The Center for Post Carbon Logistics

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All Concerned,

The Mission of The Center for Post Carbon Logistics (CPCL) is to research and assist in the implementation of appropriate post carbon maritime technology needed to keep commerce and transportation viable by responding to the interrelated connectivity, communication, equity, economic, ecological, and energy crises of the 21st Century. The CPCL has made extensive comments on New York State's Climate Leadership and Community Protection Act, and New York City's Comprehensive Waterfront Plan section on Working Waterfront and Transportation of Goods.

As a result of the CPCL's mission and the recent RFEI from New York City regarding Maritime transport, it is appropriate that the CPCL respond with a statement of how our efforts already support these objectives, and how the City can meet or exceed their goals by looking outside their own borders. A focus on Regional Marine Services as defined in the RFEI will do the most to meet the City's goal of using marine highways, cycletrucks, and a working waterfront to tackle roadway congestion, improve safety, and reduce the ecological impact of the City's economy.

The CPCL is uniquely situated to respond to this RFEI. Andrew Willner, the Executive Director, spent almost 30 years as the NY-NJ Baykeeper and on its Board, and is intimately familiar with the geography of and ecological issues in the NY Harbor, as well as all the water it connects to. He also ran a shipyard in the Harbor for many years, was the Mate on Schooner *Pioneer,* and Master of several commercial power and sail auxiliary vessels in New York Harbor and the East Coast of the US, and a number of other skills and life experiences which all converge on the topic of sustainable maritime trade. He has published academic papers and popular articles in online and print publications, and presented at regional and international conferences on post carbon logistics and climate adaptive port operations.

Steven Woods, the CPCL Operations Fellow, holds a Master's Degree in Resilient and Sustainable Communities, and wrote his thesis on supplying New York City's food by sailing vessel as an adaptation to climate change. He has continued supporting sustainable freight operations in New York and beyond by writing a case study of sail freight on the Hudson River, working with the International Windship Association, sailing on Schooner *Apollonia*, and presenting at regional and international conferences.

Brad Vogel serves as Andrus Sustainable Logistics Fellow through CPCL, and is the only coastwise Sail Freight cargo broker in the United States. He works extensively with Schooner *Apollonia* and other vessels in the development of sail freight cargo leads, coordinating logistical issues, and arranging dockage. With intimate knowledge of the challenges facing all components of the cargo chain from zero-carbon first miles to port calls, cargo loading, waterfront access, and cargo bike based last mile transport, Brad's experience is critical to understanding and expanding these sustainable transportation systems. He served as editor in chief of the Tulane Maritime Law Journal.

With extensive experience and knowledge of the challenges facing a transition to zero-emissions maritime transportation in the Northeast, we are in a unique position to collaborate and advise on decarbonized transport initiatives. We work with a broad coalition of organizations and maritime businesses, including cargo owners, cargo and passenger vessels, zero-carbon last-mile providers, and naval architects. This document is in support of zero-emissions maritime trade, and resilient small ports.

OVERALL CONTEXT

The causes and consequences of climate change are well understood and described in great detail elsewhere, therefore this document will not focus on these effects and threats as such. The context of this response reflects a larger systems view of regional marine services and the potential for marine movement of goods and people; one which looks at more than the trucks coming into the NYC roadways, but those simply passing through as well. The City's objectives are unlikely to be met by simply working within its own borders, due to the geography involved. The City reaching outside its own borders to improve life in the metro area is not novel: The preservation of farm and other conservation land in the Catskills in order to protect the City's water supply is a prime example of this type of extra-mural work which the City has engaged in for over a century.

The costs of overcrowded roadways are extremely high, as acknowledged in the RFEI. By diverting as much trade as possible off the roadways and onto the water, these costs can be significantly reduced. As New York has some of the most congested roadways in the United States, it is imperative to relieve this pressure. Any reduction in truck miles traveled reduces emissions as well as congestion, and reduced congestion leads to reduced emissions per vehicle.

For example, reducing truck miles and emissions in the New York Metro Area (NYMA) hinges on a significant geographical junction which sits in the middle of the NYMA: Long Island is only accessible by roads going through New York City, via the Queens Expressway Bridge from the North or East, or across the Verrazano Narrows Bridge from the West and South. By creating and subsidizing the use of coastal trade from New Jersey to ports along the shores of Long Island, a significant amount of trucking miles could be avoided on the Verrazano Narrows Bridge, while a series of ferries from Southern New England and the Hudson Valley to Long Island would similarly reduce truck traffic on New York's highways. Connections between Boston and Philadelphia on sailing container vessels could remove hundreds of trucks per day, as could similar zero-emissions coastal services which bring trade around, as opposed to through, the city's highways and bridges.

Even to allow for deliveries within the City's boundaries, outer-ring hubs for modal shift should be encouraged in the Hudson Valley, New Jersey, and Connecticut. The farther out the cargo switches, the lower the roadway congestion will be and the lower the climate forcing emissions. This will also reduce congestion at the peripheries of the city, allowing for freer movement and higher air quality for all the Metro Area's citizens, particularly in disadvantaged areas. The more points of embarkation for cargo outside the city, the more resilient and emissions efficient the entire system will be.

By expanding the available pool of ports which might be used for freight trans-shipping the overall impact on New York's roadway congestion, greenhouse gas emissions, and quality of life can be enhanced. While initial constructions may be sited in close proximity to the City, creating an expanding network over the next few years is an economically beneficial plan which can alleviate the significant problems the City is now facing. In cooperation with State-Level initiatives to revitalize the New York State Canal System, full-length maritime connections can be restored to the Champlain Valley, Central and Western New York, and the Great Lakes, creating amplified benefits to the state as a whole.

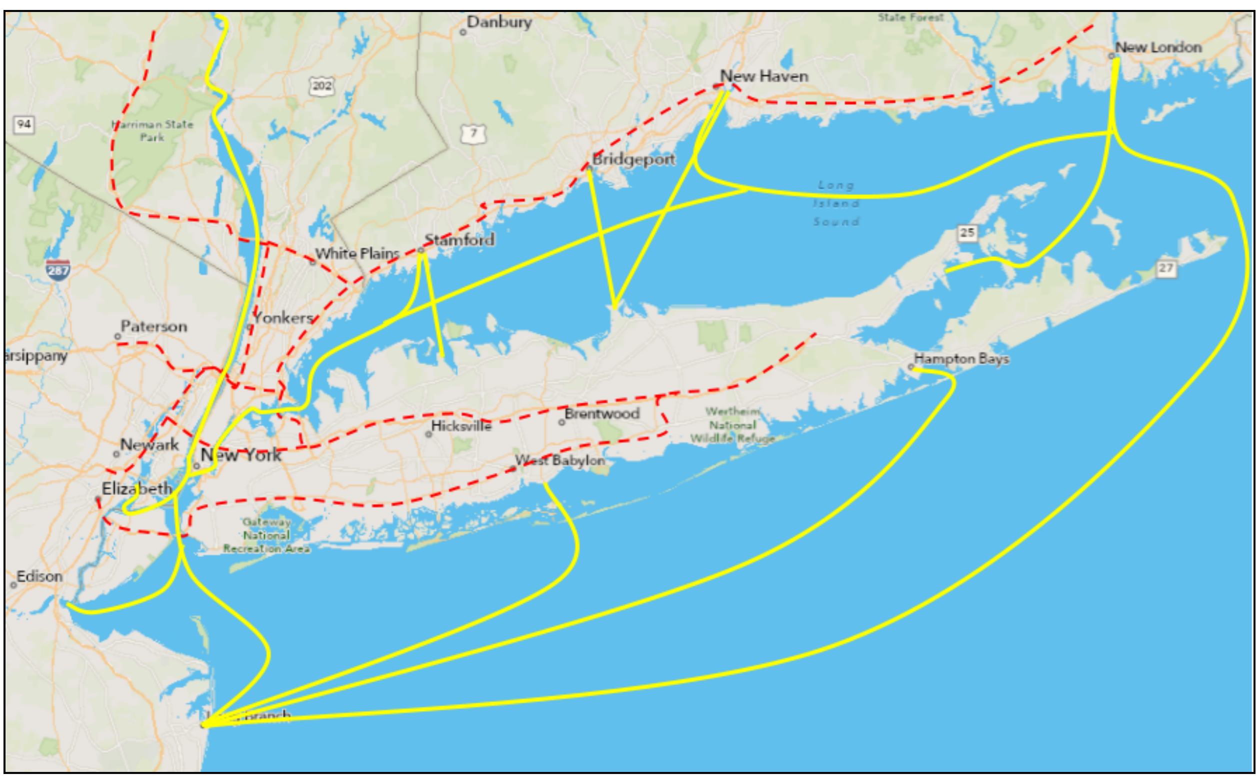
One of the greatest advantages of this plan of action is that it can be implemented immediately and with little investment or administrative overhead: Simply creating a program to pay for trucks to travel free-to-operator on a number of existing ferries will immediately divert traffic as this is advertised. This increase in business for ferry companies will create an incentive to increase their capacity on existing routes. As the success of such a pilot program grows, other routes and ports can be deployed and put into service. With a coherent regional plan to create mutual advantage, a large-scale maritime sector can be revived in the New Jersey-New York-Connecticut corridor.

SITE LOCATIONS

The following site locations are all outside the City's jurisdiction, in keeping with this brief's focus on the larger northeastern freight transport system and Regional Marine Services. It is assumed that the City is already focusing on where best to deploy at least two maritime micro hubs in each borough of the City, a siting task which requires an intimate knowledge of inbound freight flows in the city at this moment, and best left to active cargo operators for specific site selection. The suggestions herein are based on the larger trends of where that cargo originates, or can be made to originate, in the most efficient manner for both ecological and economic impacts.

Where possible, ports with existing facilities have been chosen as they can be put into service immediately. Other locations can have spud barge ports (see below) deployed inexpensively in protected waters. By focusing on existing and easily deployed locations, a faster response to the interests of New York's citizens can be realized. In many cases the initial goals of this RFEI can be met using existing facilities and assets, simply through a readjustment of financial incentives and subsidies. For example, simply paying the fare for trucks bound from Connecticut to Long Island on existing ferries will reduce or eliminate a significant economic barrier for trucks bound to Long Island, and divert a significant amount of traffic over the Throgs Neck and Whitestone Bridge corridors from New England.

With a more developed system, small container facilities installed at or near the Eastern end of Long Island, New London, CT, Newburgh, NY, and the Northern New Jersey shore would allow for feeder routes connecting these points to both the City, and to each other. This will allow mode-shifting to maritime transport for cargo destined to and around the City, with minimal disruption to time tables or additional operating expenses. Breakbulk and palletized cargo can be handled on almost any accessible waterfront, even with limited space for staging areas on the quay.



Map showing road communications in dashed red lines, and proposed coastal sailing routes in solid yellow lines. These roughly correspond to marine highways M-95, M-87, and M-295. The indicated routes are not exhaustive and can be expanded rapidly.

SELECTED INITIAL PORT LOCATIONS:

New Haven, CT: Already has a significant port. The addition of a small Container Terminal would compliment the break bulk and bulk terminals currently in place. Intersection of Interstates 95 and 91, making this a good point for transfers.

Port Jefferson, NY: A pre-existing ferry dock can be used until a small combined container and breakbulk terminal can be built in the Southwest corner of the bay.

New London, CT: Existing RO-RO Ferry infrastructure and port accommodations can be adapted to breakbulk or palletized operations rapidly with the addition of a spud-barge depot. RO-RO facility can be used as-is where possible for intensified ferry services to the Eastern end of Long Island.

Kingston, NY: Kingston's Rondout Creek and Hudson River working waterfront has been a key contributor to the region's economic wellbeing for over two centuries. With a naturally protected deep water harbor and extensive riverfront area, there is a reason this was one of the busiest ports North of New York Harbor for almost a century. Feeney Shipyard is on Kingston's Rondout Creek, one of the few New York shipyards capable of building next-generation small ships.

Newburgh-Beacon, NY: Newburgh-Beacon is a prime location for deploying a spud-barge depot, due to the close proximity to Interstates 87 and 84, allowing traffic for the city to use more northerly roads and avoid the congested I-95 corridor and southern stretches of I-87. Breakbulk cargo from the Newburgh hinterland already flows into the City via Schooner *Apollonia*, and a small terminal there could increase this volume significantly. This would also allow cargo passing from New Jersey and Long Island to Upstate locations to bypass the New York City road system. If operationally feasible, a small container terminal in the area is worth consideration.

Albany-Troy, NY: Southern Troy is a prime location for a small container and breakbulk terminal. It is the northernmost tidal point on the Hudson River, and allows for traffic on Interstates 90 and 87 to be diverted far earlier onto the water. A nearby alternative is the Port of Albany, approximately 8 miles south of Troy, and could be improved with a container and breakbulk terminal. Albany is the location of Scarano Boat Works, a New York yard capable of building the next generation of vessels.

Kearney Point, NJ: Kearney Point has deep water and some pre-existing infrastructure, with good roadway and rail connections. This makes it an ideal location for trans-shipment of goods bound for the City's maritime hubs.

Belford, NJ: Fresh and frozen seafood and produce from New Jersey can flow into the City from Belford, Monmouth County NJ.

Carteret, NJ: Carteret, located on the Arthur Kill west of Staten Island, is where Apollonia has picked up coffee beans. There are ambitious plans for the town's waterfront, including a ferry terminal which could be designed for combined passenger and freight use. Carteret is also in the heart of central New Jersey's warehousing, distribution, and transportation hubs.

Additional information for a regional network is contained in the attached paper "A Northeast Sustainable Maritime Transportation Development Plan." The larger view includes New York, New Jersey, and New England waters, including the New York State canal system and Lake Champlain. With the development of small sustainable freight projects in Long Island Sound, a significant number of trucks can be diverted immediately, with these other routes contributing their share in a short time.

SERVICE, MANAGEMENT, AND OPERATIONS

Creating micro-hubs for maritime cargo use in the city itself is a necessary and critical step towards diverting freight from trucking, but without corresponding facilities toward the distant end of the supply chain the usefulness of these micro hubs will be constrained. Thus, the City will need to encourage the deployment of facilities distant from the city by up to 150 miles in each direction. This is a coincident benefit to the State Transportation Departments in New Jersey, New York, and Connecticut, as the same decongestion benefits will be seen in their jurisdictions as a result of a similar modal shift.

The suggested method of deploying experimental port facilities is to use a Spud Barge Depot model, which includes the three major components needed for docking and handling cargo: Reliable depth of water, temporary warehousing, and an easy place to tie up. Small amounts of cargo handling gear can also be provided, though most vessels should be able to rely on their ship's gear to handle the majority of their cargo. Reliable ramps for use with cargo bikes and trailers will also be useful and appropriate to the scale of cargo handled by most smaller vessels in this coastal trade.

The advantage of the Spud-Barge port design is its modularity, very low capital expense, and ability to move. If a chosen location proves a poor fit for any reason, the barge can simply be moved to a more favorable place. If a favorable location for a barge-port is found, it can be left in service until permanent improvements are made, then moved to the next trial location. While these will not be well suited to large-scale container operations, the handling of breakbulk, super-sacks, and palletized cargo is entirely possible with these facilities, which will make them far more favorable for cargoes going into the city for relay to cargo bike last-mile delivery.

More information on small cargo port requirements can be found in the "Ports" section of the Sail Freight Handbook's second edition, available from the CPCL as a free ebook, noted in the References of this document. Port locations are mentioned above and in an attached paper.

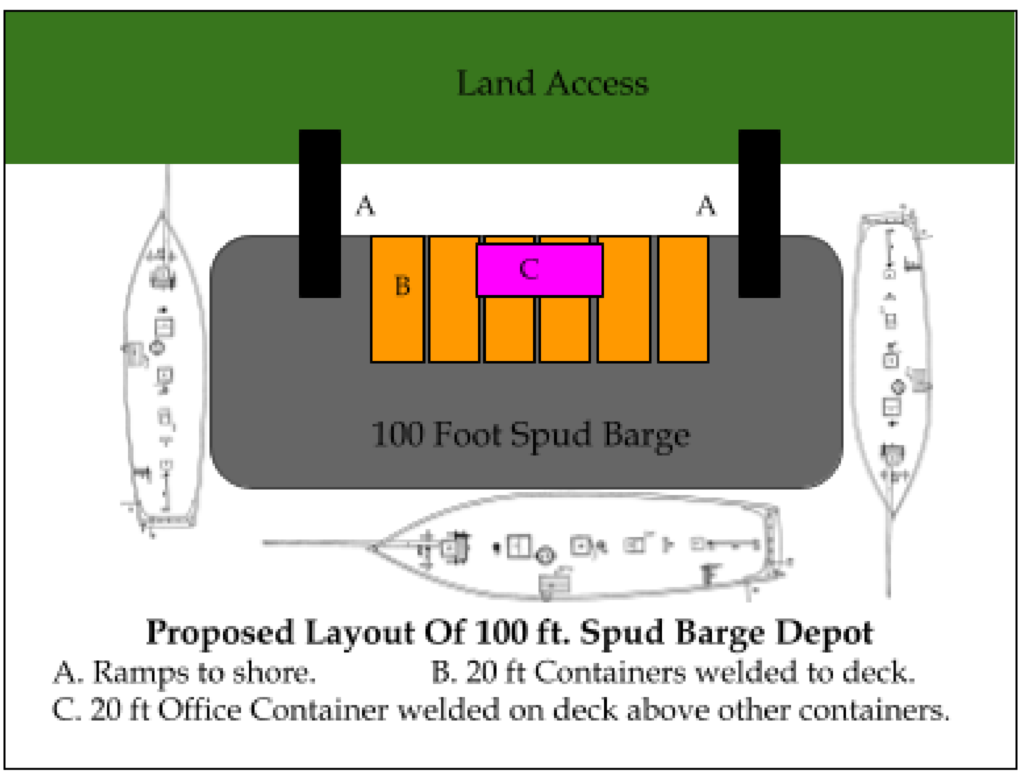


Figure 5: From *Sail Freight Handbook* 2nd Edition. Pp 170. CC-BY-NC-ND 4.0

Due to the capital requirements of container handling, it is recommended that palletized cargo be prioritized for these ports. Lift-On/Lift-Off pallet operations can retain many of the benefits of containerization for speed of cargo handling, while reducing the capital costs of both port and vessel equipment. By transporting smaller loads by boat more frequently, a large number of smaller or only partially-loaded trucks can be diverted from the City's roadways, which is far more advantageous for reducing both congestion and greenhouse gas emissions per unit of freight carried.

For initial stages of development, it may be possible to contract with existing commercial marinas to keep a small amount of space open for cargo operations at very low expense for the City, creating the opportunity to immediately take action on these priorities. Schooner *Apollonia* already uses commercial marinas for cargo operations, using ship's gear and an onboard bike and trailer for cargo handling and last mile delivery. By selecting suitable sites both within and outside the City's borders, small vessels piloting these services can be put into action at a slight subsidy, increasing the likelihood of both an attempt and success, leading to larger vessels in service. This will likely restrict operations to vessels under 65 feet and 50 Gross Register Tons, however these vessels can still divert a significant amount of cargo while turning a profit if appropriate assistance is given in shifting cargo to these vessels.

Installation of electric charging stations on these maritime hubs will be an important part of harbor operations for a decarbonized motor-vessel fleet, but slightly less important to a primary wind propulsion fleet. Slightly less convenient to deploy on a barge than on land, this can still be integrated with a spud barge port with the appropriate engineering and electric mains access.

Labor negotiations with the appropriate Unions need to be prioritized as both an operational and regulatory necessity. Longshore labor managing these hubs needs to be trained, skilled, well equipped, and reliable. This is unlikely to be achieved without the cooperation of labor unions and regulators, and should be worked into the operating plans of each hub as they are developed. It is recommended that a certain cargo tonnage capacity be declared as the standard below which the vessel's crew are allowed to handle all cargo themselves, with an option to hire union crews. Any vessel over this tonnage will be required to hire at least once longshore crew. Likely, this threshold will fall somewhere between 50-100 tons. The sooner this is resolved, the smoother implementation will be.

Training for mariners will also need to be prioritized in the New York Metro Area for this plan to succeed. The Harbor School, as well as SUNY Maritime, and potentially Community Colleges can fill this role, as well as other institutions in the region. A regional specialized school has been proposed in the Hudson Valley focusing on shipbuilding, ship maintenance, mariner, logistics agent, and longshore trades training, and other related professional development and initial education. These schools should be licensed to teach Standards of Training and Certification for Watchkeeping (STCW) Basic Training and Master Certifications, in addition to other courses. Sail Training programs which both grant sea time toward licenses and teach essential skills will be especially valuable in the first few years of development.

FINANCIAL FEASIBILITY

Business cases have already been calculated for several of these routes, including a New Haven - Port Jefferson sailing cargo ferry (See Attached Paper). For example, a 40 foot, 7.5 ton capacity vessel on this route, if sailing full each way for 350 crossings per year could theoretically make up to $127,000 in the first two years. This would remove about one truck per day from New York City roads. A 35 ton capacity, 65 foot schooner on the same route could likely take 4 trucks off the city's roads per day, while making up to 3 million dollars in the first two years, without subsidy. This equates to removing 169,360 truck miles traveled annually along the same roadways, which would displace some 846 tonnes of CO_2 emissions per year, which could be credited toward New York City decarbonization goals. If such a ferry were created as a C-Corporation in the State of New York, 50% owned by the City of New York, a share of these profits could be used to subsidize other activities while reducing expenses and social harms in the city. This could be an extremely beneficial situation for New York City, with minimal outlay. With more than one such ferry established, the additional economic and ecological benefits increase rapidly.

There are similar benefits to subsidizing extra-territorial port facilities by purchasing stock and providing startup capital. Where a small port is able to make even small profits, the City will benefit from the profits, which can be dedicated to paying for the operation of free port facilities in the City itself. In some cases, the companies running these small terminals could be owned by NYC, the supporting State DOT, and a municipality, extending greater mutual benefit for cooperation.

A joint State-level DOT project between New Jersey, New York, and Connecticut to create ports and diversionary coastal shipping along the routes illustrated above can be led and subsidized by the City of New York. By assisting in the creation and operations of these terminals, creating toll and other barriers to truck traffic on city roads, and subsidizing the operations of these extramural ports and their vessels, the economic distance between two points can be lessened with maritime trade and lengthened on roadways. For example, if one truck passing through the City's road network on the way from New Haven to Montauk is determined to have a social cost of $900 (exclusive of the cost to the CT and NYS DOT for road maintenance), a subsidy of $300 to a Cross-Sound ferry which prevents the truck from ever touching the roads between New Haven and Port Jefferson is well worth the cost. This is especially the case if that subsidy is divided between the City and States, as it pays the ferry charge ($4.60/ft x 65 feet) for the trailer on the ferry, while saving the City some $600 in road maintenance, traffic administration, congestion costs, and emergency services. Gradually increasing the tolls on bridges for the same class of truck to a discouraging level will make the ferry look ever-more economically favorable.

A route from the vicinity of Sandy Hook or Raritan Bayshore, NJ, to New London, CT, could reduce traffic through the New York Metro Area significantly, while also saving the NJ-NY-CT State Departments of Transportation a significant amount of money. By contributing to a joint fund these three states could pay for the creation or rehabilitation of marine terminals, pay for part of the operating expenses for the vessel and terminals, and then contract a maritime firm to divert hundreds of thousands of tons of freight away from one of the most congested road corridors in the US while saving money and carbon emissions overall.

More detailed analysis of the prospects for related routes are given in two attached papers. The Northeast Sail Freight Plan paper gives a regional outlook on a large-scale regional maritime trade network in relatively small vessels, while the draft paper on financial analysis of small sailing cargo vessels gives the approximate budgets necessary for building and operating the vessels. While the numbers given in those papers are based on working with active freight forwarders who will divert cargo to these vessels, no specific forwarders have been identified as interested in such operations.

OPERATIONAL AND REGULATORY BARRIERS

Federal-Level regulations may create difficulties for implementing these systems quickly, but they are not insurmountable. For example, the Jones Act requires all vessels moving cargo between US Ports to be US built, US Owned, US Flagged, and crewed by at least 75% US Citizens or Nationals. Due to serial disinvestment in the maritime field, there are insufficient shipyards to build a massive fleet in a very short time, though a decade or two would be enough to create sufficient capacity to keep all of New York City's cargo moving on the water. However, if small vessels are used which can be built in the remaining Hudson Valley shipyards, a large fleet could be built in a short time, given sufficient funding.

More local Regulatory changes which would encourage a transition to maritime freight include free commercial docking for up to one hour (with reasonable rates thereafter) at the facilities in NYC, along with a very high toll on trucks entering the city for deliveries (in conjunction with congestion pricing). A very high toll for trucks passing through the city or over a bridge would similarly bring the economic competitiveness of maritime freight ever higher, and bring the costs of trucking in line with their externalities. A high fuel tax in the New York Metro Area would be complementary as well.

Policy measures which can immediately make marine freight movement viable include:

- Make ferry passages from Connecticut to Long Island Free-To-Operator for freight traffic,
- Drastically Increase tolls for trucks passing through or into the City or over bridges,
- Set Truck-Free times where no trucks are allowed to cross the New York City bridges in favor of passenger vehicles,
- Deploy public-access spud-barge depots throughout the New York Metro Area,
- Subsidize deployment of cargo-bike based delivery within the New York Metro Area,
- Subsidize and deploy spud-barge based cargo hubs in New Jersey, Connecticut, Long Island, and the Hudson Valley,
- Subsidize freight traffic on existing ferry routes and the purchase of additional ferry vessels for these routes to increase capacity, such as dedicating space on Staten Island ferries for cargo bikes and trailers,
- Provide free or low-cost docking at all NYC-Controlled cargo docks,
- Create a grant or zero-interest loan program for shipbuilding at New York State yards with conditions on the contract requiring these vessels work within the NJ-NY-CT region.

There are vessel designs already available which are well suited to this type of coastal trade, both for the riverine trade to and from the Hudson Valley, Cross-Harbor, Cross-Sound, and around Long Island routes. Many of these can be built rapidly, are made for zero-emissions operation, can handle all cargo using ship's gear, and require relatively few crew per ton of cargo capacity, as mentioned above and explained in the attached papers. At least one of these is designed specifically for the Hudson River and Long Island Sound, as well as connections into the New York State Canal System, can be built for around $1 million, and is capable of carrying 100 tons. As a lack of vessels is a significant operational hurdle, and there are few existing vessels which can be converted to cargo use in the short term, subsidizing ship construction may also be necessary for early proof-of-concept phase operations.

A shortage of shipyards will complicate the construction of these vessels. New York has few shipyards, aside from Feeney's Shipyard in Kingston, Derecktor Shipyard in Mamaroneck, and Scarano Boat Works in Albany. Feeney's business is primarily repair, refit, and inspection of existing vessels as opposed to new construction, however, the yard may be capable of new builds for vessels under 100 tons. There is a similarly restricted shipbuilding capacity in the Northeast in general, which will require the construction and import of vessels from the Gulf Coast or elsewhere unless efforts are made to change the situation. The capacity of these shipyards is unknown at this time, but not likely to provide more than a dozen vessels per year at present capacity. Home-built vessels, such as the *Ceres* built by the Vermont Sail Freight Project, are possible options which do not require a major shipyard, but are small capacity vessels requiring a larger number of crew, mooring space, and coordination for the same tonnage.

The small number of licensed and credentialed mariners may also pose a challenge. Any vessel over 15 Gross Register Tons or 40 feet in length will require a licensed captain, and likely some compliment of credentialed crew. The availability of appropriately licensed captains and trained mariners must be studied and matched to the proposed fleet until training programs can be brought online. For deck crew, very short courses of as little as two weeks can be sufficient for new hands, but a corps of skilled deckhands will need to be set up with them. Able Seafarers will require at least 6 months of sea time to qualify for their posts, and will need to clear STCW Basic Training to gain safety and lifeboat skills certificates. Officers such as Mates and Masters will need far more sea time, up to two years for Near Coastal licenses, in addition to testing and competency requirements. All crew members will need to pass pre-employment and random drug tests under federal regulations. These concerns will not make maritime trade impossible in the New York region, but will possibly serve as a break on initial expansion if training programs are not included in the City's plans. Subsidization of Community College and trade school programs within the New York Metro Area and surrounding regions such as the Hudson Valley, New Jersey, and Connecticut would be extremely helpful in addressing this concern.

CONCLUSIONS

Transportation is not the same as motion: Goods and people must be moved between two points to achieve an objective. For any transportation system, be it road, rail, or water based, there must be links at or near the points of embarkation and debarkation, and these must be close to the origins and destinations of the people and goods in question. Without considering the distant end of a transportation system the efficacy of its core will be diminished; in the context of Marine Transport of freight into New York City, these distant ends will invariably be outside city limits.

By applying a regional and systems lens to this challenge and working in concert with neighboring states and municipalities, the benefits of short sea shipping can be significantly amplified and expanded at little cost to the City of New York or its neighbors. This can drive regional jobs growth, assist in relocalizing the New York economy, and reduce greenhouse gas emissions, as well as decongesting the New York Metro Area's road network. The more regional coastal trade is established, the greater the impact to the City will be.

While there are challenges to reestablishing an industry which declined rapidly after the 1920s, none of them are insurmountable, and most can be solved simply and inexpensively. With a five year plan for expansion, this industry can add hundreds of jobs in the City and surrounding areas, reduce noise, air, water, and carbon pollution, while relieving the severe roadway congestion plaguing the New York Metro Area.

Any questions concerning this RFEI Response may be directed to Director Andrew Willner by email at a andrew@postcarbonlogistics.org

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Operation of a sail freighter on the Hudson River: Schooner Apollonia in 2021

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Abstract: In the discussion of sail freight worldwide, little analysis exists to illuminate the effects of sail freight vessels engaged in shipping along rivers. Even less of the literature provides meaningful, in-depth insight into the operations of such vessels. The 64-ft (19.5 m) schooner *Apollonia*, a small general cargo vessel and the only active, operational sail freighter in the United States, operates on the Hudson River and in New York Harbor. The ship's logs and other data from 2021, the *Apollonia's* first sail freight season, are examined here to gauge the performance of small sail freighters on river trade routes. The available data shows sail freight has a strong advantage over comparable trucking in fuel use per Ton-Mile.

INTRODUCTION

In the last half century, Wind Propulsion has been widely acknowledged since the Oil Crisis of the 1970s as a means of reducing fuel use in maritime transportation, and research started in that era has been resumed as climate and economic concerns force change in the maritime industry. Small sail freighters engaged in coastal or inland waterway trading with break bulk general cargo have been ignored in this discussion of working sail's revival, however. These vessels are neither bulkers carrying loose cargo such as iron ore or grain, nor do they use intermodal shipping containers. The cargo is instead loaded directly into the hold in smaller packaging, such as sacks, crates, boxes, coolers, and barrels. Analysis of logs, cargo, and fuel-use data from the schooner *Apollonia* operating on the Hudson River and New York Harbor allows for a comparison of these vessels to other methods of cargo transportation.

Sail freight is defined as "The maritime movement of cargo under primarily wind power."[1] As can be seen in the figure below, this includes sail and motor-sailing vessels which rely on their engines for less than half of their propulsive power.[2] Sail-Assist and conventional motor ships are excluded from this definition, but are by far the most-discussed in journals at this time.

[1] Woods, Steven. "Sail Freight Revival: Methods of calculating fleet, labor, and cargo needs for supplying cities by sail." Master's Thesis. Prescott College, 2021. Pp 6. www.Researchgate.net

[2] Wind Ship Development Corporation, *Wind Propulsion For Ships Of The American Merchant Marine* Norwell, MA: WSDC, 1981. Pp II-5

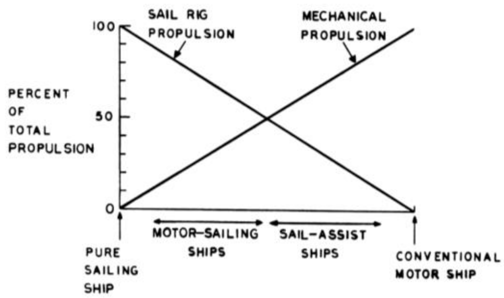

Figure 1: "Motor Sailing Propulsion Spectrum" in: Wind Ship Development Corporation, *Wind Propulsion For Ships Of The American Merchant Marine* Norwell, MA: WSDC, 1981. Pp II-5.

While there is considerable space within the sail freight continuum for high levels of engine use, the majority of coastal and inland trading under sail at this time is in small general cargo vessels which are either engineless, as with the ketch *Nordlys*,[3] or use engines only when docking or for safety reasons in crowded harbors, like the schooner *Apollonia*.

The tonnages involved in most studies of wind-assisted ship propulsion allow for comparison with conventional merchant ships. There are multiple studies which show the fuel saved from sail retrofits to existing vessels, compared to the ship's previous performance.[4] However, these are based on places where maritime shipping is the rule, such as small island states and archipelagoes, or transoceanic shipping. This is not the case when looking at inland and coastal vessels which displace rail and road transport instead of other ships.

Another element worth noting in this study is the *Apollonia*'s goals. The ship and her crew are not looking solely to reduce carbon emissions, though this is a significant part of their mission. Their goal overall is to have an environmental, economic, and social impact, the "Triple Bottom Line." This entails an extra educational bottom line, changing the way people think about the Hudson River, waterways, transportation, and supply chains. The economic mission involves paying more in labor than on fossil fuels. There is significant interaction between goals: Ecological improvements have a social impact by reducing pollution, while economic changes have social impacts on jobs and livelihoods. This multifaceted impact is outside the scope of this paper, which will be limited to assessing the comparative CO2 intensity of sail freight vessels and fossil fueled trucks.

THE SCHOONER *APOLLONIA*

The *Apollonia* is a steel J Murray Watts design from 1946, built in Baltimore, MD. Acquired in 2016, she spent 4 years in repair and retrofit before launching for a first season of relationship building and experimentation in 2020, including one circuit from Hudson, New York to New York City with a small number of cargos. 2021 was the first season of regular operations. *Apollonia* has a sail area of 122 square meters, and is equipped with a Detroit diesel engine of approximately 125 Horsepower.

[3] "Nordlys" https://fairtransport.eu/nordlys/ Accessed 27 November 2021.

[4] R.G. MacAlister "The retrofitting of sail to two existing motor ships of the Fiji Government fleet." *Proceedings of Regional Conference on Sail-Motor Propulsion* (Manila: Asian Development Bank, 1985)

Schooner *Apollonia* Critical Data:
Length: 64 ft/19.5m Beam: 15 ft/4.5m
Rig: 2 Masted Bald-Headed Gaff Schooner.
Sail Area: 122 sq m/1320 sq ft.
Cargo Deadweight: 10 Short Tons/9.07 tonnes.
Cargo Volume: 600 Cu ft/17 Cu M/½ TEU.
Displacement: 36 tons. Draft: 7 ft
Engine: 125 HP/92 KW Detroit Diesel.
Fuel Capacity: 250 Gal/946 Liters.
Crew: 4

Fig 1: Schooner *Apollonia* under sail off Rondout Lighthouse, 24 July 2022. Courtesy, Steven Woods.

APOLLONIA'S 2021 OPERATIONS

The *Apollonia* made five circuits from Hudson, NY to New York City on the Hudson River: one per month from May through October, excepting June. Cargo was generally transported first- and last-mile by means of an electric-assist cargo bike and trailer powered by solar panels mounted on the wheelhouse of the vessel, minimizing the emissions of first- and last-mile transportation. This use of low energy intensity land transportation proves the viability of a sustainable cargo system, as well as allowing the ship to carry her own shoreside delivery capabilities. In addition, the use of a cargo bike avoids heavily congested roads. Handling of all break bulk cargo was by the "Armstrong Method" aided by ship's gear such as block and tackle.

The typical crew of four consisted of Master, Mate, Bosun, and Deckhand. All crew served as dockers as no longshore or stevedore crews were available or hired. Sailing was by both night and day depending on wind, tide, and current conditions, which dictated the watch rotation. Due to the small crew size, there was little real differentiation of roles.

Figure 2: Map of *Apollonia*'s Port Calls.[5]

APOLLONIA'S CARGO

The *Apollonia*'s main cargo was Malted Grains moving from the Germantown, NY area to several breweries down the Hudson River and around New York Harbor. These were exclusively embarked at Hudson, NY, packed in 50 pound sacks. Many other cargos were included in the season, including solar panels, a printing press, coffee, beer, tea, mead wine, salt, a cargo of wine and chocolate cross-loaded from the French Sail Freighter *Grain de Sail* in New York Harbor, 1 ton of peppers from Milton to Hudson, hot sauce, maple syrup, yarn, honey, jam, condiments, rope, CBD, pepper flakes, soap, skincare products, and other goods. A barrel of Rye Whiskey, aging on the ship since 2020, was carried until the October run. Another cargo was 11,500 pounds of Red Oak logs from Kingston to Brooklyn for an urban mushroom farm.

TABLE 1: MALT CARGO DATA

DESTINATION	DIST from Hudson NY	WEIGHT (Lb)	TON-MILES
Poughkeepsie	41.4	2,505	51.85
Beacon	56.35	3,900	109.88
Peekskill	73.6	3,600	132.48
Ossining	85.1	6,550	278.7
Yonkers	98.9	2,950	145.88
LIC, Queens	130	4,750	308.75
GBX	138	9,700	669.3
	TOTALS:	33,955lb/16.98 tons	1,696.84 ton-miles

[5] Esri *Light Gray Canvas Reference* [Basemap] Scale Not Given. February 2022. https://basemaps.arcgis.com/arcgis/rest/services/World_Basemap_v2/VectorTileServer (Accessed 1 March 2022)

TABLE 2: ADDITIONAL CARGO DATA					
Origin	**Destination**	**Cargo**	**Weight (Lb)**	**Distance**	**Ton-Miles**
Milton	Hudson	Peppers	2,000	78.2	78.2
Poughkeepsie	South St	Flour	1,500	91.1	68.32
Kingston	GBX	Mushroom Logs	11,500	97.75	562
GBX	Ossining	Coffee	440	55.2	12.15
GBX	Kingston	Coffee	120	97.75	5.87
Hudson	Newburgh	Whiskey, Barrel	150 (est)	56.35	4.23
GBX	Kingston	Whiskey, 2 cases	50 (est)	97.75	2.44
Milton	South Street	Pumpkins	2,900	85.35	123.76
Milton	GBX	Pumpkins	500	87.4	21.85
Milton	Ossining	Pumpkins	100	39.1	1.96
Milton	South Street	Apples, 8 boxes	160(est)	85.35	6.83
Milton	South Street	Squash, Assorted	200	85.35	8.54
Milton	South Street	Grapes, 3 flats	30 (est)	85.35	1.28
Milton	South Street	Cider, 2 cases	30 (est)	85.35	1.28
GBX	Kingston	Printing Press	500 (est)	97.75	24.44
				Additional Ton Miles:	923.15
				TOTAL TON MILES:	2,619.99

ABBREVIATIONS: GBX=Gowanus Bay Terminal. **South St**= South Street Seaport Museum, Manhattan. All locations are in New York State. All distances in Statute Miles for comparison to trucking.

Small cargos included ceramic plates, books, apparel, and postcards. The ship also carried what were essentially classical "Tramping" cargos, purchased by the ship and sold on her own account.[6] This makes tracking the ton-miles involved with these cargos difficult, and these small and tramping goods have been excluded from the study. We will focus only on major cargos here, understanding the figures produced are a minimum impact.

The principal cargos and destinations for malt remained the same over the course of the season, and have been consolidated in Table 1 above. Other cargos are given in more detail in Table 2. Official river miles between ports, converted to statute miles, are used to give a uniform comparison, but the total miles covered by *Apollonia* were much greater due to tacking, jybing, and other maneuvers.[7]

FUEL USE DATA

Fuel Use for *Apollonia* over the season is estimated at 37 gallons over 38 hours of engine use.[8] Not all engine hours were recorded prior to July 2021 due to recordkeeping changes aboard ship, and

[6] Thomas F. Tartaron, *Maritime Networks in the Mycenaean World* (New York: Cambridge University Press, 2013). Pp 30-32

[7] United States Department of Commerce, *Distances between United States Ports,* 13th ed. (Washington DC: US Department of Commerce, 2019).

[8] The *Apollonia*'s fuel tank was not full at the season's start, and fuel purchase records from 2020 have been lost. The tank does not have a gauge, and was not "sticked" before the season began. About 40 gallons were added in 2021 and visual inspection at the end of the season shows the fuel level slightly above where it was in May. There was no plan of making these studies when the 2021 season began.

engine hours are only noted in full hours, limiting the precision of these figures. Approximately 18 hours of engine time was spent on educational programming out of Hudson, NY separate from the vessel's cargo runs. This gives an average rate of about 0.97 gallons per hour, which is reasonable for rarely exceeding clutch speed on the engine. Fuel use per voyage was calculated by the total hours of engine operation noted in the log for each voyage; total fuel used for cargo transport was about 19.47 gallons for the season.

Without the installation of costly and complicated differential fuel gauges on the ship the collection of more precise fuel use data is impossible. Such approximations are generally in line with methods used in other studies where this equipment was not available, and the data is considered sufficient for the purpose of this paper.[9] The Schooner *Apollonia* has an estimated efficiency of 134.6 Ton-Miles per gallon of diesel fuel.

Examining a single voyage with better records shows the October run moved 397.37 ton-miles with three engine hours, giving 136.55 ton-miles per gallon, or 51.77 tonne-kilometers per liter. Other voyages at higher percentages of the schooner's maximum load, or lower engine use will score differently, but are less well documented.

ENGINE USE STRATEGY

Apollonia's engine use strategy is quite simple: The engine is only used for safety purposes and docking where necessary. If the tide is against the vessel's course, she drops anchor or ties up in port, instead of employing the engines. If there was no wind, she would occasionally use only the tide for propulsion. This is substantially the same engine use strategy as 17th and 18th century Hudson River sloop masters,[10] and was adopted due to ecological as opposed to economic imperatives. This leads to a very low engine use figure, averaging less than 4.5% of hours under way over the season. 60% of voyages show less than 3.75% of hours underway involved engine use. As previously mentioned, the engine was rarely, if ever, brought above idle RPMs.

TABLE 3: *Apollonia* Engine Use and Sailing Data

Month	Sailing Days	Hours Sailing	Hours at Anchor	Hours at Port	Average VMC	Engine Hours	% Engine Hours
May	11	89.25	67.5	113.75	2.48	4 (est)	4.48
July	14	108.25	58.25	139.5	2.13	4	3.70
August	13	95	77.75	85.25	2.74	6	6.32
September	12	86.5	48.75	100	2.83	3	3.47
October	10	80	48.1	102.95	2.85	3	3.75

[9] R.G. MacAlister "The retrofitting of sail to two existing motor ships of the Fiji Government fleet."
[10] Paul E Fontenoy. *The Sloops of the Hudson River: A Historical and Design Survey* (Mystic: Mystic Seaport Museum, 1994)

Apollonia used her engine less than 4.5% of the time, making her a near-pure-sail vessel. The hope for future seasons is to reduce this engine use intensity as much as possible, though with the docks available it is likely that some level of engine use will be unavoidable.

Speed and distance actually traveled by *Apollonia* is a complex calculation. Due to the inland and tidal nature of the Hudson River, it is frequently necessary to drop anchor when the tide or current is against the intended course when sailing. Due to a longer ebb than flood tide, it is easier to go South. The winds on the Hudson do not lend themselves to consistent sailing, which requires frequent tacking and gybing. There were a total of 62 days of operations over the season, with 459 hours sailing and 300.35 at Anchor. *Apollonia* made an average Velocity Made good on Course (VMC) ranging from 2.35 to 2.85 Knots while under way, with speed being higher, but unrecorded. A trend of increasing VMC through the season is noted in the logs, likely reflecting increased crew skill. Overall VMC once hours at anchor are included amounts to a seasonal average of 1.578 knots.

While the tide cycle on the Hudson River is approximately 6 hours, favorable winds cannot be scheduled so regularly. Whether the vessel's next stop would be at anchor or at dock depended on a multitude of factors and could not be reliably predicted far in advance.

When examining coastal Sail Freight, there will be different sailing characteristics in open waters, which may impact average VMC. *Apollonia* makes frequent stops, using her engine when docking frequently in comparison to a longer coastal route. As was found by Perez *et al* studying large ships, the advantages of Sail Freight are greatest on long routes with low engine use.[11] This confirms historic trends noted by Riesenberg[12] and Erikson.[13] The fewer stops or maneuvers a motor-sailer makes on their route the better expected fuel efficiency will be.

COMPARISONS TO TERRESTRIAL TRANSPORTATION

Apollonia is involved in inland waterway trading, which means she should not be compared to oceangoing cargo vessels due to the tonnages, cargos, and routes involved. The average freight-ton efficiency in the US for trucking is not a good comparison as this average is skewed by the relatively high efficiency of very large trucks moving cargo very long distances.[14]

A few other concerns arise for making a valid comparison: *Apollonia* is not capable of moving containerized cargo, making her a general cargo ship. As rail lines are not generally loaded with break bulk cargo, this means rail should also be excluded. In the case of other sail freighter designs using containerized cargo, such as those by Derek Ellard, the comparison would rightly be with large trucks or rail. In the case of his Electric Clipper 180, carrying 36 TEUs, the appropriate comparison would be rail.

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11 Perez, S; Guan, C; Mesaros, A; Talay, A, "Economic Viability of bulk cargo merchant sailing vessels", *Journal of Merchant Ship Wind Energy*, 17 August 2021. (Accessed 3 December 2021) https://www.jmwe.org/uploads/1/0/6/4/106473271/jmwe_17_august_2021.pdf

12 Felix Riesenberg, *Standard Seamanship For The Merchant Service* 2nd ed. (New York: D. Van Norstrand, 1936) pp 11.

13 See: Georg Kahre, *The Last Tall Ships: Gustaf Erikson and the Aland Island Sailing Fleets, 1872-1947* Basil Greenhill, Ed. (London: Conway Maritime Press, 1990)

14 In 2018 trucks moved 2,033,921 million ton-miles, using 28,987 million gallons of fuel, averaging 70 ton-miles per gallon. SEE: Bureau of Transportation Statistics *National Transportation Statistics* www.bts.gov/us-tonne-kilometers-freight AND www.bts.gov/content/combination-truck-fuel-consumption-and-travel (Accessed 15 Nov 2021)

Something like the Electric Clipper 100 carrying 4 TEUs would be more accurately compared to a class 8 truck.[15]

As with the 1920s when Walter Hedden studied *How Great Cities Are Fed*, it is small trucks which move most food and goods within 100 miles of major cities.[16] The cargo taken on *Apollonia* moved to its destination principally in 2½ ton box trucks before transitioning to Sail Freight in 2021. Apollonia has a similar cubic capacity to a 12 foot box truck, at about 600 cubic feet, which would be in the same class as a 2½ to three ton truck. A 2½ ton truck at 12 miles per gallon gives a maximal theoretical efficiency of 30 ton-miles per gallon, which is similar to figures given by the National Highway Safety Administration in 2006.[17] This holds for essentially all the cargos involved with *Apollonia*, excepting those likely moved by less efficient pickup trucks, and is the appropriate comparison.

COMPARISON TO BOX TRUCKS

Apollonia's Ton Miles of transport avoided the use of around 67.9 Gallons of fuel, and she has an advantage of 104.6 ton-miles per gallon against the theoretical optimum for 2½ ton trucks.[18] The *Apollonia* requires only 22.3% of comparable ideal trucking fuel use values. If account is taken of empty miles back to the malthouse or point of origin for these trucks, the advantage is immediately doubled. In this case, fuel use is less than 12% of trucking.

It should be noted this comparison contrasts real-world results aboard *Apollonia* with theoretical best-case conditions for the trucks. If the trucks are less than fully loaded, the ton-mile efficiency of the truck declines. Further, the New York Metro Area is a maze of congested roads with dozens of over-capacity *Passages Obligés* such as bridges and major intersections, leading to 335.9 million gallons of wasted fuel[19] and an economic cost of 18.26 billion dollars in 2019.[20] These figures alone bring the 30 ton mile per gallon figure for trucks into question when looking at the New York Metro Area, giving *Apollonia* a further advantage, though the effects of road congestion on truck fuel efficiency are not considered here. If there are any other disadvantages for the truck, such as steep climbs or sub-optimal maintenance, its efficiency declines. In terms of carbon impacts, the consumption of tires, lubricants, spare parts, and road wear should be included in the calculation for trucks,[21] while *Apollonia*'s inputs are essentially fuel, one tenth of a set of sails annually, and a small amount of paint.

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15 Derek Ellard "The Electric Clippers" gosailcargo.com (accessed 1 December 2021)

16 Walter P Hedden, *How Great Cities are Fed* (New York: D.C. Heath, 1929).

17 NHTSA *Factors and Considerations for Establishing a Fuel Efficiency Regulatory Program for Commercial Medium- and Heavy-Duty Vehicles* (Washington, DC: NHTSA, 2010) https://www.nhtsa.gov/sites/nhtsa.gov/files/nhtsa_study_trucks.pdf (Accessed 28 November 2021) Pp 12-13. The figure given for typical ton-miles for vehicles in this study is quite clearly a multiplication of the load capacity by the average miles per gallon, not accounting for deadheading or partial loads.

18 It is worth noting that even when compared to the optimal efficiency of 10 ton trucks, *Apollonia* retains an advantage of 22.6 tm/gal using her observed real-world efficiency. When comparing her maximum efficiency to the same 10 ton trucks, she is over 5.5 times more efficient.

19 Bureau of Transportation Statistics "Annual Wasted Fuel Due To Congestion" *National Transportation Statistics* https://www.bts.gov/content/annual-wasted-fuel-due-congestion (Accessed 18 January 2022)

20 Bureau of Transportation Statistics "Annual Highway Congestion Cost" *National Transportation Statistics* https://www.bts.gov/content/annual-highway-congestion-cost (Accessed 18 January 2022)

21 David Austin, *Pricing Freight Transport to Account for External Costs* (Washington DC: Congressional Budget Office, 2015). https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/workingpaper/50049-Freight_Transport_Working_Paper-2.pdf. Pp 2 Summary.

Given better freight ton efficiency data for small trucks and historical data for the same cargo movements, a more accurate calculation of *Apollonia*'s impact could be made. This data is not readily available, and the above are the likely floor for efficiency gains from small Sail Freighters on inland routes using an auxiliary diesel engine.

Intensity as a percentage of maximum load weight for *Apollonia* is worth considering. The maximum a 10 CDWT capacity could have carried per circuit would be 2,346 ton miles. This assumes a two-way voyage from Hudson to New York City, each leg of which is 117.3 miles long, with a full hold. For five trips, this would be a maximum of 11,730 ton-miles. *Apollonia* only moved slightly over 21.5% of this maximum in 2021, as some runs were not made with a completely full hold, while others, such as a 2,000 load of peppers from Milton to Hudson, were affected by cargo density. *Apollonia*'s maximum theoretical fuel efficiency would be some 626 ton-miles per gallon of fuel (266 tkm/l), at the crew's current skill level and engine use patterns.

This maximum figure is over twenty times that of comparable trucking, nearly 9 times the average for trucking in the US, and 25% better than rail figures of around 500 ton-miles per gallon. With the time allowed by the season on the Hudson, a total of 12 voyages could be undertaken, which may result in higher realized efficiency through higher average cargo intensity or less engine use per ton-mile across the season.

The issue of cargo density as mentioned above is important for both trucks and sail freighters: It would be impossible to fit 10 tons of fresh peppers into the hold of the ship or onto most trucks, and cubic space should play into this calculation. As Malt is generally between .3-.7 tons per cubic meter in density (load factor), this is a serious concern for *Apollonia*'s main trade reaching full tonnage loads due to cargo density and the limits of storage space, meaning neither will likely reach their theoretical efficiencies in service. If fuel were allocated to vehicles based solely on their maximum theoretical fuel efficiency, no cargo moved by fossil fuels or electrified transport would ever arrive on target. This lack of clear information on average or real-world relative energy and carbon intensity for various vehicle types is a significant problem for sustainable transportation planning and research. By contrast, over 5,000 years of precedent has shown a lack of fuel does not fundamentally affect sail freighters' ability to reach their destination, though it may affect port-to-port time and scheduling.

Turning to Carbon Emissions, at 22.48 pounds of CO2 per gallon of diesel[22] *Apollonia* emitted about 437.68 pounds of CO2 in the course of her operations. A 2.5 ton truck would emit 1,963.25 pounds (890.5 kg) of CO2, assuming no deadheading and maximum efficiency loads. In the worst-case scenario, *Apollonia* avoided over 1,530 pounds (694 kg) of carbon emissions in 2021. Her impacts on particulates, SOx, NOx, and other pollutants will be proportionate, and the issue of noise pollution is not covered here.

IMPLICATIONS FOR INLAND AND COASTAL SAIL FREIGHT EFFICIENCY

There are lessons to be learned from the *Apollonia* for inland and coastal Sail Freight in small vessels. Internal Combustion Engine propulsion experiences economies of scale, and becomes more efficient the larger a vessel becomes.[23] As sail freight vessels grow in CDWT terms both important

[22] Energy Information Administration. *Carbon Dioxide Emissions Coefficients* https://www.eia.gov/environment/emissions/co2_vol_mass.php (Accessed 8 February 2022)

[23] WSDC, *Wind Propulsion For Ships Of The American Merchant Marine* Pp X-6

efficiency metrics, Ton-Mile Fuel Efficiency and Tons Per Sailor, increase so long as engine use patterns remain the same. The application of electric engines with underway battery recharging will give further advantages against all forms of terrestrial transport. Engineless coastal vessels will have a much higher fuel efficiency in the middle legs of their voyages, but must use tugs when entering certain ports, inducing some fuel use on the terminal ends of the voyage which will be difficult to measure accurately. This will give a significant incentive in climate adaptation planning to shift cargo to coastal and inland sail-motor freighters where possible, but will need to be tested once such vessels are in service and can give real-world comparisons.

How the overall distance traveled by *Apollonia* compares to trucking routes for the same cargo has not been examined, but may conceal other difficulties in measuring efficiency by changing the relative ton miles by river or road. From Hudson Valley Malt to Sing Sing Kill brewery is 78.2 miles by truck, but 85.1 river miles from Hudson to Ossining. This makes comprehensive comparison complex, but does not affect relative fuel efficiency.

OPPORTUNITIES FOR FURTHER RESEARCH

The *Apollonia* refined her routing over the course of 2021 to optimize her circuit. This involved stopping at ports only while headed in one direction, for example. This reduces the total number of dockings per circuit, which can have a significant effect on the amount of engine time used per voyage. Less engine use translates directly to less fuel use for the same number of ton-miles. The skill of the crew and their familiarity with both the ship and the waters they sail will only grow as the operation continues, which will be worth examining when data becomes available.

No economic analysis of the *Apollonia* has been undertaken, and is outside the scope of this study. Examining the economics of coastal and inland sail freighters will have to be made based on a vessel and route pairing to make the appropriate comparison. Fuel cost and trucking rates will also play a role in making such a comparison, both of which are quite volatile at this time.

Research with small sail freighters equipped with other engine types, such as electric motors powered by batteries, propeller regeneration, and solar charging systems is worth funding once such vessels are available for study. Their ecological footprint will be significantly different than *Apollonia*'s, and their engine use strategy could be far more intensive without increasing carbon emissions or other pollution. Vessel design is outside the scope of this paper, and these vessels have yet to be commissioned, making a comparison impossible at this time.

The complete effects of *Apollonia*'s operations are difficult to quantify, such as social impact. This could be measured in the lives prolonged by a lack of pollutants released in New York City, traditional skills learned, and educational moments which changed how people think of transportation, consumption, and waterways like the Hudson River and New York Harbor. These topics are outside the scope of this study.

CONCLUSION

Schooner *Apollonia*'s cargo and fuel use records from 2021 show that the ton-mile fuel efficiency of even a very small sail freighter is far higher than comparable trucking. Operational results show a fuel efficiency of 134.6 ton-miles per gallon of diesel fuel while operating at 21.5% tonnage intensity, as compared to an average of 70 tm/gal for US trucking overall. When compared to the 2½ ton box trucks she replaces, she has an advantage of 104.6 tm/gal at the same intensity against the truck at 100% intensity. If *Apollonia* were used at full CDWT capacity with current engine use patterns, she would give 626 tm/gal, 25% better than rail, nearly 21 times better than 2½ ton trucks, and just under 9 times more efficient than the US trucking average.

Due to the engine use strategy of the ship, considerable time was spent at anchor. Over 62 days of operations, 459 hours were spent underway, with 300.35 at anchor. Velocity Made good on Course (VMC) while under way ranged from 2.35-2.85 knots, while overall VMC including time at anchor was 1.578 knots.

The nature of navigation and winds on the Hudson River make these results applicable principally to this route and engine use pattern. Predominant winds force frequent tacking and jybing, and the slightly longer ebb tide makes southbound travel easier than northbound. It is clear that larger vessels will be more efficient, and other routes which require less docking and maneuvering under power will increase efficiency, making these figures a likely floor of fuel efficiency for inland and coastal sail freighters.

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Coastal And Inland Shipping In The Northeast US: A Plan For Expanding The Fleet And Zero Carbon Shipping.

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Any expansion of Sail Freight and sustainable maritime coastal shipping in the United States will need to be made within the next decade, and preferably in a rational manner with mutually supporting projects. Without a coherent plan around current cargo and passenger flows, and taking advantage of existing projects and bordering waters, the success of any new project is less probable. New sail freight endeavors which can use both mutual support networks and the published plan as part of their business case when seeking investors will have a significant advantage.

By ensuring a plan is laid out and publicized early, alongside supporting handbooks and training programs, there is a higher chance of overall success. Further, the carbon emission savings impact of mutually supporting maritime transport projects is likely to be more significant than a number of independent projects which are unable or unwilling to cooperate.

The proposed plan covers the US Coastline from Maine to the Delaware River, and inland waterways such as the New York Canal System, Great Lakes Exclusive. The proposed deployment of infrastructure uses established and published open-source designs, such as spud barge ports, or existing commercial or recreational infrastructure capable of handling small scale cargo operations. Scaled out through 2030, this plan gives the latest desirable date for each expansion, a preliminary look at the required types of vessels, capital expenses, and potential cargos for each portion of the operational theater. By expanding from the only region with an operational sail freighter, mutual support links are maintained. With this proposed plan sketched out, a coherent investment strategy can be developed for launching more vessels, creating the appropriate sailor training resources, and recruiting supporters such as maritime academies, community colleges, and cargo owners. Without this type of strategic planning, there is little chance for isolated projects to succeed on the scale necessary to capture a large volume of coastwise trade during the coming energy transition.

KEY WORDS: Sustainable Transportation; Sail Freight; Coastal Trade; Small Vessels; Energy Transition.

The only region of the US currently home to a sustainable maritime cargo initiative is the Hudson Valley with the Schooner *Apollonia*,[1] making this region the natural starting point for a national revival of sustainable maritime trade. This said, expansion of this trade should be encouraged in a particular sequence, specifically designed to maximize mutual support and thus economic survivability of the enterprises. Using small vessels and relatively short packet routes as the proving ground for solar, electric, and wind propulsion for coastal and inland maritime trade, this model also democratizes the fields of cargo transportation and energy,[2] and sheds a polytechnic (Mumford 1974)[3] outlook on transportation for the anthropocene. This is a plan which admits of participation by both professional sailors and amateurs interested in taking practical and immediate action to counter the climate crisis. To successfully scale to a large operation making a significant impact on climate forcing emissions in the northeast, there will have to be an eventual construction of dedicated larger vessels, professional crew trained and recruited, and some degree of professionalization, but this need not displace non-professional operations, especially on shorter routes from ports of aggregation that larger vessels will operate from. The ideal

[1] Only *Apollonia* is considered here for the simple reason that the actual sustainability and carbon intensity of maritime operations by Harbor Harvest has not undergone peer-reviewed evaluation. Until this is accomplished, their sustainability compared to other efforts remains in doubt, as they have published no figures on fuel consumption or impacts on their own.

[2] Energy Sovereignty is very rarely linked to sustainability, as Food Sovereignty is linked to food and social justice, but will become progressively more important as the energy transition continues. Food sovereignty for urban populations is effectively impossible without energy and transportation sovereignty to move the food from rural to urban regions. See: Pablo Cotarelo, David Llistar y Alfons Pérez, Àlex Guillamon, Maria Campuzano, And Lourdes Berdi. "Defining Energy Sovereignty" *El Ecologista, Ecologistas en Acción Magazine* nº 81, summer 2014 http://www.ecologistasenaccion.org

[3] For more information on polytechnics, see: Lewis Mumford. *The Pentagon Of Power: The Myth Of The Machine, vol two.* New York: Harcourt Brace Jovanovich, 1974

outcome from this plan over the next generation would be integration of maritime transport in the Northeast to the point it becomes integrated seamlessly into the lifeways of the region once again, with a lively small vessel fleet and a low environmental impact.

The specific benefits of coastal and canal trade under sail and using electric vessels has been explored elsewhere and will not be covered in detail here. Suffice it to say the reductions to carbon emissions, fuel demand, roadway congestion, noise pollution, air pollution, traffic casualties (Morency, Gauvin, Plante, Fournier, and Morency 2012), infrastructure-based emissions, and other hazards are significant, and if scaled could have a major impact on the carbon emissions, public health impacts, and economics of transportation in the Northeast (Woods and Merrett 2022). With roadway congestion costing 18.2 Billion dollars in the New York Metro Area alone in 2019, it can be plainly seen that removing vehicles reduces congestion, as 2020 resulted in a mere 11.2 Billion dollars under the effects of the COVID-19 Lockdowns (BTS 2023a). Further, the number of hours lost annually to congestion per commuter in the New York Metro Area dropped from 96 to 56 in the same period (BTS 2023b). This congestion wasted just short of 336 million gallons of fuel in 2019, with all the associated greenhouse gas, particulate, and noise emissions which go with this expenditure of fuel (BTS 2023c). The benefits for towns and cities in creating a climate resilient working waterfront are similarly discussed elsewhere, but are wide-ranging; economic, social, financial, and environmental benefits are to be found in resilient combined working and recreational waterfronts (Willner 2021). This plan aims to bring these benefits to the Northeast United States in an expanding and reliable manner over the coming years.

The boundaries of this plan are defined as the six New England States, New York, and New Jersey, Great Lakes Exclusive. Each of the Great Lakes needs their own sail freight plans, due to the complicating nature of the Canadian Border and the population centers along their shores. However, as these waterways link to those treated in this plan, there is reason to take care any developments in Lakes Erie and Ontario are coordinated with any action taken on this plan. For example, if a sail freight project were to start on Lake Erie before Lake Ontario, it would be wise to push for a connection to Buffalo before Oswego when the next opportunity for expansion presents itself. The same general rule applies to any developments in the Chesapeake Bay or other nearby regions.

It is apparent that small sail freighters are only economically viable on relatively short routes, and larger vessels with a better Tons-Per-Sailor ratio are needed for mid- to long-distance trade (Woods 2021). However, this plan concentrates mostly on short- to mid-distance trade where relatively low tons-per-sailor values are tolerable during initial stages of exploration and expansion. As volumes of trade increase and longer inter-regional links are made, larger vessels for long distance trade can be considered for addition to the fleet. It is assumed here that small groups may employ their own recreational vessels, as occurred during the 2022 Northeast Grain Race, to carry some freight, meaning not all the ships employed in the sustainable freight systems will be designed as freight vessels.

The use of varying electric canal vessels and sail freighters in different fleet districts will be required to access some ports. For example, the identified Sail Ports in this plan can be accessed by sail freighters or low-air-draft electric canal boats, while Steam Ports are effectively accessible only to canal boats because of bridges or other circumstances which make them unfavorable to sailing vessels (Koltz 1980). Various vessel plans have been identified as usable on these routes, including *Ceres*-Class sailing barges (Woods 2023), and designs by Derek Ellard (Ellard 2020), Tad Roberts (Tad Roberts Yacht Design n.d.), Bruce Roberts (Roberts n.d.), and TransTech Marine (Uttmark 2015), among other possibilities. Solar Sal vessels designed similarly to the Hudson River Maritime Museum's tour boat *Solaris* would be well suited to steel construction for unsupported cargo use in canals; a wood prototype was employed on the New York State Canal system in 2015 hauling 4 tons of cardboard over 300 miles.[4]

The plan as outlined with the appended list of ports will require at least 4 sail freighters and 1 canal vessel, though 4 Canal Vessels and 5 Sail Freighters would be a more reasonable minimum. The division of the plan into routes is the preferred means of determining capacity needs, with at least 10 packet routes as defined later in the paper. This is exclusive of long-distance fleets and interregional links which may be involved, such as the Transatlantic Fleet, currently involving Schooner *Grain de Sail* and soon the 3-masted Schooner *Vega* of Sail Cargo Inc.. Longer-distance coastal routes such as links to the Chesapeake Bay, Gulf of Mexico, or other locations along the coast are possible, but will only be viable once local networks are established in those areas. Any plans or progress which can be made to create independent regional networks like that outlined in this paper should be encouraged, and once they

[4] Conversation with Solar Sal Designer Dr. David Borton, 2022.

are established a concerted effort to establish at least an annual voyage to link the networks must be made.

Port infrastructure should be assumed to start with commercial marinas and public docks, evolving into Spud-Barge Depots as trade volume demands and capital becomes available. Described in detail in the *Sail Freight Handbook*, these barge depots can be self-supporting, easily deployed, and modularly chained together to create an appropriately sized depot for any protected location. With appropriate warehousing provided by on-barge sheds or intermodal containers, these depots can serve as an interim measure until permanent shoreside infrastructure is created, then moved to new locations as the trade network expands and the backlog of inland waterway and port infrastructure repairs are worked through (American Society Of Civil Engineers 2021). If they are found especially useful, the barge depots can be left in place as a permanent piece of infrastructure (Woods 2023: 141-170). To retain symmetrical terminology, facilities are classified using the Anchorage-Harbor-Port hierarchy used in the *Sail Freight Handbook*:

> Anchorages… are the most basic type of accommodation for shipping, and may be no more advanced than a sandy beach to pull a boat ashore safely. The classification also covers single quays and jetties, places where lightering can be accomplished easily from anchor...
>
> Harbors… are more developed than anchorages, and… normally have at least limited support services, such as warehousing, shipwrights, and shore gear for handling cargo, but can still be quite small and relatively undeveloped.
>
> Ports, on the other hand, have everything and are primarily based around maritime trade, as opposed to simply having the capability…. These are also the points normally associated with Customs offices, international and transoceanic trade, and other large scale maritime activities. (Woods 2023: 141)

Most Anchorages as indicated in this paper will rely on either public docks or commercial marinas as the sole infrastructure, while Harbors have the potential for shore gear, space, and additional support dedicated to cargo operations. Many Anchorages would qualify to be upgraded to Harbors after the installation of a barge depot. Ports require a major city and extensive support structures, including Customs Entry for connection to international sustainable maritime freight networks.

The business models and vessels for some of these trade routes have already been developed. Schooner *Apollonia* is actively creating trade routes along the Hudson River (Woods and Merrett 2022). TransTech Marine has developed a model for carrying wine and foodstuffs between the Finger Lakes and Long Island Sound (Uttmark 2015). The Vermont Sail Freight Project's temporary success at bringing Champlain Valley produce to New York City was fundamentally sound, though short lived due to a lack of human and financial resources (Woods 2021).

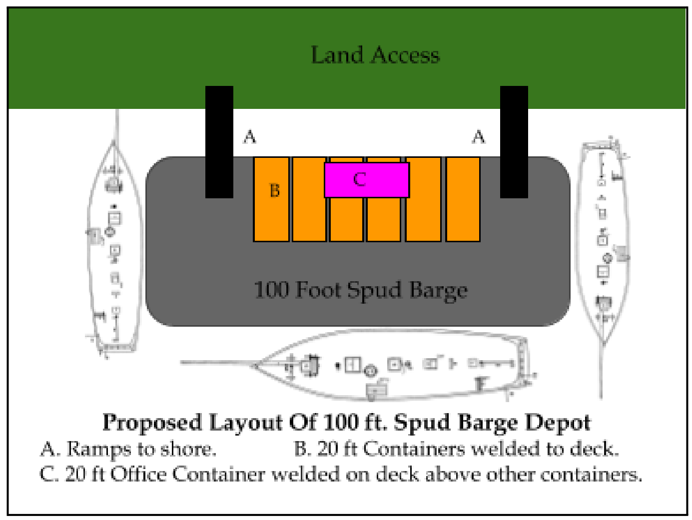

Figure 1: Proposed Spud Barge Layout as given in the *Sail Freighter Handbook*, Pp 169-170. CC BY-NC-ND 4.0.

The Logical Topology of the plan as outlined relies on the hub-and-spoke model illustrated in the *Sail Freight Handbook*, page 16. Each of the ports listed on the following tables will likely have its own feeder networks, and serve as aggregation points for other cargo on smaller vessels. Trunk Lines between the major ports using larger vessels at a relatively low frequency should be established only when volume becomes significant; early long-distance trade should be effected by down-the-line trading. Interlocking packet routes are assumed for all vessels and some vessels may be used on more than one route until trade volume makes further ship construction necessary.

Estimates for shipbuilding costs in steel have ranged from $300,000-2,500,000 for sail freighters, approximately $1,000,000 for solar-electric canal vessels, and up to $300,000 for barge depots. Each of the proposed steel vessels would be approximately 65 feet in length over all, and capable of carrying up to 30 tons of cargo. Small vessels for scouting routes could be built using the far less capital-intensive design of the Sailing Barge *Ceres* on well-protected canals and rivers, or refit recreational cruising sailboats offshore, neither of which should cost over 20% of the lowest estimate for new, purpose built vessels.

Recruiting and training sufficient sailors will also be a challenge; to not incorporate this element into the expansion plan is to prepare for failure at the first stage of expansion. Exclusive of longshore crews, brokers, sailmakers, shipwrights, chandlers, and other supporting trades, each canal vessel requires two crew, and each schooner requires four. For continuous operations, two alternating crews should be arranged, requiring four and eight people with the appropriate licenses and credentials per vessel type respectively. For the fully developed minimum plan outlined here, an absolute minimum of 40 sailors, at least 12 of whom are licensed master mariners, is required. An additional buffer of 50% should be added to deal with scheduling difficulties which will routinely arise. Incentives should be given to make cargo sailing more appealing than charter sailing on other tall ships or charter boats, and pay must be sufficient. In addition, training efforts should be taken seriously on the cargo vessels themselves, to ensure those who are interested in the field but have no experience are able to join it without paying massive sums for formal sail training. The more small vessels there are involved in this trade, the more sailors will be needed, inflating the need for good training programs for both knowledge and practical skill. Recruitment for future windjammer sailors must begin now so that a sufficient number can take over vessels as they are launched, and so they can begin to create these sustainable transportation businesses and projects elsewhere with whatever vessels and partners present themselves.

The following tables outline the existing infrastructure, potential support, and expansion priorities for sustainable maritime freight operations in the Northeast. A list of ports has been identified as important to developing regional trade in the Northeast. As current Sail and Sustainable Maritime Freight projects and attention are focused in and around the Hudson Valley (Schooner Apollonia 2023) and Long Island Sound (Harbor Harvest 2023) this plan assumes infrastructure and further projects should be designed to support and intermesh with these developments as much as possible. Some of the locations identified have further spur routes from their local area which will generally be less than a day's sailing and can be served entirely on inland waters, as mentioned in the Notes column. Ports identified as Sail and Steam Ports are major intersections of open water and sailing systems. Ports to develop are given in rough priority order; those already in service in Italics.

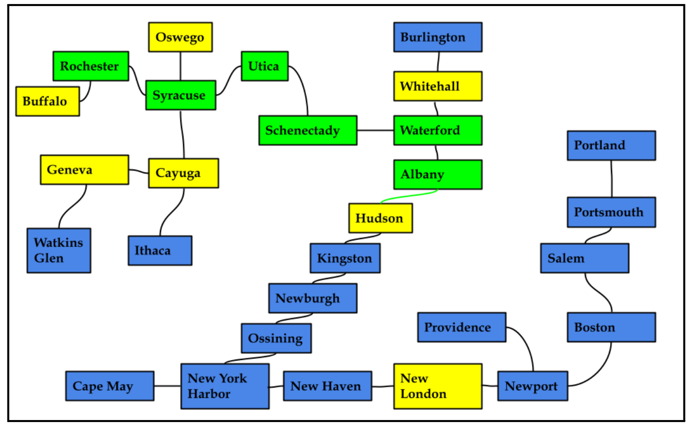

Figure 2: Schematic Diagram of Northeast Maritime Freight Network.

There are a number of organizations which may be willing to support the expansion of Sail and Sustainable Maritime Freight in the Northeast (See Appendix C). The appended table is exclusive of those cargo owners actively shipping their products with Schooner *Apollonia*. Organizations and institutions such as MARAD and other similar State and Federal programs are not enumerated here as both redundant and thus far completely unhelpful in establishing or expanding sustainable small scale shipping operations. Those organizations already giving active support to *Apollonia* are noted, as are those which supported other sail freight endeavors in the past. Shipyards have not been included in these tables, but alongside marinas will be critical to effectively expanding the sustainable cargo fleet.

These ports and organizations will be used to support minimum fleets on 10 identified packet routes, many of which link to each other. Tramp vessels have not been incorporated into this plan or analysis as they have not proved economically viable with small vessels in the past. If there are sufficient free days for vessels involved in regular packet runs, some tramping operations may be possible as a form of additional revenue and activity, but should not be relied upon in the short- or mid-term revival of zero-carbon coastal trade. It should be possible to use the packet arrangements outlined above to establish minimum linking services in early developmental stages of this system. Where possible, depots should be concentrated around the interfaces between packet routes, and routes should only be grown out one link at a time so as to have the longest distance chain possible for down-the-line trade.

It is worth noting that the list of ports given in Appendix A and B is not exhaustive, and only covers the major nodes of such a network. For example, a vessel operating on the Narragansett Bay route may call at Fall River, New Bedford, Little Compton, Martha's Vineyard, and East Hampton. Overlap between packets may also occur at more than designated nodes, though the targeted nodes will most likely be the first to receive additional infrastructure. An example of this would be Erie Canal packets going as far as Albany or Hudson to transfer cargo instead of at Waterford; this can be helpful in reducing labor requirements for transferring breakbulk cargo. However, this must be managed carefully in early stages of establishing trade so as not to create competition where cooperation should be the rule.

Clearly, the fleet outlined in the appended tables (Appendix C) will need to be matched to shipping volume and sailing frequency; by keeping vessels in constant use very few will be required in the early stages of this project. With any luck, trade volume will be sufficient to drive fleet numbers higher, though this cannot be guaranteed in initial stages for every packet line. In some of the exploratory stages for each route *Runcible Spoon*-esque (Boykett 2022) uninspected cargo vessels may be the least expensive and most useful way to make the expansion; these vessels can then be re-assigned as needed to scout the next route. If necessary, they can remain in place to act as feeder vessels to the major ports, especially where the small vessels are part of a local Farmer's Ships or Community Supported Shipping initiative.

Where local sustainable maritime shipping movements present themselves, these should be supported even if it requires modifying previous plans. For example, if a Gulf of Maine or Lake Champlain sail freight project forms before expansion is made into the Erie Canal, expansions to link to these projects should be prioritized over Erie Canal expansion. This would mean either moving into Long Island Sound or the Champlain Canal before the Erie canal is developed. Where possible in early stages, small steps should be encouraged, such as connecting the Hudson Valley to the Erie Canal as far as Utica, for example. Once these links are consolidated, the packet can expand out along its planned route as far as cargos present themselves. The steps to expansion in the tables above are guidelines given with the latest desirable date for each occurrence; faster progress is not to be avoided if circumstances permit. Advantage should be taken of the 200th anniversary of the Erie Canal's opening, and the 8-year 250th anniversary of the American Revolution to use historic commemorations and grant funding to assist in expanding sustainable cargo operations, even if this requires some concessions be made to using historically patterned vessels in initial stages of expansion. The proof-of-concept work, trade relationships, and market creation which can be part of such commemorative events will at the very least lay the foundation for more permanent and modern operations in the years following. Hiring replica ships for cargo operations in addition to their public history mission may be possible, and can bring more vessels into the fleet at least on a tramping model for the proof-of-concept and reconnaissance phases.

Further research remains to be done for these plans. Lists of interested cargo owners, additional supporting organizations, funded research opportunities for university departments, and designing suitable cargo vessels all need to be accomplished for this plan to have a solid shot at success. Some of these elements have been accomplished already, but must be prioritized. Small-scale pilot projects, even on as little as an annual-voyage basis using improvised vessels, should be established in regions with a short link to the existing theater of operations in the Hudson Valley, such as Lake Champlain and Long Island Sound, to prepare the ground for later operations. Similar regional plans for the Chesapeake Bay, Gulf of Mexico, each of the Great Lakes, and possibly other regions should be made, with the express purpose of creating similar networks in those areas which can be connected at a later date.

A directory of interested cargo owners, supporters, and businesses should be built for the region, with the object of identifying where small pilot projects are likely to succeed. For example, if sufficient support can be found ranging from Boston to Northern Maine, a new Maine Sail Freight Project should be established immediately for at least annual voyages. By taking the time to create an open list of supporters, other projects can more quickly evaluate their prospects and build business plans to secure financing, a serious obstacle to getting any sail freight venture off the dock. Creating Open Letters of Intent or Pledges for businesses along each packet route to sign, declaring a willingness to ship by sustainable maritime means if a critical mass of, say, more than twelve businesses sign on to the letter, would be a significant development and assist in creating many smaller maritime freight projects. Special attention should be paid to recruiting marinas, city docks, boat clubs, food co-ops, local businesses, farmers, and small producers in each area.

As previously expressed, leaving sustainable maritime coastal trade to grow organically is unlikely to succeed in the time remaining to decarbonize the economy, at a level capable of taking up the slack from trucks and trains rendered inoperable by energy shortages. By establishing and openly publishing expansion plans, a mutually-supporting business model can be encouraged regionally, while spurring others to form their own plans and take action toward building this critical re-emerging industry. Without cooperation and mutual aid among vessels in the initial stages of re-establishment, however, there is little hope for a lively sail freight sector in the Northeast US or anywhere else; planning expansions to match both demand and ability to give mutual support is a good way to ensure success for all.

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APPENDIX A: IDENTIFIED SAIL PORTS, NORTHEASTERN UNITED STATES:

Facilities: A=Anchorage; H=Harbor; P=Port. Cargo Capabilities: B: Breakbulk; P: Palletized; C: Containerized

Location	**Draft**	**Air Draft**	**Facilities**			**Cargo**			**Notes**
			A	**H**	**P**	**B**	**P**	**C**	
Kingston, NY	16	50	X	X		Y	P		First experimentation with Barge Depots made here in 2023.
Hudson, NY	10	---	X	X		Y	P		Air Draft dictated by Hudson River Bridges.
Ossining, NY	6	---	X			Y			Low tide depth is problematic for many vessels.
Poughkeepsie, NY	16	---	X			Y			
Newburgh, NY	30	---	X			Y	P		
Tarrytown, NY	9	---	X			Y			
Carteret, NJ	9	---	X	X		Y	P		There is one lift bridge on the Arthur Kill which closes twice daily.
Albany, NY	12	21	X	X		Y	P	P	Air Draft must pass under multiple Bridges, one low turn bridge.
Troy, NY	12	24	X			Y			One drawbridge involved which could slow travel significantly.
RETI Barge, Red Hook, NYC	22	---	X	X	X	Y	P		Prototypical Barge Depot. Trunk Line to Boston.
Burlington, VT	15	---	X	X		Y	P		
New Haven, CT	13	62	X			Y	P		Air draft with lift bridge up.
New London, CT	15	---	X	X		Y	P		Aggregation to Mystic, New Haven.
Newport, RI	12	---	X	X	X	Y	P	P	Aggregation Point to Providence, Fall River, Martha's Vineyard, Montauk.
Port Henry, NY	11	---	X			Y			Aggregation Point for West Coast of Lake Champlain.
Oswego, NY	12	-/15	X	X		Y	P	P	Oswego Canal has same restrictions as Erie Canal: 12ft draft/15ft Air Draft. Aggregation point for Lake Ontario.
Boston, MA	17	---	X	X	X	Y	P	P	Principal Destination of NH and Maine Cargos. Trunk Line to NYC.
Portland, ME	9	55	X	X		Y	P		Aggregation Point for Down East Maine harbors. Berths before bridge.
Portsmouth, NH	8	---	X	X		Y	P		Lift Bridge in harbor. Depth given for public docks, channel depth 35 ft.
Ithaca, NY	8	---	X	X		Y	P		
Cayuga, NY	12	-/15	X			Y			Air Draft in Seneca lake unrestricted; 15 ft in canals. Aggregation Point for Seneca and Cayuga Lakes..

Notes: Facilities indicated as in *Sail Freighter Handbook*. Draft and Air Draft in feet, over 100 ft indicated by "---" UNK indicates unknown value. Cargo Type Capabilities, Y=Yes; N=Not Practicable; P=Possible.

APPENDIX A: IDENTIFIED SAIL PORTS, NORTHEASTERN UNITED STATES, CON'T:

Facilities: A=Anchorage; H=Harbor; P=Port. Cargo Capabilities: B: Breakbulk; P: Palletized; C: Containerized

Location	Draft	Air Draft	Facilities			Cargo			Notes
			A	H	P	B	P	C	
Cape May, NJ	8	---	X			Y	P		
Providence, RI	14	-/35	X			Y	P		Berths may be available before fixed bridge.
Salem, MA	21	---	X			Y			Beverly Harbor Inclusive.
Gloucester, MA	16	---	X			Y			
Bath, ME	19	70	X			Y			Lift bridge present in harbor.
Newburyport, MA	9	---	X			Y			
Sandwich, MA	8	---	X			Y			

Notes: Facilities indicated as in *Sail Freighter Handbook*. Draft and Air Draft in feet, over 100 ft indicated by "---" UNK indicates unknown value. Cargo Type Capabilities, Y=Yes; N=Not Practicable; P=Possible.

APPENDIX B: IDENTIFIED STEAM PORTS, NORTHEASTERN UNITED STATES:

Facilities: A=Anchorage; H=Harbor; P=Port. Cargo Capabilities: B: Breakbulk; P: Palletized; C: Containerized

Location	Draft	Air Draft	Facilities			Cargo			Notes
			A	H	P	B	P	C	
Troy, NY	12	15	X			Y	P		One drawbridge involved which could slow travel significantly.
Whitehall, NY	12	15	X			Y	P		Aggregation Point for Lake Champlain Basin.
Waterford, NY	12	15	X			Y	P		Junction of Erie and Champlain Canals.
Schenectady, NY	12	15	X			Y	P		
Utica, NY	12	15	X			Y	P		Mid Central New York Aggregation Point.
Syracuse, NY	12	15	X	X		Y	P		Initial Western Aggregation Point. Juncture of Oswego Canal.
Finger Lakes, NY	12	-/15	X			Y			Air Draft in the lakes is unrestricted; 15 ft in canals. Seneca and Cayuga lakes inclusive.
Oswego, NY	12	15	X	X		Y	P	P	Oswego Canal has same restrictions as Erie Canal: 12ft draft/15ft Air Draft. Aggregation point for Lake Ontario.
Rochester, NY	12	15	X	X		Y	P	P	
Buffalo, NY	12	15	X	X		Y	P	P	Access point to Lake Erie.
Cayuga, NY	12	-/15	X			Y	P		Air Draft in the lakes in unrestricted; 15 ft in canals. Aggregation for Seneca and Cayuga Lakes inclusive.
Norwich, CT	20	75	X			Y			Subsidiary to New London Sail Port.
Hartford CT	12	81	X			Y			Subsidiary to New London Sail Port.
Camden, NJ	16	---	X			Y			Subsidiary to Cape May Sail Port.
Ocean City, NJ	8	15	X			Y			Subsidiary to Cape May Sail Port. One swing bridge inland route.

Notes: Facilities indicated as in *Sail Freighter Handbook*. Draft and Air Draft in feet, over 100 ft indicated by "---" UNK indicates unknown value. Cargo Type Capabilities, Y=Yes; N=Not Practicable; P=Possible.

APPENDIX C: POTENTIAL SUPPORTING ORGANIZATIONS

Support Types: $= Financial; L= Logistical; T=Training; O= Other. N= None; P= Possible; Y=Yes.

Organization	Location	Support				Notes
		$	**L**	T	**O**	
Center For Post Carbon Logistics	Kingston, NY	P	Y	Y	Y	The CPCL a driving force for sustainable maritime shipping in the US over past 3 yrs.
Hudson River Maritime Museum	Kingston, NY	N	Y	Y	Y	Currently Supports *Apollonia* and has Sail Freight Exhibit.
South Street Seaport Museum	NYC, NY	N	Y	P	Y	SSSP Already provides docking.
Mystic Seaport Museum	Mystic, CT	N	P	P	P	
The Gundalow Company	Portsmouth, NH	N	P	P	P	Previously expressed interest in Northeast Grain Race.
Lake Champlain Maritime Museum	Vergennes, VT	N	P	N	P	Supported VSFP.
Erie Canal Museum	Syracuse, NY	N	P	N	P	
SUNY Buffalo Sustainable Transportation Graduate Program	Buffalo, NY	P	P	N	P	Research funding may be available.
UVM Sustainable Development Graduate Program	Burlington, VT	P	P	N	P	Linked to Civil Eng prog/ NIST. Research funds possible.
Nat Inst For Sustainable Transportation	UC Davis, CA	P	N	N	P	Research funds possible.
Northeast Grainshed Alliance	Northeast Region	N	P	N	P	The NGA participated in the 2022 Northeast Grain Race.
The Greenhorns	Northeast Region.	P	P	N	P	Supported VSFP, Maine Sail Freight Project.
Tall Ships America	Newport, RI	N	N	Y	P	
U. WA Grad. Prog. Sustainable Transport	WA	P	N	N	P	Research funds possible.
International Windship Association	UK	N	N	P	Y	Advocacy, Policy, and Advertising support.
Grain de Sail	France	P	N	N	Y	Met *Apollonia* in New York.
WindSupport NYC	NYC	P	P	P	Y	
American Sailing Association	National	N	N	Y	P	
US Sailing	National	N	N	Y	P	
Nat. Working Waterfront Network	National	N	P	P	P	Port design and implementation support possible.
Future Of Small Cities Institute	Troy, NY	N	P	N	P	Supports *Apollonia*'s Operations.
Transportation Sust. Research Ctr	UC Berkeley	P	N	N	P	Research funding possible.
Cycling Logistics Association	New York	P	P	N	P	Zero-carbon last mile networks.
Sustainable Transport Council	National	P	P	P	P	

APPENDIX D: SUGGESTED PACKET ROUTES:

Packet Name	Covered Ports Of Call
Hudson River Sail	Hudson-Kingston-Poughkeepsie-Newburgh-Ossining-Tarrytown-New York
Hudson River Electric	Hudson-Albany-Troy-Waterford-Whitehall
Erie Canal	Waterford-Schenectady-Utica-Syracuse-Rochester-Buffalo
Oswego Canal	Syracuse-Oswego
Finger Lakes	Syracuse-Cayuga Lake-Ithaca-Seneca Lake-Watkins Glenn-Geneva
Narragansett Bay	Newport-Providence-Fall River-Martha's Vineyard
Gulf Of Maine	Bath-Portland-Portsmouth-Newburyport-Gloucester-Salem-Boston
Lake Champlain	Whitehall-Port Henry-Burlington
Long Island	New York-New Haven-New London-Newport
New Jersey	New York-Carteret-Ocean City-Cape May-Camden

APPENDIX E: INTERESTED PARTIES FROM 2022-2023 NORTHEAST GRAIN RACE PLANNING

Party	Location	Cargo Source	Notes
Schooner Ardelle	Gloucester, MA	N/A	Interested in Sail Freighting.
Blue Ox Malt House	Lisbon Falls, ME	(Producer)	
Short Path Distillery	Everett, MA	Lisbon Falls, ME	Looked for 1 ton of Malt for special edition liquor.
New York Cider Co	Ithaca, NY	(Producer)	Ships Cider to Brooklyn.
The Gundalow Company	Portsmouth, NH	N/A	Interested in Sail Freighting
Schenectady Distilling Co	Schenectady, NY	(Producer)	Shipping Whiskey to NYC.

N.B.: Direct participants via *Apollonia* and *Solar Sal* Exclusive. All these participants had the potential and connections to draw in additional participants within their networks, though efforts to organize a cargo between Bath, ME and Boston, MA were not successful for a number of reasons.

APPENDIX F: EXPANSION PLAN BY YEAR THROUGH 2030

Year	Expansion	Notes
2024	1. Barge Depot installed, Kingston. 2. Andrus Fellowship funded yearly. 3. Solidify backhaul cargo flows. 4. Expand existing cargo flows. 5. Explore Long Island Sound Cargo.	Requires 1 Schooner, already in service. Hudson River Sail Packet in service since 2020.
2025	1. Permanent Captains Hired. 2. Depot Established in Hudson. 3. Explore canal E. of Utica/S. of Whitehall. 4. Use existing solar boats on canals. 5. Create social events around all port calls. 6. Establish Hudson River Electric Packet.	Requires 1 Schooner, 1 Canal Boat. Existing Solar Boats may be hired from Solar Sal Boats for the next few years. Bicentennial of Erie Canal Opening.
2026	1. Depot In New York Harbor. 2. Depot In Waterford, NY. 3. Solar Freighter Under Construction. 4. Establish Erie Canal Packet to Utica. 5. Establish formal brokerage firm. 6. Create Annual Long Island Run.	Requires 1 Schooner, 1 Canal Boat. Integration of Transatlantic networks should be initiated via NY Harbor. Zero-Carbon Last-Mile transport at all ports.
2027	1. Depot Established Ossining. 2. Canal Traffic to Finger Lakes. 3. Establish Long Island Packet. 4. Create Annual Gulf Of Maine Run.	Requires 2 Schooners, 1 Canal Boat. Consider hiring commercial schooner for Gulf Of Maine experimental runs.
2028	1. Depot Established Whitehall 2. Establish Lake Champlain Packet 3. Establish New Jersey Packet. 4. Expand Canal Traffic to Rochester. 5. Establish Narraganset Bay Packet.	Requires 3 Schooners, 1 Canal Boat. Initial Explorations for Boston-NYC Trunk Line around Cape Cod.
2029	1. Depot Established Ithaca. 2. Expand Canal Traffic to Buffalo. 3. Establish Finger Lakes Packet. 4. Establish Depot: Newport. 5. Establish Depot: Syracuse.	Requires 3 Schooners, 2 Canal Boats. Finger Lakes packet requires 2 small sailboats and 1 canal boat. Canal service provided by Syracuse-Oswego Packet Boat.
2030	1. Depot Established Buffalo. 2. Establish Oswego Packet. 3. Establish Gulf of Maine Packet. 4. Establish Depots: New London, Portland.	Requires 4 Schooners, 2 Canal Boats. Explore Great Lakes Cargo Opportunities. Initial Exploration of Chesapeake Bay Trunk Line via Canal.

Economic Viability Of Small Sail Freighters In The US Coastal Trade.

Steven Woods

Abstract: There is a reasonable amount of doubt in the overdeveloped world's maritime sector about the economic viability of small sail freighters in coastal trade. With relatively large crews for small tonnage capacities over long range as is typical for conventional maritime trade, this is of course a bad arrangement for profitability. However, in comparison to trucks along a congested road corridor in a coastal trading role, these small sail freighters are found to be viable on most routes. This study examines the viability question for eight routes in comparison to trucking, using available information about US trade to create Pro Forma financial statements based on each route. It is found that on select routes even vessels as small as 15 Gross Register Tons are economically viable if they can be kept full and down and major expenses such as insurance controlled. Additional analysis of the model's limitations is included, with financial statements appended.

Keywords: Wind Propulsion; Short Sea Shipping; Sustainable Transportation; Economic Decoupling; Economic Degrowth.

INTRODUCTION

At the 2023 Sustainability In Ship Design and Operation Conference at Webb Institute and the US Merchant Marine Academy, the author presented a paper on the need for a set of open source sail freighters ranging in size from 15 to 100 Gross Register Tons.[1] While there was some enthusiasm for the vessels, and the idea that an owner-operator could take on the world of maritime freight transportation without millions of dollars in capital behind them, there was well-founded doubt as to the vessel's economic viability for maritime trade.

These vessels certainly go against current wisdom in the maritime industry: They are small and cannot take on long distance trade. Conventional economic studies look at minimum distances for wind propulsion to be viable, and deal with vessels three or more orders of magnitude larger than those examined in this paper.[2] Skepticism is natural when looking at a comparison to other ships, but this is not the mode of transport against which small coastal sail freighters will compete: They will be in competition against trucks and trains, but mostly trucks in the US. This means on differing routes there are higher levels of revenue available on certain routes, especially where roadways are congested and there are large amounts of cargo moving. In the Northeast US, this is a considerable stretch from Boston, MA to Richmond, VA along the coast, with many of the urban centers accessible from the water. This environment is ideal for adopting a revived coastal trade, especially as the Northeast Region begins to look at climate adaptation seriously.

In conversations with Capt. Geoff Beorne of the sail freighter *Lo Entropy*, it became clear that smaller vessels will be viable only over shorter routes, making a large number of

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[1] Woods, Steven. "A Service-Pattern Sail Freighter: The Need For A Scalable Open-Source Sail Freighter Design." *Proceedings of the Sustainability In Ship Design and Operation Conference 2023, 6-7 Nov 2023, Glen Cove and King's Point NY.* King's Point: Journal Of Merchant Ship Wind Energy, 2023. https://www.researchgate.net/publication/375184586

[2] Perez, S; Guan, C; Mesaros, A; Talay, A, "Economic Viability of bulk cargo merchant sailing vessels" *Journal of Merchant Ship Wind Energy,* 17 August 2021. https://www.jmwe.org/uploads/1/0/6/4/106473271/jmwe_17_august_2021.pdf

voyages annually. This idea helped form the model shown in this paper, alongside ideas already developed in my Master's Thesis.[3] By combining these ideas with evidence gathered in working with Schooner *Apollonia* in 2022, along with some financial estimates, the economic grounds for these vessels can be established.

This short paper seeks to show several possible routes in the Northeast US which would be economically viable for these vessels, as outlined in the plan also presented at SISDO 2023.[4] Not all routes will be viable when competing directly against trucking, but there are other elements to bring into play: if carbon levies are raised, or the social cost of carbon is brought to the fore in infrastructure and new development debates, the majority of these sail freighters suddenly become extremely worthwhile simply due to the direct emissions from trucking they displace.

The methods of this paper can be applied to other routes outside the Northeast US, whether they be in the Chesapeake Bay, Great Lakes, Caribbean, Aegean, Pacific, or Scandinavia. While units of currency may change, and rates of pay or insurance differ, by simply plugging in the required data

ECONOMIC MODEL ASSUMPTIONS

The assumptions used in this paper are designed to make as difficult a case for these vessels as possible. For example, the crew is paid $200 per day per sailor for all sailing days of the year, and port fees are kept at $3 per foot per day, a relatively high average for most marinas in the Northeast. Engine use strategies are universally set to "Emergency and Docking," using diesel engines, meaning the fuel cost estimates are assuredly excessive compared to reality in operation.[5]

Construction costs were roughly estimated and may not be accurate, but should be slightly over estimated for all vessels. Woods' thesis price of the Electric Clipper 64 was projected at about $1,000,000 for a 50-ish GRT vessel. The same applied to the EC110 which is about 130 GRT (simplified measure) was costed at about 1.9 million dollars. Insurance costs and maintenance cost are set at 10% of the vessel's construction cost estimate, which still furnishes a rather large sum on all vessels. Revenue estimates are kept deliberately low by excluding secondary forms of revenue such as passengers, trainees, co-branded products, or any other combination of revenue streams and reliance is placed entirely on fares for cargo. The number of voyages was likewise kept to a lower end of the reasonable possible range to minimize revenue predictions. Interest on ship's financing is not included, nor is the sale of stock.

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[3] Woods, Steven. "Sail Freight Revival: Methods of calculating fleet, labor, and cargo needs for supplying cities by sail." Master's Thesis. Prescott College, 2021. www.researchgate.net/publication/354841970

[4] Woods, Steven. "Coastal And Inland Shipping In The Northeast US: A Plan For Expanding The Fleet And Zero Carbon Shipping." *Proceedings of the Sustainability In Ship Design and Operation Conference 2023, 6-7 Nov 2023, Glen Cove and King's Point NY.* King's Point: Journal Of Merchant Ship Wind Energy, 2023. www.researchgate.net/publication/375184736

[5] Schooner *Apollonia* uses their engines less than 4% of hours underway, making one hour per day of sailing a reasonable level to expect. However, longer routes with fewer stops have a tendency to reduce overall engine use, making these numbers assuredly overstatements. SEE: Woods, Steven, and Sam Merrett. "Operation of a sail freighter on the Hudson River: Schooner Apollonia in 2021" *Journal of Merchant Ship Wind Energy*, 2 March 2022. www.researchgate.net/publication/358971392

TABLE 1: ECONOMIC MODEL ASSUMPTIONS

Assumption	OSSF 15	OSSF 25	OSSF 50	OSSF 100	Notes
Port Charges per day	135	180	216	285	$3 per ft per day
Insurance	10%	10%	10%	10%	
Maintenance	10%	10%	10%	10%	
Fuel per day	4 gal	4 gal	4 gal	4 gal	At $5/gallon
Crew strength	2	4	6	6	
Crew expense per day	400	800	1200	1200	$200/sailor/day
Winter Storage	2000	3000	-	-	$50/ft
Marina Slip	4000	6000	-	-	$100/ft
Pallet Capacity	7.5	15	35	70	64 ft^3 per pallet
CDWT	7.5	15	35	70	
Construction Cost	500,000	750,000	1,000,000	2,000,000	
Length Over Spars	45	60	72	95	For docking fees
Provisioning	25	25	25	25	Per Sailor-day
Cargo Handling Time	1 hour	2 hours	4 hours	1 day	

Canal Wherrys are always booked at only 2 crew, and have a limited season of 180 days assigned to them. Due to the seasonal nature of these vessels, winter storage is included in expenses at $50 per foot. Hybrid or electric propulsion is assumed for these vessels with a diesel backup generator, keeping fuel expenses and carbon emissions as low as possible.

The choice of ten percent for insurance and maintenance cost of the vessels is informed by both past precedents and reasonable mathematics. The Vermont Sail Freight Project's boat *Ceres* paid approximately $3,200 on a boat which cost some $20,000 to build using a large amount of volunteer labor, which likely doubled the vessel's construction cost.[6] Maintenance costs at ten percent give a generous amount of funding for replacement parts and some savings for paint and new sails as needed, but may be higher than necessary for most vessels, leaving more money available for insurance. Port fees may well be kept below the totals gives here through long term contracts or other means.

PACKET ROUTE PARTICULARS

Several packet runs were explored using a proprietary financial calculator. Eight routes, all part of the published Northeast Sail Freight Expansion Plan through 2030, are

[6] Andrus, Erik. "Vermont Sail Freight Project." Accessed 9 October, 2020. https://vermontsailfreightproject.wordpress.com/.

plotted below.[7] All sailing is assumed at 100 nautical miles per day on average; routes assumed are only between two ports for simplicity, but a longer route with more stops is a reasonable business model. Sailing distances were taken from available official publications for each route involved.[8] Each voyage is a one-way trip, with a second voyage returning the vessel to the port of origin.

Portland-Boston: 100 sailing miles, 1 day sailing, 320 voyages per year, 107 truck miles.

Boston-New York: 400 sailing miles; 4 days sailing, 85 voyages per year, 216 truck miles.

New York-Cape May: 128 Nautical miles, 2 days sailing, 180 voyages per year, 158 truck miles.

New Haven-Port Jefferson: 23 sailing miles, 1 day sailing, 350 voyages per year, 117 truck miles. Marina Slip on both sides.

Newport-Martha's Vineyard: 45 sailing miles, 1 sailing day, 350 voyages, 45 trucking miles.

Newport-Block Island: 26 sailing miles, 1 day sailing, 350 Voyages per year, 40 Trucking Miles.

Buffalo-Albany via Erie Canal (Seasonal): 363 miles, 5 days sailing, 36 voyages per year, 288 truck miles.

Burlington-New York via Champlain Canal (Seasonal): 267 miles, 5 days sailing, 36 voyages, 298 truck miles.

There are some limitations to a few of these routes. For example, the island of Martha's Vineyard currently has a monopoly for transportation of freight to the island in the form of the Steamboat Authority, which provides licenses to other operators. These expenses are not included here, and will add some cost to the routes in these cases. As mentioned above, for seasonal routes a winter storage fee is included, and the number of voyages possible is reduced significantly. For routes with extremely frequent voyages, the cost of two permanent slips is used as opposed to normal port fees, as this is significantly more cost effective than paying commercial wharf expenses twice daily. This increases profit margins significantly, but at higher levels of earnings is not necessary to meeting a ten year payback period.

Other routes may well be viable for these vessel outside the Northeast US. The Chesapeake Bay offers a number of good routes which are work exploring with this methodology connecting farms on the Delmarva peninsula to the mainland. Miami to San Juan Puerto Rico may likewise prove profitable using an OSSF 100, and supplying the Florida Keys from Tampa Bay may also be viable. Deploying these vessels, especially the

[7] Woods. "Coastal And Inland Shipping In The Northeast US"
[8] United States Department of Commerce. *Distances between United States Ports.* 13th ed. Washington DC: US Department of Commerce, 2019. nauticalcharts.noaa.gov/publications/docs/distances.pdf

larger variants, in Hawaiian waters seems intuitive and immediately profitable. The Caribbean countries could see a large advantage by implementing these vessels due to fuel costs and climate concerns, as well as the absolute necessity of waterborne transport to their economies. In addition, most small island states in the Pacific may be able to adapt these designs to their own circumstances and conditions.

CARGO DESCRIPTION AND TRUCKING PRICES

The cargo for this exercise is assumed to be non-hazardous pallets of one short ton, requiring 64 ft^3 each. Longshore fees of $20/pallet are included for each end of the voyage's loading and unloading, which using ship's gear and ship's crew would seem reasonable. The vessel is assumed to be full and down, or nearly so, for all routes unless noted otherwise.

For a meaningful comparison of freight rates in the region, estimates were gathered from www.Freightquote.com for the example pallet by less-than truck load (LTL) on each route.[9] Generic addresses close to the docks were used for pickup and dropoff locations for every route, with business and no other special services needed. Lowest price was always taken, and the pickup was scheduled for 4 days out. The prices per pallet on the routes chosen were rounded to the nearest dollar and are given below with the approximate cost per ton-mile for the route:

Portland-Boston:	$ 222	($2.07 /ton-mile)
Boston-New York:	$ 521	($2.41 /ton-mile)
New York-Cape May:	$ 285	($1.80 /ton-mile)
New Haven-Port Jefferson:	$ 280	($2.39 /ton-mile)
Newport-Martha's Vineyard:	$ 738	($16.40 /ton-mile)
Newport-Block Island:	$ 130	($3.25 /ton-mile)
Buffalo-Albany:	$ 192	($0.66 /ton-mile)
Burlington-New York:	$ 470	($1.58 /ton-mile)

The differences between the US Average Trucking Ton-Mile Revenue and Pallet Rates were considerable, as the Bureau of Transport Statistics gives an average rate of about 25 cents.[10] Unsurprisingly, none of the vessels examined here were viable on any route using this rate for freight revenue.

RESULTS

A vessel was considered viable on a given route if the total profits after 10 years were positive at a given percentage of cargo capacity used. This result was accomplished by simply dividing the net revenue from year one by the net revenue from year two, which is considered a normal operating year. It is assumed that the vessel keeps the same cargo space usage for each voyage during this 10 year span, making the probability of clearing the debts in less than 10 years relatively high on some routes. This is in holding with the

[9] www.freightquote.com accessed 16 December 2023.
[10] BTS "Table 3-21: Average Freight Revenue Per Ton-Mile." *National Transportation Statistics*. Washington: Bureau of Transport Statistics, 2023
www.bts.gov/content/average-freight-revenue-ton-mile

aforementioned most difficult model to overcome for viability, and the challenges set into the model as explained above should be noted as continuing for all years examined.

Since the trucking rates on all routes were considerably higher than the average cents per ton-mile figure given by the BTS, especially on the Newport-Martha's Vineyard run, the number of voyages is manageable for at least the two larger vessels in all but one case: The Erie Canal's rate was insufficient for any vessel to break even within the possible 36 voyages. The average percentage of cargo space used varies from as low as 12% to as high as 91% depending on the route and vessel combination. The Newport-Martha's Vineyard run unsurprisingly had the smallest percentage requirement, with Burlington-New York having the highest figure across all vessels. The Appendixes include pro forma financial statements for each route, with each vessel.

TABLE 2: VIABILITY BY FREIGHTER CAPACITY AND ROUTE

ROUTE	OSSF 15	OSSF 25	OSSF 50	OSSF 100
Portland-Boston	83%	73%	51%	41%
Boston-New York	~~F&D~~	91%	59%	43%
New York-Cape May	~~F&D~~	90%	60%	46%
Port Jefferson-New Haven	58%	52%	38%	31%
Newport-Martha's Vineyard	22%	20%	15%	12%
Newport-Block Island	~~F&D~~	~~F&D~~	81%	65%
Buffalo-Albany via Erie Canal	~~F&D~~	~~F&D~~	~~F&D~~	~~F&D~~
Burlington-New York via Champlain Canal	~~F&D~~	~~F&D~~	81%	71%

Notes: Non-viable routes are ~~struck through.~~

Aside from economic viability, the effects on carbon emissions are an important aspect of this exercise. Each vessel can move a certain number of ton-miles of cargo per season, using the maximum number of voyages for each route given above and their cargo capacity. The formula for this model has been simplified by assuming that fuel consumption is uniform per day, and all trucking is clocked at the US Average of 107.5 g co2/tkm (.0006 tonnes per ton mile).[11]

$$(Voyages \times Pallets \times Trucking\ Miles \times 0.0006\ t\ CO2) - (Gal\ Fuel \times sailing\ days \times 0.01\ t\ co2)$$

TABLE 3: ANNUAL EMISSIONS IMPACT BY ROUTE IN METRIC TONS CO2

ROUTE	OSSF 15	OSSF 25	OSSF 50	OSSF 100

[11] Energy Information Administration. "Carbon Dioxide Emissions Coefficients." https://www.eia.gov/environment/emissions/co2_vol_mass.php (Accessed 8 February 2022)

Portland-Boston	141.3	295.4	706.2	1,425.3
Boston-New York	69	151.6	372	757.5
New York-Cape May	113.6	241.6	582.8	1,180.1
Port Jefferson-New Haven	170.3	354.6	846	1705.9
Newport-Martha's Vineyard	56.9	127.8	316.8	647.5
Newport-Block Island	49	112	280	574
Buffalo-Albany via Erie Canal	39.5	86.1	210.5	428.3
Burlington-New York via Champlain Canal	41.1	89.4	218.1	443.4
One Vessel Working Each Route:	**680.7**	**1,458.5**	**3,478.4**	**7,162**

Part of the conversation about these results should be costs avoided on land. While the cost of congestion in lost fuel and time on overcrowded highways is discussed elsewhere far better, there are some economic costs which should be incorporated into the model here as an infrastructural savings. These include savings on roadway maintenance, public health effects of removing trucks from roadways, and so on.[12] Many of these effects are indirect and relatively small per vessel, but will be magnified very rapidly when a significant fleet is deployed. The economic effects of the related boom in jobs for supporting trades and direct employment are also not included in this economic analysis.

Incorporating just the Social Cost of Carbon into the equation generates significant further incentives for adopting these vessels. For example, in New York State the undiscounted social cost of carbon is listed at $2,200 per metric ton,[13] the value of even the least effective of these modal shifts is some $86,900. The most effective vessel and route combination, an OSSF 100 on the Port Jefferson-New Haven run, would give a social benefit of some 3.75 million dollars per year on a vessel which cost only two million to build. This route is especially important for these purposes because it displaces a relatively large number of trucks which have to pass through some of the nation's most congested roadways, and proved economically viable during the last Oil Crisis.[14] All but two routes for the OSSF 100 pay for half the vessel's construction cost per year by this metric, and the same is found with the OSSF 50. The two smaller vessels each require longer periods of operation to pay their construction costs through avoided carbon, but the pay back period is not long in any case.

[12] Austin, David. *Pricing Freight Transport to Account for External Costs.* Washington DC: Congressional Budget Office, 2015. www.cbo.gov/sites/default/files/114th-congress-2015-2016/workingpaper/50049-Freight_Transport_Working_Paper-2.pdf.

[13] NYS DEC *Establishing A Value Of Carbon: Guidelines For Use By State Agencies.* Albany: New York State Department Of Environmental Conservation, 2023. Https://Extapps.Dec.Ny.Gov/Docs/Administration_pdf/Vocguide23final.Pdf

[14] Setinberg, Carol. "A Phoenix raises a stir" *New York Times* 18 Mar 1984. www.nytimes.com/1984/03/18/nyregion/a-phoeix-raises-a-stir.html

Increasing costs in the model do not prohibit profitability on all routes. The OSSF 100 full and down on the Boston-New York run with a construction cost of $7,000,000, crew pay at $250/day, and insurance and maintenance costs remaining set at 10% of construction cost still came up with a payback time of 10 years. The OSSF 50 remained within the 10 year viability period under the same increased burdens up to a construction cost of 2.8 million dollars. Of course these higher expenses increase the minimum hold capacity use requirement for viability, but do not completely preclude an economical employment of the vessel.

FEEDER ROUTES AND VESSELS

The use of OSSF 15 vessels for feeder routes into ports of consolidation has been considered in some informal discussion as part of these sail freight networks, especially where costs for truck transport are high entirely due to traffic congestion and longer distance as they drive around a body of water. To illustrate a few of these routes, the Massachusetts Bay is used as a model, and four routes are explored using the previous assumptions. Port fees are kept at a daily fee as opposed to marina slips, due to the high expense of marina slips in this area. The routes are as follows:

Boston-Gloucester: 26 sailing miles, 1 day sailing, 350 voyages, 35 truck miles, $184/pallet.
Boston-Plymouth: 40 sailing miles, 1 day sailing, 350 voyages, 40 truck miles, $184/pallet.
Boston-Provincetown: 49 sailing miles, 1 day sailing, 350 voyages, 116 truck miles, $427/pallet.
Boston-Portsmouth: 61 sailing miles, 1 day sailing, 350 voyages, 64 truck miles, $232/pallet.

The Gloucester and Plymouth packets were viable at 95%, Portsmouth made the cut at 75%, and Provincetown was viable at a mere 41% with the OSSF 15. The later is likely to be a reasonable route to put one of these vessels on, as Provincetown's population of up to 60,000 and natural harbor would make securing 3-6 pallets from Boston every other day relatively easy, waters remain relatively protected through the entire route, and costs could still be paid if the leg back to Boston was in ballast routinely. This is not surprising, as the route's geometry is extremely similar to that of the New Haven-Port Jefferson run, but with a significantly higher price per pallet.

For the Provincetown route, another vessel's numbers were also run: An inexpensive 36 foot fiberglass sloop converted to carry 3 tons. This vessel, making the same route as described above with two crew, a purchase cost of $10,000, insurance set to 50%, and the remainder of the model unmodified, was able to pay off all capital expenses and pocket $7,900 within two years at 56% capacity. After the purchase was paid off, annual operations could be undertaken at a mere 55% of capacity while breaking even. Full and down, the vessel stands to make some $205,000 per year in net profit. While maintenance costs may be higher than an annual expenditure of $1,000, there is clearly plenty of room for error in this budget, and three years' operations can pay for an OSSF 15 in cash. The use of this type of salvaged sail freighter as an initial scout vessel can establish the possibility of sail freight routes while requiring low initial capital investment. This type of vessel will also be successful on routes such as Newport-Martha's Vineyard, and similar single-day routes with reliable cargo and high trucking charges. These types of vessels will likely be a good means of connecting very small volume ports with the major hubs, but as they are essentially refit boats, they need not be designed and built as part of the OSSF set.

DISCUSSION

It is clear from the results of this analysis that if costs are kept under control and cargo is available, sail freighters under 100 Gross Register Tons (GRT) are economically viable on a multitude of routes already proposed for their employment in the Northeast US. Even at relatively low levels of capacity use, the vessels can still give a 10 year return on investment, with a predicted 20-50 year service life if well maintained, thus allowing for their future replacement.

An important element for investors is the amount of money which could be made in total if the vessel were to meet its maximum capacity. For the Boston-New York run, the OSSF 100 would be able to net some $1.2 million in profits within two years. Even an OSSF 15 operating the Newport-Martha's Vineyard run would be able to clear $2.7 million in net profit in two years, completely paying off the vessel, and standing to make over $1.6 million in annual earnings thereafter. This means a properly employed OSSF 15 on the Newport-Martha's Vineyard run could pay cash for an OSSF 100 to make the Boston-New York run within two years with cash left over, and the two vessels combined making some $3.5 million per year within 48 months of starting the service.

Other forms of ownership and operation are not included here, such as Community Supported Shipping wherein a group of cargo owners each pay a share of the vessel's costs for the year in exchange for as much shipping as the vessel can take on. These models are quite different than a regular revenue based model, and may be better suited to small operations than to a prediction of economic viability.

Changing the capacity of sail freighters, especially in the smaller sizes, will make them far more viable. The Vermont Sail Freight Project's *Ceres* carried 10 tons at 14.5 GRT,[15] and Tad Robert's 60 foot, 27 GRT cargo schooner design is rated to carry 36 short tons.[16] By increasing the capacity of these two smallest open source vessels, they become viable on more routes, particularly for the OSSF 15 on the Boston-New York (88%) and New York-Cape May (88%) routes, even with crew costs kept at $250 per day. As the vessels have yet to be designed, the particulars of cargo capacity have not been firmly determined and fixed, but the values given in this paper reflect the minimum requirements from the work this is based on.

Sail training, cobranding, passengers, carbon credits, and sponsors are all options for other streams of revenue available to sail freighters which have not been incorporated into this model. For most sail freight operations, sail training is an integral and essential part of their model, and enables the cargo mission by filling gaps in funding.[17] While the number of trainees a small vessel can accommodate may be very limited, the value of having a few berths available may make longer distances or less profitable routes (such as the Erie Canal) economically viable. Passenger service on a leisure basis may also be a revenue stream of

[15] Andrus, "Vermont Sail Freight Project."
[16] Tad Roberts Yacht Design. "60 Ft Cargo Schooner" www.tadroberts.ca/services/new-design/sail/steelcargoschooner60
[17] De Beukelaer, Christiaan, *Trade Winds: A Voyage To Zero-Emissions Shipping* Manchester: Manchester University Press, 2023

interest to windjammer captains on shorter routes, but can add to requirements for regulatory compliance.

The last piece to be discussed, but possibly the most important, is the issue of attracting cargo. All of the models incorporated in this paper assume there is cargo available which cargo owners will be willing to send by sail. This is likely the case, but the extremely price-elastic demand for transportation means the service will need to depend on being cost competitive. By undercutting other services, the slight delay which might be entailed by using sail freight should become effectively unimportant for most goods, and in some cases it will be easier to undercut trucking rates than in others. In most cases, having the ear of an established freight forwarder looking to reduce their costs will be critical to obtaining the volume of cargo needed to make these services economically viable. While piecemeal gathering of interested cargo owners may work for the smaller vessels with limited capacity to fill, the larger vessels will undoubtedly require a formal pipeline of cargo to keep the hold sufficiently full.

CONCLUSIONS

It is clear that in competition with trucking on coastal routes, small sail freighters can be competitive if run on tight margins and with patient capital investors who are willing to wait a number of years for a significant return. On certain routes, the vessel could be paid off and investors seeing a net return within two to three years if an intensive schedule is run and the necessary permits acquired, such as with Nantucket, Martha's Vineyard, Provincetown, and Boston-New York runs.

It is important to note that transportation is, to most people, simply transportation: They don't especially care how something travels, so long as it gets there on time and in good shape. It is especially beneficial if that also happens at the lowest possible price. In almost any market, the coastal sail freighter will have to compete on price alone, and in that competition it must meet the costs of trucking. Until the externalities of our current transport system are internalized through appropriate taxes, fees, and a carbon levy, there will be no economic force aside from price to shift cargo to these more ecologically sound means of keeping the commercial gears turning.

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Sail Freight Project Financials
ROUTE: Boston-New York
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 85 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	137,700	$2.41	332,137.50
Gross Revenue			**332,137.50**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	680	$200.00	136,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, Per Gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	680	$25.00	17,000.00
Longshore Labor Fees, per pallet	1,275	$20.00	25,500.00
Port Fees, $3/ft/day	110	$135.00	14,850.00
Total Expenses			**800,150.00**
Net Income			**(468,012.50)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	137,700	$2.41	332,137.50
Gross Revenue			**332,137.50**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	680	$200.00	136,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, per gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	680	$25.00	17,000.00
Longshore Labor Fees, per pallet	1,275	$20.00	25,500.00
Port Fees, $3/ft/day	110	$135.00	14,850.00
Total Expenses			**300,150.00**
Net Income			**31,987.50**
		Total Profits First Two Years	**(436,025.00)**

Sail Freight Project Financials

ROUTE: Boston-New York

OPEN SOURCE SAIL FREIGHTER 25

YEAR 1: 85 Voyages 91%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	250,614	$2.41	604,490.25
Gross Revenue			**604,490.25**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,360	$200.00	272,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, Per Gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,360	$25.00	34,000.00
Longshore Labor Fees, per pallet	2,550	$20.00	51,000.00
Port Fees, $3/ft/day	110	$180.00	19,800.00
Total Expenses			**1,283,600.00**
Net Income			**(679,109.75)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	250,614	$2.41	604,490.25
Gross Revenue			**604,490.25**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,360	$200.00	272,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, per gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,360	$25.00	34,000.00
Longshore Labor Fees, per pallet	2,550	$20.00	51,000.00
Port Fees, $3/ft/day	110	$180.00	19,800.00
Total Expenses			**533,600.00**
Net Income			**70,890.25**
		Total Profits First Two Years	**(608,219.50)**

Sail Freight Project Financials
ROUTE: Boston-New York
OPEN SOURCE SAIL FREIGHTER 50
YEAR 1: 85 Voyages 59%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	379,134	$2.41	914,485.25
Gross Revenue			**914,485.25**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,040	$200.00	408,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, Per Gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,040	$25.00	51,000.00
Longshore Labor Fees, per pallet	5,950	$20.00	119,000.00
Port Fees, $3/ft/day	110	$216.00	23,760.00
Total Expenses			**1,808,560.00**
Net Income			**(894,074.75)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	379,134	$2.41	914,485.25
Gross Revenue			**914,485.25**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,040	$200.00	408,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, per gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,040	$25.00	51,000.00
Longshore Labor Fees, per pallet	5,950	$20.00	119,000.00
Port Fees, $3/ft/day	110	$216.00	23,760.00
Total Expenses			**808,560.00**
Net Income			**105,925.25**
		Total Profits First Two Years	**(788,149.50)**

Sail Freight Project Financials
ROUTE: Boston-New York
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 85 Voyages 43%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	552,636	$2.41	1,332,978.50
Gross Revenue			**1,332,978.50**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,040	$200.00	408,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, Per Gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,040	$25.00	51,000.00
Longshore Labor Fees, per pallet	11,900	$20.00	238,000.00
Port Fees, $3/ft/day	110	$285.00	31,350.00
Total Expenses			**3,135,150.00**
Net Income			**(1,802,171.50)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	552,636	$2.41	1,332,978.50
Gross Revenue			**1,332,978.50**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,040	$200.00	408,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, per gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,040	$25.00	51,000.00
Longshore Labor Fees, per pallet	11,900	$20.00	238,000.00
Port Fees, $3/ft/day	110	$285.00	31,350.00
Total Expenses			**1,135,150.00**
Net Income			**197,828.50**
		Total Profits First Two Years	**(1,604,343.00)**

Sail Freight Project Financials

ROUTE: Boston-New York

OPEN SOURCE SAIL FREIGHTER 100

YEAR 1: 85 Voyages Full and Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	1,285,200	$2.41	3,099,950.00
Gross Revenue			**3,099,950.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,040	$200.00	408,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, Per Gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,040	$25.00	51,000.00
Longshore Labor Fees, per pallet	11,900	$20.00	238,000.00
Port Fees, $3/ft/day	110	$285.00	31,350.00
Total Expenses			**3,135,150.00**
Net Income			**(35,200.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	1,285,200	$2.41	3,099,950.00
Gross Revenue			**3,099,950.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,040	$200.00	408,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, per gallon	1,360	$5.00	6,800.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,040	$25.00	51,000.00
Longshore Labor Fees, per pallet	11,900	$20.00	238,000.00
Port Fees, $3/ft/day	110	$285.00	31,350.00
Total Expenses			**1,135,150.00**
Net Income			**1,964,800.00**
		Total Profits First Two Years	**1,929,600.00**

Sail Freight Project Financials
ROUTE: Buffalo-Albany
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 36 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	77,760	$0.67	51,840.00
Gross Revenue			**51,840.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	540	$20.00	10,800.00
Port Fees, $3/ft/day	221	$135.00	29,835.00
Total Expenses			**727,485.00**
Net Income			**(675,645.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	77,760	$0.67	51,840.00
Gross Revenue			**51,840.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	540	$20.00	10,800.00
Port Fees, $3/ft/day	221	$135.00	29,835.00
Total Expenses			**227,485.00**
Net Income			**(175,645.00)**
		Total Profits First Two Years	**(851,290.00)**

Sail Freight Project Financials
ROUTE: Buffalo-Albany
OPEN SOURCE SAIL FREIGHTER 25
YEAR 1: 36 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	155,520	$0.67	103,680.00
Gross Revenue			**103,680.00**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	60	$50.00	3,000.00
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	1,080	$20.00	21,600.00
Port Fees, $3/ft/day	221	$180.00	39,780.00
Total Expenses			**1,048,980.00**
Net Income			**(945,300.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	155,520	$0.67	103,680.00
Gross Revenue			**103,680.00**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	60	$50.00	3,000.00
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	1,080	$20.00	21,600.00
Port Fees, $3/ft/day	221	$180.00	39,780.00
Total Expenses			**298,980.00**
Net Income			**(195,300.00)**
		Total Profits First Two Years	**(1,140,600.00)**

Sail Freight Project Financials
ROUTE: Buffalo-Albany
OPEN SOURCE SAIL FREIGHTER 50
YEAR 1: 36 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	362,880	$0.67	241,920.00
Gross Revenue			**241,920.00**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	72	$50.00	3,600.00
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	2,520	$20.00	50,400.00
Port Fees, $3/ft/day	221	$216.00	47,736.00
Total Expenses			**1,386,336.00**
Net Income			**(1,144,416.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	362,880	$0.67	241,920.00
Gross Revenue			**241,920.00**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	72	$50.00	3,600.00
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	2,520	$20.00	50,400.00
Port Fees, $3/ft/day	221	$216.00	47,736.00
Total Expenses			**386,336.00**
Net Income			**(144,416.00)**
		Total Profits First Two Years	**(1,288,832.00)**

Sail Freight Project Financials
ROUTE: Buffalo-Albany
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 36 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	725,760	$0.67	483,840.00
Gross Revenue			**483,840.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	95	$50.00	4,750.00
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	5,040	$20.00	100,800.00
Port Fees, $3/ft/day	221	$285.00	62,985.00
Total Expenses			**2,653,135.00**
Net Income			**(2,169,295.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	725,760	$0.67	483,840.00
Gross Revenue			**483,840.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	95	$50.00	4,750.00
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	5,040	$20.00	100,800.00
Port Fees, $3/ft/day	221	$285.00	62,985.00
Total Expenses			**653,135.00**
Net Income			**(169,295.00)**
		Total Profits First Two Years	**(2,338,590.00)**

Sail Freight Project Financials
ROUTE: Burlington-New York
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 36 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	80,460	$1.58	126,900.00
Gross Revenue			**126,900.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	540	$20.00	10,800.00
Port Fees, $3/ft/day	221	$135.00	29,835.00
Total Expenses			**727,485.00**
Net Income			**(600,585.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	80,460	$1.58	126,900.00
Gross Revenue			**126,900.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	540	$20.00	10,800.00
Port Fees, $3/ft/day	221	$135.00	29,835.00
Total Expenses			**227,485.00**
Net Income			**(100,585.00)**
		Total Profits First Two Years	**(701,170.00)**

Sail Freight Project Financials
ROUTE: Burlington-New York
OPEN SOURCE SAIL FREIGHTER 25
YEAR 1: 36 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	160,920	$1.58	253,800.00
Gross Revenue			**253,800.00**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	60	$50.00	3,000.00
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	1,080	$20.00	21,600.00
Port Fees, $3/ft/day	221	$180.00	39,780.00
Total Expenses			**1,048,980.00**
Net Income			**(795,180.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	160,920	$1.58	253,800.00
Gross Revenue			**253,800.00**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	60	$50.00	3,000.00
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	1,080	$20.00	21,600.00
Port Fees, $3/ft/day	221	$180.00	39,780.00
Total Expenses			**298,980.00**
Net Income			**(45,180.00)**
		Total Profits First Two Years	**(840,360.00)**

Sail Freight Project Financials
ROUTE: Burlington-New York
OPEN SOURCE SAIL FREIGHTER 50
YEAR 1: 36 Voyages 81%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	304,139	$1.58	479,682.00
Gross Revenue			**479,682.00**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	72	$50.00	3,600.00
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	2,520	$20.00	50,400.00
Port Fees, $3/ft/day	221	$216.00	47,736.00
Total Expenses			**1,386,336.00**
Net Income			**(906,654.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	304,139	$1.58	479,682.00
Gross Revenue			**479,682.00**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	72	$50.00	3,600.00
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	2,520	$20.00	50,400.00
Port Fees, $3/ft/day	221	$216.00	47,736.00
Total Expenses			**386,336.00**
Net Income			**93,346.00**
		Total Profits First Two Years	**(813,308.00)**

Sail Freight Project Financials
ROUTE: Burlington-New York
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 36 Voyages 71%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	533,182	$1.58	840,924.00
Gross Revenue			**840,924.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	95	$50.00	4,750.00
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, Per Gallon	720	$5.00	3,600.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	5,040	$20.00	100,800.00
Port Fees, $3/ft/day	221	$285.00	62,985.00
Total Expenses			**2,653,135.00**
Net Income			**(1,812,211.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	533,182	$1.58	840,924.00
Gross Revenue			**840,924.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	360	$200.00	72,000.00
Winter Storage, per ft	95	$50.00	4,750.00
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, per gallon	720	$5.00	3,600.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	360	$25.00	9,000.00
Longshore Labor Fees, per pallet	5,040	$20.00	100,800.00
Port Fees, $3/ft/day	221	$285.00	62,985.00
Total Expenses			**653,135.00**
Net Income			**187,789.00**
		Total Profits First Two Years	**(1,624,422.00)**

Sail Freight Project Financials
ROUTE: New Haven-Port Jefferson
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 350 Voyages 58%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	178,133	$2.39	426,300.00
Gross Revenue			**426,300.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**878,500.00**
Net Income			**(452,200.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	178,133	$2.39	426,300.00
Gross Revenue			**426,300.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**378,500.00**
Net Income			**47,800.00**
		Total Profits First Two Years	**(404,400.00)**

Sail Freight Project Financials
ROUTE: New Haven-Port Jefferson
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 350 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	307,125	$2.39	735,000.00
Gross Revenue			**735,000.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$135.00	49,275.00
Total Expenses			**921,025.00**
Net Income			**(186,025.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	307,125	$2.39	735,000.00
Gross Revenue			**735,000.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$135.00	49,275.00
Total Expenses			**421,025.00**
Net Income			**313,975.00**
		Total Profits First Two Years	**127,950.00**

Sail Freight Project Financials
ROUTE: New Haven-Port Jefferson
OPEN SOURCE SAIL FREIGHTER 25
YEAR 1: 350 Voyages 52%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	319,410	$2.39	764,400.00
Gross Revenue			**764,400.00**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,400	$200.00	280,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$200.00	12,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,400	$25.00	35,000.00
Longshore Labor Fees, per pallet	10,500	$20.00	210,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,444,000.00**
Net Income			**(679,600.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	319,410	$2.39	764,400.00
Gross Revenue			**764,400.00**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,400	$200.00	280,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$200.00	12,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,400	$25.00	35,000.00
Longshore Labor Fees, per pallet	10,500	$20.00	210,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**694,000.00**
Net Income			**70,400.00**
		Total Profits First Two Years	**(609,200.00)**

Sail Freight Project Financials
ROUTE: New Haven-Port Jefferson
OPEN SOURCE SAIL FREIGHTER 50
YEAR 1: 350 Voyages 38%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	544,635	$2.39	1,303,400.00
Gross Revenue			**1,303,400.00**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$200.00	14,400.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	24,500	$20.00	490,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**2,183,900.00**
Net Income			**(880,500.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	544,635	$2.39	1,303,400.00
Gross Revenue			**1,303,400.00**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$200.00	14,400.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	24,500	$20.00	490,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,183,900.00**
Net Income			**119,500.00**
		Total Profits First Two Years	**(761,000.00)**

Sail Freight Project Financials
ROUTE: New Haven-Port Jefferson
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 350 Voyages 31%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	888,615	$2.39	2,126,600.00
Gross Revenue			**2,126,600.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$200.00	19,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	49,000	$20.00	980,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**3,878,500.00**
Net Income			**(1,751,900.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	888,615	$2.39	2,126,600.00
Gross Revenue			**2,126,600.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$200.00	19,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	49,000	$20.00	980,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,878,500.00**
Net Income			**248,100.00**
		Total Profits First Two Years	**(1,503,800.00)**

Sail Freight Project Financials
ROUTE: New York-Cape May
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 180 Voyages Full and Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	213,300	$1.80	384,750.00
Gross Revenue			**384,750.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	720	$200.00	144,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, Per Gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	720	$25.00	18,000.00
Longshore Labor Fees, per pallet	2,700	$20.00	54,000.00
Port Fees, $3/ft/day	185	$135.00	24,975.00
Total Expenses			**848,175.00**
Net Income			**(463,425.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	213,300	$1.80	384,750.00
Gross Revenue			**384,750.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	720	$200.00	144,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, per gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	720	$25.00	18,000.00
Longshore Labor Fees, per pallet	2,700	$20.00	54,000.00
Port Fees, $3/ft/day	185	$135.00	24,975.00
Total Expenses			**348,175.00**
Net Income			**36,575.00**
		Total Profits First Two Years	**(426,850.00)**

Sail Freight Project Financials

ROUTE: New York-Cape May

OPEN SOURCE SAIL FREIGHTER 25

YEAR 1: 180 Voyages 90%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	383,940	$1.80	692,550.00
Gross Revenue			**692,550.00**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,440	$200.00	288,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, Per Gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,440	$25.00	36,000.00
Longshore Labor Fees, per pallet	5,400	$20.00	108,000.00
Port Fees, $3/ft/day	185	$180.00	33,300.00
Total Expenses			**1,372,500.00**
Net Income			**(679,950.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	383,940	$1.80	692,550.00
Gross Revenue			**692,550.00**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,440	$200.00	288,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, per gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,440	$25.00	36,000.00
Longshore Labor Fees, per pallet	5,400	$20.00	108,000.00
Port Fees, $3/ft/day	185	$180.00	33,300.00
Total Expenses			**622,500.00**
Net Income			**70,050.00**
		Total Profits First Two Years	**(609,900.00)**

Sail Freight Project Financials
ROUTE: New York-Cape May
OPEN SOURCE SAIL FREIGHTER 50
YEAR 1: 180 Voyages 60%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	597,240	$1.80	1,077,300.00
Gross Revenue			**1,077,300.00**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,160	$200.00	432,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, Per Gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,160	$25.00	54,000.00
Longshore Labor Fees, per pallet	12,600	$20.00	252,000.00
Port Fees, $3/ft/day	185	$216.00	39,960.00
Total Expenses			**1,985,160.00**
Net Income			**(907,860.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	597,240	$1.80	1,077,300.00
Gross Revenue			**1,077,300.00**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,160	$200.00	432,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, per gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,160	$25.00	54,000.00
Longshore Labor Fees, per pallet	12,600	$20.00	252,000.00
Port Fees, $3/ft/day	185	$216.00	39,960.00
Total Expenses			**985,160.00**
Net Income			**92,140.00**
		Total Profits First Two Years	**(815,720.00)**

Sail Freight Project Financials
ROUTE: New York-Cape May
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 180 Voyages 46%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	915,768	$1.80	1,651,860.00
Gross Revenue			**1,651,860.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,160	$200.00	432,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, Per Gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,160	$25.00	54,000.00
Longshore Labor Fees, per pallet	25,200	$20.00	504,000.00
Port Fees, $3/ft/day	185	$285.00	52,725.00
Total Expenses			**3,449,925.00**
Net Income			**(1,798,065.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	915,768	$1.80	1,651,860.00
Gross Revenue			**1,651,860.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,160	$200.00	432,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, per gallon	1,440	$5.00	7,200.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,160	$25.00	54,000.00
Longshore Labor Fees, per pallet	25,200	$20.00	504,000.00
Port Fees, $3/ft/day	185	$285.00	52,725.00
Total Expenses			**1,449,925.00**
Net Income			**201,935.00**
		Total Profits First Two Years	**(1,596,130.00)**

Sail Freight Project Financials

ROUTE: Newport-Block Island

OPEN SOURCE SAIL FREIGHTER 15

YEAR 1: 350 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	105,000	$3.25	341,250.00
Gross Revenue			**341,250.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**878,500.00**
Net Income			**(537,250.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	105,000	$3.25	341,250.00
Gross Revenue			**341,250.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**378,500.00**
Net Income			**(37,250.00)**
		Total Profits First Two Years	**(574,500.00)**

Sail Freight Project Financials
ROUTE: Newport-Block Island
OPEN SOURCE SAIL FREIGHTER 25
YEAR 1: 350 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	210,000	$3.25	682,500.00
Gross Revenue			**682,500.00**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,400	$200.00	280,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$200.00	12,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,400	$25.00	35,000.00
Longshore Labor Fees, per pallet	10,500	$20.00	210,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,444,000.00**
Net Income			**(761,500.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	210,000	$3.25	682,500.00
Gross Revenue			**682,500.00**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,400	$200.00	280,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$200.00	12,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,400	$25.00	35,000.00
Longshore Labor Fees, per pallet	10,500	$20.00	210,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**694,000.00**
Net Income			**(11,500.00)**
		Total Profits First Two Years	**(773,000.00)**

Sail Freight Project Financials

ROUTE: Newport-Block Island

OPEN SOURCE SAIL FREIGHTER 50

YEAR 1: 350 Voyages 81%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	396,900	$3.25	1,289,925.00
Gross Revenue			**1,289,925.00**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$200.00	14,400.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	24,500	$20.00	490,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**2,183,900.00**
Net Income			**(893,975.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	396,900	$3.25	1,289,925.00
Gross Revenue			**1,289,925.00**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$200.00	14,400.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	24,500	$20.00	490,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,183,900.00**
Net Income			**106,025.00**
		Total Profits First Two Years	**(787,950.00)**

Sail Freight Project Financials
ROUTE: Newport-Block Island
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 350 Voyages 65%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	637,000	$3.25	2,070,250.00
Gross Revenue			**2,070,250.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$200.00	19,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	49,000	$20.00	980,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**3,878,500.00**
Net Income			**(1,808,250.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	637,000	$3.25	2,070,250.00
Gross Revenue			**2,070,250.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$200.00	19,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	49,000	$20.00	980,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,878,500.00**
Net Income			**191,750.00**
		Total Profits First Two Years	**(1,616,500.00)**

Sail Freight Project Financials

ROUTE: Newport-Martha's Vineyard

OPEN SOURCE SAIL FREIGHTER 15

YEAR 1: 350 Voyages 22%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	25,988	$16.40	426,195.00
Gross Revenue			**426,195.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**878,500.00**
Net Income			**(452,305.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	25,988	$16.40	426,195.00
Gross Revenue			**426,195.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$200.00	140,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**378,500.00**
Net Income			**47,695.00**
		Total Profits First Two Years	**(404,610.00)**

Sail Freight Project Financials
ROUTE: Newport-Martha's Vineyard
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 350 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	118,125	$16.40	1,937,250.00
Gross Revenue			**1,937,250.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$100.00	70,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, Per Gallon	350	$5.00	1,750.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**803,250.00**
Net Income			**1,134,000.00**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	118,125	$16.40	1,937,250.00
Gross Revenue			**1,937,250.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	700	$100.00	70,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$200.00	9,000.00
Fuel, Diesel, per gallon	350	$5.00	1,750.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	700	$25.00	17,500.00
Longshore Labor Fees, per pallet	5,250	$20.00	105,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**303,250.00**
Net Income			**1,634,000.00**
		Total Profits First Two Years	**2,768,000.00**

Sail Freight Project Financials

ROUTE: Newport-Martha's Vineyard

OPEN SOURCE SAIL FREIGHTER 25

YEAR 1: 350 Voyages 20%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	47,250	$16.40	774,900.00
Gross Revenue			**774,900.00**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,400	$200.00	280,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$200.00	12,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,400	$25.00	35,000.00
Longshore Labor Fees, per pallet	10,500	$20.00	210,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,444,000.00**
Net Income			**(669,100.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	47,250	$16.40	774,900.00
Gross Revenue			**774,900.00**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,400	$200.00	280,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$200.00	12,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,400	$25.00	35,000.00
Longshore Labor Fees, per pallet	10,500	$20.00	210,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**694,000.00**
Net Income			**80,900.00**
		Total Profits First Two Years	**(588,200.00)**

Sail Freight Project Financials
ROUTE: Newport-Martha's Vineyard
OPEN SOURCE SAIL FREIGHTER 50
YEAR 1: 350 Voyages 15%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	82,688	$16.40	1,356,075.00
Gross Revenue			**1,356,075.00**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$200.00	14,400.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	24,500	$20.00	490,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**2,183,900.00**
Net Income			**(827,825.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	82,688	$16.40	1,356,075.00
Gross Revenue			**1,356,075.00**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$200.00	14,400.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	24,500	$20.00	490,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,183,900.00**
Net Income			**172,175.00**
		Total Profits First Two Years	**(655,650.00)**

Sail Freight Project Financials
ROUTE: Newport-Martha's Vineyard
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 350 Voyages 12%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	132,300	$16.40	2,169,720.00
Gross Revenue			**2,169,720.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$200.00	19,000.00
Fuel, Diesel, Per Gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	49,000	$20.00	980,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**3,878,500.00**
Net Income			**(1,708,780.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	132,300	$16.40	2,169,720.00
Gross Revenue			**2,169,720.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	2,100	$200.00	420,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$200.00	19,000.00
Fuel, Diesel, per gallon	1,400	$5.00	7,000.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	2,100	$25.00	52,500.00
Longshore Labor Fees, per pallet	49,000	$20.00	980,000.00
Port Fees, $3/ft/day	365	$0.00	-
Total Expenses			**1,878,500.00**
Net Income			**291,220.00**
		Total Profits First Two Years	**(1,417,560.00)**

Sail Freight Project Financials
ROUTE: Portland-Boston
OPEN SOURCE SAIL FREIGHTER 15
YEAR 1: 320 Voyages 83%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	213,144	$2.07	442,224.00
Gross Revenue			**442,224.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	640	$200.00	128,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, Per Gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	640	$25.00	16,000.00
Longshore Labor Fees, per pallet	4,800	$20.00	96,000.00
Port Fees, $3/ft/day	365	$135.00	49,275.00
Total Expenses			**895,675.00**
Net Income			**(453,451.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	213,144	$2.07	442,224.00
Gross Revenue			**442,224.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	640	$200.00	128,000.00
Winter Storage, per ft	45	$0.00	-
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, per gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	640	$25.00	16,000.00
Longshore Labor Fees, per pallet	4,800	$20.00	96,000.00
Port Fees, $3/ft/day	365	$135.00	49,275.00
Total Expenses			**395,675.00**
Net Income			**46,549.00**
		Total Profits First Two Years	**(406,902.00)**

Sail Freight Project Financials

ROUTE: Portland-Boston

OPEN SOURCE SAIL FREIGHTER 15

YEAR 1: 320 Voyages Full & Down

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	256,800	$2.07	532,800.00
Gross Revenue			**532,800.00**
Vessel Purchase	1	$500,000.00	500,000.00
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	640	$200.00	128,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, Per Gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	640	$25.00	16,000.00
Longshore Labor Fees, per pallet	4,800	$20.00	96,000.00
Port Fees, $3/ft/day	365	$135.00	49,275.00
Total Expenses			**897,925.00**
Net Income			**(365,125.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	256,800	$2.07	532,800.00
Gross Revenue			**532,800.00**
Insurance	1	$50,000.00	50,000.00
Crew Labor, per Sailor Day	640	$200.00	128,000.00
Winter Storage, per ft	45	$50.00	2,250.00
Seasonal Marina Slip, per foot	45	$0.00	-
Fuel, Diesel, per gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$50,000.00	50,000.00
Provisioning, per person-day	640	$25.00	16,000.00
Longshore Labor Fees, per pallet	4,800	$20.00	96,000.00
Port Fees, $3/ft/day	365	$135.00	49,275.00
Total Expenses			**397,925.00**
Net Income			**134,875.00**
		Total Profits First Two Years	**(230,250.00)**

Sail Freight Project Financials
ROUTE: Portland-Boston
OPEN SOURCE SAIL FREIGHTER 25
YEAR 1: 320 Voyages 73%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	374,928	$2.07	777,888.00
Gross Revenue			**777,888.00**
Vessel Purchase	1	$750,000.00	750,000.00
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,280	$200.00	256,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, Per Gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,280	$25.00	32,000.00
Longshore Labor Fees, per pallet	9,600	$20.00	192,000.00
Port Fees, $3/ft/day	365	$180.00	65,700.00
Total Expenses			**1,452,100.00**
Net Income			**(674,212.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	374,928	$2.07	777,888.00
Gross Revenue			**777,888.00**
Insurance	1	$75,000.00	75,000.00
Crew Labor, per Sailor Day	1,280	$200.00	256,000.00
Winter Storage, per ft	60	$0.00	-
Seasonal Marina Slip, per foot	60	$0.00	-
Fuel, Diesel, per gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$75,000.00	75,000.00
Provisioning, per person-day	1,280	$25.00	32,000.00
Longshore Labor Fees, per pallet	9,600	$20.00	192,000.00
Port Fees, $3/ft/day	365	$180.00	65,700.00
Total Expenses			**702,100.00**
Net Income			**75,788.00**
		Total Profits First Two Years	**(598,424.00)**

Sail Freight Project Financials
ROUTE: Portland-Boston
OPEN SOURCE SAIL FREIGHTER 50
YEAR 1: 320 Voyages 51%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	611,184	$2.07	1,268,064.00
Gross Revenue			**1,268,064.00**
Vessel Purchase	1	$1,000,000.00	1,000,000.00
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	1,920	$200.00	384,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, Per Gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	1,920	$25.00	48,000.00
Longshore Labor Fees, per pallet	22,400	$20.00	448,000.00
Port Fees, $3/ft/day	365	$216.00	78,840.00
Total Expenses			**2,165,240.00**
Net Income			**(897,176.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	611,184	$2.07	1,268,064.00
Gross Revenue			**1,268,064.00**
Insurance	1	$100,000.00	100,000.00
Crew Labor, per Sailor Day	1,920	$200.00	384,000.00
Winter Storage, per ft	72	$0.00	-
Seasonal Marina Slip, per foot	72	$0.00	-
Fuel, Diesel, per gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$100,000.00	100,000.00
Provisioning, per person-day	1,920	$25.00	48,000.00
Longshore Labor Fees, per pallet	22,400	$20.00	448,000.00
Port Fees, $3/ft/day	365	$216.00	78,840.00
Total Expenses			**1,165,240.00**
Net Income			**102,824.00**
		Total Profits First Two Years	**(794,352.00)**

Sail Freight Project Financials
ROUTE: Portland-Boston
OPEN SOURCE SAIL FREIGHTER 100
YEAR 1: 320 Voyages 41%

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	982,688	$2.07	2,038,848.00
Gross Revenue			**2,038,848.00**
Vessel Purchase	1	$2,000,000.00	2,000,000.00
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	1,920	$200.00	384,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, Per Gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	1,920	$25.00	48,000.00
Longshore Labor Fees, per pallet	44,800	$20.00	896,000.00
Port Fees, $3/ft/day	365	$285.00	104,025.00
Total Expenses			**3,838,425.00**
Net Income			**(1,799,577.00)**

YEAR 2

Line-Item	Quantity	Per Unit	Amount
Gross Revenue, Freight	982,688	$2.07	2,038,848.00
Gross Revenue			**2,038,848.00**
Insurance	1	$200,000.00	200,000.00
Crew Labor, per Sailor Day	1,920	$200.00	384,000.00
Winter Storage, per ft	95	$0.00	-
Seasonal Marina Slip, per foot	95	$0.00	-
Fuel, Diesel, per gallon	1,280	$5.00	6,400.00
Maintenance Costs	1	$200,000.00	200,000.00
Provisioning, per person-day	1,920	$25.00	48,000.00
Longshore Labor Fees, per pallet	44,800	$20.00	896,000.00
Port Fees, $3/ft/day	365	$285.00	104,025.00
Total Expenses			**1,838,425.00**
Net Income			**200,423.00**
		Total Profits First Two Years	**(1,599,154.00)**

NYSERDA Agreement #25543

Eriemax:

Assessment of Green Ship Technologies and Plan for Deployment on the Erie Canal / NYS Barge Canal System

Final Report

(Progress Report 7 per Agreement)

Prepared for

New York State Energy Research & Development Authority

Prepared by

TransTech Marine Co.
Est. 1979
Brooklyn, NY
Geoff Uttmark MM, MSc , BSc
Principal Investigator

April 2015

NOTICE

DISCLAIMER

This report was funded in part through grant(s) from the New York State Energy Research and Development Authority (NYSERDA). This report does not constitute a standard, specification, regulation, product endorsement, or an endorsement of manufacturers.

CONTENTS

INTRODUCTION

TransTech Marine Co. (TTMC) responded to NYSERDA PON 2271 with the following proposal and was subsequently awarded Agreement 25543:

"*Eriemax*"

Proposal to Conduct Technical Assessment of Green Ship
Technologies and Develop a Pro-Active Plan for Their
Deployment to Create a Modern Freight-way via
The Erie / New York State Barge Canal System

After three years of in - depth research and design, including some false-starts that delayed the project and for which we wish to express our appreciation to our sponsors for their forbearance, TransTech is pleased to submit this Final Report.

EXECUTIVE SUMMARY

As the title of this report indicates, there were two separate related components of the investigation. "Assessment of Green Ship Technologies" comprised technical review of off-the-shelf technologies to determine if an appropriate vessel design for the intended purpose existed, that purpose being to determine if modern "green" marine transport technology can contribute to reinvigoration of commercial use of the Erie / NYS Barge Canal. Some off-the shelf technologies were found to be appropriate to the intended purpose, however a design of correct size was not discovered, hence, preliminary design of a suitable vessel to help launch a "proof-of-concept" project was undertaken.

The second part of this investigation, "… and Plan for Deployment on the Erie / NYS Barge Canal System" encompassed two tasks: 1) Creation of a business plan to provide a model for pro-active re-developers of the Erie / NYS Barge Canal freight corridor, and 2) Identification of an appropriate mechanism to capitalize new *Eriemax* initiatives that can be easily replicated by any *community* [1].

This Final Report is intended to provide an actionable plan for any community that appreciates the benefits to be realized from greater utilization of the Erie / NYS Barge Canal. They are multitudinous and accrue at every level of society, including local and regional economic stimulation, reduction in air pollution achieved by freight switching to the cleaner marine transport mode, skilled jobs creation in ship building and ship operations, employment in marine terminal and freight distribution activities and production of financial rewards for transport entrepreneurs.

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[1] As described in Community / Co-op Shipping Model, please see page 34, instant.

AVAILABLE MARINE TRANSPORT MARKETS

The objective of the investigation is to increase commercial utilization of the Erie / NYS Barge Canal so obviously communities, farms and factories along and proximate to the waterway are primary beneficiaries of increased use of the waterway. These communities were never the sole beneficiaries of the Erie / NYS Barge Canal, of course. The waterway enables deep penetration into the Midwest via the Great Lakes and connects to the Atlantic Ocean via the Hudson River. Hence, the Canal actually serves three markets which in turn define the types of marine equipment that can be used to serve shippers in those markets:

:

1) "***Contained Canal***" - comprises communities and hinterlands along the Canal itself. Cargoes from central New York State bound for New York City move via the Canal and Hudson River as they always have, as far as Erie Basin on the Brooklyn waterfront, the true southern terminus of the Erie Canal, and other points in the harbor. These waters are sheltered and all marine transport technologies considered (next section) are suitable on them.

2) "***Conduit Canal***" - provides access / egress to / from the entire Great Lakes region. This greatly expands the potential cargo base. However, marine equipment needed for navigating the Great Lakes is more robust than what is needed for canal and riverine work, though not as robust as what is needed to navigate near-coastal waters of the Atlantic Ocean.

   Two routes to / from the Great Lakes are available through the Erie / NYS Barge Canal. The original east - west canal enters Lake Erie at Buffalo. Just west of Syracuse the north - south Oswego Canal enters Lake Ontario near Oswego. From Lake Ontario, the upper lakes (Erie, Huron, Michigan and Superior) are reached via the Welland Canal in Ontario, Canada.

3) "***Connected Canal***" - considers the Erie / NYS Barge Canal as an integral component of the US Inland and Intracoastal Waterway System as defined by the US Army Corps of Engineers (Figure 1). The necessity to sail in Atlantic Ocean waters in some places necessitates the most seaworthy marine equipment. However, the tradeoff is maximum vessel employment flexibility and access to the greatest number of shippers. This could be particularly valuable in winter time when the Erie / NYS Barge Canal is closed; an ocean-capable vessel could operate in coastal ocean service, rather than lay-up for the winter.

Figure 1

Connected Canal was selected as the geographic target market. This naturally had ramifications on the design effort and vessel cost, however, greater flexibility and market size are of paramount value. TransTech also took note of the following:

> "The Ford Motor Company developed a very successful "motorship" in the early 1920s that could navigate the Great Lakes, the New York State Canal System and the Intercoastal Waterway all the way into the Caribbean. The vessels were swift through locks and safe beneath the low bridges of the Western Canal."[2]

The Ford ships obviously were designed to take advantage of the second round of expansion and other improvements made to the Erie / NYS Barge Canal which were completed in 1919. Since over a hundred near sister ships followed the prototype into service on the Lakes and Canal and the last of these ships operated into the 1990s, the case for building in maximum range and flexibility is very strong.

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[2] **NEWYORK STATE CANAL SYSTEM -MODERN FREIGHT-WAY,** Final Report, Prepared for **NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY** And **NEW YORK STATE DEPARTMENT OF TRANSPORTATION GOODBAN BELT, LLC** Buffalo, NY, NYSERDA Contract Number 11104, NYSDOT Task Assignment C-08-27, May 2010.

.RIVER – SEA SHIP 80’ LOA
(RSS – 80)

Four off-the-shelf technologies that were investigated in detail are presented pictorially in Figures 2. Each technology is evaluated against “*Connected Canal”* service requirements in Figure 3.

Figure 2

Eriemax **Technology Vs. Service Requirement**

	Contained Canal	***Conduit Canal***	***Connected Canal***
Tug & Barge	Yes	Limited	Limited
Tug-Barge Unit	Yes	Yes	Yes
Motorized Barge	Yes	No	No
River-sea Ship	Yes	Yes	Yes

TTMC April 2013

Figure 3

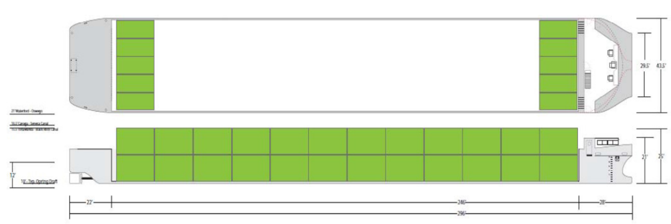
To assist technology selection, NYSERDA provided TransTech a copy of *NEW YORK STATE CANAL SYSTEM - MODERN FREIGHT-WAY*[3], prepared by Goodban Belt, LLC in 2010. The arguments this study makes and the method proposed for “jump-starting” expanded commercial use of the Erie / NYS Barge Canal are compelling. However, TransTech chose not to proceed in this investigation’s direction for three reasons:

[3] IBID

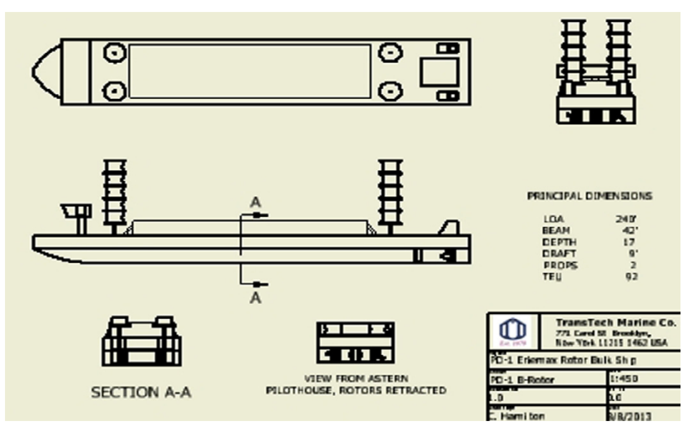
1) Goodban Belt selected a large motorized barge for its proposed inaugural service. As indicated in Figure 3, motorized barges are not suitable for operation on the Great Lakes or Atlantic Ocean, thus limiting operations to canal, riverine and other sheltered waters. While Goodban Belt's proposed initial service would indeed be large, growth prospects would be limited by equipment limitations.

2) The enormous shipper identified by Goodban Belt, namely, the NYC Department of Sanitation, unquestionably has the cargo volume to support a new barge service, and should in fact be moving more garbage out of the city by water to reduce road congestion and air pollution. NYC DOS is not a replicable customer, however. "Top down" stimulus by a single, government, mega-shipper is less likely to create a large, diverse fleet of ships utilizing the Erie / NYS Barge Canal than would a "bottom up" widely replicable, pro-active business model.

3) Like Goodban Belt, TransTech did consider using larger vessels initially. *Eriemax* PD-1 (Figure 4, bottom) bears resemblance in size, capacity, speed and cost to Goodban Belt's motor barge (Figure 4, top). The capital cost of either design is far beyond the means of a trade corridor that is rich in history but short on recent memory of profits to justify large capital investment. Hence, TransTech's development of *Eriemax* PD-1 and consideration of similar approaches by others was abandoned to pursue a smaller, lower cost, (re)-entry-level design solution.



296' LOA, 120 TEU $8.2 M



240' LOA, 92 TEU $7.5 M

Figure 4

Notably, a tug-barge unit is also able to meet "*connected canal"* service requirements. Ability to separate cargo and propulsive units is supposed to improve economies (by increasing utilization of the power unit), however, in practice most TBU's operate in the permanently-joined mode; that is, rarely do they actually operate in the drop-and-swap mode because of scheduling and other difficulties. TBUs in the smaller size range are not less costly to build than a ship of equal capacity, nor are they automatically less costly to operate. But TBUs do incur speed and sea-keeping penalties compared to self-propelled ships, as well as potentially higher maintenance costs and greater crew fatigue. Hence, the decision was made to proceed with a small river - sea ship design.

RSS – 80 Design Evolution

River-Sea Ship 80' LOA is designed against TransTech's Green Marine Technology Chart (Figure 5), using "greenest" technologies presently available, with new-builds becoming progressively "greener" as improved technologies come into the market.

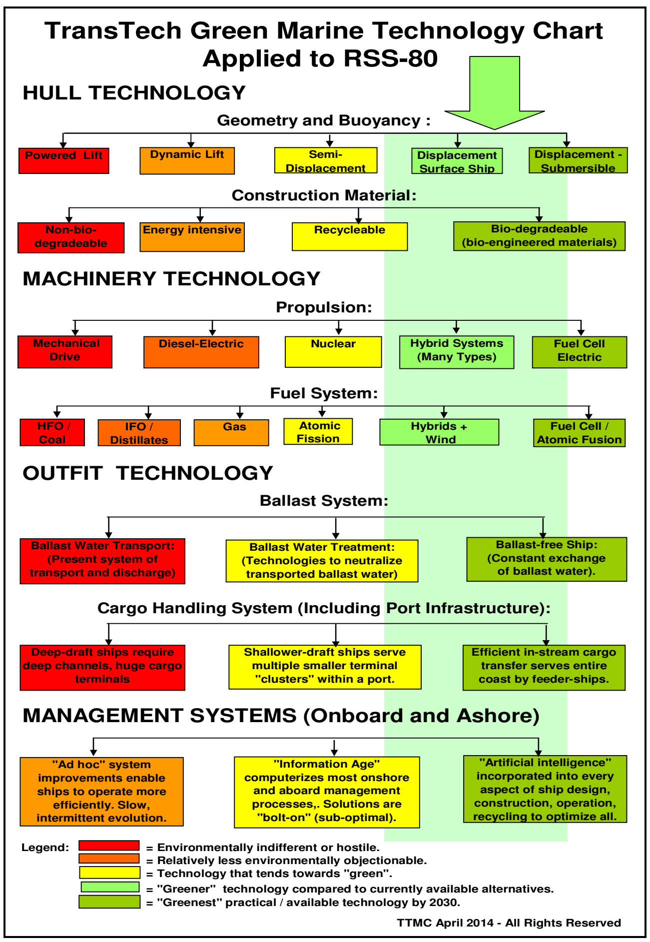


Figure 5

The mantra for designing RSS - 80 was: "*Build like a barge, operate like a tugboat*". Summary information follows:

Design Requirements / Constraints:

Hull	Steel, simple curvature with chines. Broad skeg.
Mach' / Props / Speed	Hybrid sail diesel electric / sail / 2 rotatable, retractable motor-driven rudder propellers / 7.0 - 8.0 knots
Outfit	Sail booms double as cargo derrick jib booms for working cargo. Roller type hatch covers.
Capacity	10,000 cu. ft. (250 MTs) 100 deadweight tons 18 TEU equivalents
Compliment	4 crew for 16 hrs. / day, 9 crew for 24 / 7.
Endurance	Two weeks / 2,000 miles
Flag / Class	USA / ABS
Constraints	LOA 80.0 ft. (minimum to qualify for ABS load line) Draft 9.0 ft. (working limit in Erie / NYS Canal) Air T 14.5 ft. (lowest bridge 15.5 ft. clearance)

Principal Dimensions, Form Coefficients & Preliminary Hydrostatics:

Principal dimensions, form coefficients and preliminary hydrostatics are presented in Figure 6.

Hull Shape:

All hull surfaces use flat or two-plane (simple) curvature steel plate, no three-plane (complex) curvature and no castings for ease of construction (Figure 7).

Construction Sequence:

RSS – 80 is designed for "kit" construction; all major structural parts are pre-cut and numbered in a factory then shipped to the construction site for assembly (Figures 8 and 9). Simplified construction process enables fabrication of the hull in rudimentary building facility, including brown-field. Machinery and outfit systems are likewise pre-packaged for remote site installation.

RSS-80

Principal Dimensions, Form Coefficients & Hydrostatics

			Notes & Formulas
Principal Dimensions:			
LOA	80.00	Ft.	
LBP	80.00	Ft.	Plumb bow and transom
Beam	20.00	Ft.	
Depth	10.00	Ft.	
Draft	5.25	Ft.	
Draft scantling	7.5	Ft.	
Form Coefficients:			
Block Coefficient	0.695		
Prismatic Coefficient	0.818		
Midship Coefficient	0.850		
Waterplane Area Coefficient	0.825		
Hydrostatics (at DWL full load, no trim or heel)			
Displacement - Salt Water	140.00	LTsw	LWL x BWL x T full load x Cb
Design Displacement	313,600.00	Pounds	
Volume of Displacement	4900.00	Cu. Ft.	
Displacement / Length Ratio	273.44		Displ in LT / ((LWL / 100)^3) This is medium DL ratio. Heavy vessel has D L ratio > 320.
Sail Area	1500	Sq. Ft.	Preliminary … SA/D indicates SA can increase
Sail Area to Displacement Ratio	5.20		SA / (Displ in cu ft)^.6667 Range for heavy displacement vessels is 10 to 15
Waterplane Area (approx.)	1320.00	Sq. Ft.	Cwp x LWL x B
Tons per Inch Immersion	3.81	LT	(LWL x B x 0.08333) / 35 cu ft. per ton SW
Moment to Trim 1 inch (MTi)	30492.00	Foot / Pounds	Approx.: (0.35 x (waterplane area)^2)/B
Wetted Surface (Taylor)	1652	Sq. Ft.	
Wetted Surface (Denny)	1674	Sq. Ft.	

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Figure 6

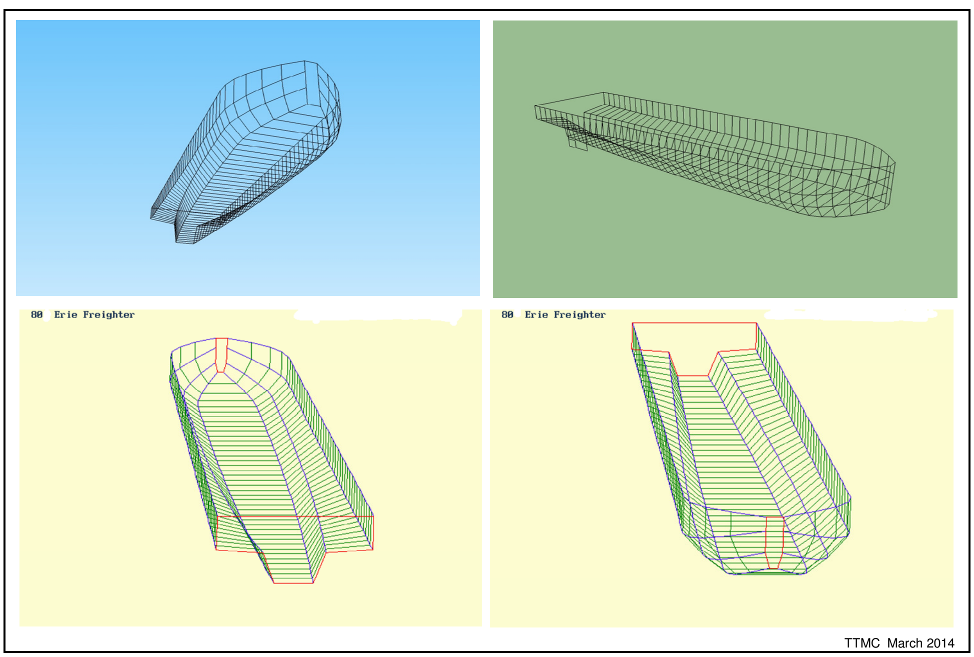


Figure 7

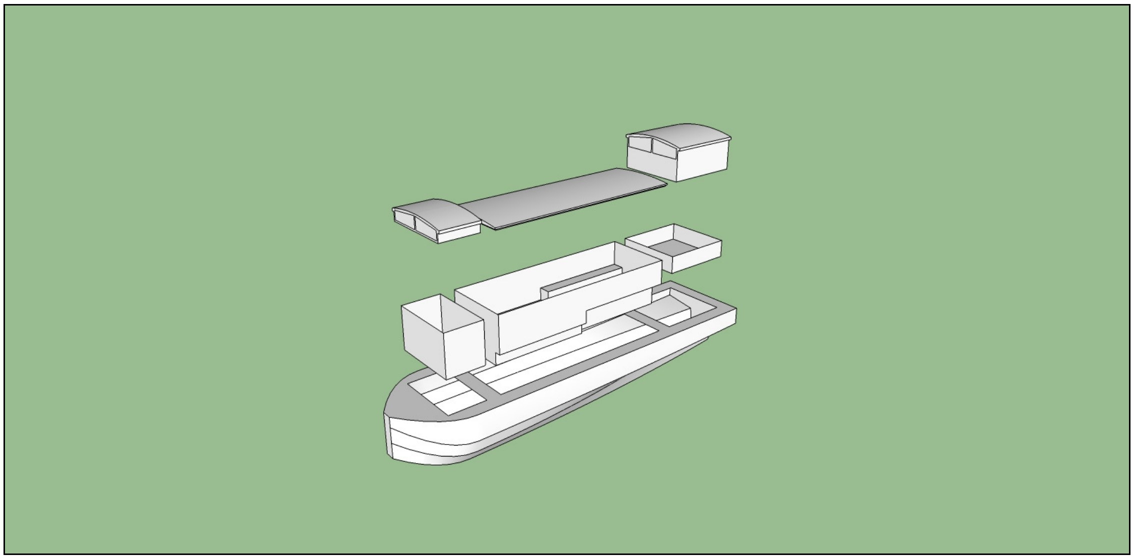


Figure 8

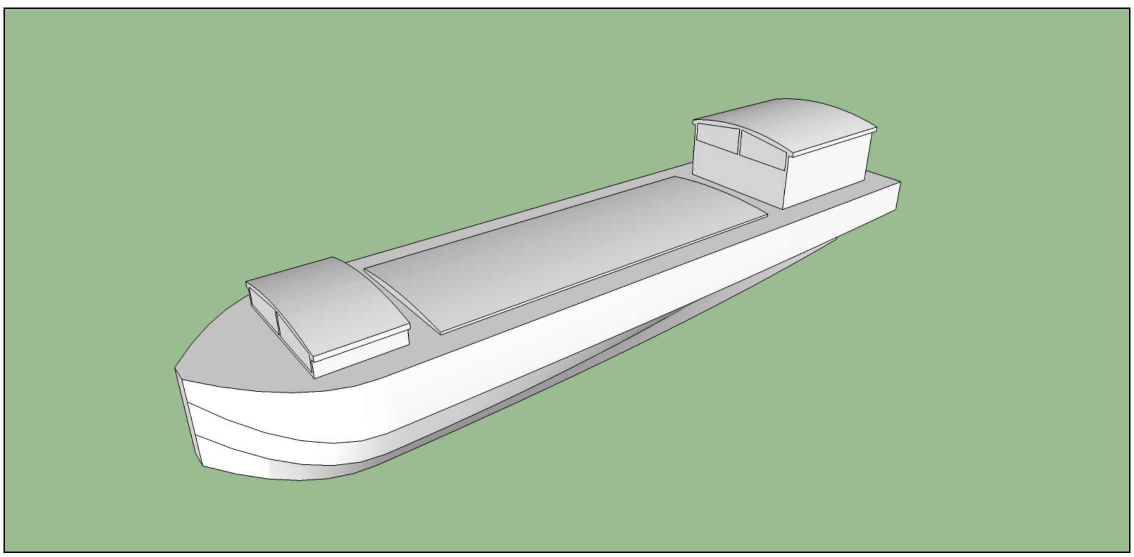


Figure 9

Propulsion System:

RSS - 80 will use a hybrid diesel-electric / sail propulsion system (Figure 10). When transiting the Erie / NYS Barge Canal, propulsion is by twin electric motors powered by batteries and diesel generators. A wide skeg is fitted to enable placement of the main battery compartment to be as low as possible where the weight will make the greatest contribute to stability and sail-carrying ability (Figures 11 and 12).

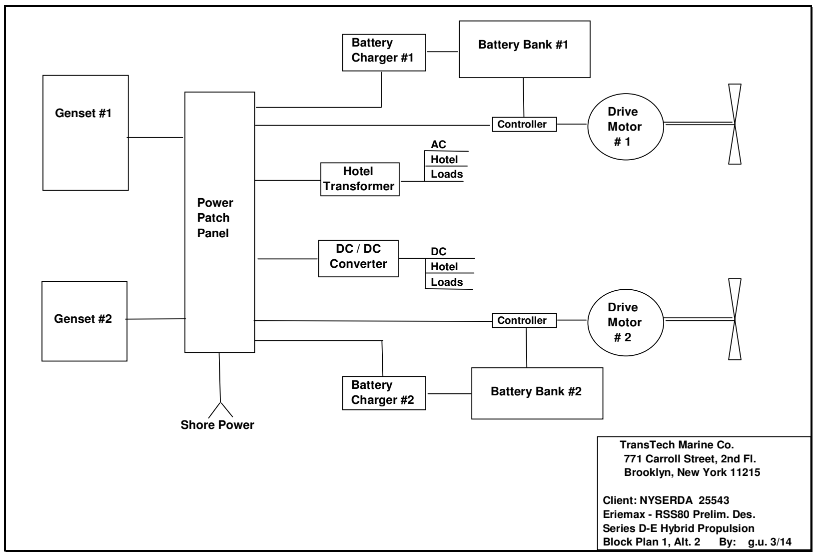


Figure 10

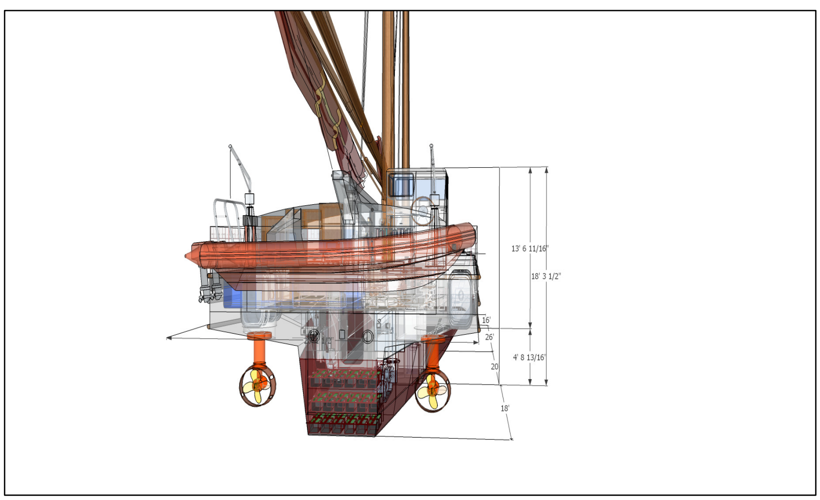


Figure 11

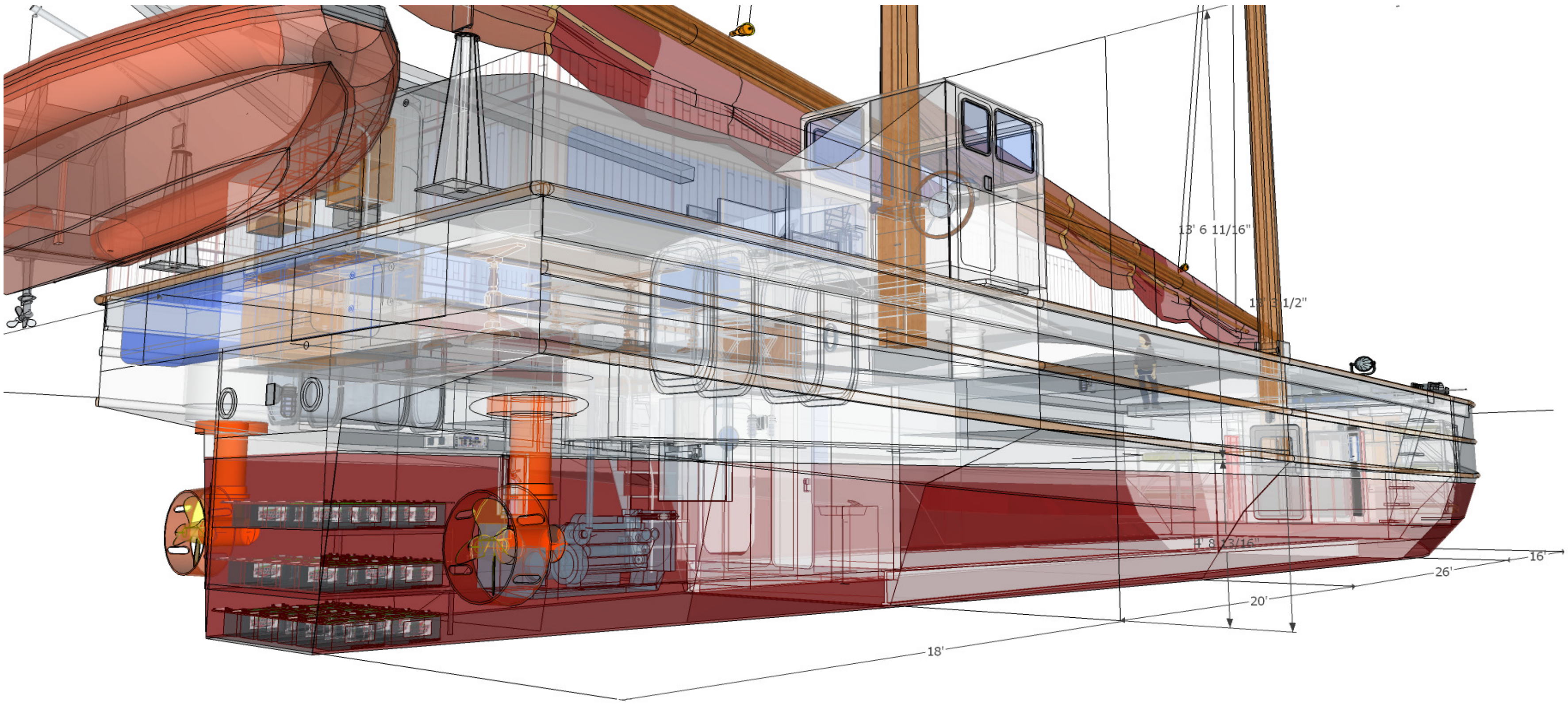


Figure 12

At full propulsive power of 70 kW (about 95 BHP), RSS-80 will be capable of about 7.5 knots (Figure 13). Economy in power and fuel consumption is gained by operating at speed-to-length ratio of 0.85. Steaming at a more conventional SLR of about 1.0 would increase RSS-80's speed by only a knot while increasing power consumption by fifty percent. Slower speed is acceptable because RSS - 80 is purposefully designed for what TransTech calls the WIT transport model (Warehouse in Transit), rather than the JIT model (Just in Time). For many commodities, WIT is believed to be more in tune with current societal needs, economic realities and environmental priorities than the outdated, over-used JIT model that often speeds goods along highways in hours merely to spend days in a warehouse awaiting final local delivery. Numerous surveys have established that cargo shippers and consignees favor economical transport over higher priced express transport in most cases, the exception being perishable commodities.

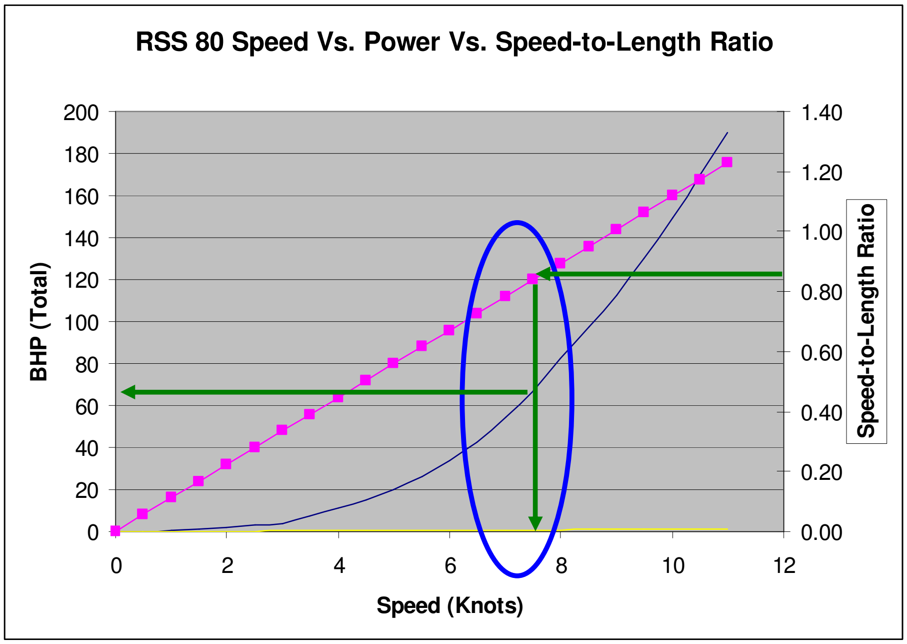


Figure 13

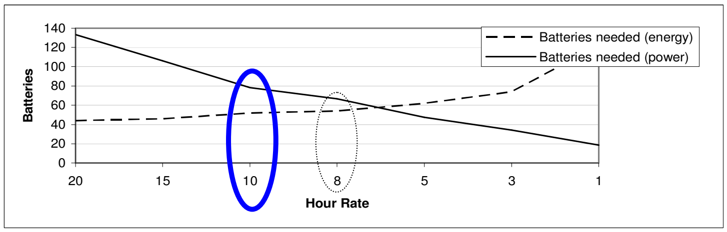
Energy Storage:

Navigation in the Erie / NYS Barge Canal is restricted to daylight hours. RSS - 80's propulsion and house load power needs will be met by a battery bank comprised of 72 deep-cycle lead-acid batteries (Figure 14) and two 35 Kw generators. Both generators can be shut down at night, using only battery power for house loads. One or two generators can be run during the day time to optimally meet power requirements and re-charge batteries (Figure 15).

RSS 80 Battery Bank Size Calculation

Model: **Surrette Series 4000 T12 250M - HD Marine Deep Cycle.** **Weight =** 130 lb_f

Hour rate =	20	15	10	8	5	3	1	hr
AmpHours =	275	259	234	220	193	162	99	Amp-hr
Voltage =	12	12	12	12	12	12	12	Volts
Amperage =	13.75	17.27	23.40	27.50	38.60	54.00	99.00	Amps
Max. D. O. D. =	0.50	0.50	0.50	0.50	0.50	0.50	0.50	Percent
Energy per battery =	3.30	3.11	2.81	2.64	2.32	1.94	1.188	kW-hr
Specific Energy =	25.38	23.91	21.60	20.31	17.82	14.95	9.138	W-hr / Lb.
Power per battery =	0.17	0.21	0.28	0.33	0.46	0.65	1.188	kW
Specific Power =	1.27	1.59	2.16	2.54	3.56	4.98	9.138	W / Lb.
Batteries needed (energy) at D.O.D. = 50%	44	46	52	54	62	74	122	
Batteries needed (power) at D.O.D. = 50%	133	106	78	67	47	34	19	



Recommended Number of Batteries to Satisfy Both Energy and Power Requirements at 10 Hour Rate = **72** **batteries**

Total Weight of Battery Bank = **9360** **lb_f**
4.2 **LT**

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Figure 14

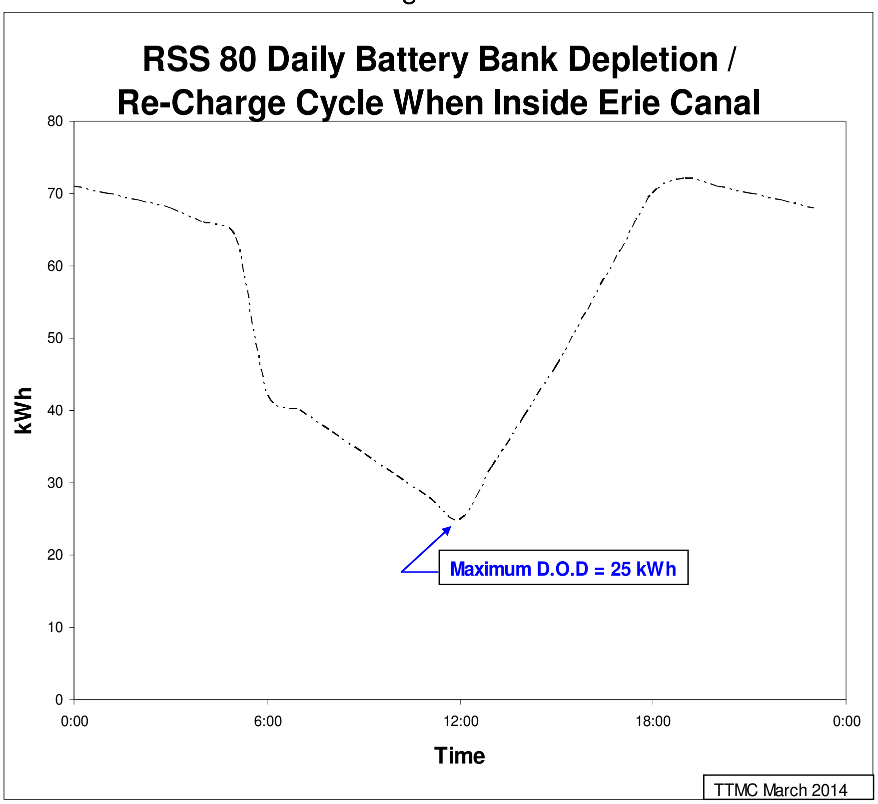


Figure 15

Sail Propulsion:

RSS - 80 will use Chines junk style lug sails on two masts to simplify handling by a small crew (Figure 16). The masts are fitted in tabernacles to enable them to fold down. The main boom on each mast serves as jib of a derrick to work cargo in port. Under sail in favorable conditions, RSS - 80 will be capable of about 6.5 knots.

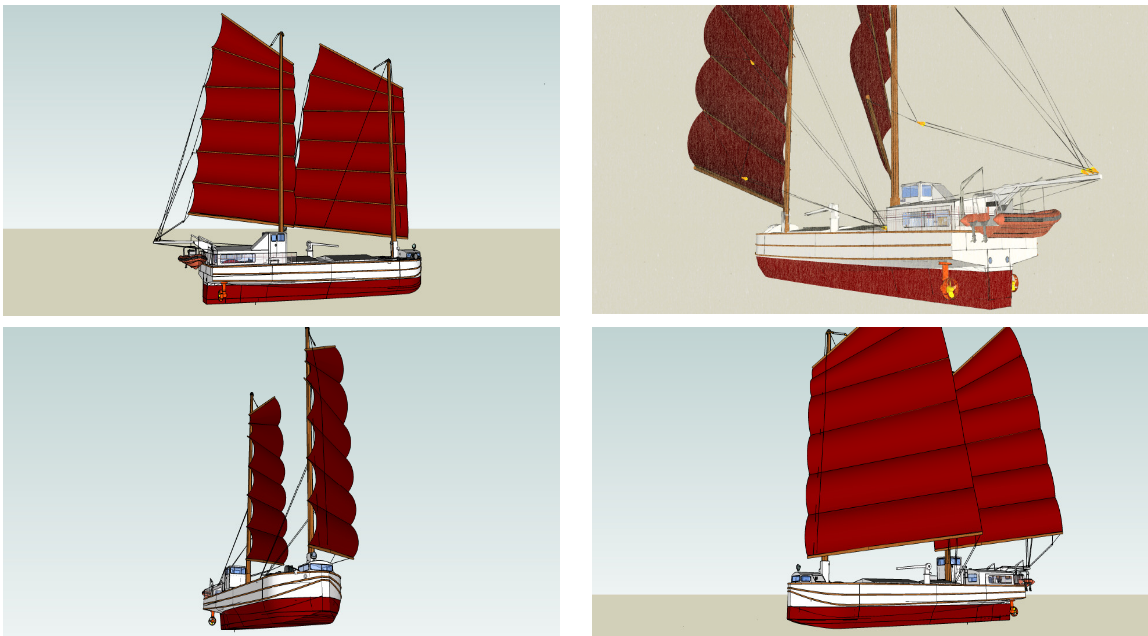


Figure 16

Cargo Stowage and Access:

RSS - 80 is first a foremost a commercial cargo carrier. Cargo holds are large and unencumbered (Figure 17) and decks are kept clear for working cargo (Figure 18).

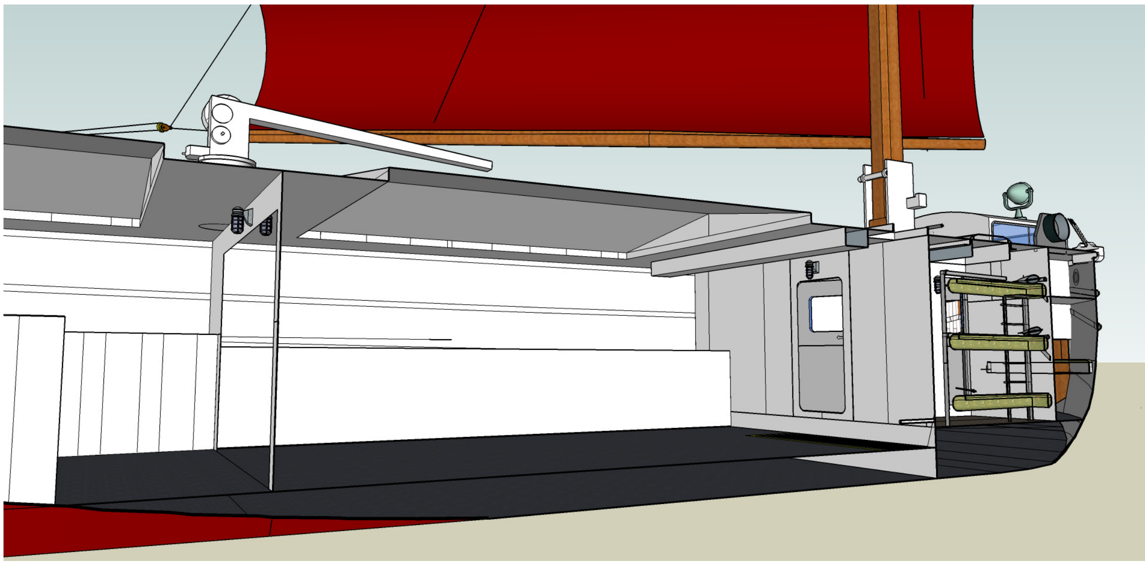


Figure 17

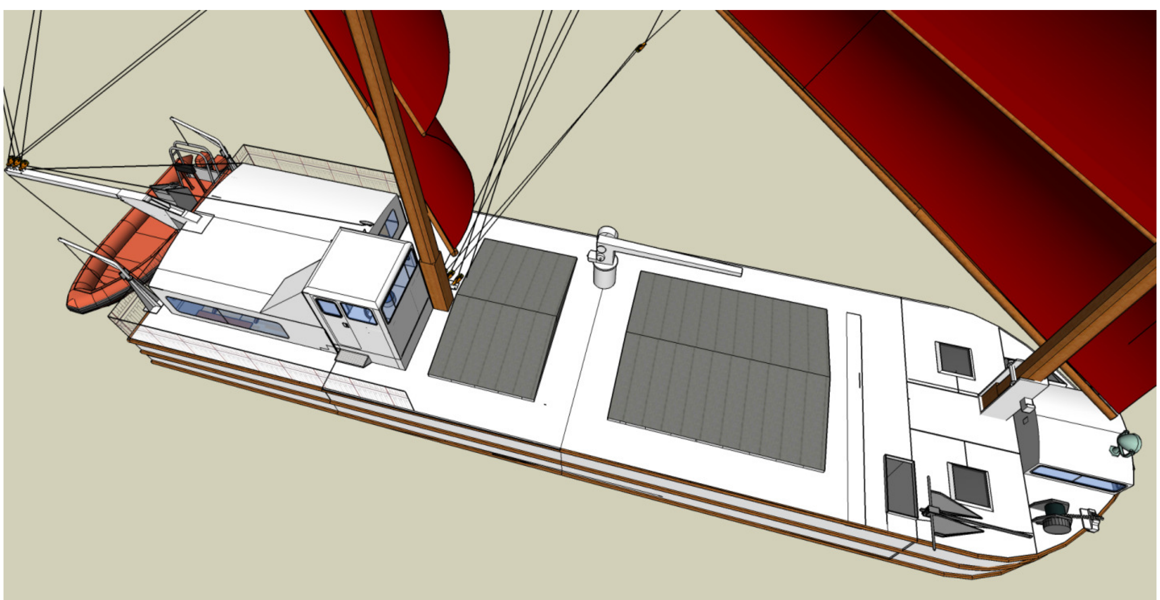


Figure 18

Accommodation Space:

Last but not least, RSS – 80 is a comfortable live-aboard vessel of comparable standard to European River Rhine barges that are often operated by a live-aboard family, or North American tuna seiners which can spend many months at sea and therefore are outfitted to a high standard. RSS - 80's aft cabin combines owner's stateroom, navigation bridge and small office (Figures 19 and 20). The forecastle is fitted with bunkbeds for crew members. Comfortable outfit is not a luxury since small cargo ships often operate on tight schedules and thin margins and it is an established fact that rested crews make fewer errors.

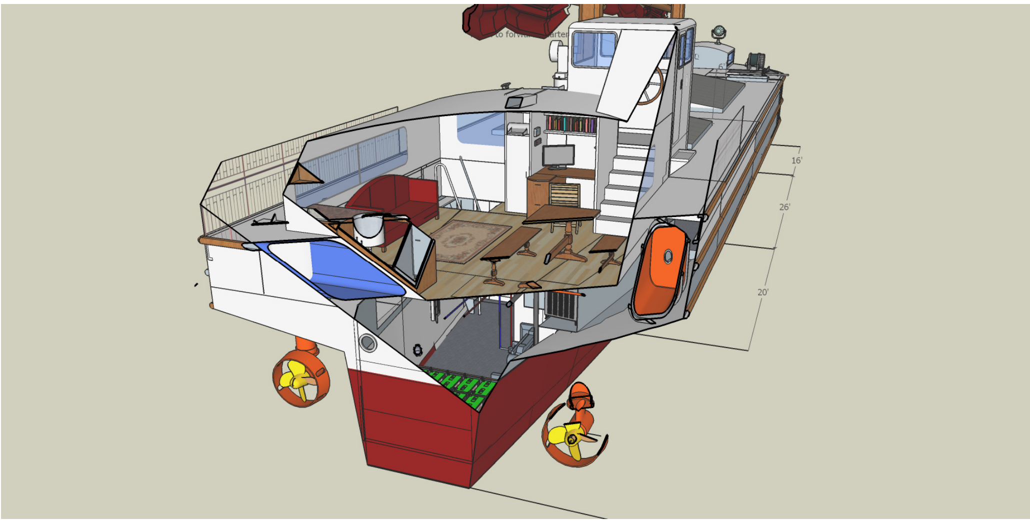


Figure 19

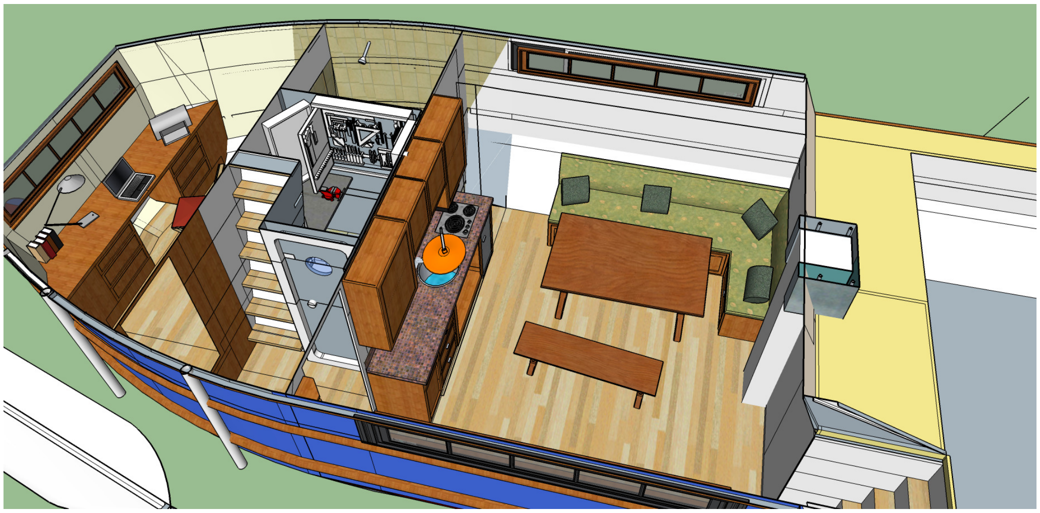


Figure 20

Cost Estimate:

The original minimum acquisition cost of RSS - 80 was put at $660,000 (Figure 21). This is the “volunteer labor / donated build site” price and even with those allowances, the initial estimate is now thought to be too low in light of the fact the propulsion and energy storage systems have been upgraded. A more realistic “community build ” price of RSS - 80 is now put at about $800,000. Doubling this figure is not unrealistic were a professional ship builder to take charge. Nevertheless, even at $1.5 million, RSS - 80 is but one fifth the cost of TransTech’s PD-1 or Goldman Belt’s motor barge, albeit cargo capacity is also significantly lower. RSS - 80 is offered as the more plausible design around which to begin efforts to reinvigorate commercial use of the Erie / NYS Barge Canal. In the case of using public markets to finance projects (see Capitalization Plan, p. 32, instant) a “sweet spot” appears to exist for initiatives able to be capitalized at not more than $1 million, since this is the cap for a number of funding instruments.

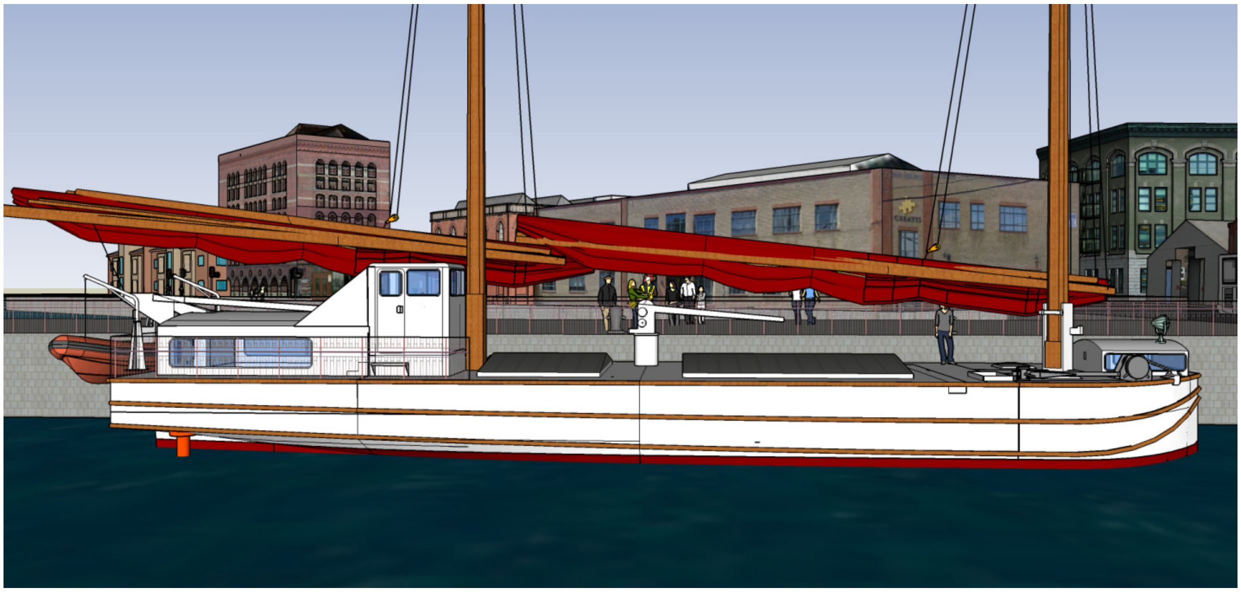
TransTech Preliminary Cost Estimator
Eriemax RSS - 80
Summary Sheet

Owner:	Hudson - Erie	LOA)Ft.)	80.00	Speed / Props:	7.5 / 2	Date:	April 2014
	Freight Transport Co.	LBP (Ft.)	80.00	Mach'y Type:	Hybrid Electirc		
Type:	Eriemax	Beam (Ft.)	20.00	kW (total)	80	Project No:	NYSERDA 25543
	Sea River Ship	Depth (Ft.)	10.00	Range (n.m.):	2500		Eriemax RSS-80
Trade:	U.S. Coastal,	Draft (scantling)	7.50	Crew:	9	Prepared by:	G. F. Uttmark
	Great Lakes.	Light Ship (LT)	40.00	Passengers:	0		TTMC
	Bays, Sounds	Deadweight (LT)	100.00	Loaded Disp. (LT)	140.00		Alt. 0 / Rev. 0

Weight Group	Quantity Tons	Material Cost Per Ton	Labor Productivity (hours per ton assembled)	Material Cost per Weight Group	Labor Hours per Weight Group	Labor Rate	Labor Cost per Weight Group	**Total Cost**
Hull	28.8	800	100	23036	2879	35.00	100781	**123817**
Outfit	4.5	2500	300	11161	1339	65.00	87054	**98214**
Mach'y/Bat'y	6.7	8000	250	53571	1674	45.00	75335	**128906**
Misc	1	1000	200	1000	200	35.00	7000	**8000**
Material & Labor SUB -TOTAL	**41.0**			**88768**	**6093**		**270170**	**358938**
Build Site Costs (Pct. of Materials Cost and Pct. of Labor Cost)			0.100			0.050		
				8877			13508	
Engineering Costs (Pct. of Materials Cost and Pct. of Labor Cost)			0.050			0.050		
				4438			13508	
DIRECT CONSTRUCTION COST				**$102,083**			**$297,187**	**$399,270**
Shipyard Overhead Rate (Pct. of Total Direct Labor Cost)			0.650					
Shipyard Overhead Expense								**193171**
Shipyard Profit & Escalations Rate (Pct. of Direct Build Cost + Overhead)			0.100					
Shipyard Profit + Escalations								**59244**
SHIPYARD DELIVERED PRICE (Ex-Spares)								**$651,685**
Spare Parts Package (Pct. of Direct Materials Cost)			0.100					
Spare Parts Package per Vessel								**8877**
SHIPYARD DELIVERED PRICE (Inc. Spares)								**660562**
Discount for Series Production (Neg. Pct. of Delivered Price, Ex-Spares)			0.000					
Discountfor for Series Production								**0**
TOTAL DELIVERED PRICE PER VESSEL								**$660,562**

Figure 21

BUSINESS PLAN



The Vision:

The vision is to start a movement, literally and figuratively. The “movement” is to create a fleet of community-owned (next chapter, instant), environmentally benign ships to profitably trade and transport by inland and coastal waterways cargoes that are inherently amenable to the marine mode.

Green ships that are economical to build and operate can deliver cargo at competitive freight rates and with lower carbon footprint than can be achieved by other transport modes or older marine equipment. Success of a pilot project will show the way to many others. When a fleet of RSS-80s (or larger) is operating, there will be many winners:

- All of society will enjoy cleaner air as lower emissions marine transport reduces congestion on highways.
- Producers of goods that are amenable to water transport will be able to get their goods to consumers more cleanly and economically.
- Consumers of the goods will benefit from lower transport costs, and in some cases, from the cachet that attaches to delivery of the goods by water.

- Communities that build and operate an RSS - 80 (or larger) will have greater control of their transport value chain while improving brand recognition and environmental awareness wherever the ship travels.

- Since US law requires ships in domestic commerce to be built in the US and crewed by American citizens, many new employment opportunities in “green” transport technology and operations will be created.

Strategy:

A pilot project can begin anywhere but before any kind of marine equipment is needed, first is needed a cargo that requires transport, and second is needed suitable docks at which to load and unload the vessel.

Cargo: Wine is offered as a plausible cargo on which to base an RSS - 80 pilot project. Three factor endowments combine with three comparative advantages, and good timing, to improve the chances of success. (Factor endowments are inherent whereas comparative advantages are created, either by individual effort or government incentive).

Factor Endowment 1 - Colossal (Base) Cargo Market:

New York State is the third largest producer of wine in the US, behind California and Washington. Over 1,600 vineyards and 400 wineries across the state produce almost 200,000,000 bottles of wine annually.

Wine production in New York State is centered in five main regions: Lake Erie Region, Niagara Escarpment, Finger Lakes, Hudson Valley, eastern Long Island, especially the North Fork. Smaller regions abut Lake Champlain and the shore of Lake Ontario. <u>All of the wine producing regions in New York State are connected to each other and to the greater New York City metropolitan region by water</u> (Figure 22).

source: www.newyorkwines.org

Figure 22

Factor Endowment 2 - NYS Unsurpassed Waterways System:

The Erie / NYS Barge Canal is comprised of four waterways (Erie Canal, Champlain Canal, Oswego Canal, Cayuga -Seneca Canal) that place the state among the most navigable in the nation. The four canals traverse 524 miles in total. The waterway remains the only all-water link between the Atlantic Ocean and the Great Lakes that is wholly within the continental United States, providing direct waterborne access amongst and between eight American states and Ontario, Canada.

In a "JIT" economy the Erie / NYS Barge Canal has notable challenges that include seasonality, low bridges and lack of night-time navigation. Notwithstanding these handicaps, cargo that *can* move via the Erie / NYS Barge Canal will reach east coast ports south of Boston in less time and at lower cost than freight moved to Atlantic coast ports via the Welland Canal / Saint Lawrence Seaway system. This is illustrated in Figure 23 for a Canal - capable ship traveling, for example, from Duluth, MN to the port of New York and New Jersey.

Of particular note in Figure 23 is that while transit time from Duluth to the Port of New York and New Jersey via the Erie / NYS Barge Canal is a day and half shorter than via the Welland Canal / Saint Lawrence Seaway system, the total mileage is but half. This has a major impact on fuel consumption and carbon footprint. The message is quite clear: Seaway size ships (about 30,000 dwt) carrying, for example, US Midwest or Canadian grain to Europe or Asia will not be replaced by Eriemax size ships (about 2,500 dwt) using the Erie / NYS Barge Canal. However coastal river-sea vessels trading between the Great Lakes and ports on the US Atlantic seaboard south of Boston and as far south as the Caribbean and Central America would be advantaged by using the Erie / NYS Barge Canal route. Not only is the Erie / NYS Barge Canal route faster and cleaner, it is also more economical because its halves the fuel bill and avoids the tolls on the Welland Canal / Saint Lawrence Seaway system, which are not inconsequential (Figure 24).

Duluth, MN to Erie Basin, Brooklyn
via Saint. Lawrence Seaway and Atlantic Ocean

	NM	Locks	Hours	Days
Duluth to Sault Saint Marie	342		24.4	
Soo Locks + St. Marys River	70	1	12.0	
Sault Ste. Marie to Port Huron, MI	269		19.2	
Lake St. Clair + Detroit River	77		7.3	
Detroit to Port Colborne, Ont.	244		17.4	
Welland Ship Canal	24	8	16.6	
Port Weller, Ont. - Kingston, NY	202		14.4	
Kingston, NY to Montreal (St. Law. S'way)	168		24.0	
Saint Lawrence Seaway		7	7.0	
Subtotal: Great Lakes + Seaway	**1396**	**16**	**142.4**	**5.9**
Montreal to Port NY via Atlantic Ocean	1534		109.6	4.6
Dwell Time + Misc.	0		24.0	1.0
TOTAL:	**3098**	**16**	**276.0**	**11.5**

Resource: www.nauticalcharts.noaa.gov/nsd/distances-ports/distances.pdf

Duluth, MN to Erie Basin, Brooklyn
via Erie / NYS Barge Canal

	NM	Locks	Hours	Days
Duluth to Sault Saint Marie	342		24.4	
Soo Locks + St. Marys River	70	1	12	
Sault Ste. Marie to Port Huron, MI	269		19.2	
Lake St. Clair + Detroit River	77		7.3	
Detroit to Buffalo, NY	261		18.6	
Subtotal: Great Lakes	**1019**	**1**	**81.6**	**3.4**
Erie / NYS Barge Canal	353	35	118.4	4.9
Troy, NY to Erie Basin, Brooklyn	134		19.1	0.8
Dwell Time + Misc.	0		24.0	1.0
TOTAL:	**1506**	**36**	**243.1**	**10.1**

Resource: www.nauticalcharts.noaa.gov/nsd/distances-ports/distances.pdf

TransTech Marine Co.

Figure 23

Pro Forma Saint Lawrence Seaway Toll - 2013

Typical 1500 DWT River-Sea Ship
(Tolls are in Canadian Dollars)

	Loaded - General Cargo	Loaded - Bulk Cargo	Ballast Condition
Cargo Toll (CDWT = 1500)	3,727.20	1,546.80	0.00
GRT Charge (GRT = 1200)	119.40	119.40	119.40
Lockage Charge (7 Seaway locks)	180.25	180.25	180.25
	$4,026.85	$1,846.45	$299.65
Toll in US Dollars ($1 CDN = $.9842 US)	**$3,954.37**	**$1,813.21**	**$294.26**

TTMC 4/2013

Pro Forma Welland Canal Toll - 2013

Typical 1500 DWT River-Sea Ship
(Tolls are in Canadian Dollars)

	Loaded - General Cargo	Loaded - Bulk Cargo	Ballast Condition
Cargo Toll (CDWT = 1500)	1,689.00	1,055.85	0.00
GRT Charge (GRT = 1200)	191.04	191.04	191.04
Lockage Charge (per GRT)	324.00	324.00	324.00
	$2,204.04	$1,570.89	$515.04
Toll in US Dollars ($1 CDN = $.9842 US)	**$2,164.37**	**$1,542.61**	**$505.77**

TTMC 4/2013

Figure 24

Factor Endowment 3 - Giant / Sophisticated Consumer Market:

Wine, as well as spirits, beer and many other products, is not a time-sensitive cargo. In fact, it is reputed to benefit from the motions of ocean transport in the same way that bourbon whiskey does. The advertisement in Figure 25 from *Wired* Magazine (April, 2014, p. 32) says in part, “On the ocean, endless rocking agitates the bourbon … (and) … sea air tops it off with a bit of brine.” More to the subject of wine aficionados, a French company shipping wine to Montreal by barkentine reported the reduced air pollution from using a sailing ship and slow agitation of ocean passage added value to their wine in the eyes of their customers.

For cargoes like wine where perception and opinion impart value, it is not necessary to prove that waterborne transport improves taste, if it indeed does. Sophisticated consumers appear to appreciate that a product that is aged slowly and is supposed to be consumed slowly is in no way harmed, possibly improved - and certainly benefits the environment, if it travels a slower, cleaner more leisurely route to market.

032 ALPHA
WHISKEY IAN ALLEN

BOOZE CRUISE
HIGH PROOF ON THE HIGH SEAS

AMERICAN WHISKEY is having a moment—and it’s a long time coming. Brown liquor generally spends at least a few years in a barrel stacked in a warehouse, soaking up wood flavors. That means a substantial wait for new product. So whiskey makers are always trying to speed up the process, using everything from shaking to pressure cooking to bombardment with ultrasonic waves. But Trey Zoeller, founder of Jefferson’s Bourbon, thinks he has a better solution: He puts his booze on a boat. ¶ On the ocean, endless rocking agitates the bourbon “like a paint can in a shaker,” Zoeller says, increasing contact with the cask. That accelerates extraction, while sweltering daytime temperatures send the bourbon further into the barrel’s wood, and cold nights increase oxidation, making for deeper, more mellow booze. The sea air tops it all off with a bit of brine. ¶ In just three and a half years on a shark research vessel, Zoeller’s first five-barrel batch grew up fast, earning good reviews and selling out almost immediately. Now he’s testing on a larger scale. In May, 192 barrels of bourbon will return home after six months on a container ship, hopefully mature enough to compete with booming super-premium whiskeys and justify a retail price of $80. Zoeller plans to keep casks on the water on a continuous basis, tasting and refining as his bourbon zigzags the globe. A cargo ship seems like an unlikely time machine, but if it works it’ll be worth the trip. —MIKE OLSON

Figure 25

	National Rank	Consumption (lpc / annum)
New Hampshire	1	19.6
Vermont	2	17.5
Massachusetts	3	16.9
New Jersey	4	14.6
Connecticut	6	14.4
Rhode Island	8	14
Delaware	9	13.5

New York State is the fourteenth largest consumer of wine in the US at 11.9 liters per capita per annum, behind Oregon (12.2) and ahead of Alaska (10.9). Wine consumption in New York State is greatest in the Greater New York City metropolitan region, the nucleus of the proposed pilot project. Also encouraging is the fact that seven of the top ten win consuming states in the US are within the operating range of the pilot project RSS – 80 vessel.

Almost all wine-consuming states are also wine producers, though not as large as New York State. Dynamic trade can develop between different wine producing states because of the abundance of varieties. This is akin to Americans consuming European beers while Europeans consume American beers … because they like to. Trade in like commodities is “ceremonial trade”, which has been shown to expand with consumer wealth and sophistication.

Since any wine transported by modern *green* ships would benefit from the cachet attached thereto, backhaul, ceremonial trade wine and spirits cargoes would multiply revenues, while increasing costs only marginally.

Comparative Advantage 1 – NYS "Farm Wineries" Laws:

In 1976 New York State passed the Farm Winery Act which allowed small grower-producers to sell directly to consumers, as well as reducing certain fees and providing tax and marketing advantages. Originally, the law required farm wineries to sell only estate-grown wines, but it was amended in 1978 to allow the use of any New York-grown grapes in wine sold at a farm winery.

A brilliant aspect of the Farm Winery Act was inclusion of a special permit for wineries to open up to five satellite stores in tourist areas within the state, rather than restricting sales to the farm (winery) proper. The 1976 law was so successful in encouraging creation / expansion of wineries in New York State that many other wine-producing states have since passed similar laws.

In 2011 the New York Fine Winery Bill was signed into law by Governor Andrew Cuomo. The new law further reduces regulatory burdens for New York farm wineries and simplifies the opening of branch stores as extensions of the farm winery.

Farm wineries are a form of value-added marketing that represent a huge component of New York State's 5 million visitors annually agritourism industry. Assuming the RSS - 80 pilot project can succeed in locating a docking location in New York City that will permit retail wine sales, TransTech believes one and perhaps several New York State wineries could be interested in opening a waterfront farm winery store. The ability to sample great New York State wines transported by perhaps the greenest freight transportation system in the country would stand excellent chance of becoming a tourist attraction in its own right, as well as a local economic stimulus and source of additional cash flow for the pilot project.

Comparative Advantage 2 – RSS - 80 Itself :

TransTech believes RSS - 80 itself will create a comparative advantage because it will rank among the greenest transport systems in the country and transporting wine by water as a first step in reinvigorating commercial use of the Erie / NYS Barge Canal will simply be interesting to people. (In the course of doing this R&D investigation, TransTech discovered that few people are aware the Erie / NYS Barge Canal is still operational as a commercial waterway … in fact, it is in excellent condition with modern size fully operational locks).

Comparative Advantage 3 - Proactive Community / Co-Op Finance:

Ocean shipping is one of the first industries where finance of the major asset became a comparative advantage in its own right. The practice of dividing ownership of a ship into sixty-four shares originated in medieval Italy. From Italy the practice spread across Europe where share offerings launched some of the most successful maritime ventures in history, including the Dutch East India Company and the Hudson Bay Company. The practice also came to the US where it was used to capitalize construction of schooners in Maine for transport of coal along east coast US and Canada.

TransTech believes that "community" ownership of a vessel that is transporting a consumer good must be beneficial. The subject of how this is to be achieved to launch the proposed pilot project is discussed in the next chapter of this report, Capitalization Plan.

Timing:

Arguments for increasing use of the waterborne transport mode are many and strong, and have been recited in many fora. They include …

- Global warming
- Peak oil
- Congested highways / Difficulty of building more
- Railroads operating at +100 percent load factor
- Vehicle emissions / Air quality issues
- "Third mode" national security advantages

TransTech could add to the above list that quality jobs would be created by building and operating a large fleet of RSS - 80s (or larger subsequent vessels) and that such initiatives would produce substantial beneficial ripple effects in the form of lower transport costs, cleaner transport footprint, regional economic revitalization and green ecotourism development.

Docking Locations: A pendulum service is proposed for the pilot project that operates as follows: Finger Lakes – NYC – North Fork, LI – NYC – Finger Lakes. A complete circuit of the pendulum would require about ten days with two days slack time built into the voyage. A large number of wineries are on or near navigable waterways (Figure 26).

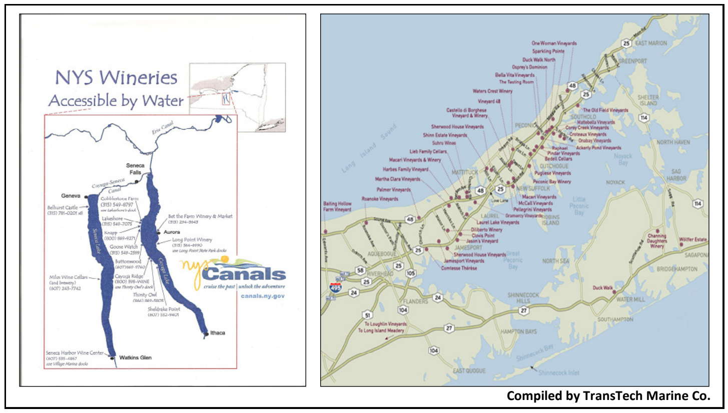


Figure 26

Many locations are available along the Erie / NYS Barge Canal for loading / discharging vessels the size of RSS - 80 (Figure 27). In addition to public terminals, some wineries have private docks at which small vessels can load and unload cargoes.

New York State Canal System - Terminal Locations

		Loading/Unloading			Mooring			
Terminal Location	Section	Available	Length (Ft.)	Not Available	Available	Length (Ft.)	Not Available	Comments
Fort Edward - Hudson River	1		640	X	X	320		Village holds permit for park on site
Fort Edward - Lock C-7	1	X	300		X	300		Access through Section yard. Loading limited. Mooring limited. CC uses wall.
Mechanicville	1	X	330		X	330		City & Chamber hold permits to use site and 100 ft dock.
Plattsburgh, Pier	1	X	200 x 400		X	400		City holds permit to use site, has requested lease. DEC holds MOU to use site.
Port Henry, Pier	1	X	320		X	390		Village holds permit to use site, including for docks along landside of terminal.
Thomson	1	X	230		X	230		Limited area to offload; land access must be obtained from others; currently under permit
Troy	1	X	575		X	575		Abandoned portion. 50 ft width to offload; land access must be obtained from others; currently under permit
Whitehall	1		470	X	X	470		Town holds permit to use site
Crescent	2	X	150		X			
Waterford	2	X	600		X	600		Limited offloading area. Town holds permit to use site.
Canajoharie	3	X	410		X	410		Limited offloading area, Town holds permit to use site.
Fonda	3	X	300		X	300		Section office. Use can not impact Canal operations.
St. Johnsville	3		150	X	X	150		Town holds permit to use site as marina.
Frankfort	4		300	X			X	Needs dredging, dock obstructions
Herkimer	4		500		X	500		Floating dock not available
Ilion	4		600	X			X	Leased by Ilion
Little Falls	4		600	X			X	Leased by Little Falls
Rome	4		910		X	900	X	Westerly portion has floating docks
Sylvan Beach	4		1910	X		500		Permitted to the Village
Verona Beach	4				X	600		Available but used by recreational vessels
Utica	4		1160	X			X	condition of harbor walls is questionable
*Three Rivers	5		350	X			X	Wall is unsound and closed.
Baldwinsville	5	X	690 & 570		X			Grant for recreational use
Brewerton (North)	5	X		X				Only the floating section is left.
Brewerton (South)	5	X	570		X			60' in center permitted to cruise operator. Coast Guard and Town have requested permit for the rest
Cleveland	5	X	240		X			DEC Fishing access permit
Fulton	5	X	800		X			
Oswego	5	X	594		X			Frequent municpal activities
Syracuse - North Dock	5		365	X			X	No docks left in Syracuse.
Syracuse - North Pier, North	5	X	335		X			
Syracuse - North Pier, South	5	X	365		X			
Syracuse - South Dock	5		735	X			X	No docks left in Syracuse.
Syracuse - South Pier, North	5	X	335		X			
Syracuse - South Pier, South	5	X	365		X			
*Waterloo	6	X	100		X			Large area from old DOT Residency
Lyons	6	X	360		X			Will be for recreational use via grant
Newark	6	X	550		X			Above lock only. Wall in village is for recreational use.
Palmyra	6	X	570		X			Village has to develop west end of wall for boat launch. Overhead issue with Route 21 bridge and UDS in area.
Seneca Falls	6	X	340		X			South wall only. Permitted to village for recreational use
Macedon	6		200		X	200		Upper end of Lock E-30. Heavy equipment can enter the area.
Weedsport	6	X	150		X			
*Adams Basin	7	X	530		X			Roadway construction needed for loading / Used often by Corporation Floating Plant
*Gasport	7	X	300		X			Roadway construction needed for loading / Municipal park is adjacent
*Knowlesville	7	X	250		X			Roadway construction needed for loading / Municipal park is adjacent

Source: NYS Canal Authority

Figure 27

The preferred docking location in New York City is along the Brooklyn waterfront, ideally near Erie Basin (Figure 28) since this will reinforce the connection to the waterway's colorful past (Brooklyn's Erie Basin is the southern terminus of the Erie Canal). Wine will be distributed throughout the city from the terminal via low-emissions hybrid powered vans that run on natural gas or electricity. The terminal will feature a Farm Winery store and sampling room. TransTech believes a waterfront Farm Winery store would become an important ecotourism destination since the waterfront provides a pleasant ambiance to sample wine and the very low carbon footprint RSS - 80 vessel would itself be an attraction to visitors, thereby contributing to local and regional economic redevelopment.

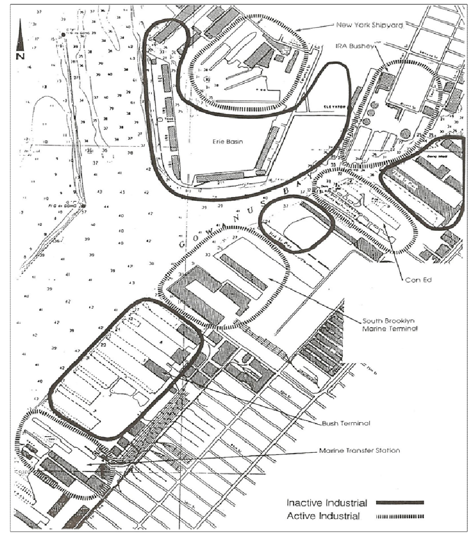


Figure 28

Expansion Opportunities:

The foregoing business plan summary described one RSS - 80 opportunity centered on wine transport. After a success pilot project demonstrates the enormous benefits to be derived from intensive use of the Erie / NYS Barge Canal by modern marine equipment, there are probably hundreds of expansion opportunities. The following illustrates how the frame created by a successful pilot project might be filled in:

1. Build out wine trading and transport business:

   Wine trade and transport in New York State provide large expansion opportunities beyond the initial route. As can be seen in Figure 29, the Niagara Escarpment and Lake Erie wine producing regions extend around all of Lake Erie (including Ontario, Canada, though not shown). In fact, except for Minnesota, all of the Great Lakes states have wine producing regions bordering the Lakes, two of the most famous being Michigan's Grand Traverse Bay (Figure 30) and Wisconsin's Door County Peninsula (Figure 31). Both regions are served by excellent ports.

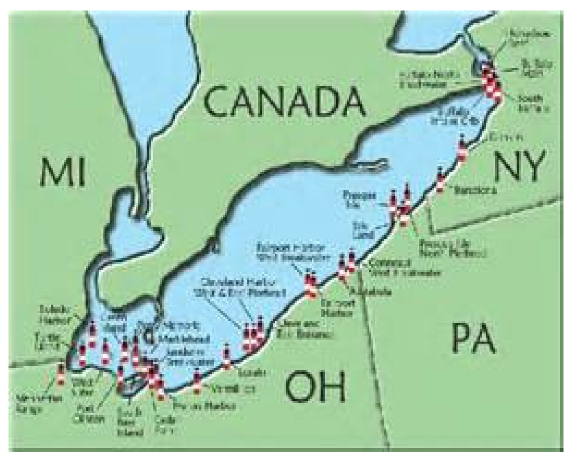


Figure 29

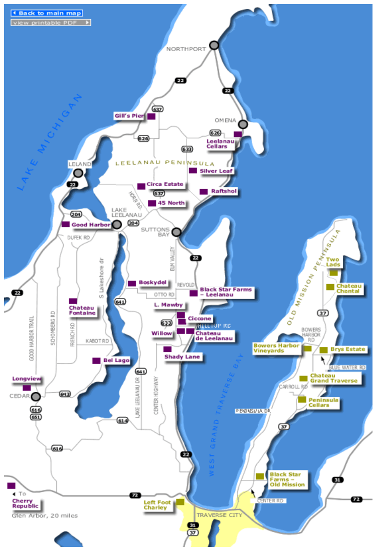


Figure 30

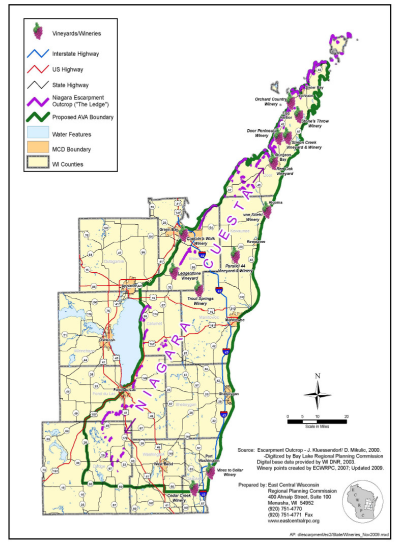


Figure 31

2. Expand into craft spirits and beers:

   New York is the ninth largest beer consuming state in the US and hosts many craft distillers and breweries, as do many neighboring states. Like wines, beers and spirits are non-perishable and benefit from the cachet attached to *green* marine transport.

3. Expand into condiments and long-lived edibles:

   Maple syrup, honey, preserved jams and jellies, dried fruits, cheeses, boutique grains and flour are a sample of long-lived foodstuffs that would probably gain value from *green* marine transport in the eyes of environmentally conscious consumers.

4. Expand into lower value / higher volume commodities:

   As the number and size of Eriemax vessels increases, unit throughput costs will decrease, making it profitable to transport larger volumes of lower value goods. Size progression of Erie / NYS Barge Canal-capable river-sea-ships should follow similar size progressions as the marine equipment that made the original Erie Canal part of American legend. Success begat success, small barges pulled by mules grew to large barges pulled by tugs, then to self-propelled barges, finally to lakes and coastal river-sea-ships. That is the goal of RSS - 80. Every large fleet starts with a lead ship.

CAPITALIZATION PLAN

Three business models were investigated to identify the most promising means to capitalize an RSS - 80 pilot project.

Industrial Shipping Model:

The industrial shipping model uses economy of scale to minimize unit cost. Scale economies are gained by building the largest practicable ship for a given trade. Established shipping companies have longstanding relationships in every sector of the ship capitalization markets. Transactions in the hundreds of millions of dollars are not uncommon for fleet renewal, expansion, strategic acquisitions, etc. Only rarely do the traditional shipping capital markets take on unknown risks or unknown entities. It does occur when a financially strong shipper, such as NYC Department of Sanitation, can put the full faith and credit of New York City into its shipping application. However, as noted earlier in this report, such financial clout would emphatically not be available to other projects.

In deciding against its own *Eriemax* PD-1 design and Goodban Belt's motor barge, TransTech concluded initiatives of this scale are beyond the ability of start-up enterprises to capitalize in a (presently) undeveloped trade. Attention then turned to smaller size vessels and other capitalization possibilities.

Owner - Master Model:

Attractions of a small, live-aboard cargo-carrying vessel are many, including affordable construction, low operating cost and docking flexibility. However, in many instances transport of cargo under normal commercial terms requires a "classed" vessel, the minimum length of which in the US is 80 feet LOA. This requirement points to a significantly larger vessel than many less formally operated owner / master cargo carriers. TransTech counts any cargo vessel up to about 65 feet in length that can be operated by a crew of two as being in the owner-master class.

Eventually the owner-master model was rejected because a cargo vessel must be large enough to transport sufficient freight to cover all its expenses, including cost of capital. It must be commodious enough for comfortable living aboard, and it should qualify for ABS classification. The inability of the owner / master model to provide sufficient scale and formality in order to have any kind of meaningful transport impact in the freight markets turned the search for capital toward a model that falls between the industrial shipping and owner / master models.

Community / Co-op Shipping Model:

Community / Co-op shipping is any group that joins together for the purpose of creating a commercial marine transport service. The group can be for or non-profit, independent or part of another group. A *community* might be a port …

> "Between 1817 and 1820, the number of small vessels of 18 to 65 tons burden increased rapidly, until each of the ports along Lake Erie's southern shore had one of its own[4]."

A *community* can be a group of shippers seeking more competitive access to markets such as was the case in the 1970s when French farmers created Brittany Ferries provide direct access to markets in Britain (Figure 32). Today, Brittany Ferries is one of the largest ferry companies in the world.

Farmers turn shipowners to create new demand

'Cornouailles' joins the cauliflower run

IT IS JUST over four years ago that a group of Breton farmers got together to find a way of transporting their produce to the UK faster and cheaper. This was the beginning of Brittany Ferries. Previously Breton produce had been transported several hundred miles by land to the traditional cross-Channel ports of France and then across to the UK, the produce (mainly cauliflowers and other vegetables) often arriving in poor condition. It was then that the farmers decided to do something themselves; they built their own port at Roscoff and sent out tenders for a year-round shipping service. But nobody took up the offer so the French farmers decided to set up their own service and launched Brittany Ferries. The major shareholder in Brittany Ferries parent company, BAI, is the Comité Economique de Fruits et Legumes de Bretagne.

PRINCIPAL PARTICULARS
'Cornouailles'
Passenger/car ferry
Yard No. 735
Trondhjems Mek Verksted, Norway
Brittany Ferries, France

Length oa	109.70m
length b.p.	98.00m
Breadth mld	16.50m
Depth to upperdeck	10.65m
Depth to main deck	5.25m
Draught max. scantlings	5.20m
Draught as a passenger ship	4.30m
Main propulsion system	Twin Deutz-Pielstick 16PA6V diesels, each rated 5 6000bhp
Service speed	19 knots
Capacity	500 passengers and 200 cars

Figure 32

[4] History of Great Lakes Navigation, Larson, John W., National Waterways Study, U.S. Army Engineers Water Resources Support Center, Institute for Water Resources, January, 1983.

A *community* can be a shipyard in search of new markets or it could be a group of entrepreneurs desiring to enter the transport business or many other parties. All are communities who might benefit from building and operating an *Eriemax* RSS - 80. The Community / Co-op shipping model was ultimately selected as offering the most pro-active mechanism to catalyze a pilot project and to replicate its success across many communities and shipping constituencies.

The Community / Co-op shipping model is consistent with the intent of the JOBS Act (Jumpstart Our Business Startups Act) which was signed into law by President Obama on April 5, 2012. This law provides a mechanism to capitalize construction and operation of *Eriemax* RSS - 80 vessels. Titles I (Reopening American Capital Markets to Emerging Growth Companies), V (Private Company Flexibility and Growth), and VI (Capital Expansion) of the law became effective upon enactment. Title II (Access to Capital for Jobs Creators) became effective on July 10, 2013 and Titles III (Crowdfunding) and Title IV (Small Company Capital Formation) are scheduled to come into force by October 2015. These will then be published in the Federal Register and become law 60 days later. Hence, by early 2016 all titles of the JOBS Act will be available for projects like *Eriemax* RSS - 80.

ShipShares LLC has been created and web site www.shipshares.com is under construction to present the prospectus for HEFTTCo. (Hudson-Erie Freight Trade & Transport Co.) to the internet community. This is a pilot project (Figure 33). The web site and prospectus will be complete as all titles of the JOBS Act come into full force. Parties interested in learning more about this opportunity are invited to contact the project primary researcher and designer, Geoff Uttmark:

geoff-nyc@shipshares.com

TransTech would like to end this final report by again thanking NYSERDA for its sponsorship, encouragement and patience in this undertaking. *Eriemax* RSS - 80 was a worthy challenge. After much effort we are confident of the way forward and of the tremendous benefit this initiative can produce for enormous numbers of people at the regional, state, local and community levels.

Business Plan
&
Solicitation of Indication of Investor Interest

Hudson-Erie Freight Trading & Transport Company
(Hereafter, HEFTTCo.)

Proposed Offering of
900,000 Common Shares
Par Value $ 0.01 at a price of $1.10 per share

Ship Shares LLC®

Manager Placing Agent

HEFTTCo. is A Development Stage New York State Enterprise

HEFTTCo. is soliciting indication of investor interest in acquiring 900,000 shares of the Company's common stock (the "shares") at a per share offering price of $1.10 (the proposed "offering"). The minimum subscription would be 1000 shares ($1,100). Both the indicated offering price and number of shares offered have been arbitrarily determined and could change materially in a formal (or legally permitted unregistered) offering. This business plan is strictly a solicitation of investor interest in acquiring shares in HEFTTCo. as one possibility to capitalize the company. It is neither an offer to sell shares, nor is it an invitation to buy shares which can only be done legally through properly executed investment documents, including exemption from registration of the offering, if applicable. The level of interest indicated in acquiring shares in HEFTTCo. will assist in determining if the expense of making a formal (or legally permitted unregistered) offering is warranted. Affirmation of interest in possible acquisition of shares shall in no way at any time under any circumstances oblige a respondent to acquire shares in HEFTTCo.

Figure 33

A Service-Pattern Sail Freighter: The Need For A Scalable Open-Source Sail Freighter Design.

Steven Woods
The Center For Post Carbon Logistics

As sail freight gains traction in the sustainable shipping debate, there is a need for accessible and versatile coasting ship designs capable of serving a wide variety of harbors, which can be built quickly and at relatively low capital intensity. These vessels will then take over what would otherwise be transport by rail or road along the most congested corridors in the US using near-zero carbon emissions propulsion. This not only reduces emissions from the transport itself, it reduces congestion and makes the entire land transportation system more efficient and safe.

These vessels must be made to fit regulatory boundaries for captain licensing, length, tonnage, etc. There is a distinct need for a Liberty Ship-like sail freighter specifically maximizing each step of the regulatory ladder to encourage the building and operating of these coastal traders in the Northeastern US. The uninspected cargo vessel category is already covered by a variety of simple and easily available vessel designs which can be modified for cargo use and built inexpensively as Farmer's Ships and other democratic pilot projects in plywood or other materials.

The proposed modular/scalable sail freighter design is still theoretical and requires the attention of a naval architect, but lays out the requirements for such a set of vessels. By designing around regulatory and small harbor restrictions, this design attempts to get the absolute maximum out of each category to allow for a rapid build-out of a coastal sailing fleet. These vessels will be relatively low capital, require only small crews, and serve as a proving and training ground for an expanding windjammer fleet. The proposed vessels will be single chine steel hulls in four sizes, and with two possible rigs. A loaded draft of 6-8 feet allows for use of a wide range of harbors, single chine construction in steel simplifies and speeds construction. The choice of simple gaff or marconi schooner rigs broadens the applicable regions and trade which the vessels can effectively undertake. The application of roller furling and modern winches keeps crew requirements relatively low.

Where designs which fit or nearly fit these requirements exist, they should be bought out (including any necessary modifications) and made open source where possible. This set of designs may be a good starting place to make this effort realistically possible and immediately implementable. Further work can be started from this foundation or started anew, depending on where interest and funding can be acquired.

KEY WORDS: Sail Freight; Small Vessels; Coastal Trade; Open Source; Wind Propulsion.

The use of sail freight for displacing cargo from land based modes to seaborne zero emissions transport is a viable and historically proven way to reduce energy requirements and carbon emissions. The theoretical economic and emissions benefits of wind propulsion for large vessels on transoceanic routes has already been established by several studies (Perez, Guan, Mesaros and Talay 2021; Wind Ship Development Corporation 1981), but there has been little attention paid to the potential carbon offsetting available from coastal trade under sail (Woods and Merrett 2022). The use of sail in coastal trade reduces particulate emissions, noise pollution, traffic congestion, and their associated medical and climate impacts in both port areas and directly inland (American Society Of Civil Engineers 2021). These are desirable in terms of transport decarbonization and as a form of jobs program for the maritime trades, however, the main bottleneck in the short- to mid-term will be producing a sufficient fleet of windjammers to take up the cargo necessary. For example, New York City, if provided with its minimum food needs by sail, would require around 2 million tons of shipping. The majority of current sail freighters worldwide are refit vessels which were built many decades (and come over a century) ago, and the supply of these vessels is extremely limited. Even including the addition of rigs to motor vessels below 300 tons as was accomplished with the currently-serving SV *Kwai* and others during the 1970s Oil Crisis, there are few remaining vessels to be converted (Satchwell 1986). Construction of a large fleet in a short time will be necessary to ensure there is sufficient transport capacity to feed major cities without cooking the planet (Woods 2021).

There are few available plans for sail freight vessels currently available, and most of these are optimized for sailing, as opposed to getting the maximum out of the restrictions they will have to operate under. These restrictions come not from harbor depths, air draft, or other physical restrictions, but principally from regulatory barriers such as inspection requirements, captaincy license categories, and the availability of trained crew. These constraints will likely be the main things which need to be kept in mind, and designed around. The second priority is to design for simple, rapid construction of a large fleet. These regulatory hurdles can be maximized as much as possible through good design around these constraints before others.

Vessels under 15 GRT and 40 feet in length fall under the heading of Uninspected Cargo Vessels, and should be included in this design process for a number of reasons. These are already covered by a number of designs suitable for backyard boatbuilding, such as a number of plans by George Buehler (Buehler 1991), Bruce Roberts (Roberts, n.d.), and the now open-source plans of the Vermont Sail Freight Project's sailing barge *Ceres* (Woods 2023a). These (very) small vessels are well suited to the role of Farmer's Ships (Shaw 1939), feeder vessels, operations in low volume trade routes, and where unlicensed sailors are the only crew available. They are a form of democratic and egalitarian sail freighter which will likely proliferate in the near future, especially as scout ships establishing trade routes. In many ways, these are frontier vessels like the Scow Schooners of the 19th century Great Lakes and other locations, mostly made where low capital reserves and limited skill were the limiting factor in shipbuilding (Martin 2018), and will likely have an economic role similar to the Galway Hookers of Northwestern Ireland (O Sabhain 2019). However, they cannot reasonably take up the strain of longer trunk routes, high-volume packet routes, or transoceanic trade where the larger Service-Pattern vessels will have a more prominent role.

Despite the passing of the 1969 convention on tonnage measurement of ships, US regulations are still written using Gross and Net Register Tons of 100 cubic feet each for regulatory purposes (USCG Marine Safety Center 2022). There have been a number of ship designs based around maximizing profits through manipulating multiple tonnage systems; in many cases this has both endangered ships and their crews (Vasudevan 2010). This should be avoided for any open-source sail freighter, as the maximization is not for profits, but the optimal use of captain's licenses. Care should be taken to make these designs compatible with STCW and other similar regulations, including measurement under the 1969 Convention rules; this makes for simpler regulatory compliance and easier adoption worldwide. Keeping lengths under 24 meters, for example, solves two problems: The vessels need not be measured under the Convention rules, and most STCW/SOLAS regulations will not apply (USCG Marine Safety Center 2022). Similarly, for inclusion under USCG subchapter T regulations the vessel must be under 65 feet in length, which may be quite possible for the 25 and 50 GRT vessels described in this paper. As the vessels grow larger, they will need to abide by progressively stricter regulations, but these vessels will require a much higher capital outlay regardless, and their crews will need to become progressively more professional. This is a good thing and these regulations exist for very good reason; however, there is no reason to have a potentially viable ship design become unavailable to a sail freight endeavor simply because it is two feet too long or 1.5 GRT over a regulatory limit as is the case with some designs discussed in this paper.

The proposed service pattern sail freighters should fit the available licenses, all of which are *up to* the tonnage limit. This means each should be just barely shy of the targeted number, for example 14.9/24.9/49.9/99.9 GRT, but labeled for convenience at the next full integer. As they are designed as coasters, there is less worry about STCW requirements, though compliance would not be amiss for the larger vessels as it will open up further markets. The basic requirements of the designs are as follows:

SERVICE-PATTERN SCHOONER REQUIREMENTS:

- ☛ 4 Hull varients: 15GRT/25GRT/50GRT/100GRT
- ☛ 2 Rig variants: Schooner (Marconi and Gaff).
- ☛ ≤ 9 foot loaded draft.
- ☛ CDWT of at least 7.5/15/35/70 tonnes at Stowage Factor of 2.6 m^3/tonne.
- ☛ Simplified, inexpensive, rapid construction in steel.
- ☛ 15/25 GRT model should include scantlings for plywood home builds.
- ☛ Under 65 feet LOA where practicable (T-Boat Regulations).
- ☛ Sufficient motor power for docking and emergency use.
- ☛ Small enough fuel or energy storage to prevent reliance on motoring.
- ☛ Optimized for breakbulk/ palletized/ super sack (non-containerized) cargo.
- ☛ Sufficient ship's gear to handle palletized drafts to and from the dock.
- ☛ Use of roller furling, winches, etc. to reduce crew requirements.

Single chine construction and avoidance of complex curves wherever possible will make the construction not only faster, but simpler and possible without a large amount of specialized equipment. The technique employed in the designs of the INDOSAIL system proposed in 1985 at the ADB Conference on Wind-Assisted Propulsion of employing different center segments for an otherwise identical vessel, making it effectively modular, is worth considering where possible (Wiriadidjaja and Schenzle 1985). This may not work for all 4 possible vessels and may require creating a small and large size ship instead, which uses different central segments, but the same bow and stern, aiding mass production and design efforts.

By keeping the crew requirement low through the application of winches and other mechanical aids, the cost of operation will be kept to a reasonable minimum, an important consideration for these vessels as the energy transition is in early stages. As the freight rates of trucks and trains are kept artificially low by a number of factors (Austin 2015), and these are the modes which coastal and inland trade will be competing against (Woods and Merrett 2022), labor aboard these vessels must be kept to a safe minimum. Additional crew members who are included simply for hauling on lines make no sense when winches can do the same job reliably for a fixed initial cost.

These vessels should be able to provide a wide range of services on varied waters and at varied levels of capital intensity. They can be grown with the fleet's demands and the captain's license tonnage, while serving as training vessels for new crew members. The most common types are likely to be 50 and 100 GRT vessels. However, the inclusion of the 25 GRT vessel is important due to the likely prevalence of 25 GRT Masters when compared to other license types. These smaller schooners will also have a role to play as feeder vessels, training platforms, and scouting ships for new markets, so their construction should not be ignored or belittled in favor of the more capital intensive larger vessels.

The use of traditional sail and traditional rigs is well supported in this role by several factors: Traditional sail is well understood, has low capital requirements, and performs well in a wide variety of conditions (Scott 1985). In the sizes of vessel dealt with here, not all crew need be licensed, which simplifies most recruitment issues which might arise. There are a wide variety of training programs through commercial and recreational associations on the handling of traditional sail in a racing or cruising context, as well as training on square rig sailing from organizations such as Tall Ships America. Trained sailors will therefore be easier to find for these vessels than for a flettner rotor equipped ship, and the rig will be more affordable overall. The strategic materials and energy requirements of traditional rigs are also low, making them a more climate positive option than complex systems better left to larger vessels (Woods 2023b). Schooners are a highly efficient rig in terms of crew requirements, an in 1906 averaged a crew of 5 and 42.9 Tons Per Sailor, though they ranged from 10-4914 Net Register Tons, across a sample of 5,947 vessels (see Fig 2) (Woods 2021). On a less objective note, there are also few things more worth watching than a traditional sailing vessel making its way up the coast, and this romantic, esthetic appeal may well be a significant influence on getting a sufficient mass of people behind the sail freight movement to keep it commercially viable. Flettner Rotors, Wing-Sails, and other modern wind propulsion systems lack this particular quality.

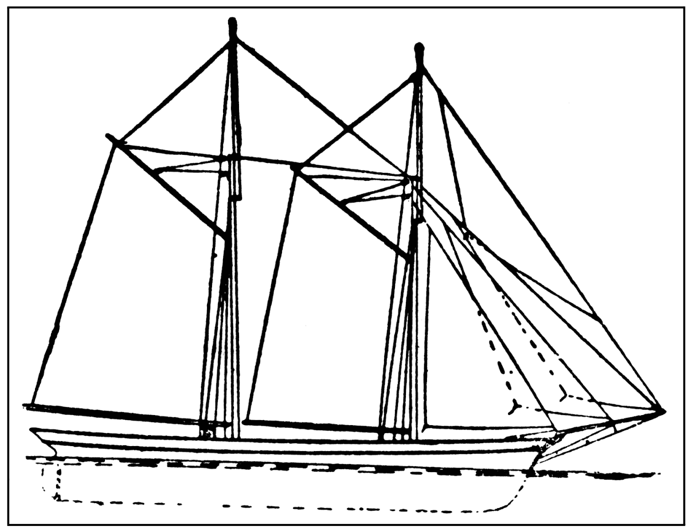


Figure 1: Schooner Illustration from Mee and Thompson, *The Book Of Knowledge* 1912.

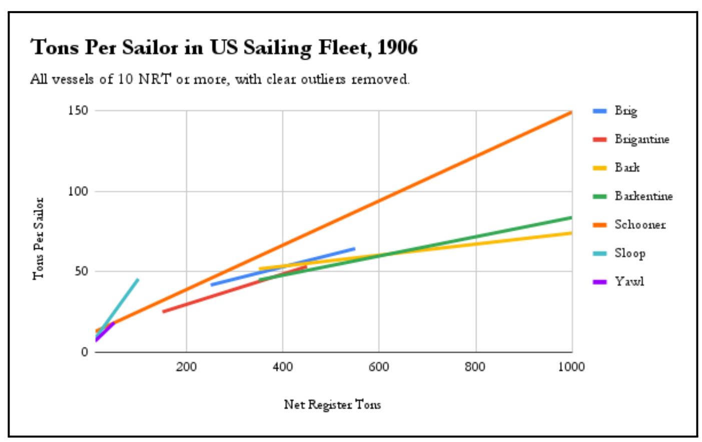


Figure 2: Image from Woods (ed), *Sail Freight Handbook* pp 35. CC-BY-NC-ND 4.0.

There are similarities between the proposed Service Pattern vessels and oil-crisis era vessels, such as those proposed for use in the Kingdom of Tonga (Palmer and Corten 1985), among others. Some of these designs already effectively exist, and can be purchased into the open source field without much further modification or effort beyond funding the purchase. For example, Tad Robers has a cargo schooner design which fits these requirements, but at 60 feet the larger design is 28.6 GRT, as opposed to the 25 which should be targeted (Tad Roberts Yacht Design n.d.). The proposed Electric Clippers of Derek Ellard are specifically designed for mass production, and fit some of these requirements as well at various sizes (Ellard 2020). The River Sea Ship designed by Trans-Tech Marine for NYSERDA in 2015 is a similar idea, and currently open-source (Uttmark 2015). Another open source design by the Greenheart Project is slightly too large for the 100 GRT license (Scherpenhuijsen Rom *Et Al* 2021). A cargo schooner design by Thomas Colvin, found in his book *Steel Boat Building*, is available but not only exceeds the Uninspected Cargo Vessel parameters for length overall, it carries only 7 tons of cargo, making it effectively uneconomical due to initial cost and possible revenue with such a small hold capacity in a license-demanding vessel size (Colvin 1985). The use of unmodified historical designs, while viable, are still unlikely to max out the regulatory categories necessary to maximize the utility of a modern fleet (Davis 2012).

Avoiding cargo containerization for these vessels is an important point. Not only is moving containers a waste of space and energy (Woods 2023b), it is inefficient at this scale of operation. Palletization should provide all the necessary efficiency gains from unitization without a significant investment at every port to handle containers. Specifically, the Euro-Pallet dimensions should be used due to their provision for full and half pallets which can be used according to the ship's hold size (EPAL n.d.). Ship's gear can handle palletized or breakbulk cargo without a significant challenge or supporting infrastructure, a critical consideration when small ports are just re-establishing cargo operations (Woods 2023a; Koltz 1980), with the additional benefit of loading and discharging cargo in a fifth of the time needed for breakbulk handling (Goertz 1976). Most commodities which are easily shipped by sail freighter can be or are shipped with the highest economic efficiency on pallets or in super sacks, as this reduces labor and handling significantly compared to breakbulk handling. As sailors will likely have to be their own dockers through the early stages of the sail freight resurgence, there is a great advantage to be found in reducing dockside labor wherever possible. For short-sea container traffic, other designs will be needed, such as the Electric Clipper 180 designed by Derek Ellard (n.d.).

With the smallest Oceans license granted by the US Coast Guard being 200 GRT, and this being applicable to near-coastal waters as well, it would be logical to extend the design to 200 GRT. This would require further regulatory compliance work, such as meeting STCW requirements. These vessels would likely be involved in mostly longer distance trade such as long coastal runs between larger ports, and transoceanic trade in coffee, alcohol, and other high-value cargo in the early stages of their deployment. Whether a single chine simplified design for these larger vessels would be wise is a question for naval architects to answer. Vessels over 100 GRT should not be considered a priority for the early stages of this effort, however, and can be derived from the initial designs at a later date if needed.

A prudent designer for these vessels might also apply the same principles to canal boats, fitting them to the dimensions of the New York State Canal and other significant inland waterway lock and prism dimensions. The 15/25/50/100 GRT steps to suit captaincy requirements, and keeping to less than 65 feet whenever possible to stay under T-Boat regulations will still apply; the greatest variation will be in the powering of the hulls and energy storage for a preferably electric motor vessel. Use of Lead-Acid batteries as dual-purpose ballast and a generous amount of charging capability should be included, by whatever means are available. Placing ship's gear in a tabernacle or other foldable mounting will also be important anywhere there are air draft restrictions, such as the 14 foot limit on the New York State Canal System. Again, some designs which can be adapted or used directly already exist, such as the River Sea Ship by Trans-Tech Marine, but they are not optimized for the regulatory categories treated in this paper (Uttmark 2015).

Similarly, for areas where a transition between canal and more open water environments are going to be frequent, such as the New York State Canals in the Central New York and Finger Lakes Regions, as well as small routes in many other areas, a derivative of the Norfolk Wherry would be in order. This vessel, if copied at similar tonnages (15/25/50) provides several advantages in its design for vessels in and out of canals frequently, notably the counter-weighted mast and tabernacle arrangement which made sailing in canals and the Broads viable (Wherry Maud Trust n.d.). For this particular vessel, removing or adding central hull sections to the same plan (with associated changes to the rig) will be a useful design feature to adopt, and will reduce work considerably. Their easily flattened Cat rig, when paired with an electric motor, would make traffic in areas like the intercoastal waterway, New York Canal system, and areas with frequent change between canal and lake operations possible mostly under sail. This means a lower capital expenditure, lower shore power demand, and lower strategic material commitments for these feeder fleets. Air Draft should be kept to 12 feet or less with the mast down, with a maximum length of 64 feet and a shallow draft. If carefully thought through, a solarized motor-only version of this wherry could serve as the canal boat described in the above paragraph.

Spud Barge Depots and other infrastructure components which will need to be deployed in the near future, and will not require a significant amount of effort for naval architects, should also be developed and published (Woods 2023a). A Service-Pattern Barge Depot given in three sizes, for example 40, 80, and 120 feet in length, with a beam set at 50% of the length for a simple barge would be a few day’s work to factor out the scantlings and instructions to make local construction without specialized facilities or tools possible. These barge depots should be designed for plywood or steel construction as economic pressures demand, based on the size of the barge.

By creating a ready and publicly available set of sailing vessel designs which take maximum advantage of regulatory categories, there is a better chance of getting as much capacity as possible out of any small vessel fleet and crews. There is a need for these vessels worldwide, from the South Pacific islands to New York Harbor, and the longer it takes to make these vessel plans available and build them, the worse the transport situation will become in terms of carbon emissions and congestion before any significant improvement can be made. Potentially thousands of jobs on and off the boats are waiting to be created for this project, and what’s needed to start the industry along is a reasonable set of ship plans.

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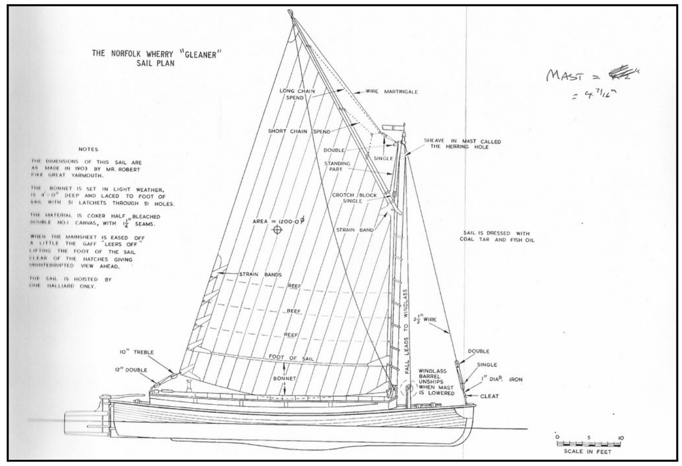

Figure 3: From Clark, *Black Sailed Traders: Keels and Wherries of Norfolk and Suffolk*. London: David & Charles, 1972

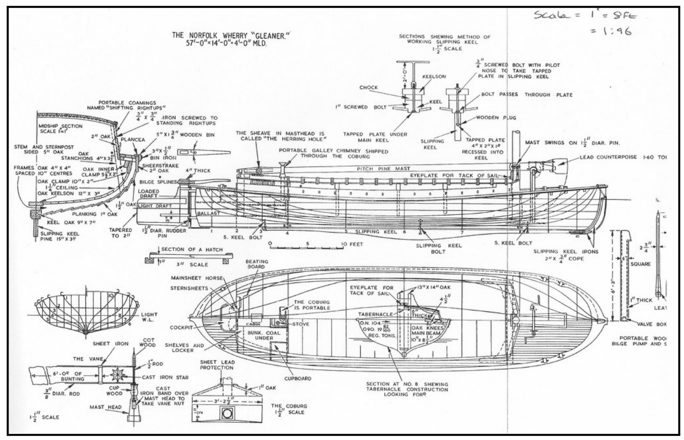

Figure 4: From Clark, *Black Sailed Traders: Keels and Wherries of Norfolk and Suffolk*. London: David & Charles, 1972

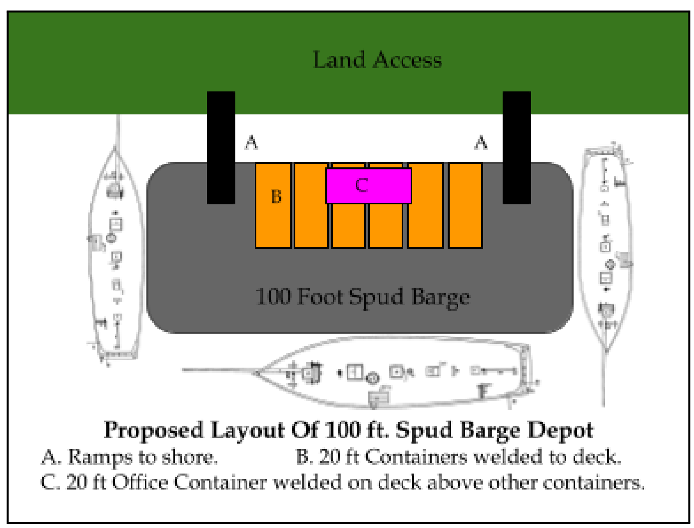

Figure 5: From *Sail Freight Handbook* 2nd Edition. Pp 170.

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APPENDIX: OPEN SOURCE SAIL FREIGHTER REQUIREMENTS.

All Schooners + Barge Depot + Wherry.

- ☛ Plans will be released into Public Domain/CC-BY-SA 4.0 in their entirety, as one set, via CPCL and likely the IWSA Small Vessels Publication.
- ☛ Plans to include Lines Plans, General Arrangement, Sail Plan(s), Stability Curves.
- ☛ Vessels max out just below 15, 25, 50, 100 GRT, designed for fast, easy construction.
- ☛ All vessels to be provided with ship's gear for cargo handling as specified.
- ☛ Palletized and breakbulk cargo only. No provision for containers at this scale.
- ☛ Target Stowage Factor to be 80 Cu Ft per short ton; 2.5 Cu M per Tonne.
- ☛ Outfitting should be made as work-boat and simple as possible. The owners can provide for more comfort if they decide it is necessary.
- ☛ Ship Class Designation: OSSF [GRT]

Open Source Sail Freighter 15:

- ☛ Under 40 ft and 15 GRT
- ☛ Preferably 32-36 feet LOA with 40 ft LOS, if possible, to reduce capex/opex.
- ☛ Designed specifically for home-builds in plywood or steel (Beuhler or Roberts type plans). This requires a bit more detail and instruction than the others which will be built exclusively by shipyards. To include construction drawings, materials list, welding hours estimation.
- ☛ Minimally complex rig: Marconi or Gaff Sloop (preferably both options provided) with basic sailing skillset in mind. Self-tacking jib highly encouraged.
- ☛ Tabernacle and keel-stepped mast options if possible.
- ☛ Minimum 7 CDWT, preferably more, but not to exceed 14.9 short tons. 17.5 cu m.
- ☛ Hold and gear compatible with half Euro-Pallets loaded to 125kg.
- ☛ 2 crew design, with 3rd provided for in pilot berth or hammock.
- ☛ Design for minimal expense and low maintenance.

OSSF 25:

- ☛ Tabernacle rig or keel-stepped.
- ☛ Under 65 feet.
- ☛ Minimum 15 CDWT. 37.5 cu m.
- ☛ Hold and gear compatible with half Euro-Pallets loaded to 125kg.
- ☛ 2-4 Crew. 2 Watches of 2 people preferred.

OSSF 50:

- ☛ Tabernacle Rig as an option possible, otherwise keel-stepped.
- ☛ Topsail schooner option with roller furling would be nice, but not required.
- ☛ Under 65 feet if possible.
- ☛ Minimum 30 CDWT. 75 cu m.
- ☛ Hold and gear compatible with Euro-Pallets loaded to 250kg.
- ☛ 4-6 Crew. 2-3 Watches of 2-3 sailors.

OSSF 100:

- ☛ 9-12 Crew (3 watches of 3-4 sailors)
- ☛ Under 79 ft LOA if at all possible.
- ☛ Minimum 60 CDWT. 150 cu m.
- ☛ Hold and gear compatible with Euro-Pallets loaded to 500kg.

OSSF-B: (Barge Depot)

- ☛ Designed to be linked together into the size of depot required. Not always permanent infrastructure, so an easily towable design would be useful.
- ☛ Preferably 60 feet long, 40 feet wide for working space.
- ☛ 4+ Spuds sufficient to hold in protected waters.
- ☛ Distribution pattern on deck for warehousing containers without destabilization.
- ☛ Cargo Handling Gear comparable to OSSF 50.

OSCW 15/25/50 (Open Source Cargo Wherry)

- ☛ 12 ft Air Draft with mast down and 6 foot maximum draft.
- ☛ Electric propulsion with multiple charging options preferred.
- ☛ Cat Rig and Counterbalanced mast as with originals.
- ☛ Marconi and Gaff Rig Variants, Marconi paired with roller furling into Mast.
- ☛ Requirements otherwise as with OSSF of same tonnage.
- ☛ Unrigged Variant with maximized solar panels for regions with unfavorable winds.