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Needs

Dynamic Techno - Economical Scenario Simulation Model for Sustainable Waterborne Activities and Transport

D2.1 Regional maritime application of the model

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Document information	
Short description	This deliverable describes the dataset that was developed for effectively applying the dynamic techno-economic model, devised in WP1, on the Greek coastal shipping network. Different information sources were exploited to this end, allowing to properly set and describe the base-case scenario.
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Executive summary

This report sets the basis for the application of the techno-economic model developed in WP1 in the Greek coastal shipping sector. The coastal shipping network in Greece is one of the most dense networks in Europe, providing connections between 143 ports for serving the needs of the country's 170 inhabited islands and accommodating the large touristic flows that visit them during the extended summer period. The resulting environmental implications are thus significant, and the need to effectively mitigate them is urgent.

The report presents all key data that have been collected for understanding the current state of practice. These are mainly derived from three databases (i.e. MarineTraffic, Clarksons Research and HKSTHEEA) with the authors completing through missing information, tackling data inconsistencies and properly processing all raw data so that meaningful aggregated data can be exploited.

2021 was selected as the reference year for all data given that operations in 2020 were untypical due to COVID-19 and data for 2022 were not yet available at the time of analysis. In 2021, the Greek coastal shipping network was served by 153 vessels grouped in 10 categories based on their specific type. After calculating transport work, in terms of both passengers and cars, for each one of these categories, three groups were selected as most representative (i.e. catamarans and medium and large RoPax vessels) since they were found to account for more than 90% of the calculated transport work. The vessels included in these three selected groups amounted to 74, and for each one of them representative routes and corresponding operational data are provided. The latter will be utilized for building the base case scenario in the model, considering though 21 groups that the 74 vessels were categorized based on their individual characteristics so as to adhere to the modeling efforts required.

Ports called by the selected vessels are also indicated, highlighting the ones holding a prominent position in the network as well as the ones where LNG bunkering facilities are currently being established and expected to start operations within the next couple of years.

At the end of the report, with the aim to properly inform the next WP activities, an overview and qualitative assessment of greening technologies applicable to ferries is provided, highlighting the ones presenting the highest implementation potential.

List of abbreviations

AIS	Automatic Identification System
CAPEX	Capital Expenditures
COVID-19	Coronavirus Disease of 2019
DWT	Deadweight tonnage
GHG	Greenhouse gases
GT	Gross tonnage
ICE	Internal Combustion Engine
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
LOA	Length Overall
MMSI	Maritime Mobile Service Identity
MRV	Monitoring, Reporting & Verification
MS	Member State
OPEX	Operational Expenditures

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1. Introduction

With more than 170 inhabited islands representing 20% of the country's total area and over 15% of its population, coastal shipping in Greece accounts for one of the most dense short sea shipping networks in Europe, acting as the "bridge" that connects the islands to the mainland, ensuring social cohesion and fostering economic development of the island regions. Given the intensity of operations and the large seasonality that characterizes the network, serving large flows of passengers over the extended touristic period as well as of goods for meeting their needs, the resulting environmental implications are important and thus the need to deploy more environmentally-friendly marine fuels is urgent. The Greek coastal shipping network serves therefore as an appropriate case study for applying the dynamic techno-economic developed in WP1, and formulating and assessing a number of realistic scenarios that can drive this environmental and energy transition.

The main objective of this deliverable therefore is to describe the key characteristics of the Greek coastal shipping network that will shape the base case scenario. Route, port, fleet and vessel operational data have been retrieved from various sources and have been properly processed for building-up the base-case as accurately as possible, ensuring in that way that the scenarios to be developed as a next step are realistic enough. 2021 was selected as the reference year, given that 2020 was untypical due to COVID-19, and 2022 data were not fully available at the time of analysis. The data that were collected and processed by the project team include:

- *Shipping routes*, including both port-to-port and inter-range (i.e. calling at multiple ports). UN/LOCODEs are used for codifying each route
- *Shipping routes' characteristics*, including total (actual) length of each route, total number of services provided at each route for the reference year, and total number of distance travelled at each route for the reference year. The latter two are also being broken-down per the actual vessel providing the service.
- *Port characteristics,* including number of berths, key commodities handled, AIS max DWT, GT, draft, LOA and beam, industrial facilities in place, and green linked facilities (e.g. LNG bunkering)
- *Fleet data*, including general information (i.e. vessel name, IMO or MMSI number, type, flag, gross register tonnage, summer DWT, overall length, breadth extreme, year of built), ownership and associated parties (i.e. vessel manager, vessel builder, engine builder, classification society), structure and machinery (number of decks, hull material, hull type, number of engines, engine bore, number of engine cylinders, engine power, engine RPM, engine stroke, propeller, fuel type, fuel consumption[1] and speed[2]), dimensions (i.e. length B/W perpendiculars, registered length, breadth moulded, depth, draught), tonnage, capacity and loadline (i.e. net tonnage, displacement summer, freeboard summer, total capacity in passengers and cars)
- *Vessel operational data,* including, per transport leg and vessel, median average and max speed, median voyage time, loads for both passengers and cars. THETIS-MRV data[3] for the reference year were also available and were utilized (i.e. total CO_2 emissions, CO_2

[1] For some vessels
[2] Service speed and max speed
[3] For vessels exceeding 5.000 GT

emissions from all voyages between ports under a MS jurisdiction, CO_2 emissions for all voyages which departed from ports under a MS jurisdiction, CO_2 emissions from all voyages to ports under a MS jurisdiction, CO_2 emissions which occurred within ports under a MS jurisdiction at berth, CO_2 emissions assigned to passenger transport, CO_2 emissions assigned to freight transport, Annual time spent at sea, Average annual fuel consumption per distance, Average annual fuel consumption per transport work (pax), Average annual fuel consumption per transport work (freight), Average annual CO_2 emissions per distance, Average annual CO_2 emissions per transport work (pax), Average annual CO_2 emissions per transport work (freight)).

Given the large dataset that was available, a bottom-up approach was followed for adhering to the model's structure. More specifically, all vessels that provided services during the reference year were categorized, based on their specific type, and then, for each category, transport work in terms of both passenger and vehicle miles was calculated. As a next step, those vessel categories that accounted, during the reference year, for over 90% of transport work, for both passengers and cars, were selected. These were found to be catamaran vessels and RoPax (medium-sized and large) vessels, with their total number amounting to 74. For each of those 74 vessels, a representative shipping route was selected and relevant data were provided (i.e. sailing distance at each route, number of transport journeys completed over the route during the reference year, average fuel consumption of each vessel per distance, total trip time, average utilization of passenger and car capacity, average and max speed per transport leg of each route). Ports called by those vessels are also identified and listed (83 in total), enabling also to identify the ones with a more prominent position in the selected part of the overall network. In two of these (i.e. Piraeus and Heraklion), LNG bunkering facilities are currently being established, expected to be operational within this and the next year respectively.

The number of selected vessels had however to be reduced so that the modelling work is manageable. To this end, the 74 selected vessels were grouped into 21 representative groups considering the key characteristics of each vessel (i.e. beam, draft, power, speed and passenger and car capacity).

As a last step that will properly inform the next project activities, an overview of greening technologies applicable to ferries is provided, highlighting the ones presenting the highest implementation potential.

2. Categorization of vessel types

In 2021, the Greek coastal shipping network was served by 153 vessels providing connections between 143 ports located both in the mainland and the islands. All vessels qualify as ferries, being though of different type and size, thus providing services of different quality. Their deployment over the different lines depends on the vessels' characteristics (e.g. capacity, speed, etc.) vis-a-vis the corresponding demand which, as stated before, presents large seasonality due to heavy touristic flows that are attracted and are being served during the extended touristic period (i.e. May to September)[4]. Shipping lines attracting no commercial interest are subsidized following a structured procedure that has been set by the Greek Ministry of Maritime Affairs and Insular Policy, so that social cohesion and economic growth of those island regions is ensured.

Table 1 below lists all information that was retrieved for 151 out of the aforementioned 153 vessels. For two vessels (i.e. Kasos Princess and Kalymnos Dolphin), no relevant information could be found on the three databases that were used as the main sources of information (i.e. MarineTraffic, Clarksons Research and HKSTHEEA[5]).

Table 1: Fleet data

A/A	Field name	Description	Unit measurement / Categories	Source
1	Vessel name	Current name of the vessel (*and list of all previous names*)	-	HSKTHEEA, Marine Traffic, Clarksons Research
2	International Maritime Organization (IMO) Number	Vessel identification number consisting of the letters "IMO", followed by a unique 7-digit number	-	Marine Traffic, Clarksons Research
3	Maritime Mobile Service Identity (MMSI) number	Vessel identification number consisting of a unique 9-digit number used in marine traffic monitoring systems	-	Marine Traffic, Clarksons Research
4	Vessel type - generic	Generic type of the vessel	Passenger vessel Freight vessel	Marine Traffic
5	Vessel type - detailed	Specific type of the vessel	Freight vessel ▪ Ro-Ro Passenger vessel ▪ Hydrofoil ▪ Open-type RoPax ▪ Catamaran ▪ High-speed craft ▪ Small passenger vessel ▪ RoPax (very small, small, medium, large)	MarineTraffic and authors' categorization

[4] Almost half of the vessels are deployed only during the extended touristic period so as to accommodate the high demand
[5] Digital System for Vessel Seat Reservation and Ticket Issuing in Greece (https://isktheea.hcg.gr)

A/A	Field name	Description	Unit measurement / Categories	Source
6	Flag	Flag to which the vessel is registered	Countries	Marine Traffic and Clarksons Research
7	Gross Register Tonnage	The registered gross tonnage of the vessel	Registered tons	Marine Traffic and Clarksons Research
8	Summer DWT	Measure of how much weight a vessel can safely carry (excluding the vessel's own weight)	Metric tons	Marine Traffic
9	Overall length	Overall length of the vessel	Meters	Clarksons Research
10	Breadth extreme	Extreme breadth of the vessel	Meters	Marine Traffic
11	Year of built	Year that the vessel was built	-	Marine Traffic and Clarksons Research database
12	Vessel manager	Name of the managing company of the vessel	-	Marine Traffic
13	Vessel builder	Name of the shipyard where the vessel was built	-	Marine Traffic
14	Engine builder	Name of the company that built the vessel's engine	-	Marine Traffic and Clarksons Research
15	Classification society	Name of classification society assigned to the vessel	-	Marine Traffic
16	Number of decks	Number of decks of the vessel	-	Marine Traffic
17	Hull material	Material used for constructing the vessel's hull	▪ Alloy ▪ Light Alloy ▪ Steel	Marine Traffic
18	Hull type	Type of the vessel's hull depending on its size and shape	▪ Double hull ▪ Partly double bottom ▪ Single hull	Marine Traffic
19	Number of engines	Number of engines of the vessel	-	Marine Traffic
20	Engine bore	Diameter of the bore of the vessel's engine	Millimetres	Marine Traffic
21	Number of engine cylinders	Number of cylinders of the vessel's engine	-	Marine Traffic
22	Engine power	Total power of the engine of the vessel	kW	Marine Traffic
23	Engine RPM	Revolution per minute (RPM) of the vessel's engine	RMP	Marine Traffic
24	Engine stroke	Length of the stroke of the vessel's engine	Millimetres	Marine Traffic

A/A	Field name	Description	Unit measurement / Categories	Source
25	Propeller	Type and number of propellers installed on the vessel, and number of blades attached.	▪ Fixed pitched solid propeller ▪ Screw propeller controllable pitch ▪ Water jet	Marine Traffic
26	Fuel type	Type of fuel that the vessel consumes	Marine Diesel	Marine Traffic and Clarksons Research database
27	Fuel consumption	Average fuel consumption of the vessel (at certain conditions)	▪ Per day (at average speed) ▪ Per distance ▪ Per transport work (passengers & freight)	Marine Traffic, THETIS-MRV
28	Design speed	Speed that the vessel is designed to sail under certain conditions	Knots	Marine Traffic
29	Max speed	Maximum sailing speed that the vessel can reach	Knots	Marine Traffic
30	Length between perpendiculars (LPP)	Length measured between perpendiculars for the vessel	Meters	Marine Traffic
31	Registered length	Length of vessel measured from the fore-side of the head of the stem to the aft side of the head of the stern post or, in the case of a ship not having a stern post, to the fore-side of the rudder stock.	Meters	Marine Traffic
32	Breadth moulded	Moulded breath of the vessel	Meters	Marine Traffic
33	Depth	Extreme depth of the vessel	Meters	Marine Traffic
34	Draught	Maximum draught of the vessel.	Meters	Marine Traffic
35	Net tonnage	Net tonnage of the vessel	Metric tons	Marine Traffic
36	Displacement summer	Total weight of the vessel when loaded to its summer draft	Metric tons	Marine Traffic
37	Freeboard summer	Distance from the water line to the tonnage deck or main deck of the vessel, when the latter is loaded up to the summer mark of the load line.	Meters	Marine Traffic

A/A	Field name	Description	Unit measurement / Categories	Source
38	Total capacity in passengers	Maximum number of passengers that the vessel can carry per voyage	Passengers	Websites of vessel owners and builders, other sources (desk research)
39	Total capacity in cars	Maximum number of cars that the vessel can carry per voyage	Cars	Websites of vessel owners and builders, other sources (desk research)
40	CO_2 emissions	Amount of CO_2 pollutants emitted	Tons	THETIS-MRV

The 151 vessels for which data were available were grouped, based on their detailed type, in ten (10) different categories (Table 2).

Table 2: Fleet categorization per specific type of vessel

A/A	Vessel category	Number of vessels	*Notes*
1	Ro-Ro	2	-
2	Hydrofoil	8	-
3	Open-type RoPax	36	*Of which, 13 are double-ended*
4	Catamaran	20	*Of which, 10 are of smaller size*
5	High-speed craft	4	-
6	Small passenger vessel	13	-
7	RoPax (very small)	5	-
8	RoPax (small)	9	-
9	RoPax (medium)	20	-
10	RoPax (large)	34	-

Operational data for the reference year are available for all 151 vessels. To this end, transport work, in terms of both passengers and freight, was calculated for each one of the aforementioned 10 categories (Table 3).

Table 3: Transport work per vessel category for the reference year (2021)

A/A		Transport work			
	Vessel category	Passenger miles	% of total	Vehicle miles	% of total
1	Ro-Ro	323.652	0,01%	1.417.395	0,14%
2	Hydrofoil	22.705.597	0,57%	-	-
3	Open-type RoPax	190.639.096	4,82%	43.333.959	4,20%
4	Catamaran	420.707.346	10,64%	89.467.461	8,67%
5	High-speed craft	74.747.454	1,89%	14.308.242	1,39%
6	Small passenger vessel	17.471.007	0,44%	-	-
7	RoPax (very small)	6.545.465	0,17%	313.533	0,03%
8	RoPax (small)	63.607.283	1,61%	8.564.165	0,83%
9	RoPax (medium)	269.941.528	6,83%	42.719.988	4,14%

10	RoPax (large)	2.886.406.186	73,02%	831.453.565	80,60%
Total		**3.953.094.614**	**100%**	**1.031.578.308**	**100%**

According to Table 3, Catamaran vessels along with RoPax vessels (medium and large) account for **90,49%** of network coverage in terms of passengers and **93,41%** in terms of freight. To this end, those three categories, which comprise of 74 vessels in total (see Table 2), were selected for establishing the base case.

Given their high number though, not all 74 vessels could be modelled. To this end, based on certain characteristics (i.e. breadth, draft, power, speed and capacity in terms of both passengers and cars[6]), the 74 vessels were structured into 21 groups (Tables 4-6).

Table 4: Grouping of selected catamaran vessels

Catamarans	***Group characteristics***						
	LPP [m]	Breath [m]	Draft [m]	Speed [knots]	Power [kW]	Capacity [Pax No]	Capacity [Cars No]
Group 1	74	25	4	40	28.300	1.103	207
Group 2	73	23	3	36	26.000	1.142	159
Group 3	65	26	2,6	35	14.600	700	75
Group 4	77	25	3,8	40	28.800	1.040	210
Group 5	36	10,4	1,9	35,4	4.550	339	7
Group 6	48	12,5	1,6	43	9.050	426	-

Table 5: Grouping of selected RoPax (medium) vessels

RoPax (medium)	***Group characteristics***						
	LPP [m]	Breath [m]	Draft [m]	Speed [knots]	Power [kW]	Capacity [Pax No]	Capacity [Cars No]
Group 1	61,2	11,7	3	14	1.200	780	60
Group 2	61,26	14	3,8	13	1.900	453	150
Group 3	71,5	14,8	3	16	2.940	660	127
Group 4	74	14	3,7	15,7	3.650	562	106
Group 5a	77	14,7	3,7	17	5.300	939	98
Group 5b					2.880		
Group 6	86,4	16,8	4,2	17	5.400	867	190
Group 7	65	22	5	18	8.300	1.225	175
Group 8	108	19	4,2	21,8	10.740	1.100	180

Table 6: Grouping of selected RoPax (large) vessels

RoPax (large)	***Group characteristics***						
	LPP [m]	Breath [m]	Draft [m]	Speed [knots]	Power [kW]	Capacity [Pax No]	Capacity [Cars No]
Group 1	191,22	26,4	7,3	29	67.200	2.289	711
Group 2	177,8	28	6,8	23	23.000	1.872	696
Group 3	133,3	21	5,2	26	31.800	2.024	424
Group 4	132	23	5,6	19,3	11.100	1.172	333
Group 5	160,6	25,7	6,5	27	44.500	1.854	780
Group 6	114	19,2	5,1	22,5	13.400	1.547	250

[6] Where applicable

Group 7	105	19	4,5	19	7.700	1.004	261

The number of vessels serving the network has been pretty consistent over the last 5 years, as depicted in Table 7 below, with the exception of 2020 when due to COVID-19, demand and consequently operations were significantly impacted. If 150 vessels is taken as the main reference basis, ±10-12% variations are to be expected in the future for meeting growing demand or adhering to another shock that the sector might experience in the future (not very likely). Of course, the number of vessels, as an indicator, should be treated with caution, since vessel capacities may change in the future for meeting differentiated customer expectations (e.g. the number of catamarans and high-speed crafts has increased over the years for reducing voyage time and offering a better travel experience to customers).

Table 7: Number of vessels serving the Greek coastal shipping network over the past 5 years

Year	Number of vessels providing services on the network	% change
2018	146	
2019	150	+2,7%
2020	137	-8,6%
2021	153	+11,7%
2022[7]	162	+5,8%

3. Shipping routes and representative journeys

For the reference year (2021), the Greek coastal shipping network comprised of 693 unique shipping routes (Figure 1). One fourth of them were port-to-port, while the majority were inter-range connecting minimum three to maximum fourteen ports (Table 8).

[7] According to Jan-Aug data

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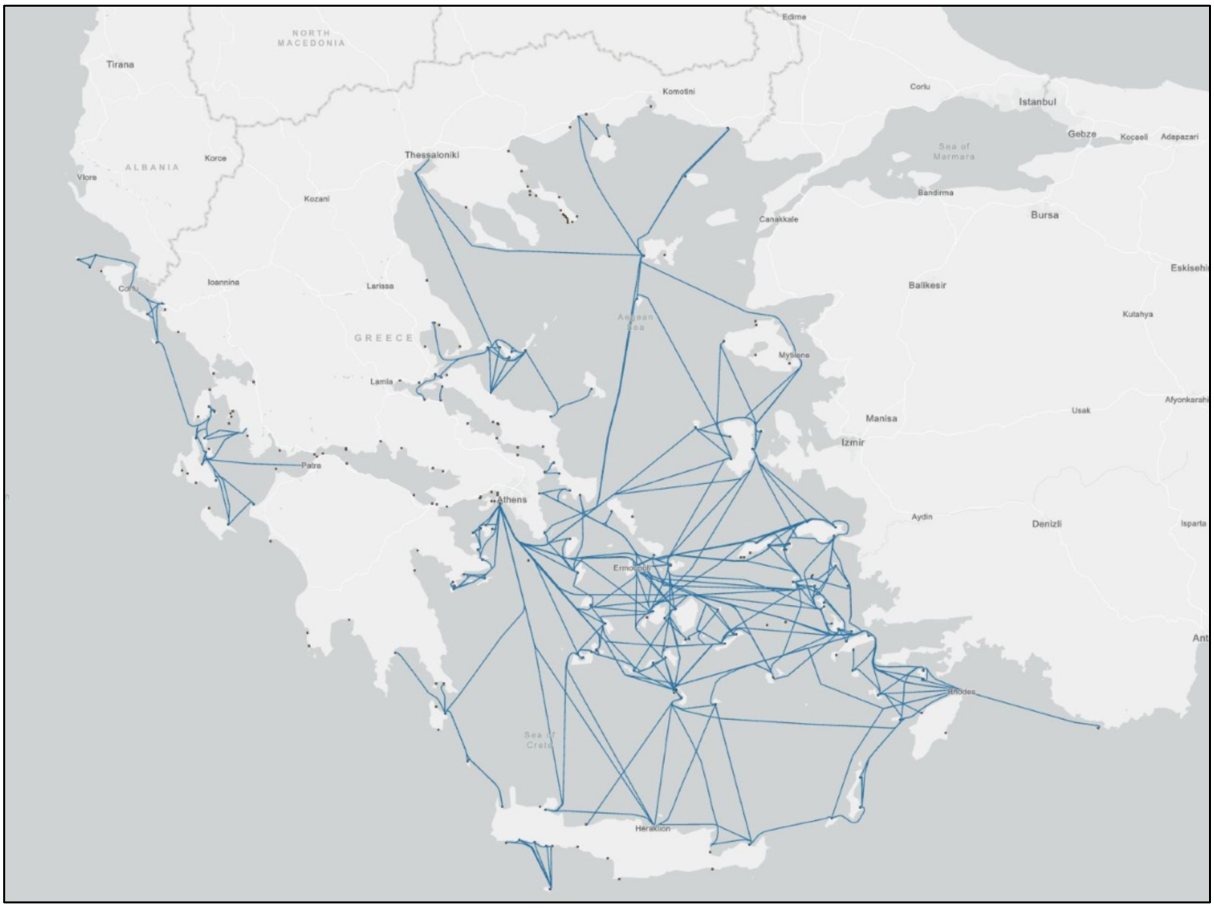

Figure 1: Visualization of the Greek coastal shipping network in 2021

Table 8: Break-down of shipping routes per number of ports called

Number of ports connected	Number of unique shipping routes	% of total unique shipping routes
2	174	25,1%
3	93	13,4%
4	104	15%
5	78	11,2%
6	57	8,2%
7	58	8,4%
8	34	4,9%
9	25	3,6%
10	28	4%
11	11	1,6%
12	14	2%
13	10	1,4%
14	7	1%

The selected 74 vessels provided completed 843 transport journeys which represents about 62% of all services provided over the Greek coastal shipping network. The most representative shipping route for each vessel (i.e. route over which most journeys were conducted) is illustrated in Figure 2 below and listed in Table 9, indicating also the number of journeys the selected vessel completed over this route during the reference year, the total

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(sailing) distance of each route and the average fuel consumption of the selected vessel per distance in 2021[8]. It should be noted that among those 74 shipping routes, 60 of them are being served by only one of the selected vessels. The remaining 14 vessels provide services over 11 routes as depicted in Table 10.

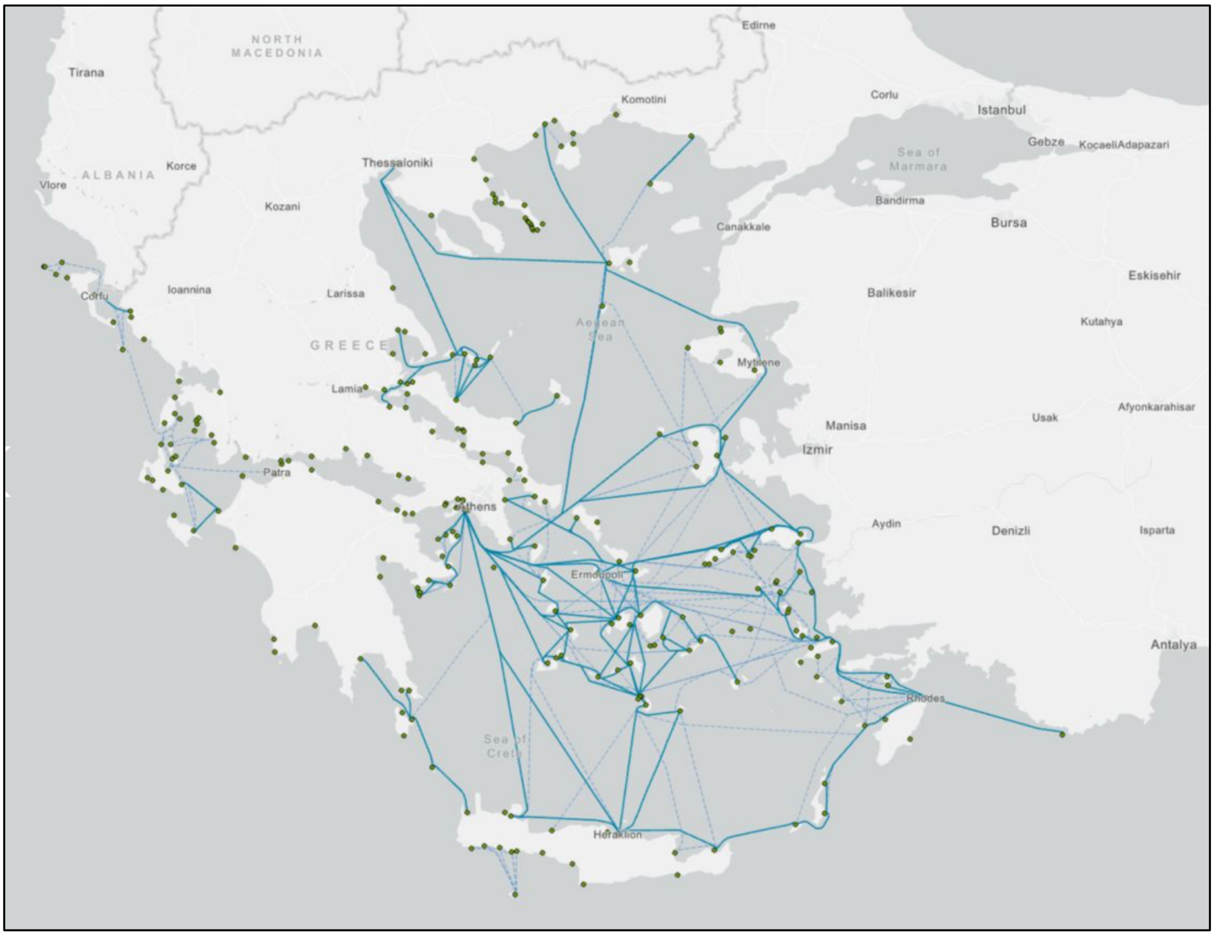

Figure 2: Map of representative shipping routes (continuous lines) of the selected 74 vessels

Table 9: List of representative shipping routes of the selected 74 vessels

Vessel name	**Representative shipping route** (port UN/LOCODES)	**Number of transport journeys completed over each route in 2021**	**Total route (sailing) distance** [nm]	**Average annual fuel consumption per distance** [kg / nm]
ACHAEOS	GRPIRGRAEGGRAGG	333	20	No data
ACHILLEAS	GRSKUGRKIM	367	23	No data
ADAMANTIOS KORAIS	GRAXDGRSAM	258	30	No data
AGIA THEODORA	GRIGOGRCFU	635	17	No data
AGIOS SPIRIDON	GRCFUGRIGO	411	17	No data
ANDREAS KALVOS	GRPKEGRKYL	341	22	50,79
APOLLON HELLAS	GRAEGGRPIR	359	16	No data
AQUA BLUE	GRLAVGRAGOGRMYRGRKVA	100	220	No data

[8] Data from THETIS-MRV

Vessel name	Representative shipping route (port UN/LOCODES)	Number of transport journeys completed over each route in 2021	Total route (sailing) distance [nm]	Average annual fuel consumption per distance [kg / nm]
AQUA JEWEL	GRKISGRPOAGRDIKGRGYT	59	94	62,34
ARIADNE	GRRHOGRKGSGRVTHGRPIR	24	323,5	211,76
ARTEMIS	GRJSYGRPASGRSERGRKREGRKMS GRADL	93	91	No data
BLUE GALAXY	GRCHQGRPIR	142	156	197,08
BLUE HORIZON	GRPIRGRHER	111	174	166,43
BLUE STAR 2	GRRHOGRKGSGRKMIGRPKKGRPMS GRJSYGRPIR	82	292	243,01
BLUE STAR CHIOS	GRSKGGRMYRGRMJTGRJKHGRVTH GRKARGRFOUGREYDGRJMKGRJSY GRPIR	14	539	154,67
BLUE STAR DELOS	GRJTRGRJNXGRPASGRPIR	156	154	227,57
BLUE STAR MYCONOS	GRKARGREYDGRJMKGRJSYGRPIR	29	173	201,29
BLUE STAR NAXOS	GRJTYGRAIGGRDONGRJNXGRPAS GRPIR	151	184	123,81
BLUE STAR PAROS	GRJMKGRTINGRJSYGRPIR	248	101	132,68
BLUE STAR PATMOS	GRJTRGRIOSGRJNXGRPASGRPIR	57	157	220,53
CALDERA VISTA	GRJSYGRPASGRJNXGRFOLGRSII GRIOSGRTRSGRJTRGRANA	26	140	No data
CHAMPION JET 1	GRSKGGRJSIGRSKOGRALOGRKYM	28	154	131,5
CHAMPION JET 2	GRADLGRKREGRSERGRPIR	199	102	131,57
DIAGORAS	GRMJTGRJKHGRPIR	41	207	106,96
DIONISIOS SOLOMOS	GRJTRGRIOSGRSIIGRFOLGRKMS GRADLGRKREGRSERGRKYTGRPIR	98	179	No data
DODEKANISOS EXPRESS	GRRHOGRKAS	58	69	No data
DODEKANISOS PRIDE	GRRHOGRSYMGRKGSGRKMIGRPKK GRLIPGRAGN	45	130,5	No data
EKATERINI P	GRRAFGRTINGRJMKGRJNXGRKOF	67	118	75,67
ELYROS	GRPIRGRCHQ	151	157	208,79
EXPRESS SKIATHOS	GRALOGRSKOGRGLOGRJSIGRVOL	265	67	No data
FAST FERRIES ANDROS	GRJMKGRTINGRANDGRRAF	206	38	163,69
FESTOS PALACE	GRPIRGRHERGRSUD	87	229	260,84
FIOR DI LEVANTE	GRKYLGRPKE	394	22	87,66
FLYING CAT 5	GRPIRGRPTRGRHYDGRERMGRSPE GRPHE	95	66	No data
FLYING CAT 6	GRPIRGRPTRGRHYDGRERMGRSPE GRPHE	179	66	No data
FLYINGCAT 3	GRRAFGRTINGRJMKGRJNX	50	94	No data
FLYINGCAT 4	GRPIRGRPTRGRHYDGRSPE	84	57	No data
HERMES	GRCFUGRIGO	557	17	No data
HIGHSPEED 4	GRKTPGRKOFGRJNXGRPASGRPIR	62	152	171,3
IONIS	GRLAVGRKEA	278	15	No data
KEFALONIA	GRKYLGRPKE	241	22	97,45
KERKYRA EXPRESS	GRCFUGRIGO	185	17	No data
KNOSSOS PALACE	GRPIRGRHERGRSUD	102	229	255,51

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Vessel name	Representative shipping route (port UN/LOCODES)	Number of transport journeys completed over each route in 2021	Total route (sailing) distance [nm]	Average annual fuel consumption per distance [kg / nm]
KRITI I	GRHERGRPIR	173	174	181,81
KYDON PALACE	GRSUDGRPIR	117	157	288,18
MACEDON	GRKEAGRLAV	348	15	No data
MARE DI LEVANTE	GRZTHGRKYL	1.028	17	81,1
MARMARI EXPRESS	GRLAVGRKEA	340	15	No data
NAXOS JET	GRJTRGRHER	34	64	No data
NISSOS RODOS	GRHERGRPIR	66	173	164,93
NISSOS SAMOS	GRMJTGRJKHGRINOGRPAAGRPIR	70	221	159,12
OLYMPUS	GRJTRGRADLGRKREGRPIR	26	168	No data
PANAGIA SKIADENI	GR088GRRHO	13	46	No data
PANORAMA	GRMRMGRRAF	117	15	No data
PHIVOS	GRAEGGRPIR	391	16	70,76
PORFYROUSA	GRDIKGRNEA	245	14	No data
POSIDON HELLAS	GRAEGGRPIR	225	16	No data
POWER JET	GRHERGRJTRGRIOSGRJNXGRJMK GRPASGRJNXGRJTRGRHER	43	287	No data
PREVELIS	GRPIRGRADLGRJTRGRANAGRHER GRJSHGRKSJGRAOKGRDIAGRHAL GRRHO	41	437	87,35
PROTEUS	GRVOLGRJSIGRGLOGRKYM	81	67	No data
SANTORINI PALACE	GRHERGRJTRGRJNXGRPASGRJMK GRJSYGRPIR	28	251	No data
SEA JET 2	GRADLGRKREGRPASGRJMKGRJNX GRKOFGRKTPGRJTRGRFOLGRADL GRKREGRSERGRPIR	97	333	No data
SIFNOS JET	GRPASGRJMK	23	25	No data
SPEED CAT 1	GRPIRGRPTRGRHYDGRSPE	185	40	No data
SPORADES STAR	GRKVAGRMYRGRAGOGRLAV	16	219	No data
STAVROS	GRRHOGRKAS	141	70	No data
SUPER FERRY	GRJMKGRTINGRANDGRRAF	249	74	104,07
SUPEREXPRESS	GRRAFGRTINGRJMKGRJNXGRPAS GRIOSGRJTR	107	163	165,4
SUPERJET	GRADLGRKREGRPASGRJLKGRJNX GRKOFGRKTPGRJTRGRFOLGRADL GRKREGRSERGRPIR	115	332	No data
SUPERSTAR	GRPASGRJNXGRJMKGRTINGRAND GRRAF	107	113	132,45
SYMI	GRAKOGRGLYGRJSIGRGLOGRKYM GRANLGRALO	10	112,5	No data
THEOLOGOS P	GRJMKGRTINGRANDGRRAF	238	74	102,05
THUNDER	GRJNXGRJMKGRJSYGRPIR	73	121	163,69
WORLDCHAMPION JET	GRJTRGRIOSGRJNXGRJMKGRJSY GRPIR	107	169	245,62

Table 10: List of representative shipping routes served by more than one of the selected vessels

	Representative shipping route (port UNLOCODES)	Selected vessels providing services over the route
1	GRCFUGRIGO	AGIOS SPIRIDON, HERMES, KERKYRA EXPRESS
2	GRAEGGRPIR	APOLLON HELLAS, PHIVOS, POSIDON HELLAS
3	GRHOGGRKAS	DODEKANISOS EXPRESS, STAVROS
4	GRJMKGRTINGRANDGRRAF	FAST FERRIES ANDROS, SUPER FERRY, THEOLOGOS P.
5	GRPIRGRHERGRSUD	FESTOS PALACE, KNOSSOS PALACE
6	GRKYLGRPKE	FIOR DI LEVANTE, KEFALONIA
7	GRPIRGRPTRGRHYDGRERMGRSPEGRPHE	FLYING CAT 5, FLYING CAT 6
8	GRPIRGRPTRGRHYDGRSPE	FLYINGCAT 4, SPEED CAT 1
9	GRLAVGRKEA	IONIS, MARMARI EXPRESS
10	GRHERGRPIR	KRITI I, NISSOS RODOS
11	GRADLGRKREGRPASGRJMKGRJNXGRKOF GRJTPGRJTRGRFOLGRADLGRKREGRSERGRPIR	SEA JET 2, SUPERJET

It is worth also noting that for 6 representative shipping routes, their return part has also been listed as another representative route in Table 9. Those 6 returns routes are indicated in Table 11 below, with all but one accounting for port-to-port routes.

Table 11: Return shipping routes selected as representatives routes

Representative shipping route (port UN/LOCODES)	Vessel providing service over the route
GRIGOGRCFU	AGIA THEODORA
GRPKEGRKYL	ANDREAS KALVOS
GRLAVGRAGOGRMYRGRKVA	AQUA BLUE
GRCHQGRPIR	BLUE GALAXY
GRPIRGRHER	BLUE HORIZON
GRKEAGRLAV	MACEDON

4. Operational data of selected vessels

For all 74 representative shipping routes, operational data were available for the reference year at voyage level. Those comprised of the actual time of departure from each port of call, actual time of arrival at the next port of call[9], average and max speed per transport leg (i.e. from port-to-port), average load in terms of both passengers and cars. Given the large dataset available, appropriate processing and aggregation of data had to be performed. Table 12 below provides, for all 74 representative shipping routes, the total average sailing time, and the average load in terms of both passengers and cars.

[9] Thus time spent at each port of call can also be calculated

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Table 12: Total average trip time and average capacity utilization (passengers and cars) for all 74 representative shipping routes

Vessel name	**Representative shipping route** (port UN/LOCODES)	**Total average sailing time** [min]	**Average % of occupied capacity** [pax]	**Average % of occupied capacity** [cars]
ACHAEOS	GRPIRGRAEGGRAGG	81	9,8%	14,2%
ACHILLEAS	GRSKUGRKIM	89	27%	43,8%
ADAMANTIOS KORAIS	GRAXDGRSAM	105	16,8%	14,4%
AGIA THEODORA	GRIGOGRCFU	67	17,8%	81,2%
AGIOS SPIRIDON	GRCFUGRIGO	80	19,5%	44,4%
ANDREAS KALVOS	GRPKEGRKYL	79	17,4%	75,9%
APOLLON HELLAS	GRAEGGRPIR	66	11%	41,3%
AQUA BLUE	GRLAVGRAGOGRMYRGRKVA	769	2,3%	5,8%
AQUA JEWEL	GRKISGRPOAGRDIKGRGYT	333	3,8%	12%
ARIADNE	GRRHOGRKGSGRVTHGRPIR	893	5,7%	10,8%
ARTEMIS	GRJSYGRPASGRSERGRKREGRKMS GRADL	363	2,9%	5,8%
BLUE GALAXY	GRCHQGRPIR	461	31,6%	38,7%
BLUE HORIZON	GRPIRGRHER	536	29,9%	51,6%
BLUE STAR 2	GRRHOGRKGSGRKMIGRPKKGRPMS GRJSYGRPIR	550	2,9%	3%
BLUE STAR CHIOS	GRSKGGRMYRGRMJTGRJKHGRVTH GRKARGRFOUGREYDGRJMKGRJSY GRPIR	1583	1,4%	2,7%
BLUE STAR DELOS	GRJTRGRJNXGRPASGRPIR	373	9,3%	11,2%
BLUE STAR MYCONOS	GRKARGREYDGRJMKGRJSYGRPIR	422	6,4%	6,5%
BLUE STAR NAXOS	GRJTYGRAIGGRDONGRJNXGRPASGRPIR	501	3,6%	5,3%
BLUE STAR PAROS	GRJMKGRTINGRJSYGRPIR	267	8,2%	11,6%
BLUE STAR PATMOS	GRJTRGRIOSGRJNXGRPASGRPIR	390	8%	6,5%
CALDERA VISTA	GRJSYGRPASGRJNXGRFOLGRSIIGRIOS GRTRSGRJTRGRANA	356	0,9%	1,3%
CHAMPION JET 1	GRSKGGRJSIGRSKOGRALOGRKYM	286	11,4%	9,8%
CHAMPION JET 2	GRADLGRKREGRSERGRPIR	175	8,9%	7%
DIAGORAS	GRMJTGRJKHGRPIR	653	9,6%	23,5%
DIONISIOS SOLOMOS	GRJTRGRIOSGRSIIGRFOLGRKMSGRADL GRKREGRSERGRKYTGRPIR	602	1,4%	2,4%
DODEKANISOS EXPRESS	GRRHOGRKAS	150	14,6%	4,3%
DODEKANISOS PRIDE	GRRHOGRSYMGRKGSGRKMIGRPKK GRLIPGRAGN	260	4,2%	1,5%
EKATERINI P	GRRAFGRTINGRJMKGRJNXGRKOF	354	7,9%	8,4%
ELYROS	GRPIRGRCHQ	498	33,4%	59,3%
EXPRESS SKIATHOS	GRALOGRSKOGRGLOGRJSIGRVOL	214	3%	6,9%
FAST FERRIES ANDROS	GRJMKGRTINGRANDGRRAF	330	6,6%	9,5%
FESTOS PALACE	GRPIRGRHERGRSUD	648	13,3%	18,4%
FIOR DI LEVANTE	GRKYLGRPKE	81	18,4%	74,8%
FLYING CAT 5	GRPIRGRPTRGRHYDGRERMGRSPE GRPHE	160	4,9%	-

Vessel name	Representative shipping route (port UN/LOCODES)	Total average sailing time [min]	Average % of occupied capacity [pax]	Average % of occupied capacity [cars]
FLYING CAT 6	GRPIRGRPTRGRHYDGRERMGRSPE GRPHE	154	5,7%	-
FLYINGCAT 3	GRRAFGRTINGRJMKGRJNX	153	12,5%	-
FLYINGCAT 4	GRPIRGRPTRGRHYDGRSPE	103	7,9%	-
HERMES	GRCFUGRIGO	60	25,5%	43,7%
HIGHSPEED 4	GRKTPGRKOFGRJNXGRPASGRPIR	288	8%	6,9%
IONIS	GRLAVGRKEA	56	16,9%	43,9%
KEFALONIA	GRKYLGRPKE	68	12,7%	77,6%
KERKYRA EXPRESS	GRCFUGRIGO	61	21%	100%
KNOSSOS PALACE	GRPIRGRHERGRSUD	648	16,1%	19,6%
KRITI I	GRHERGRPIR	546	24,5%	55,8%
KYDON PALACE	GRSUDGRPIR	432	21,3%	32,2%
MACEDON	GRKEAGRLAV	60	12,3%	49,6%
MARE DI LEVANTE	GRZTHGRKYL	62	23,1%	71,6%
MARMARI EXPRESS	GRLAVGRKEA	56	17,8%	36,1%
NAXOS JET	GRJTRGRHER	126	31,1%	8,2%
NISSOS RODOS	GRHERGRPIR	532	14,3%	48,4%
NISSOS SAMOS	GRMJTGRJKHGRINOGRPAAGRPIR	697	4,6%	8,2%
OLYMPUS	GRJTRGRADLGRKREGRPIR	542	3,9%	4%
PANAGIA SKIADENI	GR088GRRHO	93	41,6%	4,5%
PANORAMA	GRMRMGRRAF	56	22,4%	31,3%
PHIVOS	GRAEGGRPIR	59	15,3%	39,7%
PORFYROUSA	GRDIKGRNEA	66	33,9%	40,4%
POSIDON HELLAS	GRAEGGRPIR	61	10,7%	51,8%
POWER JET	GRHERGRJTRGRIOSGRJNXGRJMK GRPASGRJNXGRJTRGRHER	537	9,7%	2,2%
PREVELIS	GRPIRGRADLGRJTRGRANAGRHER GRJSHGRKSJGRAOKGRDIAGRHAL GRRHO	1511	2%	3,8%
PROTEUS	GRVOLGRJSIGRGLOGRKYM	269	17,9%	19%
SANTORINI PALACE	GRHERGRJTRGRJNXGRPASGRJMK GRJSYGRPIR	468	7,7%	6,4%
SEA JET 2	GRADLGRKREGRPASGRJMKGRJNX GRKOFGRKTPGRJTRGRFOLGRADL GRKREGRSERGRPIR	590	6,4%	-
SIFNOS JET	GRPASGRJMK	47	70%	-
SPEED CAT 1	GRPIRGRPTRGRHYDGRSPE	115	8,4%	-
SPORADES STAR	GRKVAGRMYRGRAGOGRLAV	776	10,4%	22,1%
STAVROS	GRRHOGRKAS	278	5%	7,9%
SUPER FERRY	GRJMKGRTINGRANDGRRAF	227	5%	23,8%
SUPEREXPRESS	GRRAFGRTINGRJMKGRJNXGRPAS GRIOSGRJTR	287	5%	10%
SUPERJET	GRADLGRKREGRPASGRJLKGRJNXGRKOF GRKTPGRJTRGRFOLGRADLGRKREGRSER GRPIR	579	6,3%	-
SUPERSTAR	GRPASGRJNXGRJMKGRTINGRAND GRRAF	347	3,2%	10,6%
SYMI	GRAKOGRGLYGRJSIGRGLOGRKYMGRAN LGRALO	488	4,5%	16,9%
THEOLOGOS P	GRJMKGRTINGRANDGRRAF	231	6,4%	10,5%

Vessel name	Representative shipping route (port UN/LOCODES)	Total average sailing time [min]	Average % of occupied capacity [pax]	Average % of occupied capacity [cars]
THUNDER	GRJNXGRJMKGRJSYGRPIR	227	7,1%	5,7%
WORLDCHAMPION JET	GRJTRGRIOSGRJNXGRJMKGRJSYGRPIR	255	7,3%	3,3%

For each transport leg of the 74 representative shipping routes, the average and max speed are listed in Table 13, while the average time spent at each port of call is indicated in Table 14.

Table 13: Average and max speed per transport leg for all 74 representative shipping routes

Vessel name	Departure port (UN/LOCODE)	Arrival port (UN/LOCODE)	Average speed [knots]	Max speed [knots]
ACHAEOS	GRPIR	GRAEG	14,2	14,7
ACHAEOS	GRAEG	GRAGG	13,3	14,2
ACHILLEAS	GRSKU	GRKIM	15,2	15,8
ADAMANTIOS KORAIS	GRAXD	GRSAM	16,5	17,3
AGIA THEODORA	GRIGO	GRCFU	14,2	14,6
AGIOS SPIRIDON	GRCFU	GRIGO	11,9	12,3
ANDREAS KALVOS	GRPKE	GRKYL	16,3	16,7
APOLLON HELLAS	GRAEG	GRPIR	13,9	14,2
AQUA BLUE	GRLAV	GRAGO	16,8	17,7
AQUA BLUE	GRAGO	GRMYR	16,7	17,6
AQUA BLUE	GRMYR	GRKVA	17,3	18,1
AQUA JEWEL	GRKIS	GRPOA	16,6	17,2
AQUA JEWEL	GRPOA	GRDIK	16,3	17
AQUA JEWEL	GRDIK	GRGYT	16,7	17,2
ARIADNE	GRRHO	GRKGS	21,6	23,1
ARIADNE	GRKGS	GRVTH	21,7	23,2
ARIADNE	GRVTH	GRPIR	21,7	23
ARTEMIS	GRJSY	GRPAS	14,5	14,9
ARTEMIS	GRPAS	GRSER	14,4	14,9
ARTEMIS	GRSER	GRKRE	14,4	14,8
ARTEMIS	GRKRE	GRKMS	14,3	14,8
ARTEMIS	GRKMS	GRADL	14,5	15
BLUE GALAXY	GRCHQ	GRPIR	20,1	21,2
BLUE HORIZON	GRPIR	GRHER	19,3	20,1
BLUE STAR 2	GRRHO	GRKGS	22,3	23,6
BLUE STAR 2	GRKGS	GRKMI	23	25,7
BLUE STAR 2	GRKMI	GRPKK	22,8	26
BLUE STAR 2	GRPKK	GRPMS	23	25,9
BLUE STAR 2	GRPMS	GRJSY	23	24,5
BLUE STAR 2	GRJSY	GRPIR	24,7	26,4
BLUE STAR CHIOS	GRSKG	GRMYR	19,2	20,2
BLUE STAR CHIOS	GRMYR	GRMJT	18,8	19,7
BLUE STAR CHIOS	GRMJT	GRJKH	19,8	20,6
BLUE STAR CHIOS	GRJKH	GRVTH	19,7	20,5
BLUE STAR CHIOS	GRVTH	GRKAR	22,8	24,1
BLUE STAR CHIOS	GRKAR	GRFOU	23,4	24,7
BLUE STAR CHIOS	GRFOU	GREYD	23,9	25,6

Vessel name	Departure port (UN/LOCODE)	Arrival port (UN/LOCODE)	Average speed [knots]	Max speed [knots]
BLUE STAR CHIOS	GREYD	GRJMK	22,9	23,8
BLUE STAR CHIOS	GRJMK	GRJSY	23,3	24,9
BLUE STAR CHIOS	GRJSY	GRPIR	19,9	22
BLUE STAR DELOS	GRJTR	GRJNX	23,9	25,2
BLUE STAR DELOS	GRJNX	GRPAS	23,9	25,3
BLUE STAR DELOS	GRPAS	GRPIR	24,4	25,5
BLUE STAR MYCONOS	GRKAR	GREYD	24,3	25,2
BLUE STAR MYCONOS	GREYD	GRJMK	24,2	25,2
BLUE STAR MYCONOS	GRJMK	GRJSY	24	25,1
BLUE STAR MYCONOS	GRJSY	GRPIR	23,8	25,1
BLUE STAR NAXOS	GRJTY	GRAIG	21,4	22,1
BLUE STAR NAXOS	GRAIG	GRDON	21	21,9
BLUE STAR NAXOS	GRDON	GRJNX	21,1	22,3
BLUE STAR NAXOS	GRJNX	GRPAS	21,4	22,2
BLUE STAR NAXOS	GRPAS	GRPIR	21,8	22,7
BLUE STAR PAROS	GRJMK	GRTIN	21,6	22,4
BLUE STAR PAROS	GRTIN	GRJSY	21,6	22,4
BLUE STAR PAROS	GRJSY	GRPIR	22,2	23,1
BLUE STAR PATMOS	GRJTR	GRIOS	23,4	24,4
BLUE STAR PATMOS	GRIOS	GRJNX	23,2	24,4
BLUE STAR PATMOS	GRJNX	GRPAS	23,3	24,6
BLUE STAR PATMOS	GRPAS	GRPIR	23,5	24,8
CALDERA VISTA	GRJSY	GRPAS	24,3	25,6
CALDERA VISTA	GRPAS	GRJNX	21,1	22,8
CALDERA VISTA	GRJNX	GRFOL	21,7	22,6
CALDERA VISTA	GRFOL	GRSII	21	23,2
CALDERA VISTA	GRSII	GRIOS	22,4	23,9
CALDERA VISTA	GRIOS	GRTRS	21,2	22,6
CALDERA VISTA	GRTRS	GRJTR	22,1	22,6
CALDERA VISTA	GRJTR	GRANA	24,2	27,1
CHAMPION JET 1	GRSKG	GRJSI	30,3	34,9
CHAMPION JET 1	GRJSI	GRSKO	31,6	35
CHAMPION JET 1	GRSKO	GRALO	28,3	34
CHAMPION JET 1	GRALO	GRKYM	32	35,1
CHAMPION JET 2	GRADL	GRKRE	34,8	36,6
CHAMPION JET 2	GRKRE	GRSER	31,4	35,6
CHAMPION JET 2	GRSER	GRPIR	34,1	36,6
DIAGORAS	GRMJT	GRJKH	18,9	20,1
DIAGORAS	GRJKH	GRPIR	18,8	19,9
DIONISIOS SOLOMOS	GRJTR	GRIOS	17,3	17,7
DIONISIOS SOLOMOS	GRIOS	GRSII	16	17,7
DIONISIOS SOLOMOS	GRSII	GRFOL	16,9	17,9
DIONISIOS SOLOMOS	GRFOL	GRKMS	16,8	17,7
DIONISIOS SOLOMOS	GRKMS	GRADL	16,9	17,8
DIONISIOS SOLOMOS	GRADL	GRKRE	17,2	17,7
DIONISIOS SOLOMOS	GRKRE	GRSER	16,6	17,6
DIONISIOS SOLOMOS	GRSER	GRKYT	17,2	18
DIONISIOS SOLOMOS	GRKYT	GRPIR	17,3	18
DODEKANISOS EXPRESS	GRRHO	GRKAS	28,2	30,4
DODEKANISOS PRIDE	GRRHOG	RSYM	28,1	29
DODEKANISOS PRIDE	RSYM	GRKGS	29,3	30,5
DODEKANISOS PRIDE	GRKGS	GRKMI	29,3	30,2

Vessel name	Departure port (UN/LOCODE)	Arrival port (UN/LOCODE)	Average speed [knots]	Max speed [knots]
DODEKANISOS PRIDE	GRKMI	GRPKK	27,1	29,3
DODEKANISOS PRIDE	GRPKK	GRLIP	28,6	34,3
DODEKANISOS PRIDE	GRLIP	GRAGN	30	30,4
EKATERINI P	GRRAF	GRTIN	19,5	20,3
EKATERINI P	GRTIN	GRJMK	19,4	19,9
EKATERINI P	GRJMK	GRJNX	19,5	20,4
EKATERINI P	GRJNX	GRKOF	19,3	20,4
ELYROS	GRPIR	GRCHQ	18,8	20,4
EXPRESS SKIATHOS	GRALO	GRSKO	17,8	18,2
EXPRESS SKIATHOS	GRSKO	GRGLO	17,6	18,5
EXPRESS SKIATHOS	GRGLO	GRJSI	15,9	18,1
EXPRESS SKIATHOS	GRJSI	GRVOL	17,8	18,5
FAST FERRIES ANDROS	GRJMK	GRTIN	19,1	19,9
FAST FERRIES ANDROS	GRTIN	GRAND	19,4	20,2
FAST FERRIES ANDROS	GRAND	GRRAF	19,2	20,2
FESTOS PALACE	GRPIR	GRHER	20,1	21,2
FESTOS PALACE	GRHER	GRSUD	24,8	26,7
FIOR DI LEVANTE	GRKYL	GRPKE	16	16,7
FLYING CAT 5	GRPIR	GRPTR	22,9	24,5
FLYING CAT 5	GRPTR	GRHYD	22,9	24,9
FLYING CAT 5	GRHYD	GRERM	24,1	25,5
FLYING CAT 5	GRERM	GRSPE	24,1	25,5
FLYING CAT 5	GRSPE	GRPHE	24	24,8
FLYING CAT 6	GRPIR	GRPTR	23,9	25,4
FLYING CAT 6	GRPTR	GRHYD	23,6	25,7
FLYING CAT 6	GRHYD	GRERM	24,7	26,2
FLYING CAT 6	GRERM	GRSPE	24,9	26,6
FLYING CAT 6	GRSPE	GRPHE	23,9	25,2
FLYINGCAT 3	GRRAF	GRTIN	35,6	37,3
FLYINGCAT 3	GRTIN	GRJMK	35,5	37,2
FLYINGCAT 3	GRJMK	GRJNX	35,3	38,5
FLYINGCAT 4	GRPIR	GRPTR	31,7	34,8
FLYINGCAT 4	GRPTR	GRHYD	31,4	34,8
FLYINGCAT 4	GRHYD	GRSPE	33,3	35,2
HERMES	GRCFU	GRIGO	16,2	17,2
HIGHSPEED 4	GRKTP	GRKOF	29,5	34,9
HIGHSPEED 4	GRKOF	GRJNX	30,6	34,4
HIGHSPEED 4	GRJNX	GRPAS	30,9	34
HIGHSPEED 4	GRPAS	GRPIR	31,3	33,6
IONIS	GRLAV	GRKEA	15,7	16,6
KEFALONIA	GRKYL	GRPKE	18,9	20,1
KERKYRA EXPRESS	GRCFU	GRIGO	15,8	16,5
KNOSSOS PALACE	GRPIR	GRHER	20,1	21,3
KNOSSOS PALACE	GRHER	GRSUD	24,6	26,6
KRITI I	GRHER	GRPIR	19	20,1
KYDON PALACE	GRSUD	GRPIR	21,6	22,8
MACEDON	GRKEA	GRLAV	14,2	14,9
MARE DI LEVANTE	GRZTH	GRKYL	15,6	16,2
MARMARI EXPRESS	GRLAV	GRKEA	15,5	16,2
NAXOS JET	GRJTR	GRHER	29,8	31
NISSOS RODOS	GRHER	GRPIR	19,4	20,4
NISSOS SAMOS	GRMJT	GRJKH	18,8	19,9

Vessel name	Departure port (UN/LOCODE)	Arrival port (UN/LOCODE)	Average speed [knots]	Max speed [knots]
NISSOS SAMOS	GRJKH	GRINO	16,4	19
NISSOS SAMOS	GRINO	GRPAA	18,4	19,8
NISSOS SAMOS	GRPAA	GRPIR	18,9	20,1
OLYMPUS	GRJTR	GRADL	18,5	19
OLYMPUS	GRADL	GRKRE	17,2	18,9
OLYMPUS	GRKRE	GRPIR	18,2	19,1
PANAGIA SKIADENI	GR088	GRRHO	14,4	15,7
PANORAMA	GRMRM	GRRAF	14,8	15,3
PHIVOS	GRAEG	GRPIR	15,3	15,9
PORFYROUSA	GRDIK	GRNEA	12,4	12,9
POSIDON HELLAS	GRAEG	GRPIR	14,9	15,3
POWER JET	GRHER	GRJTR	30,1	31,5
POWER JET	GRJTR	GRIOS	30,7	33,1
POWER JET	GRIOS	GRJNX	30,4	32,2
POWER JET	GRJNX	GRJMK	30,5	32
POWER JET	GRJMK	GRPAS	31	33
POWER JET	GRPAS	GRJNX	30,2	32,8
POWER JET	GRJNX	GRJTR	33,3	34,7
POWER JET	GRJTR	GRHER	32	33,1
PREVELIS	GRPIR	GRADL	16,7	17,4
PREVELIS	GRADL	GRJTR	16,9	17,6
PREVELIS	GRJTR	GRANA	16,6	17,4
PREVELIS	GRANA	GRHER	17,1	17,7
PREVELIS	GRHER	GRJSH	17,4	18,1
PREVELIS	GRJSH	GRKSJ	17,2	18,1
PREVELIS	GRKSJ	GRAOK	16,5	17,7
PREVELIS	GRAOK	GRDIA	16,6	17,9
PREVELIS	GRDIA	GRHAL	17,2	18
PREVELIS	GRHAL	GRRHO	17,3	18
PROTEUS	GRVOL	GRJSI	14,1	14,8
PROTEUS	GRJSI	GRGLO	14,2	14,8
PROTEUS	GRGLO	GRKYM	14,6	15,2
SANTORINI PALACE	GRHER	GRJTR	31,4	33
SANTORINI PALACE	GRJTR	GRJNX	30,9	34,4
SANTORINI PALACE	GRJNX	GRPAS	30,3	33,4
SANTORINI PALACE	GRPAS	GRJMK	31	32,7
SANTORINI PALACE	GRJMK	GRJSY	32	33,9
SANTORINI PALACE	GRJSY	GRPIR	31,8	34,4
SEA JET 2	GRADL	GRKRE	32,9	34,2
SEA JET 2	GRKRE	GRPAS	32	33,8
SEA JET 2	GRPAS	GRJMK	32,5	33,3
SEA JET 2	GRJMK	GRJNX	32,7	34,7
SEA JET 2	GRJNX	GRKOF	31,7	34,7
SEA JET 2	GRKOF	GRKTP	29,9	34,3
SEA JET 2	GRKTP	GRJTR	33,6	35,1
SEA JET 2	GRJTR	GRFOL	31,8	33,2
SEA JET 2	GRFOL	GRADL	32,7	33,8
SEA JET 2	GRADL	GRKRE	32,9	34,2
SEA JET 2	GRKRE	GRSER	30	33,6
SEA JET 2	GRSER	GRPIR	33	34,5
SIFNOS JET	GRPAS	GRJMK	30,6	31,5
SPEED CAT 1	GRPIR	GRPTR	27,9	29,6

Vessel name	Departure port (UN/LOCODE)	Arrival port (UN/LOCODE)	Average speed [knots]	Max speed [knots]
SPEED CAT 1	GRPTR	GRHYD	27,3	29,8
SPEED CAT 1	GRHYD	GRSPE	28,9	30,4
SPORADES STAR	GRKVA	GRMYR	16,4	17,3
SPORADES STAR	GRMYR	GRAGO	15,9	17,2
SPORADES STAR	GRAGO	GRLAV	16,9	18
STAVROS	GRRHO	GRKAS	15,3	16,1
SUPER FERRY	GRJMK	GRTIN	18,7	19,3
SUPER FERRY	GRTIN	GRAND	18,9	19,6
SUPER FERRY	GRAND	GRRAF	18,8	19,7
SUPEREXPRESS	GRRAF	GRTIN	31,4	33
SUPEREXPRESS	GRTIN	GRJMK	30,9	34
SUPEREXPRESS	GRJMK	GRJNX	32,8	35,4
SUPEREXPRESS	GRJNX	GRPAS	32,1	35,3
SUPEREXPRESS	GRPAS	GRIOS	34,6	35,9
SUPEREXPRESS	GRIOS	GRJTR	35,8	37,3
SUPERJET	GRADL	GRKRE	33,2	34,7
SUPERJET	GRKRE	GRPAS	32,2	33,8
SUPERJET	GRPAS	GRJLK	33,4	34,1
SUPERJET	GRJLK	GRJNX	32,9	35
SUPERJET	GRJNX	GRKOF	32,2	35,2
SUPERJET	GRKOF	GRKTP	30,8	34,5
SUPERJET	GRKTP	GRJTR	33,7	34,9
SUPERJET	GRJTR	GRFOL	32,5	33,9
SUPERJET	GRFOL	GRADL	33,8	34,8
SUPERJET	GRADL	GRKRE	33,2	34,7
SUPERJET	GRKRE	GRSER	30,7	34,6
SUPERJET	GRSER	GRPIR	33,6	35,4
SUPERSTAR	GRPAS	GRJNX	18,7	19,5
SUPERSTAR	GRJNX	GRJMK	18,7	19,2
SUPERSTAR	GRJMK	GRTIN	18,9	19,4
SUPERSTAR	GRTIN	GRAND	19	19,7
SUPERSTAR	GRAND	GRRAF	18,9	19,7
SYMI	GRAKO	GRGLY	13	13,8
SYMI	GRGLY	GRJSI	12,1	13,6
SYMI	GRJSI	GRGLO	11,8	12,8
SYMI	GRGLO	GRKYM	12,3	13,2
SYMI	GRKYM	GRANL	12,5	13,2
SYMI	GRANL	GRALO	12,6	13,2
THEOLOGOS P	GRJMK	GRTIN	18,4	19
THEOLOGOS P	GRTIN	GRAND	18,7	19,4
THEOLOGOS P	GRAND	GRRAF	18,6	19,3
THUNDER	GRJNX	GRJMK	30,9	33,1
THUNDER	GRJMK	GRJSY	30,7	33,6
THUNDER	GRJSY	GRPIR	31,4	34
WORLDCHAMPION JET	GRJTR	GRIOS	39,6	41,5
WORLDCHAMPION JET	GRIOS	GRJNX	38,7	41,6
WORLDCHAMPION JET	GRJNX	GRJMK	38,2	40,3
WORLDCHAMPION JET	GRJMK	GRJSY	38,5	40,9
WORLDCHAMPION JET	GRJSY	GRPIR	38,1	41

Table 14: Average time selected vessels spent at the ports of call of the representative shipping routes

Vessel name	Port of call (UN/LOCODE)	Time spent at port [min]
ACHAEOS	GRAEG	10
AQUA BLUE	GRAGO	20
AQUA BLUE	GRMYR	72
AQUA JEWEL	GRPOA	19
AQUA JEWEL	GRDIK	57
ARIADNE	GRKGS	52
ARIADNE	GRVTH	52
ARTEMIS	GRPAS	24
ARTEMIS	GRSER	10
ARTEMIS	GRKRE	17
ARTEMIS	GRKMS	12
BLUE STAR 2	GRKGS	48
BLUE STAR 2	GRKMI	29
BLUE STAR 2	GRPKK	29
BLUE STAR 2	GRPMS	29
BLUE STAR 2	GRJSY	25
BLUE STAR CHIOS	GRMYR	23
BLUE STAR CHIOS	GRMJT	58
BLUE STAR CHIOS	GRJKH	29
BLUE STAR CHIOS	GRVTH	95
BLUE STAR CHIOS	GRKAR	46
BLUE STAR CHIOS	GRFOU	15
BLUE STAR CHIOS	GREYD	39
BLUE STAR CHIOS	GRJMK	28
BLUE STAR CHIOS	GRJSY	27
BLUE STAR DELOS	GRJNX	27
BLUE STAR DELOS	GRPAS	34
BLUE STAR MYCONOS	GREYD	32
BLUE STAR MYCONOS	GRJMK	20
BLUE STAR MYCONOS	GRJSY	21
BLUE STAR NAXOS	GRAIG	18
BLUE STAR NAXOS	GRDON	13
BLUE STAR NAXOS	GRJNX	31
BLUE STAR NAXOS	GRPAS	35
BLUE STAR PAROS	GRTIN	20
BLUE STAR PAROS	GRJSY	39
BLUE STAR PATMOS	GRIOS	20
BLUE STAR PATMOS	GRJNX	26
BLUE STAR PATMOS	GRPAS	39
CALDERA VISTA	GRPAS	15
CALDERA VISTA	GRJNX	10
CALDERA VISTA	GRFOL	12
CALDERA VISTA	GRSII	9
CALDERA VISTA	GRIOS	15
CALDERA VISTA	GRTRS	8
CALDERA VISTA	GRJTR	33
CHAMPION JET 1	GRJSI	23
CHAMPION JET 1	GRSKO	27
CHAMPION JET 1	GRALO	20
CHAMPION JET 2	GRKRE	13

Vessel name	Port of call (UN/LOCODE)	Time spent at port [min]
CHAMPION JET 2	GRSER	9
DIAGORAS	GRJKH	52
DIONISIOS SOLOMOS	GRIOS	24
DIONISIOS SOLOMOS	GRSII	11
DIONISIOS SOLOMOS	GRFOL	19
DIONISIOS SOLOMOS	GRKMS	16
DIONISIOS SOLOMOS	GRADL	44
DIONISIOS SOLOMOS	GRKRE	26
DIONISIOS SOLOMOS	GRSER	14
DIONISIOS SOLOMOS	GRKYT	19
DODEKANISOS PRIDE	GRSYM	9
DODEKANISOS PRIDE	GRKGS	9
DODEKANISOS PRIDE	GRKMI	11
DODEKANISOS PRIDE	GRPKK	6
DODEKANISOS PRIDE	GRLIP	8
EKATERINI P	GRTIN	23
EKATERINI P	GRJMK	26
EKATERINI P	GRJNX	22
EXPRESS SKIATHOS	GRSKO	29
EXPRESS SKIATHOS	GRGLO	18
EXPRESS SKIATHOS	GRJSI	27
FAST FERRIES ANDROS	GRTIN	24
FAST FERRIES ANDROS	GRAND	30
FESTOS PALACE	GRHER	106
FLYING CAT 5	GRPPTR	17
FLYING CAT 5	GRHYD	11
FLYING CAT 5	GRERM	11
FLYING CAT 5	GRSPE	9
FLYING CAT 6	GRPTR	18
FLYING CAT 6	GRHYD	11
FLYING CAT 6	GRERM	12
FLYING CAT 6	GRSPE	10
FLYINGCAT 3	GRTIN	17
FLYINGCAT 3	GRJMK	26
FLYINGCAT 4	GRPTR	17
FLYINGCAT 4	GRHYD	12
HIGHSPEED 4	GRKOF	16
HIGHSPEED 4	GRJNX	18
HIGHSPEED 4	GRPAS	24
KNOSSOS PALACE	GRHER	90
NISSOS SAMOS	GRJKH	52
NISSOS SAMOS	GRINO	19
NISSOS SAMOS	GRPAA	19
OLYMPUS	GRADL	53
OLYMPUS	GRKRE	26
POWER JET	GRJTR	26
POWER JET	GRIOS	15
POWER JET	GRJNX	12
POWER JET	GRJMK	23
POWER JET	GRPAS	19
POWER JET	GRJNX	11
POWER JET	GRJTR	26

Vessel name	Port of call (UN/LOCODE)	Time spent at port [min]
PREVELIS	GRADL	56
PREVELIS	GRJTR	98
PREVELIS	GRANA	21
PREVELIS	GRHER	81
PREVELIS	GRJSH	26
PREVELIS	GRKSJ	30
PREVELIS	GRAOK	60
PREVELIS	GRDIA	16
PREVELIS	GRHAL	22
PROTEUS	GRJSI	36
PROTEUS	GRGLO	31
SANTORINI PALACE	GRJTR	31
SANTORINI PALACE	GRJNX	18
SANTORINI PALACE	GRPAS	25
SANTORINI PALACE	GRJMK	20
SANTORINI PALACE	GRJSY	19
SEA JET 2	GRKRE	35
SEA JET 2	GRPAS	196
SEA JET 2	GRJMK	28
SEA JET 2	GRJNX	26
SEA JET 2	GRKOF	26
SEA JET 2	GRKTP	27
SEA JET 2	GRJTR	67
SEA JET 2	GRFOL	53
SEA JET 2	GRADL	272
SEA JET 2	GRKRE	35
SEA JET 2	GRSER	46
SPEED CAT 1	GRPTR	19
SPEED CAT 1	GRHYD	13
SPORADES STAR	GRMYR	82
SPORADES STAR	GRAGO	20
SUPER FERRY	GRTIN	22
SUPER FERRY	GRAND	30
SUPEREXPRESS	GRTIN	18
SUPEREXPRESS	GRJMK	20
SUPEREXPRESS	GRJNX	13
SUPEREXPRESS	GRPAS	18
SUPEREXPRESS	GRIOS	16
SUPERJET	GRKRE	14
SUPERJET	GRPAS	24
SUPERJET	GRJLK	26
SUPERJET	GRJNX	19
SUPERJET	GRKOF	12
SUPERJET	GRKTP	14
SUPERJET	GRJTR	36
SUPERJET	GRFOL	15
SUPERJET	GRADL	29
SUPERJET	GRKRE	14
SUPERJET	GRSER	9
SUPERSTAR	GRJNX	16
SUPERSTAR	GRJMK	23
SUPERSTAR	GRTIN	20

Vessel name	Port of call (UN/LOCODE)	Time spent at port [min]
SUPERSTAR	GRAND	26
SYMI	GRGLY	24
SYMI	GRJSI	25
SYMI	GRGLO	28
SYMI	GRKYM	48
SYMI	GRANL	19
THEOLOGOS P	GRTIN	23
THEOLOGOS P	GRAND	26
THUNDER	GRJMK	21
THUNDER	GRJSY	19
WORLDCHAMPION JET	GRIOS	14
WORLDCHAMPION JET	GRJNX	11
WORLDCHAMPION JET	GRJMK	16
WORLDCHAMPION JET	GRJSY	14

5. Port network

Out the 143 ports connected via all 153 vessels, 86 ports are being connected via the selected 74 vessels. As depicted in Table 15 below, a large share of the representative shipping routes converge at (a) major hub ports in the mainland (e.g. Piraeus – GRPIR, Rafina – GRRAF, Heraklion – GRHER, et.), acting as key points of passengers' and freight's origin and final destination, as well as (b) ports located at highly touristic areas / islands (e.g. Mykonos – GRJMK, Santorini – GRJTR, Naxos – GRJNX, etc.).

Table 15: Number of representative shipping routes which with each port is included

Port UN/LOCODE	Number of representative shipping routes containing the port
GRAGN	1
GRAGO	2
GRAKO	1
GRAGG	1
GRANL	1
GRADL	7
GRAIG	1
GRAEG	4
GRAXD	1
GRALO	3
GRANA	2
GRAND	4
GRVTH	2
GRVOL	2
GRGLY	1
GRGLO	3
GRGYT	1
GRDIK	2
GRDIA	1
GRDON	1
GRERM	2
GREYD	2

GRZTH	1
GRIGO	4
GRHER	9
GRSKG	2
GRJTR	13
GRTRS	1
GRIOS	6
GRKVA	2
GRKMI	2
GRKRE	6
GRKAR	2
GRAOK	1
GRKSJ	1
GRKIS	1
GRKAS	2
GRKTP	3
GRKEA	3
GRCFU	4
GRKMS	2
GRKOF	4
GRKYT	1
GRKYL	4
GRKYM	3
GRKIM	1
GRKGS	3
GRPKK	2
GRLAV	5
GRLIP	1
GRMRM	1
GRJMK	17
GRMYR	3
GRMJT	3
GRJNX	15
GRNEA	1
GRINO	1
GR088	1
GRPAS	13
GRPMS	1
GRPIR	36
GRPTR	4
GRPKE	3
GRPHE	2
GRPOA	1
GRRAF	8
GRRHO	7
GRSAM	1
GRSER	5
GRJSH	1
GRSII	2
GRJSI	4
GRSKO	2
GRSKU	1
GRSUD	3
GRSPE	4

GRSYM	1
GRJSY	9
GRTIN	8
GRHYD	4
GRFOL	4
GRFOU	1
GRHAL	1
GRCHQ	2
GRJKH	3
GRPAA	1

Out of the aforementioned 86 ports, only at 4 of them[10], there are plans for establishing and start operating LNG bunkering facilities within the next two years (Figure 3). These are the ports of Piraeus (GRPIR), Thessaloniki (GRSKG), Heraklion (GRHER) and Igoumenitsa (GRIGO), with the national gas company DEPA acting as the operator of those facilities. No plans for the bunkering of other alternative fuels have been established to date.

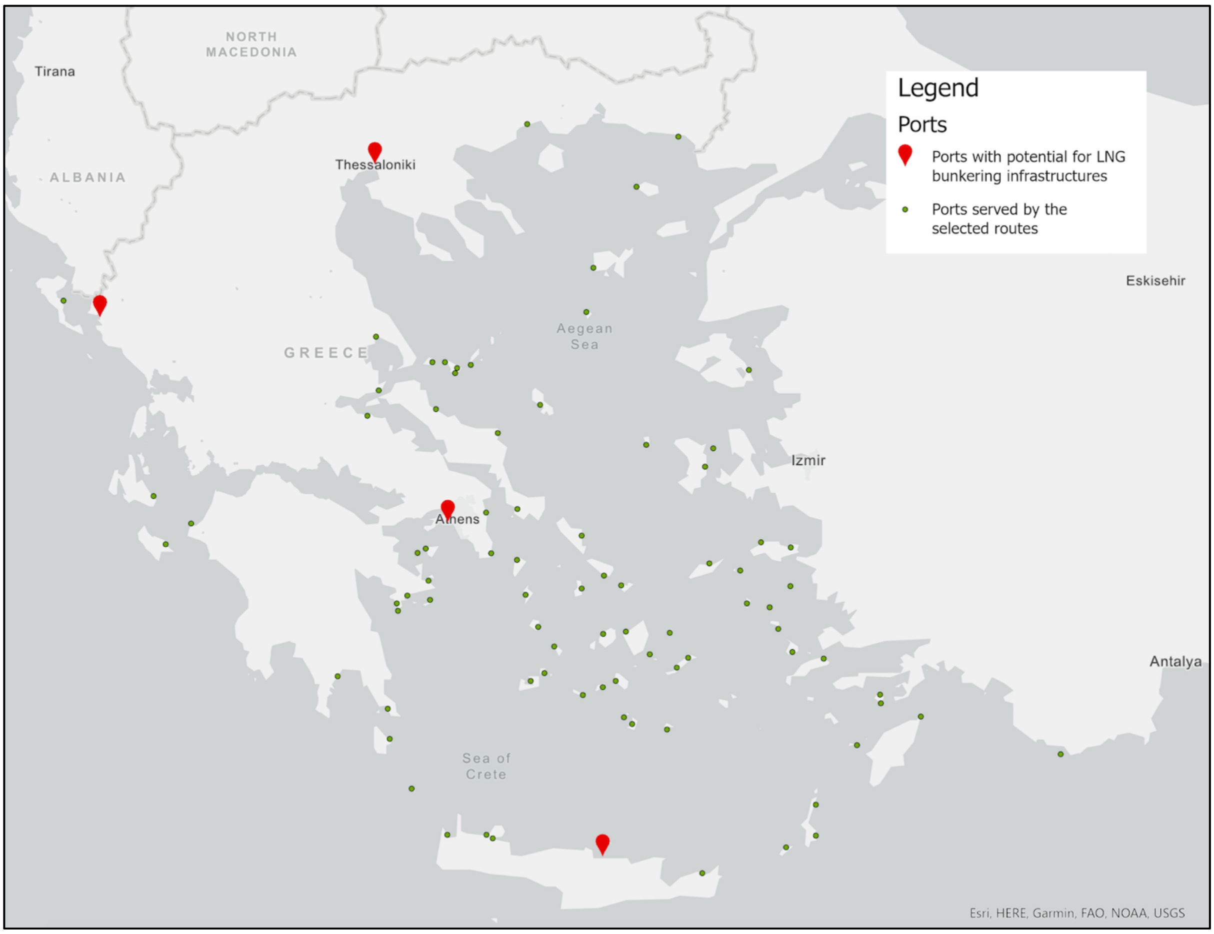

Figure 3: Map of Greek ports called by the selected vessels and indication of ports where LNG bunkering facilities are planned to be established

[10] There are also plans for establishing a LNG bunkering facility at the port of Patra (GRGPA), but none of the selected vessels called at this port during the reference year

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6. Greening technologies

According to the results of STEERER project[11], for both newbuilds and retrofitted ferries providing services over a range of 200 nautical miles[12], greening efforts will mostly focus on hybrid and fully electric solutions as well as on fuel cells[13], with *regional conditions* and *policy priorities* pushing one or the other type of solution to the forefront. For ferries covering longer distances[14], internal combustion engines (ICE) powered with alternative fuels (e.g. LNG, hydrogen, methanol) will be the most competitive solution, supported by energy efficiency measures and smart bunkering solutions at port facilities.

The above statements are clearly reflected in the current mix of the world fleet of ferries, with hybrid and fully electric vessels accounting for the larger share (Table 16). The same also applies on the existing orderbook.

Table 16: Mix of world fleet of ferries and current orderbook per type of fuel / power source used

Type of fuel / power source		Ferries in operation (world)	Ferries orderbook (world)
LNG		46	7
Hydrogen		2	2
Methanol		1	1
Batteries	Hybrid	220	30
	Plug-in hybrid		15
	Fully electric		23

Source: Laasma et al. (2022) based on DNV data

An interesting assessment of the different marine fuels / power sources that can be applied in coastal shipping has been conducted by Laasma et al. (2022) in their recently published work[15]. As depicted in Table 17, the authors used a Likert scale for assessing seven (7) different fuels / sources in terms of their technical readiness, regulatory status with regard to their use on-board passenger vessels, their life-cycle zero-emission potential, associated costs (CAPEX and OPEX) and the possibility to work well in severe ice conditions.

Table 17: Assessment of different marine fuels / power sources with regard to their applicability in coastal shipping

Type of fuel / power source	Technical Readiness	Regulations	Zero emission		CAPEX	OPEX	ICE
			Well-to-Tank	Tank-to-Wake			

[11] Deliverable 2.1 - State-of-Play of Decarbonization of waterborne transport "technology application atlas"
[12] This is the mostly the case within the Greek coastal shipping network addressed herein. Indicatively, 83,8% of the selected vessels meet this threshold (see Table 9)
[13] Vessels with significant hotel loads are expected to act as early adopters
[14] Smaller part of the Greek fleet / coastal shipping network as noted above
[15] Laasma, A., Otsason, R., Tapaninen, U. & Hilmola, O-P. (2022) Evaluation of Alternative Fuels for Coastal Ferries. Sustainability, 14(24), 16841. ttps://doi.org/10.3390/su142416841

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Hybrid			If not fossil source	No grid energy				
Plug-in hybrid			If not fossil source					
Fully electric			If not fossil source		Battery cost			
LNG	Methane slip		Fossil	Methane slip				
Hydrogen			If not fossil source					
Methanol	Safety	Passenger	If not fossil source					
Ammonia	Poisonous	Passenger	If not fossil source					

Rating map:

0	1	2	3	4

Source: Laasma et al. (2022)

According to previous table, the plug-in hybrid system presents the most promising potential[16]. It scored well with regard to both its technical readiness and regulatory environment, since such systems are already in use (i.e. battery systems up to 1.000 kWh have been widely installed to-date) while shore-based automatic charging systems are also in commercial use. The system also scored well in terms of costs, since it is already approaching market conditions (covering peak loads), while it can allow for carbon-free energy use when e-fuels or synthetic e-fuels are used as fuels in ICEs, and renewable energy is utilised in shored-based electricity systems. However, a lower score, but still comparatively high, was provided in both zero-emission categories, since e-fuel production opportunities remain very limited as e-fuels are still economically uncompetitive for commercial use today, while in the majority of cases onshore electric supply is based on non-GHG emission free sources[17].

A hybrid system was evaluated as the second most promising option. Similarly to the plug-in hybrid system, there is opportunity to achieve carbon neutrality using e-fuels. However, the hybrid system received a lower rating in the tank-to-wake stream, , compared to the plug-in system, since no charging at ports is involved and thus more considerable bunker reserve or denser bunkering is required to be served by road transport raising the traffic load of fuel trucks on port roads.

Fully-electric solutions followed next, with electricity shortages being flagged as a major concern (especially for island and remote regions) given the large shift of road transport towards electrification. Installation costs for ensuring adequate battery capacity onboard are high (hence the lower score in CAPEX), while the use of such systems in harsh ice conditions still presents difficulties.

For ferries covering longer distances, LNG received the highest score, although its use in new construction projects has been decreasing mainly due to the problem of methane slip. The lower score in the well-to-tank stream is mainly attributed to the fossil fuel nature of the system, while the score in the tank-to-wake stream is due to the fact that the system is not completely emission-free at its current stage of development.

[16] For ferries providing services over a range of 200 nautical miles, as stated before
[17] The use of renewable sources for energy production applies to all energy carriers investigated

Methanol followed next. Although there are already technical solutions for using methanol as a marine fuel, such systems require almost 2,5 times more space onboard ferries for both fuel storage and technical handling. Furthermore, it still cannot be used independently as the only power source, and hence two alternative systems are required to be onboard which further reduces the available useful space. Despite the IMO already having regulated the use of methanol, there have not been many instalments on ferries yet[18], whilst domestic regulations are also not favouring to-date the use of a relatively toxic fuel in passenger shipping. Due to those reasons, as well as due to the fact that there is still no ground-based methanol infrastructure for scaled production, methanol received low scores in the technical readiness, regulations and cost criteria. A medium score was received in the well-to-tank stream, given that methanol is mainly produced from fossil fuel-based feedstocks[19].

Hydrogen received a slightly lower score than methanol, mainly due to the highest costs involved. More specifically, at today's prices, system costs (i.e. CAPEX) of various solutions using hydrogen as marine fuel are 2-2,5 times higher than the currently used diesel systems. According to forecasts[20], hydrogen (OPEX) will not become competitive, in terms of price, to diesel not before 2050.

Ammonia was ranked last mainly due to the toxicity challenges and the significant related risks that exist, which while manageable, add complexity to ship designs thus limit the range of ships for which ammonia can serve as a suitable fuel. According to a recent study of American Bureau of Shipping, CE Delft and Arcsilea for the European Maritime Safety Agency[21], those are mostly deep-sea cargo vessels and not short-sea, passenger vessels.

Taking a regional perspective, further details on these power sources will be provided at D2.2, which will be used as a basis for setting in D2.3, realistic scenarios for the uptake of the most promising solutions within the coastal shipping network of Greece.

7. Conclusions and recommendations

Exploiting various information sources and taking a bottom-up approach, carefully processing and aggregating large amount of fleet and traffic data available to the team, the base case of the Greek coastal shipping network was established herein. The information reported feeds into the model development process taking place in WP1, so that the final version of the model successfully adheres to the characteristics of the coastal shipping sector in Europe.

The information presented herein will be coupled with additional information on regional production capacities of alternative fuels (D2.2) as well as with required technical information at both vessel (e.g. updated design, etc.) and port side (e.g. bunkering speed, etc.) so that, taking a network-based approach, realistic scenarios for the uptake of the most promising solutions can be formulated. Those will be presented, for validation and if necessary update

[18] Stena Germanica is the only methanol-fuelled ferry currently in operation (since 2015)

[19] McKinlay, C.J., Turnock, S.R., Hudson, D.A. (2021) Route to zero emission shipping: Hydrogen, ammonia or methanol? International Journal of Hydrogen Energy, 46(55), 28282-28297. https://doi.org/10.1016/j.ijhydene.2021.06.066

[20] Di Micco, S., Minutillo, M., Forcina, A., Cigolotti, V., Perna, A. (2021) Feasibility analysis of an innovative naval on-board power-train system with hydrogen-based PEMFC technology, E3S Web Conference, 312, 07009. https://doi.org/10.1051/e3sconf/202131207009

[21] ABS, CE DELFT and ARCSILEA (2022) Potential of Ammonia as Fuel in Shipping. Report commissioned by EMSA. Available at: https://www.emsa.europa.eu/publications/item/4833-potential-of-ammonia-as-fuel-in-shipping.html

to a range of relevant stakeholders and experts, including representatives of the Greek Ministry of Maritime Affairs and Insular Policy who have already taken important actions for greening the Greek coastal shipping sector and advancing to a more sustainable future.