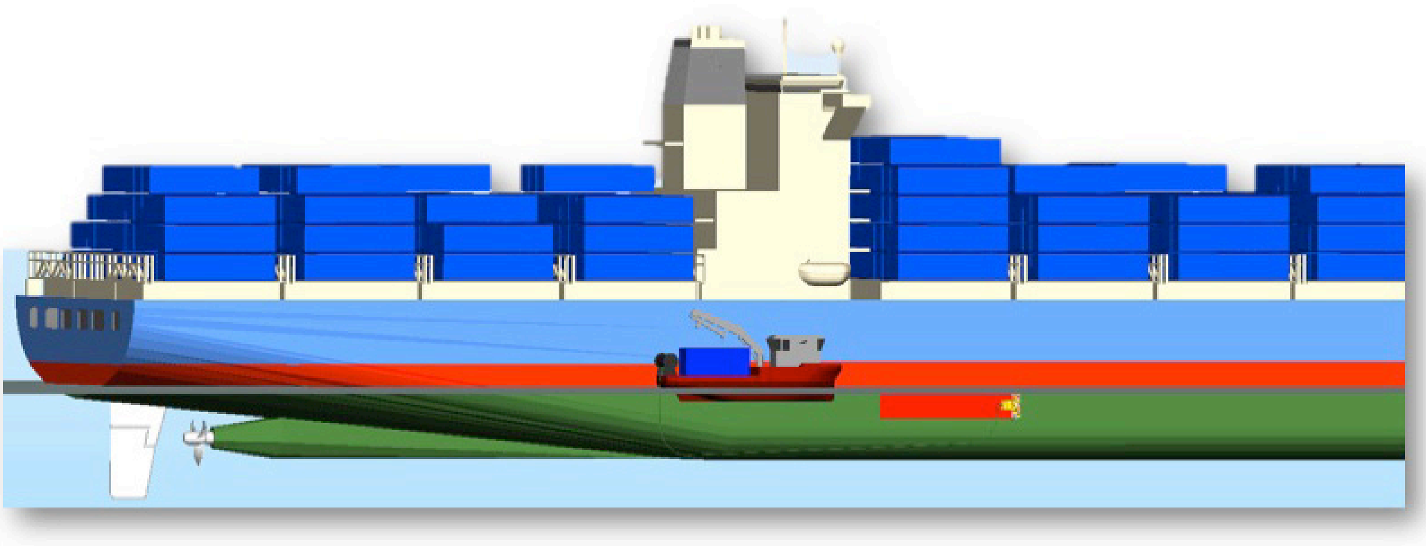
REPORT SNO 6426-2012

Collection efficiency of the ECOsubsea prototype hull cleaner. A preliminary study



Norwegian Institute for Water Research

– an institute in the Environmental Research Alliance of Norway

REPORT

Main Office
Gaustadalléen 21
NO-0349 Oslo, Norway
Phone (47) 22 18 51 00
Telefax (47) 22 18 52 00
Internet: www.niva.no

Regional Office, Sørlandet
Jon Lilletuns vei 3
NO-4879 Grimstad, Norway
Phone (47) 22 18 51 00
Telefax (47) 37 04 45 13

Regional Office, Østlandet
Sandvikaveien 59
NO-2312 Ottestad, Norway
Phone (47) 22 18 51 00
Telefax (47) 62 57 66 53

Regional Office, Vestlandet
Thormøhlens gate 53 D
NO-5006 Bergen Norway
Phone (47) 22 18 51 00
Telefax (47) 55 31 22 14

Regional Office Central
Pirsenteret, Havnegata 9
P.O.Box 1266
NO-7462 Trondheim
Phone (47) 22 18 51 00
Telefax (47) 73 54 63 87

Title	Report No..	Date
Collection efficiency of the ECOsubsea prototype hull cleaner. A preliminary study.	6426-2012	02.10.2012
	Project No. O-12298	Pages Price 9
Author(s) Helge Liltved	Topic group Environmental Technology	Distribution Open
	Geographical area	Printed NIVA

Client(s)	Client ref.
ECOsubsea AS	Tor M. Østervold

Abstract

ECOsubsea AS wanted to investigate the ability of the ECOsubsea prototype hull cleaner to collect the waste removed from vessels. The purpose of the study was to provide preliminary indications of how efficient the cleaning and suction unit will collect the particles detached during cleaning based on model trials.

4 keywords, Norwegian	4 keywords, English
1. Skrogvask	1. Hull cleaning
2. Biomasse	2. Biomass
3. Oppsamling	3. Collection
4. Modellforsøk	4. Model trials

Helge Liltved
Project Manager

James Berg
Director of Innovation and Technology

ISBN 978-82-577-6161-5

Collection efficiency of the ECOsubsea prototype hull cleaner. A preliminary study.

Preface

The collection efficiency of the ECOsubsea hull cleaner was tested in model trials at Austevoll in Hordaland County, Norway. Norwegian Water Research Institute by Dr. Helge Liltved was the primary investigator, and responsible for sample collection and reporting. From ECOsubsea, Tor M. Østervold was the project leader and person in charge.

Grimstad, 02.10.2012

Helge Liltved

Contents

Summary

ECOsubsea AS has developed a prototype hull cleaner for in-water cleaning and collection of waste from vessels. ECOsubsea wanted to investigate the collection efficiency of the prototype. The purpose of the study was to provide preliminary indications of how efficient the cleaning and suction unit will collect the particles detached during cleaning based on model trials. To simulate fouling, steel plates were painted with a Latex paint mixed with particles of wood. The steel plates were submerged in a tank with seawater, and the cleaning was conducted by suction of the waste to a filter for separation of solid waste.

The solid collected by the cleaning unit was evaluated in two different ways:

1. By determination of the wet mass collected on the Sobye filter during a cleaning operation. Smaller particles that pass the filter screen were not included. By subtracting the wet mass in the residual water in the test-tank after cleaning, the collection efficiency of the cleaning system was calculated. The dry weight of the wet mass retained was determined.
2. By determination of the suspended solid (SS) concentration in the suction water from the test-tank during a cleaning operation and multiplying by volume to find the mass collected. The residual mass in the test-tank after cleaning, and the back-ground suspended solid concentration in ambient seawater, were subtracted to determine collection efficiency.

In both cases, the residual paint on the steel plates after cleaning was assumed to be zero. Visual inspection showed that very little paint was left on the plates after cleaning.

The results from the study indicate that the collection efficiency of the prototype is high (>95%) under the model conditions applied. It remains to show similar collection efficiency under realistic fouling conditions. However, the trials indicate that it is possible to operate the prototype in such a way that the main part of the waste from the cleaning operation can be collected and handled, and only a small fraction of the waste will be discharged to the aquatic environment.

It was indicated from the current study that the applied Soby filter failed to retain a fraction of the finer particles. The filter screen applied was rather course, with mesh openings of 150 µm. It is recommended to optimize the filter system to also collect smaller particles from the cleaning operation. This can be done by replacing the filter screen with finer mesh openings.

1. Introduction

In-water hull cleaning is prohibited in some countries due to possible pollution and spreading of indigenous organisms to the aquatic environment. IMO is currently preparing new regulations regarding procedures for cleaning of vessels as a remedy to stop the spreading of invasive species, transported with ships. A possible solution to the problem is to collect all waste from the cleaning operation and employ settling tanks or filters to separate fine particulates from liquid waste prior to discharge to the sea. In addition, the water could be e.g. UV irradiated prior to discharge to inactivate residual organisms not retained by the separation units and achieve the required treatment targets.

The engineering company ECOsubsea AS has developed a prototype hull cleaner for in-water cleaning of vessels. The cleaning unit will remove fouling from the vessel by hydraulic shear forces, and an applied suction will collect and transport waste material through a pipe to a filter for separation of solid waste. The solid waste will be further dewatered and used or disposed of.

ECOsubsea AS wanted to investigate the ability of the prototype to collect the waste removed from vessels by the applied suction. The purpose of the study was to provide preliminary indications of how efficient the cleaning and suction unit will collect the particles detached during cleaning based on model trials. To simulate fouling, steel plates were painted with a Latex paint mixed with spoons of wood. The steel plates were submerged in a tank with seawater, and the cleaning was conducted by suction of the waste to a filter for separation of solid waste.

2. Material and methods

A paint, Latex Butinox-07 C-base (colorcode: S3040-G30Y) mixed with spoon of wood (6:1) was spread on steel plates with size 3m x 1.5 m (**Figure 1** left). The painted area was approximately 2.60 m x 1.05 m = 2.7 m^2. For one plate, it was used approximately 210 g paint. The paint had a dry content of 55%, which gives 115 g dry matter (DM). Before each test run, the paint was allowed to dry for approximately 0.5 h.

A test-tank with a surface area of 3 m x 1.5 m was filled with seawater to a depth of 0.34-0.46 m (**Figure 1** right). The seawater had the following characteristics:

pH = 8.1
Suspended solids (SS) = 12 mg/l
Salinity = 22.9 PSU

2.1 Evaluation of the solids collected by the cleaning and suction unit

The painted steel plate was submerged in the test-tank. The cleaning and suction unit was started with high pressure fresh water supply. The unit was manually directed over the steel plate to remove the painting. The suction water from the cleaning unit was lead through a pipe to the Sobye filter unit with mesh openings of 150 µm (**Figure 2** left). The clean water that passed the filter screen was discharged to the sea, while particles collected on the screen was back-flushed to a second screen mounted on a small tank (**Figure 2** right). Water discharged to the sea was sampled and analysed to determine the amount of suspended solid that passed the filter. The solid collected on the second screen was weighed, and solid content was analysed. The volume of water collected in the small tank was measured, and the amount of suspended solid in the water was analysed to calculate the amount not retained on the screen.

After the cleaning of the steel plate was finished, the residual water volume in the test-tank was measured and filtered to collect particles left in the water. In one test run, the water was homogenized by stirring and sampled to determine the suspended solid concentration before discharge.

By the procedures described above, the amount of solids collected by the cleaning and suction unit was determined in two different ways:

1. By determination of the wet mass collected on the Sobye filter during a cleaning operation. Smaller particles that pass the filter screen were not included. By subtracting the wet mass in the residual water in the test-tank after cleaning, the collection efficiency of the cleaning system was calculated. The dry weight of the wet masses retained was determined.

2. By determination of the suspended solid (SS) concentration in the suction water from the test-tank during a cleaning operation. Concentration was multiplied by the water volume to find the mass collected. The residual mass in the test-tank after cleaning, and the back-ground suspended solid concentration in ambient seawater, were subtracted to determine collection efficiency.

In both cases, the residual paint on the steel plates after cleaning was assumed to be zero. Very little visible paint was left on the plates after cleaning.

Suspended solid (SS) was determined by the Eurofins Laboratory, Moss, Norway according to NS-EN 872 and NS 4733. A glassfiber filter GF/F (0.7 µm) is washed with distilled water, dried at 105 ^{o}C for 30 minutes, then ignited at 480 ^{o}C for 2 hours and finally weighed. A known volume of the sample is filtered and the filter was dried for 2 hour and weighed. The SS is represented by the weight increase. Lowest reported value: 1.5 mg/l.

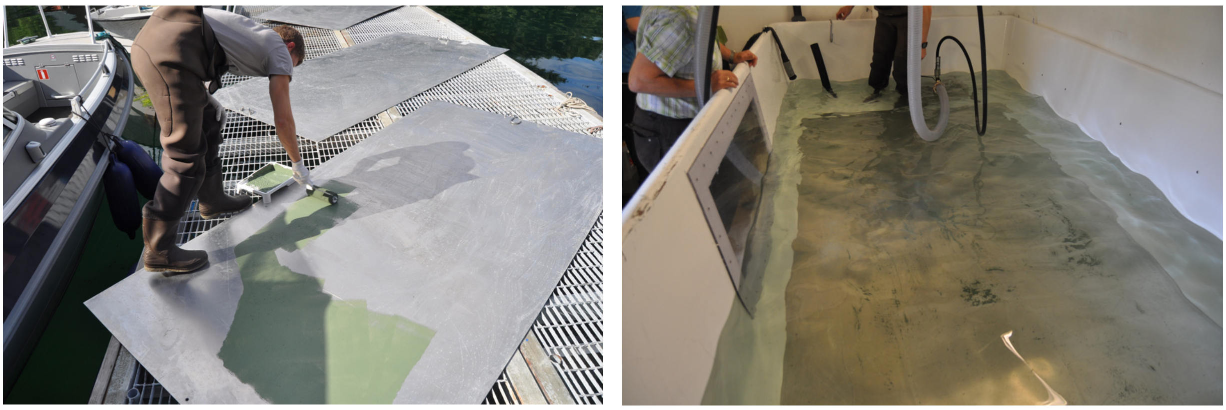


Figure 1. Painting of the steel plates (left), and cleaning of the steel plates in the test-tank (right).

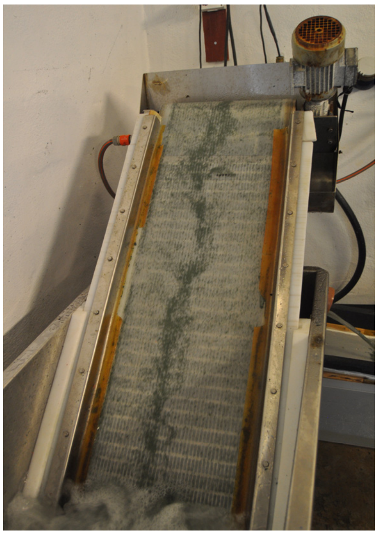


Figure 2. Collection of waste particles on the filter screen (left) and collection of particles in the filter back-flush water (right).

3. Results

3.1 Collection efficiency based on solid retainment on the filter screens

In Table 1, the results of the measurements from the four different test runs are shown. The results are based on what was collected on the screen systems. Particles with size smaller than the mesh openings in the screens (150 µm) may have passed through and may therefore not be included in the results. The results and conclusions will therefore apply only for particles that are big enough to be retained on the screens. It is assumed that the water content of the collected waste was the same in all samples.

Table 1. Mass collected and not collected by the cleaning unit during four different test runs. The results show the wet weight of the mass retained on filter screens.

Test run	Collected, g wt*	Not collected, g wt	Efficiency, %
1	159	3	98.1
2	201	5	97.6
3	206	6	97.2
4	189	9	95.5
Average	188,8	5,8	97,1

*wt = wet weight

The collected waste had a dry solid content of 34%. This means that the average retained amount of dry solids was 64.2 g, while the amount of dry solids that had not been retained was 2.0 g. Approximately 210 g paint was used for each steel plate. With a solids content of 55%, approximately 116 g dry solid was applied. The substantial higher solid content in the paint than retained on the screen indicates that a substantial amount of paint had smaller size than the screen openings, and passed the Sobye filter. This is verified by the data presented in table 2, indicating an average mass of 32.1 g in the effluent water from the Sobye filter during a cleaning operation. By adding this, the amount of solid in the waste water was 96.3 g, which is closer to the 116 g solid in the paint.

3.2 Collection efficiency based on concentration measurements

3.2.1 Mass collected by the cleaning unit

The measured concentrations of suspended solid (SS) in influent water and effluent water to the filter during cleaning operations (test run 2 and 4) are shown in table 2. The background concentration of 12 mg/l in local seawater was subtracted. The masses were calculated by multiplying concentrations with the amount of water used during cleaning.

Table 2. Measured concentrations of suspended solids (SS), and calculated masses, in influent water and effluent water to the filter during cleaning operations (test run 2 and 4). The background concentration of 12 mg/l in local seawater was subtracted.

Test run	Conc. infl, mg/l	Conc. effl , mg/l	Volume infl, m^3	Mass infl, g	Mass effl, g
2	300-12=278	66-12=54	0.72	200.2	38.9
4	230-12=218	-	0.47	102.5	25.4
Average	248	54	0.60	151.3	32.1

The results from Table 2 indicate that a mass of 151.3 g was transported to the filter during the cleaning procedure. This is substantial higher than the mass found on the screens in section 3.1 (64.2 g and 96.3 g, without and with smaller particles included). As discussed in section 3.1, the mass of 151.3 g will also contain smaller paint particles that passed the filter screen. It should be pointed out that the value is calculated from only two concentration measurements, and may therefore not be representative of the concentration during the cleaning procedure. Compared to the applied paint (116 g dry weight), the value is too high and indicate that more samples, or a composite sample, should have been collected to give a better estimate of the mass transport during the cleaning operation.

3.2.2 Mass not collected by the cleaning and suction unit

After cleaning of the steel plate during test run 2, the residual water was homogenized by stirring and sampled. The water volume was 1.88 m^3 and the SS concentration was 14 mg/l. By subtracting the background level of 12 mg/l of the local seawater, the contribution from the cleaning operation was 2 mg/l. It is assumed that the background level particles are small and will pass the filter screen. By multiplying with the volume, a mass of 3.8 g was calculated.

3.2.3 Collection efficiency

By dividing the average mass in the influent water to the Soby filter (151.3 g) by the total mass from a cleaning operation (151.3 g + 3.8 g = 155.1), a collection efficiency of 97.5% was found.

NIVA: Norway's leading centre of competence in aquatic environments

NIVA provides government, business and the public with a basis for preferred water management through its contracted research, reports and development work. A characteristic of NIVA is its broad scope of professional disciplines and extensive contact network in Norway and abroad. Our solid professionalism, interdisciplinary working methods and holistic approach are key elements that make us an excellent advisor for government and society.

Norwegian Institute for Water Research

Gaustadalléen 21 • NO-0349 Oslo, Norway
Telephone: +47 22 18 51 00 • Fax: 22 18 52 00
www.niva.no • post@niva.no