Fleet for the Future

A Net-Zero Emissions NOAA Fleet by 2050

Response to the NOAA Science Advisory Board

July/August 2024 Meeting

Vision

As the nation's lead agency in the application and operation of oceanographic, atmospheric, and climate sciences, NOAA has the responsibility to be a leader in mitigating the climate impact of its operations. The marine vessels that support NOAA's research, exploration, and mapping missions are also significant sources of carbon emissions.

Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," and Executive Order 14057, "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability," acknowledge that the climate crisis will require both significant short-term global reductions in greenhouse gas (GHG) emissions and net-zero global emissions by mid-century or before. There is also a recognition that the United States government has a responsibility to take actions to minimize emissions from its own sources, including vehicular fleets and facilities. Meeting the net-zero goal by 2050 will incentivize new innovation in the United States and globally.

Taking inspiration from these Executive Orders, NOAA's ambitions for its own net-zero emissions fleet can help meet this objective: the ***Fleet for the Future***. In addition to onboard emissions reductions, NOAA will also look to shoreside opportunities and other reductions that can be gained through facilities and changes in logistics and mission efficiencies. Though there have been notable advances in net-zero emissions technologies and alternative fuels in the maritime sector, there remains significant questions and costs that prevent immediate incorporation into NOAA vessels currently under construction. Future opportunities for dual fuel capacity, increased battery storage, and other advances may be incorporated into future NOAA ship designs or retrofits, where possible. Current ships are being constructed with low emissions, hybrid diesel engines and other efficiencies that can begin emissions reductions and increase fuel efficiency today.

Decarbonizing NOAA's fleet and seagoing operations by 2050 will require innovative practices and a strong and immediate commitment to innovation and deployment. By initially using approaches to increase our efficiency, and later, as decarbonization pathways grow in availability and opportunity, NOAA sees a path, pending available appropriations, to harness modern and future innovations to transform its fleet. By 2050, NOAA-operated vessels and small boats aim to achieve net-zero-emissions while also enabling a dramatic enhancement in ocean observations, fisheries science, and marine research.

Guiding Principles

In pursuing the ***Fleet for the Future***, NOAA will:

1. Define "net-zero emissions" as accounting for ship-based greenhouse gas emissions, as well as shoreside facilities and activities, supply chain (e.g., fuel and supplies), logistics, and other opportunity areas for emissions reductions, such as increased telepresence

and use of uncrewed systems. NOAA will prioritize direct emissions reductions over offsets.

2. Capitalize on cross-agency collaboration and technical assistance opportunities (*e.g.,* Department of Energy and Department of Transportation), as well as international efforts and examples from other governments, industry, and academic institutions, to achieve net-zero through a robust plan.

3. Harness public-private partnerships to develop new technologies and designs nimbly and creatively, and to support the New Blue Economy.

4. Share NOAA's plans and findings as widely as possible to encourage uptake internationally and by the private sector.

5. Use the effort to build a diverse workforce of the future both in the broader maritime community and within the NOAA Commissioned Officer Corps.

6. Look for opportunities in its annual budget proposals to begin socializing the ***Fleet for the Future*** and request investments from Congress.

Current Status of Net-Zero Emissions for a Maritime Fleet

International and domestic momentum is gradually building behind decarbonizing the maritime sector. That said, the maritime sector is notably slower in capability to adapt to technological innovations given the relatively longer service life and greater variety of vessel types and purposes than other emissions sources or transportation sectors. The International Maritime Organization (IMO), "a specialized agency of the United Nations" of which the United States is a Member State, sets standards for safety at sea for the international maritime community. The IMO is making progress on a "Net-Zero Framework" as it pursues temporarily staged goals for the international maritime community. The Department of Energy is supporting the United States in its co-leader role of Mission Innovation: Zero-Emission Shipping, an international collaboration to spur innovation and achieve a number of "well-to-wake" zero-emission goals. The United States is also a co-lead with Norway of the Green Shipping Challenge that continues to build from its initial launch at the 2022 United Nations Climate Change Conference or Conference of the Parties of the UN Framework Convention on Climate Change (COP27).

Despite the U.S. leadership in these collaborative and ambitious efforts, the federal government has focused largely on the commercial maritime fleet instead of U.S. government (USG) vessels. The vast majority of those USG vessels are under the Department of Defense or Department of Homeland Security (Coast Guard). However, NOAA, National Science Foundation, Maritime Administration, and other agencies do manage vessels and small boats. It has been difficult to elevate these vessels in the federal decarbonization conversation given their limited number

compared to the overall scale of the maritime industry and other vessel types operating in or from the United States. For example, NOAA estimates the average fuel burn in its fleet of 15 research vessels is 1,581 gallons of diesel per day. One Panamax container ship can burn around 63,000 gallons of fuel per day. NOAA sees an opportunity to set an example via its own fleet while also pursuing its role as an expert and collaborator in these larger decarbonization efforts.

CHALLENGES

Decarbonization progress in the maritime industry has lagged behind other sectors due to a number of constraints and concerns:

- Alternative Fuels - Currently, there is no one alternative, lower emissions fuel that has risen to the top as the dominant solution. Each fuel (or battery) has certain constraints and challenges that elevate or eliminate options based on the unique vessels and use cases for which they are being considered.

  Among the considerations for each fuel type are:

  - *Combustibility* - Some alternative fuels, like hydrogen, carry an increased safety risk that will require additional safety training for crew, equipment, and other preventive measures to ensure health and safety of the vessel and its crew. NOAA vessels operate both in very remote locations, where support in case of an accident would be extremely difficult to receive, and in highly utilized areas where damage and injury to others is a critical consideration.

  - *Toxicity* - Some alternative fuels can be potentially harmful to the vessel crew if they are exposed, and/or can cause particular harm to the environment if there is a leak or if they are released into the ocean. NOAA always holds the health and safety of its crew, Commissioned Officers, scientists, and guests as its utmost concern. The agency also sometimes operates its vessels in particularly sensitive marine environments.

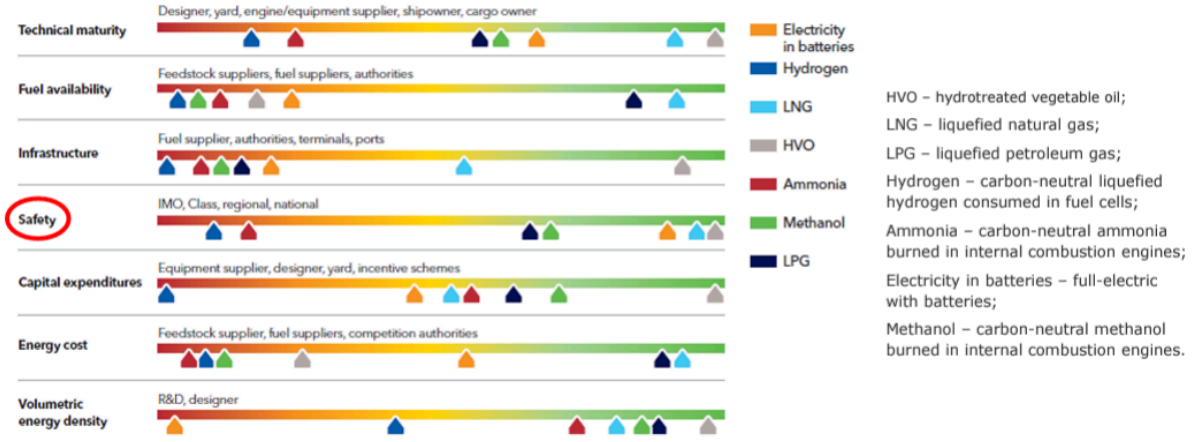
  - *Energy density* - Traditional diesel-based marine fuels have a very high energy density allowing for less volume to produce substantial power for the vessel. Alternative fuels have lower energy density which requires larger bunkering space. That space will need to be taken from other uses or areas of the vessels, meaning less room for science or people on NOAA's vessels.

  - *Storage requirements* - Some alternative marine fuels require storage at very low temperatures. This can be energy intensive and require additional expertise and equipment on board that will need to be maintained and monitored.

- *Well-to-wake emissions* - Though the combustion of alternative marine fuels may produce lower greenhouse gas emissions than diesel, not all fuels are currently capable of being produced at scale in a low or zero emissions manner. There are different degrees of net emissions reductions currently available pending on the derivation of an alternative fuel or battery lifecycle.

- *Availability* - Given the disparate tacts in the maritime industry and other challenges outlined above, supply and access to alternative marine fuels is not yet fully reliable. A disjointed fuel selection process is also contributing to the fuel and port infrastructure concerns further detailed below.

The Alternative Fuel Barrier Dashboard – indicative status of key barriers for selected alternative fuels in 2020



[1]

- Fuel and Port Infrastructure - There is a chicken and egg dilemma between the fuel production, transportation, supply infrastructure, ports, and vessel operators/owners. One component cannot alone dictate the needs of the entire industry and all financial decisions are linked. A robust fuel production and supply/transportation chain requires certainty in customers and their locations. Ports do not want to invest in bunkering and fueling infrastructure for multiple fuel types unless there is demand and resources to do so. And the maritime operators cannot be confident in alternative fuel decisions and vessel improvements unless they know their choice of fuel will be reliably serviceable. NOAA's comparatively limited fleet is not large enough to drive the market so it must select a decarbonization pathway that makes the most economic and mission focused sense for its fleet while balancing the realism of its choice given where more major market drivers land.

[1] *See, for example, an analysis presented as part of 2021 IMO presentation by DNV-GL, adapted from its "Maritime Forecast to 2050" report; the most recent Forecast is available for download at https://www.dnv.com/maritime/publications/maritime-forecast-2023/download-the-report/.*

- Vessel Improvements, Capacity, and Uniqueness - There is limited supply and availability of "drop-in" alternative fuels, or fuels that will not require an engine or system overhaul to use. In nearly all cases, engine system replacements, bunkering retrofits, and other vessel improvements would be required on existing ships to manage alternative fuels or significant battery power. New vessels can be constructed with alternative fuels in mind, but experienced shipyards, equipment availability, and competition/cost increases in the maritime construction sector make this a very expensive proposition as well. NOAA's vessels are particularly challenging given both their collective uniqueness as a fleet among the larger maritime community (even among USG ships), but also in their individual uniqueness of mission, homeport, and operations.

- Workforce - While NOAA is optimistic that managing a net-zero fleet will serve as an excellent recruiting tool for wage mariners and Commissioned Officers, it will still be in stiff competition with the private sector and other marine operators. Shipyards are also struggling to secure enough labor to meet existing contracts with current standards in engines and shipbuilding; requests for unique modifications could further limit trained/specifically skilled workforce availability.

- Costs - Given the limited supply of alternative marine fuels and supporting supply chains, and the novel nature of net-zero technologies, costs are anticipated to be markedly higher than using current technologies and fuel.

OPPORTUNITIES

NOAA aims to harness the domestic and international momentum to build on its own 2050 decarbonization strategy, and to inspire others to join as collaborators and leaders in their own maritime efforts. In particular, NOAA is looking to the Departments of Energy and Transportation as both technical advisors and collaborators in achieving its goal. Additional capacity requirements will provide NOAA with a unique recruitment opportunity, pending available appropriations, to support not only particularly skilled wage mariners and NOAA Commissioned Officer Corps members, but also acquisition specialists, engineers, and program managers that can design and implement a robust ***Fleet for the Future*** program.

Examples from Other Maritime Leaders

The following examples of net-zero emissions fleet and other emissions reductions programs reflect a growing body of public and private innovators in this space. NOAA continues to extend its network and build working relationships with these and other expert groups as the net-zero conversation and technologies advance.

- International Maritime Organization (IMO) - The 2023 IMO Strategy on Reduction of GHG Emissions for Ships targets for GHG emissions reductions by 2030 (at least 20%), 2040 (at least 70%), and 2050 (net-zero). Carbon dioxide emissions are specifically targeted to reduce by at least 40% by 2030 in international shipping.

- International Organization for Standardization (ISO) - The ISO Technical Committee 8/Subcommittee 25 Maritime GHG Reduction is responsible for standardization of ship GHG assessments and documentation procedures, bunkering and/or charging operations associated, and on-dock power generation. NOAA is a representative contributing to their efforts.

- U.S. Navy - In its "Climate Action 2030" report, the Navy reinforced the "nation's commitment to net-zero emissions by 2050." The report calls for the use of "hybridization, electrification, alternative lower-carbon fuels, and advanced propulsion solutions" that maintain both "combat capability and [the] energy transition."

- National Renewable Energy Laboratory (NREL) - Among its work in alternative fuels, NREL has studied biofuel options for marine vessels.

- UK National Oceanography Centre - UK Research and Innovation set a goal of achieving net zero by 2040 and to "be a leader in environmental sustainability for the sector." A summary report outlined the plan to achieve net-zero in the current 15-vessel fleet (3 global class; 7 regional class; 5 coastal class) which will require "a re-wired ecosystem which no longer has the large, multi-role research ship at its center, but which accepts that a large, lean-crewed, green fuelled platform … will be a key enabler for marine scientific research."

- Scripps Institution of Oceanography - Scripps is pursuing a new coastal research vessel that will use a hydrogen-hybrid propulsion system. It selected a naval architect company last year and received funding from the State of California to support the effort.

    - USDOT Maritime Administration (MARAD) partnered with Scripps on a feasibility study through its Maritime Environmental and Technical Assistance (META) program. MARAD has also examined hydrogen fuel cell ferry feasibility in San Francisco Bay and a number of other decarbonization opportunities.

- Maersk - Maersk, the second largest container shipping company in the world, committed to net zero by 2040. It has 25 green methanol vessels on order, the first of which was delivered earlier this year. They also signed the first major green methanol offtake agreement in the shipping industry.

    - Amazon has invested in supporting zero-emission cargo shipping, specifically selecting Maersk's methanol vessels for shipping needs.

- Fugro - Fugro manages a significant vessel fleet dedicated to supporting technical and geographical surveys and mapping efforts. They committed to reaching net zero by 2035, and are eyeing increased uncrewed surface vehicles (USV), less crew on vessels, and conversions to battery hybrid and methanol systems.

- Hurtigruten Group - The Norwegian travel group is pursuing a net-zero cruise ship by 2030, which would make it the first to do so. Current designs incorporate wind and solar sails, as well as extensive battery banks. It currently operates four battery-hybrid ships that use biofuels and other energy saving measures.

- Fortescue - The Australian iron ore company has taken on decarbonization and touts a "green industrial revolution" leadership role. It recently sailed its green ammonia-capable ship, FFI *Green Pioneer*, to COP 28 in Dubai.

Starting the Transition

Decarbonizing NOAA's fleet and seagoing operations by 2050 will require innovative practices, additional appropriations, and a strong and immediate commitment to innovation and deployment. As NOAA designs its new ships, the IMO goal of reducing global emissions by 2050 will influence the design of these ships. Though there have been notable advances in net-zero emissions technologies and alternative fuels in the maritime sector, there remains significant questions and costs that prevent immediate incorporation into NOAA vessels currently under construction.

By initially using approaches to increase our efficiency, and later, as decarbonization pathways grow in availability and opportunity, NOAA sees a path to harness modern and future innovations to transform its fleet and shoreside facilities and operations. Future opportunities for dual fuel capacity, increased battery storage, and other advances may be incorporated into future NOAA ship designs or retrofits, if appropriations allow. Taking advantage of such potential opportunities would likely require hiring new staff, harnessing outside expertise through contracted consultants or other partnerships. By 2050, NOAA-operated vessels and small boats will achieve net-zero-emissions while also enabling a dramatic enhancement in ocean observations, fisheries science, and marine research.

Current ships are being constructed with low emissions, hybrid diesel engines and other efficiencies that can begin emissions reductions and increase fuel efficiency today. NOAA's forthcoming Oceanographic vessels and Charting and Mapping vessels will similarly adopt hybrid, electric-diesel engines.

In addition to onboard improvements, NOAA will also look at how best to incorporate facilities, system operations, supplies, and logistics planning into "net-zero emissions" strategies to gain additional emissions reductions where possible. NOAA's new vessel facilities, such as the newly opened Ketchikan, AK pier and the forthcoming facilities and piers in Charleston, SC and Newport, RI, will have the latest technology to support NOAA ships, shoreside power to reduce engine use and emissions while in port, and are designed to be more resilient to the changing climate.

NOAA has begun the transition and is proactively taking actions to reduce emissions and increase efficiencies within the current and future fleet and associated shoreside infrastructure and operations. NOAA has identified three strategies that can mitigate the impact of its activities on GHG emissions and support the transition of the NOAA Fleet to net-zero emissions by 2050. These include:

- Avoiding future GHG emissions through smart design and climate-informed decision making.
- Reducing GHG emissions through greater efficiencies and reduced energy consumption, in fleet Shipboard Energy Efficiency Management Plans.
- Innovating through partnerships to capitalize on research and development and new technologies.

Achieving net-zero operations is a complex challenge and cannot be addressed by any one mitigation tactic. There are varying paths available to NOAA to achieve a net-zero emissions fleet by 2050. How NOAA achieves this complete transition to net-zero will depend on a variety of factors including technological advancement, employee training, strategic partnerships, federal fleet alignment, shoreside infrastructure, availability of resources, and an all-of-government strategy.

Current Activities by NOAA

NOAA's Office of Marine and Aviation Operations is already well in progress to pursuing advances towards net-zero:

INDUSTRY ENGAGEMENT

- Issued Request for Information (RFI) to solicit input on viable new technologies, alternative fuels, ship design, and future classification rules. Conducted virtual meetings with all respondents with follow up questions and open discussion about the responses to the RFI.

- Continue to meet with design agents, shipbuilders, and equipment manufacturers as technology advances and designs mature to incorporate net-zero goals.

- Technology costs for systems to handle alternative fuels are costly and require more space onboard vessels. Alternative fuels require more in quatity in order to achieve the same energy conversion which drive the size of vessels.
- Work with potential suppliers to establish partnerships for a supply chain and bunkering of alternative fuels.

DEPARTMENTAL COLLABORATION

- Engage with Naval Facilities Engineering Systems Command (NAVFAC) on their plans for alternative fuels in their ports.
- Engage with the Department of Homeland Security with their strategy on future ship acquisitions.
- Maintain relationships with Maritime Administration, Department of Energy, Council on Environmental Quality, and other federal expert agencies.

EMISSIONS REDUCTIONS

- Consideration of power generation updates to fisheries survey vessel (FSV) class ships as they go through their midlife repair period. Retrofitting of systems to Tier 4 engines is costly and requires an abundance of space that is difficult for scrubber systems; Tier 2 or Tier 3 systems would still be an improvement over the current Tier 1 and Tier 2 that they currently sail with.
- Implement usage of alternate fuels where possible (e.g., B5 biofuels).
- Transition lighting to light-emitting diode (LED) fixtures.
- Transition variable frequency drives to more efficiently operate heating, ventilation, and air conditioning (HVAC) systems to reduce the load on the power plant.
- Lower overall fuel consumption through optimizing design of the hull form and ship systems.

OPERATIONAL AND MANAGEMENT STRATEGIES

- Encouraging operators to follow more efficient mission profiles to increase emissions reductions across the NOAA Fleet.
- The NOAA Fleet council has been tasked to begin to work on a strategy to consider emissions for efficient utilization of the NOAA Fleet. This would be similar to strategies that industry shipping organizations have adopted to meet emissions targets.

- Each ship is developing an International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI shipboard energy efficiency management plan to document efficiency solutions.

TECHNOLOGY INTEGRATION

- Implement and fully utilize automation technologies that integrate ship systems (e.g., power management systems) to optimize power utilization and demand.

- New technology is the single best way to reduce point source emissions. The NOAA Ships *Oceanographer* and *Discoverer* will have the following improvements to address point source emissions:

    - Latest in power generation technology from SIEMENS and use lithium ion batteries as a power reserve and peak attenuation method.

    - Advanced emissions-reducing diesel-electric propulsion systems (NOAA's first Environmental Protection Agency (EPA) Tier 4 5 diesel engines), Cummins Tier 4 diesel engines. Specifically, EPA Tier 4 introduced a sixty three percent reduction in particulate matter emissions over Tier 3 standards for many of the engines above 600 kilowatt (kW) power output. EPA Tier 4 also introduced a sixty four percent reduction in nitrous oxides and hydro-carbon emissions over Tier 3 standards for many of the engines above 600 kW power output. NOAA's "newest" ships reflect the Strictest EPA emissions requirement for off-highway diesel engines. FSVs were delivered with Tier 1 and Tier 2 (Reuben Lasker) engines. This transition is the most significant reduction for the NOAA Fleet.

    - The new propulsions systems are projected to use 15,000 gallons less fuel per year for equivalent sized vessels operating traditional fixed speed diesel engines resulting in a reduction of 5,700 tons of CO2 per year.

    - The OMAO performed extensive hull testing, under an interagency agreement with the United States Navy, during the preliminary design stage to ensure both the hull and the propeller produced no noise or bubble interference while maximizing fuel efficiency.

    - The NOAA Class B request for proposal required the same or better technology as for *Oceanographer* and *Discoverer*. NOAA continues to take a holistic approach in increasing overall vessel efficiency by looking at anticipated mission profiles and matching them to the best available techniques/technology to reduce the overall carbon footprint and overall environmental impact of each vessel over its lifecycle.

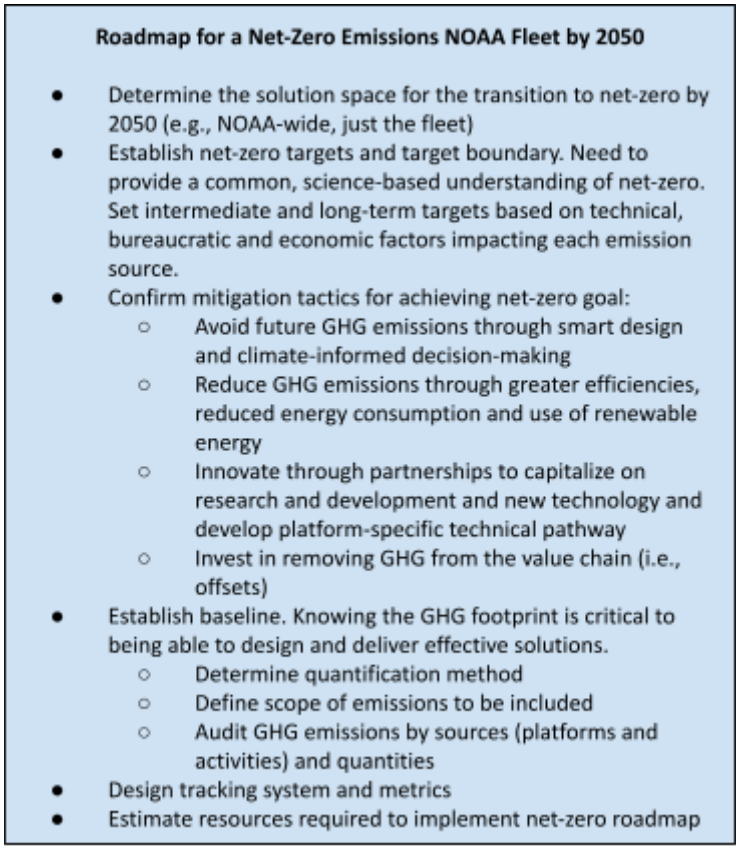
MAINTENANCE APPROACHES

- Annual, five year, and midlife maintenance packages will include integral modifications to ships to improve energy efficiency and reduce emissions.
- Develop maintenance procedures to handle alternative fuels and new technologies. Train the workforce on safety measures. Determine the proper certifications for new technologies and handling of alternative fuels and implement within the fleet.

Realizing the 2050 Fleet

Achieving a net zero-emissions fleet by 2050 will require:

- Knowledge transfer from other nations, U.S. Federal agencies, State experts, academia, and private sector leaders to merge rapidly into a NOAA plan.
- Phased procurement of new vessels (and retrofit, where possible) for all classes and missions of vessels incorporating fossil-fuel reduction and elimination technologies, as available appropriations allow.
- A cross-agency mission coordination and efficiency strategy to continue emissions reductions during the fleet rebuilding timeline.



- Workforce training/retraining, including within the NOAA Commissioned Officer Corps.
- Refreshed NOAA workforce and Corps recruitment materials and tactics.
- Consistent, committed, and multi-year funding to support the long-term ***Fleet for the Future*** strategy, including supporting a dedicated staff to drive the program forward.
- Robust, forward-looking requirements for the ***Fleet for the Future*** utilizing a net-zero-emissions fleet and autonomous and uncrewed systems.

Benefits of a Net-Zero-Emissions Fleet

The ***Fleet for the Future*** will offer:

- Expanded NOAA leadership in fleet management and climate change mitigation.
- Additional ecological benefits beyond emissions reduction and climate change mitigation through additional quieting technologies and other advances in vessel design and construction.
- A new pathway to engage with potential staff and Corps officers who have a particular interest in clean energy technologies.
- Renewed investment in public-private partnerships.
- U.S. leadership as one of the world's largest fleets of net-zero-emissions research vessels.