# Submission form for Ocean-Shot Concepts-Round 2

Response ID:26 Data

## 1. (untitled)

**1. Ocean-Shot Contact Information: *Note - This information will be shared with the National Committee for the Ocean Decade in order to receive feedback. It will also be made publicly available if the Ocean-Shot concept is accepted into the Ocean-Shot Directory.**

Primary Contact Name (First & Last) : Andrew Heyes
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**2. Ocean-Shot Title**

Novel Coastal Ecosystems: Engineered Solutions to Accelerate Water Quality Restoration using Engineered Aeration

**3. Author(s): *Please list contributors to the submitted Ocean-Shot concept with first and last names in the order you wish them to be referenced for *potential* use in the Ocean-Shot Directory. Examples can be found here:**

Lora Harris, Jeremy Testa, Laura Lapham, Andrew Heyes

**4. Ocean-Shot Directory Summary (Please provide a short introduction/description of the Ocean-Shot concept for *potential* use in the Ocean-Shot Directory, 100 word limit. Examples can be found here.):**

Low-oxygen conditions occurring in coastal waters are increasingly driven by nutrient release from human activities impairing ecosystems. Climate changes and ecosystem regime shifts have altered the baselines used to generate restoration targets, so remediation trajectories are now uncertain and management efforts may fall short. A solution involves augmenting nutrient reduction efforts with engineered aeration to make up the difference. Aeration of the water column could not only reverse hypoxia but also accelerates processes that naturally remove nutrients. Thoughtful studies of ecosystem function under engineered conditions are needed to determine feasibility of these solutions and document potential unintended consequences.

**5. Abstract (describe hypothesis, scientific and/or technological objective, 200 word limit):**

The increasing reliance on the coastal zone for food through harvesting natural stocks and accelerating aquatic farming is at risk from existing sources of nutrient runoff and ever expanding coastal development. While nutrient reductions are effectively being implemented in some countries, traditional watershed-based reductions may be insufficient, demanding bridge technologies to help mitigate the impacts. Aeration or oxygenation of the surface water is one approach – which has been widely applied in enclosed freshwaters - and can stimulate nutrient turnover and mineralization. However this is not simple to implement in the coastal zone and requires careful study in order to engineer cost effective site specific solutions. While intending to be beneficial, multiple ecosystem processes could be unintentionally impacted by aeration, such as aquatic life behavior caused by bubble fields and shifting oxygen regimes, to the release of contaminants with the coastal ocean being a repository of human wastes. A detailed understanding of hydrodynamics and biogeochemistry is required in order to design a cost effective, minimal impact system and the far-reaching impacts of aeration can only be understood through a combination of empirical and numerical modeling efforts

**6. Please select the challenges (no more than 3) that are most relevant to your concept (Expanded reference below):**

Challenge 1: Understand and map land and sea-based sources of pollutants and contaminants and their potential impacts on human health and ocean ecosystems, and develop solutions to remove or mitigate them.
Challenge 2: Understand the effects of multiple stressors on ocean ecosystems, and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.
Challenge 3: Generate knowledge, support innovation, and develop solutions to optimize the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions.

**7. Describe how your Ocean-Shot addresses the selected challenges (150 word limit).**

Nutrient sources that cause hypoxia originate from agriculture and human effluents, and while wastewater is often effectively treated, agricultural inputs may be stored for decades. Consequently, agricultural nutrient management is difficult (food production must be maintained) and creates a legacy of nutrients, slowing restoration. Furthermore, limited achieved nutrient reductions are occurring against a changing baseline of climate with warming waters having lower oxygen saturation levels. It is possible we can increase system resilience while waiting for effective nutrient mitigation installation by "making up the difference" with aeration (Challenges 1 and 2).Because the pressures of warming and sustained nutrient inputs are likely to increase with changing climate and the increasing demand for food, we already face a future where mitigation can barely keep up (Challenge 3). Studies that demonstrate how aeration impacts a waterway are needed to develop and demonstrate systematic approaches that lead to effective mitigation while minimizing undesirable effects.

**8. Vision and potential transformative impact (200 word limit):**

It is the realization that nutrient mitigation alone will probably not achieve the desirable reductions in nutrient loads to coastal waters in a timely fashion that has driven us to examine alternatives. Well- designed engineered solutions, such as aeration, could bridge the gap with surgical interventions to support healthy, productive ecosystems by stemming further degradation. We recognize that because some damage is irreparable, restoring ecosystems to pre-impact conditions is unlikely. However, what we can achieve are better, more diverse functioning ecosystems for both humans and organisms alike that inhabit the coastal ocean. Our vision is that a network of marine scientists, engineers, government agencies, and coastal community members can envision, test, implement, and evaluate an engineered aeration system that rapidly generates improved oxygen conditions that far exceed those achievable from land. Through consultation with our colleagues we have found that by utilizing the workings of a particulate ecosystem, interventions could be less dramatic and cost effective than one might imagine. The reward is a more balanced ecosystem that will provide opportunities for a variety of "consumers". What are needed are effective demonstrations to embolden governments to act.

**9. Realizable, with connections to existing U.S. scientific infrastructure, technology development, and public-private partnerships (150 word limit):**

Aeration has been implemented in US lakes and reservoirs mainly to improve the quality of fishing and limit the release of sulfidic waters that might harm downstream aquatic life. Tidal examples are limited. In the Chesapeake Bay, engineered aeration has been used to lower sulfide emissions for a small tributary, involving studies and partnerships among county government, engineering firms, and academicians. Larger scale efforts to consider aeration of the Chesapeake Bay and Baltic Sea have been considered. More science along with shifting mitigation practices to include in situ tidal best management practices are only just beginning to open up the possibility of incentivizing these solutions with existing policy. There are clear avenues to scale these efforts to other systems and to consider innovative design solutions such as net zero emission technologies to power aerators or innovate new energy networks (e.g. electrolytic production of hydrogen) to supply oxygen.

**10. Scientific/technological sectors engaged outside of traditional ocean sciences (100 word limit):**

Addressing issues of coastal hypoxia will require the integration of ocean sciences with engineers, economists, ecologists, hydrologists and chemists. We piloted such a focus group to discuss our Chesapeake Bay study and found that additional expertise might also be involved. Social scientists to consider public perception, or energy specialists to consider system life cycle impacts on emissions would also be important players. This work touches on philosophical questions around mitigation and sustainability in a way that is relevant for all practitioners working on restoration endeavors, along with futurists and planners who consider impacts of decision making over the long term.

**11. Opportunities for international participation and collaboration (100 word limit):**

Hypoxia in coastal waters is a global concern. Aeration has been suggested in the Baltic but concerns around feasibility, costs, and unintended consequences have brought controversy to its application. These issues warrant research and attention. Nevertheless, nations everywhere realize that water quality goals will be challenging to reach without some engineering interventions. Interactions with the international community would be essential in terms of lessons learned already and a broader understanding of systems under stress which might be candidates span country boundaries. This team has connections in the Baltic (Sweden, Finland) to engage in these conversations.

**12. Develops global capacity and encourages the development of the next generation of ocean scientists (100 word limit):**

To develop, implement and enact a larger aeration study will require a large number of scientists, engineers, and managers

working together in a transdisciplinary context. We need a workforce with this experience in team science and problem solving, as well as a systems thinking mindset. The team proposing this study includes members actively working to diversify the geoscience workforce, which does not currently match U.S. demographics in terms of representation. Following a multi-context approach to training geoscientists, as would be required in this effort, has the potential to recruit new talent and innovative thinking to meet these challenges.

## 2. Thank You!

**Thank You Email**

Jun 30, 2021 13:00:23 Success: Email Sent to: heyes@umces.edu