BLUE SKY
MARITIME COALITION

ROADMAP TO NET-ZERO EMISSIONS: NORTH AMERICAN WATERBORNE TRANSPORTATION

November 2023

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Many aspects of this document are expansions of ideas, insights and knowledge presented in Blue Sky Maritime Coalition publications that can be found on Blue Sky's website.

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Disclaimer. This document represents the collaborative thinking of a range of stakeholders across maritime shipping and reflects the Blue Sky Maritime Coalition approach, vision, and mission. The content of this document represents Blue Sky and should not be attributed to any individual Blue Sky Maritime Coalition member or members.

PRESIDENT'S MESSAGE

This Roadmap report outlines a strategy to achieving our mission of facilitating collaboration across the maritime shipping value chain to accelerate the transition of waterborne transportation in the United States and Canada toward net-zero greenhouse gas emissions. It describes the key, early challenges that we face and initial action plans to address those challenges.

The mission of Blue Sky is essentially, a highly complex, change management challenge, and it is useful to highlight the key principles of managing change that influenced the development approach for this Roadmap. Four principles are described and highlighted in the graphic below:

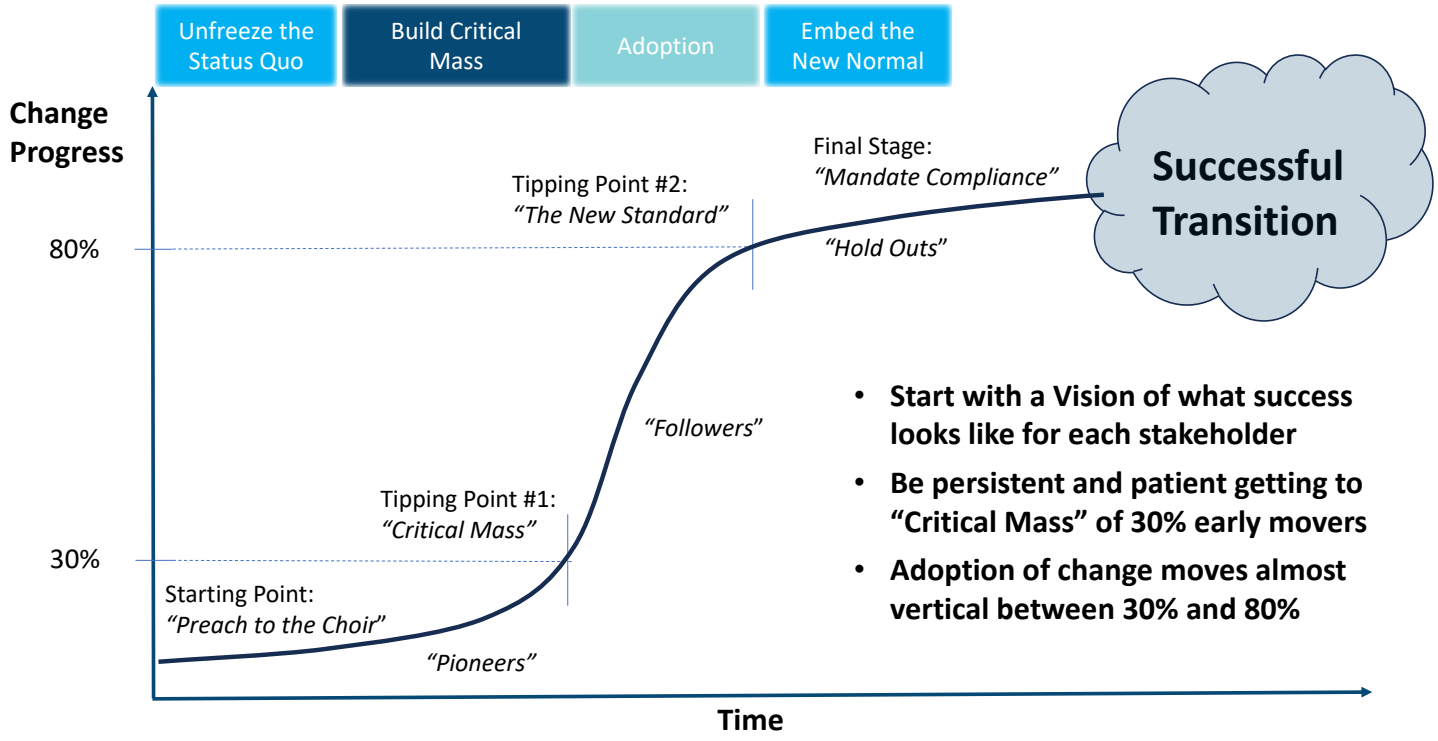
Principle 1: Start by developing a vision of what success looks like.
We will not succeed unless we are working on the same problem. This means looking at the future from the perspective of every stakeholder that in some way influences or is influenced by the change.

Principle 2: Find your champions.
Change is hard and disruptive. You need people that are passionate to start the process of unfreezing from the status quo and are willing to act as if the future is already here. If you focus on converting those who don't agree with the problem, you will spin your wheels and slow the change process.

Principle 3: Build a critical mass of first movers to 30 percent; time is an "S-Curve" and not linear.
You don't have to bring in all stakeholder groups to build a critical mass of first movers. If you can get 30 percent of stakeholders acting through local or regional clusters to bring technology and innovation to fruition, more will want to engage, and you will almost instantly jump to 80 percent adoption as reluctant followers join the ranks. The time to reach the overall change here is not linear. It is common to spend more than half of the time to affect change to get to the critical mass tipping point of 30 percent.

Principle 4: Mandate compliance to affect final adoption.
If you try to regulate or mandate the change in the early stages, you will not be able to efficiently manage the change process. The coalition of first movers who have been assembled will slip back into the status quo and those resisting change will entrench in their positions. The opposite is true at the final stages. Those that stay entrenched will only be swayed by regulation and mandates. For maritime decarbonization, this means policy makers and regulators have the majority of action steps in this phase, while private sector innovation and public demand will drive the change in the earlier stages.

Principles of Change



Blue Sky is founded on collaboration, innovation, systems thinking and vision-led action planning. The nature of innovation is based on change, disruption, dissenting viewpoints and the pioneering spirit needed to find new ways of working.

Blue Sky and its members remain committed to deep collaboration across the entire maritime value chain and transportation sector and would welcome your thoughts and feedback… especially the dissenting elements!

Best regards,

David H. Cummins
President & CEO

BLUE SKY
MARITIME COALITION

EXECUTIVE SUMMARY

The maritime sector is experiencing a technological revolution that must mature in less than three decades to meet 2050 net-zero ambitions. It requires a complete transformation of the operational technologies and business models that have dominated for nearly a century. Unprecedented levels of collaboration are required to accelerate and achieve these transformations for emissions reduction.

This is why Blue Sky Maritime Coalition ("Blue Sky" or "the Coalition") was launched to facilitate collaboration across the maritime shipping value chain to accelerate the transition of waterborne transportation in the United States (U.S.) and Canada toward net-zero greenhouse gas emissions.[1]

We envision a shipping sector value chain in the U.S. and Canada that operates in a net-zero GHG emissions ecosystem driven by collaboration and systems prioritization of life-cycle performance. A key outcome of this vision is by 2050, the maritime sector will achieve commercially viable, net-zero GHG emissions, maximizing both environmental and economic value for all stakeholders, and supporting healthy, economically vibrant and diverse communities in the U.S. and Canadian maritime corridors.

This report sets forth Blue Sky's Roadmap toward the achievement of commercially viable, net-zero GHG emissions across the North American Waterborne Transportation (NAWT) sector. Accomplishing emission reductions in line with Paris Agreement commitments requires transformational change, and envisioning success in 2050 is a precursor to achieving that success. Accordingly, this Roadmap articulates 2050 vision statements for stakeholders that influence the pathways to get there. Following Blue Sky's mission and guiding principles, the Roadmap identifies the actions necessary to address the challenges and achieve the 2050 vision.

The process of creating the Roadmap was to first start with defining a vision of what the future looks like after we have successfully achieved net-zero, GHG emissions. Effort was taken to ensure that the vision covered the breadth of stakeholders that are impacted in any way by the changes to the maritime value chain in North America, and that the sum of these vantage points was internally consistent (such that different vision statements did not contradict each other). From there, we identified key challenges to move from today's status quo to the future vision and the immediate actions that need to be prioritized to address these challenges. Table I describes these priority actions.

1 For the purposes of this document, Blue Sky is aligned with the Intergovernmental Panel on Climate Change's (IPCC) definition of net-zero greenhouse gas emissions: "… in which human-caused residual GHG emissions… are balanced by human-led removals… over a specified period and within specified boundaries." "Residual GHG emissions are the greenhouse gas emissions that remain after taking all possible actions to implement emissions reductions." Source: ISO Online Browsing Platform https://www.iso.org/obp/ui/#iso:std:iso:iwa:42:ed-1:v1:en.

Table 1.

Key Challenges and Near-Term Actions

Challenges and Actions

Built in Maritime System Inefficiencies and Siloed Approaches

- Enable Optimization Through Digitalization
- Accelerate Green Shipping Corridor Initiatives
- Monetize Value Chain Approach

Lack of Trusted, Accurate & Verifiable GHG Emission Inventories

- GHG Emissions Study for North American Waterborne Transportation
- Emissions Data Collection System
- Establish Common Emission Methodologies

There Is No "One-size Fits All" Solution for Vessels

- Support Development of Pilot/ Demonstration Projects
- Develop Condition-based Approaches for Retrofits

Fuel and Energy Infrastructure Lacking Demand to Reach Scale

- Green Shipping Corridors Fuel Clusters
- Fuel Production Mapping
- Multimodal Aggregated Fuel Demand
- Port/ Utility/ Maritime Collaboratives

Patchwork of Policy and Regulations

- Develop Approval Roadmap for Regulatory Processes
- Design Inclusion Pathway for Domestic Maritime in National Action Plans
- Develop Incentives for Uptake of Emission Reduction Technology for Maritime

Customer Willingness to Pay

- Develop Innovative Commercial/ Financial Constructs
- Grow Maritime Participation in Carbon Credit Markets
- Develop Consistent Carbon Intensity Values

While this Roadmap serves to inform the Coalition's strategy and priority actions going forward, it also includes actions that are needed by all stakeholders, not just those that are part of Blue Sky.

Climate change, policy, technology and economic considerations are dynamic and will be ever-evolving. As such, we anticipate this document will be regularly revised as activities and innovations demand re-evaluation of the steps to deliver on the net-zero emission vision.

To ensure readers' clarity on these strategic objectives, supplemental background information with additional details is included in the Appendices.[2]

2 A detailed view of the current state of the North American maritime industry's operations can be found in Appendix I of this document, which provides useful background on the current starting point for the transition to a net-zero greenhouse gas emissions value chain. Appendix II provides more details on vision elements for each stakeholder group. Appendix III provides success stories, and Appendix IV provides additional resources.

I. INTRODUCTION

The maritime industry is widely known as a difficult-to-decarbonize sector. The challenges are even greater for domestic operations within the U.S. and Canada. The maritime sector is fragmented and is characterized by varied business conditions, disjointed policies and regulations, and distinct operating environments. There are huge variations between the numbers and types of vessels, cargo carried, operational needs and market positioning across North America.[3]

As such, there is no singular timeline, technology or approach that will achieve emission reductions across all North American vessels or operations. A one-size-fits-all approach to reduce and abate emissions across maritime stakeholders is bound to fail. Coordinated but differentiated and complementary efforts are needed to achieve emission reduction over time.

The maritime sector is experiencing a technological revolution – that will need to mature in less than three decades to meet 2050 net-zero ambitions. This is less than the lifespan of a typical U.S. ship. This necessitates a complete transformation of the operational technologies and business models that have dominated for nearly a century. Figure 1. below describes the shipping industry's previous technological revolutions.

Unprecedented levels of collaboration are required to accelerate and achieve these transformations for emissions reduction. It's also important to recognize the role that maritime transportation will play in other sectors. The shipping of clean energy fuels is an important enabler for broader global sustainability goals, beyond decarbonization of maritime operations.

3 For an in-depth assessment, please read Blue Sky's "Pathways to Net-Zero 2050 in the North American Marine Shipping Industry: Vessel Inventories and Emissions – Pathways and Challenges."
https://www.bluesky-maritime.org/_files/ugd/8ed502_cccb99cb45274488af1629639446f4a4.pdf

Figure 1.
Shipping's Four Propulsion Revolutions

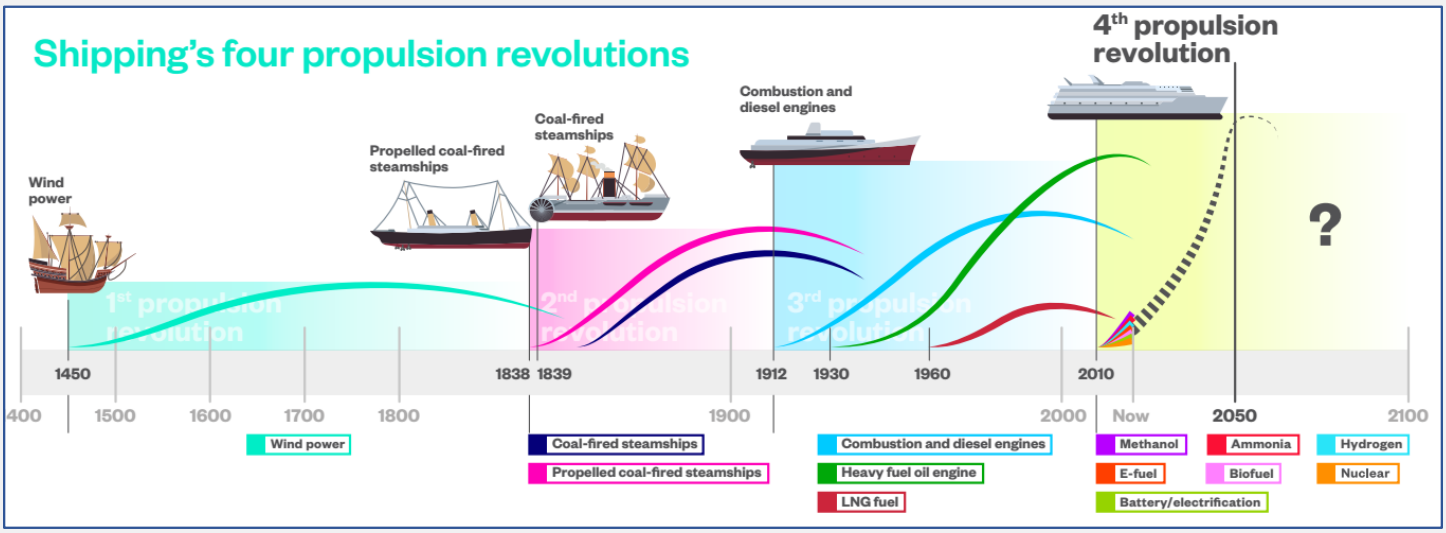


Figure 1 presents shipping's propulsion revolutions and highlights the growing quantity of propulsion source options with each phase. The transition into the 5th revolution must occur at a rapid, transformational pace compared to the previous transitions.
Source: International Chamber of Shipping: A zero emission blueprint for shipping https://www.ics-shipping.org/wp-content/uploads/2021/11/A-zero-emission-blueprint-for-shipping.pdf.

A. BLUE SKY ORGANIZATIONAL BACKGROUND

The Coalition launched in 2021 as the first organization of its kind with a goal to facilitate the collaborations necessary to achieve commercially viable, net-zero[4] GHG emissions by 2050 across the North American maritime shipping value chain. Recognizing the unique challenges to decarbonization that exist in the U.S. and Canadian markets, Blue Sky brings together the wide range of businesses integral to maritime shipping. As a non-profit organization with 120[5] member entities from across the entire marine shipping value chain, Blue Sky recognizes that engagement with the full value chain—on which each organization's success depends—is critical to the achievement of meaningful, economically viable reductions in GHG emissions. This collaborative, value chain approach distinguishes Blue Sky from most other maritime sector decarbonization organizations that focus on tank-to-wake or well-to-wake emissions.

4 For the purposes of this document, Blue Sky is aligned with the Intergovernmental Panel on Climate Change (IPCC) definition of net zero greenhouse gas emissions, which is as follows:
"condition in which human-caused residual GHG emissions (3.2.9) are balanced by human-led removals (3.3.3) over a specified period and within specified boundaries."
Note 1 to entry: Human-led removals include ecosystem restoration, direct air carbon capture and storage, reforestation and afforestation, enhanced weathering, biochar and other effective methods.
Note 2 to entry: The words "human-caused" and "human-led" are intended to be understood as synonymous with the word "anthropogenic" in IPCC definitions."
IPCC AR6 Working Group III Annex 1, modified, IWA 42:2022(en), Net zero guidelines (iso.org)

5 Member organization count as of October 2023. This membership includes shipbuilders, owners, operators, academic and research institutions, charterers, classification societies, engine manufacturers, financial institutions, investors, fuel providers, government, regulators, industry advisors, NGOs and port authorities.

Blue Sky's key priorities are to encourage collaboration between technical and commercial interests and serve as an interface between the public sector and private sector—with outcomes that advance pathways to GHG emission reduction consistent with the U.S. and Canadian commitments to the Paris Agreement. As a member-led organization, Blue Sky focuses on facilitating action-based, results-oriented collaborations that leverage the distinct characteristics of the North American maritime industry. We offer unique value to our members, including:

- Thought leadership capabilities and access to a diverse network of stakeholders and resources in both business and government sectors (including intellectual capacity);
- Green shipping corridor leadership and participation which helps to identify needs and connects the dots among key stakeholders; and
- Member-driven engagement and support to identify and facilitate projects to accelerate the North American maritime value chain's pathway to net-zero emissions.

Blue Sky is uniquely positioned to facilitate, design and promote this Roadmap. The organization's mission, regional focus and emphasis on value chain stakeholders generate practical and organizationally inclusive actions.

B. BLUE SKY MISSION

Blue Sky Maritime Coalition's mission is to facilitate collaboration across the maritime shipping value chain to accelerate the transition of waterborne transportation in Canada and the United States toward net-zero greenhouse gas emissions.[6]

This mission statement was developed in 2021 when Blue Sky was launched, and it continues to drive our actions today. When applying to join Blue Sky, entities must align with the statement that Blue Sky Maritime Coalition members recognize the need to address global climate change and are committed to this mission. This mission describes why the Coalition is needed and what we are here to do. It sets our focus on the U.S. and Canada, given the many unique characteristics of operations within this geography.

C. BLUE SKY GUIDING PRINCIPLES

Blue Sky's Guiding Principles are the values and boundaries that guide the vision, strategy and prioritized actions of the Coalition, and they have informed the development of this Roadmap for actions across NAWT. They are the strategic guidelines that align our decision-making processes across all Coalition activities.

6 For the purposes of this document, Blue Sky is aligned with the Intergovernmental Panel on Climate Change (IPCC)'s definition of net-zero greenhouse gas emissions: "… in which human-caused residual GHG emissions… are balanced by human-led removals… over a specified period and within specified boundaries."
"Residual GHG emissions are the greenhouse gas emissions that remain after taking all possible actions to implement emissions reductions." Source: ISO Online Browsing Platform https://www.iso.org/obp/ui/#iso:std:iso:iwa:42:ed-1:v1:en

Blue Sky is driven by the following **Guiding Principles**:

Collaboration: We are committed to collaboration across all stakeholders of the North American waterborne transport value chain aligned to the goal of accelerating the path to net-zero GHG emissions

Innovation: We are vision driven, welcome constructive challenges and strive for an iterative approach to innovative solutions

Systems-Based Approach: We pursue a pragmatic and systems-based approach to accelerate the impact on emissions reductions

We describe the details of our Guiding Principles below:

Collaboration

Collaboration is key to our success. We accelerate and elevate our missions and goals by working together as a 'coalition of the willing.' We are open-minded and committed stakeholders. We value voices across the maritime value chain and associated organizations. We invite and consider different perspectives and approaches.

» We can accelerate and elevate our aligned missions by working together with a focus on U.S. and Canadian waterborne transportation.
» Collaboration across the maritime value chain and associated organizations is critical to driving action.
» Stakeholders include all direct or indirect emitters of GHG emissions. This includes all people and organizations that play a key role in the value chain itself as well as those that support, affect or are affected by the value chain operations.

Innovation

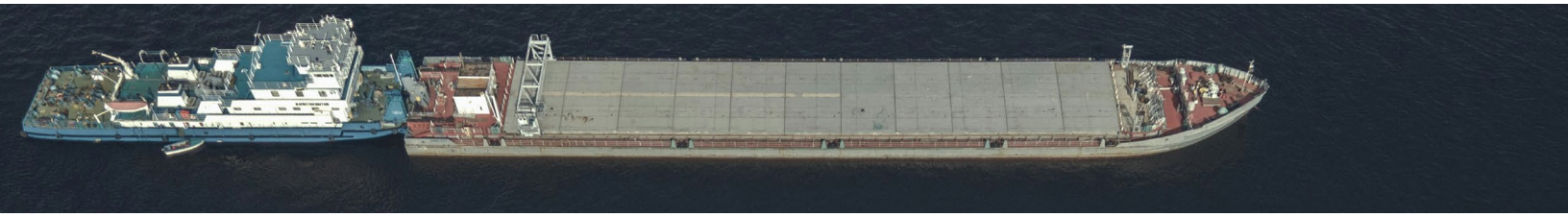
We champion innovation. Blue Sky works collaboratively with stakeholders to drive disruptive innovation. We identify and leverage best practices that enable and amplify our shared vision. We support first movers with practical solutions. We challenge the status quo and question and rethink current assumptions and norms.

» To achieve our vision, we embrace innovation and disruptive systems thinking that challenges the norm.
» We value diverse voices and thrive on constructive creativity, dissent and friction that drives innovative thinking and action.

Systems-Based Approach

We seek to develop self-sustaining, resilient and growing economies that optimize the maritime value chain as a whole rather than the sum of its parts. We pursue a systems approach that improves the economic health and environmental stewardship of the entire value chain before optimizing the individual bilateral transactions that make up the maritime economic value chain.

» We take a pragmatic approach where all participants can identify the benefits to themselves and their customers or constituents.
» We embrace a systems-based approach that encourages evaluations of the full supply chain and life-cycle impacts.
» We are action-oriented and strive to start small, think big and scale fast.



II. ROADMAP TO NET-ZERO EMISSIONS

Blue Sky's Roadmap to Net-Zero GHG Emissions: North American Waterborne Transportation was developed by having the Coalition's broad membership base consider what the future would look like once net-zero goals are successfully achieved. This Roadmap consists of vision statements for all stakeholders along the value chain, key challenges to address in moving from today's status quo to the future vision, and the immediate actions that need to be prioritized in order to meet these challenges and achieve that vision. These actions are critical to deliver on the 2050 goal of a commercially vibrant maritime shipping sector with net-zero GHG emissions across the full North American value chain.

The purpose behind creating this Roadmap was to first ensure we were working from a common vision, and secondly to create an action plan that would guide and align our efforts across the NAWT value chain as we move toward that vision. Action steps were developed by working backwards from the future vision statements to prioritize long, medium and short-term actions and milestones as shown in the Vision-based Action Planning graphic below (Figure 2).

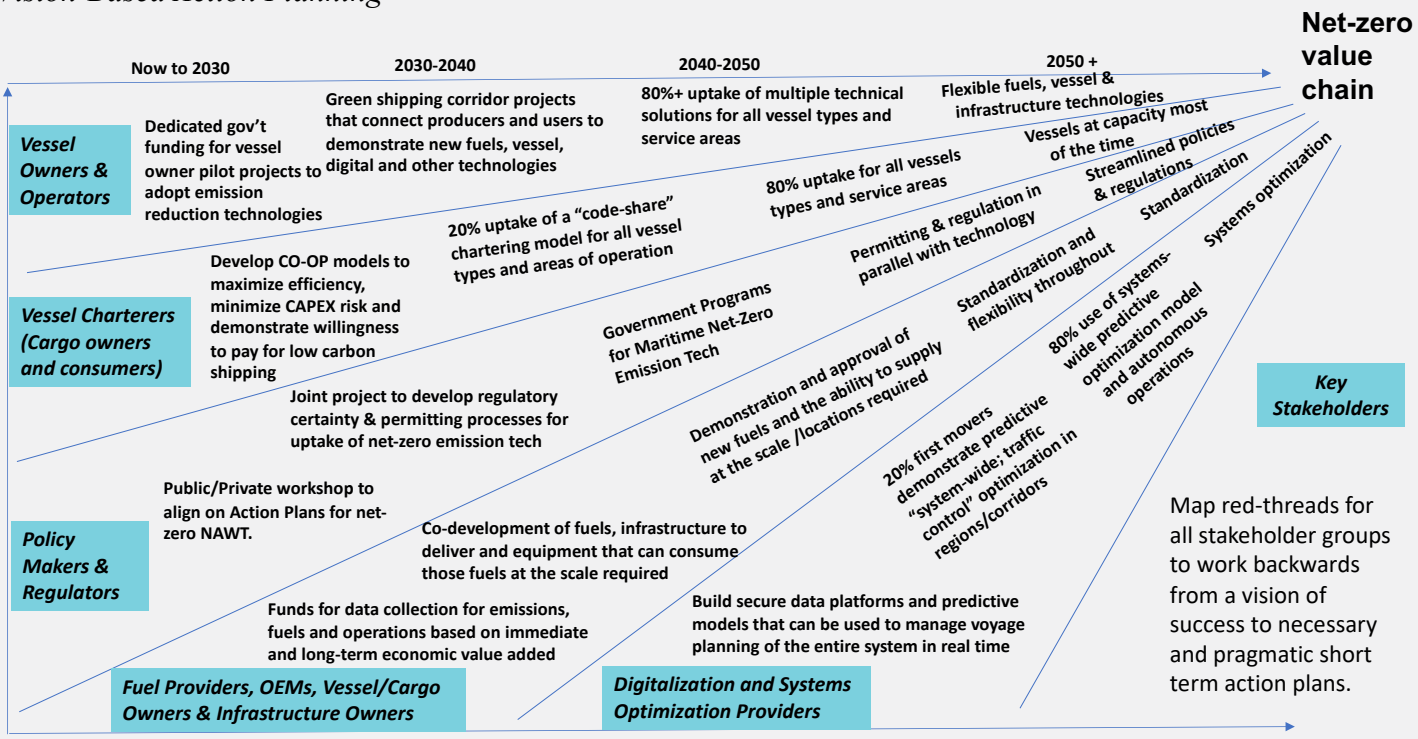
The vision describes what we see in the future and how that differs from today, such as:

- Ports, vessels and equipment technologies that are flexible and can bunker different fuels.
- Predictive models that anticipate when a vessel is needed at a terminal creating an optimized, Uber-like model that enables many vessels to operate close to full capacity.

- Streamlined policies and regulations and new public/private sector models.
- Standardization in technologies, commercial constructs and new fuel infrastructure.
- Systems-level thinking and digital technology advancements which allow optimization and operational efficiency of the entire value chain.

From this vision, we worked backwards and asked, what should be in place 5-10 years before achieving this vision and what actions would push this across the finish line? What would be needed in the mid-term, 10 years before that, to enable getting to that final stage? Finally, we came to what do we have to be doing today in order to reach that mid-term stage?

Figure 2.
Vision-Based Action Planning



A. BUILDING THE VISION

While a crystal ball is not required, it is critical that we start the transition process by imagining a future in which net-zero GHG emissions have been achieved economy-wide by 2050. Foundational elements of developing this vision include understanding the stakeholder landscape and what "success" in 2050 will look like for each one. Looking backward from the 2050 vision, we identified the supply-chain relationships, technological advances, infrastructure, policies, practices, and more that will be needed to transform the vision into reality. Going forward

we will need to work to develop the collaborative relationships necessary to drive actions to achieve success. We will continue to promote flexibility to future-proof potential solutions and acknowledge that success requires a vision of the future to inform near-term actions. Within this context, the overall NAWT Vision Statement is set forth below.

Vision Statement

We envision a shipping sector value chain in the U.S. and Canada that operates in a net-zero GHG emissions ecosystem driven by collaboration and systems prioritization of life-cycle performance. By 2050, the maritime sector will achieve commercially viable, net-zero greenhouse gas emissions, maximizing both environmental and economic value for all stakeholders, and supporting healthy, economically vibrant, and diverse communities of the U.S. and Canadian maritime corridors.

Broad Vision Elements

At a high level, a view of the maritime sector less than three decades from now will represent an unprecedented transformation in every aspect of its current operations and life cycle of activities. Changes include:

- Technology:
  - » Innovation uptake in efficient operations, alternate fuels, carbon capture and other energy technologies for vessels and shoreside infrastructure.
  - » A digital transformation that will change the very nature of operations and optimize maritime transportation as an entire system.
  - » AI models and predictive algorithms will provide multi-modal optimization connections with other transportation sectors.

- Maritime Industry:
  - » Highly collaborative and efficient as a "system." A company's competitive edge will relate more to availability, efficiency and emissions profiles.

- Commercial:
  - » Optimization of commercial constructs and the way cargo owners interface with vessel owners by enabling an on-demand approach that leverages predictive data and analytics.
  - » Lenders and lessors will provide a framework for integrating climate considerations into lending decisions to promote net-zero GHG emissions by 2050.
  - » Charterers, owners and related stakeholders will be aligned on the use of alternative incentives such as tax, fuel and other credits to lower transaction costs for green investment.

- Government:
  - » Policy and regulatory procedures that work efficiently in concert with industry and across different governmental agencies.
  - » Industry, government and academia collaboration becomes commonplace and enables the rapid pace of innovation and uptake.

- Society:
  - » Consumers will require environmental stewardship at the same priority level as economic value.
  - » A workforce that draws from diverse sources and established pathways for a Just Transition that provides training for new skillsets that do not exist today.

- Environment:
  - » The ecological health of aquatic ecosystems is greatly improved.
  - » Emission impacts for near port communities are significantly reduced.
  - » Climate change impact will be at a slower pace than in previous decades.
  - » Climate change reversal technologies are employed.

Understanding the System of Stakeholders

As described in Appendix I, the maritime shipping value chain is a "system of systems"— a complex value chain on its own that is directly connected to the value chains of other industry sectors—including power/energy, chemicals, finance, insurance, manufacturing and more. Thus, a systems approach to understanding and managing the needs and expectations of stakeholders is required.

To understand the landscape of this system, all stakeholders and subgroups were mapped out. Once identified, vision elements for what 2050 could look like for each of these groups were developed. The stakeholders and visions were developed through extensive engagement with our membership through the Workstreams and in-person meetings. Appendix II sets forth a map of the stakeholders and the vision elements that were identified for each one. Developing the vision elements for each stakeholder helps facilitate collaboration and identify the value propositions for different entities involved. This groundwork was essential in setting the stage for the action planning to enable working backwards from 2050 and understanding the perspectives of all stakeholders that relate to the value chain.

B. DEVELOPING THE SHORT-TERM ACTION PLAN

Blue Sky's Action Plan first identifies the challenges to achieving a vision of net-zero GHG emissions and then sets forth the key activities that can best help to accelerate the transition. It is inevitable that as we, and the world, make progress in learnings, new technologies and other innovations, our vision and view of these challenges will shift. What is most important is to start taking action now without waiting for absolute clarity on the future, as acting now will generate new learnings and innovations that will be critical success factors for the transition.

Listed below are six key challenges and 18 associated early actions that can help drive the innovation that we will need to achieve our goals and realize our vision:

1. Maritime System Inefficiencies and Siloed Approaches

The value chain consists of multiple bi-lateral negotiations strung together in every commercial, technical, operational and policy/regulatory interface. We need a systems-based approach to efficiency to create new methods, procedures and practices that optimize the system as a whole.

Key Initial Actions:

- Enable Optimization Through Digitalization
  - » Build a machine learning predictive algorithm platform to eventually manage voyage planning of the entire system in real time.
  - » Improve operational efficiency with real-time navigational charts.
  - » Enable port traffic control systems.
- Accelerate Green Shipping Corridor Initiatives
  - » Develop, lead and drive project implementation through regional efforts that include systems-based approaches.
- Monetize Value Chain Approach
  - » Work with policy and finance stakeholders to design ways to monetize the value chain approach such as co-op models to de-risk investment, increase economic value for all and maximize vessel capacity utilization.

2. Lack of Trusted, Accurate and Verifiable GHG Emissions Inventories for the Domestic NAWT Sector

We currently do not have an accurate way to understand the magnitude of current GHG emissions. IMO calculation methods such as CII and EEXI are grossly inaccurate for the types of vessels and operational services that make up the NAWT sector.[7] The startup company, Fuel Trust, notes that trace GHG components in today's low-sulfur diesel fuel can vary emissions by 30 to 40 percent, depending on where the vessel was bunkered (diesel fuel coming from different refineries with different crude oil mixtures).

Key Initial Actions:

- Emissions Study for North American Waterborne Transportation
  - » Advocate for relevant agencies to conduct a comprehensive and scientifically rigorous study of the total GHG emissions from domestic maritime transportation in North America (e.g., National Academy of Science).
- GHG Emissions Data Collection System
  - » Implement an anonymized emissions data collection system for the U.S. and Canada. Require reporting to a third-party organization to ensure anonymous data aggregation.
  - » Establish funding mechanisms for the use of real-time measurements of GHG emissions on vessels. Start with key vessel categories to improve emission models.
- Establish Common Emission Methodologies
  - » Establish trusted and verifiable methodologies for measuring and collecting GHG emission data by vessel type and operational profiles.
  - » Develop guidance to calculate emissions from system-based inefficiencies (e.g., voyage planning, port congestion) and move toward standardization of methodologies.

7 A Perspective on IMO Efficiency Measures: Opportunities for Improvement, Blue Sky Maritime Coalition, November 2022.

3. There Is No "One-Size-Fits-All" Solution for Vessels

The NAWT sector is largely made up of bespoke vessels with unique operating profiles and long lifespans (up to 50 years). New alternative fuels lack the energy density to match current fuels. There is a large financial gap for commercially viable clean technology deployment at scale, and demonstration projects to validate new technologies are not on pace to reach the scale needed in the next few decades.

Key Initial Actions:

- Support the Development of Pilot/Demonstration Projects
  - » Develop a dedicated government funding program for vessel owners and operators to adopt emission reduction technologies.
  - » Drive a diverse set of pilot projects onboard and onshore. Support needs to include matchmaking for partnerships, grant development, industry in-kind support, as well as incubator and accelerator programming to drive key demonstrations.
  - » Reverse-engineer existing projects to share knowledge and inspire followers to act.
- Develop Condition-based Approaches for Retrofits
  - » Condition-based approaches should address regulatory, class, underwriting insurance and business aspects of older vessels that have gone through retrofits for emission reduction. Commercial contracting needs to reflect the age of the retrofit vessel.

4. Fuel and Energy Infrastructure Projects Lack Demand to Reach Scale

Fuel providers are not able to build new production and distribution facilities without volume and demand certainty. Fuel users cannot order new equipment or build new vessels without certainty on price and availability, and there are not enough alternative fuel demonstration projects to validate these fuels at the pace needed. Also, cooperation and funding are lacking for multi-modal transport studies/projects related to energy and fuel.

Key Initial Actions:

- Green Shipping Corridor Fuel Clusters
  - » Leverage Green Shipping Corridors for projects that connect producers and users in a region for clusters of utilization. Leverage Hydrogen Hub regions with a port and maritime focus. Develop a Request for Proposal (RFP) for Future Fuel Options as a potential model for other Green Corridors.
- Fuel Production Mapping
  - » Track national alternative fuel production capacity and forecast production increases to understand where there are opportunities to drive demand with deployments.
  - » Identify fuel utilization hubs for high-demand port and maritime applications.
- Multimodal Aggregated Fuel Demand
  - » Develop partnerships across multimodal transportation modes to aggregate fuel demand across the entire value chain.
- Port / Utility / Maritime Collaboratives
  - » Develop pilot projects that will establish strong and consistent collaboration between ports (their users) and utilities to allow for alternative energy systems and e-fuel production to be established and effective. Document business case and methods for scaling to additional regions.

5. Patchwork of Policy and Regulations

Government agencies and regulatory authorities do not prioritize maritime for funding or permitting support. There is an absence of maritime in carbon markets (LCFS) and eligibility within regulatory regimes (Renewable Fuel Standard). Eligible ships operating in California are required to comply with CARB at berth regulations and ships trading in the EU are required to comply with their Emissions Trading System (ETS).

Key Initial Actions:

- Develop Approval Roadmap for Regulatory Processes
  - » Develop a roadmap for approving new technologies across government regulatory agencies and different ports and terminals nationwide and binationally (starting with bulk hydrogen transportation). Work with agencies to support the "modernization" of regulations to keep pace with technological advancements.
- Design Inclusion Pathway for Domestic Maritime in National Action Plans
  - » Conduct analysis on U.S. and Canadian flag vessels on financial implications of regulations that would require net zero by 2050.
  - » Evaluate existing regulations for best practices and unintended consequences (e.g., Canada's domestic Carbon Intensity Indicator (CII), IMO-CII, CARB at Berth Regulation, EU ETS, Canadian domestic CII methods, etc.)
  - » Design what it would look like if domestic emissions were included in the U.S. National Action Plan for net-zero emissions by 2050 and publish position paper.
- Develop Incentives for Uptake of Emission Reduction Technology Solutions for Maritime
  - » Develop a dedicated government funding program for vessel owners and operators to adopt emission reduction technologies.
  - » Provide funding for green shipping corridor leadership and project implementation.
  - » Replicate Department of Energy programs for aviation and tailor in support of maritime (e.g., Sustainable Maritime Fuel Grand Challenge).

6. Customer Willingness to Pay

The willingness of cargo owners and end consumers to accept higher prices to enable maritime GHG emission reductions is not on par with what is needed to incentivize shipowners and other stakeholders that bear the capital risk of the changes needed.

Key Initial Actions:

- Develop Innovative Commercial / Financial Constructs
  - » Design Charter Party Clauses for shared carbon ownership and develop new chartering and owner/operator models.
  - » Develop a "Book and Claim" System for NAWT.
  - » Develop new financing and market measures.
  - » Develop a "Carbon Trading Desk" that is assessed by a carbon tax.
- Grow Maritime Participation in Carbon Credit Markets

- Develop Consistent Carbon Intensity Values
  - » Identify consistent carbon intensity values for renewable fuel and audit procedures through the production and distribution network including feedstock. Unified approach on renewable diesel (Renewable H2 and Direct Air Capture).

To implement this action plan, cross-functional collaboration across Blue Sky Workstreams will be needed to assemble various project teams. Blue Sky will then identify the most appropriate Workstream to lead each project and determine the required resources to complete the project. Cross-function collaboration is essential to enable swift mobilization and tangible, sustainable results. Figure 3 presents a visualization of this cross-functional collaboration and the multi-faceted approach necessary to generate impactful results.

For those actions that require leadership from entities outside of Blue Sky, the Workstreams will identify steps to inform and engage the external partners. Blue Sky will work to support other organizations and their efforts, such as the launch of the Congressionally authorized Center for Maritime Innovation.

Figure 3.
Blue Sky's Multi-Faceted Approach to Identify and Prioritize Actions

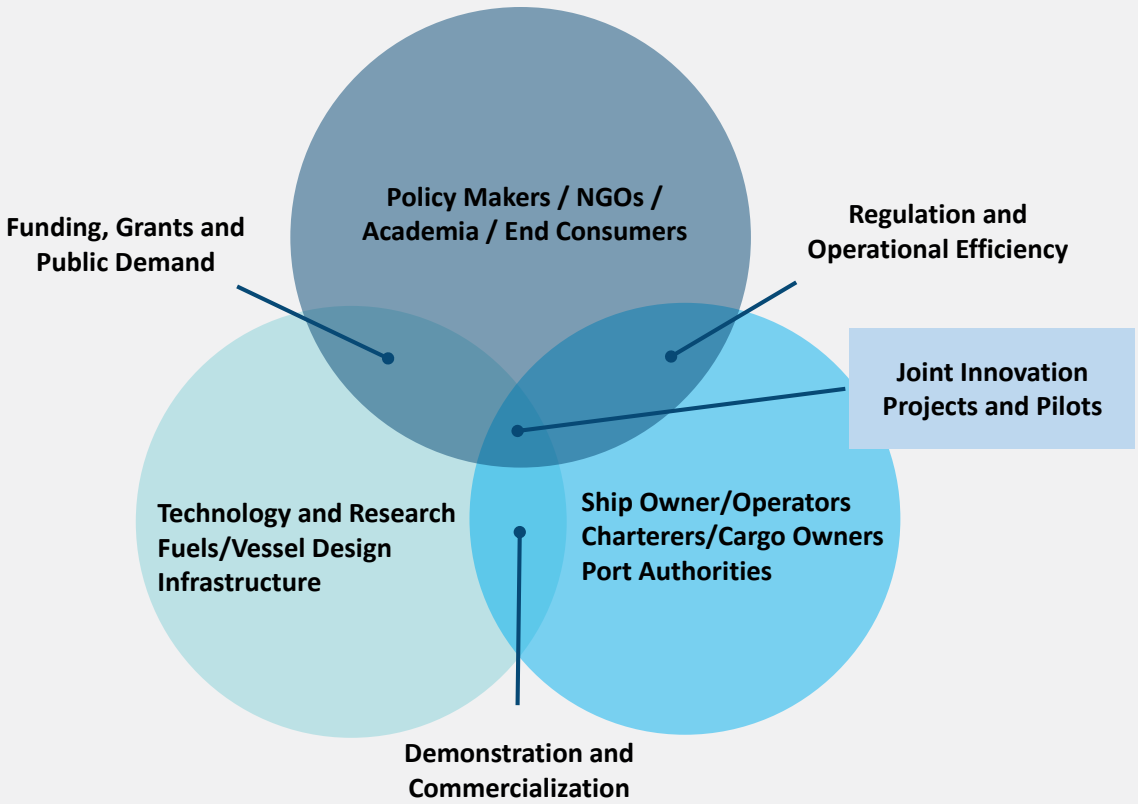


Figure 3 displays the alignment of our action items within the strategy and vision of Blue Sky. Source: Blue Sky Maritime Coalition.

III. CONCLUSION

Blue Sky Maritime Coalition envisions an integrated and efficient maritime value chain that thrives in a carbon-constrained economy and supports healthy stakeholders and environments. It's also important to recognize the role that maritime transportation will play in other sectors. The shipping of clean energy fuels is an important enabler for broader global sustainability goals, beyond decarbonization of maritime operations.

Our Roadmap is a snapshot in time that will need continuous iteration and enhancement. There is no "one-size-fits-all" solution to the decarbonization challenge that our maritime sector is facing. The key is to identify the steps we can take now to begin to work together toward that 2050 vision. If we continue to wait on the sidelines because the challenge is too daunting, we will never reach the goal. If we continue to work in our silos and come up with actions that only benefit our individual companies or organizations, we will not reach net zero. Only by working together in collaboration, by taking a systems-based approach, and by taking action on the near-term priorities can we reach our shared net-zero vision.

IV. APPENDICES

A. APPENDIX I: MARITIME INDUSTRY OPERATIONS BACKGROUND

Maritime shipping is critical to the U.S., Canadian, and global economies. Over 80 percent of the world's goods are transported by water. In the U.S., maritime shipping represented nearly 2 percent of the Gross Domestic Product (GDP) in 2019[8], while the figure is about 1.8 percent of the GDP in Canada.[9] About two-thirds of all U.S. imports arrive by water and over 70 percent by tonnage; 41 percent of total exports (by value) depart the country by water.[10] Major economic sectors, such as energy and agriculture, rely heavily on the inland waterways.

Maritime transportation is not only foundational to the transport of goods across and within North America, but also is currently the most efficient, environmentally sustainable, lowest GHG-emitting, and often the lowest-cost freight transportation option available. Consumers, responding to the need to decarbonize, are often selecting waterborne transportation in lieu of other, more carbon-intensive methods of shipping. As global trade increases, emissions associated with maritime shipping are increasing.

The urgency to decarbonize is becoming ever more pressing. Absolute reduction of carbon emissions produced by the maritime industry is a generally accepted common goal of most all global carriers. The IMO has set an ambition to reach net-zero GHG emissions by or around 2050; and a commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030. The Blue Sky Maritime Coalition has adopted the challenge of accelerating the path to achieve "net zero" emissions across the entire maritime value chain in the U.S. and Canada.

In January 2023, the first U.S. National Blueprint for Transportation Decarbonization: A Joint Strategy to Transform Transportation (the U.S. Blueprint or Blueprint) was issued by the Department of Transportation, the Department of Energy, the U.S. Environmental Protection Agency, and the U.S. Department of Housing and Urban Development collectively. Recognizing the transportation sector as the single largest sector contributor to U.S. emissions (at 29 percent of 2021 totals[11]), the Blueprint attributes three percent of total U.S. transportation sector emissions to U.S. maritime emissions.[12]

Transport Canada is currently conducting stakeholder engagement on a Marine Climate Action Plan. The Canadian Transportation 2030 Emissions Reduction Plan was published in 2022. While not specific to shipping it does reference certain marine-related goals under the "Waterways, Coasts and the North" theme.[13]

8 Data from 2019 represents the most recent year not impacted by the pandemic and that was available from the Marine Economy Satellite Account (MESA) data produced by the U.S. Bureau of Economic Analysis and the U.S. National Oceanic and Atmospheric Administration (NOAA). Such data includes only coastal activities within the Exclusive Economic Zone (EEZ) and Great Lakes and does not include inland waterways.

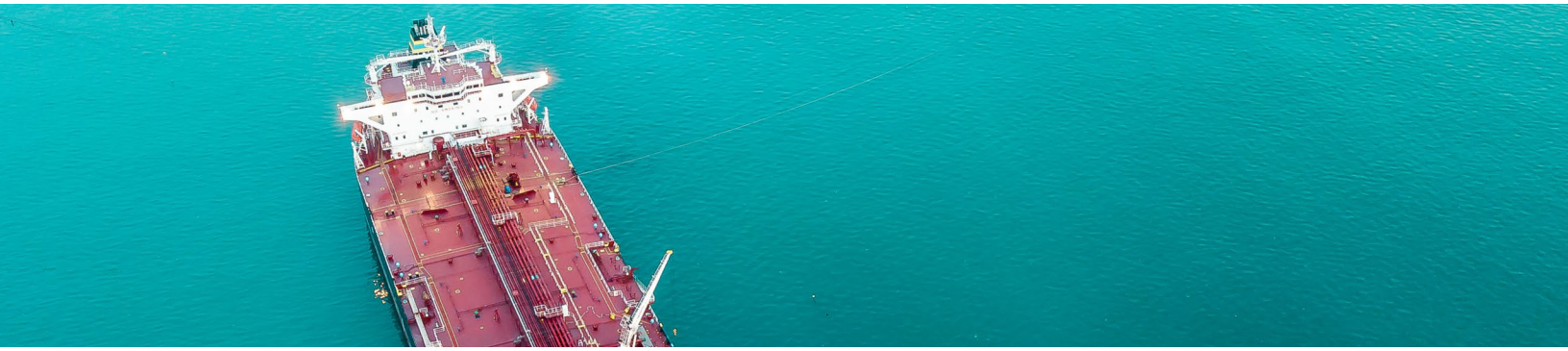
9 According to Canada's Angus Reid Institute, a non-profit independent research foundation.

10 American Society of Civil Engineers, ASCE (based on data from the Freight Analysis Framework of the Bureau of Transportation Statistics, U.S. Department of Transportation.

11 EPA, Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021, EPA 430-D-23-001.

12 There is a recognized need for improvements in measuring the GHG emissions associated with maritime shipping, in particular within the U.S. Blue Sky has previously issued two reports on accounting for GHG emissions within the North American Waterborne Transportation sector, and recently submitted formal comments to EPA on this subject as EPA prepares to finalize its most recent annual Inventory of U.S. Greenhouse Gas Emissions and Sinks (see note 4, above).

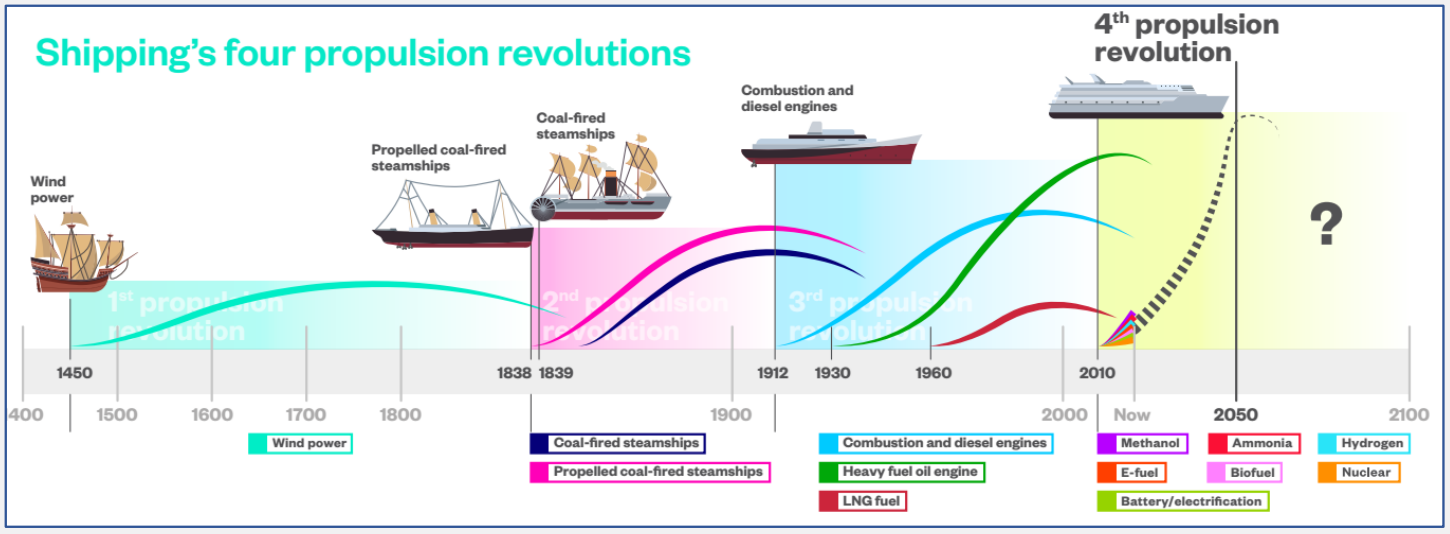
13 Transportation 2030: Waterways, Coasts and the North (canada.ca)



The development of these strategies for transportation emission reduction provides an opportunity to come together across the maritime value chain and work with the government to develop a detailed action plan for accelerating the transformation needed to accomplish the aligned visions.

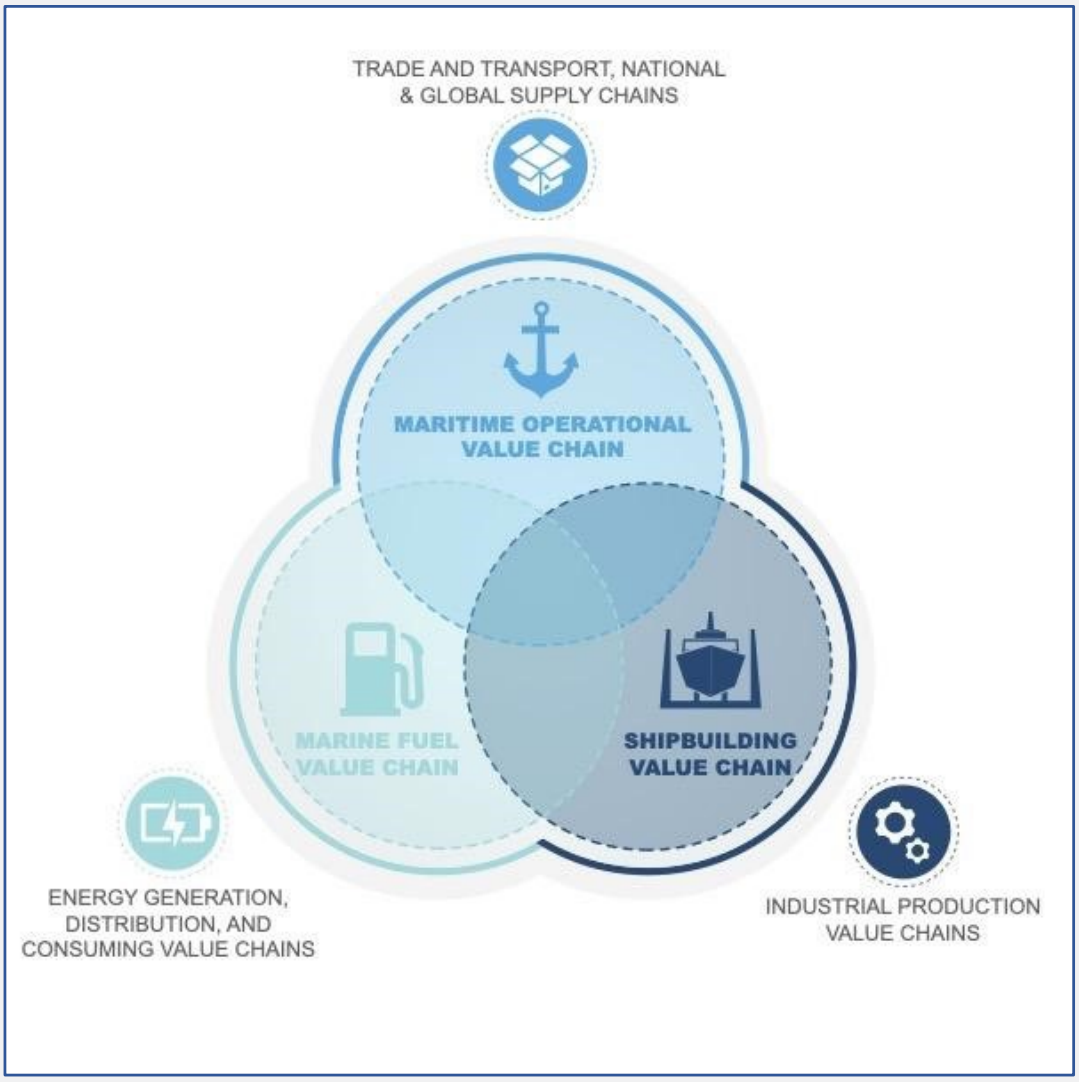
The maritime sector is experiencing a technological revolution – that will need to mature in less than three decades to meet 2050 net zero ambitions. This is less than the lifespan of a typical U.S. ship. This necessitates a complete transformation of the operational technologies and business models that have dominated for nearly a century, as well as a major scaling up of finance for this transition. Unprecedented levels of collaboration are required to accelerate and achieve these transformations for emissions reduction.

Figure A.1
Shipping's Four Propulsion Revolutions



The figure above presents shipping's propulsion revolutions and highlights the growing quantity of propulsion source options with each phase. The transition into the 5th revolution must occur at a rapid, transformational pace compared to the previous transitions. Source: International Chamber of Shipping: A zero emission blueprint for shipping https://www.ics-shipping.org/wp-content/uploads/2021/11/A-zero-emission-blueprint-for-shipping.pdf

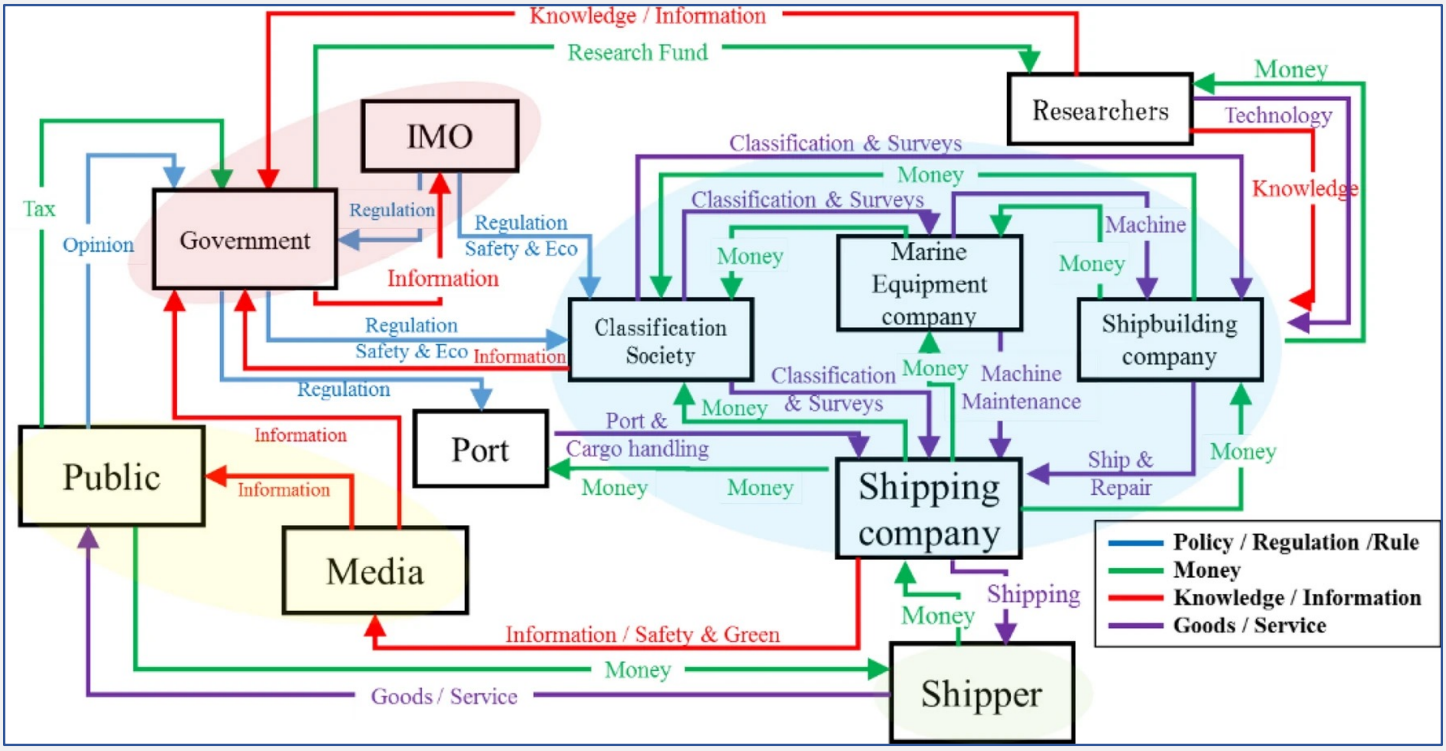
Figure A.2
Maritime Value Chain



The figure above shows how the reach and complexity of the maritime value chain includes connections to other industrial and transportation value chains—a value chain of value chains.. Source: Blue Sky Maritime Coalition's National Science Foundation Innovation Engine application.

The interactive relationships of maritime and external value chains result in many opportunities to learn from others and transfer maritime innovations and research to non-maritime industries— virtually every modern manufacturing and industry sector is represented in some aspect of maritime operations. Progress and development in decarbonizing the maritime value chain will improve decarbonization efforts in other sectors because of the huge percentage of goods and services moved across the nation's waterways and ports. Investment in maritime decarbonization can easily translate to innovation across the entire economy because maritime innovations can be easily commercialized and leveraged outside of the maritime space.

Figure A.3
Stakeholder Value Network of the Maritime Industry



The figure above presents the complexity and interconnected relationships between maritime stakeholders. Systems analysis for deployment of internet of things (IoT) in the maritime industry
SpringerLink: https://link.springer.com/article/10.1007/s00773-020-00750-5

The figure above presents the relationships between stakeholders within the global maritime industry and its surroundings. Each rectangle represents a stakeholder, and the arrows demonstrate the flow of value between stakeholders, including goods or services.

The complex and interconnected relationships within the maritime supply chain create vulnerabilities that finally reached public attention due to disruptions in the delivery of goods that occurred during the pandemic. According to the Maritime Transportation Data Initiative Final Report[14]:

> *"The pandemic revealed some deeply concerning practices about how participants within the supply chain communicate, interact, and share information. At its best, the supply chain provides seamless and timely transitions. At its worst, it is made up of a series of independent operators that are not well coordinated or invested in the supply chain. The complexity of the system that moves intermodal cargo in the United States is stunning, and our Nation's supply chain requires an intricate ballet of services to work in constant coordination. Breakdown by even one component of the intermodal system will affect the entire system."*

14 Federal Maritime Commission, April 2023, https://www.fmc.gov/wp-content/uploads/2023/04/MTDIReportandViews.pdf

The way the maritime value chain is designed creates inefficiency, through stepwise, sequential bilateral negotiations. This can lead to a situation that can be described as the 'Tragedy of the Commons' where each pursues actions which are individually beneficial, but the collective system experiences diminishing returns. The current system does not incentivize optimization of operations for emissions reductions. Achieving a low-carbon future requires that we drive a systems approach rather than an aggregate of multiple individual solutions by entities or subgroups of the value chain. Unless we approach solutions as part of a collective, systems-wide optimization challenge, we are unlikely to achieve our decarbonization ambitions. This approach would change the very nature of how the global value chain operates.[15]

The inland waterways are especially efficient modes of transport with vessels designed for the depth and width allowances in the areas they operate with vessels often utilizing underway fueling to optimize trip efficiency and barge hauls that are very synchronized. But optimization between vessel owners/operators, charterers, ports and other inter-modal transportation systems is lacking. The NAWT is not currently operated as an optimized system that values emission reductions. Individual companies may have optimized vessels or fleets for their individual operations; however, systems-based optimization examples are rare, especially those that engage players across the supply chain.

There are localized examples where shared data is being utilized to provide the supply chain with tools for planning and increased operational efficiency of transportation. The Port of Los Angeles uses a digital technology platform called "The Port of Los Angeles Signal" that is powered by "Wabtec's Port Optimizer™." This is used to predict incoming cargo volume and share with stakeholders in the regional supply chain so they can plan accordingly. The data is updated daily. Nine of the Port of Los Angeles' top 10 carriers are feeding data into the Optimizer. They have also launched three other digital tools under the Port Optimizer umbrella for data sharing (in real time or with five-minute updates) on returning empty cargo containers, truck turn times, and long-term cargo volume predictions.[16]

Wabtec advertises this tool as follows: "*Port Optimizer is an Initiative to create digital infrastructure as a competitive differentiator for port authorities looking to increase efficiency and throughput*." The value proposition for this tool is providing a competitive advantage for ports by increasing their local efficiency, not the efficiency of the transportation overall system. While data-driven tools such as this are an example of increasing data sharing for port efficiency, there is no systematic connection to other ports to optimize just-in-time arrivals, reduce wait times at anchor, or re-route to other ports with a focus on efficiency or emission reductions. There is currently no incentive for ports to optimize the system when their revenue is based solely on the volume of vessels utilizing their berths.

Maritime operators are facing growing demands for data and information from various stakeholders, such as regulators, customers, investors and the public. Some of the drivers for more transparency and reporting are environmental and social responsibility, supply chain efficiency and resilience, safety and security, trade facilitation and compliance.

15 Setting us up for successful maritime decarbonization: a menu of possible perceived actions for today and tomorrow. Wolfgang Lehmacher, Mikael Lind, Gavin Allwright, Jeremy Bentham, David Cummins, et al, October 2023.

16 Port of Los Angeles optimizes inbound logistics - Logistics Management (logisticsmgmt.com). Port Optimizer™ | Supply Chain | Business | Port of Los Angeles.

Typically, metrics for companies are typically based on profit and safety. Reduction in emissions is rarely given a monetary value in shipping transactions, and there are few direct incentives available for emissions reductions. But international and domestic regulations are evolving and starting to change that dynamic.

In March 2022, the U.S. Securities and Exchange Commission (SEC) proposed rule amendments on Climate Related Disclosures that would require public companies to provide certain climate-related financial data, and GHG emissions insights, in public disclosure filings. As part of the proposed rule, companies would have to disclose emissions they are directly responsible for, as well as emissions from their supply chains and products. But many companies are proceeding as if the rule is in force.[17]

The European Union's Emissions Trading System (ETS) is globally the largest compliance carbon market, assigning or auctioning allowances to carbon-emitting industry installations. Companies must either meet their allocated carbon cap or buy allowances on the secondary market to satisfy their obligation. The EU-approved proposals include the maritime industry in the ETS program starting in 2023, phasing in through 2026.[18] Half of the emissions for voyages beginning or ending in the EU count toward a company's carbon cap, while all emissions count if the journey remains within EU territories. Companies that do not comply face fines or an expulsion order for not complying within two reporting periods. While shipowners are responsible for the responsible parties in this policy, there is much discussion in the industry on how the costs for these emissions will be allocated among the value chain.[19]

Incentives to accelerate the path to net-zero emissions in the U.S. and Canadian markets are rapidly evolving, with federal and state government compliance markets targeting the adoption of lower carbon fuels (such as Low Carbon Fuel Standards) and implementing regional carbon pricing programs. But the carbon market across geographies remains fragmented and often misses the mark for maritime industry-specific needs. The absence of maritime in science-based carbon markets such as the Low Carbon Fuel Standard (LCFS) and limited eligibility within other regulatory regimes like the Renewable Fuel Standard (RFS) puts the maritime sector at a disadvantage. Without credits, fuel producers are disincentivized to provide fuel to the maritime sector (estimated credit value of ~$125/MMBTU).

While our current maritime transportation system is not optimized for GHG emissions reductions, it is becoming increasingly important for the industry as companies strive to create a roadmap for reducing environmental and community impacts, in addition to being prepared for future regulatory changes. Decarbonization requires significant coordination across the complex interactions of full industry value chains, as well as inter-agency and cross-entity collaboration to chart the course on policy incentives and regulatory pathways that enable the transition to net-zero emissions.

17 SEC's Climate-Disclosure Rule Isn't Here, but It May as Well Be, Many Businesses Say - WSJ.

18 Country Snapshot: EU | Global law firm | Norton Rose Fulbright.

19 https://www.bluesky-maritime.org/_files/ugd/8ed502_b79ca475fe954b26912034fcd2e617b3.pdf.

B. APPENDIX II: STAKEHOLDER MAPPING AND VISION ELEMENTS

As an important step in developing the Roadmap, stakeholders and subgroups were identified and outlined to consider their roles as part of the full maritime shipping value chain landscape. Once this was mapped out, we developed vision elements for what 2050 could look like for each of these groups. This process was accomplished through extensive in-person and virtual engagement with our membership.

By developing the vision elements for each stakeholder, we were able to define each stakeholder's value proposition in a net-zero value chain and incorporate this insight into a consistent overall vision of the future.

This groundwork was essential to set the stage for action planning. It enabled us to better understand the perspectives of all stakeholders related to the value chain, so we could then work backwards from 2050.

Foundational elements of developing the Coalition's vision included:

1. Identifying all stakeholders that impact or will be impacted by the transition.
2. Understanding the stakeholder landscape and what "success" in 2050 will look like for each one.
3. Understanding what needs (technological, economic, social and more) each stakeholder must have satisfied in order to have confidence in both (i) the industry's collective ability to achieve the needed emission reductions and (ii) the value the transition will bring to the individual stakeholder.

Vision statements for specific stakeholder groups are presented below.

Table B.1
Stakeholder Mapping

Stakeholder	Subgroup
Vessel Owner / Operators	Blue Water Vessels
	Brown Water Vessels
	Ship Assist Tugs
	Harbor Service Provider
	Government Vessels
	Private Vessels
	Fishing, Passenger Vessels
	Foreign-owned
	Jones Act Vessels
	U.S. Flagged Fleet (Non-Jones Act)
Shipyards	Public Owned
	Private Owned
	Ship Construction Yards
	Ship Repair Yards
	Offshore Structure Construction and Repair Yards
Engine Manufacturers / OEM Providers	Tech Providers
	Tech Developers
Ports and Terminals	Coastal
	Inland
	Public/Private
	Intermodal Yards
	Port Authorities Port Bureaus
Locks and Dams	

Stakeholder	Subgroup
Mineral and Mining Operations	
Steel Producers	
Recyclers	HK Compliant vs.Non-compliant
Cargo Owners / Charterers	Beneficial Cargo Owner's Groups
Freight Forwarders	Consumers, Supply Chain Marketers to Consumers
Government	Federal and State/Province Policy Makers
	Federal and State/Province Regulators
	Federal and State/Province Agencies
	IMO and Similar Global Organizations
Class Societies / Specifiers	
CAPEX Providers	Investors
	Financiers/Lenders
Advocacy Organizations	Lobbyists/Trade Associations
	Trade Groups
NGOs / Interest groups	
Service Providers	Insurance Providers
	Legal Service Providers
	Leased Facility Providers
Utility & Transmission Providers	Public Utilities
	Private Utilities

Table B.1 - continued
Stakeholder Mapping

Stakeholder	Subgroup
Fuel Providers	
Fuel Producers	Traditional Fuel Producers
	Alternative and E-fuel Producers
Technology Partners	Vessel Design Firms / Naval Architects
	Research Providers
	Systems Engineers
Educational Providers	Universities
	Vocational / Technology Schools / Community Colleges
	High Schools
	Middle Schools
	Other: Academies
Maritime Industry Workers	Crew
	Pilots
	Stevedores
	Youth – Future Maritime Industry Workers
Third Party Providers for Vessels & Infrastructure	Mechanics, Electricians, etc.
Data Centers & Digital Providers	AI/Machine Learning Optimization Platforms
	Cyber Security
	Emission Measurement and Tracking
	Data Service Providers (blockchain, et al)

Stakeholder	Subgroup
Society	Government Tax Base
	Taxpayers and Society at Large
	Communities and People that Live Along Shipping Corridors
	End Consumers that Require Goods Delivered via Marine Transport Sector
Indigenous Peoples (prefer Partners, not Stakeholders)	U.S.: Federally Recognized (Indian) Tribes and State-Recognized Tribes and Tribes Not Recognized by State or Federal Governments
	Canada: The Term 'Indigenous Peoples' Includes First Nations, Inuit and Métis People in Canada
Other Transport Sectors	Truck
	Rail
	Aviation

Table B.2

Stakeholder Group Vision Elements

Stakeholder Group	Vision Elements
Vessel Owner / Operators	• Voyage planning is dictated by a systems' predictive algorithm which helps ensure maximum efficiency of the maritime sector as a whole. • Vessels are flexible to use multiple fuel types. • Many vessels are autonomous with reduced crew onboard (and potentially unmanned). • Real rime "Rapid Charts" enable maximum cargo for actual water levels, in lieu of today's Army Corps/NOAA surveys.
Shipyards	• Domestically manufactured content and technologies are fully available at commercially viable prices. • Yards have full capabilities for repower, remake, retrofit and newbuilds; condition-based evaluation for establishing vessel "age." • Moving into materials that do not involve steel (as automotive and aviation sectors have done). • Shipyards are driving new more standardized technology development though integrated design and systems relationships.
Engine Manufacturers / OEM Providers	• Significant standardization in vessels and main equipment components. • Equipment commercially available that can utilize multi-fuel options (e.g., engines, fueling, duel systems, storage, fuel cells, etc.). • Retrofit kits for existing vessels. • Tech acceleration culture has evolved with investments and improved linkages between start-ups and established maritime industries.
Ports and Terminals	• Able to provide bunkering of multiple fuels and standardized electric charging. • Port Handling Equipment is standardized and electrified completely. • Very high degree of autonomy connected to machine learning predictive algorithm which helps ensure maximum efficiency of the maritime sector as a whole (all vessels, ports and terminals optimized, including interfaces to truck, rail and aviation sectors where ports provide a nexus).
Locks and Dams	• Optimized and fully maintained lock and dam infrastructure for greater movement of vessels and goods. • More goods moving over waterways vs. other less efficient transportation modes. • Waterway movement takes fewer barges to move greater tons.

Table B.2 - continued
Stakeholder Group Vision Elements

Stakeholder Group	Vision Elements
Mineral and Mining Operations	• Zero-emission mining and operations. • Mining of alternatives to critical materials/rare earth elements.
Steel Producers	• Green steel's contribution to the total marine-grade pool is near max capacity. • Green Premium is non-existent now, since all steel is green steel.
Recyclers	• Industry is marked by efficient circularity of all materials. • Processes/systems in place to ensure the recycling value chain is up to the same standard as the rest of the value chain, including contributions to emission reductions.
Cargo Owners / Charterers	• Much of today's truck and rail movements shift to water/vessels. • Predictive algorithms and "traffic control" type systems-wide optimization makes chartering more like an Uber model and code-sharing cooperation between vessel owners.
Freight Forwarders	• The logistics system is supercharged for reducing emissions, optimizing efficiency, and providing cost-effective routing. Waterborne transportation is prioritized over other transportation options for routing over 100 miles.
Government	• Regulations and Policy Regulatory Agency procedures are streamlined and aligned with the pace of technology and industry uptake. • Climate change is prioritized as a global pandemic. • Carbon tax schemes are consistently administered across all transportation and energy sectors; as common as sales tax. • Rules and regulations for ports/terminals allow for increased efficiencies and access to clean power/fuels with flexibility to enable compliance for all vessels. • Certainty of regulations de-risk CAPEX expenditures. • Fewer agencies with strong inter and intra-alignment and collaboration.
Class Societies / Specifiers	• A shift away from acting as mediator to government regulations and providing a growing share of support for optionality of design/fuels choices and other services.

Table B.2 - continued
Stakeholder Group Vision Elements

Stakeholder Group	Vision Elements
CAPEX Providers	• Lower risk of the systems-wide efficiency and connectivity between industry, government and all stakeholders drives better access to lower capital options.
Advocacy Organizations	• Help assimilate multiple trade groups that are capable of bringing multiple stakeholders into conversations and have the ability to influence sub-sectors and a larger canvas.
NGOs / Interest Groups	• Collaboration is the norm for tangential sectors and interest groups that are affected by, or have impact on, the maritime value chain.
Service Providers	• AI and digital support are commonplace as the nature of technology and commerciality changes. • New types of service models arise as the nature of technology and commerciality and public/private sector collaboration changes.
Utility and Transmission Providers	• Proactively coordinating to develop grid edge infrastructure that enables maritime decarbonization. • GHG-free energy delivered to ports and used for e-fuel production.
Fuel Providers	• Micro and modular production of fuels allows providers to move closer (reduce infrastructure costs) to maritime value chain areas of need.
Fuel Producers	• Continuously innovate new technologies that can provide drop-in, net-zero GHG emission fuels into existing assets (e.g., synthetic diesel, et al). • Alternative green fuels (e.g., ammonia, methanol) and energy sources (e.g., fuel cells, batteries). • Nuclear-powered vessels that eliminate the need for bunkering.
Technology Partners	• Machine learning-based, systems-wide electronic voyage management and route planning drives continuous change. • New propulsion systems, more ship automation and cruise control features.

Table B.2 - continued
Stakeholder Group Vision Elements

Stakeholder Group	Vision Elements
Educational Providers	• Maritime academies, training centers, simulators, working together to serve new needs of mariners and companies for zero-emission tech (e.g., vessels, safety, tech training).
Maritime Industry Workers	• Digital technology advancements continuously increase the skills and opportunities of all working groups through a Just Transition. • Expertise available across new tech areas (e.g., cryogenic LNG expert-Gas engineer). • Crew, pilots and stevedores are comfortable with both manned and unmanned equipment.
Third Party Providers for Vessels & Infrastructure	• Availability of workforce and expertise is in place for zero-emission technologies across transportation sectors, including maritime.
Data Centers and Digital Providers	• Digital is the most important technology driving all aspects of the maritime value chain as well as connectivity to all other aspects of daily life.
Other Transport Sectors	• Links between all energy and transport sectors to provide optimization of environment stewardship.
Indigenous Peoples (prefer Partners, not Stakeholders)	• All members of maritime value chain formally recognize the traditional knowledge of Indigenous Peoples and learn to respect each other's ways of knowing. • Understanding and management of the marine environment is enhanced and achieved through the required respect for, and inclusion of, Indigenous knowledge, cultures, and traditional practices.
Society	• All members of society have full understanding of the maritime sector and how their choices drive economic and environmental impacts for themselves as well as society as a whole. • Marketing to consumers includes emissions impacts of delivery and consumers make choices based upon these metrics.

C. APPENDIX III: SUCCESS STORIES: BLUE SKY MEMBERS DEMONSTRATING COLLABORATIVE LEADERSHIP

ABS Offers Milestone Reports and Comprehensive Sustainability Guidance

Blue Sky Founding Member, ABS, offers industry-leading guidance and publications to support the industry on its path to safer and more sustainable operations. Some examples include a jointly developed report with Vanderbilt University titled, *Decarbonization of the Inland Waterway Sector in the United States*, and ABS' most recent sustainability outlook titled, *Beyond the Horizon: View of the Emerging Energy Value Chains*.

The *Decarbonization of the Inland Waterway Sector in the United States* report evaluates the potential for possible future propulsion technologies and alternative fuels to reduce carbon emissions. The report also demonstrates the feasibility of near-term electrification of smaller vessels operating on the inland river system with a case study and renderings of a weighted and balanced boat retrofitted with electrical propulsion.

In its fifth edition of the ABS Outlook series, ABS' latest publication, *Beyond the Horizon: View of the Emerging Energy Value Chains*, examines in depth the carbon, ammonia and hydrogen value chains that are expected to play a significant role in the green energy transition. It concludes that the industry will need to accelerate investment in carbon capture technology, energy efficiency technologies and new fuels to achieve net zero by 2050. This report also considers the obstacles and opportunities for adoption of alternative fuels and the actions shipowners must take in order to secure their future fuel supply chain to accelerate the transition towards a greener, more sustainable future.

These documents represent the work ABS does to support its clients and the broader industry in making decisions that support more efficient and sustainable shipping.

Emission Measures Drive Net Zero Operations

Blue Sky members, SailPlan and Harvey Gulf, are collaborating on a project that demonstrates the extraordinary potential of harnessing technology for economic savings and environmental responsibility through direct emission measurements and state-of-the-art analytics that can help operators optimize their operations for emission reductions. SailPlan's technology promises a potential 80 million tons of CO_2 avoidance annually and savings of $767k per average ship.

SailPlan collects real-time emissions data through exhaust gas sensors. Using advanced technology, high-resolution data, and machine learning algorithms, they are helping companies like Harvey Gulf to reach net-zero vessel emissions, a milestone that signifies a dramatic shift toward sustainable maritime operations.

Harvey Gulf, an early adopter of SailPlan's technology, was provided with detailed insight into not only the volume of carbon emissions, but the efficiency of the combustion reactions producing those emissions. Harvey Gulf's offshore support vessels are equipped with real-time, exhaust-stack equipment provided by SailPlan. Real-time emission composition data improves reporting accuracy, optimizes onboard power usage and provides early

identification of maintenance issues. It also provides an opportunity to test new technologies and get real-time data on the findings. Leveraging the results, Harvey Gulf learned how to reduce methane slip, as well as the value of adding renewable natural gas and batteries to support operations. Supported by SailPlan's platform, they have attained net-zero emissions for this vessel.

The collaboration between SailPlan and Harvey Gulf demonstrates how two trailblazers are paving a path to follow. Their successes prove that net-zero emissions are not a distant dream, but a tangible, achievable reality that can result in economic savings.

Demonstration Project for Hydrogen Hybrid Research Vessel

Blue Sky Maritime Coalition member, UC San Diego, is planning to build a new coastal research vessel using a hydrogen-hybrid propulsion system to reduce greenhouse gas emissions. The project aims to advance the scientific understanding of the ocean and its impact on society and demonstrate the feasibility and benefits of using hydrogen as a fuel for marine transportation.

To bring this hydrogen-hybrid ship to fruition, UC San Diego conducted an initial feasibility study, as well as issuing a Request for Information (RFI) to get feedback on the best path forward for their procurement process. Blue Sky Maritime Coalition consolidated feedback and provided a response to this initial RFI to help inform their pathway.

UC San Diego has secured $35 million from the State of California and $4M from the Office of Naval Research (ONR) to support moving forward with innovative coastal research vessel. ONR has indicated that they are interested in leveraging this vessel as a test platform for new technology adoption, helping them to gain insights on their decarbonization pathway.

The ship's system will integrate hydrogen fuel cells and diesel generators. The vessel will be able to operate 75 percent of its missions' using hydrogen, a non-fossil fuel that produces only water and electricity. The vessel will also have various instruments and sensing systems to support multidisciplinary research on California's coastal oceans and climate change impacts. The vessel will serve as an educational platform for UC students and faculty, and a model for clean, nonpolluting shipboard power systems.

The 2020 feasibility study indicated that a hydrogen hybrid variant would cost 60 percent more than an otherwise-identical diesel-electric vessel. Cost and other differences (time to produce, regulatory pitfalls, bunkering, etc.) are metrics they freely share.

The Navy is not alone in its interest in the project as a test platform and a potential avenue to support knowledge sharing and improve regulatory approval processes for technology and fuels for the maritime sector. UC San Diego is happy to provide information about their experiences in bringing this vessel to fruition with Blue Sky membership and beyond. This vessel demonstration project shows how UC San Diego is leading the way in collaborative innovation and oceanographic research while contributing to university, state, and national goals of reducing GHG emissions and understanding climate change impacts.

D. APPENDIX IV: RESOURCES

Resources

American Bureau of Shipping, 2023. Beyond the Horizon: View of the Emerging Energy Value Chains. https://www.eagle.org/outlook2023.

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