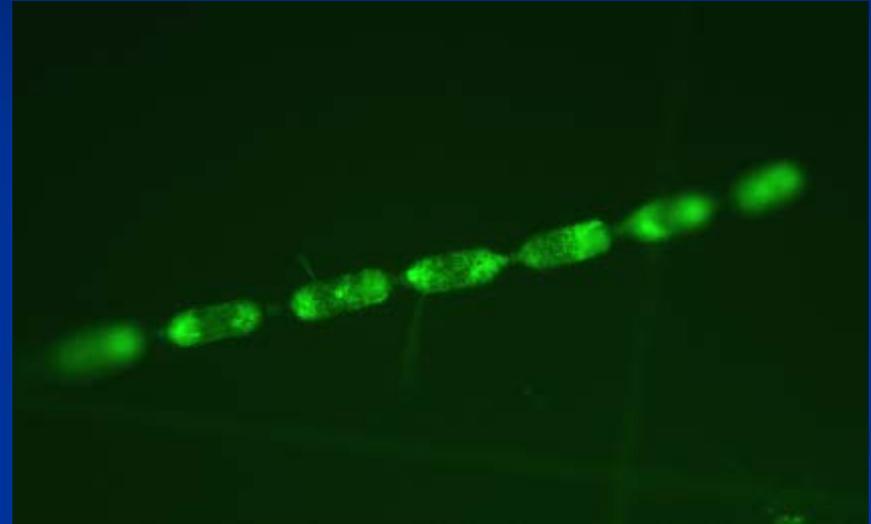




Methods and Tools for Assessing Compliance with the U.S. Coast Guard BW Discharge Standard



Prevention 1st

Long Beach, CA

8 September 2014

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U.S. Coast Guard
Environmental Standards¹



Need for Compliance Tools

- **USCG and IMO Ballast Water Discharge Standards**
 - Limits on concentration of living organisms
 - Size-classes
 - ≥ 50 μm (mostly multi-cellular zooplankton)
 - ≥ 10 - <50 μm (mostly protists)
 - *E. Coli*, enterococci, *Vibrio cholerae*
- Require significant effort and time to quantify
- Limited effort and time available during ship inspections



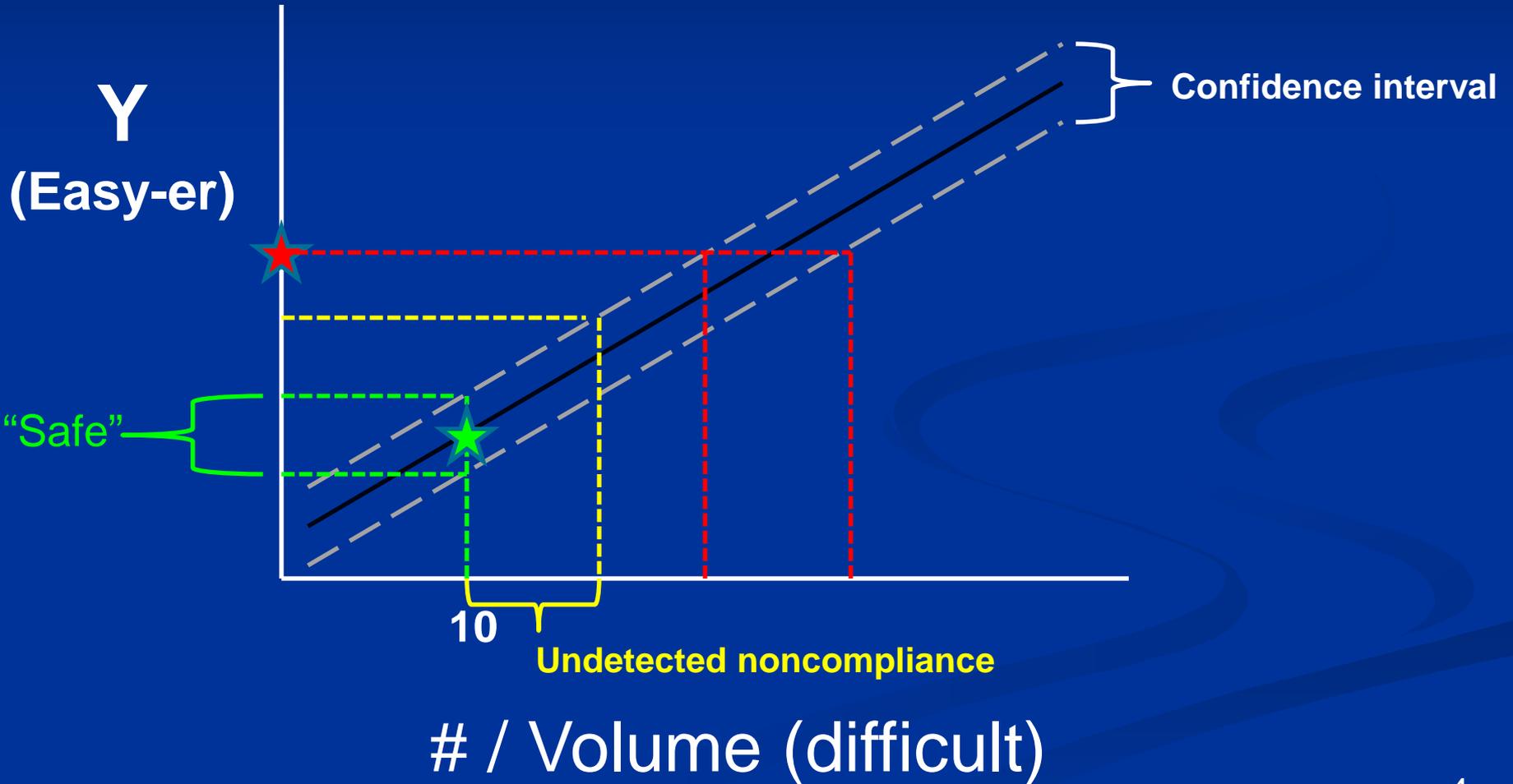
Compliance Assessment Process



- Required Documents
- Crew knowledge
- Equipment
- Samples for analysis
 - IMO
 - Indicative: establish whether ship is potentially compliant
 - Relatively quick
 - Direct (organisms) or indirect (bulk parameters)
 - Detailed: establish concentrations
 - Labor intensive and time consuming



Indicative Analysis Basic Concept





Main Efforts



Expert Workshops

Technology Availability

Variable Fluorescence

(MARAD/Alliance for Coastal Tech.)

Market Assessment

Proof-of Concept Studies

(USCG and MARAD/ACT)

Broad Agency Announcement

Prototype development

Independent Validation Tests

Compliance Tool Transition



Projects managed by USCG R&D Center, except where indicated



Expert Workshop

Technology Availability Scoping



- June 2011
- Compliance monitoring framework
 - methods, instruments and approaches for determining compliance for the various ballast water treatment types.
 - Three levels of compliance assessment
 - Increasing levels of confidence in identifying non-compliance with discharge standards:
 - 1. Measures of treatment system performance;
 - 2. Indirect measures of exceedance of the discharge standard; and
 - 3. Direct measures of compliance with the discharge standard.



Level 1: System Operation

- **Compliance monitoring instruments and methods**
 - **Indirectly or indicatively measure BWMS performance**
 - **Indicate equipment is functioning as certified.**
 - **BWMSs operating appropriately**
 - **Engineering performance parameters**
 - **Required water quality conditions met.**
 - **Operated independently by inspectors**
 - **Integrated into treatment systems**



Level 3: Direct Counts

- Detailed measurements of living organisms
- Same as, or similar to, evaluations conducted for BWMS certification
- Provide the highest level of scientific certainty of concentrations.
- Logistic challenges to use in assessment of vessel compliance
 - Effort and expertise
 - Equipment expense
 - Time



Level 2: Indirect Biological Indicators



- Quick estimate of whether concentration exceeds required limits
 - Bulk estimates of biomass
 - Chlorophyll
 - ATP
 - Enzyme activity
- Various biological, chemical, and optical instruments and methods currently available or in development
- Measurements can be collected autonomously or by inspectors.



Subject Matter Expert Opinion



Category	Parameter	Instr./Analysis	Relevance	Readiness
10 – 50 um photo-autotrophs	Variable fluorescence	Pulsed/modulated fluorometer	High	Immediate / medium
10 – 50 um all	ATP	Luminometer and reagents	High	Medium



Market Assessment

Request for Information: June – October, 2012

Technologies and methodologies

- Clear indication of compliance
- Specifications and maturity level
- Automated and/or operated manually

Provided summary of Expert Workshop on potential approaches



Market Assessment

- **Result:**
 - No technologies or methodologies ready for specific use
 - Numerous technologies and methodologies with promise
 - Require development for specific application
 - Measurement
 - Package
 - Operation



Broad Agency Announcement



- Announced July 2013
- Scope:
 - development and delivery of prototype technologies
 - on-site technical support during independent tests.
- Objective: quickly and reliably verify compliance with current USCG BWDS
- Process:
 - White Paper (brief overview)
 - Technical and Scientific Merit, Feasibility, and Rough Order of Magnitude Cost
 - Full Proposal
 - Award to develop and deliver prototype



Selected Technologies



Turner Instruments
“Ballast-Check”



Chelsea Technologies
“FastBallast”



SJSURF
Luminometer



Chlorophyll Variable
Fluorescence

ATP



Framework for Validation



Drake et al (in press). *Marine Pollution Bulletin*

How many organisms are in ballast water discharge? A framework for validating and selecting compliance monitoring tools.

■ Three-stage process:

- ➡ ■ Proof-of-concept
 - demonstrate potential
 - small scale / controlled manner
- ➡ ■ Validation and verification
 - tool measures what it is supposed to measure,
 - tool meets specific requirements (e.g., accuracy, precision)
- Final selection
 - assessment of feasibility and practicability
 - Size, cost, ease of use, maintenance, ruggedness, etc



Proof-of-Concept Case Study



Variable fluorescence; living organisms ≥ 10 μm and < 50 μm

- **Laboratory study Nov 2011 (USCG)**
 - *Tetraselmis impellucida* (12 x 15 μm)
 - Cell suspensions of $10^1 - 10^4$ cells / mL
 - Results
 - 10^1 : below detection
 - $10^2 - 10^4$: detectable
- **Expert Workshop June 2012 (MARAD/ACT)**
 - Combination of Chlorophyll and variable fluorescence measurements
 - Proposed Thresholds ($10^2 - 10^3$ mL⁻¹):
 - Chl > 1 $\mu\text{g L}^{-1}$
 - Fv/Fm > 0.3



Proof-of-Concept Case Study

- Field study Summer 2012 (MARAD/ACT)
- 2 var. fluor. and 2 chl. *in situ* instruments
 - NOT optimized for BW compliance
- 3 Locations
 - Monroe, MI: Lake Erie fresh water
 - Baltimore, MD: Chesapeake Bay brackish water
 - Moss Landing, CA: Pacific Ocean marine water
- Ambient plankton assemblages
- Results:
 - Workshop thresholds: validated
 - Some potential: near discharge standard resolution



Validation/Verification



- Fall 2014 – Spring 2016
- Naval Research Laboratory
 - Corrosion Science and Engineering Center
- Field Locations
 - Florida Keys (marine, sub-tropical)
 - Great Lakes (fresh, temperate)
 - Mid-Atlantic (brackish, temperate)
 - Coastal California (marine, temperate)
- Selected technologies + “walk-ons”
 - “walk-ons” at own cost



Scope

- **Develop test protocols for collecting measurements**
 - Range-finding
 - Protocol and experimental design
- **Lab: correlation between bulk metrics and direct counts**
 - Lab cultures - accuracy, precision, etc
 - Propose threshold
- **Field: Evaluate thresholds**
 - Samples collected over a range of temporal and spatial variations



THANK YOU

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<https://Homeport.USCG.mil/Environmental>