PORT-CITY CLOSENESS AND TURNAROUND TIME CRITICAL FOR SHORT SEA SHIPPING SUSTAINABLE PERFORMANCE A CASE STUDY: SPAIN

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Abstract: Air pollution is the most relevant externality of maritime transport and its effects are more acute in urban areas. As Short Sea Shipping (SSS) services call ports frequently and expend significant time in port, both the overall turnaround time and the port city closeness, become critical in their sustainable performance. This paper analyses the impact of maritime transport on Spanish SSS ports and identifies the ideal ones, reflecting the differences in their sustainable performance and finally identifying the characteristics that a harbour needs to gather in order to minimize air pollution impact in the maritime transport sector.

Keywords: Short Sea Shipping; externalities, air pollution.

1. Introduction

The geographical location of Spain, its orography in border regions and the fact that intra-European transport is not balanced at all, have made of Spain the perfect location to establish Short Sea Shipping (SSS) lines.

SSS line operators often seek well located (close to industrial areas) and connected (infrastructures) ports, being the answer to these requirements major ports located next to densely populated urban areas such as Barcelona.

Since SSS lines call frequently at port, these ships expend long time manoeuvring and hotelling, hence releasing harmful pollutants close to urban areas.

2. The Scenario

This paper studies the environmental performance, focusing in air pollution, of Ro-Pax ships calling at Spanish mainland ports under the existing SSS services.

2.1. SSS Air Pollution

Maritime transport is well known due to its overall environmentally friendly performance, air pollution is the weak point of this performance though. By far air pollution accounts for the vast majority of the external costs produced by maritime transport, around the 90 % (Usabiaga, 2009). Emissions from shipping represent around 40 % of global NO_x emissions and around 15 % of CO_2 emissions of global freight transport (Goldsworthy, 2010).

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Among the several environmental effects entailed by maritime transport both at sea and in ports, the scope of this paper covers the externalities produced by the air pollutants emitted by SSS Ro-Pax ships at Spanish harbours. This paper covers emissions of Particulate Matter ($PM_{2.5}$), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), and Volatile Organic Compounds (VOC-s), although other pollutants also exist these are considered the most relevant.

Air pollutants follow two different paths when causing their effects:

- On the one hand $PM_{2,5}$ and SO_2 emissions are relevant for local impact considering that they are able to cause damage in the original form they are released. This impact, as related to health problems, is dependent on the proximity between emission sources and receptors, and the population density around the emission source.
- On the other hand NO_x, VOC-s and SO_2 being ozone and aerosol precursors need to be transported some distance (hundreds of kilometres) in the atmosphere while undergoing chemical processes before generating associated secondary pollutants (ozone, nitrate aerosols and sulphate aerosols). These associated pollutants produce impacts mainly in form of sulphur deposition (acid rain), eutrophication (excess of nitrogen nutrient) and ozone formation.

In harbour cities maritime activity is often dominant source of urban pollution, hence this must be addressed adequately (Miola et al., 2009). Moreover the type of ship studied in this paper is especially relevant taking into account the frequency with which they call at port and therefore the time they spent in port.

2.2. Spanish SSS Ro-Pax Service Network

Spain is among the European Union (EU) member states the one with the longest coastline, approx. 8000 km and its state controlled port network is composed by 46 harbours managed by 28 port authorities. This together with the facts already mentioned, the strategic geographical location, border region orography and the EU willingness to achieve a better balanced transport system, has developed in numerous SSS lines calling at Spanish harbours.

27 of the aforementioned 46 harbours are located in the Iberian Peninsula, and SSS Ro-Pax lines call at eight of them. Three (Bilbao, Santander and Gijon) are located in the Atlantic and five in the Mediterranean (Barcelona, Valencia, Alicante, Almería and Algeciras). These SSS lines connect Spain directly with Great Britain, Belgium, France, Italy, Marocco, Algeria and Tunisia.

Ro-Pax ships are designed to carry both Roll on-Roll off (Ro-Ro) cargo and passengers, they usually have relatively high service speeds, of around 20 knots, short turnaround times, involve simple port operations and do not require of complex harbour infrastructures. Therefore are commonly used in SSS lines requiring both passenger and cargo capacity.

2.3. Regulatory Framework for Air Emissions From Ships

The international feature of the maritime activity, the sector itself and the governing regulatory framework makes it complex to design and implement policies in order to abate air emissions. Nevertheless, through the Strategy for Sustainable Development of the EU White Paper on Transport Policy

(European Commission, 2001b), the European Union has expressed concern about transport-related impacts.

Current regulatory actions seek to reduce emissions from ships forcing the introduction of new abatement technologies and also establishing minimum fuel quality standards.

The main regulatory body is the International Maritime Organization (IMO), the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. The International Convention for the Prevention of Pollution from Ships, MARPOL 1973/1978 (International Maritime Organization, 2008a), is the main IMO convention aimed at preventing and minimizing pollution from ships, both accidental pollution and that from routine operations and currently includes six technical Annexes.

Air pollutant emissions from ships are covered by Annex VI, in force since 2005. This annex set's limits on Sulphur Oxide and Nitrogen Oxide emissions from ship exhausts as well as Particulate Matter and prohibit deliberate emissions of ozone depleting substances. In 2008 the IMO Marine Environment and Protection Committee (MEPC) amended Annex VI, and the revised text introduced emission control areas (ECA-s) in which, due to their air quality problems, more stringent emission policies are in force since 1 July 2010.

IMO emission standards are known as Tier I-III standards. Tier I standards were established in 1997 when air pollution was introduced into the Annex VI, while Tier II-III standards were introduced in 2008 when Annex VI was amended by the MEPC.

The Annex VI establishes to sets of fuel quality and emission standards:

- Global requirements
- More stringent requirements applicable to ships operating in ECA-s

As stated by Regulation 12 of the MEPC 58/22 "an Emission Control Area shall be any sea area, including any port area designated by the organization" in which more restrictive emission regulations are applicable.

ECA-s, following a proposal from a party, can be designated specifically for SO_x, PM and NO_x, or for the three of the pollutants. Existing ECA-s include the Baltic Sea (for SO_x and in force since May 2006), the North Sea and the English Channel (for SO_x in force since November 2007) and the North American ECA (for NO_x and SO_x to enter into force in August 2011).

MARPOL Annex VI seeks a progressive reduction in SO_x emissions limiting the sulphur content in marine fuel oils. The actual sulphur cap of 4.5 % shall be reduced to 3.5 %, by January 2012 and furthermore down to 0.5 % by January 2020 (International Maritime Organization, 2008b). Since July 2010 the sulphur limit in the ECA-s is of 1 % and will be further reduce to a 0.1 % by January 2015 (International Maritime Organization, 2008b). Progressively restrictive policies regarding NO_x emissions are also being enforced by Annex VI, for instance Tier III applicable for new constructions after January 2016 (International Maritime Organization, 2008b).

Moreover the EU is going beyond IMO emission standards, and with its EC Sulphur Directives 2005/33 and 1999/32, it has established even more stringent sulphur standards, limiting the sulphur content to 0.1 % in marine fuels used by ships at berth in EU ports, with the exceptions of ships which spend less than two hours at berth and ships which switch off all engines and use shore-side electricity when at berth. Standard enforced since January 2010.

2.4. Previous Research

Several attempts have been made to estimate external costs in the transport area. The most important results were obtained by some research projects, especially those within the 4th, 5th, 6th and 7th EU-framework programs. Other projects that conducted similar research are RECORDIT (European Commission, 2001a), ENTEC (Whall, 2002), UNITE (Institute for Transport Studies, 2003), INFRAS (UIC, 2004), ExternE (ExternE, 2005), MOPSEA (Vangheluwe et al., 2007), EMMOSS (Transport & Mobility Leuven, 2007a), EMSA (Thomas, 2007), iTREN-2030 (Transport & Mobility Leuven, 2007b) and IMO proposals. RECORDIT (and thus REALISE) results were expressed at emission factor costs. Some other approaches developed in Europe, such as the MEET (Methodologies for estimating air pollutant emissions from transport), which describes a methodology for calculating the emissions from sea-going vessels.

If aforementioned projects try to estimate the emission of pollutants produced by the transport activity, there many others focusing on the impacts, cost, that pollutant emissions produce. Among the most important and the ones in which this paper is based we find Benefits Table Database: Estimates of the marginal external costs of air pollution in Europe (BETA), (Holland et al., 2002) and Clean Air For Europe programme CAFE (Holland et al., 2005).

3. The Problem

Although air pollution is well known as the major externality of maritime transport, today there is no study in Spain attempting to quantify this cost. Moreover air pollution costs have a local component and it is not fair to evaluate all ports as whole, a differentiation is required to properly evaluate SSS performance and the economic feasibility of existing alternatives for power supply in harbours.

Furthermore the existing unawareness regarding real costs that a call at port implies, makes it impossible to take efficient decisions between different alternatives taking into account that the existing criteria is not comprehensive. Therefore this paper tries to calculate site specific costs, and thus build up a criterion for the fair pricing of SSS shipping services, favouring the most sustainable services.

3.1. Methodology

The purpose of this paper is to estimate, tailored for each port, the air pollution externalities that a call at port involves for each of the 8 harbours hosting Ro-Pax SSS lines in Spain.

Taking into account great part of air pollution externalities are produced at a local scale just after the pollutants (PM and SO_x primarily) have been released, hence are site specific, to be able to achieve a real estimation high detail is required (geographical characterization of the emissions is critical).

Therefore the approach chosen for the estimation of air pollution externalities is a bottom up approach, where all the elements relevant for the costs estimation are individually assessed in order to achieve a final global result. This means that the pollution a single ship generates in a precise location is modelled in order to be afterwards aggregated to the rest.

For site specific air pollution externalities cost calculation, two estimations result critical. On the one hand the quantity of pollutants ($PM_{2.5}$, SO_2, NO_x and VOC-s) emitted must be estimated and on the other hand the impact of released pollutants also has to be estimated.

Already exist well known projects regarding both the estimation of pollutant emission (REALISE) and the estimation of the impact of the pollutants released (Benefits Table Database: Estimates of the marginal external costs of air pollution in Europe (BETA), Clean Air for Europe programme (CAFE). Our job has been to put these projects in common in order to get the desired and comprehensive results.

The following are the relevant projects put in common and used in this paper:

- Environmental impact (tones of each pollutant considered) of SSS ships at port. We have used data from REALISE project, a thematic network on Short Sea Shipping which provides a methodology to calculate external costs from both sea and road transport. The REALISE project took the datasets in the EIG (2002), based upon the COPERT III calculation module. The air emission factors of vessels, in g/kg fuel, were calculated taking the fuel consumption into account. Since not all the pollutants were listed in the EIG report, additional information was extracted from the CBS database with regards to SO_2 emissions. To evaluate the impact of the evolution of transport emissions, the scenario considered is a future hypothetical improved condition, resulting in a 10 % decrease in all current emissions, except for SO_2 and NO_x. The main engine specific fuel consumption rate is strongly affected by the propulsion systems installed, such as engine, gear, shaft and propulsion arrangements. In this analysis we consider the hourly consumption of each ship on the basis of 200 g/kW per hour, because almost all ships mentioned here are propelled by four-stoke diesel engines (Martínez de Osés and Castells, 2009).
- Benefits Table Database (BETA), published in 2002, provides a straight forward estimation of air pollution overall external costs, putting together both urban and rural externalities. BETA studies both the local and regional or transboundary impact and calculates the overall external costs. However, once in 2005 new air pollution external costs were published, under the CAFE programme, it was clearly agreed by the experts that previous external costs, given by BETA where underestimating the real costs. Therefore this paper maintains the relation given by BETA to relate urban and rural external costs, but takes updated external costs provided by the CAFE programme. The cost estimation done under the CAFÉ programme considers human exposure to $PM_{2.5}$, human exposure to ozone and exposure of crops to ozone under different sensitivity frameworks. Although more impacts are known still there is no sufficient information to evaluate them with guarantee. Moreover in the attempt to achieve comprehensive results the valuation done by the CAFÉ programme considers four different sensitivity scenarios which lead to four different results.

3.2. Analysis

Based on Realise project and in order to achieve a comprehensive bottom up approach, it was important to know:

- Characteristics of the vessels, basically power. Ships considered in our study are passenger/Ro-Ro. Ro-Ro ships are ferries designed to carry wheeled cargo and have built-in ramps which allow the cargo to be efficiently "rolled-on" and "rolled-off" the vessel when in port;
- Duration of the stages of the voyages, basically manoeuvring and hotelling stages time of the different ships;
- Emission factors of pollutants analysed.

On the other hand, based on BETA and CAFE programme it was important to know the number of inhabitants around the considered harbours, as this is the main variable producing the difference between the external costs produced by a ship calling in the different ports.

Finally, once we have gathered all the mentioned data, following the methodologies of the different projects and putting them together we can map the actual emissions of SSS services in Spanish ports and calculate the external costs produced in each.

Table 1

Ro-Pax Ships and SSS Spanish Lines

SSS Spanish Services	Ro-Pax Ships
Algeciras-Tanger Med	Passio per Formentera
Alicante-Argel	Tassili II
Almeria-Melilla	Juan J sister
Barcelona-Civitavecchia	Cruise Roma
Bilbao-Portsmouth	Cap Finistere
Gijón-St. Nazaire	Norman Bridge
Santander-Plymouth-Portsmouth	Pont Aven
Valencia-Palma de Mallorca	Fortuny

3.3. Examples

In this paper, we have analyzed the air pollution externalities that Ro-Pax ships generate for each of the 8 following harbours hosting SSS lines in Spain (Table 1):

Ro-Pax ships are commonly used in SSS lines requiring both passenger and cargo capacity. Like air pollution local impact is proportional to the affected population it is necessary to know the number of inhabitants around the considered ports. This information is shown in Table 2. Then Table 3 shows the cost of emission for each considered pollutant and harbour determined by the affected people.

Table 3 shows clearly how emission costs increase in densely populated harbour areas, for instance costs per emitted tonne in Barcelona are 12 times higher than those in Algeciras. As the objective of the paper is to valuate air pollution costs at port calling the two operation modes considered are manoeuvring stage (moving into or out of port) and hotelling stage (operations while stationary at berth). Hence we have calculated engine power (kilowatts), manoeuvring times and hotelling times. Table 4 shows the duration of time of the two stages considered:

Table 2

Population in Considered Ports

Ports	Inhabitants in urban area
Algeciras	116417
Alicante	334418
Almería	190013
Barcelona	1619337
Bilbao	175234
Gijón	277198
Santander	181589
Valencia	809267

Table 3
Cost of Pollutants in Considered Ports (in euro/ton)

Ports	Sensitivity	$PM_{2.5}$		SO_2		NO_x	VOCs
		Local	Rural	Local	Rural		
Algeciras	Sen. Case 1	92435	19000	8149	4300	2600	380
	Sen. Case 2	140981	29000	12457	6600	3800	510
	Sen. Case 3	179864	37000	15833	8400	5200	920
	Sen. Case 4	262588	54000	22585	12000	7200	1100
Alicante	Sen. Case 1	265528	19000	23409	4300	2600	380
	Sen. Case 2	404980	29000	35783	6600	3800	510
	Sen. Case 3	516676	37000	45481	8400	5200	920
	Sen. Case 4	754307	54000	64877	12000	7200	1100
Almería	Sen. Case 1	150870	19000	13301	4300	2600	380
	Sen. Case 2	230106	29000	20331	6600	3800	510
	Sen. Case 3	293570	37000	25842	8400	5200	920
	Sen. Case 4	428590	54000	36863	12000	7200	1100
Barcelona	Sen. Case 1	964315	19000	85015	4300	2600	380
	Sen. Case 2	1470763	29000	129952	6600	3800	510
	Sen. Case 3	1876407	37000	165172	8400	5200	920
	Sen. Case 4	2739408	54000	235614	12000	7200	1100
Bilbao	Sen. Case 1	139136	19000	12266	4300	2600	380
	Sen. Case 2	212208	29000	18750	6600	3800	510
	Sen. Case 3	270737	37000	23832	8400	5200	920
	Sen. Case 4	395254	54000	33995	12000	7200	1100
Gijón	Sen. Case 1	220095	19000	19404	4300	2600	380
	Sen. Case 2	335687	29000	29660	6600	3800	510
	Sen. Case 3	428271	37000	37699	8400	5200	920
	Sen. Case 4	625242	54000	53776	12000	7200	1100
Santander	Sen. Case 1	144182	19000	12711	4300	2600	380
	Sen. Case 2	219904	29000	19430	6600	3800	510
	Sen. Case 3	280555	37000	24696	8400	5200	920
	Sen. Case 4	409589	54000	35228	12000	7200	1100
Valencia	Sen. Case 1	519752	19000	45822	4300	2600	380
	Sen. Case 2	792721	29000	70042	6600	3800	510
	Sen. Case 3	1011357	37000	89026	8400	5200	920
	Sen. Case 4	1476503	54000	126992	12000	7200	1100

Table 4
Manoeuvring and Hotelling Time (in Hours) of Spanish Services

SSS Spanish Services	Manoeuvring Time (h)	Hotelling Time (h)
Algeciras-Tanger Med	2	1
Alicante-Argel	2	13
Almeria-Melilla	2	3.5
Barcelona-Civitavecchia	2	4
Bilbao-Portsmouth	2	2.5
Gijón-St. Nazaire	2	9
Santander-Plymouth-Portsmouth	2	3
Valencia-Palma de Mallorca	2	3

Both manoeuvring times and hotelling times have been concluded analysing company provided schedules and real AIS data in Marine traffic website. This is not trivial since some companies reflect in schedules shorter turnaround times than real.

Table 5
Frequency of Spanish Services

SSS Spanish Services	Frequency
Algeciras-Tanger Med	4 per day
Alicante-Argel	1 per week
Almeria-Melilla	1 per day
Barcelona-Civitavecchia	3 per week
Bilbao-Portsmouth	2 per week
Gijón-St. Nazaire	3 per week
Santander-Plymouth-Portsmouth	2 per week
Valencia-Palma de Mallorca	1 per day

From the chosen SSS lines Algeciras - Tanger Med crossing the Gibraltar strait, due to shorter distances, is the one with higher frequencies (Table5). Port calling frequency is a critical factor since a minimum time of four hours is required as turnaround time for large Ro-Pax ships. This means the higher the port calling frequency is the % of time the ship passes in manoeuvring or hotelling phases is more relevant comparing it with the sea going phase. Therefore ships operating in high frequency lines will cause higher overall air pollution costs. From REALISE data, the total annual amount of each pollutant considered (in tonnes) is:

Table 6
Annual Tonnes of Pollutants of Ships

Ships	$PM_{2.5}$	SO_2	NO_x	VOCs
Passio per Formentera	2.92	78.84	74.45	21.69
Tassili II	0.97	26.73	16.95	15.24
Juan J sister	1.51	41.39	33.02	17.15
Cruise Roma	3.04	83.02	64.73	35.85
Cap Finistere	1.42	38.81	32.23	14.88
Norman Bridge	2.10	57.82	38.98	30.78
Pont Aven	1.38	37.73	30.90	14.88
Fortuny	3.26	88.79	72.70	35.03

Table 6 shows annually emitted pollutants for each ship, and two are the critical factors when it comes to determine the amount of emissions:

- Time spent at port: Manoeuvring and hotelling phases, determined by line frequency and turnaround times;
- Ship engine characteristics and its power.

3.4. Proposal

Ports are frequently situated close to urban areas with the consequences of emissions from engines during manoeuvring and hotelling operations at port. The above example and results show the importance of SSS services and the need to reduce emissions at berth. Some proposed measures already put into practice at some ports are fuel switching and shore power. Fuel switching measure implies the use of low sulphur fuel while at berth, thus reducing SO_x and PM emissions. On the other hand, shore power measure offers multiple benefits, reducing fuel costs, emissions and also reduces the associated noise to ship engine operation. Finally, other measures include new technology like scrubbers and

Table 7
Annual Costs (in Euro) of PM and SO2 Emitted from Ships in SSS Spanish Services

Ports	Case	$PM_{2.5}$		SO_2	
		Local	Rural	Local	Rural
Algeciras	1	270126	55524	642482	339012
	2	411994	84748	982080	520344
	3	525624	108126	1248251	662256
	4	767370	157806	1780593	946080
Alicante	1	257759	66310	770979	406814
	2	393132	18444	625780	114948
	3	501560	28152	956550	176432
	4	732238	35918	1215801	224550
Almería	1	229249	28871	550538	177981
	2	349648	44066	841537	273181
	3	446083	56222	1069617	347684
	4	651246	82054	1525777	496692
Barcelona	1	2935685	57842	7058552	357016
	2	4477475	88285	10789500	547978
	3	5712385	112640	13713757	697426
	4	8339638	164393	19562272	996323
Bilbao	1	198701	27134	476154	166917
	2	303057	41415	727835	256197
	3	386642	52840	925099	326069
	4	564467	77118	1319626	465814
Gijón	1	463411	40005	1122071	248657
	2	706790	61060	1715166	381660
	3	901726	77904	2180024	485749
	4	1316450	113697	3109740	693926
Santander	1	200034	26360	479716	162280
	2	305090	40234	733280	249081
	3	389235	51333	932019	317012
	4	568254	74918	1329498	452874
Valencia	1	1696544	62019	4068598	381803
	2	2587551	94660	6219142	586023
	3	3301210	120773	7904704	745847
	4	4819511	176264	11275828	1065496

alternative energy sources such as gas or second/third generation biofuels.

In view of this, it is so important that SSS ships spend less time in port reducing freight and emission costs. As harbour emissions are directly proportional to turnaround times, any measure achieving shorter turnaround times will indirectly achieve a cut in air pollution external costs. On the other hand, the frequency of serviced route also determines the total amount of the emissions at port; the higher the frequency is the longer the vessel stays at port. In the above example, frequency route from Algeciras to Tanger Med is higher than the others and the annual tonnes of pollutants are higher too.

4. Results

Tables 7 and 8 show the obtained results for the selected SSS routes and it is easy to detect how port city closeness (number of inhabitants affected), time spent at port (turnaround times and service frequency) and ship characteristics are the critical factors defining the extent and hence the cost of the produced impact. Although of this three factors the most critical and the overriding one is the population affected by the emissions. Hence Barcelona in first place and Valencia in second are the ports which suffer from higher air pollution externalities mainly due to the number of people affected by emissions.

5. Conclusions

We have estimated the impact of some pollutants emissions of maritime transport at Spanish SSS ports and results need to be taken into account in the future.

Among the studied pollutants SO_2 is the one presenting higher externalities and

Table 8
Annual Costs (in Euro) of NO_x and VOCs Emitted from Ships in SSS Spanish Services

Ports	Case	NO_x	VOCs
Algeciras	1	193560	8244
	2	282895	11064
	3	387119	19958
	4	536011	23863
Alicante	1	44095	5791
	2	64447	7772
	3	88191	14021
	4	122110	16764
Almería	1	85873	6519
	2	125507	8749
	3	171747	15782
	4	237803	18869
Barcelona	1	168307	13625
	2	245987	18286
	3	336613	32987
	4	466080	39441
Bilbao	1	83816	5657
	2	122501	7592
	3	167632	13695
	4	232106	16375
Gijón	1	101360	11697
	2	148141	15698
	3	202719	28318
	4	280688	33859
Santander	1	80349	5658
	2	117432	7594
	3	160697	13699
	4	222504	16379
Valencia	1	189039	13312
	2	276288	17866
	3	378079	32229
	4	523494	38535

therefore we do think that both IMO and EU are working in the right direction applying progressively more stringent policies. Al though $PM_{2.5}$, NO_x and VOCs emissions also produce significant costs and must not be forgotten.

Only two of the studied pollutants present significant local impacts, $PM_{2.5}$ and SO_2. Therefore they are root cause of the difference in externalities among the studied ports. Moreover as their local impact is governed by health problems produced in exposed population, population density around harbours results determinant.

On the other hand NO_x and VOCs, do not present significant local impacts and these are considered regional. Thence they do not play a decisive role in air pollution externalities difference between ports.

In this paper we conclude that emissions from maritime transport are important and that there is very large emission reduction potential for sea-going ships in harbours. Policy makers have to be aware that the total amount of emissions at Spanish ports will increase significantly in the future and it is important to achieve a reduction of air pollution at Spanish ports where exposure of the near populations is expected to occur. Thence important measures are necessary to be implemented in ports and harbours close to densely populated urban areas.

Nevertheless, each route has different economic, geographic and environmental conditions, these must be taken into account, and a site specific evaluation is always required.

References

European Commission. 2001a. *Real cost reduction of door-to-door intermodal transport project.* Brussels: European research project RECORDIT.

European Commission. 2001b. European Transport Policy for 2010: Time to decide [online]. Available from internet: <http://ec.europa.eu/transport/strategies/doc/2001_white_paper/lb_texte_complet_en.pdf>.

ExternE. 2005. ExternE Project: Exteranlities of Energy [online]. Available from internet: <http://www.externe.info/>.

Goldsworthy, L. 2010. Exhaust emissions form ship engines-Significance, regulations, control technologies, *Australian and New Zealand Maritime Law Journal* 24(1): 21-30.

Holland, M.; Pye, S., Watkiss, P.; Droste-Franke, B. 2005. Clean Air For Europe programme [online]. Available from internet: <http://europa.eu/legislation_summaries/environment/air_pollution/l28026_en.htm>.

Holland, M.; Watkiss, P. 2002. Benefits Table Database: Estimates of the marginal external costs of air pollution in Europe [online]. Available from internet: <http://ec.europa.eu/environment/enveco/air/pdf/betaec02a.pdf>.

Institute for Transport Studies. 2003. *Unification of accounts and marginal costs for trnapsort efficiency* [online]. Available from internet: <http://www.its.leeds.ac.uk/projects/unite/>.

International Maritime Organization. 2008a. *Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 Relating Thereto (Revised MARPOL Annex VI)* [online]. Available from internet: <http://www.imo.org/Pages/home.aspx>.

International Maritime Organization. 2008b. Marine Environment and Protection Committee, Resolution, Annex 13, Regulation 14 [online]. Available from internet: <http://www.imo.org/Pages/home.aspx>.

Martínez de Osés, F. X.; Castells, M. 2009. The ecobono. A proposal based on external costs savings, *Journal of Marine Technology and environment* 2(2): 131-139.

Miola, A.; Paccagnan, V. ;Mannino, I. ; Massarutto, A.; Perujo, A.; Turvani, M. 2009. External costs of Transportation. Case study: maritime transport, JRC Scientific and Technichal Reports [online]. Available from internet: <http://www.eurosfaire.prd.fr/7pc/doc/1269355029_eur_23837_en.pdf>.

Thomas, B. W. 2007. Air emissons from ships: A US Perspective on the Challenges and Possible Solutions [CD], in: *International Workshop on Air Pollutions from Ships, particurarly* NO_x, SO_x *and PM*. 17 p.

Transport & Mobility Leuven. 2007a. Emission model for maritime, indland waterway and rail for Flanders [online]. Available from internet: <http://www.tmleuven.be/project/emmoss/home.htm>.

Transport & Mobility Leuven. 2007b. Integrated transport and energy baseline until 2030 [online]. Available from internet: <http://www.tmleuven.be/project/itren2030/home.htm>.

UIC. 2004 . *Report evaluating transport exteranl costs project*. Zurich: Infras/IWW. 168 p.

Usabiaga, J. J. 2009. *El reequilibrio modal y el Ecobono [The modal shift - Ecobono]*. Barcelona: Facultat de Nàutica de Barcelona.

Vangheluwe, M.; Mess J.; Janssen, C. 2007. *Monitoring Programme on air pollution from sea-going vessels Project, Part 2: Global change, ecosystems and biodiversity*. Brussels: Belgian Science Policy. 152 p.

Whall, C. 2002. *Quantification of emissions from ships associated with ship movements between ports in the European Community Project*. Brussels: Entec UK Limited. 21 p.

UTICAJ UDALJENOSTI LUKA I GRADOVA I VREMENA OBRTA BRODA NA ODRŽIVOST KRATKE OBALNE PLOVIDBE: STUDIJA SLUČAJA – ŠPANIJA

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Sažetak: Zagađenje vazduha predstavlja najznačajniju eksternu posledicu aktivnosti pomorskog transporta posebno u naseljenim oblastima. Kako brodovi kratke obalne plovidbe često uplovljavaju u luke na svojim linijama plovidbe, što značajno povećava vreme koje brodovi provode u ovim lukama, to ukupno vreme obrta broda, kao i blizina luke i grada postaju od suštinske važnosti za njihovo održivo funkcionisanje. U radu je analiziran uticaj pomorskog transporta na španske luke kratke obalne plovidbe i identifikovane su idealne luke za ovu vrstu transportne usluge na osnovu razlika u održivom funkcionisanju. Takođe, u radu su predložene karakteristike pristaništa koje bi mogle da dovedu do smanjenja zagađenje vazduha u sektoru pomorskog transporta.

Ključne reči: kratka obalna plovidba, eksterni efekti, zagađenje vazduha.