OES BEACON

Newsletter of the Oceanic Engineering Society

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IEEE

IEEE Oceanic Engineering Society

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Members are encouraged to submit copy highlighting 1) Chapter Events, 2) People & Company News, 3) Student & Young Professional News, 4) Technology Updates, or 5) other material of broad interest to the OES. Please send to Beacon Editor-in-Chief, Harumi Sugimatsu <harumis@iis.u-tokyo.ac.jp>. Word format, 1-1/2 space; Photos (always encouraged): jpg, 300 dpi preferred. Material becomes property of IEEE-OES. Please send e-mail or physical address corrections or updates to the EIC.

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Member Benefits—Did You Know?

IEEE Member Group Insurance Program

As an IEEE member in the USA, you're entitled to take advantage of this valuable portfolio of member benefit insurance options. Thousands of technology professionals have used the IEEE Member Group Insurance Program as a convenient, cost-effective addition to their family's financial plan more than 50 years. For more information, visit the IEEE site at: https://www.ieeeinsurance.com/ieee-us.html

From the OES BEACON Editors

Harumi Sugimatsu and Robert Wernli

Welcome to the December 2020 issue of the Beacon. I guess we could use as a theme the title of one of Clint Eastwood's movies—The Good, the Bad and the Ugly. Why? Well, the pandemic is definitely **Ugly!** The **Bad** is what it is doing to all of our conferences, symposia and meeting planning. But the **Good** is what our societies have done to overcome the Bad and the Ugly and succeeded in putting on our first Global OCEANS 2020: Singapore—U.S. Gulf Coast conference and several other on-line events that will be highlighted in this issue. Congratulations to all for doing a **Very Good** job in spite of the **Bad** and **Ugly** situation.

Harumi in the zodiac on her most recent AUV cruise.

With our Global OCEANS 2020 conference in mind, be sure to read the report on this virtual, yet very successful, event. Congratulations to the dual LOCs that came together and made this event happen with only three months to complete their task. And, that included the Student Poster Competitions (SPC) with competitors from each of the two original events. The results and the winning posters are included. And, a report on our OES award winners, who received their recognition on line at the Global event, is also included. Congratulations!

Ah, the good ol' days. Harumi, Tamaki and me sharing dinner during the OCEANS 2018 Kobe conference. Hopefully we'll be able to attend an event away from our computers in the near future. Kampai!

Our members have been active around the world, especially our student members. We have reports from the Japan and Malaysia chapters, the student chapter in Croatia on their Breaking the Surface conference and workshop, and the WIE and OES student chapter in Ecuador that held their on-line New Age in Oceanography conference. And, last but not least, Canada's Memorial University of Newfoundland hosted the OES AUV2020 conference, which also had to become virtual, yet was very successful.

The Journal EIC again provides recently released papers that are available to our members and our VP for Technical Activities provides the latest on our technical committee activities and how you can get involved. Also included are updates on our technical committee chairs and new Distinguished Lecturers. Welcome aboard!

Our members are continually active as highlighted in our VPPA's report on the WIE activities at our virtual Global OCEANS conference. There are also excellent articles on a two-week on-line event addressing Best Practices for Global Ocean Observations and also a report on sustaining long-term ocean observations that directly supports the UN Decade of Ocean Science for a Sustainable Development.

We also take pride in our members. Be sure to see the latest Member Highlights and also "Who's Who in the OES" that showcases one of our most active members and proves the benefits of being involved in your society.

There is a wealth of other information and articles in this issue that we hope you enjoy. And, as always, we'll close by inviting you to participate in your society. Submit articles and material for the Beacon. Or . . . volunteer for other society activities as a participant or an elected officer. It's your society and it is here to help you reach your professional goals. Enjoy.

VPTA Column

Malcolm Heron, OES Vice President for Technical Activities

Malcolm Heron

The season for renewing OES/IEEE membership is nearly finished (but you can still do it – there is a closing date of 15 December just so that membership lists, etc., can be made for the new year); welcome back if you have renewed already. If you are a new member, then I send you a special welcome. However, you probably will not receive the printed issue of the December Beacon until 2021, although it will be on the OES website electronically in December. This year renewing and new members have been offered membership of the Technology Committees for the first time as a part of IEEE's subscription system. You will receive an email from IEEE within 24 hours to invite you to select free membership of one or more TCs that are listed as "products" in the IEEE Memberships and Subscriptions Catalog under Technical Committees (If this link does not work, please copy and paste it into your browser). The feedback on this new process is that some renewing members did not receive their email. IEEE HQ assures us that the emails were sent, so it appears that we have a problem penetrated the filters and firewalls on people's inboxes. So, if you did not see the invitation to join an OES Technology Committee, then please look in your spam box, or simply follow the link given above.

The process of renewing the Technology Committees is now fairly complete with AdCom approving a procedure for establishing a new TC; and for disestablishment. In simple terms, establishment of a new TC requires a petition by at least six OES members, and a scope, etc., that is acceptable to existing TC Chairs. One embryonic TC is Signal Processing, and anyone interested in that should respond to vp-technical-activities@ieeeoes.org as soon as you can. The AdCom has also approved the re-structuring of Standards with the work of the Standards Technology Committee being moved to the Standards Standing Committee. This seems trivial, but it raises the profile of Standards because the Standing Committee is linked into the IEEE Standards Association. The Standards Standing Committee will be led by Christoph Waldmann who has an article on standards and sustainability elsewhere in this issue of the Beacon.

One remaining loose end for the OES Technology Committees arises from the need to address issues and projects like Plastics in the Ocean or Global Warming. The TCs are deliberately based on technologies, and this gives OES a strong point of differentiation from other ocean science societies. The challenge remains on how to coordinate the Technology Committees to apply their technology expertise to specific projects. This is a challenge to OES Technical Activities over the next couple of years.

Distinguished Lecturer Roster

Malcolm Heron, OES Vice President for Technical Activities

Each year OES appoints three Distinguished Lecturers for a four-year term. Each Distinguished Lecturer is endorsed by one of the Technology Committees and will work to promote the understanding of that technology and its applications. **Ken Foote** and **Jim Candy** will return to another term from January 2021 to 2024, and we welcome **Muarizio Migliaccio** to the DL roster. Ken Foote is endorsed by the Underwater Acoustics Technology Committee, and Jim Candy is endorsed by the Data Analytics, Integration and Modeling Technology Committee. You can see their details at https://ieeeoes.org/technical-activities/distinguished-lecturers/.

Muarizio Migliaccio

Full professor of Electromagnetics at Università di Napoli Parthenope (Italy)

Topics

1) Synthetic Aperture Radar for oil spill observation
2) Wind speed estimation by Synthetic Aperture Radar
3) Man-made targets at sea observation by polarimetric SAR

Biography

Maurizio Migliaccio is a Fellow of IEEE, and a full professor of Electromagnetics at Università di Napoli

Parthenope (Italy). His DL nomination was endorsed by the Ocean Remote Sensing Technology Committee. He has been teaching Microwave Remote Sensing since 1994 and has published about 160 peer-reviewed journal papers on remote sensing and applied electromagnetics. He offers a slate of three topics for OES Distinguished Lectures, but as for all DLs, he can be approached for lectures in his general field of expertise.

Synthetic Aperture Radar for Oil Spill Observation

Marine oil pollution monitoring is a topic of great applicative and scientific relevance. Use of remotely sensed measurements is of special interest and, in particular, the SAR because of its almost all-weather and all-day imaging capability at fine spatial resolution is the most effective tool. Conventional single-polarization SAR oil spill monitoring techniques are limited in their capability to detect oil slicks since they strongly rely on suitable thresholds, training samples, and ancillary information. Hence, an expert image analyst is due. The launch of a number of polarimetric SAR missions, along with the understanding of the peculiar physical mechanisms governing the scattering by an oil slick, led to a new paradigm (known as physical processing) that fostered a set of polarimetric algorithms particularly robust and efficient. Hence, suitable polarimetric models that exploit the departure from the slick-free sea Bragg scattering have been developed to effectively address oil slick monitoring. A set of polarimetric features extracted following such electromagnetic models have been proved to be reliable for oil slick monitoring. Polarimetric SAR observations led to a significant improvement in sea oil slick observation since they allow distinguishing oil slicks from a broad class of lookalikes in an unsupervised way.

Wind Speed Estimation by Synthetic Aperture Radar

The oceans cover over 70% of the Earth's surface, carrying out about 50% of global primary production and hosting the widest biodiversity on the planet. Ocean monitoring plays a key role in all World Meteorological Organization (WMO) programs. Within such a framework, sea-surface wind field is attracting growing attention from engineers and in order to boost the sustainable development by exploiting new "clean" energy sources (e.g., to plan and implement offshore wind energy farms). In this seminar the SAR, a microwave narrow-band coherent imaging system, is analyzed as sensor for sea surface wind estimation.

The critical analysis of three general procedures is presented along with a physical background.

Man-made Targets at Sea Observation by Polarimetric SAR

Sea man-made targets usually appear as bright spots over a dark background, this is due to some concurring physical factor: the large size of the target compared to the SAR spatial resolution, the metallic nature of the target that ensures a strong electromagnetic return and a low return of the sea surface that occurs in low-to-moderate wind regimes. When some of the aforementioned physical hypothesis do not occur the detection of man-made targets becomes a much more challenging task. In the seminar a physical-driven approach is presented along with a number of examples. In this seminar the supporting role of SAR polarimetry and physical processing for man-made target at sea detection is illustrated.

From the Journal Editor's Desk: IEEE Journal of Engineering Early Access Papers

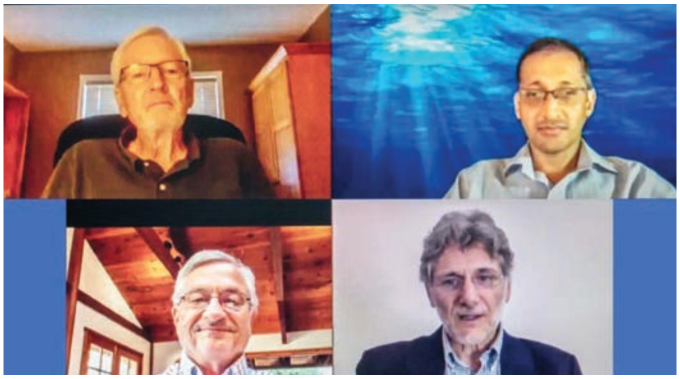
Mandar Chitre, Journal Editor-in Chief

Congratulations to the authors of our most recently approved papers for the IEEE JOE. The following papers were published as Early Access papers online on IEEE Xplore and will appear in regular issues soon. You'll find these papers now:

- Z. Liu; L. Emokpae; J. Schindall; G. Edelmann, "Experimental Study of Acoustic Channel Reciprocity in the Shallow Ocean."
- C. Christopoulou; H. G. Sandalidis; N. Vaiopoulos, "Performance of an Underwater Optical Wireless Link With a Randomly Placed or Moving Receiver."
- A. Wolek; J. McMahon; B. R. Dzikowicz; B. H. Houston, "Tracking Multiple Surface Vessels With an Autonomous Underwater Vehicle: Field Results."
- X. Zou; O. Abdelkhalik, "Modeling of a Variable-Beometry Wave Energy Converter."
- R. Shahidi; E. W. Gill, "A New Automatic Nonlinear Optimization-Based Method for Directional Ocean Wave Spectrum Extraction From Monostatic HF-Radar Data."
- W. Jobst; L. Whited; D. W. Smith, "Acoustic Clutter Removal."
- D.A. Abraham, "Signal-Phase Estimation for PRoduct Array Processors."
- J. H. Bai; W. Jo; J. H Park; R. M. Voyles; S. K. McMillan; B.-C. Min, "Evaluation of Sampling Methods for Robotic Sediment Sampling Systems."

OES Society Awards

The OES Society Awards Ceremony was held on 6th October 2020 during the Global OCEANS 2020 Singapore -U.S. Gulf Coast. This time, unfortunately we could not have a face to face ceremony. However, we could share the event with all of you from around the world. We are honored to introduce the following 2020 OES award recipients. Congratulations!



OES Awards Ceremony at the Global OCEANS 2020.

2020 Distinguished Technical Achievement Award: Mandar A. Chitre

IEEE

The IEEE Oceanic Engineering Society
takes great pleasure in presenting to

Mandar A. Chitre

The 2020 OES
Distinguished Technical Achievement Award

For development of robust high-performance algorithms for wireless underwater communication and in-situ sensing networks.

October 2020

Christian de Moustier
President
IEEE Oceanic Engineering Society

IEEE Oceanic Engineering Society

On behalf of the Society it is an honor to present this year's Distinguished Technical Achievement Award to **Mandar A. Chitre** for development of robust high-performance algorithms for wireless underwater communication and in-situ sensing networks.

Mandar is recognized for his contributions to underwater communication and networking in non-Gaussian or impulsive noise environments where many traditional modems fail to perform to their specifications. He demonstrated that propagation delay, which is usually considered a major challenge in underwater networks, is in fact an opportunity to improve network performance. This is particularly relevant for underwater communication and networking in shallow tropical waters, where snapping shrimp cacophony often drowns out communications with autonomous underwater vehicles.

Mandar is a leading innovator of practical systems for underwater acoustic communications. He founded Subnero Pte. Ltd. Singapore, a private limited (Pte Ltd) company that manufactures and distributes worldwide software-defined underwater modems based on the algorithms and protocols that he has developed in his research.

He is an Associate Professor of Electrical Engineering at the National University of Singapore, where he serves as Head of the Acoustic Research Laboratory in the Tropical Marine Science Institute. In addition, Mandar currently serves as Editor in Chief of the IEEE Journal of Oceanic Engineering.

2020 Distinguished Service Award: N. Ross Chapman

IEEE

The IEEE Oceanic Engineering Society
takes great pleasure in presenting to

N. Ross Chapman

The 2020 OES Distinguished Service Award

As Editor-in-Chief of the IEEE Journal of Oceanic Engineering (2012-2017), Chair OES Chapter Victoria BC, Chair OES Fellow Evaluation Committee, and for contributions to the governance of OES as an elected member of the Administrative and Executive Committees.

October 2020

Christian de Moustier
President
IEEE Oceanic Engineering Society

IEEE Oceanic Engineering Society

On behalf of the Society it is an honor to present this year's Distinguished Service Award to **N. Ross Chapman** for his service as Editor-in-Chief of the IEEE Journal of Oceanic Engineering (2012–2017), Chair of the OES Chapter Victoria BC, Chair the OES Fellow Evaluation Committee (2017), and for his contributions to the governance of the Society as an elected member of the Administrative and Executive Committees.

Ross joined the Editorial Board of the IEEE Journal of Oceanic Engineering in 2005 and was elected Editor in Chief of the Journal in October 2012. During his 5-year-plus tenure as Editor in Chief, Ross expanded the Editorial Board and oversaw an increase in the overall impact of the Journal as quantified by metrics in the Journal Citation Reports (for instance the Impact Factor), placing the Journal well ahead of some of its larger competitors. For reference, the impact factor of the Journal is just above 3 today.

Ross served OES in several other respects, at the local level as Chair of the Victoria British Columbia Chapter, and at the Society Level as Chair of the Fellow Society Evaluation Committee and member of the Administrative and Executive Committees. While serving in such capacities Ross always maintained a high degree of diplomacy and equanimity.

Ross has also mentored many students and young professionals. He is a true educator. He readily shares his experimental data sets, a commendable practice with all too few practitioners, and he encourages others, especially junior colleagues, to use these data while offering valuable advice and guidance.


IEEE

The IEEE Oceanic Engineering Society
takes great pleasure in presenting to

Carl Michael Pinto

The 2020 OES Presidential Award

For his extensive contributions as
Chief Financial Officer and Contract Negotiator
of all OCEANS conferences since 2016

October 2020

Christian de Moustier
President
IEEE Oceanic Engineering Society

IEEE Oceanic Engineering Society

2020 Presidential Award: Carl Michael Pinto (Mike)

On behalf of the Society it is an honor to present this year's Presidential Award to **Carl Michael Pinto (Mike)** in recognition of his extensive support and financial management of all OCEANS conferences starting with his service as Finance Chair of OCEANS 2016 Monterey. That works out to 10 OCEANS conferences so far, plus several upcoming conferences. Let's not forget that 2020 had 3 events: OCEANS 2020 Singapore, OCEANS 2020 Gulf Coast, which merged and morphed into Global OCEANS 2020: Singapore—U.S. Gulf Coast, all with complicated financial and contractual procedures.

In addition, **Mike** has been directly involved in the contracts negotiations for OCEANS conference venues and vendors, and for statements of work by Professional Conference Organizers (PCO).

Mike currently serves as the Vice President of Budget and Finance of the Marine Technology Society, co-sponsor with OES of OCEANS conferences. Before retiring at the end of 2019 Mike was the Chief Financial Officer/Treasurer of the Monterey Bay Aquarium Research Institute (MBARI) for 20 years, and of the Monterey Bay Aquarium for the previous 16 years.

Awards for OES Members

Contact the Editors With Your Submission

Jerry C. Carroll: For support and participation as Technical Program Committee/Technical Session Chair at the virtual OTC Asia 2020. Congratulations!

Dear Jerry Carroll,

First and foremost, we would like to express our sincere appreciation for your support and participation as Technical Programme Committee/Technical Session Chair at the virtual OTC Asia 2020. We sincerely hope that your participation at the virtual conference has been a rewarding one to you personally.

We are pleased to attach herewith, the e-certificate and a note of thanks from OTC Asia for your kind attention.

Once again, we thank you for your contribution and effort in making the virtual OTC Asia 2020 a successful event. It had been a pleasure working with you and looking forward to your continued support of future OTC Asia events.

OTC Asia 2020

OFFSHORE TECHNOLOGY CONFERENCE ASIA

CERTIFICATE OF APPRECIATION

Presented to

Jerry Carroll

in recognition of your participation and contribution as

Technical Session Chair

Offshore Technology Conference Asia 2020

2 – 6 NOVEMBER 2020

VIRTUAL

Neil Kavanagh

OTC Asia 2020

Oversight Committee Chairman

Chapter News

Submit Chapter News to Beacon Co-Editors and OES Chapter Coordinator

Malaysia Chapter

COVID-19 CSR Program FKEE UTHM

Reported by Abdul Kadir & Khalid Is

On July 15, 2020, IEEE OES Malaysia Chapter organized a CSR program with FKEE UTHM at Hidayah Islamic School to assist the school in conjunction with the opening of the school. Volunteers act as Frontliners to educate students on the new norms of the school environment, such as temperature screening and symptom check. Help the student understand the one-way movement plan guide. Clean the classrooms before the school session begins and after the end of the school session. Hope the Teaching and Learning atmosphere takes place in a cheerful & safe atmosphere and comply with the SOP that has been set. Hand sanitizer, masks and Sazer wipes were also donated to the school.

Photo session with the school teachers.

COVID-19 CSR Program Phase 2

Reported by Abdul Kadir & Nor Hafizah binti Ngajikin

The COVID Community Social Responsibility (CSR) Phase 2 Program was organized by IEEE OES Malaysia Chapter together with FKEE UTHM on July 21, 2020. A volunteer team was formed to serve the community at Hidayah Islamic Primary School located at Jalan Olak Batu, Ayer Hitam, Johor.

In addition to acting as a frontline (Frontliner) in helping teachers educate students on the new norms of the school environment, the team has also successfully developed an Offline Attendance System named ‘sayaHadir’. The system sayaHadir is beneficial to facilitate school or any organization to record attendance either in online or offline mode using QR-code technology.

Volunteers from FKEE UTHM.

sayaHadir is an offline attendance recording App with QR code recognition, designed to be an attendance recording solution during the COVID-19 outbreaks. With an objective to serve a large number of end-user, internet connectivity can’t be a limitation for this digital Apps. Thus, sayaHadir developed to manage attendance record by detecting QR code in the attendees’ ID card. It processes the data by producing attendance and absent lists for data analysis and reporting. This offline features also offers various benefits such as secure, manageable and economical since it does not require a web server for its operation. The use of this Offline Attendance System has been welcomed by the school and received positive feedback from the teachers.

Hopefully, the expertise can continue to be utilized to the local community. The donation also has been made to the school in terms of Face shields, Thermometers and Student tag Id for Attendance System.

COVID-19 CSR Program Phase 3, 4 & 5

Reported by Abdul Kadir

On July 22, 2020, IEEE OES Malaysia Chapter organized a CSR program COVID Community Social Responsibility (CSR) Program Phase 3 with FKEE, UTHM. The 3rd Phase of the COVID CSR FKEE program in conjunction with the opening of the second level school involving Year 1, 2, 3 & 4 students at Sekolah Rendah Hidayah, Johor. The process of arrival & compliance with new norms is running smoothly with the help of FKEE volunteers.

The COVID CSR Phase 4 & 5 program has involved 3 schools. On 23 July 2020, a phase 4 CSR program was held at Sekolah Islam Hidayah (SIH) & today a Phase 5 CSR Program was held at Sekolah Kebangsaan Seri Timbul and Sekolah Agama Seri Timbul, Senggarang, Johor.

This program is organized by IEEE OES Malaysia Chapter with Advanced Mechatronics Research Group (ADMIRE),

COVID-19 CSR Program Phase 3.

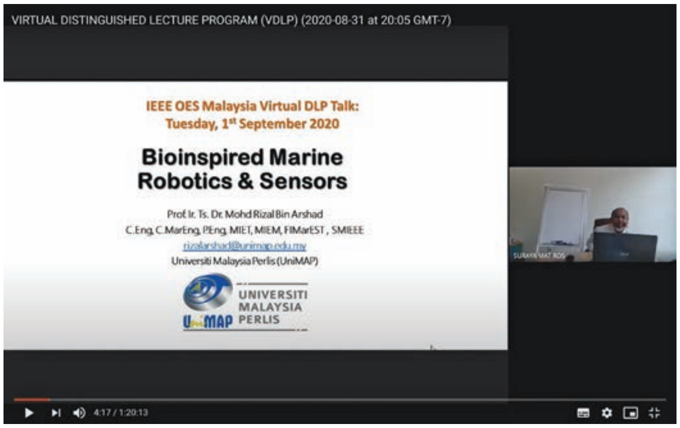
COVID-19 CSR Program Phase 4 & 5.

FKEE UTHM in collaboration with IEEE Malaysia Section AP/MTT/EMC Joint Chapter.

Virtual Distinguished Lecture Program (DLP)

Reported by Khalid Isa & Mohd Rizal Arshad

On September 1, 2020, IEEE OES Malaysia Chapter has organized a Virtual Distinguished Lecture Program (VDLP) via the Google Meet platform. The VDLP topic entitled Bioinspired Marine Robotics and Sensors, has been presented by Prof. Ir. Ts. Dr. Mohd Rizal Arshad. This VDLP was attended by 45 attendees, which include academicians, students, and industrial people. The DLP has been held for an hour, starting from 11.00 am until 12.00 pm.



VDLP session via Google Meet.

DLP presentation by Prof. Ir. Dr. Mohd Rizal Arshad.

Japan Chapter

The 4th Underwater Technology Forum-ZERO – Online

Reported by Harumi Sugimatsu, OES-J Vice Chair

The 4th Underwater Technology Domestic Forum * ZERO was held as a hybrid (face to face and virtual) meeting from

Setting up a venue for a hybrid meeting.

Online lecture on the birth ecology of whale shark form Okinawa Churaumi Aquarium.

Lecture from the venue. The topic is "A study on climate change and recent heavy rains based on earth satellite observations".

13:00 to 17:00 on 16 October 2020, on the U-Tokyo Kashiwa Campus under a state of emergency due to the spread of the Covid-19 infection.

Most of the audience and speakers attended online, however, some speakers and audience attended from the venue to liven up the meeting. As a result, there were more than 260 participants including the speakers from South Korea and Okinawa.

A benefits of online meetings is that, if there is no time difference, people living far from the venue can participate/lecture. On the other hand, a disadvantage is that it is a bit difficult to hold deeper discussions among the participants and to meet new friends.

For all of us, it is important to understand the current situation and to carry out the research activities in the best possible way.

We would like to organize this kind of hybrid conferences (half day) in collaboration with Asian countries with no time difference!

Sustaining Long-Term Ocean Observations

Christoph Waldmann, New Standards Standing Committee Chair, Senior Member IEEE OES

Christoph Waldmann

Long-term observations are critical for using ocean resources responsibly and sustainably. Many nations are cooperating to develop global and regional ocean observing networks in support of the Global Ocean Observing System (https://www.goosocean.org). However, ensuring the continuation of the existing observation system will be constrained by limited funding and cooperation among current and potential operators/users. The UN Decade of Ocean Science for a Sustainable Development will spotlight the heretofore mostly invisible role of sustained ocean data, observations and knowledge for future sustainable development solutions and climate action with the aim to shore up the sustainability of existing research infrastructure, maximize the discovery and use of observations of the ocean.

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

From the perspective of an ocean engineer, long-term ocean observations are posing specific challenges on the instruments used, which are mostly related to the performance of the involved devices under field conditions. If it comes to selecting an instrument for a particular purpose another issue comes into the picture

A moored buoy for long-term ocean measurements close to the Canary Islands (© PLOCAN, Spain).

that goes back to the ambiguity of the terms that are used in specification sheets of manufacturers, or put another way, what users understand reading those specifications. In ocean sciences there is a remarkable lack of standards that could bring a solution to that problem. Actually, in underwater acoustics a number of ISO standards exist while for other sensors only the newly developed ISO 22013 shows promise to resolve some of those issues.

The way ocean sciences is operating these days is by introducing Best Practice procedures that are designed as fit-for-purpose for different projects and applications (https://www.oceanbestpractices.org). For the moment this approach appears to be most efficient as obviously different users have different requirements on their instruments and the specification of the required performance. However, in the long run a process has to be started that at least provides a harmonization of terms and procedures across different domains, as for instance marine meteorology and oceanography. This has to be initiated to ensure comparability and better use of ocean data, also as those data are collected by huge investments in time and financial resources.

The IEEE Ocean Engineering Society (OES) has those issues on their agenda and as a matter of fact is playing a leading role in improving the situation, for instance in the establishment of the Ocean Best Practice repository (https://www.oceanbestpractices.org/repository/). Furthermore, OES is planning to foster their activities in regard to developing standards that can readily be adopted by manufacturers and infrastructure operators, with the aim to maximize the use of ocean observations.

Reference

Pearlman, J., et. al., Evolving and Sustaining Ocean Best Practices and Standards for the Next Decade, Front. Mar. Sci., 04 June 2019.

Enhancing the Ocean Best Practices System for Global Ocean Observation, Data Management and Applications

Jay Pearlman, Pier Luigi Buttigieg, Peter Pissierssens, Pauline Simpson

Nearly 500 ocean experts and enthusiasts participated in September in a virtual workshop addressing ocean observations, data management and applications. The workshop focused on ways that ocean observing across the values chain (from observations to end user decisions) can use best practices to improve interoperability and our knowledge of the oceans. The workshop also considered the capabilities of the Ocean Best Practices System (OBPS) and formulated recommendations for its enhancement.

Commonly accepted, widely used methods provide a foundational element when designing, building and operating an integrated global system [Pearlman, et al 2019]. When methods are both commonly accepted and widely used in a consistent manner, they may be termed best practices. A more formal definition of a best practice is: a **best practice** is a methodology that has repeatedly produced superior results relative to other methodologies with the same objective. To be fully elevated to a best practice, a promising method will have been adopted and employed by multiple organizations. [Bushnell, et al, 2018]

The OBPS, a UNESCO Intergovernmental Oceanographic Commission project, is a repository of ocean best practices and is implementing new technologies and solutions to facilitate the development and discoverability of best practices [Buttigieg et al 2019]. As the needs for best practices and their use has expanded, the ocean-focused communities have made recommendations for OBPS improvements through a series of annual workshops [Simpson, et al 2020]. This year, the Evolving and Sustaining Ocean Best Practices IV Workshop 2020 was held virtually between September 18–30. The workshop participants came from across the globe (see figure 1) and had a wide range of interests relating to ocean research, operations and applications. These participants offered many thoughts on the creation and use of best practices as well as recommending how the OBPS should evolve to better fulfil its vision and mission with respect to their community’s needs. The workshop consisted of three plenary sessions and eleven Working Group meetings. These Working Groups, who met multiple times during September 21–24, included topics in:

- Convergence of methods and endorsement of best practices
- Data and information management: towards globally scalable interoperability
- Developing community capacities for the creation and use of best practices

- Ethics and best practices for ocean observing and applications
- Fisheries
- Sargassum
- Marine Litter/Plastics
- Ocean Uncertainty Quantification
- Ocean Partnership Building
- Omics/eDNA
- Surface Radiation.

OBPS Workshop IV global distribution of participants and photos of some of the attendees.

There were many ideas that appeared in multiple working group reports such as training, data, convergence, and decision trees. For example, the need for the development of new virtual learning capabilities was discussed as well as the importance of effectively engaging multiple cultures as educators and trainees. Indigenous knowledge was recognized as an important element for addressing a comprehensive ocean data and information system. Participants also noted the value of increasing collaboration among existing initiatives and the importance of defining the role of ocean best practices in support of the upcoming UN Decade of Ocean Science for Sustainable Development ("Ocean Decade"). (https://oceandecade.org/)

Many of the Working Groups identified their meetings during the Workshop as an opportunity for cross-community dialogue. The desire for such fora, where community discussions can occur and where an intergenerational mix can stimulate opportunities for learning (and mentoring), was highlighted. Extending beyond the workshop, the OBPS has a forum where communities can have their own continuing sessions. This capability was received with enthusiasm. Please contact Mark Bushnell for more information (opbcommunity@oceanbestpractices.org).

Summarizing some of the key areas that arose during the workshop:

OBPS infrastructure: Improve user experience and facilitate the sharing of protocols, samples, data, and software.

Capacity development: Create dedicated online training packages for different groups to facilitate contributions to knowledge of the ocean including, for example, those working in the blue economy. It was proposed that these activities align with the Ocean Decade actions.

Potential for collaboration and partnerships: A diverse group of stakeholders is encouraged to engage more actively in the creation and use of best practices, including Early Career Ocean Professionals (ECOPs), the fisheries sector, sargassum management teams and experts in the areas of ethics. Future developments of OBPS should also support non-scientific stakeholders.

The IEEE Oceanic Engineering Society (OES) expertise in ocean engineering and science can play an important role in creating and propagating best practices in our work on sensors, platforms and systems. The contributions of the OES Technology Committees to best practices and OBPS should be expanded. For more information about the OBPS and how you can contribute, please contact: Pauline Simpson, OBPS Project Manager (p.simpson@unesco.org)

Useful Links

1) Buttigieg, PL; Caltagirone, S; Simpson, P; and Pearlman, J, (2019) "The Ocean Best Practices System - Supporting a Transparent and Accessible Ocean," OCEANS 2019 MTS/IEEE SEATTLE, Seattle, WA, USA, 2019, pp. 1-5. doi: 10.23919/OCEANS40490.2019.8962680
2) Bushnell, M; Buttigieg, P.L.; Hermes, J; Heslop, E; Karstensen, J; Muller-Karger, F; Muñoz Mas, C ; Pearlman, F; Pearlman, J; Simpson, P; (2018) "Sharing Best Practices Among Operators and Users of Oceanographic Data: Challenge, Status, and Plans of the Ocean Best Practices Project", Marine Technology Society Journal, Volume 52, Number 3, May/June 2018, pp. 8-12(5); DOI: https://doi.org/10.4031/MTSJ.52.3.11
3) Pearlman, J; Bushnell, M; Coppola, L; Karstensen, J; Buttigieg, PL; Pearlman, F; et al., (2019) "Evolving and Sustaining Ocean Best Practices and Standards for the Next Decade", Front. Mar. Sci. 6:277.doi: 10.3389/fmars.2019.00277
4) Simpson, P; Pearlman, F; and Pearlman, J; (eds) (2020) "Evolving and Sustaining Ocean Best Practices Workshop III, 02– 03 December 2019, UNESCO/IOC Project Office for IODE, Oostende, Belgium: Proceedings", Oostende, Belgium, IOC- IODE: GOOS and IEEE Oceanic Engineering Society, 37pp. DOI: 10.25607/OBP-788
5) The Evolving and Sustaining Ocean Best Practices System (OBPS) Workshop IV Agenda (https://drive.google.com/file/d/1LShINYHQY_yuqHNYew2Ukfe8iUTWhCSm/view?usp=sharing)

Memorial University of Newfoundland Hosts International Autonomous Underwater Vehicle Symposium

By: Jeff Green and Kathryn Lear (authors/editors)

This Sep/Oct, Canada's Memorial University of Newfoundland hosted the 2020 IEEE Oceanic Engineering Society (IEEE OES) Autonomous Underwater Vehicle (AUV) Symposium for the first time.

The biennial international conference was scheduled to be held in person in St. John's – the historic capital city in the Province of Newfoundland and Labrador – but the ongoing COVID-19 pandemic forced organizers to develop the event as a virtual symposium. The event took place online from Sept. 30–Oct. 3.

The conference was organized by a committee consisting of representatives from Memorial University, its Marine Institute, the National Research Council of Canada and industry.

Thanks to a strong partnership with Memorial's Conference and Event Services unit, the committee successfully delivered an innovative conference program.

Premier Event

Dr. Neil Bose, vice-president (research) at Memorial University, was the organizing committee chair. He noted IEEE OES is renowned around the world as an organizer of this premier event that brings together experts from industry, government and academia from all over the globe.

Dr. Neil Bose

"Early this year, we decided to plan for a remote online conference. The key was how to make it work," Dr. Bose noted.

"We planned presentations in a time-zone friendly asynchronous mode so it worked around the world. And we also planned networking, social events, exhibitor's spaces, workshops, cultural events and more."

Strong Representation

The 2020 symposium attracted more than 100 registrants and 70 extended abstracts and full papers from 20 countries.

Paper topics included leading edge AUV developments in navigation; design; control; sensor design and data fusion; autonomy; mission planning; applications; multi-vehicle systems and open source robotics. There were also three submissions for a student poster competition.

The primary sponsor for the symposium was Kongsberg Maritime. Richard Mills, vice-president, marine robotics sales at Kongsberg Maritime, told Memorial University's *Gazette* that as an industry leader, they felt it was important to support the research and academic community as they work to identify future challenges.

"We are keen to see new technologies and capabilities, but also how today's systems are being used in challenging environments. AUV2020 is very much a learning opportunity for us and we look forward to renewing old friendships and making new ones."

Opportunities for Advancement

Dr. Ting Zou, assistant professor, Department of Mechanical Engineering, Faculty of Engineering and Applied Science at Memorial, was the technical symposium chair.

Dr. Zou's research focuses on the development of robotic technology for multiple areas, including underwater robots like AUVs, soft inspection robots to improve current inspection techniques for complex structures and intelligent robots based on AI methodology that can work independently without human intervention.

"The control of AUV and other underwater vehicles, like biologically inspired underwater robots, is one of my research focuses," Dr. Zou told Memorial's *Gazette*.

"I will take this opportunity to investigate the state-of-the-art in AUV control techniques to work in complex underwater environments."

Dr. Ting Zou

Gina Millar, research laboratory co-ordinator with Memorial's Autonomous Ocean Systems Centre and symposium committee member, has worked in the water robotics industry for more than 15 years.

Ms. Millar says the majority of her time is spent working with the university's International Submarine Engineering *Explorer* AUV, a deep-diving AUV rated for a 3,000 metre depth.

"The people I'm working with currently are conducting oil spill research. Some of their biggest challenges right now are their levels of autonomy with the vehicle," Ms. Millar said in an interview with Memorial's *Gazette*.

"Basically, we want the vehicle to make higher levels of thought processes and decisions. I think it is something that is important for the industry in general."

"The AUV world is a small one, so we all have similar problems and it's nice to get together with other people and do some brainstorming," she added.

Special Honours

During the 2020 symposium, several awards were presented to members of the international AUV community.

Rising Star Recipients

There were two recipients of the Rising Star Award.

This award is to "Honor mid-career researchers and faculty that have made a demonstrable difference to our field and have the potential of continuing on the stellar track that they are following."

The 2020 winners of the Rising Star Awards were: Dr Michael Jakuba, WHOI, USA and Prof Martin Ludvigsen, NTNU, Norway.

Dr. Jakuba completed his PhD degree in the MIT WHOI Joint Program in 2007 in the area of hydrothermal plume detection work that was later applied to detecting and characterizing the plume from the Deepwater Horizon Oil spill.

He went on to do a postdoc at the University of Sydney before returning to WHOI where he is currently a Senior Engineer.

He has been at the forefront of AUV design and deployments and been on a large number of oceanographic research cruises with various autonomous vehicles including the ABE and Sentry AUVs, the HROV Nereus, SeaBED-class AUVs, as well as Iver2 and REMUS AUVs.

Some of his notable achievements include the design and build of the Clio biogeochemical AUV Sampler and being the lead on the HROV Nereid Under-Ice.

Martin Ludvigsen is Professor and manager of the Applied Underwater Robotics Laboratory (AUR-Lab) at the Department of Marine Technology, NTNU where he teaches the course Underwater Engineering in Trondheim, Norway.

Over the course of his career he has worked on a variety of projects including on Marine Archaeology—notably on the Ormen Lange project, on imaging with ROVs, AUVs and Surface Vehicles and in pioneering work in the Arctic environment in Svalbard on diurnal phytoplankton migration in the polar night. He is also a co-founder and CTO of the highly successful Blueye Robotics.

IEEE OES AUV Lifetime Achievement Award

This award is presented to the person who has significant achievement and contribution on AUV technology in their lifetime.

The IEEE OES AUV Lifetime Achievement Award was presented to Prof. António Manuel Pascoal, a Professor at Instituto Superior Técnico (IST) in Lisbon, Portugal, and the head of the DSOR—Dynamical Systems and Ocean Robotics Laboratory at IST.

António Pascoal has been working on Navigation, Guidance, and Control of Autonomous Vehicles, and Networked

Control and Estimation at IST, Lisbon, Portugal, since the early 90's. He obtained his PhD in Control Science from the University of Minnesota, Minneapolis, in 1987.

He pioneered the development of ocean robotics in Europe and is one of the most influential professors in ocean robotics in the world.

He was one of the driving forces behind the development of the MARIUS AUV in one of the first European projects on ocean robotics. With his team, he has successfully designed the Caravela AUV, the Delfim class ASVs, the Maia AUV and the Autonomous Vertical Profiler (both developed in cooperation with his collaborators at the National Institute of Oceanography in Goa, India), the Medusa class ASV and AUVs, including the Deep-Sea Medusa. Recently, he also led the design of a through-water wireless optical modem.

He was IST's Principal Investigator for ten EU funded collaborative research projects and several national research projects. These EU projects included the design of the vehicle and mission control systems of Sirene, an autonomous underwater shuttle, the design and implementation of the advanced multi-vehicle MORPH system capable of executing data acquisition and habitat mapping tasks in complex 3D environments, and the development of an innovative set-up between a diver and companion autonomous robots (underwater and surface) that exhibit cognitive behavior through learning, interpreting, and adapting to the diver's behavior, physical state, and actions in the CADDY project.

He has supervised 10 PhD students and holds 2 patents. His former PhD students have moved to very important positions in academia and industry in Portugal and in Europe and Asia. António's contributions in education are outstanding, not only because of breadth and depth, but also because of the engaging aspects of his method.

He has published a total of 70 book chapters and peer reviewed journal papers and 250 conference papers (h-index 34, i10-index 127).

He published seminal papers on path and trajectory tracking, on coordination and formation control under limited communications, as well as on navigation and acoustic positioning, with recent focus on cooperative navigation and control and on feature-based navigation.

His laboratory has built close collaboration links with international institutions and has attracted graduate students from all over the world to pursue their MSc and PhD degrees in fields related to dynamical system theory and ocean and aerial robotics. He also established strong collaboration links all over the world, including Europe, USA, Brazil, India, Korea, Japan and Macau. In particular, he has a 3-decade long cooperation with the National Institute of Oceanography in Goa, India,

He was Associate Editor of the IEEE Journal of Oceanic Engineering and of the International Journal of Systems, Control and Communications, Chair of the IFAC Technical Committee Marine Systems, 2008–2014, and the Representative of the Portuguese Foundation for Science and Technology (FCT) to EurOcean, the European Center for Information on Marine Science and Technology.

He has been the driving force behind the organization of several important workshops and conferences. He is the co-chair of the IEEE/MTS OCEANS 2021 conference that will take place in Porto, Portugal, in May 2021.

Finally, his contributions to OES, and to the society in general, are truly unique and engaging in their world-wide expression.

Community Appreciation Award

The Awards Committee also presented a one-time AUV Community Appreciation Award to Dr. Tom Curtin for his stellar work in identifying the hardest problems in terms of autonomous marine systems. He played a critical role in shepherding the technology while mentoring the people doing the work. This included his efforts related to funding the Spray, Slocum and University of Washington gliders. In funding the Odyssey (later Bluefin), Remus (Hydroid) and other AUVs and in pushing the entire concept of Autonomous Ocean Sampling Networks including multiple vehicle navigation, communications and docking. And finally this award is also for his continuing work for the good of the community with his engagement in K-16 involvement in marine technology.

IEEE OES International Symposium on Underwater Technology
Sponsored by
IEEE/OES Japan Chapter
Institute of Industrial Science (IIS), the University of Tokyo
Earthquake Research Institute (ERI), the University of Tokyo
Technically Co-sponsored by
IEEE Oceanic Engineering Society (IEEE/OES)

UT21 Online - SPECIAL EVENT MARCH 2 2021
UNDERWATER VIDEO COMPETITION

General Co-Chairs
Katsuyoshi Kawaguchi: Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Chang-Kyu Rheem, IIS, The University of Tokyo
Masanao Shinohara, ERI, The University of Tokyo
Technical Program Committee Co-Chairs
Toshihiro Maki, IIS, The University of Tokyo
Katsunori Mizuno, The University of Tokyo
Blair Thornton, IIS, The University of Tokyo /University of Southampton
Robert L Wernli, First Centurion Enterprises
Weilin Hou, ONRG Singapore
Secretariat
Harumi Sugimatsu, IIS, The University of Tokyo

We are delighted to announce a special online event for UT21, to fill the gap years until the next face-to-face meeting planned in March 2023.

Competition Outline
This project aims to stimulate research and development in undersea technology and oceanographic monitoring by providing intellectual stimulation to researchers and engineers by introducing their research and attractive videos to each other. In addition, we aim to build momentum for UT21, which has been postponed for two years.

Scope of Application
UT21 calls for videos designed to promote the appeal of Underwater Technology (Undersea Engineering) to a wide audience. Specific themes for the videos are as follows:

1. Environmental Monitoring
2. Marine Robotics
3. Marine Mineral Resources
4. Renewable Energy
5. Marine Construction
6. Observatory and Disaster Mitigation
7. Fishery Engineering
8. Acoustics and Communications
9. Sensors
10. Underwater Technology with Covid-19

Competition Categories

Category 1 Research Presentation
Video is expected to be of an applicant speaking on research, however as long as the video describes the research, the format is not limited to conventional presentation style. Please provide a clear and interesting summary of your research.
Category 2 General
Any style of presentation is acceptable. For example, trouble, funny or unusual scenes, beautiful or exciting scenes captured on video during underwater experiment.

Eligibility
Applicants must register for this event. Failure to register by the date separately specified may result in cancellation of the application.
Applicants must agree to the terms and conditions of competition.
Only one (1) entry per person in each category may be submitted.

How to Apply
Apply through the competition website to be available from October 1.

Video Requirements
- Video must be between one to three minutes (between 1'00" and 3'00").
- Only videos uploaded to YouTube will be considered for the competition. The privacy setting for the video must be "Unlisted". If you wish to apply the video previously uploaded to YouTube as "Public" for this competition, you must change the privacy setting to "Unlisted" or make a new upload.
- Sound is not required.
- The language must be English. For non-English speech, English subtitles must be provided.
- Include required information in the description section of the YouTube upload. (such as title, author, note that the video is submitted to UT21 Online Video Competition, etc. Details to be announced later.)
- If the video has been previously published at another conference, on YouTube, or other social networking sites, please specify the date and medium of publication at the time of entry.
- Videos that have been or will be submitted to other video competitions are not acceptable.

Selection Guidelines
Research Presentation Category: Clarity and communication.
General Category: Impression made on committee members

Results
Winners will be announced on March 2, 2021 during UT21 Online event.

Prizes
The following prizes will be awarded in each category.
Grand Prize (1 winner per category)
Runner-up (1 winner per category)
Young Researcher Prize (2 winners per category)

Schedule
Application Period Tuesday, October 1 - Friday, December 18, 2020
Announcement of selected finalists: Early February 2021
Advance voting deadline, final judging: Late February 2021
Online event with awards ceremony: March 2, 2021 (JST)

For inquiries, contact: info@ut2021.org

http://www.ut2021.org

Underwater Technology 2021
UT 21
from 1998

IEEE Oceanic Engineering Society OES

IEEE / OES Japan Chapter

Institute of Industrial Science · The University of Tokyo ·

Earthquake Research Institute University of Tokyo

A Blast from the Past! . . . OES Exhibits, Ready & Waiting!

Bob Wernli—Beacon Co-Editor-in-Chief, photos by Stan Chamberlain

OES Exhibits are always ready and waiting at all our conferences. Thanks to those who spend many hours helping in the booths. There's nothing like meeting with our present, and future, members face-to-face.

OCEANS '18 Kobe.

OCEANS '17 Aberdeen.

OCEANS '17 Anchorage.

OCEANS '16 Shanghai.

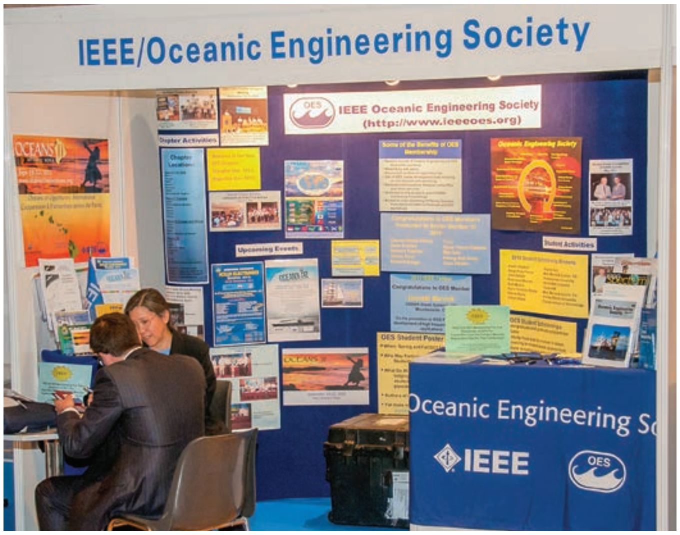
OCEANS '15 Genova.

OCEANS '14 St. Johns.

OCEANS '14 Taipei.

OCEANS '13 Bergen.

OCEANS '12 Hampton Roads.



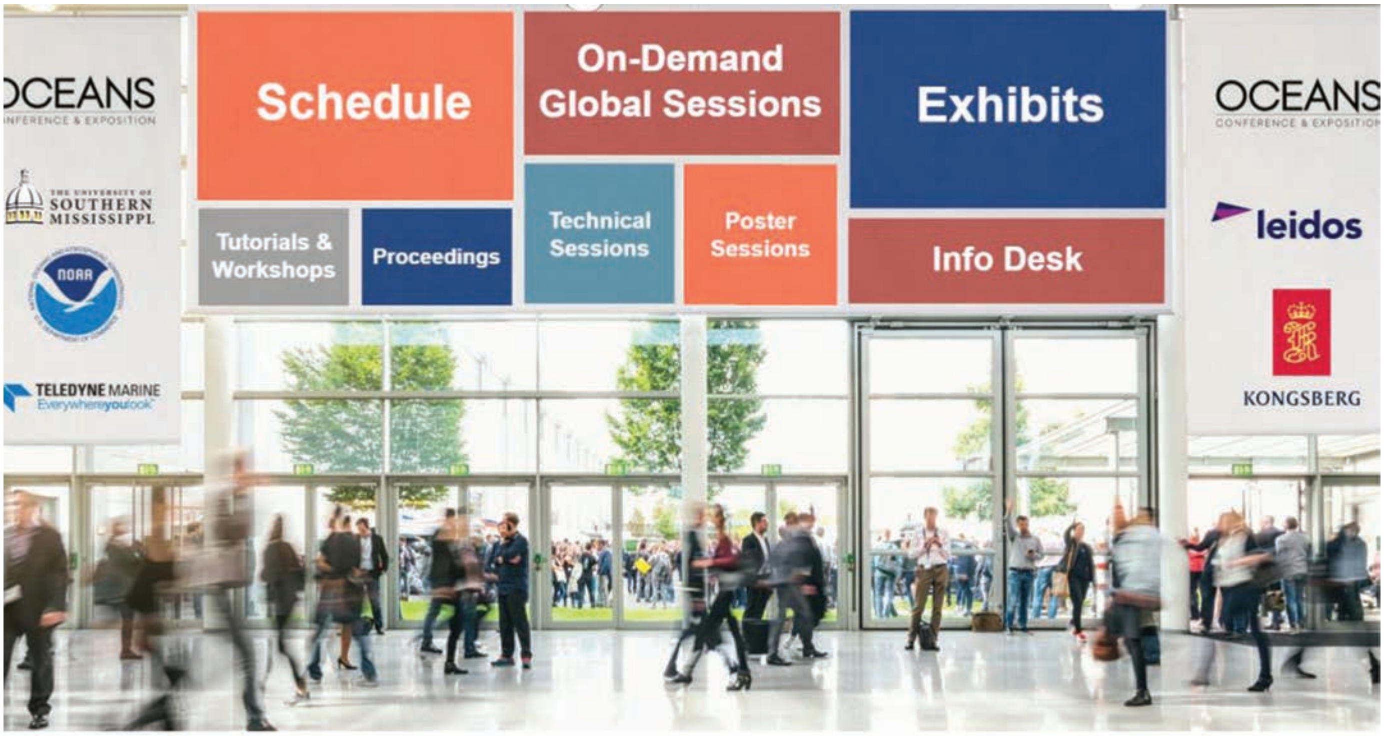
OCEANS '11 Santander.


OCEANS '07 booth at OCEANS '06 Singapore.

OCEANS '05 Brest.

Global OCEANS 2020: Singapore-U.S. Gulf Coast—An Overview

Venugopalan Pallayil & Craig A. Peterson, General Co-Chairs



The first ever virtual IEEE OES/MTS OCEANS conference, Global OCEANS 2020: Singapore-U.S. Gulf Coast, was held during 05 to 31 Oct 2020. This virtual conference was also unique as it combined two regional OCEANS into a single Global OCEANS. The ongoing COVID-19 pandemic has made it impossible for delegates to meet and greet through an in-person conference. However, technology has made it possible to keep us connected over virtual platforms. This may not have been a replacement for the usual in-person conference, but we had made every effort to make it as rewarding and exciting as possible working within the various constraints. The decision to host a virtual conference has been based on our desire to stay active, engaging and relevant considering that the ongoing pandemic and its effects are likely to stay for a year or more. It was also the best way (and possibly the only alternative) to provide an opportunity for our researchers, who have spent time and resources, to prepare their research contributions and showcase them to a wider scientific community. It was also an opportunity for many of our 'old schools', who have not been too optimistic about success of a virtual OCEANS, to get accustomed to virtual technology platforms. Whether we like it or not, virtual conferences have become the order of the day and we expect the trend to continue at least for the year 2021, and perhaps even beyond.

Way to Virtual Conference

OCEANS 2020 Singapore, which was originally scheduled during 6-9 April 2020 was initially rescheduled to Aug 2020, when the first signs of the COVID-19 virus spread became evident. This was also considering the fact that a good percentage of our research papers came from China, and our proximity to where the virus had first been detected. The above decision was taken when the CV-19 was not yet declared a pandemic by the World Health Organisation (WHO), and the transmission of the virus was mostly contained to Asia. However, soon after, most of Europe and the U.S.A. started to feel the havoc created by the deadly virus, and the COVID-19 was declared as a pandemic by WHO. Many countries declared travel restrictions as well as a shutdown of all main businesses and meetings. This forced Singapore to move the conference into a virtual mode, and the plans were underway to host a virtual conference. At the same time, the OCEANS 2020 Gulf Coast organizing committee was also considering moving into a 'virtual OCEANS,' as the spread of CV-19 in the U.S became uncontrollably high and in-person conferences were banned for the foreseeable future. A decision was soon taken, with the approval of both LOCs and JOAB, in consultation with the society leadership, to host a joint virtual conference. Two of the Co-Chairs of the two organizing committees held many meetings online prior to this decision, which helped planning to smoothly progress. A joint virtual conference made more sense both technically and operationally, as many delegates would not have wanted to or been able to attend two virtual OCEANS back to back.

Global Organising Committee, PCO Selection and Virtual Platform Selection

The first step in the organization of a joint virtual conference was the formation of an organizing committee to run the show. The easiest way to do this was to merge the two LOCs, and that is exactly what we did. We held our first meeting in June 2020 and we had little over 3 months to plan and execute the conference organization. Since then, the Global Organising Committee met twice every week to charter, discuss, and monitor the progress of work towards a successful execution.

There were two major steps involved before we could move with the organization. One was the selection of a PCO and the other was identifying a virtual platform suitable to host our conference. MCI USA had been appointed as the PCO to run North American in-person conferences from 2016–2021, however, they did not have good experience running virtual technical conferences. Furthermore, they had limited exposure to virtual platforms. The committee had to come out with a new SOW for the PCO, as there existed no SOW pertaining to virtual conferences. Note also that the committee was inexperienced with organizing a virtual conference and unfamiliar with most jargon associated with it. Nevertheless, in the interest of time and ease of transition, MCI-USA was maintained as the PCO to run the Global OCEANS 2020 conference. The willingness and confidence shown by MCI-USA also boosted the confidence of the joint organizing committee.

Prior to joining hands, the two LOCs had already run through some of the available virtual platforms that would be suitable to run OCEANS. There was a whole suite of virtual platforms ranging from simple webinar meetings to highly complex 3D Avatar featured versions. The PCO had recommended two platforms for our consideration, and the committee selected Cloud Conventions as our choice of virtual platform. Though MCI-USA had no prior experience working with this platform, they did a good job of hosting the technical programs, social programs, and exhibition in the short time available. The only downside was that the committee could not see the operational virtual platform until 2 days before the actual conference starting date.

Technical Programme

The technical programme had all the main components of an in-person OCEANS conference. This included the following:

1) Plenaries or Keynote speeches
2) Town Hall presentations
3) Panel discussions
4) Technical presentations
5) Tutorials
6) Student Poster Competitions

There were over 500 technical papers presented during this conference. The delegates were required to pre-record their presentations and upload the video on to the virtual platform. The technical presentations were available on demand throughout the conference dates. The attendees could post their queries in a chat box, and the respective presenters could visit and post their answers as needed. The delegates were also required to provide a PDF of their full paper for publication on the IEEE Xplore database.

There were many plenary and panel sessions, covering various aspects of ocean science and technologies, delivered by experts who are renowned in their respective fields. The plenaries and panel session presentations were almost all pre-recorded, but all question and answer sessions were streamed live immediately after the presentations were over. There were also Townhall presentations specific to local themes, some of which were streamed live.

The student poster competitions (SPC) were held in two tracks; the Singapore track and Gulf Coast track. Each track had its own 3-podium prize winners. 24 students from 15 different countries participated and presented their works during

Plenary.

Panel Discussion.

Women in Engineering Panel.

the SPC event. A joint prize presentation ceremony was showcased where the winners were announced, and where the supporting organisations were also acknowledged for their contributions to the conduction of the SPC. Thanks to Office of Naval Research Global, Schmidt Ocean Institute, NOAA and University of Southern Mississippi for supporting the SPC event. More details of the SPC can be found in a separate report published elsewhere in this Newsletter.

There were four tutorials and one workshop, which were offered free for registered participants. The objective of this was to boost and supplement attendee participation.

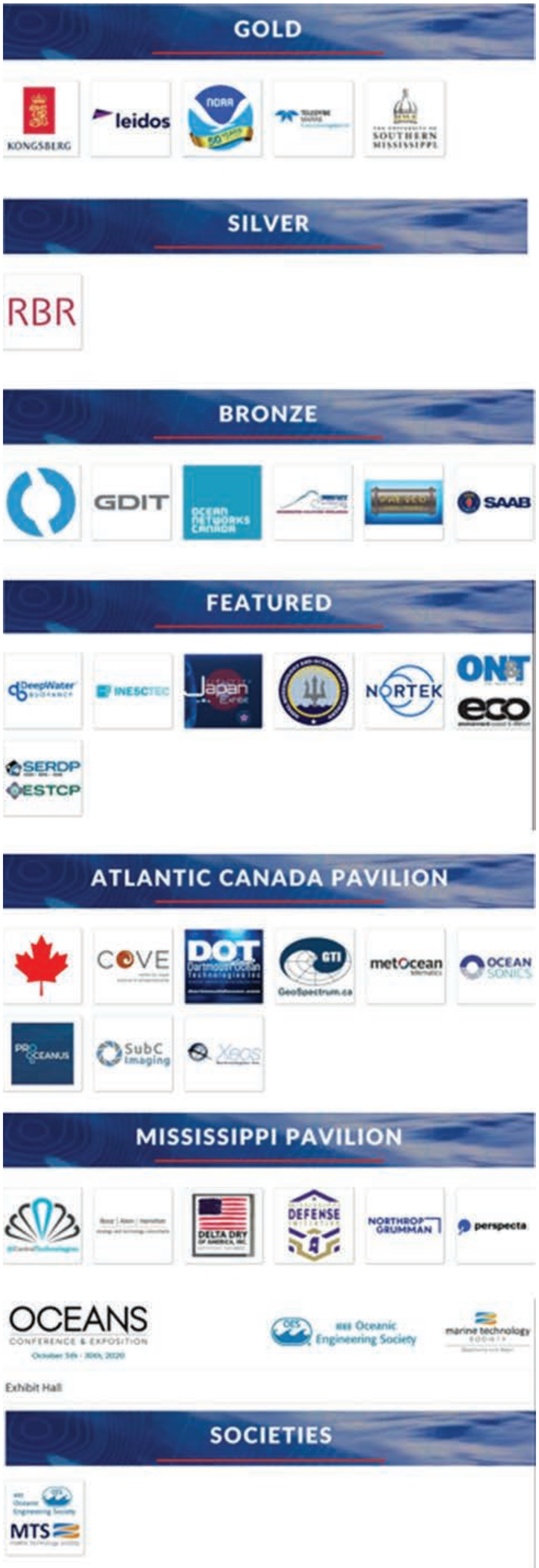
Details of the various technical programmes are still listed on the Global OCEANS conference website: https://global20.oceansconference.org. The registered delegates can download the proceedings from this link: https://globaloceans2020.org/proceedings/

The main technical live sessions were planned until 14 October after which all presentations were made available on demand until 31 October.

Exhibition

As it was the first time a virtual OCEANS exhibition was being organized, neither the organizing committee nor the PCO had a pre-planned marketing strategy. Strategies were developed on the go, and over extended discussions at GOC meetings. MCI-USA rose up to the challenges of marketing, and came out with exhibitor packages which were finalized after discussion at the GOC meetings. It was satisfying that the conference was able to meet 90% of its targeted exhibition sales goal.

A virtual exhibit hall was setup using the Cloud Convention's conference platform in which the exhibitors were allocated booths. Specific exhibit hours were included for attendees to visit the booths. Depending on the subscribed exhibition package, exhibitors were given options to organize meetings with the visitors in private virtual rooms. Participating exhibitors are shown below.



Social Programmes

To keep the 'taste and flavor' of OCEANS intact, the virtual conference also hosted events like Women in Engineering and Young Professionals meetings. These events were not only very professionally organized, but also well attended. All of the talks were pre-recorded and streamed during allocated time slots. The videos were available on-demand. Other social programmes included IEEE OES and MTS award functions. The OES award function will be reported separately in this Newsletter.

Conclusion

The OCEANS global organizing committee, society leadership, and our PCOs have all put in a relentless effort over many months to deliver a successful virtual OCEANS conference. Our inexperience in the area of virtual conferences presented many challenges. For example, it was a challenge to sync our operations across the globe. It was also a challenge to find suitable event timings to reach out to our global audience. Nevertheless, we believe that we have done a great job in the short time available to us. We had over 1000 attendees who had registered for the conference, and considering this was our first attempt at a virtual conference, the numbers are quite satisfying. We would like to hear from you on the positives of the conference, and we also welcome comments on areas that need improvement.

We would like to place on record our sincere gratitude to our honorary chairs, plenary, panel and townhall speakers, tutorial and workshop presenters, student poster competition judges and also to the technical paper presenting authors and the many attendees. We would also like to thank our reviewers, patrons, exhibitors, supporting organisations and host institutions for their kind support, which made this conference technically and financially possible.

The support extended by IEEE HQ was also commendable. The GOC and Societies worked with their Event Emergency Response Team (EERT) to have our conferences cancelled or rescheduled in conversation with the venues, contractors, and PCOs. The EERT, along with Veraprise, helped transfer the electronic Copyright Forms (eCF) from Singapore OCEANS into the Gulf Coast OCEANS, to make a single Global OCEANS technical programme. Relevant budget approvals were also fast-tracked so that the committee could make the necessary progress in our activities without any delay, and still meet financial requirements.

We hope all of you have enjoyed our 'virtual technical feast' on oceans science and technology over 25 days. We look forward to your continued support for future virtual or hybrid OCEANS conferences. Though we all have missed the in-person conferences both in Singapore and the Gulf Coast, we still have an opportunity to meet in 2024 and 2023, respectively.

IEEE Oceanic Engineering Society

Since 1983 the Oceanic Engineering Society (OES) has endeavored for the advancement of the theory and practice of electro technology, allied branches of engineering, and related arts and sciences, applied to all bodies of water.

OES members are engaged in all aspects of science, engineering, and technology that address research, development, and operations pertaining to all bodies of water. Members are encouraged to promote close cooperation and exchange of technical information while fostering the technical and professional growth through mentorship, access to periodicals, conferences, and professional networking.

Learn more at https://ieeeoes.org/

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Incredible Women in Engineering Programs at Virtual OCEANS 2020

Brandy Armstrong—VP Professional Activities

I hope you were able to catch the first global (combined Singapore and Gulf Coast), virtual, OCEANS. This was an OCEANS full of exciting firsts, including extended Young Professional and Women in Engineering (WIE) programs.

IEEE Women in Engineering Welcome and Panel

The Women's Program started strong Tuesday, October 6th, with an IEEE WIE panel moderated by myself featuring 3 former OCEANS student poster competition (SPC) winners and one SPC judge. Each panelist presented on how their careers have evolved including difficulties overcome, lessons learned, and successes and support received along the way. This is the latest in an ongoing series of panels held at OCEANS to encourage networking, support and mentorship of women in engineering and provide an opportunity for women to see other women succeeding in their field and hear their narratives.

Panelists included:

Dr. Ruth Perry, Marine Scientist and Regulatory Policy Specialist, Shell Exploration and Production Americas

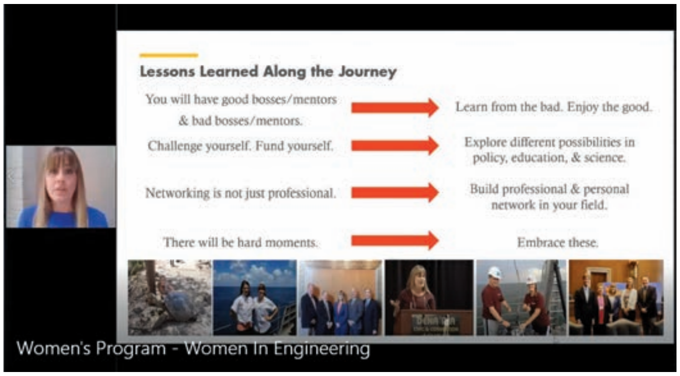
Dr. Allison Penko, Coastal Engineer, U.S. Naval Research Laboratory

Dr. Nina Stark, Associate Professor of Civil and Environmental Engineering, Virginia Tech

Dr. Malika Meghjani, Assistant Professor, Singapore University of Technology and Design

After short presentations by each of our panelists, viewers submitted their questions through the chat box. Questions covered diverse topics from work life balance and how to deal with gender bias in the workplace to the importance of support through friendship and mentorship. With women from Academia, Industry, and Government represented in the panel, it showed that YES you can pick a path that speaks to your passions and be very successful. You don't have to take my word for it, here is one male participant's glowing feedback:

"The Women in Engineering session was incredible. Men in all areas but especially in leadership positions would benefit from seeing it."



Dr. Ruth Perry summarizes lessons she has learned along her journey.

Allison Penko talk's about her journey as a woman in STEM during the IEEE Women in Engineering panel.

Our panelists used the lessons learned along their journeys to give some great advice for success as women in engineering:

- Find your champions/mentors and work with them
- Normalize motherhood in the workplace
- Build a support structure (friends, mentors, professional network)
- Embrace challenges, but not alone
- Give yourself Grace

Town Hall on Women in Leadership in Ocean Science

The next event was on Friday October 9th, a Town Hall on Women Leadership in Ocean Science and Technology. Speakers included:

Rita Colwell, University of Maryland

Ken Bailey, NOAA

Anne Miglarese, Saildrone

Christi Montgomery, United States Navy

Marie Colton, Hydros LLC

Viewers were asked to actively participate by answering questions using Mentimeter. Topics discussed included how to fix the "leaky pipeline" (why we lose so many women before they reach mid-career) to how we can ensure women are supported and heard.

Picture a Scientist Viewing and Panel

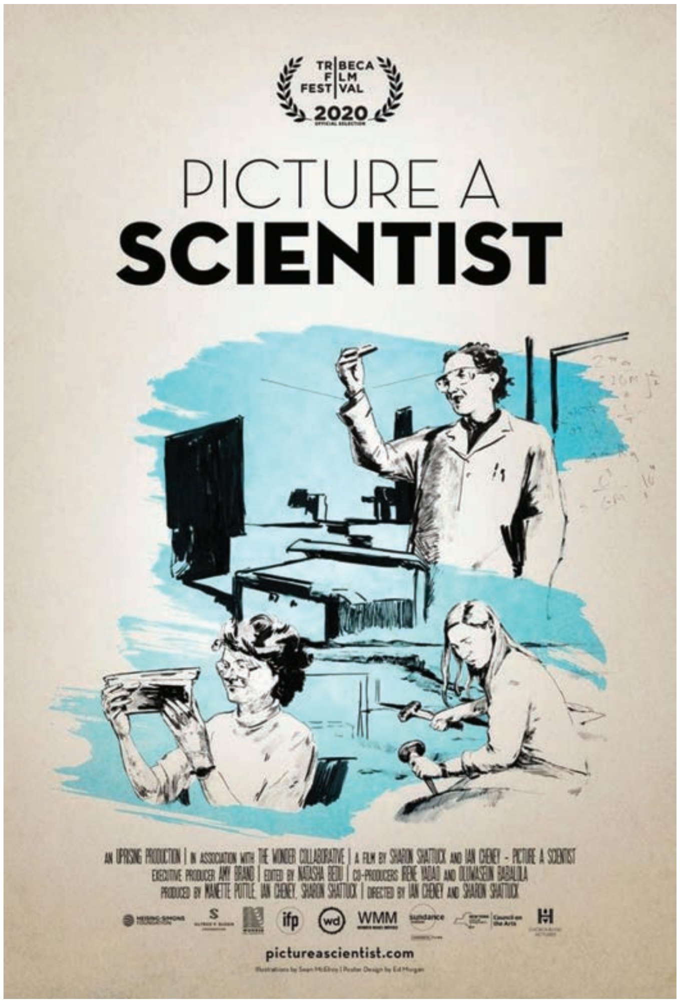
The Women's Program concluded with a free screening of Tribeca Film Festival Documentary Picture a Scientist and a panel on October 21st, Wonder Woman Day. The showing was followed by a panel discussion led by Zdenka Willis. Panelists included:

Dr. Penny Chisholm, Institute Professor, Civil and Environmental Engineering, Department of Biology, MIT

Dr. Rita Colwell, University Professor at the University of Maryland at College Park and Johns Hopkins Bloomberg School of Public Health and President of CosmosID, Inc.

Nicole LeBoeuf, Acting Assistant Administrator for the National Oceanic and Atmospheric Administration's (NOAA's) National Ocean Service

Dr. Karen St. Germain, Division Director of the Earth Science Division, in the Science Mission Directorate at the National Aeronautics and Space Administration (NASA) Headquarters



Dr. Mandy Joye, Regents' Professor, Department of Marine Sciences, University of Georgia

Brandy Armstrong, Research Scientist, The University of Southern Mississippi School of Ocean Science and Engineering

Mentimeter was again used to let panelists and audience members see what sectors were represented (.edu, .gov, etc), what career stages were represented (student, early, mid, late, retired) and how the documentary made viewers feel. Panelists addressed a wide variety of topics including why diversity in science is important, how to assert yourself and how to find (or be) an ally in the workplace.

To join the continuing conversations started this year at OCEANS, please join us on LinkedIn in the Women in Leadership in Marine Technology and Science group.

IEEE OES WIE Testimonial

In conjunction with the Women's Program, IEEE OES released a testimonial from four pioneering OES WIE members including myself, Marinna Martini, Harumi Sugimatsu, and Milica Stojanovic. Social media coordinator Manu Ignatius recorded and edited the testimonial while Young Professional Boost laureate Rajat Mishra interviewed our WIE members. If you would like to watch and share our message to aspiring members please visit the IEEE OES YouTube channel .

We collected a lot of great feedback on the programs to help us improve future programs for Women in Engineering. One recommendation, which we have been and will continue to work on, is featuring more diverse panelists. If you are interested in participating or helping to organize a future WIE program or have recommendations, please reach out to me. Let's work together to make future programs more diverse and ensure that all members (and potential members) of our Women in Engineering community are represented.

The recent IEEE OES testimonial from four pioneering OES WIE members including myself, Marinna Martini, Harumi Sugimatsu, and Milica Stojanovic was released during virtual OCEANS 2020.

The Student Poster Competition at Global OCEANS 2020

Shyam Madhusudhana, OES Student Poster Competition Chair

The Student Poster Competition (SPC) is a flagship event of the MTS/OES OCEANS conferences in which undergraduate and graduate students from colleges and universities around the world participate. The SPC was envisioned and created by Col. Norman Miller and was first implemented in 1989. It has been a feature of OCEANS conferences ever since. Typically, 15-20 students are selected to participate in the Competition, based on reviews (two stages) of their abstracts. The selected students get an opportunity to present, at the OCEANS conference, a poster describing their work.

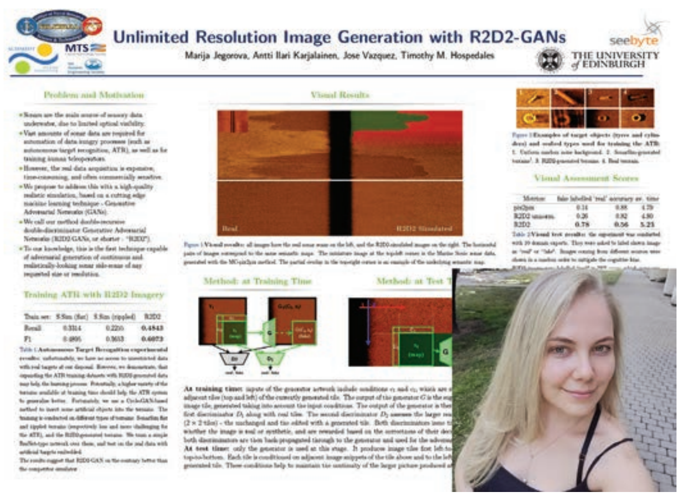
Given the pandemic-induced lockdowns and travel restrictions around the globe, this year's Singapore and Gulf Coast OCEANS conferences were merged into a unified virtual event, Global OCEANS 2020, in ensuring continuity in the OCEANS conferences series. The SPCs of the constituent editions of the conference, however, were held independently, with 11 and 13 student participants in the Singapore and Gulf Coast editions, respectively. For this SPC, the participating students were required to switch to electronic posters. Poster formats were prescribed beforehand to ensure that the submitted posters were conducive for online presentations. The students were also required to submit a pre-recorded 5-minute video of their presentations providing a quick overview of their study orally. Interactions between participants and judges were facilitated via managed one-on-one Q&A sessions during the conference.

I would like to congratulate the Local Organizing Committee (LOC) General Chairs and the LOC SPC Chairs for beating all pandemic-related predicaments and "pulling off" a successful SPC event. The SPC leadership included LOC SPC Chairs Too Yuen Min (from Singapore OCEANS) and Stephan Howden (from Gulf Coast OCEANS). I also take this opportunity to thank the sponsors—Office of Naval Research, Office of Naval Research-Global, Schmidt Ocean Institute and National Oceanic and Atmospheric Administration—for their support of this year's SPC and also for their continued support for OCEANS conferences in general.

The full list of participants (including the prize winners) together with their affiliation, poster title and an abstract of their poster are given below.

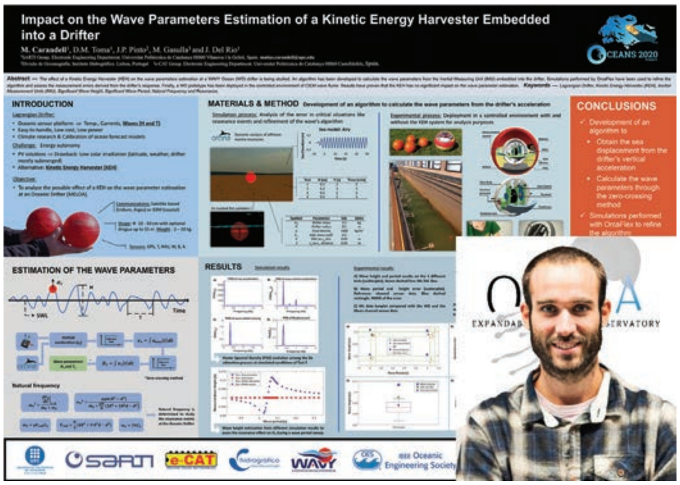
Singapore SPC

First Prize, Norman Miller Award (Certificate & $3000 prize)
Marija Jegorova, The University of Edinburgh, UK
Unlimited Resolution Image Generation with R2D2-GANs
Abstract—In this paper we present a novel simulation technique for generating high quality images of any predefined resolution. This method can be used to synthesize sonar scans of size equivalent to those collected during a full-length mission, with across track resolutions of any chosen magnitude. In essence, our model extends Generative Adversarial Networks (GANs)



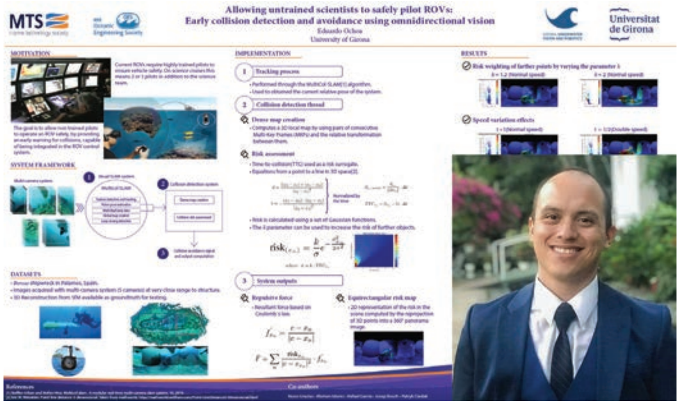
based architecture into a conditional recursive setting, that facilitates the continuity of the generated images. The data produced is continuous, realistically-looking, and can also be generated at least two times faster than the real speed of acquisition for the sonars with higher resolutions, such as EdgeTech. The seabed topography can be fully controlled by the user. The visual assessment tests demonstrate that humans cannot distinguish the simulated images from real. Moreover, experimental results suggest that in the absence of real data the autonomous recognition systems can benefit greatly from training with the synthetic data, produced by the R2D2-GANs.

Second Prize (Certificate and $2000 prize)
Matias Carandell, Universitat Politecnica de Catalunya, Spain
Impact on the Wave Parameters Estimation of a Kinetic Energy Harvester Embedded into a Drifter



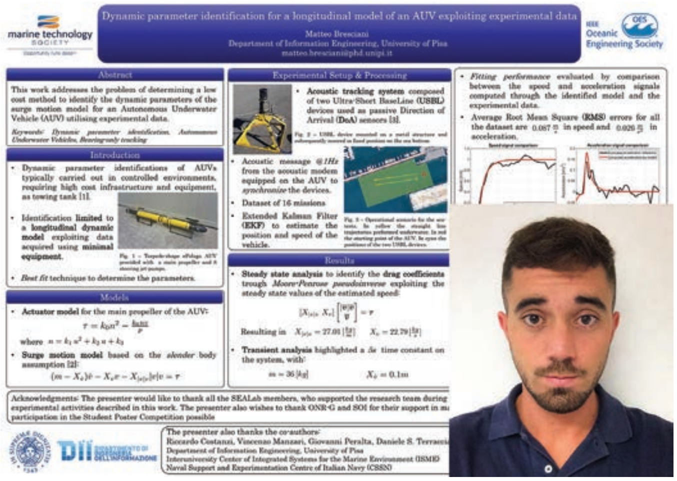
Abstract—The effect of a Kinetic Energy Harvester (KEH) on the wave parameters estimation at a WAVY Ocean (WO) drifter is being studied. An algorithm has been developed to calculate the wave parameters from the Inertial Measuring Unit (IMU) embedded on the drifter. Simulations performed by OrcaFlex have been used to refine the algorithm and assess the measurement errors derived from the drifter response. Finally, a WO prototype has been deployed in the controlled environment of CIEM wave flume. Results prove that the KEH has no significant impact on the wave parameter estimation.

Third Prize (Certificate and $1000 prize)
Eduardo Ochoa Melendez, University of Girona, Spain
Allowing untrained scientists to safely pilot ROVs : Early collision detection and avoidance using omnidirectional vision

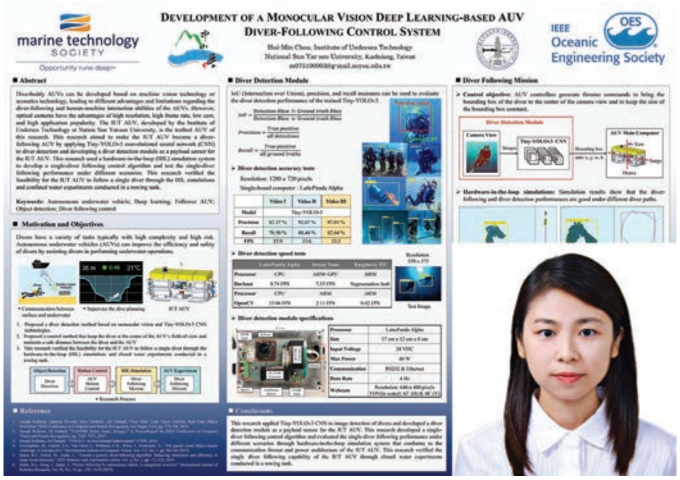


Abstract—The study of underwater environments involves multiple hazards that can compromise the safety of robots. Underwater missions require a high level of attention from Remotely Operated Vehicle (ROV) operators to avoid damage to the robot. For this reason, there is a growing trend in research to develop systems with new capabilities, such as advanced assisted mapping, spatial awareness and safety, and user immersion. The aim of this work is to devise a system that provides the vehicle with proximity awareness capabilities for navigation in complex environments. By using the advantages of omnidirectional multi-camera systems, a much higher level of spatial awareness can be achieved. This paper presents a visual-based multi-camera system which is able to detect the presence of nearby objects in the environment, to create a local map of points, and to assign collision risk values to this map. The system exploits this information to generate warnings when approaching potentially dangerous obstacles and at the same time creates a collision risk map that provides a proximity awareness representation of the environment.

Matteo Bresciani, Università di Pisa, Italy
Dynamic parameters identification for a longitudinal model of an AUV exploiting experimental data
Abstract—This work addresses the problem of determining a low cost method to identify the dynamic parameters of the surge motion model for an Autonomous Underwater Vehicle (AUV) utilising experimental data. With this goal, various sea tests were planned and carried out, involving minimal equipment. In particular, an acoustic tracking system composed of passive Direction of Arrival (DoA) sensors was used to track the vehicle while moving underwater. Such dataset was exploited to identify the values of the dynamic parameters with a best fit approach. Eventually, the comparison between the signals computed through the identified model and the experimental data has been reported as a preliminary evaluation.



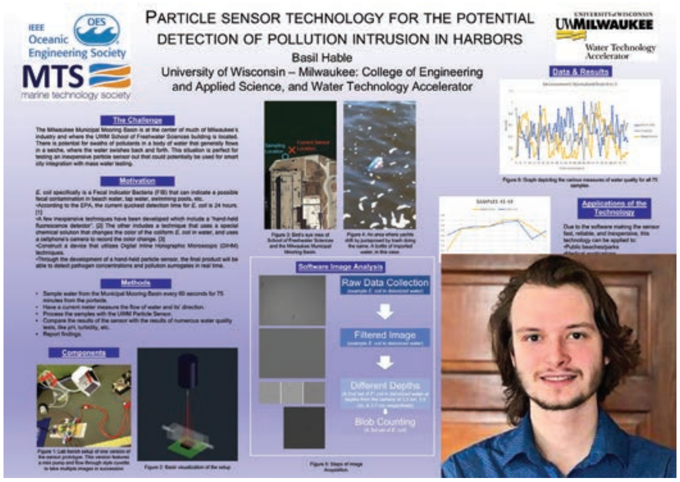
Hui-Min Chou, National Sun Yat-sen University, Taiwan
Development of a Monocular Vision Deep Learning-based AUV Diver-Following Control System



Abstract—Divers have a variety of tasks typically with high complexity and high risk. Autonomous underwater vehicles (AUVs) can improve the efficiency and safety of divers by assisting divers in performing underwater operations. A dive-buddy AUV should have the ability to follow a diver and interact with a diver. Dive-buddy AUVs can be developed based on machine vision technology or acoustics technology, leading to different advantages and limitations regarding the diver-following and human-machine interaction abilities of the AUVs. Compared with sonar devices, the main limitation of optical cameras is their short underwater visibility range. However, optical cameras have the advantages of high resolution, high frame rate, low cost, and high application popularity. The IUT AUV, developed by the Institute of Undersea Technology at Nation Sun

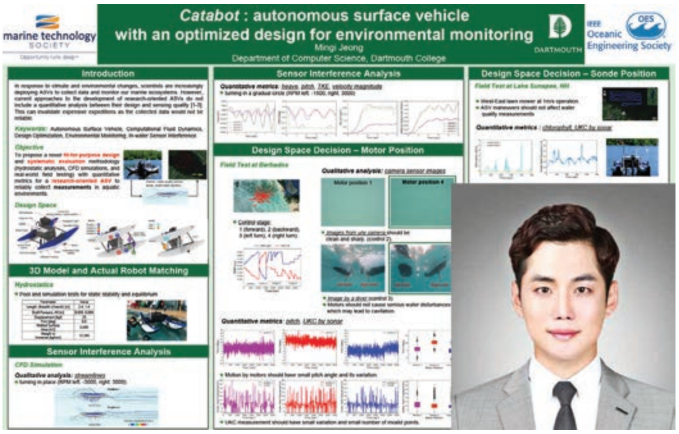
Yat-sen University, is the testbed AUV of this research. This research aimed to make the IUT AUV become a diver-following AUV. This research applied Tiny-YOLOv3 convolutional neural network (CNN) to image detection of divers and developed a diver detection module as a payload sensor for the IUT AUV. This research developed a single-diver following control algorithm and evaluated the single-diver following performance under different scenarios through hardware-in-the-loop simulation (HIL) system that conforms to the communication format and power architecture of the IUT AUV. This research verified the single-diver following capability of the IUT AUV through closed water experiments conducted in a towing tank.

Basil Hable, University of Wisconsin-Milwaukee, USA
A novel particle sensor for the detection of pollution intrusion in harbors



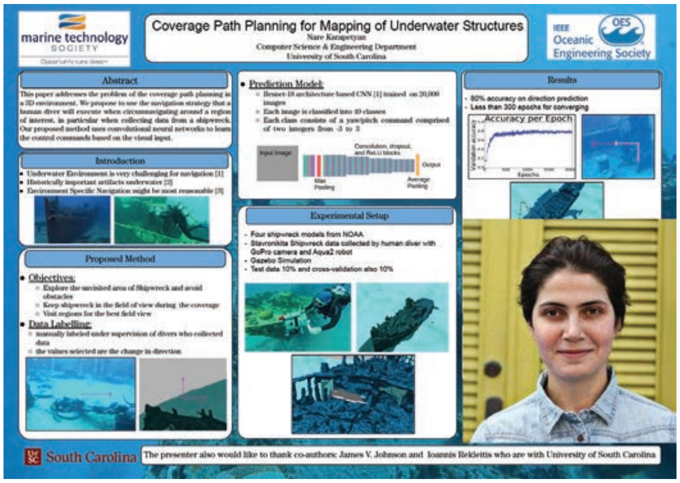
Abstract—The University of Wisconsin – Milwaukee's School of Freshwater Sciences is built at a port serving building materials companies, a grain elevator complex, a salt warehouse, a nearby oil company, an industrial refuse dumping ground, and has the city of Milwaukee, Wisconsin, USA's sewage treatment plant across the river. Naturally, this area is a testbed for finding environmentally-sound business solutions for public and private entities at the confluence of the Kinnickinnic River and Milwaukee Municipal Mooring Basin. Our group has developed an optical sensor for detecting particulate matter suspended in water at a lower cost and faster speeds than traditional methods. This manuscript will discuss the implementation and effectiveness of the sensor for detecting changes in the port's water quality.

Mingi Jeong, Dartmouth College, USA
Catabot: Autonomous Surface Vehicle with an Optimized Design for Environmental Monitoring
Abstract—This paper presents an optimized design of research-oriented ASVs and a systematic design evaluation methodology for reliable in-water sensing. The objective is to minimize the interference on sensor readings by any ASV maneuver. The design space includes motors and sensors locations. In addition, this paper analyzes modularity – i.e., the effects of new sensor's installation. All prototype designs are thoroughly tested using



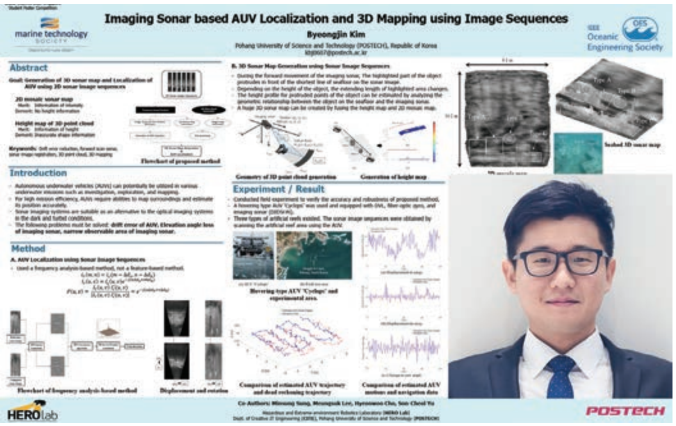
hydrostatic analyses, Computational Fluid Dynamics (CFD) simulations, and real-world field testings. Quantitative metrics, including trim, pitch, velocity magnitude of flow, and turbulence, are used to compare different configurations. Our experiments show that a motor configuration at the back part of the straights hulls is the most optimal design, resulting in high-quality data collection.

Nare Karapetyan, University of South Carolina, USA
Coverage Path Planning for Mapping of Underwater Structures



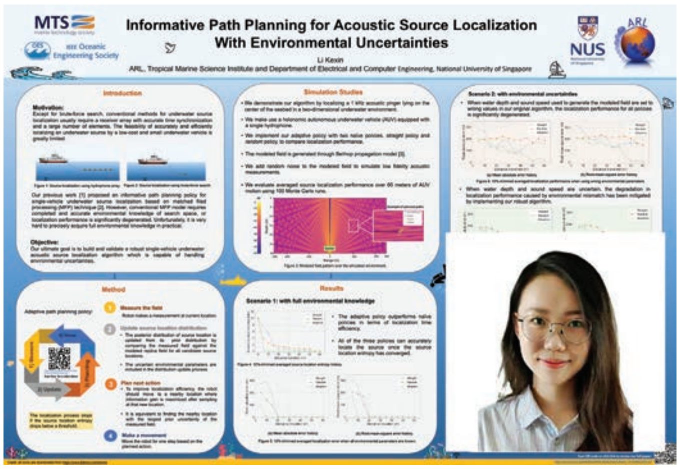
Abstract—This paper addresses the problem of the coverage path planning in a 3D environment for surveying underwater structures. We propose to use the navigation strategy that a human diver will execute when circumnavigating around a region of interest, in particular when collecting data from a shipwreck. In contrast to the previous methods in the literature, we are aiming to perform coverage in completely unknown environment with some initial prior information. Our proposed method uses convolutional neural networks to learn the control commands based on the visual input. Preliminary results and a detailed overview of the proposed method are discussed.

Byeongjin Kim, Pohang University of Science and Technology, Republic of Korea
Imaging Sonar based AUV Localization and 3D Mapping using Image Sequences



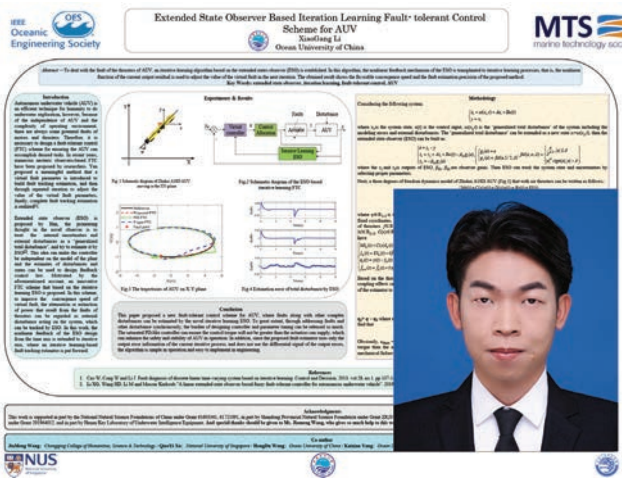
Abstract—This paper proposes a three-dimensional (3D) sonar mapping method and autonomous underwater vehicle (AUV) localization method using two-dimensional (2D) sonar image sequences of an imaging sonar. The 2D sonar image sequences are registered to generate a 2D mosaic sonar map. In this process, we can estimate the displacement and rotation relationship between the sonar image pairs, and use this to estimate the position of the AUV. A 3D point cloud is generated from 2D sonar image sequences. This method takes advantage of the mobility of the AUV to reconstruct the height information, and partially solves the ambiguity issues in the elevation angle of the imaging sonar. The height map is generated by accumulating the 3D point cloud. By fusing two maps, we can generate a 3D sonar map. We verified the proposed method by conducting field experiments. Three types of artificial reef on the seabed were scanned, and a 3D sonar map was created. In the process, the trajectory of the AUV was estimated and compared with the trajectory of the dead reckoning.

Kexin Li, National University of Singapore, Singapore
Informative Path Planning for Acoustic Source Localization With Environmental Uncertainties



Abstract—Source localization in the context of underwater environment has been recognized as an important but challenging research topic. Conventional methods usually require a receiver array with accurate time synchronization and a large number of elements. The feasibility of accurately localizing an underwater source by a low-cost and small underwater vehicle is greatly limited. Our previous work has successfully applied matched field processing concept to do single-vehicle underwater source localization with informative path planning. However, it requires accurate environmental knowledge of entire search space. In this paper, we focus on improving the robustness of our originally proposed approach. This improvement aims to ensure that our proposed source localization approach performs well even with the presence of environmental uncertainties. Simulation studies show that our robust method is capable of mitigating the effect of environmental mismatch in the MFP model for source localization.

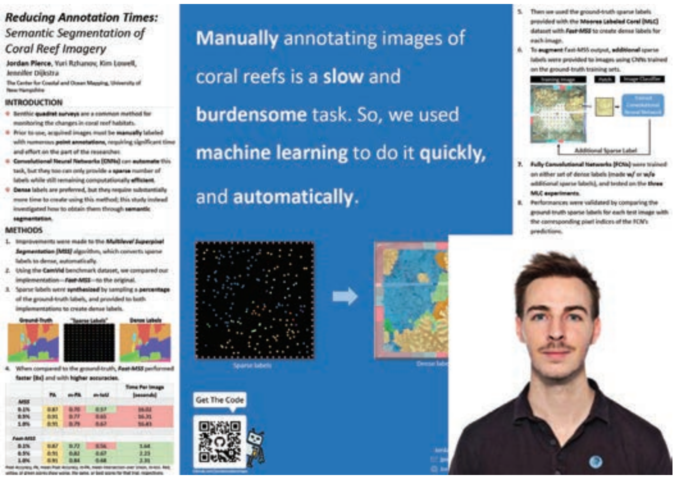
XiaoGang Li, Ocean University of China, China
Extended State Observer Based Iteration Learning Fault-tolerant Control Scheme for AUV



Abstract—To deal with the fault of the thrusters of AUV, an iterative learning algorithm based on the extended states observer (ESO) is established. In this algorithm, the nonlinear feedback mechanism of the ESO is transplanted to iterative learning processes, that is, the nonlinear function of the current output residual is used to adjust the value of the virtual fault in the next iteration. The obtained result shows the favorable convergence speed and the fault estimation precision of the proposed method.

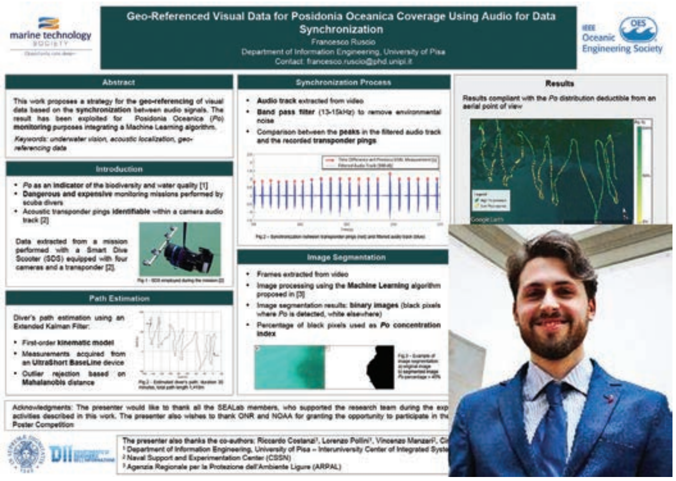
Gulf Coast OCEANS

First Prize, Norman Miller Award (Certificate & $3000 prize)
Jordan Pierce, University of New Hampshire, USA
Reducing Annotation Times: Semantic Segmentation of Coral Reef Survey Images
Abstract—Benthic quadrat studies requiring time-intensive manual image annotation are currently a critical component of assessing the health of coral reefs. Patch-based image classification using convolutional neural networks (CNNs) can automate this task by providing sparse labels, but remain computationally inefficient. This work extends the idea of automatic image annotation by using fully convolutional networks (FCNs) to provide dense labels through semantic segmentation. We present



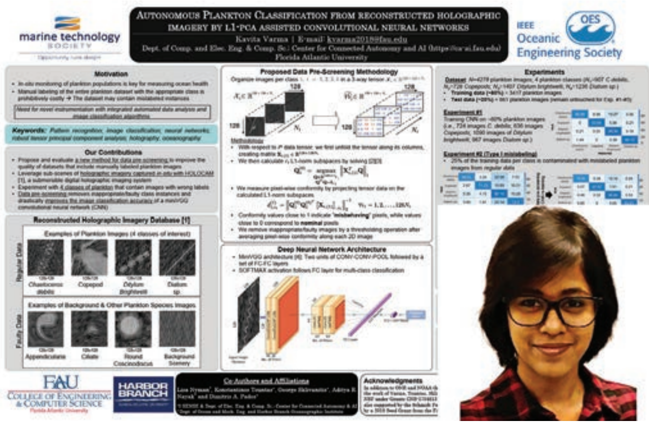
an improved version the Multilevel Superpixel Segmentation (MSS) algorithm, which repurposes existing sparse labels for images by converting them into the dense labels necessary for training a FCN automatically. Our implementation—Fast-MSS—is demonstrated to perform considerably faster than the original without sacrificing accuracy. To showcase the applicability to benthic ecologists, we validate this method using the Moorea Labeled Coral (MLC) dataset as a benchmark. FCNs are evaluated by comparing their predictions on test images with the corresponding ground-truth sparse labels. Our results indicate that FCNs' perform with accuracies that are suitable for many ecological applications, and can increase even further when trained on dense labels augmented with additional sparse labels provided by a patch-based image classifier. The contributions of this study help move the field of benthic ecology towards more efficient monitoring of coral reefs through entirely automated processes.

Second Prize (Certificate and $2000 prize)
Francesco Ruscio, University of Pisa, Italy
Geo-referenced visual data for Posidonia Oceanica coverage using audio for data synchronization



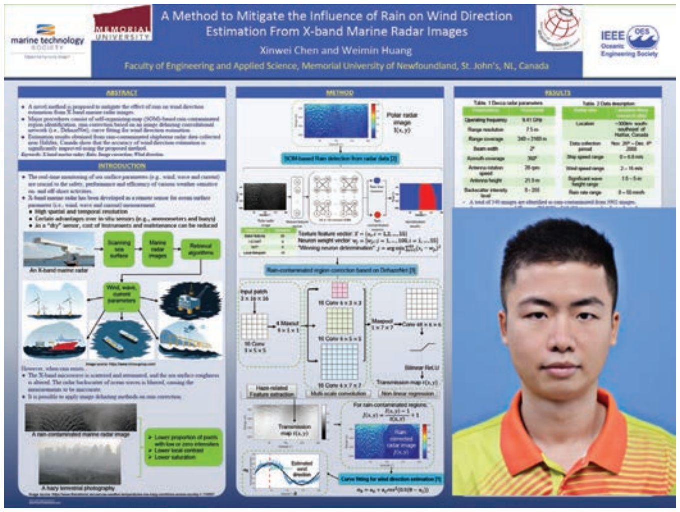
Abstract—The supervision of underwater areas is essential for the preservation of marine ecosystems. In the Italian context, Professional divers of Environmental Protection Agencies are periodically involved in monitoring activities that are repetitive, dangerous, and expensive. The Ligurian Regional Agency for the Environmental Protection (ARPAL) and the University of Pisa (UNIPI) are collaborating towards the employment of robots and ICT tools to improve the monitoring activities in terms of safety, cost and time effectiveness. This paper reports a strategy to geo-reference underwater visual data using audio for data synchronization. The work refers to a visual dataset acquired by a Smart Dive Scooter (SDS) during a Posidonia Oceanica (Po) monitoring activity in front of the Ligurian Coast. The proposed strategy concerns the synchronization between the audio track recorded by a camera and the transponder pings adopted for the SDS acoustic positioning system. The paper also reports the exploitation of the geo-referenced optical data for the identification of Po meadow over the mission area using a Machine Learning algorithm. The results are very promising and can lead to an accurate geo-referenced identification of Po and the reconstruction of the surveyed area.

Third Prize (Certificate and $1000 prize)
Kavita Varma, Florida Atlantic University, USA
Autonomous Plankton Classification from Reconstructed Holographic Imagery by L1-PCA-assisted Convolutional Neural Networks



Abstract—Monitoring and characterization of plankton species abundance and distribution in both freshwater and marine environments around the world is key for forecasting harmful algal bloom events that can cause substantial damage to aquatic ecosystems as well as the local economy. In this paper, we leverage reconstructed imagery from a novel submersible holographic system to test experimentally a new data analysis tool for robust training of a convolutional neural network (CNN) toward rapid high-confidence classification of plankton. Manual labeling oft he entire plankton dataset with the appropriate class is often prohibitively costly, therefore the dataset may contain mislabeled instances. We test a new method based on L1-norm principal-component analysis to improve the quality of labeled data sets. We carry out experiments with four classes of plankton that may contain images with wrong labels. First, the training data in each class is contaminated with images that belong to one of the four classes. Then, we consider images from other plankton species and images of background scenery that contaminate the training data of the four classes. We show that L1-norm tensor-conformity curation of the data identifies and removes inappropriate class instances from the training set and drastically improves the classification accuracy of a miniVGG CNN in both cases.

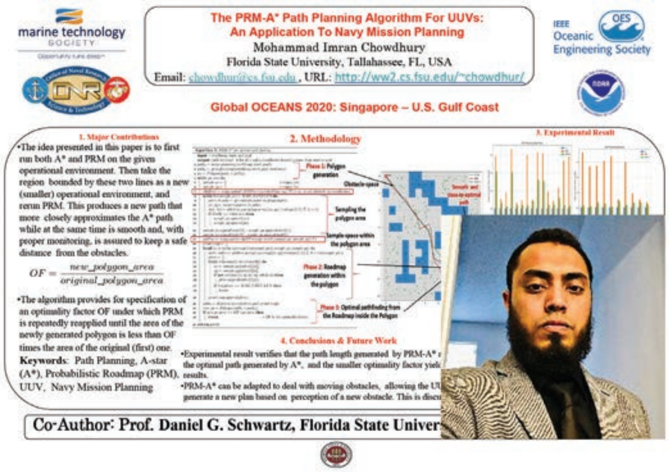
Xinwei Chen, Memorial University of Newfoundland, Canada
A Method to Mitigate the Influence of Rain on Wind Direction Estimation From X-band Marine Radar Images



Abstract—In this paper, a novel scheme is employed to mitigate the influence of rain on wind direction estimation from X-band marine radar data. Rain-contaminated regions with blurry wave signatures are first identified using the self-organizing-map(SOM)-based clustering model. Pixels located in those regions are then corrected using a deep-neural-network-based image dehazing model called DehazeNet. After obtaining the rain-corrected radar image, wind direction can be obtained using the classic curve-fitting-based method. Shipborne marine radar data collected under precipitation in a sea trial off the east coast of Canada are utilized to validate the proposed scheme. Experimental results show that the accuracy of wind direction estimation is significantly improved using the proposed scheme with a reduction of root mean square deviation (RMSD) by 19.1°.

Mohammad Imran Chowdhury, Florida State University, USA
The PRM-A Path Planning Algorithm For UUVs: An Application To Navy Mission Planning*
Abstract—This paper presents a novel path planning algorithm for unmanned underwater vehicles (UUVs) that arises by combining two well-known algorithms in such a way as to exploit their respective advantages while mitigating their deficiencies. The two algorithms are A-star (A*) and Probabilistic Road Map (PRM). The operational environment is given as a portion of open sea interspersed with various obstacles. The *free space* is the portion not occupied by obstacles.

A* employs heuristic search to explore the free space for a path from the start to the goal. This algorithm always returns

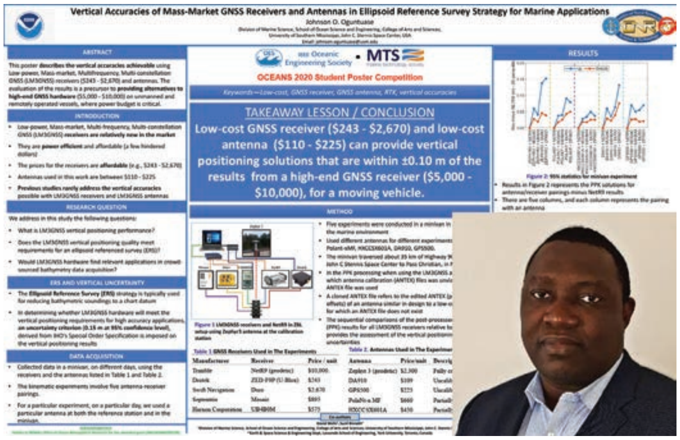


the shortest (optimal cost) path. A drawback is that the path sometimes runs dangerously close to an obstacle. In addition, the computed path can have sharp turns that are difficult for the UUV to negotiate.

PRM starts with a random sampling of the points in the free space. Once some predetermined number of such points are chosen, each point is paired with some of it's free space neighbors, and these pairs are recorded in what is called a road map. Then Dijkstra's algorithm is applied to the road map using nearest neighbor information to find a path from the start node to the goal. This has the advantage that the resulting path is smooth (no sharp turns) and stays safely away from the obstacles. It has the drawback that the path is not optimal; it can be much longer than necessary.

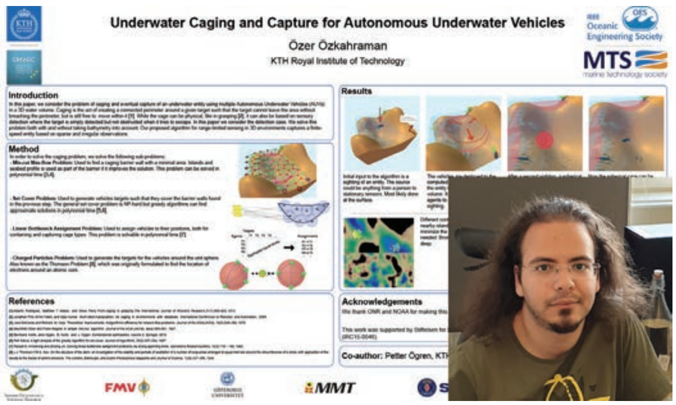
The idea presented in this paper is to first run both A* and PRM on the given operational environment. Then take the region bounded by these two lines as a new (smaller) operational environment, and rerun PRM. This produces a new path that more closely approximates the A* path while at the same time is smooth and, with proper monitoring, is assured to keep a safe distance from the obstacles. This procedure can be repeated as many times as desired, each time producing a better approximation of the optimal A* path.
While the focus here has been on UUVs, the same approach can be applied for unmanned surface vehicles (USVs).

Johnson Oguntuase, University of Southern Mississippi, USA
Vertical Accuracies of Mass-Market GNSS Receivers and Antennas in Ellipsoid Reference Survey Strategy for Marine Applications
Abstract—This paper describes the vertical accuracies achievable using Low-power, Mass-market, Multifrequency, Multi-constellation GNSS (LM3GNSS) receivers, and antennas, and evaluates the results as a precursor to providing alternatives to high-end GNSS hardware on emerging remotely operated and unmanned systems, such as autonomous surface vehicles (ASV), small unmanned aircraft systems (sUAS), and offshore GNSS buoys. The LM3GNSS receivers are relatively new in the market, and they are affordable ($243–$2,670). Given their low-power characteristics, they readily fulfill the power budget requirement aboard marine systems. In the first round of our



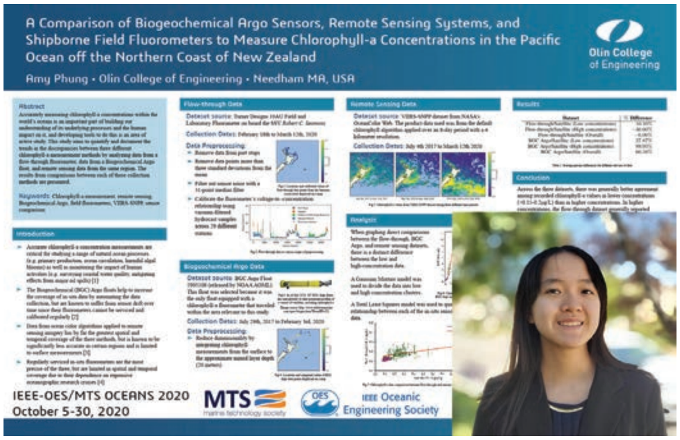
studies, we conducted five experiments in a minivan, which traveled at approximately 80 km per hour (50 mph) with matching pairs of receivers and antennas. We assume that the results should be comparable to solutions aboard a marine vessel at typical hydrographic survey speeds (10–20 km per hour {5–10 knots}). The matching pairs of receivers include four LM3GNSS hardware, Trimble NetR9 receiver, and Zephyr3 antenna. The results show that LM3GNSS receivers are capable of achieving vertical positioning uncertainties that are within 10 cm of the geodetic results (95% confidence level).

Özer Özkahraman, KTH Royal Institute of Technology, Sweden
Underwater Caging and Capture for Autonomous Underwater Vehicles



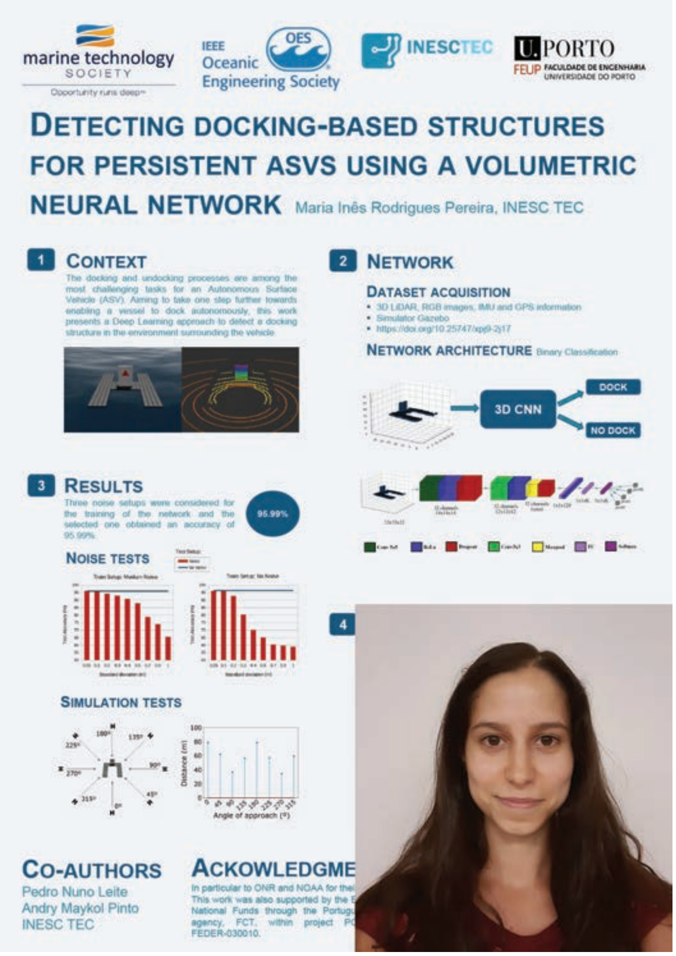
Abstract—In this paper, we consider the problem of caging and eventual capture of an underwater entity using multiple Autonomous Underwater Vehicles (AUVs) in a 3D water volume We solve this problem both with and without taking bathymetry into account. Our proposed algorithm for range-limited sensing in 3D environments captures a finite-speed entity based on sparse and irregular observations. After an isolated initial sighting of the entity, the uncertainty of its whereabouts grows while deployment of the AUV system is underway. To contain the entity, an initial cage, or barrier of sensing footprints, is created around the initial sighting, using islands and other terrain as part of the cage if available. After the initial cage is established, the system waits for a second sighting, and the possible opportunity to create a smaller, shrinkable cage. This process continues until at some point it is possible to create this smaller cage, resulting in capture, meaning the entity is sensed directly and continuously. We present a set of algorithms for addressing the scenario above, and illustrate their performance on a set of examples. The proposed algorithm is a combination of solutions to the min-cut problem, the set cover problem, the linear bottleneck assignment problem and the Thomson problem.

Amy Phung, Olin College of Engineering, USA
A comparison of Biogeochemical Argo sensors, remote sensing systems, and shipborne field fluorometers to measure Chlorophyll-A concentrations in the Pacific Ocean off the northern coast of New Zealand



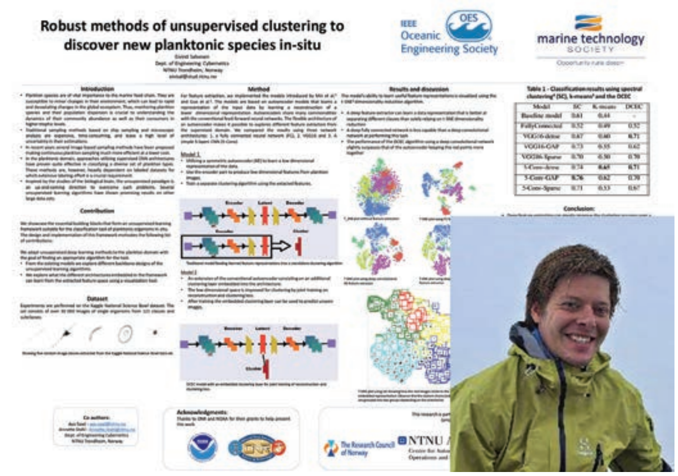
Abstract—Accurately measuring chlorophyll *a* concentrations within the world's oceans is an important part of building our understanding of its underlying processes and the human impact on it, and developing tools to do this is an area of active study. Some methods used today to collect this data include in-situ fluorometers on board automated Biogeochemical Argo-floats, flow-through fluorometers on board ocean going vessels, and ocean color algorithms applied to remote sensing data. While shipborne field fluorometers are the most accurate of the three since they can be recalibrated before and after each expedition, they are limited in spatial and temporal coverage due to their dependence on expensive oceanographic research cruises. The Biogeochemical floats help to increase the coverage of fluorometer data by automating the data collection, but are known to suffer from sensor drift over time since their fluorometers cannot be serviced and calibrated regularly. Remote sensing data has by far the greatest spatial and temporal coverage of the three methods, but is known to be significantly less accurate in certain regions and is limited to surface measurements. This study compares these three measurement methods by analyzing data collected by a 10AU Field and Laboratory Fluorometer connected to a flow-through system, data from a Biogeochemical Argo float, and satellite data from the VIIRS-SNPP dataset in the same region. The results of comparisons between each of these collection methods are presented.

Maria Pereira, University of Porto, Portugal
Detecting Docking-based Structures for Persistent ASVs using a Volumetric Neural Network



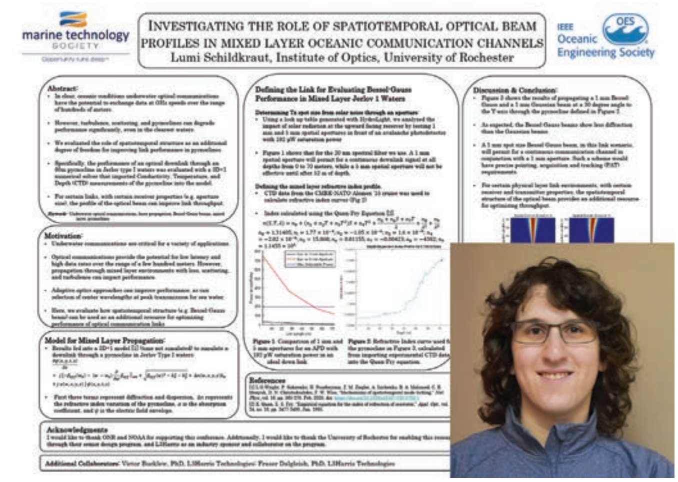
Abstract—In recent years, research concerning the operation of Autonomous Surface Vehicles (ASVs) has seen an upward trend, although the full-scale application of this type of vehicles still encounters diverse limitations. In particular, the docking and undocking processes of an ASV are tasks that currently require human intervention. Aiming to take one step further towards enabling a vessel to dock autonomously, this article presents a Deep Learning approach to detect a docking structure in the environment surrounding the vessel. The work also included the acquisition of a dataset composed of LiDAR scans and RGB images, along with IMU and GPS information, obtained in simulation. The developed network achieved an accuracy of 95.99%, being robust to several degrees of Gaussian noise, with an average accuracy of 93.34% and a deviation of 5.46% for the worst case.

Eivind Salvesen, NTNU, Norway
Robust methods of unsupervised clustering to discover new planktonic species in-situ



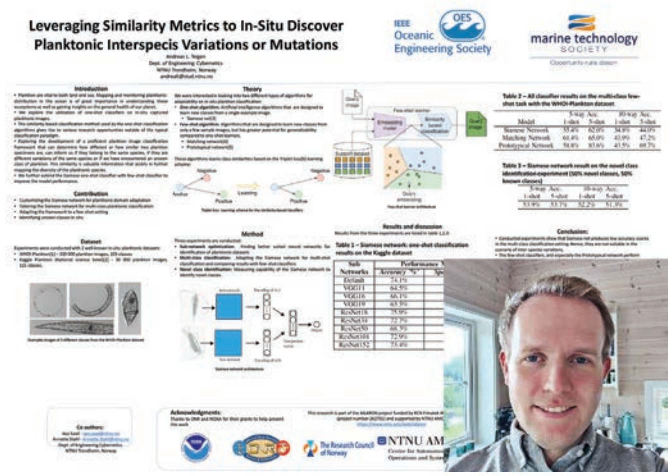
Abstract—Plankton species are of vital importance to the marine food chain. They are susceptible to minor changes in their environment, which can lead to rapid and devastating changes in the global ecosystem. Thus, monitoring plankton species and their population dispersion is crucial to understanding the dynamics of their community abundance as well as their consumers in higher trophic levels. Technological advancements of systems providing high-resolution imaging augmented by powerful computing devices made it possible to infer the distribution from sampling millions of planktonic images at low cost. Yet, this requires an extensive and time consuming manual labeling effort. The process of training to distinguish different species on manually labeled data is called supervised learning. The objective of this paper is to find new algorithms capable of minimizing the training supervision and assisting in discovering unseen classes. We explore the use of unsupervised classes of models for in-situ classification and identification of planktonic images. The aim is to embed those models into existing robotic imaging platforms to enhance the classification ability and to allow the discovery of new classes without any prior knowledge or exhaustive labeling effort. This work compares different models and shows their abilities to learn essential data structures over the National Science Bowl planktonic dataset.

Lumi Schildkraut, University of Rochester, USA
Investigating the Role of Spatiotemporal Optical Beam Profiles in Mixed Layer Oceanic Communication Channels



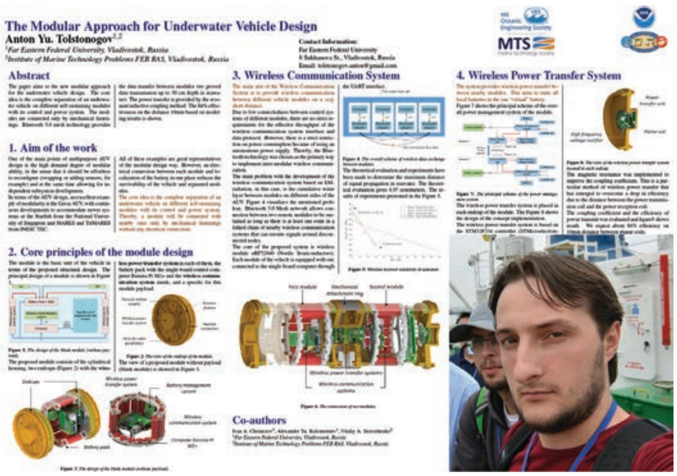
Abstract—Underwater optical communication channels can provide access to GHz speed communications between assets located within a few hundred meters range of each other. However, channel phenomena such as turbulence, scattering layers, and propagation through density gradients (pycnoclines) even in the clearest of natural waters, can significantly degrade channel performance. Here, the role of the spatiotemporal structure of the optical resource is considered as a mechanism for improving performance of a surface-to-subsea downlink scenario through a typical pycnocline in clear, oceanic waters. A 3D+1 numerical solver was developed to incorporate experimentally collected CTD measurements of a pycnocline in the upper 80 m of the mixed layer in order to evaluate and compare the propagation of semi non-diffracting Bessel-Gauss beams and standard Gaussian beams through Jerlov Case 1 waters. In certain link environments with certain initial beam parameters, we find that utilizing nonstandard optical resources can provide system performance advantages.

Andreas Teigen, NTNU, Norway
Leveraging Similarity Metrics to In-Situ Discover Planktonic Interspecies Variations or Mutations



Abstract—Planktons are vital to our planet's ecosystems. Mapping and monitoring planktonic-distribution in the ocean is of great importance in understanding these ecosystems as well as gaining insights on the general health of our planet. The task of identifying different planktonic species and their concentrations is a critical yet challenging part of this endeavor. In this paper, we explore the utilization of *one-shot* classifiers on in-situ captured planktonic images. The similarity-based classification method used by the *one-shot* classification algorithms gives rise to various research opportunities outside of the typical classification paradigm. Exploring the development of a proficient plankton image classification framework that can determine how different or how similar two plankton specimens are, can inform us if they belong to the same species, if they are different variations of the same species or if we have encountered a completely unseen classes of plankton. This similarity is valuable information that assists in further mapping the diversity of the planktonic species. We further extend the Siamese *one-shot* classifier with *few-shot* classifier to improve the model performance. Empirical evaluations of the new extension yield promising results.

Anton Tolstonogov, Far Eastern Federal University, Russia
The Modular Approach for Underwater Vehicle Design



Abstract—The authors propose a new modular design of an underwater vehicle in the article. The core idea is the complete separation of an underwater vehicle on different self-sustaining modules with its control and power system. It is proposed that wireless technology will provide data and power transfer between modules. The approach might be useful for design low-cost underwater vehicles for surveying in shallow water (up to 100 meter depth) with different replaceable payload modules. The paper presents the principal design of modules and their joint.

The communication system's design based on Bluetooth Mesh is presented. The experiment shows reliable data transmission upto 35mm in seawater and up to 100mm in seawater with plastic supports between module housings.

The power management system is presented and discussed in the paper. The paper presents its overall design and the wireless power transfer system as the most critical node. The last one aims to unite batteries of all vehicle modules in the one "virtual" battery. It is shown that power transfer efficiency is up to 84% on distance 10mm between planar coils due to implementing the magnetic resonance method.

Winning Poster Paper—Singapore

Unlimited Resolution Image Generation with R2D2-GANs*

Marija Jegorova[1], Antti Ilari Karjalainen[2], Jose Vazquez[2], Timothy M. Hospedales[1]

***Abstract*— In this paper we present a novel simulation technique for generating high quality images of any predefined resolution. This method can be used to synthesize sonar scans of size equivalent to those collected during a full-length mission, with across track resolutions of any chosen magnitude. In essence, our model extends Generative Adversarial Networks (GANs) based architecture into a conditional recursive setting, that facilitates the continuity of the generated images. The data produced is continuous, realistically-looking, and can also be generated at least two times faster than the real speed of acquisition for the sonars with higher resolutions, such as EdgeTech. The seabed topography can be fully controlled by the user. The visual assessment tests demonstrate that humans cannot distinguish the simulated images from real. Moreover, experimental results suggest that in the absence of real data the autonomous recognition systems can benefit greatly from training with the synthetic data, produced by the R2D2-GANs.**

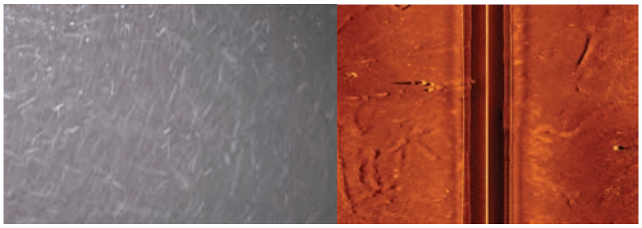


Fig. 1: **Examples of underwater sensors. Left:** optical camera - an example of visibility in northern seas, this effect is called *marine snow*, it is caused by high density of fine floats. In cases of poor visibility, sonars are often preferred over the cameras as more perceptually robust. **Right:** sonar side-scan. Port (left) is real, starboard (right) is synthesized.

I. Introduction

Underwater optical visibility is often impaired due to the effect called marine snow, shown in Figure 1 (left), especially in cold seas. Because of that sonars are the primary source of the sensory information for autonomous vehicles operating underwater. The real-life underwater data collection is expensive, time-consuming, and impossible to carry out in certain locations.

However, the vast amounts of data are necessary for automating a number of the data-intensive applications, such as training of autonomous target recognition systems (ATR), as well as training human operators. The data shortage can be addressed by using the limited available data to train a high-quality simulator, capable of producing realistically looking synthetic imagery.

In this paper we propose a technique for synthesis of full-mission-long high-resolution seabed sonar scans, building upon the previously presented method, MC-pix2pix [1], suitable for lower resolution sonars. We suggest to extend the principle of MC-pix2pix further, enabling the resulting generative model not only to preserve all the strengths of its predecessor, but also to generate the data of any chosen high resolution, in principle - any desired resolution.

The speed of the data generation depends on the hardware, sonar range, and on the required resolution. For instance, for Marine Sonic sonars (512 pixels across track $\times 2$ channels) the generation rate is almost 20 times faster than the rate of the real data acquisition. For higher resolution sonars, like EdgeTech (approximately 4620 pixels across track $\times 2$ channels), the rate is at least twice faster than the rate of the real data acquisition. These estimates have been acquired with GTX 1080 Ti graphics card (12Gb RAM).

We call our method double-recursive double-discriminator Generative Adversarial Networks (R2D2-GANs, or "R2D2" for the sake of conciseness). To our knowledge, this is the first technique capable of adversarial generation of continuous and realistically-looking sonar side-scans of any requested size or resolution.

Potential applications of R2D2 can go far beyond the sonar imagery, as it can produce any type of large resolution imagery, provided a sufficient amount and quality of the initial training examples.

The visual examples of the results of the R2D2-GANs are provided in the Figure 2. Results demonstrated in this work are acquired with the image-to-image translation based architecture [2], which could be easily altered to accommodate another type of GAN, in order to better facilitate different simulation objectives.

II. Related Work

The focus of this paper is the simulation of continuous side-scan sonar imagery of any requested size and resolution, with the user-controlled topography. Because of the visual nature and preferred stochasticity of such simulation, we focus on the corresponding family of the generative models.

Generative Adversarial Networks (GANs) were first introduced in 2014 [3]. Since then, they grew into a highly diverse class of methods and became the most popular way of the realistic image and video generation [4], image completion [5], super-resolution [6], and style transfer [7], [2], [8], [9]. There has also been a number of alternative applications, such as

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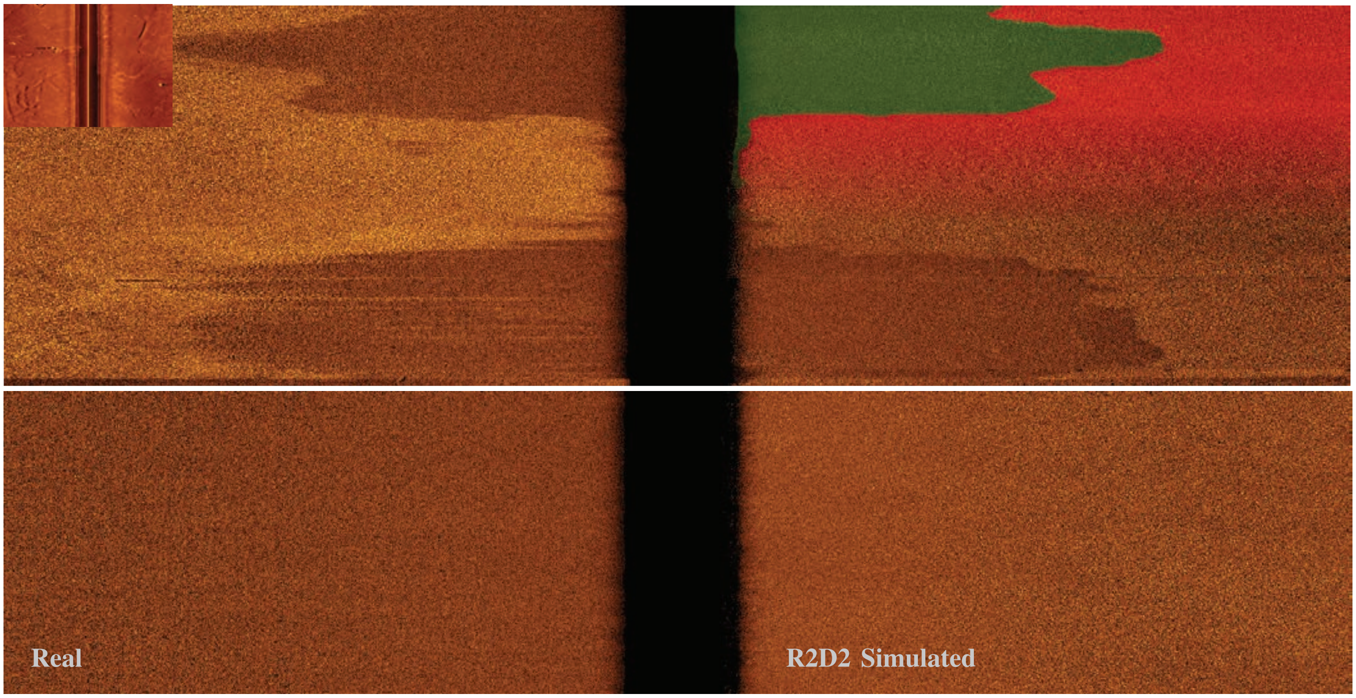

Fig. 2: **Visual results:** all images have the real sonar scans on the left, and the R2D2-simulated images on the right. The horizontal pairs of images correspond to the same semantic maps. The miniature image at the top-left corner is the Marine Sonic sonar data, generated with the MC-pix2pix method [1]. The rest of the images are EdgeTech sonar scans, generated with R2D2-GANs, provided in a relative scale according to the corresponding across track resolutions. The partial overlay in the top-right corner is an example of the semantic map, used by a generator network in order to control the topography of the simulation according to preferences of the user.

generation of socially acceptable trajectories [10] and control policy generation with GANs [11], [12]. Nevertheless, the visual data still stays the primary domain of application and development of the GAN models.

Despite that, there is still a relatively limited number of applications of GAN-based methods to the underwater sonar domain. Until recently the only application was the sonar imagery enhancement, mostly for the ATR training purposes - applying CycleGANs-powered style transfer to enhance the synthetic targets for the ATR training sets [13], and refining underwater video images [14]. However, there is almost no work focusing on the generation of the whole missions worth of the synthetic sonar data with complex terrains.

The first published work to bridge this exception was MC-pix2pix [1]. This method produces continuous full-mission-long sonar images for smaller across track resolution sonars (such as Marine Sonic). The results are both indistinguishable from real by human experts and capable of boosting the performance of the ATR systems. MC-pix2pix facilitates realistic conditional generation of the user-specified terrains with a modified pix2pix-style image translation. MC-pix2pix exploits Markov assumption for sequential generation of the image fragments in the along track direction, providing the continuity of the resulting image. An additional advantage of this piece-wise architecture is that it is relatively undemanding about the hardware. It is being supported even for the GPUs with very modest RAM capacities, which is almost never an option for the other higher-resolution GAN types.

Our new method, the R2D2-GAN, retains the general performance level of the MC-pix2pix method and completely surpasses the former on the magnitude of the across track image resolution it is capable of generating.

III. METHOD

The R2D2 belongs to the family of GANs. More specifically the R2D2 is an extension of the Markov-conditional image-to-image translation technique, MC-pix2pix [1], repurposed to enable image generation in larger resolutions.

GANs at a glance: the default GAN architecture usually consists of two neural networks. The first one, called the discriminator, learns to distinguish the real training images from the synthetic ones, whereas the second one, the generator, trains to create synthetic images that the discriminator cannot distinguish from real ones. Both networks are trained completely from scratch, gradually improving performance in an iterative manner via adversarial training. The final result of the GAN training is usually the trained generator network capable of generating diverse realistic images.

There are multiple conditional flavours of this basic architecture. Henceforth we focus on the paired image-to-image translation techniques, of which the pix2pix [2], [8] is a prime example. This choice is dictated by the requirement of the user-controlled topography.

The main features of the R2D2 technique: (i) incremental recursive generation (extending the Markov principle from [1]) applied along two axes (rather than just one, like in

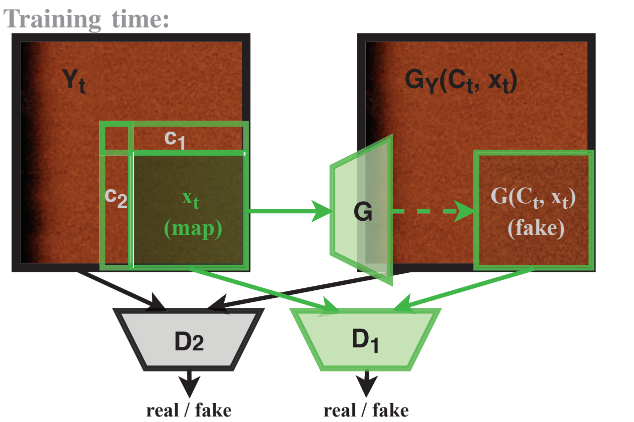

Fig. 3: **At training time:** inputs of the generator network include conditions c_1 and c_2, which are small snippets of adjacent tiles (top and left) of the currently generated tile. The output of the generator G is the suggested synthetic image tile, generated taking into account the input conditions. The output of the generator is then assessed by the first discriminator D_1 along with real tiles. The second discriminator D_2 assesses the larger real image variants (2×2 tiles) - the unchanged and the edited with a generated tile. Both discriminators issue their decisions on whether the image is real or synthetic, and are rewarded based on the correctness of their decisions. Losses of both discriminators are then back-propagated through to the generator and used for the adversarial training.

[1]). This allows for handling any across track resolution. (ii) an additional discriminator is introduced for the coherence control of resulting larger scale images. Figures 3 and 4 provide the schematic illustration of the method.

At training time: as per scheme in Figure 3, first, the larger training images and their semantic maps are partitioned into multiple tiles. The generator inputs noise and the semantic maps of the current tile - for topography control. It also uses the additional conditions that include the location of a pixel in the across track direction and small snippets taken from the adjacent tiles above and to the left of the current tile. These are to ensure the continuity of the resulting large image. The generator is trained to produce realistic images given the above inputs and conditions.

The discriminator D_1 then tries to distinguish the real imagery from the simulated. The discriminator D_2 does the same, but processing the larger images (2×2 tiles) with the newly generated tiles embedded into them, and tries to distinguish them from the real unedited larger images.

The results provided in this paper are building upon the fully-convolutional pix2pix-style architecture with 9 resnet blocks [2], extended with additional conditions to support incremental recursive generation and additional "bigger picture" discriminator D_2 to further encourage the smoothness and continuity of the resulting image. This model is adversarially trained for 10 epochs with batch-size 3, and 3 gradient updates of discriminator D_1 corresponding to each gradient update of the generator. The training loss function can be

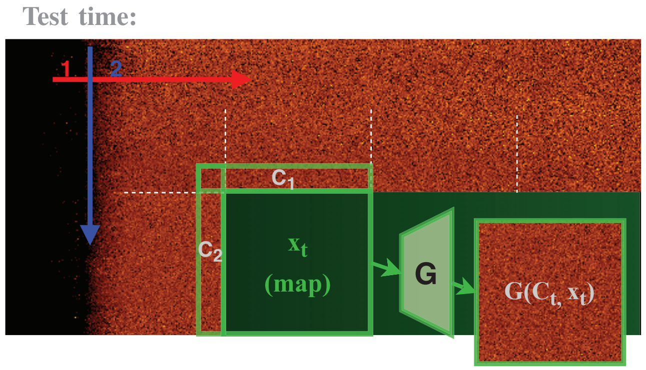

Fig. 4: **At test time:** only the generator is used at this stage. It produces image tiles first left-to-right, and then top-to-bottom. Each tile is conditioned on adjacent image snippets of the tile above and to the left of the currently generated tile. These conditions help to maintain the continuity of the larger picture produced at test time.

summarised as follows:

$$G_t^{\star} = \arg\min_G \max_D \{\mathbb{E}_{\mathbf{C}_t,x_t,y_t,z}[\|y_t - G(\mathbf{C}_t, x_t, z)\|_1]$$

$$+ \frac{1}{2}\Big(\mathbb{E}_{\mathbf{C}_t,x_t,y_t}[logD_1(\mathbf{C}_t, x_t, y_t)] + \mathbb{E}_{X_t,Y_t}[logD_2(X_t, Y_t)]$$

$$+ \mathbb{E}_{z,\mathbf{C}_t,x_t}[1 - logD_1(\mathbf{C}_t, x_t, G(\mathbf{C}_t, x_t, z))]$$

$$+ \mathbb{E}_{\mathbf{C}_t,z,X_t}[1 - logD_2(X_t, G_{Y_t}(\mathbf{C}_t, x_t, z))]\Big)\} \quad (1)$$

where x_t are semantic maps and y_t are real sonar images per tile. X_t and Y_t are larger (2×2 tiles) semantic maps and sonar images respectively. X_t and Y_t include tiles x_t and y_t correspondingly. z is a random noise vector, and $\mathbf{C}_t = [c_1, c_2]$ are the condition variables for the generator. $G_{Y_t}(\mathbf{C}_t, x_t, z)$ stands for a larger image Y_t (2×2 tiles), where the native tile y_t is replaced by the generated tile $G(\mathbf{C}_t, x_t, z)$. The first line of Equation (1) represents the L1 loss, a regularization term meant to reduce the blurring in the generator output [2]. The second line stands for the losses of both discriminators classifying the real data, and the last two lines are their losses of classifying the generated data.

At test time: the trained generator produces the entire image continuously piece by piece, first left-to-right, and then top-to-bottom, in accordance with the requested semantic maps. Refer to the Figure 4 for the schematic explanation.

Generalisation: the underlying technique of the R2D2 can be generalised beyond the specific GAN architecture. Nearly any GAN-based network, depending on the objectives and constraints of a specific task, can in principle be extended for the incremental recursive generation in a manner similar to the R2D2. The results provided in this paper are based on extending pix2pix-style architecture [2] solely for the purpose of providing the user with full control over the topography of the synthesized mission via utilisation of semantic maps.

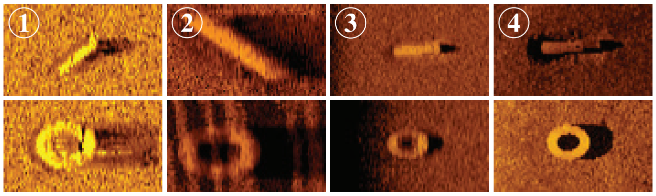

Fig. 5: **Examples of target objects (tyres and cylinders) and seabed types used for training the ATR:** 1. Uniform random noise background. 2. SonarSim-generated terrains[1]. 3. R2D2-generated terrains. 4. Real terrains. All of these targets are inserted into the terrains using the Cycle-GAN-based technique [13], because of the limited availability of the real data with real targets.

Metrics:	fake labelled 'real'	accuracy	av. time
pix2pix	0.14	0.88	4.79
R2D2 unnormalized	0.26	0.82	4.80
R2D2	**0.78**	**0.56**	**5.23**

TABLE I: **Visual test results:** the experiment was conducted with participation of 10 human experts possessing the daily experience of dealing with the sonar imagery. They were shown an equal number of images generated by different sources (both simulated and real) and asked to label them as "real" or "fake". Images coming from different sources were shown one after the other in a random order to mitigate the cognitive bias.
R2D2 images were labelled "real" in 78% cases, which compares well with the benchmarks, as well as with real images labelled "real" (90%). Humans also were able to distinguish it from real with accuracy of 56 %, which is close to random chance in a two-class problem ("real" / "fake"). The last column of the results shows how long (in seconds) on average it took to classify an image. R2D2-produced images took significantly longer to process, compared to the other methods.

IV. Experimental Setup

Visual quality tests: a number of assessments were conducted in order to quantify the realism of the obtained imagery. We invited 10 domain experts to evaluate a selection of synthetic images created with the R2D2 and with classic pix2pix (for comparison), along with the real images. Participants inspected these images, labelling them as "real" or "synthetic" ("fake").

All the image sets of the compared methods were presented in even proportions. Furthermore, all of the image sets (both real and synthetic) correspond to exactly the same set of the semantic maps to ensure the best possible comparability. Images acquired from the different sources were shown sequentially, one at a time, in order to avoid the cognitive bias. For the same reason there was no prior information provided on the proportion of real vs. synthetic images. The only information provided was that the test set contains both real and synthetic images.

Although the time taken to inspect each particular image was recorded and analysed, there was no time constraints imposed on the participants during the test time.

Autonomous target recognition (ATR) training: we argue that our proposed technique does not solely look good to human eye, but also can be of help for the autonomous systems training. For instance, assuming the lack of training data for the ATR, one could boost the training with the R2D2-generated data. Unfortunately, we do not possess unrestricted real data for sonars in EdgeTech resolution range (4620 or higher across track resolution), that would contain any real objects. Which is why we use the Cycle-GAN-based technique [13] to embed the artificial objects. In our specific case - cylinders and tyres, see Figure 5. In fact, there is a very small amount of unrestricted real seabed scans available, so we have to use what little real data we have for the test set.

There are a few training sets: (i) uniform random noise background, (ii) SonarSim[1] terrains - flat and rippled (respectively easier and harder for ATR to learn to operate on), and (iii) R2D2-generated terrains. Finally, we test the trained ATR performance on the small amount of the real sonar images we have available.

We use a simple ResNet-type architecture for ATR, trained from scratch for this experiment. Both the training and the test sets are rather small, due to the unavailability of the real data. Note that we do not claim the state-of-art level of ATR results here, only the relative benefit of using the R2D2-generated data in the absence of the real training data.

V. Results

The visual results of the R2D2-GANs are shown in Figure 2, there is very little to no difference between the real (left) and synthetic (right) images. Also, please note the relative difference in scales between the typical data generated with MC-pix2pix (top-left corner) and R2D2-GANs (right). Because of the iterative recursive generation along both axes, R2D2 is practically unlimited in the data resolution it is able to generate. Naturally, there is always a trade-off between the magnitude of the generated image resolution and the generation speed.

The image assessment scores by human experts, presented in the Table I, are based on the results collected from 10 human experts with various level of expertise, but dealing with sonar imagery on a daily basis. The individual assessment metrics are as follows:

(i) R2D2 synthetic imagery is labelled "real" by humans in 78% of the cases. This is the highest score across the competing methods, which also compares reasonably well to 90% score for the real images classified as real.

(ii) Human classification accuracy being close to 50%, i.e. near random chance for two-class problem ("real" / "fake"), indicated inability of humans to tell apart the real and synthetic images. The R2D2 shows the lowest human classification accuracy score of 56%. This is comparable with the 52% score obtained by the MC-pix2pix in an identical

[1] SonarSim - standard hard-coded and vaguely realistic side-scan simulator as used in [13], capable of generating various seabed textures with limited user control over the type of generated data, but not the exact topography.

Train set:	Noise	SonarSim (flat)	SonarSim (rippled)	R2D2-GAN
Recall	0.00	0.3314	0.2255	**0.4843**
F1	0.00	0.4895	0.3653	**0.6073**

TABLE II: **Autonomous Target Recognition experimental results:** unfortunately, we have no access to unrestricted data with real targets at our disposal. However, we demonstrate, that expanding the ATR training datasets with R2D2-generated data may help the learning process. Potentially, a higher variety of the terrains available at training time should help the ATR system to generalise better. Fortunately, there is a Cycle-GAN-based method [13] to insert some artificial objects into the terrains, that is useful in this case. The training is conducted on 4 different types of terrains: uniform random noise, SonarSim[1] flat and rippled terrains (respectively less and more challenging for the ATR), and the R2D2-generated terrains. We train a simple ResNet-type network over these, and test on the real data with artificial targets embedded.
The results suggest that random noise in this case is completely useless, whereas R2D2-GAN on the contrary performs better than the competitors.

experiment [1], which is a remarkable result considering the significantly higher complexity of the current task of the higher-resolution generation.

(iii) We do not attribute any definite meaning to the average time spent on inspection of each separate image. Nevertheless, images produced by R2D2-GANs take the longest to classify. We suggest to interpret this as the R2D2-generated synthetic imagery posing the higher challenge for distinguishing it from real.

Our method outperforms the original pix2pix according to all the metrics in this assessment. It is also comparable with the current state of art - MC-pix2pix [1], which achieves the human labelling accuracy of 52% for images of much smaller resolutions. The R2D2, however, surpasses this competitor by the resulting resolution of the complete images it is capable of generating, while maintaining the comparable quality of the generated results.

ATR performance results are available in Table II. Both recall and F1-score[2] suggest that the R2D2-generated terrains provide significantly better training material compared to the random noise and SonarSim simulator.

VI. CONCLUSIONS

This paper presents the R2D2-GANs - a novel technique for generating the realistic synthetic imagery of any specified resolution and topography. This work provides both the quantitative and qualitative evidence confirming the realism of the images produced with our method. The empirical assessment also suggests significant advantages for the ATR systems trained with R2D2-generated data.

The presented technique is in principle compatible with nearly any type of GANs, which might be of benefit for alternative objectives than those explored in this work. Thus providing the user with the ultimate control over the exact nature of the preferred data generation process. The R2D2-GANs are practically unlimited in the image resolution they can generate (at expense of the generation speed), which makes them immediately applicable to even higher resolution sonars, such as the Synthetic Aperture Sonars. Nonetheless, in the future work we intend to optimise this method further to make sure the fastest possible speed of the image generation for even higher resolutions.

[2]F1-score - harmonic mean between the precision and the recall of the ATR system. Higher values correspond to the better performance.

VII. ACKNOWLEDGEMENTS

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Winning Poster Paper—Gulf Coast

Reducing Annotation Times: Semantic Segmentation of Coral Reef Survey Images

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Abstract*—*Benthic quadrat studies requiring time-intensive manual image annotation are currently a critical component of assessing the health of coral reefs. Patch-based image classification using convolutional neural networks (CNNs) can automate this task by providing sparse labels, but remain computationally inefficient. This work extends the idea of automatic image annotation by using fully convolutional networks (FCNs) to provide dense labels through semantic segmentation. We present an improved version the Multilevel Superpixel Segmentation (MSS) algorithm, which repurposes existing sparse labels for images by converting them into the dense labels necessary for training a FCN automatically. Our implementation—Fast-MSS—is demonstrated to perform considerably faster than the original without sacrificing accuracy. To showcase the applicability to benthic ecologists, we validate this method using the Moorea Labeled Coral (MLC) dataset as a benchmark. FCNs are evaluated by comparing their predictions on test images with the corresponding ground-truth sparse labels. Our results indicate that FCNs' perform with accuracies that are suitable for many ecological applications, and can increase even further when trained on dense labels augmented with additional sparse labels provided by a patch-based image classifier. The contributions of this study help move the field of benthic ecology towards more efficient monitoring of coral reefs through entirely automated processes.

Index Terms—Coral Reefs, Marine Images, Semantic Segmentation, Convolutional Neural Networks (CNNs), Fully Convolutional Networks (FCNs), Dense, Sparse, Annotations

I. Introduction

Coral reefs provide a number of ecosystem services including a high biodiversity comparable to that of the Amazon Rainforest [1], a habitat to one-quarter of all marine life [2], and are of cultural and economic significance to millions of people. Unfortunately, through climate change and other anthropogenic means, a number of stressors are threatening the health of coral reefs around the world.

To rapidly assess the response of coral reefs to changing environmental conditions, a number of remote sensing techniques have been used. One of the most common is benthic habitat surveys where researchers collect underwater images of a coral reef using randomly placed quadrats [3]. These images are then uploaded into an annotation software tool such as Coral Point Count (CPCe), which randomly projects a number of points onto each image and tasks the user with manually labeling the class category that each point is superimposed on [4]. Coverage statistics such as relative abundance, mean, standard deviation and standard error for each annotated species can then be estimated for each image, or for the entire research area. Such point-based annotation software and analysis tools are a standard method of calculating metrics allowing habitat changes to be tracked across space and time. Nonetheless, they are expensive and time-consuming as the user must manually annotate each image.

Recently, convolutional neural networks (CNNs) have been adopted to automate the annotation of images, drastically reducing the amount of time and effort required by the user. The 'patch-based' image classification technique has been demonstrated as a method for assigning labels to different taxa automatically [5, 6, 7]. However, like the manual method this technique can only provide sparse labels. Hence typically less than one percent of all an image's pixels are actually provided with a label, potentially resulting in misleading coverage statistics. Ideally, coverage statistics would be calculated using dense labels (i.e. pixel-wise labels), unfortunately this style of annotation is typically not used by benthic ecologists.

In this study we investigate the ability to obtain dense labels for previously unannotated benthic habitat imagery through semantic segmentation, a task within the field of computer vision. Early attempts at achieving this included using the roving-window style operation to classify each individual pixel in an image. More efficient methods soon followed by using segmentation algorithms to first sub-divide the image into smaller components comprised of pixels that share similarities in attributes such as color or texture [8], and then classifying

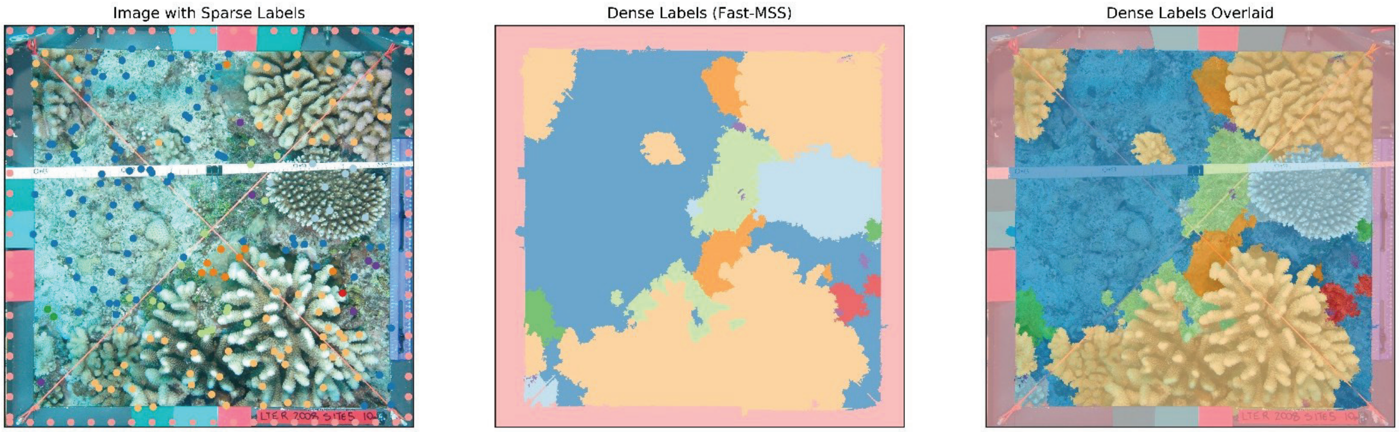

Fig. 1 – A side-by-side comparison between an image in the MLC dataset with its original sparse labels (left), the dense labels created using Fast-MSS when supplied with additional sparse labels (center), and those same dense labels overlaid on the original image (right). Note that labels, both sparse and dense, are color-coded based on class category.

each of those. After the success of CNNs as demonstrated in [9], researchers began modifying the architecture to be used for other computer vision tasks including semantic segmentation. One of the first modifications was the fully convolutional network (FCN), which was so successful that its fundamental design as an autoencoder has become a standard in this field [10]. However, like all deep learning algorithms a FCN requires a non-trivial amount of labeled samples to learn from, which can often be a significant hurdle for many ecological studies.

Because sparse labels are already ubiquitous within the field of benthic ecology, we demonstrate how researchers can repurpose their existing annotation files using the *Multilevel Superpixel Segmentation* (MSS) algorithm to convert them into dense labels automatically [11]. These can serve as the pixel-wise labels necessary for training a FCN, which would make it trivial to obtain dense labels for novel images collected during future studies.

Thus, the **primary contributions** of this study are two-fold: (1) we create an improved implementation of MSS that performs significantly faster and with classification scores that are comparable—if not better—than the current state-of-the-art, which we demonstrate through a comparison using the CamVid semantic segmentation benchmark dataset; (2) the performance of our improved implementation—*Fast-MSS*—is independently validated by creating dense labels for the images in the Moorea Labeled Coral (MLC) dataset, a notoriously difficult benchmark dataset that includes three classification experiments created to test the performance of computer vision algorithms with real benthic habitat survey images. In this study, the ground-truth sparse labels provided with each image in the training sets are used with Fast-MSS to create dense labels that a FCN can then learn from (Fig. 1). Once trained, we use it to perform semantic segmentation on the images in the test sets, thus setting the baseline scores for this task. To our knowledge, this dataset has only been used to assess the accuracy for patch-based image classification algorithms making this work the first to adapt it for the purposes of semantic segmentation.

II. Related work

In 2012, Beijbom *et al.* released the MLC dataset and set the baseline classification scores for each of the three experiments by using handcrafted feature descriptors that account for both color and texture by using a *Maximum Response* (MR) filter bank with the *Bag of Visual Words* (BoVW) algorithm [5].

In 2015, Mahmood *et al*. surpassed the results published in [5] by using features extracted from the VGGNet [12] using only the pre-trained weights learned from the ImageNet dataset [6]. They incorporated information at multiple scales by using what they termed the 'Local-Spatial Pyramid Pooling' technique, which extracted multiple patches of different sizes all centered on the same annotated point, later combining them into a single feature descriptor using a max pooling operation [6].

The current state-of-the-art for patch-based image classification was created in 2018 by Modasshir *et al*. [7]. They used a custom CNN called the Multipatch Dense Network (MDNet), which learned class categories at multiple scales and adopted the use of densely connected convolutional layers to reduce overfitting.

With regards to semantic segmentation, King *et al.* [13] developed an annotation tool for creating dense labels for images of coral reefs more efficiently by using *Simple Linear Iterative Clustering* (SLIC), an over-segmentation algorithm that aggregates pixels of an image into visually homogenous regions of similar size called 'superpixels' [14].

Alonso *et al.* also explored the use of an over-segmentation algorithm for a similar purpose, but used it to propagate the labels of existing sparse labels for an image to the adjacent pixels in an attempt to create dense labels automatically [11, 15]. Originally they segmented the image into a pre-defined number of superpixels first, and then propagated the class label of any sparse labels that happened to have an X, Y location that lay within the boundaries of a superpixel to the associated pixels. However, the major drawback to this method was determining how many superpixels should be formed; as discussed in [11], having a large number of superpixels allows for the contours of objects to be a better fit, but it also increases the number of superpixels that are left without a label.

This trade-off was later addressed in the MSS algorithm, which, as the name implies used not one but multiple iterations of the over-segmentation algorithm [11]. Starting with the first iteration, the image is segmented into a rather large number of superpixels such that each one is small enough to capture the finer details between bordering semantic groups. Then for each successive iteration the number of superpixels formed *decreases* making each one larger and as a result, encompasses more pixels ensuring that all pixels are provided with a label.

III. Methods

A. Fast Multilevel Superpixel Segmentation

In this study, two improvements were made to the MSS algorithm that significantly increased the speed in which dense labels are generated for an image while improving accuracy

The first improvement was a modification to how the labels created during each iteration are combined together to form a set of dense labels for the image. After each iteration of MSS, the class labels that were propagated to adjacent pixels are stored in 2-dimensional array with dimensions that are equal to the height H, and width W, of the original image, where each index contains the potential class label for the corresponding pixel found within the image (i.e. segmentation map). Collectively these 2-dimensional arrays create a 3-dimensional array or 'stack' with the shape (H x W x I), where I is equal to the total number of iterations.

The original MSS implementation joined each of the 2-dimensional arrays in the stack starting with the one made during the first iteration so that the smaller superpixels that captured the finer details are not overwritten by superpixels from subsequent iterations [15]. In the Fast-MSS implementation, the dense labels were made by calculating the statistical mode of class labels across the 3rd dimension of the stack. As it was mentioned previously partitioning an image into a larger number of superpixels results in each one being rather small, which, depending on the number of existing labels could lead to many pixels being left unlabeled. If this occurs for the same pixel index for the majority of the iterations, then that pixel index will also hold a null class label in the resulting dense labels. To avoid this, when calculating the mode during the final step, in the scenario where the most common class label is the null class, it is replaced with the second most common class label instead.

The second improvement was the use of *Fast-SLIC* as the over-segmentation algorithm. Fast-SLIC follows the same methodology as SLIC but includes optimization techniques such as color quantization, subsampling, parallelization and integer-based arithmetic. These optimizations allow the algorithm to be ran on an off-the-shelf CPU with reduced latency that is comparable to implementations made to be ran on a GPU [16].

To highlight the differences between the Fast-MSS implementation and the original a comparison was performed using the CamVid Road Scenes dataset, a semantic segmentation benchmark used within the domain of autonomous vehicles (Fig. 2, [17]).

Three trials were conducted in which sparse labels were synthesized for each image (600 in total) by uniformly sampling a different percentage of the ground-truth dense labels following a grid formation (see Table 1). From these sparse labels, Fast-MSS and the current state-of-the-art were used to generate dense labels that were then compared with the original dense labels (ground-truth).

The metrics used to quantify the differences between the resulting dense labels and the ground-truth were pixel accuracy (PA), mean pixel accuracy (m-PA) and mean Intersection-over-Union (m-IoU). Also included in the comparison is the amount of time required to generate dense labels for all the images, and an approximation for the amount of time required per image.

The metrics and the original MSS algorithm were implemented using the code that was published by [11], with the recommendations of 1500 and 50 for the initial and final number of superpixels across 15 iterations [15]; the Fast-MSS implementation[1] used 7500 and 80 for the initial and final number of superpixels across 20 iterations.

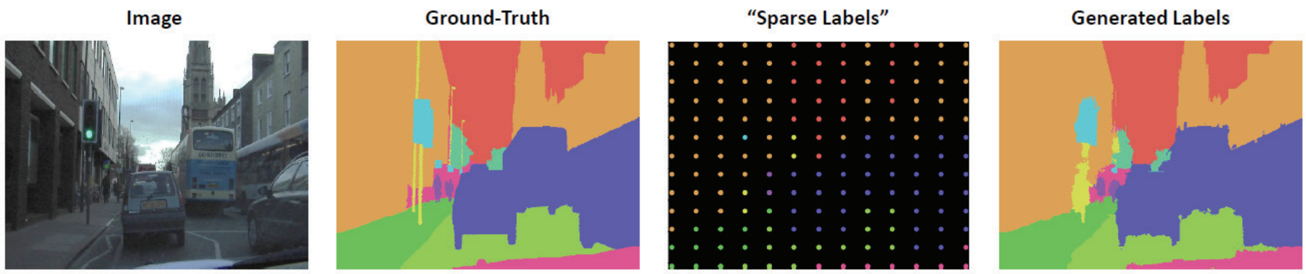

Fig. 2 – Generating dense labels using Fast-MSS. From left to right: an image from the CamVid dataset, the corresponding ground-truth dense labels, the synthesized sparse labels, and the dense labels generated from those sparse labels using Fast-MSS. Note that labels are color-coded based on class category, and that sparse points are enlarged for display purposes.

[1]https://github.com/jordanmakesmaps/Fast-Multilevel-Superpixel-Segmentation

B. *Creating Dense Labels from Sparse Ground-Truth*

1) *Moorea Labeled Coral (MLC) Dataset*

In 2012, Beijbom *et al.* published the MLC dataset to serve as the first large-scale benchmark to gauge the progress of algorithms that perform coral reef image classification [5]. The dataset is comprised of 2,055 images taken of the same sites across three years (2008-2010) with approximately 400,000 manually annotated labels. Outlined with it are three patch-based image classification experiments that use the nine most abundant class categories to test an algorithm's ability to generalize across time.

This study performed the same three experiments as originally outlined in [5], but included the 'Off' class category, which signifies the location of the metal quadrat frame and transect tape within each image. Due to inconsistences in how annotators chose to label these point [18], we chose to discard the original annotated points and replaced them by providing the pixels along the perimeter of each image (using an offset of 35 pixels) with the 'Off' label instead (see Fig. 1). These artificially placed points work well to help generate dense labels for the 'Off' class category that the deep learning models can then learn from, but they are not included in any of the experiments or used when calculating any of the metrics.

2) *Adding Sparse Labels with a Patch-based Image Classifier*

During the comparison using the CamVid dataset, up to 0.1% of the total amount of ground-truth labels were sampled to mimic the presence of sparse labels; however, the MLC dataset has far less labels available (~0.005%). Therefore, we investigated if a patch-based image classifier could be used as a reliable method for adding additional sparse labels to each image automatically, and if doing so helped increase the classification scores of the resulting dense labels.

Thus, two sets of dense labels were made for each image: one that was supplied with additional sparse labels using a patch-based image classifier, and the other using only the original ground-truth sparse labels that were provided with the MLC dataset. These two sets of sparse labels were converted into dense using Fast-MSS and used to train two sets of FCNs whose classification scores on the test set for the three experiments were used to validate this method.

To avoid data contamination and biasing the FCNs, three different patch-based image classifiers were created: one for each of the MLC experiments. Classifiers were only trained on patches that were extracted from images that belonged to the same experiment that they would later provide additional labels to, and of course, classifiers were only trained on patches that were extracted from images within the experiment's training set and not the testing set. Following the method outlined in [5], [6], and [7], image classifiers were trained on 112-by-112 pixel patches centered on each of the original ground-truth sparse labels associated with every image in each experiment's training set.

Providing additional labels involved first uniformly extracting patches from each image in the training set following a grid formation (Fig. 3). In total, approximately 2000 patches were sampled from each training image, representing potentially 2000 additional labels, or roughly .05% of the total number of pixels in the image. Extracted patches were then passed to a classifier as input. The output for each was a corresponding vector representing the probability distribution of class categories that the center-most pixel of the patch likely belonged to. For each patch the extracted location, the presumed class label, and the difference between the two highest probability distributions (i.e. top-1 and top-2 choices) were recorded. This difference in probabilities is the confidence level of the classifier when making the prediction. If the difference was small, the classifier is less confident about its top-1 choice (i.e. the presumed class label).

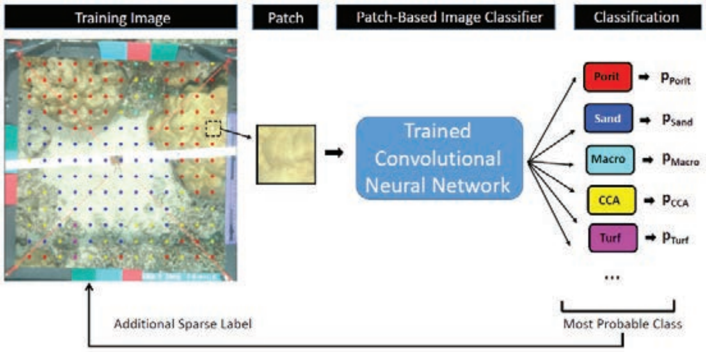

Fig. 3 – A diagram illustrating how a patch-based classifier was used to provided additional sparse labels to each image in an experiment's training set. After the classifier was trained, 112-by-112 pixel patches were uniformly sampled from the training images following a grid formation and passed to the classifier as input. If specific criteria were met, then the presumed class label was provided to the center-most pixel where the patch was extracted.

The difference in probabilities were used to filter out sparse labels that were more likely to have been misclassified. By setting a confidence threshold value of 0.5, approximately 15% of those additional labels were removed from each image. A second filter removed any sparse labels with class categories that were not already recorded in the image by the human annotator. Any additional labels that remained through this filtering process were concatenated to the original ground-truth labels associated with the image to create the first set of sparse labels; the second set used only the original ground-truth labels. Both sets were then provided with the points labeled 'Off' as explained in the previous section.

These two sets of sparse labels were then converted into two sets of dense labels using Fast-MSS. When generating dense labels for either sets, the number of segments to partition the image into during the first and last iteration were 2000 and 100, respectively, and iterations was set to 20.

Unfortunately, the accuracy of these dense labels could not be validated quantitatively as the MLC dataset does not provide any ground-truth dense labels, just sparse. Because Fast-MSS used these same sparse labels to generate the dense labels, relying on them for validation purposes would result in deceivingly high accuracies. Instead the dense labels were evaluated by using them as training data for multiple FCNs, which were then compared based on their classification scores

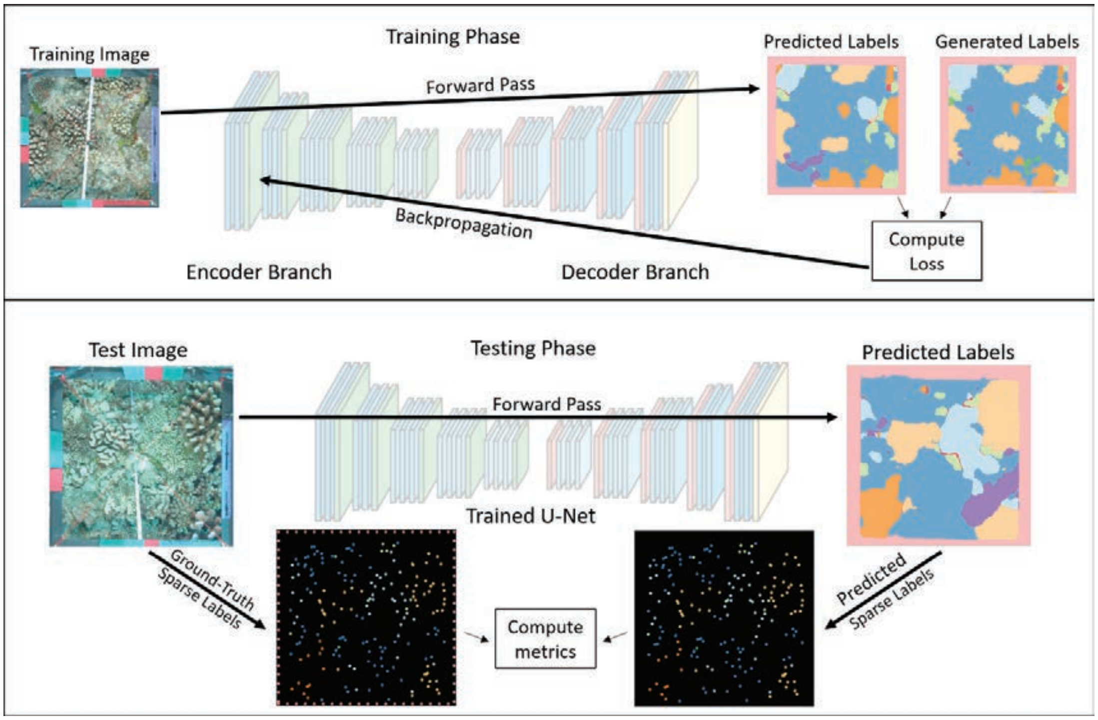

Fig. 4 – Diagram inspired by a figure in [11] illustrating a U-Net architecture using a generic encoder on the MLC dataset for semantic segmentation. Models were trained with images and dense labels generated by Fast-MSS, and metrics were calculated by comparing the ground-truth sparse labels for each image in the test set against the corresponding pixel indices within the predicted dense labels for the same image.

using the original ground-truth sparse labels within the test set for each of the experiments.

C. Experiments

This study used the same experimental setup to split data as outlined in [5]. For experiment one, K-fold cross-validation was used to split the 2008 data into three folds, two of which were used for training and the remaining was used for testing; this was done three times so that each fold was used for both training and testing, and scores were later averaged. Experiment two used all of the data from 2008 for training and tested on data from 2009, and experiment three used all of the data from 2008 and 2009 for training, and tested on data from 2010. This same setup was used for splitting the data for both the patch-based image classifiers and the semantic segmentation models.

Metrics for each of the three experiments were calculated by using the original sparse labels within the test sets as ground-truth, compared against what the deep learning model predicted for the corresponding image. However, because the ground-truth is in the form of sparse labels and the deep learning model produces dense labels, only the pixel indices that were provided with labels by the original MLC annotators could be used to validate the deep learning model's predictions (Fig. 4). Furthermore, because the 'Off' class category is not included in the original experiments, any of the dense labels that were predicted as 'Off' (approximately 1%) were replaced with the top-2 choice label instead.

The metrics used were classification accuracy, precision and recall. Classification accuracy was computed by calculating the subset accuracy, which requires that the predicted label match exactly the ground-truth label. Precision and recall were calculated by computing a confusion matrix that incorporated all of predictions and ground-truth samples from the test set for an experiment, calculating the metric for each individual class, and then averaging them together to obtain the final score (i.e. macro-averaged).

D. Model Training

For patch-based image classification, the NASNet architecture [19] was used to train three different classifiers, one for each of the experiments. Models were initialized with weights pre-trained on ImageNet and consisted of the convolutional-base followed by a max pooling operation, a dropout layer (80%) and then finally a single fully connected layer with 10 output nodes. Image patches that were extracted from the original images with dimensions of 112 pixels x 112 pixels were resized to 224 pixels x 224 pixels during training, normalized between 0 and 1, and then heavily augmented using *ImgAug* [20] to reduce overfitting.

Categorical-cross entropy was used as the loss function along with the optimizer Adam with an initial learning rate of 10^{-2} using the *ReduceLROnPlateau* callback to reduce it by a factor of 0.5 for every three epochs in which the validation loss failed to decrease. Because the problem is multi-categorical classification, the activation function used was softmax; models were trained for 50 epochs with a batch size of 32 as this represented the maximum amount of memory that could be allocated during training by the GPU being used.

For semantic segmentation, the U-Net architecture was used and we experimented with eight different encoders: DenseNet-201 [21], EfficientNet-b0, EfficientNet-b4 [22], InceptionV3 [23], ResNet-34, ResNet-50, ResNet-101 [24], and VGGNet-19 [12]. All segmentation models were implemented in Python using the *Segmentation Models* library provided by [25].

Each of the encoders was initialized with pre-trained weights from the ImageNet dataset and was left frozen (i.e. immutable) for the entire process; only the weights in the decoder were updated during training. Images were pre-processed in the same way as the images were when the original encoders were trained on the ImageNet dataset. Dense labels were converted into one-hot-encoded form with a shape of (B x H x W x C) where B and C represent the batch size and the number of class categories, respectively. Augmentations were randomly performed on each sample using *ImgAug* in the form of simple affine transformations (flips, flops, rotations) and a channel shuffle operation that randomly swaps the location of each channel in the image.

During preliminary analysis we found that when training with larger images, the resulting models produced better segmentation maps, but due to differing computational requirements for each of the encoders and the amount of memory that could be allocated by the GPU, images were reduced in size to 736 x 736 during training and testing for all encoders. Consequently, this resulted in the batch size having to be equal to one (i.e. a single image).

Soft-Jaccard was used as the loss function, which is a differentiable proxy that attempts to maximize the Intersection-over-Union metric [26]. The optimizer chosen was Adam, with an initial learning rate of 10^{-3} along with the *ReduceLROnPlateau* callback using the same settings as described before. The activation function was softmax, and models were trained for 20 epochs.

All model training was performed on a PC equipped with a NVIDIA GTX 1080 Ti GPU and an Intel i7-8700 CPU, using the Keras deep learning framework and the Tensorflow numerical computational library.

IV. Results

Table 1 shows the comparison between Fast-MSS and the original implementation using the CamVid dataset. Alongside each metric we report the percentage of pixels that were sampled from each image (360 pixels x 480 pixels) to synthesize the sparse labels. For each of the three trials Fast-MSS was comparable to—if not better than—the current state-of-the-art, and by using *Fast-SLIC* the amount of time needed to produce dense labels was drastically reduced.

Table 1 – Comparison between Fast-MSS and the original implementation using CamVid.

	% of pixels	PA	m-PA	m-IoU	Time (sec.)	Time per Image (sec.)
[11]	0.1	0.87	0.70	0.57	9613	16.02
	0.5	0.91	0.77	0.65	9787	16.31
	1.0	0.91	0.79	0.67	9862	16.43
Fast-MSS	0.1	0.87	0.72	0.56	984	1.64
	0.5	0.91	0.82	0.67	1338	2.23
	1.0	0.91	0.84	0.68	1386	2.31

Note: All trials were conducted on the same PC with an Intel i7-8700 processor. Scores are colored red, yellow, or green if they are lower, the same, or higher than the other implementation's score, respectively. For each metric 1.0 represents a perfect score.
Abbreviations: PA, pixel accuracy; m-PA, mean pixel accuracy; m-IoU, mean Intersection-over-Union.

The results of the trained FCNs on the three MLC experiments can be seen in Table 2 and 3. We compared each of the encoders, as well as the effect of having additional sparse labels provided to each image using the patch-based image classifier. As seen in Table 2, the general trend shows that models using the DenseNet and EfficientNet encoders performed with a higher classification accuracy than the others.

Table 2 – Classification accuracies for each model on all three experiments, trained with and without additional sparse annotation labels.

Encoder	Accuracy		
	Exp 1	Exp 2	Exp 3
Without Additional Labels			
DenseNet-201	0.716	0.626	0.802
EfficientNet-b0	0.709	0.620	0.797
EfficientNet-b4	0.703	0.613	0.827
InceptionV3	0.662	0.580	0.795
ResNet-34	0.676	0.630	0.805
ResNet-50	0.668	0.612	0.787
ResNet-101	0.672	0.612	0.771
VGGNet-19	0.618	0.571	0.771
With Additional Labels			
DenseNet-201	**0.754**	0.614	**0.839**
EfficientNet-b0	0.737	**0.649**	0.824
EfficientNet-b4	0.737	0.645	0.836
InceptionV3	0.673	0.570	0.811
ResNet-34	0.714	0.642	0.814
ResNet-50	0.696	0.595	0.809
ResNet-101	0.686	0.617	0.785
VGGNet-19	0.648	0.606	0.773

Note: Scores are colored red, yellow, or green if they are lower, the same, or higher than the average score for that experiment, respectively. Bold numbers show the best performing encoder, with 1.0 representing a perfect score.

More interesting is the difference in classification accuracy between models that were trained with additional sparse labels against models that were trained without them. Models that were trained with dense labels that had received additional sparse labels saw an increase in accuracy by approximately 3%, on average.

The same trend among models using the DenseNet and EfficientNet encoders can also be seen with regards to precision and recall. However, the average increase for both of these metrics for models trained with additional sparse labels was approximately 7% compared to those trained without (Table 3).

Table 3 – The precision and recall for each model on all three experiments, trained with and without additional labels.

Encoder	Precision			Recall		
	Exp 1	Exp 2	Exp 3	Exp 1	Exp 2	Exp 3
Without Additional Labels						
DenseNet-201	0.598	0.476	0.497	0.549	0.473	0.564
EfficientNet-b0	0.574	0.517	0.493	0.531	0.483	0.521
EfficientNet-b4	0.565	0.523	0.538	0.517	0.485	0.575
InceptionV3	0.500	0.435	0.481	0.457	0.451	0.471
ResNet-34	0.567	0.519	0.478	0.520	0.508	0.472
ResNet-50	0.476	0.505	0.528	0.498	0.503	0.533
ResNet-101	0.533	0.469	0.476	0.491	0.484	0.504
VGGNet-19	0.481	0.402	0.425	0.391	0.401	0.363
With Additional Labels						
DenseNet-201	**0.632**	0.517	0.584	**0.593**	**0.602**	0.604
EfficientNet-b0	0.607	0.561	0.565	0.559	0.494	0.580
EfficientNet-b4	0.631	**0.626**	**0.597**	0.563	0.554	**0.627**
InceptionV3	0.541	0.453	0.535	0.502	0.474	0.494
ResNet-34	0.524	0.547	0.494	0.518	0.475	0.594
ResNet-50	0.540	0.487	0.513	0.520	0.461	0.538
ResNet-101	0.553	0.531	0.560	0.521	0.505	0.499
VGGNet-19	0.518	0.466	0.461	0.397	0.363	0.392

Note: Scores are colored red, yellow, or green if they are lower, the same, or higher than the average score for that experiment, respectively. Bold numbers show the best performing encoder, with 1.0 representing a perfect score.

V. Discussion

The increase is classification scores between models trained and without additional sparse labels is in agreement with what was observed from the comparison using the CamVid dataset: that additional sparse labels can positively affect the quality of the resulting dense labels, and that deep learning models trained on them are also likely to achieve gains in classification scores. This validates the use of the patch-based image classifier in this study and also provides evidence for its use in future studies, which may save researchers a significant amount of time and resources by automating the task of sparse image annotation.

The top scoring FCNs are suitable for many benthic ecology applications, and would be expected to increase even further in performance if provided with additional images to learn from. Typically, when validating the predicted segmentation maps (i.e. dense labels), they are compared to ground-truth segmentation maps, but because the MLC only has sparse labels these were used instead. This form of validation does provide some indication of performance, although it is not the most beneficial format as it does not take into account the other 99.5% of labels that were predicted by the deep learning model. Looking at a randomly sampled segmentation map produced by a trained DenseNet model, the predicted sparse labels that tend to be misclassified are those that are located along the borders of different semantic groups (Fig. 5). This is not unexpected as the transition between neighboring class categories is often not sharp in contrast, but instead is usually fuzzy and complex.

However, some of the misclassified predictions could also be attributed to incorrect ground-truth labels as a result of imprecise point localization. It has already been established in [18] that 'Off' points were labeled inconsistently, where some that were clearly on the quadrat were provided with labels of class categories that were nearby; the same could also be true for labels of other class categories. Unfortunately, without properly annotated segmentation maps to serve as ground-truth these questions cannot be completely addressed.

VI. Conclusion

This research demonstrates methods that can be used to quickly and efficiently monitor change in benthic habitats. Point-based annotations created by software tools like CPCe are already ubiquitous within this scientific community as a method for calculating coverage statistics, and help to assess a reef's general health both spatially and temporally.

Presently, the task of manually providing annotations to each image collected during a benthic habitat quadrat survey is tedious, time-consuming and prohibitive with regards to cost and project scale. With computer vision and deep learning algorithms, this study demonstrates how an existing set of sparse labels for an image can be converted into dense, allowing for the calculation of more robust coverage statistics. By adding improvements to the MSS algorithm, we demonstrate through a comparison using the CamVid semantic segmentation benchmark dataset that our enhanced implementation performs significantly faster and with classification scores that exceed those created by the original.

We then demonstrate how Fast-MSS can be used to generate the dense labels necessary for training a deep learning semantic segmentation algorithm by using the ground-truth sparse labels associated with each training image in the MLC dataset. Following the same experimental setup first outlined in [5], this study trains multiple FCNs and uses them to set the baseline scores for semantic segmentation. Furthermore, classification scores are shown to increase when additional sparse labels are provided to each image using a patch-based image classifier. These results provide evidence for the effectiveness of this technique and illustrates their potential for efficient monitoring of coral reefs through an entirely automated processes.

Future work will incorporate Fast-MSS into an annotation software tool equipped with a graphical user interface (GUI) making it accessible to all users regardless of their proficiency in Python or command-line interfaces, and disseminating it for public use.

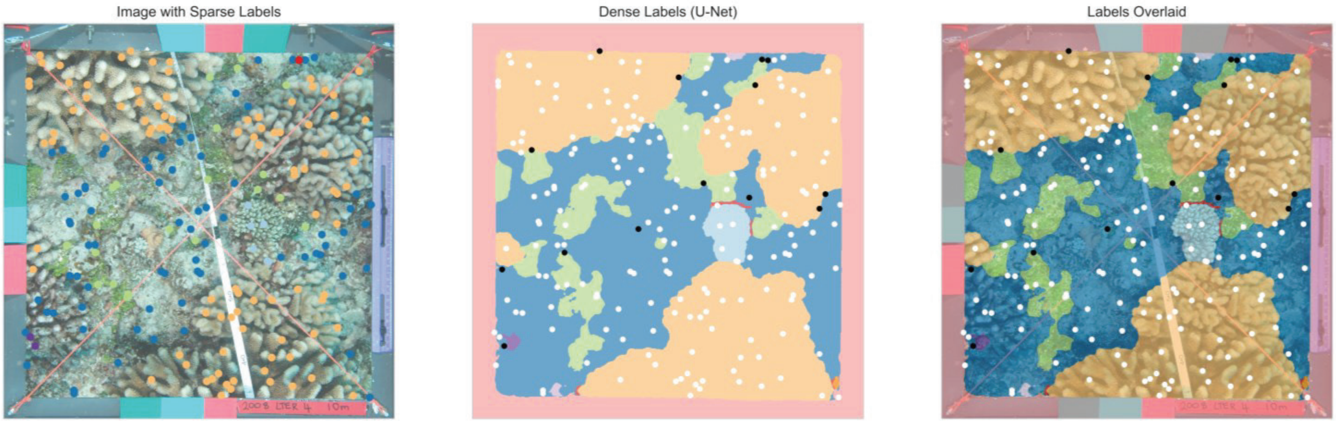

Fig. 5 – A side-by-side comparison between an image and its labels. From left to right: the original image with ground-truth sparse labels superimposed, the dense labels predicted by a deep learning model, and those same dense labels overlaid on top of the original image. The sparse labels in the last two columns are colored white if predicted correctly, or black if incorrectly.

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Who's who in the IEEE OES

Milica Stojanovic, IEEE Fellow, OES TCC Chair for Underwater Communication, Navigation and Positioning

When I told my children that I was asked to write a story about myself, they laughed hard. Through the laughter, I heard ``Who asked?" and "Good luck to them!" and "Is there a page limit?"

Yes, dear reader, I like to talk, and when no one wants to listen any longer, I start writing it down. So praise the page limit, and please read on.

I hope that this will not be terribly disappointing, but I was not born knowing that I wanted to be an ocean engineer—or any engineer, or a professor for that matter. What I wanted to be (at the tender age of three, according to my parents), was a hairdresser. Seriously. Now look at that picture:

Would you let a person with hair like mine be your hairdresser? I don't think so.

The other person in the picture is my husband Zoran. He is a serious guy; he never let me cut his hair, and he always knew that he wanted to be an engineer (he works at Analog Devices). The two of us came to the U.S. in 1989 and began graduate studies in electrical and computer engineering at Northeastern University in Boston. At that time, my advisor, Professor John Proakis, had a project with the Woods Hole Oceanographic Institution, and so I was introduced to ocean engineering. Thank you, Professor, for that and for much more.

Milica and Zoran. Taken circa OCEANS'18.

The project involved using acoustic waves to transmit digital information through the ocean. The problem was wonderfully hard, requiring all of our brains and a good amount of faith. Luckily, there was a light (perhaps I should say sound) at the end of the tunnel, and our work eventually lead to the development of the first high-speed acoustic modem, known today as the "WHOI micro-modem." It also resulted in a lasting friendship and collaboration with the team of Woods Hole engineers headed by Lee Freitag. (Many years later, I even officiated at Lee's wedding, despite the fact that I once almost lost an entire array of his hydrophones at sea.)

Solving an engineering problem really means opening the door to two new ones, and so I never left the area of underwater acoustic communications. As part of my work, we spent summer months in Woods Hole, where our children (a boy-girl-boy sandwich) had the luxury of running barefoot and meeting new friends from all around the world. While they were falling in love with the Wood Hole summer scene, I fell in love with the work that began in graduate school. Here I am, almost thirty years later, still working on the next two problems. My job titles have changed, from a Principal Scientist at MIT to a Professor at Northeastern, but the love has not. I love my ocean engineering and my next two problems.

I would like to use this opportunity to thank all of the Ocean Engineering Society for recognizing that love and the results that came out of it. In 2010, I was awarded the IEEE Fellowship ("for contributions to underwater acoustic communications"), and in 2015, the IEEE OES Distinguished Technical Achievement Award. I am very proud of these achievements. One of the award ceremonies was held at the OCEANS Conference in Sydney. On the evening of the ceremony, to which we were to go by boat, it was raining cats and kangaroos. I felt obliged to dress up, something that does not come to me naturally. I shoved the party shoes into a handbag and put on a skirt over hiking boots for the boat ride. The sea was rough, but once we got there, a jazz band and mountains of sushi did their magic, and I got lost in conversations with friends. Then I heard my name being called. As I scrambled up the stairs to the stage, a voice yelled from the audience: "*Nice boots*!" I looked down at my feet—the boots were still there. I looked at the audience—René Garello was there. OES is full of extraordinary friends who just know how to give support when it is needed.

How could anyone not like that? OES is indeed like an extended family. We make fun of each other and we go on family trips too. OCEANS Conferences took us all to fantastic places. Our youngest made his first steps in the conference hotel bar in Seattle at OCEANS'99. Our daughter hung out with my students in the white nights of OCEANS'13 in Bergen (I had to sleep because I was to give a tutorial the next day), and she planned a memorable five day hut-to-hut hiking trip that to this day reigns supreme on our top ten list. Finally, back at that OCEANS'10 in Sydney, I was accompanied by our oldest son. While I was attending sessions, he had procured tickets for the two of us for some ultra-important rugby game (All Blacks vs. Australia?). As it turned out, the game was on the night of the award ceremony. My dear friend Lee Freitag immediately intervened, offering to take my place and go to the game instead of accompanying me to the ceremony. Isn't that just how a family behaves?

Speaking of the family, the Sydney guy is now a doctor, the Bergen girl is studying to become a doctor, and the Seattle baby is in college, thinking that he wants to be an architect. When we are not at work, our life revolves around mountains and skiing. In this picture, you can see me caught in a passersby's camera, on top of a snowy peak:

Most pictures are worth a thousand words, but some are just the opposite. See that last Instagram comment? Come to think of it, that is all I ever wanted to be—a cool mom. My children might still think that their mother's job is to talk to the whales, but they

now surely ski better than I do, and yes, they love to make fun of me. If I succeed in a cooking endeavor, which is not often, I might be rewarded with "*Almost* like Sandipa's." Sandipa Singh, besides being my cooking nemesis, is my best-ever office mate and friend, a fabulous parent and a WHOI ocean engineer par excellence. Nevertheless, I hope that this Instagram comment from one of my children was genuine. So, to all my young colleagues who are wondering if it is possible to be both a parent and an engineer, the answer is a resounding yes. Remember, you have the entire OES family standing behind you, and some day, you will be standing behind another young person.

So dear reader, we are nearing that page limit. For the end I was thinking that instead of me writing about myself, I should ask a colleague to say something. Then I remembered a note that another OES family member, John Potter, had sent me after UComms'18. Among other things, he wrote: "…and thank you for your irreverence, sprinkled liberally throughout the conference." Well, I have changed my mind about asking others to write something about me. Who knows what they might say!

Instead, here is something slightly less incriminating for the end: a photo that a friend and colleague from the MIT AUV Lab, Rob Damus, recently dug out:

Can you imagine what a huge smile Rob's photo brought to my face? Sixteen years have passed since then, full of exciting work and great friendship. None of it would have happened were it not for ocean engineering. Let us hope that the pandemic will release its grip, and that we will soon be able to travel and spend some time together again.

Sailing after a 2004 experiment in Greece with Rob Damus and Lee Freitag. One is holding the camera, and the other is probably just holding his breath—can I be trusted this high with no skis on?

Member Highlights

Contact the Editors if you have Items of Interest for the Society

Voyage With Birds
Harumi Sugimatsu, BEACON Newsletter Editor-in-Chief

We have a voyage for surveying the seabed mineral resources using AUVs and an ROV from October to November this year as well as last year. We could see several islands during the voyage but could not meet anyone other than the passengers on the ship, but we met some booby (Sula leucogaster) chasing flying fish. They stayed with us during the voyage as friends. Enjoy their charming appearances.

Chasing the flying fish.

A family of booby with red legs (Sula Sula).

Social distancing?

Welcome New and Reinstated Members

Australia
Hung D Nguyen

Canada
Robert Gash
Yang Shi

China
Tianhao Cai
Anyan Jing
Ye Li
Songzuo Liu
Wang De Qing
Yunxuan Song

Croatia
Kristijan Krcmar
Fran Penic
Marijana Peti

Estonia
Michail Panteris

Hong Kong
Chaejun Park

Japan
Kazuo Ouchi

Korea (South)
Jongmin Cheon
Hangil Joe

Latvia
Arturs Aboltins

Malaysia
Ali Farzamnia
Raisuddin Khan
Ahmad Anas Yusof

Mexico
Jose Carlos Aguilar

Pakistan
Shahbaz Hassan

Sweden
Andreas Gallstrom

Thailand
Natt Leelawat

United Kingdom
Catalina Francu
Angus L Haston
Yi Huang
Yang Luo
Katarzyna Patryniak
Arran Prothero
Brian Gordon Sellar
Jake Walker

USA
Angelique Barniak
Samuel Cabrera Valencia
Aaron Covrig
Nicholas Craig Evans
Nick Frearson
Alan Thompson Gardner
Kevin Richard Hardy
Devon James Kalsi
Joseph Klamo
H. R. Kolar
Sam Mahdad
Eugene D Mcgee
Christopher R Mcgrath
Alexander Miller
Michael R Richardson
Angely M. Rivera
Ananya Sen Gupta
Ryne Smith
Andrew Storey
Peter Traykovski
James Tudor
Edward P Weaver
Jerry Wiggert
William P Wilson
Michael N Witlin

RoboSub Competition—OES Can Really Pick 'EM

Bob Wernli—Beacon Co-Editor-in-Chief

At the 2019 RoboSub competition, OES gave the society's Innovation Award to Team Inspiration, which was the only high school and middle school team in the competition and were not only highly scored technically and verbally, but they "were greatly inspirational." They also conduct a lot of community outreach to spread their love of robotics. More information can be obtained on the team at: https://team11128.wixsite.com/main.

For the 2020 RoboSub competition, I again volunteered as a judge for OES, however, due to the pandemic, the competition was virtual, and the teams were evaluated on their technical design report, video presentation and the website. The virtual competition was not conducive for OES to give an Innovation Award again due to the judging assignments, however, our prior award winner—Team Inspiration—again stood out and took first place overall with the following results:

- Ranked 1st out of 33 teams in Technical Design Report
- Ranked 1st out of 33 teams in Website
- Ranked 2nd out of 33 teams in Video
- Ranked 1st out of 33 teams in Overall Performance

Team Inspiration receiving the Innovation Award plaque from yours truly at the 2019 RoboSub Award Event.

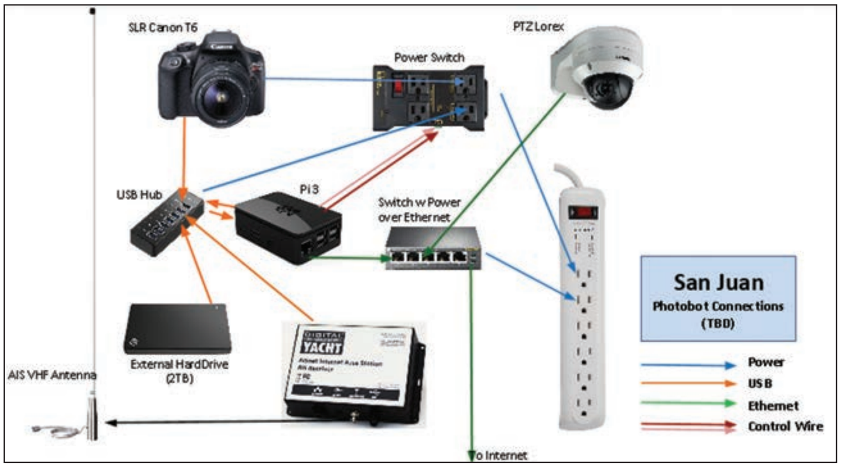
Team Inspiration is the only middle/high school team to win the world title in the 23 years of RoboSub competition. Congrats again to Team Inspiration.

Shore-based Monitoring and Quantification of Vessel Activities: University of Victoria Photographic Observation Study (POS).

Ben Morrow, M.Sc. Candidate/OES Student Member

With the support of IEEE OES Victoria Chapter, Ben Morrow, alongside researchers Norma Serra and Dr. Patrick O'Hara have developed and installed three remote shore-based passive systems for the monitoring of nearshore regions to capture marine vessel traffic and marine mammal presence and activities around Sooke, BC, in western Canada.

These systems consist of cameras and in-situ automatic identification systems (AIS). The initial "photobot" was developed in 2019 and several iterations have occurred to improve the systems. At present, as seen in the diagram, they consist of two cameras, (Lorex PTZ and Canon SLR), a digital yacht AIS receiver with Shakespeare antennas, web-controlled power bars for on/off capabilities calibrated to sunrise and sunset, which are controlled remotely with raspberry pi's (via Dataplicity). Each system accesses internet either via a LAN or LTE router and draws power either directly through 120V or remotely through 12V rechargeable deep-cycle batteries.



Photobot diagram.

"Photobots" are made from durable PVC watertight cases with rubber gaskets, have precise windows cut out and glassed over to fit camera lenses, and are fitted with sunshades and polarizing filters for glare reduction. Each camera continuously takes approximately 2600 photos/day, with data being collected 365 days per year at each site. Due to the enormous data volume, a number of processing tools were developed by Ph.D. candidate Tunai Marquez and undergraduate student Gregory O'Hagan to speed up processing times, in order to serve the particular research questions. Various tools have been created in Python and MATLAB including one that links AIS identifications to images using timestamps and positions calibrated in camera's fields-of-view, one that allows for the semi-automatic annotation of types of marine vessels, and deep learning algorithms for the passive detection of vessels.

Researchers Ben Morrow and Dr. Patrick O'Hara installing a photobot for passive coastal monitoring on top of the Sheringham Point lighthouse, west of Sooke, BC.

The team would like to thank IEEE OES Victoria Chapter for their generous contribution for the technology and supporting hardware in making this project feasible. The POS project's aims are to develop and utilize tools to observe and analyze marine vessel activities, marine fauna, and their interactions, in order to inform policy and management. For more information, please visit the Photographic Observation Study website at https://www.poscanada.org.

Breaking the Surface in 2020

Anja Babić, Nadir Kapetanović, Igor Kvasić

The IEEE OES University of Zagreb Student Branch Chapter (UNIZG SBC) was one of the co-organisers of this year's Breaking the Surface conference and workshop. The event took place from 27 September to 4 October in Biograd na Moru, Croatia, and despite challenging conditions and limited attendance, the conference succeeded in bringing together experts in maritime robotics and applications and maintained its annual tradition.

Breaking the Surface 2020 opening session.

Breaking the Surface is known for its hands-on tutorials and lectures, exciting presentations of new equipment and networking through social events. It was a great challenge to organize such a conference in 2020, but by combining increased organisational effort, a reduced number of international and in-person guests, strong support from local experts, and virtual lectures from around the world, BtS continued to foster interaction and knowledge sharing in various marine-related areas. Significantly, six of our chapter members, Frane Rogić, Anja Babić, Ivan Lončar, Vladimir Slošić, Igor Kvasić, and Nadir Kapetanović had the opportunity to share the latest developments and results of their PhD research and discuss ideas with colleagues from various fields of engineering in specially organised sessions that enriched this year's BtS programme.

In his presentation titled "Underwater Localisation", Frane Rogic´ spoke about a method often used to locate small underwater vehicles—the use of single range measurements from a known location combined with dead reckoning to calculate real-time localisation. As he pointed out, underwater localisation and navigation still pose a major challenge in underwater robotics, especially when reliability and accuracy are required. His research focuses on finding the most meaningful location for a single static beacon, ranging from it to an autonomous vehicle. This extends to the so-called breadcrumb algorithm, which he implemented by having an AUV add to its surroundings new static beacons with uncertain positions, which then provide new range measurements that help with the localisation problem.

Frane Rogić, IEEE OES UNIZG SBC Member, presenting "Underwater Localisation" on Monday September 28th 2020.

Anja Babić introduced her work focusing on a marine robot swarm, which was developed with the aim of autonomous long-term monitoring of environmental phenomena in the very challenging ecosystem of Venice, Italy. The swarm is made up of autonomous surface platforms named aPads and underwater robotic sensor nodes named aMussels. Anja described her work on a scenario where this system has to autonomously perform its monitoring mission and survive for a long period of time by exchanging energy, and in which the available maximum capacity of 5 aPad platforms, which are the system's charging centers, is usually exceeded by the number of active charging requests. This in turn means careful planning and optimization of robot activities are necessary. Therefore, Anja developed a two-layered system of decision-making algorithms: a specific solution-focused set of low-level algorithms and a high-level

Anja Babić, IEEE OES UNIZG SBC Chair, presenting "A Hyper-heuristic Approach To Achieving Long-term Autonomy In A Heterogeneous Swarm Of Marine Robots" on Monday September 28th 2020.

hyper-heuristic that selects between these algorithms depending on various performance indices. Anja also presented data collected during experiments conducted in Biograd last year.

Next, Ivan Lončar presented the results of his research in a presentation titled “Acoustic Localisation Of Underwater Sensors Using Cooperative Unmanned Marine Vessels.” As he mentioned, underwater monitoring is a popular research topic, focusing on the use of low-cost underwater acoustic sensor networks (UASNs) for tasks such as oceanographic data acquisition and underwater event detection. Underwater localization plays a crucial role in the georeferencing of the collected data. Typically, localization systems for UASNs use a fixed infrastructure for supported localization. The approach proposed by Ivan uses ASVs as localization anchors to reduce costs and improve mobility. He developed a method for a localization algorithm based on time difference of arrival to plan the trajectory of a formation of ASVs. The goal of this method is to achieve the desired localization accuracy of the entire UASN.

Ivan Lončar, IEEE OES UNIZG SBC Treasurer, presenting “Acoustic Localisation Of Underwater Sensors Using Cooperative Unmanned Marine Vessels” on Monday September 28th 2020.

Vladimir Slošić, our newest member, spoke about production, testing and possible use-cases of underwater acoustic beacons as one way to address the challenges of underwater communication and localization. Low cost, low power underwater acoustic beacons (or pingers, as Vladimir called them) with an acoustic range of up to several hundred meters are increasingly being produced. The concept of the pinger was discussed—Vladimir talked about how it would work, what its purpose was and what technologies it was based on. Secondly, the main production and testing challenges were mentioned. Finally, Vladimir suggested some possible applications and showed results of several proof-of-concept tests he had done in pools, lakes, and the Adriatic Sea.

Igor Kvasić introduced the audience to the topic of underwater interaction between humans and robots and the possibilities of finding a robust and reliable sonar image processing method for detection and tracking. This is not only a practical challenge, but also an outstanding safety feature. Igor gave an overview of current imaging sonar technologies as well as methods for object detection, with a focus on methods that have

Vladimir Slošić, IEEE OES UNIZG SBC Member, presenting “Production, testing and possible use-cases of underwater acoustic beacons” on Tuesday September 29th 2020.

the potential to be used to detect a specific object, such as a human diver, and to determine their applicability in real-time operation. Igor also showed some preliminary results he has achieved training neural networks on diver datasets he collected himself.

Igor Kvasić, IEEE OES UNIZG SBC Co-Chair, presenting “Sonar-based Object Detection Methods” on Wednesday September 30th 2020.

Nadir Kapetanović emphasized the importance but also the complexity of online methods for efficient mapping of an unknown large-scale marine area using a side-scan sonar onboard an autonomous marine vehicle. Ensonifying some parts of the survey area (that contain detected interesting objects) in more detail, while covering the rest of the area less thoroughly is the idea at the core of one dynamical programming-based and three heuristics-based coverage path planning algorithms that he proposed in his research. The proposed coverage algorithms provide a coverage solution based on local information gain computed from the side-scan sonar data during the mission execution. Apart from the coverage path planning problem, Nadir addressed the problem of anomaly detection in side-scan sonar imagery by making a performance comparison of various image processing methods on simulated as well as real-world side-scan sonar imagery datasets.

Nadir Kapetanović, IEEE OES UNIZG SBC Secretary, presenting "Online Seabed Coverage Path Planning For An Autonomous Marine Vehicle Based On Sonar Data" on Wednesday September 30th 2020.

All of these presentations, as well as a round-table discussion organised as part of the INNOVAMARE project and talks given by international guests and long-term BtS supporters such as António Pascoal and Fausto Ferreira, were streamed online using Microsoft Teams and are available on demand on the LABUST YouTube channel.

Our PhD student members also stepped up and gave several interesting tutorials and demonstrations outside by the marine pool and two of the bays in Biograd frequently used for our experiments. On Wednesday, September 30th, Vladimir Slošić and Kristijan Krčmar gave a 90-minute tutorial on the manufacturing process of underwater locator beacons (the previously mentioned "pingers"). This included both the perspective of mechanical engineering, including 3D modeling, 3D printing, and manufacture, as presented by Kristijan, and electrical engineering, including electronics and algorithm development, as presented by Vladimir.

Underwater localization beacon presentation taking place on Wednesday September 30th 2020.

That same afternoon, Nadir gave a practical tutorial in which he gave a short presentation about the Lightweight Autonomous Underwater Vehicle (LAUV) Lupis, including its hardware and software components. This tutorial described and demonstrated how LAUV Lupis is used, controlled and tracked by a USBL system and how its side-scan sonar and camera-based survey/inspection missions are planned and executed under consideration of various operational safety measures. The attendees then deployed the vehicle and started the designed mission, after which the collected side-scan and camera images were analysed, taking into account the prospects for detecting anomalies in sonar images and photogrammetric methods applied to the collected visual data.

Nadir overseeing tutorial attendees while they design survey missions for LAUV Lupis in Neptus mission control and review software.

Anja Babić, Ivan Lončar and Marko Križmančić presented the results of The Horizon 2020 Future and Emerging Technologies project subCULTron during a hands-on tutorial titled "The Basics Of A Monitoring Mission" on Thursday, October 1st. During this tutorial, a brief introduction and demonstration of aPad and aMussel robots were given, including accessing basic interfaces, communication, and programming, execution, and monitoring of an example mission.

Introductory note given by Anja and Ivan about the subCULTron project.

Ivan presenting the hardware and software architecture of aMussels underwater robots equipped with various environmental sensors.

Deployment of an aPad in an example mission at the seawater pool in Biograd na Moru.

An important mission of our SBC is not only work strictly in the fields of science and technology, but also education and dissemination. We pay special attention to working with bright young minds and always try to involve local communities. This year we had the opportunity to welcome students from a local high school in Biograd specialising in the fields of naval architecture, shipbuilding, and naval engineering. Our members, Igor Kvasić and Nadir Kapetanović, were happy to show the pupils marine robots and their latest capabilities in action. Furthermore, the students had the opportunity to manually maneuver one of the aPads as well as our newly acquired Blueye PRO ROV. They were thrilled to take part in the demonstration of the robotic equipment and more than happy to manually control the vehicles.

It's always nice to share knowledge with younger enthusiasts, introduce them to a field of research and development most of them have never heard of, change their perspective on science in general and spark their curiosity. Hopefully, some of them will choose their career in science and work with us in the future!

Being socially responsible and complying with the latest epidemiological recommendations, we were able to hold a social event on the evening of the first day of the Breaking the

Nadir showcasing the LAUV Lupis, aMussels, BlueROV2 and Blueye PRO ROV to the audience of bright high school students from Biograd na Moru, Croatia.

Igor presenting the USV aPad and AUV D2 to the highschool students from Biograd na Moru, Croatia.

Students enjoying the chance to manually control the USV aPad in the seawater pool.

IEEE OES UNIZG SBC team group photo in front of their banner.

Surface conference, Monday, September 28th. Although the number of participants at this year's BtS was reduced by about five times compared to previous years and the guests were mainly local, we did not want BtS to lose its spark and one of its main priorities—networking and exchange of ideas. At this event, which we called "IEEE OES UNIZG SBC's Equipment Showcase," the latest activities of the student branch were presented, including a small exhibition. Participants were able to ask our members all about the equipment they work with in a more relaxed environment.

Some of the "exhibition booths" set up for the equipment showcase.

This year's unusual edition of the Breaking the Surface conference was certainly a memorable one from an organisational perspective. It was held in the face of great uncertainty and with a significantly reduced number of participants. We have tried to bridge the gap from in-person lectures to virtual and streamed ones as seamlessly as possible. Despite the success of the event, we hope next year's BtS will return in its well-established form and we hope to once again get to enjoy it with all our international friends and colleagues.

The New Age of Oceanography

Miriam E. Lucero-Tenorio, César A. Enderica-Posligua, Gema M. Camacho-Viteri, Karen M. Mirabá-Peñafiel

An important objective of the IEEE technical chapters is to transmit to society, engineers and future professionals the technological advances in different branches of engineering through activities such as conferences and publications. For this reason, we were driven to develop an online conference called "The New Age of Oceanography," which was successfully hosted in Equador from 14–19 September of this year with an international lineup of speakers. The objective of our conference was to provide information to the members of the chapter and other attendees on technological advances applied to bodies of water.

Description of the Event

The concept of oceanography is becoming more and more popular, defining itself as the science that studies the waters, the bottom of the sea, the oceans and the atmosphere, from the physical, geophysical, chemical and biological points of view.

While the importance of these scientific investigations is increasingly recognized, the needed advancement of scientific knowledge requires support from the industrial, economic, administrative, and legislative bodies of society. Only then can that knowledge manifest itself more strongly through the appearance of new technologies for sampling and observation and new methods of data processing and analysis.

In order to share some of the most current research with the community of related interests in oceanography, we developed, promoted and hosted "The New Age of Oceanography" at which speakers from several nations presented their research, analytical results, professional opportunities and technological developments.

The event solicited current and relevant technical topics in several different areas of oceanographic engineering:

- Marine Technology
- Numerical models applied in oceanography
- Robotics in fisheries research.
- Ocean Policy
- Underwater acoustics
- Perspectives in ocean engineering
- Remote Sensing

And as you will see from the Event Schedule and lineup of speakers below, the conference covered that ground and more.

Event Schedule

<u>**Monday, September 14 2020**</u>

La ciencia del mar y su tecnología.
<u>Instructor:</u> MSc. Jesús Ledesma
Machine Learning can help us build better underwater exploration robots
<u>Instructor:</u> PhD. Yogesh Girdhar

<u>**Tuesday, September 15 2020**</u>

Phytoplankton blooms: New initiative using marine optics a basis for monitoring programs.
<u>Instructor:</u> Phd. Eduardo Santamaria del Angel

Figure 1. Event instructors "The New Age of Oceanography".

Importancia del sistema eléctrico en las construcciones navales sistema de puesta a tierra
Instructor: Eng. Henry Soledispa
Modelación morfodinámica a cauces naturales
Instructor: PhD. Andrés Vargas

Wednesday, 16 September 2020
Satellite Remote Sensing.
Expositor: PhD. Maurizio Migliaccio, PhD.

Thursday, 17 September 2020
Exploring the blue frontier with cooperative marine robots
Instructor: PhD. Antonio Pascoal
Monitoring ocean form space
Instructor: PhD. Milton Kampel
Identificación de patrones meteorológicos de la convección profunda mediante métodos de observación.
Instructor: MSc. Hugo Rico
Ictiobot, vehículos autónomos submarinos.
Instructor: PhD. Gerardo Acosta

Friday, September 18 2020
Full-Day Workshop involves fundamentals of GPU and CUDA C/C++ Programming.

Figure 2. Organizing committee of "The New Age of Oceanography".

Instructor: PhD. Yohong Rosa Zheng
Modulación de señales acústicas con códigos ZADOFF CHU, para estimar tiempos de vuelo en el sistema subacuático.

Instructor: MSc. Santiago Murano
Real Time Current Profiles in Support of Offshore Oil and Gas Operations.
Instructor: PhD. Todd Morrison

Saturday, 19 September 2020
Estudiando el océano en Ecuador
Instructor: MSc. Leonor Vera
Funciones R para monitoreo de variables oceanográficas
Instructor: Eng. Freddy López.

Event Organizers

This successful and well attended event was organized by the IEEE Ecuador Section of Women in Engineering (WIE) and by the OES Student Chapter of the IEEE-ESPOL Student Branch (Figure 2).

Event Results

As shown in Figure 3, the conference had 177 registered attendees and averaged 136 participants in each of six online technical sessions. At its peak, 151 attendees (85.3%) from around the world were logged in and listening to the presentations.

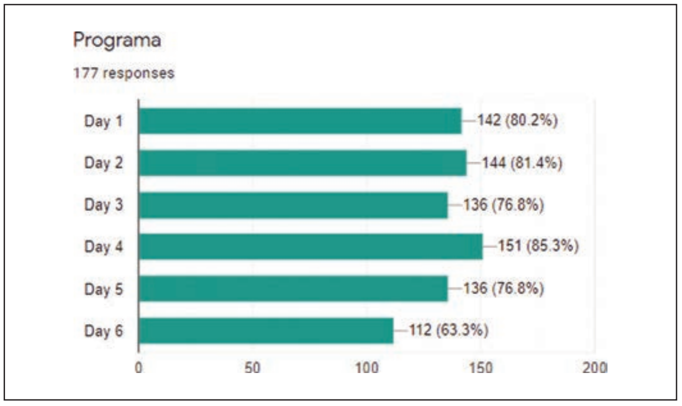


Figure 3. Attendance evolution by day.

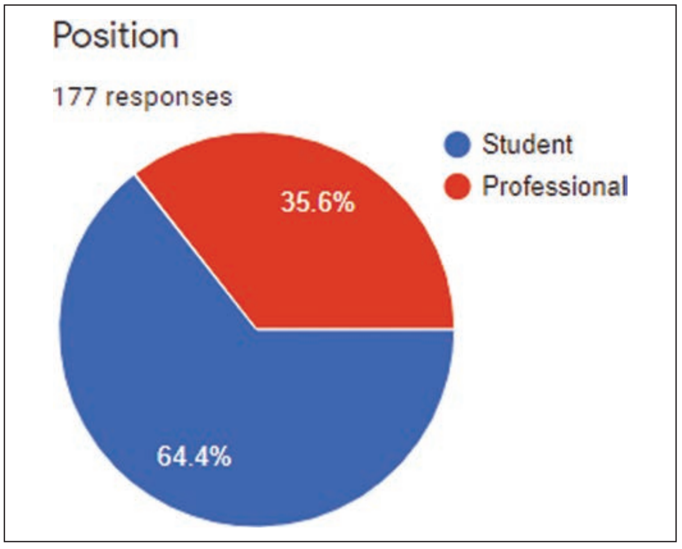


Figure 4. Average distribution of attendees to the event, classified by professionals and students.

A poll of attendees showed that 35.6% (63 people) classified themselves as oceanographic professionals and 64.4% (114 people) classified themselves as students in an oceanographic discipline.

The enormous participation of the student membership was seen as a huge benefit, both to the students and to the professionals. Follow-on contacts were encouraged.

Notably, only 23.7% of attendees were already IEEE members and only 12.4% were OES members (Figures 5 and 6). There is a significant growth opportunity here for the Society and for IEEE to increase the membership.

Recordings of the event will be available on the YouTube® platform through the OES IEEE ESPOL account. Our intention is to be accessible to people who did not attend or wish to see the presentations again.

We leave you with some example slides and screen captures from what we hope will only be the first "New Age of Oceanography" conference.

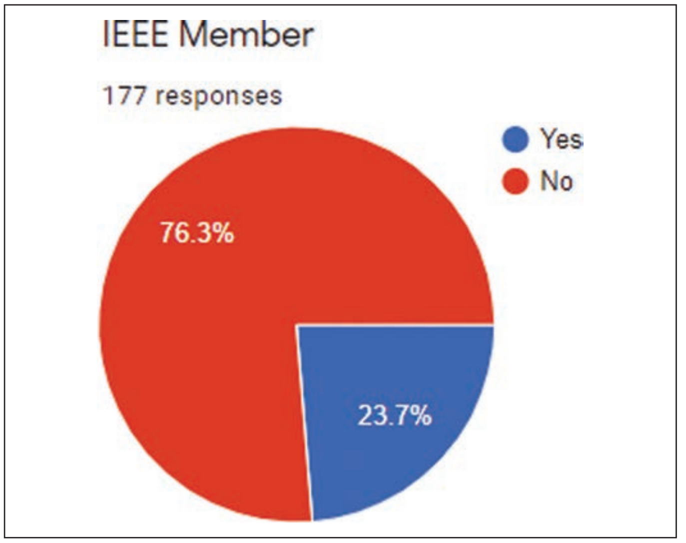


Figure 5. Average distribution of attendees to the event, classified IEEE members.

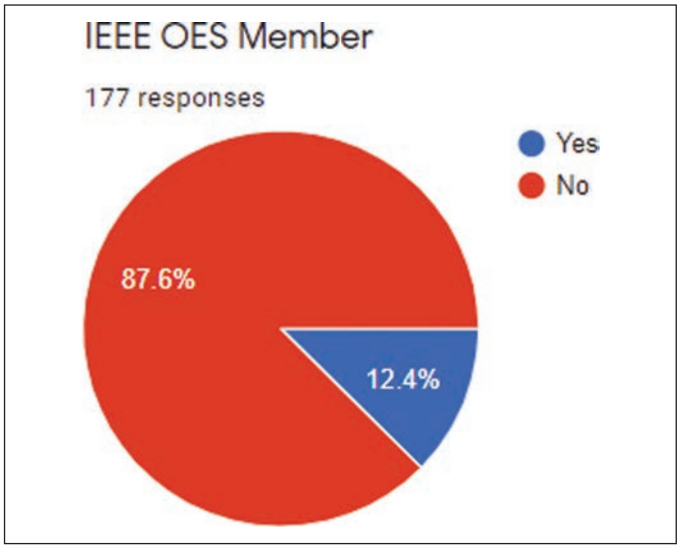


Figure 6. Average distribution of attendees to the event, classified by OES IEEE membership.

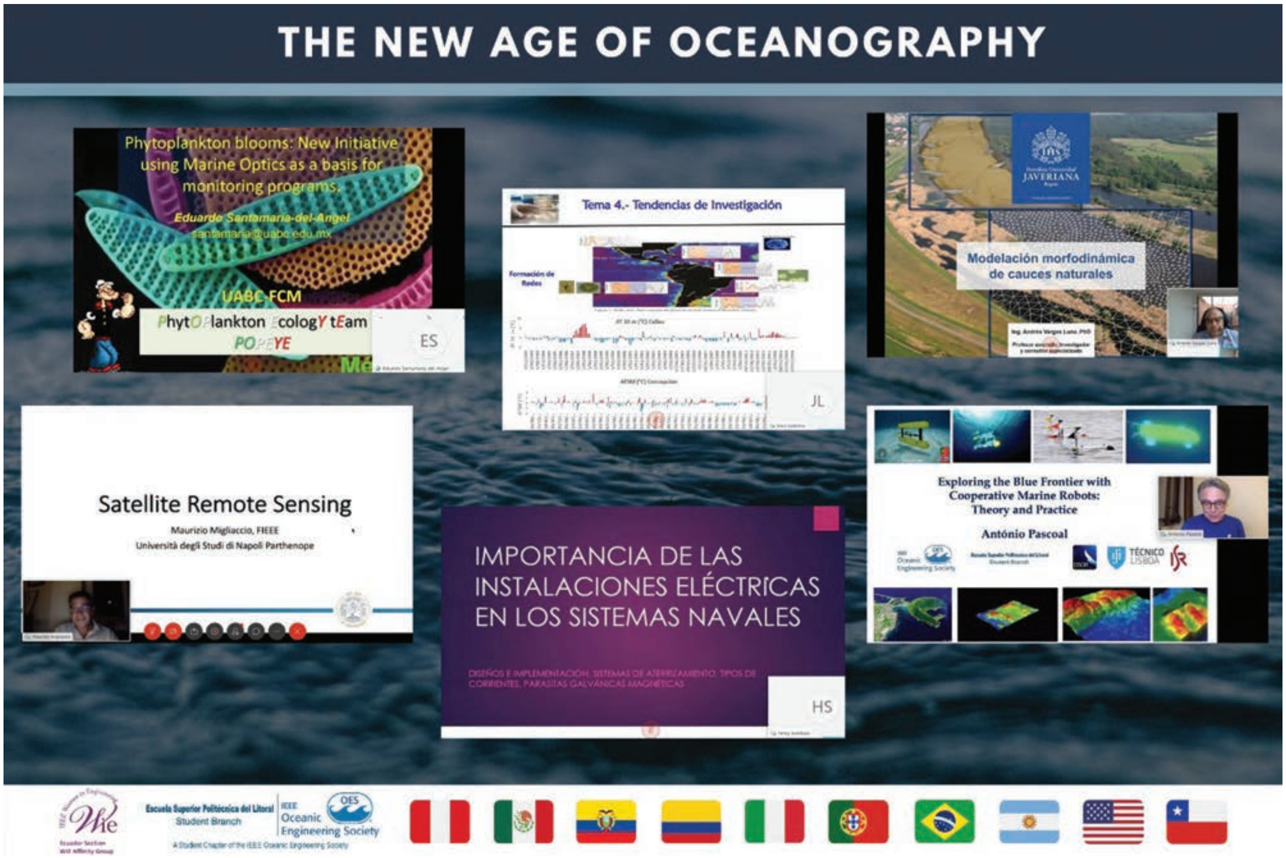


Figure 7. Event summary.

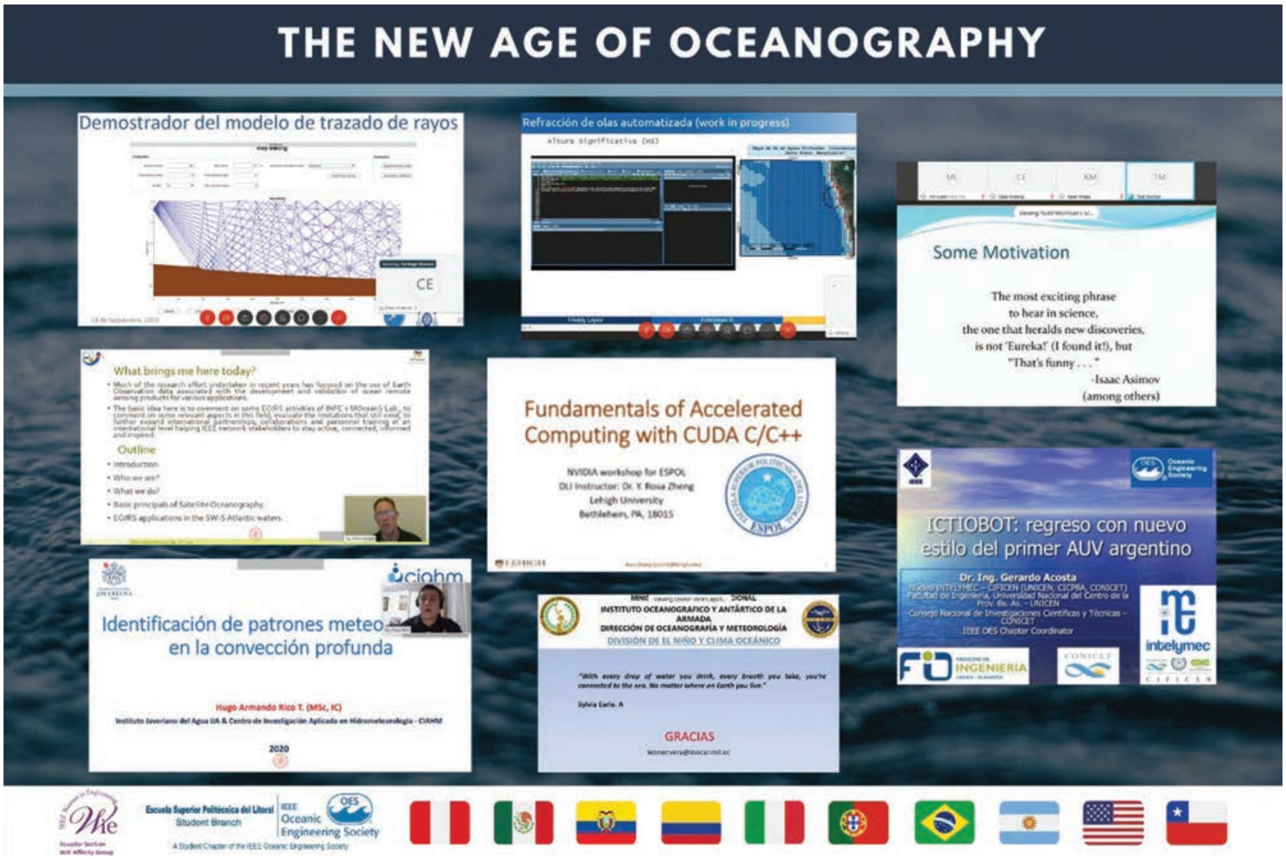


Figure 8. Event summary.

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