

Biological testing of ships' ballast water indicates challenges for the implementation of the Ballast Water Management Convention

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[ICES/IOC/IMO Working Group on Ballast and Other Shipping Vectors]

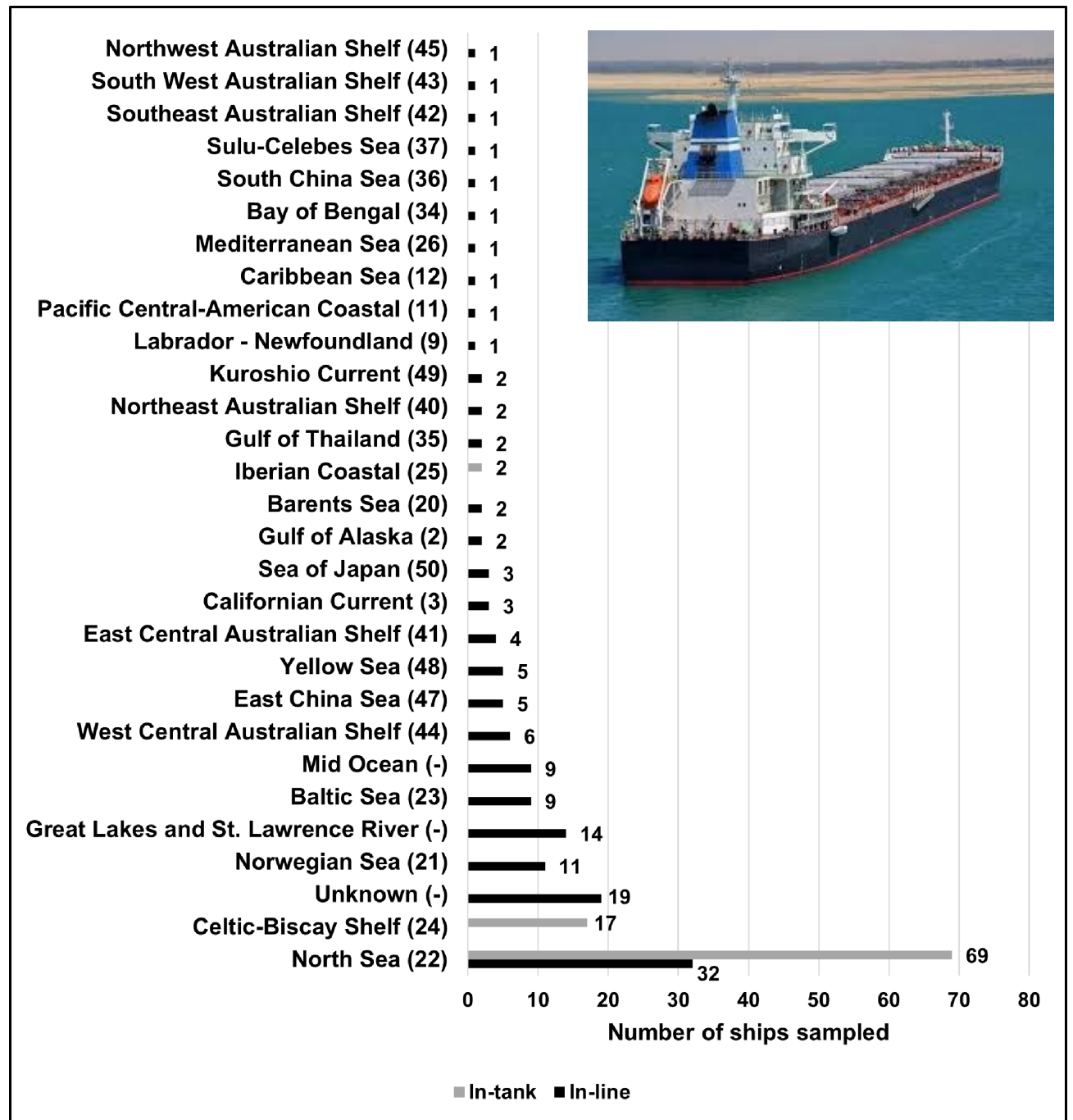


Background

- Despite type-approval and commissioning testing requirements, it cannot be assured that each BWMS will function and perform effectively onboard ships in operational service.
- The study compiled data from multiple studies of treated ballast water samples to collate a larger sample size and conduct statistical and trend analyses on D-2 standard compliance.
- The study aimed to;
 1. Determine how often ships utilizing BWMS complied with the D-2 standard;
 2. Assess whether ballast water compliance of ships has improved over time; and
 3. Evaluate how various ship-specific factors, such as type and age of BWMS, mesh size of the filters, and source and holding time of ballast water affected D-2 standard compliance rates.

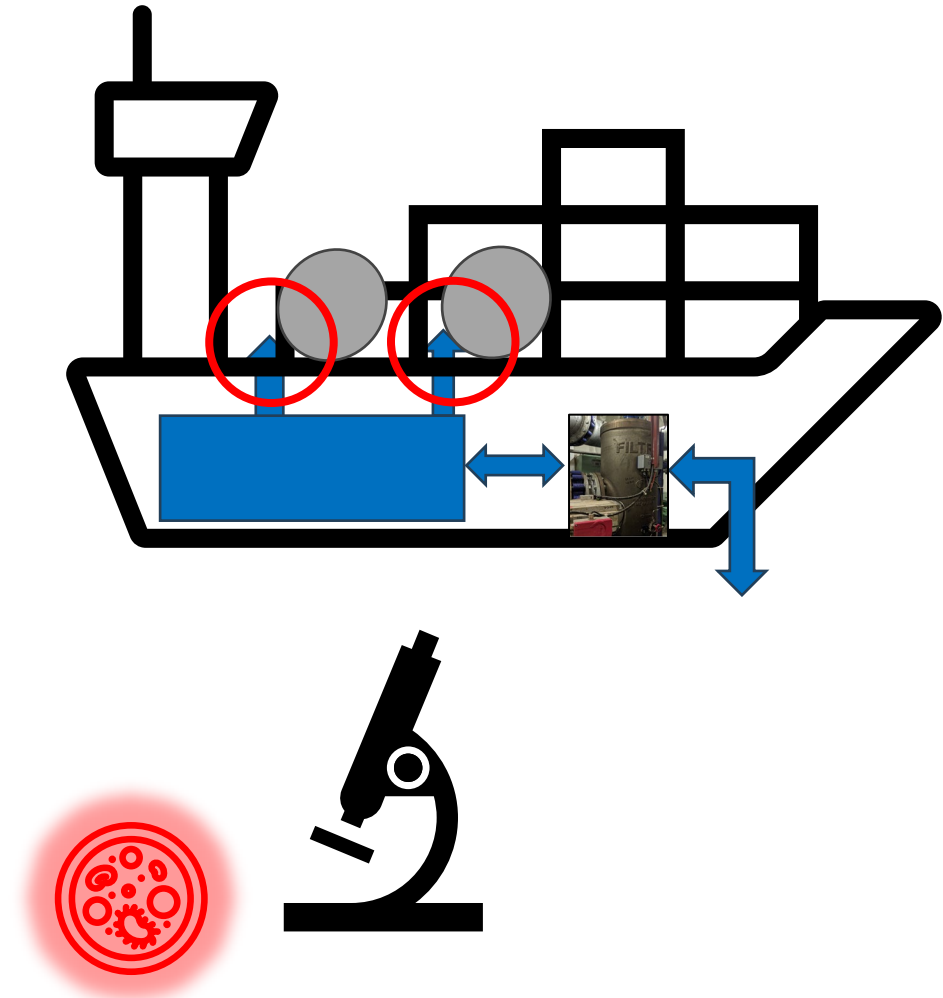
Methods

- 6 research groups provided data for detailed analysis samples from 228 ships' ballast water from 2017 to 2023 were
- 228 ships sampled included 222, 225 and 44 samples for $\geq 50\mu\text{m}$ and < 50 to $\geq 10\mu\text{m}$ -sized organisms, and indicator microbes, respectively).
- Samples originated from several large marine ecosystems.



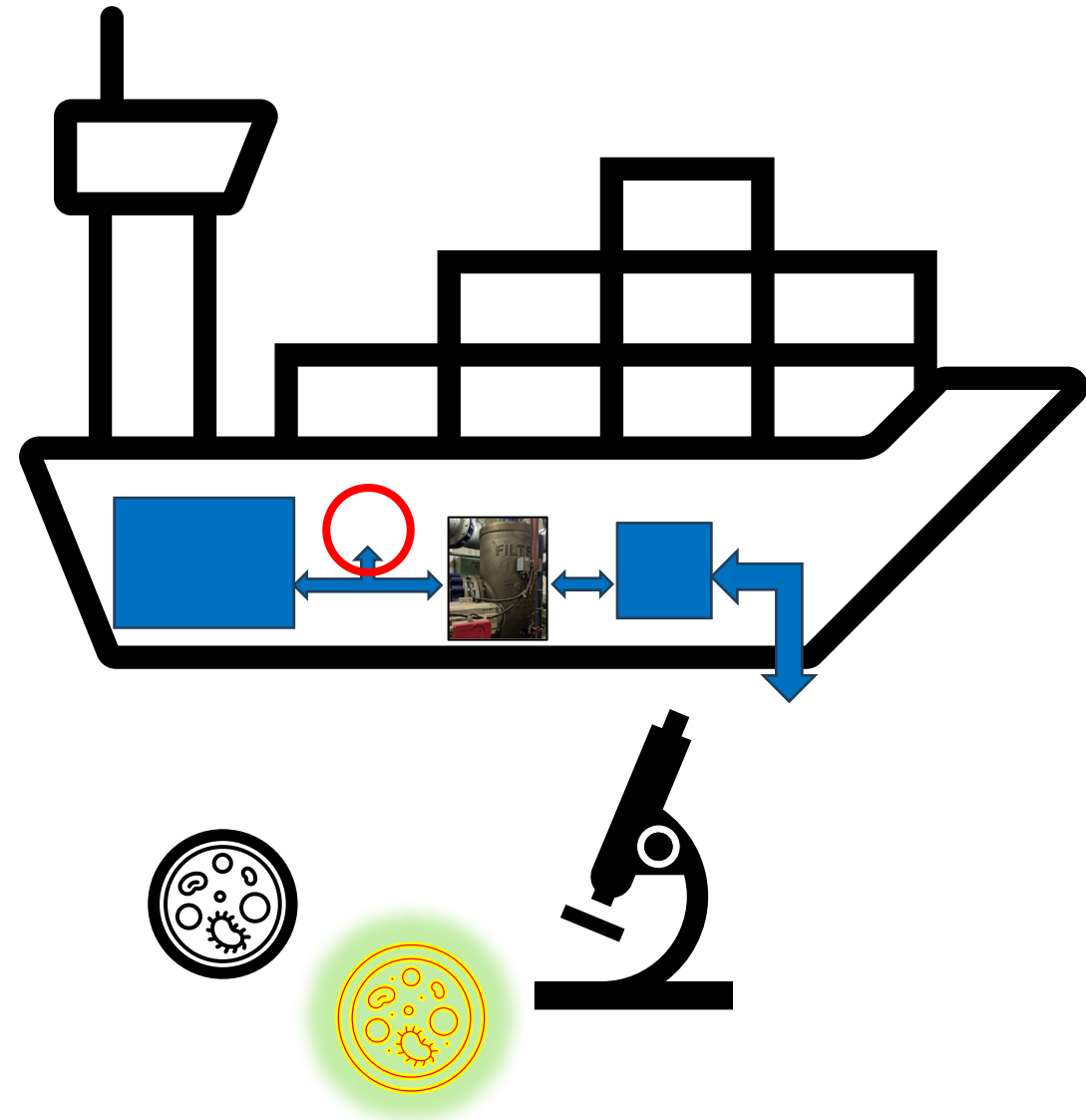
Methods – in-tank sampled ships

1. 88 ships were sampled from the tank through opened manholes using a pump – all samples were from operational BWMS under compulsory compliance monitoring.
2. Viability assessment was done for $\geq 50\mu\text{m}$ and < 50 to $\geq 10\mu\text{m}$ -sized organisms by staining with Neutral RED and preserving samples for identification and enumeration later.



Methods – in-line sampled ships

1. 140 ships were sampled from the ballast water discharge line – 50 of these were sampled for mandatory commissioning testing, 90 were sampled from ships with operational BWMS under voluntary compliance monitoring.
2. $\geq 50\mu\text{m}$ and < 50 to $\geq 10\mu\text{m}$ -sized organisms were analyzed as live counts using microscopes. Separate test kits for indicator microbes.



Statistical analyses

1. Compliance to the D-2 standard was a categorical response variable.
2. Trend analysis – Chi-squared test was used to detect whether compliance depended significantly on the sampling year (2017-2023, only for compliance monitoring samples).
3. Two logistic regression models were done for in-tank and in-line samples to detect whether BWMS filter mesh size, ballast water source, type of BWMS, BWMS age in years (only for the in-line samples), ballast water holding time in hours, and testing purpose (compliance vs. commissioning testing, in-line samples) significantly affected compliance rates.

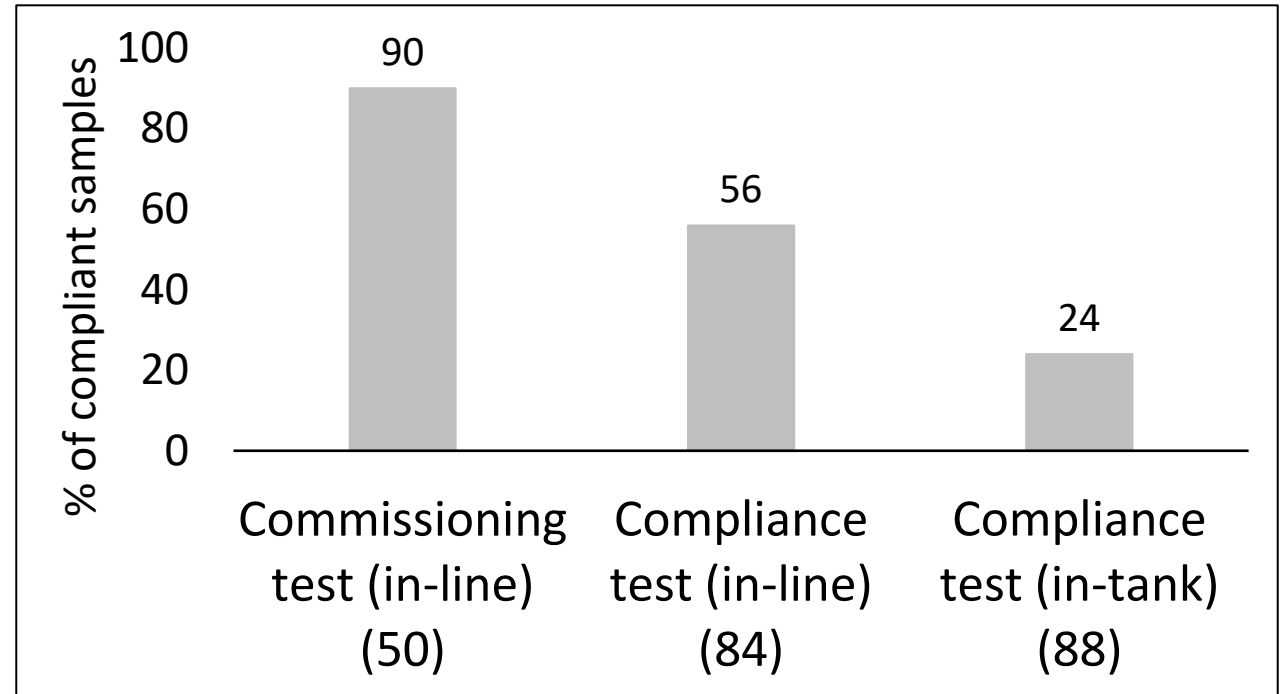
Results



All but one of the 44 samples analyzed for indicator microbes and 223 of 225 samples analyzed for the <50 to $\geq 10\mu\text{m}$ -sized organisms were compliant with the D-2 standard.



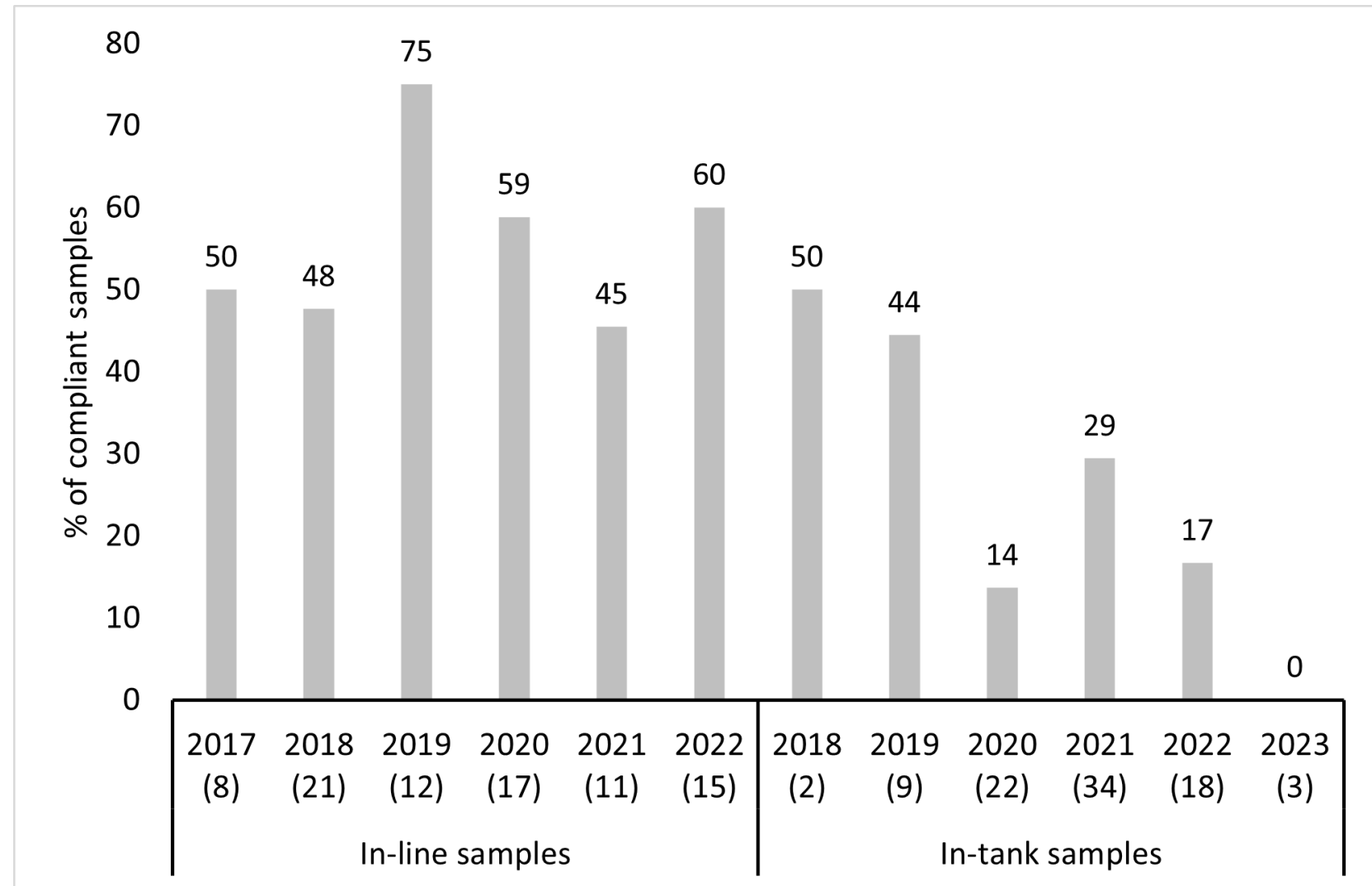
49% of the 222 samples failed to meet the D-2 standard for $\geq 50\mu\text{m}$ -sized organisms.



Percentage of compliant samples for each sample category. Number of samples per category is provided in brackets.

Results

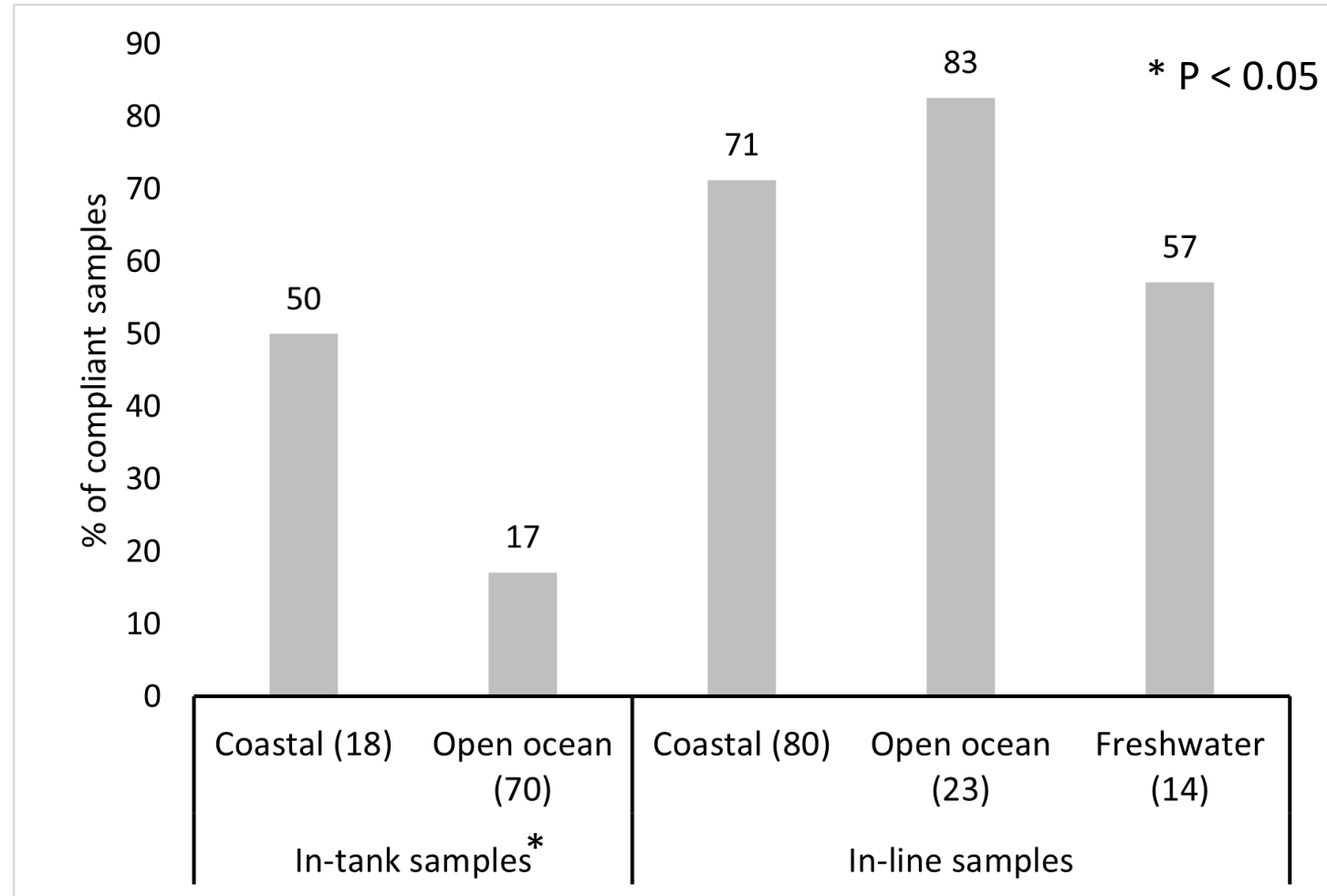
- Compliance did not improve over time (was not affected by sampling year, $p > 0.05$)



Percentage of compliant in-tank and in-line samples during compliance testing by year (D-2 standard, $\geq 50\mu\text{m}$ -sized organisms). Number of samples each year is provided in brackets.

Results

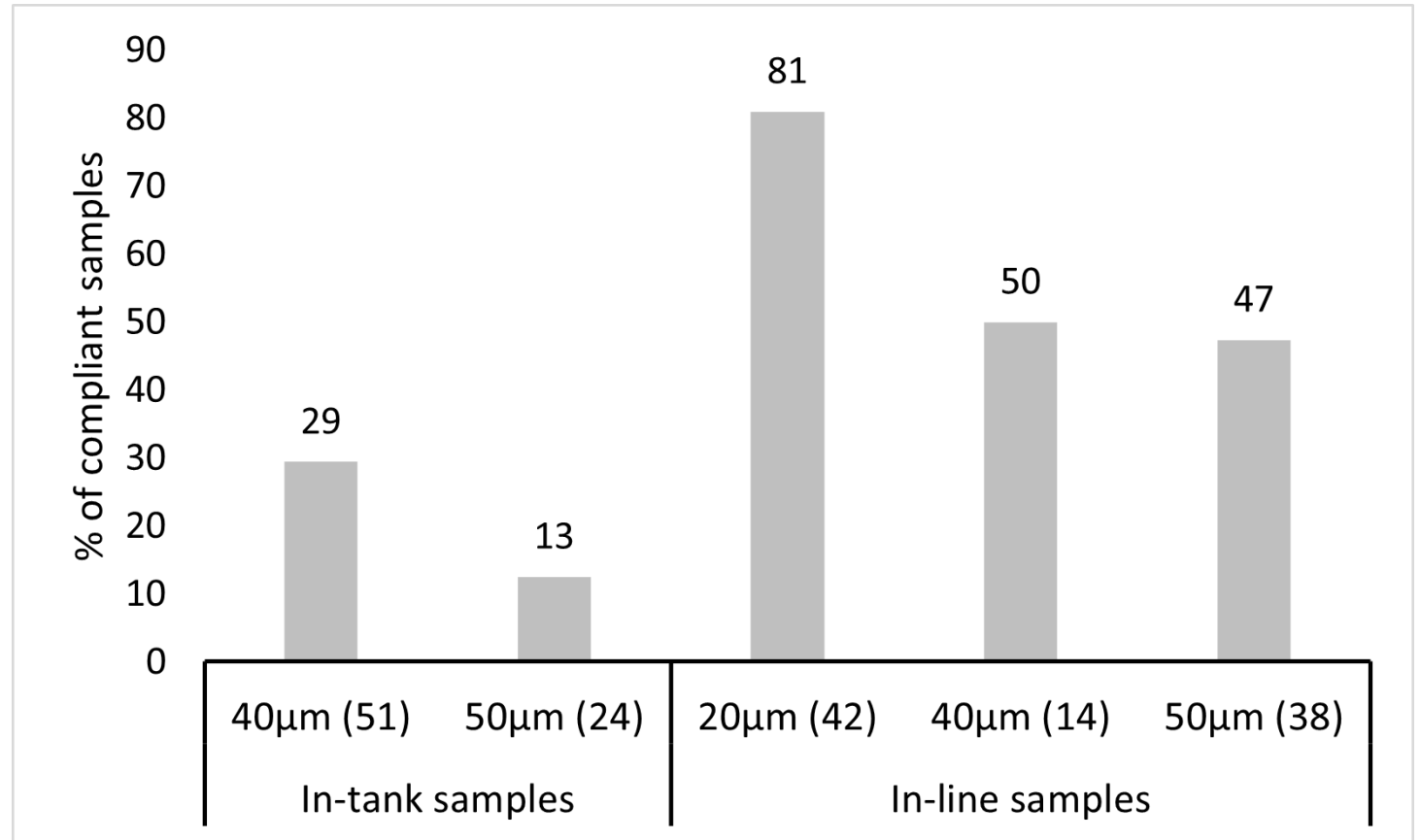
- Clear ship- or BWMS-specific variables that would have affected on D-2 standard compliance were not detected.
- However, both types of samples showed that compliance differentiated between the open ocean and coastal ballast water source categories (Difference was significant for the in-tank samples).



Percentage of compliant in-tank and in-line samples by ballast water source: freshwater, coastal and open ocean. Number of samples per ballast water source category is provided in brackets.

Results

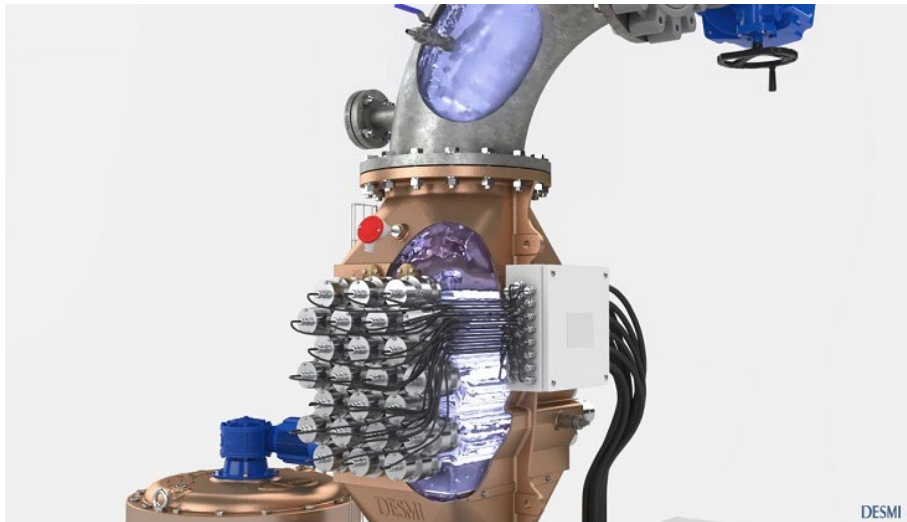
- BWMS filter mesh size – BWMS with 20µm filter mesh size were more likely compliant than BWMS with 40 ($p < 0.1$) and 50µm ($p < 0.01$) filter mesh (in-line samples).
- No significant differences between in-tank sampled ships ($p = 0.11$)



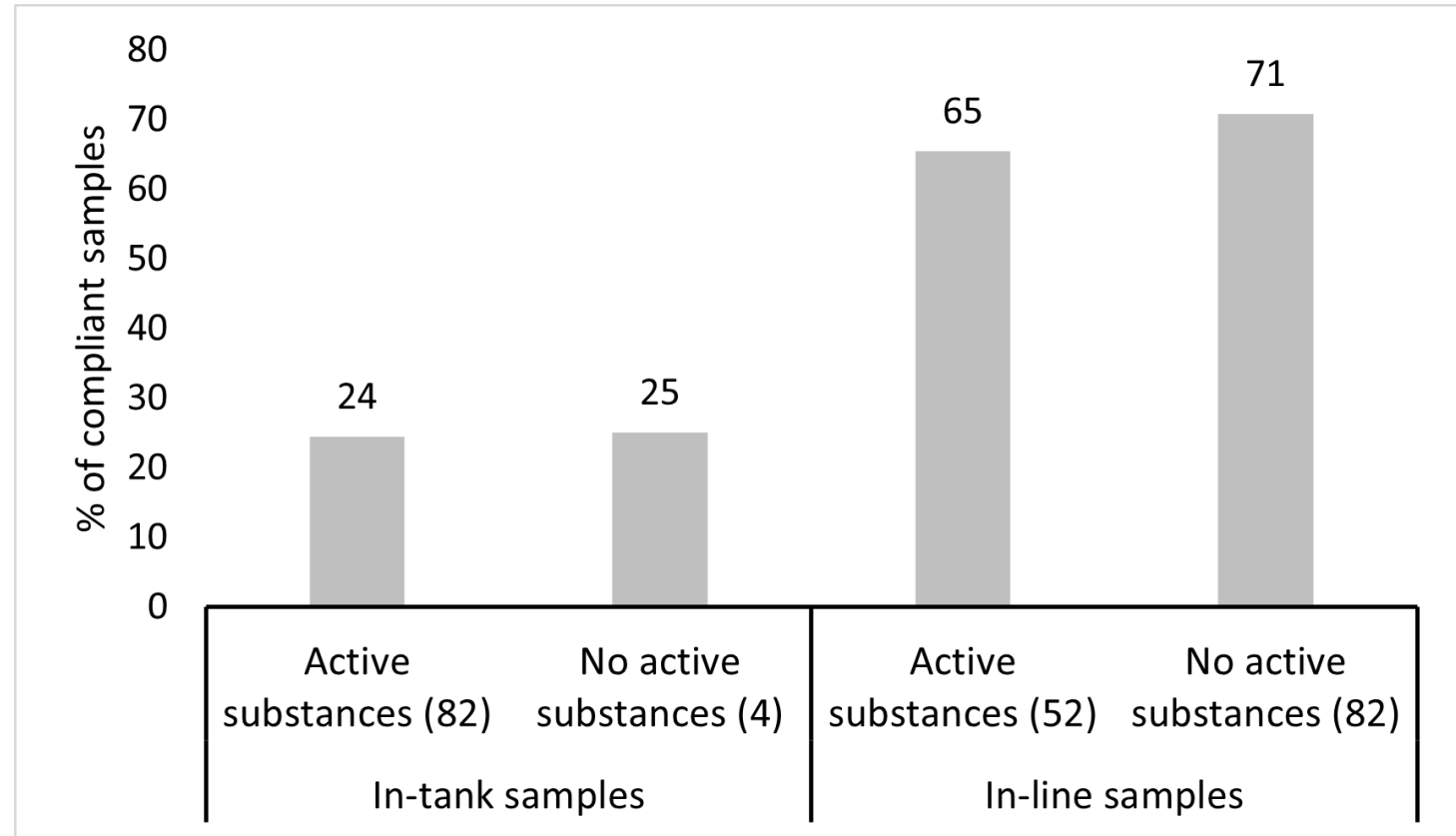
Percentage of compliant in-tank and in-line samples associated with the most frequently occurred filter mesh sizes within the BWMS of the tested ships. Number of samples per filter mesh size category is provided in brackets.

Results

- BWMS type – systems that did not utilize active substances were more likely compliant than systems utilizing active substances (in-line sampled ships, $p < 0.05$).
- No significant differences between in-tank sampled ships.



UV filtration of the ballast water in the DESMI CompactClean BWMS



Percentage of compliant in-tank and in-line samples by BWMS type: with and without active substances. Number of samples per BWMS type is provided in brackets.

Conclusions

- Compliance has not improved over time – compliance testing should be increased to ensure that BWMS remain operational, and ships meet D-2 standard in the future.
- More research should be done on BWMS filtration units and technologies to determine which technical specifications result in best removal of $\geq 50\mu\text{m}$ organisms.
- All parties concerned with sampling and analysis of ballast water are encouraged to compare sampling and analysis methods to verify their representativeness and accuracy.
- Non-compliance may be due to treatment failure, tank contamination, improper system installation and/or insufficient crew training, hence better crew training for operation and maintenance of the entire system has the potential to further improve ballast water management success.

Acknowledgements

ICES/IOC/IMO Working Group on Ballast and Other Shipping Vectors



The Canadian Shipping Vectors Research Team is supported by Transport Canada and Fisheries and Oceans Canada



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