Vard Marine Inc.

GREYWATER GENERATION ESTIMATES FOR THE BC COAST

381-000

Rev 1

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WWF Canada

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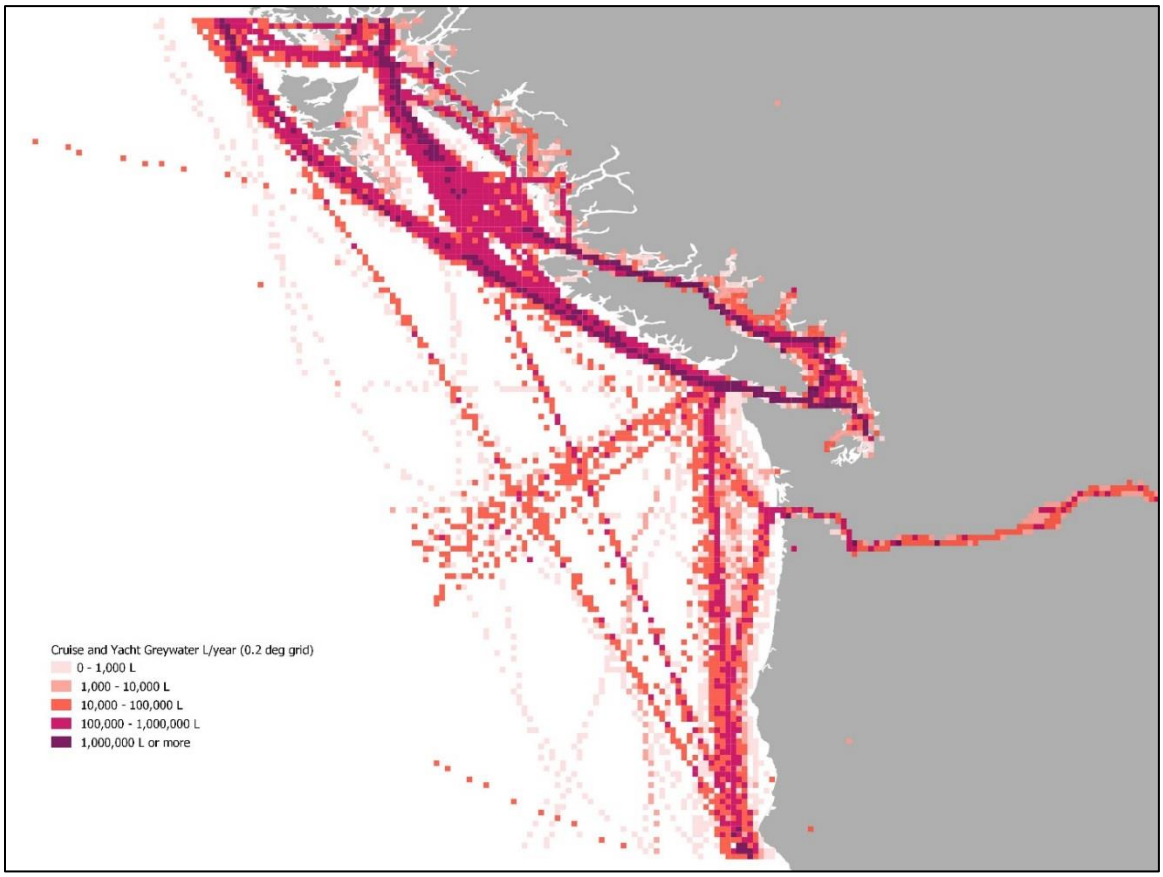
SUMMARY OF REVISIONS

Rev	Date	Description	Prepared by	Checked by
0	21 May 19	PRELIMINARY DRAFT FOR CUSTOMER REVIEW	MT	MS
1	17 June 19	UPDATE AND INCORPORATION OF CUSTOMER COMMENTS	MT	CO

EXECUTIVE SUMMARY

This study builds on existing work, applying the previously developed estimation approaches for greywater generation to all vessel traffic off the coast of British Columbia between 55 and 40 degrees latitude North in 2017. The purpose of this study is to help WWF-Canada fill the knowledge gap that exists on the coast of British Columbia with respect to greywater, helping to strengthen WWF-Canada's position on greywater on a national scale.

This study uses a dataset of all recorded AIS data from 2017 for the area of interest and greywater generation rates per person on board a given type of vessel to create estimates for the quantity of greywater generated in the area of interest. This study estimates that 1.54 billion L of greywater may have been generated near the BC coast in 2017, with 1.37 billion L having been generated by vessels involved in the tourism industry such as cruise ships, yachts, and expedition vessels. The following figure shows a heatmap of the estimates of greywater generation in the area of interest:



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LIST OF ACRONYMS

AIS	Automatic Identification System
DWT	Deadweight Tonnes
EEZ	Exclusive Economic Zone
ICCT	International Council on Clean Transportation
IMO	International Maritime Organization
KW	Kilowatts
LOA	Length Overall
MARPOL	International Convention for the Prevention of Pollution from Ships
NSPS	National Shipbuilding Procurement Strategy
TC	Transport Canada
CSA	Canada Shipping Act
CCGS	Canadian Coast Guard Ship
USCG	United States Coast Guard
SOLAS	Safety of Life at Sea

1 INTRODUCTION

In 2016, the first major cruise ship, carrying 1600 passengers, transited the Northwest Passage. This spurred WWF-Canada to research the environmental impacts of greywater (water from sinks, showers and galleys on ships) and the greywater discharge regulations ships must follow. Greywater can have a variety of environmental impacts, including:

- Nutrients in greywater can lead to dead zones caused by excessive algal growth.
- Oil and grease coat the gills of fish and prevent them from being able to breathe.
- Increased particulate matter in the water can potentially suffocate smaller species such as crabs, lobsters and sponges.
- Invasive species in greywater can be introduced into the ecosystem.

Greywater treatment is well understood in terms of both how to treat greywater and how much will be produced for a given type of vessel. Designing appropriate management systems and regimes is entirely feasible, and examples of successful implementation can be found around the globe. There is not however any publicly available assessment of how much greywater is truly being generated in Canadian waters.

Since 2017, WWF-Canada has been engaging with Transport Canada to update the greywater regulations in the Arctic. WWF-Canada chose to focus on the Arctic region as a first step due to the sensitivity of this environment. Monitoring of greywater treatment and regulatory compliance in the Canadian Arctic is non-existent. Regulations do exist, however without a framework for measuring and establishing compliance they are effectively no different than guidelines or suggestions.

In 2015, Vard Marine Inc. conducted a report for Transport Canada titled “Projections for ship-generated waste travelling through the Canadian Arctic”. This report used 2013 ship traffic data to generate current and projected estimates for waste and included maps of waste carried and generated.

In 2018, Vard Marine Inc. supplied WWF-Canada with an updated version of the greywater section of the above-mentioned report using 2016 ship traffic data.

This study builds on this existing work, applying the previously developed estimation approaches for greywater generation to all vessel traffic off the coast of British Columbia between 55 and 40 degrees latitude North in 2017. The purpose of this study is to help WWF-Canada fill the knowledge gap that exists on the coast of British Columbia with respect to greywater, helping to strengthen WWF-Canada’s understanding of greywater on a national scale.

1.1 STUDY SCOPE

This study provides WWF-Canada with the following data products in addition to this report:

- An SQLite-based database for all 2017 vessel traffic in the area of interest. This traffic data is derived from marine Automatic Identification System (AIS) data collected by ExactEarth, and pre-processed by the International Council on Clean Transportation (ICCT), as provided to Vard Marine Inc. This database allows a user to submit queries and extract records for vessels by type, unique vessel, or other discriminators
- GIS shapefiles for AIS data and greywater generation heatmaps for tourism traffic in the area of interest
- A Microsoft Excel based summary spreadsheet detailing the estimates of greywater generated for all vessel types in the database
- Image files of the heatmaps for greywater generation for tourism traffic in the area of interest

2 SUMMARY OF VESSEL TRAFFIC DATASET

2.1 DATASET DESCRIPTION

The report uses a dataset provided by Exact Earth which includes all AIS data captured by Exact Earth for the coast of British Columbia, below 50 degrees North. The extends above this boundary slightly including AIS for vessels between 55 degrees North and 40 degrees North. **Figure 1** below shows an overview of all the AIS data used for this analysis. The estimates for generated greywater in this study are based on the entirely of tis AIS dataset.

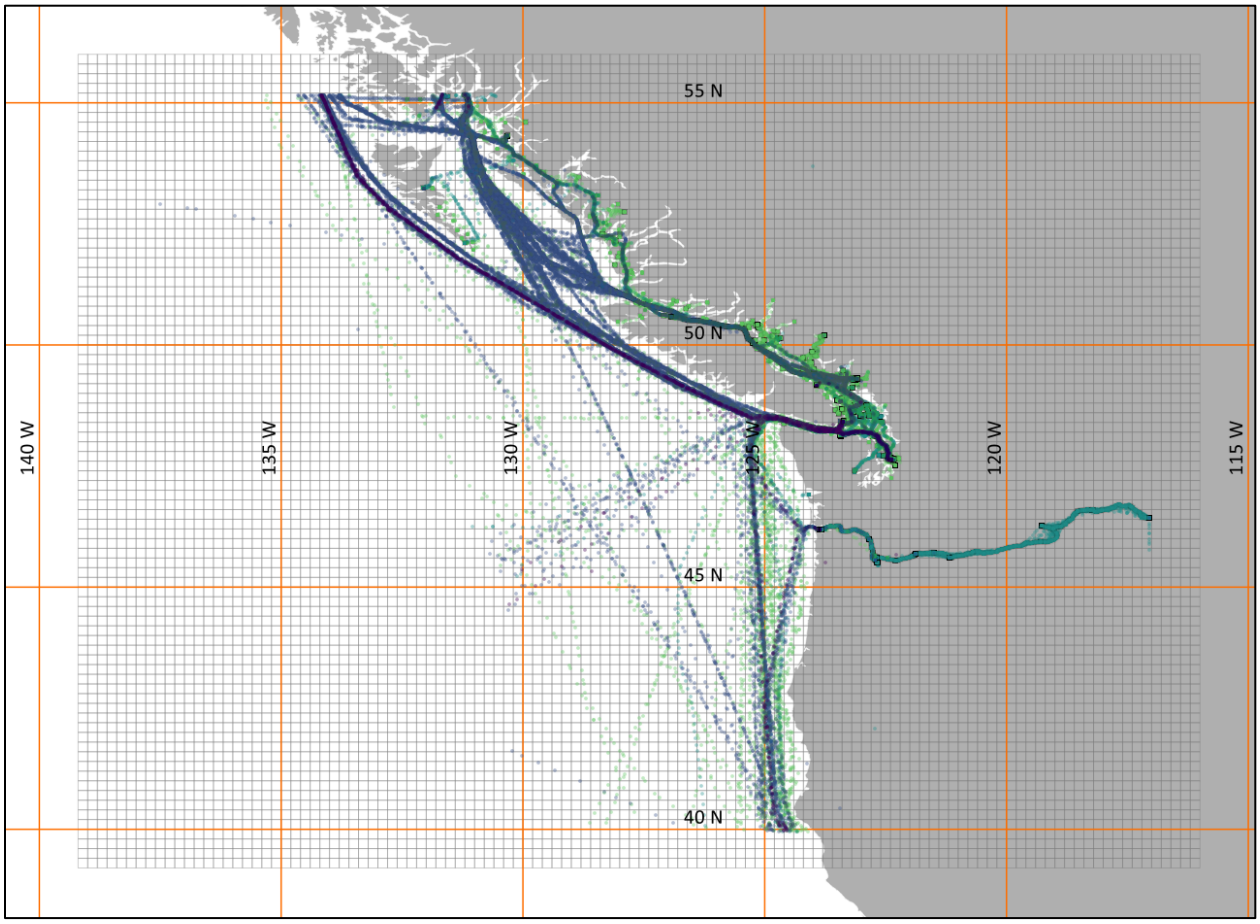

Figure 1: Overview of all AIS data used

AIS messages are used for safety in navigation and are intended to be read by ground stations, other vessels in range, aircraft, or any other interested party with a receiver. Exact Earth use a satellite array to record AIS messages from vessels anywhere in the world. AIS transmits the location, particulars, and current performance (speed, heading, etc.) of a vessel.

Under IMO SOLAS Chapter V virtually all seagoing vessels are required to have an AIS transponder. Specifically, AIS must be fitted aboard all ships of 300 gross tonnes or more age on international voyages, cargo ships of 500 gross tonnes or more not engaged on international voyages, and all passenger ships irrespective of size.

AIS is not perfect however. AIS data is not always reliable, accurate, or free of data imperfections, and coverage can be imperfect. AIS was not developed as a satellite service but as a line of sight transmission, so reading the data from satellites may introduce issues such as gaps in satellite coverage in addition to these underlying potential issues. Despite the latter issues, AIS data on a large scale provides an excellent overview of vessel activity, and when considered in a dataset of many millions of data points as this study does the data is entirely suitable.

The data was provided to Vard by the ICCT and has been pre-processed. The following details further describe the technical specifications for the dataset:

- ICCT pre-processed the dataset to calculate the approximate distance travelled by the vessel in the time elapsed between subsequent AIS records for each vessel.
- ICCT pre-processed the dataset to determine the vessel type for all records
- ICCT pre-processed the dataset to determine the number of persons on board for all records
- Vard noted that the estimates for persons on board were based on a vessel characteristics database intended for characterizing global traffic levels, and were therefore not sufficiently accurate for this analysis. Vard replaced all passenger count data for passenger vessels with newly developed data as follows:
    - All “yacht” category vessels were individually considered and researched based on build specifications or other open records to determine the likely compliment.
    - All “cruise ship” category vessels were individually considered and researched based on published itineraries or company marketing materials to determine their likely compliment.
    - Ferries were considered likely to have highly variable passenger counts, and due to often shorter ferry routes around British Columbia (e.g. few overnight sailings, some sailings passengers remain in their vehicles, some vessels have large restaurant complexes and others will have minimal grey water generation) these vessels were excluded from the analysis.
- All other vessel types were given estimates for compliment size based on expected crew size for vessels of a given complexity. These compliments are shown in **Table 1**.

2.2 ASSUMPTIONS

This study presents the quantities of greywater which are likely to have been generated at a given point within the area of interest. These greywater estimates are based on the following generation rates, as shown in Section 3.2 and validated in Section 3.5.1:

- 253.6 L per person per day for cruise vessels and yachts
- 125.0 L per person per day for commercial vessels

Vessel and voyage data was developed with the following assumptions:

- The time of the AIS report is from the AIS timestamp and is assumed to be correct
- The distance travelled by the vessel in the time elapsed since the previous AIS report has been pre-calculated by ICCT. This assumes that the vessel has travelled in a reasonably straight path between points
- The assumptions for total persons on board vessels other than cruise ships and yachts are based on a typical vessel of each vessel category

Table 1 below lists the assumed persons on board for non-tourism vessels used in the estimation of generated greywater:

Table 1: Assumed POB for Vessel Types in 2017 Dataset

Vessel Type	Default Assumed POB
bulk carrier	20
chemical tanker	15
container	20
cruise	n/a – estimated for each vessel in the 2017 dataset
ferry-pax only	*n/a – vessel type not included in analysis*
ferry-ro-pax	*n/a – vessel type not included in analysis*
general cargo	20
liquefied gas tanker	20
oil tanker	15
refrigerated bulk	15
Roro (roll on/roll off cargo)	30
vehicle	30
yacht	n/a – estimated for each vessel in the 2017 dataset
miscellaneous-fishing	*n/a – vessel type not included in analysis*
miscellaneous-other	*n/a – vessel type not included in analysis*
naval ship	*n/a – vessel type not included in analysis*
offshore	*n/a – vessel type not included in analysis*
service-other	*n/a – vessel type not included in analysis*
service-tug	*n/a – vessel type not included in analysis*

2.3 DATA FORMATS

2.3.1 SQL DATABASE

In order to manage the large quantity of data used by the project, Vard have packaged the final data set into a SQLite database. This database uses standard SQL syntax, and is fully useable using any free SQL database client, such as SQLite Studio (https://sqlitestudio.pl)

2.3.2 MICROSOFT EXCEL SUMMARY SPREADSHEET

The study includes a Microsoft Excel spreadsheet which provides a summary of all traffic considered in the study, as well as collated AIS reports for each vessel type in the ExactEarth 2017 dataset. This spreadsheet was used to create the summary tables shown in this report and can be used to develop other statistical analyses of the vessel traffic in the 2017 dataset.

Please note when using the spreadsheet that it contains a very large number of data points and will be slow to process Microsoft Excel's native calculations. It is recommended that the calculation method in Microsoft Excel be set to "Manual" when using the spreadsheet.

2.3.3 GIS SHAPEFILES

All shapefiles provided as part of this study are in a standard ESRI compatible shapefile format, and are natively readable by any contemporary GIS including ESRI products, QGIS, Google Earth, etc.

2.4 OVERALL TRAFFIC SUMMARY

Table 2 below provides an overview of traffic off the coast of British Columbia in 2017. Note that some vessels have been excluded from the analysis because either how they were defined in the original dataset was unclear, or it was not possible to create a reasonable operational profile for the purposes of estimating greywater generation.

Table 2: Activity by Vessel Type in British Columbia, 2017

Vessel Type	Individual Vessels	Distance Sailed (nm)	Total Days in Area of Interest
bulk carrier	1805	2,625,704	130,509
chemical tanker	135	457,272	10,022
container	429	1,371,618	52,073
cruise	48	636,775	6,291
ferry-pax only	15	*Not calculated*	*Not calculated*
ferry-ro-pax	73	*Not calculated*	*Not calculated*
general cargo	191	405,926	15,429
liquefied gas tanker	19	16,676	267
oil tanker	89	334,077	6,431
refrigerated bulk	14	61,827	2,043
roro	12	286,830	3,086
vehicle	223	469,293	18,619
yacht	50	77,370	5,807
miscellaneous-fishing	*Not calculated*	*Not calculated*	*Not calculated*
miscellaneous-other	*Not calculated*	*Not calculated*	*Not calculated*
naval ship	*Not calculated*	*Not calculated*	*Not calculated*
offshore	*Not calculated*	*Not calculated*	*Not calculated*
service-other	*Not calculated*	*Not calculated*	*Not calculated*
service-tug	*Not calculated*	*Not calculated*	*Not calculated*
Totals	**3103**	6,743,368	250,577

2.5 TOURIST VESSEL TRAFFIC

The project is based on a complete list of all known cruise ship and yacht voyages in British Columbian waters occurring in the baseline year 2017.

Each AIS report is associated with a discrete vessel record, and by extension the particulars for that vessel. Because all passenger vessels larger than small personal watercraft are required to carry an AIS transponder this report captures all significant yachts and cruise ship traffic in British Columbia. A small number of local vessel sailings, such as small recreational craft, may not be captured, however it is assumed that all voyages with a significant duration, distance, and resulting potential for the generation of greywater have been included.

The following figure shows the distribution of traffic around Vancouver Island in 2017. In this figure, darker coloured points represent AIS reports corresponding to greater estimated greywater generation.

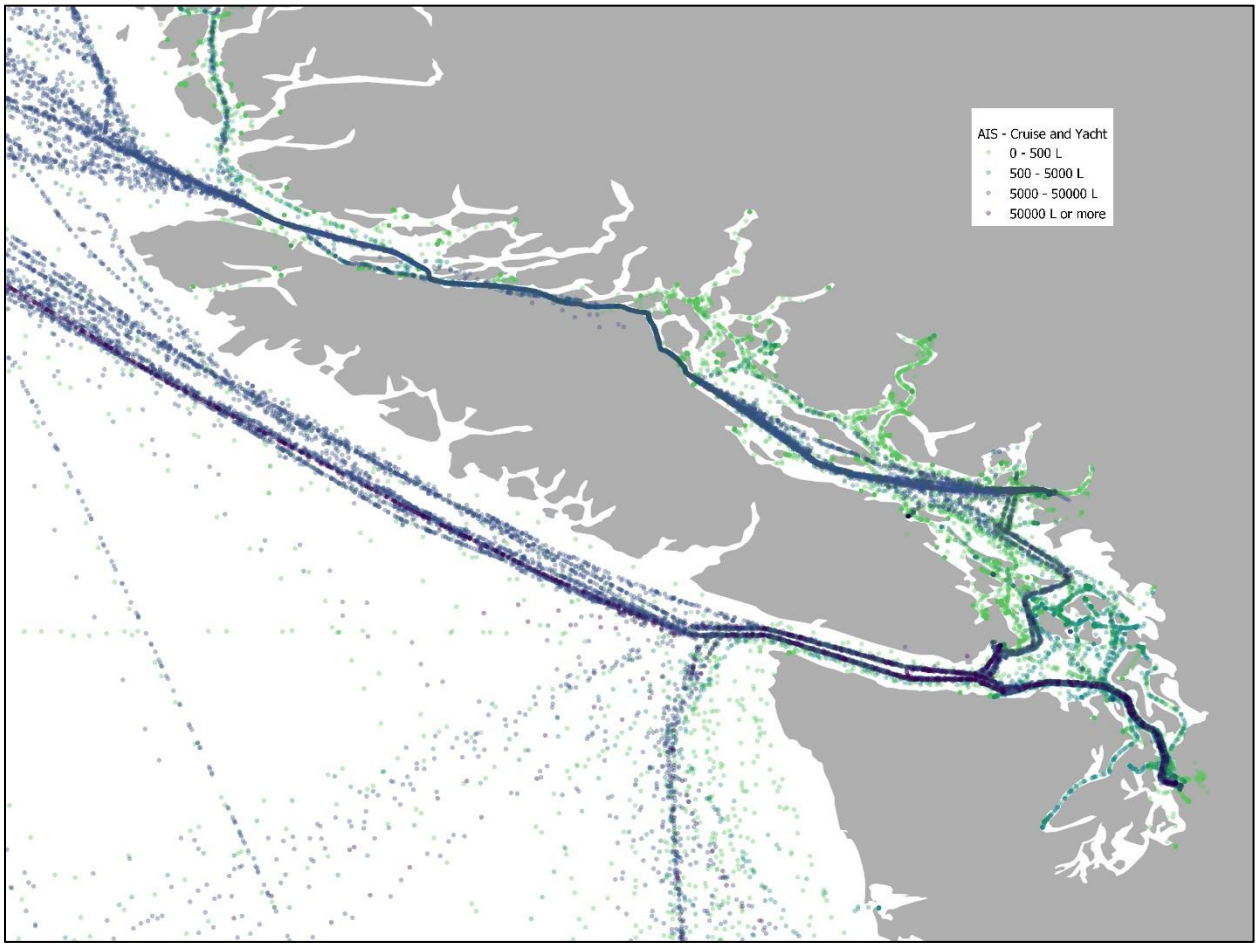

Figure 2: AIS data for yacht and cruise ship traffic around Vancouver Island, 2017

3 GREYWATER GENERATION

3.1 OVERVIEW

Greywater includes waste water from sinks baths, showers, laundry and galleys. It is important to recognize that greywater is not a MARPOL waste stream and is therefore only regulated by local regimes.

All the greywater data presented in this report is derived from a set of assumed metrics. It presents a useful overview of where greywater is likely being generated, however the following limitations should be noted:

- The generation rates are estimates based on a uniform generation rate throughout any given voyage made by a vessel. It is not possible to determine exactly how much is being generated where.
- Where greywater is discharged is unknown.
- Generation rates will vary across different types of vessels. For example, the overall level of passenger comfort on different cruise ships and the amenities available to passengers which require water will be different between a luxury cruise ship and more "expedition" oriented ship.

It is more difficult to determine how much greywater could have been discharged in this region. Generation rate estimates are averages for the relevant vessel type in more global operations. As a result, they may differ from the actual rates for vessels used in British Columbia. Many ports have zero discharge regulations, for example.

In general, this study may not be a basis for determining where and how much greywater ends up in the ocean. It is however a basis for evaluating risk and studying traffic patterns.

3.2 GREYWATER GENERATION RATE ESTIMATION

The waste generation metrics for greywater from the 2009 EPA study used in the Vard 2015 Study[1] have been used to develop the estimates in this report. These rates are:

- Cruise Ships: 253.6 L per day per person
- Cargo Vessels: 125.0 L per day per person

The cruise ship value is applied to all passenger vessels, and the cargo ship value was applied to all other vessel types. Per the previous study, no relation was found between the per person generation rate of greywater and the number of people on board.

The conditions found in British Columbia would not likely influence the greywater generation rate, as this amount is based on ship type and the number of persons on board. A better estimate of the actual generation rate based on ship type would improve accuracy. For example, fishing and smaller vessels may not have the laundry, shower and galley facilities that larger commercial ships have.

[1] VARD Marine Inc, "Projections for ship-generated waste travelling though the Canadian Arctic" 2015

3.3 DETAILED GREYWATER WASTE ESTIMATES

This section provides greywater estimates by applying the estimated generation rates described in Section 3.2 and the procedure detailed in Section 3.4 to the AIS data in the 2017 dataset.

Note that this represents the total amount of grey water likely to have been generated inside the area of interest only.

An estimated 1.54 Billion L of greywater may have been generated near the BC coast in 2017. The following table provides a summary of the quantities of greywater generated by each vessel type. Note that while cruise ships produce the most greywater the contribution from other vessel types is non-trivial due to the volume of ships.

Table 3: Greywater generated in the Waters of British Columbia, 2017

Vessel Type	Individual Vessels	Greywater (L)
bulk carrier	1805	107,028,854
chemical tanker	135	6,635,312
container	429	20,590,625
cruise	48	1,368,494,970
ferry-pax only	15	*Not calculated*
ferry-ro-pax	73	*Not calculated*
general cargo	191	12,145,937
liquefied gas tanker	19	478,021
oil tanker	89	5,540,000
refrigerated bulk	14	1,027,578
roro	12	7,983,125
vehicle	223	9,264,687
yacht	50	5,393,110
miscellaneous-fishing	*Not calculated*	*Not calculated*
miscellaneous-other	*Not calculated*	*Not calculated*
naval ship	*Not calculated*	*Not calculated*
offshore	*Not calculated*	*Not calculated*
service-other	*Not calculated*	*Not calculated*
service-tug	*Not calculated*	*Not calculated*
Totals	**3103**	**1,544,582,221**

3.4 GREYWATER HEATMAPS

In this type of heatmap the greywater generation values represent the total amount of greywater likely generated during the vessel's time in the area of interest, distributed within cells of a grid onto which the vessel's AIS records have been mapped. The total amount of greywater generated within each cell is calculated as follows:

1. The quantity of greywater generated at each AIS report is pre-calculated based on the estimated generation rate from Section 3.2 as follows:

   Total greywater (L) = POB * Gen. rate for 1 POB (L/day) * Time since last AIS update (h) / 24

2. The AIS data is plotted as Longitude/Latitude X/Y point data in GIS.
3. A grid is created in GIS at the desired resolution.
4. A calculation routine in GIS counts the number of AIS data points in each grid cell and weights each AIS data point based on the quantity of greywater estimated per (1).
5. The results of the calculations in (4) are saved to the attribute table of grid, and then used to assign colours to the legend for that map layer.

Figure 3 below shows the AIS data overlaid with the generated heatmap cell grid.

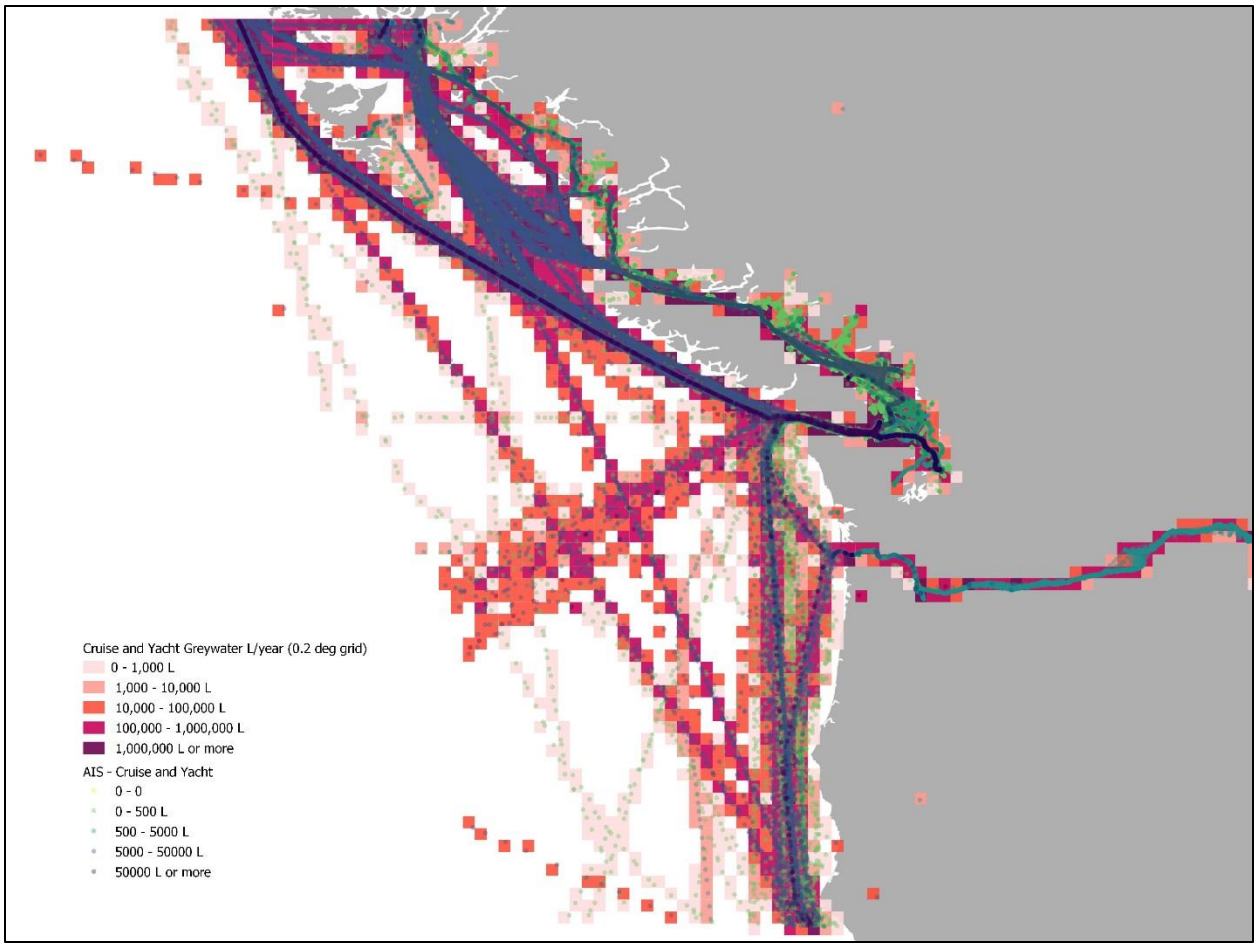

Figure 3: AIS data for yacht and cruise ship voyages overlaid with heatmap grid cells

The following figure shows all cruise ship and yacht traffic around Vancouver Island with a 3 nautical mile limit from shore overlaid on the map. As noted throughout this report this analysis does not suggest that vessels are necessarily discharging grey water inside this limit. It does however show that a large portion of passenger vessel traffic is present within the 3nm limit.

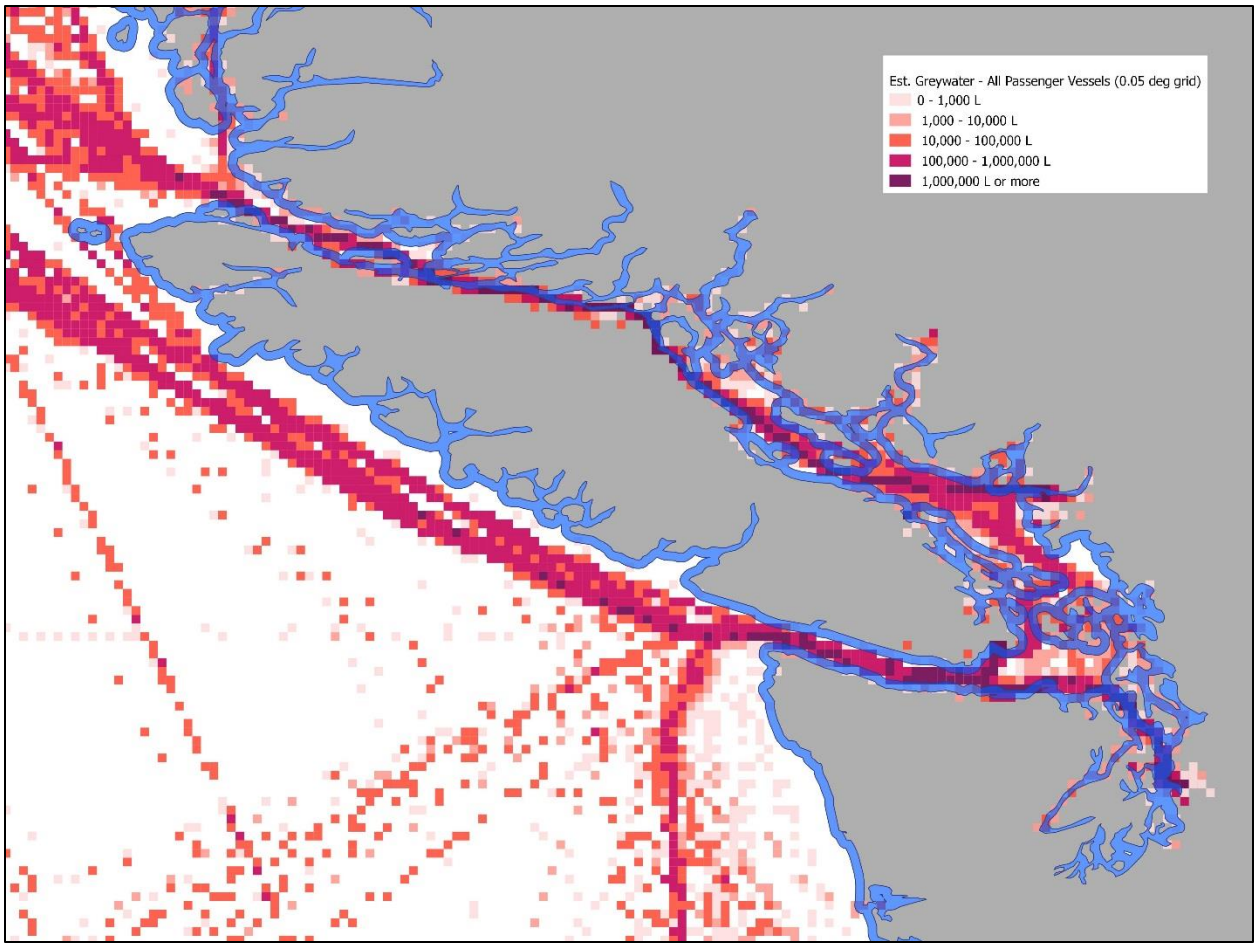

Figure 4: AIS data for yacht and cruise ship voyages overlaid with heatmap grid cells

The following sections show the distribution of greywater generation in British Columbia for cruise ships and yachts. More intensely coloured regions represent larger quantities of total waste generated within the bounds of the region.

3.4.1 YACHT (NON-CRUISE SHIP) TRAFFIC

In this study, yachts are categorized based on the ICCT dataset pre-processing. As a general assumption, yachts are almost all privately owned vessels (e.g. those on board would typically not have bought a ticket to sail).

There are 50 unique vessels classified as yachts in the 2017 dataset. These vessels are mostly 40m to 60m in length, with only 4 of which have more than 40 persons on board.

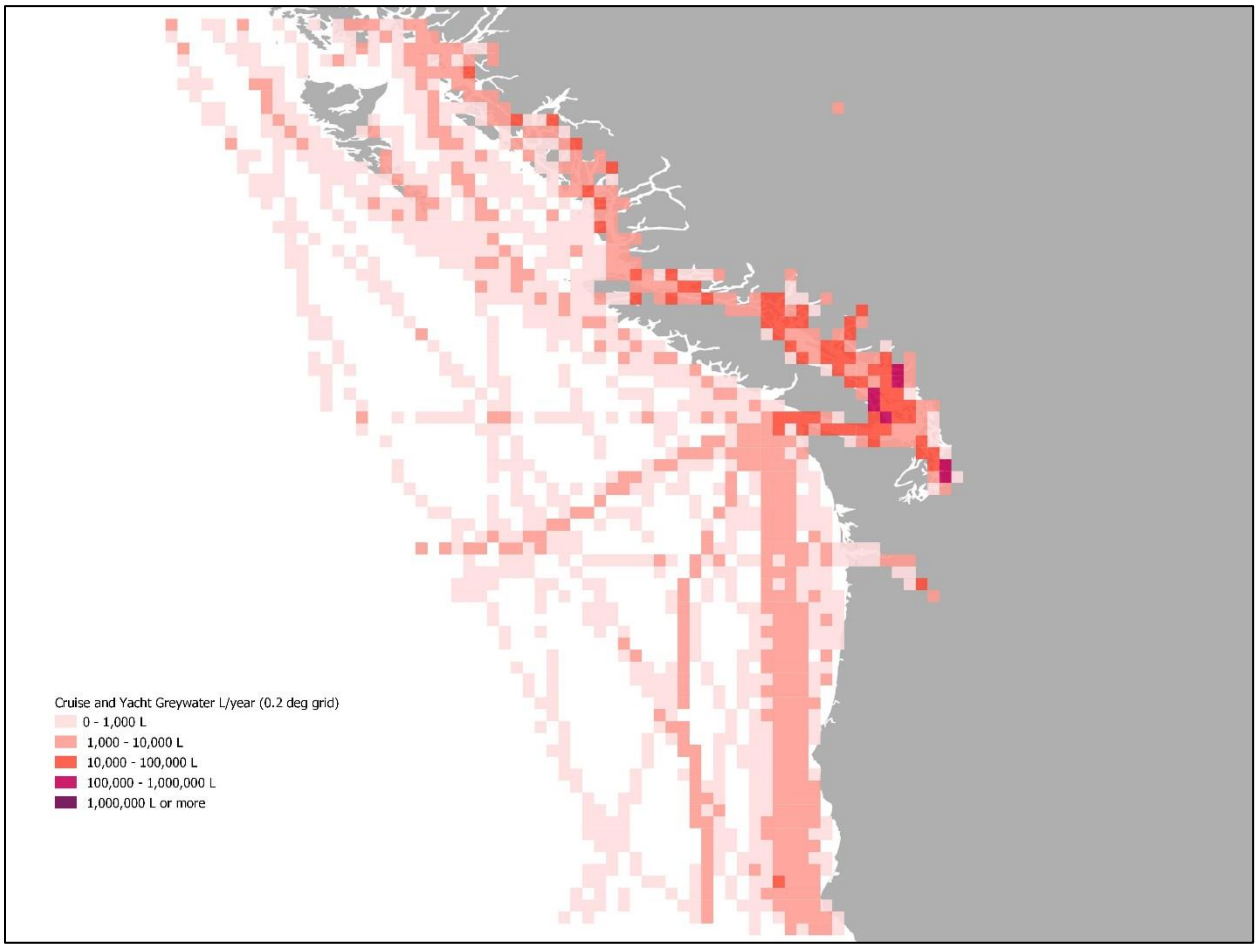

Figure 5: Heatmap of estimated greywater generation for yacht traffic off the coast of British Columbia, 2017. Map resolution of 0.2 degrees per grid square, showing and overview of the entire coast.

Figure 6: Heatmap of estimated greywater generation for yacht traffic off the coast of British Columbia, 2017. Map resolution of 0.1 degrees per grid square, showing and overview of the entire coast.

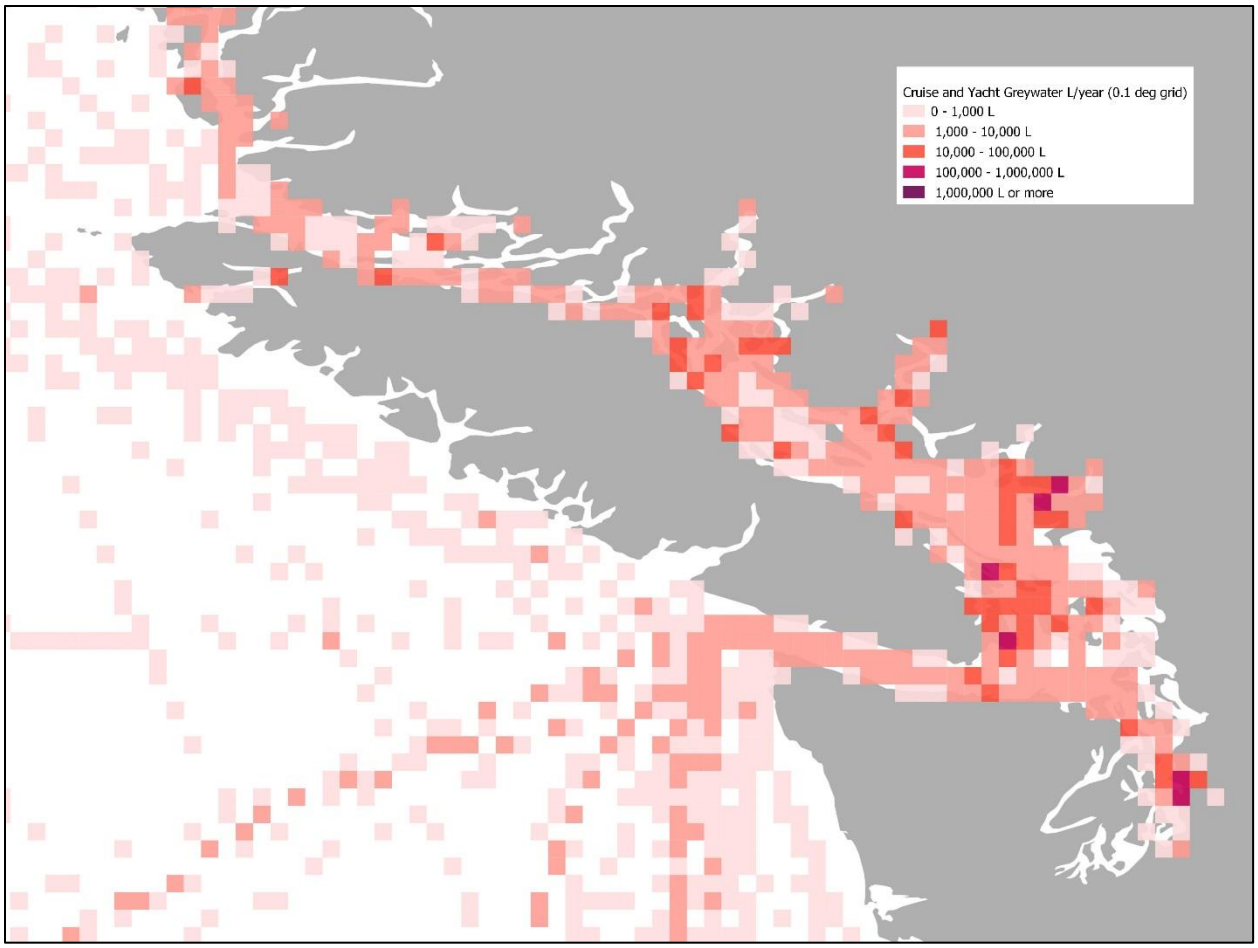

Figure 7: Heatmap of estimated greywater generation for yacht traffic off the coast of British Columbia, 2017. Map resolution of 0.1 degrees per grid square, showing the area around Vancouver Island.

3.4.2 CRUISE SHIP TRAFFIC

In this study, cruise ships are categorized based on the ICCT dataset pre-processing. There are 48 unique vessels classified as cruise ships in the 2017 dataset. These vessels vary in length from small expedition vessels to 5000 POB large cruise ships, with 29 having more than 1000 persons on board.

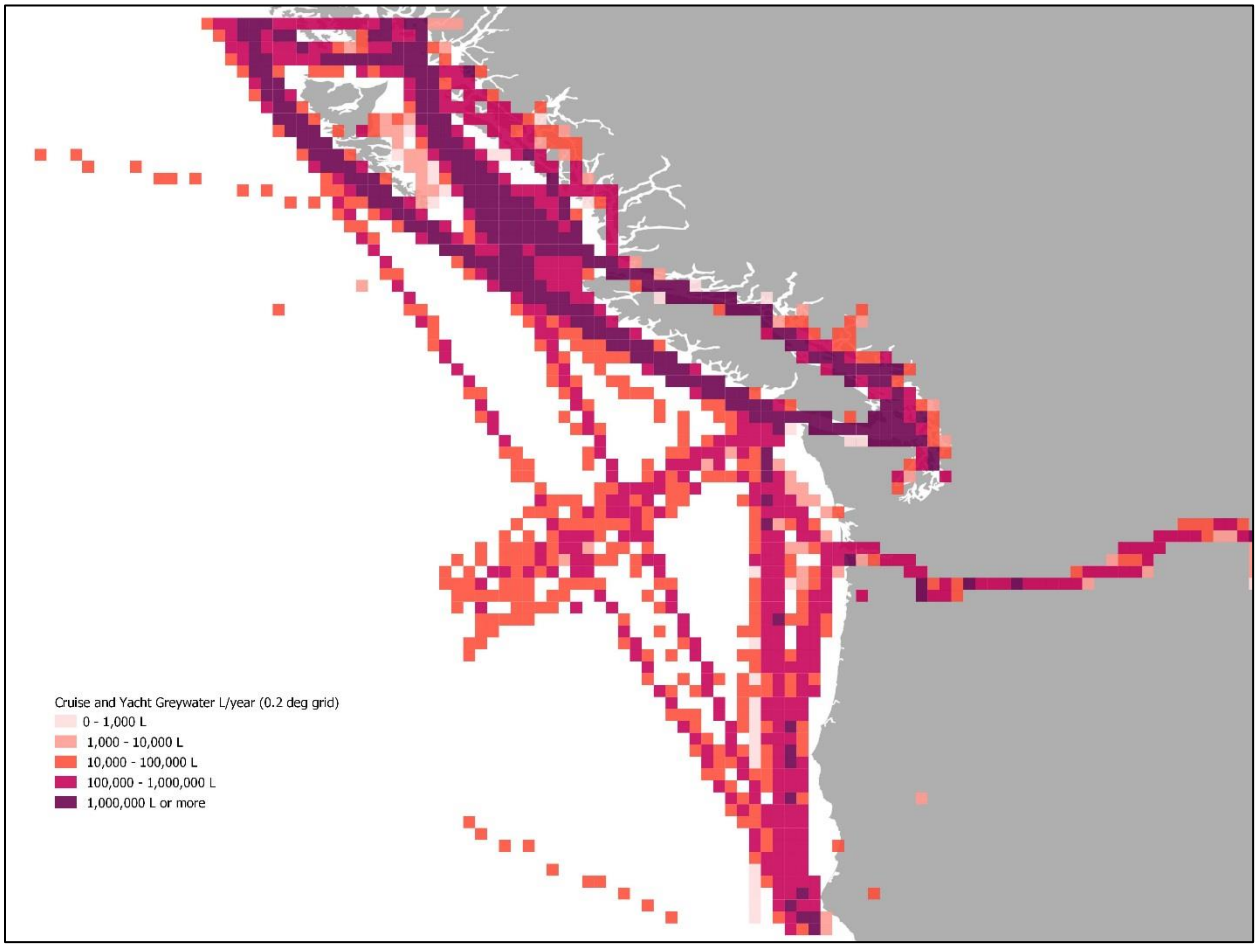

Figure 8: Heatmap of estimated greywater generation for cruise ship traffic off the coast of British Columbia, 2017. Map resolution of 0.2 degrees per grid square, showing and overview of the entire coast.

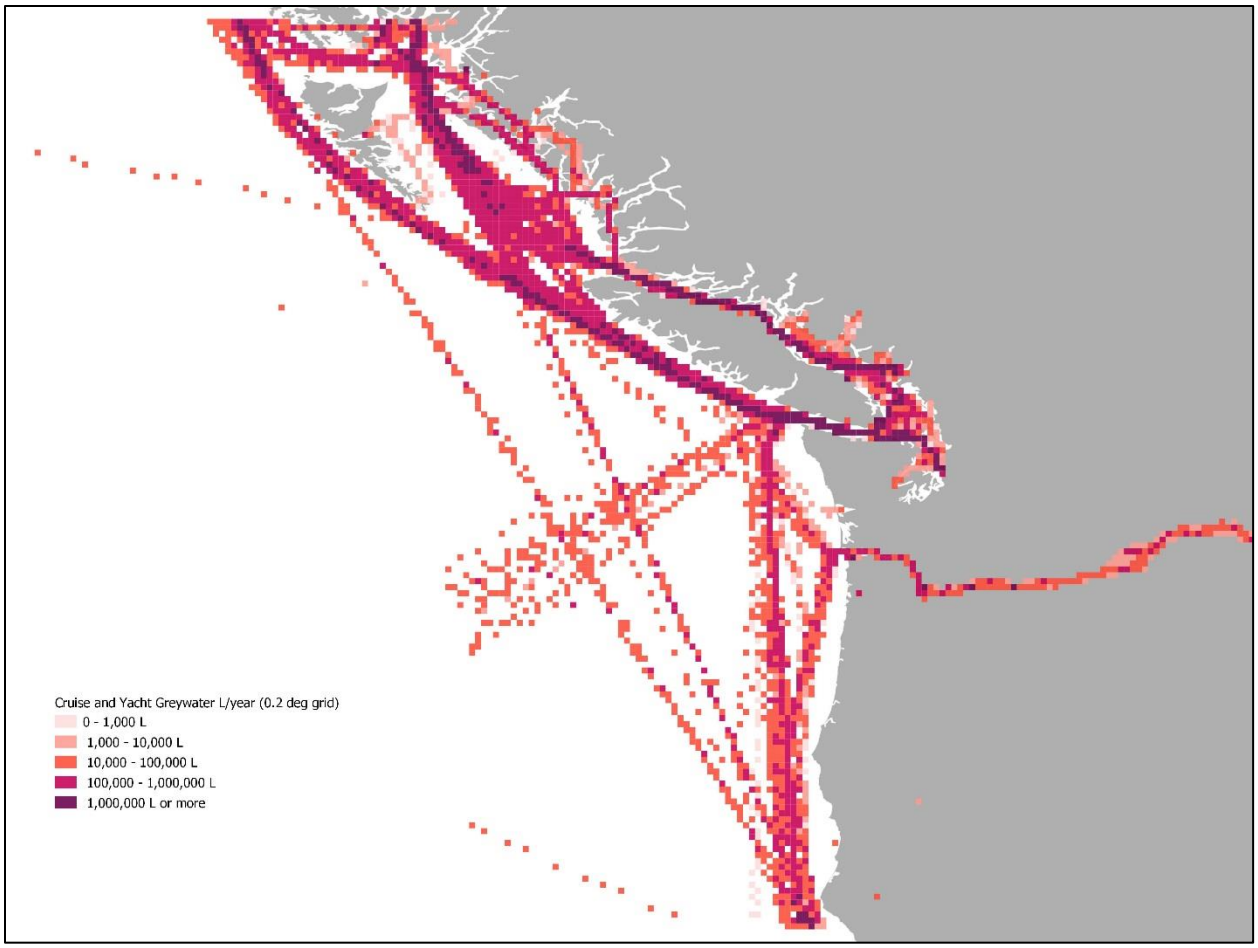

Figure 9: Heatmap of estimated greywater generation for cruise ship traffic off the coast of British Columbia, 2017. Map resolution of 0.1 degrees per grid square, showing and overview of the entire coast.

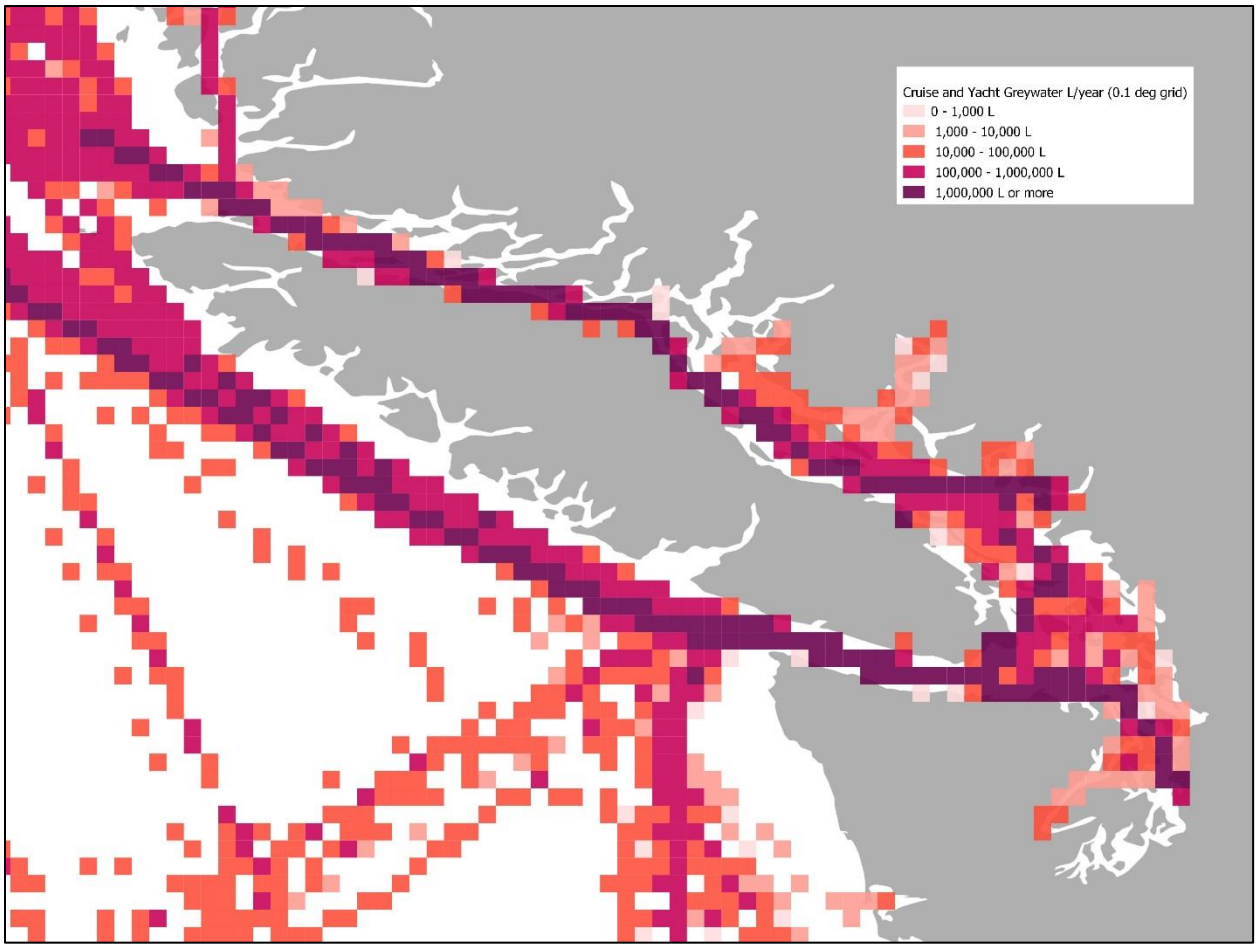

Figure 10: Heatmap of estimated greywater generation for cruise ship traffic off the coast of British Columbia, 2017. Map resolution of 0.1 degrees per grid square, showing the area around Vancouver Island.

3.4.3 ALL TOURISM TRAFFIC COMBINED

The heatmaps for combined yacht and cruise ship traffic are shown in the following figures.

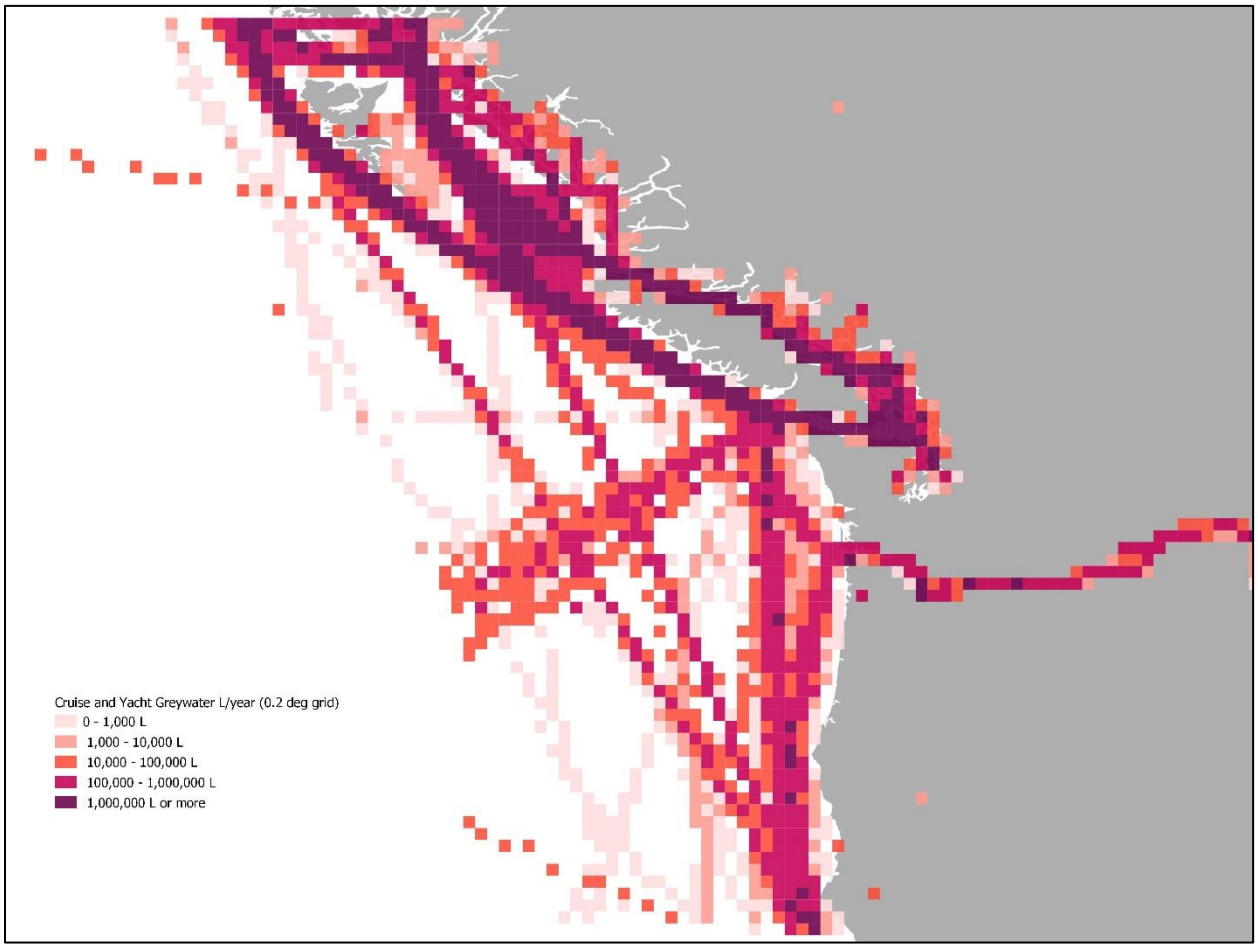

Figure 11: Heatmap of estimated greywater generation for combined yacht and cruise ship traffic off the coast of British Columbia, 2017. Map resolution of 0.2 degrees per grid square, showing an overview of the entire coast.

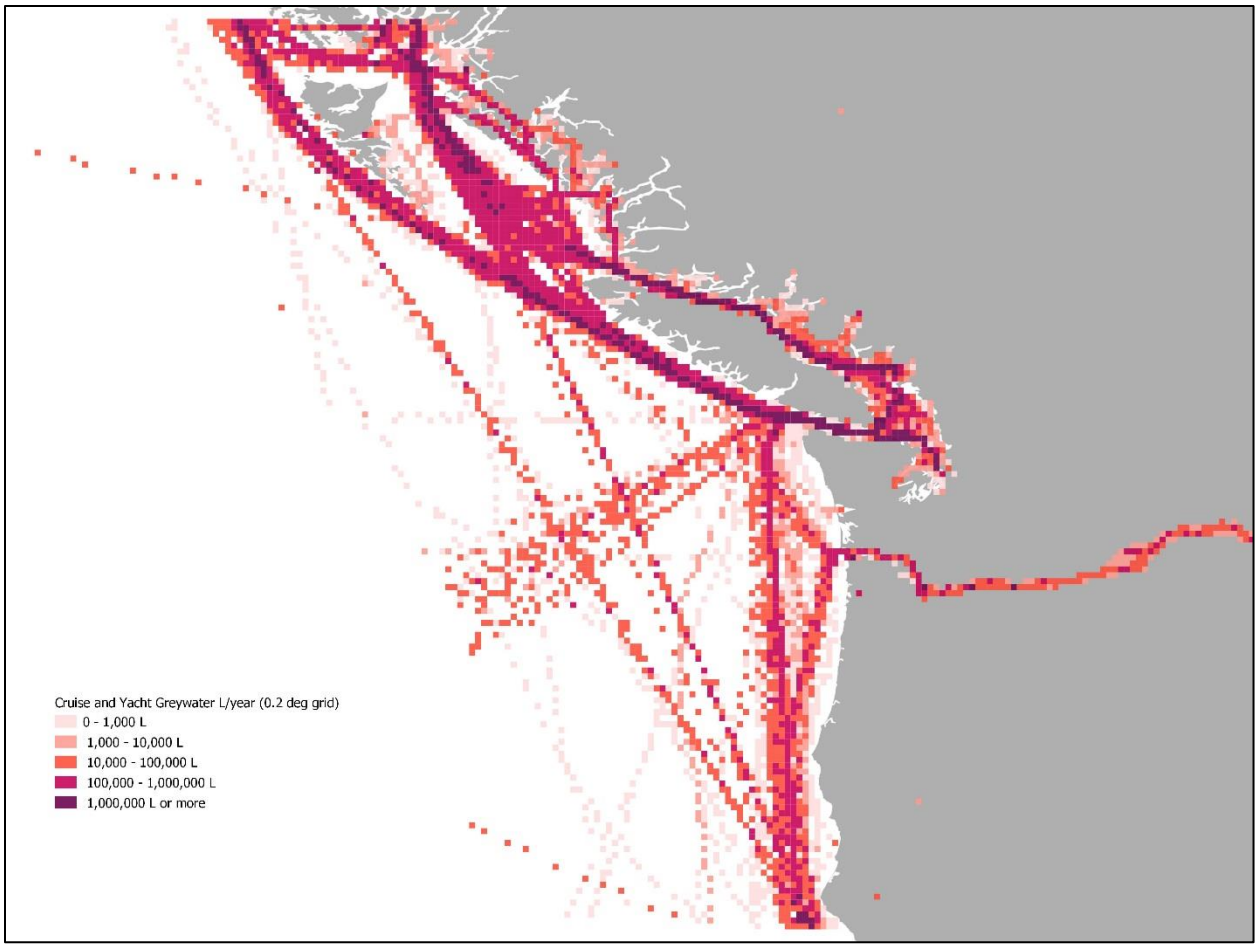

Figure 12: Heatmap of estimated greywater generation for combined yacht and cruise ship traffic off the coast of British Columbia, 2017. Map resolution of 0.1 degrees per grid square, showing an overview of the entire coast.

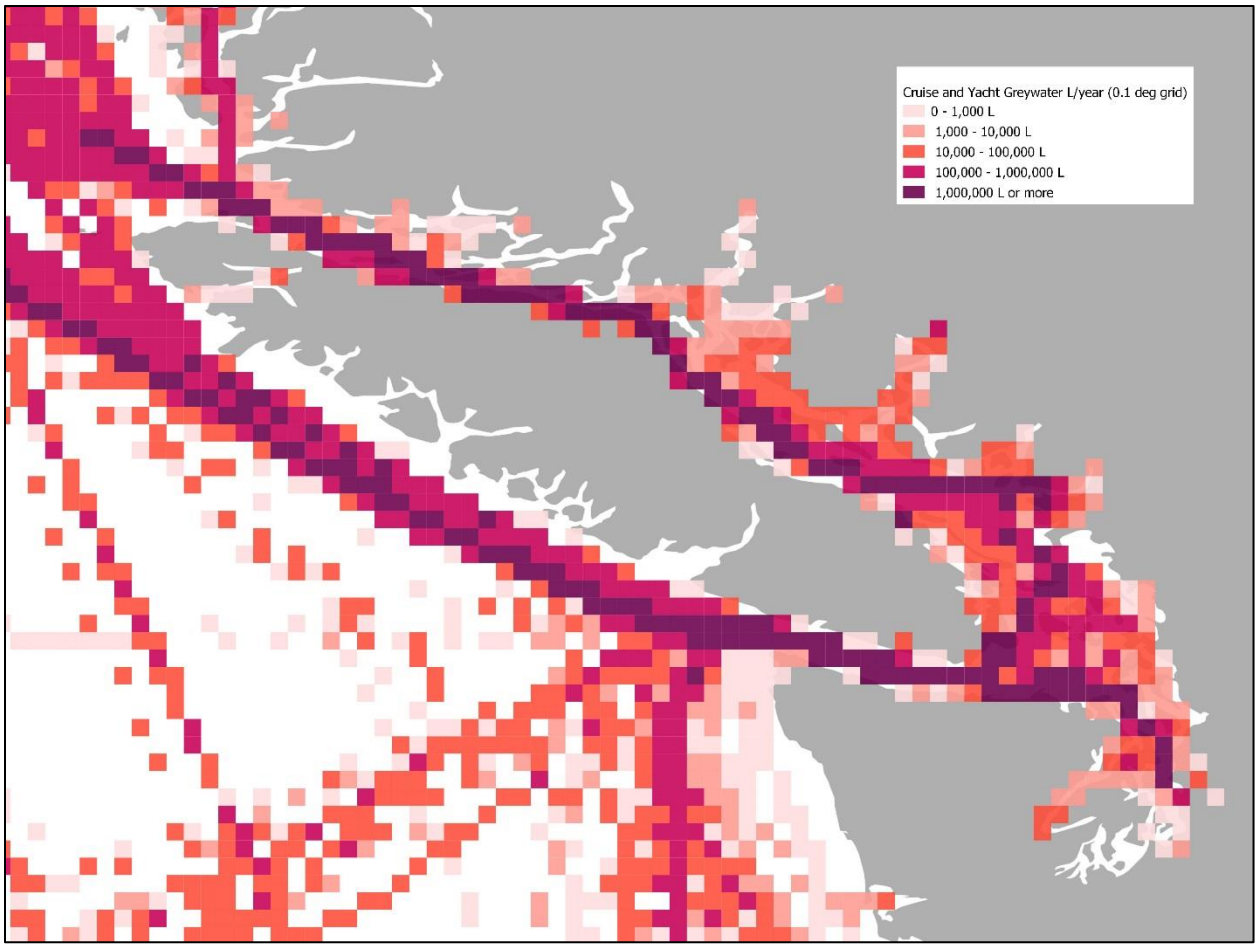

Figure 13: Heatmap of estimated greywater generation for combined yacht and cruise ship traffic off the coast of British Columbia, 2017. Map resolution of 0.1 degrees per grid square, showing the area around Vancouver Island.

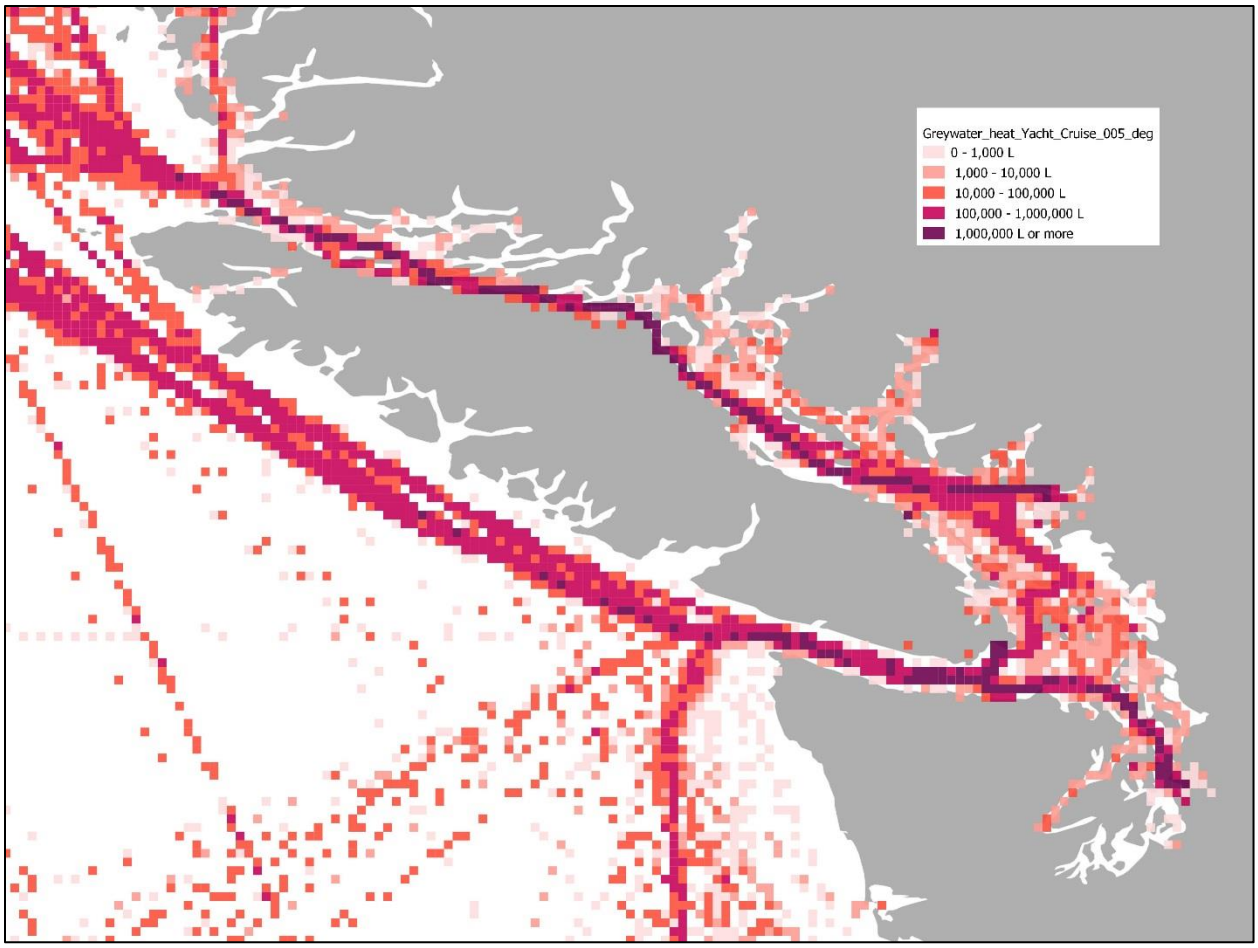

Figure 14: Heatmap of estimated greywater generation for combined yacht and cruise ship traffic off the coast of British Columbia, 2017. Map resolution of 0.05 degrees per grid square, showing the area around Vancouver Island.

3.5 VALIDATION OF WASTE ESTIMATING PROCEDURES

In the previous 2015 Vard study the validation task consisted of a literature review of published research into waste generation on ships, and a comparison of any available metrics or empirical data found to the values generated by the estimating procedures used in the project.

Informal discussions were held with various industry contacts in the commercial shipping and tourism sectors as part of the previous study. These contacts were unable to provide additional insight into generation rates as they are not an aspect of operations which is closely tracked.

Vessels are designed with marine systems capacities which meet all the requirements (class society notations, MARPOL, etc.) for their crew and passenger loads. The ship owners are concerned with regulatory compliance and will discharge waste in a compliant manner as and when required - the specific waste generation rates which feed into the ship's marine systems are essentially irrelevant to their day-to-day operations.

Much of the information found during the previous 2015 Vard study's validation task is from the 2009 EPA study referenced in this report. The following sections provide additional references which were also used by the previous 2015 Vard study for validation.

3.5.1 HELCOM 2014 – BALTIC SEA SEWAGE PORT RECEPTION FACILITIES

The HELCOM Overview 2014 Baltic Sea Sewage Port Reception Facilities report provides information on the status of sewage port reception facilities (PRFs) and their use in the Baltic Sea area in 2014, with a focus on international cruise traffic.

The report incorporates estimates for sewage (defined as black water and grey water only for this report) which are comparable to the generation rate for cargo ships from the Vessel Literature Review used by this project. The generation rates for cruise ships are considerably lower than those suggested by the sources in the Vessel Literature Review, primarily due to the relatively shorter average cruise durations for the Baltic Sea.

Table 4: Comparison of HELCOM Overview Generation Rates to Project Estimated Rates

Rate Type	Volume	Units	Volume	Units
Overnight ferries between Helsinki and Stockholm in the Baltic Sea	0.1	m^3/person/day	100	L/person/day
Average from HELCOM-CLIA survey	0.17	m^3/person/day	170	L/person/day
Port of Copenhagen maximum	0.13	m^3/person/day	130	L/person/day
Project cruise ship generation rate (black water and grey water)	-	-	**285.4**	**L/person/day**
Project cargo ship generation rate (black water and grey water)	-	-	**156.8**	**L/person/day**

The report addresses the large variation in sewage generation amounts as follows:

"Due to the large variation of such sewage production estimations this report does not include ready calculated figures of discharge needs in m^3/hour. Instead, the estimations are presented as a value which gives the reader estimated total discharge need in volume per time unit, if multiplied with a sewage generation estimation of choice such as those listed above."

The report also provides detailed outflow estimates in m^3/hour for 33 European ports based on survey responses.

3.5.2 ESTIMATED NUTRIENT LOAD FROM WASTE WATERS ORIGINATING FROM SHIPS IN THE BALTIC SEA AREA (VTT 2007)

The 2007 VTT report *Estimated Nutrient Load From Waste Waters Originating From Ships In The Baltic Sea Area* is referenced by the report in **Table 4** above, and provides some additional estimations for sewage and grey water generation rates.

The purpose of this study was to estimate the nutrient load from waste waters originating from ships in the Baltic Sea area. The study also includes information about regional maritime traffic, waste water management, and legislation. The nutrient load originating from pleasure craft was not included in the study.

The study includes estimates of the amount of waste water generated in L/person as a function of the voyage time in hours. It also gives various estimates of sewage and grey water generation rates from different sources, though these are apparently dependent on the type of sewage system on board. The wastewater generation values provided by the report suggest that generation rates increase as voyage durations increase due to the requirement for additional passenger services. The peak rates were estimated to be in excess of 100L/person/day for longer voyages with basic amenities, which is relatively consistent with this project's estimate of 125L/person/day.

4 DISCUSSION AND CONCLUSIONS

4.1 PROJECT OUTCOMES

This study meets the requirements of the original statement of work and should be a useful component of WWF-Canada's understanding of greywater in Canadian waters.

- The study provides a complete view of all vessel traffic in the area of interest for 2017 and provides estimates for greywater generation for each vessel in the dataset.
- The study provides a sound basis for presenting estimates of greywater generation and overall potential distribution of greywater in the area of interest.
- The study provides the underlying dataset and a variety of pre-created maps suitable for future studies, analysis, stakeholder engagement, and publishing.

The largest challenge associated with the study was managing the sheer number of AIS records included in the 2017 dataset. For example, there are over 1 million individual AIS records for bulk carriers. This has been addressed through the creation of a SQL database to hold the records, allowing the end user to export lists of desired vessel types using the pre-created queries, or to create new queries as needed for future work.

4.2 SENSITIVE REGIONS

The area of interest for this study includes a number of marine sensitive areas. In some cases there may be multiple areas (with different official designations and different types of sensitivities) close to vessel traffic. Guidance to vessel operators sailing in or near these regions will need to be developed with care to ensure that it is unambiguous and possible to practically implement. **Figure 15** below shows an example of multiple marine sensitive areas overlaid with AIS traffic.

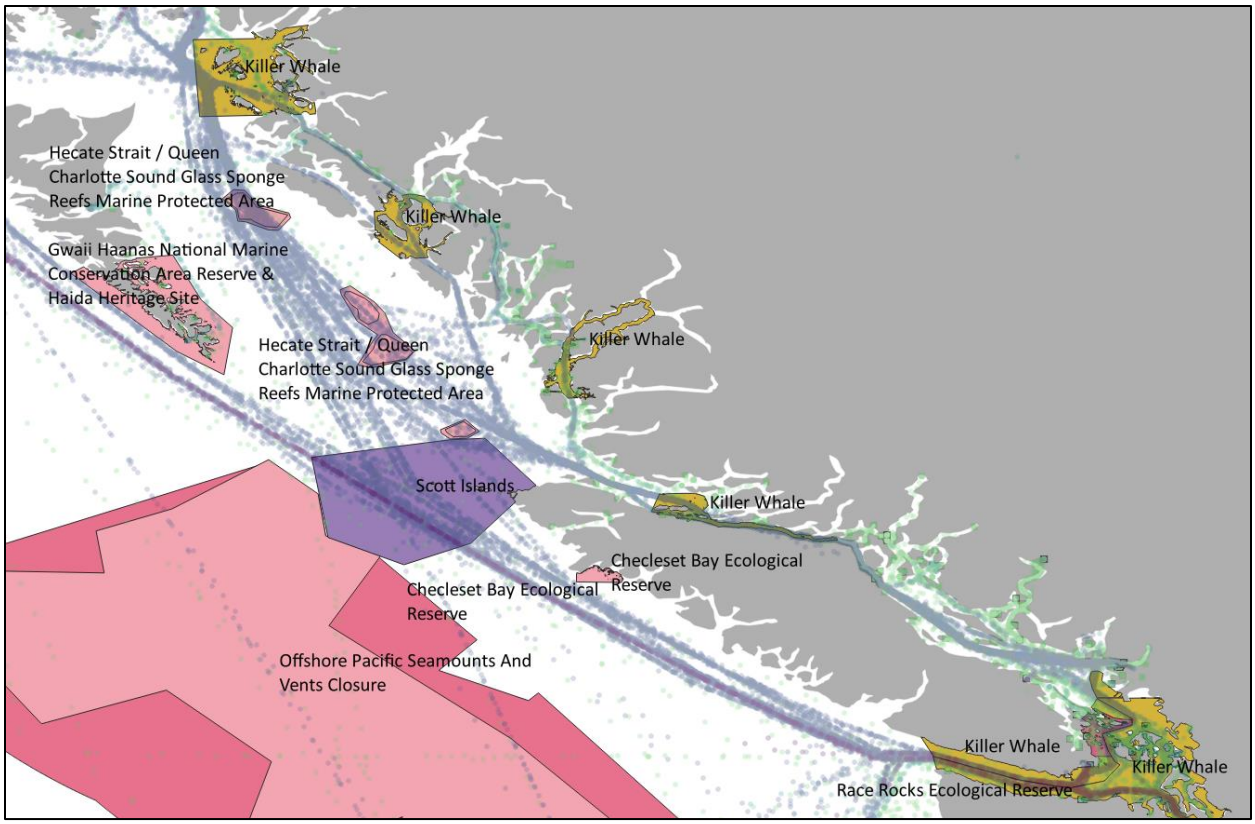

Figure 15: Marine sensitive areas and AIS traffic

4.3 GAPS IN SCIENCE AND MONITORING

Greywater treatment is relatively well understood in terms of both how to treat greywater and how much will be produced under any given circumstances. Where greywater is actually discharged is virtually impossible to quantify, however most inland waterways and marinas in BC ban all discharges. New large passenger vessels must treat grey water prior to discharging it within 3 nm of the coast or release it outside of 3 nm.

The most significant gaps to consider in the short term are:

- More information is needed on whether efforts are being made to reduce the use of chemical inputs which are potentially incompatible with biological treatment plants.
- More information is needed on how vessel operators for larger passenger vessels are handling greywater. Larger vessels are unlikely to have sufficient carrying capacity to not treat and discharge greywater, so what systems are being used and what standards the operators are working to should be explored.
- More information is needed on how Canada plans to monitor and enforce greywater discharge regulations.

4.4 RECOMMENDATIONS

This report's recommendation is that inquiries should be made to a variety of vessel operators to determine how they are treating and discharging greywater:

- What kind of treatment plants do they use
- How much greywater can they carry
- Where do they discharge
- If (and how) they are monitoring discharged greywater to determine the effectiveness of their treatment system.
- If they regularly sample their greywater to test the performance of their treatment plant regardless of discharging.

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