The question as to the IMO regulatory requirements for an effective Indicative Measurement of Ballast Water

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What is the size of the problem?

Every year 10 billion tons of ballast water are transported throughout the globe (IMO/MEPC, 1998), with ~7000+ species of living organisms transferred daily (Carlton, 2001). Over the past decade concern as to the impact of various invasive species and human pathogens inadvertently transported in the ballast of ships—and their role in disrupting local ecosystems, displacing local indigenous species and posing a risk to human health—has received significant attention from the International Maritime Organisation (IMO). Regulations formed under the IMO convention for ballast water management aim at reducing the risk of damage caused by these invasions and halt the potential for regional economic loss and entered into force on September 8th, 2017.

Ballast water discharge

What is the acceptable level of viable organisms?

Regulation D-2 of the IMO convention requires that ballast water discharged from ships contain

i. less than 10 viable organisms with minimum dimension ≥50 µm per m3

ii. fewer than 10 viable organisms with minimum dimension between 10 µm and 50 µm per mL

The question as to the determination of a representative sample is adequately covered by empirical research carried out by David and Gollasch (2011), published by the European Maritime Safety Agency (2011), in which an in-depth assessment of indicative sampling techniques and how representativeness may be achieved is evaluated.

Does the IMO require indicative analysis?

The IMO indicative sampling guideline G2 paragraph 6.3 states: Prior to testing for compliance with the D-2 standard, it is recommended that as a first step, an indicative analysis of ballast water discharge may be undertaken to establish whether a ship is potentially compliant or non-compliant. Such a test could help the party identify immediate mitigation measures, within their existing powers, to avoid any additional impact from a possible non-compliant ballast water discharge from the ship.

David and Gollasch, (2011) suggest various methods for the indicative analysis of ballast water and highlight three core groups of organisms: a) 8 methods for phytoplankton b) 6 methods for zooplankton and c) 11 methods for bacteria.

What technologies and methodologies for sampling are available?

Table 1 highlights eight appropriate methods for analysis of organisms less than 50µm and greater than or equal to 10µm, indicating ease of handling and time required to process a result. The ease of use/handling is indicated by +/not easy and +++/ very easy, portability and potential for onboard testing is shown. Plankton algae organisms dominate this class size

Table 1. Methods for organisms less than 50µm and greater than or equal to 10µm in minimum dimension.

Method	Ease of Handling	Time to result (for sample processing)	Portable	Tested Onboard	Level of biological expertise needed
DNA	+	<60 min	no	no	high
RNA	+	<60 min	no	no	high
ATP	++	<30 min	yes	yes	low
Chl a	+	<30 min	yes	no	low
Oxygen	++	<90 min	yes	Yes, EMSA voyages	low
PAM (*Hach BW680)	+++	<10 min	yes	yes	low
Flow camera	++	<60 min	no	no	high
Holographic microscopy	++	<20 min	no	no	high

Source: David and Gollasch, (2011)

Table 2 highlights six appropriate methods for the analysis of organisms greater than or equal to 50µm, indicating ease of handling and time required to process a result, the ease of use/handling is indicated by +/not easy and +++/ very easy, portability and potential for onboard testing is shown. Zooplankton organisms dominate this class size.

Table 2. Methods for organisms greater than or equal to 50µm in minimum dimension.

Method	Ease of Handling	Time to result (for sample processing)	Portable	Tested Onboard	Level of biological expertise needed
DNA	+	<60 min	no	no	high
RNA	+	<60 min	no	no	high
ATP	++	<30 min	yes	yes	low
Visual Inspection	+++	<5 min	yes	Yes, EMSA voyages	medium
Stereomicroscope	++	<40 min	yes	Yes, EMSA voyages	high
Flow Camera (hand-held)	+	<30 min	yes	yes	high

*Source: David and Gollasch, (2011) * Not included in the original research paper – included here for further reference*

Table 3 (next page) highlights eleven appropriate methods for the analysis of bacteria indicating ease of handling and time required to process a result. The ease of use/handling is indicated by +/not easy and +++/ very easy, portability and potential for onboard testing is shown.

Table 3. Methods for bacteria analysis

Method	Ease of Handling	Time to result (for sample processing)	Detection of cfu	Portable	Tested Onboard	Level of biological expertise needed
DNA	+	<60 min	no	no	no	high
RNA	+	<60 min	no	no	no	high
ATP	++	<30 min	no	yes	yes	low
IDEXX 1	+ (sealer needed)	Incubation time ca. 24hrs	yes (by calculation	yes, sealer and incubator needed	yes	medium
IDEXX 2	+	Incubation time ca. 48 hrs.	no	yes, incubator needed	yes,	medium
Moller & Schmelz	+	Incubation time 24-48 hrs.	yes (counts)	yes, incubator needed	yes, EMSA voyages	medium
Petrifilm 3M	++	Incubation time 24 -72hrs	yes (counts)	yes, incubator needed	yes	low
Quantitube Easygel	+	Incubation time 18 -48 hrs.	yes (counts)	yes, incubator needed	yes	low
Hand-held fluorimeter (*Hach BW680)	+++	With incubation time ca. hrs., without<10 min	no	yes	no	low
TECTA Endetec	++	2 – 18 hrs.	no	yes	no	low
New Horizons Diagnostics	+++	30 min to 20 hrs., depending on the medium	no	yes	no	low

*Source: David and Gollasch, (2011) * Not included in the original research paper, included here for further reference*

How can stakeholders comply with IMO expectations for indicative analysis?

Research carried out by Gollasch et al., National Institute of Biology, Slovenia (2015) highlights the efficacy of pulse-amplitude-modulated (PAM) fluorometry as a methodology ideally suited to the rapid detection of indicatively living phytoplankton cells active in the IMO prescribed range of <50 µm and >10 µm.

Findings of the study carried out by Gollasch et al. offers a tangible solution to all stakeholders seeking to ensure compliance with current IMO regulations. A specific and detailed reference to the suitability of PAM instruments due to their ease of use, rapid results generation, straightforward technical tool with no requirement for biological or other specific training for person carrying out the analysis, are all cited as critical positive elements for the onboard use of PAM instruments to carry out indicative analysis. The findings of Gollasch et al. are also corroborated in similar research carried out by: Reavie et al, Natural Resources Institute (2010), Steinberg et al (2011a, b), Welschmeyer and Maurer, GEF – UNDP-IMO Globallast Partnership Programme (2011) and Stehouwer et al, IMO-WMU Research and Development Forum (2012).

What next?

With the adoption of the BWM in 2017, all stakeholders agree not only to prevent, minimise and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments, but also to ensure complete compliance. Article 9 of the convention places the responsibility on port authorities to carry out inspections, failure of which would result in costly delays, schedule disruption, and hefty fines for significant breaches.

As an internationally recognised water quality expert, Hach brings more than 70 years of experience in solving a wide range of water quality issues, including the guidance and support required by the Maritime Industry to meet IMO regulations. For more information, access the study on indicative ballast water analysis methods commissioned by The Finnish Transport Safety Agency (Trafi). This research sites Hach's Ballast Water Validation Kit as the "Easiest to use handheld device without filtration steps," – Bradie 2016.

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