Editorial Board

Andrew M. Clark, Ph.D., P.E. The Link Foundation

Alicia M. Gorton, Ph.D., PMP Pacific Northwest National Laboratory

Ann E. Jochens, Ph.D. Texas A&M University

Donna Kocak L3HARRIS Technologies

Ralph Rayner, Ph.D. London School of Economics

Brock Rosenthal Ocean Innovations

Prasanta K. Sahoo, Ph.D. Florida Institute of Technology

Editorial

Liesl Hotaling VP of Communications

Kelli Hunsucker, Ph.D. Emily Ralston, Ph.D. Co-Editors

Amy Morgante Managing Editor

Administration

President

Kathleen Herndon, Ph.D. Executive Director

Amanda Johnston Director of Marketing, Communications, and Membership

Kristina Norman Director of Events

Monica Ostrander Director of Programs The Marine Technology Society is a not-for-profit, international professional society. Established in 1963, the Society's mission is to promote the exchange of information in ocean and marine engineering, technology, science, and policy. Please send all correspondence to: The Marine Technology Society 1100 H Street NW, Suite LL-100 Washington, DC 20005 (202) 717-8705 Tel. (202) 347-4302 Fax MTS Journal:

Journal@mtsociety.org Publications & Subscriptions: mtsoffice@mtsociety.org

Currents: news@mtsociety.org

kathleen.herndon@mtsociety.org.
Events: krisina.norman@mtsociety.org.
Programs: mostrande@mtsociety.org.
Membership: amanda.johnstor@mtsociety.org.
Communications & Marketing:

amanda.johnston@mtsociety.org
Online: www.mtsociety.org

SHEET TO SEE WAS ARREST AND AR

MEMBERSHIP INFORMATION

may be obtained by contacting the Marine Technology Society. Benefits include:

Free subscription to the online Marine

- Technology Society Journal
- Free subscription to the bimonthly newsletter, Currents, covering events, business news, science and technology, and people in marine technology
- Member discounts on all MTS publications
- Reduced registration rates to all MTS and MTS-sponsored conferences and worleshops
- M 15-sponsored conferences and workshops
 Member-only access to an expansive Job Bank and Member Directory
- Reduced advertising rates in MTS publications
- National recognition through our Awards Program

Individual dues are \$75 per year. Student membership dues are \$25 per year. Life membership is available for a one-time fee of \$1,000. Patron, Emerius, Institutional, Business, Corporate, and Early Career memberships are also available.

ADVERTISING

Advertising is accepted by the Marine Technology Society Journal. For more information on MTS advertising and policy, please contact mtsoffice@mtsociety.org

COPYRIGHT

Copyright © 2021 by the Marine Technology Society, Inc. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by the Marine Technology Society, provided that the base fee of \$1.00 per copy, plus .20 per page is paid directly to Copyright Clearance Center, 222 Rosewood Dr., Danvers, MA 01923.

For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Service is 0025-3324/89 \$1.00 + 20. Papers by U.S. Government employees are declared works of the U.S. Government and are therefore in the public domain.

The Marine Technology Society cannot be held responsible for the opinions given and the statements made in any of the articles published.

ABSTRACTS

MTS Journal article abstracts, if available, can be accessed for free at http://www. ingentaconnect.com/content/mts/mtsj.

Print and electronic abstracts of MTS Journal articles are also available through GeoRef chupd/ www.aegiweb.org/georef/s. Aquatic Science and Fisheries Abstracts, published by Cambridge Scientific Abstracts e-http://www.csa.com/ factsheets/aquclust-set-c-phps-, and Geobase's Oceanhore published by Elsevier Science.

CONTRIBUTORS

Contributors can obtain an information and style sheet by contacting the managing editor. Submissions that are relevant to the concerns of the Society are vedcome. All papers are subjected to a stringent review procedure directed by the editor and the editorial board. The fournal focuses on technical material that may not otherwise be available, and thus technical papers and notes that have not been published previously are given priority. General commentaries are also accepted and are subject to review and approval by the editorial board.



Opportunity runs deep™

MTS Life Members

The Marine Technology Society recognizes and appreciates our Life Members.

Denis J. Adams Monika Aggarwal **Shawn Alam Edward P. April** Jason C. Aspin Skylar Banfi Ronald J. Bernier Pamela M. Betts Justin D. Bishop **Mark Bokenfohr** Douglas A. Briggs David D. Briggs **Walter Britton Hunter C. Brown** Thiago F. Carvalho James D. Case Paulstephen Chierico Kai R. Christensen Andrew M. Clark **Andrea Copping** Richard L. Crout Stephen C. Cumbee Sebastien De Halleux Marc Deglinnocenti Richard P. Dermody Stuart C. Duffield Troy M. Endicott Norman B. Estabrook Craig L. Etka **Charles Fernandez** Martin J. Finerty John Flynn Tom R. Ford William A. Friedl Yanbo Gao Matthew E. Gardner Jim Garrington Jose A. Giron Jerome Gory **Marty Greska**

Thor A. Haarseth

Walter E. Hanson

John B. Harmon **Hartley Hoskins** Liesl A. Hotaling John R. Huff Frank W. Hughes Pamela J. Hurst Toshio livama **Robbie Ingram** Corey J. Jaskolski Ann E. Jochens Colin M. Jones Paul Jubinski Michael J. Jugan Laurie A. Jugan Samuel T. Kelly Debbi A. Kill Day Hong Kim Hvuna Ki K. Kim Heinrich Klefenz James M. Knight Jay Larsen Nordeen Larson Zhenhai Liu Terry L. Loftis Michael R. Lombardi David L. Low Diann K. Lynn Lorenz C. Magaard Justin E. Manley Stephen J. Mariadas **Andreas Marouchos** Koichi Masubuchi Martha M. Mayer James B. Mccormick Craig N. Mclean Samuel P. Menefee **Drew Michel** Jerry L. Miller **Richard Mills** William Milwee Ryan L. Morton

Daniel J. Moss

Won-Bae Na James B. Newman **Eva-Marie Nosal Phil Nuytten Jeff Obrien** James H. Osborn Ottar L. Osen Masayoshi Ozawa **Sudhir Pai** Joseph A. Pica Charles A. Richards Chuck A. Richards Brock J. Rosenthal Jonathan O. Samuell Christian P. Sarason David Scaradozzi Stig O. Settemsdal **David Shelton** Andrew J. Sherrell **Mark Smits** Robert C. Spindel Raymond E. Staton Kim H. Sun S N. Thakur **Arthur C. Trembanis** Gregory M. Vaughn Philomene A. Verlaan Hao Wang Keisuke Watanabe **Curtis Waters Leonard T. Whitlock** Raymond A. Williams John C. Wiltshire **Arthur Yan** Rui Ye **Hua Zhang** Yu Zhang Quan Zhou John D. Zittel Tibiebiowei Zuofa

Marine Technology Society Member Organizations

GOLD MEMBERS

Fugro USA Houston, Texas

Teledyne Marine Systems North Falmouth, Massachusetts

SILVER MEMBERS

ASV, LLC

Broussard, Louisiana

Blue Robotics

Torrance, California

DNV GL Houston, Texas DOF Subsea USA Houston, Texas

GE Energy Power Conversion

Houston, Texas

General Dynamics Mission Systems

Pittsfield, Massachusetts

Glenair, Inc.
Glendale, California
Harris Corporation
Melbourne, Florida
Innerspace Corporation

Covina, California

iXblue Katy, Texas

Klein Marine Systems, Inc. Salem, New Hampshire

Kongsberg Maritime, Inc.

Houston, Texas

MacArtney, Inc.
Houston, Texas

Maritime Assurance & Consulting Ltd.

Aberdeen, UK

Oceaneering Advanced Technologies

Hanover, Maryland

Phoenix International Holdings, Inc.

Largo, Maryland
Saildrone, Inc.
Alameda, California
Sebastion AS
Ulsteinvik, Norway

South Bay Cable Corp. Idyllwild, California

TE Connectivity (SEACON) Middletown, Pennsylvania

Team Trident Katy, Texas SMALL BUSINESS MEMBERS

Baker Marine Solutions Covington, Louisiana

BioSonics, Inc. Seattle, Washington

Blade Offshore Services Ltd. Gosforth, Newcastle upon Tyne, UK

BlueWave Robotics, LLC Norcross, Georgia

Compass Publications, Inc. Arlington, Virginia

Continental Shelf Associates

Palm City, Florida

EOMAP

Santa Barbara, California

Exocetus Autonomous Systems Wallingford, Conneticut

Falmat, Inc.

San Marcos, California

Global Marine Consultants and Surveyors Limited

Aberdeenshire, Great Britain

Global Marine Solutions, LLC

Alexandria, Virginia

Greensea

Richmond, Vermont

GTA, Inc. Knoxville, Tennesse

I3P Consultants, LLC Boynton Beach, Florida

M3 Marine Expertise Pte Ltd

Singapore

Makai Ocean Engineering, Inc.

Kailua, Hawaii

Mark Tool and Rubber Co., Inc./MTE

Engineered Materials LLC Franklin, Louisiana

Okeanus Science & Technology, LLC

Redmond, Washington

OneStep Power Solutions, Inc.

Houston, Texas

Pirie & Smith Limited

Aberdeen, UK

QPS

Portsmouth, New Hampshire

Rio Engineering, Inc. Austin, Texas

RJE International, Inc. Irvine, California

SeaLandAire Technologies, Inc.

Jackson, Mississippi

Seatrec, Inc

Vista, California

Seis GEaR Inc.

Stafford, Texas

Sonardyne, Inc.

Houston, Texas

Steve E Mason

The Woodlands, Texas

Stress Engineering Services, Inc.

Houston, Texas

TALON Technical Sales, Inc.

Houston, Texas

Vessel Technology Ltd.

Banchory, UK

INSTITUTIONAL MEMBERS

Centre for Ocean Ventures and Entrepreneurship (COVE)

Dartmouth, NS

Centre for Robotics & Intelligent Systems

Houston, Texas

Consortium for Ocean Leadership

Washington, DC

International Seabed Authority

Kingston, Jamaica

IOOS Association

Harpswell, Maine

Michigan Technological University

Houghton, Michigan

NTNU

Trondheim, Norway

NOAA/PMEL

Seattle, Washington

ocarrie, washington

Schmidt Ocean Institute
Lake Forest Park, Washington

Stockton University

Port Republic, New Jersey

University of Southern Mississippi

Hattiesburg, Mississippi

Marine Technology Society Officers

BOARD OF DIRECTORS

President

Zdenka Willis

Veraison Consulting LLC

President-elect

Justin Manley

Just Innovation, Inc.

Immediate Past President

Richard Spinrad, Ph.D., CMarSci

Oregon State University VP—Section Affairs

Richard Crout

Naval Research Laboratory

VP—Education Josh T. Kohut

Rutgers University VP—Research, Industry, and Technology

Jim Hanlon COVE

VP—Communications

Liesl Hotaling Eidos Education

Treasurer and VP-Budget and Finance

Mike Pinto MBARI (Ret.)

VP—Government and Public Affairs

Jerry L. Miller, Ph.D. Science for Decisions

SECTIONS

Canadian Maritime

Vacant Florida

John Flynn

Flynn Technical Solutions LLC

Great Lakes Hans Van Sumeren

Northwestern Michigan College

Gulf Coast Laurie Jugan

MSET Consultant Hampton Roads

Jim Ĥaluska

Old Dominion University

Hawaii Noriko Shoji

NOAA Houston Ronald Hughes

The Blackfin Group

India Dr.R.Venkatesan

National Institute of Ocean Technology

Japan

Hidevuki Suzuki University of Tokyo Monterey Bay Jill Zande MATE Center

New England Rhonda Moniz SeaBotix

Norway Vacant

Newfoundland and Labrador

Oregon

Jeremy Childress Oregon State University

College of Oceanic & Atmospheric Sciences

Puget Sound Fritz Stahr

University of Washington

San Diego Larry Hagstrom Sidus Solutions

Singapore Vacant

South Korea

Vacant

Washington, D.C. Jake Sobin

Kongsberg

PROFESSIONAL COMMITTEES Research, Industry and Technology

Bioinspired Marine Design

Jason Geder

U.S. Naval Research Lab William Sandberg

George Mason University

Buoy Technology Rick Cole

RDSEA International, Inc.

Don Peters

Woods Hole Oceanographic Institution

Cables and Connectors

Deepwater Field Development Technology

Dr. Benton Baugh Radoil, Inc. Diving

Michael Lombardi Ocean Opportunity Michael Max

Hydrate Energy International LLC

Dynamic Positioning Pete Fougere

Portsmouth, NH Manned Underwater Vehicles

William Kohnen HYDROSPACE Group

Moorings Jack Rowley

Oceanographic Instrumentation

Offshore Structures & Seafloor Engineering

Vul Thang SACS Software Peter Marshall

Remotely Operated Vehicles

Chuck Richards C.A. Richards and Associates, Inc.

Ropes and Tension Members Christopher Lindanger

Deep Sea Mooring Underwater Imaging Dr. Fraser Dalgleish L3Harris Technologies

Unmanned Maritime Systems

Andrew Ziegwied

Education

Marine Archaeology Dr. Stephen Wood

Florida Institute of Technology

Marine Education

Ed Bailev

Northwestern Michigan College

Marine Geodetic Information Systems

Vacant

Marine Materials Dr. R. Venkatesan

National Institute of Ocean Technology

Ocean Exploration

Physical Oceanography/Meteorology

Travis Miles Rutgers University Remote Sensing Vacant

Government and Public Affairs

Arctic Technology

Vacant

Marine Law and Policy

Vacant

Marine Mineral Resources

Alex Barnard

Maritime Cyber Security and Infrastructure

Committee Daniel E. Turissini SPYRUS Solutions, Inc. Ocean Economic Potential Vacant

Ocean Observing Systems

Ian Walsh WET Labs Ocean Pollution Ryan Morton Ánadarko Petroleum Renewable Energy

STUDENT SECTIONS

AMET University

Vacant

Arizona State University

Bannari Amman Institute of Technology

Brigham Young University Dalhousie University **Duke University**

Florida Atlantic University Florida Institute of Technology

IIT Dehli

IIT Madras Long Beach City College

Marine Institute

Memorial University

Monterey Peninsula College National Institute of Technology, Tiruchirappalli

New Horizon College of Engineering

New Jersey

NIT Trichy North Carolina State University Northeastern University Oregon State University

Rutgers University Sri Sairam College of Engineering

SRM University Stockton University

University of Hawaii

Texas A&M University—College Station Texas A&M University Corpus Christi Texas A&M University at Galveston The College of William & Mary United States Naval Academy University of Florida

University of Houston University of New Hampshire University of North Carolina-Charlotte University of Puerto Rico, Mayagüez

University of South Carolina University of Southern Mississippi

University of Washington

Webb Institute Zakir Husain College of Engineering and Technology

HONORARY MEMBERS (†deceased)

†Robert B. Abel †Charles H. Bussmann †John C. Calhoun, Jr. †Iohn P. Craven †Paul M. Fye Sue Ingle Owen †David S. Potter †Athelstan Spilhaus †E. C. Stephan †Allyn C. Vine

†James H. Wakelin, Jr.

UPCOMING MTS JOURNAL ISSUES

May/June 2021

Introduction to The UN Decade of Ocean Science for Sustainable Development

July/August 2021

Best of OCEANS 2020

September/October 2021

Lakebed 2030: Energizing the Great Lakes Community

November/December 2021

Civilization at a Turning Point: The Case of Polymetallic Nodules

January/February 2022

Technologies Advancing Polar Science

March/April 2022

Advances in Buoy Technology



Opportunity runs deep™

Check the Society website for future *Journal* topics. www.mtsociety.org

CALL FOR PAPERS

The MTS Journal
includes technical
papers, notes and
commentaries
of general interest in
most issues.

Contact Managing Editor

Amy Morgante

(morganteeditorial@gmail.com)
if you have material you
would like considered. Also
contact the managing editor
if you would like to submit
a proposal to guest edit a
themed issue of the MTSI.

Specifications for submitting a manuscript are on the MTS website under the Publications menu, www.mtsociety.org

E-mail:

Journal@mtsociety.org

Or visit our homepage at

www.mtsociety.org