

Capture carbon, keep the poles frozen, and arrest sea level rise: a research hub for coastal science, engineering and engagement

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Coastal communities are faced with the present and continual threat of sea level rise, which can intensify coastal storm damage and inundate homes, working waterfronts, and military bases. A collected and sustained effort is needed to address this global challenge, which is particularly serious for the coasts of the United States given its concentration of population and economic infrastructure. Individuals, industries, and governments are more likely to take on this important work when there is a positive, tractable, and hopeful vision. To advance action and address the root cause of sea level rise, a quantifiable, strategic, and achievable goal is needed.

We propose that the National Science Foundation create a research hub that has the overarching goal of capturing carbon, keeping the poles frozen, and arresting sea level rise.

The pressing need for long-term research programs targeted at arresting sea level rise at short (storm surge damage) and long (inundation) time scales has been clearly documented (IPCC). Arresting sea level rise would preserve global ecological stability with direct application to human food production, maintain the United States' strategic advantage of a frozen Arctic, and sustain coastal communities, economies, and quality of life on US coasts. While all of the ongoing efforts to reduce and capture carbon emissions are needed and must continue, more must be brought on line to address one of the greatest threats and challenges of our generation. We have not yet integrated technological and natural solutions for capturing atmospheric carbon ***in the coastal zone*** in a coordinated, tactically-driven research program with strategic vision.

The specific objective of this long-term and sustained research hub is ***to work with multiple disciplines and sectors to find economically feasible and scalable solutions for coastal carbon sequestration that will keep the poles frozen and arrest, then reverse, sea level rise.***

This research hub will have five simultaneous and integrated research components that span NSF Directorates, involve multiple partnerships across sectors, and foster the free and open sharing of ideas, models, and technologies. The specific aims are to:

1. **Predict how much carbon must be removed from the atmosphere to keep the poles frozen and arrest sea level rise.** The specific and tangible goal of maintaining polar ice sheets and the frozen Arctic is a critical feature of this program. Quantifying the amount of atmospheric carbon removal that is needed to achieve this goal will help drive investigations and investments in the efforts to sequester atmospheric carbon within the coastal zone and elsewhere. It will also allow prediction of the expected height of sea level rise before it is arrested and ultimately reversed, which will provide specific targets, with confidence intervals, to guide adaptation and mitigation efforts.
2. **Discover, understand, and quantify natural carbon sequestration processes in oceans, estuaries and lakes.** Numerous processes exist that could sequester carbon in coastal ecosystems (e.g., calcium carbonate production in whiting events, oyster shell and coral reef formation, salt marsh, seagrass, and mangrove growth). Interdisciplinary teams are needed to understand existing contributions of ecosystems to carbon sequestration, to identify new candidate processes for carbon sequestration, and to develop ideas for technology, infrastructure, and restoration that can be scaled up to make a meaningful reduction in atmospheric carbon.
3. **Engage public, private, and nonprofit sectors in assessing feasibility and tradeoffs.** Partnerships with a public, private and nonprofit sectors (e.g. industry, managers, civic society) would be developed to understand their needs and perspectives and help identify economically feasible and tractable solutions for carbon capture that can be implemented broadly along coasts worldwide. In addition to applying and enhancing understanding from the social science perspective, this effort also is important for fostering the team work needed to efficiently move discoveries from ideas to implementation.
4. **Engineer technologies and enhance coastal ecosystems for carbon sequestration.** A substantial effort to transform basic discoveries into implementable technology and ecosystem enhancement for carbon capture is required. For example, new technologies could help flip the cement cycle from carbon emitting to carbon capture. The effort should integrate the needs, perspectives, and innovations of public, private, and nonprofit sectors.
5. **Catalyze action across industry, government and communities by co-developing implementation strategies.** A feature of this program is that it provides a positive vision and proactive pathways to restore hope in the public role of science and innovation for social good. It will foster a sense of human agency, which research has shown is necessary to motivate action. Design and feasibility studies that include diverse publics

in an open team approach are critical to the successful uptake and use of scientific information. Research to deepen understanding of the engagement and co-development process will iteratively enhance the broader impacts of this research hub and extend carbon capture solutions worldwide.

By working simultaneously on these research components across a network of interdisciplinary research teams, this research hub would directly address the root cause of sea level rise, harness the numerous disciplines and perspectives needed to create implementable solutions, and provide a vision and goal that would give people the agency, volition, and hope needed to act and succeed.

NSF has the mission, expertise and capacity to lead the basic science needed to solve what is perhaps the most pressing problem that has ever threatened our coastal populations and environment, and to turn the tide against sea level rise.