Statement by the Golden Bear Research Center concerning ballast treatment efficacy
26 February 2018

We, the staff of the Golden Bear Research Center (GBRC), wish to provide some perspective as a ballast water management system (BWMS) type-approval testing facility to an article that appeared in a recent issue of MARITIME EXECUTIVE, titled "Ballast Water Treatment System Testing Under Fire" (February 10, 2018). The article, like several others to come out since the announced closing of two test facilities, accurately captured the fact that current ballast water regulations, by their specificity, encourage subjective interpretation of the regulations when considering measurement criteria for both IMO and USCG Type Approval test procedures. However, we believe the pessimistic tone regarding the apparent efficacy of type-approved BWMSs or the rigorousness of their testing, that has emerged as a result, is without warrant.

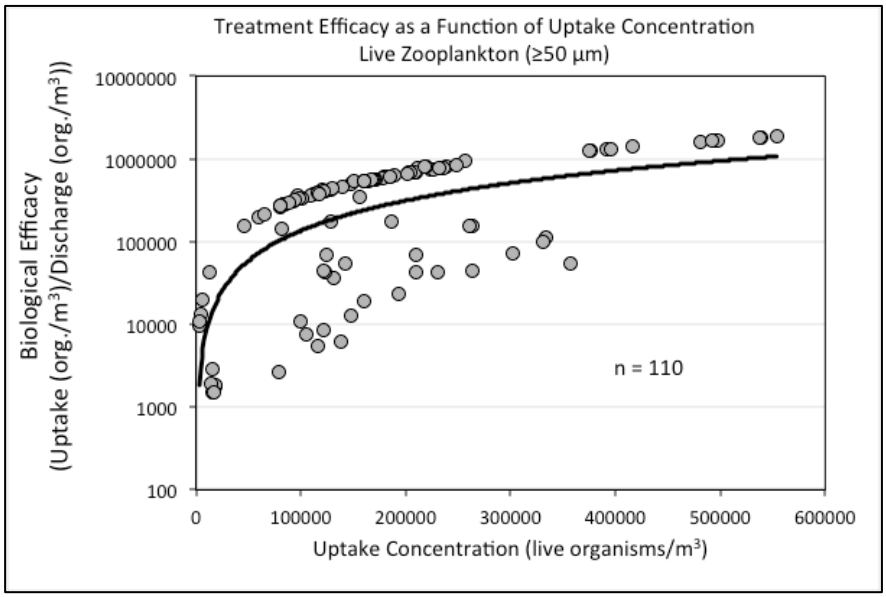
We agree, for instance, with Dr. Mario Tamburri that 'non motility' in suitably large stationary eggs of some invertebrates would be considered compliant with the stated USCG ballast regulations for the definition of 'non-living' organisms (non-motile = non-living), even though those non-motile eggs may hatch living/swimming juveniles at a later time. We cite here another potential unsettling circumstance considering the interpretation of organism size, as it relates to ballast water discharge standards. The toxic, domoic-acid-producing, pennate diatom, *Pseudonitzschia* sp. (a single-celled phytoplankter), is responsible for routine shellfishery closures and marine-life kills along the west coast of North America (Scholin et al., 2004); the size of many sub-species of *Pseudonitzschia* is approximately 5 µm x 70 µm. According to both IMO and USCG specifications, those organisms would not be counted within the regulated size class of organisms ≥10 - <50 µm, since their 'minimum dimension (5 µm) is less than the regulated 10 µm limit.

It is clear to us that the international and federal ballast water discharge standards (BWDSs) need attention/correction to modify literal interpretations of the law that seem counterintuitive to ballast water management. However, there seems to be a swelling doomsday sentiment that examples, such as above, point to patent failure of ballast water treatment systems in the abatement of the aquatic invasive species problem.

We take objection to such a position. A global and realistic evaluation of ballast water treatment efficacy must be considered.

The global fleet of approximately 60,000 commercial shipping vessels, subject to ballast regulations, produces roughly 3 billion cubic meters (3 billion metric tons) of discharged ballast water annually on a world-wide basis (Endresen et al., 2004). This constitutes the anthropogenic global transport vector due to ballast discharge that we are attempting to manage (ignoring the natural vector due to oceanic/coastal circulation, see below). The existing ballast water discharge standards define a 'line in the sand' whereby an inflexible, binary judgement of 'pass or fail' is concluded (by regulators, by extremists, by industry, by the lay population). However, the quantitative impact of ballast water effectiveness is seldom considered.

We made a recent compilation of over 100 side-by-side comparisons of the concentrations of 'living' organisms pumped into our test facility during both land-based and shipboard tests in relation to the final discharge concentration of living organisms after ballast treatment; e.g., a simple comparison of 'what goes in vs. what goes out' (Figure). The reduction value (uptake live concentration ÷ discharge live concentration; y axis of Figure) as a function of incoming challenge concentration (x axis) ranged from 1,000x to over 1,000,000x; more than half of the comparisons fell in the range 100,000x to 1,000,000x, or, using the terminology of food and drinking water management, a 5-log to 6-log reduction in targeted organisms (log_{10}). In fact, the actual reduction is likely larger because the data were conservatively calculated using fixed minimum detection levels in treated water even when no live organisms were observed at all.



This level of organism reduction demonstrates that ballast water treatment effectiveness is fantastically high, approaching and even exceeding the stringency required in drinking water testing/food management practices. If the global fleet of commercial vessels collectively and routinely utilized shipboard BWMSs, the active fleet of 60,000 ships might be reduced to an 'effective' world-wide fleet of 0.6 to 0.06 ships total, using 5-log and 6-log reductions implied above. Would we suspect shipping to be a major global vector in the anthropogenic spread of aquatic invasive species at that level?

Two sobering points must be accepted: 1) Ships must have reliable treatment systems installed and operated, routinely and collectively, to engage the global plan into action. Shipping-based species transport is a 'give and take' condition and all participants must be fully engaged in order to ensure the management plan operates properly. 2) A realistic acknowledgement must be given to the fact that ballast water management, even if coupled with perfect control of all anthropogenic species transport vectors (vessel biofouling, waterway construction, etc.) CANNOT eliminate the global spread of invasive species entirely; it is an abatement program, but likely not an elimination program. A simple local example will illustrate this point. A single semi-diurnal tide cycle in San Francisco Bay floods approximately 3-4 billion cubic meters of external oceanic/coastal water through the Golden Gate daily (Conomos 1987), equivalent to, or exceeding, the *total global* volume of ballast water discharged annually. The point-source nature of anthropogenic ships' ballast discharge

must be managed, but the transport of aquatic species due to natural global ocean currents, riverine flow and tidal pumping will likely never be eliminated.

As all stakeholders (shipping companies, technology vendors, regulators, and testing facilities) continue to work towards effective, attainable regulations, let us remember that a one million-fold reduction in anthropogenic ballast water organism transport is cause for celebration, not criticism.

Sincerely,

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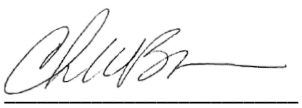

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