MH Systems, Inc.

May 4, 2009

San Diego Unified Port District
Environmental Services
P.O. 120488
San Diego, CA 92112-0488

Attention: Eileen Maher

Dear Ms. Maher:

Enclosed is the proposal titled**:** Conduct Land Based Tests to Confirm Scripps Institution of Oceanography's (SIO) Laboratory Kills of Aquatic Nuisance Species (ANS)

Project Description: The land-based tests of the very successful laboratory tests are required by the International Maritime Organization (IMO) of the United Nations for qualification of the MH Systems ballast water treatment system. Following the G (8) guidelines of the IMO, MH Systems' will provide SIO with necessary hardware (two tanks -7ft diameter x 7 feet high, instrumentation, etc) and procedures for conducting the tests. MH Systems will submit the results to the IMO as well as to the San Diego Unified Port District (SDUPD).

Time Line: The entire proposed effort is estimated to require 9 months after the receipt of the contract.

Project Manager's Contact information: Mo Husain 858 452 1280 husainm@mhsystemscorp.com

Cost of Proposal: $99,956.00

Benefit to San Diego Bay: The ballasting ships of the world are badly polluting the harbors as they empty their ballast water containing harmful foreign organisms. San Diego harbor is no exception according to California State Lands Commission. Recognizing this the SDUPD supported MH Systems in preparing the contract design of this BWT system for installation in the SIO operated oceanographic research vessel R/V Melville. The shipboard installation and test (being funded separately) with the land based tests confirming the kill results will certify the safety of Melville's ballast discharge. It will also provide this example to other ships de-ballasting in San Diego.

-more-

10951 Sorrento Valley Road, Suite 2F
San Diego, CA 92121
Mailing Address: P.O. Box 825, Del Mar, CA 92014

Phone: 858-452-1280 Fax: 858-452-6035
Web Site: www.mhsystemscorp.com
E-mail: husainm@mhsystemscorp.com

MH Systems, Inc.

Source of Matching Funds: MH Systems has been and will continue to financially support the SIO scientists conducting additional laboratory tests required by IMO to accompany the land based tests and the MH Systems' staff of engineers will contribute hours of effort not being funded by the project. Furthermore, Dr. Horst Felbeck of Scripps Institution of Oceanography is also contributing hours of his own effort. Thus the total matching fund contribution is: 33%

We share your dedication in protecting and improving the environmental conditions of San Diego Bay, and we look forward to working with you and with the San Diego Unified Port District.

Sincerely yours,

Mo Husain
President

10951 Sorrento Valley Road, Suite 2F
San Diego, CA 92121
Mailing Address: P.O. Box 825, Del Mar, CA 92014

Phone: 858-452-1280 Fax: 858-452-6035
Web Site: www.mhsystemscorp.com
E-mail: husainm@mhsystemscorp.com

Proposal

To Conduct Land Based Tests

To

Confirm Scripps Institution of Oceanography Laboratory Kill of Aquatic Nuisance species (ANS)

Submitted to

San Diego Unified Port District

By
M H Systems, Inc.
10951 Sorrento Valley Road, 2F
San Diego, CA 92121
POC: Mo Husain -Phone: 858 452 1280

And

With Support from

Scripps Institution of Oceanography
University of California
San Diego

Email: HusainM@mhsystemscorp.com

May 4, 2009

Table of Contents

List of Enclosures:

1. Final Report - Forwarding Letter only. Entire Report is on SDUPD Website

2. "Stopping the Stowaways" – Exploration Magazine – Scripps Institution of Oceanography

MH Systems, Inc.

I. Introduction:

Background: San Diego Port and Bay Area problems with ballast water discharge: San Diego harbor has problems with ballast water discharge. According to statistics generated by the California States Lands Commission, approximately 75,000 and 76,000 metric tons per year was discharged in 2006 and 2007 respectively. 48% of the ballast water discharge comes from auto carriers.

Eliminating the pollution of the San Diego Bay by polluted ballast water protects the bay water habitat encourages restoration of marine life and prevents indigenous marine organism from damage by the pervasive pollution. Ships coming to our harbor must empty ballast water prior to loading. Ships' ballast water taken in any other port can be inhabited with species that are injurious to indigenous species in our bays/ports. Moreover, port water-bodies are generally connected to a vast network of inland waterways. A ballast water treatment system is urgently required that can economically 'kill' Aquatic Nuisance Species (ANS) and thus protect indigenous species and permitting restoration of both flora and fauna species that are natural to our bay or port area of waters. The SDUPD recognized this situation and last year took the lead in initiating the activities necessary to protect this harbor. A contract was awarded to MH System for this purpose as described more further herein. Also, environmental education has been and will continue to be unusually well supported by this proposal since the additional biology research will be conducted at Scripps using undergraduate students under the supervision and guidance of the Scripps project manager, Professor Horst Felbeck . (See article enclosed – *"Stopping the Stowaways" – Exploration Magazine – Scripps Institution of Oceanography)*

MH Systems, Inc.

The System: The ballast water system that can protect the San Diego Harbor has been developed by the naval architects and marine engineers of MH Systems in cooperation with marine biology scientists of Scripps Institution of Oceanography (SIO). The ballast water is treated by inert gas. The inert gas is bubbled through the ballast water via a row of pipes with diffusers located at the bottom of the tank. The inert gas is from a marine inert gas generator and is composed of approximately 84% nitrogen, 12-14% CO_2 and about 2% oxygen. The ballast water is equilibrated with gas from the inert gas generator. As a result the ballast water becomes hypoxic, killing many organisms, and contains CO_2 levels much higher than normal causing the pH to drop from the normal pH of sea water (pH8) to approximately pH6. These changes induces hypercapnia in the organisms, killing the remainder. After the gas has bubbled through the ballast water the CO_2 has been essentially completely absorbed (no carbon foot print) and the gas is exhausted in compliance with the design by the classification society Det Norske Veritas.

After 5 years of research and system design studies and analysis, the system is now ready for demonstration to the International Maritime Organization (IMO) of the UN for approval. The demonstration must comply with the requirements in the G(8) section of the IMO ruling. This requires additional laboratory tests, land based pilot scale tests and system installation, trials and tests on board a ship as such as the Scripps' research ship R/V Melville, based in San Diego. A preliminary design was prepared and SDUPD awarded a contract which included the vital component - Contract Design of the system for installation of the BWT system on R/V Melville. The Contract Design facilitates fixed price bidding by competing shipyard for production of the system and installation on the R/V Melville. .

Required Tasks(for IMO Approval): Activities required to test ballast water treatment by Inert gas consists of three (3) parts: (1) *Additional Laboratory Test by Scripps –MH Systems, Inc.*

initiated funding in March, 2008, (2) ***Land based tests –the subject of this proposal and request for funding from SDUPD***, and (3) S*ystem installation and tests on R/V Melville*

.

The matching funds shown are estimated to be $33,300 – 33% of the proposed cost. Furthermore, MH Systems, Inc. has requested funding from the Senate (Defense) Appropriation Committee and House Appropriation (Defense) Committee for $880,000 (FY 2010) for the installation of the ballast water treatment system on board R/V Melville.

Land-based tests: The land-based testing (in parallel with the laboratory tests) serves to validate at pilot scale level the biological efficacy of the MH Systems ballast water treatment system under consideration for to the IMO for approval. The tanks for the land based test set-up will be two tanks (7 ft diameter and 7ft high) about 2100 gallons each. One tank will be fully instrumented for continuous monitoring. As required by section G(8) of IMO rules, following are the excerpts from IMO guidelines for land based tests as shown in Table 1:

TABLE 1

1. For any given set of test cycles (5 replicates is considered a set) a salinity range should be chosen in one of the following combinations:

Salinity	> 32 PSU	15 - 25 PSU	< 3 PSU
Particulate Organic Carbon (POC)	> 1 mg/l	5 - 10 mg/l	5 - 10 mg/l
Particulate Organic Carbon (POC)	> 1 mg/l	5 - 10 mg/l	5 - 10 mg/l
Total Suspended Solids (TSS)	< 5 mg/l	< 5 mg/l	< 5 mg/l

2. At least two sets of test cycles will be conducted, each with a different salinity range and associated dissolved and particulate content as shown herein.
3. Test organisms may be either naturally occurring in the test water, or cultured species that may be added to the test water. The organism concentration should comply with section 4 below:
4. The following parameters will characterize the influent water.
5. Test organisms of greater than or equal to 50 micrometers or more in minimum dimension should be present in a total density of preferably 10^6 but not less than 10^5 individuals per cubic meter, and should consist of at least 5 species from at least 3 different phyla/divisions;
6. Test organisms greater than or equal to 10 micrometers and less than 50 micrometers in minimum dimension should be present in a total density of at least 10^4 individuals per milliliter, and should consist of at least 5 species from at least 3 different phyla/divisions;
7. Heterotrophic bacteria should be present in a density of at least 10^4 living bacteria per milliliter;
8. The variety of organisms in the test water should be documented according to the size classes mentioned above regardless if natural organism assemblages or cultured organisms were used to meet the density and organism variety requirements.
9. The following bacteria, except V. cholerae, can be tested in this land based test, if proper permits are available otherwise smaller scale laboratory should be used.
   1. Coliform; 2. Enterococcus group; 3. Vibrio cholerae; 4. Heterotrophic bacteria.
10. If cultured test organisms are used, then it should be ensured that local applicable quarantine regulations are taken into account during culturing and discharge.

Land-based monitoring & sampling

1. organisms of greater than or equal to 50 micrometers or more in minimum dimension;
2. organisms greater than or equal to 10 micrometers and less than 50 micrometers in minimum dimension;
3. for coliform, enterococcus group, Vibrio cholerae and heterotrophic bacteria; and
4. toxicity testing of treated water, from the discharge, for Ballast Water Management System (BWMS) that make use of Active Substances and also for those BWMS that do not make use of Active Substances but which could reasonably be expected to result in changes to the chemical composition of the treated water such that adverse impacts to receiving waters might occur upon discharge.

Set forth below are the descriptive titles of the tasks required to perform the land based tests. In Section III of the Cost Proposal cost and schedule of each task is presented.

TASK 1. Design the tanks (and modifications) for installation and tests

TASK 2. Design the diffuser system

TASK 3. Design the Instrumentation System

TASK 4. Purchase Hardware

TASK 5. Install the tanks at Scripps as instructed (in a area where sea water is available)

TASK 6. Test the Diffuser System

TASK 7. Assist Scripps Scientists to initiate testing with ANS as described in **Table 1.**

TASK 8. Conduct tests at Scripps

TASK 9. Project management and report preparation to SDUPD and IMO

Concluding remark: By the middle of 2010, the 'additional' laboratory test and the land based test will have been completed and the contract design sent to the shipyards for bids. Subsequent installation and test will make R/V Melville's ballast water safe and provide the techniques to make all ballasting ships safe for San Diego.

APPENDIX A.

II. Qualifying Experience

During the last five years MH Systems naval architects, marine engineers and system analysts and marine biology scientists and undergraduate students at the Scripps Institution of Oceanography have conducted research, ship design studies and analyses of the MH Systems Ballast Water Treatment system. This research, design and analyses have been documented in papers presented in International Symposium in Helsinki, London, Ireland and Singapore and are available for review. The Singapore paper describes the impending installation in R/V Melville and being pertinent to this proposal is enclosed.

In 2004, MH Systems completed a $3.4 million dollar project with the office of Naval Research (ONR) to test on the tanker USNS Shoshone the system that MH Systems developed to mitigate the outflow of crude oil in the case of a grounding damage or collision. The concept for the ballast water treatment evolved from this concept. Robert Apple, the proposed project manager for this project was also the Project Manager for the ONR contract. Contract Numbers- N00014-02-C-0515 for the last contract: Contracting Officer: Todd T Hanson and John T. McCain – (703 696 4525)

In 2007, MH Systems received a contract from the San Diego Unified Port District (SDUPD) for $100,000 for “Initiate Activities Required to Test Ballast Water Treatment by Inert Gas”. This contract was concluded by October 30, 2008. The Point of Contact for this contract at SDUPD) was Eileen Maher.

Scripps Institution of Oceanography is, of course, known internationally as one of the great centers of marine biology research and education. Professor Horst Felbeck, the associate of this project is internationally known for his work in marine biology and also as co-author with Apple and Husain all of the papers on ballast water treatment discussed above.

Sub-Consultants – Scripps Institution of Oceanography of the University of California, San Diego is a subcontractor for the biological research and tests. Their associate Project Manager is Dr. Horst Felbeck. Scripps statement of work is summarized in page 3 and 4 (Land-based tests), and discussed with cost in appendix B. Dr. Felbeck's resume is in appendix C.

Following personnel are ex-employees of MH Systems, Inc. They will be re-hired as contactor/sub-consultant on as needed basis:

Steve Donley He is an experienced marine engineer with extensive experience in the Inert Gas Generator system design. He will assist with diffuser design.

Joe McDonald He is an experienced electronics/test engineer. He will assist with instrumentation design.

John Murray He is an experienced marine draftsman and designer. Formerly with National Steel and Shipbuilding Company (NAASCO). He will assist with drafting.

John Angles He is an ex-VP of MH Systems, Inc. and is now semi-retired. He is a noted Marine Engineer and has had extensive experience in the design of ship's machinery system of naval and commercial ships including design of machinery system of large super-tankers as director of engineering at National Steel and Shipbuilding (NASSCO). He will be on call for assisting in all tasks.

Ian Hirschsohn He is a nationally known professional in Computer Science and software development. He will assist with instrumentation design.

Charles F. Quirmbach He is an experienced analyst. He will assist with the analysis of the test setup.

APPENDIX B

III. Cost Proposal

The tasks that MH Systems will accomplish and the costs are presented first. Then the descriptions of the research to be conducted by Scripps is summarized with their costs.

The proposed tasks are to be completed in six (6) to eight months (8).

Task Title

TASK 1. Design the tanks (and modifications) for installation and tests

TASK 2. Design the diffuser system

TASK 3. Design the Instrumentation System

TASK 4. Purchase Tank, Tank Hardware & Electronic Instruments

TASK 5. Install the tanks at Scripps as instructed (in a area where sea water is available)

TASK 6. Test the Diffuser System

TASK 7. Assist Scripps Scientists to initiate testing with ANS as described in **Table 1.**

TASK 8. Conduct Tests (Scripps)

TASK 9. Project management and report preparation

Total Cost By Task Elements 1

	Labor	Material	OH	Total
TASK 1. Design the tanks (and modifications) for installation and tests	6,720.00			6,720.00
TASK 2. Design the diffuser system	5,560.00			5,560.00
TASK 3. Design the Instrumentation System	5,000.00			5,000.00
TASK 4. Purchase Tank, Tank Hardware and Electronic Instruments		31,200.00	2%	31,824.00
TASK 5. Install the tanks at Scripps as instructed	2,000.00			2 ,000.00
TASK 6. Test the Diffuser System	4,500.00			4 ,500.00
TASK 7. Assist Scripps Scientists to initiate testing with ANS	2,200.00			2,200.00
TASK 8. Conduct Tests (Scripps)		34,855.00	2%	35,552.00
TASK 9. Project management and report preparation	6,600.00			6,600.00
				99,956.00

MH Systems, Inc.

Hourly Rates for Personnel

Mo Husain	$ 120 / hour
Bob Apple	$ 110 / hour
Steve Donley	$ 84 / hour
Joseph McDonald	$ 62 / hour
John Murray	$ 70 / hour
John Angles	$ 110 / hour
Ian Hirschsohn	$ 110 / hour
Charles Quimbach	$ 100 / hour
Dr. Horst Felbeck (SIO)	$ 85 /hour (without overhead)

Matching Fund Estimate

Donation to Scripps

From MH Systems for Additional Laboratory Tests $1,000.00

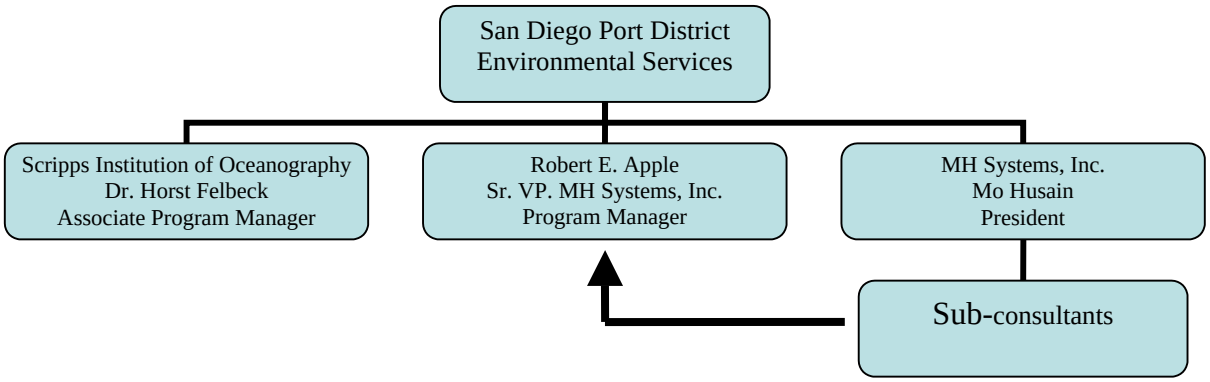
Labor $ in-kind contribution:

Mo Husain	120 hrs @ $120/hour	$14,400.00
Bob Apple	40 hrs @ $110/hour	$ 4,400.00
John Angles	40 hrs @ $110/hour	$4,400.00
Charles Quirmbach	40 hrs @ $100/hour	$4,000.00
Horst Felbeck (SIO)	60 hrs @ $85/hr	$ 5,100.00
	TOTAL	$33,300.00

Appendix C

IV - Personnel

Project Organization Chart



Mr. Robert E. Apple is the Program Manager.

Dr. Horst Felbeck of Scripps Institution of Oceanography is the` Associate Program Manager

Mr. Mo Husain, President of MH Systems, Inc. will supply the individuals sub-consultants (all were previous employees of MH Systems)

List of Sub- Consultants:

Steve Donley – Inert Gas System

Joe McDonald – Control System and Sensors

Ian Hirschsohn. – Computer Science, Control System & Sensors

John Murray – Piping Arrangement

John Angeles – Senior Marine Engineer (former VP of MH Systems)

Charles Quirmbach – Senior Analyst

CS Controls – A subcontractor specializing in Control System hardware and instrumentation

Resume

Following are the resumes of Key Personnel:

Mo Husain – President, MH Systems, Inc.
Mo Husain is the developer of the American Underpressure System - an advanced spill avoidance system for oil tankers. Mr. Husain provides overall direction of all advanced technical projects within the MH Systems organization. A graduate of the University of Michigan in Naval Architecture and Marine Engineering, Mr. Husain has over 30 years experience in ship systems engineering, specifically in the field of Hydrodynamics of ships, Loads and Motion analysis, probabilistic design criteria analysis, and design and development of high performance weapons platforms.

Robert Apple - Program Manager
Mr. Apple has a MSME degree and 40 years experience in the leading of research, designs, and the managing of maritime projects. He was project manager for the contract machinery design of six new classes of warships including the first nuclear cruiser (CGN9)and first Nuclear Destroyer - DLGN 25. As Vice President of Litton Ship Systems, was program manager that won the billion dollar design contract for the General Purpose Amphibious Assault Ship (LHA) He was SNAME representative on the Accreditation Board for Engineering and Technology (ABET). Currently, he is the program director at the MH Systems, Inc.

Dr. Horst Felbeck – Associate Program Manager
Marine Biology Research Division
Scripps Institution of Oceanography, 0202
University of California, San Diego
La Jolla, CA 92093-0202

Dr. rer. nat. 1979 Westfälische Wilhelms-Universität, Münster, Germany

7/1998 - present	Professor of Marine Biology, Scripps Institution of Oceanography
7/1988 - 6/1998	Associate Professor of Marine Biology, Scripps Institution of Oceanography
7/1983 - 6/1988	Assistant Professor of Marine Biology, Scripps Institution of Oceanography
1/1983	Postgraduate Research Biologist, Scripps Institution of Oceanography
1979 - 1982	Postdoctoral fellow, Scripps Institution of Oceanography; Advisor: Dr. George Somero

MH Systems, Inc.

John Angles

Educated at Kirkcaldy Technical College, Scotland, Mr. Angles is a graduate in Marine Engineering and Naval Architecture under the engineering apprenticeship program at Burntisland Shipbuilding, Scotland. He has thirty five years of experience in ship design and shipbuilding. In National Steel & Shipbuilding, Mr. Angles was the Manager of Marine Engineering – he was responsible for all machinery system of new construction including machinery design of Exxon Valdez.

Ian Hirschsohn

Mr. Hirschsohn has a M.S. in Aeronautical Engineering from Princeton University and a M.S. in Engineering Sciences from Purdue University. He was in the Ph.D. program in the University of California, San Diego in Statistical Analysis of Fluid Turbulence using large mainframes; he left the program to found ISSCO, Inc., a leading graphics software development company. He has over 30 years of experience in software development, computer architecture and hardware design.

Steve Donley

B.S. degree in Mechanical Engineering from University of Southern California. Design Engineer in charge of Ship's machinery and piping systems. Extensive experience in Inert Gas Systems, piping calculations, stress analysis and writing of ships construction specification.

Joseph McDonald

30 years of experience in designing control and electronic systems of ships.
Extensive experience in test and trials of ships.
He is involved in all aspects of engineering and Control Systems including modeling, signal processing and analysis of computer systems.

Charles F Quirmbach

Mr. Quirmbach has a BS from the California Institute of Technology and an MS from the University of California, Los Angeles. He has 35 years of engineering and scientific experience

in the marine and aerospace industries. His experience includes analysis and design of high performance vessels, system requirements and interface definitions of major US Naval Vessels and responsible for design, manufacturing and quality standards and testing of inertial grade gyroscopes, accelerometer, and inertial navigation systems for specific applications by the U.S. Navy.

Supporting Documents

1. University of California, San Diego
   Detailed budget request for the period from 09/01/08 through 08/31/09.

2. Budget Justification for requested funding of Scripps Institution of Oceanography in support of activities delineated in this proposal.

3. Technical Paper presented in Singapore, September 2006. (Singapore Paper September 2006.pdf)

REFERENCES

1. Harmonized implementation of the Guidelines for Approval of Ballast Water Management Systems (G8) MEPC.125 (53)

   INTERNATIONAL CONVENTION FOR THE CONTROL AND MANAGEMENT OF SHIPS' BALLAST WATER AND SEDIMENTS, 2004 – BWM.2/Circ.8, 27 October, 2006

Detailed budget according to UCSD guidelines

UCSD SALARIES & EMPLOYEE BENEFITS (2009/10) **MH Systems, Inc.**

Name and Payroll Title	* Monthly Salary Recharge Rate	Actual F/T Equivalent Person-Months Dedicated to Project	Total Salaries and Emp. Benefits Requested
Horst Felbeck Professor	$0	0.00	$0
TBN Undergraduate Student Researcher (20h/wk @ $11hr)	$880	4.00	$3,520
TBN Undergraduate Student Researcher (20h/wk @ $11hr)	$880	4.00	$3,520
TBN Undergraduate Student Researcher (20h/wk @ $11hr)	$880	4.00	$3,520

*Salary recharge rates are calculated for actual productive time only (except for non-faculty academic sick leave which is charged as direct). The rates include components for employee benefits, provisions for applicable merit increases and range adjustments in accordance with University policy. As required to meet project objectives, separate rates for remote location allowance or premium overtime costs may be used.

TOTAL SALARIES & EMPLOYEE BENEFITS $10,560

EQUIPMENT: (ITEMIZE)

TOTAL EQUIPMENT $0

PROJECT SPECIFIC SUPPLIES, MATERIALS & OTHER EXPENSES: (ITEMIZE)

Laboratory Supplies $10,000

OTHER: $2,000

Project specific costs that include telephone equipment, tolls, voice and data communication charges, photocopying, faxing, postage, subscriptions, and laboratory office supplies are requested. Supply and expense items, categorized as project specific, and computer and networking services are for expenses that specifically benefit this project and are reasonable and necessary for the performance of this project. UCSD applies a direct charge equivalent exclusion calculating the D.A. indirect costs, as required in the draft federal interpretations of A-21 section F.6.b.

TOTAL SUPPLIES, MATERIALS & OTHER $12,000

TRAVEL: (DESTINATION & PURPOSE-ITEMIZE TRANSPORTATION, PER DIEM & MISC.)

Domestic:	airfare	no. days	per diem	taxi/bus	registr.	no.trips	total
None	$0	0	$0	$0	$0	0	$0
Trip Detail Here	$0	0	$0	$0	$0	0	$0

TOTAL TRAVEL $0

TOTAL DIRECT COSTS $22,560

INDIRECT COSTS: (based on modified total direct costs & negotiated rate with cognizant audit agency DHHS):

Rate: On-Campus 54.5%

*Base: $22,560

*Base is total direct cost less tuition remission, equipment and ship time.

INDIRECT COST $12,295

TOTAL AMOUNT REQUESTED $34,855

SCRIPPS INSTITUTION OF OCEANOGRAPHY BUDGET JUSTIFICATION - 2009

Personnel costs: The three undergraduate helpers will maintain the testing tank, count and analyze water samples, and sample the incubations. They also will aid in changing the configuration of the gassing setup and record changes in the physical and biological parameters of the water. Each of them will work a maximum of 20 hours/ week. Since the experiments have to be monitored and samples have to be taken on a 24 h basis 3 students will be needed.

Land based testing supplies: One pH electrode and one oxygen electrode will monitor the water in each tank during the incubations. They will be installed at 50% height. The electrodes are constructed for field work and will be attached to fittings in the tank. The two independent meters (one for each tank) will each record temperature, pH, and oxygen concentration and log up to 500 data points for each parameter.

The tanks will be gassed with Trimix, i.e. a gas mix of 2% oxygen, 12 % CO_2 with a balance of nitrogen. While it is possible to buy tanks custom filled with this gas, it is much more economical to mix it on site. One custom made tank (225 cubic feet of gas) costs $150, while the individual components cost far less (CO_2 $15 for 50 lbs; nitrogen 228 cuft, $15; oxygen, 244 cuft, $15). Since the gas use will be high and costs for gases will be a major component of the proposal, we decided to use mass-flow meters and controllers for this purpose. The channel controller/power supply is the central controlling unit for the mass-flow meters. It allows to dial in different relative ratios of gases needed to equilibrate the water in the test tank. All gases needed and all electronic equipment such as electrodes, pH/ oxygen meters, flow controllers and meters, cables etc. will be supplied and installed by MHS.

Laboratory testing supplies: The supply costs are based on past experience for the use of test kits, biochemicals, and general lab supplies.

Appendix D

V. Non Profit Status - Not Applicable

VI. Subconsultants

Sub-Consultants – Scripps Institution of Oceanography of the University of California, San Diego is a subcontractor for the biological research and tests. Their associate Project Manager is Dr. Horst Felbeck. Scripps statement of work is summarized in page 3 and 4 (Land-based tests), and discussed with cost in appendix B. Dr. Felbeck's resume is in appendix C.

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Ian Hirschsohn He is a nationally known professional in Computer Science and software development. He will assist with instrumentation design.

Charles F. Quirmbach He is an experienced analyst. He will assist with the analysis of the test setup.

CS Controls – A subcontractor specializing in Control System hardware and instrumentation

Appendix E.

VII Applicant Disclosure No Environmental Violations

VIII Agreement

MH Systems, Inc. accepts the agreement in the RFP-Environmental Projects Benefiting San Diego Bay dated 03-11-2008 by San Diego Unified Port District Environmental Services including insurance and indemnification clauses.

IX Conflict of Interest

MH Systems, Inc. and Scripps Institution of Oceanography are not now performing services of any kind for any person or entity that would conflict with the services to be provided to the SDUPD under this agreement. Furthermore, MH Systems, Inc. agrees that they would not perform services that would conflict with the service to be provided under this RFP.

X Additional Information

We wish to emphasize that MH Systems, Inc. and Scripps have developed this system during the last five years. The results have been presented at international symposia in London, Helsinki, Finland, and Singapore. The paper presented in Singapore is attached.

In 2007, Board of Port Commissioners of San Diego Unified Port District has awarded a contract to MH Systems, Inc. of San Diego to initiate activities related to test ballast water treatment (BWT) system on board R/V Melville – an Oceanographic Research Vessel operated by the Scripps Institution of Oceanography (SIO). The contract was completed in October 2008.

In 2007, The MH Systems Ballast Water Treatment (BWT) System has had its mechanical design certified by the prestigious classification Society, Det Norske Veritas of Norway. Accordingly, MH Systems, Inc. received “Certificate of Design Approval” for its BWT system for Tanker and Non-Tanker vessels.

Planning for the Forthcoming Full Scale Test of Ballast Water Treatment by Gas with Elevated CO2 On-Board a Scripps Institution of Oceanographic Research Vessel

Mo Husain
Robert E. Apple
MH Systems, Inc.
10951 Sorrento Valley Road, 2F, San Diego, CA 92121, USA
HusainM@mhsystemscorp.com

Horst Felbeck
Scripps Institution of Oceanography, University of California, La Jolla, CA 92093-0202, USA
hfelbeck@ucsd.edu

Abstract

This paper describes planning for a full-scale Ballast Water Treatment (BWT) system on a Scripps Institution of Oceanographic Research Vessel. Discussed are the planned tests, type of treatment, shipboard system description, shipboard testing, and additional laboratory tests and land based tests.

The BWT System will be installed and tested for approval by the Flag States. The system bubbles gas from a marine inert gas generator into the ballast water via a system of pipes in the tanks with attached diffusers. The gas is approximately 84% nitrogen, 12% to 14% CO_2 and 2% oxygen. The water becomes hypoxic with elevated levels of CO_2 that induces hypercapnia in the organisms. The pH is lowered to about 5.5 by the formation of carbonic acid. In the laboratory experiments a gas mixture closely resembling the marine inert gas was bubbled in flasks of sea water containing a broad spectrum of representative invasive species. Excellent kill results were obtained on species of crabs, mussels, barnacles, rockfish, brittle stars, shrimp, copepods and bacteria. The preliminary installation design of the system including test protocols is presented which will qualify the system under IMO Convention guidelines [1].

Keywords: Carbon Dioxide, pH, Hypoxic, Hypercapnia , Marine Inert Gas Generator, Shipboard Test, Land-Based Test, Control System, Scripps Institution of Oceanography

1.0 Introduction

For more than four years naval architects and marine engineers at MH Systems, Inc. and marine biologists from the Scripps Institution of Oceanography have been developing a ballast water treatment (BWT) system. The system is relatively uncomplicated, using conventional marine components, yet uniquely effective. While laboratory tests were conducted at Scripps, the engineers at MH Systems were preparing installation design and economic studies. Tankers from

20,000 dwt to 300,000 dwt were investigated as well as a bulk carrier. Results were presented to the BWT technical community in Helsinki, London [2] and Ennis/Ireland.

The system is now at a stage for full scale investigations in parallel with additional laboratory tests including a land based mini-scale tests. An Oceanographic Research Vessel operated by the Scripps Institution of Oceanography of La Jolla, California will be used for the full scale tests. The testing protocol developed by the IMO [1] will be followed. We are in the process of applying for type approval from Det Noske Veritas (DnV) that will be followed by a formal submittal to the Flag States. This paper will describe the planning of the program in adequate detail to inform the BWT community.

1.2 The MH Systems Ballast Water Treatment System and the Scripps Test Ship

The system described evolved from the observation that the inert gas from a standard marine inert gas generator can treat ballast water so that virtually every type of aquatic nuisance species is destroyed. This is because the ballast water becomes lethal for marine organisms by removing the oxygen (hypoxic) and lowering the pH by raising the CO_2 concentration. A suite of selected aquatic marine species including the bacterium *Vibrio cholerae* were tested concerning the effects of inert gas. In all of these cases, the kill effects were sufficient to satisfy the demands of the proposed IMO regulations. Many species were already dead after a few minutes of treatment.

The Scripps Oceanographic vessel that has been selected is the R/V Melville. The vessel has 10 salt water clean ballast tanks, Figure 1. They range in size from a pair of 14,605 gallon tanks to the smallest pair of 7,322 gallons each. The distance from the after most pair of tanks to the tank in the fore peak is 187 feet (57 m). The total capacity of the 10 tanks is approximately 102,000 gallons or 391 long tons (390 m tons).

Group 1 – Ship System

1. Pre-installation Investigation; 2. Installation, Design, and Long Lead Time Material Ordering; 3. Sensing, Control and Monitoring Sub-system; 4. Inert Gas Generating subsystem; 5. Inert Gas Distribution and Bubbling sub-system; 6 Gas Exhausting System

Group 2 – Bio-Science

1. Additional Laboratory (Research) Test; 2. Land based Tests; 3. Shipboard Tests

This paper will provide extended discussions on each of the above elements of the program.

1.3 Group 1 - Ship Systems

Pre-installation Investigation

It is important that the gas insertion system efficiently treat the ballast water in each of the ballast tanks. Therefore, some physical aspects of the system require further definition prior to the installation design. Optimal gas transfer is dependent on the total gas exchange surface between bubbles and water. It is therefore dependent on the size of the bubbles (smaller bubbles have a larger surface to volume ratio, i.e. they exchange gas faster) and the number of bubbles

(the more bubbles the larger the exchange surface). Calculations indicate that this can be accomplished with piping near the tank bottom, separated by 10 feet and with diffusers installed every 4 feet in each pipe. A simple experimental set up has been formulated to optimize the bubbling. A series of 1" plastic pipes of 'fittable' length will have diffusers installed at various separations from 2 feet to 5 feet. The supply manifold will be designed with the flexibility of allowing the runs of piping to be separated from 4 to 10 feet. When a measured amount of gas is injected through diffusers into a closed but vented tank, the effects on the gas composition of the water can easily be measured. It will therefore be possible to determine an optimal combination of diffuser surface, diffuser spacing, diffuser material and pore size, and gas flow rate.

Installation Design and Long Lead Time Ordering Items

The detail design of the system and associated production drawings can be prepared in about 4 months. It is anticipated that the inert gas generator, because of its small size required for Scripps vessel must be ordered in advance from overseas, which may require about 6 months for delivery.

Sensing, Control and Monitoring Sub-system

This sub-system must comply with the IMO requirements. The inert gas generators are similar to small auxiliary boilers and have been in operation under the control of marine engineers for years. These machines and valves are all automatically controlled with manual over-ride in case of emergency.

In the IMO requirement the words "necessary treatment dosages" may imply a system that uses biocide. However, the MH Systems BW Treatment system utilizes infusion of inert gas (by bubbling) until the ballast water attains a state of hypoxia with a pH of nearly 5.5. Even if infused continually, these final values will not change, as they are dependent on (and in equilibrium with) the composition of the inert gas. Thus this requirement is not strictly applicable. The water will hold that state until discharge. In this state, the water is lethal to all required organisms. The gassing is controlled by the remote and automated control valving system, which can permit sequential tank treatment, or multiple tank treatment simultaneously. When a tank has attained a state of lethality, further infusion of inert gas will cease.

The control system designed for this Ballast Water Treatment system is inherently self-monitored. The MH Systems controls are active dynamically during the period of infusion of inert gas i.e. bubbles in the ballast water. Then as the lethality is set, the system is active in the steady state condition during the contact time – probably for about 24 to 48 hours. The oxygen concentration and pH of the water of each tank is monitored and recorded for each tank, sequentially, in real time. The control system software of this Ballast Water Treatment System includes self-diagnosis of failed sub-systems as well as all monitoring equipment. A data logging subroutine will periodically log all operating parameters and alarm activation and deactivation.

Inert Gas Generating Sub-system

A standard marine inert gas generator will be used for generating the inert gas. Preliminary calculations indicate that a 200 m^3/hour should be adequate or a 500 m^3/hour maximum. The generator is packaged and skid mounted for easy installation. The suppliers of these generators are based in Europe and Korea with a lead time of at least 6 months. The foot print of this generator is approximately 3'x 6' and 7' high. The generator package includes a blower which may not be adequate to overcome the static head of the ballast water in the tank and the piping loss. It is estimated a 20 psi compressor will be adequate for the purpose.

Inert Gas Distribution and Bubbling Subsystem

This subsystem consists of a piping group and a group of remotely controlled valves. A single 3 inch supply line pipe is installed amidship the length of the ship from the gas generator to the peak tank. Two inch distribution piping is installed athwartship from the supply pipe to each pair of ballast tanks (total of 4) and is also manifolded at the bottom of the tank for the bubble piping. The 1 inch bubble piping runs fore and aft from the manifold and with 10 foot separation. Each bubble pipe has a row of diffusers installed with either three feet or four feet separation. The required separation distance will be determined from the laboratory tests.

The function of the valving is to control the flow of gas to each tank as required for the state of lethality in that tank. Various tanks have different requirements for gas bubbling due to the differences in size. Therefore a supply valve is required for each tank and will probably be placed at the junction of the supply pipe and the distribution pipe. The valves will be electric solenoid controller type.

Gas Exhausting System

After the inert gas has bubbled through the ballast water it has taken in oxygen (hypoxic water) and the carbon dioxide content has been reduced (lowering the pH) but still not life supporting. To ensure safety, the regulatory agencies have suggested the installation of exhaust piping to the deck space. On tankers the inert gas and fuel oil vapor in the ullage space is vented on deck area via a goose neck fitting. The exhaust subsystem will require some design studies to optimize.

Facilities for Kill Testing

The condition monitoring system will be used both for testing the tanks for oxygen content and pH as well as for obtaining ballast water samples for examination of kill success. Water samples from all ten tanks are obtained upon command remotely and passed through a pH and oxygen monitor and the results can be viewed from the control room. The effectiveness of the system to kill all of the required aquatic nuisance species and bacteria must be measurable and the methodology of determining this must be rigorously established. The IMO [1] has promulgated an extensive set of procedures to be followed.

1.4 Group 2 - Bio-Science

Additional Laboratory (Research) Test

MH Systems will be able to meet the pending S.363 [3] and IMO discharge standards, as shown in the Table 1. It uses the concerted effects of three methods to kill organisms in ballast water: decrease of the oxygen concentration, increase of the CO_2 levels and decrease of the pH. Reactions of prokaryotes, plants and eukaryotes to changes in these parameters vary widely. While some species are killed within seconds or minutes others may survive for several days or even longer. Our experiments demonstrate that all of the species tested were killed at the latest within a few hours to 48 hours. The already completed tests will have to be augmented with experiments with algae and microorganisms such as planktonic larvae and eggs, phytoplankton, and bacteria. Many published references investigating the effects of the individual parameter changes confirm that most species will be killed quickly by the proposed treatment.

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Land-based tests

The land-based testing (in parallel with the laboratory tests) serves to determine the biological efficacy of the BWMS under consideration for Flag State approval. These tests aim to ensure ability to replicate the experiment, and perhaps comparability to other treatment equipment. The tank for land based test set-up will be a minimum of 1 m^3. The land-based will be conducted, monitored, sampled and analyzed in accordance with IMO Guidelines [1].

Table 1. Discharge Standards For Ballast Water Treatment and MH Systems' BWT ability to meet the criteria.

Item	IMO Regulation D-2	Pending US PL S.1578	Can MH Systems' BWT meet the criteria? If yes, what is the method of proof
Concentration of organisms in discharge water	"..less than 10 viable organisms per cubic meter greater than or equal to 50 micrometers in minimum dimension.." "..less than 10 viable organisms per milliliter less than 50 micrometers in minimum dimension and greater than or equal to 10 micrometers in minimum dimension;"	less than 0.1 living organisms per cubic meter that are 50 or micrometers in minimum dimension "..less than 0.1 living organisms per milliliter that are less than 50 micrometers in minimum dimension and more than 10 micrometers in minimum dimension	**Yes** The system can kill all marine organisms found in ballast water, however test verifications needed to show compliance with discharge standards will be performed by laboratory tests at Scripps. Please see "Additional Laboratory (Research) Test Plan"
Concentrations of Indicator Microbes	Toxicogenic Vibrio Cholerae (01 and 0139) with less than 1 colony forming unit (cfu) per 100 milliliters or less than 1 cfu per gram (wet weight) zooplankton samples; Escherichia coli less than 250 cfu per milliliters; Intestinal enterococci less than 100 cfu per milliliters.	1 colony-forming unit of Toxicogenic V. cholera (01 and 0139) per 100 milliliters, or less than 1 colony forming unit of that microbe per gram of wet weight of zoological samples; 126 colony forming units of E. coli per 100 milliliters; 33 colony-forming units of intestinal enterococci per 100 milliliters	**Yes** Initial results using V. cholerae (strain N16961) indicated rapid removal of the bacterium. We plan to use E. coli and various enterococci in full scale studies and V. cholerae (strain 01 and 0139) in further laboratory experiments. Please see "Additional Laboratory (Research) Test Plan"

Shipboard Test

Success criteria for shipboard testing will be met by following IMO Guidelines [1]in evaluating the performance of BWMS installation(s) on a ship or ships, and the information and results will be supplied to the Administration. Following are samples of IMO criteria:

1 Test plan to be provided prior to testing.

2 Documentation that the BWMS is of a capacity within the range of the Treatment Rated Capacity for which it is intended.

3 The amount of ballast water tested in the test cycle onboard should be consistent with the normal ballast operations of the ship and the BWMS should be operated at the Treatment Rated Capacity for which it is intended to be approved.

4 Documentation of the results of three consecutive, valid test cycles showing discharge of treated ballast water in compliance with Regulation D-2 [1].

5 Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the values of Regulation D-2.1 and control tank viable organism concentration exceeding the values of Regulation D-2.1 on discharge.

Reporting of test results

After approval tests have been completed, a report should be submitted to the Administration. This report should include information regarding the test design, methods of analysis and the results of these analyses. The results of biological efficacy testing of the BWMS should be accepted if it is shown that the system has met the standard in Regulation D-2 in all test cycles.

1.5 Possible Problems or Concerns

Several important decisions must be made at the start of the installation design process. The 3 inch supply should, if possible, be installed on the main deck to avoid numerous water tight bulkhead penetrations. Also this may permit easier access to the valves for maintenance and repair. If totally unavoidable, then watertight penetration will be accomplished in accordance with the Classification Society rules. The entire piping installation must be coordinated with shipyard personnel on a not to interfere with shipyard activities, as much as possible. Also, distributive systems, the control sensing system and the ballast water sampling system must also be installed with minimum ship disruption.

A concern is the requirement for extensive testing that must not interfere with the ships primary operational commitment. Another concern which has been evaluated to be not a serious issue is whether ships crew, without augmentation, can operate the system and conduct the necessary testing and documentation, without appreciable burden on the existing ship crew. The

fact that the system will be installed on a research ship is extremely advantageous, because the issue will be properly explored.

1.6 Conclusion

For more than 10 years, the world wide scientific and engineering community has been trying to develop a BWT system to the stage where trials and tests may be performed for rulemaking. Yet, no system has been selected for operational use. Extensive laboratory tests have been made, in some cases pilot scale research has been conducted and some shipboard experimental activity has occurred. However, no shipboard system has yet been presented to the regulatory agencies for the required full scale testing and approval. This program might be possibly the first to achieve approval for several reasons. The system uses standard marine components that have been approved for many years. The system has no unusual operating requirements. The system not only is not detrimental to the ship, it is expected to actually reduce ballast tank corrosion due to reduction of oxygen in the tank. And finally, the program anticipates and provides for additional basic investigative efforts and even initial shipboard research and refinements as the regulatory testing is initiated.

Without interfering with the oceanographic research vessel's primary mission, a firm schedule for ballast water treatment test and research is not practical. We expect the full scale tests on board the research vessel can be accomplished in less than six months. Additional laboratory tests and land based test may require four to six months and can be started three or four months before the start of the full scale test. Therefore, with proper planning we should be able to complete the full scale test in about 12 to 14 months.

2.0 References

[1] **International Maritime Organization** International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004", 16 Feb 2004

[2] **Husain, et al** – Ballast water treatment by De-oxygenation with elevated CO_2 for a shipboard installation – a potentially affordable solution - 2nd International Ballast Water Treatment R&D Symposium, 21-23 July 2003, IMO, London

[3] **Ballast Water Management Act of 2005 - S.1578** ; a pending US Public Law