Bureau of Safety and Environmental Enforcement

Oil Spill Preparedness Division

Advancing the BOWHEAD Ice Management System

Final Report

October 2024

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US Department of the Interior
Bureau of Safety and Environmental Enforcement
Oil Spill Preparedness Division

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Final Report

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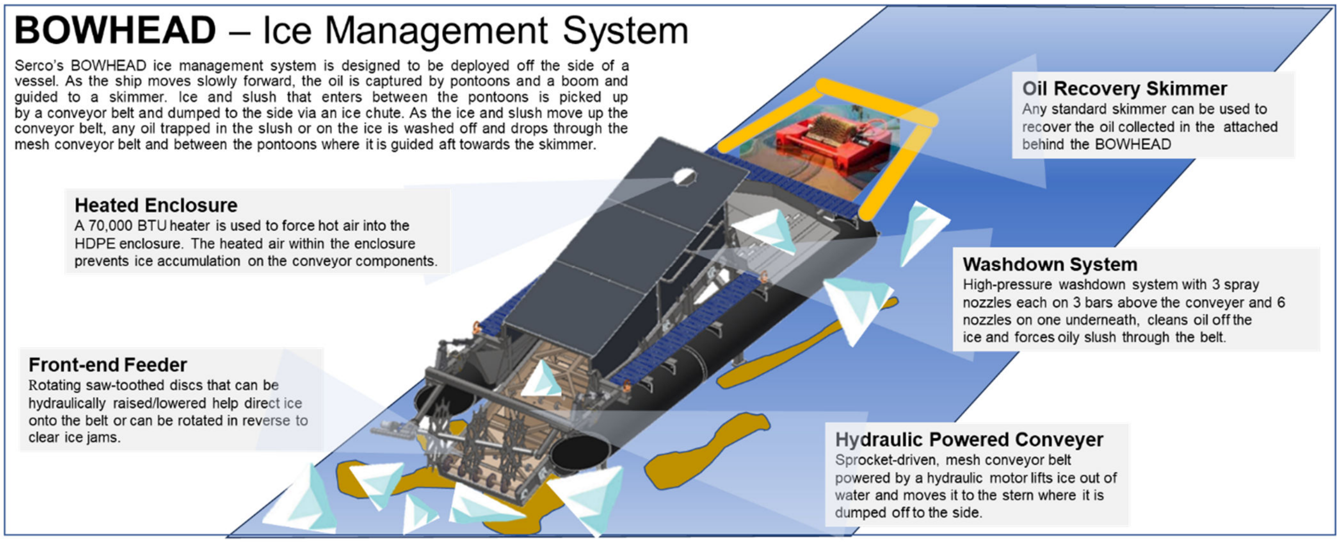
GRAPHICAL ABSTRACT



EXECUTIVE SUMMARY

Oil spill response in Arctic conditions is heavily impacted by ice conditions. Ice is an obstacle to cleaning oil spills from the water surface, and it has an irregular surface that collects oil and must itself be cleaned. Serco, Inc. developed and tested an ice management system, called BOWHEAD, to address the problem of recovering oil in an ice-infested environment. From 1995 to 2002, SINTEF Applied Chemistry™ and other partners performed extensive testing to tackle this problem under the Mechanical Oil Recovery in Ice Infested Waters (MORICE) project (Jensen et al., 1999; Jensen & Mullin, 2003; Jensen & Solsberg, 2000, 2001, 2002; Johannessen et al., 1996; Johannessen et al., 1998). In 2019, the Bureau of Safety and Environmental Enforcement (BSEE) contracted with Serco, Inc. to design and test an ice management system based on the experience with MORICE.

BOWHEAD was designed to assist oil cleanup endeavors in Artic conditions with up to 70 percent ice coverage. The system is made almost entirely of stainless steel to withstand the harsh marine and weather conditions. The main body is a large conveyer belt and frame, supported by pontoons. At the forward end of the device is a hydraulic motor-powered front-end feeder that pushes ice towards the conveyer mouth. A spray bar washdown system is set atop a frame over the conveyer belt to clean off the ice as it moves up the conveyer. At the aft end, an ice chute drops the clean ice off to the side and out of the way of the skimmer, which follows behind to collect the oil from the water surface.

Serco and BSEE tested the prototype BOWHEAD at the National Oil Spill Response and Renewable Energy Test Facility (Ohmsett) facility in Leonardo, NJ in January and February 2021. The system was tested for capabilities including ice handling, ice cleaning, and oil flow through the system. Overall, the system performed well and was promising for the intended application. The BOWHEAD Final Report recommended changes and improvements for future testing and operational use, all of which could be done as retrofits to the existing system, most of which Serco completed in 2023 (Johnson, 2021).

Serco and BSEE tested the new BOWHEAD2 in February 2024 at Ohmsett. The objective of these tests was to evaluate the performance of the BOWHEAD2 in simulated arctic environmental conditions to include ice and oil and compare the performance to that of standard recovery techniques currently used for ice-infested waters. The test was designed to follow ASTM Standard F3350-18 (*Standard Guide for Collecting Skimmer Performance Data in Ice Conditions*, 2018) as closely as possible.

Even with some continuing issues with oil flow to the skimmer, the BOWHEAD2 ice management system and a standard disk skimmer performed much better than the disk skimmer alone using traditional tactics. With the system operating at the higher speed where the best recovery was seen, the BOWHEAD2 recovery rates in the 70% ice coverage were ~10 gpm. This is compared to ~1.3 gpm for the skimmer alone in 70% ice coverage, an improvement of more than 7 times. The report concludes with recommendations for an ideal future design.

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1 Introduction

Oil spill response in Arctic conditions is heavily impacted by ice conditions. Ice is an obstacle to cleaning oil spills from the water surface, and it has an irregular surface that collects oil and must itself be cleaned. Serco's BOWHEAD is a system designed to provide an ice-free zone for skimmers to recover oil under these arctic conditions. The BOWHEAD design focuses on simplicity, scalability, ease of operation, deployability, and flexibility for use with multiple different skimmer configurations.

BOWHEAD was designed to assist oil cleanup endeavors in Artic conditions with up to 70 percent ice coverage. The system is made almost entirely of stainless steel to withstand the harsh marine and weather conditions. The main body is a large conveyer belt and frame, supported by pontoons. At the forward end of the device is a hydraulic motor-powered front-end feeder that pushes ice towards the conveyer mouth. A spray bar washdown system is set atop a frame over the conveyer belt to clean off the ice as it moves up the conveyer. At the aft end, an ice chute drops the clean ice off to the side and out of the way of the skimmer, which follows behind to collect the oil from the water surface.

1.1. Background

There is an ongoing need to improve oil recovery in drift ice conditions. The Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) 2022-2027 Oil Pollution Research and Technology (R&T) plan identified developing "methods, tools, and technologies customized to the specific characteristic of cold and harsh environment" as a Standing Research Area (SRA) 30400 priority (ICCOPR, 2021). This need is supported by a 2017 review of oil spill response capabilities and technologies for ice-covered Arctic marine waters that identified limits with collecting oil in ice using standard oil containment booms and recovering the collected oil with skimmer equipment (Wilkinson et al., 2017). In an ice environment, an oil containment boom towed from a vessel captures ice along with the oil which can put a strain on the boom and potentially cause damage. The oil that is contained within the boom must be recovered with skimmers, many of which are not designed for handling ice (Wilkinson et al., 2017). Rope mop and brush skimmers are preferred in this environment, but even these skimmers have low recovery rates and efficiencies when recovering in ice conditions. As described in the Arctic Council's Emergency Prevention, Preparedness and Response (EPPR) report "Guide to Oil Spill Response in Snow and Ice Conditions in the Arctic," ice within the oil recovery area reduces the flow of oil to the skimmer head which reduces performance (EPPR, 2015). In addition, ice chunks can enter the skimmer's sump area where they can clog the pump or recovery hose during recovery operations. Section 5.1 discusses the current tactics proposed by Alaskan response organizations. Because the BOWHEAD system is designed to prevent ice from entering the boomed recovery zone, it allows for enhanced oil recovery using standard oil recovery skimmers.

The BOWHEAD design was built on the results of the Mechanical Oil Recovery in Ice Infested Waters (MORICE) project (Jensen et al., 1999; Jensen & Mullin, 2003; Jensen & Solsberg, 2000, 2001, 2002; Johannessen et al., 1996; Johannessen et al., 1998). As stated in the MORICE final report, "an oil-in-ice spill could involve anything from very light ice conditions, where the presence of ice can be treated as a simple debris problem similar to situations frequently encountered in open water, to heavy ice conditions where the oil is trapped between floes or is intermixed with small ice forms or encapsulated in ice and virtually inaccessible for recovery." Because of this wide range of potential conditions, no one-size-fits-all solution is possible. In designing BOWHEAD, we focused on oil in a scattered 30-70% ice coverage area that could consist of small pieces of ice and slush as well as larger pieces of ice (but limited in size), as described in the Broad Agency Announcement (BAA).

The BOWHEAD design derives from extensive testing performed by SINTEF Applied Chemistry™ and other partners from 1995-2002 to tackle the problem of removing oil in an ice-infested environment. The researchers determined that a conveyor belt type system that lifted the ice momentarily out of the water to be mechanically washed was an effective way of removing oil from the ice. Once the ice is removed from the water, a standard brush style skimmer worked very efficiently to remove the majority of the oil from the water surface. This solution was the end-product of a multi-phase process. The MORICE project started with a literature review and brainstorming sessions to identify solutions that were plausible and could be used in an operational setting. Many of the concepts were tested in the lab and then finally down selected to the three most viable. These concepts, including the mechanical conveyor belt system, were then tested at Ohmsett in January 2002 (Jensen & Mullin, 2003; Jensen & Solsberg, 2002).

As a result of this extensive testing, it was determined that a lifting graded belt (LGB) combined with a brush and drum skimmer system could be extremely effective in removing oil from ice. However, there were many technical factors that had to be overcome during the testing. For example, the MORICE system was designed to be operated independently of other vessels, requiring additional accommodations for propulsion, a human operator, and recovered oil storage. The greatest challenge was building a system that uses a conveyor belt type lifting mechanism, which can be heavy and cumbersome in comparison to the existing oil removal equipment currently deployed operationally in the field. To create BOWHEAD, Serco developed a design for a new ice conveyor system that builds upon the work of the MORICE project but removes unnecessary features while expanding on MORICE to create a system that is easier to deploy and use. In developing this concept, we leveraged our experience in building and testing systems for oil recovery in ice infested water (ICEHORSE 1 and 2 (Johnson et al., 2016, 2018)).

Serco designed BOWHEAD to be deployed off the side of a vessel. As the ship moves slowly forward into the areas with the least ice concentration, the oil is captured by pontoons and a boom and guided to an oil skimmer. Ice and slush that enters between the pontoons is picked up by a conveyor belt and dumped to the side via an ice chute. As the ice and slush moves up the conveyor belt, any oil trapped in the slush or on the ice is washed off and drops through the perforated conveyor belt and between the pontoons where it is guided aft towards the skimmer. BOWHEAD effectively deflects ice in front of the forward moving ice conveyor and is able to lift ice (as well as small debris, limbs, and logs) out of the water so that a standard skimmer can be used to remove the oil from the ice-free and debris-free water. Fig. 1 provides a conceptual drawing of Serco BOWHEAD in operation.

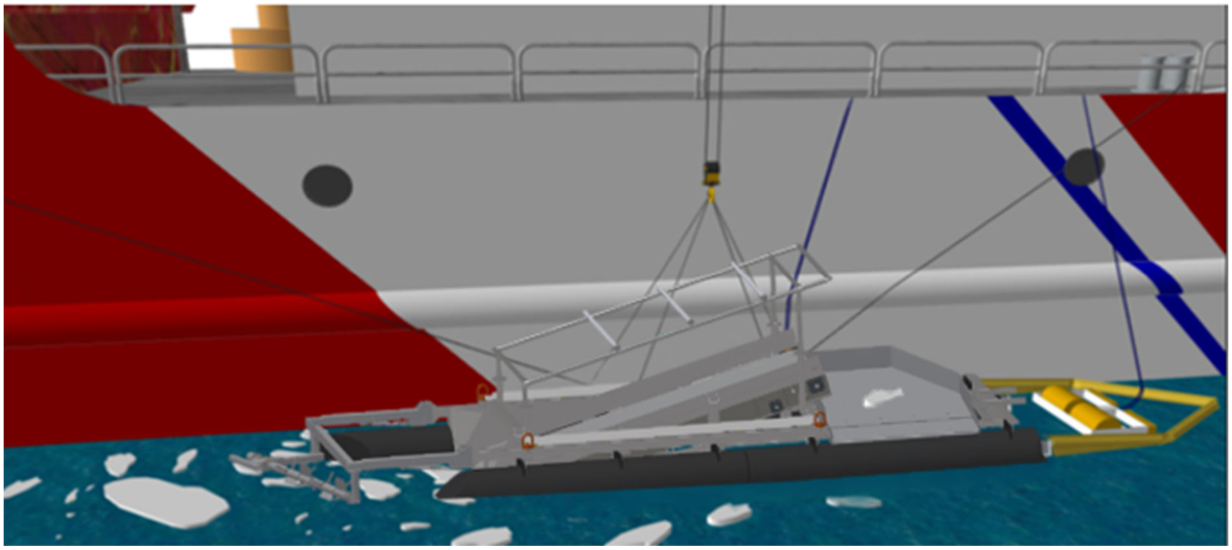

Fig. 1 Conceptual drawing of Serco BOWHEAD in operation.

1.2. Original BOWHEAD Testing

Serco and BSEE tested the prototype BOWHEAD at the National Oil Spill Response and Renewable Energy Test Facility (Ohmsett) facility in Leonardo, NJ in January and February 2021. They tested the system for capabilities including ice handling, ice cleaning, and oil flow through the system. Overall, the system performed well and was promising for the intended application. The BOWHEAD Final Report recommended changes and improvements for future testing and operational use, all of which could be done as retrofits to the existing system (Johnson, 2021). Section 2 addresses the completion of those modifications, which are focused in three areas:

- Ice Management
  - Revised front feeder
  - Hydraulic lift system
  - Conveyor belt
  - Outboard pontoon
- Oil Movement to Skimmer
  - Ice chute and catwalk
  - Framework changes
  - Spray shield
- Operational and Durability
  - Canopy frame modifications (repairs)
  - Spray bars
  - Enclosure covering
  - Heater

2 BOWHEAD Retrofits

2.1. Ice Management

2.1.1. Revised Front Feeder

The rotating arm and driving motor have been moved further up away from the water; this provides more protection for the motor from ice and allows for larger diameter spiked wheels (see Fig. 2). The paddles/spikes previously attached have been replaced with larger spiked wheels which will be able to grip the ice better and either pull it towards the conveyer mouth or move it away preventing ice blockage at the conveyer mouth. The larger diameter wheels also allow for longer contact with the ice. Fig. 3 is a photo of the new front feeder system (circled in orange).

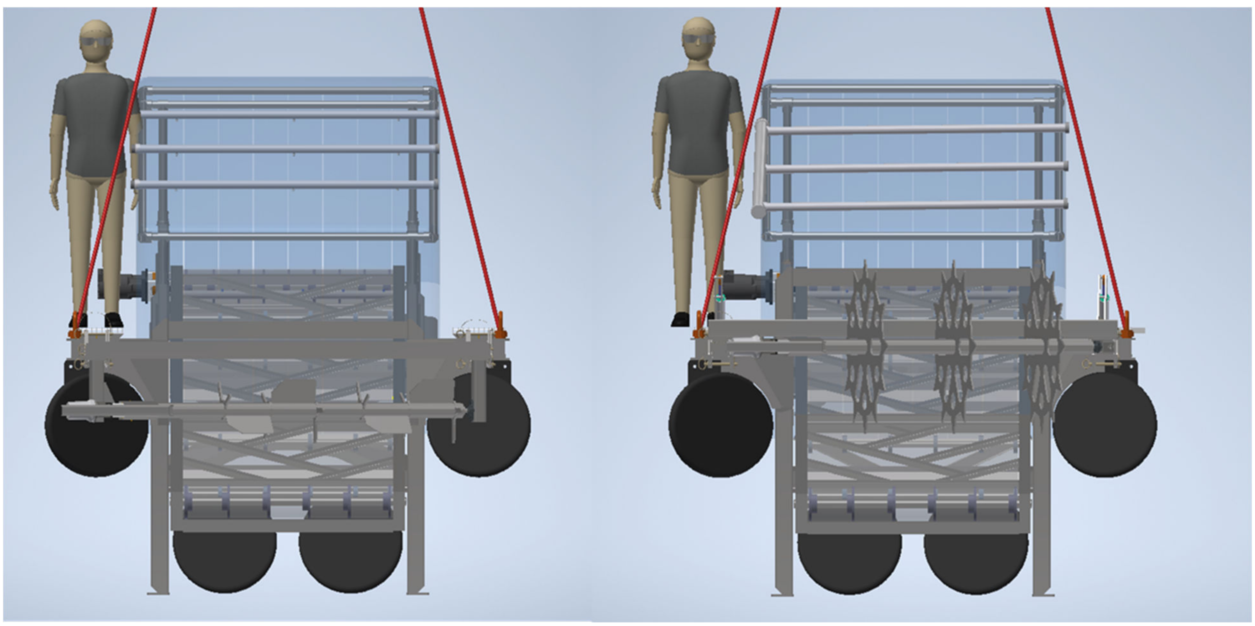

Fig. 2 Redesigned front feeder system on right, original system on left.

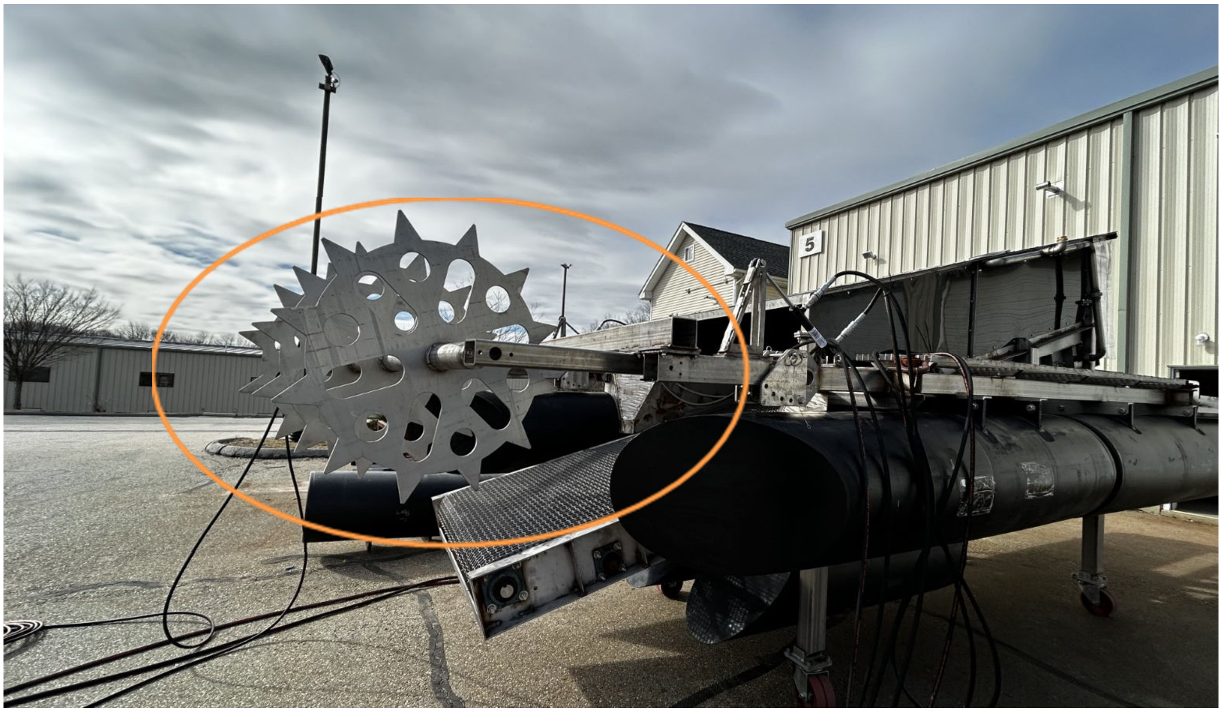

Fig. 3 New front feeder with larger spiked wheels.

2.1.2. Hydraulic Lift System

A large limitation to the initial feeder design was the inability to adjust the height while in use. This has been modified to a hydraulic actuator solution which will allow the user to raise and lower the feeder as needed to accommodate variations in the ice height (see Fig. 4). To accommodate the two new hydraulic actuators an additional hydraulic circuit was added to the Hydraulic Power Unit (HPU). The original design did not adequately account for the weight of the front feeder and the limited moment arm for the applied force and did not work. The system was examined and redesigned. Fig. 5 and Fig. 6 show the completed hydraulic lift system. The left picture in Fig. 5 shows the front lift attachment that was made much stronger and moved as far forward as possible. The pad eye at the aft end was also made stronger (Fig. 5 right picture). Both attachments were upgraded to one-inch stainless steel pins. A new larger hydraulic cylinder (two-inch bore, 9425-pound (lb) capacity) was purchased, tested, and functioned as desired.

Fig. 4 Proposed hydraulic actuator system on right, original configuration on left.

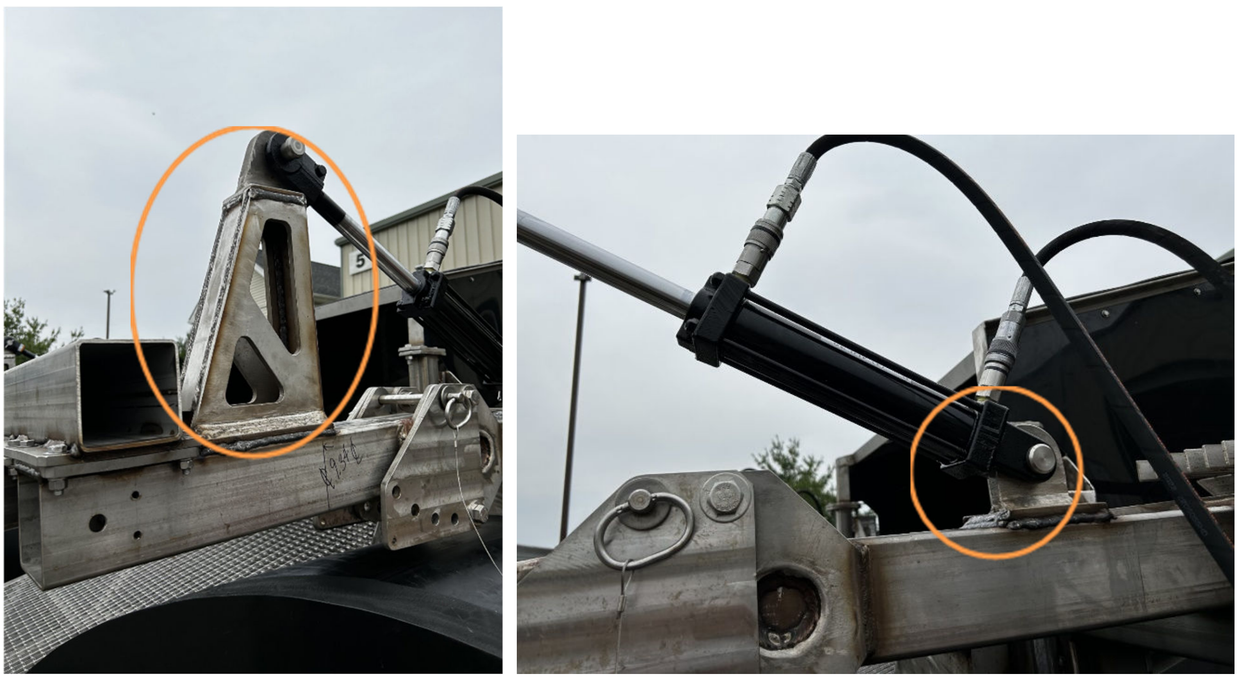

Fig. 5 Redesigned hydraulic lift components.
On left the forward lift attachment, on right the back attachment pad eye.

Fig. 6 Redesigned hydraulic lift.

2.1.3. Conveyor Belt

The original conveyor belt was designed with a combination of roof top flights and pin up flights. The roof top flights (or cleats) were not strong enough and many bent during testing. Since the pin up flights worked effectively, the half of the belt that had the roof top flights was replaced with a new belt section that has the pin up flights. Although difficult to see, the pin up flights are visible in Fig. 7.

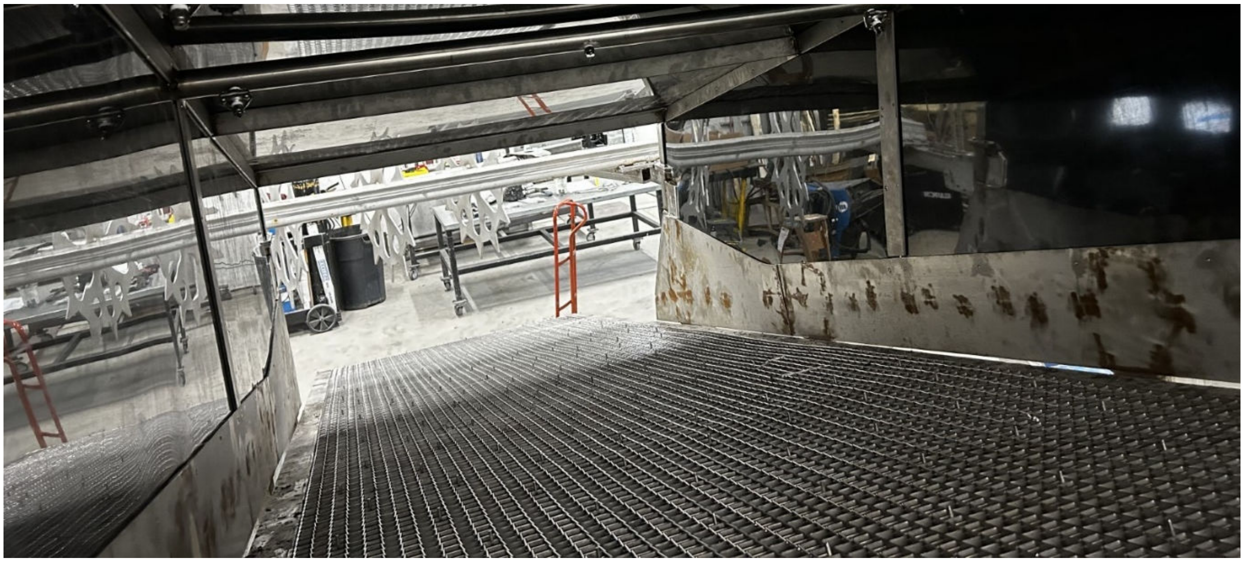

Fig. 7 Photo of inside the spray canopy showing the belt with pin up flights.

2.1.4. Outboard Pontoon

The original outboard (port) pontoon had a wedge shape (see Fig. 8). The thought was that this would allow ice that was too big for the opening to ride up the pontoon and be diverted to the side. However, in practice, with the front feeder system in place, this wedge just created a choke point where ice could get wedged. The front end has been angled to match the inboard (starboard) pontoon in order to alleviate this and allow ice to be directed either into the opening or diverted to the side (see Fig. 9). Since the pontoon is in sections, this just required the replacement of the front half of the port pontoon (see Fig. 10).

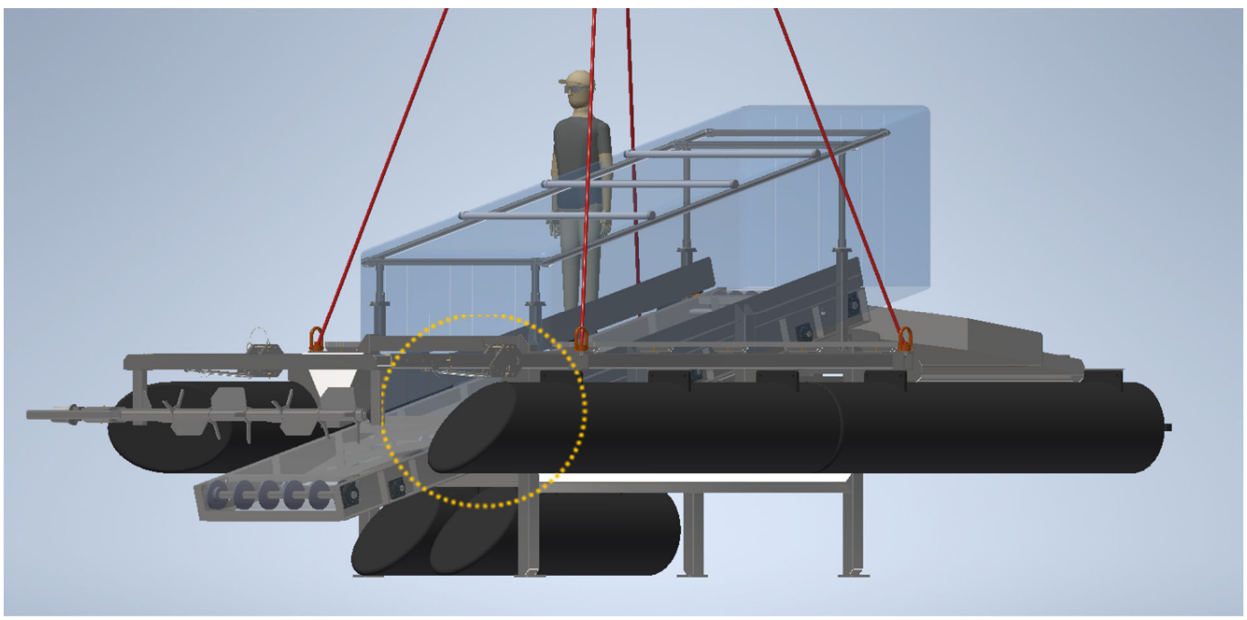

Fig. 8 Angled view of BOWHEAD with outboard pontoon end circled.

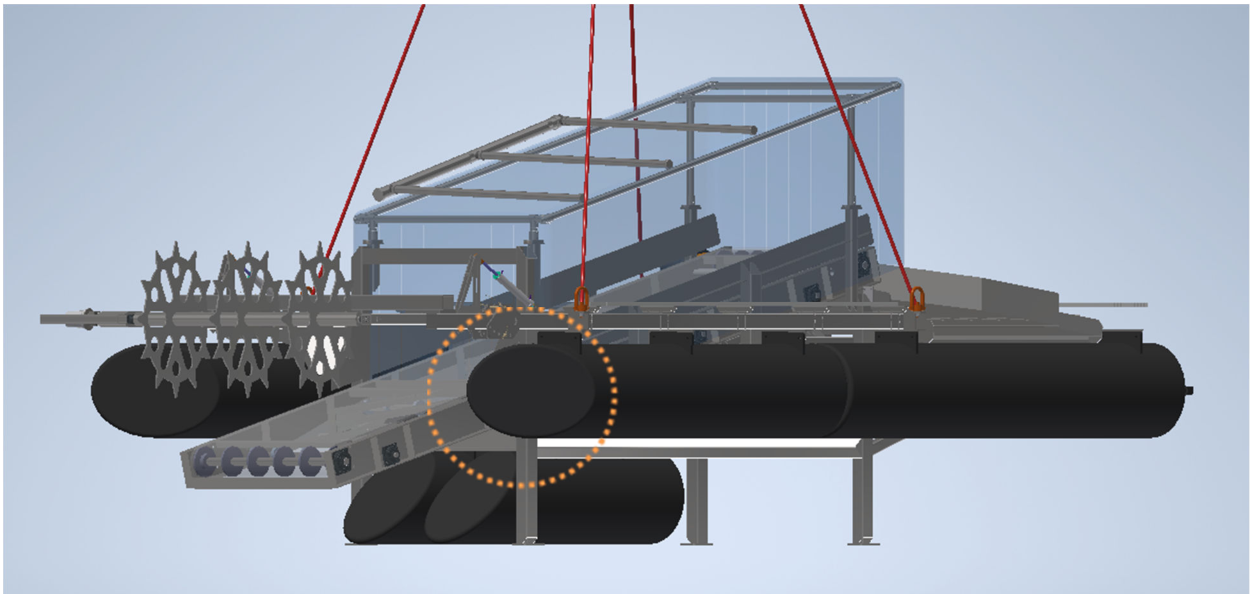

Fig. 9 Angled view of BOWHEAD with outboard pontoon suggested change (circled).

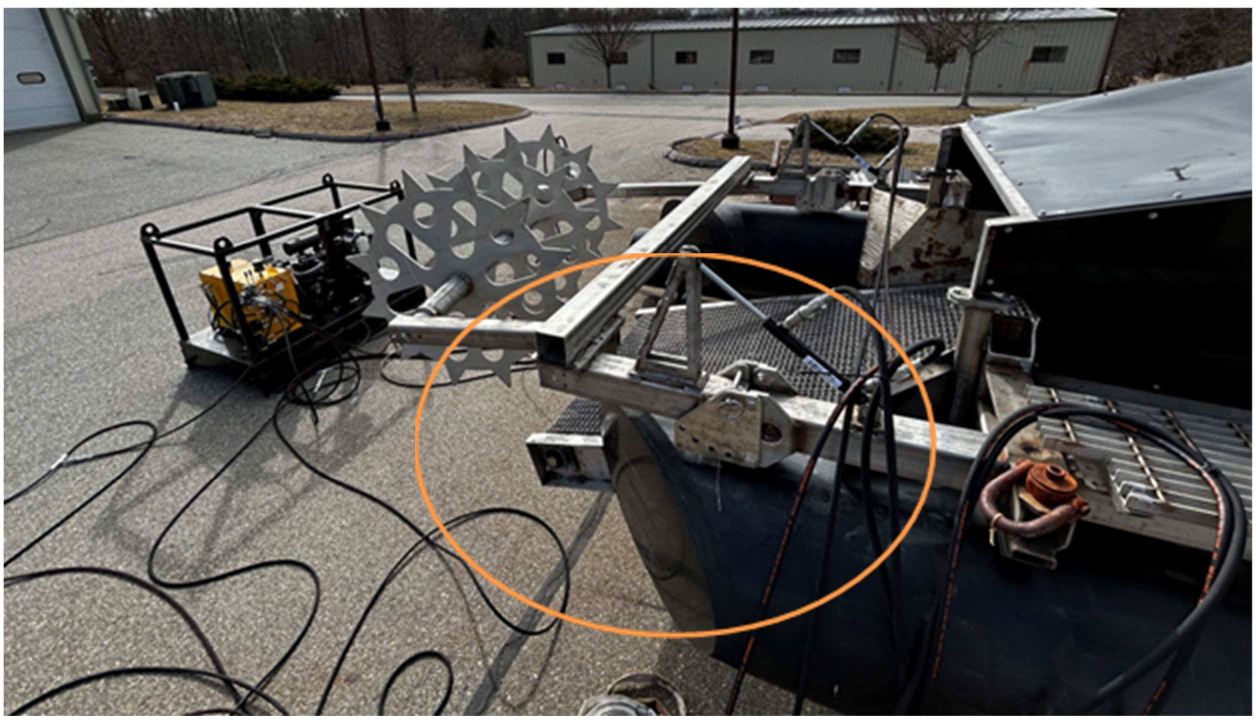

Fig. 10 Photo of replaced port forward pontoon (new angle circled in orange).

2.2. Oil Movement to Skimmer

2.2.1. Ice Chute and Catwalk

During testing we noticed that the ice chute became covered in ice and oil, and this oil was dumped off to the side. In order to recover this oil that would otherwise be lost, the redesign included slots cut in the angled decline of the chute. This allows the oil that is coming off the ice to drop through and be recovered (see Fig. 11). The original design had included a spot to mount the heater on the stern of the BOWHEAD but during testing it was determined that it made more sense to keep the heater on the supply vessel away from the water and oil. In the redesign, a catwalk has been added behind the ice chute to provide a safe way to reach the far side of the system while it is in the water (see Fig. 12 and Fig. 13).

Fig. 11 Photos showing the slots cut into the ice chute (circled in orange).

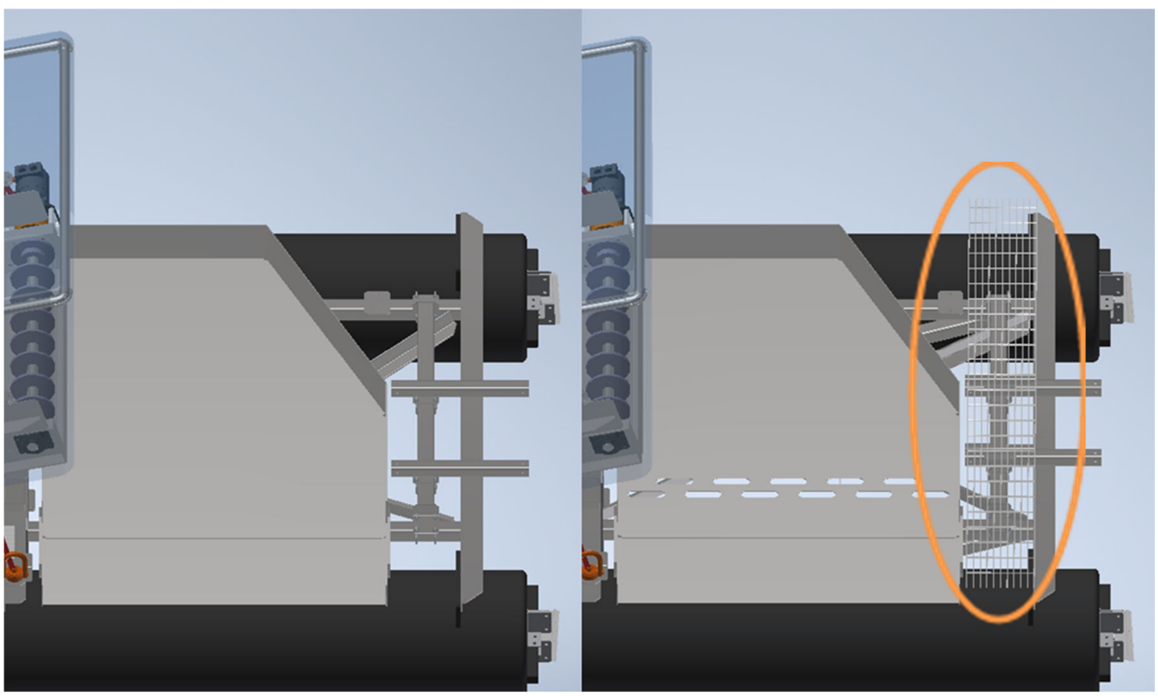

Fig. 12 Ice chute and stern of BOWHEAD as-built (left) and suggested updates (right).

Fig. 13 Photo showing the new catwalk across the stern.

2.2.2. Framework Changes

During testing it became apparent that the supporting framework at the waterline was blocking oil from traveling back to the skimmer. Adjustments to the framework, as shown in the comparison in Fig. 14, would allow for increased water and oil flow beneath the system. It is a little difficult to see, but the changes involve removal of parts of the frame, and relocation of some bracing in order to increase water flow. Serco engineers reviewed the frame and proposed to also modify the conveyor frame to remove waterline blockages (see Fig. 15). The completed frame modifications are shown in Fig. 16 and the updated conveyor bed is shown in Fig. 17.

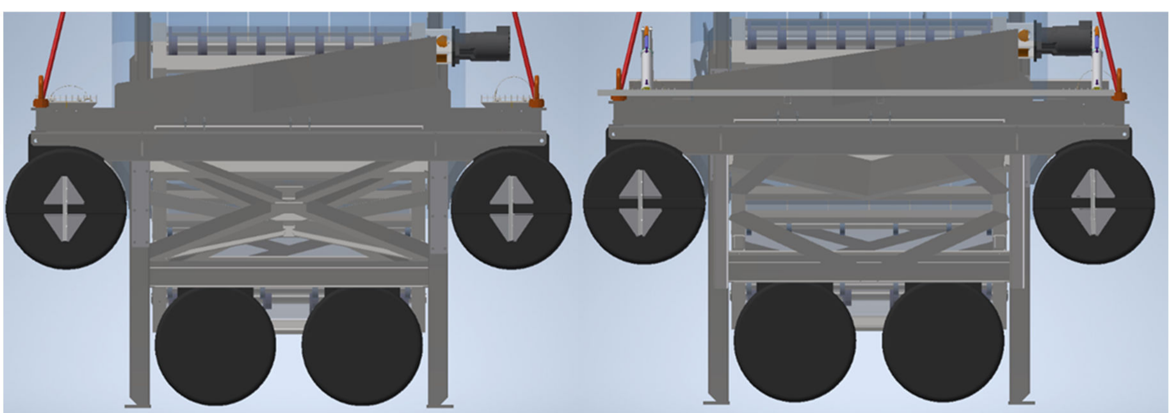

Fig. 14 Framework cleanup at the waterline before (left) and after (right)
View is from astern looking forward; the waterline is indicated by dashed lines.

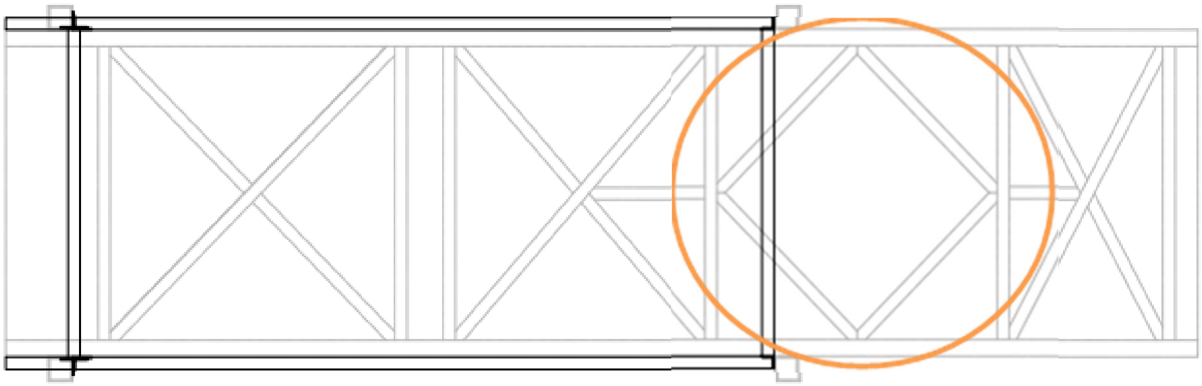

Fig. 15 Design for reworked conveyor bed (change circled in orange)

Fig. 16 Completed frame modifications (circled in orange).

Fig. 17 Photo of reworked conveyor belt – changes to bed circled in orange.

2.2.3. Spray Shield

The spray from the spray bars, although very effective at cleaning off the ice, created a water wall disrupting the path of the oil underneath the conveyor. To alleviate this the redesign includes a spray shield, as shown in Fig. 18, to block the high-powered spray and allow the oil and water to be distributed downward in a less forceful manner. The spray shield will be above the waterline and direct the captured oil and water aft. A photo of the completed spray shield is in Fig. 19.

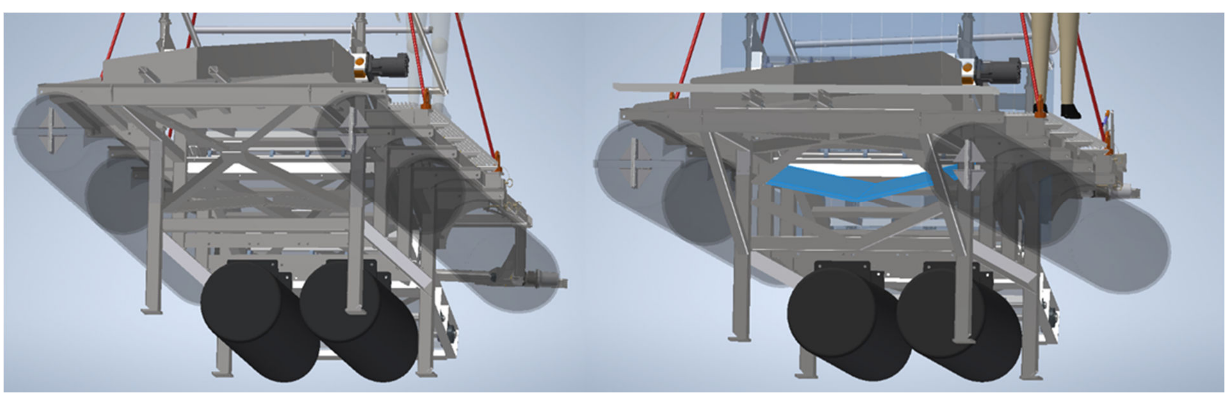

Fig. 18 Framework cleanup at the waterline.

The left shows before the modification and the right shows after (right); the spray shield is highlighted in blue. View is from below, astern looking up and forward.

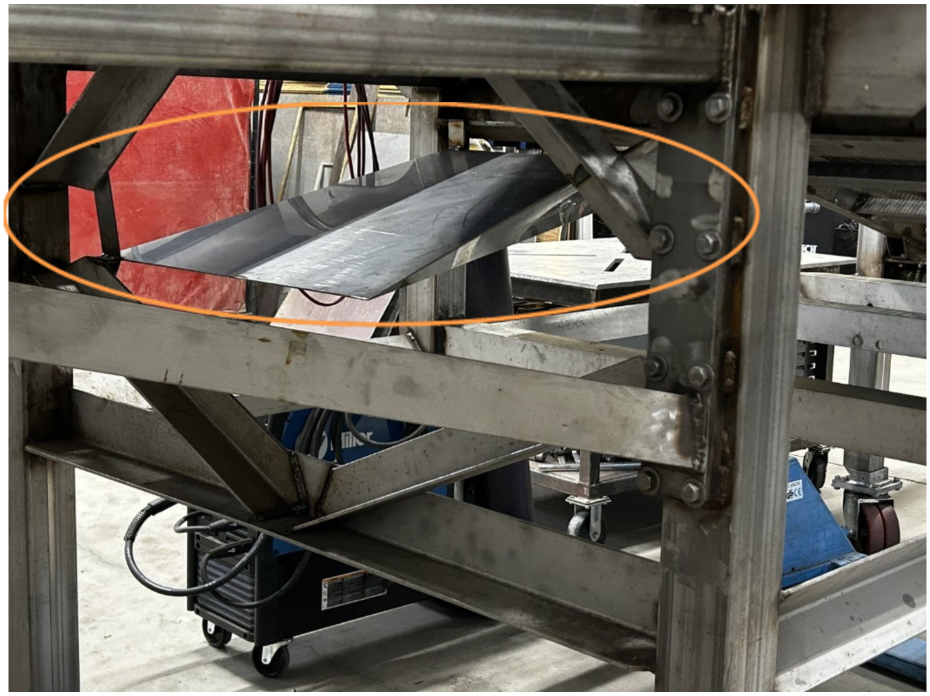

Fig. 19 Photo of completed spray shield (circled in orange).

2.3. Operational and Durability

2.3.1. Canopy Frame Modifications (Repairs)

The original BOWHEAD featured a crossbar across the front of the frame that was quite low; although not an issue with any of the man-made ice blocks, this could have caused issues when dealing with ice of varying sizes in the real-world environment. Fig. 20 the original location of the bar on the left and the proposed new location on the right. The bar was raised allowing for ice size variation. During shipping of the BOWHEAD back to CT, it was damaged requiring replacement of the entire canopy support (see Fig. 21). This provided an opportunity to redesign the entire canopy frame – the height was lowered to basically the height of the proposed new crossbar in Fig. 20 (right) and the frame material switched to lighter weight angle stock instead of piping. This also facilitated the attachment of the high-density polyethylene (HDPE) panels and fixed spray bars (discussed below). Fig. 22 shows the new frame under construction.

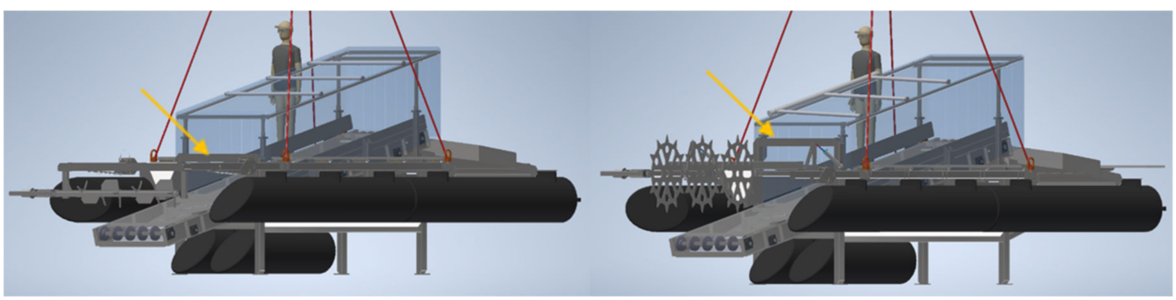

Fig. 20 Angled view of front feeder system.
The original is on the left and proposed new version on right. Arrows indicate the crossbar to be raised.

Fig. 21 Photo of damaged canopy frame.

Fig. 22 Photo of new frame under construction.

2.3.2. Spray Bars

Post testing, we realized the ideal placement of the spray bars was higher up on the frame so that the water spray can be captured by the new spray shield. It would also be better to have more spray bars directed aft rather than forward to ensure deflection of the oil and water aft. The new configuration has the two forward spray bars angled slightly aft and the third, aftmost, spray bar angled slightly forward. This, coupled with the side nozzles angled in, and a spray bar below angled up, provides water coverage on all sides of the ice blocks while directing the water flow into the spray shield. In addition, for increased robustness, the individual polyvinyl chloride (PVC) spray bars have been replaced with stainless steel pipes that are permanently mounted to the frame. All four spray bars have been piped together with a single hose connection (instead of three separate hoses). The connected spray bars with single hose connection are shown in Fig. 23 and Fig. 24.

Fig. 23 Spray bar manifold on port side of the frame (circled in orange), with single hose connection at the top, middle.

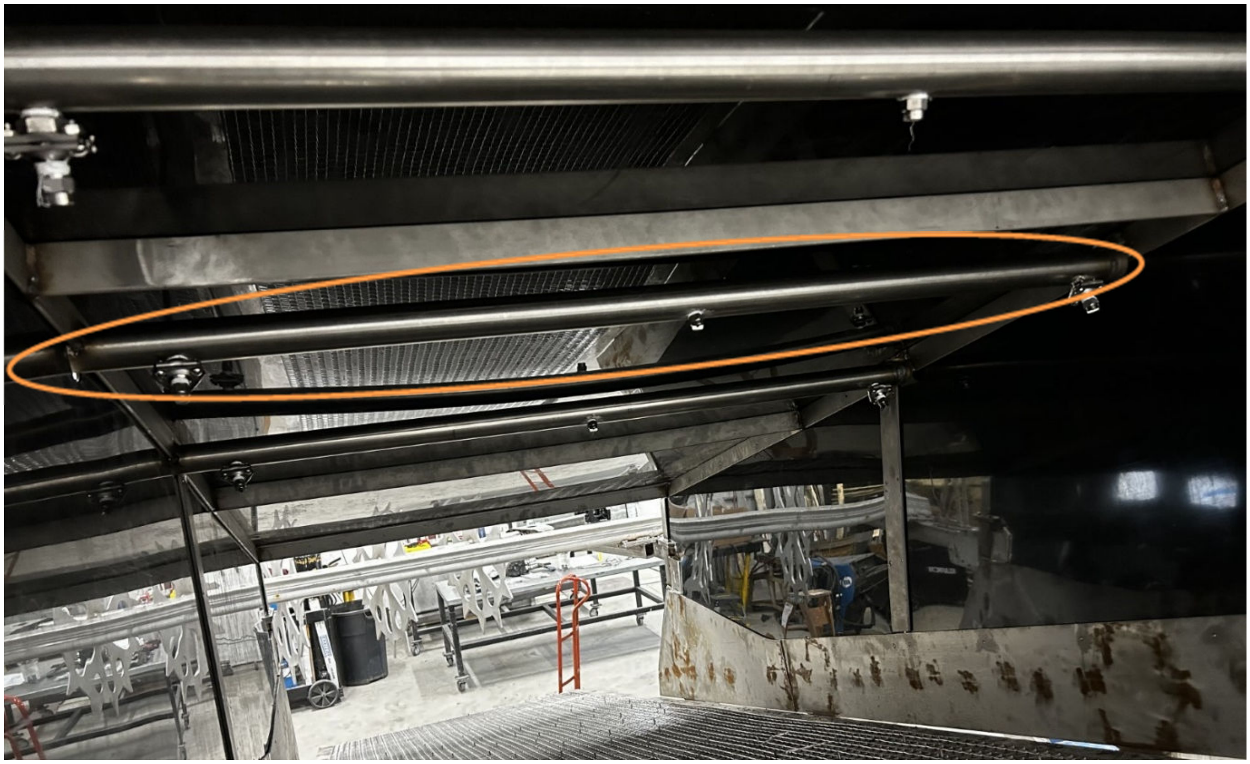

Fig. 24 Photo of inside the spray canopy showing the mounted spray bars (one circled in orange).

2.3.3. Enclosure Covering

The enclosure has been made more insulated and more secure against the wind by replacing all of the tarping with permanent composite panels. The solid panels are attached to the frame with screws so that the panels can still be removed if necessary. The solid panels should also be easier to wash and decontaminate. The new enclosure can be seen in Fig. 25; circled in orange are the flexible strips (similar to what is used on commercial walk-in freezers) to keep the heat in at the stern but let the ice out.

Fig. 25 New solid panel enclosure with flexible strips across the stern to allow the ice to exit (circled in orange).

2.3.4. Heater

As part of the enclosure changes, a better attachment point for the heating duct was designed to allow for easier attachment and removal of the heating duct work (see Fig. 26).

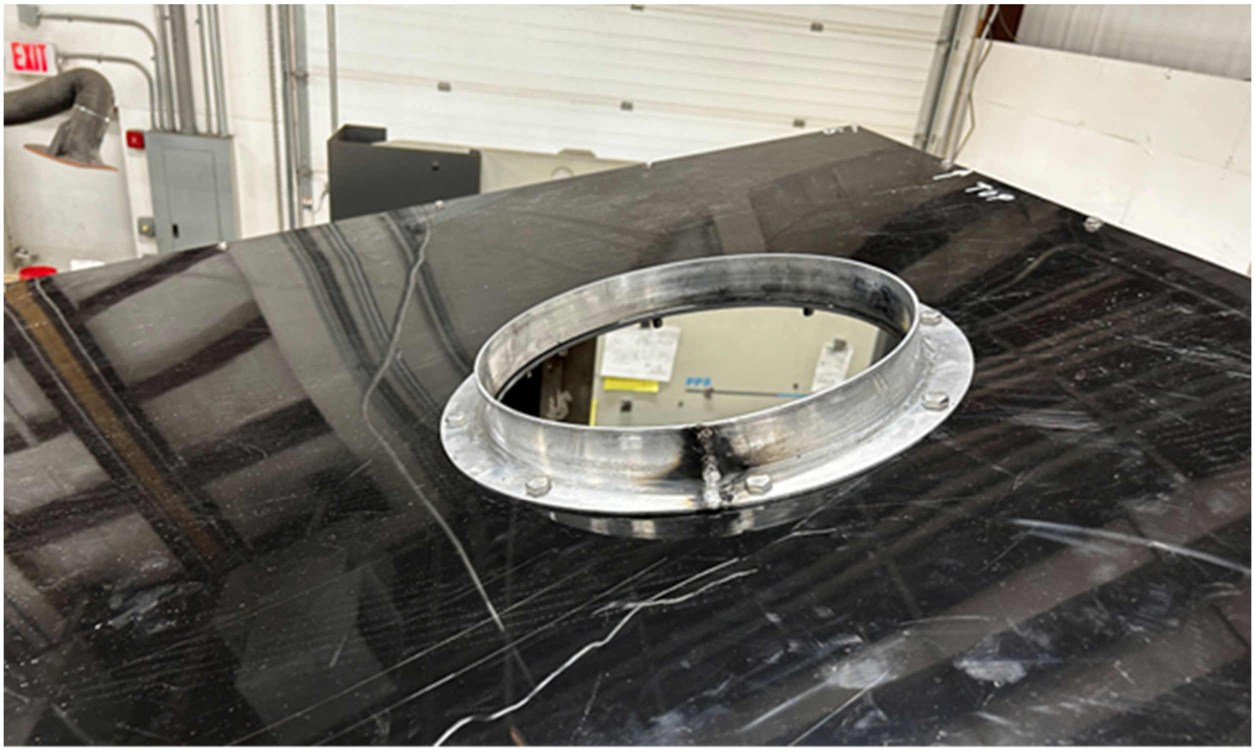

Fig. 26 Heating duct attachment ring on top of enclosure.

3 BOWHEAD2 Test Design

The objective of the February 2024 tests at Ohmsett was to evaluate the performance of the BOWHEAD2 in simulated arctic environmental conditions to include ice and oil and compare the performance to that of standard recovery techniques used currently for ice-infested waters. The test was designed to follow American Society for Testing and Materials (ASTM) Standard F3350-18 (*Standard Guide for Collecting Skimmer Performance Data in Ice Conditions*, 2018) as closely as possible. This section covers the BOWHEAD2 test design. Section 5.2 discusses the standard recovery technique setup.

For this test the BOWHEAD2 system was tethered between the two bridges and used in a dynamic mode (see Fig. 27). A long lane was boomed off with a width of approximately 16ft. The original design length of the lane was 100ft. However, the boom attachments took up about 50ft of length, leaving only 50ft of travel. The team extended the lane to 150ft to compensate and allow sufficient travel space for the BOWHEAD2. The test lane was loaded with ice to get approximately 70 percent coverage, 120 blocks (40” x 40” x 9”). A mix of full-size blocks and pieces was used. 450 gallons of Hydrocal 300 oil was added to the tank to get to a level of 1-inch across the area (see Fig. 28). New oil was occasionally added to replace oil that was recovered in order to maintain the 1-inch oil coverage. Ohmsett personnel used a chiller to lower the tank water temperature during the test to make the ice last longer.

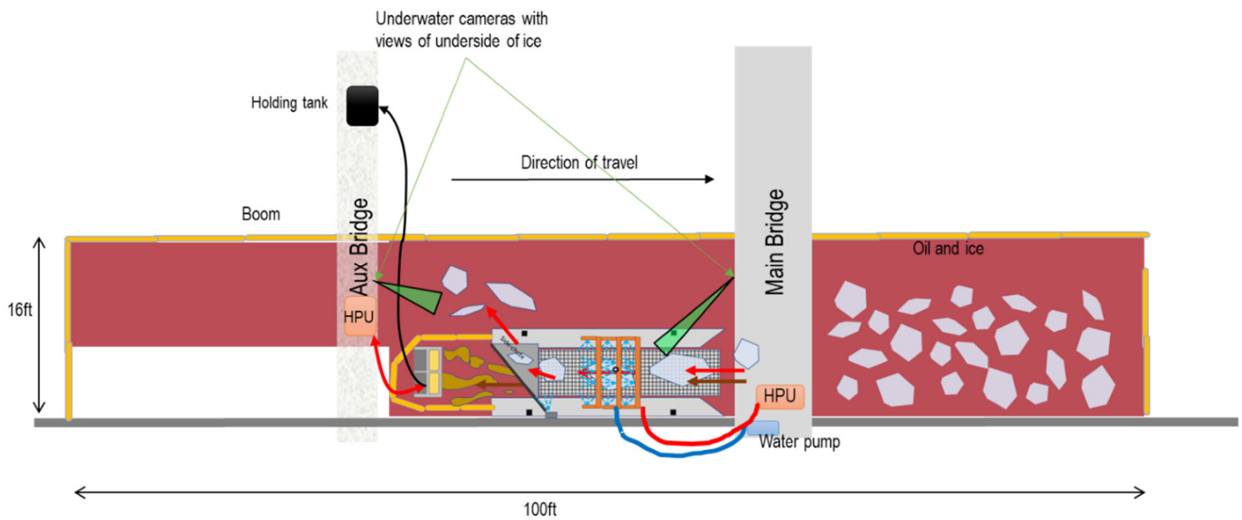

Fig. 27 BOWHEAD2 test configuration.

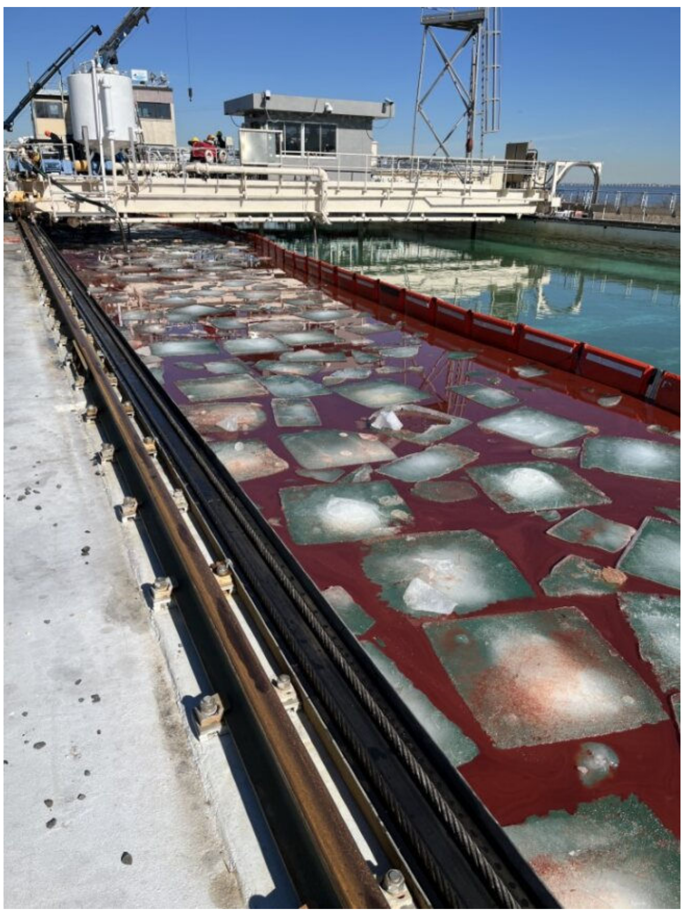

Fig. 28 BOWHEAD2 initial oil and ice setup.

For each trial, the bridges (with BOWHEAD2) advanced down the lane at speeds ranging from 0.1 – 0.7 kt. The BOWHEAD2 conveyer speed was adjusted to maximize the oil recovery rate. The front feeder was used as necessary. The amount of oil recovered, and the time spent in oil recovery, were measured to calculate a recovery rate for each trial. At the end of each trial, the entire system was towed slowly backwards up the lane to the start.

4 BOWHEAD2 Test Results

Table 1 provides a summary of the BOWHEAD2 test data. The table includes the speed of advancement, the total time the BOWHEAD2 was moving, the time during which the skimmer was active and recovering oil, the overall rate of fluid recovery in gallons per minute (gpm), the rate at which fluid was recovered calculated after decanting most of the water from the recovered fluid, and the final recovery rate calculated after lab testing the decanted fluid to determine oil content. More test details can be found in APPENDIX B. All tests were conducted with Hydrocal 300 oil and 70 percent ice coverage. Some test events did not have lab samples so there is no oil recovery rate calculated (marked by the *).

Table 1 BOWHEAD2 dynamic test matrix

#	Speed (kt)	Test Time (minutes)	Recovery Time (minutes)	Total Fluid Recovery Rate (gpm)	Decanted Fluid Recovery Rate (gpm)	Oil Recovery Rate (gpm)
1	0.1	8:37	5:51	19.9	2.0	1.2
2	0.1	8:23	7:30	8.4	2.3	1.5
3	0.1	8:17	7:00	19.2	4.8	3.3
4	0.1	8:33	6:45	9.5	2.2	0.8
5	0.3	2:45	1:16	17.3	4.6	1.2
6	0.3	2:25	1:46	37.1	3.3	1.0
7	0.1	5:44	3:24	8.6	3.0	*
8	0.3	3:00	2:03	8.5	4.3	*
9	0.1	4:36	2:59	14.2	3.9	*
10	0.3	2:47	1:47	9.81	1.6	*
11	0.5	2:00	1:28	14.9	7.0	*
12	0.5	1:49	1:12	4.9	3.6	*
13	0.3	2:51	2:21	13.6	9.9	8.5
14	0.5	(boom snagged on tow point)				
15	0.5	1:50	1:13	19.2	15.6	10.6
16	0.5	1:45	1:11	16.0	14.8	11.2
17	0.7	1:15	0:56	23.4	15.6	8.6
18	0.7	1:16	0:54	17.8	13.0	7.8
19	0.3	2:44	2:10	20.9	10.8	8.2
20	0.3	2:49	2:01	18.8	2.9	*
21	0.1	7:11	5:48	10.1	1.0	*
22	0.1	6:50	5:49	8.5	1.0	*
23	0.3	2:38	2:13	11.8	2.6	*

In general, the best recovery rates occurred at higher speeds, which is a benefit as higher speeds are easier to maintain for the vessel and also decrease the time spent on recovery. Also, the operator became more proficient with use of the feeder system and belt speed with experience.

4.1. Ice Management

The ice management functions of BOWHEAD2 were improved by the retrofits and performed as designed to meet BSEE's original objectives. The feeder and hydraulic lift improvements definitely helped get the ice onto the belt. Fig. 29 shows ice being fed to the BOWHEAD2 conveyor. The new tips on the belt did not bend. The positioning of the pontoon was a minor improvement, and it may be better to rotate it so that it is angled in to help funnel the oil into the system. This might also funnel more ice in, but the system can easily handle a higher ice load.

Fig. 29 Ice being fed onto BOWHEAD2 conveyor belt.

4.2. Oil Movement to Skimmer

Although oil movement was increased and improved upon previous performance, the flow of oil to the skimmer needs additional improvements. The framework changes to move it out of the oil flow was not entirely successful as the added weight of the new feeder system raised the waterline of the BOWHEAD2 and put more of the frame in the water. The spray shield worked to direct the oil, but also caused problems with oil flow because it was below the waterline with the increased weight. Fig. 30 shows the spray shield interfering with the oil flow. Starting with test 9, the team used a crane to lift the front of the system (simulating adding additional flotation), which appeared to improve the oil flow. Fig. 31 shows the straps from the crane lifting front of BOWHEAD2. Future improvements will need to address additional flotation.

The holes in the ice chute definitely helped deflect more of the oil to the skimmer.

Fig. 30 BOWHEAD2 spray shield interfering with oil flow.

Fig. 31 Straps from crane lifting front of BOWHEAD2.

4.3. Operational and Durability

The catwalk was very useful and provided a much safer walkway for making adjustments to the system. The modified enclosure covering did an excellent job containing the oil spray. Fig. 32 shows the oiled enclosure on the original BOWHEAD versus the clean enclosure on BOWHEAD2 after 3 days of testing.

Fig. 32 Enclosure covering for BOWHEAD (left) and BOWHEAD2 (right).

5 Current Ice Management Tactics

This section describes the current recommended tactics for recovering oil in ice infested waters using an oil skimmer. This method was simulated at Ohmsett and the results were compared to using BOWHEAD2.

5.1. Description of ACS and CISPRI Tactics

Alaska Oil Spill Response Organizations (OSROs) such as the Cook Inlet Spill Prevention and Response, Inc. (CISPRI) and Alaska Clean Seas (ACS) publish tactics to recover oil in ice in their technical/tactics manuals. CISPRI's CI-OW-1 tactic for oil recovery (Fig. 33) is stated for use in up to 30%-50% ice concentration (CISPRI, 2019). This tactic utilizes a boom deployed from the side of a vessel to collect oil and ice. From discussions with CISPRI, in this tactic the boom collects the ice and oil and recovers the oil among the ice with an oleophilic skimmer such as a rope mop skimmer. The vessel then reverses direction to "empty" the ice from the boom and repeats the operation. Providing a system to prevent ice from entering the boomed area should enhance the effectiveness of this tactic and may allow the tactic to be extended to greater ice concentrations such as 70 percent. Fig. 34 from the Oil Spill Recovery Institute files shows an OSRO exercise illustrating use of this tactic. A vessel mounted boom system demonstrates collection of ice and a rope mop skimmer demonstrates how oil in ice would be recovered. ACS does not have a similar tactic listed in their manual (ACS, 2017).

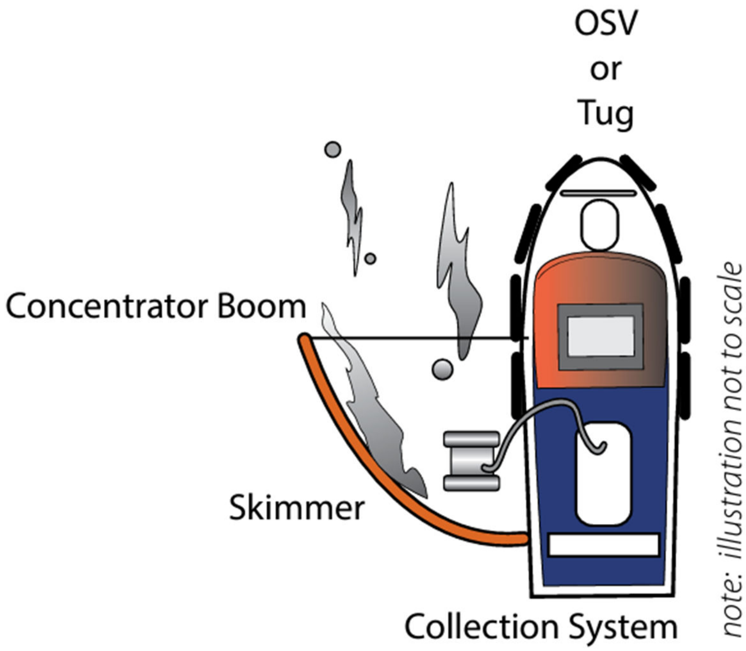

Fig. 33 CISPRI tactic CI-OW-1 for recovering oil in ice concentrations up to 30%-50%.

Fig. 34 Ice collected in a containment boom (left) and rope mop skimmer poised above ice ready to recover oil within the ice (right).

CISPRI Tactic CI-OW-2 and ACS Tactic R-31 are both specified for recovery of uncontained oil in ice concentrations titled “dynamic ice skimming” (CISPRI, 2019) or “free skimming” (ACS, 2017). These similar methods utilize a skimmer deployed in oil and ice to conduct recovery operations as shown in Fig. 35.

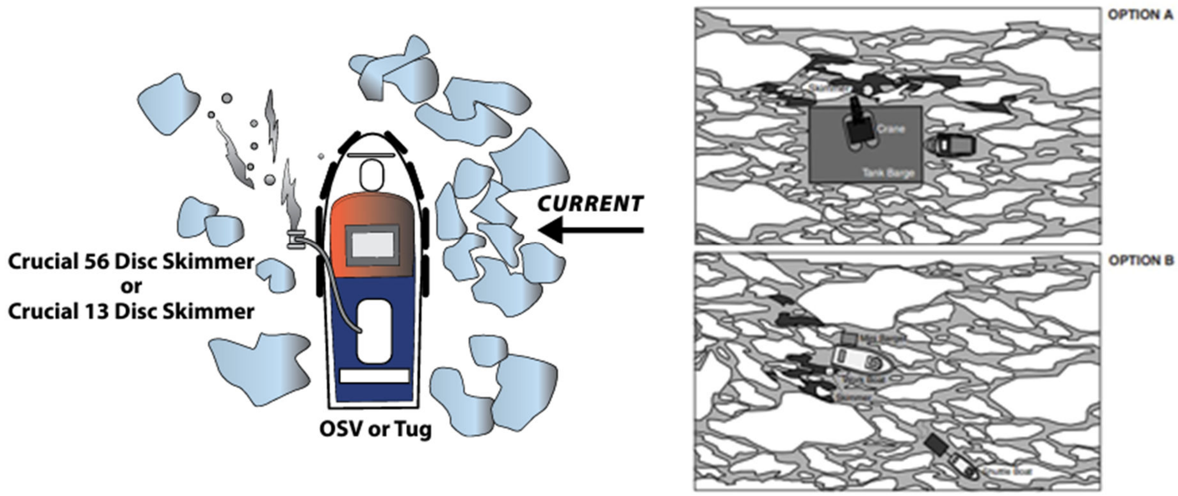

Fig. 35 Dynamic or free ice skimming.

Tactic CI-OW-2from CISPRI Technical Manual (left) and tactic R-31 from ACS Tactics Manual (right).

5.2. Skimmer in Ice Test Setup

For this test, the team set up the tank for a response tactic similar to dynamic or free ice skimming as shown in Fig. 35. As noted earlier, this test was designed to follow ASTM Standard F3350-18 (*Standard Guide for Collecting Skimmer Performance Data in Ice Conditions*, 2018) as closely as possible. The test team kept the 16-ft lane from the week before and set the bridges 16 ft apart (see Fig. 36). The team filled the lane with enough ice blocks to produce approximately 70 percent ice coverage (100 blocks). Oil was added to the tank to get to a level of 1-inch across the area, using about 300 gallons of Hydrocal 300.

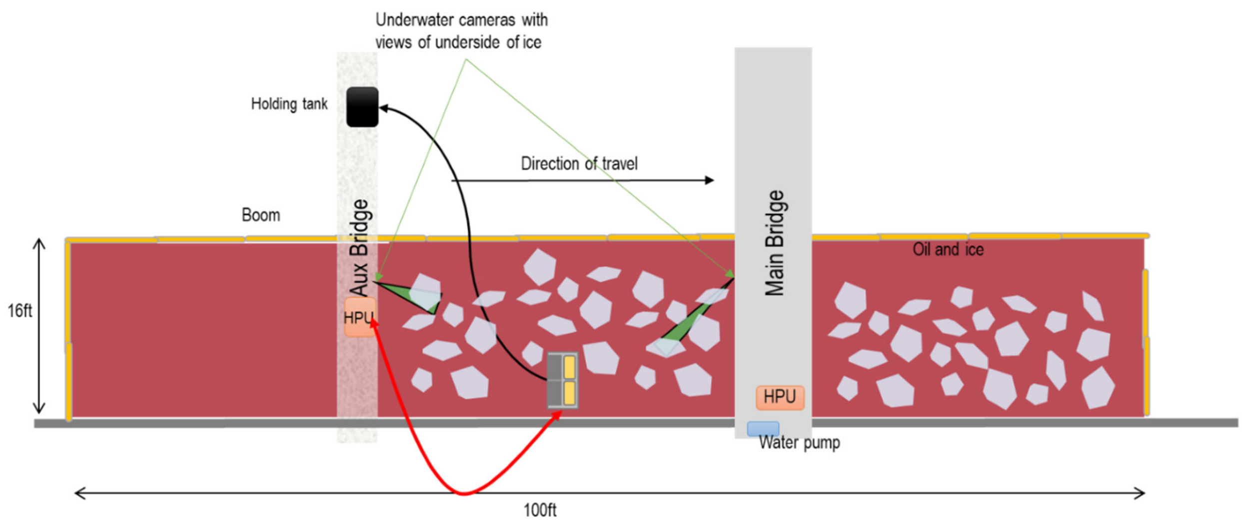

Fig. 36 Traditional dynamic test configuration.

The original plan was for the bridges to advance down the lane at speeds ranging from 0.1 – 0.5 kt, similar to the BOWHEAD2 testing. The team modified this to have the test be more similar to tactics described in Section 5.1. The skimmer was suspended from a crane. The crane operator maneuvered the skimmer to get to patches of oil. When no good patches could be found between the bridges, the bridges were moved to find better patches. ASTM Standard F3350-18 calls for each test to continue until one third of the oil has been removed. The team modified this to run the tests for about the average length of time in other skimming in ice tests (Ross, 2013), finally settling on 17 minutes per run for the 70 percent ice coverage.

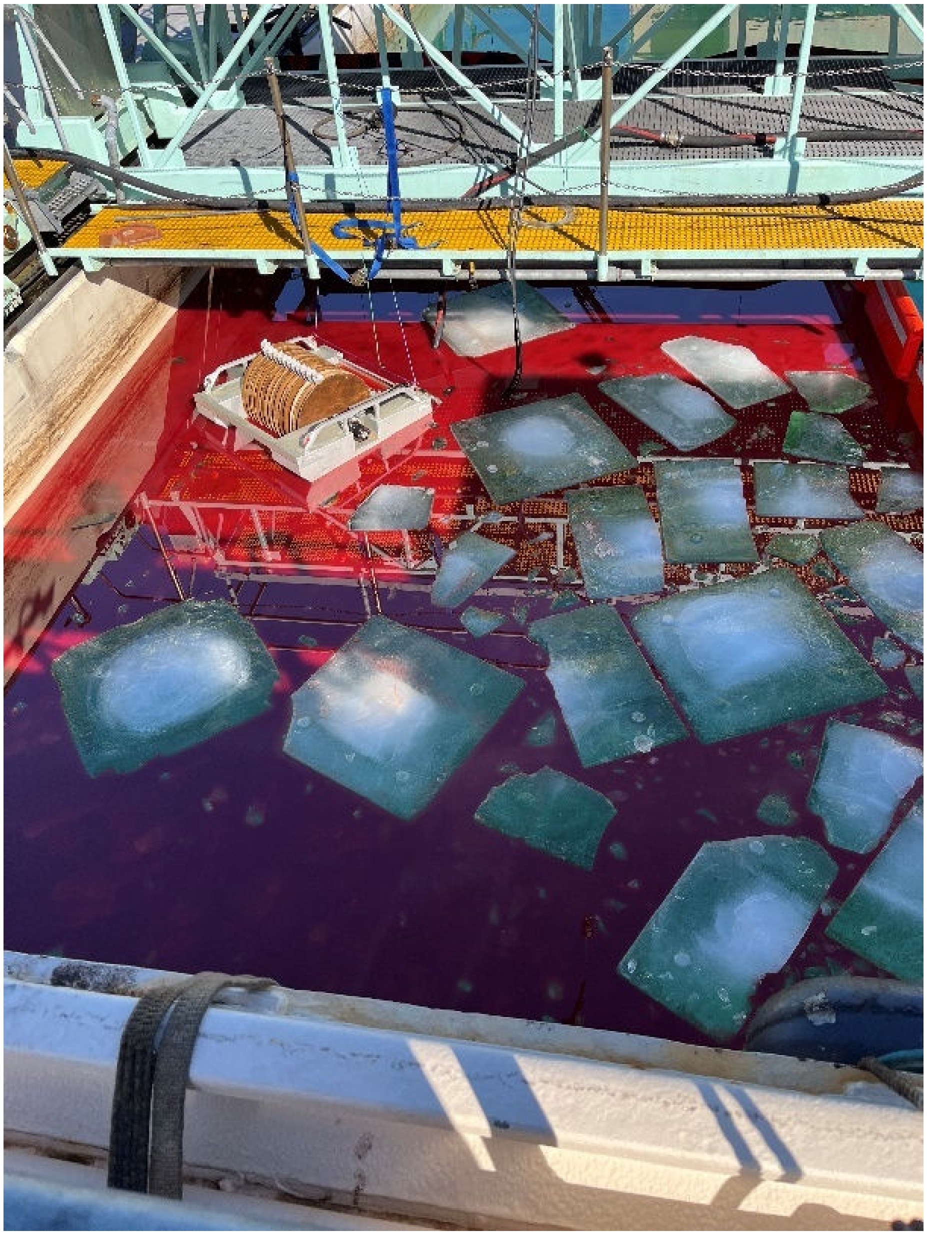

Fig. 37 Crucial 13 skimmer at the beginning of its tests.

On the last day of testing the wind pushed most of the ice to one end of the lane. This allowed the team to run three recovery tests in approximately 30 percent ice coverage (see Fig. 38). The ice piled at the other end of the lane allowed for one more test at approximately 70 percent ice coverage (see Fig. 39).

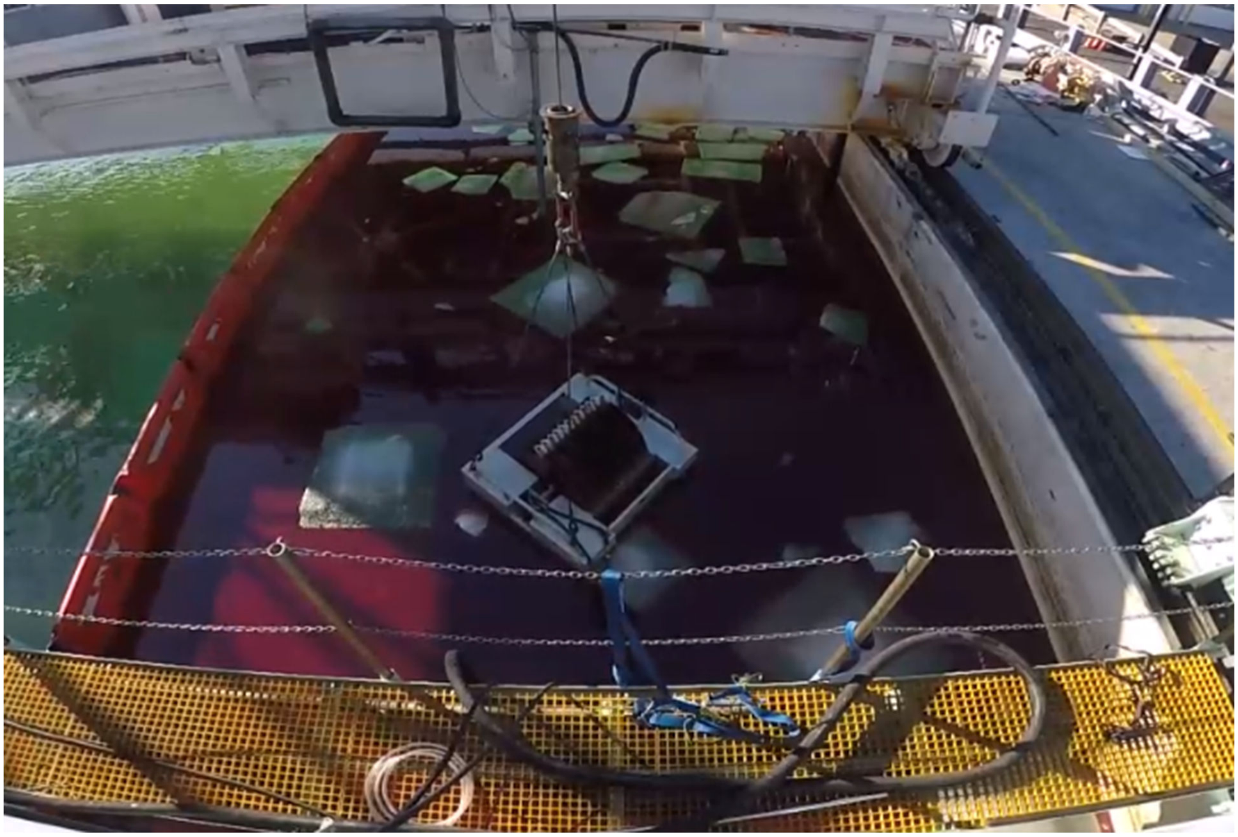

Fig. 38 Ice at one end of the lane providing approximately 30 percent coverage for runs 29-31.

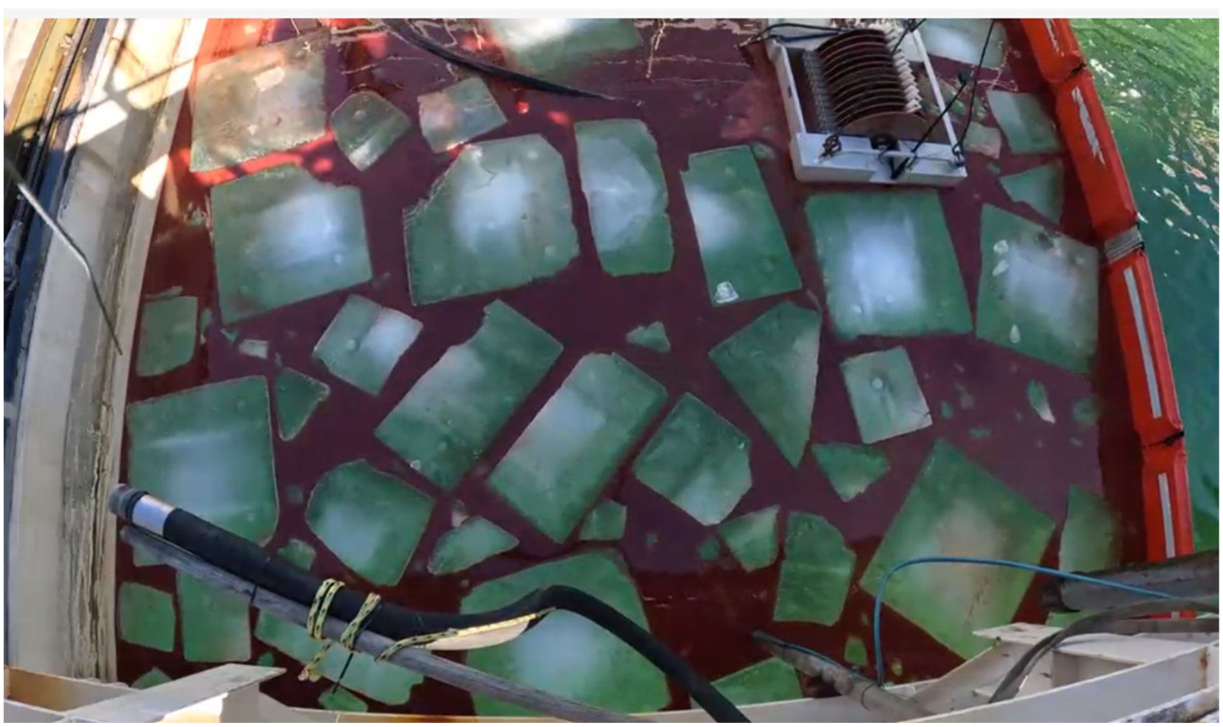

Fig. 39 Ice at the other end of the lane providing approximately 70 percent coverage for run 32.

5.3. Skimmer in Ice Test Results

Table 2 provides a summary of the skimmer alone test data. The table includes the approximate ice coverage, which is 70 percent for most of the tests and 30 percent for three of the last four tests. The 30 percent ice coverage tests were for comparison to data associated with ASTM Standard F3350-18. The table also lists the bridge movement (if any), the time during which the skimmer was active and recovering oil, the overall rate of fluid recovery in gallons per minute (gpm), the rate at which fluid was recovered calculated after decanting most of the water from the recovered fluid, and the final recovery rate calculated after lab testing the decanted fluid to determine oil content. The last three columns are similar to those in the BOWHEAD2 tests. More detail can be found in APPENDIX B. A standard test length of 17 minutes was chosen for the 70% ice coverage tests to allow sufficient time for measurable quantities of oil to be recovered. For the 30% coverage tests, since the recovery rate was much higher, shorter test durations of 5 minutes were used. As expected, the skimmer had a better recovery rate at 30 percent ice than 70 percent. The team noted that when the skimmer pulled oil towards it, the ice flowed with the oil (see Fig. 40).

Fig. 40 Oil and ice flowing towards skimmer.

Table 2 Crucial 13 disc skimmer dynamic test matrix.

#	Ice coverage	Bridge Movement	Recovery Time (minutes)	Total Fluid Recovery Rate (gpm)	Decanted Fluid Recovery Rate (gpm)	Oil Recovery Rate (gpm)
24	~ 70%	10-ft jumps	17:00	2.7	0.8	0.8
25	~ 70%	10-ft jumps	17:00	2.6	1.2	1.2
26	~ 70%	10-ft jumps	17:00	2.7	1.4	0.7
27	~ 70%	10-ft jumps	17:00	3.8	2.1	1.4
28	~ 70%	10-ft jumps	17:00	3.5	1.0	1.0
29	~ 30%	None	5:00	11.3	7.9	7.9
30	~ 30%	None	5:00	8.1	5.7	5.7
31	~ 30%	None	5:00	9.6	5.7	5.7
32	~ 70%	None	17:00	4.4	2.1	2.1

6 Conclusions

Even with some continuing issues with oil flow to the skimmer, the BOWHEAD2 ice management system and Crucial 13 disk skimmer performed much better than the Crucial 13 disk skimmer alone using traditional tactics. With the system operating at the higher speed where the best recovery was seen, the BOWHEAD2 oil recovery rates in the 70% ice coverage ranged from ~8-11gpm with an average of 9.5 gpm. This is compared to 0.7-2.1 gpm (average of 1.2 gpm) for the skimmer alone in 70% ice coverage, a factor of almost 8 improvement.

7 Recommendations

The BOWHEAD2 would be more useful for oil recovery with some additional modifications to the frame to increase the oil flow to the skimmer. One of the frame modifications planned was not actually accomplished due to oversight. Additional flotation is also needed to compensate for the increased weight forward. During the testing, the crane was used as a substitute for this.

An even greater increase in oil recovery rate could be obtained with a larger redesign effort. In the original design we were very concerned about managing the ice and the system is very robust in this regard. In fact, it can handle a much greater amount of ice than is possible to funnel into the system. We also overestimated how much ice would need to go through the system vs. would go around it. By making the system wider, more oil can be captured and funneled to the back for recovery. The feeder and belt size can remain the same as it can handle the increased ice load this would also create. This wider design would also open up additional channels for the oil to flow aft along the outsides of the conveyor belt.

The original design also included a lot of structure underneath to enable the system to be free-standing when out of the water. This is unnecessary and impedes oil/water flow. Basically, everything below the surface would be removed – except for the end of the conveyor (this is still needed slightly below the surface to assist in picking up the ice). All structure would be across the top of the pontoons – much like a pontoon boat. A separate cradle could be provided for out-of-water storage of the system.

The new design would feature only the surface pontoons (eliminating the subsurface ones). To provide sufficient buoyancy, these could be made larger in diameter and extend farther forward (compared to the current design). In the new design the booms and the beams attaching the pontoons to the center structure (conveyor and canopy) would be removable. This would allow the system to be transported in a standard ISO container (maximum width of ~7.5 ft).

In summary the ideal future design (BOWHEAD3) would include:

- Wider structure (increased swath)
- Everything but conveyor on top of pontoons (no underwater structure)
- Larger pontoons (diameter and length)
- Removable pontoons and supports (maximum width <7.5ft)

A concept drawing of this is included in Fig. 41.

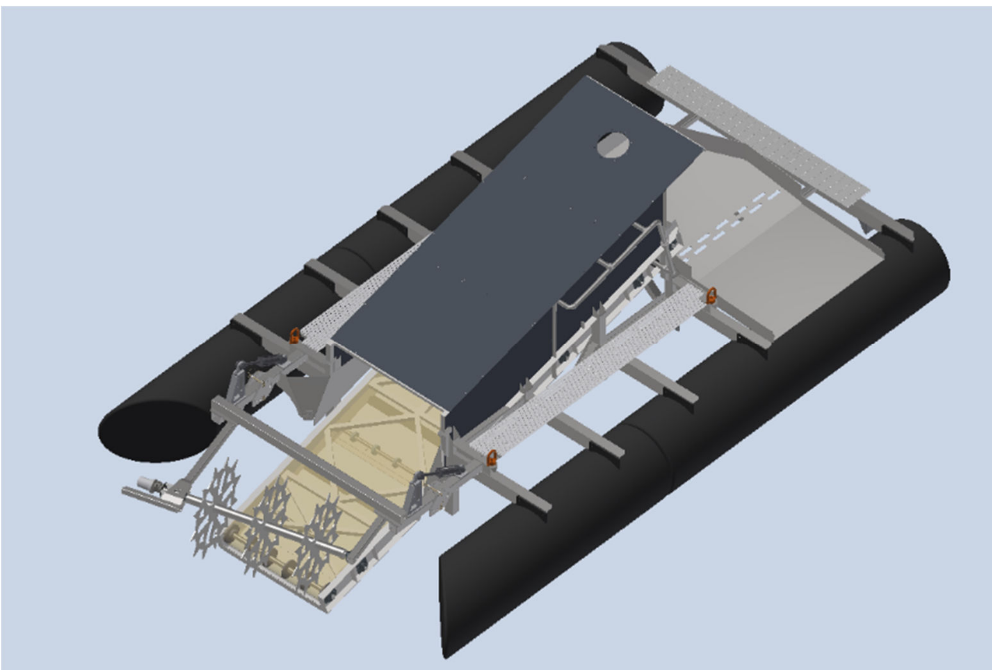

Fig. 41 Proposed BOWHEAD3 design.

8 Acknowledgements

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9 Disclaimer

The views expressed herein are those of the authors and are not to be construed as official or reflecting the views of BSEE, or any agency of the U.S. Government.

10 References

ACS. (2017). *Alaska Clean Seas Technical Manual Volume 1 Tactics Descriptions* [Technical Manual].

CISPRI. (2019). *Technical Manual*.

EPPR. (2015). Guide to Oil Spill Response in Snow and Ice Conditions in the Arctic.

ICCOPR. (2021). *Oil Pollution Research and Technology Plan: FY 2022-2027*. https://safety4sea.com/wp-content/uploads/2022/01/ICCOPR-ORTP-Plan-2022_01.pdf

Jensen, H., Lorenzo, T., & Solsberg, L. (1999). *Mechanical Oil Recovery in Ice Infested Waters (MORICE) - Phase 3* [BSEE Report](310ac).

Jensen, H., & Mullin, J. (2003). MORICE—new technology for mechanical oil recovery in ice infested waters. *Marine Pollution Bulletin*, *47*(9-12).

Jensen, H., & Solsberg, L. (2000). *Mechanical Oil Recovery in Ice Infested Waters (MORICE) - Phase 4* [BSEE Report](310ad).

Jensen, H., & Solsberg, L. (2001). *Mechanical Oil Recovery in Ice Infested Waters (MORICE) - Phase 5* [BSEE Report](310ae).

Jensen, H., & Solsberg, L. (2002). *Mechanical Oil Recovery in Ice Infested Waters (MORICE) - Phase 6 - Final testing in Oil and Ice* [BSEE Report](310af).

Johannessen, B. O., Jensen, H., Solsberg, L., & Lorenzo, T. (1996). *Mechanical Oil Recovery in Ice Infested Waters (MORICE) - Phase 1* [BSEE Report](310aa).

Johannessen, B. O., Lorenzo, T., Jensen, H., & Solsberg, L. (1998). *Mechanical Oil Recovery in Ice Infested Waters (MORICE) - Phase 2* [BSEE Report](310ab).

Johnson, G. W. (2021). *Serco BOWHEAD* [Final Report]. https://www.bsee.gov/sites/bsee.gov/files/research-reports/1102aa.pdf

Johnson, G. W., Grayson, C., Dykstra, K., & Fitzpatrick, M. (2016). *Methods for Mechanical Removal of Surface Oil in Ice Infested Waters (ICEHORSE I)* [ICEHORSE Final Report](Deliverable 7).

Johnson, G. W., Grayson, C., Dykstra, K., & Fitzpatrick, M. (2018). *ICEHORSE II Development and Testing* [ICEHORSE Final Report](Deliverable 7).

Ross, S. (2013). *Skimmer Tests in Drift Ice: Ice Month 2013 at Ohmsett* [Report](Prepared for Bureau of Safety and Environmental Enforcement).

Standard Guide for Collecting Skimmer Performance Data in Ice Conditions. (2018). [International Standard](F3350-18).

Wilkinson, J., Beegle-Krause, C. J., Evers, K.-U., Hughes, N., Lewis, A., Reed, M., & Wadhams, P. (2017). Oil Spill Response Capabilities and Technologies for Ice-covered Arctic Marine Waters: A Review of Recent Developments and Established Practices. *Ambio*, *46*.

APPENDIX A: Technical Summary

REPORT TITLE: Advancing the BOWHEAD Ice Management System

CONTRACT NUMBER(S): 140E0122C0007

FISCAL YEARS(S) OF PROJECT FUNDING: FY2022-2024

CUMULATIVE PROJECT COST: $298,022

COMPLETION DATE OF REPORT: 2 August 2024

BSEE COR(S): Kristi McKinney, Ann Slaughter

BSEE CO(S): William Rilee

PROJECT MANAGER(S):Dr. Gregory Johnson

AFFILIATION OF PROJECT MANAGER: Serco, Inc.

ADDRESS: 1 Chelsea St., Ste 200, New London CT 06320

PRINCIPAL INVESTIGATOR(S)*: Dr. Gregory Johnson

KEY WORDS: Arctic, Oil Spill Recovery, Oil in Ice

* The affiliation of the Principal Investigators(s) may be different than that listed for Project Manager(s).

APPENDIX B: Test Data

Table B-1 BOWHEAD2 complete test data

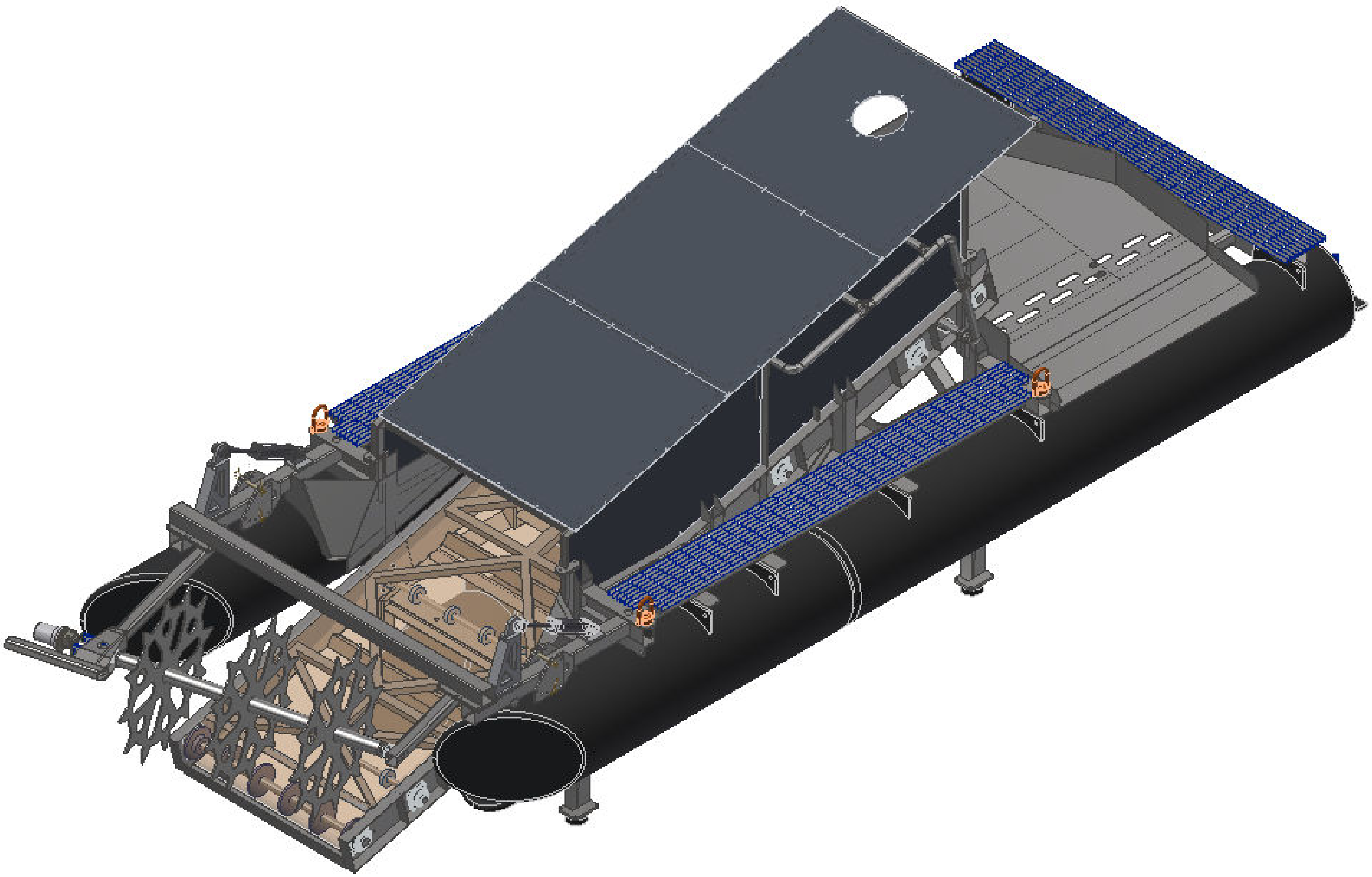
BOWHEAD2										From Ohmsett Data Sheets				
Test #	Date	Approx. Start time	Speed	Test Time	Recovery Time	Fluid Recovered		Fluid after Decant		Recovered Oil			Notes	Oil Added
						gal	gpm	gal	gpm	gal	gpm	Eff %		
GPS Time:		8:20:55	Kongsberg time:		18:37:11	Time	10:16:16	70% Ice coverage					Water Temp: 31-33, Air Temp: 29, Wind: light from North, Water surface: calm	450 gal
1	7-Feb	0833	0.1	8:37	5:51	116.6	19.9	11.7	2.0	6.9	1.2	6%	some small ice blocks were in the pocket blocking skimmer recovery	0
2	7-Feb	0911	0.1	8:23	7:30	62.7	8.4	17.5	2.3	11.5	1.5	18%	not great flow back to skimmer	37
3	7-Feb	0944	0.1	8:17	7:00	134.1	19.2	33.5	4.8	22.8	3.3	17%	spray on - more volume but more water? Flow still a problem. Removed ballast from stern	0
4	7-Feb	1124	0.1	8:33	6:45	64.1	9.5	14.6	2.2	5.2	0.8	8%		20
5	7-Feb	1155	0.3	2:45	1:16	21.9	17.3	5.8	4.6	1.5	1.2	7%	started with a large jamb of ice at start of test (oops). At times not much oil in front	0
6	7-Feb	1204	0.3	2:25	1:46	65.6	37.1	5.8	3.3	1.8	1.0	3%	air temp at 37 by 1130	0
GPS Time:		13:29:50	Kongsberg time:		23:47:05	Time	10:17:15	70% Ice coverage					Water Temp: 31-33, Air Temp: 41, Wind: none, Water surface: calm	
7	7-Feb	1347	0.1	5:44	3:24	29.2	8.6	10.2	3.0				rig oil dispensing in front of bowhead at ~20gpm to simulate having wider opening funneling oil	70
8	7-Feb	1418	0.3	3:00	2:03	17.5	8.5	8.7	4.3				same setup	151
9	7-Feb	1448	0.1	4:36	2:59	42.3	14.2	11.7	3.9				rig crane to lift bowhead in front a couple of inches - simulate better floatation - dispense oil	99
10	7-Feb	1456	0.3	2:47	1:47	17.5	9.81	2.9	1.6				same setup	52
GPS Time:		8:55:10	Kongsberg time:		19:12:29	Time	10:17:19	70% Ice coverage					Water Temp: 31-33, Air Temp: 41, Wind: none, Water surface: calm.	
11	8-Feb	0900	0.5	2:00	1:28	21.9	14.9	10.2	7.0				20 gpm dispense	35
12	8-Feb	0906	0.5	1:49	1:12	5.8	4.9	4.4	3.6				spray on 20gpm dispense	37
13	8-Feb	0919	0.3	2:51	2:21	32.1	13.6	23.3	9.9	20.1	8.5	63%	spray on 20 gpm dispense	56
GPS Time:		14:57:25	Kongsberg time:		1:14:45	Time	10:17:20	70% Ice coverage					Water Temp: 32-34, Air Temp: 46, Wind: none, Water surface: calm. Added 75 blocks of ice	
14	8-Feb	1458	0.5										no spray no oil disp no pumping - aborted run when snagged boom on towpoint and broke the attachment point	
GPS Time:		8:34:10	Kongsberg time:		18:51:34	Time	10:17:24						Water Temp: 32-34, Air Temp: 46, Wind: none, Water surface: calm.	
15	9-Feb	0847	0.5	1:50	1:13	23.3	19.2	18.9	15.6	12.9	10.6	55%	spray on - no oil dispense	
16	9-Feb	0900	0.5	1:45	1:11	18.9	16.0	17.5	14.8	13.3	11.2	70%	no spray - no oil dispense	
17	9-Feb	0910	0.7	1:15	0:56	21.9	23.4	14.6	15.6	8.0	8.6	37%	spray on - no oil dispense	
18	9-Feb	0923	0.7	1:16	0:54	16.0	17.8	11.7	13.0	7.0	7.8	44%	no spray - no oil dispense	
19	9-Feb	0932	0.3	2:44	2:10	45.2	20.9	23.3	10.8	17.7	8.2	39%	spray on - no oil dispense	
GPS Time:		10:45:25	Kongsberg time:		21:02:48	Time	10:17:23	70% Ice coverage					Water Temp: 34, Air Temp: 45, Wind: Light from South, Water surface: calm.	
20	9-Feb	1050	0.3	2:49	2:01	37.9	18.8	5.8	2.9				spray off - no oil dispense	
21	9-Feb	1108	0.1	7:11	5:48	58.3	10.1	5.8	1.0				spray off - no oil dispense	
22	9-Feb	1124	0.1	6:50	5:49	49.6	8.5	5.8	1.0				spray off - no oil dispense	
23	9-Feb	1139	0.3	2:38	2:13	26.2	11.8	5.8	2.6				spray off - no oil dispense, remove boom at wall side of pocket	

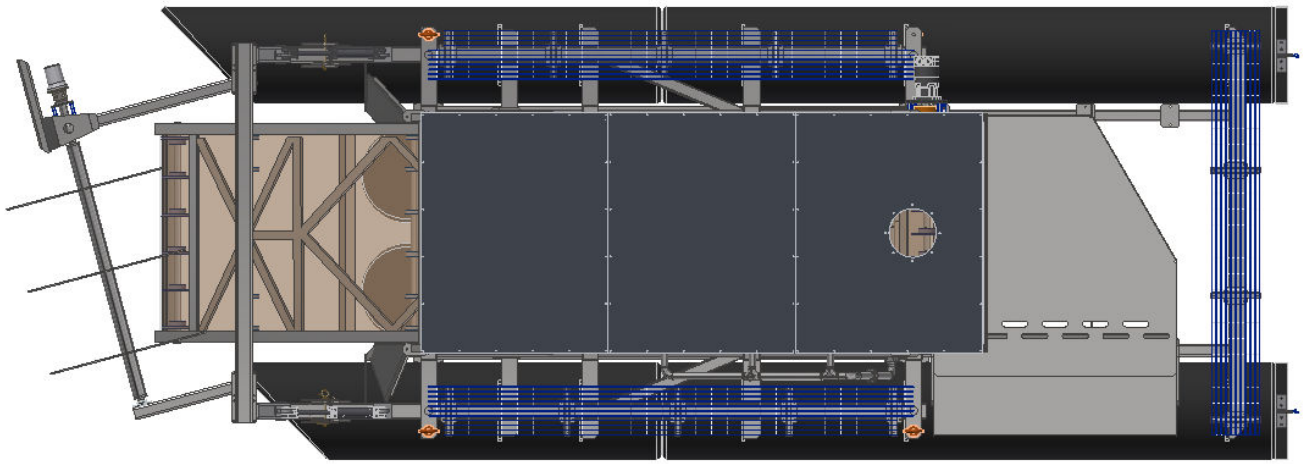
The gpm highlights indicate the best results.

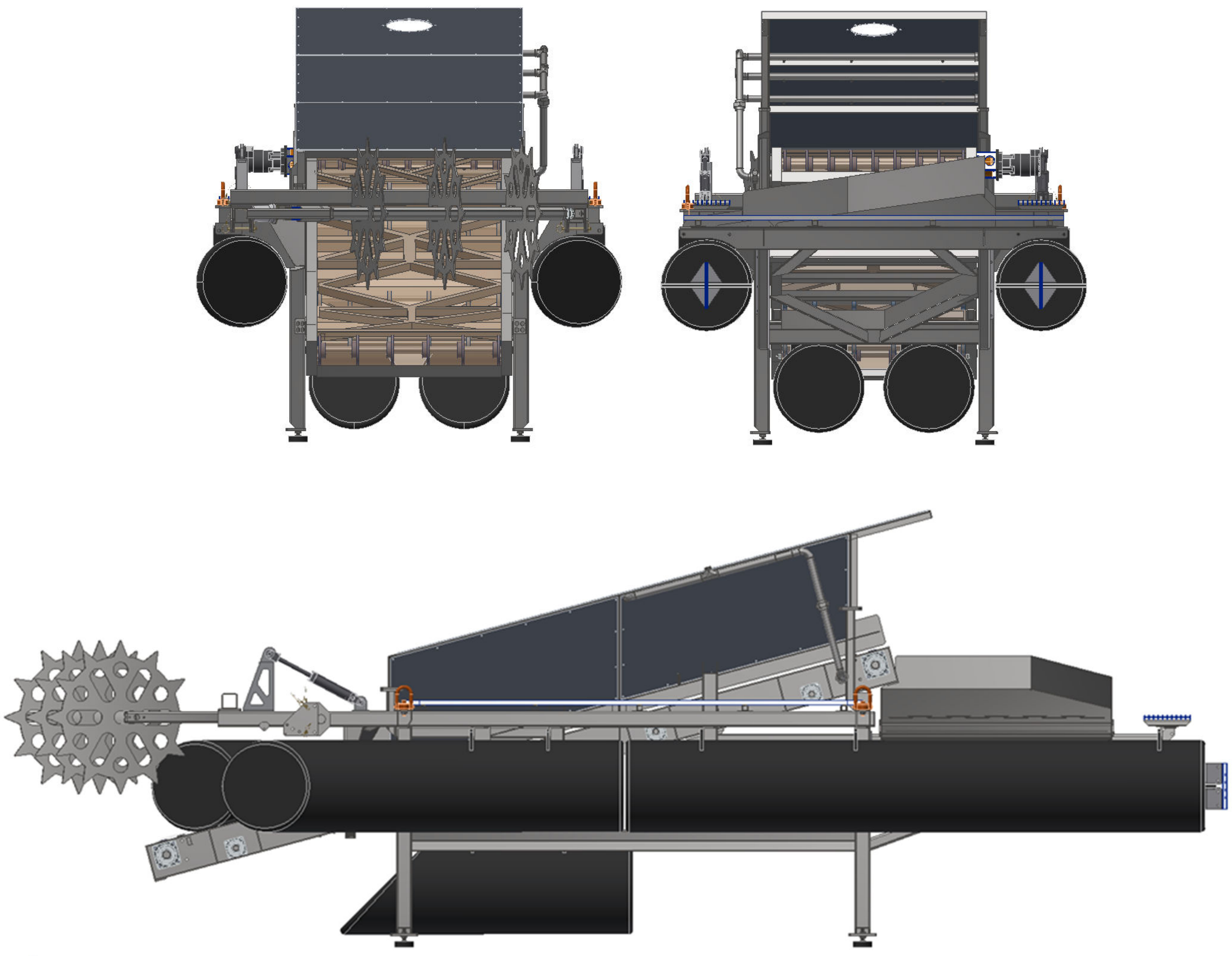
Table B-2 Crucial 13 disc skimmer complete test data

SKIMMER										From Ohmsett Data Sheets				
Test #	**Date**	**Approx. Start time**	**Movement**		**Recovery Time**	**Fluid Recovered**		**Fluid after Decant**		**Recovered Oil**			**Notes**	**Oil Added**
						gal	**gpm**	**gal**	**gpm**	**gal**	**gpm**	**Eff %**		
GPS Time:		11:24:40	Kongsberg time:		21:42:31	Time	10:17:51	**70% Ice coverage**					Water Temp: 32-33, Air Temp: 32, Wind: light from NNW-NW, Water surface: calm	300
24	15-Feb	1127	10 ft jumps		17:00	46.6	2.7	18.9	1.1	14.2	0.8	30%	stopped at 17min due to HPU out of gas. S to N. Drag skimmer with crane	0
25	15-Feb	1159	10 ft jumps		17:00	43.7	2.6	29.2	1.7	20.7	1.2	47%	N to S more clear space. Drag skimmer with crane	0
GPS Time:			Kongsberg time:			Time	0:00:00	**70% Ice coverage**					Water Temp: 32-33, Air Temp: 35, Wind: Light from NNW, Water surface: calm	
26	15-Feb	1333	10 ft jumps		17:00	46.6	2.7	23.3	1.4	11.7	0.7	25%	S to N. Lift skimmer to move. Recovery looked worse, mostly water	0
27	15-Feb	1408	10 ft jumps		17:00	64.1	3.8	35.0	2.1	24.5	1.4	38%	N to S. Lift skimmer to move.Recovered better than last time	0
28	15-Feb	1435	10 ft jumps		17:00	59.8	3.5	23.3	1.4	16.3	1.0	27%	S to N. Drag skimmer. Ice got aught in between discs	0
GPS Time:			Kongsberg time:			Time	0:00:00	**30% Ice coverage**					Water Temp: ?, Air Temp: 34, Wind: 20-25 kts from NW-W, Water surface: light ripples.	200
29	16-Feb	0853	no movement		5:00	56.8	11.4	49.6	9.9	39.6	7.9	70%	less small chunks - seemed to be good oil redovery. Moved 8 ft N	0
30	16-Feb	0907	no movement		5:00	40.8	8.2	40.8	8.2	28.6	5.7	70%	should be best case - was not bothered by ice. Move 8ft S	0
31	16-Feb	0918	no movement		5:00	51.0	10.2	40.8	8.2	28.6	5.7	59%		151
GPS Time:			Kongsberg time:			Time	0:00:00	**70% Ice coverage**					Water Temp: ?, Air Temp: 36, Wind: 25kts fm W, Water surface: light ripples	
32	16-Feb	1022			17:00	74.3	4.4	52.5	3.1	35.2	2.1	47%	start at S end in high concentration. 5 ft N, 5 ft S, 5 ft S	

APPENDIX C: BOWHEAD Drawings







APPENDIX C: Abbreviations and Acronyms

ºC	Degrees centigrade
ºF	Degrees Fahrenheit
ACS	Alaska Clean Seas
ASTM	American Society for Testing and Materials
BAA	Broad Agency Announcement
BSEE	Bureau of Safety and Environmental Enforcement
CISPRI	Cook Inlet Spill Prevention and Response, Inc.
cP	Centipoise
DOI	Department of the Interior
EPPR	Emergency Prevention, Preparedness and Response
ft	Foot or feet
gpm	Gallons per minute
HDPE	High-density polyethylene
HPU	Hydraulic Power Unit
ICCOPR	Interagency Coordinating Committee on Oil Pollution Research
kt(s)	Knot(s)
lb	Pound
LGB	Lifting graded belt
MORICE	Mechanical Oil Recovery in Ice Infested Waters
Ohmsett	National Oil Spill Response and Renewable Energy Test Facility
OSPD	Oil Spill Preparedness Division
OSRO	Oil Spill Response Organization
PVC	Polyvinyl chloride
R&T	Research and Technology
VOF	Volume of Fluid

Department of the Interior (DOI)
The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Safety and Environmental Enforcement (BSEE)
The mission of the Bureau of Safety and Environmental Enforcement works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.

BSEE Oil Spill Preparedness Program
BSEE administers a robust Oil Spill Preparedness Program through its Oil Spill Preparedness Division (OSPD) to ensure owners and operators of offshore facilities are ready to mitigate and respond to substantial threats of actual oil spills that may result from their activities. The Program draws its mandate and purpose from the Federal Water Pollution Control Act of October 18, 1972, as amended, and the Oil Pollution Act of 1990 (October 18, 1991). It is framed by the regulations in 30 CFR Part 254 – Oil Spill Response Requirements for Facilities Located Seaward of the Coastline, and 40 CFR Part 300 – National Oil and Hazardous Substances Pollution Contingency Plan. Acknowledging these authorities and their associated responsibilities, BSEE established the program with three primary and interdependent roles:

- Preparedness Verification,
- Oil Spill Response Research, and
- Management of Ohmsett - the National Oil Spill Response Research and Renewable Energy Test Facility.

The research conducted for this Program aims to improve oil spill response and preparedness by advancing the state of the science and the technologies needed for these emergencies. The research supports the Bureau's needs while ensuring the highest level of scientific integrity by adhering to BSEE's peer review protocols. The proposal, selection, research, review, collaboration, production, and dissemination of OSPD's technical reports and studies follows the appropriate requirements and guidance such as the Federal Acquisition Regulation and the Department of Interior's policies on scientific and scholarly conduct.