Presentation Outline

- Background
- Science and Operational Requirements
- Results from Technical Studies
  - Research Vessel Features
  - Mission Sensitivity Studies
- Project Schedule
- Some Closing Thoughts
Background
# U.S. Research Capable Icebreakers

(Operational and Planned)

<table>
<thead>
<tr>
<th>Geographic Area</th>
<th>Vessel Ownership</th>
<th>Primary Mission</th>
<th>Icebreaking Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic</td>
<td>UNOLS (ARRV)</td>
<td>Science</td>
<td>0.8 m (2.5 ft)</td>
</tr>
<tr>
<td></td>
<td>USCG (Healy)</td>
<td>Multi-mission</td>
<td>1.4 m (4.5 ft)</td>
</tr>
<tr>
<td>High Arctic</td>
<td>USCG</td>
<td>Multi-mission</td>
<td>1.8 m (6 ft)</td>
</tr>
<tr>
<td>Antarctica</td>
<td>Commercial</td>
<td>Science</td>
<td>0.9 - 1.4m (3 - 4.5 ft)</td>
</tr>
</tbody>
</table>
This presentation will show the conceptual design of a dedicated research vessel with icebreaking capability for use in the Antarctic, but Arctic capable.
Science and Operational Requirements
NATHANIEL B. PALMER - 1992 to present
Critical New Research Requirements

- Enhanced icebreaking capabilities 1.4m (4.5 ft) at 3 kts
- Increased endurance to 80 days and 20,000 miles at 12kts
- Increased accommodations for 50
- Moon pool for geotechnical drilling - provides access to the water column through a controlled interface (no ice, limited surge, and turbulence)
- Ability to tow nets and research instrumentation from the stern during icebreaking
- Acoustically quiet
- Hull form designed for the installation of bottom mounted sensing instruments and operation during icebreaking
ANTARCTICA

Minimum Sea Ice Extent (multiyear ice)

Maximum Sea Ice Extent

First Year Sea Ice

Problematic Sea Ice Areas for NBP

South Pole

Minimum Sea Ice Extent (multiyear ice)
Additional Science and Operational Requirements

- Capability to conduct autonomous underwater vehicle remotely operated vehicle (AUV/ROV) operations
- Jumbo piston coring (JPC) capacity for 50 m
- Compliance with International Maritime Organization (IMO) guidelines for Arctic vessels
- Reduced air emission from diesel engines and incinerator and other features for a “greener” ship
- Provision for a helicopter flight deck and hangar
- Space for 6 portable lab containers
- Aloft, enclosed platform for science observations
- Inter-deck elevator and wide passage way on main deck
Desired Operating Profile

<table>
<thead>
<tr>
<th>Activity</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science operations away from port and in-transit</td>
<td>265</td>
</tr>
<tr>
<td>In-port preparations for science operations</td>
<td>35</td>
</tr>
<tr>
<td>Repairs and maintenance</td>
<td>65</td>
</tr>
<tr>
<td>Total days</td>
<td>365</td>
</tr>
</tbody>
</table>
Results from Technical Studies
Above water features of PRV
Underwater view of PRV box keel with bottom mapping sensors
Principal Characteristics

LOA  120.2 m  Draft  10.2 m
LWL  108.3 m  Displacement  13,900 MT
Beam  22.3 m  Shaft Power  15,000 kW
Some Environmental Features Incorporated in the PRV

Rate of greenhouse emissions reduced by 90% compared to existing vessel

No emissions in port; PRV connects to shore side electric power (cold ironing)

In addition:

- Designed for 40-year ship life and environmentally friendly disposal
- Waste water and waste oil treated to highest international standards
- Environmental management system on-board and ashore

Improved hull form reduces energy by 20%

Double hull construction minimizes risk of oil spill

Employs latest ballast water exchange and treatment technology

Hull coated with non-toxic paint
Emission Reduction per Horsepower

- NBP-1990 Engines: 100% NOx+THC (g/kW-hr), 100% PM (g/kW-hr)
- PRV-2007 Engines without optional treatment: 100% NOx+THC (g/kW-hr)
- PRV-2007 Engines with 2003 optional technology: 45% NOx+THC (g/kW-hr), 20% PM (g/kW-hr)
- PRV-2007 Engines with 2007 optional technology: 12% NOx+THC (g/kW-hr), 6% PM (g/kW-hr)
To achieve the emission goal -- there is a need to reduce the quantity of sulfur in diesel fuel oil.

Sulfur inhibits the use of NO$_x$ and particulate matter emission reduction equipment (such as catalysts and filters) which are needed to meet U.S. Environmental Protection Agency regulations for air quality.
The Future of Ultra-Low Sulfur Diesel Fuel in the U.S.
U.S. Marine Fuel Oil
Sulfur Levels in 2004 and 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Marine Diesel Oil (ppm)</th>
<th>Heavy Fuel Oil (ppm)</th>
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</thead>
<tbody>
<tr>
<td>2004</td>
<td>3,400</td>
<td>27,000</td>
</tr>
<tr>
<td>2011</td>
<td>15</td>
<td>27,000</td>
</tr>
</tbody>
</table>
Homogeneous Charge Compression Engine (HCCI)

- Economical – 25 percent fuel reduction
- Ultra low emissions – near zero
  - Oxides of Nitrogen (NOx)
  - Particulate Matter (PM)
- Operate on gasoline, diesel fuel, alternative fuel
- Has marine application
- “May be” commercialized in light-duty passenger vehicles by 2010
Combustion occurs simultaneously throughout the cylinder volume rather than a flame front.
It is not here yet!

Research is still on-going in such areas as

- Controlling ignition timing over a wide range of speeds and loads.
- Limiting the rate of combustion heat release at high-load operation.
- Providing smooth operation through rapid transients.

Major engine manufacturers are conducting HCCI research and EPA funding some aspects.
Results from Mission Sensitivity Studies
Sensitivity Studies

Added Science Mission Capability

Cost
($ Millions of Dollars)
Project Schedule
# Project Timeline

(Vessel lease)

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Pre-RFP Development</td>
<td></td>
</tr>
<tr>
<td>Compile RFP Documents and Issue</td>
<td></td>
</tr>
<tr>
<td>Bidding, Evaluation, and Contract Award</td>
<td></td>
</tr>
<tr>
<td>Shipyard Design and Construction</td>
<td></td>
</tr>
<tr>
<td>Acceptance Trials and Final Outfitting</td>
<td></td>
</tr>
<tr>
<td>Transit to Southern Hemisphere Port</td>
<td></td>
</tr>
</tbody>
</table>
# Icebreaking Research Ship

## Duration from Inception to Delivery

<table>
<thead>
<tr>
<th>Ship</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic (ARRV) Ownership UNOLS</td>
<td>17</td>
</tr>
<tr>
<td>High Arctic (replacement for POLAR Class) Ownership USCG</td>
<td>15</td>
</tr>
<tr>
<td>Antarctic Ownership Commercial (lease to NSF)</td>
<td>11</td>
</tr>
<tr>
<td>NATHANIEL B. PALMER (lease)</td>
<td>6 (5)</td>
</tr>
</tbody>
</table>
## Estimated Schedule for New U.S. Research Vessel Deliveries

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>Ownership</th>
<th>Delivery Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic (ARRV)</td>
<td>UNOLS</td>
<td>2011 to 2013</td>
</tr>
<tr>
<td>High Arctic (replacement for POLAR Class)</td>
<td>USCG</td>
<td>2022 to 2024</td>
</tr>
<tr>
<td>Antarctic</td>
<td>Commercial (lease to NSF)</td>
<td>2015 to 2017</td>
</tr>
</tbody>
</table>
Alaska Region Research Vessel

<table>
<thead>
<tr>
<th>Trait</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOA</td>
<td>72 m</td>
</tr>
<tr>
<td>Beam</td>
<td>16 m</td>
</tr>
<tr>
<td>Draft</td>
<td>5.5 m</td>
</tr>
<tr>
<td>Scientist berths</td>
<td>26</td>
</tr>
<tr>
<td>Endurance</td>
<td>45 days</td>
</tr>
<tr>
<td>Icebreaking</td>
<td>0.76 m</td>
</tr>
</tbody>
</table>
Impact of an Ice-Diminishing Arctic on Naval and Maritime Operations
Some Closing Thoughts
Design and build for:

- 40 year ship life
- Set the standard for protecting the environment
  - Green icebreakers
- High skill level of personnel (ice piloting and ice navigation are the most critical skills)
A Vision of the Future

The year is 2040
and climate change continues with the disappearance of Arctic ice

The latest U.S. research icebreaker is observed off Point Barrow, Alaska.