Green Technologies for the UNOLS Academic Research Fleet

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3rd NSF Large Facilities 2010 Operations Workshop

UNOLS

UNOLS: University-National Oceanographic Laboratory System

*Founded in 1971

*60 U. S. institutions with ocean science programs

*16 UNOLS operator institutions

-21 oceanographic research vessels

-National Deep Submergence Facility (WHOI)

-National Oceanographic Aircraft Facility

-National Oceanographic Seismic Facility (LDEO)

~ $1.5 billion assets

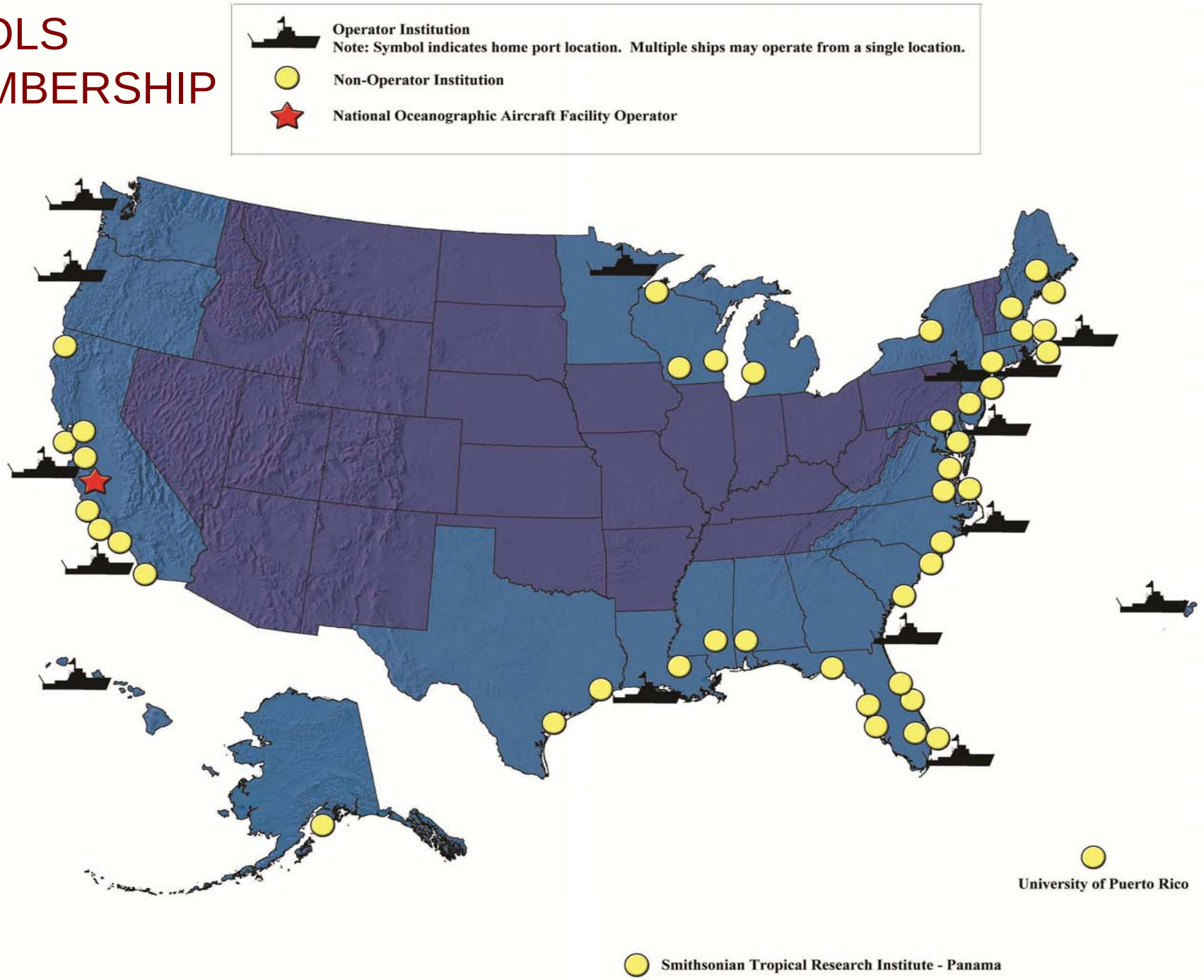
UNOLS Goals

*Promote broad, coordinated access to oceanographic research facilities

*Support continuous improvement of existing facilities

*Plan for and foster support for the oceanographic facilities of the future

UNOLS MEMBERSHIP



UNOLS – National Oceanographic Facilities

- National Deep Submergence Facility (*Alvin*, *Jason*, AUV)

- National Oceanographic Aircraft Facility at CIRPAS/NPS

- National Oceanographic Seismic Facility (R/V *Marcus Langseth*)

The UNOLS Fleet – 2010

SHIP/CLASS	Operator	Owner	BUILT	Conv/Mid-Life	LOA m (ft)	Science Berths	Ship Age
Global Class							
Melville	SIO	NAVY	1969	1991	85 (279)	38	41
Knorr	WHOI	NAVY	1970	1989	85 (279)	34	40
Thomas G. Thompson	UWASH	NAVY	1991		84 (274)	36	19
Roger Revelle	SIO	NAVY	1996		84 (274)	37	14
Atlantis	WHOI	NAVY	1997		84 (274)	37	13
Marcus G. Langseth	LDEO	NSF	1991	2005-2007	71 (235)	35	18
Ocean Class							
Kilo Moana	UHAWAII	NAVY	2002		57 (186)	29	8
Intermediate Class							
Wecoma	OSU	NSF	1976	1994	56 (185)	18	34
Endeavor	URI	NSF	1977	1993	56 (184)	18	33
Oceanus	WHOI	NSF	1976	1994	54 (177)	19	34
New Horizon	SIO	SIO	1978	1996	52 (170)	19	32
Regional Class							
Point Sur	MLML	NSF	1981		41 (135)	12	29
Cape Hatteras	DUKE	NSF	1981	2004	41 (135)	14	29
Atlantic Explorer	BIOS	BIOS	1982	2006	51 (168)	20	28
Regional/Coastal Class							
Robert Gordon Sproul	SIO	SIO	1981	1985	38 (125)	12	29
Pelican	LUMCON	LUMCON	1985	2003	32 (105)	14	25
Walton Smith	UMIAMI	UMIAMI	2000		30 (96)	16	10
Hugh R. Sharp	UDEL	UDEL	2005		44 (146)	14	5
Local Class							
Savannah	SKID/UG	SKID/UG	2001		28 (92)	19	9
Blue Heron	UMINN	UMINN	1985	1999	26 (86)	6	25
Clifford Barnes	UWASH	NSF	1966	1984	20 (66)	6	44

UNOLS Ship Requests

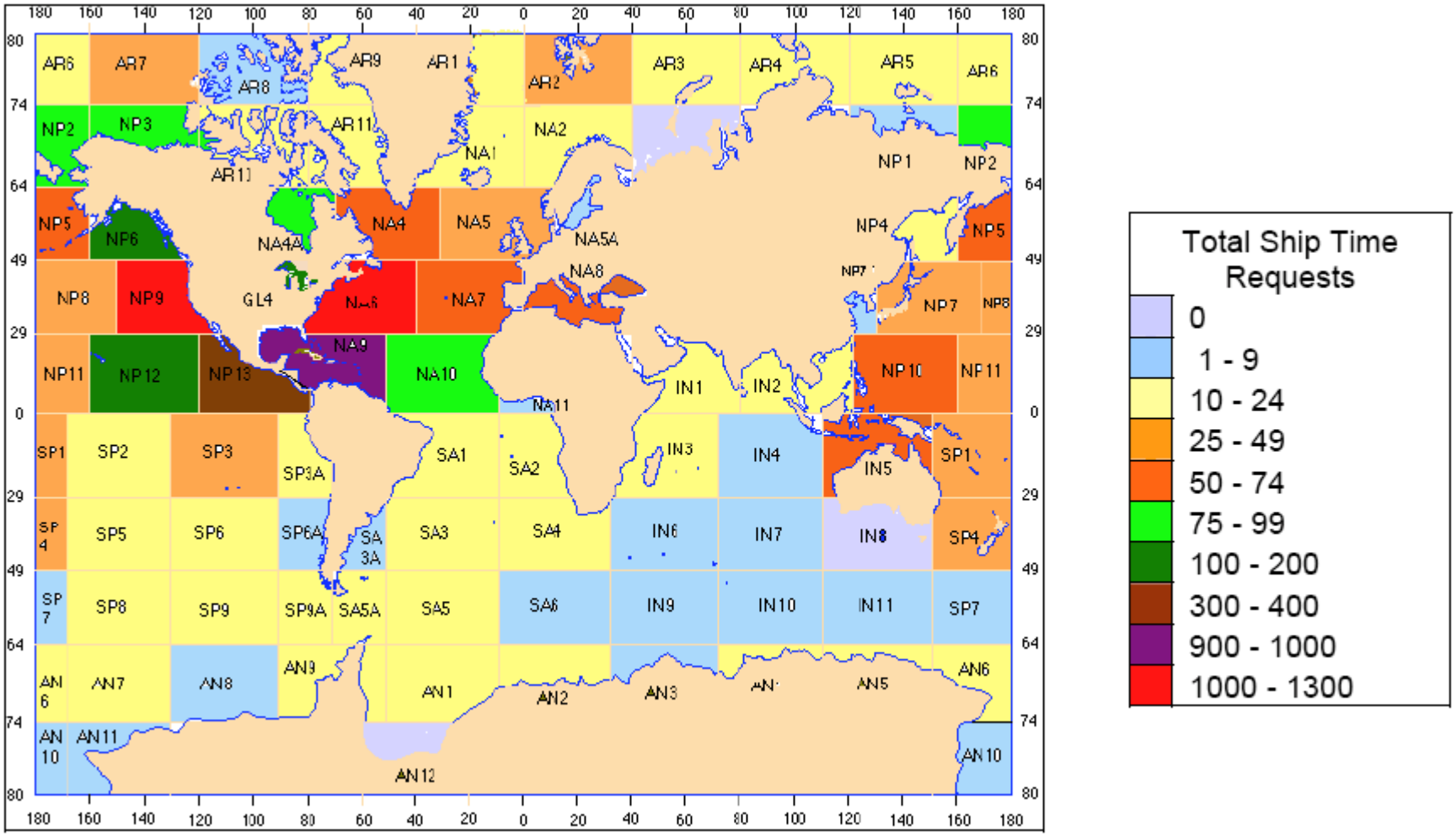
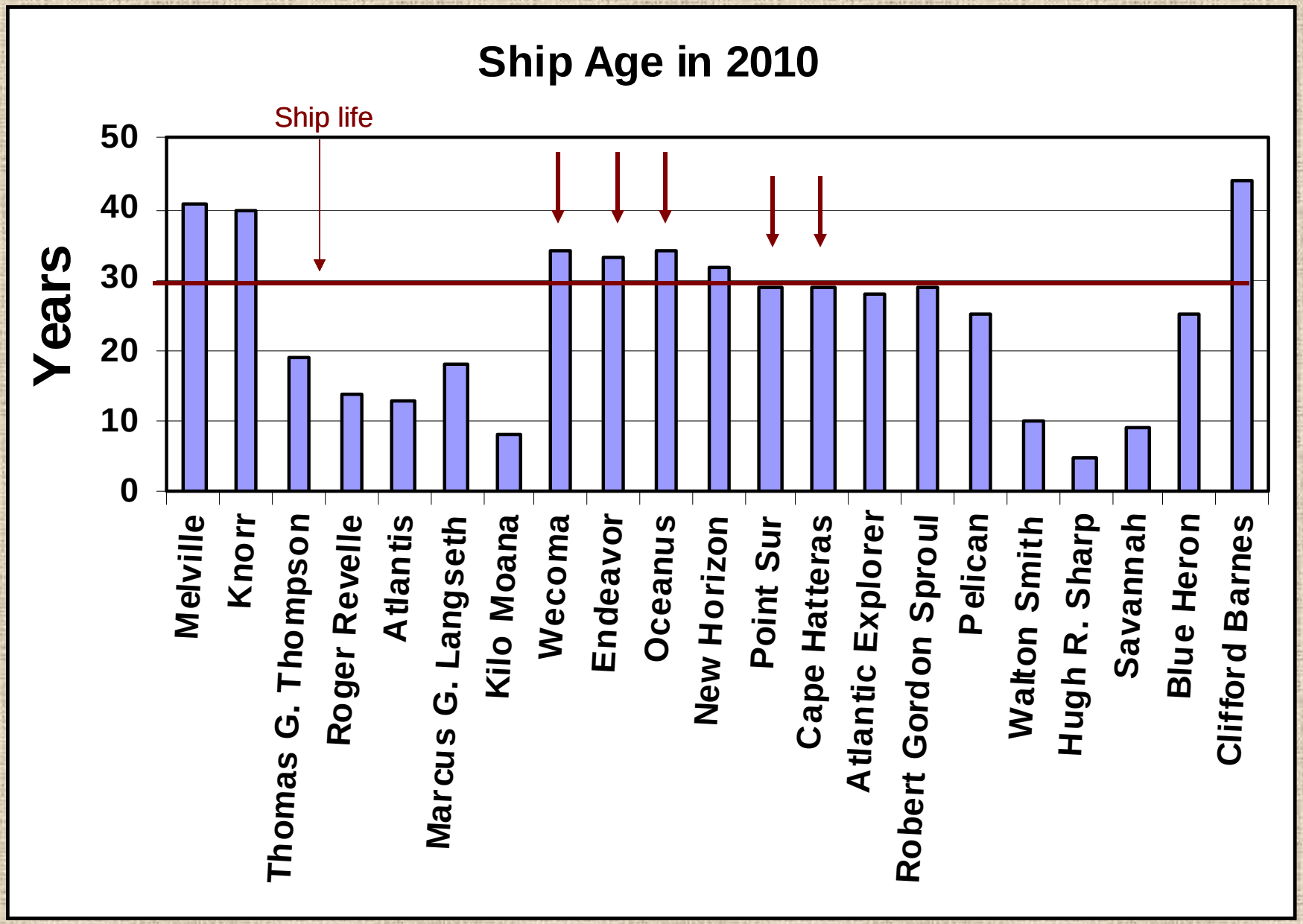


Figure 34. Geographic Distribution of Ship Time Requests (2000 to 2006)

From: UNOLS Fleet Improvement Plan, 2009 (www.unols.org)


Ship Age in 2010
Ship life
Years
50
40
30
20
10
0
Melville
Knorr
Thomas G. Thompson
Roger Revelle
Atlantis
Marcus G. Langseth
Kilo Moana
Wecoma
Endeavor
Oceanus
New Horizon
Point Sur
Cape Hatteras
Atlantic Explorer
Robert Gordon Sproul
Pelican
Walton Smith
Hugh R. Sharp
Savannah
Blue Heron
Clifford Barnes

2010 UNOLS GOAL

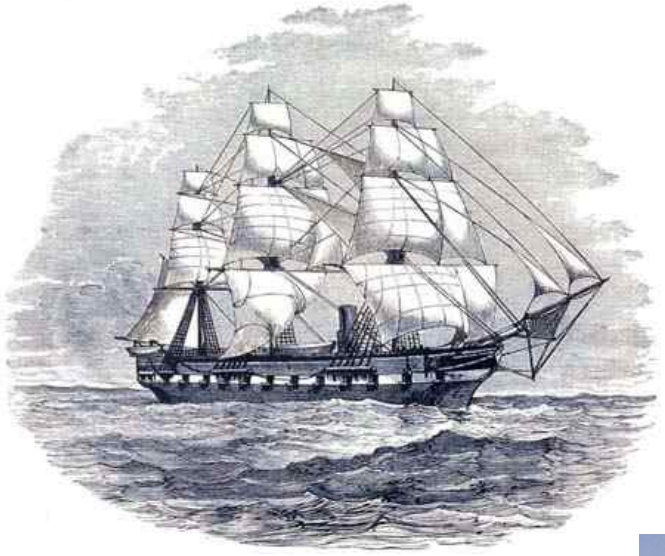
"Greening the Fleet – UNOLS should explore how to make the present and future fleet more environmentally sustainable. New and existing technologies and practices should be used in the construction, operation, and recycling of research vessels and UNOLS should take a leadership role in promoting a green U.S. research fleet, as we move forward in developing the academic fleet."

MOTIVATION

1. Environmental stewardship
2. Educational outreach
3. Finances

GREEN SHIPS AND BLUE WATERS

GREENING THE UNOLS FLEET



http://www.geology.19thcenturyscience.org/books/hmsc.jpg

Solar Sailer- Sydney, Australia

Creating a Green Fleet

Life Cycle of a Vessel:

1) Construction

2) Operation

3) Recycling

Hornblower Yachts- San Francisco: Ferry Design

Construction and Operation

1) Hull and design
2) Propulsion, fuel and lubricants
3) Power systems
4) Fluids; water and sewage
5) Interior: cabins, labs, galley and mess areas (Leadership in Energy and Environmental Design-LEED)

LEED Project Checklist

Sustainable Sites		**14 Possible Points**
Prereq 1	Construction Activity Pollution Prevention	Required
	Reducing Pollution during Yacht Construction	
Credit 1	Site Selection	1
Credit 2	Development Density & Community Connectivity	1
Credit 3	Brownfield Redevelopment	1
Credit 4.1	Alternative Transportation, Public Transportation Access	1
Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
Credit 4.3	Alternative Transportation, Low Emitting & Fuel Efficient Vehicles	1
Credit 4.4	Alternative Transportation, Parking Capacity	1
Credit 5.1	Site Development, Protect or Restore Habitat	1
Credit 5.2	Site Development, Maximize Open Space	1
Credit 6.1	Stormwater Design, Quantity Control	1
Credit 6.2	Stormwater Design, Quality Control	1
Credit 7.1	Heat Island Effect, Non-Roof	1
Credit 7.2	Heat Island Effect, Roof	1
Credit 8	Light Pollution Reduction	1
Water Efficiency		**5 Possible Points**
Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1
Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
Credit 2	Innovative Wastewater Technologies	1
	Reducing potable water consumption and grey water generation	
Credit 3.1	Water Use Reduction, 20% Reduction	1
Credit 3.2	Water Use Reduction, 30% Reduction	1
Energy & Atmosphere		**17 Possible Points**
Prereq 1	Fundamental Commissioning of the Building Energy Systems	Required
	Ensuring that the energy-related systems are performing as designed.	
Prereq 2	Minimum Energy Performance	Required
	Establishing a minimum level of energy efficiency.	
Prereq 3	Fundamental Refrigerant Management	Required
	Eliminating ozone depletion by using non-CFC refrigerants.	
Credit 1	Optimize Energy Performance	1–10
	Achieving energy cost savings by improving efficiencies.	

LEED Criteria Applied to Boat Building

(From: Peters, M., 2009, The Large Green Yacht, Part 2, *Professsional Boatbuilder*, #117, February/March, 26-43.)

OPERATION:

1) Propulsion

*New designs: solar, wind

a) Solar Sailor
b) M/V Auriga Leader

2) Power systems

3) Fuels and lubricants: Biofuels

a) NOAA Green Ship Initiative
b) Cape Hatteras Biofuel Experiment

WIND

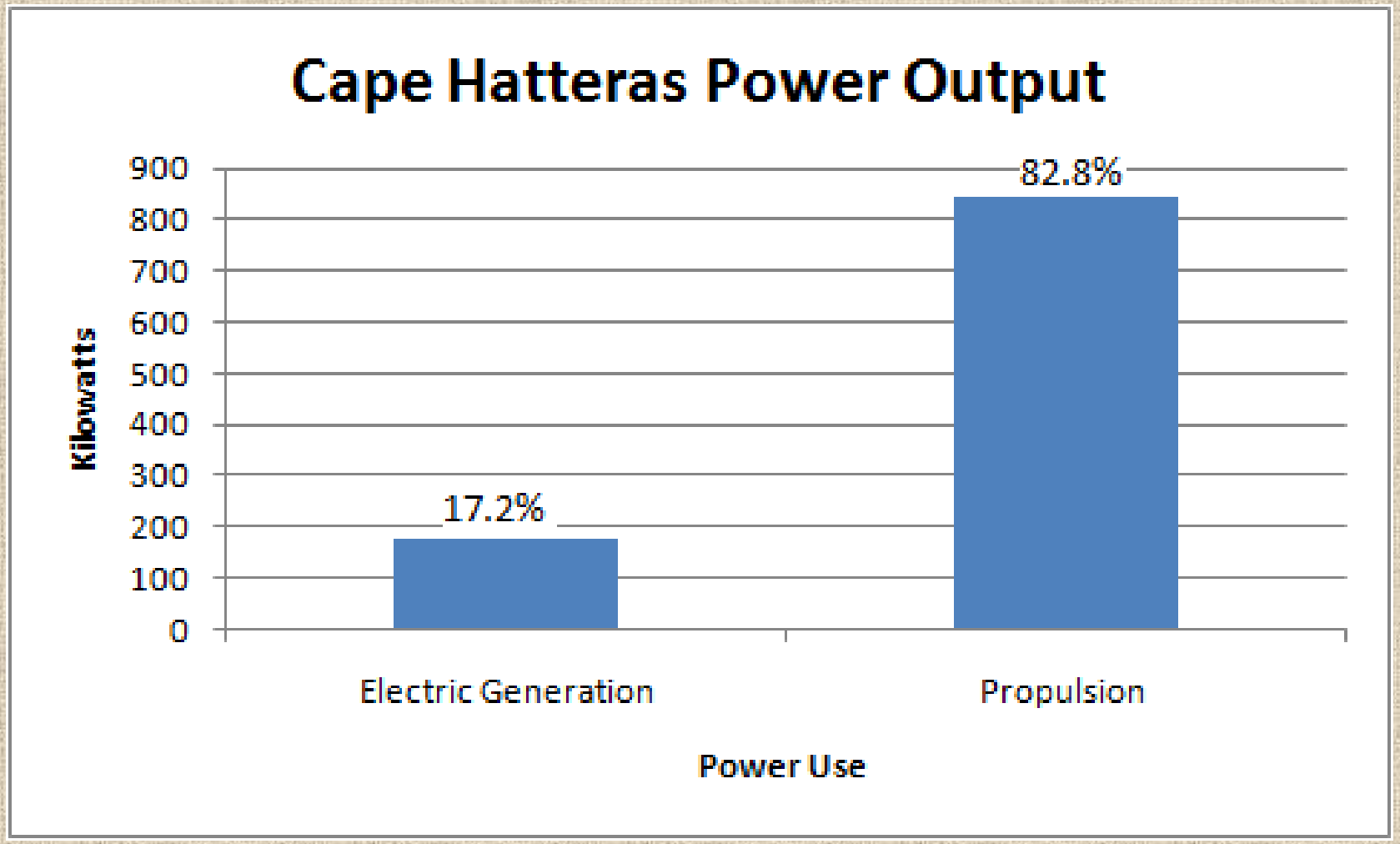
Solar Sailor:

*Solar wings used as solar collectors and as sails

http://www.solarsailor.com/

Power Systems

The *M/V Auriga Leader* has 328 solar panels to provide power for the ship's main electrical grid. (http://www.inhabitat.com/2009/07/06/auriga-leader-cargo-ship-gets-power-from-solar-panels/)


Cape Hatteras Power Output
900
800
700
600
500
400
300
200
100
0
Kilowatts
17.2%
82.8%
Electric Generation
Propulsion
Power Use

BIOFUELS: Ethanol and Biodiesel

Objective: convert Great Lakes vessels with petroleum-based fuels to renewable and environmentally friendly products

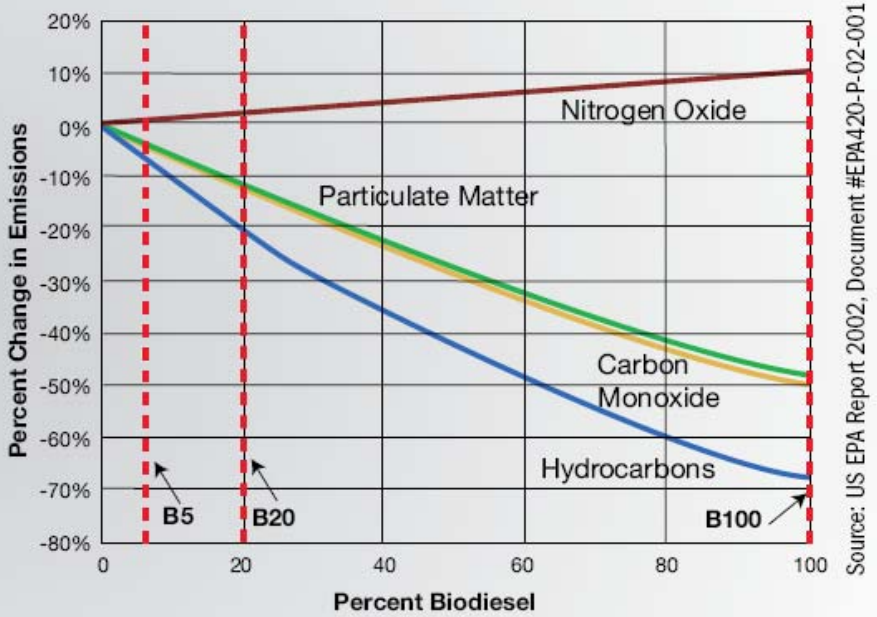
NOAA GREEN SHIP INITIATIVE

Development of Biodiesel and Bio-Products in Marine Applications

Environmental Research That's Environmentally Friendly

There were many motivating factors for undertaking the Green Ships project. These include:

- Reducing ecosystem impact of ship-based research activities.
- Reducing workplace health and safety hazards.
- Advancing renewable technologies.
- Lessening dependence on fossil fuels.



R/V Cape Hatteras

Duke/University of North Carolina Oceanographic Consortium

CAPE HATTERAS BIOFUEL EXPERIMENT
Waste Vegetable Oil for Diesel Power

Cape Hatteras; Mark Smith, Chief Engineer and John Wilder, Marine Superintendent

OPERATION

*Configured generator to run on waste vegetable oil (WVO)
*WVO preheated to 70^{o}C (heat exchange on generator)
*Initial start-up with diesel fuel and WVO heated
*Once heated, WVO introduced into generator fuel line
*Diesel fuel switched back near shutdown to remove WVO from system

LOGISTICS

*Restaurants contacted; tank and pump mounted on trailer; WVO transferred, filtered, stored, and transferred to ship
*Reliable pick-up service on schedule (2-3 hours) from restaurant
*WVO filtered.
*Storage tanks-shore facility and vessel
*Install pipes/valves/heat exchange system on main engines

RECYCLING

Green Passport

- IMO's Guidelines on Ship Recycling (2003): Green Passport- inventory of material in ship's structure, systems, and equipment that may be hazardous to health and the environment
- Maintained through the life of the ship
- Green Passport can be used to formulate a safe and environmentally sound plan for decommissioning a ship
- Raises awareness of hazardous material
- Lloyd's Register- verifies Green Passport for both new and existing vessels
- 2010-2011- Cape Hatteras Pilot Study
- http://www.lr.org/Industries/Marine/Services/Consultancy/Green+Passport.htm
- http://www.lr.org/NR/rdonlyres/5EA619D8-0788-47DE-806A-FE2E6C7FAC6F/43816/GreenPassport0606.pdf

(RINA Green Star: ballast water; chemicals)

GREENING THE FLEET: FUTURE CONSIDERATIONS

*Additional costs will be incurred to address or incorporate "green" solutions

*Many of these expenses will be front-loaded: construction phase, but

* Green technology may reduce operational costs during the lifetime of the vessel

* Green solutions need to be customized for individual ships or missions

PLASTIKI

7th Annual

Green Ship Technology Conference

26 March 2010

The 7th Green Ship Technology Conference

Meeting the green technology challenges for sustainable shipping

The 7th international Green Ship Technology conference, organised by Informa Maritime Events, took place at a time of rapid developments for the maritime community, and a week before MEPC 60.

In terms of meeting the various **environmental challenges posed by the increasing focus on shipping's effect on the environment** and climate change, the conference participants discussed the key environmental issues facing the industry today, from developing technological innovations and efficient design to reduce shipping's environmental impact, to individual companies' roles in developing corporate responsibility plans to create effective environmental and vessel management plans.

Speakers in 20

Keynote Adc
Betina Hage
Permanent S
Ministry for E
Business Af

Ryan Albert,
Protection A

Christian Bre
Danish Mari

Lars Vang C
CEO, hernin
Chairman, **D**

Green Ship Technology Program Highlights:

- A discussion of environmental regulation v. self assessment
- Designing an environmentally sustainable ship
- Managing environmental hazards in the ship repair/ship building yard
- Alternatives for reducing emissions, including emissions trading and seawater scrubbing
- Current developments in ballast water treatment systems and the likelihood of adoption for commercial use

*Alternative propulsion methods and energy sources

- The challenges ahead for paints and coatings
- Port developments in reception facilities and monitoring of air quality

Kalender

GSF at SMM in Hamburg
7. September 2010

Det Maritime Danmark

DTU FORCE TECHNOLOGY
Dansk Center for Maritim Teknologi

Skibsteknisk Selskab

WELCOME TO GREEN SHIP OF THE FUTURE

Green Ship of the Future is a Danish joint industry project aiming at developing and demonstrating technologies for reduction of air emissions from ships.

Within the four main focus areas: Machinery, Propulsion, Operations and Logistics, the overall target is to

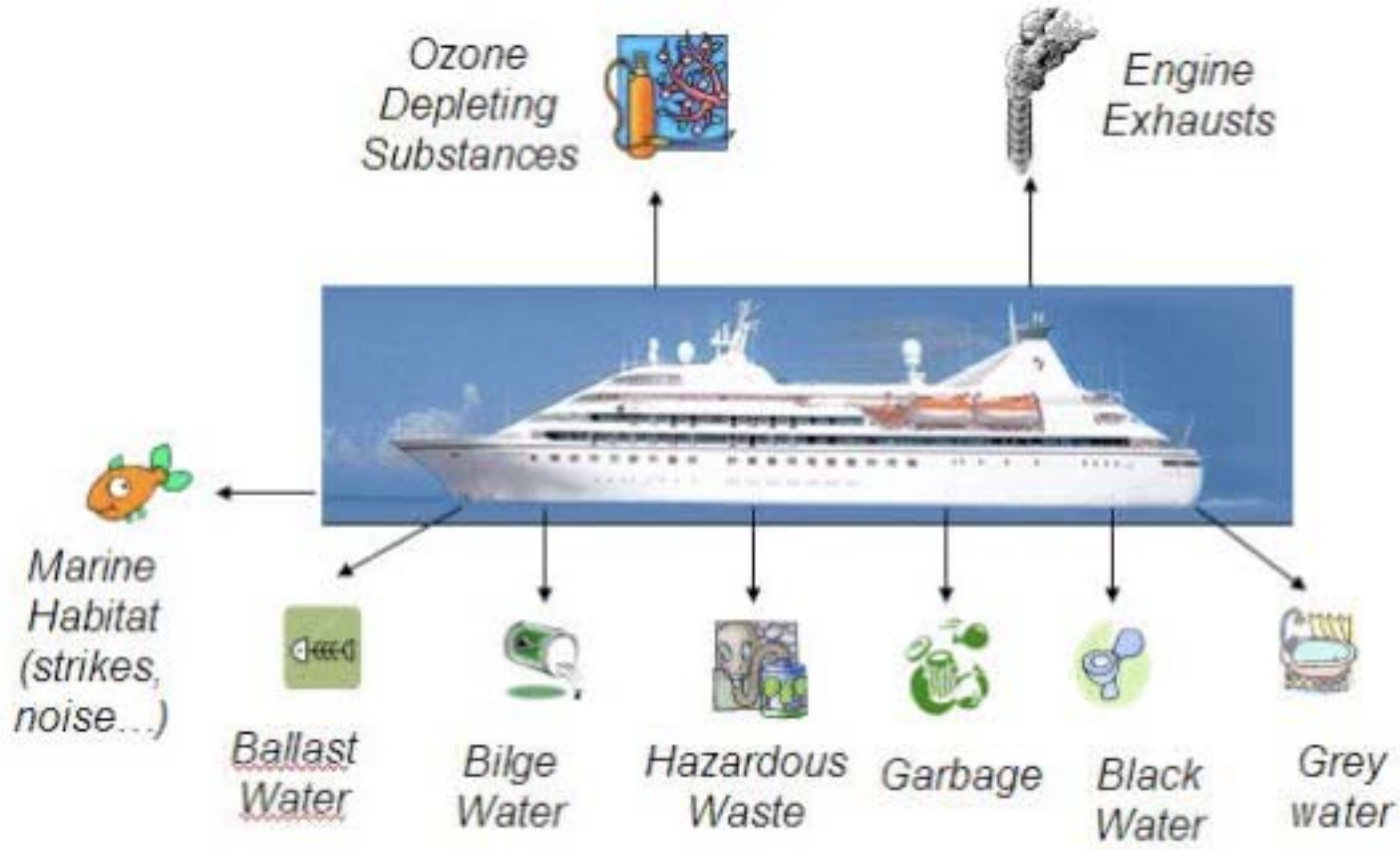
Reduce CO_2 emissions by 30% **Reduce SO_x emissions by 90%** **Reduce NO_x emissions by 90%**

Pathway to SUSTAINABILITY

MV Explorer

V.Ships

Onboard Environmental Management and Waste Streams



SEMESTER AT SEA®
ISO Green Certified

MV Explorer

GO

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Goals: Pathway to Sustainability Initiative

SEMESTER AT SEA AND THE INSTITUTE FOR SHIPBOARD EDUCATION HAVE A VISION FOR CREATING AN INNOVATIVE, CONSCIENTIOUS, AND INTERNATIONALLY RESPONSIBLE GREEN SHIP ENVIRONMENT.

- Verify and reduce environmental footprint
- Implement sustainable policies and programs

- Recycling and waste management
- Waste and emission reduction
- Energy conservation
- Sustainability awareness
- Carbon offset
- Corporate partnership

- Integrate the Academic Program
  Begins Spring 2010

- Create themes around environmental issues
- Launch longitudinal research projects
- Integrate curricular activities

- Install Advanced Environmental Management Systems

- Waste treatment and management
- Exhaust emission scrubbers
- Ballast water management
- Emission control initiatives

- Create shore-side sustainable initiatives

- R&D on visionary initiatives

Life Cycle Analysis:

Assess environmental and economic impacts of a product or service (Cradle to Grave)

1)Goal and scope
2)Inventory analysis
3)Impact assessment
4)Interpretation

Patagonia: The Footprint Chronicles

http://www.patagonia.com/web/us/footprint/index.jsp


Materials Resources and Extraction
End-of Life Issues (recycling, etc)
Processing Impact on Environment
LIFE CYCLE ANALYSIS
Materials for Green Energy
Design for sustainability
Use of Sustainable Materials
Economic, Social and Legislative Issues

A Pilot Study: Cape Hatteras Life Cycle Analysis

*Fuel comparisons: impact of diesel, waste oil and biodiesel

*Lighting options

(Dr. Dalia Patino, Duke)

The Cape Hatteras: Diesel vs. Biodiesel LCA

Allison Herren, Jada Tullos, Hackson Naftel and Parker Crowe

Comparative Life Cycle Analysis of Petroleum Diesel and Soybean-Based Biodiesel for the Cape Hatteras

Brent Fitzgerald, Gabriel Kwok,
and Patrick McNamara

Cape Hatteras:
A Streamlined Life Cycle Assessment of Diesel vs. Biodiesel Use

20 April 2010

Presented by: Karina Lassner, Gaby Carbonell & Jessie Margolis

Lighting on the Hatteras

Minna Friedlander
Dan Kolomeets-Darovsky

Scope Definition- “Cradle to Grave”

- Diesel fuel produced from crude oil and used to power the boat
- Biodiesel fuel produced from cooking oil and used to power the boat

Assumptions

- Hours boat used per year: 4,152 hours
- Average kWh used per day on ship: 720 kW/day
- Diesel storage capacity on board - 28.6k gallons
- Diesel fuel costs 2009: $208,271
- Diesel fuel consumption 2009: 119,000 gallons
- Total amount of fuel purchased in 2009: 105,439 gallons
- Capacity of generator : 175 kW
- Diesel purchased from local vendor in the vessel's specific port of call usually via tanker truck
- Biodiesel made from cooking oil in USA

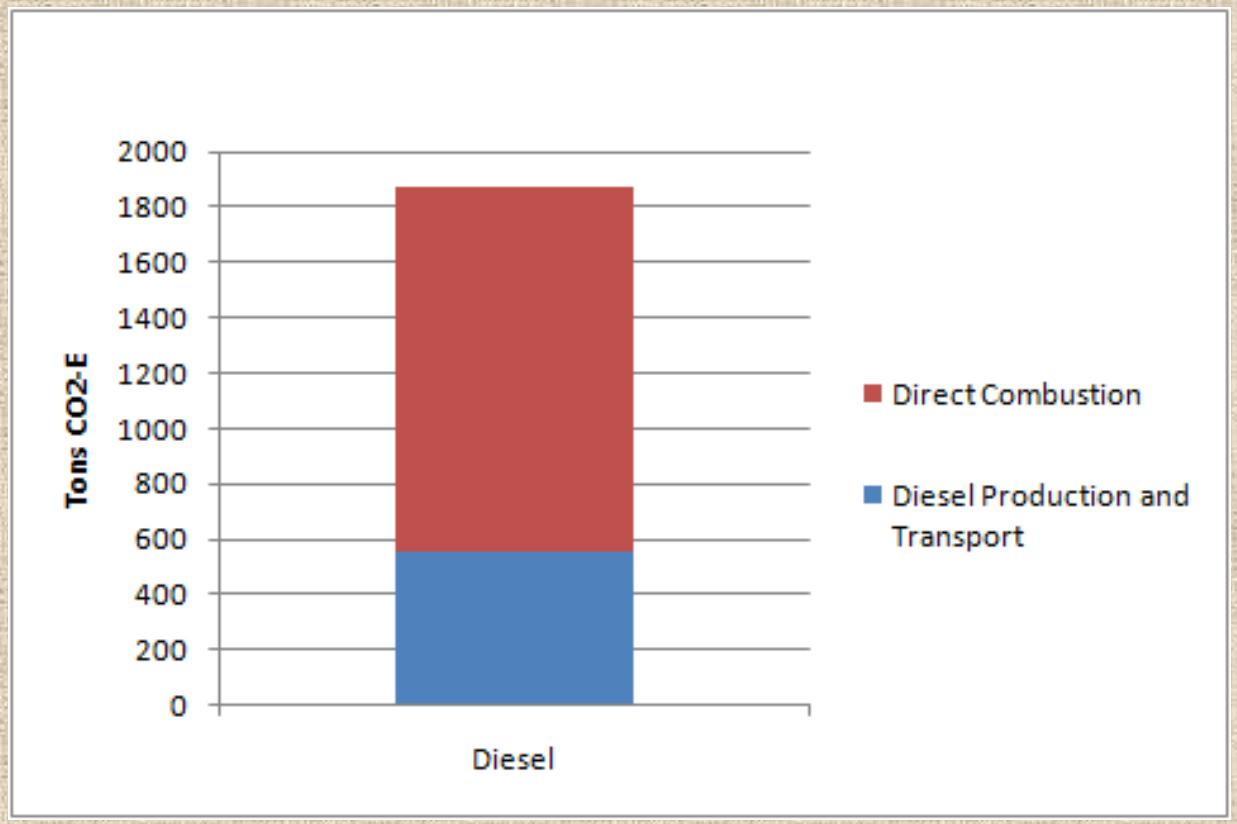
Goal

- Intended Application
  - To choose which fuel, petroleum diesel or soybean-based biodiesel from Potter Oil, is better for the Cape Hatteras Academic Vessel
- Reason for LCA
  - To improve the eco-efficiency of the operations and maintenance of the vessel

Goal

To compare the life cycle greenhouse gas (GHG) emissions (only carbon dioxide and methane), of biodiesel made from used cooking oil (UCO) to petroleum diesel when used as fuel for *Cape Hatteras*.

Baseline Diesel Results

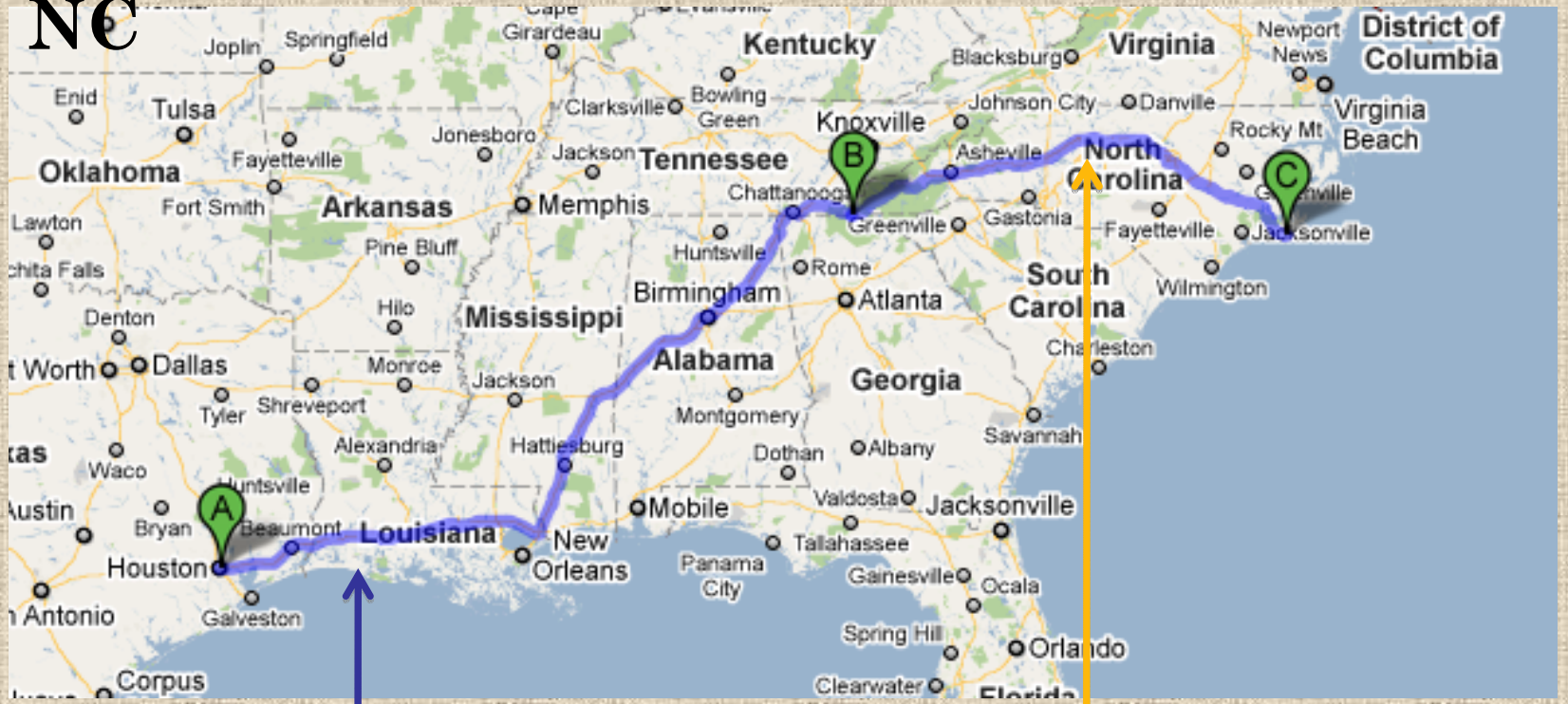


LCIA: Petroleum Diesel

Impact Category: Global Warming Potential (kg CO2-eq)					
Emission	Production & Refining	Travel by Pipeline	Travel by Truck	Ship Combustion	Total
Carbon Dioxide	980	116	39	8,296	9,431
Methane	288	6	0	11	304
Total	1,268	122	39	8,306	9,736

LCI: PETROLEUM DIESEL

Houston, TX → Selma, NC → Beaufort, NC



Colonial Pipeline (1200mi)

Combination Truck (120mi)

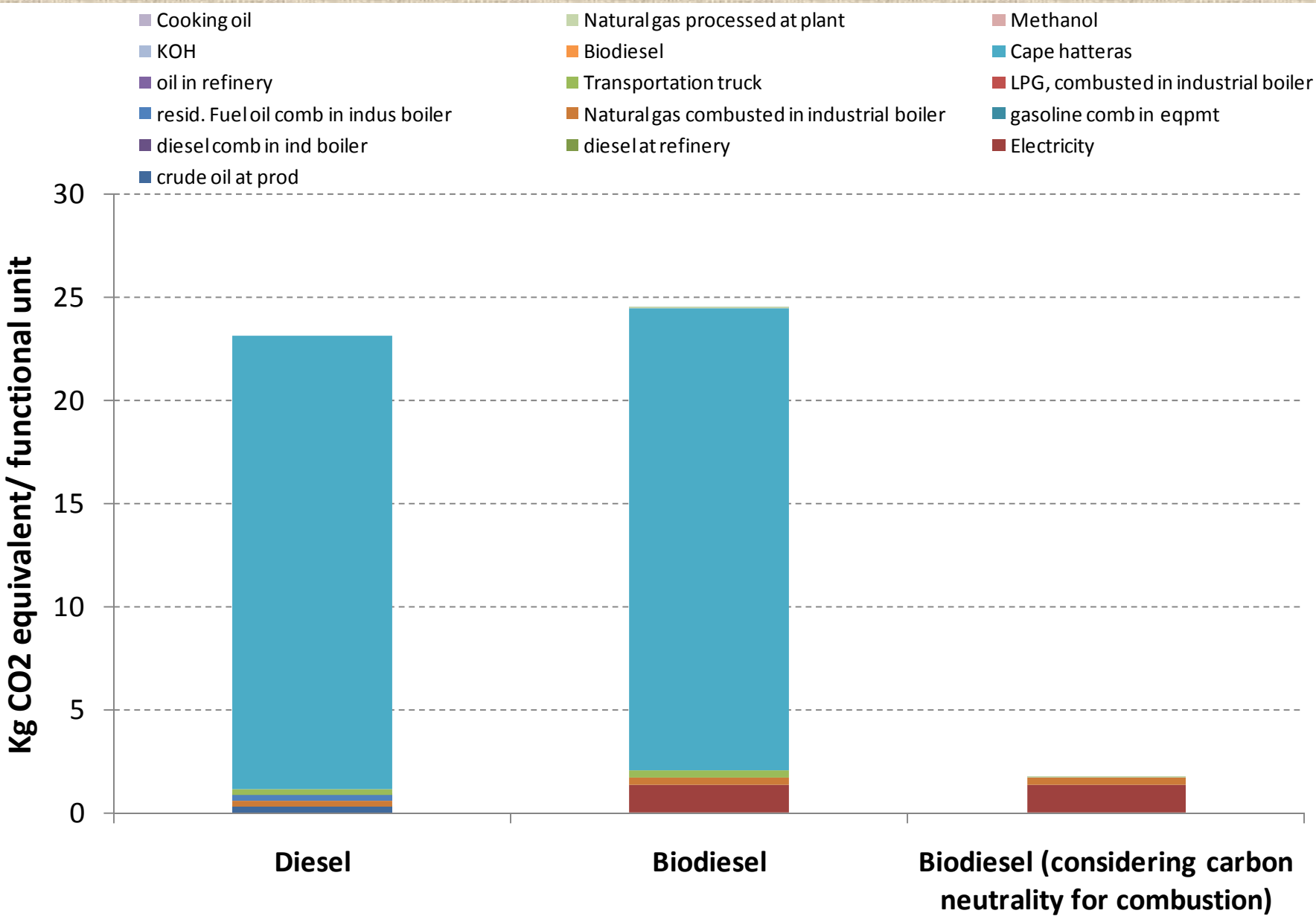
Biodiesel heat & carbon content

Data	Diesel	B100	
Carbon (mass %)	86.78	77.22	
Density (kg/m3 at 15°C)	842.6	887.2	
Energy content (MJ/kg)	45.562	39.719	
Energy content(MJ/L)	38.391	35.238	
Calculations	**Diesel**	**B100**	**Difference**
Liters for tkm	*0.027224**	0.02965993	**8.95%**
Molecular mass of Carbon	12	12	
Molecular mass of CO2	44	44	
Mass of CO2 emitted per liter of fuel (kg)	0.07299019	0.07450628	**2.03%**

Methane emissions for truck transportations are considered to be 0.52% lower than fossil diesel emissions.

Sources:
1. Fuel efficiency and exhaust emissions for biodiesel blends in an agricultural tractor. Y.X. Li, N.B. McLaughlin*, B.S. Patterson and S.D. Burtt. s.l. : CANADIAN BIOSYSTEMS ENGINEERING, 2006, Vol. 48.

Comparative Results



Conclusions

- In comparing biodeisel to petroleum diesel in this case, biodiesel is an environmentally preferable alternative. This may not be true of the following conditions are not met:
  - UCO
  - Locally sourced and processed

Greening the Fleet: Work in Progress:

1. RVOC questionnaire on how to make existing ship operations more environmentally friendly- (Liz Caporelli-WHOI)-initiate discussion within the fleet on environmental sustainability

2. Green Passport- *Cape Hatteras*

3. Proposed UNOLS workshop

Greening the U.S. Academic Fleet: A UNOLS Workshop

Objective: An Assessment of Current Technologies, Designs and Practices for Environmentally Sustainable Research Vessels

Time: Spring, 2011

Location: Nicholas School of the Environment, Duke University, Durham, NC

Composition: 25-30 invitees, with representation from Council, RVOC, RVTEC, FIC, NSF, Navy, NOAA, architects and naval designers, industry, and marine scientists interested in attending.

Format: 1 ½ day workshop with invited presentations on various aspects of green ships: design, technology, practices

Funding: Proposal for support of the workshop to be submitted to NSF and ONR

Announcement: UNOLS website and mailing lists, advertisement for workshop in EOS

LONG TERM GOALS:

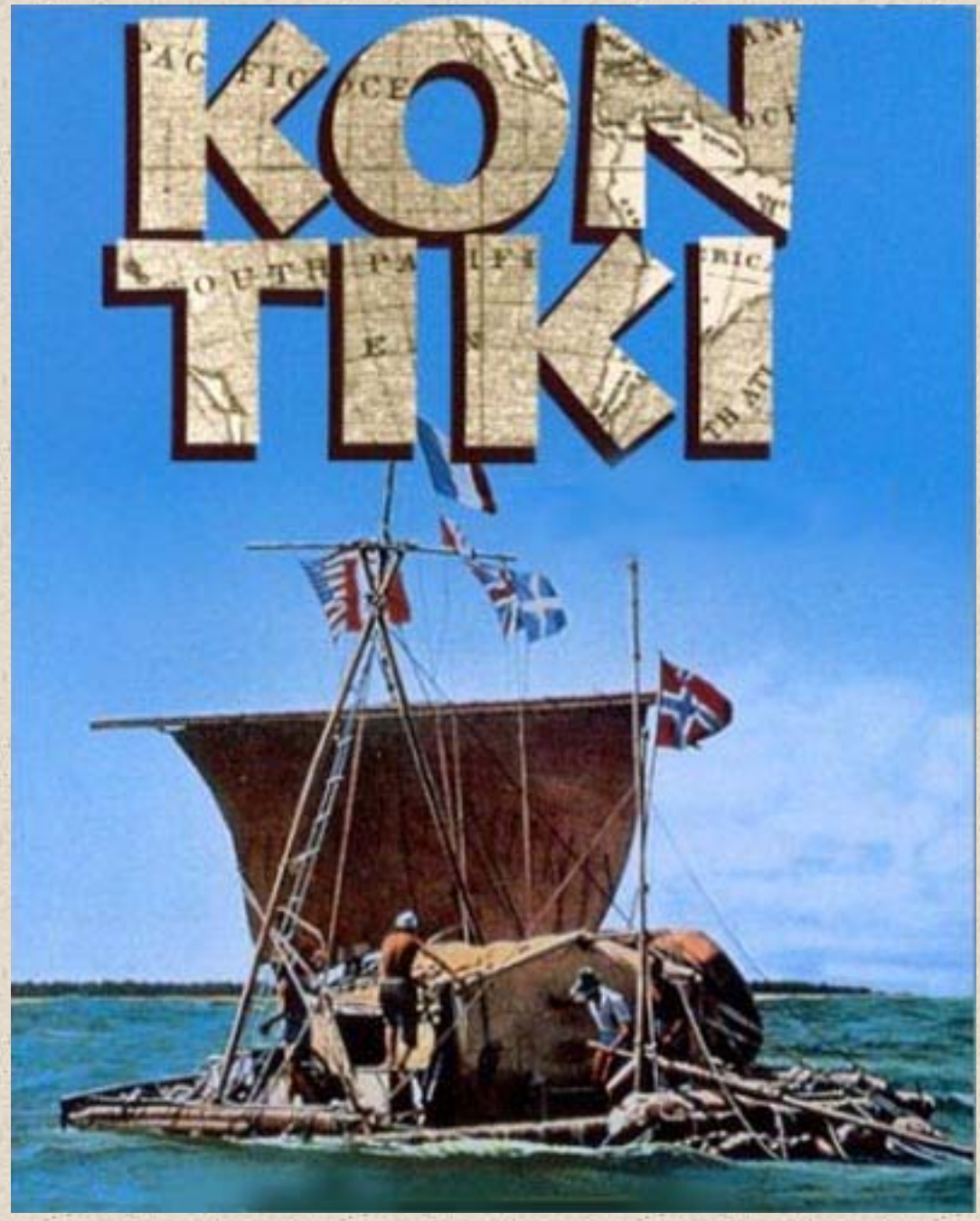
1) Promote environmental sustainability within UNOLS

2) Guidelines for construction, operation and recycling of UNOLS Research Vessels

3) Development of green vessel guidelines for U.S. vessels (outreach)

4) Promote environmental awareness on UNOLS ships with U.S. ocean scientists (outreach)

5) Ocean Class and Regional Class vessel construction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