

Underwater Robotics

Science, Design & Fabrication

Steven W. Moore, Ph.D.
California State University Monterey Bay

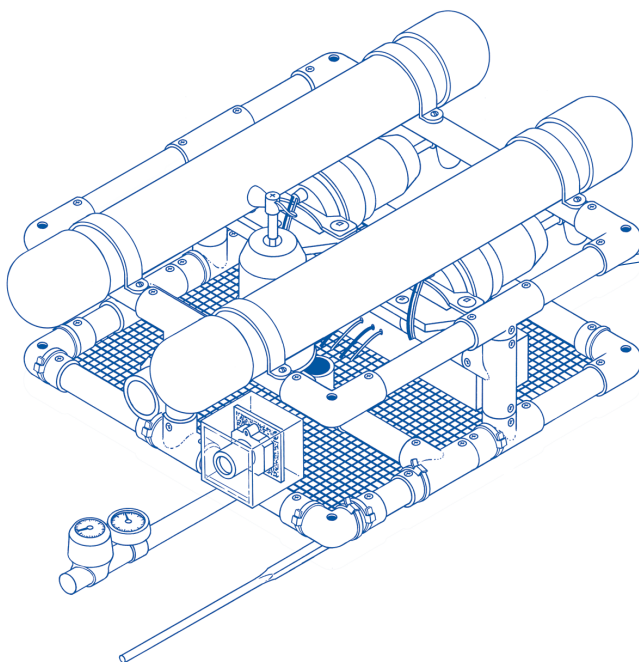
Harry Bohm

Vickie Jensen
Westcoast Words



Marine Advanced Technology Education (MATE) Center
Monterey, CA

Nola Johnston
Design and original illustrations



© 2010 by Marine Advanced Technology Education (MATE) Center

Authors: Steven W. Moore (PhD), Harry Bohm, Vickie Jensen

Editor: Vickie Jensen

Design and Illustration: Nola Johnston, Nola Johnston Graphic Design & Illustration

Textbook Project Coordinator: Jill Zande

Copy Editing: Ann Harmer, Bluff Hollow Editing

Chapter Consolidation: Caroline Brown

Indexing: Patricia Buchanan, Buchanan Indexing & Editing

Cover photo: © Patrick J. Endris/AlaskaPhotoGraphics.com

Back cover photos: Chess-playing ROVs, Scott Fraser, Long Beach City College, Electrical Department; ROV-building students and ROV in ocean, Dr. Steven W. Moore

Printed and bound in Hong Kong

All rights reserved. No part of this work may be reproduced or distributed in any form or by any means, electronic or mechanical, including photocopying and recording, or by any information storage or retrieval system without prior written permission from the Marine Advanced Technology Education (MATE) Center.

Marine Advanced Technology Education (MATE) Center

980 Fremont Street

Monterey Peninsula College

Monterey, CA 93940

www.marinetech.org

Publisher's Cataloging-in-Publication data

Moore, Steven W.

Underwater robotics : science, design & fabrication / Dr. Steven W. Moore, Harry Bohm, Vickie Jensen ; Vickie Jensen, editor ; Jill Zande, textbook project coordinator.

p. cm.

Includes index.

ISBN 978-0-9841737-0-9

1. Remote submersibles--Design and construction. 2. Remote submersibles--Handbooks, manuals, etc. 3. Robotics. 4. Underwater exploration. 5. Underwater navigation. I. Bohm, Harry. II. Jensen, Vickie, 1946-. III. Underwater robotics : science, design, and fabrication. IV. Title.

TC1662 .M66 2010

623.82/05—dc22

2010926065

TABLE OF CONTENTS

Front Materials:

Preface: Drew Michel	vi
Preface: Don Walsh	vi
Introduction	vii
How to Use This Book	viii
Updates and Orders	ix
Disclaimers	ix
Acknowledgements	x
Photo and Illustration Acknowledgements	xii

Chapter 1: Underwater Vehicles	1
Chapter 2: Design Toolkit	61
Chapter 3: Working in Water	119
Chapter 4: Structure and Materials	157
Chapter 5: Pressure Hulls and Canisters	203
Chapter 6: Buoyancy, Stability, and Ballast	247
Chapter 7: Moving and Maneuvering	299
Chapter 8: Power Systems	359
Chapter 9: Navigation and Control	443
Chapter 10: Hydraulics and Payloads	529
Chapter 11: Operations	573
Chapter 12: <i>SeaMATE</i>	633

About the Textbook Team	711
--------------------------------------	-----

Appendices:

Appendix I: Dimensions, Units, and Conversion Factors	712
Appendix II: Useful Constants, Formulas, and Equations	716
Appendix III: Hydrostatic Pressure	719
Appendix IV: Material Properties	721
Appendix V: How to Find Parts... ..	723
Appendix VI: How to Find Additional Information	727

Glossary	729
-----------------------	-----

Index	758
--------------------	-----

PREFACE BY DREW MICHEL

Life member and fellow in the Marine Technology Society (MTS), chair of the MTS ROV Committee since 1992, co-chair of the annual Underwater Intervention Conference, senior member of the Institute of Electrical and Electronic Engineers (IEEE). Drew Michel has worked for over four decades in the undersea industry.

Underwater Robotics: Science, Design & Fabrication is the text and reference book that underwater robotics educators have been waiting for. Best of all, it lives up to expectations, with an amazing collection of technical information, stories, and photos in one convenient place.

The primary purpose of this book is to introduce newcomers to the very complex world of subsea technology, but it is also a fascinating look back at the development of subsea inventions for work and exploration. This text explains where we are today, explores possibilities for the future, and encourages individuals to consider careers in this field. Equally as important, the book provides readers with a sense of perspective—a look back at where we’ve traveled on this long subsea journey and the interesting characters who led the way. It starts with understanding the consequences of human exposure to pressure, moves through the courageous era of sitting in cramped submersibles, and arrives at today’s reality of telepresence in the undersea world.

Underwater Robotics: Science, Design & Fabrication is an invaluable tool for young minds working on starter projects and provides the material to help them move to advanced

options and continue to learn. It is also a reference book for those working in the industry and will be a valuable addition to the collections of those who have had long careers in the undersea arena. Picture a young student learning how to solder for the first time. Then see that student a year later, wiring the control system on his or her team’s entry in the MATE International ROV Competition. Then, fast-forward 10 years to that same person, now an ROV supervisor, browsing through a well-worn copy of the book while sitting in the ROV control room of a major offshore energy project or scientific expedition. This book has the potential to inspire and enable those dreams.

Finally, a word about those who made this book happen. There are people in this world who go to work every day to earn enough money to be able to live and do the things they enjoy. Then there are others whose work is their love. The educators I have had the good fortune to deal with in my 44 years in this industry fit that latter category. The people at the MATE Center and many others who worked long and hard to make this book a reality certainly are part of that fraternity. They deserve high praise for their perseverance and dedication.

PREFACE BY DON WALSH, PhD

Captain USN (ret), oceanographer, marine policy specialist, former dean and professor (University of Southern California), Honorary President of the Explorers Club, and member of U.S. National Academy of Engineering. In 1960, Don Walsh and Jacques Piccard piloted the U.S. Navy bathyscaph Trieste to the deepest point in the world’s oceans, a feat never repeated.

Underwater Robotics: Science, Design & Fabrication is most welcome in the world of ocean engineering. It is a well-organized survey of all major aspects of underwater engineering, and it leads students, educators, industry professionals, technology enthusiasts, and other interested readers through each subject area in an intelligent and engaging way.

Ocean engineering is a relatively new field of study. It is also an interdisciplinary field, in which a basic knowledge of mathematics, earth sciences, physics, computer technology, business, and the engineering arts and sciences is required, even for entry-level and support staff. While there are many excellent academic programs throughout the world that train ocean engineers and offer degrees in oceanography, the area of technical education for professionals who support ocean engineering work is still in the early stages of development. Qualified professionals are in high demand, yet few comprehensive training programs or learning materials are available—until now.

This book fills a real need for a broad introduction to oceanographic work. The stories, technical information, scientific knowledge, and projects provide an excellent “tour of the horizon” of this fascinating, wide-ranging interdisciplinary field. Some of the essential concepts and principles that apply to underwater technology can be daunting to those who are new to this work; the authors are to be congratulated for providing easy access to complicated material.

Underwater Robotics: Science, Design & Fabrication is produced by the Marine Advanced Technology Education (MATE) Center at Monterey Peninsula College in California. Supported by the National Science Foundation since 1997, the MATE Center works with schools and colleges nationwide to raise awareness of ocean science, technology, and engineering fields. MATE also strives to provide education and professional development for individuals working in these fields, and to recruit and train new technical professionals. This book is a significant contribution to that mission.

INTRODUCTION

There is a story behind every good book, and this one is no exception. Our story begins in 1999 with the MATE Center's discovery of the book *Build Your Own Underwater Robot and Other Wet Projects*, co-authored by Harry Bohm and Vickie Jensen. It was perfect timing, as our marine workforce studies indicated that the skills needed to design, build, and operate underwater vehicles (and other “wet” technologies) were in high demand. We immediately contacted Harry about expanding the book into a series of modules for a new college-level course on underwater robots at Monterey Peninsula College. Harry wrote those modules, keeping one step ahead of instructor Frank Barrows; both finished up amazed at the enthusiasm and learning going on in that classroom. In the summer of 2000, Harry delivered MATE's first summer institute focused on ROVs. The teachers who participated were also hooked. We knew that we were on to something!

Later that year, MATE asked Vickie and Harry to edit the modules into a full-scale textbook. As that book started to take shape, so did MATE's very first ROV competition. MATE called upon Harry's knowledge and expertise in the development of that program as well. From engineering the underwater props to creating the stories that put the mission tasks in context, Harry helped to build the competition from the ground up—just as he helped so many of the students to build their first ROVs.

As the competition gained momentum over the next few years, so did the textbook. In 2003, Dr. Steve Moore joined the writing team. His content expertise and classroom teaching experience were perfect complements to Harry's ability to think outside of the box and turn everyday materials into incredible inventions and Vickie's editorial prowess, organizational skills, and ability to channel creativity into words on a page.

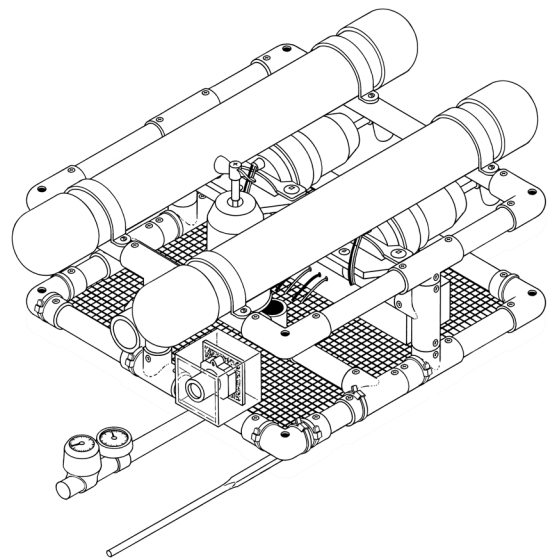
Building underwater robots often takes more time, more prototypes, more money, and more effort than ever envisioned at the start of the project. It turns out that the same is true for underwater robot textbooks! The process of this writing

project has taken us on an incredible journey of underwater robotics education, one that saw the modules MATE commissioned for our very first college course grow into this 769-page textbook. It also involved our summer faculty development institutes and MATE's annual competition program that engages thousands of teachers and students from around the world.

Underwater Robotics: Science, Design & Fabrication wouldn't have been possible without Harry setting the vision and Steve and Vickie contributing their knowledge and expertise to carry it out. The MATE Center is forever grateful to these individuals and the contributions that they have made to our mission.

And this is where our story ends—or, rather, begins with you and the book that you hold in your hands. We look forward to seeing how you write the next chapters.

—Jill Zande, MATE Associate Director
and textbook project coordinator



HOW TO USE THIS BOOK

Underwater Robotics: Science, Design & Fabrication welcomes you to the exciting world of underwater vehicle technology! This book provides an engaging blend of real-life stories, up-to-date technical information, and pragmatic “how-to” advice. It also guides you through the process of designing, building, and diving your own small custom-made, remotely-controlled underwater craft. You can use the *SeaMATE* ROV to carry out various underwater missions, from basic exploration to challenging search and recovery adventures.

The book is written primarily for high school and college students who want to have fun while developing marketable technical and teamwork skills. It is also a handy reference for educators, hobbyists, and others interested in marine technology, electronics, robotics, and similar topics. As an introductory book, this text assumes no prior experience with robotics or underwater vehicles; however, it does presume a working knowledge of high school algebra and geometry.

This textbook is structured to be highly flexible. If you are new to underwater vehicle design and construction (as many readers will be), it’s probably best to read the chapters in order, since each builds to some extent on the previous chapters. On the other hand, if you already have experience with much of the material covered in this book, you may find it more useful to use this text as a reference and jump directly to the chapter you need at the moment. The choice is up to you.

How the Text is Organized

Underwater Robotics: Science, Design & Fabrication is not a conventional textbook, but then subsea technology is not a conventional academic discipline—it’s interdisciplinary! So this book covers physics, marine biology, oceanography, math, chemistry, construction, tool use, design strategies, troubleshooting, project planning, and teamwork—all subjects that will help you create more successful underwater vehicles.

Chapters 1–2 provide an introductory overview of manned and unmanned underwater craft (from earliest times to modern day) and offer pragmatic strategies for designing underwater robots.

Chapters 3–10 introduce the opportunities and challenges of working under water, then focus on specific technical solutions, ranging from structure and materials to power systems and payloads. Each of these chapters introduces relevant science and engineering concepts, as well as their pragmatic application to underwater robotics. There are ample visual and textual examples, from basic home-built robotic vehicles to complex commercial craft.

Chapter 11 is a different kind of technical chapter, one that moves beyond vehicle design and concentrates on the real world of subsea work and the logistics of preparing for and carrying out simple missions.

Chapter 12 provides you with an opportunity for guided hands-on learning, with detailed plans and instructions for assembling a “build-as-you-learn” ROV called *SeaMATE*. Readers can either construct this shallow-diving project in stages, coordinating it with their progress through each of the technical chapters, or they can tackle it independent of the other chapters. Chapter 12 also discusses options for upgrading *SeaMATE* or for building even more sophisticated ROVs or AUVs.

Textual Aids and Information

- Each of the chapters begins with a section called *Stories from Real Life* that highlights a real-world event related to the main focus of that chapter.
- All chapters also include an outline, a list of learning outcomes, the main text of the chapter, and a summary.
- The text features more than 500 photographs and illustrations. This wealth of color photographs helps readers connect with actual examples of subsea robotics. The straightforward illustrations are designed to expand and explain textual concepts.
- The authentic examples in this text help bridge the gap between theory and the excitement of on-the-job experience. While many of these focus on North America, the authors stress the worldwide application of underwater technology and exploration. Teachers and students are encouraged to supplement this text with other, locally relevant examples.
- Most measurements are given in metric units, such as meters and newtons; however, imperial equivalents are usually provided to assist those readers who may be more familiar with imperial (English) units, such as feet and pounds.
- The glossary contains definitions of hundreds of key terms. These are emboldened when first presented or explained in the text.
- A set of appendices provides helpful tables of information, useful facts, equations, and suggestions for sourcing parts, materials, and additional resources.
- A complete index helps locate page references to relevant topics as well as types and properties of vehicles, plus names of people, institutions, and individual craft.

UPDATES AND ORDERS

Book Orders

To get pricing and shipping information and to order individual copies of the textbook online, contact Westcoast Words at the address below. You are also welcome to call them for information regarding bulk orders, educational or wholesale discounts, and shipping costs.

Westcoast Words

Email: info@westcoastwords.com

Phone: 604-731-5565

www.westcoastwords.com

Updates and Comments

In the interest of keeping future editions of this book as accurate and current as possible, please forward any comments, corrections, or updates to the MATE Center.

Marine Advanced Technology Education (MATE) Center

Monterey Peninsula College

980 Fremont Street

Monterey, CA 93940

Phone: 831-645-1393

Email: info@marinetech.org

www.marinetech.org

DISCLAIMERS

Views Expressed

Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and the Marine Advanced Technology Education (MATE) Center and do not necessarily reflect the views of the National Science Foundation or the Marine Technology Society's ROV Committee.

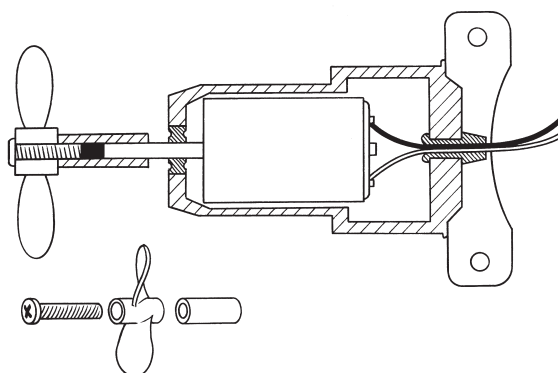
Safety Alert

Throughout the text, the authors have made a good-faith effort to alert readers to potential hazards and have stressed the importance of safety and common sense. However, it is not possible to anticipate and discuss every conceivable situation that might arise during the construction, testing, or operation of an underwater vehicle. Ultimately, it is up to each individual to make sure that he or she is aware of potential hazards and is operating within his or her safe limits.

Therefore, the authors and the Marine Advanced Technology Education (MATE) Center can accept no liability for accidents or injuries incurred during or in association with the construction, testing, or operation of any of the projects suggested herein. In particular, note that this book does NOT provide instruction in the design, construction, testing, operation, or maintenance of submersibles that carry living passengers. Likewise it does not cover boating and water safety skills or the safe use of high voltage power sources.

Endorsements

Today there are thousands of excellent parts and materials that are designed for or can be adapted to use in underwater robotics projects. The textbook has endeavored to give a representative sampling, however it is not possible to include mention of every product manufacturer or distributor. Note that where there is mention of a commercial product or citation of a trade name it does not constitute an official endorsement of that product by the authors or the Marine Advanced Technology Education (MATE) Center. Readers are always encouraged to conduct their own product research. *Appendix V: How to Find Parts* provides tips and suggestions for locating parts and materials suitable for a variety of underwater projects.



ACKNOWLEDGEMENTS



MATE salutes the many individuals, companies, organizations, universities and schools who have been extremely generous in sharing expertise and resources. Your efforts have made a significant contribution to the scope and quality of this book. While it is not possible to name everyone who helped, MATE would specifically like to acknowledge those that follow. We also salute readers like you, who dare to dream.

Heartfelt thanks to you all,

A handwritten signature in black ink, reading "Jill M. Zande".

—Jill Zande, MATE Associate Director
and textbook project coordinator



Funding

This textbook is based on work supported by the National Science Foundation under Awards DUE-0703197, DUE-0832284 and DUE-0302905, and printed with the assistance of the Marine Technology Society's ROV Committee. The MATE Center is extremely grateful for this on-going support.



MATE Leadership and Advisors

- Monterey Peninsula College, especially Michael Gilmartin, Dean of Instruction, Occupational and Economic Development
- MATE Center Director Deidre Sullivan
- Members of MATE's Textbook Advisory Committee
 - Frank Barrows, instructor (ret.) in Submersible and Automotive Technology, Monterey Peninsula College
 - Kevin R. Hardy, Director of Engineering, Deep Sea Power and Light formerly with Scripps Institution of Oceanography/UCSD
 - Drew Michel, MTS ROV Committee chair, CEO and Principal Consultant, ROV Technologies, Inc.
 - Ronald W. Roehmholdt, Director of Exhibits, Naval Undersea Museum
 - Al Trice, General Manager, ISE (International Submarine Engineering)
- MATE's National Visiting Committee (past and present members)
 - Dr. Lynne Carter, NOAA RISA Program, Southern Climate Impacts Planning Program
 - Dr. Thomas R. Consi, University of Wisconsin, Milwaukee
 - Elizabeth Corbin, President of Marine Technology Society
 - Dr. Sylvia Earle, Deep Ocean Exploration and Research
 - Dr. Robert Ford, Neo-Tech South, Inc.
 - Bruce Gilman, past President of the Marine Technology Society
 - Jim McFarlane, International Seabed Authority
 - Justin Manley, Liquid Robotics
 - Drew Michel, MTS ROV Committee chair, CEO and Principal Consultant, ROV Technologies, Inc.
 - John Peterson, Oceaneering International, Inc.
 - Jill Singer, State University of New York, Buffalo
 - Fritz Stahr, University of Washington
 - Jerry Streeter, past President of the Marine Technology Society
 - Dr. Don Walsh, Captain USN (ret), Honorary President of the Explorers Club, U.S. National Academy of Engineering member



Technical and Editorial Reviewers

- Mark Atherton, Kongsberg Mesotech
- John Bergman, CyVect Corporation
- Knute Brekke, Deputy Chief Pilot, ROV *Ventana*, Monterey Bay Aquarium Research Institute
- Ted Brockett
- Dr. Tom Consi, Shaw Associate Scientist, University of Wisconsin-Milwaukee, Great Lakes WATER Institute
- Nicole Crane, former MATE Center Director
- Dr. James P. Delgado, Executive Director, Institute of Nautical Archaeology
- Lee-Ann Ennis, marine educator, formerly with Vancouver Public Aquarium
- Tomiko Johnston, engineer, OceanWorks International
- Bill Kirkwood, Associate Director of Engineering, Monterey Bay Aquarium Research Institute
- Dr. Paul Kraeutner, Underwater Research Lab, Simon Fraser University
- Guy Immega, CEO (ret.), Kinetic Sciences Inc.
- Glenn McDonald, Woods Hole Oceanographic Institution
- Dr. Tom Murphree, Research Professor, Naval Postgraduate School
- Phil Nuytten, President, Nuytco Research Ltd.
- Scott Olson, Project Engineer, Perry Slingsby Systems
- Dr. John Pollock, President, Underwater Archaeological Society of British Columbia
- Dr. Jay Powell
- Nels Powell, Jensen Technologies
- Peter A. Robson and Associates
- Mary Schendlinger, editorial consultant
- Peter Thain, along with Beckie Thain, Lydia Burnett, Virginia Davis, Aubrey Senyard of the White Rock South Surrey Home Educators
- Steve Thone
- Bob Wernli, First Centurion Enterprises
- Li Xeuman (Lisa Li), School of Engineering, Simon Fraser University
- Students from the very first Spring 2000 Introduction to Submersible Technology class at Monterey Peninsula College
- 2001 MATE Summer Institute class: Bah Aahl, Joe Beydler, Ike Coffman, Ted Davis, Bill Falls, Sharon Flanagan, Kelly Kiefer, Barry Kilch, Steve Moore, Erica Moulton, Susan Phillips, Tom Rebold, Gary Scott, Joe Shewmaker, Bill Speed, Joel Spencer, Edd Spidell, Steve Struble, Annemarie Sullivan, Sandra Taylor, Susan Teel, Norman Thomas, Morrie Walworth, Joseph Zawodny

Authors' Families

The authors greatly appreciate their extremely patient and supportive spouses and families.

PHOTO AND ILLUSTRATION ACKNOWLEDGEMENTS

MATE sincerely appreciates the individuals, companies, organizations, schools, and universities who gave permission to use photographs and images. This textbook is significantly better because of their generosity!

As we sorted through thousands of photographs for this project, we tried to provide correct credit and caption references. If we've inadvertently erred, please contact us so that we can make the correction in future printings.

Principle Photographers

Randall Fox and Steve Van Meter/VideoRay LLC deserve special thanks for their extensive photo documentation of numerous MATE regional and international competitions. The authors have also given freely from their personal photo collections and produced a number of new images to illustrate or clarify concepts presented in the text. All of these photographs make a significant contribution to the educational impact of this textbook.

Key Image Contributors/Consultants

- Scott Fraser, Long Beach City College, Electrical Dept.
- Dr. Daniel Jones, SERPENT Project Coordinator, National Oceanography Centre (Southampton, UK)
- Glenn McDonald, WHOI
- Drew Michel, Marine Technology Society's ROV Committee
- Duane Thompson, MBARI
- Steve Thone

Illustrations

The Naval Undersea Museum, Keyport, Washington, kindly made a number of their illustrations available for use throughout the book. Authors Harry Bohm and Dr. Steven W. Moore designed the majority of the technical illustrations, which were rendered expertly by Nola Johnston. Westcoast Words also shared illustrations from *Build Your Own Underwater Robot and Other Wet Projects* and *Build Your Own Programmable LEGO® Submersible*.

Companies

- Alstrom; Barbara Gardner, Wes Gerriets
- American Underwater Search & Survey, Ltd.; John P. Fish
- Atlantis Submarines; Janet Griffiths, Dereck Hamada
- Bluefin Robotics Corp.; Deanna Abraham
- BlueView Technologies, Inc.; Rick Elento
- Comsub; Rod McLean for HYCO
- CSIP; Simon Gilligan
- Deepsea Power & Light; Kevin Hardy
- Deep Sea Systems International, Inc. (Division of Oceaneering International, Inc.); Chris Nicholson
- Deep Marine Technology Inc.; Lisa Robinson
- Divulgação Petrobras/Agência

- EdgeTech Marine; R.J. Jablonski
- Electropaedia website <http://www.mpoweruk.com/performance.htm>; Barry Woodbank
- Flexible Engineered Solutions Ltd.; Ian Latimer, Vikki Mason
- GRI Simulations Inc.; Stephen Dodd, Cory Sheppard
- IFREMER, France
- Imagenex Technology Corp; Disa Wilhelmsen
- Infotainment USA, Inc.; Mark Ward
- International Submarine Engineering (ISE) Ltd.; Jim McFarlane, Linda Mackay, Al Trice
- Inuktun Services, Ltd.; Roy Coles, Colin Dobell, Shiho Uzawa
- J.W. Fishers Mfg.; Chris Coombs, Jack Fisher
- John Wiley and Sons, Inc., Permissions Dept.; Judith Spreitzer
- Kongsberg Mesotech, Mark Atherton
- Kongsberg Maritime Ltd.; Lisbeth Ramde
- Kraft Telerobotics
- L-3 Communications Klein Associates, Inc.; Debbie Durgin
- Nuytco Research Ltd.; Phil Nuytten
- OceanWorks International; Jim English, Lyn Garbay, Adam Goldbach, Derek White
- Oceaneering International, Inc.; Peg Newman
- Parallax, Inc.; Lauren Davis
- Perry Slingsby Systems, Ltd.
- Power-Sonic Corporation
- Remote Presence, Ireland; Karl Bredendieck
- Rinspeed Inc.; Frank M. Rinderknecht
- Saab Seaeye Ltd.; James Douglas
- Saipem America; Jennifer Williams
- Schilling Robotics; Meagan Anderson, Jason Stanley
- SeaBotix, Inc.; Jesse Rodocker
- SeaTools, B.V.; Jan Frumau, Berdien Kaper
- SMD Ltd. (Newcastle upon Tyne); Victoria Bosi, Mike Jones
- Sonsub (Division of Saipem Group); Robert Corkren
- Southwest Research Institute (SWRI); Deborah Deffenbaugh, Matt James, B.K. Miller, Jesse Ramon,
- Stone Aerospace; Dr. Bill Stone
- Sub Aviator Systems Ltd.; Alfred McLaren
- SubConn Inc.; Michael Stewart
- Submertec Ltd.; Peter Sharphouse
- Teledyne Impulse; Heather Butler, Raymond Hom
- Transocean (Houston); Guy Cantwell, Dr. Ian Hudson
- Tritech; Paul Hudson
- VideoRay LLC; Brian Luzzi
- Wikimedia Commons
- Wikipedia Commons

Institutions and Schools

- AUVSI Foundation; Daryl Davidson, Executive Director
- California Institute of Technology, Jet Propulsion Laboratory
- California State University Monterey Bay, Seafloor Mapping Lab; Pat J. Iampietro, Dr. Rikk Kvitek
- Canadian Scientific Submersible Facility, Yvonne Baier
- Carbonear Collegiate
- Cornell University Autonomous Underwater Vehicle Team
- Deutsches Bundasarchiv (German Federal Archives)
- Flower Mound High School
- Friends of the Hunley; Kellen Correia, and cpgphoto.com
- Hawaii Undersea Research Laboratory; Bernard Greeson, Terry Kerby, Rachel Orange
- Harbor Branch Oceanographic Institution; Geoff Oldfather, Jan Petri
- Institute of Nautical Archaeology; Dr. James P. Delgado, Chastity Hedlund
- Japan Agency for Marine-Earth Science and Technology (JAMSTEC); Toshihiko Chiba, Yukako Kawaguchi, Eiichi Kikawa, Shozo Tashiro
- Long Beach City College
- Marine Advanced Technology Education (MATE) Center
- Marine Institute, Memorial University of Newfoundland
- Marine Technology Society, ROV Committee
- Massachusetts Institute of Technology (MIT) Project Orca (see MIT below)
- Massachusetts Institute of Technology (MIT) Sea Grant College Program; Nancy Adams, Dr. Chrysostomos Chrysostomidis, Franz Hover, John Leonard, Henrik Schmidt, Brandy Moran Wilbur
- Monterey Bay Aquarium Research Institute (MBARI); Lisa Borok, David Fierstein, Kim Fulton-Bennett, Bill Kirkwood, Debbie Meyer, Todd Walsh
- NASA
- National Science Foundation
- NOAA
- NOAA/AOML; Rick Lumpkin
- NOAA Aquarius Reef Base; Otto Rutten
- NOAA National Ocean Service, Pacific Islands Navigation; Lt Jeffrey Taylor
- Oceanexplorer NOAA
- Rancho Santa Fe School; David Warner
- San Diego iBotics Student Engineering Society; Paul Wisecaver
- Scripps Institution of Oceanography, Marine Physical Laboratory; Dr. M. Dale Stokes
- Scripps Institution of Oceanography, UC San Diego; Rob Monroe
- SeaPerch Project; Susan Giver Nelsen
- SeaTech 4-H Club; Lee McNeil, Lee Thieman
- Simon Fraser University, Underwater Research Lab
- Society of Naval Architects and Marine Engineers (SNAME); Susan Evans
- SONIA Team (<http://www.sonia.estmtl.ca>); Kevin Larose
- Southampton Oceanography Centre, U.K.
- U.S. Geological Survey, Coastal and Marine Geology Program; Patrick Barnard and Daniel M. Hanes
- United States Naval Historical Center; Donald M. McPherson, Kent Weekly
- University of Bath; Nic Delves-Broughton, Vicky Just, Dr. William Megill
- University of California San Diego, Argo Program; Megan Scanderbeg
- University of Oslo, National History Museum; Hans Arne Nakrem
- University of Washington, Applied Physics Laboratory; Russ Light, Brian Rasmussen
- Vancouver Maritime Museum
- Woods Hole Oceanographic Institution; Andy Bowen, Jayne Doucette, Erika Fitzpatrick, Dave Fratatoni, Christopher Griner, Dr. Susan Humphris, Tom Kleindinst, Glenn McDonald, Stephanie Murphy, Joanne Tromp

Other Individuals

(not listed above)

- James Bellingham, MBARI
- Michael Broxton, MIT
- Dick Buist
- Dr. Thomas R. Consi
- Scott Coté, Coté Consulting
- Dr. Susan Crawford, Naval Undersea Museum Foundation (Keyport, WA)
- Gail Drake, Battlefield High School and Northern Virginia Community College
- Patrick J. Endris, AlaskaPhotoGraphics.com
- Jonathan Gero, Harvard University graduate student, now with Space Science and Engineering Center, U. of Wisconsin-Madison
- Al Harvey, the Slide Farm
- Jay Henson
- Jeremy Hertzberg, Monterey Peninsula College
- Jim Hutchinson, Historical Diving Society U.K.
- Jaochim Jakobsen, Rebikoff-Niggeler Foundation
- Ian MacDonald, Texas A&M
- Neil McDaniel
- Dr. Angela Leimkuhler Moran, United States Naval Academy
- Scott Olson, Perry Slingsby Systems
- Dylan Owens
- Michael Paris
- Toby Ratcliffe, Naval Surface Warfare Center, Carderock Division
- Donnie Reid

- Christina M. Shaw, U.S. Navy Journalist 2nd Class
- Anne Smrcina, Stellwagen Bank National Marine Sanctuary
- Robert Spencer
- John Andrew Terschak
- Peter Thain
- Dr. L.T. Wang, Professor, Dept of Mechanical Engineering, National Taiwan University of Science and Technology
- Dr. Fred Watson, California State University Monterey Bay
- John F. Williams, U.S. Navy Chief Journalist
- Michael Derek Wood, SubOceanic Sciences Canada Ltd.
- Kyle Worcester-Moore
- Jill Zande