



# SHEBA

## Sustainable Shipping and Environment of the Baltic Sea region

BONUS Research Project

Call2014-41

### Deliverable 1.3, type DB

#### Activity data for the Baltic pleasure boats,

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## *Pleasure boat activity data*

### *Summary*

In contrast to commercial marine vessel traffic, pleasure boat activities in the Baltic Sea shipping cannot be estimated based on the Automatic Identification System (AIS) since AIS-equipment is not mandatory for small pleasure boats. Since little or no information exists on the activities of pleasure boats, their contribution has all but been ignored in environmental impact studies of shipping.

The provided pleasure boat activity data is based on survey data, fuel sales statistics, marina locations and a newly developed pleasure boat modelling approach by FMI. It should be noted that the derived activity datasets for pleasure boats have significant uncertainties due to the nature of used input data, which includes qualitative survey data as well as manual analysis of satellite images of coastlines and archipelagos. The date of used information ranges between 2010 and 2016, which further increases the margin of error.

The D1.3 report describes the provided datasets and the methodology used to produce them. The provided datasets of D1.3 will be used to generate various activity data required by consecutive work of WPs 2, 3 and 5. The developed pleasure boat simulation model will also be improved during the SHEBA project.

### **Description of provided activity data**

#### *a) Gridded fuel consumption and travel estimates*

Gridded binary data describing estimated annual totals (gasoline fuel consumption, diesel fuel consumption, travel distances) for pleasure boat activities (with geographical distribution) have been delivered to Helmholtz Zentrum Geestacht (HZG) and deposited to HZG Powerfolder system for all partners to download. Fuel consumption was selected to be the main driver for pleasure boat activities since it can be used for the assessment of exhaust emissions and impact studies in work packages 2 and 3 together with pleasure boat fleet characteristics.

The data has been provided in netCDF format using Climate and Forecast naming conventions. In order to gain access privileges to the SHEBA Powerfolder, contact Mr Gisbert Breitbach ([gisbert.breitbach@hzg.de](mailto:gisbert.breitbach@hzg.de)). Some<sup>1</sup> of the gridded output can be visualized in web browser through the SHEBA Data Portal:

[http://codm.hzg.de/sheba/thredds/godiva2/godiva2.html?server=http://codm.hzg.de/sheba/thredds/wms/publicAll/WP1-Emissions/pleasureBoat\\_activity\\_netcdf.nc](http://codm.hzg.de/sheba/thredds/godiva2/godiva2.html?server=http://codm.hzg.de/sheba/thredds/wms/publicAll/WP1-Emissions/pleasureBoat_activity_netcdf.nc)

#### *b) Hourly temporal variation of activities*

Based on AIS-data a temporal variation function on an hourly basis was estimated and has been uploaded to the SHEBA Powerfolder. A text file containing the temporal profile can be accessed by all partners and can be used to establish dynamic activity datasets when combined with the abovementioned gridded datasets.

#### *c) List of marina locations with estimated boat counts*

A great deal of effort by all consortium partners was made in the analysis of small marina locations and their pleasure boat capacities.

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<sup>1</sup> Estimated Annual total fuel consumption of pleasure boats in the Baltic Sea in 2014.

Based on satellite image analysis, survey data and local authority contacts a list of marinas in the Baltic was produced to facilitate the modelling of pleasure boat activities nearby the listed marina locations (See section 3). The list includes more than 3000 locations for pleasure boats and accounts for more than 250 000 boats. The list has been uploaded to the SHEBA Powerfolder and can be accessed by all partners.

## 1. Top down statistics

For the preparation of pleasure boat activity datasets, in close collaboration with IVL, TUT, SDU and HZG existing and available information for all riparian states were collected. This included survey data (Sweden, Germany, and Denmark), prior local modelling results (Finland) and port statistics (Baltic states and Denmark). The primary goal of this analysis was to estimate total fuel consumption of pleasure boats for all riparian states as well as to establish their fleet characteristics and total boat counts.

### 1.1 Sweden

A detailed questionnaire survey conducted by the Swedish Transport Agency (from Båtlivsundersökningen, 2010) formed the basis of the top-down statistics. The survey included qualitative information on the activities of 881 000 pleasure boats in Sweden, including fleet characteristics and fuel consumption. The survey also included a classification of four sub-types for pleasure boats, which were also incorporated in SHEBA (Table 1).

Table 1: Sub-types for pleasure boats incorporated from Swedish surveys.

<b>OSB</b>	Open small boat with engine less than 10hp. Includes engineless boat type, such as jolly-boats and rowing boats.
<b>MB</b>	Motorboat with engine larger than 10hp with no possibilities for overnight stay
<b>LMB</b>	Large motorboat with possibilities for overnight stays
<b>LMSB</b>	Large motor sailing boat with possibilities to stay overnight

Since pleasure boat activity data in SHEBA needs to be quantitative rather than qualitative<sup>2</sup>, the questionnaire data was transformed into quantitative estimates through averaging (For example, range for gasoline consumption of 0 – 25 litres was interpreted as 12.5 litres). Furthermore, it was assumed that all boat owners with unsure answers (“Don’t know”) followed the distribution of answers indicated by the rest of the given answers. In other words, the unsure answers were eliminated from the data. The resulting quantitative survey data estimates have been summarized in Table 2.

Table 2: quantitative survey data estimates for Swedish pleasure boats in the Baltic Sea.

	<b>OSB</b>	<b>MB</b>	<b>LMB</b>	<b>LMSB</b>
<b>Fuel [t]</b>	477	14250	11641	1964
<b>use of Diesel [%]</b>	15 %	20 %	48 %	91 %
<b>Boats in the Baltic Sea</b>	24416	122590	49866	33979
<b>Average unit travel distance [km]</b>	57	228	323	695
<b>Total travel distance [10<sup>3</sup> km]</b>	1389	27961	16098	23626

<sup>2</sup> Quantitative example: Swedish motor boats consumed X tons of diesel fuel in total. Qualitative example: 20% of Swedish motor boats consumed between X to Y tons of diesel while 15% didn’t know their diesel consumption.

For the geographical distribution of activities a dataset (shapefile, from Swedish Environmental Protection Agency) describing approximately 2000 marina locations was available. This included all the harbour/marina sites. For the small boat marinas, all harbour locations with large vessels were filtered out.

### ***1.2 Finland***

A study conducted by VTT (Finnish Maritime Administration, 2005) concluded that in Finland, there was about 390 000 small boats with a motor. The national small boat registry (Finnish Transport Safety Agency, 2015) lists over 195 000 small boats powered by an engine, which is about half of the previous assessment. The discrepancy of boat numbers may be partly because the new boat registry requires an active registration of all boats with an engine. If a boat is not actively used, it may not be included in the small boat registry.

The information contained in the small boat registry is only an indication of the total fleet of boats, because it does not distinguish between boats used in Baltic Sea coastline and those used in inland waters. For this reason, the satellite imagery from the Finnish coastline was searched for small boat marina locations. Vessel counting was done based on available mooring places for boats, not the actual boats themselves, because it was likely that some of the boats were in use during the time satellite image was taken. On the other hand, counting the mooring places automatically assumes 100% usage of available capacity. Regardless, 475 boat marinas were found in the Finnish coastline, Turku archipelago area and Ahvenanmaa islands. These marinas had space for over 50 600 vessels. The annual fuel consumption for the Finnish small boats was estimated based on the typical annual consumption of a vessel derived from the Swedish survey. No official records exist for fuel sold to small boats in Finland. Obviously, the approach taken in this task contains inherent uncertainties, because it assumes that the fleet composition and usage patterns are similar both in Finland and Sweden.

### ***1.3 Denmark***

The Danish Maritime Authority registers leisure boats over 20GT (type of boat, type of propellant or homeport is not available), but no register of all Danish leisure boats was seen to be available.

Based on the information taken from <http://www.sejlnet.dk/havneguide> it was possible to locate 338 marinas in the Danish part of the Baltic Sea. This information included the geo-reference of the marina, the number of mooring places as well as contact details for further contact to individual harbours. The largest of the harbours were contacted by telephone and e-mail to inquire whether the marina had a separate fuel station, so that an estimation of fuel consumption could be made. 15 of the biggest marinas fit the conditions and were able to inform about the fuel consumption in their marina.

The fuel consumption was divided into diesel and gasoline, including guest boats, when possible. The data was then used for the estimation of the rest of the marinas<sup>3</sup> and were used in later pleasure boat activity simulations.

### ***1.4 Germany***

A telephone survey formed the basis of the bottom-up statistic, which was used to obtain information on the annual fuel sales in litres (diesel and petrol) from the German water petrol

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<sup>3</sup> A difference between marinas North of Copenhagen with a fairly high per boat energy consumption and a lower consumption in the marinas of Jutland was observed. Currently, this information was not utilized since the built simulation model assumes all marinas within a country to have similar features.

stations in the Baltic Sea. All 39 petrol stations on the German Baltic Sea coast were contacted and information from 35 stations was received and recorded. Research was conducted prior to the survey on the number of water petrol stations and their connected berth.

The number of berths is relevant to the research, since the study examined whether the revenue per berth is similar in different regions on the German Baltic Sea coast and can therefore be transferred to other regions. Since there is no exact statistic on how many German leisure boats exist in the Baltic Sea, this study relates to a previous study which equates the number of berth to the number of existing vessels.

An online questionnaire formed the basis of the top-down statistics. The survey was conducted by 265 German leisure boat owners who sail the Baltic Sea. The survey asked technical questions regarding the characteristics of their vessel, such as motor and fuel consumption, as well as information on their activities. Activities were divided into two categories: popular short trips and popular long trips. The boats in the survey were classified into three sub-types: sailing boats with engines, sailing boats without engines, and motorboats.

### ***1.5 Poland, the Baltic states and Russia***

Local authorities were contacted for existing inventories and surveys for pleasure boat activities. Unfortunately, inventories were not available and pleasure boat activity in the Baltic Sea for Poland, Lithuania, Latvia, Estonia and Russia were estimated based on marina locations (listed port areas, satellite images) and supporting information. The mix of gasoline and diesel use was taken from the Swedish survey data.

Small harbours along the eastern coast of the Baltic Sea were positioned based on reference locations in <http://en.seaclub.lv/ports/estonia/> and by satellite images. The total number of crafts for Estonian pleasure boats were estimated to be 1075 crafts, which compare to national registry database (700 yachts + small ships which include 134 motorboats and 206 workboats).

Total fuel consumption for the abovementioned countries were estimated by scaling fuel consumption data of Sweden with number of people living near the coast (Eurostat<sup>4</sup>) within a range of 5 km. The combined population of Kaliningrad and St. Petersburg was used to derive the Russian population living near coast of the Baltic Sea.

## **2. Temporal profile of activities**

While AIS-data in 2014 cannot be used to produce reliable pleasure boat activity data, AIS-data does contain enough small pleasure crafts for the estimation of temporal variation of activities. The resulting temporal variation of activities can be used across the Baltic Sea for all pleasure crafts. It should be noted the ships that are not IMO-registered but still sending AIS-messages can also be pilot vessels, S&R crafts, small tugs and service vessels. Thus, pleasure boats (which probably represent a small subset of LMB and LMSB vessels) need to be filtered out from the AIS data.

AIS data from Helcom in 2014 and the FMI-STEAM model was used in this analysis. First, a collection of ships were isolated from the AIS-data. These ships were filtered out from the rest of the ships using the following criteria:

- Active only during 1<sup>st</sup> May – 30<sup>th</sup> September

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<sup>4</sup> Link to Eurostat data: [http://ec.europa.eu/eurostat/statistics-explained/index.php/Coastal\\_regions\\_-\\_population\\_statistics](http://ec.europa.eu/eurostat/statistics-explained/index.php/Coastal_regions_-_population_statistics).

- Total travel distance does not exceed a selected threshold value<sup>5</sup>
- Is not an IMO-registered ship
- Ship is not active regularly<sup>6</sup>

Using the conditions above, approximately 2000 unknown vessels were filtered with FMI-STEAM model for further analysis. A clear majority of these ships are Swedish. Danish and German vessels and the geographical distribution of activities should not represent all pleasure boat activities well enough to be used in this study.

Finally, the filtered pleasure boats were modelled using the FMI-STEAM model (all ships were assumed to have identical vessel attributes) and the resulting profile for fuel consumption as a function of time has been presented in Figure 1. This profile thus reflects changes in boat activity, only, and disregards differences in boat properties. According to the estimated profile, June-August contains approx. 75% of all activities. Also, there is a strong diurnal variation and weekends during 10am – 2pm have the highest activities.

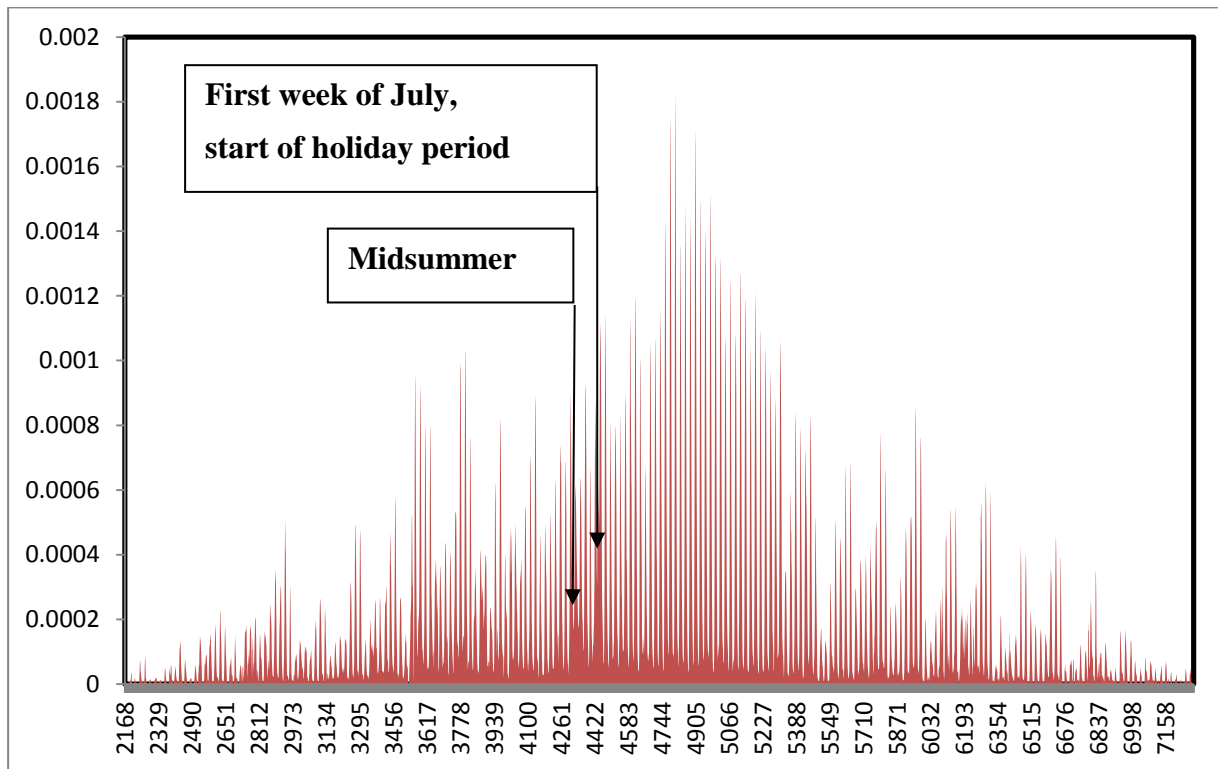


Figure 1: Estimated temporal profile of pleasure boat activities in the Baltic Sea based on AIS-data. Horizontal axis describes the hour of year and the vertical axis is the relative hourly weight for activities. The sum of weights is equal to 1.

### 3. Geographical distribution of activities

Since little or no information of the geographical distribution of pleasure boat activities exists, it was decided that the best approach in SHEBA is to model the geographical distribution

<sup>5</sup> 2400km, which should include approximately 94% of LMSB pleasure boats and 99% of other pleasure boats, based on the Swedish survey data.

<sup>6</sup> Based on the “fraction of time being monitored” in FMI-STEAM model. This measure indicated how large a portion per month the vessel has been cruising, manoeuvring and berthing while sending AIS-data. For pleasure boats this fraction should not exceed 25%.



based on marina locations. The key assumption was that the geographical distribution of pleasure craft activities can be associated to the vicinity of pleasure craft harbours. This assumption is backed up by the Swedish survey (Båtlivsundersökningen, 2010) which indicates that the clear majority of pleasure boats operate very locally near their marinas<sup>7</sup>.

A list of pleasure craft harbours (boat place counts, location) for each riparian state was collected based on survey data, existing national studies and satellite image analysis (see Figure ). Then, a new simulation model for the geographical distribution of pleasure boat activities was built specifically for the SHEBA project (the new simulation model works as an extension to FMI-STEAM).

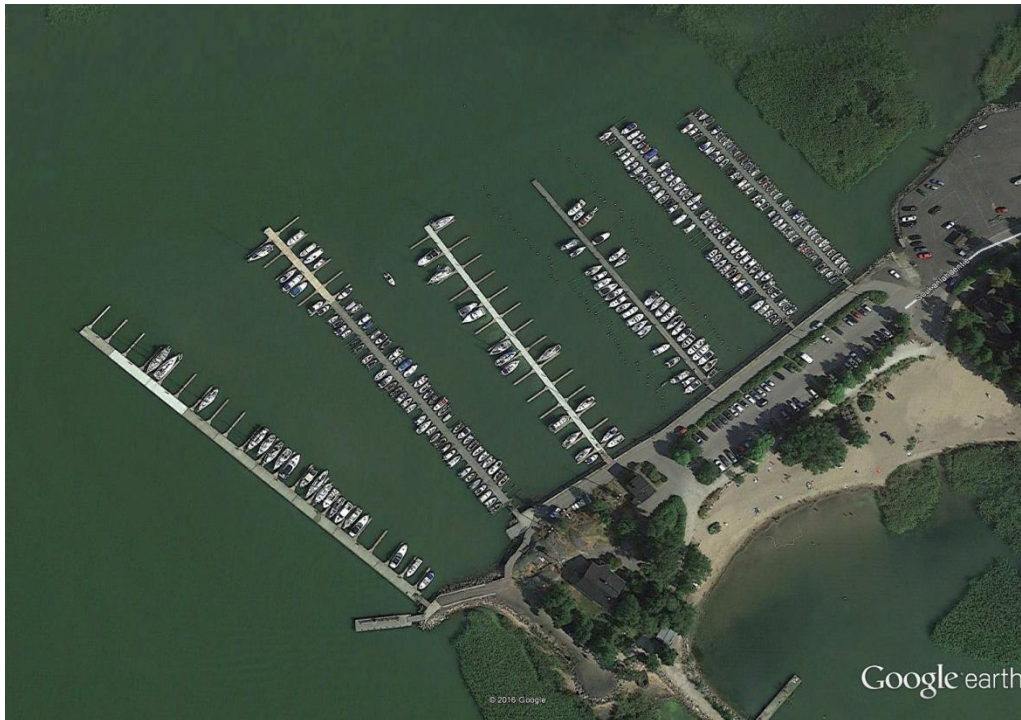


Figure 2: An example of satellite imagery used to calculate the number of boat places in a small boat marina (Soukka/Espoo, Finland).

The new simulation model reads as input the temporal variation profile (Section 2), the total fuel consumption of national pleasure craft fleets (Section 1) and a list of small harbour details (location, ship amounts). The list of marinas was built in cooperation with all consortium partners in SHEBA. As a result, the list includes more than 3000 locations for pleasure boats and accounts for more than 250 000 boats in total. It should be noted that the **list of boat mooring place counts and locations are indicative and their main purpose is to geographically distribute pre-defined national pleasure boat activities** – the total amount of activities (e.g. fuel consumption) and fleet characteristics are still based on survey data (Section 1).

### ***3.1 Technical details for the simulation model***

For the assessment of activities for each harbour the new simulation model uses land-use maps (GIS-data) to distinguish the list of *candidate locations* around each marina. Simply put,



each location at sea in a 50km radius<sup>7</sup> around the marina is a candidate location for activities while nearby locations on-ground are discarded.

The geographical distance from the marina and the vicinity of coastline and islands will affect the distribution of activities around the marina. For each *candidate location*, a distance metric is calculated. The distance metric is simply the geographical distance from the harbour, but an additional penalty term will be applied if the candidate location has no land mass nearby (thus it has been assumed that pleasure boats favor the coastline and archipelagos). Finally, the candidate locations are ranked by the distance metric and activities from each vessel listed in the harbour are assigned to the candidate locations<sup>8</sup>. Since all pleasure boat activities are being distributed around the marinas, the inter-marina travels that occur are not considered at this point.

### 3.2 Example simulation for total annual fuel consumption

The simulation model was run over April-October for the listed marinas and the resulting geographical distribution of fuel consumption is presented in Figure 3.

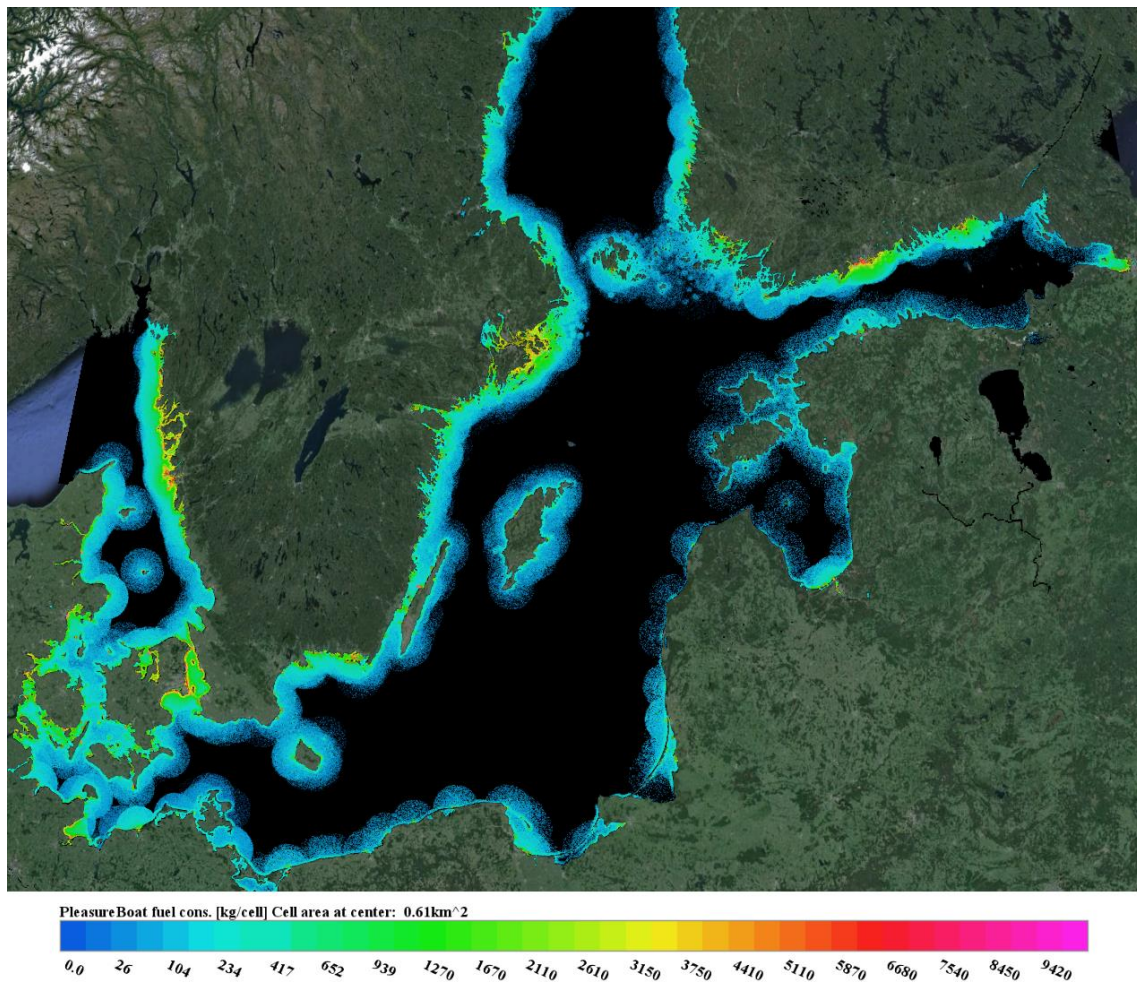


Figure 3: Estimated annual fuel consumption of the Baltic pleasure boats based survey data, AIS-data and a simulation model. The gulf of Bothnia has been excluded from the figure for visualization purposes. Satellite image layer has been given by Google Earth.

<sup>7</sup>According to Table 11 of the Swedish survey (Båtlivsundersökningen, 2010) only 10.2% of pleasure boats owners confirmed to have boat trips that exceed 25 nautical miles (approx. 46 km).

<sup>8</sup>A natural (Gaussian “bell-curve”) probability density function was assumed for the distribution of activities as a function of the distance metric.

Based on the survey data the total amount of fuel consumption for the Baltic pleasure boats can be estimated to be around 65000 tonnes annually, of which 30000 tonnes comes from Swedish vessels. The largest hotspots for pleasure boat activities are modelled to occur nearby Gothenburg, Copenhagen, Stockholm and Helsinki. However, the uncertainty is large (several tens of percent). Information on national fuel consumption was especially scarce for Finland, Poland, the Baltic states and Russia. Based on the vessel amounts observed and listed in Poland, the Baltic states and Russia, however, their contribution to fuel consumption is likely to be small in contrast to all other Baltic countries.

### References and links

Finnish Maritime Administration, “Veneilyn määrä ja taloudelliset vaikutukset Suomessa”, FMA publications 5/2005., [http://www2.liikennevirasto.fi/julkaisut/pdf5/mkl\\_2005-5\\_veneilyn\\_maara.pdf](http://www2.liikennevirasto.fi/julkaisut/pdf5/mkl_2005-5_veneilyn_maara.pdf)

Swedish Transport Agency, Båtlivsundersökningen 2010, <https://www.transportstyrelsen.se/sv/sjofart/Fritidsbatar/Statistik-och-fakta--fritidsbatar/batlivsundersokningen/Batlivsundersokningen-2010/>

Unofficial Danish port guide, <http://www.sejlnet.dk/havneguide>

Unofficial pleasure boat port list for the Baltic states, <http://en.seaclub.lv/ports/estonia/>