Small vessel marine sanitation device technology review

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Small Vessel Marine Sanitation Device Technology Review

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Final Report

Prepared for Transport Canada

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EXECUTIVE SUMMARY

Transport Canada (TC) has contracted the National Research Council Canada (NRC) to assess and develop marine sanitation device (MSD) technologies for use onboard small vessels (under 400 gross tonnes with a particular focus on fishing vessels of 15-150 gross tonnes). Accordingly, NRC has developed a research protocol to address this issue. The project will ultimately involve laboratory-scale experiments and full-scale field trials; however, the portion of the study described in this document is a desktop review of existing MSD manufacturers and products. The purpose of this review is to update the existing inventory commissioned by TC in 2014 and determine which MSD units are best suited for use onboard small vessels.

Based on the results of the technology review, two or three units will be selected for purchase and will be evaluated in a laboratory setting. While this component of the study is focused on ship-based solutions, future phases may be expanded to include an assessment of shore-based technologies. The desktop review process and its results are outlined in the current technical report.

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LIST OF ACRONYMS AND SYMBOLS

CAD	Canadian dollars
EME	Energy, Mining, and Environment (NRC Portfolio)
IMO	International Maritime Organization
kg	Kilograms
KM	Knowledge Management (NRC Shared Service)
m^3	Cubic metres
OCRE	Ocean, Coastal, and River Engineering (NRC Portfolio)
LPD	Litres per day
MARPOL	International Convention for the Prevention of Pollution from Ships
MSD	Marine sanitation device
MV	Marine Vehicles (NRC Program)
NL	Newfoundland and Labrador
NRC	National Research Council Canada
SOW	Statement of work
TC	Transport Canada
USCG	United States Coast Guard
USD	United States Dollars

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1 INTRODUCTION

The International Maritime Organization (IMO) is responsible for "the safety and security of shipping and the prevention of marine pollution by ships" (IMO, 2014). Pollution discharged from ships is regulated by the IMO - International Convention for the Prevention of Pollution from Ships (MARPOL). This includes emissions such as oil and noxious liquid substances, air pollutants, garbage, and sewage. Annex IV of MARPOL highlights the discharge of raw sewage from ships into the sea as posing a hazardous threat to human health (1973, as amended). While MARPOL represents a very important regulatory framework, the fact that it is designed to set global standards means its scope is inherently broad. This can pose significant challenges for operators since vessels can vary greatly by factors such as operating location, intended use, and size. As such, it is sometimes necessary to refine existing standards or develop new technologies so that unique operational constraints can be addressed and mitigated.

Small vessel operators often face challenges when trying to satisfy the sewage emission requirements of MARPOL. This is due, in part, to the limited space available for existing marine sanitation device (MSD) systems that were designed primarily for much larger ships capable of accommodating big holding tanks and processing equipment. Another sewage management issue encountered by smaller vessels, and particularly those operating in Canadian waters, is related to the fact that they often operate out of ports that are not equipped with treatment facilities. Moreover, in areas where some sort of treatment facility is available, its capacity is typically limited to collection and minimal (if any) treatment, followed by discharge into the ocean.

A recent TC search through the Canadian Vessel Registry for fishing vessels indicated there are roughly 23,000 fishing vessels in the Small and Large Vessel Registries. This represents a significant number of operators who could benefit from the development of MSD systems for small vessels. Recognizing this market potential, TC commissioned a study that inventoried smaller marine sanitation devices that were market ready. Only three units were identified as being small and relatively inexpensive. The study did not include an assessment of the possibility of those units being integrated into a fishing vessel or other small vessels. In other words, the need and demand for small vessel MSDs has been communicated by the industry and recognized by TC; however, there is a research gap preventing the development of appropriate and affordable fit-for-purpose technologies. Therefore, the scope of existing research must be expanded to include such an assessment so that practical research-based solutions can be developed for Canadian operators.

To achieve this end, TC has contracted the National Research Council Canada (NRC) to assess and develop MSD technologies specifically for use onboard small vessels (under 400 gross tonnes with a particular focus on fishing vessels of 15-150 gross tonnes). Accordingly, NRC has developed a research protocol to address this issue. The project will ultimately involve laboratory-scale experiments and full-scale field trials; however, the portion of the study described here is a desktop review of existing MSD manufacturers and products. The purpose of this review is to update the existing inventory commissioned by TC in 2014 and to determine which MSD units are best suited for use onboard small vessels.

Based on the results of the technology review, two or three units will be selected for purchase and will be evaluated in a laboratory setting. While this component of the study is focused on

ship-based solutions, future phases may be expanded to include an assessment of shore-based technologies. The desktop review process and its results are outlined in the current technical report.

2 METHODOLOGY

The primary design and execution of the research protocol employed throughout this technology review is provided by NRC-Knowledge Management (KM). KM is a shared service of NRC and provides support to the various NRC Portfolios across the country. Its services include holding and maintaining large databases, filtering and analyzing large datasets, and gathering competitive market intelligence. As such, KM is aptly suited to conduct a thorough and efficient review of exiting MSD technology.

2.1 Objective

The search is designed to compile a list of MSD manufacturers and products for small vessels under 400 gross tonnes (with a particular focus on fishing vessels of 15-150 gross tonnes).

2.2 Scope

The scope of the search is global; however, priority is given to Canadian MSD manufacturers, followed by American companies, and then other countries. This aligns with the SOW since a desired outcome of this study is the development and production of a Canadian product for use in Canadian waters.

2.3 Search Parameters

Given the study's particular focus on Canadian fishing vessels, their expected occupant complements were taken into account when establishing the operational requirements of the MSDs. Typically, these vessels will have between two and seven people onboard depending on the location and type of work being done (i.e. type and size of marine life being harvested). This also aligns with the protocol described in the TC report (2014) to which this technology review is serving to update. While some MSDs are rated for capacity based on the number of people, others are presented by volume per day. Assuming a full complement of seven people, and allowing for additional contingency, an upper limit for MSD capacity is set at approximately 200 litres per day (LPD).

When available, other considerations include:

- Design – e.g. modular versus one all-inclusive unit
- Logistics – e.g. availability, delivery time to Canada, etc.
- Product Certifications – e.g. IMO, United States Coast Guard, etc.
- Treatment Method – chemical, electrochemical, biological, other
- Dimensions and Weight – e.g. space requirements, etc.
- Electrical Requirement – e.g. 110 volt, gravity flow, etc.

Purchase price is also used as a secondary selection factor when trying to refine the number of viable MSD options. This is not due to any financial constraints placed on the project, but rather because of the anticipated concerns of the operators who will ultimately use the MSDs. It is hoped the technology will be more accessible to smaller scale fishing operators and pleasure

craft owners by trying to keep the price per unit below $10,000 Canadian dollars (CAD). This will also reduce the financial burden that may be experienced during purchase and installation of MSDs, as well as increase compliance with the regulations.

These parameters will dictate which units will be considered for inclusion in the laboratory-scale testing phase of this project. As is explained in sections 3 and 4 of this document, similar selection criteria were applied and used to determine which MSDs would indeed be purchased and tested in the laboratory.

2.4 Sources

The search will be conducted online and included the following resources:

- The United States Coast Guard Maritime Information Exchange – Approved Equipment Listing
- Individual company websites (manufacturers, distributors, etc.)
- General internet searches
- Discussions with sales and product representatives (via email and phone)

3 RESULTS

The MSD technology review yielded several manufacturers and products that were considered for possible inclusion in the subsequent phases of this project. Specifically, the search highlighted two Canadian companies with previous or ongoing MSD sales and distribution (Table 1), 11 American MSD manufacturers (Table 2), and a total of 31 products with individual model numbers. Appendix A (Table 3 and Table 4) lists all of the relevant product information associated with the MSD units that are manufactured by the companies included in Table 2 and that satisfy the parameters of this study. Based on this information, three MSD units have been selected for laboratory-scale testing in the next phase of this project; two are manufactured by AHEAD Sanitation Systems (models AT-6T and AT-10STP) and the third is made by Microphor (model M-8 Plastic).

Table 1: Information pertaining to Canadian small vessel MSD companies.

Name	City, Province	Website	Notes
Scanship Canada Inc.	Victoria, BC	http://www.scanship.no/	Canadian subsidiary of a larger Norwegian company.
Hydroxyl Systems Inc.	Victoria, BC	http://www.hydroxyl.com/	Website resolves to Headworks International. Hydroxyl went out of business sometime in 2011.

Table 2: Information pertaining to American small vessel MSD companies.

Name	City, State	Website	Notes
AHEAD Sanitation Systems	Broussard, Louisiana	http://www.aheadtank.com/	-
Environmental Marine	Bronson, Kentucky	http://envmar.com/	Ties to Skimoil
Galley Maid	Okeechobee, Florida	http://www.galleymaid.com/	-
H2O	Lafayette, Louisiana	http://www.watermaker.com/	-
Headhunter	Fort Lauderdale, Florida	http://www.headhunterinc.com/	-
Microphor	Willits, California	http://www.microphor.com/	Parent company: Wabtec
Raritan Engineering	Millville, New Jersey	http://www.raritaneng.com/	-
Redfox Environmental Services	Youngsville, Louisiana	http://www.redfoxenviro.com/	-
Seahorse Manufacturing	Lydia, Louisiana	http://seahorsemanufacturing.com/	-
Scienco/FAST	Sunset Hills, Missouri	http://www.sciencofast.com/	A division of Bio-Microbics, Inc.
Skimoil	Carrboro, North Carolina	http://www.skimoil.com/	Ties to Enviro Marine

The search found two additional American companies that only produce MSDs in sizes ranging above the ~200 LPD cutoff. Namely, these are ACT2 Technologies (Fort Lauderdale, Florida) and Groco/Gross Mechanical Laboratories (Stevensville, Maryland). It should also be noted that all of the companies listed in Table 2 have MSD product ranges with capacities well above 200 LPD. These units are typically installed on much larger vessels such as ferries, tankers, and cruise ships.

Given the number of American-made products available on the market, as well as the project's mandate to focus on North American companies, a similarly thorough search of other global manufacturers was not conducted since it would complicate the process of evaluating the more locally produced products. Also, there would likely be fewer logistical challenges associated with partnering with a Canadian or American company to produce MSDs for use onboard smaller vessels operating in Canadian waters compared to an international partner. However, after a broad preliminary search, it was noted that manufacturers exists in the following countries: Czech Republic (ACO Marine), Spain (Detegasa), Greece (Environmental Protection Engineering), Finland (Evac, Wärtsilä), Germany (Hamann, Ocean Clean, RWO), Denmark (Gertsen & Olufsen), Japan (Goko Seisakusho, Taiko Kikai Industries), Norway (Jets, Scanship), China (Jiangsu Nanji Machinery, Wuhan Centark Environmental Protection Equipment), Italy (Pollution Control Engineering, Selmar Technologies, Tecnicomar), and the United Kingdom (Victor Marine).

4 DISCUSSION

The companies and products highlighted by this technology review were evaluated to determine which would be best suited for installation onboard small fishing vessels and pleasure craft operating Canadian waters. Like the search parameters outlined above, this evaluation involved applying considerations of capacity, design, physical size, cost, and logistics, as well as more specific factors that are uniquely associated with small vessels operating in Canadian waters (e.g. available plumbing, space and weight limitations, etc.).

4.1 Planned Laboratory-Scale Testing Inclusions

Two models manufactured by AHEAD Sanitation Systems (AT-6T and AT-10STP; Figure 1) are planned for inclusion in the next phase of the project – laboratory-scale testing and evaluation. These MSDs have been selected for several reasons. First, they both feature a simple design in which three treatment chambers (i.e. aerobic processing, settling, and chlorination) are housed inside a semi-rectangular plastic box (Figure 1, left). Notably, the AT-10STP features the same three-chambered base unit with an added fourth component downstream to provide additional filtration after chemical treatment has taken place (hence the higher IMO MEPC.159(55) rating; Figure 1, right). Second, compared to units built by other companies, these units have low volumes and weights while at the same time providing a high capacity near the upper limit of ~200 LPD. Third, AHEAD offers the added convenience of being able to order two different models that each conform to the two different IMO standards (i.e. MEPC.2(VI) and MEPC.159(55)), rather than having to order the units from two separate manufacturers. They also offer quick order processing and shipping. Lastly, the price of these MSDs is below the $10,000 limit and lower than those of other products with similar capacities.

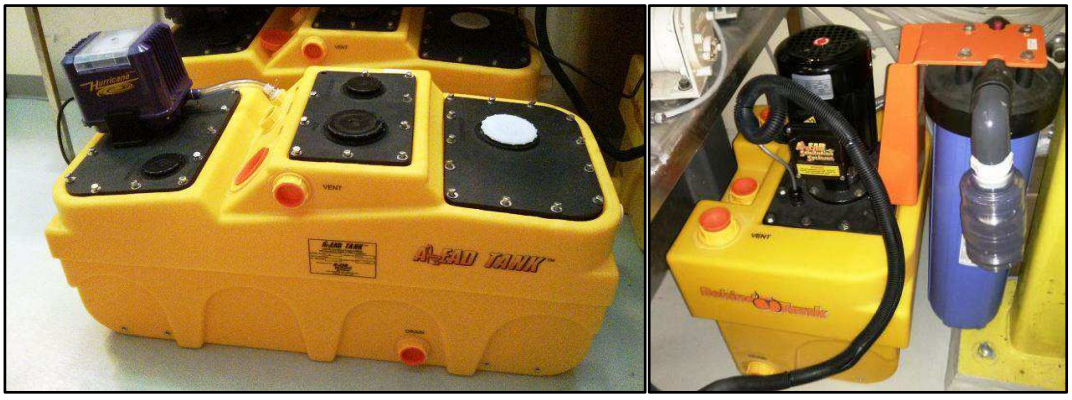

Figure 1: AHEAD Sanitation Systems MSD main treatment unit (AT-6T; left) and optional enhanced filtration component (AT-10STP; right).

Initially, the laboratory-scale tests were to be limited to these two AHEAD units. However, after speaking with representatives of the Professional Fish Harvesters Certification Board of Newfoundland and Labrador (PFHCB-NL) and the Fish, Food, and Allied Workers (FFAW) Union of NL, as well as conducting surveys onboard several fishing vessels and pleasure craft operating out of Petty Harbour, NL, St. John's, NL, and Manuels, NL, the research team realized that even smaller units may be most practical and preferred in some instances.

Due to spatial constraints both on and below deck, existing plumbing arrangements, and stability concerns related to large units and holding tanks, retrofitting exiting vessels may pose significant challenges in terms of time, cost, and the potential need for recertification. In light of this, the research team believes that it is prudent to design the project to assess the feasibility of two approaches to outfitting small vessels with MSDs: one for new builds and another for retrofitting existing vessels. It is intended that centralized AHEAD units adapted with NRC-developed bioelectrochemical sewage treatment technology will be appropriate for use onboard new vessels that have been designed accordingly (i.e. a naval architect has allocated the necessary deck space and plumbing in the plans). In terms of retrofits, it is intended that each existing toilet will be outfitted with its own MSD that has been modified to include the same NRC-developed technology and will make use of existing plumbing.

Consequently, it is suggested that the laboratory-scale testing and evaluation protocol be expanded to include a small MSD manufactured by Microphor (M-8 Plastic; however, Figure 2 shows the slightly larger M-10 Plastic unit, as a picture of the M-8 is not available). It is believed that this unit, or a modified version of it, will be small enough to fit within the space available under a standard toilet (typically around 0.6 x 0.7 x 0.3 meters). This particular MSD was selected because it is one of the smallest and lightest weight units available. It is hoped that this unit will keep total cost relatively low since installation would be simple, there would be no major plumbing modifications required, its low volume would be unlikely to trigger vessel recertification after installation, and it is modular (one-size-fits-all toilets). This also suggests that they will be relatively easy to produce, store, and service.

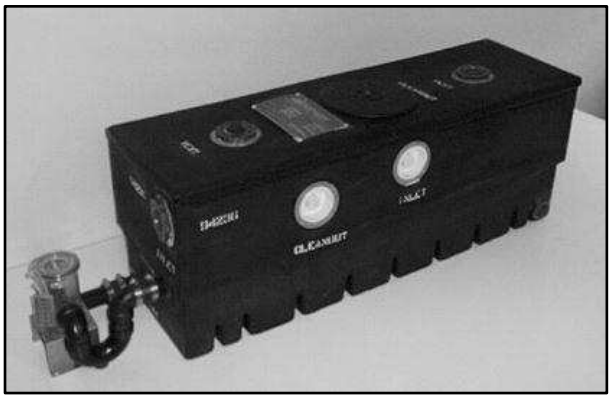

Figure 2: Microphor M-10 Plastic MSD.

4.2 Planned Laboratory-Scale Testing Exclusions

The MSDs manufactured by the remaining nine American companies, as well as the other models produced by AHEAD and Microphor, are recommended for exclusion from assessment throughout the remainder of the project. The justifications for this, on a per-company basis, are as follows:

- Scienco/FAST is the only other manufacturer offering units that meet both IMO standards; however, they are much more expensive than AHEAD (beyond the range considered). They are also much larger and very heavy. It is worth noting, however, that this company is the only one currently producing modular MSDs. Although the principle

remains the same and involves three separate processes (aerobic, settler, and chlorination chamber), each process takes place in a separate cylindrical vessel connected by piping (i.e. they are not all housed in the same larger plastic container). This is done to accommodate restricted areas during installation.

- The Environmental Marine/Skimoil MSDs are similar in design to AHEAD; however, they only produce one acceptable model that meets one IMO standard (MEPC.2(VI)). Also, its capacity is only half of that of the AHEAD units.
- The Headhunter and Galley Maid MSDs do not meet either of the IMO requirements. Also, the Galley Maid units have relatively low capacities, and the Headhunter units are very expensive (well beyond the range considered).
- The H2O unit is expensive, large, and heavy.
- Similarly, the Seahorse units are also expensive and heavy, and their SMSD models are significantly larger than all others considered. Also, their designs include a high-pressure pump and filter. The filter is made of a carbon-laced fabric and has to be replaced every two to three months. Lastly, the units do not currently meet IMO standards; however, the company claims that they can be modified to meet MEPC.159(55). It was also indicated that doing so would likely add $2000-$3000 extra to the purchase price.
- When contacted directly, Redfox indicated that their units are very large and would not be appropriate for use onboard small fishing vessels and pleasure craft. The lack of IMO certification and relatively high cost of their units were additional reasons to exclude these MSDs.
- Raritan uses a different technology (electrochemical) and design (no holding chambers for aerobic processing, settling, and chemical treatment) that could make it much more difficult, if not impossible, to modify using the NRC technology. Also, the huge capacities of these units would be excessive given the number of people typically onboard small fishing vessels and pleasure craft.

5 ACKNOWLEDGEMENTS

The funding required to conduct the Small Vessel Marine Sanitation Device Study (including the desktop technology review described in the current technical report) was provided by Transport Canada. On behalf of NRC, the authors would like to express their gratitude to TC for the opportunity to participate in this project. Also, the authors would like to thank their colleagues at NRC-EME, NRC-Construction, NRC-KM, and NRC-OCRE for their important contributions.

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7 APPENDICES

7.1 Appendix A – MSD Information

Table 3: Information on MSDs manufactured by AHEAD, Environmental Marine/Skimoil, Galley Maid, H2O, Headhunter, Seahorse Manufacturing, and Scienco/FAST.

Company	Model	Treatment Method	Capacity (LPD)	IMO Certification	USCG[3] Certification	Volume (m^3)	Dry Weight (kg)	Electrical Requirement	Price (USD)
AHEAD[1]	AT-6T	Biological[2]	212	MEPC.2(VI)	33 CFR 159, Type II	0.25	30	Gravity Flow	3,895
	AT-10STP	Biological	212	MEPC.159(55)	33 CFR 159, Type II	0.59	41	Gravity Flow	7,215
Enviro Marine / Skimoil	400	Biological	95	MEPC.2(VI)	33 CFR 159, Type II	0.17	19	Gravity Flow, Electric	4,500
Galley Maid	EPS: 12, 24, 32, AC	Biological	76	-	33 CFR 159, Type I	0.51	32	Gravity Flow, Electric	1,047
H2O	CZ-34	Biological	128	MEPC.159(55)	33 CFR 159, Type II	0.96	272	Gravity Flow, Electric	8,414
Headhunter	RF-50B, TW-50LP	Biological	189	-	33 CFR 159, Type II	0.13	43	Gravity Flow, Electric	10,000-18,000
Seahorse Manufacturing	CMP40	Biological	Up to 6 People[4]	MEPC.159(55)[5]	33 CFR 159, Type II	0.66	175	Gravity Flow, Electric	7,400
	CMP70	Biological	Up to 12 People[4]	MEPC.159(55)[5]	33 CFR 159, Type II	1.13	179	Gravity Flow, Electric	7,800
	SMSD200	Biological	Up to 6 People[4]	MEPC.159(55)[5]	33 CFR 159, Type II	2.14	272	Gravity Flow, Electric	10,300
	SMSD300	Biological	Up to 12 People[4]	MEPC.159(55)[5]	33 CFR 159, Type II	3.80	318	Gravity Flow, Electric	10,900
Scienco/FAST	L-1XM	Biological	235	MEPC.159(55)[5]	33 CFR 159, Type II	1.25	400	Gravity Flow, Electric	15,000

[1]Units selected for purchase and inclusion in laboratory-scale trials are highlighted in yellow.
[2]Most "biological" treatment methods use a biological aerobic system coupled with a secondary chemical component (usually chlorination).
[3]USCG = United States Coast Guard
[4]Despite specific requests for capacities in LPD, Seahorse provided these values in terms of persons onboard only.
[5]These models do not currently meet IMO standards, but Seahorse claims that they can be modified to conform to MPEC.159(55).

Table 4: Information on MSDs manufactured by Microphor, Raritan, and Redfox.

Company	MSD Model	Treatment Method	Capacity (LPD)	IMO Certification	USCG Certification	Volume (m^3)	Dry Weight (kg)	Electrical Requirement	Price (USD)
Microphor[1]	M-8 Plastic	Biological	10	-	33 CFR 159, Type II	0.16	23	Gravity Flow	1,995
	M-10 Plastic	Biological	11	-	33 CFR 159, Type II[2]	0.32	50	Gravity Flow	2,595
	M-14	Biological	34	-	33 CFR 159, Type II	0.44	68	Gravity Flow	2,950
	M-30	Biological	57	-	33 CFR 159, Type II	0.29	132	Gravity Flow	7,940
	M-40	Biological	76	-	33 CFR 159, Type II	0.36	163	Gravity Flow	9,295
	M-50	Biological	95	-	33 CFR 159, Type II	0.53	200	Gravity Flow	11,235
	M-50 Plastic	Biological	95	-	33 CFR 159, Type II[2]	0.53	95	Gravity Flow	4,995
	M-100	Biological	190	-	33 CFR 159, Type II	0.85	281	Gravity Flow	16,075
Raritan	Electroscan: EST12, EST24, EST32	Electro-Chemical	2,178[2]	-	33 CFR 159, Type I	0.047	11	Electric	1,900-2,300
	PURASAN: PST12EX, PST24EX, PST32EX	Electro-Chemical	2,178[2]	MEPC.159(55)	33 CFR 159, Type I	0.031	10	Electric	2,400-2,500
Redfox	RF-50-FG	Biological	189	-	33 CFR 159, Type II[2]	N/L[3]	N/L	Gravity Flow, Electric	9,000
	RF-50-FP	Biological	189	-	33 CFR 159, Type II	N/L	N/L	Gravity Flow, Electric	

[1]Units selected for purchase and inclusion in laboratory-scale trials are highlighted in yellow.
[2]These models are listed on the manufacturer's websites as being USCG certified; however, they do not appear in the USCG database.
[3]These models are certified for use onboard vessels under 65 feet (19.7 m) and for occupant complements of around four people. However, because they use electrochemical treatment, they can treat wastewater at a high rate despite their relatively small size.
[4]N/L = "not listed," meaning the corresponding information was not included on the manufacturer's website or the USCG database. When Redfox was contacted directly, they indicated that these units are very large and would not be appropriate for use onboard small fishing vessels or pleasure craft.