IMAROS 2 – WP 4

Test report from Desmi mechanical recovery trial period 3

DESMI - week 19, 2025

NCA Test Facilities – Horten, Norway

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Description of Horten test facility

The National Centre for Testing of Oil Spill Response Equipment, located in Horten, Norway, offers the opportunity to test oil skimmers under controlled yet highly realistic conditions. The test centre features an indoor saltwater basin with a dual-bottom design. Measuring 30 meters in length, 7 meters in width, and up to 4.5 meters in depth, the basin is equipped to simulate both currents and wave conditions. Figure 1 provides an illustration of the basin layout. Testing was conducted at water temperatures ranging from 14 to 14.5°C and air temperatures between 14 and 18°C.

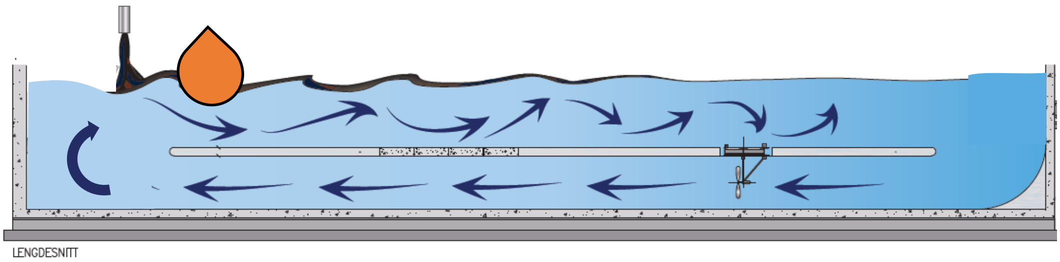

Figure 1: Illustration of the test basin with blue arrows indicating water current and a wave ball outlined with orange colour.

Test procedure

The skimmer was tested according to the NCA's "Procedure for testing oil skimmers in the National Centre for Testing of Oil Spill Response Equipment" with a configuration shown in figure 2. With the help of the current the oil slick flowed into the boom, where the skimmer was placed to enable recovery.

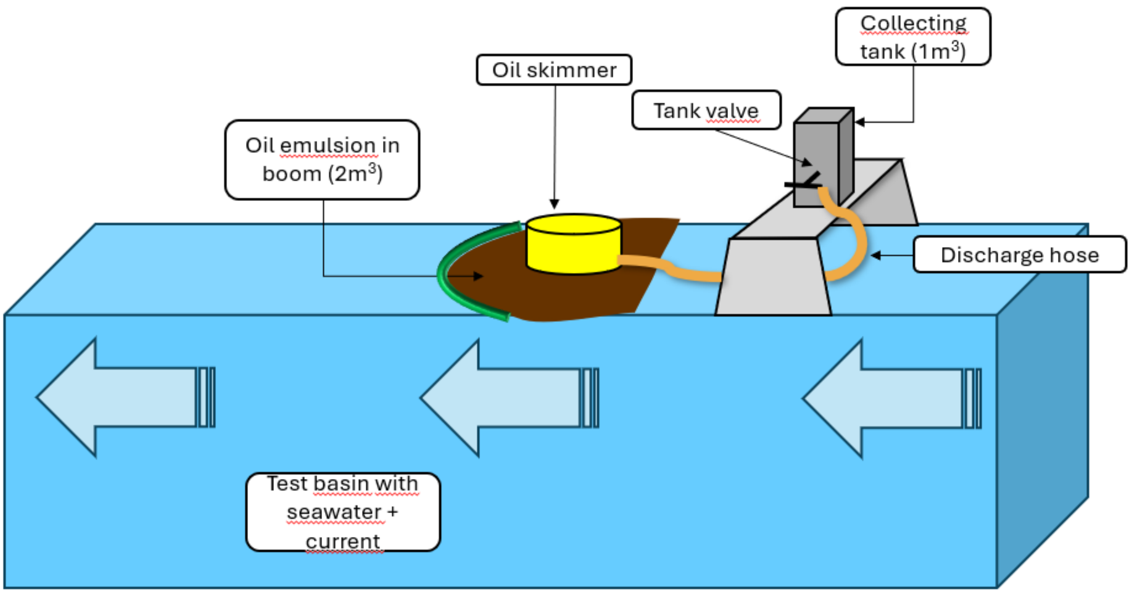

Figure 2: Illustration of the configuration used in the test basin.

The following test setups were conducted:

Test 3:	<u>Capacity test of oil emulsion in boom with current:</u> Oil emulsion (approximately 50% water) and skimmer placed in the boom, with current simulating towing of boom. The speed of the current is approximately 0.6 knots. 2000 litres of oil emulsion is poured into the basin, and the goal is to recover 800 litres of oil to the collecting tank. The best result of three similar repetitions will decide the recovery rate. After the test run, the oil in the collecting tank settles for 15 minutes, before draining the free water to measure the true amount of oil emulsion recovered.
Test 4:	<u>Capacity test of oil emulsion in boom with current and waves:</u> Similar setup as test 3, in addition with waves.

For more details of the test procedure, see appendix 1.

The test oils

Table 1 shows the three test oils used in the recovery tests, with results of viscosity and pour point of the fresh oil samples, and the viscosity range of samples taken of the oil emulsion during testing. There were in total 6 samples taken during the tests at different stages to measure for water content in emulsion, viscosity, and density. The samples were analysed at the laboratory of Sintef Ocean. See appendix 4 and 5 for Sintef memo of the oil analyses conducted for the mechanical recovery trials. A list describing where and when the samples of emulsion were taken during testing in the recovery trial periods is found in appendix 3.

Table 1: some characteristics of the three oils used in the tests.

Imaros 2 ID	Oil type	Viscosity of fresh oil at 10°C ($10s^{-1}$)	Viscosity of emulsion at 10°C ($10s^{-1}$)	Pour point (°C)
IM-27	VLSFO	23,104	18,281 – 23,896	12 (9, 24)*
IM-28	VLSFO	36,277	69,832 – 80,372	27 (21, 30)*
IM-29	ULSFO	932	11,346 – 14,954	27 (15, 24)*

**For pour point, the first value is from the oil suppliers' certificate of analysis. The values in brackets are measured minimum and maximum pour point from Sintef and Cedre laboratories. Pour point measurements seems to be subjected to uncertainties and is described in more detail in deliverable D3.1 Summary report of WP3 – Characterisation and Impacts chapter 3.1.4.*

Description of the skimmer and additional equipment

Desmi provided a modified version of the Octopus In-Line skimmer with several features designed to recover challenging LSFOs (figure 3). A brush belt module with large openings between brush belts placed in front of integrated and adjustable floats, allows for minimal oil flow obstructions. The hopper edge is low in relation to the surface level, with steep walls designed to give minimal flow restrictions to the pump below. Thrusters are positioned relatively deep in the central position.

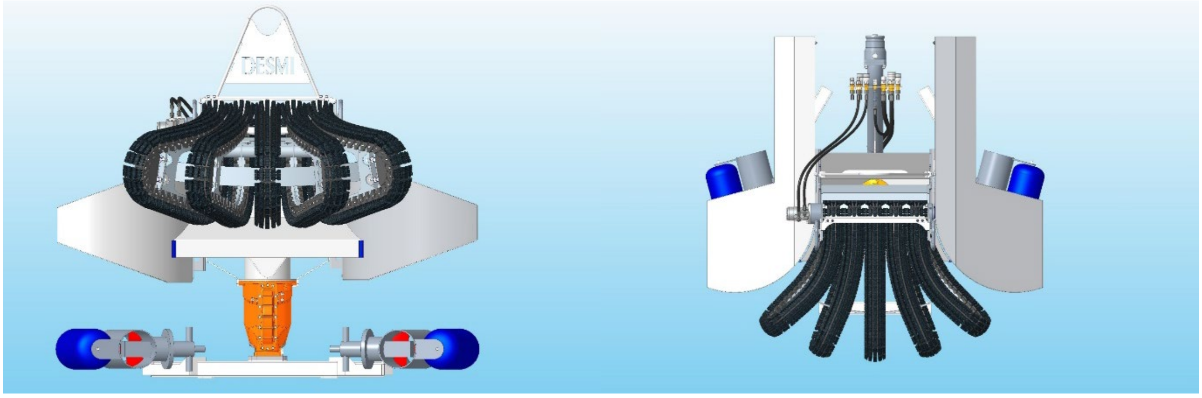

Figure 3: Illustration of the DESMI modified Octopus skimmer (from Desmi).

The pump was a DOP pump, type 200 with the following data:

- Work pressure: 210 bar (max. hydraulic requirement)
- Viscosity max.: >3,036,000 mPas
- Capacity: 66 m^3/h max
- Pressure max.: 13 bar

Results

Table 2: overall results of best measured oil emulsion recovery rates for the tests conducted with the modified DESMI Octopus skimmer.

Oil	Skimmer	Hose	Additional equipment	Test no.	Oil recovery rate
IM-27	Modified Octopus	4” flat hose	Thrusters	3	30.2 m^3/h
IM-27	Modified Octopus	4” flat hose	Thrusters	4	30.6 m^3/h
IM-28	Modified Octopus	4” flat hose	Thrusters	3	21.5 m^3/h
IM-28	Modified Octopus	4” flat hose	Thrusters	4	25.4 m^3/h
IM-29	Modified Octopus	4” flat hose	Thrusters	3	19.7 m^3/h
IM-29	Modified Octopus	4” flat hose	Thrusters	4	27.6 m^3/h

Recovery of the IM-27 (VLSFO)

Test setups 3 and 4 were conducted on this oil, with best results of 30.2 m^3/h and 30.6 m^3/h of oil recovery rate.

The skimmer performed well on the IM-27 oil, with good recovery rates both with and without wave action. The free water uptake was also relatively low. Even though the IM-27 oil has short properties, the movement from the thrusters helped the brushes to reach the oil. Additionally, since the brushes were positioned in front of the main body of the skimmer, they always had directly access to the oil. Furthermore, the specific design of the brush positioning, angled outwards on the sides, it was found to enhance oil recovery by providing a larger surface area and better access to the oil slick. These features may have had an impact in preventing the formation of a water layer between skimmer and oil. The pump and discharge hose effectively transported the oil to the collection tank without issues.

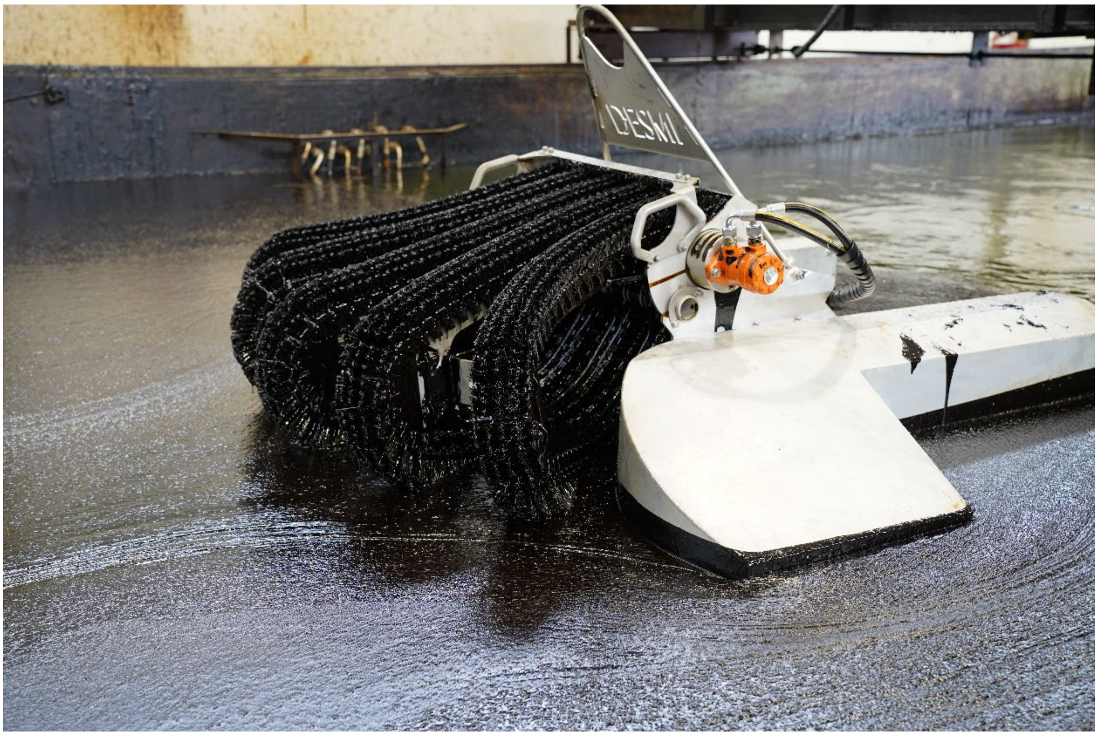

Figure 4: Photo of the DESMI modified Octopus skimmer operating in the IM-27 oil.

Recovery of the IM-28 (VLSFO)

Test procedures 3 and 4 were used on this oil, with best results of 21.5 m^3/h and 25.4 m^3/h of oil recovery rates.

Although the IM-28 exhibit little to no flow properties, the Octopus skimmer was able to use the thrusters to manoeuvre from the “seaside” toward the oil slick, forcing the oil onto the brushes, allowing for nice recovery. The brushes also occasionally dislodged and captured larger oil patches from the slick. It could be observed that some oil stuck to the back of the skimmer, making it hard to reach. The pump had no issues transporting oil from the hopper to the collection tank.

Compared to IM-27, the IM-28 recovery required more active manoeuvring in the basin, as the skimmer needed to pursue the oil and push it towards the brushes. While the thrusters provided much needed assistance for recovery, operating the skimmer in this type of oil poses higher demands on the operator in the field, who must manage the pump, brushes, and thrusters simultaneously, adding to the overall complexity of the operation.

Figure 5: Photo of the DESMI modified Octopus skimmer operating in the IM-28 oil.

Recovery of the IM-29 (ULSFO)

Test setups 3 and 4 were used on this oil, with best results of 19.7 and 27.6 m^3/h of oil recovery rates.

Even though the IM-29 exhibit both short and semi-solid properties, the skimmer achieved good recovery when the brushes operated at low rotational speed, which increased adhesion to the oil, while also keeping the free water uptake low. In contrast, higher rotational speed on the brushes introduces much more energy onto the oil surface, causing the oil in contact with the brushes to become highly fluid and slippery in addition to its already short characteristics. Hence, it is more efficient to operate the brushes at a lower speed.

Recovery rates improved further when wave action was introduced in the basin, as the resulting fragmentation of the slick into smaller patches allowed the brushes to capture oil more effectively as it detached from the main slick. Once inside the hopper, the oil flowed into the pump and through the discharge hoses without difficulty. However, it was observed that due to the spacing between the brush arms, some oil remained trapped in the gaps and was not collected into the hopper.

Figure 6: Photo of the DESMI modified Octopus skimmer operating in the IM-29 oil.

Additional ULSFO test

One of the challenges when testing mechanical recovery in the previous IMAROS project, was that the IM-16 appeared as solid oil lumps in the test basin, making it difficult for the skimmers to both collect and pump the oil from the hopper. As neither the IM-27, IM-28 or the IM-29 had similar oil lump appearance, it was decided to use an ULSFO (see table 3 for chemical parameters) from NCA's stock that have shown in other earlier trials to appear as solid oil lumps, to do an additional test to determine if Desmi's skimmer, pump, and hose was able to recover a low sulphur oil which appears as separate oil lumps in water rather than a slick.

Table 3: chemical parameters of the chosen ULSFO used for the additional test.

ULSFO (NCA stock)	
Viscosity 10°C ($10s^{-1}$)	11500
Density kg/m^3	911.5
Pour point °C	18

1000 litres of fresh ULSFO were poured into the basin from a heated IBC container. The oil was dark in colour and appeared as semi-solid small oil lumps or bigger patches on the water surface. It was then left in the basin to allow to cool down to approximately 15 °C. The ULSFO did not seem to make as solid lumps as previously experienced in other trials, conducted at lower water temperatures. Due to the water temperature in the basin being 14.5 °C, it was not possible to cool down the oil to an even lower temperature.

The skimmer was then placed in the basin, attacking the oil from the “seaside”, similarly setup as test setup 3, with the oil contained in the boom. Due to difficulties removing this oil from the collection tank, it was decided to pump the oil directly to an IBC container from the skimmer’s discharge hose. Reliable recovery rates could therefore not be measured and is not included in the report.

The skimmer was able to force the oil patches onto the brushes by using the thrusters actively. When there was no movement from the skimmer’s thrusters, bridging of the oil appeared in front of the brushes. Once the oil reached the hopper, it flowed down to the pump and delivered it through the discharge hose into the IBC container without problems. Although this test could not accurately test recovery for particularly solid oil lumps, one could still see that a dynamic skimmer is necessary for recovering this oil as well.

Conclusion

The tests demonstrated that the modified Octopus skimmer has strong potential for recovering a range of low-sulphur fuel oils, successfully recovering all three test oils with good results.

Both the hopper and pump solutions are well designed to recover the more challenging LSFOs with behaviour such as semisolid oils with sticky/poor flow properties. The brush scraper effectively directs oil almost directly into the pump, while the placement of the thrusters and floaters ensures high stability during operation and manoeuvring. The placement of the brush module at the front of the skimmer, combined with its wide working angle, provides unobstructed access and a large area for oil collection.

The tests also showed how the use of thrusters on the skimmer is very beneficial for being able to get hold of oils with poor flow properties or short and semi-solid characteristics. While the thrusters provided much needed assistance for recovery, operating the skimmer this way poses higher demands on the operator in the field, who must manage the pump, brushes, and thrusters simultaneously, adding to the overall complexity of the operation.

In conclusion, the tests offered valuable insights into the challenges of recovering LSFOs, and the concept shows strong potential as part of a broader toolbox for addressing these oil types.

Appendix

Table with complete test results conducted at the Horten Test Facility for trial period 3.

Oil-ID	*Test setup*	*Rep.*	*Time*	*Litres total*	*Litres of oil*	*Litres of free water*	*% of free water*	*Oil recovery rate (m^3/h)*	*Skimmer and additional equipment*
IM-27	3	1	1:44	806,4	739,2	67,2	8 %	25,6	Modified octopus, thrusters
IM-27	3	2	1:26	806,4	722,4	84	10 %	30,2	Modified octopus, thrusters
IM-27	4	1	1:46	806,4	739,2	67,2	8 %	25,1	Modified octopus, thrusters
IM-27	4	2	1:28	798	747,6	50,4	6 %	30,6	Modified octopus, thrusters
IM-28	3	1	2:57	806,4	546	260,4	32 %	11,1	Modified octopus, thrusters
IM-28	3	2	2:58	814,8	772,8	42	5 %	15,6	Modified octopus, thrusters
IM-28	3	3	2:01	806,4	722,4	84	10 %	21,5	Modified octopus, thrusters
IM-28	4	1	2:46	806,4	747,6	58,8	7 %	16,2	Modified octopus, thrusters
IM-28	4	2	2:52	806,4	772,8	33,6	4 %	16,2	Modified octopus, thrusters
IM-28	4	3	1:46	798	747,6	50,4	6 %	25,4	Modified octopus, thrusters
IM-29	3	1	4:15	798	739,2	58,8	7 %	10,4	Modified octopus, thrusters
IM-29	3	2	2:20	798	764,4	33,6	4 %	19,7	Modified octopus, thrusters
IM-29	3	3	2:29	806,4	781,2	25,2	3 %	18,9	Modified octopus, thrusters
IM-29	4	1	1:45	806,4	781,2	25,2	3 %	26,8	Modified octopus, thrusters
IM-29	4	2	1:43	806,4	789,6	16,8	2 %	27,6	Modified octopus, thrusters