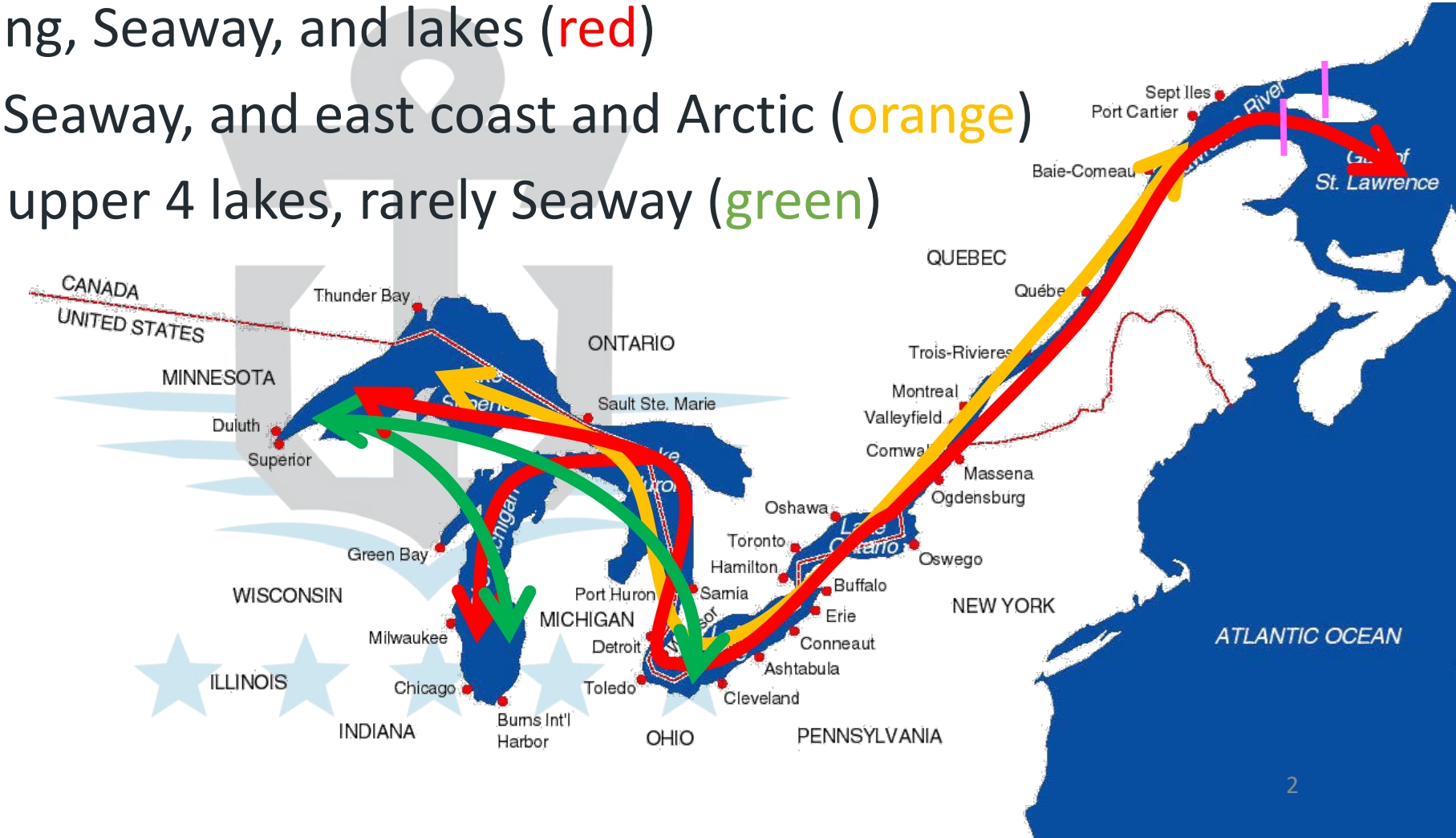
Industry Technology Development and Testing

Tom Rayburn, Lake Carriers' Association

Fleets in the Great Lakes

- Salties: oceangoing, Seaway, and lakes (red)
- Canadian: lakes, Seaway, and east coast and Arctic (orange)
- U.S.-flag: mostly upper 4 lakes, rarely Seaway (green)
- Anticosti Island (pink)



Building a better mousetrap

- Compliance with state drinking water standards
- No hold time or at most 1 hour
- Will not corrode tanks or ballasting system
- Won’t eat into cargo tonnage
- Can handle temperature swings from 0°C to 28°C and ice
- Can handle turbidity loads, tannins, and algal blooms
- Uptake and discharge rates as high as 80,000 gallons/minute for as much as 16 million gallons
- Meets a numeric ballast water discharge standard

U.S.-flag Great Lakes fleet profile

U.S.-flag Great Lakes Dry-Bulk Fleet Vessels Side-by-Side Comparison

Vessel Category (typical)	1,000' Manifold Ballast System	1,000' Independent Ballast System	609' to 806' Converted Vessels Manifold Ballast System	500' to 800' Newer Build Manifold Ballast System	Purpose-Built Barges Manifold Ballast System
Overall Length	1,000 feet	1,004 feet	767 feet	704 Feet	460 feet
Beam, Molded	105 feet	105 feet	70 feet	78 feet	70 feet
Depth, Molded	56 feet	50 feet	36 feet	45 feet	37 feet
Draft, Maximum	34 feet, 1 inch	29 feet, 1 inch	27 feet	30 feet	26 feet, 6 inches
Gross Tonnage	35,923	34,728	12,341	14,499	7,310
Net Tonnage	33,534	29,629	9,372	10,348	7,310
Cargo Type	Iron ore, coal, stone	Iron ore, coal, stone	Iron ore, coal, stone	Iron ore, coal, stone	Cement
Number of Cargo Holds	7	7	7	6	8
Capacity at Mid-summer Draft Marks	80,900 net tons (NT)	63,300 NT	25,000 NT	35,400 NT	19,450 NT
Number of Ballast Tanks	17	19	20	16	12
Ballast Tank Capacity	62,179 m^3	44,592 m^3	17,247 m^3	21,982 m^3	7,632 m^3
Number of Ballast Pumps	4	18	2	2	4
Ballast Pumping Capacity	11,812 m^3/hour	14,719 m^3/hour	4,770 m^3/hour	6,356 m^3/hour	2,728 m^3/hour
Electrical Plant	2x2,500 kW 2x600 kW	4x800 kW	2x400kW 2x800 kW	1x1,700 kW 2x600 kW 1x150 kW	2x1,285 kW 2x280 kW
Year Built/Modified	1979	1977	1952 1975 (lengthened) 1982 (converted to self-unloader)	1974	2006
Number of Vessels in Category	5	9	18	18	9
Typical Voyages per Year	53	53	140	85	140

Best management practices

- Saltie ballast water exchange
- Sea chests (re-plumbing the boat)
- Annual inspections
- Loading and discharging ballast water by pumping

Great Lakes challenges: turbidity

Total Average Suspended Solids

Total Suspended Solids	Select Lower Great Lakes Rivers and Ports				
	Buffalo River, NY	Cuyahoga River, OH	Maumee River, OH	Rouge River, MI	Grand Calumet/Indiana Harbor, IN
Minimum	1 mg/l	5 mg/l	7 mg/l	10 mg/l	5 mg/l
Maximum	>400 mg/l	>1,000 mg/l	>500 mg/l	>400 mg/l	>200 mg/l

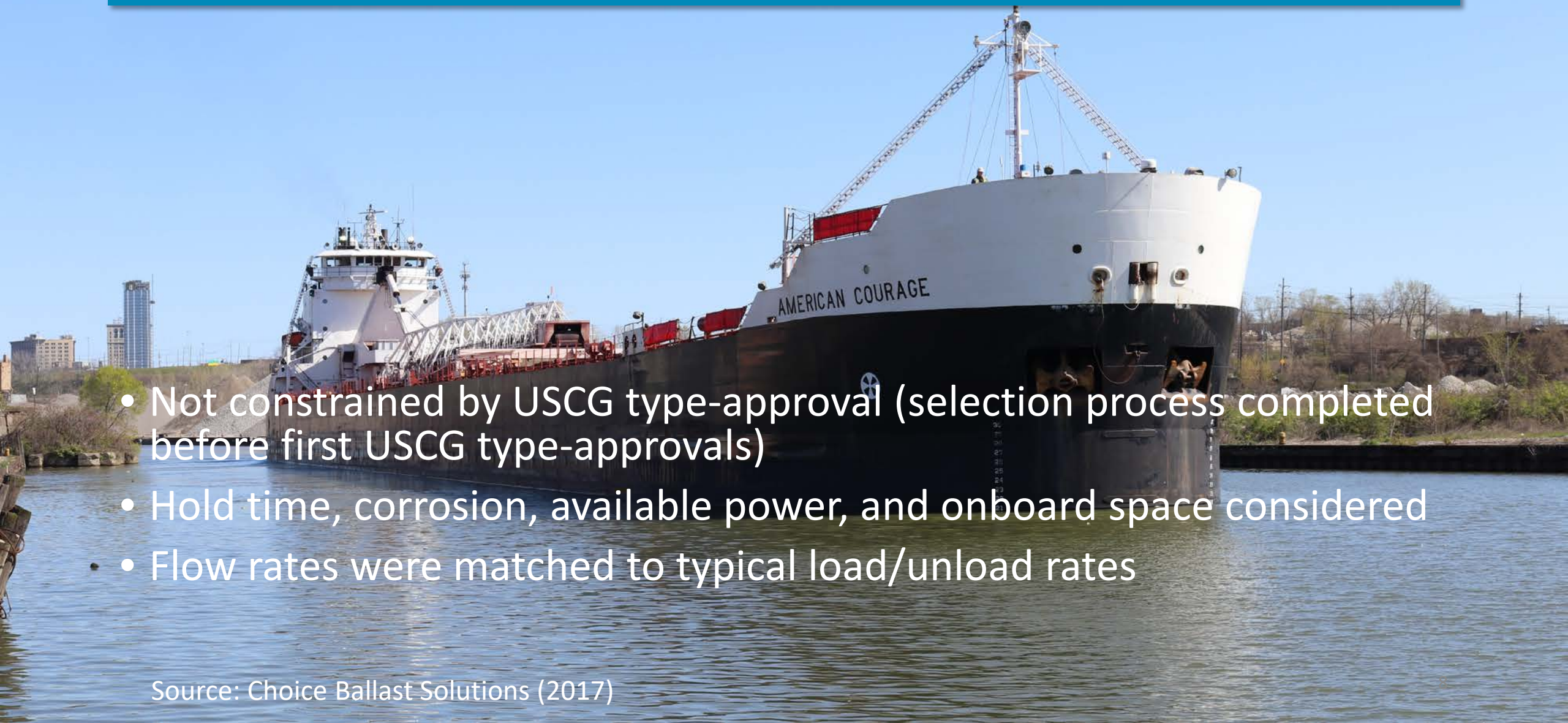




M/V Kaye E. Barker

- Launched in 1952
- Lengthened in 1975
- Conversion to self-unloader in 1980
- Repowered in 2012
- Original plate thickness: 0.375 inches
- 2014 measured thickness: 0.344 inches (91.7% of original)
- At 5 mpy, ABS 25% allowable wastage would have been met in 1970

BWMS installation, operation, maintenance



- Not constrained by USCG type-approval (selection process completed before first USCG type-approvals)
- Hold time, corrosion, available power, and onboard space considered
- Flow rates were matched to typical load/unload rates

Source: Choice Ballast Solutions (2017)

BWMS retrofit

- M/V Mesabi Miner looses 2.5% cargo space
- 13-1,000-foot vessels in fleet lose 15 trips/year or about 1 million tons with current schedules
- ". . . and 1 year in the yard" for ballast tank preparation and coating of 1,000-foot vessel
- $639 million: U.S.-flag laker fleet installation for BWMS
- $11 million: annual operation and maintenance
- $68 million: retrofitting vessels to handle shore supply

Source: Choice Ballast Solutions (2017) and Fincantieri Bay Shipbuilding (2017)

BWMS suitability for U.S.-flag lakers

U.S. Coast Guard Type-Approved Ballast Water Management System Side-by-Side Comparison

BWMS	USCG Approval No.	Filtration?	Disinfection Process	Ambient Feed or In-tank Restrictions?		Total Residual Oxidant	Corrosive?[1]	Hold Time?	Maximum Flow Rate (m3/hour)	Approved for Installation in Hazardous Locations? (46 CFR 111.105)	Approved for Installation on U.S.-flag Vessels? (46 CFR Sub. F & J)	Compatible with U.S.-flag Lakers?[2]
				Temperature	Salinity							
Optamarin	162.060/1/1	Yes	Ultraviolet (UV)	No	No	N/A	No	Yes (72 hours)	3,000	No	Yes	No HT,MFR
PureBallast 3.0 & 3.1	162.060/2/3	Yes	UV	No	No	N/A	No	Yes (72 hours)	3,000	Yes (conditional)[3]	Yes	No HT,MFR
OceanSaver[4]	162.060/3/3	Yes	Electrodialysis	Yes (>17°C)	Yes (>20 psu)	1.7 mg/L	Yes	No	7,200	No	Yes	No C,WQ,ST
Sunrui	162.060/4/1	Yes	Electrolysis	Yes (>5°C)	Yes (15 psu)	7.5 mg/L	Yes	No	8,500	No	No	No C,WQ,NA,ST
EcoChlor[5,6]	162.060/5/0	Yes	Chemical Injection	No	4.24 mg/L	4.25 mg/L	Yes	Yes (24 hours)	12,000[7]	Yes	Yes	No C,WQ,HT,ST
ERMA FIRST[8]	162.060/6/1	Yes	Electrolysis	Yes (>-2°C)	Yes (0.9 psu)	6 mg/L	Yes	No	3,000[9]	Yes (conditional)	Yes	No C,WQ,MFR,ST
Electro-Cleen	162.060/7/0	No	Electrolysis	No	Yes (1.5 psu)	9 mg/L	Yes	Yes (120 hours)	1,000[10]	Yes (conditional)	Yes	No C,WQ,HT,MFR,ST
Purimar	162.060/8/0	Yes	Electrolysis	Yes (4-40°C)	Yes (10 psu)	2.5-3 mg/L	Yes	Yes (24 hours)	6,500[11]	No	No	No C,WQ,HT,NA,ST
BIO-SEA B	162.060/9/0	Yes	UV	No	No	N/A	No	No (freshwater)	1,400	No	Yes	No MFR
Aquarius EC	162.060/10/0	Yes	Electrolysis	Yes (>15°C)	Yes (>15 psu)	10 mg/L	Yes	Yes (24 hours)	4,000	No	No	No C,WQ,HT,MFR,NA,ST
HiBallast	162.060/11/0	Yes	Electrolysis	Yes (>4°C)	Yes (>15 psu)	8 mg/L	Yes	Yes (48 hours)	8,000[12]	Yes (conditional)	Yes	No C,WQ,HT,ST
OceanGuard	162.060/12/0	Yes	Electrolysis	No	Yes (>0.85 psu)	2 mg/L	Yes	Yes (120 hours)	5,200	No	No	No C,WQ,HT,NA,ST
BallastAce	162.060/13/0	Yes	Chemical Injection	No	Yes (20 mg/L)	No	Yes	Yes (24 hours)	3,500	No	No	No C,WQ,HT,MFR,NA,ST
GloEn-Patrol	162.060/14/0	Yes	UV	Yes (-2-40°C)	No	N/A	No	Yes (48 hours)	6,000	Yes (conditional)	Yes	No HT,MFR
BALPURE	162.060/15/0	Yes	Electrolysis	Yes (15-50°C)	Yes (18-36 psu)	7-15 mg/L	Yes	Yes (24 hours)	8,570	Yes (conditional)	Yes	No C,WQ,HT,ST
inTank BWTS	162.060/16/0	No	Chemical Injection Electrochlorination[13]	Yes (0-35°C)	>22 mS/cm conductivity	2-5 mg/L	Yes	Yes (>24 hours)	N/A[14]	Yes (conditional)	Yes	No C,WQ,HT
Aquarius UV	162.060/18/0	Yes	UV	Yes (-2-45 °C)	No	N/A	No	Yes (72 hours)	1,000	No	Yes	No HT,MFR
PureBallast 3.2	162.060/19/0	Yes	UV	No	No	N/A	No	Yes (>2.5 hours)	3,000	Yes (conditional)	Yes	No MFR

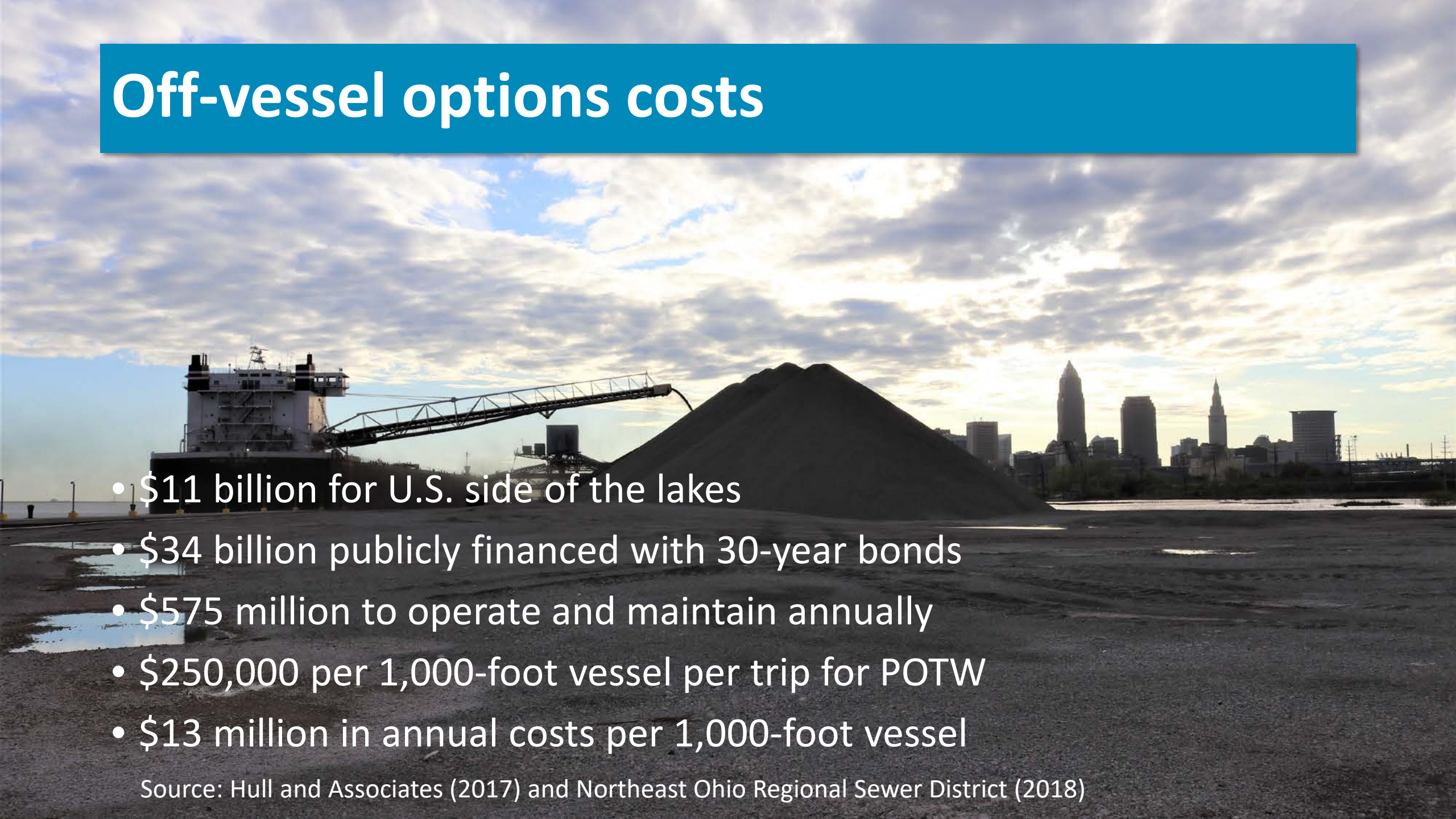
[1] International Maritime Organization G8 testing requirements include corrosion but only as it relates to tank coatings in accordance with the International Paint and Printing Ink Council.
[2] Aspects that impact compatibility of a system to a U.S.-flag laker include chemical compatibility with vessel construction ("**C**"), discharges exceeding state drinking waters limits ("**WQ**"), hold times in ballast tanks versus voyage times ("**HT**"), low rates incapable of maintaining normal load/unload rates for cargo operations ("**MFR**"), U.S. Coast Guard approval for installation and operation on a U.S.-flag vessel ("**NA**"), and/or feed stock limitations due to salinity or temperature ("**ST**").
[3] "Yes (conditional)" means certain components (e.g., power distribution unit, control unit, electrolysis unit, neutralization tank, etc.) may not be installed in areas designated as "hazardous".
[4] Requires feed water storage equivalent to 2 to 5 percent of total ballast water volume.
[5] Tested at Golden Bear facility in waters over 12°C, only.
[6] Chemical dosing (ClO_2) without neutralization process. Does not monitor for total residual chlorine at discharge.
[7] Flow rate varies from maximum listed in USCG TA certificate, 3,740 m^3/hour. Table reflects EcoChlor's reported maximum available flow rate per the manufacturer, Ecochlor.
[8] Requires feed water storage equivalent to 2 percent of total ballast water volume.
[9] Flow rate varies from maximum listed in USCG TA certificate, 10,000 m^3/hour. Table reflects ERMA FIRST's reported maximum available flow rate per the manufacturer, Erma First.
[10] Flow rate varies from maximum listed in USCG TA certificate, 12,000 m^3/hour. Table reflects Electro-Cleen's reported maximum available flow rate per the manufacturer, Techcross.
[11] Flow rate varies from maximum listed in USCG TA certificate, 10,000 m^3/hour. Table reflects Purimar's reported maximum available flow rate per the manufacturer, Samsung Heavy Industries.
[12] Flow rate varies from maximum listed in USCG TA certificate, 10,000 m^3/hour. Table reflects HiBallast's reported maximum available flow rate per the manufacturer, Hyundai Heavy Industries.
[13] System offers two options for chemical disinfection: direct injection of NaOCl or generation on board through electrochlorination.
[14] Treatment is performed in ballast water tank after uptake and before discharge. Total amount of ballast water capable of being treated with chemical capacity on board is 200,000 m^3 (52 million gallons).

Off-vessel options

- 82 U.S. ports, 60 active commercial deep-draft ports
- 1,200 docks, mostly privately owned
- Options include supplying ballast water (PWS or other) or discharging to wastewater treatment facility
- Toledo, Ohio: 25 docks spread over 14 miles of the Maumee River
- Superior, Wisconsin: city of 26,000 and POTW with 5-million-gallon normal operating capacity per day
- 2 “footers” loading, one at SMET and one at BN ore dock (6 miles apart) is about 32 million gallons of ballast water in 8-12 hours

Source: U.S. Army Corps of Engineers (2020)

Off-vessel options costs



- $11 billion for U.S. side of the lakes
- $34 billion publicly financed with 30-year bonds
- $575 million to operate and maintain annually
- $250,000 per 1,000-foot vessel per trip for POTW
- $13 million in annual costs per 1,000-foot vessel

Source: Hull and Associates (2017) and Northeast Ohio Regional Sewer District (2018)

Next

- Minnesota Pollution Control Agency
- Great Lakes and Lake Champlain Invasive Species Program

Questions?