Arctic Maritime Activity and the Black Carbon Issue: Why It Matters and the Gaps Creating Uncertainty

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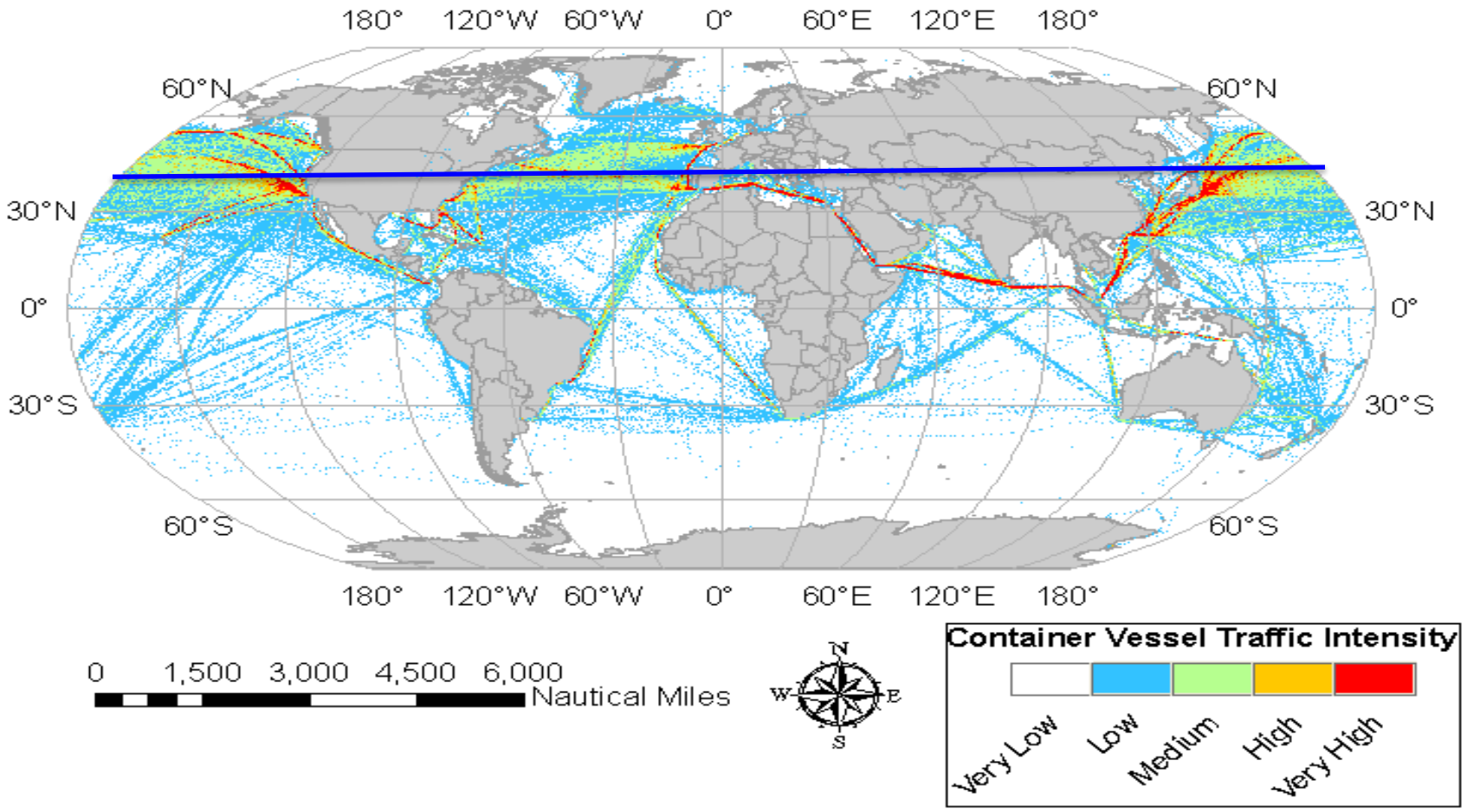
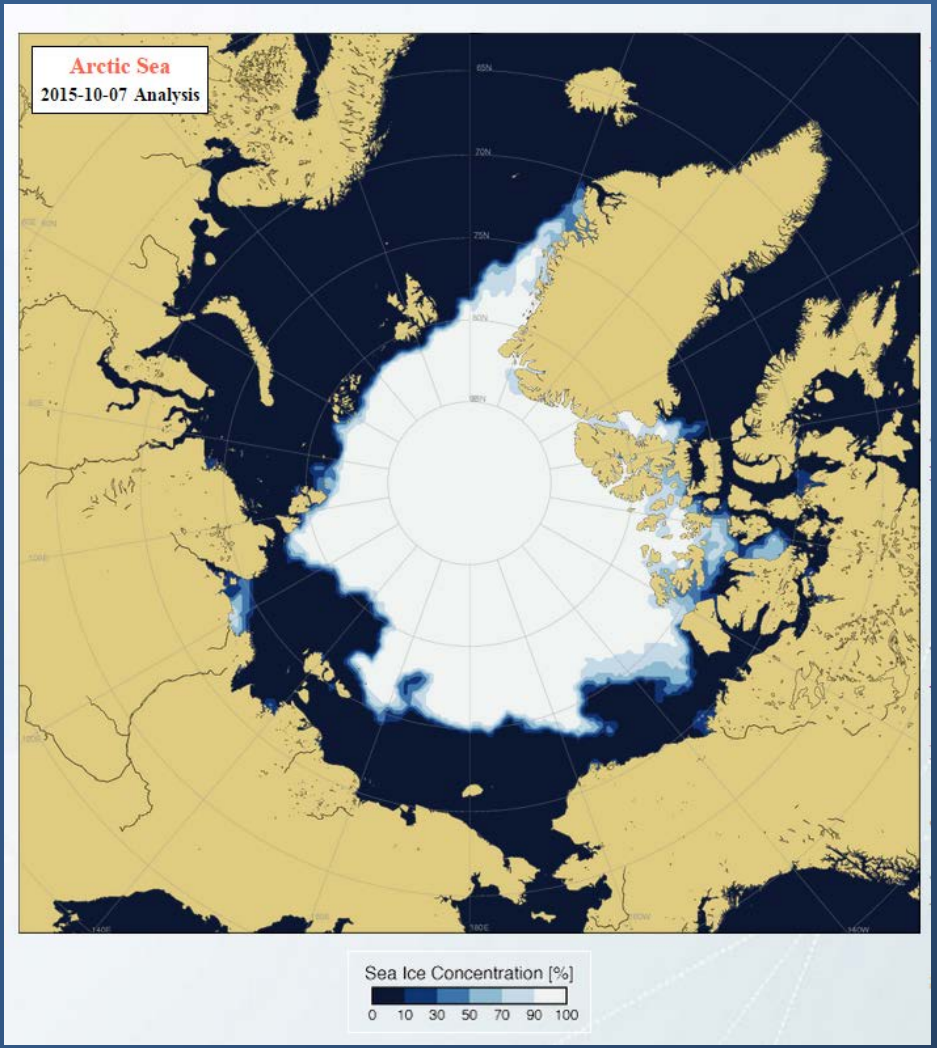
Example of Global Shipping Routes



Emissions above 40N can significantly impact climate in the Arctic

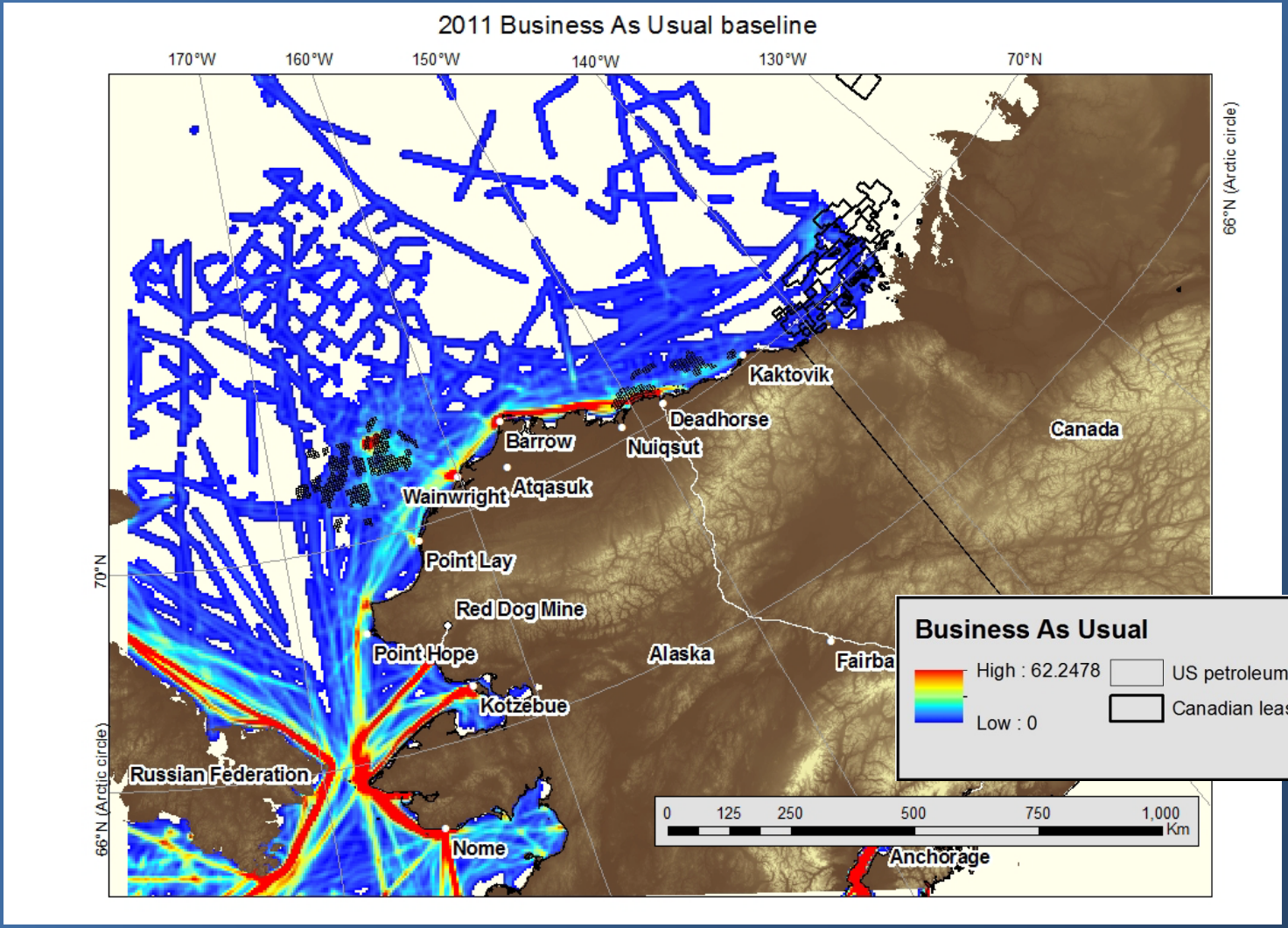
Is the Arctic “Navigation Capable”?

- Diminishing ice creates new opportunities
- 2015 had the 4th lowest sea ice extent on record
  - Note access through NWP



Global ice concentration provided by Weather News Inc;
Accessed through the Northern Sea Route Administration website

U.S. Arctic Projected Vessel Activity 2025



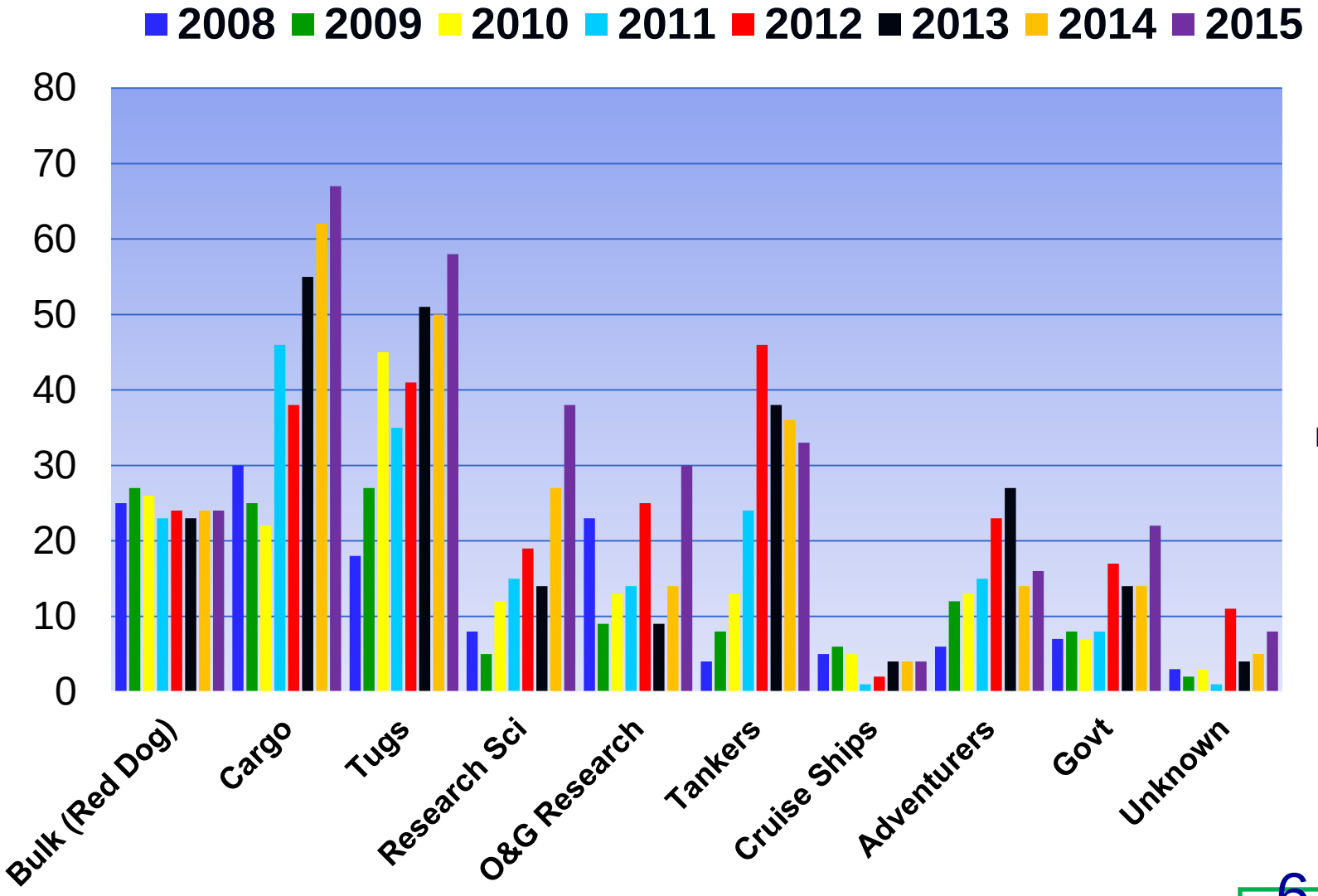
Conservative estimates of vessel traffic show a doubling over 2013 numbers

- 420 vessels; 877 transits

Factors Impacting Projections

- Oil and Gas
  - Prices
  - Exploration Activities
- New resource development
- Assumptions about ports
- Changes in tourism
- Science

2008 – 2015 D17 ARCTIC ACTIVITY



Arctic vessels in D17 area of concern

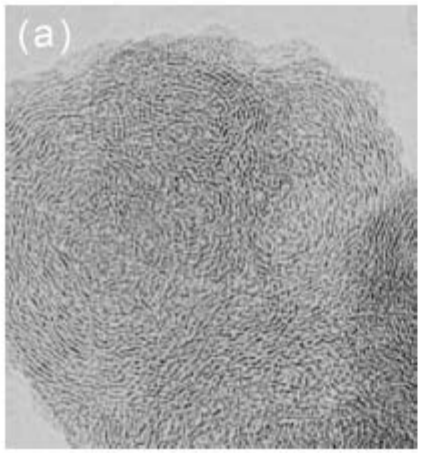
2008 = 120
2009 = 130
2010 = 160
2011 = 190
2012 = 250
2013 = 240
2014 = 250
2015 = 300

Bering Strait Transits

2008 = 220
2009 = 280
2010 = 430
2011 = 410
2012 = 480
2013 = 440
2014 = 340
2015 = 540

What is Black Carbon(BC)?

- Black carbon comes from the incomplete combustion of fossil fuels.
  - Black carbon is a component of particulate matter (PM)



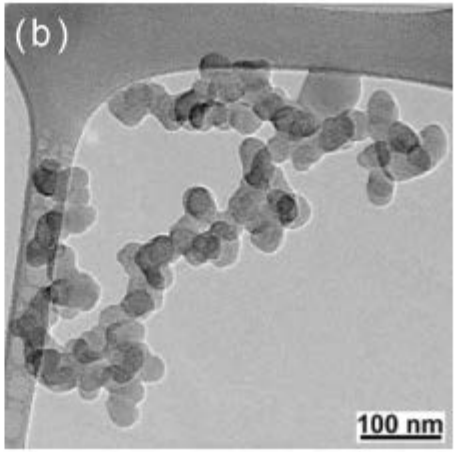
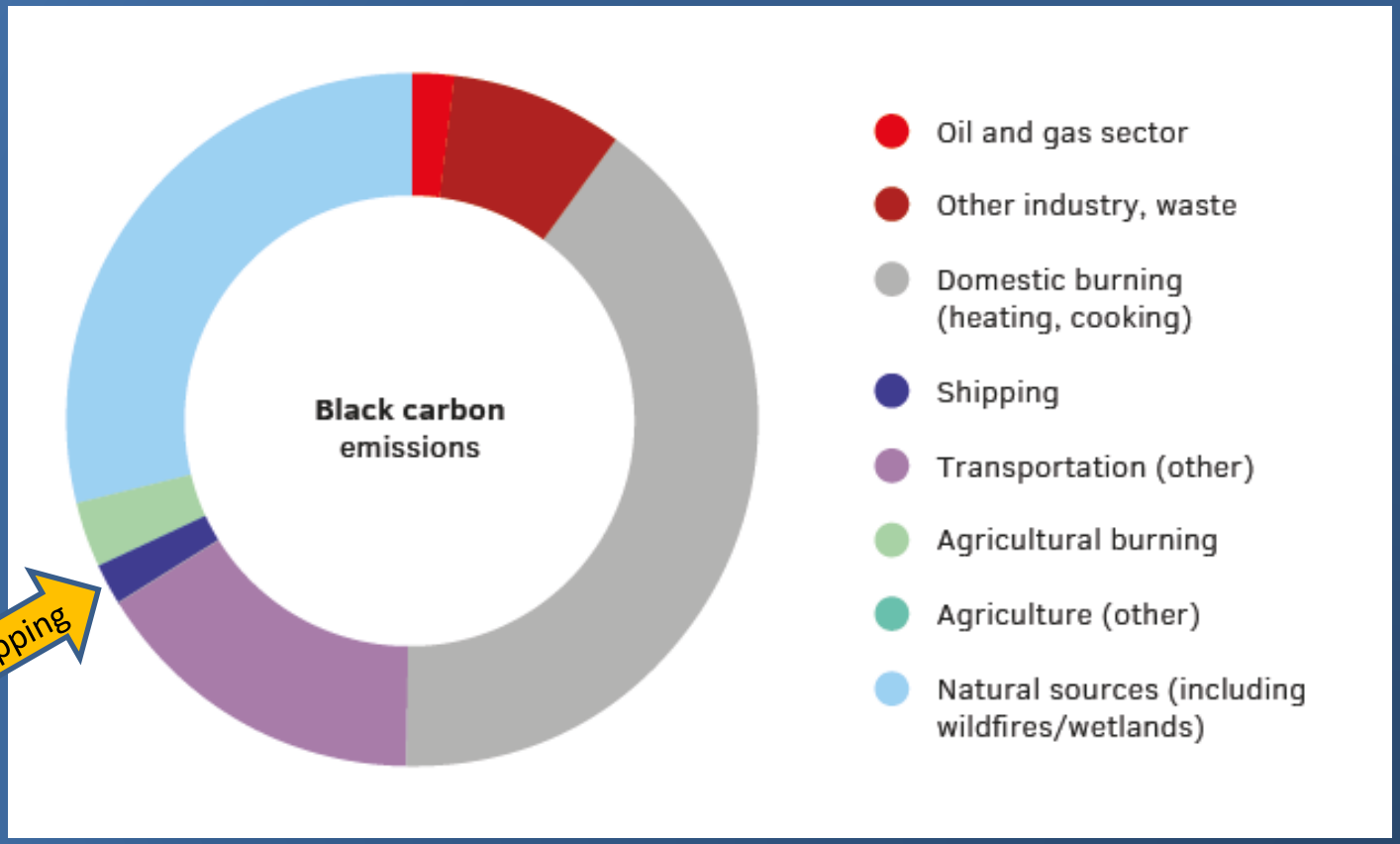


Figure 2-2. BC Images. (a) High resolution transmission electron microscopy (TEM) image of a BC spherule (Pósfai and Buseck, 2010). (b) TEM image of a representative soot particle. Freshly emitted soot particles are aggregates of soot spherules (Alexander et al., 2008).

What are the sources of BC?



BC from Shipping makes up about 2% of the total; and about 9 to 13% of diesel source PM

Are all sources of BC equal?

Short Answer: No.

- Soot mixtures can vary in composition,
- Have different ratios of organic carbon(OC) to BC,
- Usually include inorganic materials such as metals and sulfates.

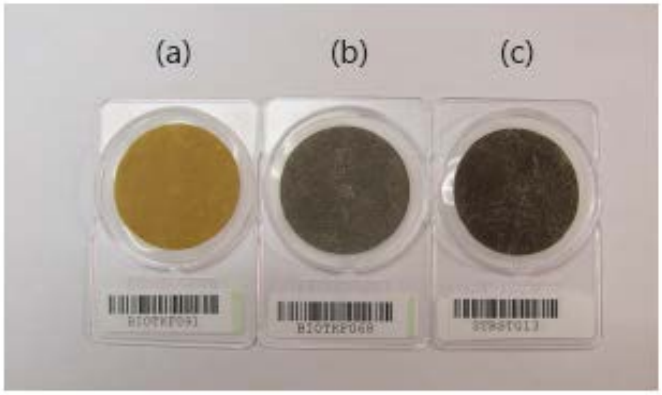
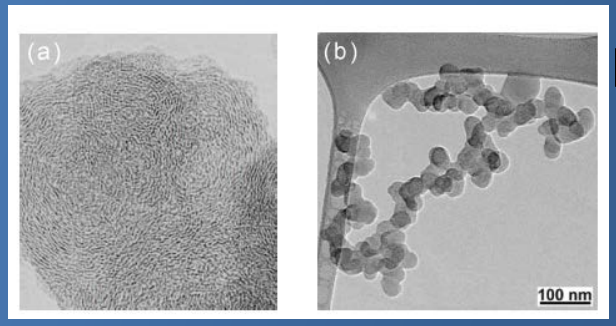


Figure 2-3. Representative Examples of Filter Samples Collected from Different Sources, including: (a) Smoldering Biomass, (b) Flaming Biomass, and (c) Diesel Exhaust. (Photo courtesy of Desert Research Institute)

The average OC:BC ratio among global sources:

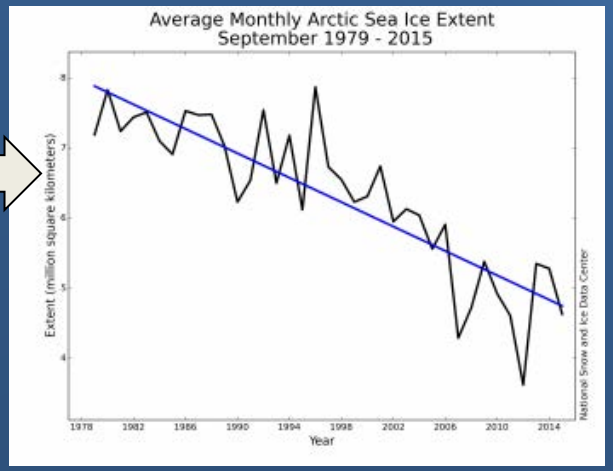
- Diesel exhaust is ~ 1:1
- Biofuel burning is ~4:1
- Biomass burning is ~ 9:1

Black Carbon Emissions Contribute to Arctic Warming



Increase in emissions of BC

Surface darkening deposition



Melting

- The Arctic is warming at twice the global average rate and is three times more sensitive to the BC warming due to albedo effects
- Vessel activity continues to increase as summer ice diminishes

How can we reduce BC from shipping?

	Technology	Potential reductions	
		PM	BC
Applied directly to ship's engines or exhausts	Diesel Oxidative Catalyst (DOC)	20-30%	Unknown
	Diesel Particulate Filters (DPF)	70-95%	95-99%**
	Exhaust Gas Scrubbers	60-80%	0-80%**
	Slide Valves	10-50%	Not reported
Require port infrastructure to be successful	Low Sulfur Diesel (from HFO)	up to 80%	30-80%**
	Emulsified Diesel Fuel	50-60%	Not reported
	LNG	99%	99%
	Shore Power	Depends on auxiliary engines	

Actual Reductions from different approaches are still uncertain

** Best estimates representing high degree of uncertainty and debate

Corbett et al. (2010) An assessment of technologies for reducing regional short-lived climate forcers emitted by ships with implications for Arctic shipping. Carbon Management 1(2), 207-225.

There are significant knowledge gaps

- Need to continue to improve our estimates of future shipping needs in the Arctic.
- Need to know more about emission factors and the impacts of switching fuel on BC emissions.
- Need to know more about the successful application of technologies and their feasibility on marine engines
- Need to understand the financial costs of implementing these measures (technology and fuel)
- Need to consider the unintended consequences
  - e.g. increases in costs to Arctic communities reliant on vessel resupply.

Thank you

- Questions?