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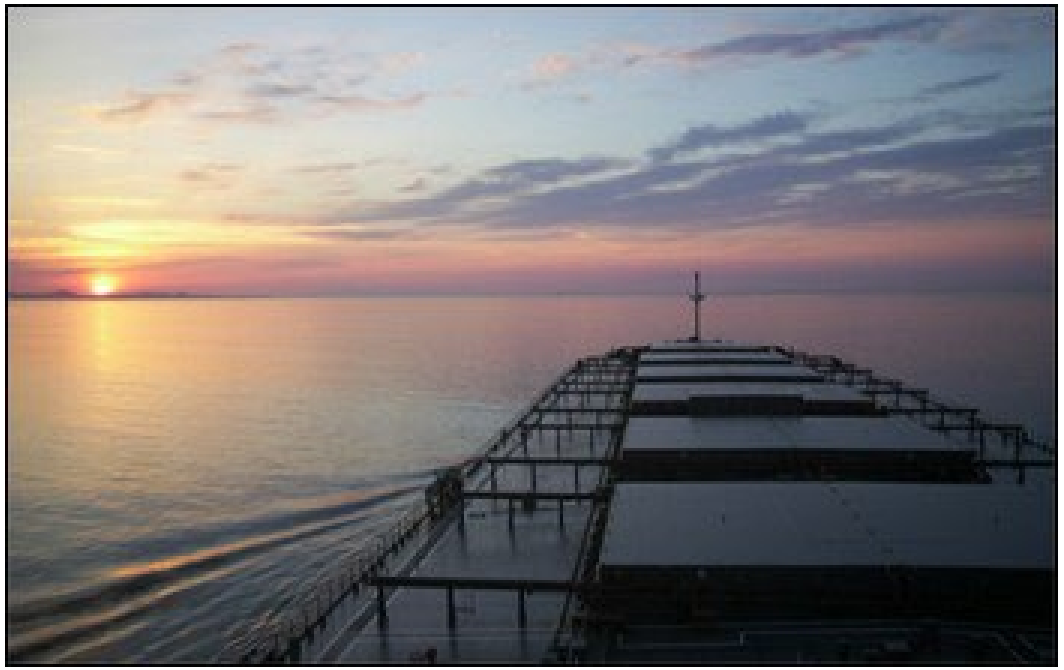
Evaluating the accuracy and practical application of ballast water compliance monitoring devices



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Objectives

Evaluate CMD accuracy

- Determine whether CMDs provide a reliable indication of [non-]compliance with Regulation D-2

Assess practical application

- Explore the benefits and drawbacks of using CMDs as a tool for compliance monitoring

CMD = compliance monitoring device

Compliance Monitoring Devices

	BQUA	BallastWISE	Ballast Eye
Units of measurement	ATP (pg m^3 or pg mL^1)	Ind. m^3 or Ind. mL^1	Ind. m^3 or Ind. mL^1
Protocol complexity	Complex	Simple	Moderate
Processing time	1 – 1.5 h / sample	1 – 1.5 h / sample	20 – 45 min. / sample (temperature dependent)
Preferred sample temp.	None	None	20 – 30°C
Serviced	Canada	Denmark	Japan

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Experiments

1) Ballast samples

- 20 treated discharge samples (marine)
- 7 paired uptake/discharge samples (fresh water)
- BQUA only

2) Natural water samples

- 7 individual tests
  - 3 marine
  - 4 fresh water
- Low, medium, high organism concentrations
- BQUA, BallastWISE, Ballast Eye

3) Ballast discharge in Arctic

- 21 treated discharge samples (marine)
- Milne Port, NU
- Ballast Eye only

Casas-Monroy *et al.* 2023 Journal of Plankton Research 45: 540–553. https://doi.org/10.1093/plankt/fbad014

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Analysis

Two regulated organism size classes:

- ≥ 50 µm (mostly zooplankton)
- ≥10µm – <50µm (mostly phytoplankton)

Analysis approach:

- Evaluated accuracy based on percentage agreement with microscopy counts above or below the D-2 standard

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CMD Accuracy

	CMD	Sample type	Water source	≥ 50 µm Agreement (%)	≥ 50 µm False negative rates (%)	10 – 50 µm Agreement (%)	10 – 50 µm False negative rates (%)
	B-QUA	Ballast	Marine	85	5	100	0
			Fresh	93	7	79	21
		Lab	Fresh	67	33	33	67
	BallastWISE	Lab	Marine	67	22	56	44
			Fresh	83	8	83	17
	Ballast Eye	Ballast	Marine	81	~10	100*	0*
		Lab	Marine	100	0	56	44
			Fresh	100	0	75	0

*All zero counts (no live cells)

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Casas-Monroy *et al.* 2023; Bailey, Howland et al. (unpublished)

Summary of the CMDs

BQUA

- Performed well during ship tests, but not lab tests (FW)
- Complex protocol
- Consumables cost
- Results difficult to convert to counts

BallastWISE

- Performed well during lab tests (no ship tests)
- Simple protocol
- Results are counts
- No consumables
- Sensitive to vibration and level positioning

Ballast Eye

- Performed well during ship and lab tests
- Protocol has moderate complexity
- Results are counts
- Consumables cost
- Warming cold sample may impact organism viability

Benefits of CMDs

Rapid detection & decision-making

- Rapid results could help PSC officers decide if further testing is needed
- Identify high-risk non-compliance

Standardization & consistency

- Automated monitoring reduces human error and improves consistency

Cost & time efficiency

- Fast and easy to use with minimal training
- Reduces lab testing time, enabling frequent, low-cost monitoring

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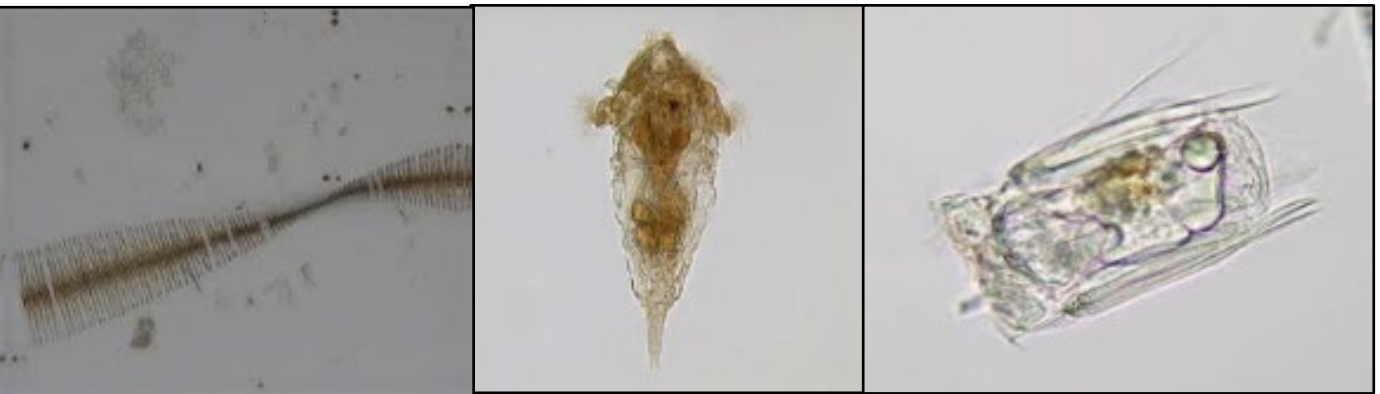
Drawbacks of CMDs

- Detection limits may vary depending on water conditions (e.g. high turbidity)
- Maintenance, repair, and training could be challenging
- Lack of international CMD standardization
- Investment risk if devices/support are discontinued
- **Challenge: obtaining representative ballast water samples (time/logistics)



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Sample Collection
Ballast Catch vs. Plankton Nets

Ballast Catch

- Susceptible to mesh explosion (pressure)
- Flow rates restricted to 30 – 40 L/min
- No flow control valve supplied
- Simple to use
- Portable

Sampling wand w/plankton nets

- Mesh with larger surface area (open unit)
- No flow rate restrictions
- Integrated flow control valve
- More complex to use, requires flow rate calculations
- Difficult to transport

Questions?

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- Fisheries and Oceans Canada

Casas-Monroy et al. 2022. Assessing the performance of four indicative analysis devices for ballast water compliance monitoring, considering organisms in the size range ≥10 to <50 µm Journal of Sea Research. https://doi.org/10.1016/j.jenvman.2022.115300

Casas-Monroy et al. 2023. Examining the performance of three ballast water compliance monitoring devices for quantifying live of organisms both regulated size class ≥50 µm and ≥10 to <50 µm Journal of Plankton Research. https://doi.org/10.1093/plankt/fbad014

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