



**The Marine Industry:
Sailing on Strong Asset Prices
for Now, Both Domestically
and Internationally**

September 21, 2022

1-2 PM EST

Presentation Not Intended for Investment Purposes

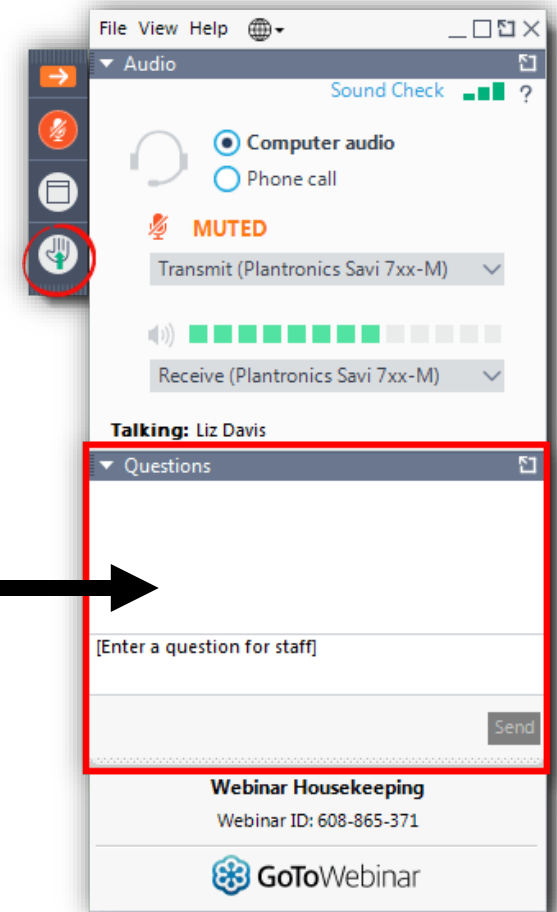
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Housekeeping



Today's web seminar is being recorded.

All questions should be submitted via the Questions Panel.



Welcome and Introductions



Bill De Jong
Principal
Global Equipment
Management Services, LLC

KARATZAS
MARINE ADVISORS & Co.

Basil Karatzas
CEO
Karatzas Marine
Advisors & Co.

Shipping Finance Advisory | Marine Appraisals & Surveys | Ship-brokerage & Auctions

“Safe Harbor” Statements

 **“And seas but join the regions they divide”**

Alexander Pope

 **“In Sea affairs, nothing is impossible, and nothing is improbable”**

*Admiral Lord Nelson, writing from
HMS Victory in 1804*

 **“If you want to build a ship, don’t drum up the men to gather wood, divide the work and give orders. Instead, teach them to yearn for the vast and endless sea”**

Antoine de Saint-Exupéry

Agenda

-  **Presenting Companies: Global Equipment Management Services
Karatzas Marine Advisors & Co**
-  **International Shipping Market Overview**
-  **International Shipping Market Challenges & Opportunities**
-  **Domestic / Jones Act Marine Market Overview**
-  **Domestic / Jones Act Marine Challenges & Opportunities**
-  **Trends to Keep in Mind / Parting Thoughts**
-  **Contact Information**

Global Equipment Management Services (GEMS)

■ Established in 2009.

■ Offices in Clayton, CA and Chester, New Hampshire



■ Management have over 65 years of leasing and remarketing experience.

■ Full-service company offering portfolio reviews, equipment inspections, appraisals, recovery, storage and remarketing services in the U.S. and abroad.

■ Clients range from the smaller regional banks and financial institutions to the larger more recognized national banks and financial institutions.

■ Equipment expertise includes rail, corporate and commercial aircraft, marine, semiconductor, trucks and trailers, material handling, machine tools and construction and mining.

■ Member of ELFA – Equipment Leasing and Finance Association.

■ Member of ISTAT – International Society of Transport Aircraft Trading.

Karatzas Marine Advisors & Co: Company Introduction

- Established in 2011, headquartered in New York City with representative offices in Houston, TX and Hamburg, Germany
- Management team bears decades of diverse shipping expertise, including husbandry agency and port operations, chartering, ship brokerage / demolitions, shipping finance and vessel appraisals & marine surveys, co-placements and JVs
- Expertise by Service Segment
 - Marine Appraisals & Valuations
 - Marine Surveys & Inspections
 - Ship-brokerage (Jones Act / American flag for inland, coastal, blue water / ocean; International Shipping)
 - Market Industry Expertise & Advisory
 - Financial Advisory & Business Brokerage
- Expertise by Market Segment & Geography
 - Geographic Distribution – Jones Act & USA, Americas, Europe, SE Asia, Far East, China
 - Market Segmentation: Jones Act Assets (Inland, “brown” water, coastal, blue water, offshore; Dry bulk vessels, Tankers, Containerships, Offshore & Drilling)
 - Capital & Operational Segmentation: Lessors / Lenders / Institutional Investors / Passive Owners; Privately- held and Family-owned companies to Publicly-listed companies and “Bulge Bracket” Operators
 - Complementary Industries – Charterers, Refineries & Oil Companies, Cargo Interests and Traders
- Demonstrably strong credentials & references (gladly provided upon request)

Karatzas Marine: Scope of Services | Corporate

Marine Appraisal & Marine Survey Services

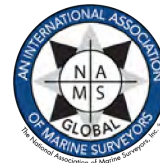
- D Marine Appraisals & Valuations (Jones Act & International)
- D Marine Surveys & Inspections (Jones Act & International)
- D Business Valuations (Companies active in the maritime industry)
- D Fully-accredited marine appraisers & surveyors with strong qualifications
- D Nationwide and International Network & Capability
- D Prompt, Professional and Independent Analysis & Reporting

Marine Brokerage Services

- D Ship Brokerage Services / Judicial Sales / Insolvency Administrator / Liquidation Trustee
 - D Jones Act / American flag for Inland, Coastal, Blue water / Ocean; International Shipping
 - D Exclusive Representation of Lessors / Banks / Lenders / Passive Owners
- D Ship Brokerage Services allow for real world market info and intelligence based on transactions, actual commercial activity, and interaction with buyers and sellers of marine assets
- D Ship Brokerage Services allow for better understanding of commercial features of appraised / surveyed marine assets and more accurate estimates of residual values

Accreditations & Professional Memberships

- Accredited Senior Appraiser (ASA), American Society of Appraisers
- Accredited in Business Valuation (ABV), AICPA
- Certified Marine Surveyor (CMS), NAMS
- Fellow of Institute of Chartered Shipbrokers (FICS), ICS in UK
- American Water Operators (AWO), (Associate) Member
- ELFA, (Associate) Member
- The Baltic Exchange, Member
- BIMCO, Member
- Society of Naval Architects & Marine Engineers (SNAME), Member
- American Bureau of Shipping (ABS), Member (past)



AN INTERNATIONAL ASSOCIATION OF MARINE SURVEYORS

A NONPROFIT ORGANIZATION WITH THE MISSION TO UPHOLD AND MAINTAIN THE ETHICS AND CREDIBILITY OF OUR MEMBER MARINE SURVEYORS



Leading Academic Credentials

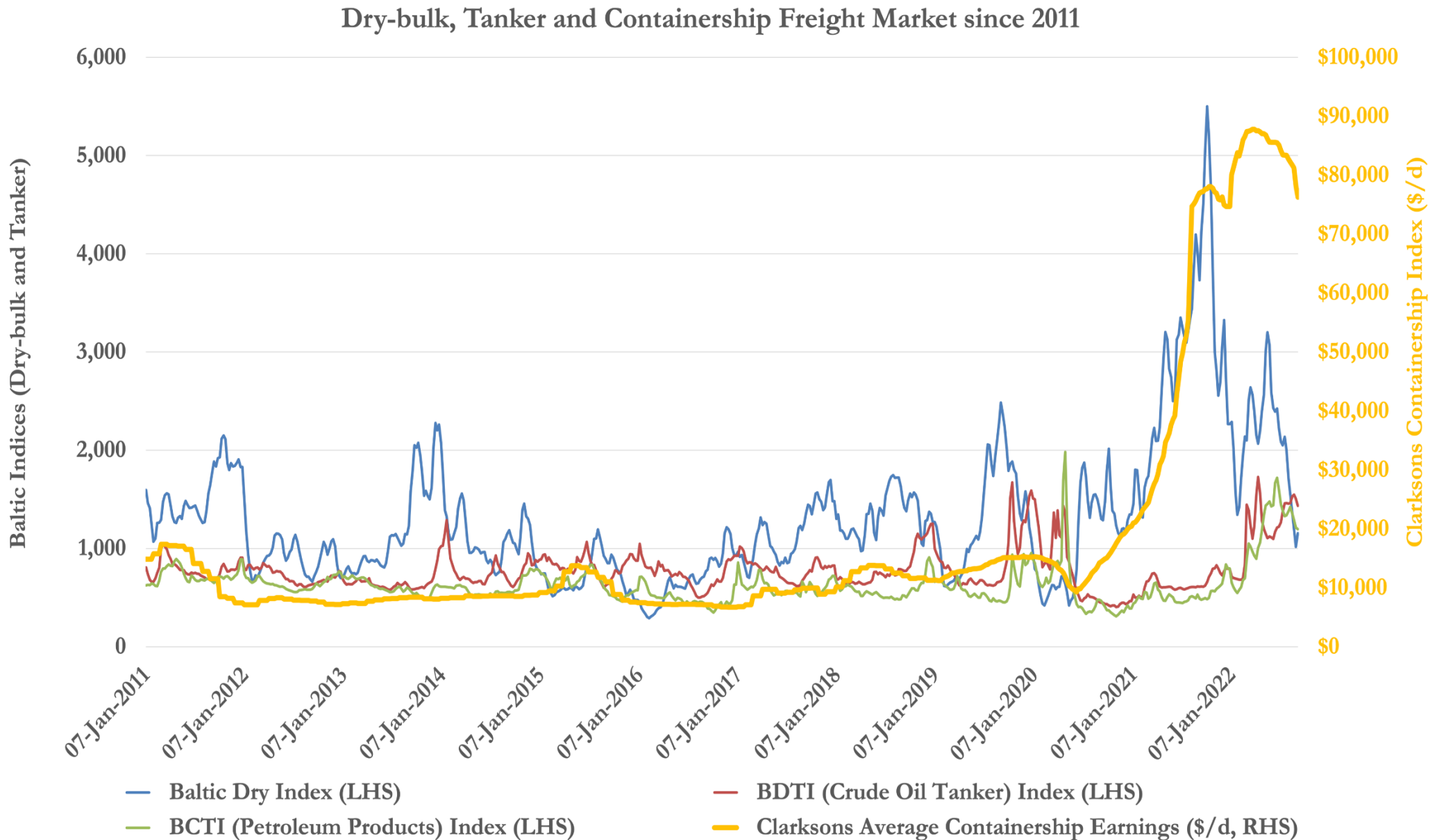
- MBAs from top-tier Business Schools (Jones, Rice University, etc)
- Rigorous Professional Development (Owner / President Management Program (OPM51), Harvard Business School; HBS Alumnus)



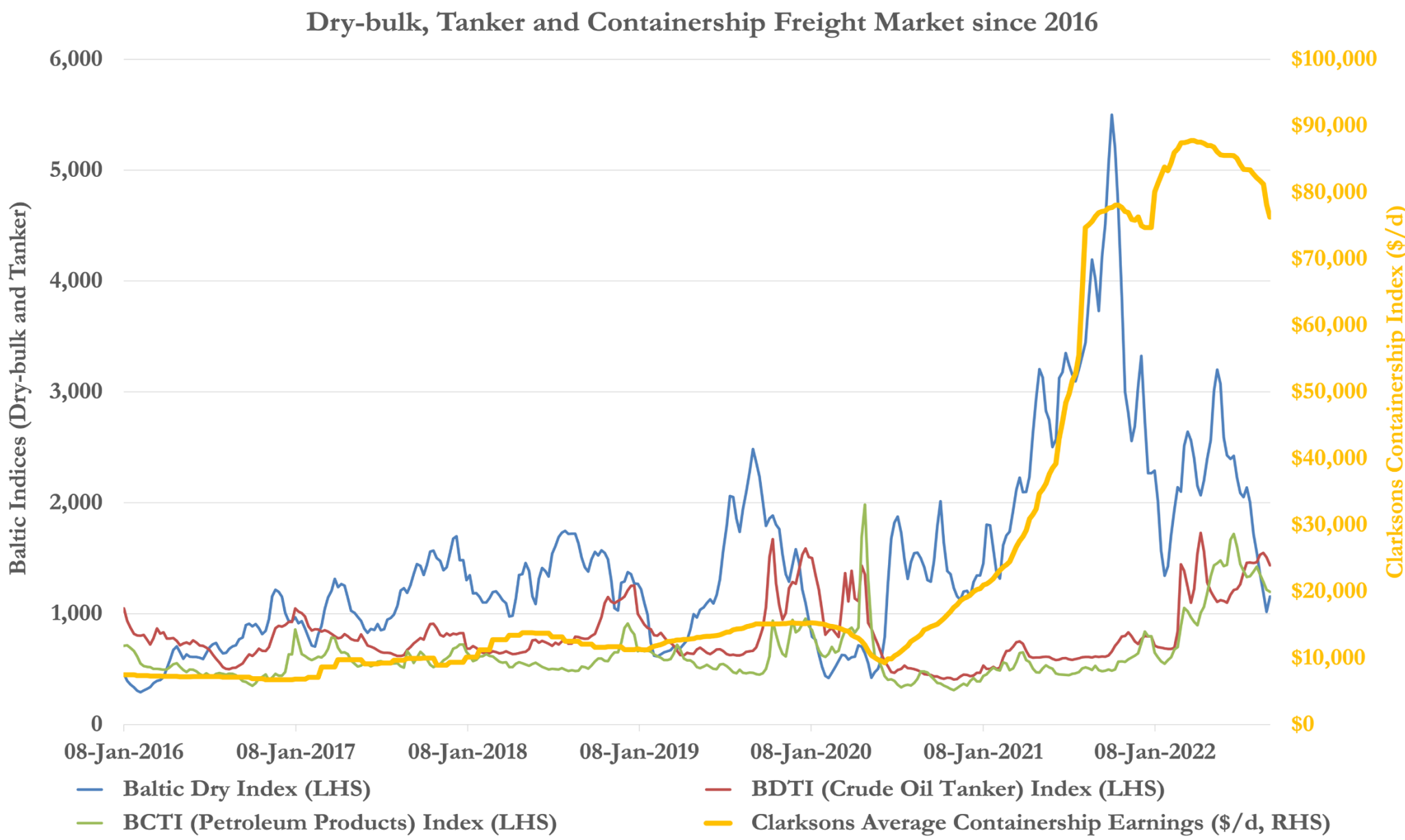
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International Shipping Freight Market since 2011

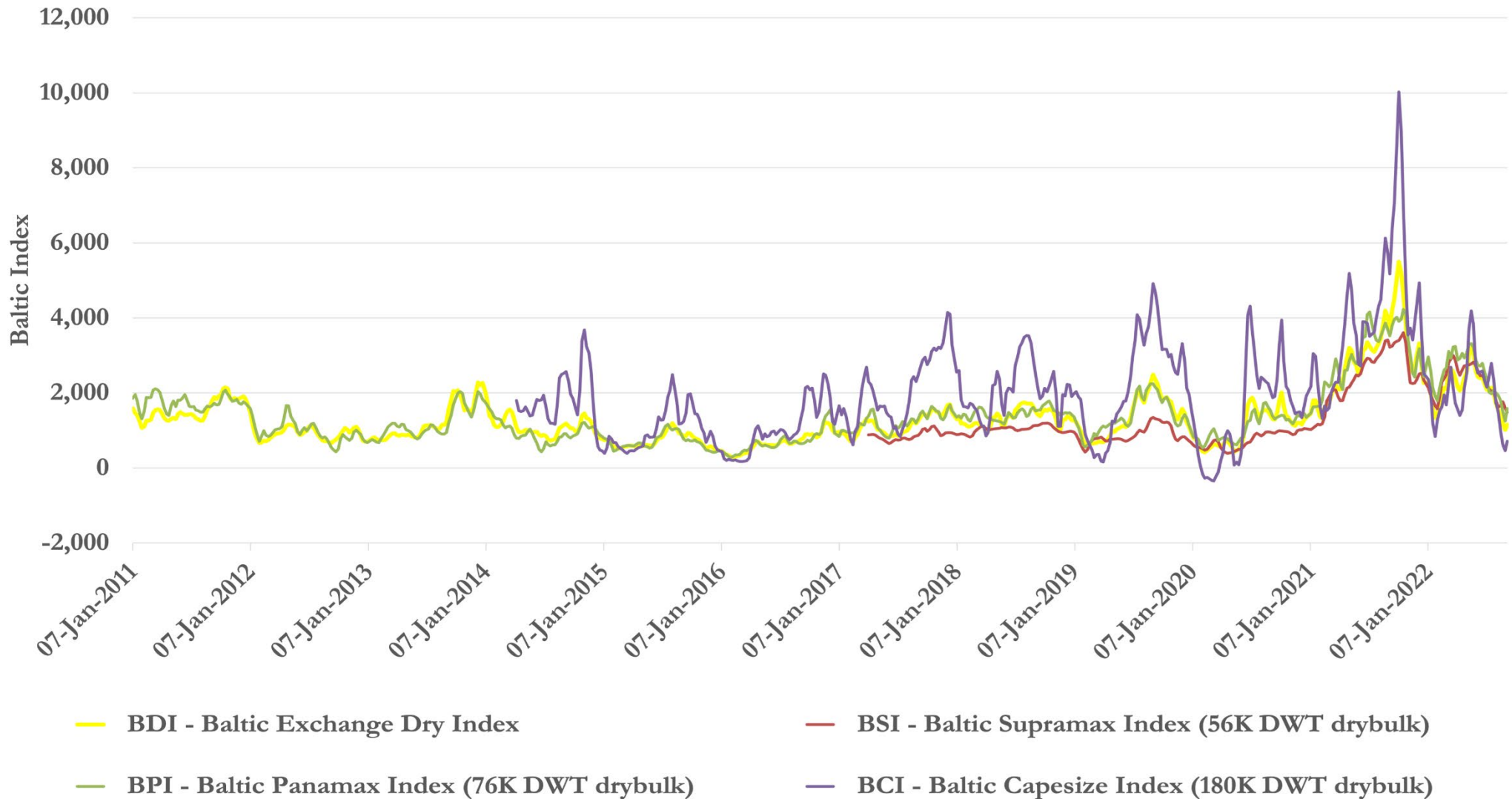


International Shipping Freight Market since 2016



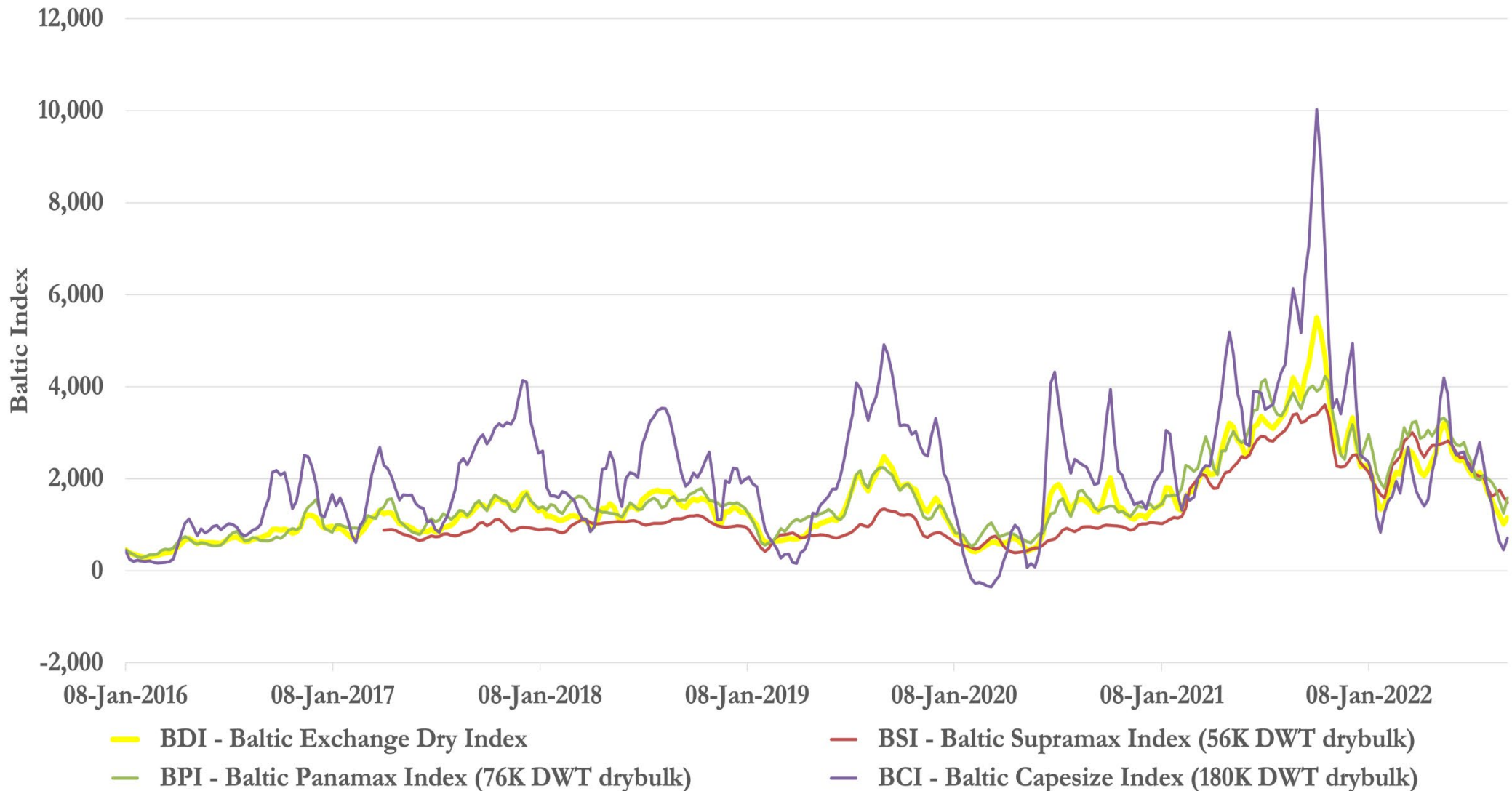
International Dry-bulk Baltic Indices since 2011

Dry-bulk Freight Indices since 2011
by Dry-bulk Asset Class (for Supramax, Panamax, Capesize and overall BDI)



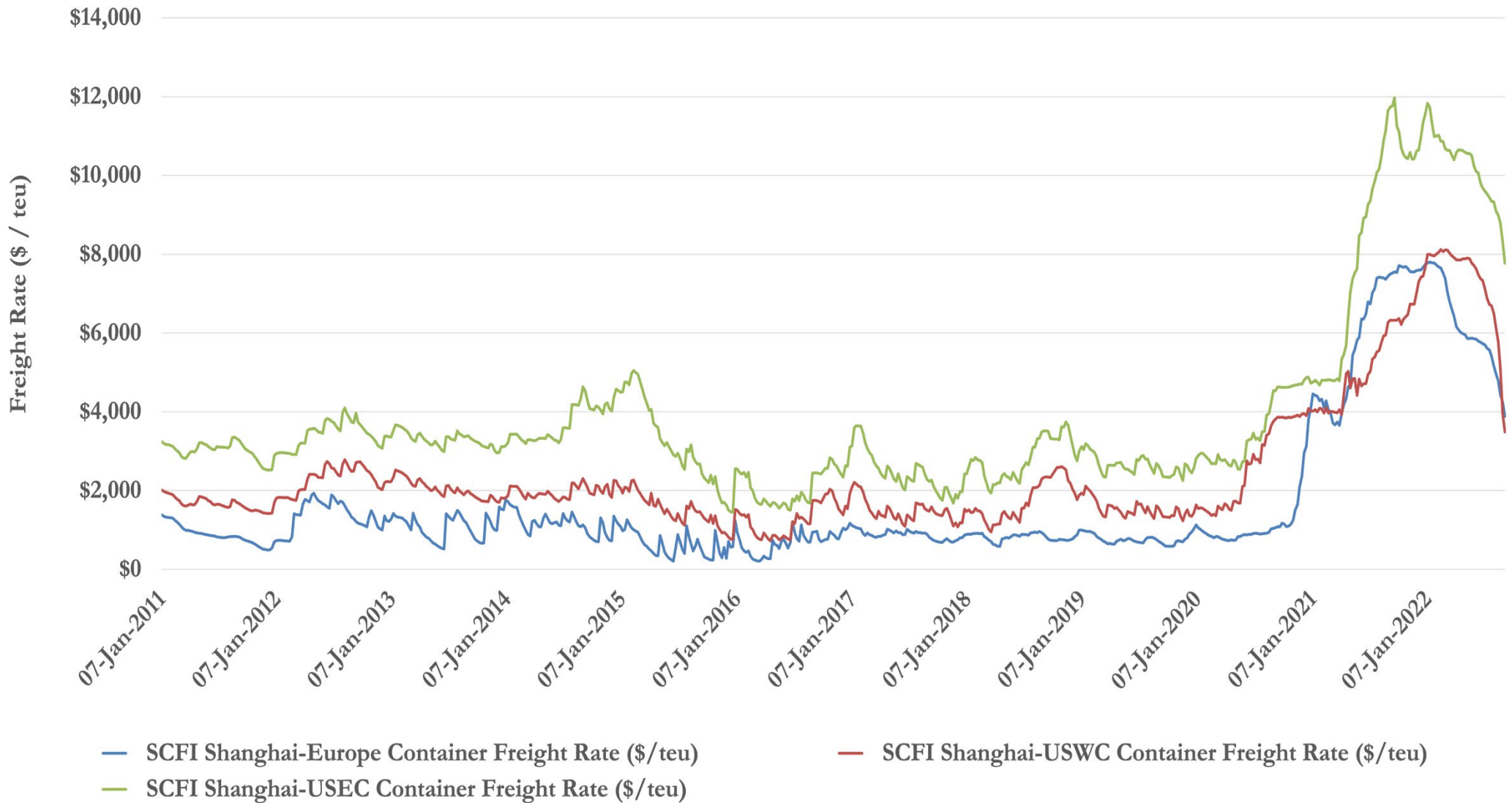
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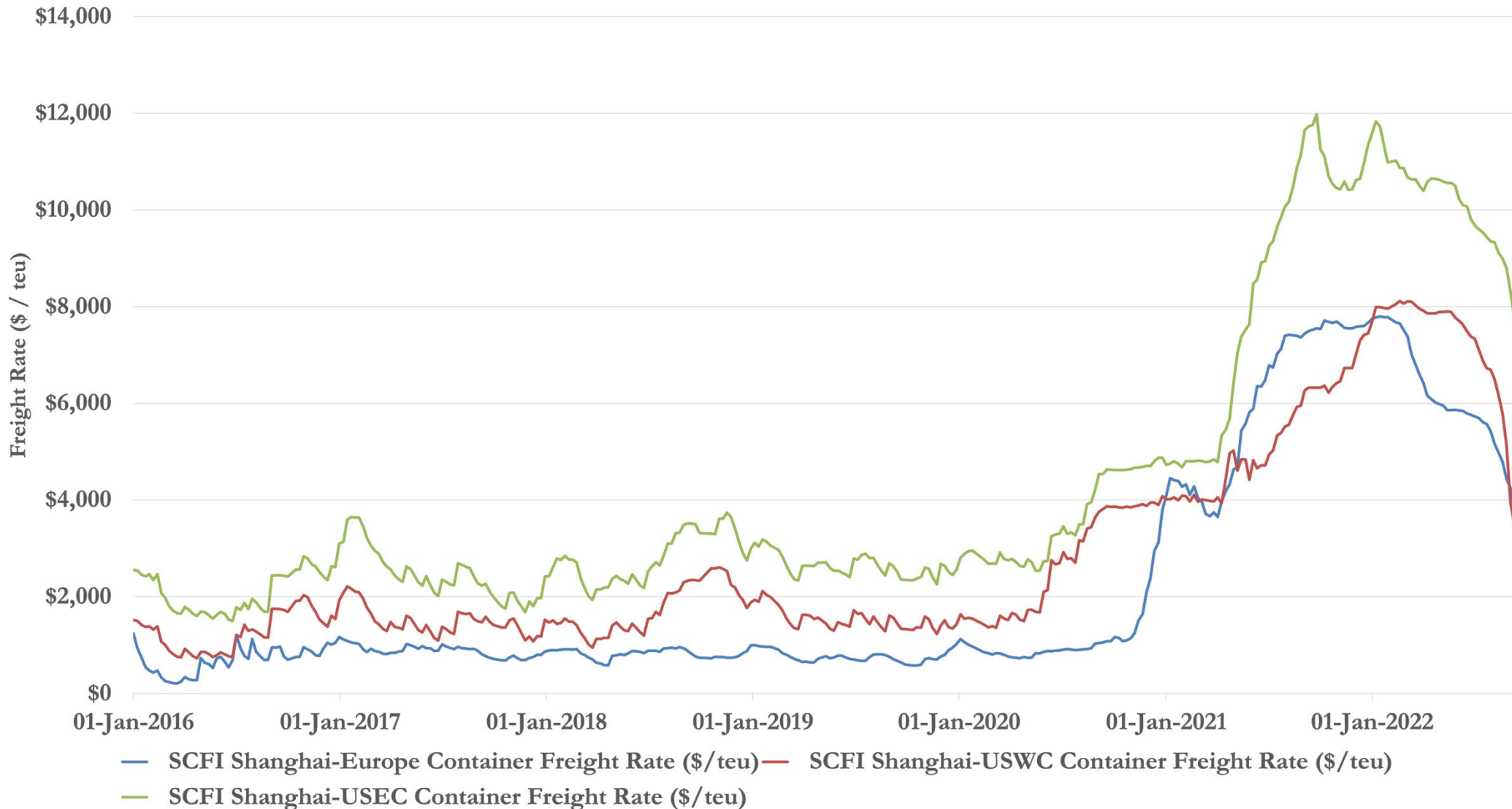
Containership Freight Rates since 2011

Containership Freight Rate (\$ / teu) since 2011
Shanghai to Europe and US (East Coast / West Coast)



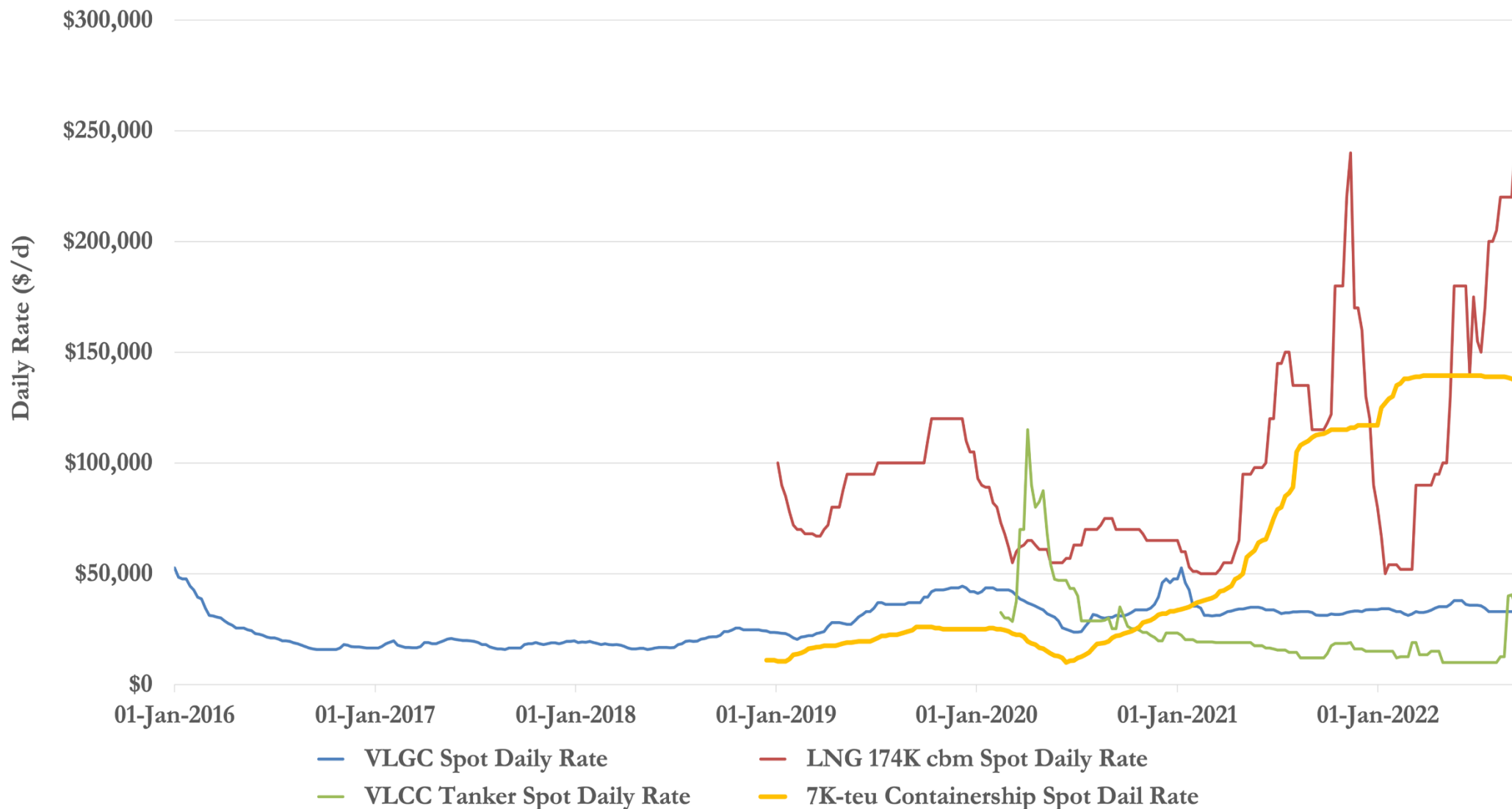
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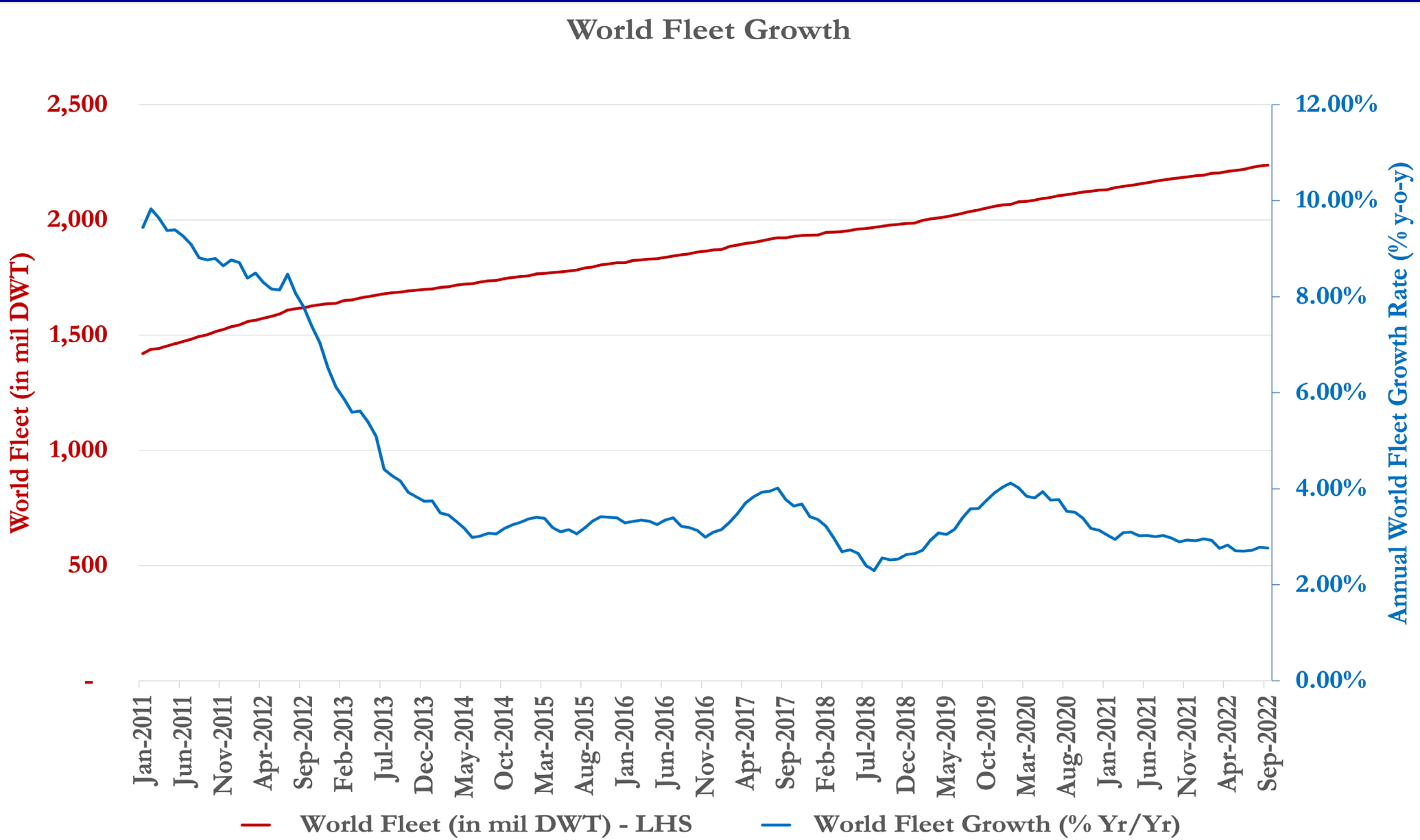


Spot Freight Rates for Large LNG, LPG, Crude Oil Tankers and Containership Vessels

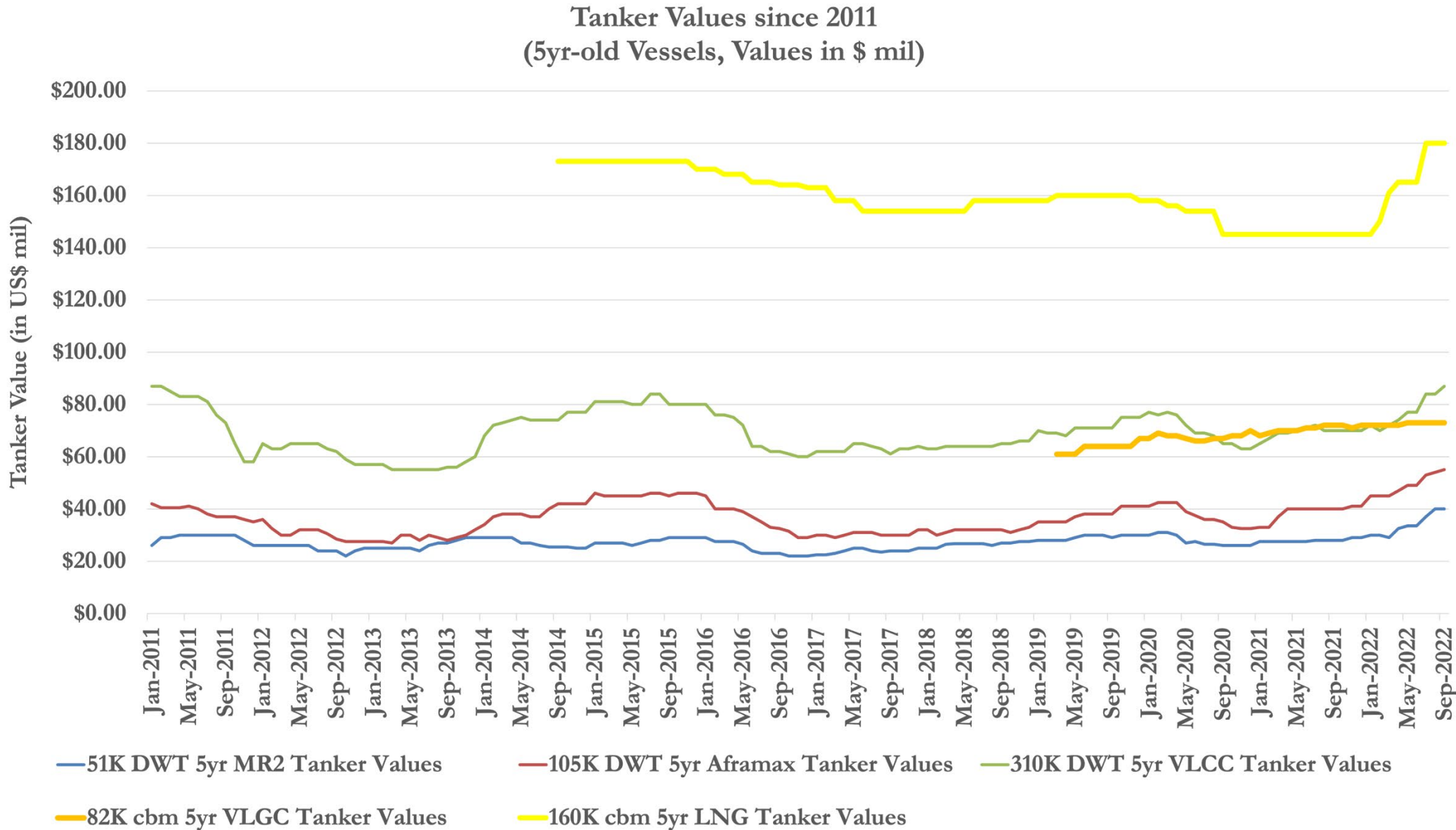
Short-term / Spot Market Daily Rates (\$/d)
Large LNG, LPG, Crude Oil (VLCC) Tanker and 7K-teu Containership Vessels



World Fleet Growth since 2011

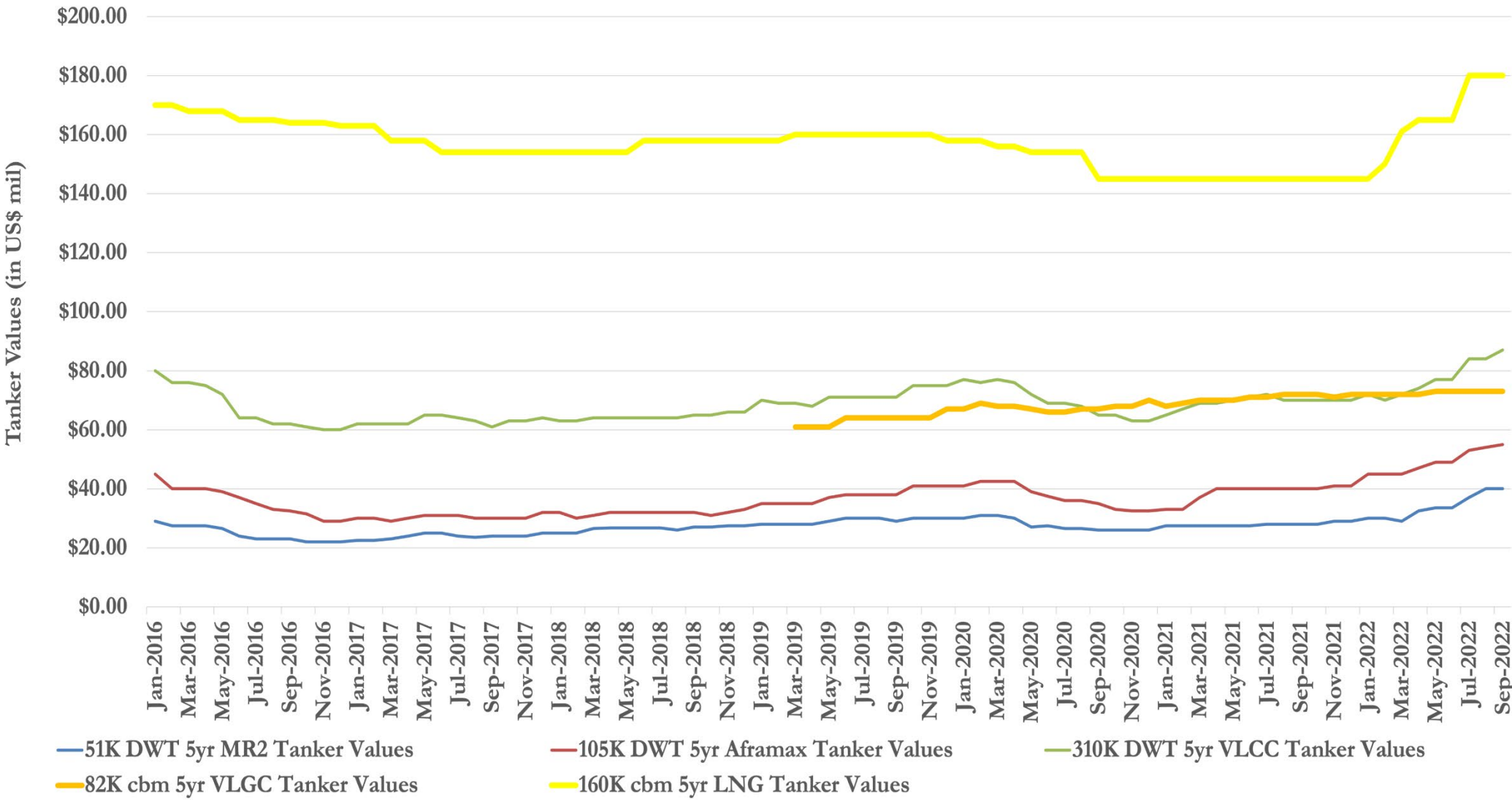


Tanker Vessel Values since 2011



Tanker Vessel Values since 2016

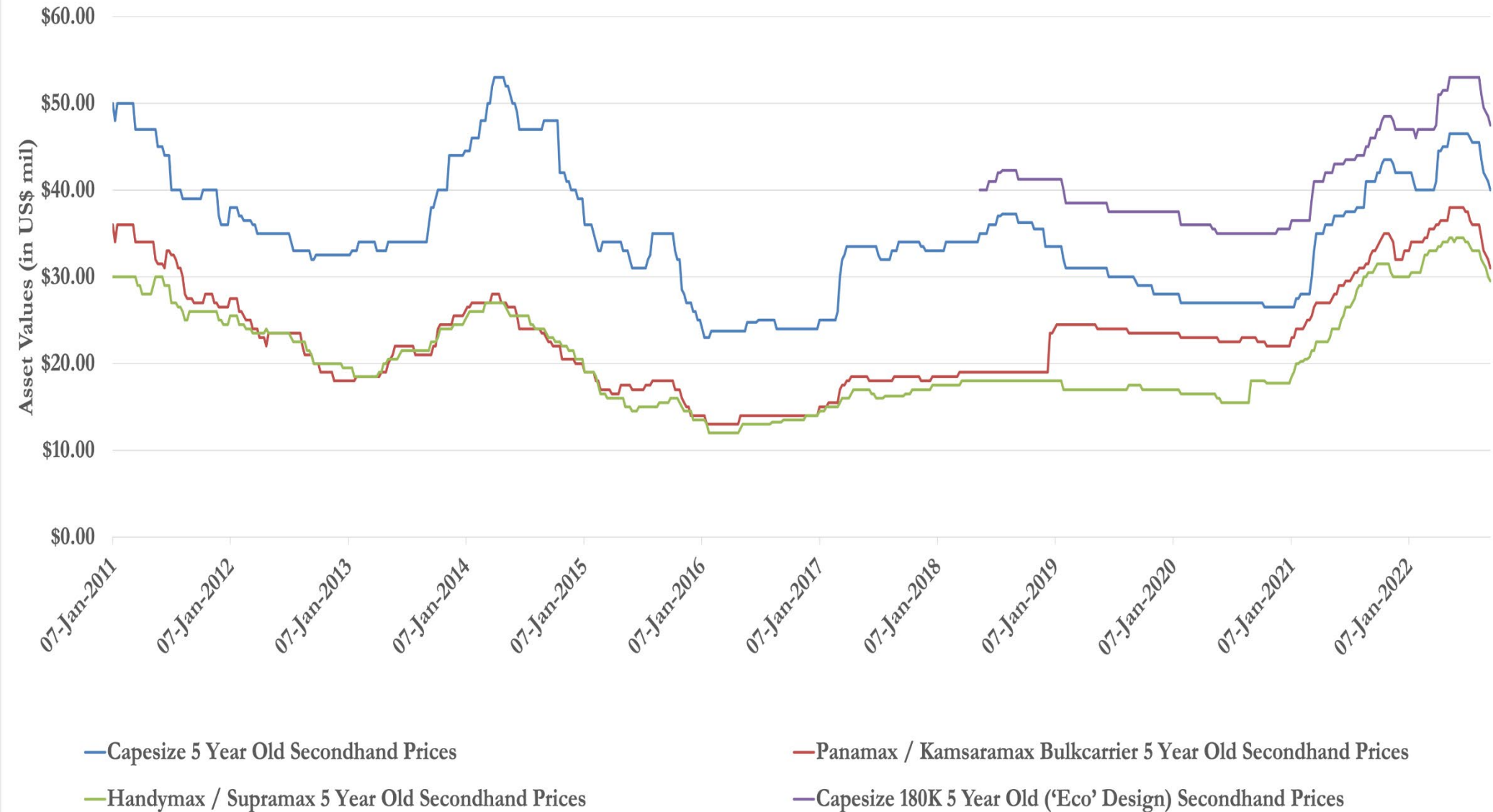
Tanker Values since 2016
(5yr-old Vessels, Values in \$ mil)



Dry-bulk Vessel Values since 2011

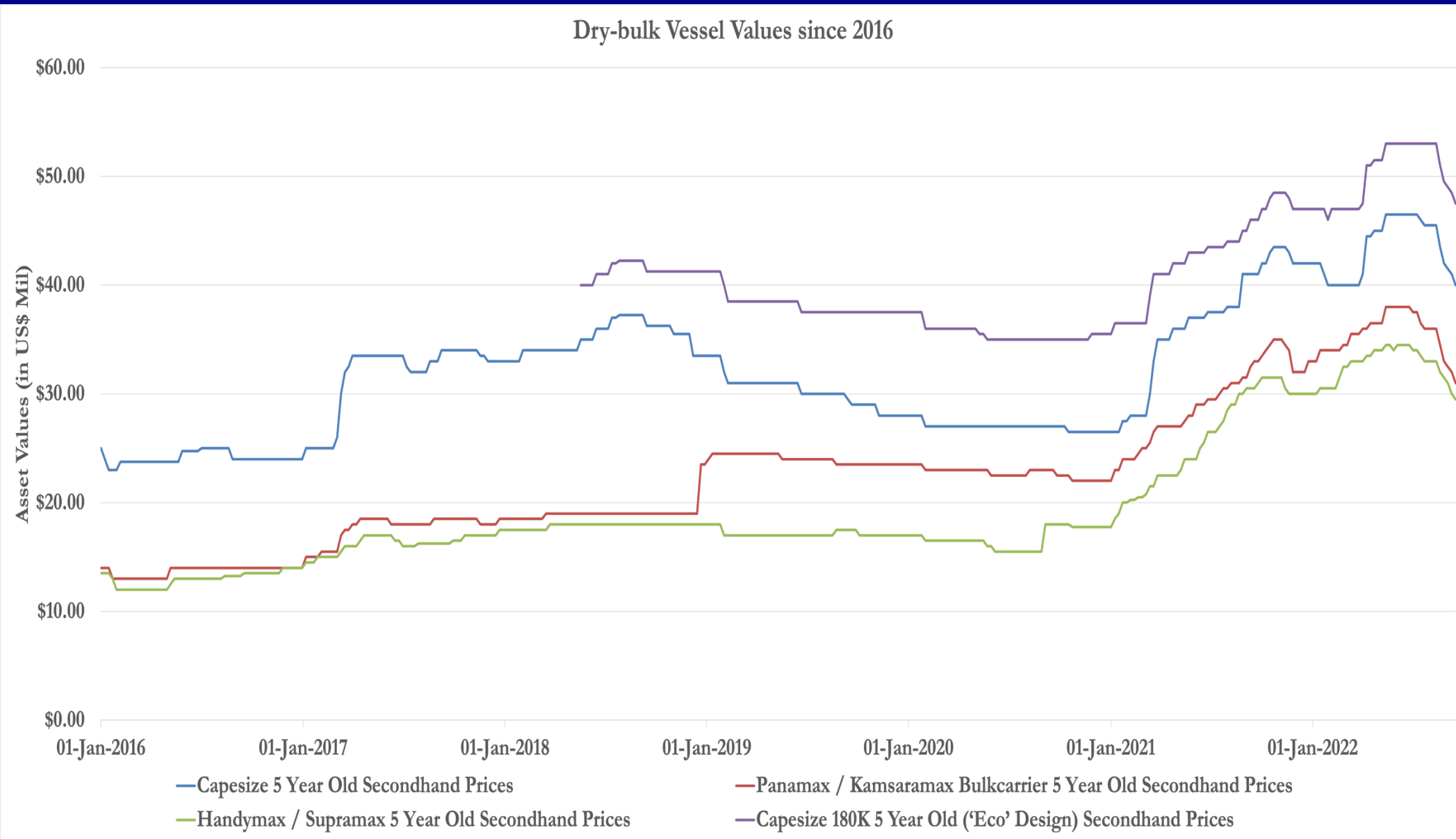
(5yr-old Vessels)

Dry-bulk Vessel Historical Prices since 2011



Dry-bulk Vessel Values since 2016

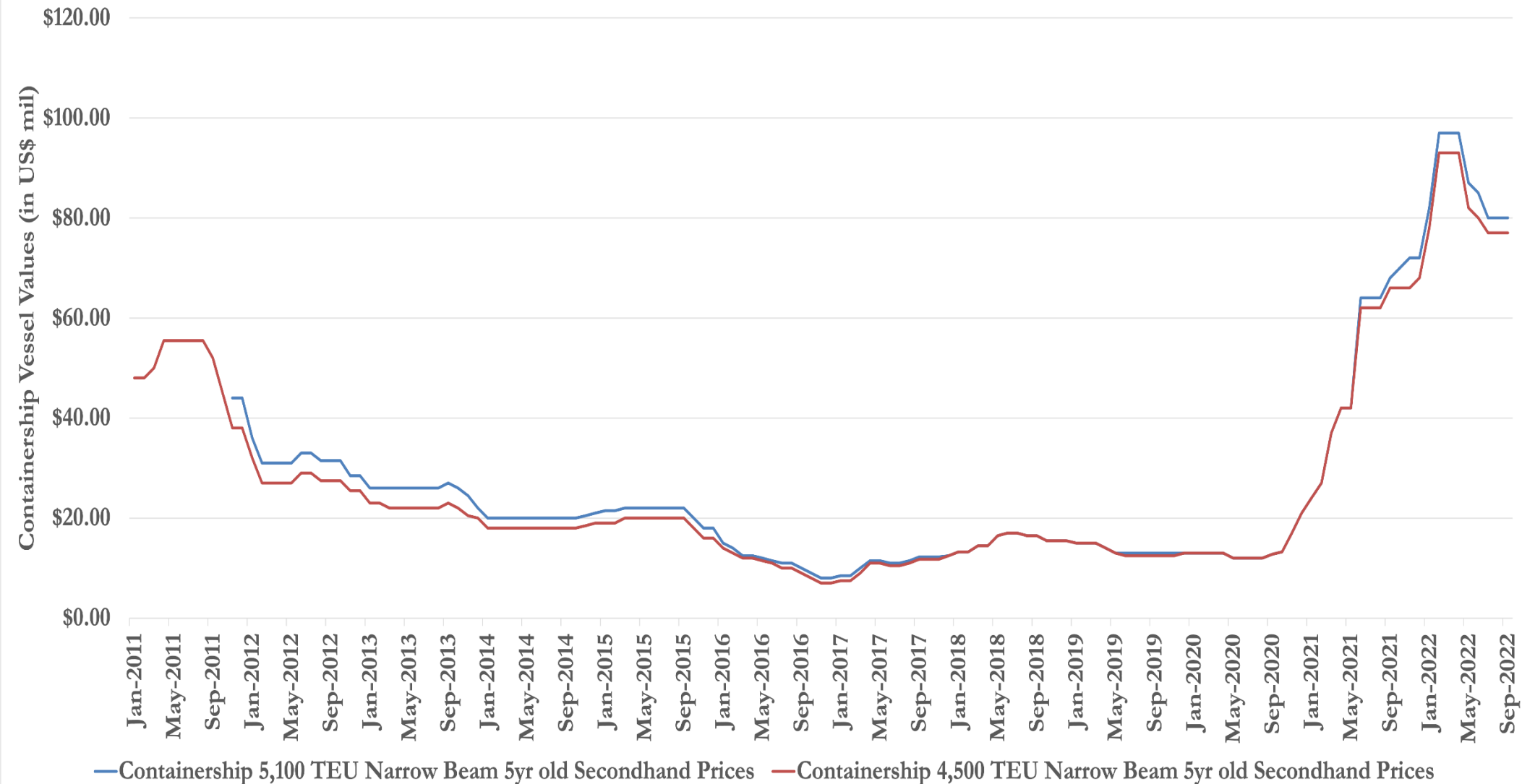
(5yr-old Vessels)



Containership Vessel Values since 2011

(5yr-old Vessels)

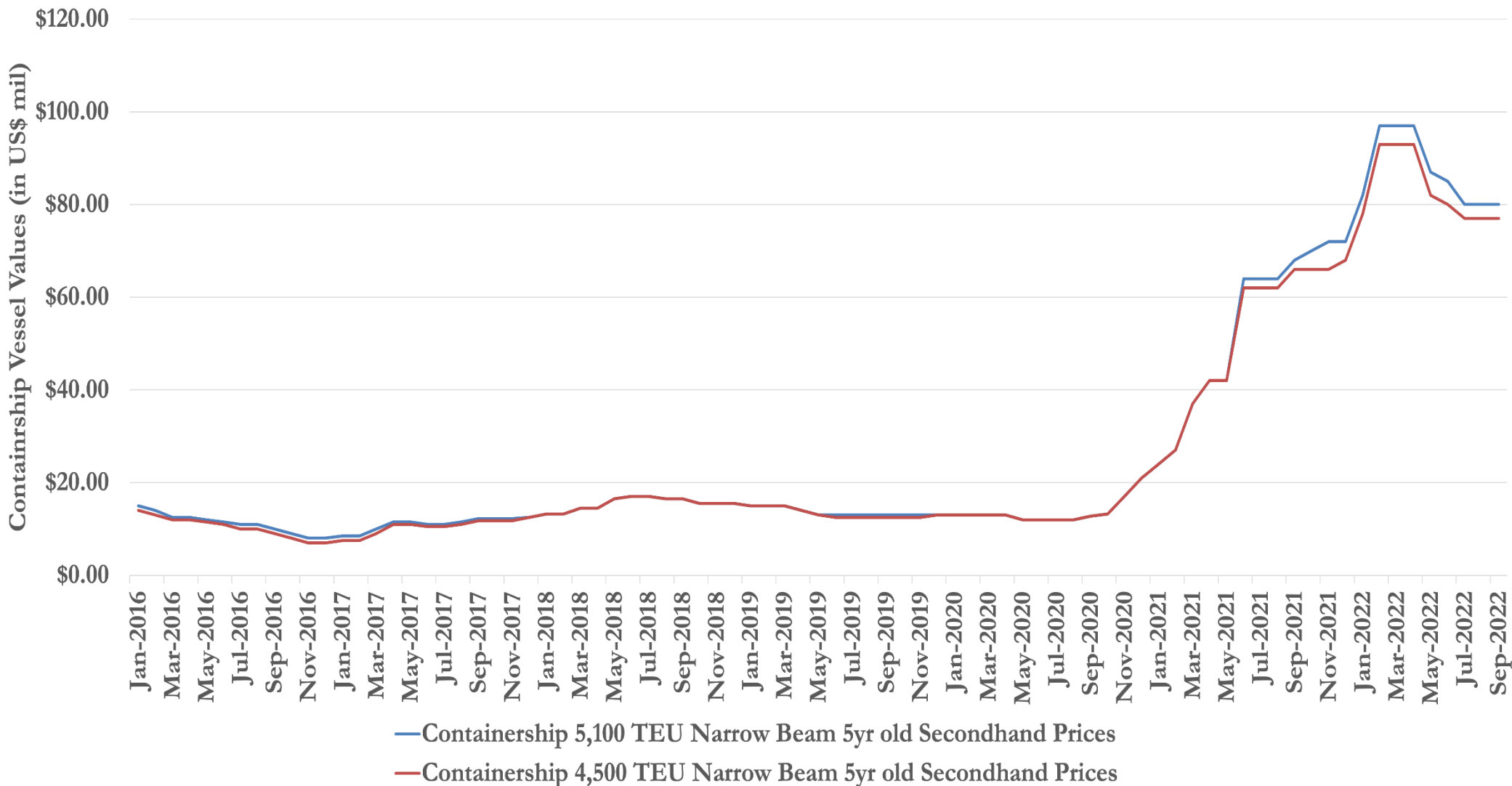
Containership Vessel Values since 2011
(Selected Asset Class, 5yr old Vessels)



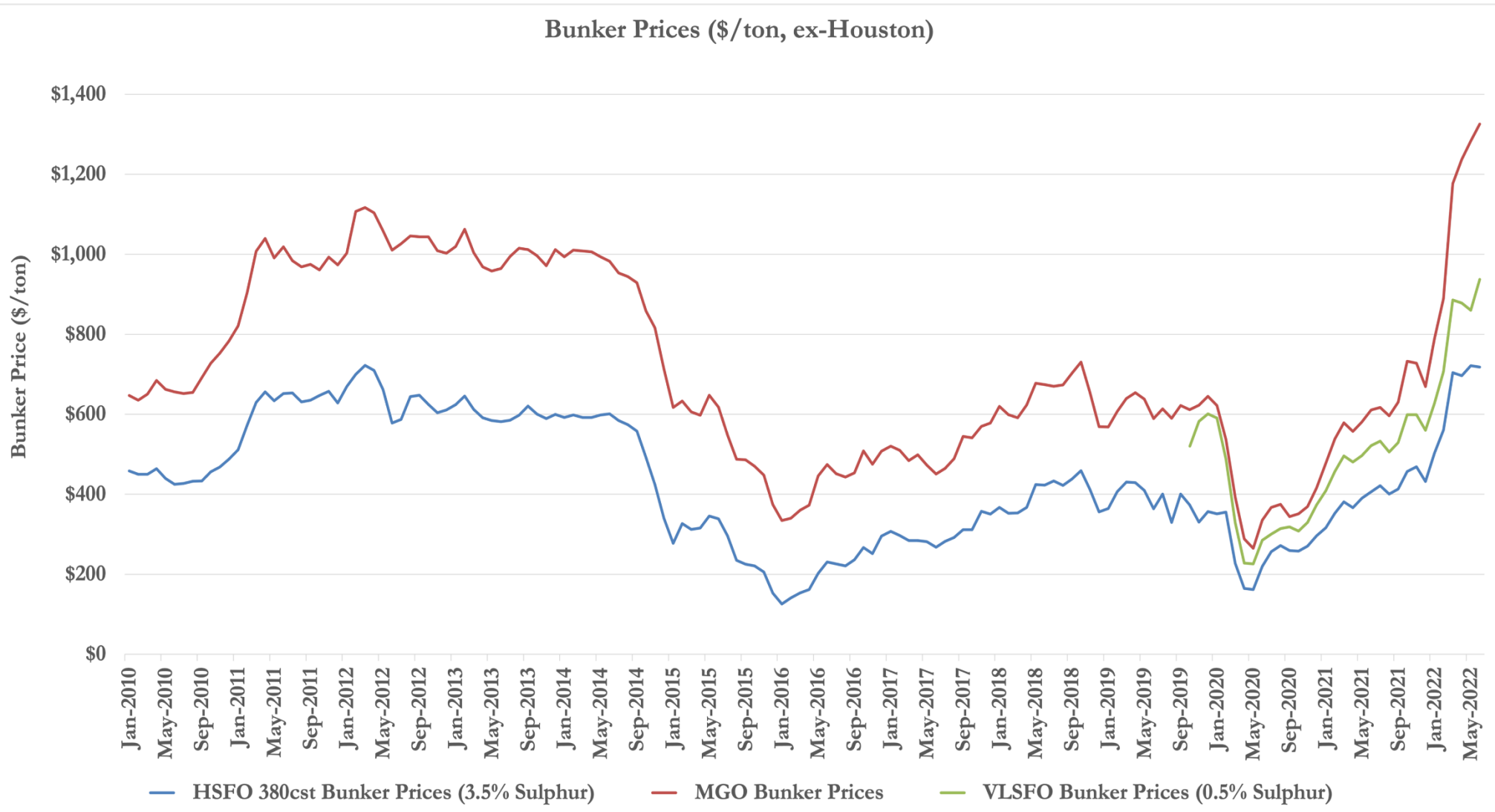
Containership Vessel Values since 2016

(5yr-old Vessels)

Containership Vessel Values since 2016
(Selected Asset Class, 5yr old Vessels)

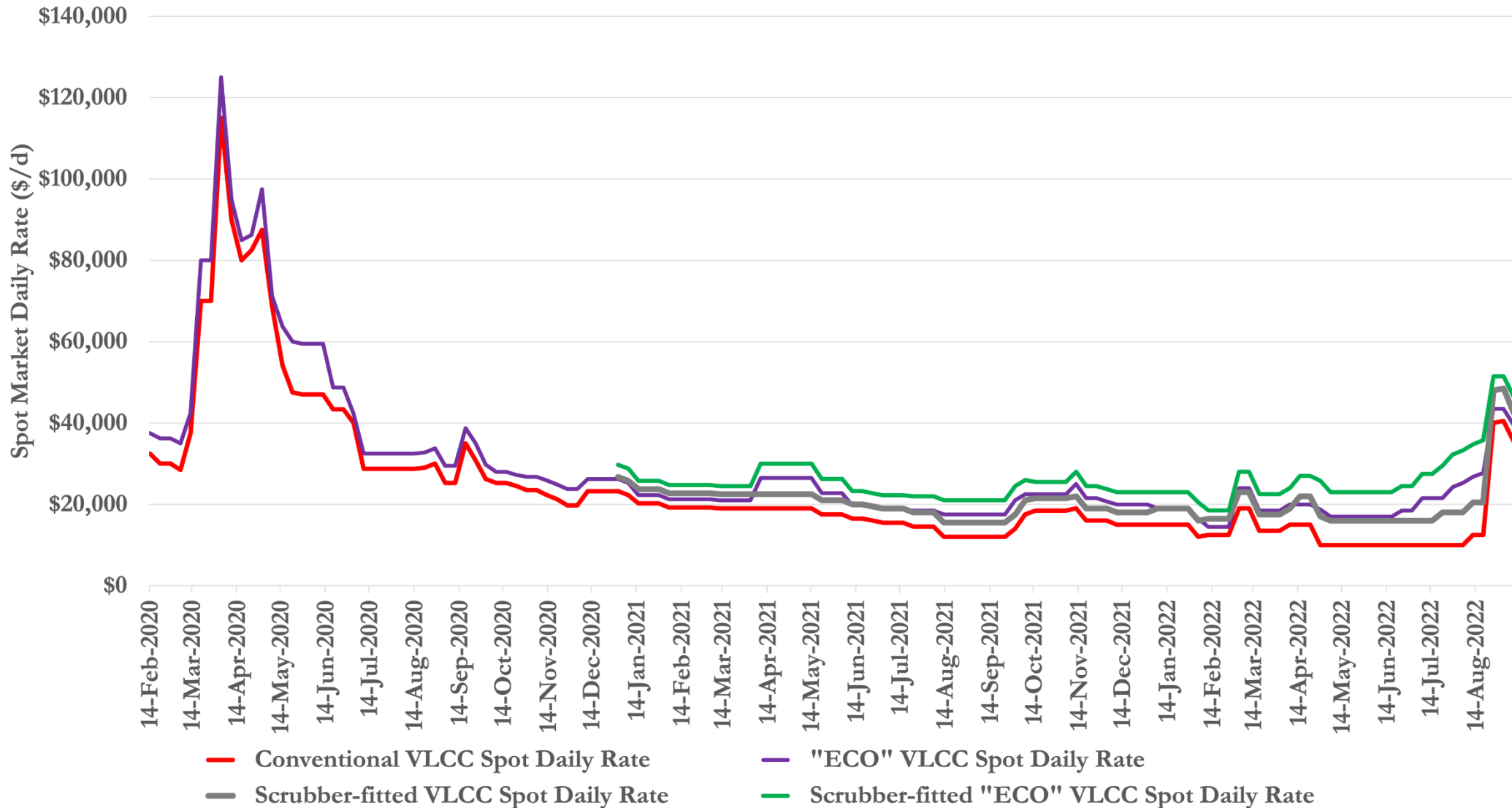


Bunker Prices since 2010



Spot Freight Rate Differential for Conventional and Scrubber-fitted Very Large Crude Oil Tankers (VLCCs)

Differential Spot Earnings for VLCC Tanker (\$/d)
for Conventional, "ECO", and Scrubber-fitted Designs



Outstanding Orderbook

	Present World Fleet (# of Vessels)	Existing Orderbook (# of Vessels)	% Orderbook
Tankers			
VLCC	869	76	8.75%
Suex	642	61	9.50%
Aframax	1080	121	11.20%
MR2 & MR1 Tanker	4264	286	6.71%
Dry-bulk			
Capesize	1931	159	8.23%
Panamax BC	2182	371	17.00%
Supramax	2983	385	12.91%
Handysize	3969	315	7.94%
Containers			
17,000+ teu	171	66	38.60%
12,000 - 17,000 teu	331	229	69.18%
8,000 - 12,000 teu	641	45	7.02%
6,000 - 8,000 teu	268	114	42.54%
3,000 - 6,000 teu	1071	124	11.58%
100 - 3,000 etu	3191	408	12.79%
Gas Tankers			
LNG	697	257	36.87%
LPG	1549	208	13.43%

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Major Themes for International Shipping

- **New regulations on emissions and environment; but...**
 - ✓ Little clarity; amalgamation of acronyms and different ways of calculating emissions
 - ✓ Multiple possible “fuels of the future”
 - ✓ Shipowners seem to have taken a step back from pre-emptively ordering more ships
- **Several publicly listed companies are controlled by institutional investors and have imposed a disciplined strategy of rewarding shareholders by increasing dividends (instead of growing their fleet by ordering more vessels)**
- **Container liner companies (i.e., Maersk), besides increasing dividends, now investing in acquiring logistics companies as they try to become “technology companies”; the success of the new strategy is to be seen, but for now, they have stayed away from ordering more vessels**
- **The Russian invasion of Ukraine presents “novel risks”**
 - Upended trading patterns from crude oil to petroleum products to dry bulk (primarily grains and coal)
 - Overall good news for shipping, as shipping thrives on uncertainty
 - Collateral benefit to the Jones Act market for dry, not so for tankers and tank barges

International Energy Market Review

- Russian invasion of Ukraine has shifted the energy market, likely permanently; major export of crude oil, but mostly of petroleum products, with Europe and US as primary buyers; sanctions on Russian energy products leads to shifting trading patterns and higher ton-mile; for now, mostly Indian and also Chinese refineries are biggest buyers of Russian crude at heavily discounted pricing, which then ship out as gasoline and petroleum products
- Europe likely to permanently unlink dependence on Russian energy imports, mostly NatGas via pipeline; positive news for the LNG tanker market, and for US LNG exports; however, in the next two years, given lack of infrastructure, both for LNG export facilities in the US and LNG import facilities in Europe, little can be done – besides positive momentum
- World is short of energy, whether for Russia or other factors (including “green” intentions)
- Germany having closed their nuclear plants, and getting squeezed on Russian energy imports, have been importing and burning coal for power generation (incrementally good for dry bulk market and US coal exports)
- Libyan crude oil production has been deteriorating, possibly posing another risk to the energy markets
- Offshore drilling does not seem to be appealing to oil majors any more, and shale drilling barely has come back; drilling for the second time existing wells at 60% of CapEx seems to be the preferred approach
- Citi (and couple more research sources) guiding for a \$65/bbl oil by year end (driven by recession)

Containership Market Overview

- **A real-life case of a Lazarus-kind-of resurrection; freight cost from Shanghai to Los Angeles, from \$400/teu to \$18,000/teu in the last two years, and back to \$4,000/teu now; in 2021, world's containership companies generated collectively more than \$210 bln in net profits**
 - While demand for containerized cargo shipment has increased with COVID19 (changing consumer pattern shifts from services to durables and goods), other factors have actually driven the market higher
 - China, unlike the US and Europe, has applied a very pro-active COVID policy and shuts down whole ports even for a couple of COVID cases, exacerbating supply chain disruptions
 - For the last year, almost 100 large containerships wait in line at any given time to dock to ports in US West Coast, with almost of 8% of the world's fleet of large containerships tied up in delays, effectively reducing tonnage supply artificially
 - Outdated port operations, accidents (i.e. MV "Ever Given" in Suez, etc) further disrupted supply Supply chain disruptions have forced shippers to put unnecessary stress on the system in an attempt to preempt future problems (i.e. ordering well in advance now, in expectations of long delays, etc)
- **As hot as this market has been, minimal over 12-18 month charter activity; lack of faith in a continuous bull market?**
- **Long-term Headwinds: if U.S. and Chinese economies are de-coupling, w? re-shoring & near- shoring replaces offshoring, then long-term prospects of industry may be questionable**
- **U.S. private equity funds did extremely well by controlling cheap and obsolete containerships at rock bottom prices (via acquisition of distressed loan portfolios from German and other European banks)**
- **For now, enjoy the moment, but be mindful of charter and loan defaults.**

Drivers for Strong Marine Asset Values

- Inflationary environment is considered beneficial for asset owners, as implicitly provides inflation protection and a “floor” for asset prices; likewise, future residual values set at nominal levels will allow for profitable exit / likely EBOs to vest
- For now, high commodity prices, material costs and supply chain disruptions have driven newbuilding prices high
- China with “zero tolerance” COVID policy have been on extensive lockdowns and minimal international travel is allowed; Chinese shipbuilding is not accessible as before, allowing shipbuilders elsewhere to be less price sensitive, especially for value-added vessels
- Although JPY stands at a 20+ year lows, Japanese shipbuilding remains focused on domestic shipowners, domestic market and trades, and not driven on international markets in terms of pricing (energy shortages and a closed economy do not seem to compensate for favorable FX rate)
- International shipbuilding capacity is full for 2025, and quality shipyards have orders for 2026 and 2027; at least for the next two years, tonnage supply is fixed and inelastic which bodes well for a balanced freight market and asset values

Marine Asset Values & Considerations

- For dry-bulk and tanker vessel assets, values close to highest they have been in the last decade; for containerships, possibly the highest ever, materially surpassing even 2008 levels
- While values may be supported by “market comparable” method, they materially overpriced based on “income method” and “replacement cost” method
- Limited period charter market
- Charter-free vessels are valued at higher levels than vessels with charter-attached
 - Appraising marine assets presently challenging, especially for containership vessels
- For creditors and lessors, time to be extremely cautious entering the market at these levels
- International shipping banks and lenders slowly re-entering the market and have been lowering their spreads (i.e., L+200 bps are common for asset-backed financing)
- Momentum more important than fundamentals
- Rhetorical Question: should an appraiser be allowed to express an opinion on values as such opinion may pertain to investments or ship mortgages?

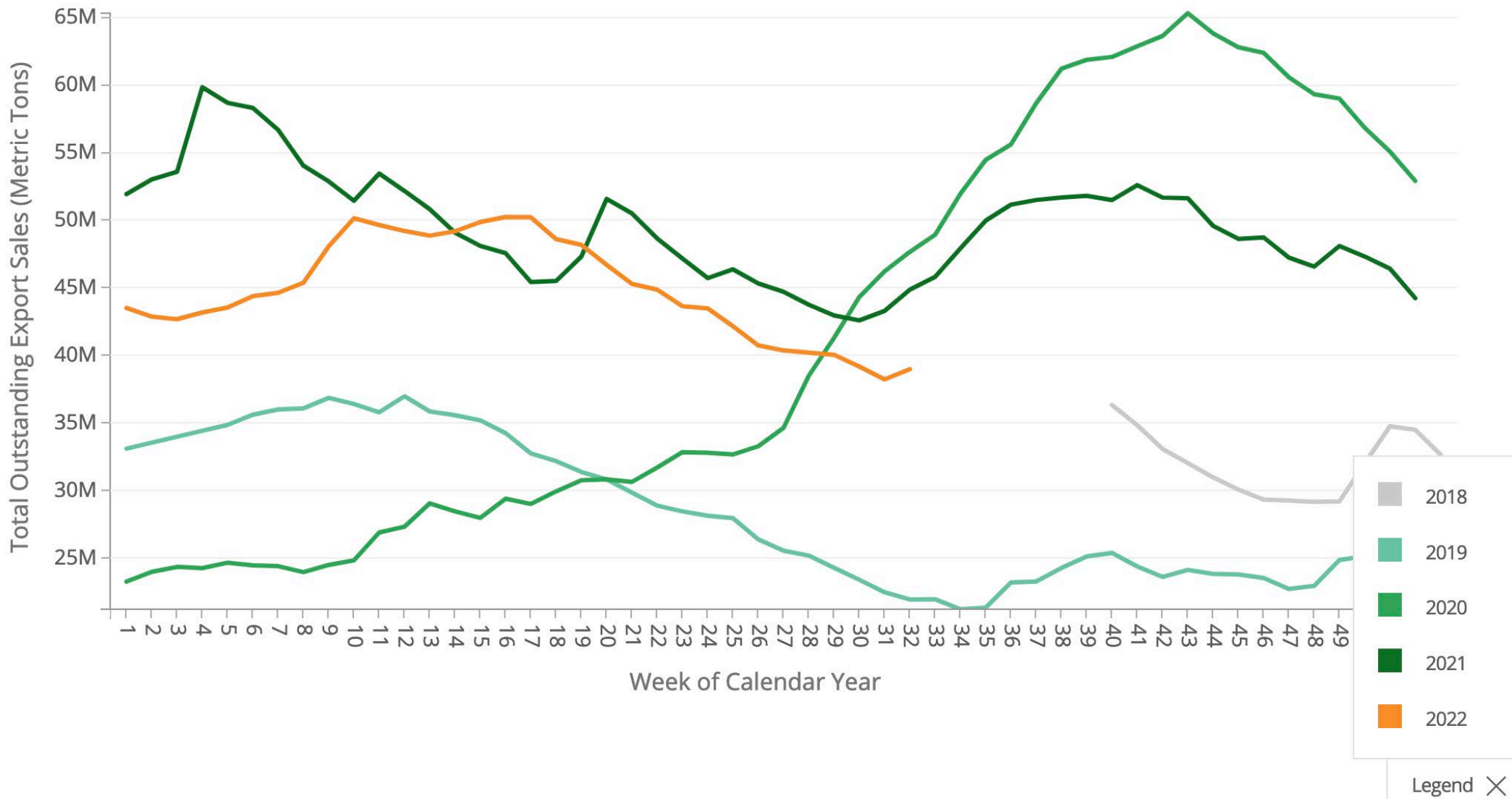
International Shipping: Thoughts and Concerns

- Ever tighter regulations for emissions and compliance for international shipping
- Lack of consensus for the future fuels for ships (LNG? LPG? Methanol? Ammonia? Biofuels? Batteries?)
- New technologies and innovation have increased risk for technological and functional obsolescence
- China constantly increasing its market share (think also “One Belt, One Road” (OBOR)) – Defaulting?
- Technology companies in supply chain more hands-on and aggressive (i.e. Amazon) than traditional retailers (i.e., Walmart); having shipping integrated in the supply chain
- ESG criteria and millennials may have an outsized impact on shipping and shape future trends
- Increased investments in software and technologies to make shipping more efficient
- Potentially crisis with crewing and crewing costs
- How can one justify the economic decision of building (and also financing) new crude oil tankers (w/ estimated 25 years economic life) when fossil fuels are on bull’s-eye for environmentalists and governments?
- COVID19: Where’s the end? Pandemic vs Endemic?
- **Historically, it reminds of mid 19th century and the end of the age of sail, with the introduction of steamships; or, a compounded scenario of the transition from single-hull to double-hull tankers (after the MT “Exxon Valdez” accident and “OPA 90” legislation)**

Agenda

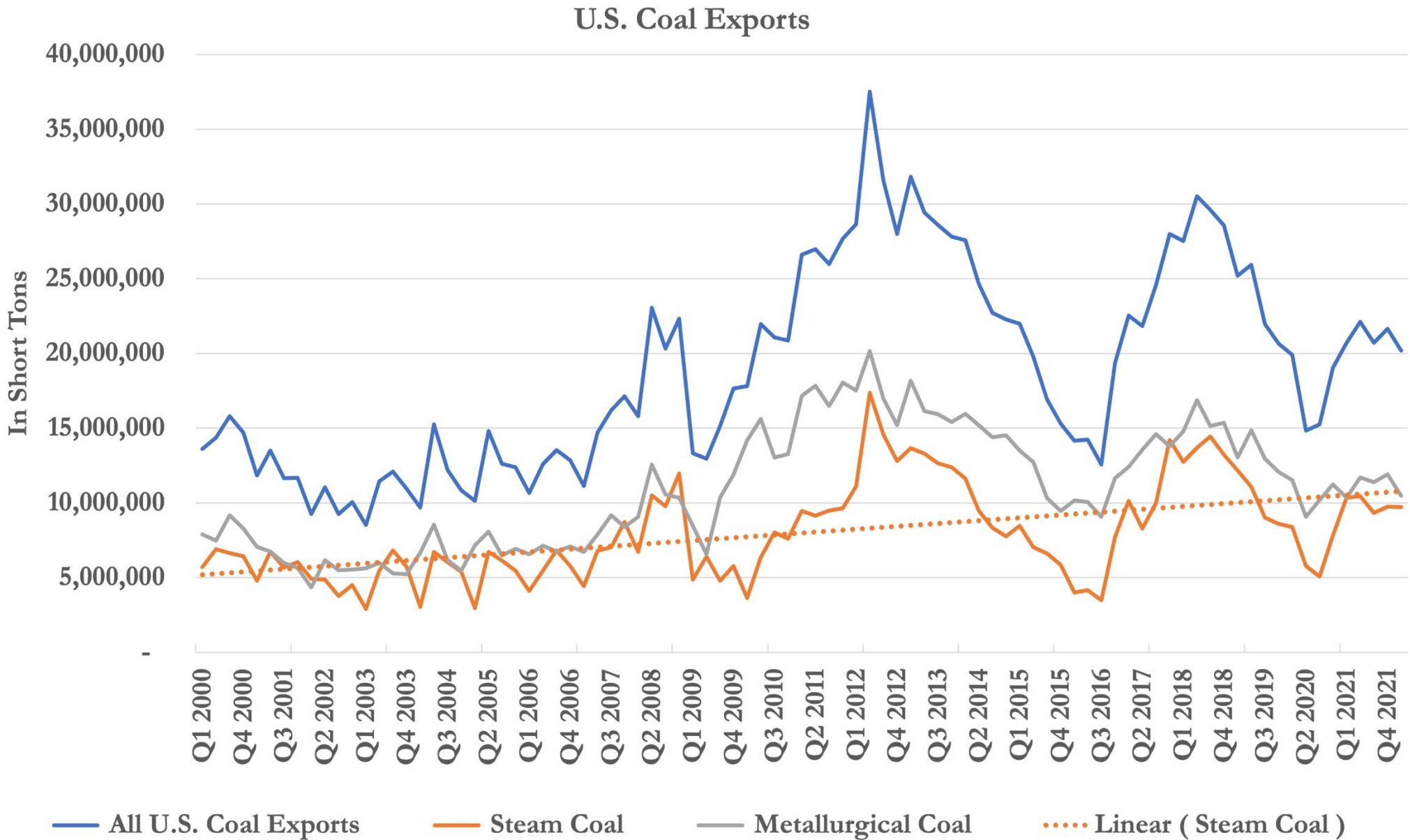
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Historical U.S. Grains Exports (Source: USDA)

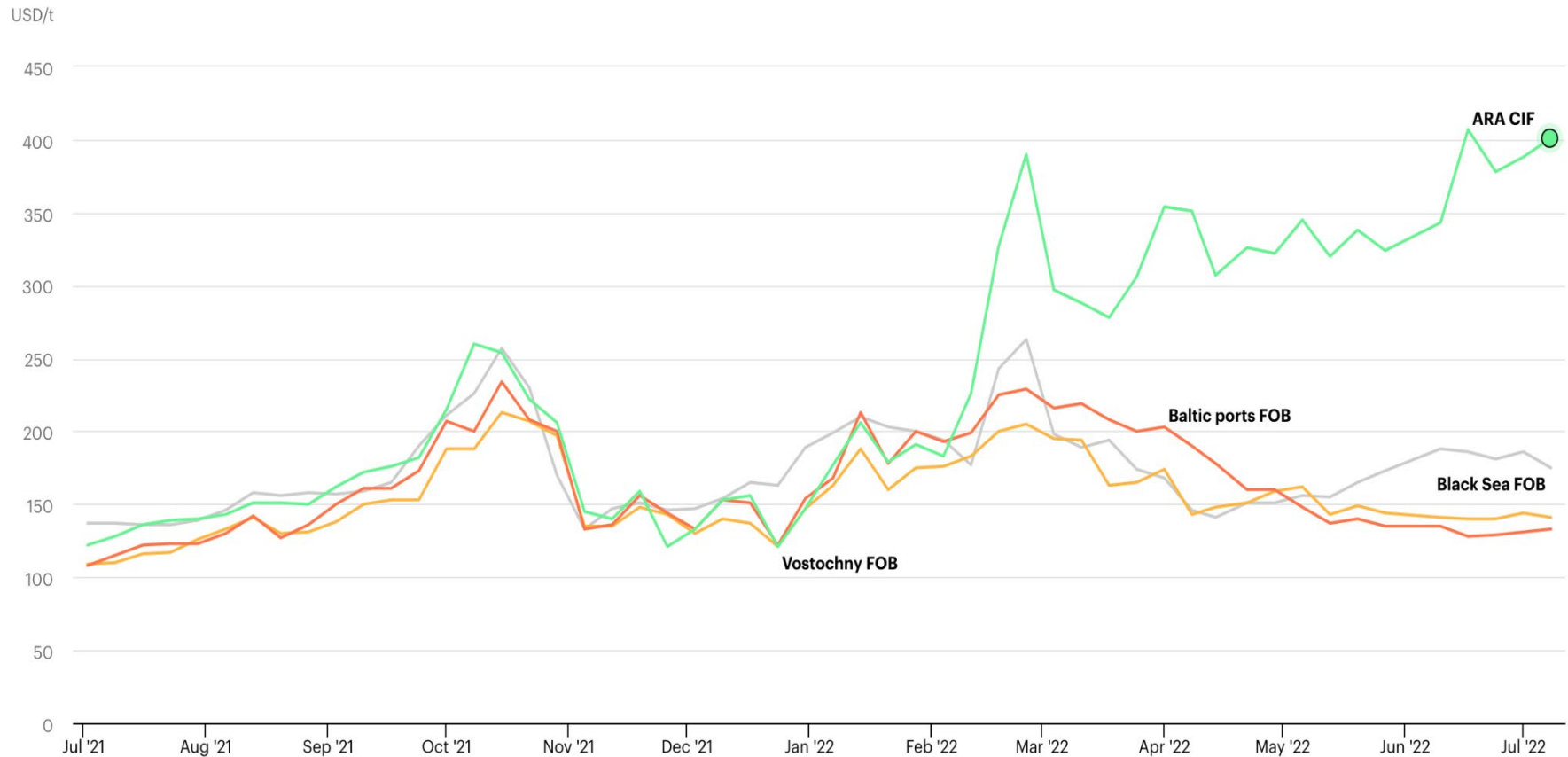


Source: DNV GL, Comparison of Alternative Marine Fuels

Historical U.S. Coal Exports (Source: EIA)



Thermal Coal Pricing in Europe



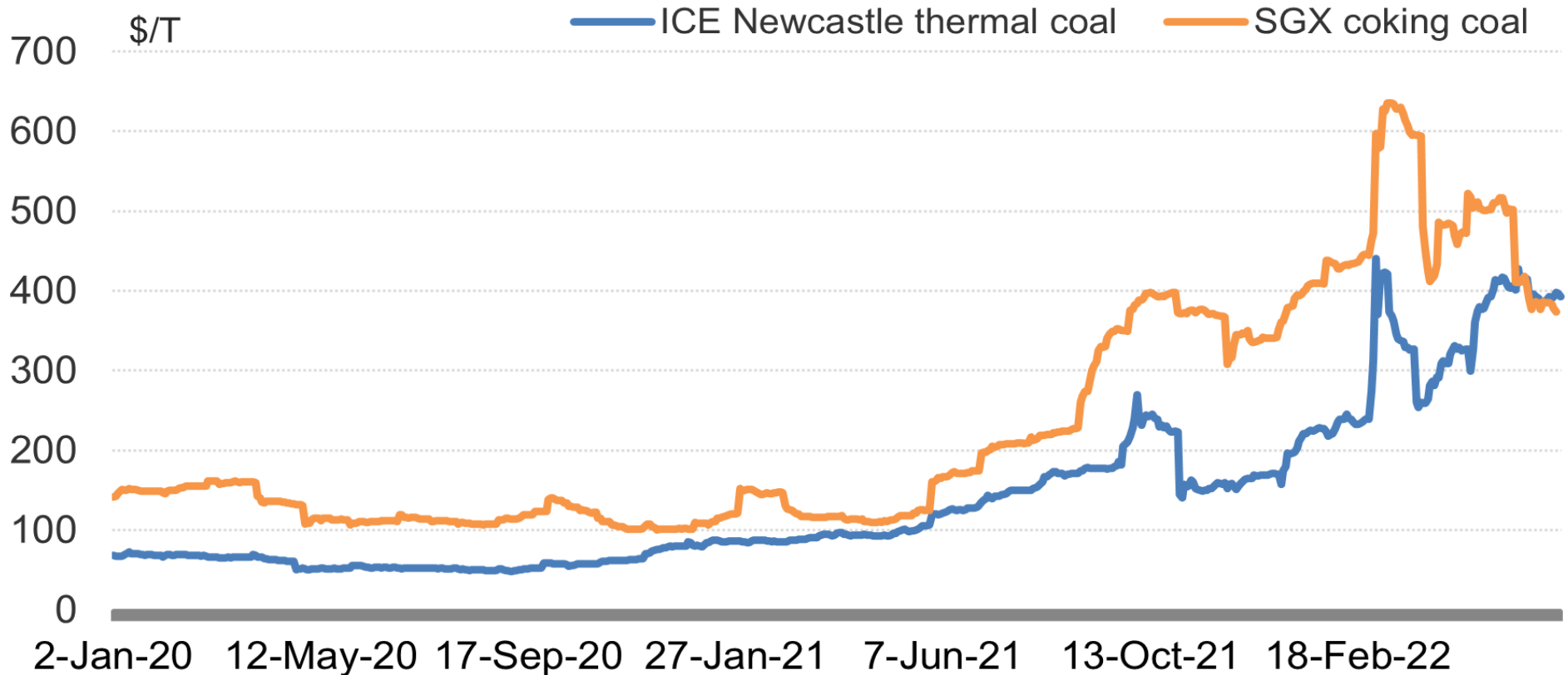
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● ARA CIF ● Baltic ports FOB ● Vostochny FOB ● Black Sea FOB

Thermal vis-à-vis Metallurgical Coal Pricing

THERMAL COAL OVERTAKES COKING

ICE Newcastle thermal coal vs SGX coking coal

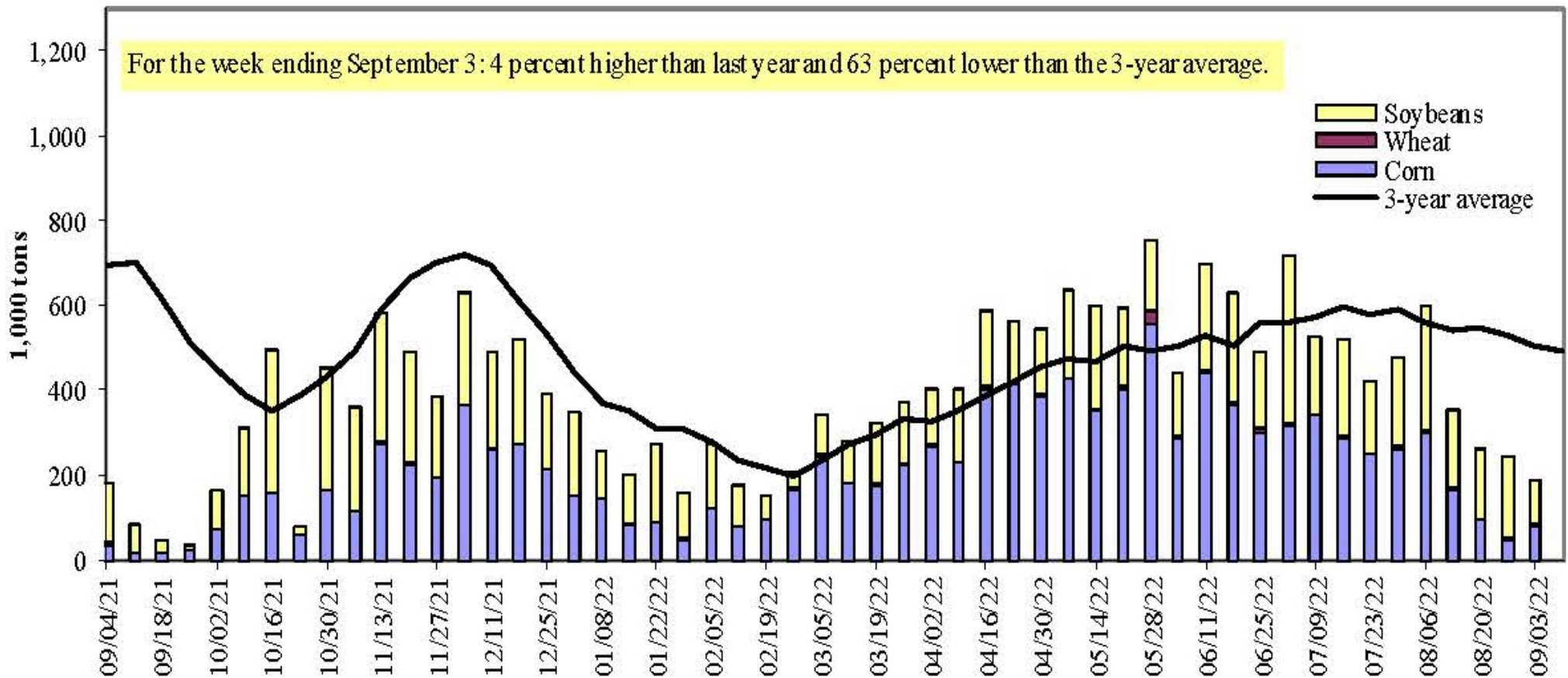


Source: Refinitiv Eikon Reuters graphic/Clyde Russell 28/06/22



Barge Movement on the Mississippi River (Source: USDA)

Barge movements on the Mississippi River¹ (Locks 27 - Granite City, IL)



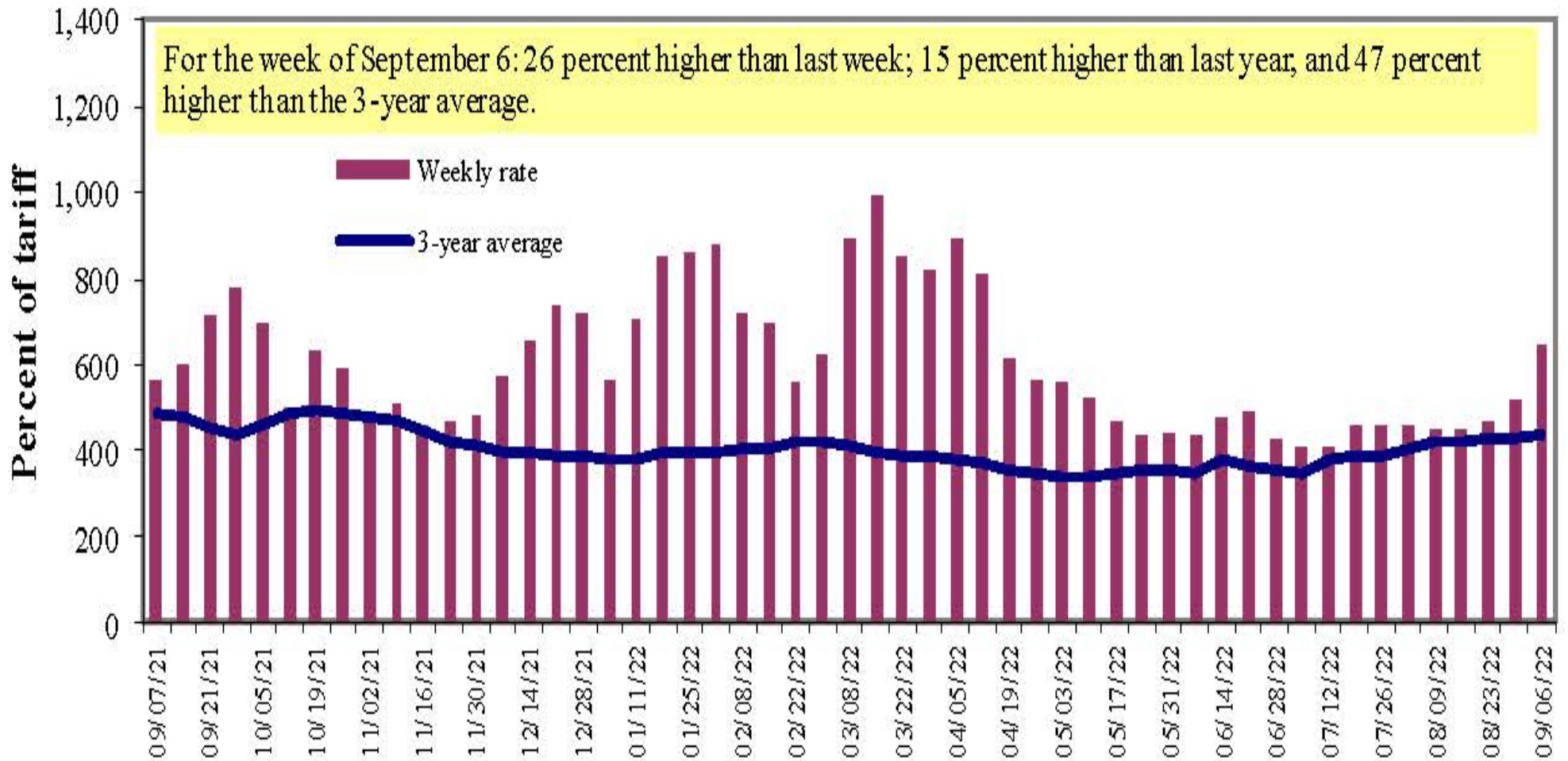
¹ The 3-year average is a 4-week moving average.

Note: The U.S. Army Corps of Engineers has recently migrated its lock and vessel database and has noted the latest data may be revised in coming weeks.

Source: U.S. Army Corps of Engineers.

Illinois River Barge Freight Rate (Source: USDA)

Illinois River barge freight rate^{1,2}

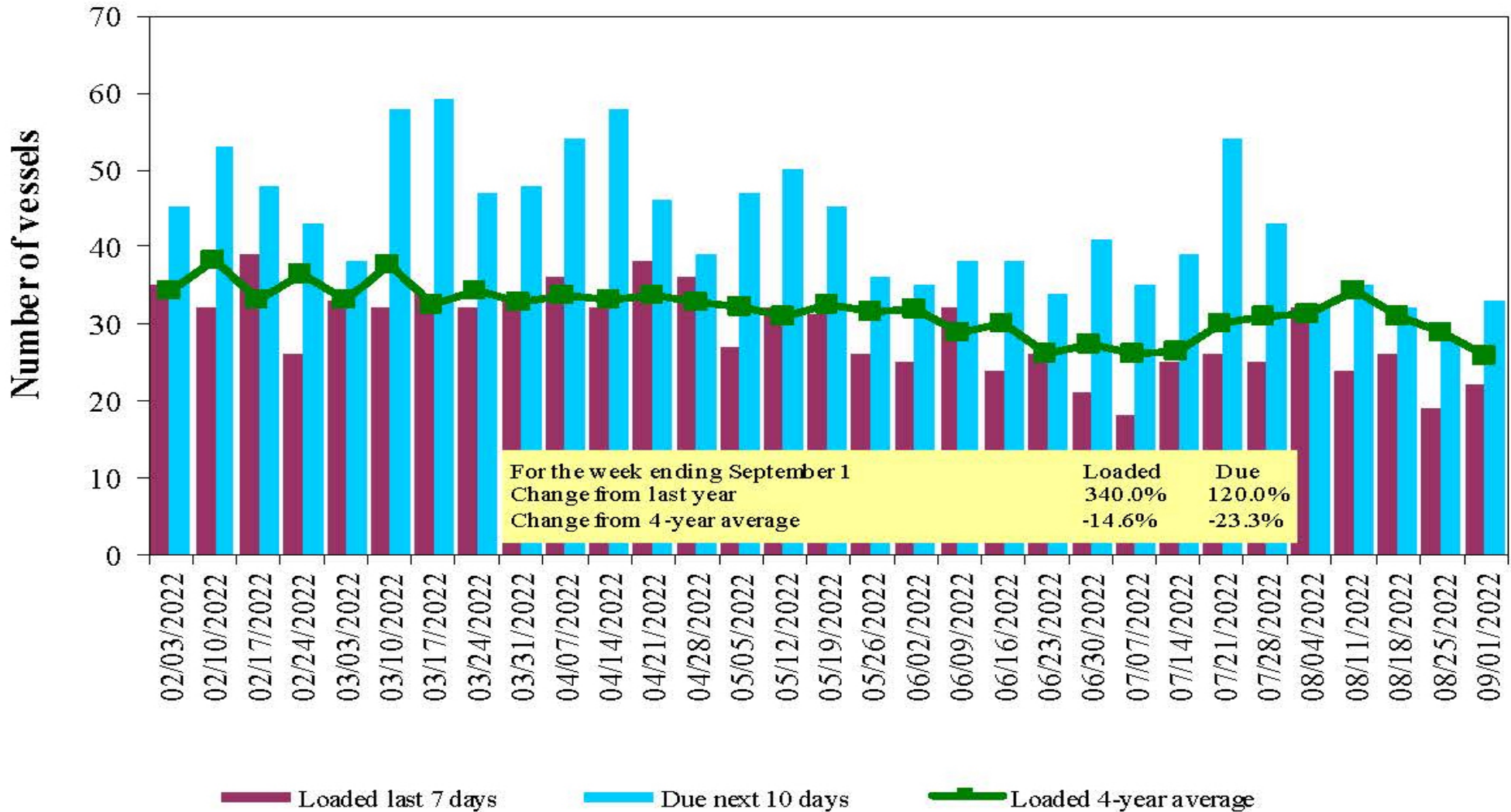


¹Rate = percent of 1976 tariff benchmark index (1976 = 100 percent); ²4-week moving average of the 3-year average.

*Source: USDA, Agricultural Marketing Service.

U.S. Gulf Vessel Loadings (Source: USDA)

U.S. Gulf¹ vessel loading activity

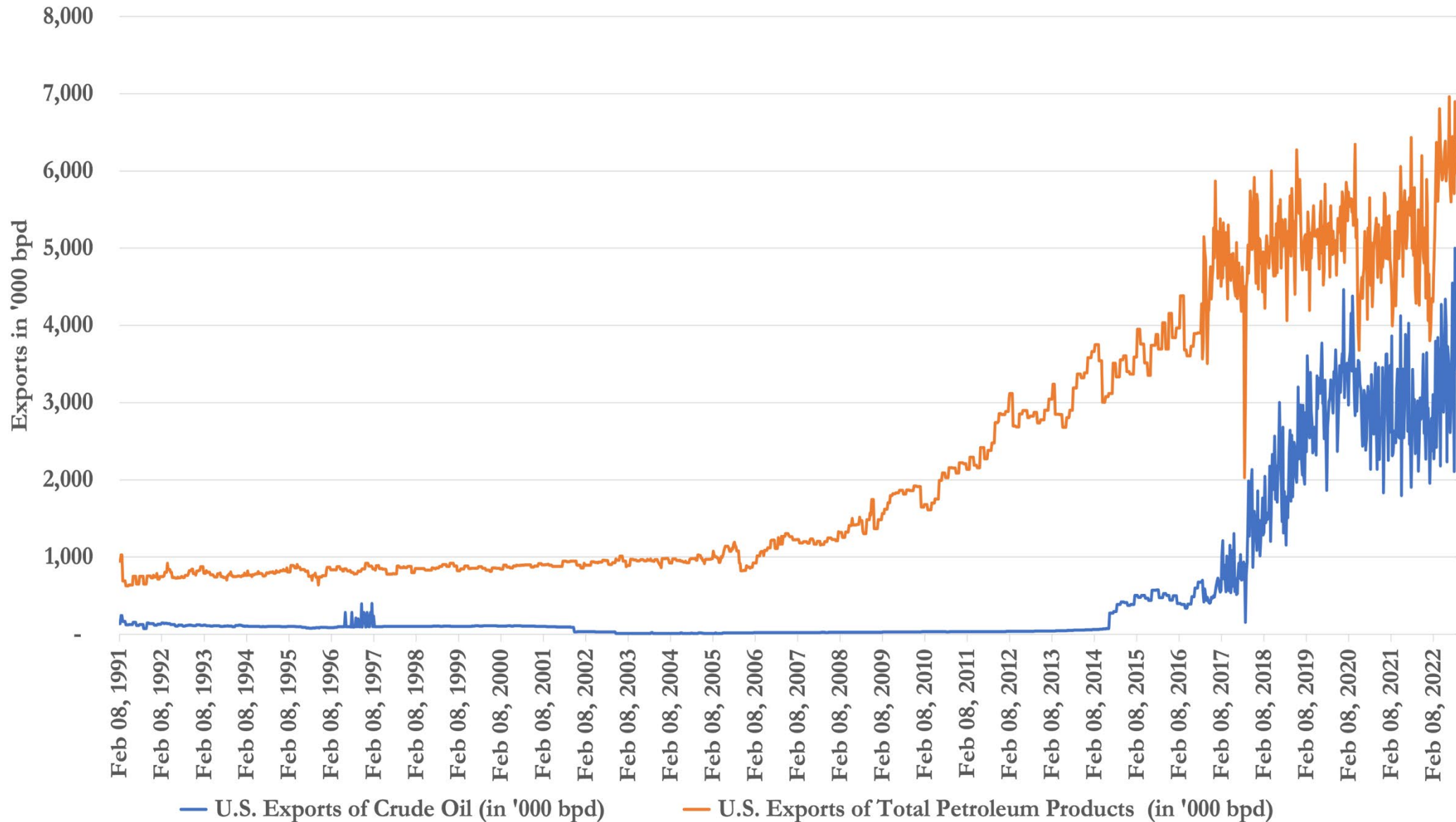


¹U.S. Gulf includes Mississippi, Texas, and East Gulf
Source: USDA, Agricultural Marketing Service.

U.S. Crude Oil & Petroleum Product Exports since 1991

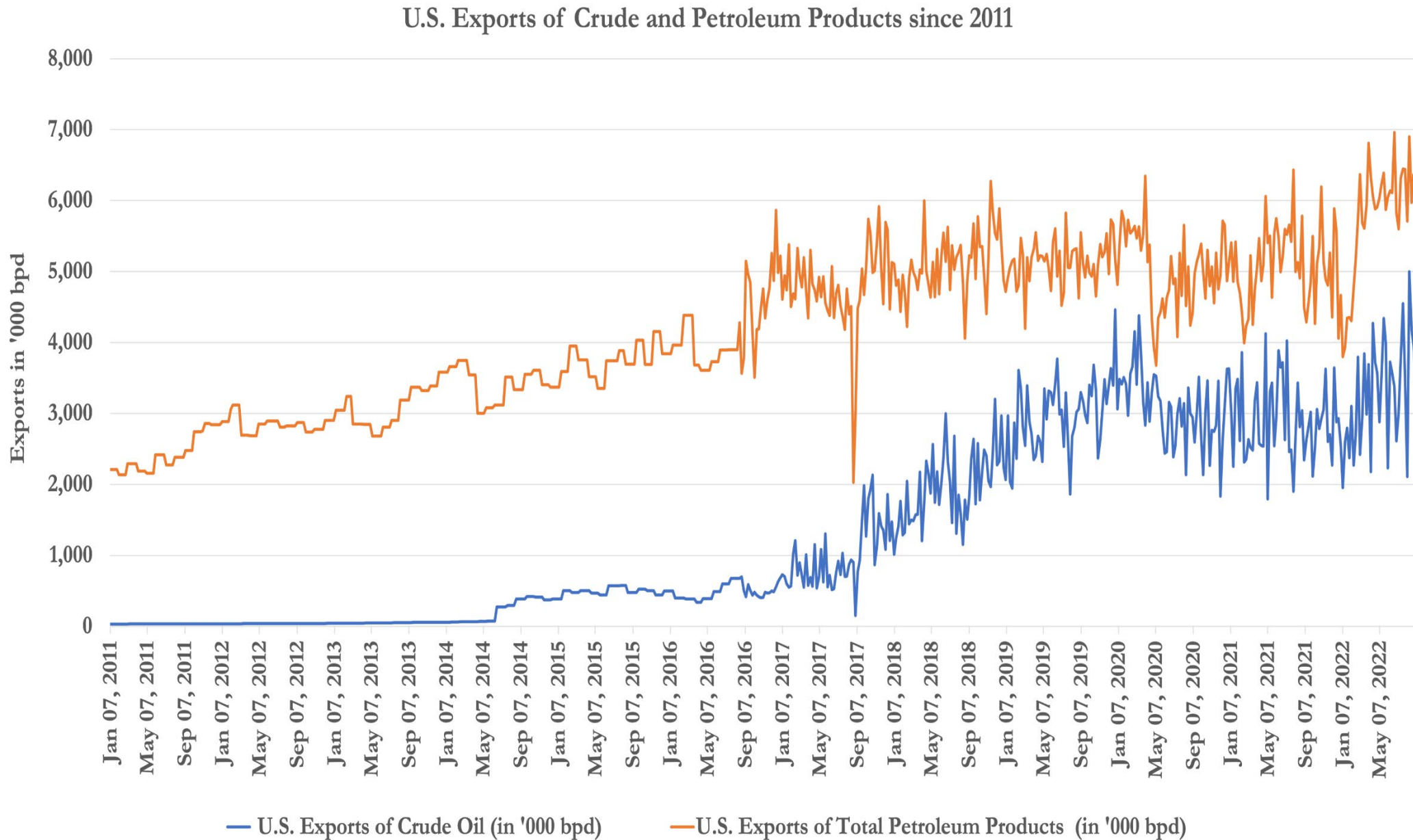
(Source: EIA)

U.S. Exports of Crude and Petroleum Products since 1991



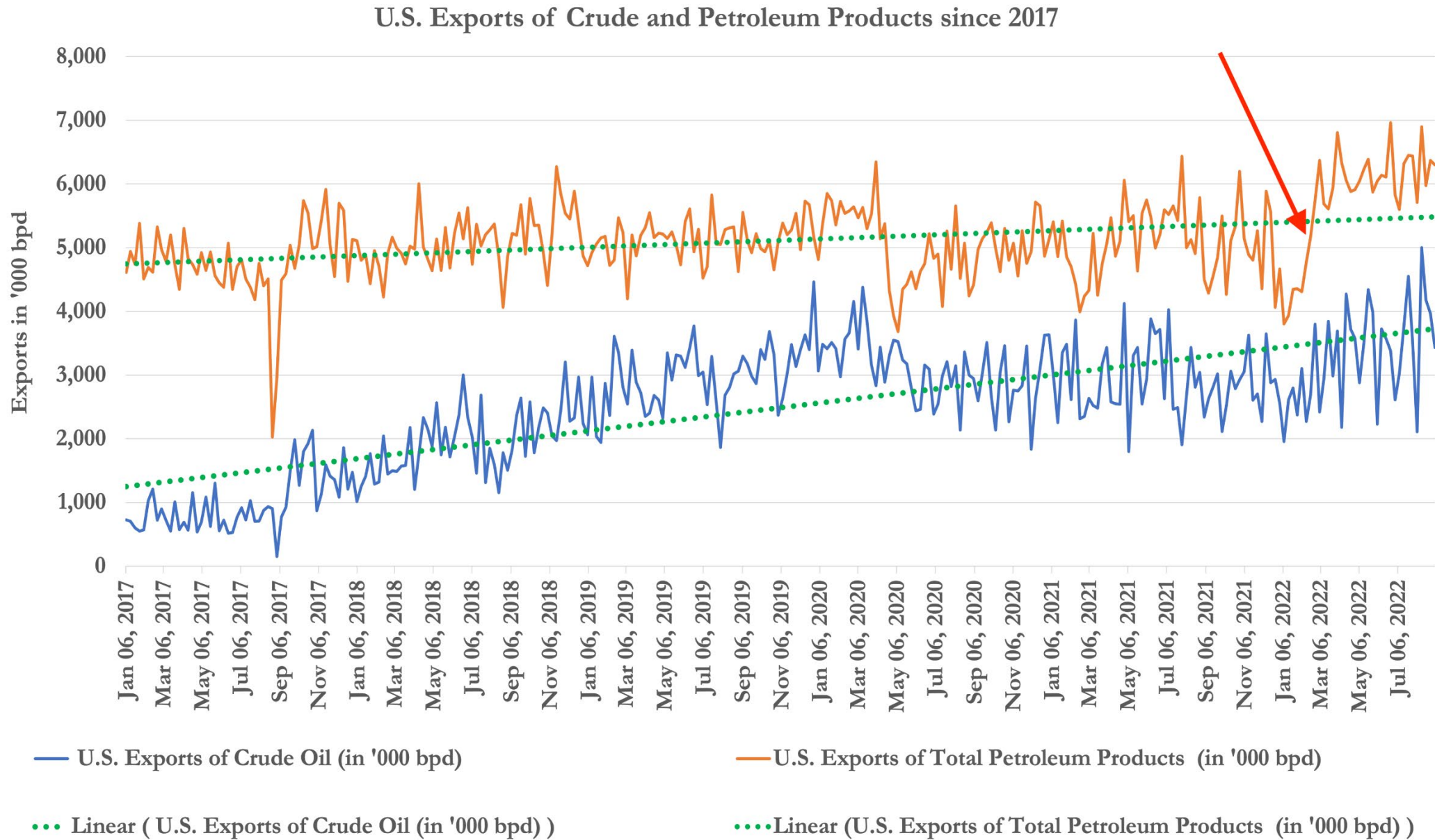
U.S. Crude Oil & Petroleum Product Exports since 2011

(Source: EIA)



U.S. Crude Oil & Petroleum Product Exports since 2017

(Source: EIA)

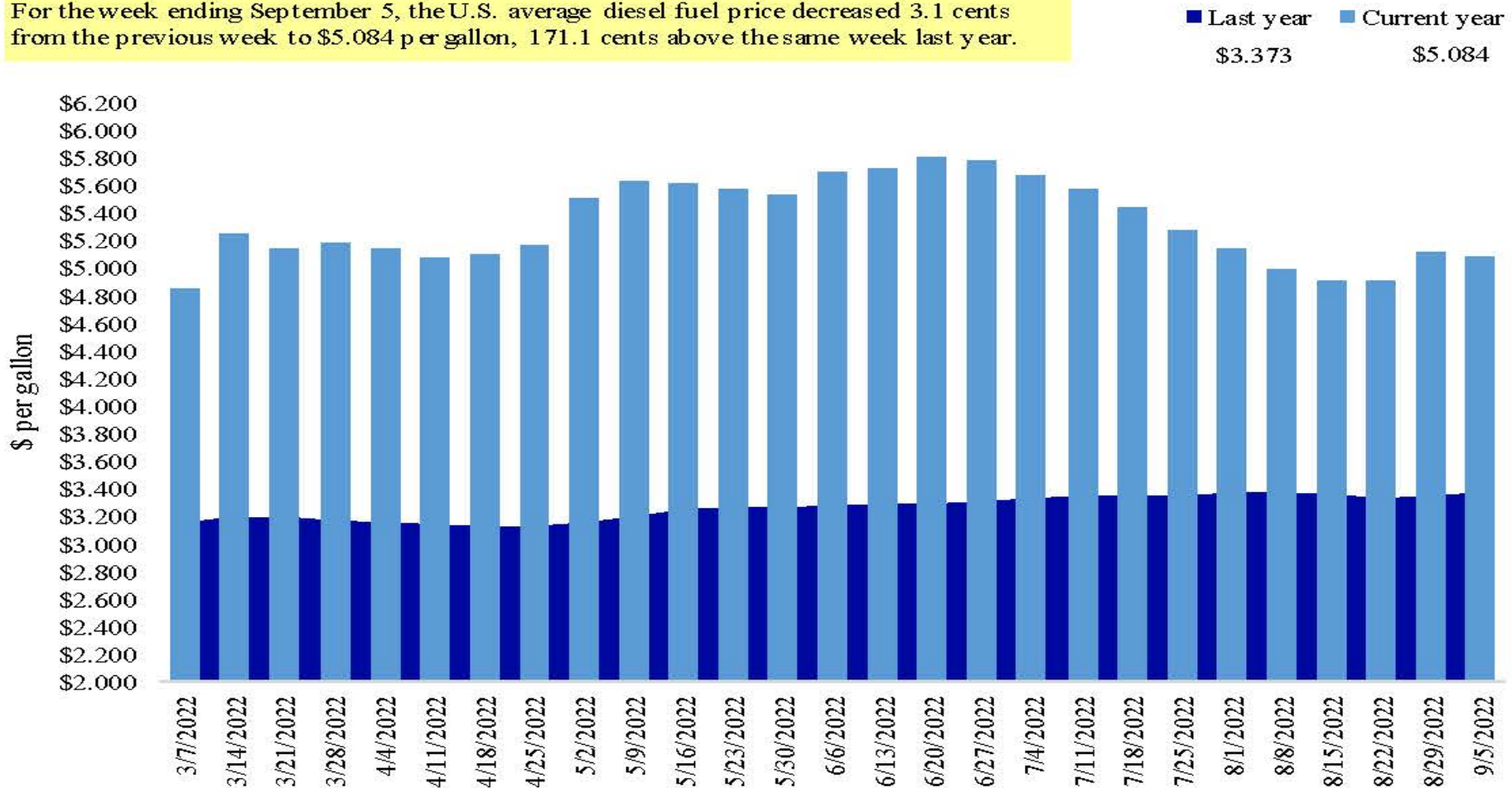


Weekly Diesel Fuel Prices

Figure 13

Weekly diesel fuel prices, U.S. average

For the week ending September 5, the U.S. average diesel fuel price decreased 3.1 cents from the previous week to \$5.084 per gallon, 171.1 cents above the same week last year.



Note: On June 13, the Energy Information Administration implemented a new methodology to estimate weekly on-highway diesel fuel prices.

Source: U.S. Department of Energy, Energy Information Administration, Retail On-Highway Diesel Prices.

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Inland Market Overview

- A more resilient market than expected; after initial COVID-induced market drop, volumes and trade have been improving
- Main commodities (i.e. grains, etc) have kept their market share
- Unexpected tailwinds of cargoes (i.e. U.S. a coal exporter again)
- Shale drilling has tapered off, but expected to pick up again with high oil prices (think of drilling sand, etc)
- Any infrastructure bill stands to further support the market
- Inland tank barge market may soon reach pre-COVID levels, based on gasoline demand (driving)
- Hot market in terms of acquisition of marine assets; however, not many asset owners want to part with their marine assets at present

Coastal Jones Act Market

In this primarily liquid cargo / energy market-driven sector, a slower than expected recovery:

- Low petroleum products demand has been negatively impacting the market (high fuel pricing, recession?)
- Weak marine fuel demand (only recently cruiseship activity has returned to normal scheduling, but with fewer vessels)
- Weak aviation fuel demand (airlines have been flying more passengers with fewer planes)
- Disrupted (world market) energy economics, with US has been exporting high amount of energy products at 10+ mil blpd (which leaves less cargo to be moved domestically)
- Weak shale drilling activity – Drilling in the GOM has been uncertain, and limited volumes of black oil along the coast, especially (close to 20% of black oil tank barges are idle)
- Publicly listed companies with exposure to the coastal market have been reporting slowly improving prospects

On the bright side:

- Nil new shipbuilding activity and minimal interest for future orders, for now

Blue Water Jones Market Overview

Again, a mostly liquid energy-driven market

- Weak shale oil activity and low international tanker freight rates have hit hard the Jones Act tanker fleet
 - ✓ Almost 25% of the Jones Act tanker fleet (both for petroleum products and crude oil) has been idled
 - ✓ Large ocean-going tank barges facing a weak market

- Cruiseship market – a weak and precarious market
 - ✓ Tourism oriented markets, such as Hawaii and Seattle, have seen very weak demand, impacting fuel trade on barges and Jones Act tankers
 - ✓ Likewise for Florida and the Eastern Seaboard

- Containerships
 - ✓ Following the international containership market, volumes for containerized cargo are improving and certain companies (i.e. Matson) managed a premium niche share of the market
 - ✓ Possibly more Jones Act containership vessels to be built?

- Government Cargo
 - ✓ With the USA adopting a more hands-off approach worldwide, demand for military-related Preferential Cargo (PL) likely to dip
 - ✓ Expectations that humanitarian aid preferential cargo will not suffer

Offshore and U.S. Gulf Market Overview

Where has the offshore market gone?

- An extremely weak market given reduced offshore drilling activity

- The prospects of the market look poor unless crude oil prices sustainably remain above \$80/bbl

 - Tremendous headwinds with trends against fossil fuels Shale oil, a substitute for offshore drilling

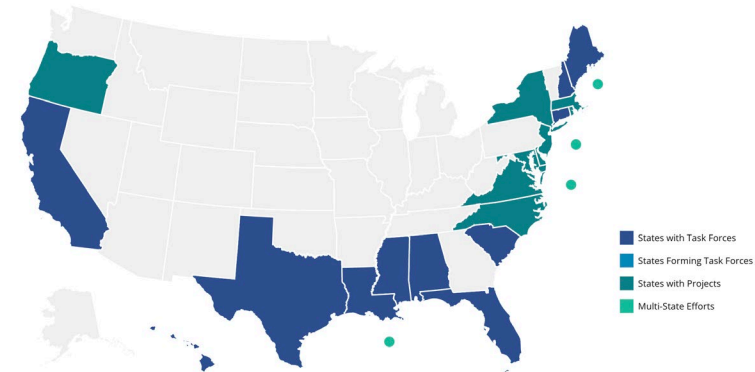
 - A graveyard of offshore shipping assets in distress, both for basic spec vessels but also modern, top-tier vessels

- Enhanced risk of technological and functional obsolescence as offshore drilling has become more technologically advanced rendering many offshore types of vessels technologically or functionally obsolete

- Possibly, a market in existential crisis by some accounts, unless the news of this industry's death is greatly exaggerated

U.S. Offshore Wind (OSW)

- Effectively, all states with access to Outer Continental Shelf (OCS) are at a varying degree of planning and activity with offshore wind farms
- Given present state of energy markets, extra incentive for renewables
- Biden Administration especially aggressive with goals with offshore wind (i.e., 30 Gigawatts (GW) by 2030 (30-GW-by-30), and 110 GW by 2050, presently at only 0.042 GW)
- Priority Financing Program for offshore wind vessels (having been designated as Vessels of National Interest) via Department of Transportation's Maritime Administration (MARAD) & Federal Ship Financing Program
- \$12 bln annual investment is expected in the industry, and recent lease auctions resulted in strong bidding and better-than-expected proceeds
- Several newbuilding orders for Crew Transfer Vessels (CTVs), Jones Act Offshore Wind Installation Vessel (WTIV) construction proceeding well, having found (innovative) financing, while a PE fund has acquired a Jones Act shipbuilder specializing in the construction of offshore wind support vessels



Jones Act Market Present Trends

The Jones Act Market, presently a dislocated market

- High commodities prices (i.e., marine steel plate) have caused the replacement cost to double for several types of Jones Act assets (i.e., hopper barges)
- Chronically high commodity prices would keep demand low, including demand for shipment (but for now, little can be done, especially for coal and grains, as demand is geo-politically driven)
- Appraising assets on replacement cost renders upwards biased values
- High replacement cost values have curtailed newbuilding activity

Tighter Regulations

- Sub-chapter M compliance (several hundred push-boats at risk of becoming regulatorily obsolete)
- Capital requirements / expenses, higher compliance risk, higher asset risk

New technologies and innovation

- Similar to international shipping, Jones Act shipping may stand at a point of technological inflection (unmanned, automated vessels, etc)
- New fuels and lower emissions even more critical for domestic shipping (batteries included)
- Trends toward a more integrated supply chain

Jones Act Market Future Trends

Offshore Wind: The next big thing for the U.S. shipping and Jones Act market?

- From Maine to the Carolinas, on U.S. West, and even for states like Texas and Louisiana, many offshore wind projects under development
- Hundreds of suitable vessels will have to be built in the US, some as expensive as \$600 million
- **Is Offshore Wind the answer to the offshore drilling industry of the past?**

Maritime Highways: Has finally its time arrived?

- Container Market: Potentially a barge-distribution system for containers be developed in the US? Container barges to move containers domestically and inland, along the coast and via the Mississippi River, relieving the already congested highway system?
- Riverway Cruiseship Market – Newbuilding delivery of Viking Jones Act cruiseship vessel *M/V “Viking Mississippi”* (386 pax, 193 staterooms, built at LaShip, LA). One among many?
- How about port infrastructure? Dredging! As more commercial (and leisure) activity increases (or shifts from other modes of transport), there will be greater need for dredging and keeping waterways navigable

Drivers for Jones Act Asset Values

- High commodity prices have kept newbuilding orders to minimum, primarily for older vessel replacement (rather than fleet expansion)
- Tight labor markets and supply chain disruptions likely to keep newbuilding prices at elevated levels for the next year
- The number of shipbuilders in the U.S. historically tends to decrease, along with shipbuilding capacity
- No additional Jones Act ocean-going (blue water) vessels can be delivered in the next five years
- Inflationary environment makes hard assets more “precious”, now and for residuals
- Market consolidation (ever susceptible) will provide support for asset values
- Presently renewed focus on “shareholder value” and rewarding shareholders with dividends rather than re-investing in the business / assets, will keep fleet expansion to a minimum

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- **International Shipping Market Challenges & Opportunities**
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Thinking of Alternative Fuels

Choices...choices...choices...

- There is clear cut clean future for tomorrow
- LNG seems to be the “default” alternative marine fuel, but only for large (blue water) vessels
- Hybrid designs a high possibility for Jones Act vessels for commercial, short distance vessels
(a battery pack for a 1,600 hp pushboat is estimated at \$1.5 mil)
- Newbuilding costs very high, and only big players carefully place high spec orders; unless there is a catalyst, replacement with high spec new assets will drag on
- Cost of fuel may become a critical factor going forward
- It can be a bifurcated market with high spec / low emission vessels and conventional vessels:
 - Conventional vessels still operate profitably, but their values can be under a cloud
 - Any asset value gap to widen in bad markets
- More pressure for “cleaner” vessels in offshore wind
- Any impact on non self-propelled assets (i.e., barges) likely to be minimal

Energy Sources to Marine Mechanical Energy

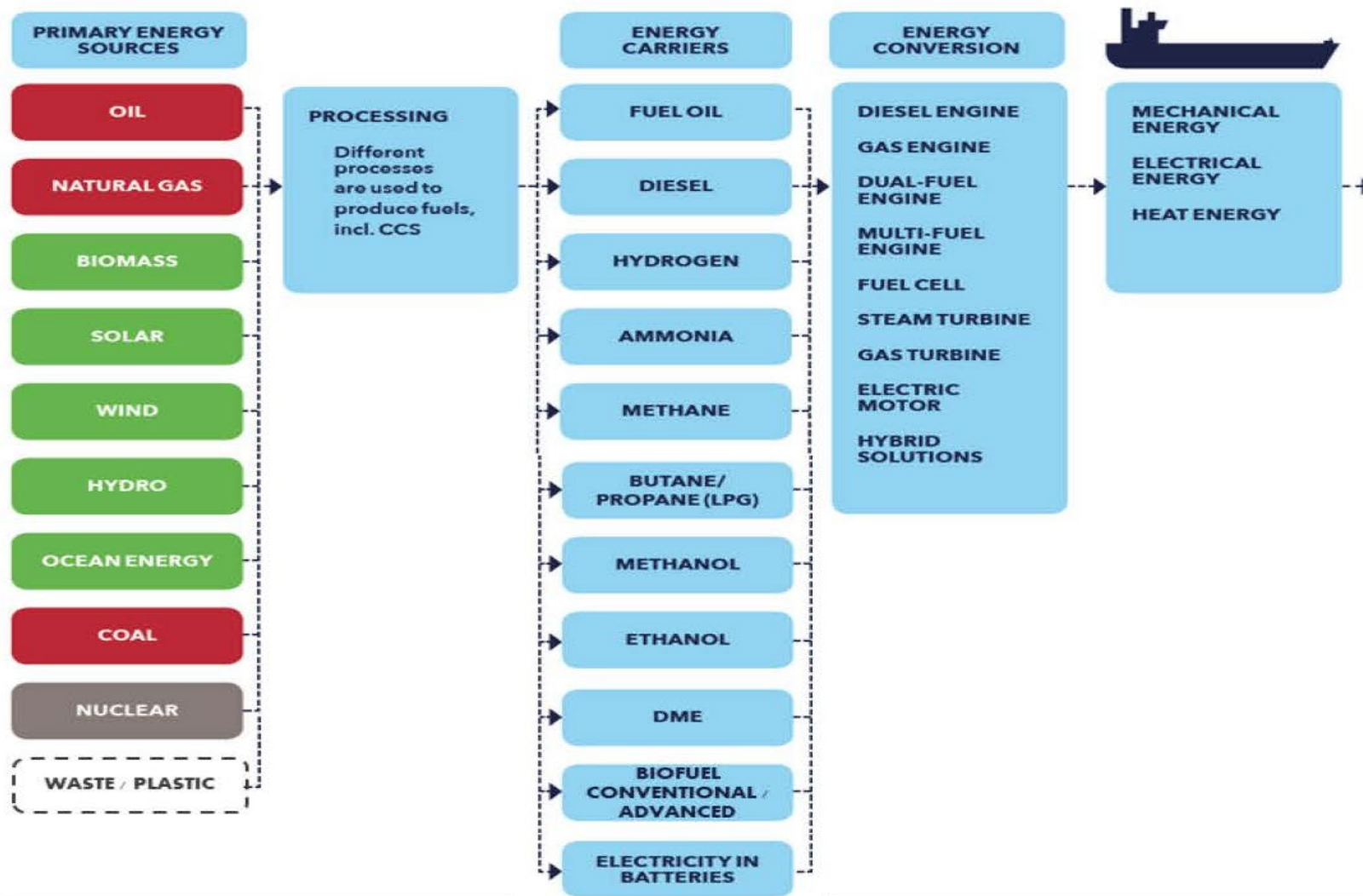


Figure 4-2: Simplified illustration of the chain from energy sources to mechanical energy for marine propulsion (/21/).

Source: DNV GL, Comparison of Alternative Marine Fuels

Alternative Fuel Sources

Alternative Fuel Sources

Fuel Type	Infrastructure	Security of Supply	Energy Density	CO ₂	SOx	Safety
Heavy Fuel Oil	●	●	●	○	○	●
Marine Diesel	●	●	●	○	●	●
LNG	●	●	●	●	●	●
LPG	●	●	●	○	●	●
Methanol (from Methane)	●	●	○	○	●	●
Methanol (from biomass)	○	○	○	●	●	●
Ammonia (from methane)	●	●	○	○	●	●
Ammonia (from renewable)	○	○	○	●	●	●
Hydrogen (from methane)	○	●	○	○	●	●
Hydrogen (from renewable)	○	○	○	●	●	●
Biofuels	○	○	●	● ●	●	●

Notes:

- **Infrastructure** refers to existing bunkering infrastructure or facilities that can be adapted to support bunkering (e.g. import/export terminals)
- **Security of supply** refers to the availability of sufficient global production to meet significant demand from the marine sector for bunkers
- **Energy density** refers to the volumetric energy content of the fuel and on-board storage requirements
- **CO₂ and SOx** refers to impact on emissions
- **Safety** refers to handling, storage and consumption risks

Source: ABS/MSI study



Source: ABS, Pathways to Sustainability through Alternate Marine Fuels

Alternative Fuel Sources

Energy source	Fossil (without CCS)					Bio	Renewable ⁽³⁾			
	Fuel	HFO + scrubber	Low sulphur fuels	LNG	Methanol	LPG	HVO [Advanced biodiesel]	Ammonia	Hydrogen	Fully-electric
High priority parameters										
• Energy density		●	●	●	●	●	●	●	●	●
• Technological maturity		●	●	●	●	●	●	●	●	●
• Local emissions		●	●	●	●	●	●	●	●	●
• GHG emissions		●	●	● ⁽²⁾	●	●	●	●	●	●
• Energy cost		●	●	●	●	●	●	●	●	● ⁽⁴⁾
• Capital cost	Converter	●	●	●	●	●	●	●	●	●
	Storage	●	●	●	●	●	●	●	●	●
• Bunkering availability		●	●	●	●	●	●	●	●	●
Commercial readiness ⁽¹⁾		●	●	●	●	●	●	●	●	● ⁽⁵⁾
Other key parameters										
• Flammability		●	●	●	●	●	●	●	●	●
• Toxicity		●	●	●	●	●	●	●	●	●
• Regulations and guidelines		●	●	●	●	●	●	●	●	●
• Global production capacity and locations		●	●	●	●	●	●	●	●	●

(1) Taking into account maturity and availability of technology and fuel.

(2) GHG benefits for LNG, methanol and LPG will increase proportionally with the fraction of corresponding bio- or synthetic energy carrier used as a drop-in fuel.

(3) Results for ammonia, hydrogen and fully-electric shown only from renewable energy sources since this represents long term solutions with potential for decarbonizing shipping. Production from fossil energy sources without CCS (mainly the case today) will have a significant adverse effect on the results.

(4) Large regional variations.

(5) Needs to be evaluated case-by-case. Not applicable for deep-sea shipping.

Source: DNV GL, Comparison of Alternative Marine Fuels

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