Golden Bear Research Center (GBRC) Update

Pacific Ballast Working Group
Seattle, WA
April 11, 2018

Christopher Brown
Scientific Program Manager
Golden Bear Research Center

Golden Bear Research Center

Department of Sponsored Projects and
Extended Learning

Golden Bear Research Center

Approved USCG sub-laboratory to DNV-GL for land based and shipboard Ballast Water Management System type approval testing

Golden Bear Research Center

Partners:

- MARAD
- Moss Landing Marine Laboratories
- California State Lands Commission
- NOAA Sea Grant
- University of Washington
- Pacific EcoRisk
- BioVir Laboratories

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Golden Bear Research Center

The Center's objectives:

- Provide an effective platform, for the research, development, testing and evaluation of technologies and practices that reduce marine vessel environmental impacts
- Advance US merchant shipping and environmental technology business interests
- Develop stewards of the environment through Cal Maritime student education, community involvement, and maritime business outreach




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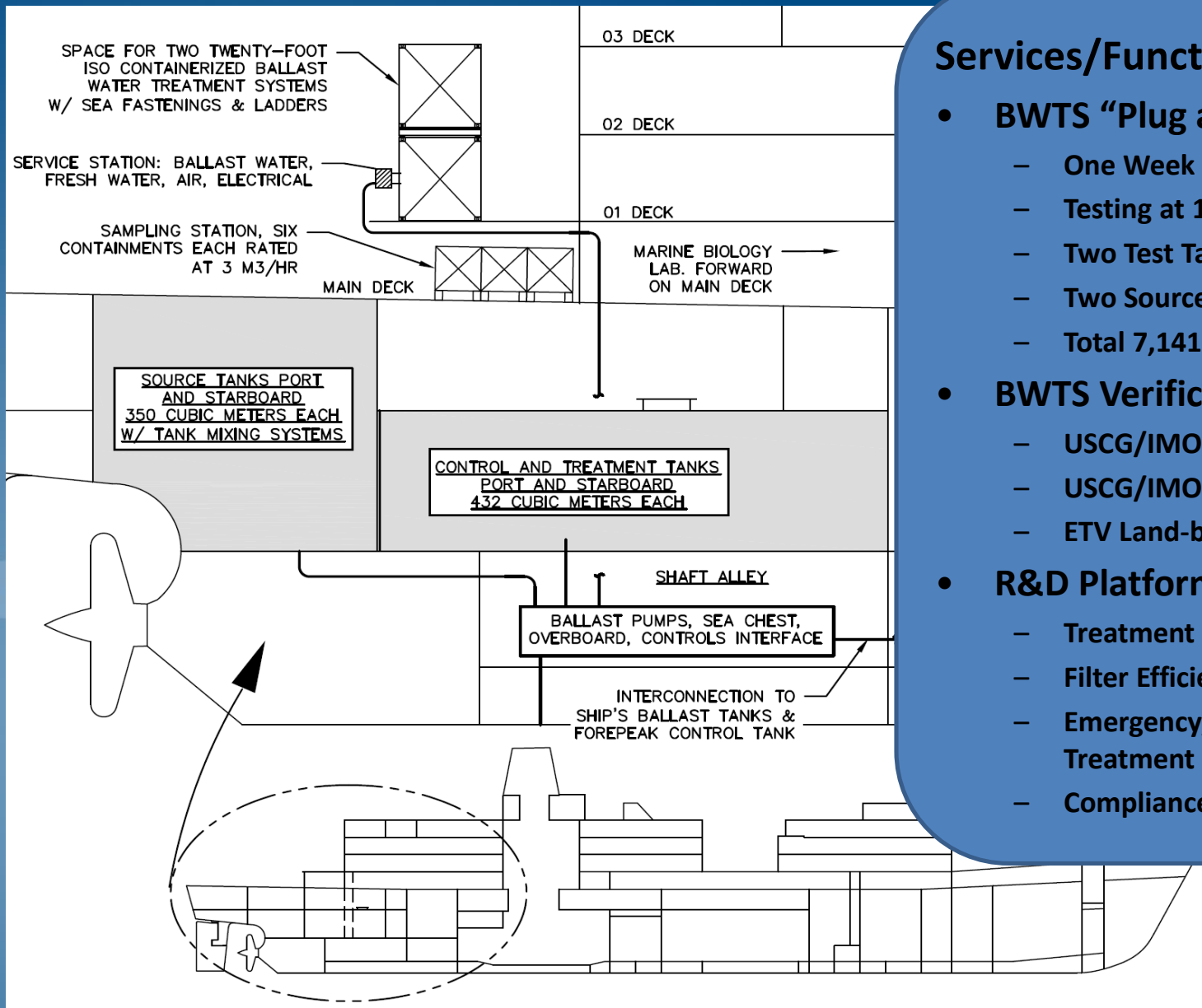
Facility Arrangement & Services

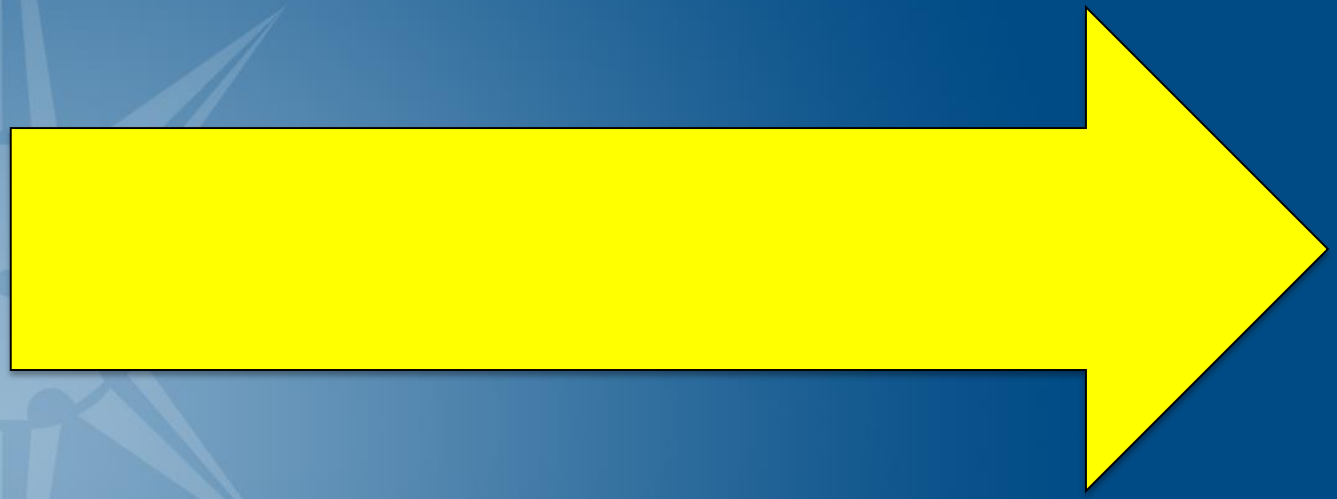


Services/Functions:

- **BWTS "Plug and Play"**
  - One Week to Install & Commission
  - Testing at 100 to 440 m3/hr
  - Two Test Tanks at 432 m3 each
  - Two Source Tanks at 350 m3 each
  - Total 7,141 m3 capacity in 28 tanks
- **BWTS Verification Testing**
  - USCG/IMO Land-based Guidelines
  - USCG/IMO Shipboard Guidelines
  - ETV Land-based Protocol
- **R&D Platform**
  - Treatment System Stress Testing
  - Filter Efficiency
  - Emergency/Interim Ballast Water Treatment
  - Compliance Monitoring Tools

Updates - Personnel

- June 2017 - Scientific Program Manager



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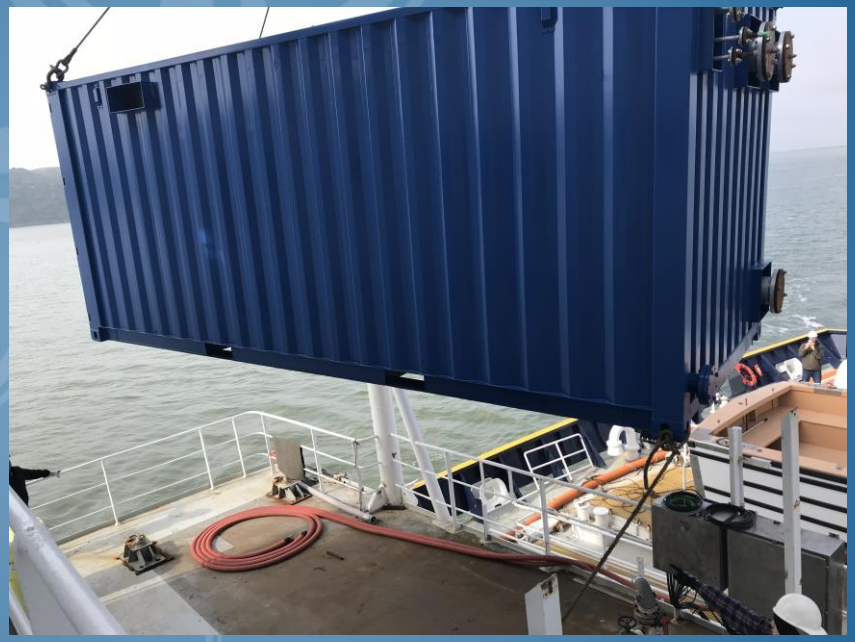
Recent/Current Projects

- Ecochlor
  - USCG/IMO land based and shipboard testing
  - Received USCG TA in late 2017
- Panasia
  - Completed USCG/IMO land based testing
  - Report recently submitted, decision is pending
- Envirocleanse
  - Completed USCG/IMO land based and shipboard testing Feb 2018.
  - Reports to be submitted 2nd quarter 2018
- Recently Installed System
  - Currently performing USCG land based and shipboard testing
  - Anticipated completion by late fall 2018

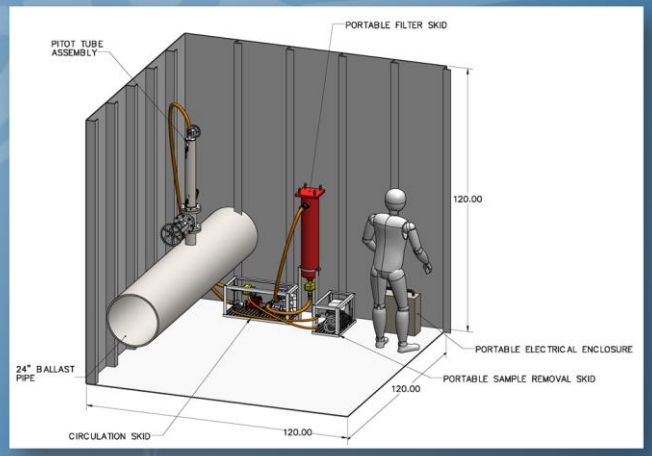

Link-Belt



Recent/Current Projects

California STATE LANDS Commission

Glosten



- Portable compliance sampling rig for collecting representative samples
- Ballast Responder
  - Portable treatment as a contingency in case of BWMS failure
- SkySails – Alternative propulsion
- Waste heat recovery technology
  - Joint project with DOE, DOD, MARAD
- RTC graduate student biofouling project
- R&D Projects – Benchtop and Pilot scale
  - Several full and small scale

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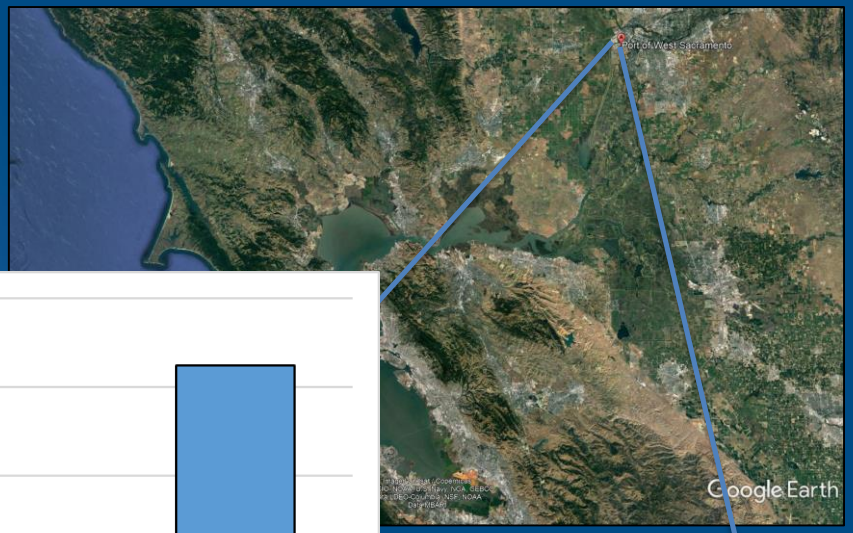
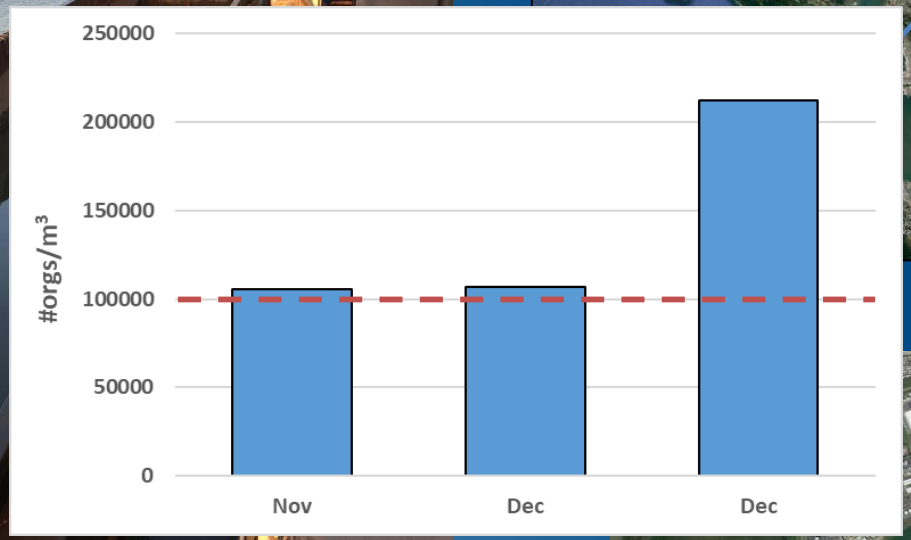
Successes – Freshwater testing





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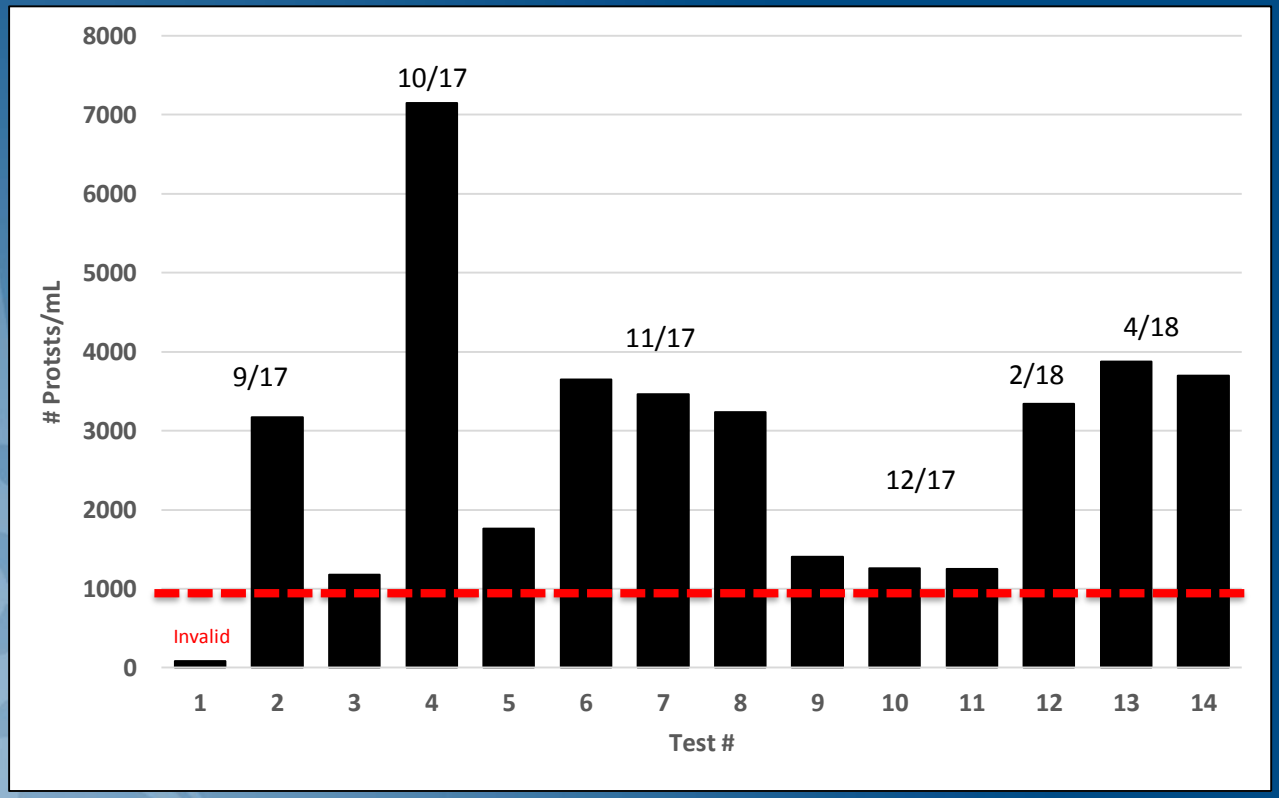
Successes – Phytoplankton

Successes – Phytoplankton



Challenge = 1,000/mL

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USCG Memo on Test Water Augmentation Validation

- USCG sent a memo to all ILs and TFs asking for verification of augment materials used in testing
  - GBRC currently augments certain water quality parameters and phytoplankton through culturing ambient populations

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Augmentation – Water Quality

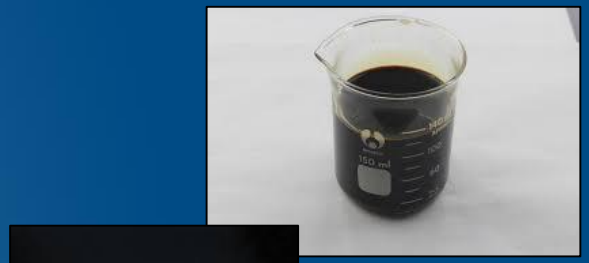
Testing Requirements

	POC (mg/L)	DOC (mg/L)	TSS (mg/L)
USCG	4	6	25
IMO	5	5	50

Ambient SF Bay Conditions

Test Water	PSU	Ambient POC (mg/L)	Ambient DOC (mg/L)	Ambient TSS (mg/L)
Fresh	0 - 1.0	0.8 - 3.2	2.0 - 3.2	3.9 - 15.6
Brackish	10.0 - 20.0	1.3 - 3.3	1.6 - 2.8	16.2 - 53.9
Marine	> 28.0	1.2 - 4.0	1.8 - 3.5	15.4 - 44.5

POC – Corn starch
TSS – Kaolin clay, Test Dust
DOC – Sodium citrate, Lignin sulfonate



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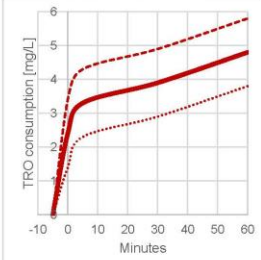
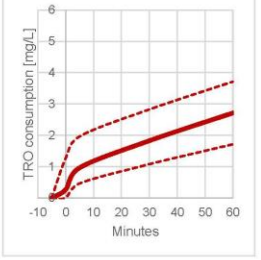
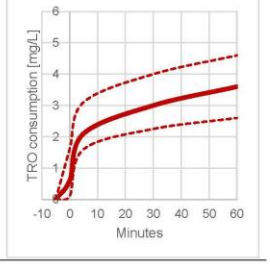
Augmentation – Water Quality

ETV Protocol states that one objective of the challenge conditions is to verify a BWMS's performance using a set of challenging, *but not rare*, water quality conditions in the natural environment.

- DOC must be augmented to achieve USCG required level of 6 mg/L for all salinities
- DOC additives may be aromatic and complex (e.g. lignin) or "simple" (e.g. sodium citrate)
- Aromatic DOC alters natural water's UV absorption, consumption of TRO, and formation of disinfection by-products whereas "simple" DOC additives do not
- "Simple" DOC sources have little to no effect on water parameters important to measuring efficacy of a BWMS (e.g. UVT%, TRO consumption)

DOC and TRO Consumption

Table 1 Target TRO consumption of test water

Water quality	TRO consumption [mg/l] after X min (Reference: TRO injected) 0 min	5 min	30 min	60 min	TRO consumption curve
Brackish water	2.4 (± 1)	3.3 (± 1)	3.9 (± 1)	4.8 (± 1)	
Marine water	0.3 (-0.5/+1)	1.0 (-0.5/+1)	1.8 (-0.75/+1)	2.7 (± 1)	
Fresh water	0.6 (-0.5/+1)	2.1 (-0.5/+1)	3.0 (-0.75/+1)	3.6 (± 1)	

Test Water	PSU	Target TRO Consumption (mg/L-hr)	Ambient (mg/L-hr)	Augmented (mg/L-hr)
Fresh	0 - 1.0	3.6 ± 1	3.2	3.8
Brackish	10.0 - 20.0	4.8 ± 1	5.1	5.7
Marine	> 28.0	2.7 ± 1	2.4	3.2

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Augmentation – Phytoplankton

- “In cases where ambient organisms are concentrated through harvesting or culturing, all efforts should be made to preserve natural relative frequency distribution in the resulting challenge water”

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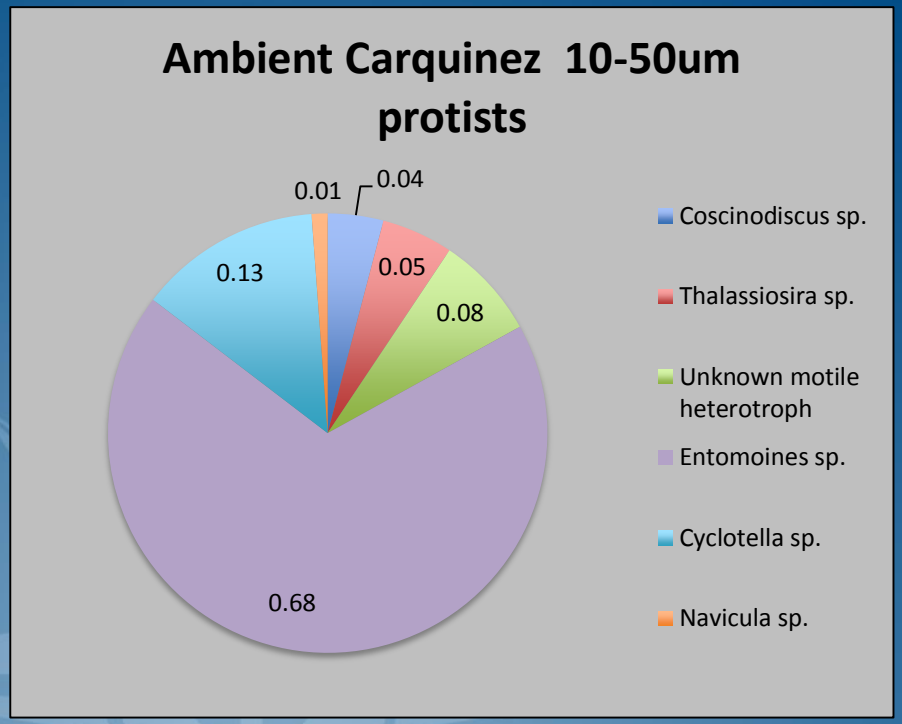
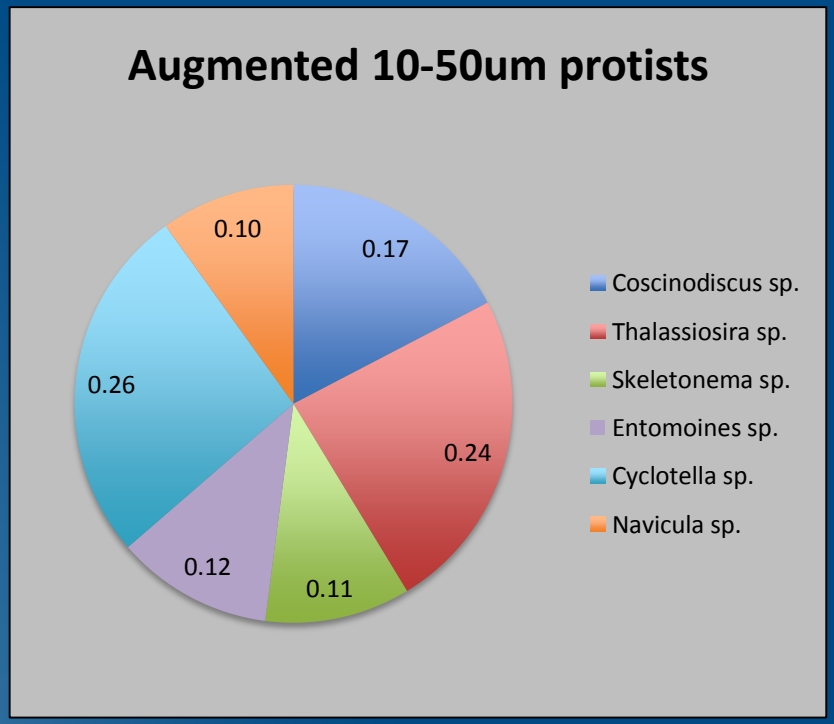
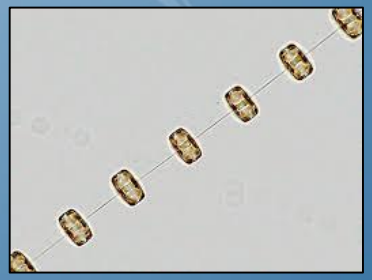
Augmentation – Phytoplankton

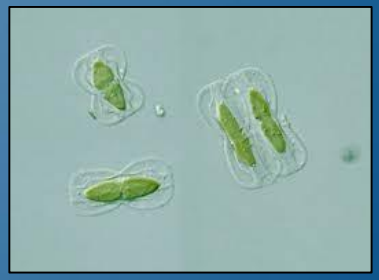


n = 171/mL

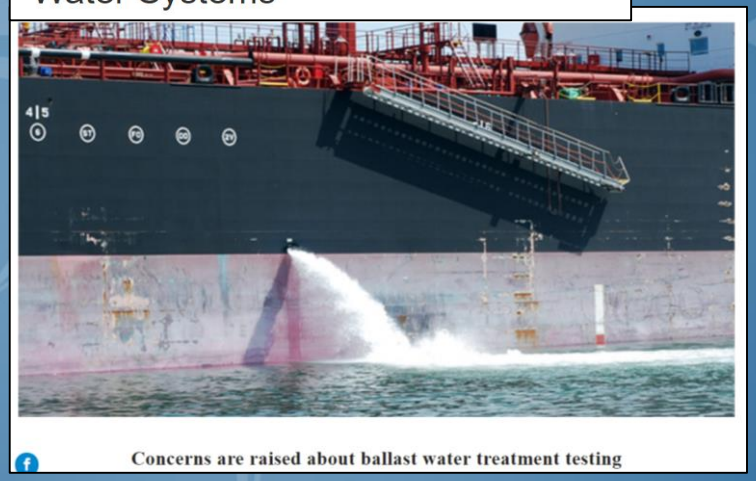


n = 2420/mL





Testing Facility Closures



- Valid concerns were raised with current regulations:
  - Non-motile = non-living
  - Organisms smaller than 10 µm in “minimum dimension”, such as several species of *Pseudonitzschia,* do not fit in a regulated size class
  - Lack of transparency with the testing process and results
- Lack of a standardized approach
  - Global TestNet

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Statements Regarding TF Closures

Statement by Global TestNet

2nd February 2018,
Annual Meeting, London

This statement is in response to stakeholders' potential concerns raised as a result of recent closure of two test facility members of the Global TestNet. These concerns may revolve around whether there is still adequate capacity to process certification tests in a timely manner, and whether the testing protocols are adequately robust.

As an international association of test facilities, we have recently welcomed new members into our organization. These additions should help to maintain testing capacity globally. The Global TestNet continues its commitment to analyse and address concerns about the BWMS testing protocols and their implementation (see mission statement below).

The Global TestNet is actively improving testing by being a forum for discussion and sharing of experiences and data, promoting comparable and accurate test results.

The growing experience base within the Global TestNet has provided the basis for better aligning implementation of methods to improve consistency and robustness of testing. Feedback from compliance checks especially during the IMO's Experience Building Phase, will be crucial to support Global TestNet progress.

Global TestNet Mission Statement:

"To promote comparable and accurate test results on the performance of ships' ballast water and biofouling management systems for certification and protection of the natural environment and biological diversity, in particular but not exclusively by facilitating an open exchange of information, transparency in methodologies and advancing the science of testing, for the public benefit."

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.

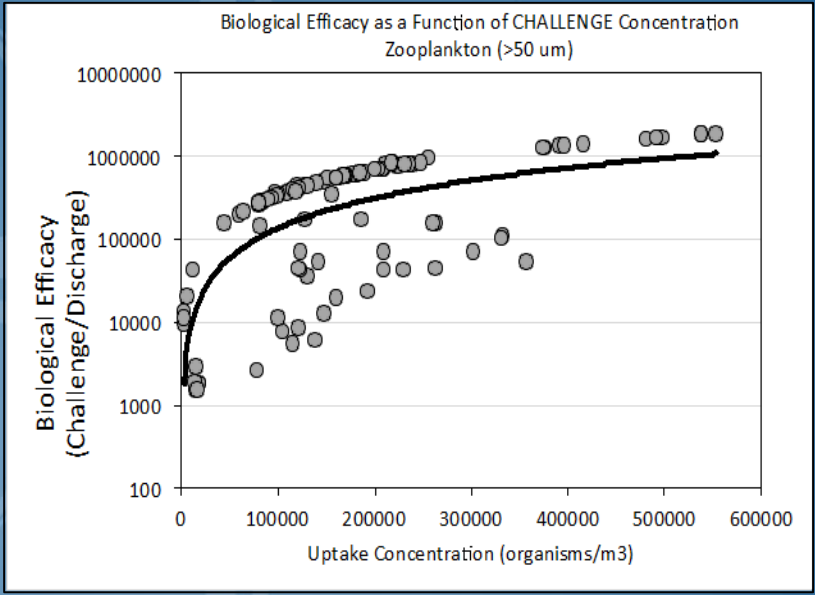
It is clear to us that the international and federal ballast water discharge standards (BWDSs) need attention/correction to modify literal interpretations of the law that seem counterintuitive to ballast water management. However, there seems to be a swelling doomsday sentiment that examples, such as 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.

GBRC Statement Regarding TF Closures

- It is clear that BWDSs need attention/correction to modify literal interpretations of the law that seem counterintuitive to ballast water management
- However, we object to the swelling doomsday sentiment that there is a patent failure of BWTS in the abatement of potentially aquatic invasive species.



- BWDS equate to a “line in the sand” rather than looking at the whole quantitative impact of BWTSs
- 110 comparisons of “uptake” vs “discharge” yielded organism reductions from 1,000 – 1,000,000x (!!), with over 50% of the samples in the 100,000 – 1,000,000x range

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GBRC Statement Regarding TF Closures

- BWTSs should be thought of as one component of a larger BWMS.
- Ships must have reliable treatment systems installed and operated, routinely and collectively
- 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
- A realistic acknowledgement must be given to the fact that ballast water management, even if coupled with perfect control of all shipping vectors (e.g. biofouling) CANNOT eliminate the global spread of invasive species entirely; it is an abatement program, but likely not an elimination program

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Other Projects- SkySails

- SkySails is the first company to successfully commercialize towing-kite technology into industrial products.
- SkySails products efficiently capture high-altitude wind energy for both mobile and stationary applications.
- The purpose of the effort is to evaluate whether the potential positives in fuel savings, and emissions reductions outweigh the potential costs

Other Projects- SkySails

- Phase 1 of the project will occur during TSGB's summer 2018 cruise
- Recently installed V-PER software will use real time data during the cruise to optimize vessel performance
- Later phases of the project will use the V-PER software to guide a sail installed on the TSGB, if Phase 1 proves feasible

Thank you!

Christopher Brown
cwbrown@csum.edu
(707) 654-1282