The R/V Sikuliaq - A New U.S. Arctic Research Platform

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Woods Hole Oceanographic Institution
Introducing the *R/V Sikuliaq*

A technologically advanced, ice capable research vessel

**Owner:** National Science Foundation

**Operator:** University of Alaska Fairbanks

**Global Class Vessel in the UNOLS Fleet**
<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length/Beam</td>
<td>261’/48’</td>
</tr>
<tr>
<td>Draft/Freeboard</td>
<td>~19’/9’</td>
</tr>
<tr>
<td>Endurance</td>
<td>45 days</td>
</tr>
<tr>
<td>Speed</td>
<td></td>
</tr>
<tr>
<td>Calm/13ft seas</td>
<td>14/12 kts</td>
</tr>
<tr>
<td>3’ level ice</td>
<td>2 kts</td>
</tr>
<tr>
<td>Diesel Fuel</td>
<td>170,000 gals</td>
</tr>
<tr>
<td>Fresh Water</td>
<td>13,150 gals</td>
</tr>
<tr>
<td>Water making</td>
<td>6,000 gals/day</td>
</tr>
<tr>
<td>Propulsion Power</td>
<td>5750 BHP, 2-Z-Drives, Tractor Mount; Bow Thruster</td>
</tr>
<tr>
<td>Science Party</td>
<td>24 + 2 techs</td>
</tr>
<tr>
<td>Crew</td>
<td>20</td>
</tr>
<tr>
<td>Science deadweight</td>
<td>100 tons</td>
</tr>
<tr>
<td>Science vans</td>
<td>3</td>
</tr>
<tr>
<td>Science storage</td>
<td>8000 cu. ft.</td>
</tr>
<tr>
<td>Science labs</td>
<td>2250 sq. ft.</td>
</tr>
<tr>
<td>Deck working area</td>
<td>4360 sq. ft.</td>
</tr>
<tr>
<td>Ice Breaking Specification</td>
<td>3 feet of level ice at 2 knots</td>
</tr>
</tbody>
</table>
Sikuliahq’s Long Trip to Alaska

Built by Marinette Marine in Marinette WI
Launched October 13, 2012
Delivered in June 2014
Science Support Capabilities

SIKULIAQ will provide the tools needed to support ocean research on emerging critical questions in high-latitude science

- Acoustically quiet, ice-capable vessel
- Acoustic systems for seafloor and water column surveys
  - EM710, EM302 Multibeam, 75 kHz and 150kHz ADCPs, TOPAS Sub-bottom profiler
  - EK60 Bioacoustics (plankton, fish) on Centerboard
- Full Suite of Meteorological and Underway Science Seawater Sensors
- Latest satellite communications systems
- ADA-friendly
- Four fume hoods
- Two environmental chambers
- Climate controlled analytical lab
- Two winches with 0.322” electromechanical cable, one trawl winch with 9/16” wire rope, one trawl winch with 0.68” electromechanical cable
- Two cranes, A-Frame, CTD Load Handling System
Retractable Centerboard

- EK-60 Scientific Sounder System
- One spare mount for project use
  - Accessible from main deck for transducer installations
Laboratory Spaces
Sikuliaq Mapserver - Developed by Steve Roberts

Displays
- Satellite imagery – RADARSAT, MODIS, AMSR2 on this cruise
- Ship position, heading, speed, and track
- Ability to plan trips with multiple waypoints and distance between points

Mapserver is a work in progress
Ice Trials

- Assess operational performance of ship in ice (AKAC Inc.)
- Training and practice in ice navigation and ship handling during all operations including science (AKAC Inc.)
  - Conducted by experienced master with 35 years experience on icebreakers, 19 years on similar vessels
- Assess ability of ship to conduct science in sea ice (Science Party)
Ice Trials (March 19-April 7)

- Most ice concentrations > 7/10s
- Ice thickness was usually <50 cm (based on visual observations)

Data Collected by Alice Orlich

Map by Steve Roberts
Ice Conditions

March 21

April 2
Sikulialiq Performance in Ice

By: AKAC Inc.

July 9th, 2015
Intended Operability of the Sikuliaq

- Year round in Bering Sea, seasonal in Chukchi and Beaufort Seas
- Prudent ice navigation is essential
- Avoid thickest ice features, and make use of open water leads where possible
Level Ice Breaking Performance

- Model Test Predictions suggest:
  - Sikuliaq can break 60cm thick ice @ 4 knots at 100% power
  - Expected to break target 90 cm thick ice continuously at 100% power
Maneuvering Performance

Azimuth thrusters and reamers make the Sikuliaq very maneuverable.

- Various maneuvers can be used to turn the ship.
- Turning Radius is approximately 100m (325 feet) in \(~25\text{cm (10″) thick level ice}\)
- Using “Captain’s Turn” in \(~25\text{cm (10″) thick level ice}\), the ship can come to a full stop and make a 180 degree turn in its original track in less than 4 minutes, from an initial speed of \(~7.5\text{ knots}\).
- In thick ice, rather than backing down a channel full of ice, the Sikuliaq can turn on the spot and transit back its channel in ahead mode.
Ridge Ramming Performance

- Very challenging to find suitable ridges for testing
- 1 ridge/rubble field was surveyed and tested
- Total maximum ridge thickness ~3.5 meters, ~250m long
- Ramming speed upon impact with ridge between 8-11 knots
- Good penetration, nearly 150 m with first ram
- Efficient extraction from ridge with low power
- Backing up channel to start new ram experienced significant propeller ice interaction, which can be mitigated by effective operation of the thrusters
Limiting Ice Conditions

- Highly deformed and consolidated pack ice under pressure
  - Transit through compacted ice toward St. Matthew Island during night of March 27th
- Backing in thick ice >~30cm, including broken ice
  - Significant vibrations as a result of propeller ice interactions
  - Ship should be operated in ahead mode if possible

Sikuliaq was stopped ~ two hours after this photo was taken, in similar ice but higher concentration
Towing Performance in Ice

- Numerous towing demonstrations and actual tows were performed successfully
- Thrusters can be used to create an ice free channel with minimal ice interference
- Procedures for effective deployment and retrieval of towing equipment with no ice interaction

Examples of towing in ice free channel in while maintaining a tow speed of 3.5-4 knots:

- March 31st, 2015
  - 10cm thick level ice

- March 21st, 2015
  - Breaking a double channel before clearing
  - 30-40cm thick consolidated ice cakes

- April 4th, 2015
  - Clearing ice using the Sikulialq's DP system.
  - 6-8/10ths of 10-50m floes ~30cm thick
Deployment over the Stern

- Using a low power, the propeller wake can maintain an area of open water at the stern while leaning up against the ice at the bow,
  - results in a very stable configuration for deployment of equipment over the stern
- Van Veen Grabs and Haps Corers performed in full ice cover over the stern in various ice conditions, with no ice interference.

- April 4\textsuperscript{th}, 2015
  - 6-8/10ths of 10-50m floes \~30cm thick
- March 23\textsuperscript{rd}, 2015
  - \~20cm thick level ice
Deploying Equipment Through Baltic Room

- Numerous CTDs were performed in various ice conditions
  - Azimuth thrusters and a setup procedure used to create an open water “pocket” in the ice on the starboard side
  - Thrusters used to allow the ship to “lean” against the ice on the port side to maintain a stable heading and position
  - This configuration allows CTD to be deployed in virtually open water

6-8/10ths of 10-50m floes ~30cm thick

Start with 20cm thick level ice

~ 10 minutes later...
Science Trials

- Physical oceanography
- Sea floor bathymetry
- Sea ice type and topography
- Sea ice microbes
- Trace metals in sea ice
- Meteorological data (heat flux)
- Seabird distributions
- Phytoplankton associated viruses
- Phytoplankton abundance, composition, production
- Zooplankton abundance and respiration
- Zooplankton abundance and respiration
- Midwater fish abundance
- Marine mammal occurrence

Science Party Composition:
Mix of non-UAF and UAF scientists
Three graduate students
Early, mid-, and late career PIs
Technical experts
## Science Sampling

<table>
<thead>
<tr>
<th>Activity</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTD</td>
<td>25</td>
</tr>
<tr>
<td>Bongo Nets</td>
<td>2</td>
</tr>
<tr>
<td>HAPS Corer</td>
<td>14</td>
</tr>
<tr>
<td>Isaacs-Kidd Midwater Trawl</td>
<td>6</td>
</tr>
<tr>
<td>Aluette Midwater Trawl</td>
<td>4</td>
</tr>
<tr>
<td>Ring Net</td>
<td>6</td>
</tr>
<tr>
<td>Sea Otter ROV</td>
<td>2</td>
</tr>
<tr>
<td>Van Veen Grab</td>
<td>26</td>
</tr>
<tr>
<td>Ice Station</td>
<td>5</td>
</tr>
<tr>
<td>Ice Cores from Manbasket</td>
<td>3-4</td>
</tr>
<tr>
<td>Ice Net</td>
<td>10</td>
</tr>
<tr>
<td>Copepod Respiration Experiments</td>
<td>5</td>
</tr>
</tbody>
</table>
Ice Stations
Hydrography

- Planned CTD Transect, stations 10 miles apart
- Ship accomplished this in ~10 hours
- Ice comprised floes with leads between so transit time was relatively fast
- Data showed warm, salty Bering Sea basin water at depth at offshore end of transect

Plots by R. Beardsley
Seabirds

GULLS

Data collected by and photo by Liz Labunski

BLACK GUILLEMONTS

Data collected by and photo by Liz Labunski

MURRES

Data collected by and photo by Liz Labunski
The “New” Sikuliah