Workshop Report
Observing Air-Sea Interactions Strategy (OASIS) for a Clean Ocean
a satellite event for the UN Decade of Ocean Science for Sustainable Development -
Clean Ocean Laboratory
November 18 and 19, 2021

SCOR Working Group #162 for developing an Observing Air-Sea Interactions Strategy
(OASIS)

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Citation:

Overview
The “OASIS for a Clean Ocean” satellite event to the UN Decade Clean Ocean Laboratory took place twice to account for different time zones, on November 18, 2021 at 1700 CET with 34 participants and on November 19, 2021 at 0200 CET with 16 participants. The event featured pre-recorded speakers’ videos and structured discussion on Zoom, and used the interactive gather.town platform (Figure 1) for poster viewing and socializing before and after the events. The event was interactive and productive, making new connections with stakeholders, and fostering instructive discussion about the OASIS strategy. Roughly one third of the team of organizers, moderators, and speakers were Early Career Ocean Professionals (ECOP), representing the stake they have in the future, and over half were women. In addition, we heard directly from community stakeholders and had representation from six continents. Overall, our group was diverse and shows the interest of the global air-sea interactions community to promote a Clean Ocean.

The satellite event began with a 5-minute welcome and introduction video by Christa Marandino, and was followed by three sessions focused on 1) the impacts of marine pollution and hazards, 2) techniques in observing marine pollution and hazards, and 3) OASIS strategy for a clean ocean. Each session contained 2-3 pre-recorded talk videos from Early Career Ocean Professionals (ECOPs), Stakeholders, and Senior Scientists, and a group discussion. The event moderators then gave a 10 minute wrap-up of some of the major takeaways of the discussions to conclude the event. All talks are available for viewing on the OASIS youtube channel: https://www.youtube.com/channel/UCikmU5CIK-w0ic0hNnl89vw/videos

Session 1 talks (impacts of marine pollution/hazards) can for the 2 events be found at: https://www.youtube.com/playlist?list=PL7lEVqN7cilzZk6OLNvtZRieVJ5zc4z7f

Session 2 talks (techniques in observing marine pollution/hazards) for the 2 events can be found at: https://www.youtube.com/playlist?list=PL7lEVqN7cilyoCbmCV3fFqBuCZMRnvrP4Q

Session 3 talks (OASIS strategy for a clean ocean) for the 2 events can be found at: https://www.youtube.com/playlist?list=PL7lEVqN7cilz8-foa0XpmqlZzJpbD-l6
The final overview and take-home messages are summarized here, but please see Appendix 1 for more details about the talks and discussions. A video of the full events can be found here.

Marine pollution was defined as including not only oil, plastics and other debris, but also trace metals and gases. Processes involving marine pollution are complicated, in some cases involving two-way air-sea interactions and two-way ocean-society interactions. For example, deposition of the harmful pollutant tropospheric ozone to the surface ocean may lead to changes in gases that are subsequently emitted to the atmosphere or Harmful Algal Blooms (HABs) induced by anthropogenic climate change or eutrophication that, in turn, impact the fisheries needed for human sustenance. The ability to model these pollution processes requires a better understanding of the physical processes over a range of scales, from surface microlayer physics to mesoscale and global oceanic currents.

Having real-time surface currents at appropriate time and space scales in coastal regions is essential for running any model as an early-warning system. In well-resourced coastal regions, high frequency radar surface currents are commonly used. These are not available, however, for most of the global coasts. New satellite capabilities being proposed for launch might provide such solutions, although careful study is needed to determine whether these missions could be used for such applications. Time series for monitoring different types of pollution may be extremely useful, but types of observations require further development (e.g., sensors, procedures, basic infrastructure). In remote regions lacking internet and power, these observations are difficult or impossible to access by local populations. Scientific installations that are inaccessible to the local communities contribute to a view of scientists as colonizers. If the information could be shared, the benefits could be life changing. This was apparent in the talk given by Lydia Ladah on the effects of harmful algal blooms on the Mexican Baja California fisheries, where the communities lack the network and infrastructure to make the relevant data, yet the fishers are willing to work together with scientists to collect data in ways that work for them.

Preventing pollution in the first place must also be part of the path to a clean ocean. This may include raising awareness in communities about plastics (e.g., apps, beach cleanup, reducing plastic waste, recycling, and proper disposal), providing data to policy makers and lobbying for the importance of a clean ocean, and community/capacity building and sharing. More exchange between data generators and users is necessary, specifically to determine what types of data are available and what is needed by local communities. Extended global observations using existing global networks are paramount for supporting a clean ocean - this includes governmental monitoring of pollution and hazards - with a set of accessible best practices!

**What can OASIS do?**
The main take-aways were that OASIS could:

- Work with SOLAS to help propose a process study of natural oxidation processes in microlayer (open ocean and coastal ocean). It may be that such a study could be a component of a larger air-sea interaction process study, for example there might be natural synergies with satellite mission process studies for measuring surface currents and other variables from space.
- The list of important pollutants and surface currents should be compared with future satellite missions (such as PACE, WACM) to evaluate their possible utility for clean ocean and emergency response and restoration tasks. This may provide added justification for these satellite missions.
- The engineering problems of working in remote regions must include solutions for data access/communication from the platform to the local shore.
- Best practices must be practices that can be implemented.
• OASIS should actively engage with operational agencies dedicated to response and restoration of marine environments. Even in government agencies that have very large involvement in the UN Ocean Decade, these branches are often almost exclusively focussed on national coasts and may be unaware of the UN Ocean Decade. OASIS may provide an opportunity for these organizations to have a global footprint.

Appendix 1 shows transcripts or short summaries of each talk, as well as the summarized takeaways from each session. Appendix 2 lists the posters that were displayed in the Gather.town poster room. Appendix 3 shows logistical information about using Gather.Town shared with participants prior to the event. Lastly, Appendix 4 describes the Consortium for Ocean Leadership’s Participant Code of Conduct & Anti-Harassment Policy, which has been adopted by OASIS.

Appendix 1: Speaker and Session Summaries

All pre-recorded videos can be found on the OASIS youtube channel at: https://www.youtube.com/channel/UCikmU5CIK-w0lc0hNnl89vw/videos

Introduction by Christa Marandino (GEOMAR, Germany)
SCOR WG #162 co-chair, Organizer (transcript)

Slide 1 - Thank you for coming to this UN Ocean Decade, Clean Ocean Lab Satellite Event – Observing Air-Sea Interactions Strategy (OASIS) for a Clean Ocean.

I am Christa Marandino and am, along with Meghan Cronin and Seb Swart, co-chair the OASIS SCOR Working Group that is “taking a "systems-as-a-whole" approach for making surface and boundary layer observations relevant to the Earth’s energy, water, and biogeochemical cycles. OASIS was recently endorsed as a UN Ocean Decade Programme and has teamed up with the Surface Ocean Lower Atmosphere Study (SOLAS) to convene this satellite activity.

Slide 2 - As we all know, the human footprint is reaching historically pristine places, such as the open ocean. I show you here just a few examples of this: the spread of surface ozone pollution, the occurrence of harmful algal blooms, and the reach of the global shipping industry.

These topics, and many others, have a key air-sea interaction component. This UN Lab is a crucial, but relatively unique, opportunity to allow the air-sea interaction community to reflect on how our traditional scientific topics interface with ocean pollution and hazards.

Slide 3 - To facilitate this process, we have convened this program with the aim to develop a roadmap for how observations and understanding of air-sea interactions can support a clean ocean, through the use of community discussion. This community discussion should include as many stakeholders as possible.

The event has three sessions with associated main questions:

Session 1) impacts of marine pollution What are the effects of pollution on air-sea biogeochemical processes, harmful algal blooms, and other processes?
Session 2) techniques in observing/understanding marine pollution What are the observational (remotely-sensed and in situ) and model tools used to support a Clean Ocean? What’s missing?

Session 3) OASIS strategy for a clean ocean What specific steps should the UN Ocean Decade OASIS programme take to support a Clean Ocean?

We hope to engage you all in discussion on these topics here today in order to develop a roadmap for OASIS, SOLAS, and other air-sea interaction interested folks to move forward. At the end of this event, we hope to summarize the main action items for this decade and beyond.

Slide 4 - One final point to support the discussion on OASIS for a Clean Ocean - This is OASIS organizational chart showing how we seek to work with community members across 5 Theme Teams. Each of these themes – developing the network and model design, capacity building and sharing, UN Ocean Decade, best practices and interoperability, and FAIR data, model and OASIS products – can be tapped to support a clean ocean, but we need engagement from the community to help us learn how.

Slide 5 - Before we get on with the event, I would like to say thank you to the organizers, moderators, and speakers that made this event happen.

Also, please remember that there are two airings of this event: 18 Nov 17:00 CET and 19 Nov 02:00 CET. There is a poster session and networking activity in gather.town for one hour before and after both airings. Please stop in and visit the posters and meet with your colleagues! There is a link and password posted in the chat.

I hope you enjoy the event!

Matthew Jones, ECOP University of York (UK) – Effects of ozone deposition

Ozone efficiently reacts with organic material, iodide and water, it is knowingly used to remove organic and inorganic pollutants. Ozone reactivity results in a cascade of reactive intermediate oxygen and nitrogen species. The cascade enhances and disrupts biogeochemical cycles. Ultimately, human induced perturbation of atmospheric ozone concentrations will affect how a marine system reacts to harmful and helpful molecules.

Transcript:

Slide 1 – Title slide
Hello, I’m Dr Matthew Jones.

I am an environmental analytical chemist, currently working in the Wolfson Atmospheric Chemistry Laboratory at the University of York in the United Kingdom.

My short talk today, entitled ‘A Clean Ocean: Natures Advanced Oxidation Processes’, will introduce how there is a balance in marine and atmospheric systems as they interact to essentially produce a self-cleansing system.
Advanced Oxidation Process is a term coined by chemical engineers for a large suite of reactions used during drinking and wastewater treatment.

These reactions typically involve a strong oxidant, with and without UV light, acting on harmful substrates, for example, toxic bacteria or organic and inorganic pollutants.

However, these processes are only echoes of what occurs in nature, with many of these processes well studied in the atmospheric sciences and microbial and molecular biology.

Atmospheric chemists have shown how advanced oxidation processes are essential in the environment and affect redox sensitive species.

While microbial and molecular biologists understand these processes in terms of organic material recycling and detoxification of reactive oxygen and nitrogen species.

What we can suppose is that over billions of years any marine biota has evolved to harness the effects or conversely nullify advanced oxidation processes. Why? Because, in and around shallow marine systems UV light is present and so too are the oxidants ozone (O\textsubscript{3}), hydrogen peroxide (H\textsubscript{2}O\textsubscript{2}), manganese oxide (MnO\textsubscript{x}) and nitrite (NO\textsubscript{3}\textsuperscript{-}).

This supposition suggests that there is a positive, yet balanced outcome for microbiology and their oceanic environment.

Of all the marine environments, there is one that is optimised towards advanced oxidation processes and this is the Sea Surface Microlayer.

The microlayer is also the marine environment that we know the least about. Though it is the most accessible it is also one of the hardest to sample. So making it an excellent choice for laboratory studies.

The microlayer is the ocean atmosphere interface and as an interface it controls feedback processes.

The organic rich nature of the sea microlayer means it has unique reflective properties.

The layer is also a source of particulate aerosols while simultaneously disrupting gas transfer fluxes into and out of the ocean.

Importantly, reactions therein have consequences that can be traced both deeper into the marine environment and back into the atmosphere itself.

One process controlled by the sea surface microlayer is the removal of lower atmosphere ozone. This removal process has significant feedback to both the atmosphere and the marine environments and is beneficial for humans.

Reactions of lower atmosphere ozone at the surface microlayer produce a strong climate feedback. Ozone will react with iodide and through a reactive intermediate species, hypoiодous
acid – HOI – produces volatile iodine species that are cloud condensation nuclei, hence the climate feedback.

This reaction also reduces any harmful lower atmosphere ozone concentrations and provides a source of the essential human nutrient, iodine.

However, the reaction of ozone also releases a cascade of reactive oxygen species into the marine environment, reactive oxygen species including hydrogen peroxide. This cascade of reactive oxygen species leads to a range of advanced oxidation processes.

The ozone iodide reaction is a balanced self-cleansing ocean process, but it is likely this balance is shifting.

Ozone uptake by iodide will be inhibited by the build-up of anthropogenic surface active molecules unreactive to ozone, such as poly-fluorinated alkyl substances (PFAS) or sodium lauryl sulfate.

Atmospheric nutrient deposition acts to increase the marine biomass but this increase results in extra organic material fluxing to the surface microlayer, which provides competition for iodide towards the ozone.

While the addition of reactive chemical species disrupts the reactive oxygen species cascade through the marine environment.

Slide 5 – Induced imbalance

The atmosphere/marine environment has an ability to self-cleanse. But as we overload the system the benefits of this self-cleaning balance are removed. The results are that the availability of an essential human nutrient decreases, the oceans find it harder to check the spread of toxic and dangerous chemicals and the likely effects on cloud formation may be huge but is as yet unknown quantity.

Lydia Ladah, CICESE (Mexico) - Baja California Fisheries - effects of HABs on hypoxia/anoxia and benthic fisheries

The unpredictable and often dramatic impacts of HABs, particularly low oxygen levels and widespread fish and invertebrate die offs, on the rural fishing communities of the Baja California peninsula Pacific are both costly and worrisome for many of the benthic fishing cooperatives in this region. Because many of these communities depend on the health of the coastal ecosystem and the organisms that thrive in these regions for their livelihoods, a better understanding of when and where these events occur would be critical to these often overlooked stakeholders. The fishing cooperatives are interested in developing and expanding an early warning system and hope to be better connected with the activities in the southern California bight, as the HABS in the California Current know no boundaries. There is increasing interest to link the coastal oceanographic monitoring program that is being undertaken by citizen science initiatives, local NGOs such as COBI, and the artesanal fishing cooperatives in these rural communities to the larger monitoring and alert systems in the California Current, keeping in mind that many of these areas lack reliable infrastructure such as road access and electricity. Continued funding for outreach and research efforts in these under-represented and marginalized communities could leverage a better understanding of the impacts of the entire California Current for all stakeholders on both sides of the border, and lead to shared local knowledge (many decades of accumulated
LEK) to eventually produce better predictions of the spatiotemporal scale of events along the entire California Current.

**Morgane Perron, ECOP University of Tasmania (Australia) – Atmospheric deposition of trace metals to the surface ocean**

The atmospheric supply of trace metals, via dry (aerosols) and wet (rainfall) deposition, may either have a beneficial or a detrimental effect on oceanic ecosystems depending on the chemical element which is deposited, its solubility and its aeolian loading. The variable and episodic nature of atmospheric emissions together with the stringent laboratory processing required to contamination-free measurements of trace metals in the environment make difficult to assess the impact of large deposition events on ocean productivity. While ship-board atmospheric sampling enables a large spatial coverage, it only provides a snapshot of the atmospheric composition at the time of the campaign. Recent studies have recently urged for the need to develop time-series aeolian sampling stations, especially in the Southern Hemisphere where little data is available. Such stations, like the kunanyi/Mt Wellington station installed in 2016 in Hobart (Tasmania, Australia) offer a long-term insight into the variability in aeolian emissions on a seasonal and inter-annual timescale, enabling to better track sources of pollution to the atmosphere and apprehend their impact on ocean ecosystems.

**Natalie Mahowald, Cornell University (USA) – Atmospheric modelling of microplastic sources to the ocean**

Plastic pollution is one of the most pressing environmental and social issues of the 21st century. Recent work has highlighted the atmospheric role in transporting human-derived microplastics to remote location. Here we use in situ observations of microplastic deposition combined with an atmospheric transport model and optimal estimation techniques to test hypotheses of the most likely sources of atmospheric plastic. Results suggest that atmospheric microplastics are primarily derived from secondary re-emission sources including road, ocean, and soil sources. However, due to limited observations and understanding of the source processes, there are still large uncertainties in source attribution. In the western USA, the dominant sources of microplastic were from roads (84%), the ocean (11%) and agricultural dust (5%). Using our best estimate of plastic sources and modeled transport pathways, most continents were net importers of plastics from the marine environment, underscoring the cumulative role of legacy pollution in contributing to the atmospheric burden of plastic. This effort is the first to use high resolution spatial and temporal deposition data along with different hypothesized emission sources to constrain atmospheric plastic. Parallel to global biogeochemical cycles, plastics now spiral around the globe with distinct atmospheric, oceanic, cryospheric, and terrestrial lifetimes. Though advancements have been made on the manufacture of biodegradable polymers, our data suggest that the non-biodegradable polymers will continue to cycle through the surface Earth. Because of the limited observations and knowledge, there remain large uncertainties in the sources, transport and deposition of microplastics. Thus, we prioritize future research directions for understanding the plastic cycle. Paper: [https://www.pnas.org/content/118/16/e2020719118](https://www.pnas.org/content/118/16/e2020719118).
Richmond Kennedy Quarcoo, Plastic Punch (Ghana) – Plastics in the ocean

Marine and coastal pollution is a big problem in Ghana. Though waste management facilities exist, they are not sufficient to cope with the amount of waste produced by the country, and waste is dumped onto beaches and into the ocean. Plastic Punch is an energetic non-profit organization aimed at protecting the coastal environment from plastic waste, providing sustainable waste management solutions, and raising awareness of the harms of single-use plastics.

Plastic Punch has developed a multifaceted approach to achieve societal engagement. The approach is targeted at inspiring behavioral change through citizen science and awareness raising towards sustainable waste management practices with emphasis on reducing plastic pollution.

To address pollution already at the shore, large beach cleanups on turtle nesting beaches are held on a regular basis. The plastic-free event brings together 200-400 volunteers who range from school-aged children through adults. Waste is collected by type (e.g. bottles, bottle caps, plastic sachets, shoes), avoiding the need for later sorting, and is counted upon collection to allow for data analysis and interpretation to influence policy and recycling. This collection strategy also gives participants a targeted mission and helps dampen the feeling of being overwhelmed by the vast quantity of trash on the beach. To get an idea of scale, on a beach cleanup on May 25th, 2019, 4 tons of waste were collected including 210,600 plastic bottles with 200 volunteers within 4 hours. Plastic waste collected is either turned into bricks for use in road construction and the non-recyclables hauled to the landfill.

Art workshops are integrated into the beach cleanups and awareness seminars, including repurposing materials gathered at the beach and physical activities such as yoga, soccer, theater, and dance. To reach a wider audience, Plastic Punch also uses tech campaigns like the “Plastic Punch Game” and the “Plastic Punch Sea Turtle App”, a mobile app to collect data on sea turtles and to encourage citizen science - all available on Google Playstore. Marine pollution is a global issue, and only through the active participation of local communities throughout the planet will we be able to effect positive change.

Miaolei Ya, ECOP Nanjing University (China) – Oceanic PAH deposition

This was a discussion of how observations and understanding of air-sea interactions can support a clean ocean. Miaolei Ya’s research interest is in marine organic geochemistry of anthropogenic organic pollutants. His talk was about polycyclic aromatic hydrocarbons at the air-sea interface. PAHs are byproducts of the incomplete combustion of organic materials such as coal and petroleum and grass, straw, wood, and other biomass. They are often considered a typical anthropogenic organic pollutant. PAHs adversely impact human health and ecosystems and are known to persist in the atmosphere. It has been proven that temperature and humidity dependent variations affect the viscosity, and shield PAH from chemical degradation. Therefore PAHs can be transported over long distances, and even participate in global transport just like persistent organic pollutants. As a result, these compounds can be found almost anywhere in the ocean, even the polar regions. In the open ocean, the exchange processes of PAH at the air-sea interface includes atmospheric deposition, volatilization, and absorption. Overall, the open sea shows a
natural absorption of PAH at the air-sea interface, however in the coastal area, the air-sea exchange characteristics are different from in the open sea.

In Miaolei Ya’s previous study in the Taiwan Strait, the researchers found the low molecular weight of PAH in the natural volatilization process, and the medium and the high molecular weight PAH shows the net deposition. Overall, because of the predominant components of low molecular weight PAH, the fossil fuel derived the PAH present in the natural volatilization at the air water interface of the Taiwan Strait. In contrast with the open sea surface, runoff and oil spill input bring PAHs to the coastal ocean, which increases the fugacity of PAH from sea to atmosphere. The number of publications and citations mentioning PAHs is increasing year by year. If we summarize the results of the studies in different oceans, we can explore the driving mechanisms for human derived PAH to participate in their global cycle. Therefore, the establishment of a global air-sea exchange observation network can effectively emphasize the impact of human activities on the ocean. In the previous investigation, the team found that there are many buoys on the West Coast of the Taiwan Strait channel. There are also many buoys along other coasts around the world. These coastal buoys can be used as an ideal sampling platform for air-sea observation of PAH and other pollutants. Further, we can establish a global database of air-sea exchange of organic pollutants on buoy sampling platforms. Passive sampling can be an ideal sampling method, and passive sampling methods of PAH and other organic pollutants in the air and sea have proven to be feasible.

In summary, to establish a global air-sea exchange network for organic pollutants, the standardization of sampling methods on the buoy platform is essential. Through comprehensive international cooperation, the global air-sea exchange and their fluxes of organic pollutants can be observed. Once the global observation network is established, we can gain a comprehensive understanding of the mechanism by which human activities affect coastal oceans as a response to climate change. This will help to develop different emission reduction strategies in different regions of the world.

Leticia Cotrim da Cunha Rio de Janeiro State University (Brazil) – Ocean acidification

Leticia Cotrim da Cunha spoke about CO₂ in the ocean and ocean acidification. Although CO₂ occurs naturally in the ocean, we can consider it a pollutant because it has been changing the carbon chemistry in seawater, changing equilibrium, and affecting ecosystems and marine organisms, especially those that produce calcium carbonate structures. In coastal areas, in Latin American Atlantic countries in general, from Brazil to Uruguay and Argentina, the concept of ocean acidification is still abstract. However, it is important and people are becoming more and more aware of the importance of observing seawater properties or essential ocean variables. Observing pH and dissolved CO₂ and the other parameters is an important way to monitor how the ocean is behaving especially in coastal areas where there is shellfish farming. Farming of oysters and mussels is an important industry/ activity in many areas along the South Atlantic coast. The next step for expanding an understanding of the importance of monitoring ocean acidification and other ocean variables, and to understand the changes that are happening, is not only to implement governmental programs from science and academia, but also for the fisheries and aquaculture industries to monitor the waters they are using, offshore, or nearshore. It is very important to have more data about what is happening to seawater, and that data needs to be collected using the best practices for ocean variables (in this case for the CO₂ and acidification variables) and it needs to be open and accessible to everyone. Leticia encouraged everyone to
go look at the [Global Ocean Acidification Observing Network webpage](#). The GOA-ON site has lots of tips and methods for data collection, and one can ask for help on how to correctly measure/monitor, so that data is comparable across the globe, for parameters of ocean acidification, pH, partial pressure of CO₂ in seawater, etc. With standardized methods, we can evolve on the monitoring, and it will be much easier to detect the most vulnerable areas, for instance where you have (seasonal) upwelling or if there is a combination of eutrophication and acidification - it is very important to have good data. These practices will help us work towards a Clean Ocean.

**Discussion Outcomes/ Major Takeaways 1700 CET**

**Session 1:**
- Marine Pollution / Hazards (e.g. harmful algal blooms) have socioeconomic impacts
  - Wherever possible: involvement of social communities to detect and mitigate hazards is crucial (e.g. monitoring network)
- Emerging pollutants are synthetic organic chemicals including organic additive release from plastics, current-use pesticides (CUPs), pharmaceuticals and personal care products (PPCPs), veterinary products, stimulants, food additives, corrosion inhibitors, biocides and illicit drugs

**Session 2:**
- Marine pollution is not only plastics -> trace metal deposition -> time series stations are key for detection.
- Models for tracking pathways of microplastics are available but temporal and spatial scales seem to be an issue.
- Plastics: Raise awareness in communities about plastics (e.g. apps, beach cleanup), provide data to policy makers, and community/capacity building -> encourage reducing plastic, recycle, and disposing properly.

**Session 3:**
- Best practices (e.g., GEOTRACES cookbook) are only useful/possible for some people/institutes/regions (Global North vs. Global South), so we need more interoperable best practices (GOA-ON is a great example)
- Need capacity sharing, mentoring, data sharing to promote a clean ocean
- Regional hubs could be a useful concept
- Increased networking can help consolidate efforts
- Work should be done on a best practice guide for microplastics - it’s in development but very basic (details about things like polymer types not included); there was discussion on how satellite data can help with (micro)plastic research - using satellites to distinguish fronts might be most useful

**Overall summary:**
- Marine pollution/hazards influence multiple transfer processes - e.g., bidirectional air-sea interactions, bidirectional ocean-society interactions
- There is a need for early warning systems and mitigation strategies, as well as for human and technological capacity sharing - this is especially true in the case of harmful algal blooms (HABs) in remote areas of the world without electricity, stable internet, etc., where rapid measurements are needed for rapid response and the community needs to make the tech sustainable for them (given their needs and challenges)
- There are many types of pollution that need to be detected and mitigated (e.g., plastic and other debris, trace metals, gases), so the issue of scales should be addressed - both in time and space - for detection, policy making, monitoring (time-series stations could be key players here, models are useful but need a bit of further development)
- Tools are not only technological - raising awareness, lobbying, and building capacity are extremely useful tools for combating marine pollution/hazards - getting scientific output into the right hands is a serious challenge that needs attention.
- More exchange between data generators and users is necessary - specifically communication of what is available and what is needed
- Extended global observations using existing global networks are paramount for supporting a clean ocean - this includes governmental monitoring of pollution and hazards - with a set of accessible best practices!

**Discussion Outcomes/ Major Takeaways 0200 CET**

**Session 1:**
- Study of natural oxidation processes in microlayer (open ocean and coastal ocean) is needed.
- The needs of different communities should be identified, and international networks like OASIS could provide technical/scientific support, which could combined with indigenous knowledge to tackle problems, e.g. HAB forecasting.

**Session 2:**
- Measurement of surface current from space is crucial, for coastal applications and for remote region studies. Both NASA and ESA have relevant missions. Satellite missions combined with HFR coastal system would allow to improve numerical models of surface current and surface drift of pollutants. Ongoing S-MODE experiment is to justify future WACM proposal, advocating WACM in the next six months is important for its inclusion into NASA's plans.
- Synergies between scientists and citizen scientists are important. Scientists should equip CSs with adequate tools and techniques. CSs are also stakeholders and OASIS could supply local ocean users with important information.
- The list of important pollutants should be compared with future satellite missions (such as PACE) to evaluate their possible utility for applied tasks.
- The complex composition of pollutants (trace metals, microplastics, etc.) can in some cases provide additional information.

**Session 3:**
- OASIS and SOLAS could team up to establish air-sea interaction process studies that could ultimately lead to satellite missions that could help clean-ocean applications in the global oceans.
- Funding is a big issue for the best practice task team.

**Overall summary:**
- Process studies including those relevant to a clean ocean could be very useful (e.g., microlayer, currents, remote sensing).
- Measuring surface currents from space could potentially be very important for emergency response and early warning systems in the world's coastal regions that do not have HF Radar. The proposed Wind and Current Meter WACM satellite mission could potentially get within 5 km of land, although some averaging needs to be done. The use of such satellite missions for these Clean Ocean applications needs further consideration.
- The engineering problems of working in remote regions must include solutions for data access/communication from the platform to the local shore
- There are potentially a lot of linkages between OASIS and the UN Ocean Decade Ocean Acidification Research for Sustainability (OARS) programme.
- Best practices must be practices that can be implemented.
- OASIS should actively engage with operational agencies dedicated to response and restoration of marine environments.

Appendix 2: List of Posters

After the 1-hour event concluded, participants had the opportunity to view posters, wander through Gather.Town, and socialize with friends and colleagues. The list of posters can be found in Appendix 2.

Participants were asked to register in advance of the event, which led to 116 registered participants. There were numerous back-to-back (and sometimes overlapping) satellite events during the Clean Ocean Laboratory. There were about 34 participants during the first event and 16 participants during the second for a total of 50 participants attending the event as a whole. All registered attendees were given the password and invited to visit the poster room and Gather.town at their leisure, so presumably some that registered for the event but were unable to attend the zoom talks participated in the poster viewing. All registered attendees were also sent the YouTube links to the talks after the session for their viewing.

Many of the posters shown were created for OceanObs19. The list of posters below are grouped by their locations in the Gather.Town Poster Room (Figure 3).

Row 1 (from the bottom of the room up)
Posters listed left to right

Rutgersson et al. - ShipTRASE, Pathways toward a sustainable and equitable use of the oceans, accounting for and minimizing the impacts of global change

Coronado-Alvarez & Hernandez-Ayon - Ocean-atmosphere interaction: CO2 flux in the Pacific off Mexico

Hathorne et al. - Coral skeletons record seawater metal pollution

Ruiz-Cooley et al. - Use of stable isotope analysis to track toxin trophic transfer: implications for ocean monitoring

Medina-Perez et al. - Experimental Approach to Understand Aerosolization Mechanisms of Toxins Produced by the Macroalga Ostreopsis cf. ovata

Row 2
Posters listed left to right

Anderson et al. - Scaling up from Regional Case Studies to a Global Harmful Algal Bloom Observing System

Kent et al. Ocean Surface Climate: Observing requirements for long-term records at the ocean surface

Lowder & Valauri-Orton - A Case Study for Delivering Capacity Development: The Ocean Foundation's Approach to Building Global Ocean Acidification Monitoring Programs Through Equipment, Training, and Support
Addey et.al. - Marine Plastics May be Altering the Carbon Cycle

**Row 3**
*Posters listed left to right*


Quintrell et. al. - Ecological Forecasts for a Rapidly Changing Coastal Ocean

Gommenginger et al. - SEASTAR: Observing Ocean Submesoscale Dynamics and Small-Scale Atmosphere-Ocean Processes in Coastal, Shelf and Polar Seas

Barker - GNOME Suite for Oil Spill Modeling

Wineteer et al. - Ocean Shot: Satellite measurements of winds and currents through Ka-Band doppler scatterometry

**Appendix 3: Pre-meeting instruction for the OASIS Gather.Town provided to registered participants**

The link and password to OASIS Gather.Town are not included below.
**Gather.Town 101 – Tips & Tricks for the event:**

- When you first log in to GatherTown, it may present you with a mini tutorial before entering the OASIS for a Clean Ocean space.

**Navigation:**
- To navigate your character throughout the different event spaces, use your arrow keys.
- Hold the “G” key on your keyboard to move through people and silence nearby conversations/video chats.

**Private Spaces:**
- There are private spaces throughout the different rooms, typically indicated by a different floor color. Upon entering one, you will also see a message on your screen that reads, “You have entered a private space.”
- All conversations outside this space cannot be heard by those within the space. Conversations within this space cannot be heard outside of it.

**Interactive Objects:**
- See Slide 4 for a comprehensive list of the objects you can find throughout the event.
- To interact with an object, press the “X” key on your keyboard.

**Chat:**
- Please keep an eye on the chat, as announcements will be made here. Also see the “pinned” notes by the tack symbol on the left side of your screen.
- When in a private space or Theme Room, use the “Nearby” option (or direct message an individual).
• Using the “Everyone” option sends a chat to all participants, even those in a different room.

**Help Desk:**
• If you are having any trouble, visit our Help Desk (white desk) in the Main Room. We will be ready to answer your questions!

**Interactive Objects**
In each room, you will find different objects to interact with by pressing the “X” key on your keyboard. Here’s a comprehensive list of the for each area:

**Foyer Room:**
• Bulletins with the link to the zoom session
• Sign outside the poster room.
• Help document on the Help Desk (white desk).

**Poster Room:**
• Bulletin, to the right of the door, that links to a document where you can leave comments and questions about the posters.
• Posters, videos, and a bulletin board at the back left of the room with links to the IMDOS poster session and the OASIS Predicted Ocean Event.

*Gather.Town is open all day 18 and 19 November 2021. Please pop in at your convenience to view posters and meet colleagues and friends.*

**Code of Conduct**

By entering our Gather.town space, you agree to our Virtual Event Code of Conduct. [Click here to read the Code of Conduct](#)

**Appendix 4. Participant Code of Conduct & Anti-Harassment Policy**


**Guiding Principles and Code of Conduct**
As a community organization, the Consortium for Ocean Leadership (COL) regularly organizes and hosts events, including meetings, workshops, conferences, trainings, and educational events, with members from multiple sectors within the ocean science, technology, education, and related communities and stakeholders. The core values of COL form the foundation on which we perform work and conduct ourselves and define how we interact with each other.

Our core values are:

**Respect for each other, and for all cultures and backgrounds:**
We embrace each other’s differences so that we may enrich the well-being of everyone. We value different experiences, backgrounds, and perspectives that bring forward creative and innovative solutions. We value a safe environment in which to offer multiple, and at times conflicting, opinions...
that drive toward common goals. We particularly value the diversity across the organization, and the contributions each person and organizational component makes to the success of us all. We are a growing and evolving organization; we value change.

**Honesty, integrity, and candor:**
We seek the truth and speak it directly.

**Credibility:**
We strive to be a trusted source of unbiased and science-based advice and information: science and technology are the ground upon which we stand.

**Professionalism:**
Demonstration of exemplary qualities in all aspects of personal presentation and conduct; we establish and adhere to high standards.

**We believe we can accomplish the most by working together.**
The participants of this meeting were chosen for the experience and perspectives they bring to the discussion; therefore, every voice is important to reaching our goal of building an Observing Air-Sea Interactions Strategy (OASIS) for a Predicted Ocean.

To those ends, in this meeting, we invite all staff and participants to abide the following code of conduct:

- **Respect for each other, and for all cultures and backgrounds:**
  - Value a diversity of views and opinions and seek out perspectives other than those already represented.
  - Seek to understand, learn, and build rather than to be right.
  - Assume that you have relative privileges and both explicit and implicit biases. Know that others may or may not have had similar opportunities, experiences, and background as you. Recognize that their contributions are equally valuable. For those from dominant identity groups, refrain from contributions that prioritize dominant experiences over those who have been marginalized.

- **Honesty, integrity, and candor/ Credibility**
  - Speak to your knowledge and experience when it is not represented in the group discussion. Avoid sharing sensitive personal information about yourself or another individual, whether or not an attendee of this event.
  - Honor confidentiality. do not share the specifics of others experiences or information without permission.
  - Speak only for yourself. Avoid contributing to assumptions or generalizations about groups, and do not ask individuals to speak for their (perceived) group.

- **Professionalism**
  - Leave space for others to engage and express comments and ideas if you have spoken recently, by speaking if you have not, and by letting people finish their thoughts before adding new ones.
  - Affirm the person, critique the ideas. Provide feedback constructively and with the intent for mutual growth, and welcome feedback and constructive dissent.
  - Be solution- and goal-oriented
    - Contribute what has not yet been said, rather than repeating or re-affirming what has.
    - Though we will be discussing topics that may involve high personal meaning and impact, refrain sharing potentially triggering information in the
group and instead utilize the support resources offered.

**Etiquette for virtual communication**
- If you would not say something to someone’s face, refrain from writing/saying it virtually.
- Know that use of strong language, capital letters, and exclamation marks can be easily misinterpreted online as unwelcome yelling or aggressive behavior.
- Remember that tone does not carry via text. People might not realize you are joking or being sarcastic.

**Supporting one another**
If you notice someone in distress, privately ask if they would like support or assistance. If yes, offer support, direct them to the workshop’s support resources, and/or ask if they would like you to contact a COL staff member.

**Reporting incidents**
Notification of an issue or concern should be done by contacting a COL staff person by phone, email, or private chat message in Gather.town.

**COL staff members responsible for this meeting:**

Maggie Chory, Program Associate  
Email: mchory@oceanleadership.org

Masha Edmondson, Program Associate  
Email: medmonds@oceanleadership.org

Cassie Wilson, Program Associate  
Email: cwilson@oceanleadership.org

Other COL reporting points of contact:  
Jasmine Hill, Meetings and Travel Specialist  
Email: jhill@oceanleadership.org

**Anti-Harassment Policy**

**Policy on Harassment**
COL is dedicated to providing a harassment-free and inclusive event experience for everyone regardless of gender identity and expression, sexual orientation, disabilities, physical appearance, race, nationality, age, religion, or any other protected category. COL will not tolerate unlawful harassment or behavior that creates an intimidating, hostile, or offensive environment at any of the events it organizes or co-organizes in any location throughout the world. All event participants are required to abide by this Code of Conduct, which is adapted from the American Geophysical Union and complies with the new directive from the National Science Foundation.

Sexual harassment is a specific kind of unlawful harassment and includes sexual advances, requests for sexual favors, unwelcome or offensive touching, and other verbal, visual or physical conduct of a sexual nature that has the purpose or effect of creating a hostile work environment. Harassment can include, but is not limited to, comments, cartoons, “jokes,” e-mail messages, computer images, physical conduct (including gestures), horseplay, stereotyping, and unwelcome touching.
Unacceptable Behavior includes, but is not limited to:

- Harassment, intimidation, or discrimination in any form.
- Physical or verbal abuse by anyone to anyone, including but not limited to a participant, speaker, guest, staff member, volunteer, sponsor, etc.
- Sexual attention or advances.
- Personal attacks directed at other participants, speakers, guests, members, staff, etc.
- Alarming, intimidating, threatening, or hostile comments or conduct.
- Nudity and/or displaying sexual images.
- Threatening or stalking anyone, including a participant.
- Other conduct which could reasonably be considered inappropriate in a professional setting.

Anyone requested to stop unacceptable behavior is expected to comply by ceasing the behavior immediately, regardless of:
- Whether they agree the behavior is a policy violation
- Whether the request comes from the target of the behavior, a bystander/witness, a member of the COL staff, or another person in charge of the meeting.

Consequences for policy violations may include but are not limited to:
- COL staff (or their designee) or security may take any action deemed necessary and appropriate, including immediate removal from the event without warning or, when applicable, refund (to include travel reimbursement).
- COL reserves the right to prohibit attendance at any future event.
- Notification of an infraction to the offender’s home institution

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