in Table 7.

Input	Unit of measure (U.M.)	Quantity per year			UEV (sej/U.M.)	Empower (seJ/year)= quantity*UEV		
		Portofino	Santa Margherita	Rapallo		Portofino	Santa Margherita	Rapallo
Solar energy	J	5.46E+16	7.75E+16	1.85E+17	1.00E+00	5.46E+16	7.75E+16	1.85E+17
Wind	J	5.31E+13	7.06E+13	5.31E+13	1.46E+03	7.76E+16	1.03E+17	7.76E+16
Rain chemical potential	J	1.24E+14	1.33E+14	2.10E+14	1.82E+04	2.26E+18	2.42E+18	3.83E+18
Rain geopotential	J	5.31E+12	2.49E+13	1.13E+14	1.05E+04	5.58E+16	2.62E+17	1.19E+18
Geothermal heat	J	8.01E+12	3.08E+13	1.07E+14	6.08E+03	4.87E+16	1.87E+17	6.49E+17
Tides	J	1.19E+12	1.03E+12	1.02E+12	1.68E+04	2.00E+16	1.74E+16	1.72E+16
Waves	J	8.32E+14	6.97E+14	8.48E+14	3.04E+04	2.53E+19	2.12E+19	2.58E+19
Soil erosion	J	9.86E+09	2.03E+11	1.17E+11	7.40E+04	7.29E+14	1.50E+16	8.66E+15
Water distributed	g	2.92E+11	1.65E+12	3.14E+12	7.64E+06	2.23E+18	1.26E+19	2.40E+19
Water losses	g	1.43E+11	8.10E+11	2.49E+12	4.37E+06	6.25E+17	3.54E+18	1.09E+19
Human labour	J	5.25E+11	5.62E+12	1.52E+13	7.38E+06	3.88E+18	4.15E+19	1.12E+20
Electricity	J	5.83E+12	2.37E+14	7.19E+14	1.74E+05	1.01E+18	4.12E+19	1.25E+20
Gasoline	J	5.18E+12	1.01E+14	2.92E+14	6.60E+04	3.42E+17	6.66E+18	1.93E+19
Diesel	J	8.69E+12	1.66E+14	5.11E+14	6.60E+04	5.74E+17	1.10E+19	3.37E+19
Lubricants and oils	J	1.32E+12	2.55E+13	7.52E+13	6.60E+04	8.69E+16	1.68E+18	4.96E+18
Methane	J	6.55E+12	1.44E+14	4.38E+14	4.80E+04	3.14E+17	6.92E+18	2.10E+19
Import	€	5.31E+06	4.88E+07	1.15E+08	1.71E+12	9.09E+18	8.35E+19	1.97E+20
					<b>Total</b>	4.58E+19	2.32E+20	5.78E+20

Table 7: Emery table of considered municipalities (detailed formulas are reported in Appendix 1, references to transformities are reported in Appendix 2)

In Portofino waves are more than the double of the greatest non renewable inputs percentage contribution (imports). This municipality system is then more based on natural resources than other ones if percentage contributions to the total emery budget are considered.

Figure 5 should be placed here

#### 4 Emery of tourism sector

Energy of tourism sector has been calculated as share of total energy considering tourists as equivalent residents, where data were not available on statistics local and national repositories. Results are shown in Table 8 and they rather follow municipalities trend. Again Rapallo requires the greatest quantity of energy to keep the tourism sector, accordingly to the trend shown by total energy of municipalities. Nonetheless the difference between the municipalities is less significant being the demand for tourism of Rapallo almost 4 times bigger than Portofino.

Waves in Portofino contribute to tourism sector for more than a half (53%). Among not renewable inputs the tourism sector import, ranging from 19% in Portofino to 38% in Santa Margherita and 35% in Rapallo, and sunbathing facilities (6% in Portofino, 11% in Santa Margherita, 10% in Rapallo) are noteworthy.

Input	Unit of measure (U.M.)	Quantity per year			UEV (sej/U.M.)	Empower (seJ/year)= quantity*UEV		
		Portofino	Santa Margherita	Rapallo		Portofino	Santa Margherita	Rapallo
Sun	J	4.23E+16	3.58E+16	5.68E+16	1.00E+00	4.23E+16	3.58E+16	5.68E+16
Wind	J	4.12E+13	3.26E+13	1.63E+13	1.46E+03	6.02E+16	4.76E+16	2.38E+16
Rain chemical potential	J	9.65E+13	6.13E+13	6.44E+13	1.82E+04	1.76E+18	1.11E+18	1.17E+18
Rain geopotential	J	4.12E+12	1.15E+13	3.47E+13	1.05E+04	4.32E+16	1.21E+17	3.65E+17
Geothermal heat	J	6.21E+12	1.42E+13	3.27E+13	6.08E+03	3.78E+16	8.65E+16	1.99E+17
Tides	J	9.22E+11	4.77E+11	3.14E+11	1.68E+04	1.55E+16	8.01E+15	5.27E+15
Waves	J	6.45E+14	3.22E+14	2.60E+14	3.04E+04	1.96E+19	9.78E+18	7.90E+18
Soil erosion	J	7.64E+09	9.37E+10	3.59E+10	7.40E+04	5.66E+14	6.93E+15	2.65E+15
Water distributed	g	2.26E+11	7.62E+11	9.63E+11	7.64E+06	1.73E+18	5.83E+18	7.36E+18
Water losses	g	1.11E+11	3.74E+11	7.62E+11	4.37E+06	4.85E+17	1.63E+18	3.33E+18
Human labour	J	4.73E+10	4.14E+11	7.68E+11	7.38E+06	3.49E+17	3.06E+18	5.67E+18
Electricity	J	4.52E+12	1.09E+14	2.20E+14	1.74E+05	7.87E+17	1.90E+19	3.83E+19
Gasoline	J	4.02E+12	4.66E+13	8.94E+13	6.60E+04	2.65E+17	3.07E+18	5.90E+18
Diesel	J	6.74E+12	7.66E+13	1.57E+14	6.60E+04	4.45E+17	5.06E+18	1.03E+19
Lubricants and oils	J	1.02E+12	1.18E+13	2.30E+13	6.60E+04	6.74E+16	7.77E+17	1.52E+18

Methane	J	5.08E+12	6.66E+13	1.34E+14	4.80E+04	2.44E+17	3.20E+18	6.44E+18
Import	€	4.12E+06	2.25E+07	3.52E+07	1.71E+12	7.05E+18	3.85E+19	6.02E+19
Marinas	num	2.60E+02	3.50E+02	9.00E+02	7.12E+15	1.85E+18	2.49E+18	6.41E+18
Sunbathing facilities	num	4.58E+05	2.54E+06	3.98E+06	4.44E+12	2.03E+18	1.13E+19	1.77E+19
					<b>Total</b>	3.67E+19	1.05E+20	1.72E+20

*Table 8: Emery table of tourism sector (detailed formulas are reported in Appendix 1, references to transformities are reported in Appendix 2)*

### Emery of cruise tourism

- 2 A database with data of the 618 passengers interviewed was created. Values of declared hours and money spent in the municipality per person during the stay in the visited municipality were
- 4 matched with enjoyed natural inputs locally available and conversion factors related to human labour and imports required to provide goods purchased during the stay. Results are shown in 9.
- 6 The average emery value per passenger is greater in Portofino, where it is more than double than in Rapallo, principally due do to the huge amount of imports and to the contribution of waves in
- 8 comparison with the other municipalities. If percentage contributions are analysed (Table 9), imports represent the main emery share for passengers landings in the three municipalities, with
- 10 a percentage always greater than the 78% (and over the 90% in Rapallo).

	Portofino	Santa Margherita	Rapallo	Portofino	Santa Margherita	Rapallo
	Emery (seJ/passenger)			Percentage		
Rain	1.29E+12	2.11E+11	1.01E+11	1.37%	0.48%	0.29%
Geoth. Heat	2.78E+10	1.64E+10	1.71E+10	0.03%	0.04%	0.05%
Tides	1.14E+10	1.52E+09	4.52E+08	0.01%	0.00%	0.00%
Waves	1.45E+13	1.85E+12	6.78E+11	15.26%	4.18%	1.98%
Human labor	5.28E+12	2.82E+12	2.23E+12	5.57%	6.37%	6.53%
Import	7.37E+13	3.94E+13	3.11E+13	77.77%	88.93%	91.14%
Total	9.48E+13	4.43E+13	3.42E+13	100.00%	100.00%	100.00%

*Table 9: Average emery per cruise passenger in the three municipalities and percentage contribution of different items*

The contribution of waves is significant in Portofino being 15% while labour is around the 5% in three considered cases. The average value per passenger, multiplied by the total number of cruise ships arrivals (Table 1) in the municipality gives the total energy required by the cruise ships sector (Figure 6).

*Figure 6 should be placed here*

As further elaboration emissions associated to the presence of each passenger during the time at mooring have been calculated as previously described (Table 10).

	NOx	SOx	PM10	PM2.5
Portofino	7.40E+01	2.16E+00	9.70E-01	9.21E-01
Santa Margherita Ligure	1.03E+02	3.03E+00	1.36E+00	9.40E-01
Rapallo	7.34E+01	2.15E+00	9.62E-01	9.40E-01

*Table 10: Average atmospheric pollutants emissions from in-port cruise ships in considered municipalities, kg/passenger*

From data in Table 10 the quantity of the kinetic energy to dilute pollutants emissions from a passengers' stay have calculated and results are shown in Table 11.

10

	seJ per passenger
Portofino	2.13E+13
Santa Margherita	2.98E+13
Rapallo	2.11E+13

*Table 11: Average quantity of resources required to dilute atmospheric pollutants emissions per passenger*

The greatest amount of resources is required in Santa Margherita principally due to the fact that ships stop longer at mooring.

**Discussion**

Emergy results from the ecological analysis provide an estimate of resources consumption, required from nature to maintain the municipalities (given the current territorial planning) and two sub-sectors: tourism and cruise ships.

These values can be translated in monetary terms (eM€) by the employment of the “Emergy-to-money ratio” and then compared with traditional economic indices, such as the value added. eM€ can be considered as a measure of the environmental cost while value added an estimate of benefits as measured by the economy (Figure 7).

*Figure 7 should be placed here*

In order to better evaluate the relevance of tourism and cruise ships sector in the local territory, in terms of both environmental cost and economic benefit, the percentage contribution of each sub-sector to municipal value has been calculated (Table 12).

The impact of tourism on total municipality is significant, in both environmental and economic terms, in Portofino, where it represents the 80% of the environmental cost and the 64% of the economic benefit; tourism impact is noteworthy also in Santa Margherita (45% environmental and 34% economic). Tourism sector, anyway, appears to be a key sector of three municipalities economies being anyway greater than the 20% in both ecological and economic terms.

The economic and ecological impact of cruise ships on the municipality proves to be relevant only in Portofino, consuming around the 4% of resources required by the territory but generating only the 1.6% of the value added.

In Rapallo and Santa Margherita the economic and ecological contribution of cruise sector on municipalities is always lower than the 1% (Table 9).

	Ecological impact			Economic impact		
	Tourism/Municipality	Cruise ships/Municipality	Cruise ships/tourism	Tourism/Municipality	Cruise ships/Municipality	Cruise ships/tourism

Portofino	80.23%	4.49%	5.60%	64.09%	1.63%	2.55%
Santa Margherita	45.15%	0.29%	0.63%	33.98%	0.09%	0.27%
Rapallo	29.85%	0.01%	0.02%	19.70%	0.00%	0.01%

*Table 12: Percentage comparison of contribution, in terms of ecological cost and economic benefit, of sub-sector on total municipality and of cruise ships sector on tourism*

The notable influence of tourism sector in the considered municipalities, as well as differences recorded can be explained if their specific development is taken into account. Liguria region was affected during the 1950s and the 1960s by mass tourism development that deeply modified the landscape and the socio-economic organisation of many towns (Salmona and Verardi, 2001; Vassallo et al., 2009). The natural environment suffered the huge building of infrastructures and second houses and in some case the local economy became completely tide to tourism with a gradual, but almost complete, neglect of traditional activities such as fishing and agriculture.

In Portofino this phenomenon was partly restrained by some typical features of this little municipality such as (Salmona and Verardi, 2001): the presence of institutions environmentally aware and advocating environmental protection, the inhospitable morphology, the presence of an elite tourism acting in a double way, from one hand claiming for preservation of natural landscape and from the other hand boosting the creation of high level facilities not accessible to masses.

As a consequence, even if the economy of Portofino gradually became dependent on tourism and a policy for environmental management was never completely planned, the area was, to some extent, preserved. On the other side the economic benefits generated by this elite type of tourism has discouraged any innovation and it lead to the decline of other economic sectors with a huge decrease in resident population. This is why the ecological percentage impact of tourism in Portofino is so huge and lower than the economic benefit despite a total requirement of resources is smaller than the other municipalities.

Rapallo, on the contrary was heavily involved in mass tourism: urbanisation happened so huge

and fast that the term “rapallizzazione” was even coined to signify the uncontrolled expansion of  
2 settlements causing negative consequences on local landscapes and physical resources (Callegari,  
2003). Nonetheless Rapallo still plays a key role representing the main economic centre on which  
4 livelihood of the area still depends (Salmona and Verardi, 2001).

Santa Margherita lays in a boundary state: here fishing, agriculture, and manufacturing activities  
6 still remain important even if the municipality represents one of the most important tourist resorts  
of the area even if not completely preserved by intensive building of infrastructures.

8 These different conditions and attitudes are mirrored by results: the three municipalities are  
driven by the tertiary sector, agriculture appear to be residual while industry is relevant only in  
10 Rapallo (6).

If percentage of emergy devoted to tourism in comparison with total emergy is interpreted as an  
12 index of a municipality's tourism propensity (Vassallo et al., 2009), it is clear the strong  
dependency of Portofino from tourism sector and a gradually lower influence in Santa Margherita  
14 and Rapallo municipalities.

With a similar approach the percentage of emergy devoted to cruise ships sector represents the  
16 relevance of this activity in the global municipality budget. As a consequence, at present, this  
activity seems to be significant only in Portofino not only in terms of passengers' landings but  
18 also in terms of economic and most of all ecological impact.

At this purpose some main reasonings are worthy to be presented.

20 The cruise ships tourism is, at present, one of the most promising activities from an economic  
point of view. Nonetheless the potential impact on ports of call should be taken into account.  
22 Cruise tourists, if repercussion on municipalities are considered, falls in the category of “hit-and-  
run” tourists, since cruise passengers spend only few hours in the resorts they visit. The major  
24 threat of this kind of tourism consists in becoming a mass tourism process leading to phenomena  
such as the so called ‘disneylandification’, which put at risk future opportunities for tourism  
26 destinations (Rouss and Alfarè, 2013).

In order to analyse this phenomenon, the environmental impact, expressed in emergy terms of a  
28 cruise passenger, has been compared on an hourly basis with resources requirement by a general  
tourist and a resident in the three municipalities (Figure 8). This index has been calculated by

dividing the total annual energy requirement of each category for the hours spent in the  
2 municipalities.

Cruise tourist resources' requirement is always greater than both resident and general tourist  
4 requirement being at least double. If cruise tourism will develop as mass tourism without actions  
taken to preserve natural environment, impacts should potentially reveal to be huge.

*Figure 8 should be placed here*

6 As a further elaboration the average environmental cost, expressed as eM€ per passenger landing,  
has been compared with average expenses and WTP per landing in the three municipalities  
8 (Figure 9).

The WTP declared by users is higher than expenses and environmental cost made by cruise  
10 passengers in three municipalities even if in Santa Margherita the three values are quite similar.  
The greater environmental cost is required in Portofino, but here can be recorded also the higher  
12 declared WTP and the higher expenses. This is probably linked to the typical conditions of  
Portofino previously described: the municipality hosts an elite type tourism, offering higher  
14 quality services in comparison with the other municipalities and a better conservation of the  
natural landscape. Presumably this push people to spend more but also to be more concerned in  
16 the protection of the area.

*Figure 9 should be placed here*

This is proved by boxplots reported in Figure 10, where WTP and Enjoyment level score are  
18 plotted (see Table 5).

Median, third quartile limit and maximum of WTP are greater in Portofino while, as far as  
20 enjoyment level score (including also the perception of the respect of natural environment in the  
municipality by cruise tourists) Portofino shows the higher median, the higher minimum score,  
22 and the greater (together with Rapallo) maximum score.

It can be then inferred that the different territorial management of the three municipalities  
24 influenced their development leading to positive (or negative) outcomes. In particular the choice  
of Portofino municipality to specialize on an elite type tourism together with a greater attention  
26 devoted to the environment produced a sort of safeguarding of both tourism and natural resources  
it is based on. Nonetheless it should be advisable to increase the sustainability level of the sector,

for example by boosting local activities and reducing imports in order to reduce the environmental cost. At this purpose, done the different bent assumed by the three municipalities, the opportunity to develop synergies should be taken into account.

Cruise tourism when introduced in such territorial assessments can cause displacements that should be carefully taken into account and could mine social, environmental and economic sustainability of the municipality.

*Figure 10 should be placed here*

Cruise landings in Portofino provoke an ecological impact, in terms of resources consumed, equal to the 4% of the entire municipality and the 6% of the entire tourism sector (Table 12). This trend, if uncontrolled and unmanaged can potentially mine the positive outcomes due to the past preservation of the municipality from mass tourism. In order to understand if the current load imposed by cruise tourism on municipalities can be fixed by territories the emergy of natural resources required to dilute atmospheric emissions per passenger generated by ships during they stay in ports has been compared with emergy of natural resources available per passenger: the ratio between these two measures is presented in Table 13.

The ratio is here proposed as a “carrying capacity index” comparing the load imposed on natural environment and the capacity of the system to counterbalance. If the ratio is lower than the unit, resources required to the environment to absorb emissions are lower than those provided and the load can be considered acceptable. On the contrary, the amount of resources required to the local environment is not available since it is used up for some other activities or limited at biophysical level.

	Carrying capacity index
Portofino	1.35
Santa Margherita	14.33
Rapallo	26.56

*Table 13: Ratio between emergy required to dilute emission and emergy of natural resources available per passenger*

Carrying capacity is exceeded in the three municipalities even if in Portofino a limit condition is

detected since the value is just beyond the unit, probably as a positive consequence of the  
2 preservation regime previously described. The other municipalities strongly suffer the  
consequences of uncontrolled past tourism development, that dramatically reduced low impact  
4 activities and not urbanized spaces.

This means that, if cruise ships activity in Portofino is excessively boosted, a proportionate effort  
6 should be made by authorities in order to limit negative impacts, such as harmful emissions, and  
to increase reservoirs of natural resources.

*Figure 11 should be placed here*

8 Moreover it must be taken into account that the number of landings in Portofino has been  
strongly reduced in the last years by legal restrictions introduced with the Ministerial Decree  
10 (D.M.) 07/03/2012 and the ordinance n. 56/2012 by the District Maritime (Coast Guard) of Santa  
Margherita Ligure, that moved the anchor zone for the cruise ships in front of Portofino  
12 municipality from 0.3 miles to 0.7 miles from MPA limits.

This limitation is imposed only to Portofino municipality, entirely within the Marine Protected  
14 Area, and then in proximity of an area of great environmental value.

The higher exposure to weather and sea conditions in the staging area for the cruise ships in front  
16 of Portofino (due to the greater distance from the coast), has caused cancellations of a share of  
cruise ships arrivals in Portofino.

18 Passengers' landings suffered a huge decrease being almost halved from 2011 (before the  
introduction of legal restrictions) to 2014 (Figure 11). Nonetheless, if cruise passengers in  
20 Portofino were brought back to the 2011 condition, the carrying capacity index would not show a  
significant increase (from 1.35 to 1.36) (Table 13). This is due to the fact that cruise tourism still  
22 remains a little share of tourism sector. Anyway it is important to consider that limits of natural  
environment are already overtaken and every intervention furtherly intensifying pressure on local  
24 environment should be carefully evaluated with a system perspective.

This should be considered by local authorities that in summer 2016 allowed again anchoring at  
26 0.3 miles. Currently cruise managers give to municipalities and private managers of marinas an  
amount equal to 4.5€ per cruise passenger landed in Portofino (50% to municipal authorities,  
28 50% to privates), 4€ in Santa Margherita (to a company whose capital is held by municipal  
authorities) and 3€ in Rapallo (given to a private company). This sort of duty should be  
30 reinvested in order to set up mitigation procedures for impacts coming from the sector (aimed at

increase natural resources availability and reduce impacts) being interpreted as a type of Payment for Ecosystem Services (Katoomba Group, 2008). Clearly measures should be taken to rationalise the entire system aiming at an equilibrium between environmental limits and economic boost.

#### 4 **Conclusions**

Emergy analysis was applied to three municipalities located along the Liguria Region coast where tourism and cruise tourism activities are considered thriving and results were compared with traditional economic indices.

The study allowed to investigate the territorial assessment of three municipalities from both an environmental and economic point of view. Differences and similarities among case studies emerged and were highlighted. Tertiary sector and in particular tourism resulted the central sectors of the economies. Nonetheless consequences from different development strategies followed in the last centuries by the three municipalities come to light in results.

In Portofino, thanks to the specialization of on an elite type tourism, together with a greater attention devoted to the environment, a sort of safeguarding of both tourism and natural resources can be recorded. Portofino productive sector appears to be strongly neglected contrariwise of Rapallo situation. Santa Margherita economy, enjoying in the past of a flourishing mass type tourism, lays in a boundary condition, posing at risk both economic and environmental compartments.

Cruise tourism sector was analysed in these territorial contexts. Ecological and economic impacts of cruise sector revealed to be significant only in Portofino while in Rapallo and Santa Margherita its contribution counts up for less than 1%.

When load imposed to local environment by cruise ships tourism, as resources required to dilute emissions, is analysed, Portofino appeared to be in a limit condition while in Santa Margherita and Rapallo a remarkable excess of carrying capacity was identified.

This condition is due to the different management approaches adopted in the three municipalities: in Portofino where a greater attention has been devoted to natural environment, the territory results more able to absorb impact, even if the limit appears to be currently reached.

As a consequence it appears evident that such phenomena as cruise tourism and tourism in general terms, even if really promising in the short term from the economic point of view, should be managed with a long term perspective aimed at integrating them in the local territorial context setting up strategies for impacts reduction or mitigation and rationalisation of territorial

ecological-economic assessment.

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## Appendix 1: Formulas employed for emergy calculation

- 2 Formulas employed for emergy calculation of entire municipalities and their tourism sectors are reported below.
- 4 For tourism impact evaluation, fluxes, excluding human labour, have been prorated according to tourists' equivalent presences in comparison with residents presences. Human labour has been
- 6 calculated basing on the number of people employed in tourism related activities obtained by local statistical annual reports.
- 8 The rate of emergy consumed by marinas and bathing establishments have been calculated for the tourism sector according to reported formulas.

10

$$\text{Sun [J/y]} = (\text{land area} + \text{marine area}) * \text{Solar radiation} * (1 - \text{albedo}) * \text{J/kcal}$$

	U.M.	Portofino	Santa Margherita	Rapallo
Land area	m2	2.55E+06	9.82E+06	3.40E+07
Marine area	m2	1.31E+07	1.10E+07	1.34E+07
Albedo	%	2.00E-01 on land and 3.50E-01 on sea		
Solar radiation	J/m2/y	5.165E+09		

12

$$\text{Wind [J/y]} = (\text{land area} + \text{marine area}) * \text{drag coefficient} * \text{air density} * \text{wind velocity}^3 * \text{sec/year}$$

	U.M.	Portofino	Santa Margherita	Rapallo
Land area	m2	2.55E+06	9.82E+06	3.40E+07
Marine area	m2	1.31E+07	1.10E+07	1.34E+07
Wind velocity	m/sec	3.02E+00		
Air density	kg/m3	1.30E+00		
Drag coefficient		3.00E-03		
Sec/year		3.15E+07		

14

$$\text{Rain (geopotential) [J/y]} = (\text{land area}) * \text{rain} * \text{water density} * \text{runoff} * \text{mean elevation} * g$$

	U.M.	Portofino	Santa Margherita	Rapallo
Land area	m2	2.55E+06	9.82E+06	3.40E+07
Rain	m/y	1.51E+00		
Water density	kg/m3	1.00E+03		
Runoff	%	5.64E+00		
Mean elevation	m	2.50E+02	3.05E+02	4.01E+02

<b>Gravity</b>	<b>m/s<sup>2</sup></b>	9.80E+00
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2 Rain (chem.) [J/y]= (land area+marine area)\*rain\*water density \*evapotraspiration\*Gibbs num.

	<b>U.M.</b>	<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>Land area</b>	<b>m<sup>2</sup></b>	2.55E+06	9.82E+06	3.40E+07
<b>Marine area</b>	<b>m<sup>2</sup></b>	1.31E+07	1.10E+07	1.34E+07
<b>Rain</b>	<b>m/y</b>	1.51E+00		
<b>Water density</b>	<b>kg/m<sup>3</sup></b>	1.00E+03		
<b>Gibbs num.</b>	<b>J/kg</b>	4.94E+03		

4 Geothermal heat [J/y]= land area\*heat flow

		<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>Land area</b>	<b>m<sup>2</sup></b>	2.55E+06	9.82E+06	3.40E+07
<b>Heat flow</b>	<b>J*m<sup>-2</sup>*y<sup>-1</sup></b>	3.14E+06		

6 Tides [J/y]= marine area\*0.5 tide num\*tide range\*water density\*gravity

	<b>U.M.</b>	<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>Marine area</b>	<b>m<sup>2</sup></b>	1.31E+07	1.10E+07	1.34E+07
<b>tide num</b>	<b>num</b>	7.30E+02		
<b>tide range</b>	<b>m</b>	1.44E-01		
<b>water density</b>	<b>kg/m<sup>3</sup></b>	1.03E+03		
<b>gravity</b>	<b>m/s<sup>2</sup></b>	9.80E+00		

8 Waves [J/y] = coast length\*1/8\*water density\*gravity\*wave height<sup>2</sup>\*wave velocity\*sec/year

	<b>U.M.</b>	<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>coast length</b>	<b>m</b>	5.25E+03	4.40E+03	5.35E+03
<b>water density</b>	<b>kg/m<sup>3</sup></b>	1.03E+03		
<b>gravity</b>	<b>m/s<sup>2</sup></b>	9.80E+00		
<b>wave height</b>	<b>m</b>	1.19E+00		
<b>wave velocity</b>	<b>m/s</b>	2.80E+00		
<b>sec/year</b>		3.15E+07		

10 Soil erosion [J/y]= crop area\*erosion rate\*organic matter percentage\*kcal/g/J/kcal

	U.M.	Portofino	Santa Margherita	Rapallo
<b>crop area</b>	<b>m2</b>	7.85E+04	1.62E+06	9.32E+05
<b>erosion rate</b>	<b>g/m2/anno</b>	2.00E+02		
<b>OM%</b>	<b>%</b>	3.00E-02		
<b>kcal/g</b>		5.00E+00		
<b>J/kcal</b>		4.19E+03		

2 Water [g/y]= water consumption (distributed+losses)\*water density

	U.M.	Portofino	Santa Margherita	Rapallo
<b>water distributed</b>	<b>m3/y</b>	2.92E+05	1.65E+06	3.14E+06
<b>water losses</b>	<b>m3/y</b>	1.43E+05	8.10E+05	2.49E+06
<b>water density</b>	<b>g/m3</b>	1.00E+06		

4 Human labour [J/y]= employees num\*working days\*daily consumption\*J/kcal

	U.M.	Portofino	Santa Margherita	Rapallo
<b>num. Employees</b>				
<i>total</i>	<i>num</i>	2.39E+02		2.56E+03
<i>tourism</i>	<i>num</i>	2.15E+01		1.88E+02
<b>working days</b>	<b>day/y</b>	2.10E+02		
<b>kcal/day</b>		2.50E+03		
<b>J/kcal</b>		4.19E+03		

6 Electricity consumption [J/y]= electricity consumption\*J/kwh

	U.M.	Portofino	Santa Margherita	Rapallo
<b>electricity consumption</b>	<b>kwh/y</b>	1.62E+06	6.58E+07	2.00E+08
<b>J/kwh</b>		3.6E+06		

8 Fuel consumption [J/y]= fuel consumption\*J/kg

	U.M.	Portofino	Santa Margherita	Rapallo
<b>gasoline cons</b>	<b>kg/y</b>	9.36E+04	1.82E+06	5.28E+06
<b>diesel cons</b>	<b>kg/y</b>	1.69E+05	3.22E+06	9.93E+06
<b>oil cons</b>	<b>kg/y</b>	3.13E+04	6.07E+05	1.79E+06
<b>energy content gasoline</b>	<b>J/kg</b>	5.53E+07		
<b>energy content diesel</b>	<b>J/litre</b>	5.15E+07		

<b>energy content oil</b>	<b>J/litre</b>	4.20E+07
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2 Gas consumption [J/y]= gas consumption (methane and LPG)\*J/m3

		<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>LPG cons</b>	<b>m3/y</b>	3.93E+00	7.80E+01	2.43E+02
<b>methane cons</b>	<b>m3/y</b>	1.68E+05	3.70E+06	1.12E+07
<b>energy content</b>	<b>J/m3</b>	3.90E+07		

4 Import [€/y]= imported goods cost

		<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>import</b>	<b>€/y</b>	5.31E+06	4.88E+07	1.15E+08

6 Bathing facilities [num/y]= presences per year

		<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>bathing facilities</b>	<b>presences/y</b>	4.58E+05	2.54E+06	3.98E+06

8 Small marinas [berth number]= berth number in marinas

		<b>Portofino</b>	<b>Santa Margherita</b>	<b>Rapallo</b>
<b>berth numbers</b>	<b>num</b>	2.60E+02	3.50E+02	9.00E+02

10

**Appendix 2: References of transformities employed in emergy tables, baseline employed**

2 **9.44E+24**

		UEV (sej/U.M.)	References
Sun	J	1.00E+00	Odum, 1996
Wind	J	1.46E+03	Odum et al., 2000
Rain			
Chemical potential	J	1.82E+04	Odum et al., 2000
Geopotential	J	1.05E+04	Odum et al., 2000
Geothermal heat	J	6.08E+03	Odum, 2000
Tides	J	1.68E+04	Odum, 1996
Waves	J	3.04E+04	Odum et al., 2000
Soil erosion	J	7.40E+04	Campbell et al., 2005
Water			
Distributed	g	7.64E+06	Paoli et al., 2008
Losses	g	4.37E+06	Paoli et al., 2008
Human labour	J	7.38E+06	Ulgiati et al., 1994
Electricity	J	1.74E+05	Odum, 1996
Gasoline	J	6.60E+04	Odum, 1996
Diesel	J	6.60E+04	Odum, 1996
Lubricants and oils	J	6.60E+04	Odum, 1996
Methane	J	4.80E+04	Odum, 1996
Import	€	1.71E+12	Pulselli et al., 2011
Marinas	num	7.12E+15	Paoli et al., 2008
Sunbathing facilities	num	4.44E+12	Paoli, 2009

4

6 **References to Appendix 2**

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- 18

## **Figure captions**

2 Figure 1: Study area with considered municipalities, ports, and anchor area for cruise ships

Figure 2: percentage of interviews performed in the different municipalities

Figure 3: expenditures by categories in different municipalities

Figure 4: importance of the establishment of the MPA according to cruise tourists replies

Figure 5: Percentage contribution of different items to energy total of the municipalities

Figure 6: Energy of cruise ships sector in considered municipalities

Figure 7: Comparison between environmental cost and economic benefit in the considered municipalities

Figure 8: Comparison of hourly requirements by resident, general tourist and cruise tourist

Figure 9: Comparison of environmental cost, WTP, expenses

Figure 10: Boxplots of WTP and enjoyment level score in the three municipalities

Figure 11: Cruise ships passengers' landings in Portofino from 2011 to 2014 (data of 2013 not available)

Figure1

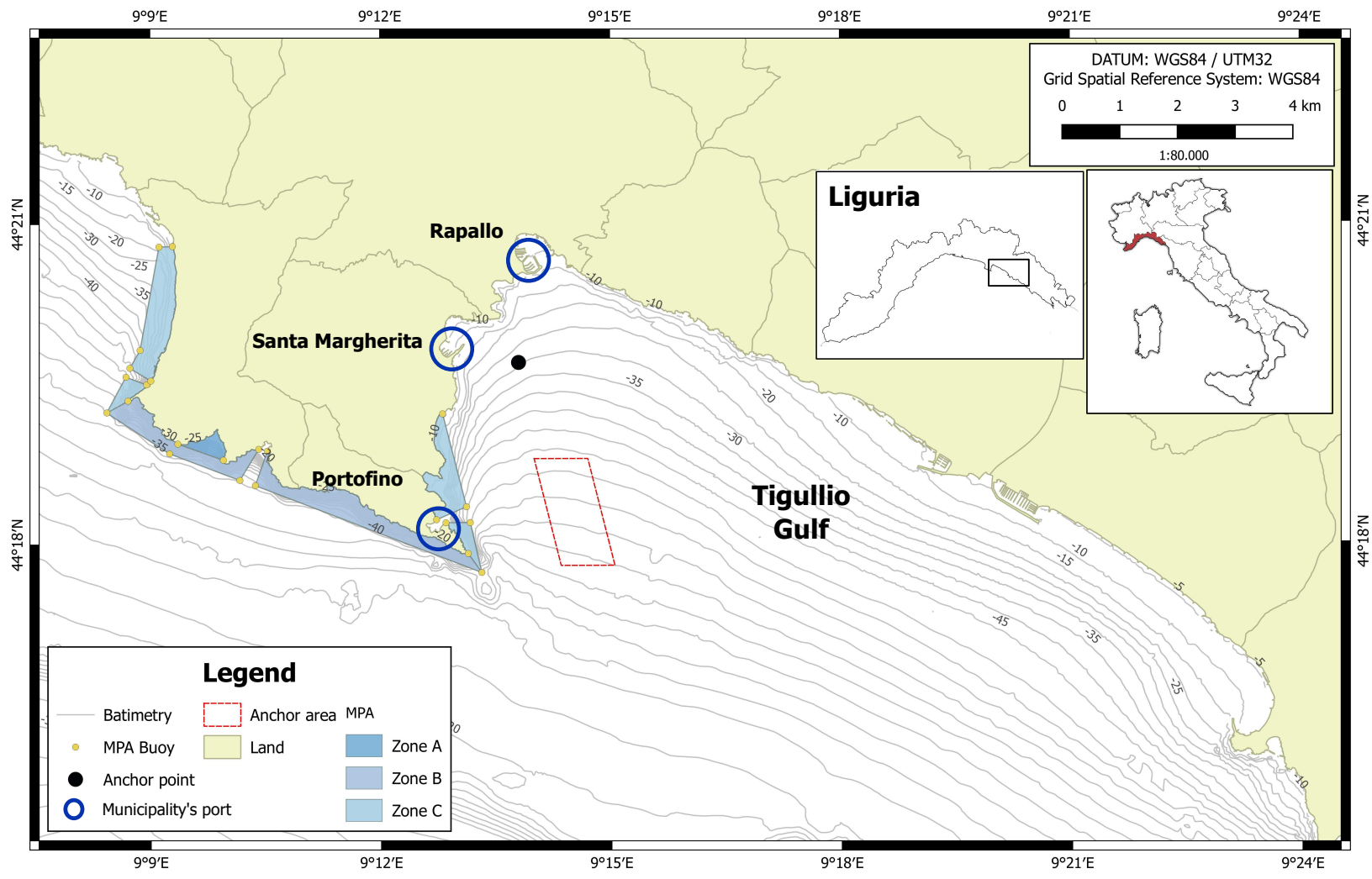


Figure2

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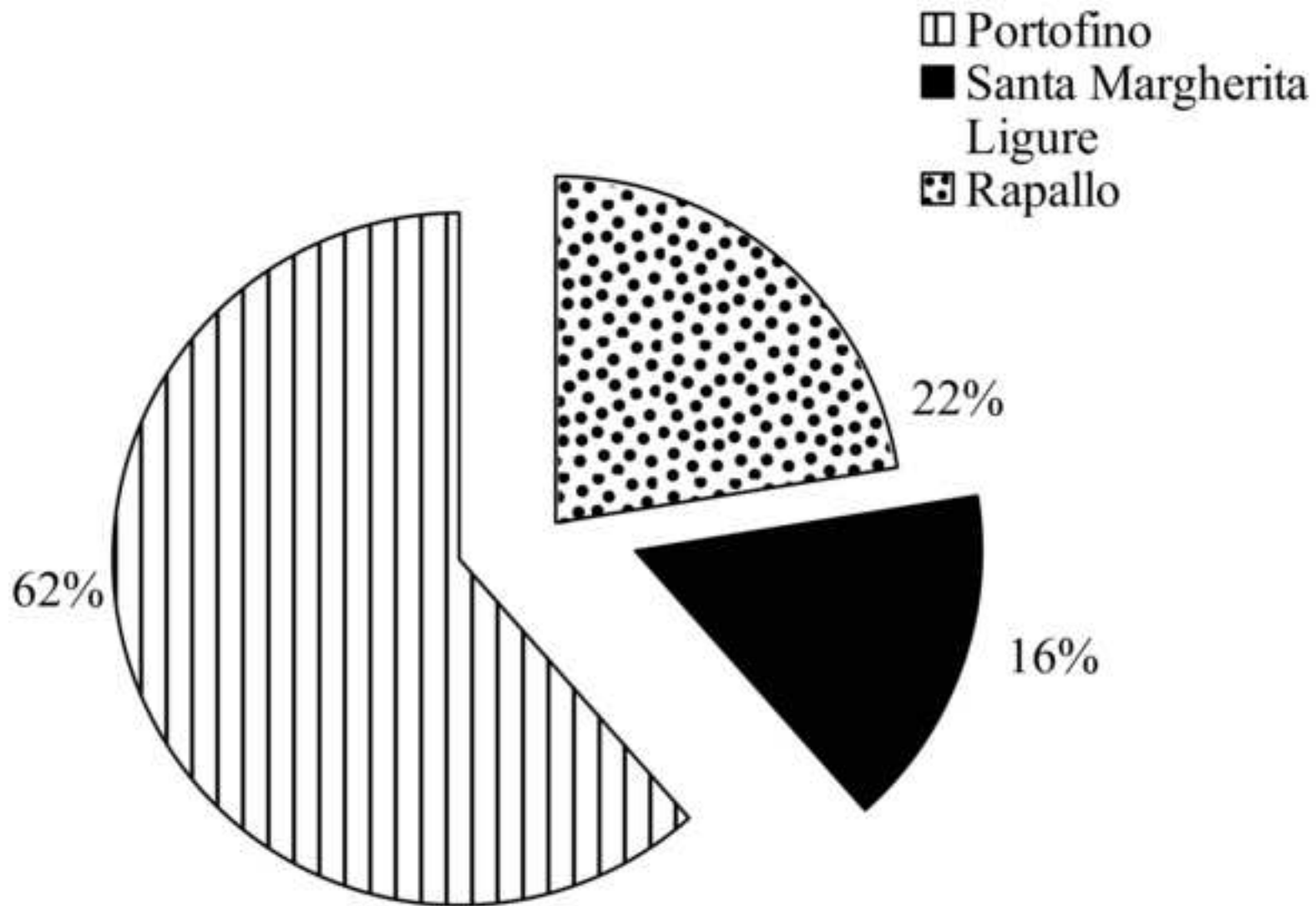


Figure3

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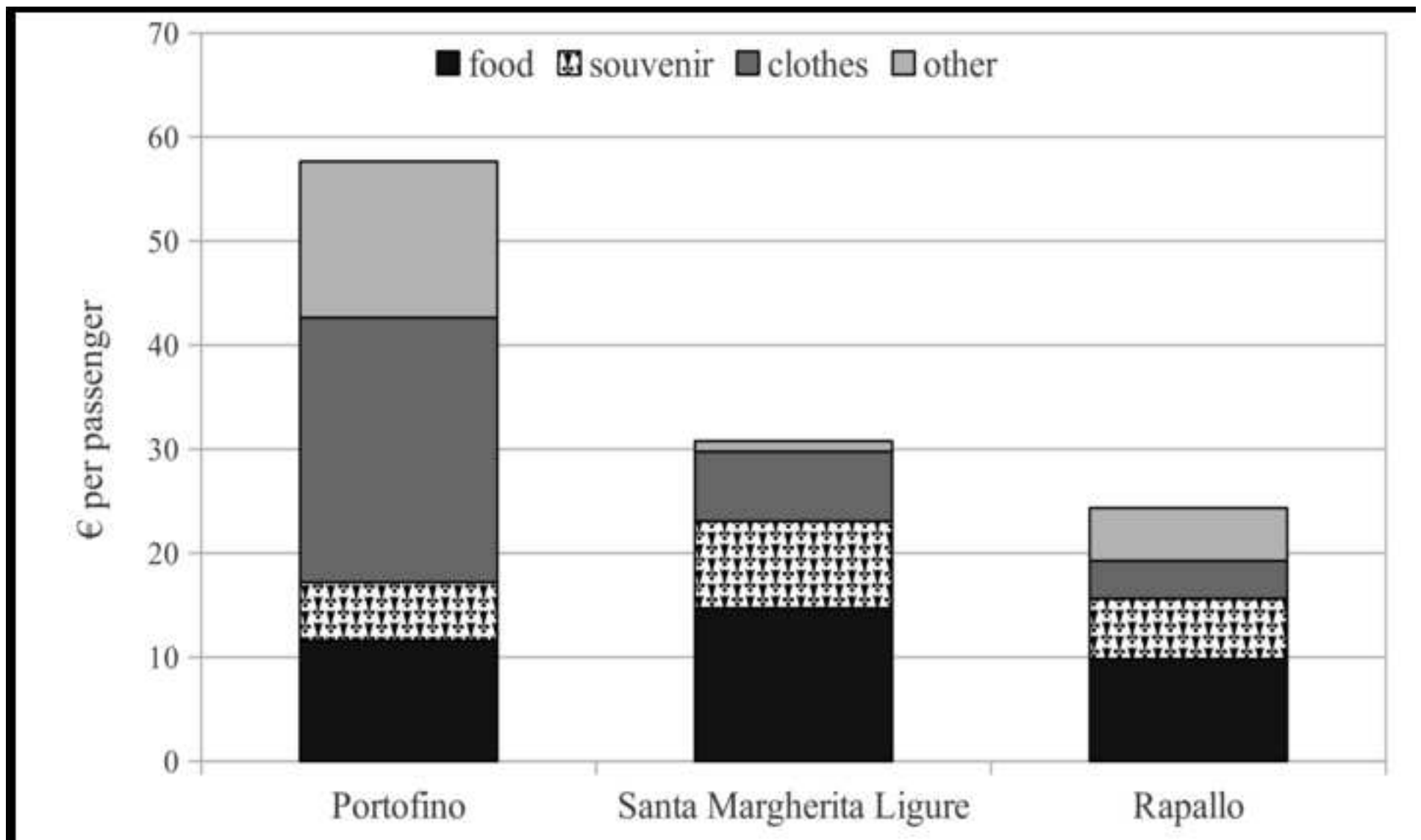


Figure4

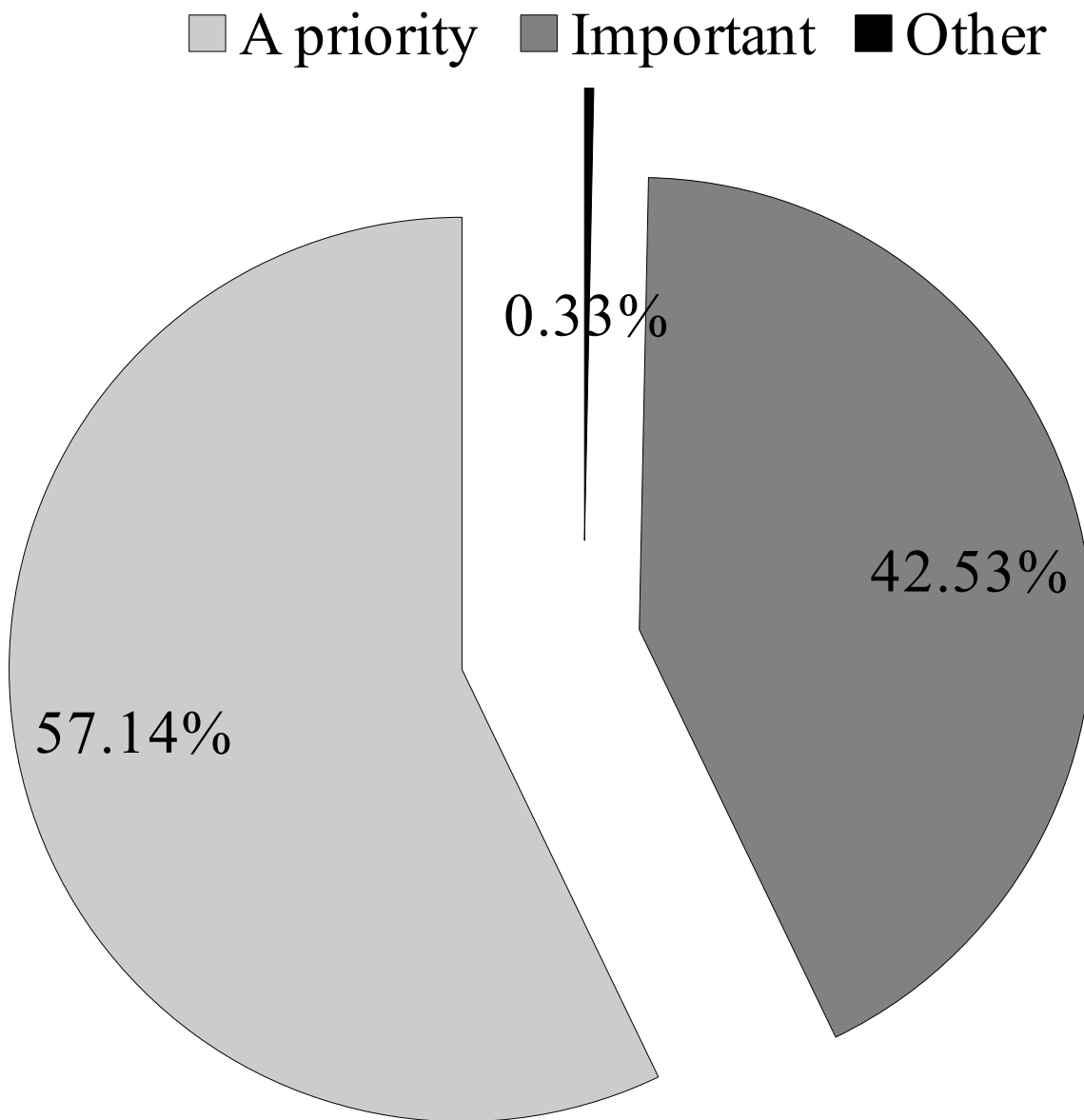


Figure5

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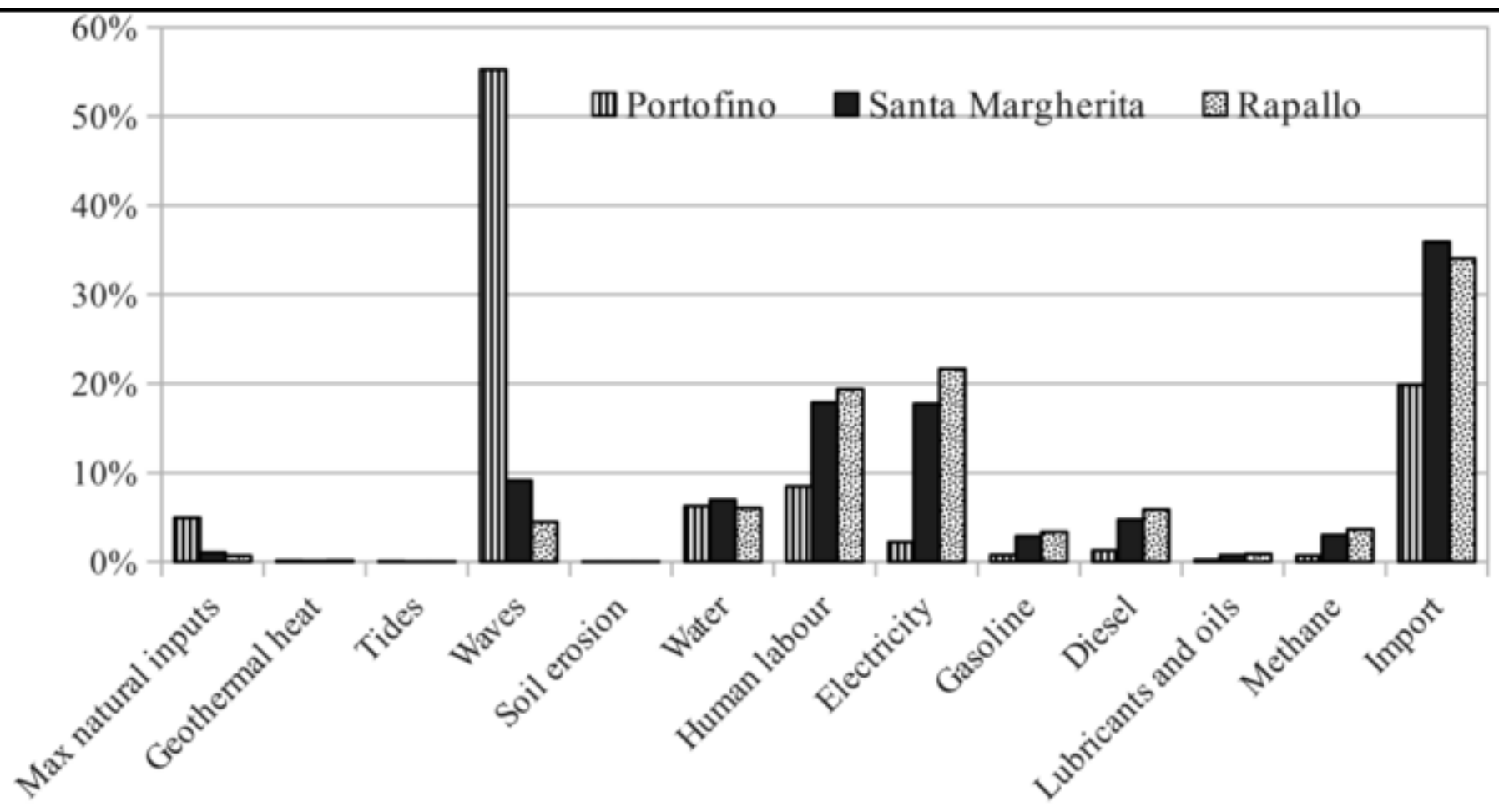


Figure6  
[Click here to download high resolution image](#)

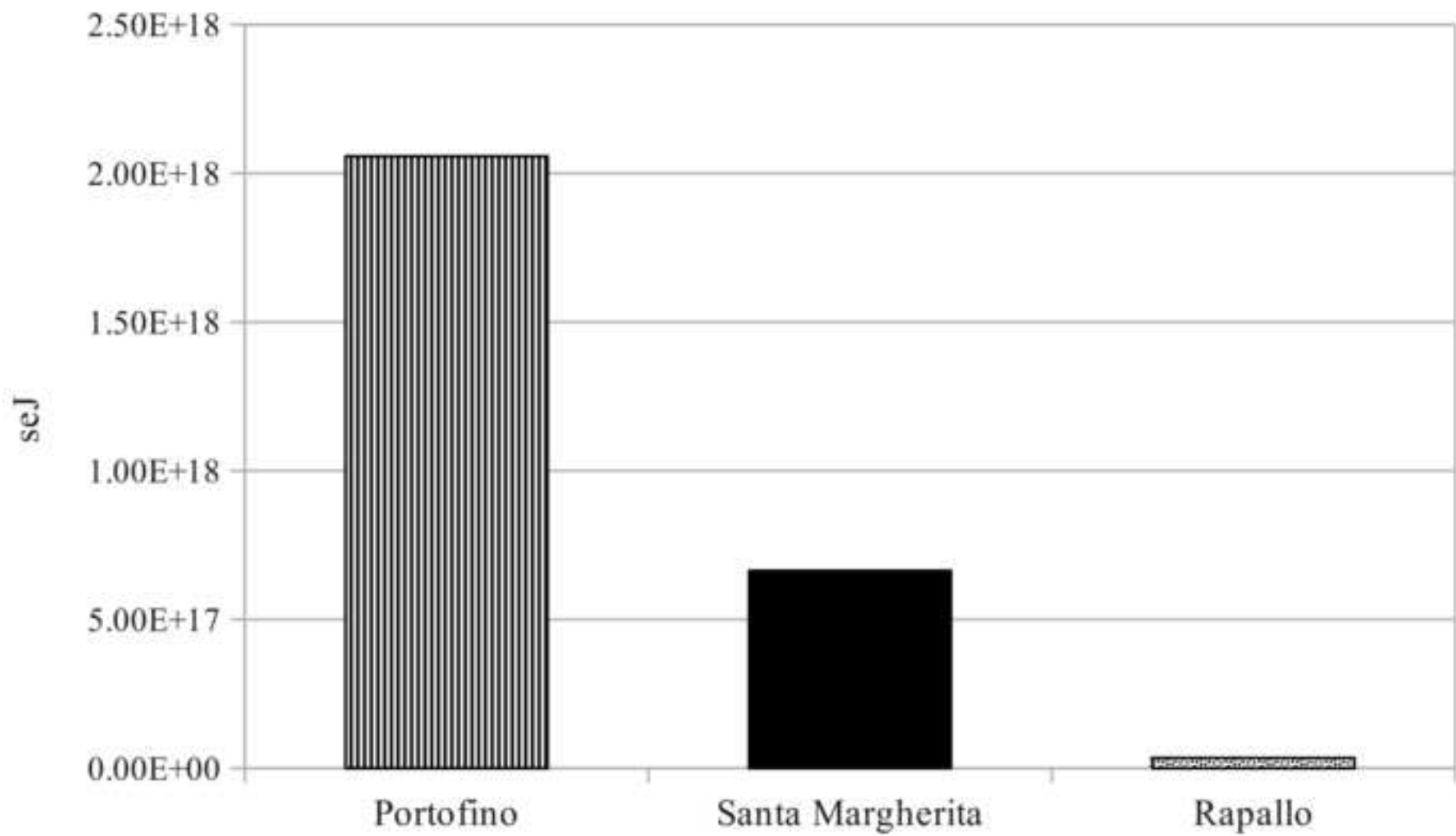


Figure7

[Click here to download high resolution image](#)

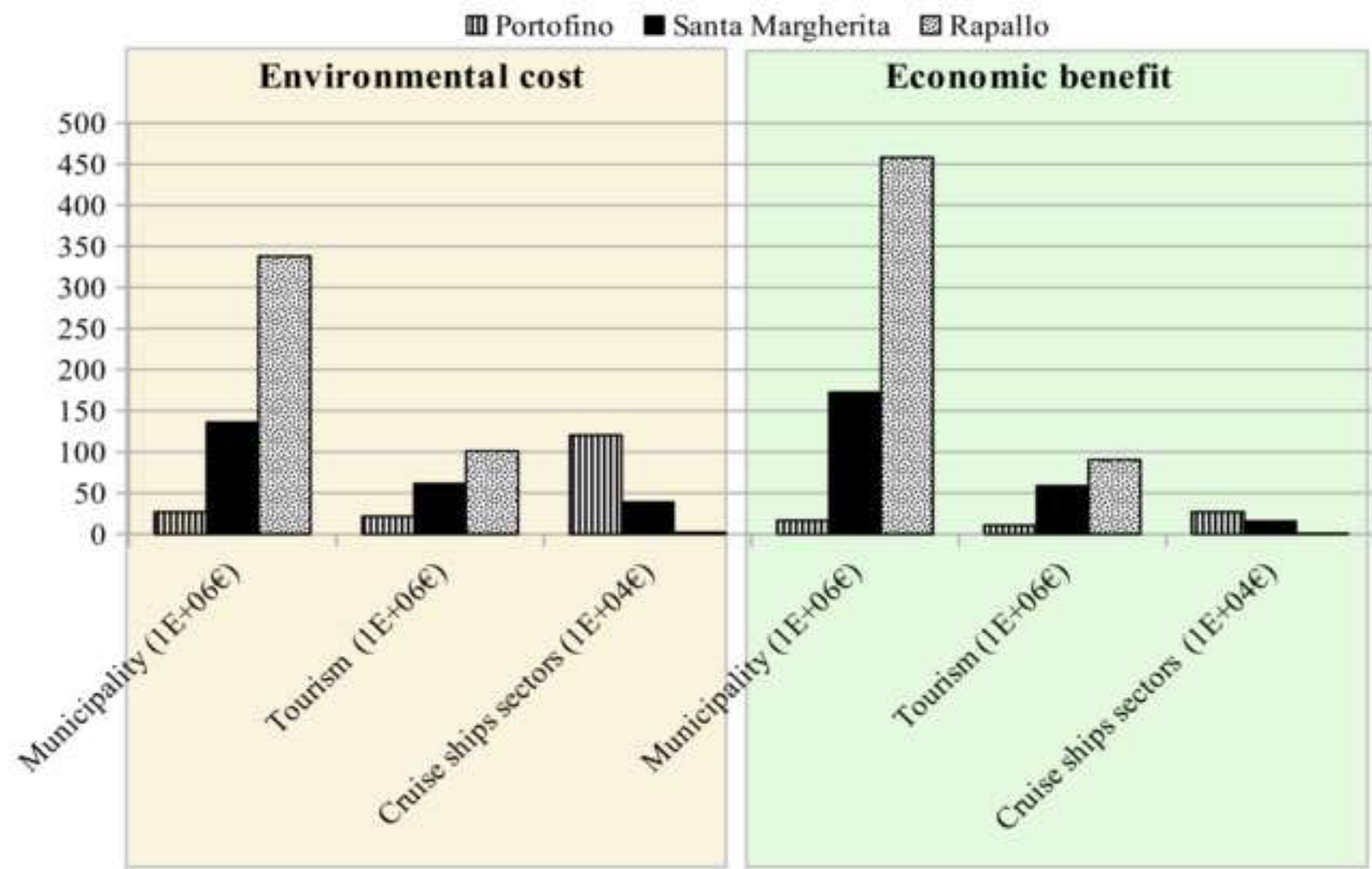


Figure8

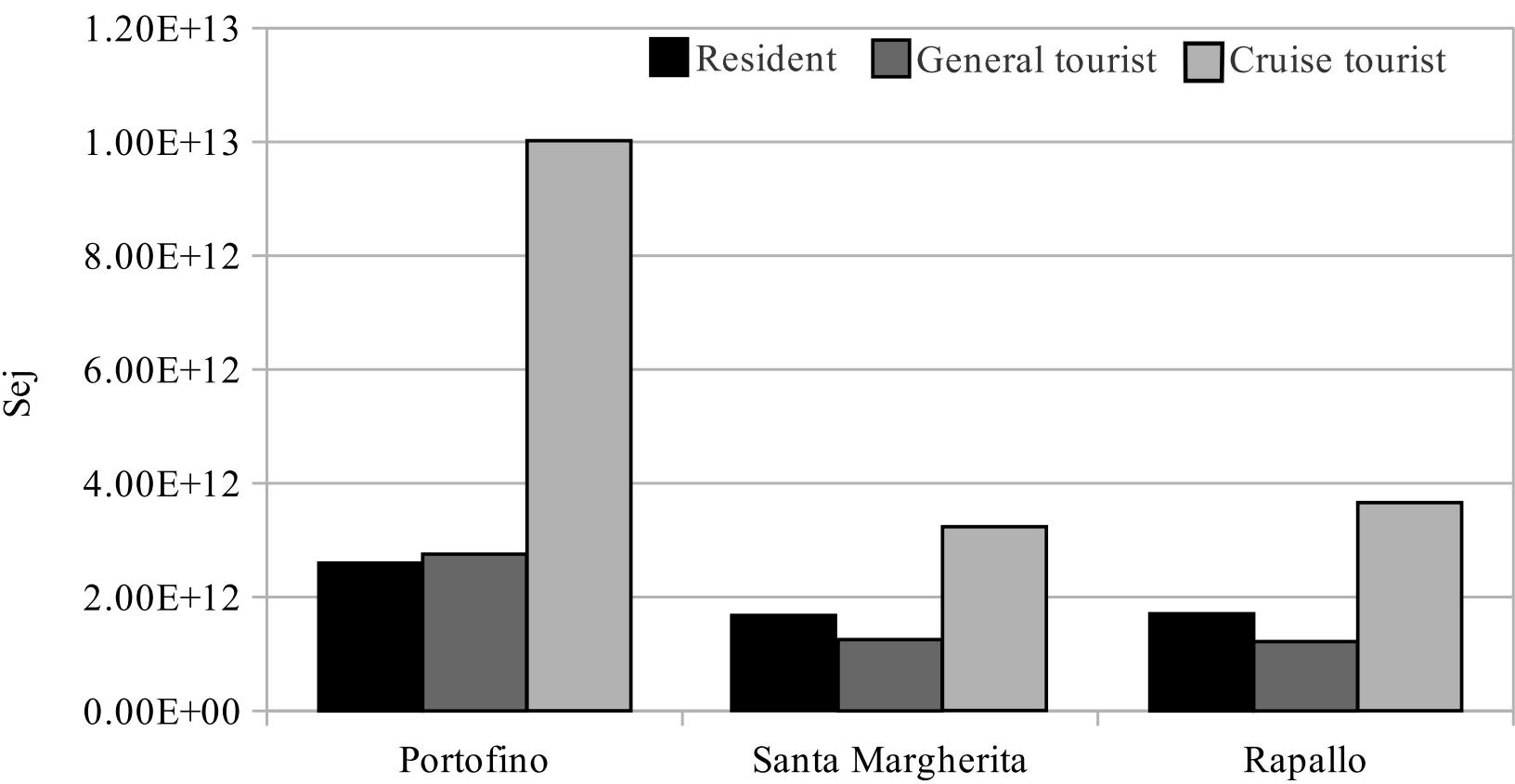


Figure9

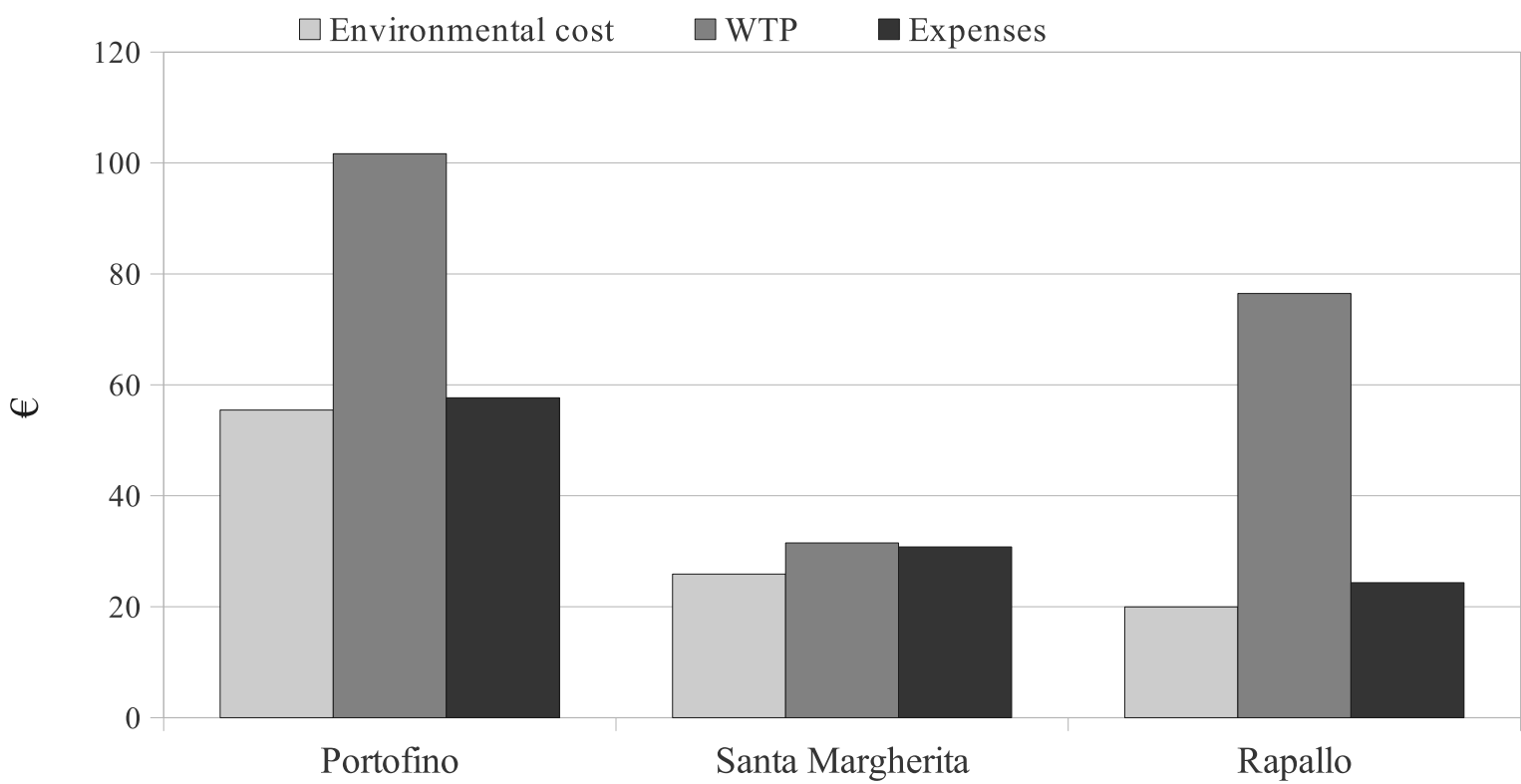


Figure10

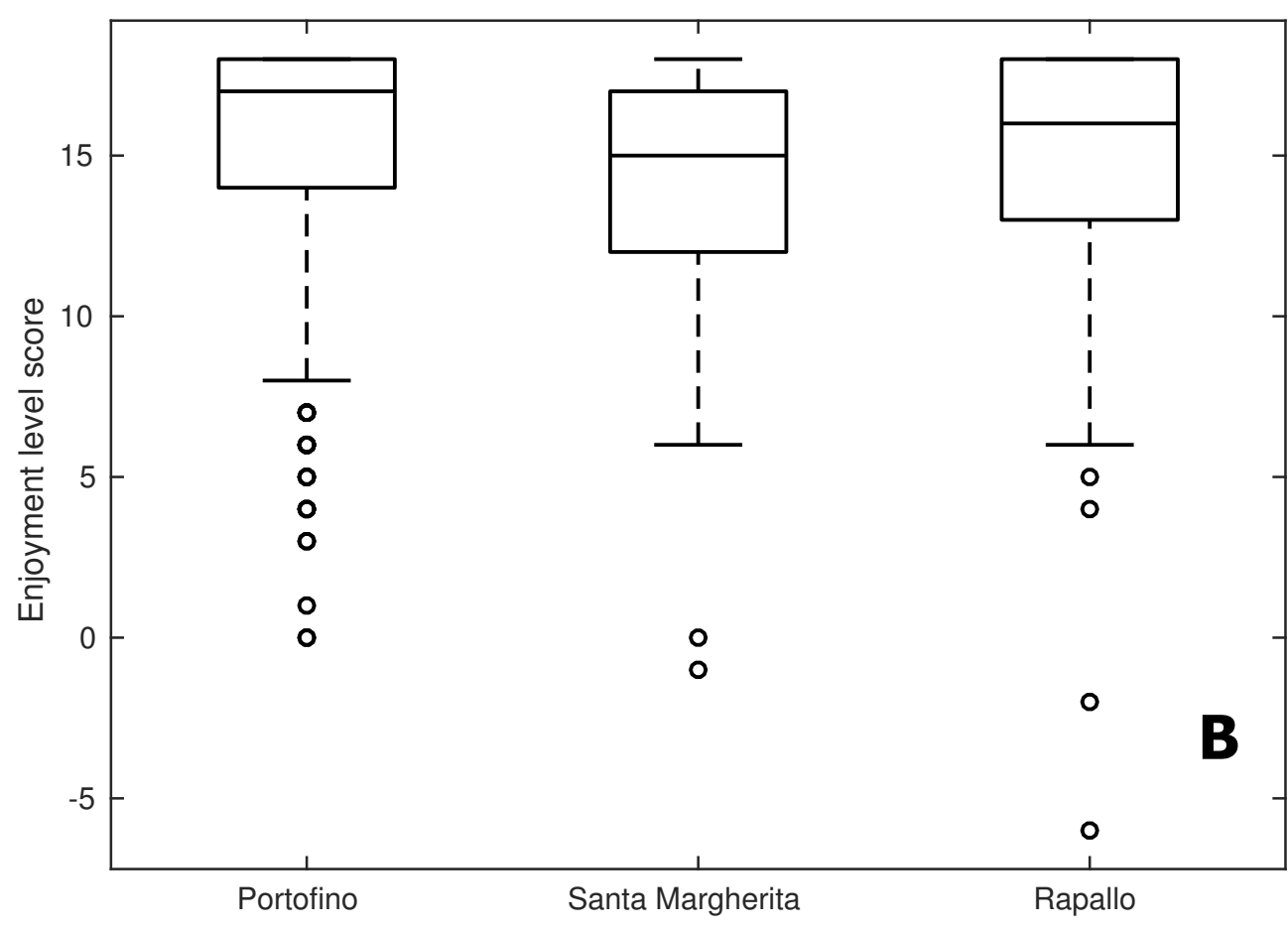
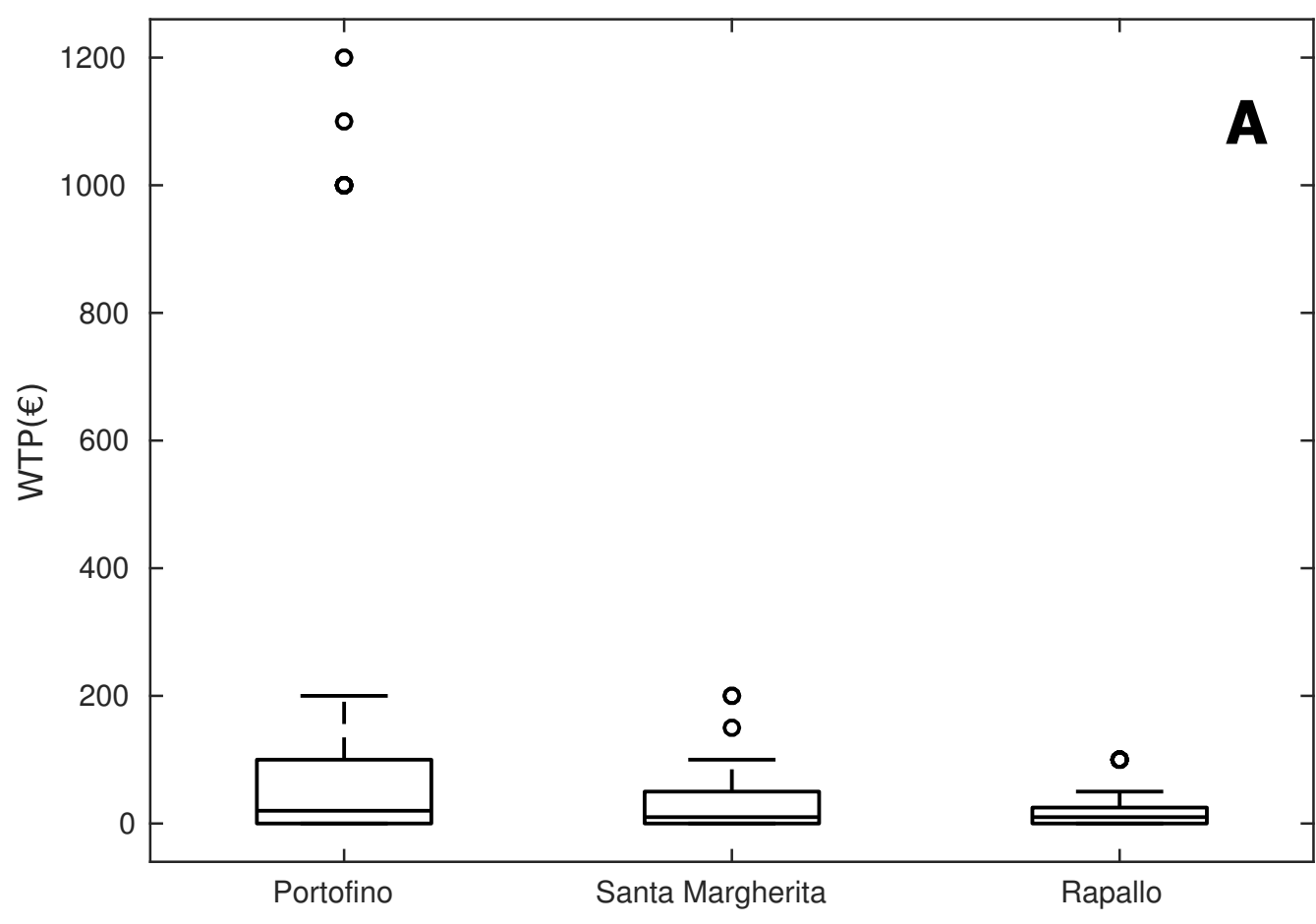


Figure11

