Monitoring non-native species in the port of Vlissingen in 2016 conform the joint HELCOM/OSPAR port survey protocol

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1. Summary

In 2016 a non-native species survey was conducted in the Sloehaven, Vlissingen, The Netherlands, following the HELCOM/OSPAR port survey protocol, which is part of the “Joint harmonised procedure for the contracting parties of HELCOM and OSPAR on the granting of exemptions under the international convention for the control and management of ship’s ballast water and sediments, regulation A-4” (HELCOM/OSPAR, 2013). In total 336 samples were taken from 149 different sampling locations in four research areas within Sloehaven region in spring and late summer. In these samples a total of 220 species were identified to the species level of which 30 were non-native.

2. Introduction

To minimize the risk that non-native species are transported with ballast water the International Maritime Organization (www.imo.org) has developed the Ballast Water Management Convention, a convention that stipulates requirements for ships that are releasing their ballast water. In practice this means that ships have to install approved ballast water treatment systems onboard, or use exemption rules, when circumstances allow it.

The convention enters into force 12 months after the ratification by 30 States, representing 35 per cent of the world merchant shipping tonnage (www.imo.org). This threshold was reached in September 2016 by accession of Finland. The convention will therefore enter into force on 8 September 2017.

In the convention the possibility of exemptions is included for shipping routes when it can be proven that ballast water transports will not pose a threat to the environment. To be able to grant such exemptions in European waters a HELCOM and OSPAR task group on Ballast water Exemptions was formed in 2012 to develop a joint HELCOM/OSPAR Harmonized Protocol (JHP) for granting exemptions to contracting parties when the Ballast Water Convention comes into effect. In 2013, a detailed description of a port survey procedure was included in the joint HELCOM/OSPAR harmonized Protocol (JHP), which was updated by the HELCOM/OSPAR task group during a meeting in December 2014 in Madrid, Spain.

The present report describes the results of the survey that was done in 2016 using this protocol in the port of Vlissingen (Sloehaven). This survey was commissioned by the Office of Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority.

3. Materials & methods

The present study was done according to the HELCOM/OSPAR survey protocol (HELCOM/OSPAR, 2013) updated in December 2014.

3.1 Research areas and locations

In the joint HELCOM/OSPAR port survey protocol it is indicated that a minimum of three research areas should be selected within a port and that these areas should be selected on the basis of the physical characters of the port and its waters (HELCOM/OSPAR, 2013). The areas that were selected within the Sloehaven were chosen based on the topography including both the sheltered parts of the port and the areas closer to the port's entrance, more exposed to the currents and waves coming from the Westerschelde. Within the areas sampling locations were chosen aiming at including a large variety of structures on which different species communities are expected to be found, like the littoral and sublittoral parts of a dike, floating docks, and pilings.

The three areas that were selected within the port, i.e. areas A, B and C, are illustrated in figure 1. Just off the coast of Vlissingen the anchorage site Everingen A is known as a place where relatively large ships exchange ballast water. This site, just outside of the port, was therefore included in the present study as Area D (Fig. 1).

Areas A to C were monitored in the spring of 2016 on 20th of May 2016 and in the in the late summer of 2016 on 5 - 9 September. Area D was sampled on 11 October 2016.

Within each area, sampling locations were chosen including various habitats, following the HELCOM/OSPAR survey protocol (e.g. some duplicate samples have to be taken at least 15 m apart from each other) The exact sampling locations that were monitored within these research areas are described in Tables 1-4 and displayed in Figs. 2-11. The habitats that were searched for species, and the sampling methods that were used, are described in more detail in the next paragraphs.

Fig. 1. Research areas and sampling locations in the Sloehaven. The different areas are displayed in more detail in Figs 2-11.

Table 1. Research area A. Sampling locations 1 to 39 (Figs. 2-6) and the sampling methods conducted there.

Sample location	Description	Sampling method	Geogr. Coordinates	Fig.
1	Bottom, sublittoral	Petite ponar	51.460906, 3.673021	3
2	Bottom, sublittoral	Chinese crab trap	51.460873, 3.672960	3
3	Fouling plates, sublittoral	Fouling plates	51.460794, 3.673030	3
4	Bottom, sublittoral	Gee's minnow trap	51.460745, 3.673060	3
5	Water column	Physical parameters, plankton, human pathogens	51.460750, 3.673162	3
6	Bottom, sublittoral	Petite ponar	51.460750, 3.673162	3
7	Pillar, sublittoral	Scrape sample	51.460571, 3.673206	3
8	Floating dock	Scrape sample	51.460590, 3.673267	3
9	Bottom, sublittoral	Petite ponar	51.460407, 3.673464	3
10	Bottom, sublittoral	Hand dredge	51.460427, 3.673439	3
11	Harbour wall	Underwater video	51.460294, 3.673431	3
12	Bottom, sublittoral	Chinese crab trap	51.462196, 3.683488	4
13	Bottom, sublittoral	Gee's minnow trap	51.462196, 3.683488	4
14	Fouling plates, sublittoral	Fouling plates	51.462148, 3.683491	4
15	Bottom, sublittoral	Petite ponar	51.462110, 3.683533	4
16	Pillar, sublittoral	Underwater video	51.462110, 3.683533	4
17	Pillar, sublittoral	Scrape sample	51.462110, 3.683533	4
18	Floating dock	Scrape sample	51.462100, 3.683467	4
19	Water column	Physical parameters, plankton, human pathogens	51.462033, 3.683548	4
20	Dike, littoral, rocks low water line	Transect at 0 m	51.461897, 3.685001	4
21	Dike, littoral, rocks low water line	Transect at 15 m	51.461805, 3.684969	4
22	Dike, littoral, rocks low water line	Transect at 30 m	51.461750, 3.685101	4
23	Dike, littoral, *Fucus vesiculosus* zone	Transect at 0 m	51.461916, 3.685045	4
24	Dike, littoral, *Fucus vesiculosus* zone	Transect at 15 m	51.461833, 3.685055	4
25	Dike, littoral, *Fucus vesiculosus* zone	Transect at 30 m	51.461916, 3.685045	4
26	Dike, littoral, *Fucus spiralis* zone	Transect at 0 m	51.461930, 3.685092	4
27	Dike, littoral, *Fucus spiralis* zone	Transect at 15 m	51.461857, 3.685119	4
28	Dike, littoral, *Fucus spiralis* zone	Transect at 30 m	51.461787, 3.685214	4
29	Water column	Physical parameters, plankton, human pathogens	51.460946, 3.685296	5
30	Fouling plates, sublittoral	Fouling plates	51.460967, 3.685626	5
31	Bottom, sublittoral	Chinese crab trap	51.460967, 3.685626	5
32	Bottom, sublittoral	Gee's minnow trap	51.460995, 3.685693	5
33	Bottom, sublittoral	Petite ponar	51.460961, 3.685670	5
34	Floating dock	Scrape sample	51.460895, 3.685506	5
35	Floating dock	Scrape sample	51.460876, 3.685384	5
36	Pillar, sublittoral	Scrape sample	51.460856, 3.685435	5
37	Bottom, sublittoral	Petite ponar	51.45797, 3.67744	2
38	Bottom, sublittoral	Hand dredge	51.45797, 3.67882	2
39	Bottom, sublittoral	Petite ponar	51.45845, 3.67892	2
40	Bottom, sublittoral	Petite ponar	51.458753, 3.680280	2
41	Bottom, sublittoral	Hand dredge	51.459863, 3.687120	2
42	Bottom, sublittoral	Petite ponar	51.459861, 3.686375	2
43	Dike, littoral, under high water line	Transect at 0 m	51.450904, 3.663196	6
44	Dike, littoral, under high water line	Transect at 15 m	51.450608, 3.663952	6
45	Dike, littoral, under high water line	Transect at 30 m	51.450708, 3.663767	6
46	Dike, littoral, *Fucus* zone	Transect at 0 m	51.450641, 3.663683	6
47	Dike, littoral, *Fucus* zone	Transect at 15 m	51.450546, 3.663894	6
48	Dike, littoral, *Fucus* zone	Transect at 30 m	51.450828, 3.663144	6
49	Dike, littoral, rocks low water line	Transect at 0 m	51.450747, 3.663069	6
50	Dike, littoral, rocks low water line	Transect at 15 m	51.450480, 3.663830	6
51	Dike, littoral, rocks low water line	Transect at 30 m	51.450567, 3.663632	6

Fig. 2. Research area A, Sampling locations 1 to 42. Sampling locations 1 to 36 are displayed in more detail in Figs. 3-5.

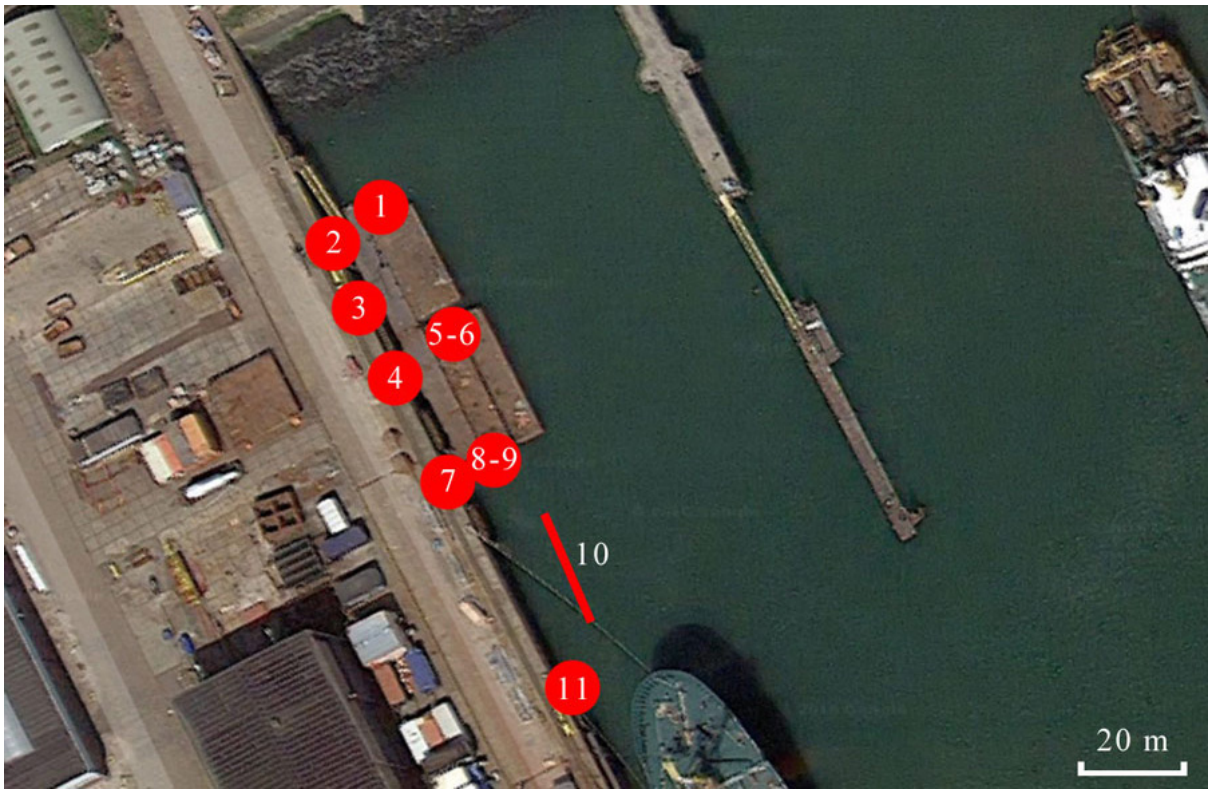

Fig. 3. Research area A, Sampling locations 1 to 11 (Table 1; Fig. 2).

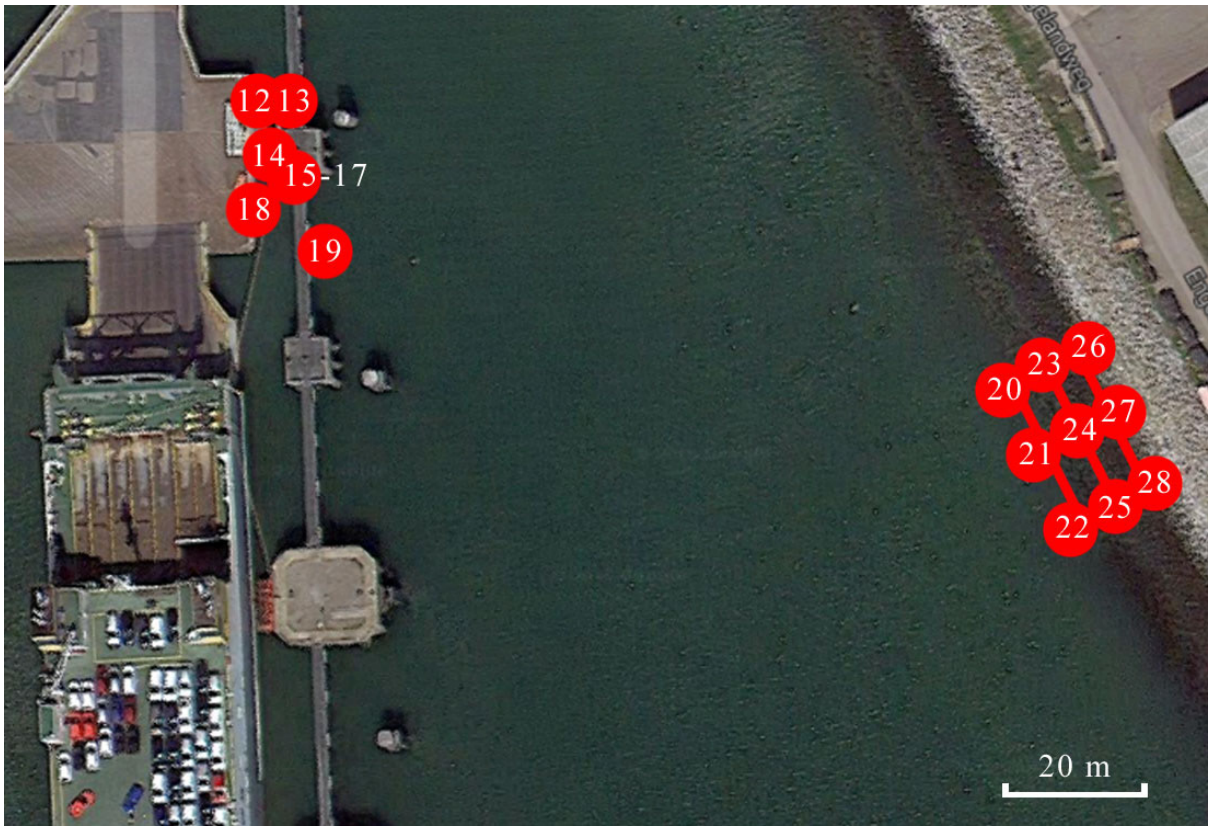

Fig. 4. Research area A, Sampling locations 12 to 28 (Table 1; Fig. 2).

Fig. 5. Research area A, Sampling locations 29 to 36 (Table 1; Fig. 2).

Fig. 6. Research area A, Sampling locations 43 to 51 (Table 1).

Table 2. Research area B. Sampling locations 52 to 91 (Fig. 7) and the sampling methods conducted there.

Sample location	Description	Sampling method	Geogr. Coordinates	Fig.
52	Dike, littoral, under high water line zone	Transect at 0 m	51.471157, 3.712613	7
53	Dike, littoral, under high water line zone	Transect at 15 m	51.471062, 3.712852	7
54	Dike, littoral, under high water line zone	Transect at 30 m	51.470965, 3.713175	7
55	Dike, littoral, *Fucus* zone	Transect at 0 m	51.471107, 3.712582	7
56	Dike, littoral, *Fucus* zone	Transect at 15 m	51.471048, 3.712828	7
57	Dike, littoral, *Fucus* zone	Transect at 30 m	51.470917, 3.713125	7
58	Dike, littoral, rocks low water line	Transect at 0 m	51.461670, 3.685073	7
59	Dike, littoral, rocks low water line	Transect at 15 m	51.470981, 3.712787	7
60	Dike, littoral, rocks low water line	Transect at 30 m	51.470869, 3.713097	7
61	Bottom, sublittoral	Hand dredge	51.471078, 3.712199	7
62	Bottom, sublittoral	Petite ponar	51.470988, 3.712116	7
63	Water column	Physical parameters, plankton, human pathogens	51.470981, 3.712196	7
64	Fouling plates, sublittoral	Fouling plates	51.470981, 3.712196	7
65	Bottom, sublittoral	Chinese crab trap	51.470981, 3.712196	7
66	Bottom, sublittoral	Gee's minnow trap	51.470981, 3.712196	7
67	Floating dock	Scrape sample	51.470981, 3.712196	7
68	Bottom, sublittoral	Petite ponar	51.470981, 3.712196	7
69	Bottom, sublittoral	Hand dredge	51.470851, 3.713133	7
70	Bottom, sublittoral	Petite ponar	51.470741, 3.713061	7
71	Water column	Physical parameters, plankton, human pathogens	51.470703, 3.713122	7
72	Fouling plates, sublittoral	Fouling plates	51.470703, 3.713122	7
73	Bottom, sublittoral	Chinese crab trap	51.470703, 3.713122	7
74	Bottom, sublittoral	Gee's minnow trap	51.470703, 3.713122	7
75	Floating dock	Scrape sample	51.470703, 3.713122	7
76	Floating dock / Pillar	Underwater video	51.470703, 3.713122	7
77	Bottom, sublittoral	Petite ponar	51.470703, 3.713122	7
78	Bottom, sublittoral	Hand dredge	51.470573, 3.714073	7
79	Bottom, sublittoral	Petite ponar	51.470480, 3.713992	7
80	Bottom, sublittoral	Hand dredge	51.470324, 3.713870	7
81	Bottom, sublittoral	Petite ponar	51.470324, 3.713870	7
82	Water column	Physical parameters, plankton, human pathogens	51.470440, 3.714056	7
83	Fouling plates, sublittoral	Fouling plates	51.470440, 3.714056	7
84	Bottom, sublittoral	Chinese crab trap	51.470440, 3.714056	7
85	Bottom, sublittoral	Gee's minnow trap	51.470440, 3.714056	7
86	Floating dock	Scrape sample	51.470343, 3.713943	7
87	Bottom, sublittoral	Petite ponar	51.469898, 3.711284	7
88	Bottom, sublittoral	Petite ponar	51.469617, 3.712244	7
89	Bottom, sublittoral	Petite ponar	51.469348, 3.713094	7
90	Bottom, sublittoral	Petite ponar	51.468930, 3.713698	7
91	Bottom, sublittoral	Hand dredge	51.469502, 3.714192	7

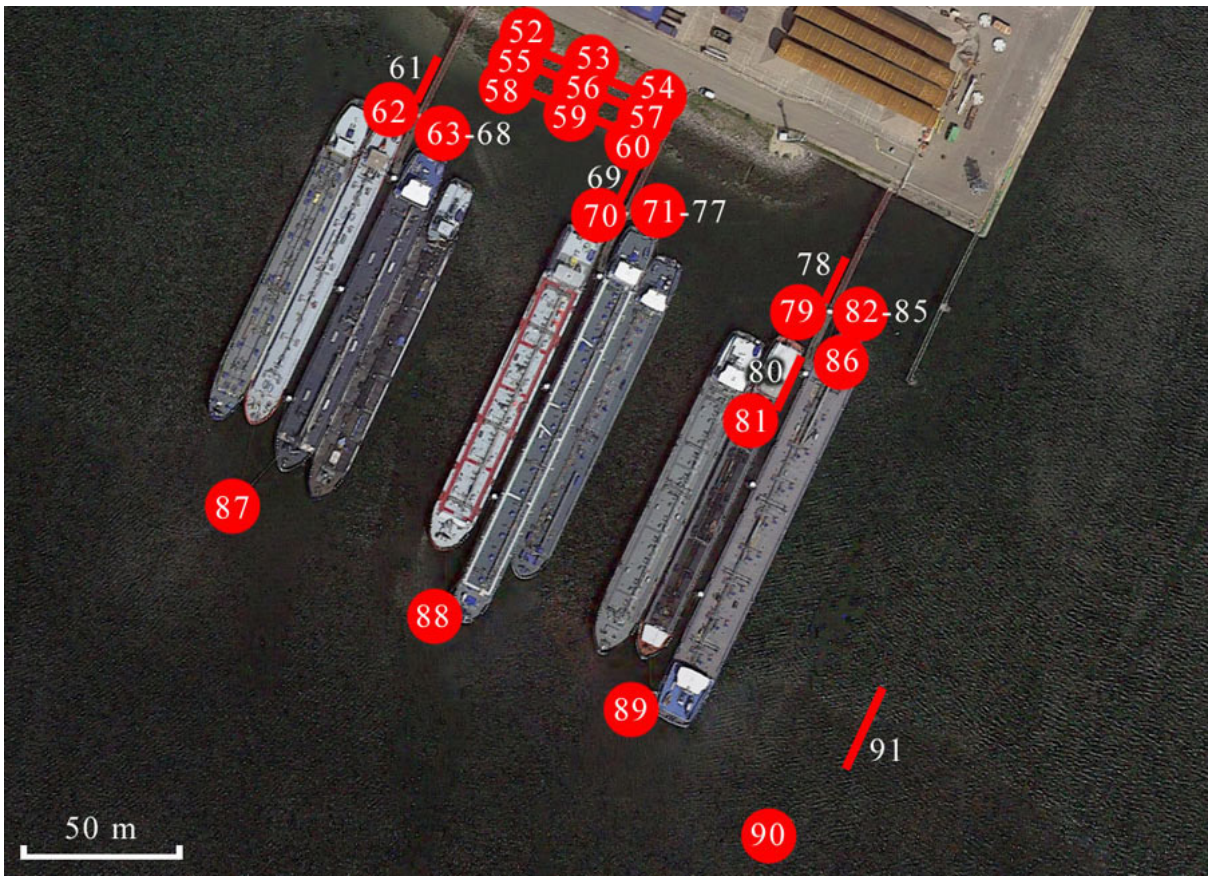

Fig. 7. Research area B, Sampling locations 52 to 91 (Table 2).

Table 3. Research area C. Sampling locations 92 to 140 (Figs. 8-10) and the sampling methods conducted there.

Sample location	Description	Sampling method	Geogr. Coordinates	Fig.
92	Bottom, sublittoral	Chinese crab trap	51.448491, 3.715740	9
93	Bottom, sublittoral	Gee's minnow trap	51.448454, 3.715780	9
94	Bottom, sublittoral	Hand dredge	51.448377, 3.715539	9
95	Floating dock	Scrape sample	51.448346, 3.715456	9
96	Water column	Physical parameters, plankton, human pathogens	51.448317, 3.715578	9
97	Fouling plates, sublittoral	Fouling plates	51.448331, 3.715667	9
98	Bottom, sublittoral	Petite ponar	51.448317, 3.715578	9
99	Pillar, sublittoral	Scrape sample	51.448331, 3.715667	9
100	Pillar, sublittoral	Underwater video	51.448331, 3.715667	9
101	Dike, littoral, rocks low water line	Transect at 0 m	51.448227, 3.716358	9
102	Dike, littoral, rocks low water line	Transect at 15 m	51.448137, 3.716569	9
103	Dike, littoral, rocks low water line	Transect at 30 m	51.448056, 3.716718	9
104	Dike, littoral, *Fucus* zone	Transect at 0 m	51.448096, 3.716795	9
105	Dike, littoral, *Fucus* zone	Transect at 15 m	51.448208, 3.716582	9
106	Dike, littoral, *Fucus* zone	Transect at 30 m	51.448274, 3.716460	9
107	Dike, littoral, under high water line	Transect at 0 m	51.448303, 3.716513	9
108	Dike, littoral, under high water line	Transect at 15 m	51.448220, 3.716634	9
109	Dike, littoral, under high water line	Transect at 30 m	51.448130, 3.716844	9
110	Bottom, sublittoral	Petite ponar	51.447805, 3.716265	9
111	Floating dock	Scrape sample	51.447807, 3.716434	9
112	Bottom, sublittoral	Chinese crab trap	51.447931, 3.716761	9
113	Bottom, sublittoral	Gee's minnow trap	51.447898, 3.716806	9
114	Water column	Physical parameters, plankton, human pathogens	51.447756, 3.716659	9
115	Fouling plates, sublittoral	Fouling plates	51.447756, 3.716659	9
116	Pillar, sublittoral	Scrape sample	51.447756, 3.716659	9
117	Harbour wall	Underwater video	51.44441, 3.70664	10
118	Harbour wall	Scrape sample	51.44481, 3.70712	10
119	Fouling plates, sublittoral	Fouling plates	51.445295, 3.708037	10
120	Bottom, sublittoral	Chinese crab trap	51.445295, 3.708037	10
121	Bottom, sublittoral	Gee's minnow trap	51.445295, 3.708037	10
122	Bottom, sublittoral	Petite ponar	51.445340, 3.707999	10
123	Bottom, sublittoral	Hand dredge	51.445479, 3.708194	10
124	Water column	Physical parameters, plankton, human pathogens	51.445479, 3.708194	10
125	Bottom, sublittoral	Petite ponar	51.445479, 3.708194	10
126	Floating dock	Scrape sample	51.445479, 3.708194	10
127	Bottom, sublittoral	Petite ponar	51.445614, 3.708417	10
128	Dike, littoral, rocks low water line	Transect at 0 m	51.445595, 3.708871	10
129	Dike, littoral, rocks low water line	Transect at 15 m	51.445713, 3.709070	10
130	Dike, littoral, rocks low water line	Transect at 30 m	51.445756, 3.709264	10
131	Dike, littoral, *Fucus* zone	Transect at 0 m	51.445548, 3.708943	10
132	Dike, littoral, *Fucus* zone	Transect at 15 m	51.445691, 3.709161	10
133	Dike, littoral, *Fucus* zone	Transect at 30 m	51.445758, 3.709264	10
134	Dike, littoral, under high water line zone	Transect at 0 m	51.445499, 3.709006	10
135	Dike, littoral, under high water line zone	Transect at 15 m	51.445658, 3.709216	10
136	Dike, littoral, under high water line zone	Transect at 30 m	51.445713, 3.709356	10
137	Bottom, sublittoral	Petite ponar	51.45164, 3.70551	8
138	Bottom, sublittoral	Petite ponar	51.45103, 3.70716	8
139	Bottom, sublittoral	Petite ponar	51.45065, 3.70799	8
140	Bottom, sublittoral	Hand dredge	51.45017, 3.70926	8

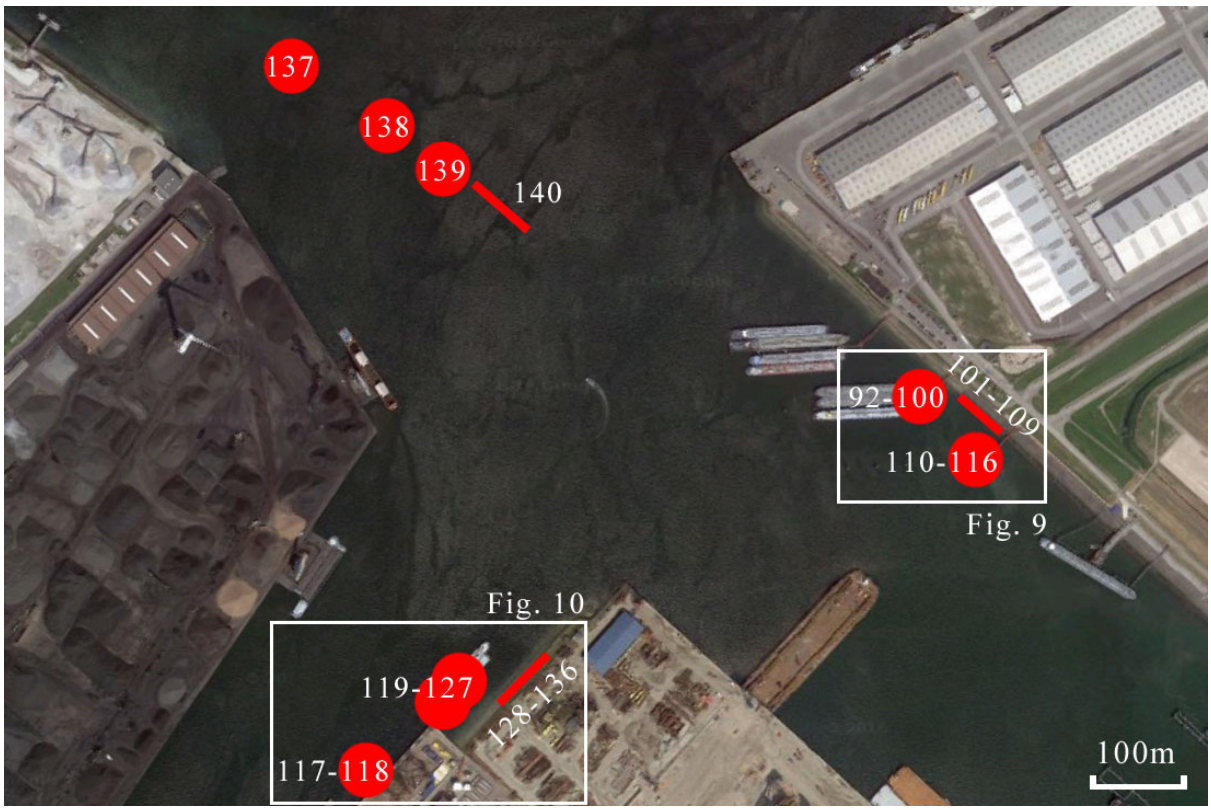

Fig. 8. Research area C, Sampling locations 92 to 140 (Table 3). Sampling locations 92 to 136 are displayed in more detail in Figs. 9-10.

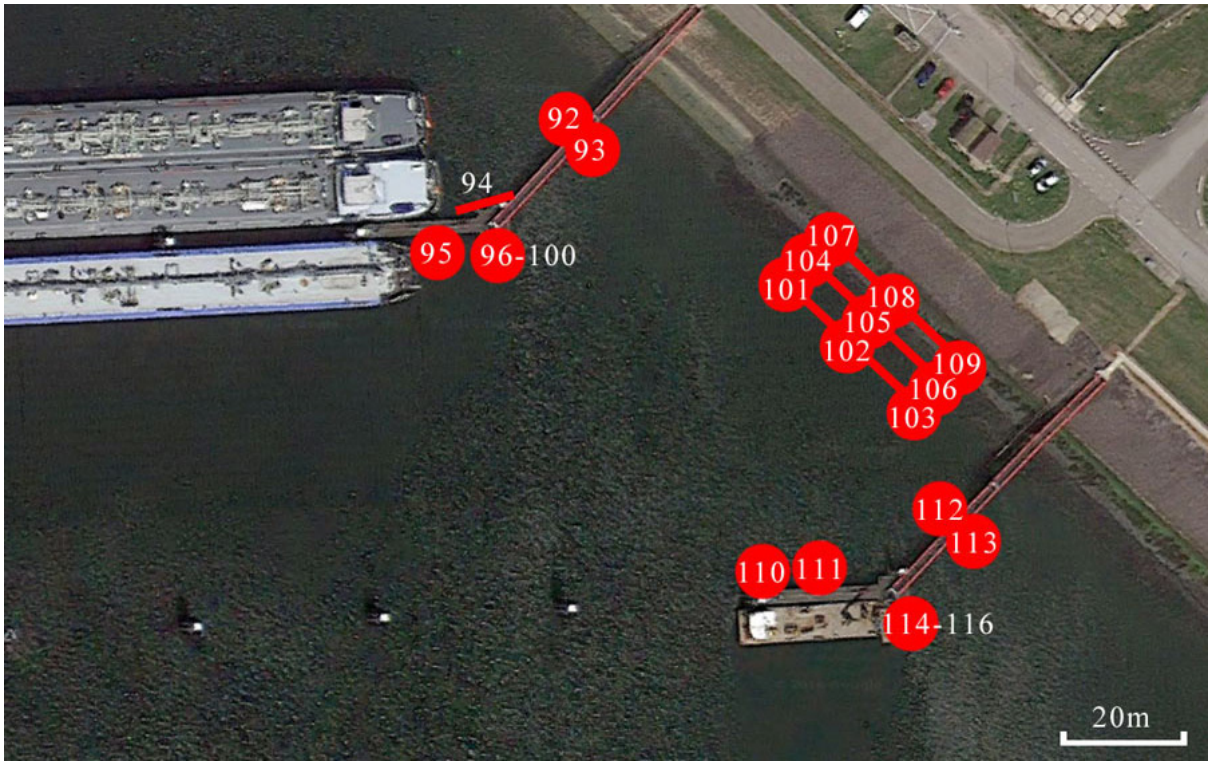

Fig. 9. Research area C, Sampling locations 92 to 116 (Table 3; Fig. 8).

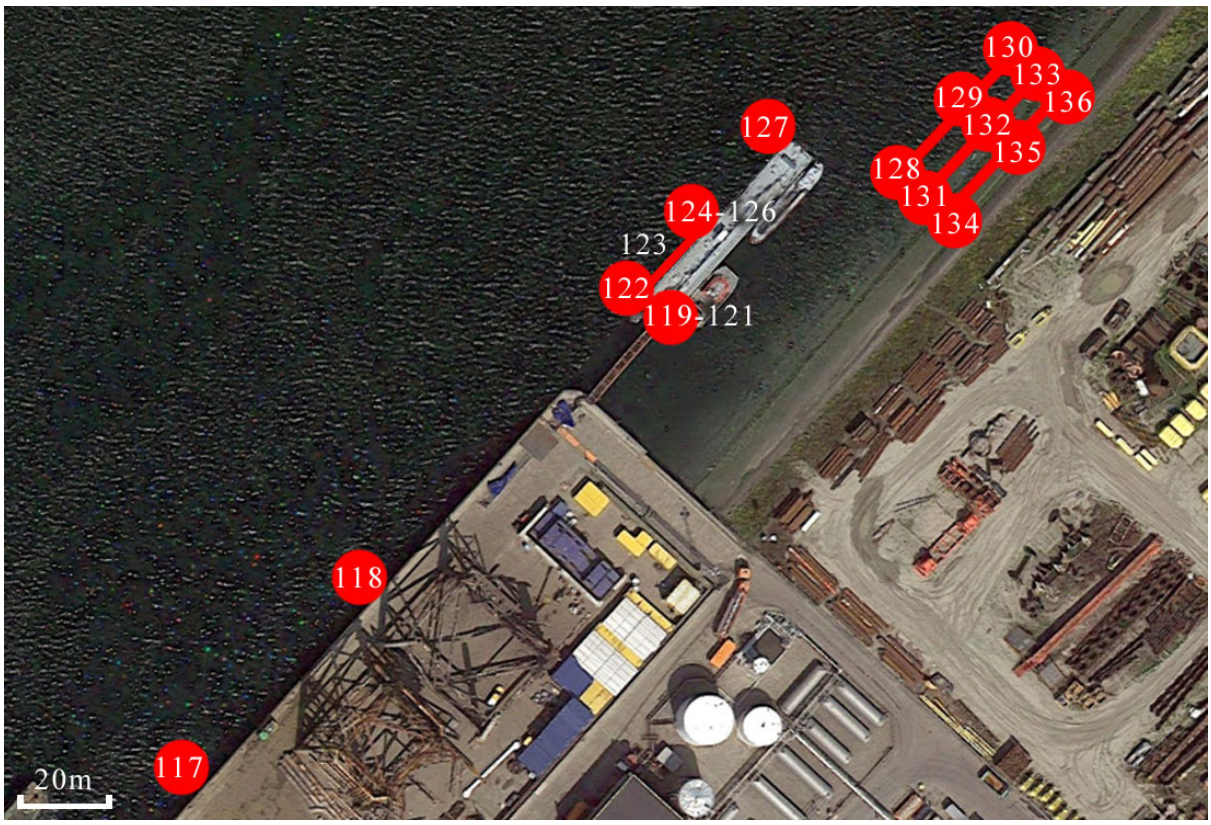

Fig. 10. Research area C, Sampling locations 117 to 136 (Table 4; ; Fig. 8).

Table 4. Research area D. Sampling locations 141 to 149 and the sampling methods conducted there. The depth of these sites ranged from approximately 27 to 55 meter.

Sample location	Description	Sampling method	Geogr. Coordinates	Fig.
141	Bottom, sublittoral	Hand dredge	51.405183, 3.726303	11
142	Bottom, sublittoral	Hand dredge	51.404103, 3.727460	11
143	Bottom, sublittoral	Hand dredge	51.403629, 3.728795	11
144	Bottom, sublittoral	Plankton	51.402793, 3.730880	11
145	Bottom, sublittoral	Plankton	51.402235, 3.733036	11
146	Bottom, sublittoral	Plankton	51.401881, 3.734427	11
147	Bottom, sublittoral	Petite ponar	51.400891, 3.733591	11
148	Bottom, sublittoral	Petite ponar	51.400534, 3.732051	11
149	Bottom, sublittoral	Petite ponar	51.40000, 3.73333	11

Fig. 11. Research area D. Sampling locations 141 to 149 (Table 4).

3.2 Sampling methods

The habitats in the Sloehaven that have to be searched for species according to the HELCOM/OSPAR survey protocol (HELCOM/OSPAR, 2013) are illustrated in figure 12. The sampling methods that were conducted to do this, are described in more detail in the following paragraphs.

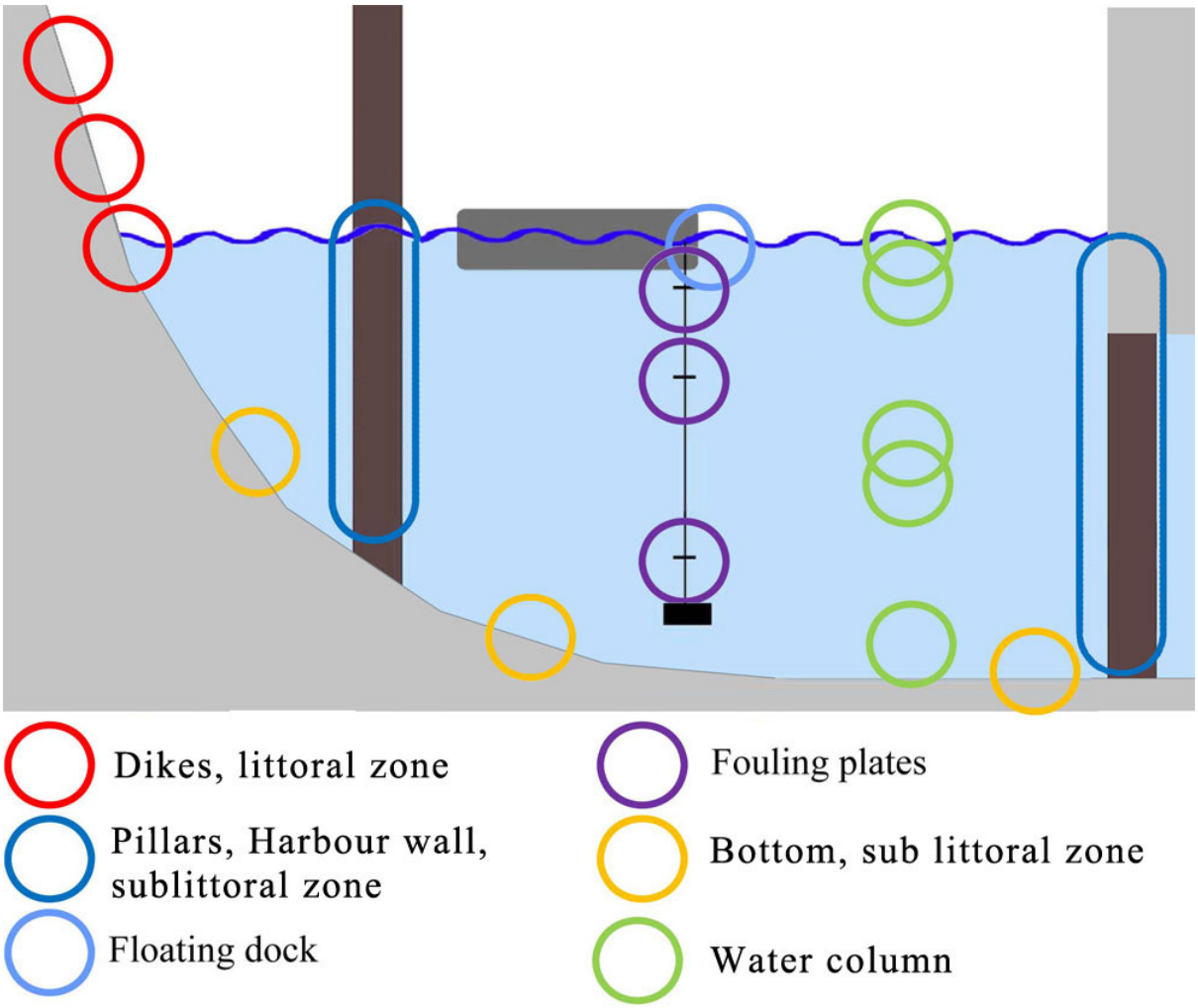

Fig. 12. Habitats sampled in the Sloehaven. Red: dike in the littoral zone; Dark blue: pillars and harbour walls in the sub-littoral zone; Light blue: floating dock; Purple: fouling plate construction; Yellow: bottom; Green: water column.

3.2.1 Physical parameters

In the research areas A to C the physical parameters temperature, pH, salinity and turbidity were measured at three locations during the monitoring in both spring and summer. The sampling locations were chosen at least 15 m apart. The sampling locations in spring were the same as those monitored in summer (Figs 2-10; Tables 1-3).

Water samples at each location were taken at three meter intervals from 30 cm depth to the bottom (Fig. 13). This was done with a Van Dorn Water sampler from KC Denmark (Fig. 14B). For each location the depth was noted.

The temperature, pH and salinity (in ppt and PSU) measurements were done with the multimeter HI9829 from Hanna instruments (Fig. 14A). The turbidity was measured with the portable turbidity meter HI 93414 from Hanna instruments (Fig. 14C).

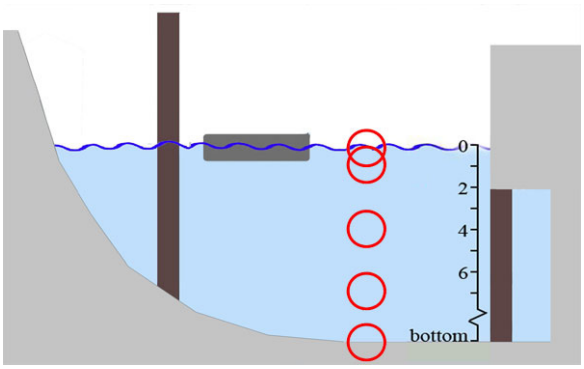

Fig. 13. Water samples were taken from the water surface (30 cm), 1 m, 4 m, 7 m and from there on in intervals of three meters to the bottom. Finally a sample was taken just above the bottom.

During the monitoring within each research area the date of the inventory, the wind speed, wind direction, and the air temperature were noted. For each location within an area the start time of the inventory and the geographical coordinates were noted.

Fig. 14. Equipment used for measuring water quality parameters. A. Multiparameter HI9829 of Hanna Instruments; B. Van Dorn water sampler of KC Denmark; C. Portable Turbidity Meter HI 93414 of Hanna Instruments.

3.2.2 Human pathogens

At the research areas A to C surface water was monitored for the presence of bacteria: Intestinal Enterococci, *Escherichia coli* and *Vibrio cholerae*. The monitoring was done in both spring and summer.

A water sample of 0.5 liter was taken from approximately 30 cm depth (Fig. 15) with a Van Dorn Water sampler (Fig. 14B) at three sampling locations per research area. These sampling locations were chosen least 15 m apart (Figs 2-10; Tables 1-3). For each research area the three water samples were pooled together. The resulting pooled samples were used to assess concentrations of *E. coli*, Enterococci and V*ibrio cholerae*. This was done with the help of *E. coli*, Enterococci and *Vibrio* spp. specific growth media (Fig. 16).

As *Vibrio cholerae*, the only *Vibrio* species that needs to be monitored according to the HELCOM/OSPAR port survey protocol, is known for its yellow colonies, *Vibrio* colonies with a yellow colour were identified to the species level with a VITEK ® MS analysis. Although not all *Vibrio* species can be identified by VITEK ® MS analysis, this method has been optimized to reliably identify *Vibrio cholerae* colonies including the pathogenic O1 and O139 strains on which one should focus according to Regulation D-2 Ballast Water Performance Standard of the "Ballast water management convention".

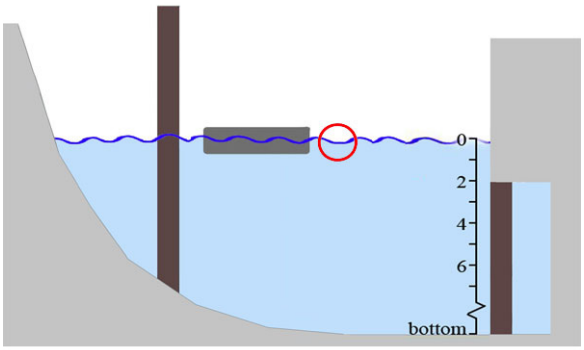

Fig. 15. Water samples for the human pathogen analyses were collected from the water surface (30 cm)

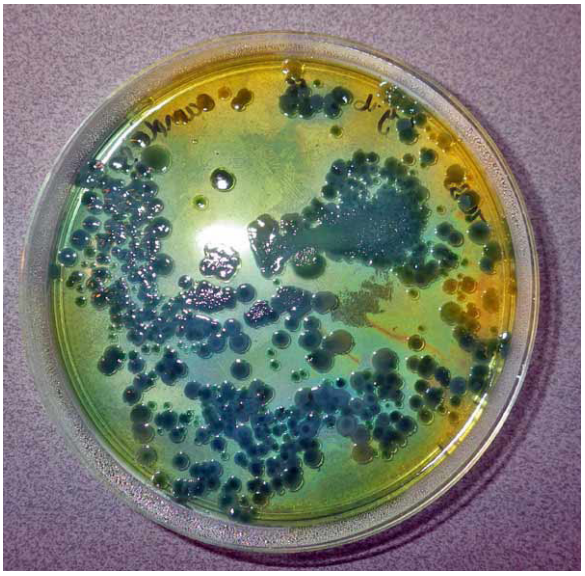

Fig. 16. *Vibrio spp* were grown on a *Vibrio* specific medium. *Vibrio* colonies with a yellow colour were identified to the species level with a VITEK ® MS analysis as they may concern *Vibrio cholerae*, which was the target of this analysis.

3.2.3 Plankton

A total of 18 water samples and 18 phytoplankton net samples were taken at 9 sampling locations in both spring and summer period, to assess the diversity of phytoplankton species in the Sloehaven:

Samples of phytoplankton have been collected by obtaining a 250 ml water sample pooled from three sites at least 15 m apart in each research area (Figs 2-10; Tables 1-3). Samples (0.5 l) have been taken at each location at the surface (1 m depth) and at 5 m depth (Fig. 17) with a Van Dorn Water sampler (Fig. 14B).

Additionally, a concentrated vertical sample was taken using a small hand held 20 µm plankton net. Three tows, at least 15 m apart have been taken to ensure for adequate sample. If the depth did not allow for a vertical tow, a horizontal tow was conducted. Haul and tow rates did not exceed 0.25 – 0.30 m/s. Clear, colourless iodine-proof bottles with tightly fitting screw caps have been used as containers. Samples have been preserved in acid Lugol solution (0.25 – 0.5 cm^3/ 100 cm^3 sample) and placed in a cooler for transport to the analysing laboratory (Koeman & Bijkerk BV).

A total of 18 zooplankton net samples were taken at 9 sampling locations in both spring and summer period, to assess the diversity of zooplankton species in the Sloehaven:

Vertical zooplankton samples have been collected with a standard 100 µm mesh drop net (Fig. 18). Three tows, at least 15 m apart have been conducted per area to ensure for adequate sample. If the depth did not allow for a vertical tow, a horizontal tow was conducted. Samples have been preserved in acid Lugol solution (0.25 – 0.5 cm^3/ 100 cm^3 sample) and placed in a cooler for transport to the analysing laboratory (Koeman & Bijkerk BV).

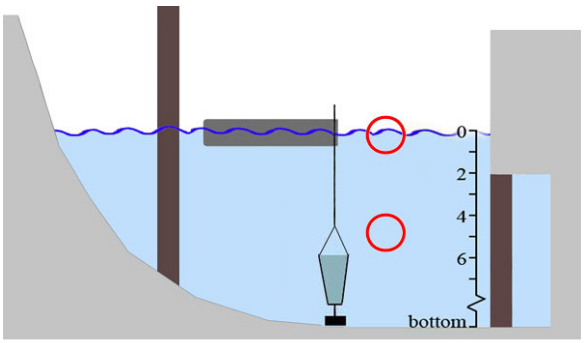

Fig. 17. Water samples that were taken from the water surface and at 5 m depth are checked for plankton.

Fig. 18. Zooplankton 100 µm mesh drop net.

A total of 21 zooplankton net samples were taken at 12 sampling locations in both spring and summer period in all four research areas (Fig. 1), to assess the diversity of larger zooplankton species:

Samples of larger zooplankton organisms including gelatinous species have been obtained using a net with mesh size 500 µm by conducting three tows at least 15 m apart per area. Tow rate was approximately 1 m/s and the net was stopped 1

m before the bottom. If the depth did not allow for a vertical tow, a horizontal tow was conducted. Samples were placed in sample bottles and in a cooler. Larger zooplankton species, including gelatinous species, were examined by GiMaRIS immediately after collection without preservation. All larger zooplankton species, including gelatinous species, were digitally photographed with a 21.1 megapixel camera (Canon EOS 5D Mark II), in a tray with seawater, while still alive. Samples were preserved on 96% ethanol.

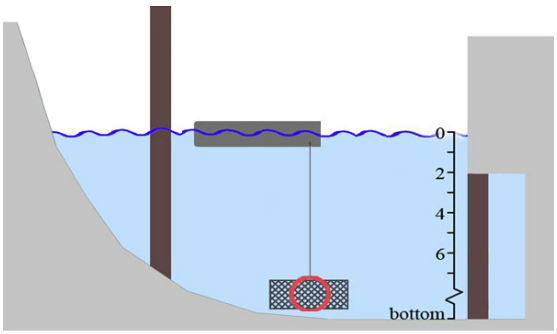

Fig. 19. Traps were attached to a dock or the harbour wall and weighted with a brick to place them on the bottom.

3.2.4 Traps

In late summer a total of 18 light weight traps were tethered to existing structures like pilings, buoys and docks (Fig. 19) to assess the diversity of mobile epifauna, such as crabs and fish, in the Sloehaven:

In research areas A to C three sampling locations were chosen at least 15 m apart (Figs 2-10; Tables 1-3). Traps were baited with frozen fish (cod) and deployed at each research site for at least 48 hours.

Two types of traps were used to sample mobile epifauna: Chinese crab traps and Gee's minnow traps (Fig. 20). The Chinese crab trap measured 63 cm x 42 cm x 20 cm, with 1.3 cm mesh netting. The Gee's minnow trap measured 45 x 22 x 22 cm, with 6 mm netting and a 8 cm mouth. The traps were weighted by attaching a brick to the frame.

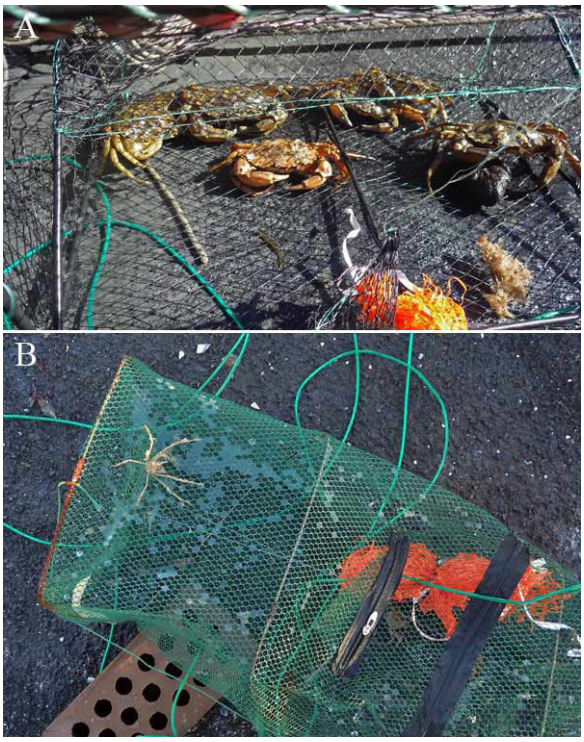

Fig. 20. The two trap types that were deployed. A: Chinese crab trap; B: Gee's minnow trap.

After retrieving the traps, the catch was identified in the field and/or placed in zipper storage bags for identification in the lab. The traps were deployed at the locations where also water samples were taken, and petite ponar grabs were conducted including a bottom sediment analysis, which can be used to describe the environment where the trap was deployed.

3.2.5 Fouling plates

A total of nine fouling plate units were deployed at 9 sampling locations to assess the fouling species diversity in the Sloehaven:

In research areas A to C three fouling plate units were deployed in spring at least 15 m apart from each other on dock structures at locations where they are not disturbed by for example port traffic (Figs 2-10; Tables 1-3).

The fouling plate units were constructed of approximately 11 m of rope (⌀ 0.5 cm), three gray 14 cm x 14 cm PVC plates and a brick (Figs 21-22). Each plate was sanded briefly on both sides prior to the deployment to provide a more hospitable settling substrate for the organisms. A hole (⌀ 0.5 cm) was drilled at the center of each plate for the rope. Plates were secured on the rope at set distances using knots secured with zipties (Figs 21-22). Units were tied securely to the dock structures so that the first plate was submerged at approximately 1 m depth, the second plate at approximately 3 m and the third plate at approximately 7 m of depth (Figs 21-22). If the depth of a site was insufficient (taking tidal differences into account) the deeper plates were removed and the bricks were tied at suitable depth for the site.

The units were retrieved during the late summer monitoring. They were carefully pulled on the dock to prevent losing organisms such as mobile epifauna. The plates were photographed and placed in labeled plastic buckets with sea water prior to transport. The bricks and ropes were packed in separate bags. All detached organisms were collected and placed into a separate labeled ziplock bags. Most organisms were photographed and identified in the field or in the laboratory directly after collecting them while they were still alive. Samples were preserved on ethanol 96%.

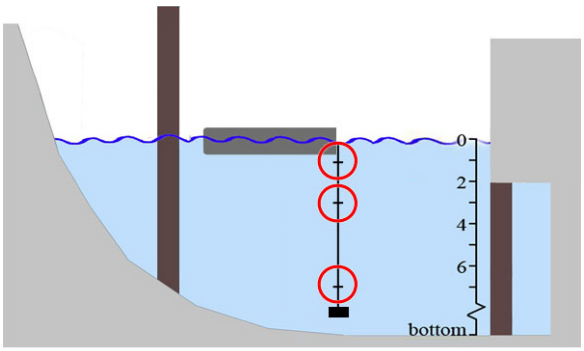

Fig. 21. Fouling plate constructions with a fouling plates at 1 m, 3 m and 7 m depth were deployed in the water. If the depth of a site was insufficient (taking tidal differences into account) the deeper plates were removed and the bricks were tied at suitable depth for the site.

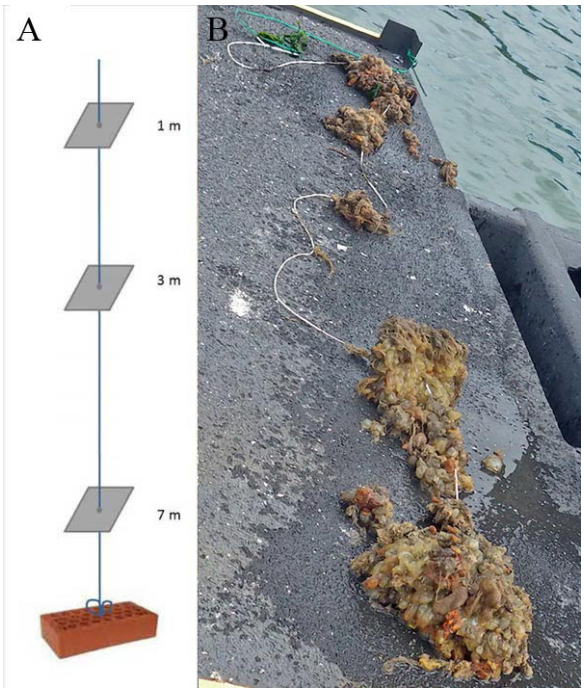

Fig. 22. Fouling plate construction. A: 14 x 14 cm fouling plates of grey PVC, hanging at various depths in the water, as illustrated in the HELCOM/OSPAR protocol; B: fouling plate construction retrieved after 3 month in the water.

3.2.6 Sub-littoral scrape samples

In research areas A to C, a total of 16 scrape samples were taken at 16 sampling locations (Figs 2-10; Tables 1-3) to assess the species diversity in the Sloehaven during the late summer monitoring.

Scrape samples were taken from floating docks, and around low tide in the sublittoral from pilings and harbor walls (Fig 23) with an aluminum hand net on a 2.5 m long pole equipped with a scraping blade (Fig. 24). For each scrape sample, the surface scraped was estimated and noted. All scrape samples were first placed in a plastic tray and photographed and identified in the field where possible. The remaining organisms were collected and preserved on either ethanol 96% (animals) or formaldehyde 4% (algae), and identified in the laboratory.

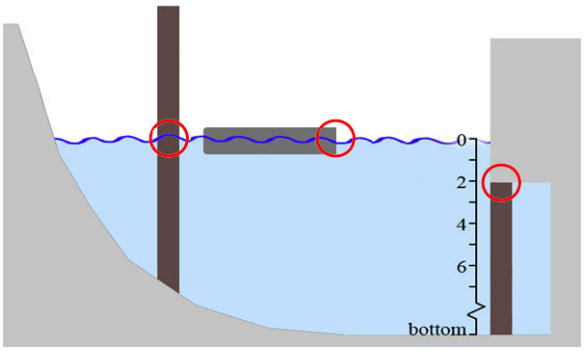

Fig. 23. Scrape samples were taken with a scrape net from floating docks and around low tide from pillars and harbour walls.

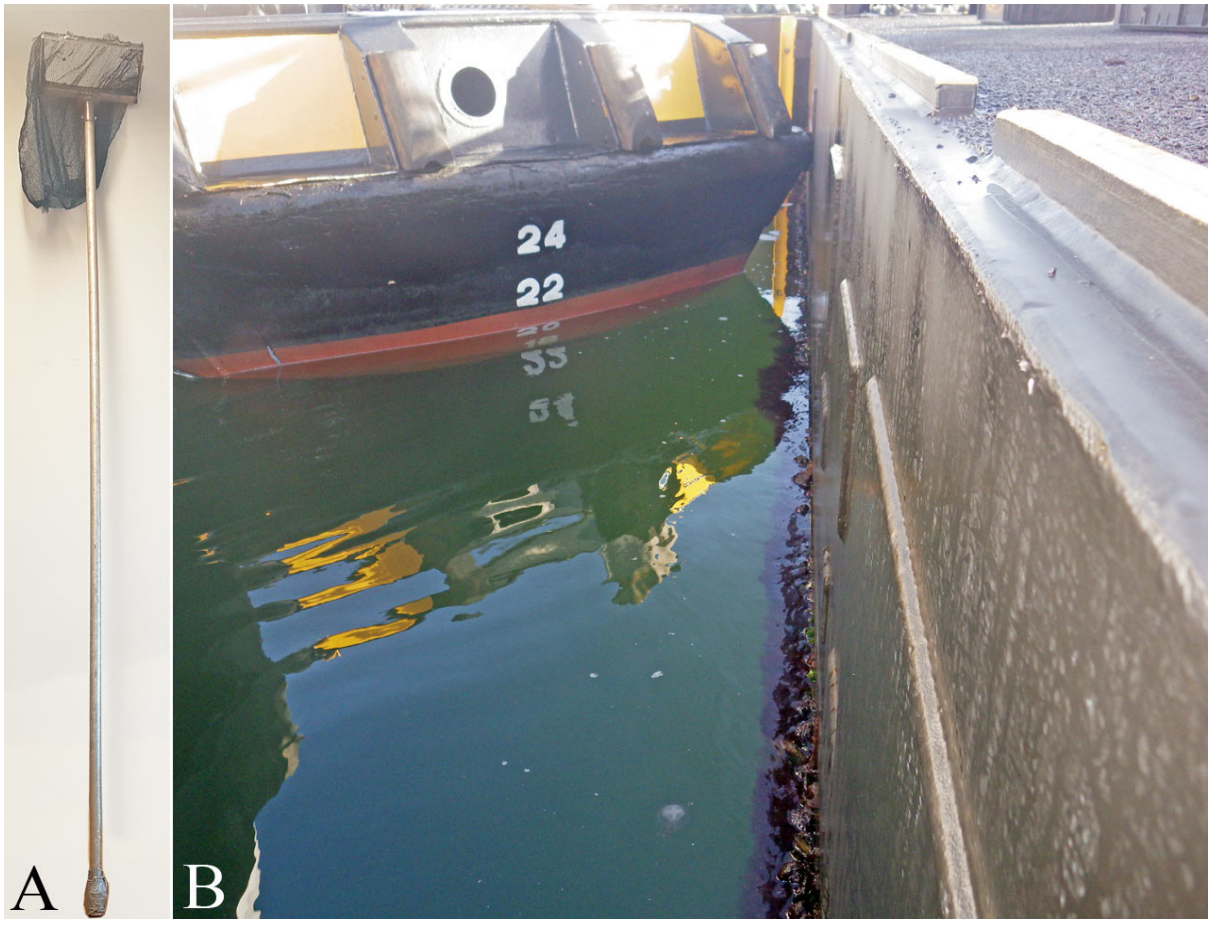

Fig. 24. Scrape samples. [A] An aluminium hand net on a 2.5 m long pole equipped with a scraping blade; [B] Scrape samples were taken from harbour walls around low tide.

3.2.7 Dike fouling, littoral zone

In research areas A to C, in a total of 15 transects, 45 samples were taken to assess the species diversities in the littoral zones of the dikes in the Sloehaven (Figs 2-10; Tables 1-3). This was done during the late summer monitoring.

In each clearly distinguishable littoral zone on the dike (Figs 25-26) three replicate 0.10 cm^2 quadrates, at least 15 m apart along a 45 meter horizontal transect, were digitally photographed. The area of each quadrate was scraped straight into zipper bags. Visual observations of additional species (for example crabs) that were encountered in the quadrates or along the transects in between the quadrate locations, were also noted. Species were identified in the field, from the photographs and in the scrape samples taken.

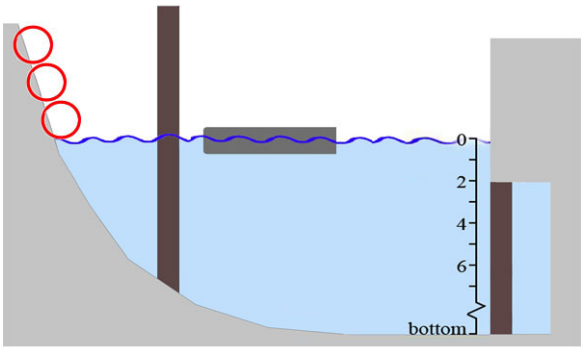

Fig. 25. Dike fouling in the littoral zone.

Organisms that were collected, were preserved on either ethanol 96% (animals) or formaldehyde 4% (algae), and identified in the laboratory.

Fig. 26.Various zones differing in fouling species communities (mainly algae) can be distinguished on a dike at low tide. [A]: *Fucus spiralis* zone; [B]: *Fucus vesiculosus* zone and [C] rocks close to the low water line.

3.2.8 Petite ponar bottom sampling

In research areas A to D, a total of 30 bottom sediment samples from 30 sampling locations. At each research area the sampling locations were chosen at least 15 m apart (Figs 2-11; Tables 1-4). They were taken to assess mainly the infauna species diversity. This was done during the late summer monitoring.

The samples were taken with a benthic grab, i.e. a petite ponar (Figs 27-28), which is suitable for taking samples both in soft sediments and in bottoms with pebbles and shells. As the petite ponar is relatively heavy, it was attached to an iron cable, with handholds every half meter. With these handholds the petite ponar can easily be lifted out of the water by hand by one person without having to be very strong.

When a sample was taken a 50 ml tube was filled with sediment to be dried and analyzed with a Geotech Sieve Analysis Field Kit (Fig. 29) in the laboratory to assess the sediment size composition. After the 50 ml subsample was taken, the rest of the bottom grab sample was sieved with a 0.5 mm sieve, and transferred to a sample jar for further biodiversity analyses in the laboratory. Organisms that were collected, were preserved on either ethanol 96% (animals) or formaldehyde 4% (algae), and identified in the laboratory.

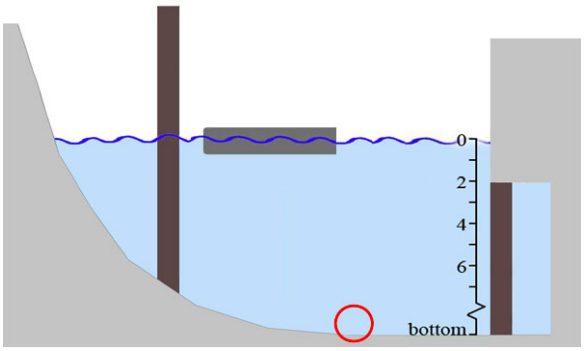

Fig. 27. Bottom samples were taken with a Petite ponar grab (Fig. 32).

Fig. 28. The Petite ponar, a modified Van Veen grab, suitable for samples of soft substrate bottoms as well as bottoms with hard substratum like pebbles and shells.

Fig. 29. The Geotech Sieve Analysis Field Kit to determine the composition of bottom sediment samples.

3.2.9 Hand dredge sampling

In research areas A to D, a total of 14 hand dredge samples were taken at 14 sampling locations to assess the species diversity in sublittoral zones. At each research area the sampling locations were chosen at least 15 m apart (Figs 2-11; Tables 1-4). These samples were taken during the late summer monitoring.

A professional 'Naturalists' hand dredge was used, weighing 5 kg, with a 450 x 185 mm frame and a net bag with a 1 mm mesh size. It was deployed and pulled over the bottom over a distance of at least 10 meter (Figs. 31-31). As the dredge can be heavy, the same cable with handholds as is described above in the case of the petite ponar was used. All hand dredge samples were first placed in a plastic tray. All organisms were photographed and identified in the field where possible. The remaining organisms were collected and preserved on either ethanol 96% (animals) or formaldehyde 4% (algae), and identified in the laboratory.

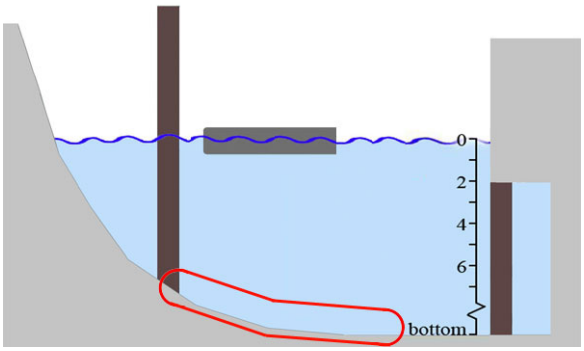

Fig. 30. Dredge samples were taken along a transect of at least 10 m.

Fig. 31. Sampling with a hand dredge.

3.2.10 Drop-down camera videos

In research areas A to C, at a total of 5 locations, at least 15 m apart (Figs 2-10; Tables 1-3), species were scored from video footage taken with a drop-down camera. This was done during the late summer period. At most locations the visibility in the port did not allow the deployment of this camera. A visibility of at least 10-15 cm is needed to identify species from videos taken with a drop-down camera.

The underwater video camera (high definition Ricoh camera with underwater housing) was slowly deployed along pilings and/or harbor walls from the surface to the bottom (Fig 32).

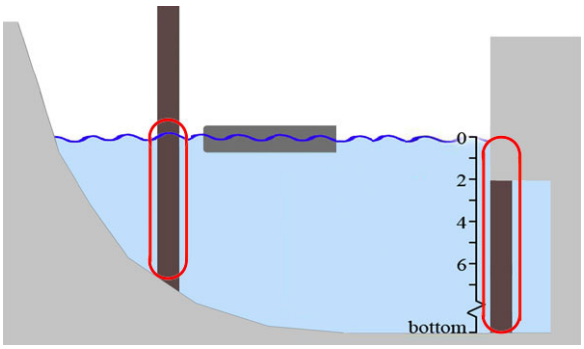

Fig. 32. The drop-down camera was slowly deployed along pilings and/or harbour walls from the surface to the bottom.

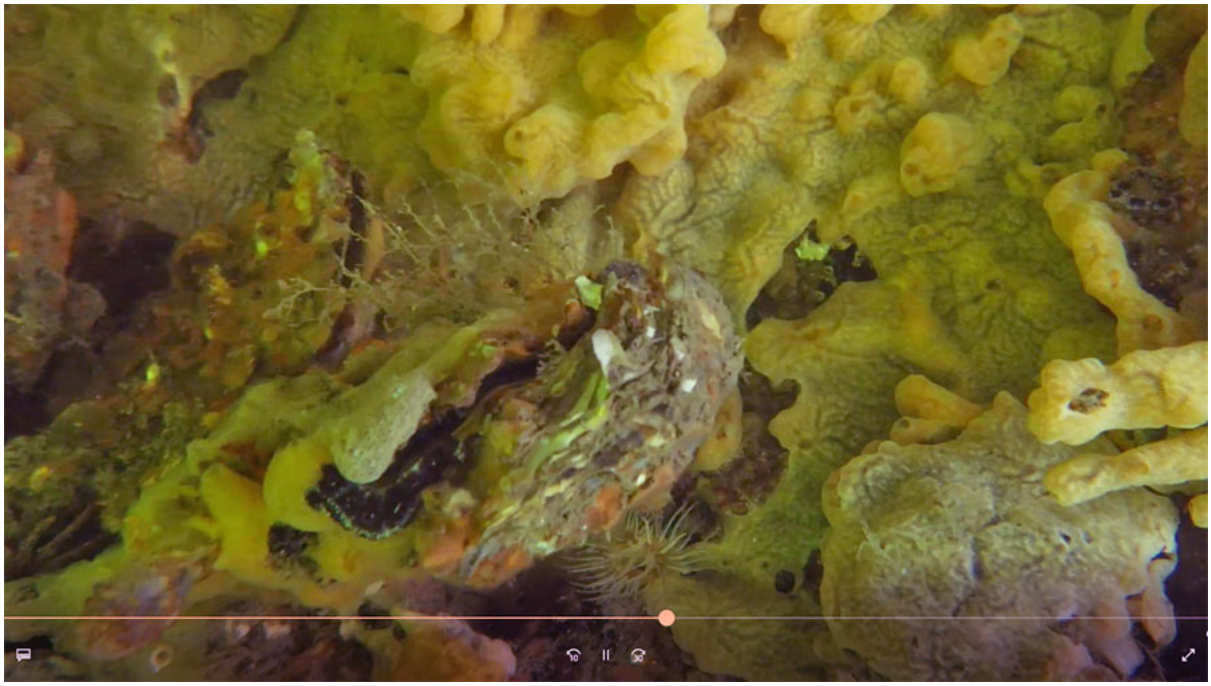

Fig. 33. Screenshot of an underwater video in area C (Fig. 1) showing e.g. the Pacific oyster *Crassostrea gigas* and the invasive colonial carpet sea squirt *Didemnum vexillum* (the white sponge like layer covering most of the surface).

4. Results

In total 336 samples were taken from 149 different sampling locations in research areas A to D. In these samples a total of 220 species were identified to the species level (Table 5). Of these species 30 concern non-natives to the Netherlands. The physical parameters that were measured and the species that were recorded with each of the monitoring methods in the different research areas, are presented in the next paragraphs. Lists of species scored in each sample, are available on request. This dataset is made compatible with the format of the HELCOM/OSPAR database that is used for the online decision support tool, which can be used in applications for exemptions to the ballast water convention.

Table 5. The 220 species that were identified to the species level in the research areas A to D (Fig. 1). The 30 non-native species are highlighed. The non-native species in this list all have their native ranges outside of NW European waters.

Species	Authority	Group	Origin	Area A	Area B	Area C	Area D
Cymbomonas tetramitiformis	Schiller	Algea (Chlorophyta)	Native	1	1	1	
Mantoniella squamata	(Manton & Parke) Desikachary	Algea (Chlorophyta)	Native		1		
Micromonas pusilla	(Butcher) I.Manton & M.Parke	Algea (Chlorophyta)	Native			1	
Pyramimonas longicauda	L.Van Meel	Algea (Chlorophyta)	Native	1	1	1	
Ulva australis	Areschoug	Algea (Chlorophyta)	Non-native		1		
Ulva curvata	(Kützing) De Toni	Algea (Chlorophyta)	Native		1		
Ulva intestinalis	Linnaeus	Algea (Chlorophyta)	Native	1			
Ulva prolifera	O.F.Müller	Algea (Chlorophyta)	Native	1			
Mesodinium rubrum	(Lohmann)	Algea (Ciliophora)	Native	1			
Leucocryptos marina	(Braarud) Butcher	Algea (Cryptophyta)	Native		1		
Actiniscus pentasterias	(Ehrenberg) Ehrenberg	Algea (Myzozoa)	Native	1			
Akashiwo sanguinea	(Hirasaka) Hansen & Moestrup	Algea (Myzozoa)	Native	1	1	1	
Archaeperidinium minutum	(Kofoid) Jørgensen	Algea (Myzozoa)	Native		1	1	
Dinophysis acuminata	Claparède & Lachmann	Algea (Myzozoa)	Native	1	1	1	
Gonyaulax spinifera	(Claparède & Lachmann) Diesing	Algea (Myzozoa)	Native			1	
Gymnodinium galeatum	J.Larsen	Algea (Myzozoa)	Native		1	1	
Gymnodinium verruculosum	P.H.Campbell	Algea (Myzozoa)	Native	1		1	
Gyrodinium spirale	(Bergh) Kofoid & Swezy	Algea (Myzozoa)	Native	1	1	1	
Heterocapsa lanceolata	Iwataki & Fukuyo	Algea (Myzozoa)	Native	1			
Heterocapsa minima	A.J.Pomroy	Algea (Myzozoa)	Native	1	1	1	
Katodinium glaucum	(Lebour) Loeblich III	Algea (Myzozoa)	Native	1	1	1	
Nematopsides vigilans	(Marshall) Greuet	Algea (Myzozoa)	Native		1		
Noctiluca scintillans	(Macartney) Kofoid & Swezy	Algea (Myzozoa)	Native		1		
Peridinium achromaticum	Levander	Algea (Myzozoa)	Native		1		
Prorocentrum micans	Ehrenberg	Algea (Myzozoa)	Native		1	1	
Prorocentrum triestinum	J.Schiller	Algea (Myzozoa)	Native	1	1	1	
Protoperidinium bipes	(Paulsen) Balech	Algea (Myzozoa)	Native	1	1		
Protoperidinium claudicans	(Paulsen) Balech	Algea (Myzozoa)	Native	1	1	1	
Protoperidinium conicum	(Gran) Balech	Algea (Myzozoa)	Native			1	
Protoperidinium depressum	(Bailey) Balech	Algea (Myzozoa)	Native		1		
Protoperidinium excentricum	(Paulsen) Balech	Algea (Myzozoa)	Native	1			
Protoperidinium leonis	(Pavillard) Balech	Algea (Myzozoa)	Native	1	1		
Protoperidinium marie-lebouriae	(Paulsen) Balech	Algea (Myzozoa)	Native	1			

Protoperidinium ovatum	Pouchet	Algea (Myzozoa)	Native	1	1		
Species	**Authority**	**Group**	**Origin**	**Area A**	**Area B**	**Area C**	**Area D**
Protoperidinium pentagonum	(Gran) Balech	Algea (Myzozoa)	Native		1		
Protoperidinium steinii	(Jørgensen) Balech	Algea (Myzozoa)	Native	1			
Protoperidinium subinerme	(Paulsen) Loeblich III	Algea (Myzozoa)	Native	1	1	1	
Protoperidinium thorianum	(Paulsen) Balech	Algea (Myzozoa)	Native	1			
Torodinium robustum	Kofoid & Swezy	Algea (Myzozoa)	Native	1			
Warnowia polyphemus	(Pouchet) J.Schiller	Algea (Myzozoa)	Native	1		1	
Actinoptychus octonarius	(Ehrenberg) Kützing	Algea (Ochrophyta)	Native	1	1		
Actinoptychus senarius	(Ehrenberg) Ehrenberg	Algea (Ochrophyta)	Native	1	1	1	
Ascophyllum nodosum	(Linnaeus) Le Jolis	Algea (Ochrophyta)	Native	1	1		
Asterionellopsis glacialis	(Castracane) Round	Algea (Ochrophyta)	Native	1		1	
Asteroplanus karianus	(Grunow) Gardner & Crawford	Algea (Ochrophyta)	Native		1		
Bacillaria paxillifera	(O.F.Müller) T.Marsson	Algea (Ochrophyta)	Native		1		
Bacteriastrum hyalinum	Lauder	Algea (Ochrophyta)	Native			1	
Biddulphia rhombus	(Ehrenberg) W.Smith	Algea (Ochrophyta)	Native	1		1	
Brockmanniella brockmannii	(Hustedt) Hasle & Syvertsen	Algea (Ochrophyta)	Native	1	1	1	
Cerataulina pelagica	(Cleve) Hendey	Algea (Ochrophyta)	Native	1	1	1	
Cerataulus radiatus	R.Ross	Algea (Ochrophyta)	Native	1			
Ceratoneis closterium	Ehrenberg	Algea (Ochrophyta)	Native	1	1	1	
Chaetoceros affinis	Lauder	Algea (Ochrophyta)	Native			1	
Chaetoceros curvisetus	Cleve	Algea (Ochrophyta)	Native		1		
Chaetoceros danicus	Cleve	Algea (Ochrophyta)	Native	1	1	1	
Chaetoceros debilis	Cleve	Algea (Ochrophyta)	Native	1		1	
Chaetoceros didymus	Ehrenberg	Algea (Ochrophyta)	Native	1	1	1	
Chaetoceros pseudocurvisetus	Mangin	Algea (Ochrophyta)	Native	1	1	1	
Chaetoceros socialis	H.S.Lauder	Algea (Ochrophyta)	Native	1	1	1	
Chaetoceros subtilis	Cleve	Algea (Ochrophyta)	Native	1	1	1	
Chaetoceros teres	Cleve	Algea (Ochrophyta)	Native			1	
Coscinodiscus concinnus	W.Smith	Algea (Ochrophyta)	Native	1	1	1	
Coscinodiscus perforatus var. pavillardii	(Forti) Hust	Algea (Ochrophyta)	Native			1	
Coscinodiscus radiatus	Ehrenberg	Algea (Ochrophyta)	Native	1	1	1	
Cymatosira belgica	Grunow	Algea (Ochrophyta)	Native	1			
Dactyliosolen fragilissimus	(Bergon) Hasle	Algea (Ochrophyta)	Native	1			
Dactyliosolen phuketensis	(B.G.Sundström) G.R.Hasle	Algea (Ochrophyta)	Native	1	1		
Delphineis minutissima	(Hustedt) Simonsen	Algea (Ochrophyta)	Native	1	1	1	
Dinobryon faculiferum	(Willén) Willén	Algea (Ochrophyta)	Native			1	
Ditylum brightwellii	(T.West) Grunow	Algea (Ochrophyta)	Native	1	1	1	
Eucampia zodiacus	Ehrenberg	Algea (Ochrophyta)	Native	1	1	1	
Fucus serratus	Linnaeus	Algea (Ochrophyta)	Native	1			
Fucus spiralis	Linnaeus	Algea (Ochrophyta)	Native	1		1	
Fucus vesiculosus	Linnaeus	Algea (Ochrophyta)	Native	1	1	1	
Grammatophora marina	(Lyngbye) Kützing	Algea (Ochrophyta)	Native	1			
Guinardia delicatula	(Cleve) Hasle	Algea (Ochrophyta)	Native	1	1	1	
Guinardia flaccida	(Castracane) H.Peragallo	Algea (Ochrophyta)	Native	1	1	1	
Guinardia striata	(Stolterfoth) Hasle	Algea (Ochrophyta)	Native	1	1	1	
Gyrosigma balticum	(Ehrenberg) Rabenhorst	Algea (Ochrophyta)	Native	1			
Helicotheca tamesis	(Shrubsole) M.Ricard	Algea (Ochrophyta)	Native	1	1	1	
Hincksia granulosa	(Smith) P.C.Silva	Algea (Ochrophyta)	Native		1	1	

Hincksia sandriana	(Zanardini) P.C.Silva	Algea (Ochrophyta)	Native		1	1	
Species	**Authority**	**Group**	**Origin**	**Area A**	**Area B**	**Area C**	**Area D**
Lauderia annulata	Cleve	Algea (Ochrophyta)	Native	1			
Lennoxia faveolata	H.A.Thomsen & K.R.Buck	Algea (Ochrophyta)	Native		1	1	
Leptocylindrus danicus	Cleve	Algea (Ochrophyta)	Native	1	1	1	
Leptocylindrus minimus	Gran	Algea (Ochrophyta)	Native	1	1	1	
Lithodesmium undulatum	Ehrenberg	Algea (Ochrophyta)	Native	1	1	1	
Melosira moniliformis	(O.F.Müller) C.Agardh	Algea (Ochrophyta)	Native	1	1		
Membraneis challengeri	(Grunow) Paddock	Algea (Ochrophyta)	Native	1	1		
Meuniera membranacea	(Cleve) P.C.Silva	Algea (Ochrophyta)	Native	1	1	1	
Minutocellus scriptus	Hasle, von Stosch & Syvertsen	Algea (Ochrophyta)	Native	1	1	1	
Navicula distans	(W.Smith) Ralfs	Algea (Ochrophyta)	Native	1			
Neocalyptrella robusta	(Norman)	Algea (Ochrophyta)	Native		1		
Nitzschia lorenziana var. incerta	Grunow	Algea (Ochrophyta)	Native	1			
Odontella longicruris	(Greville) M.A.Hoban	Algea (Ochrophyta)	Native	1	1	1	
Odontella sinensis	(Greville) Grunow	Algea (Ochrophyta)	Non-native	1	1	1	
Odontella turgida	(Ehrenberg) Kützing	Algea (Ochrophyta)	Native			1	
Paralia sulcata	(Ehrenberg) Cleve	Algea (Ochrophyta)	Native	1	1	1	
Plagiogrammopsis vanheurckii	(Grunow)	Algea (Ochrophyta)	Native	1	1	1	
Pleurosigma formosum	W.Smith	Algea (Ochrophyta)	Native	1		1	
Podosira stelligera	(Bailey) A.Mann	Algea (Ochrophyta)	Native	1		1	
Pseudo-nitzschia americana	(Hasle) Fryxell	Algea (Ochrophyta)	Native	1			
Pseudo-nitzschia delicatissima	(Cleve) Heiden	Algea (Ochrophyta)	Native	1	1	1	
Pseudo-nitzschia fraudulenta	(Cleve) Hasle	Algea (Ochrophyta)	Native	1	1	1	
Pseudo-nitzschia pseudodelicatissima	(Hasle) Hasle	Algea (Ochrophyta)	Native	1			
Pseudo-nitzschia pungens	(Grunow ex Cleve) G.R.Hasle	Algea (Ochrophyta)	Native	1	1	1	
Pseudo-nitzschia seriata	(Cleve) H.Peragallo	Algea (Ochrophyta)	Native	1			
Pseudopodosira westii	(Smith) Sheshukova & Glezer	Algea (Ochrophyta)	Native		1		
Rhaphoneis amphiceros	(Ehrenberg) Ehrenberg	Algea (Ochrophyta)	Native	1	1	1	
Rhizosolenia imbricata	Brightwell	Algea (Ochrophyta)	Native	1	1	1	
Rhizosolenia setigera	Brightwell	Algea (Ochrophyta)	Native	1		1	
Roperia tesselata	(Roper) Grunow ex Pelletan, 1889	Algea (Ochrophyta)	Native	1			
Skeletonema costatum	(Greville) Cleve, 1873	Algea (Ochrophyta)	Native		1	1	
Thalassionema nitzschioides	(Grunow) Mereschkowsky, 1902	Algea (Ochrophyta)	Native	1	1	1	
Thalassiosira eccentrica	(Ehrenberg) Cleve, 1904	Algea (Ochrophyta)	Native	1			
Thalassiosira gravida	Cleve, 1896	Algea (Ochrophyta)	Native	1	1	1	
Thalassiosira punctigera	(Castracane) Hasle, 1983	Algea (Ochrophyta)	Non-native	1	1	1	
Trigonium alternans	(Bailey) A.Mann, 1907	Algea (Ochrophyta)	Native	1	1	1	
Tryblionella coarctata	(Grunow) D.G.Mann, 1990	Algea (Ochrophyta)	Native	1		1	
Aglaothamnion roseum	(Roth) Maggs & L'Hardy-Halos	Algea (Rhodophyta)	Native	1			
Antithamnionella spirographidis	(Schiffner) E.M.Wollaston, 1968	Algea (Rhodophyta)	Non-native	1			
Ceramium cimbricum	H.E.Petersen	Algea (Rhodophyta)	Native		1	1	
Ceramium virgatum	Roth	Algea (Rhodophyta)	Native	1			
Chondrus crispus	Stackhouse	Algea (Rhodophyta)	Native		1	1	
Dasysiphonia japonica	(Yendo) H.-S.Kim	Algea (Rhodophyta)	Non-native	1	1	1	
Hypoglossum hypoglossoides	(Stackhouse) F.S.Collins & Hervey	Algea (Rhodophyta)	Native	1			
Neosiphonia harveyi	(Bailey) Kim, Choi, Guiry & Saunders	Algea (Rhodophyta)	Non-native	1			
Polysiphonia elongata	(Hudson) Sprengel	Algea (Rhodophyta)	Native	1	1	1	
Polysiphonia fucoides	(Hudson) Greville	Algea (Rhodophyta)	Native	1	1	1	
Polysiphonia stricta	(Dillwyn) Greville	Algea (Rhodophyta)	Native		1	1	

Porphyra umbilicalis	Kützing	Algea (Rhodophyta)	Native	1			
Species	**Authority**	**Group**	**Origin**	**Area A**	**Area B**	**Area C**	**Area D**
Pterothamnion plumula	(J.Ellis) Nägeli	Algea (Rhodophyta)	Native		1	1	
Ficopomatus enigmaticus	(Fauvel, 1923)	Annelida	Non-native	1			
Neodexiospira brasiliensis	(Grube, 1872)	Annelida	Non-native			1	
Nephtys hombergii	Savigny in Lamarck, 1818	Annelida	Native	1	1		
Nereis pelagica	Linnaeus, 1758	Annelida	Native	1		1	
Owenia mitraria (larvae)	Ford & Hutchings, 2005	Annelida	Native	1	1		
Pherusa flabellata	(M. Sars in G.O. Sars, 1872)	Annelida	Native	1	1		
Serpula vermicularis	Linnaeus, 1767	Annelida	Native	1	1	1	
Spirobranchus triqueter	(Linnaeus, 1758)	Annelida	Native		1	1	
Oikopleura (Vexillaria) dioica	Fol, 1872	Appendicularia	Native	1	1	1	
Aplidium glabrum	(Verrill, 1871)	Ascidiacea	Non-native	1	1	1	
Ascidiella aspersa	(Müller, 1776)	Ascidiacea	Native	1	1	1	
Botrylloides violaceus	Oka, 1927	Ascidiacea	Non-native	1	1	1	
Botryllus schlosseri	(Pallas, 1766)	Ascidiacea	Native	1	1	1	
Ciona intestinalis	(Linnaeus, 1767)	Ascidiacea	Native	1	1	1	
Didemnum vexillum	Kott, 2002	Ascidiacea	Non-native	1	1	1	
Diplosoma listerianum	(Milne Edwards, 1841)	Ascidiacea	Non-native			1	
Molgula manhattensis	(De Kay, 1843)	Ascidiacea	Non-native	1	1	1	
Perophora japonica	Oka, 1927	Ascidiacea	Non-native		1		
Styela clava	Herdman, 1881	Ascidiacea	Non-native	1	1	1	
Planktothrix agardhii	(Gomont) Anagnostidis & Komárek, 1988	Bacteria (Cyanobacteria)	Native			1	
Escherichia coli	Castellani & Chalmers, 1919	Bacteria (Proteobacteria)	Native		1	1	
Vibrio alginolyticus	Sakazaki, 1968	Bacteria (Proteobacteria)	Native	1	1	1	
Alcyonidioides mytili	(Dalyell, 1848)	Bryozoa	Native	1	1	1	
Bugulina stolonifera	(Ryland, 1960)	Bryozoa	Non-native	1			
Conopeum reticulum	(Linnaeus, 1767)	Bryozoa	Native	1	1	1	
Cryptosula pallasiana	(Moll, 1803)	Bryozoa	Native		1	1	
Electra pilosa	(Linnaeus, 1767)	Bryozoa	Native	1	1	1	
Scrupocellaria scruposa	(Linnaeus, 1758)	Bryozoa	Native	1	1	1	
Smittoidea prolifica	Osburn, 1952	Bryozoa	Non-native		1		
Tricellaria inopinata	d'Hondt & Occhipinti Ambrogi, 1985	Bryozoa	Non-native	1	1	1	
Actinia equina	(Linnaeus, 1758)	Cnidaria	Native	1			
cf Bougainvillia britannica	(Forbes, 1841)	Cnidaria	Native	1			
cf Bougainvillia muscus	(Allman, 1863)	Cnidaria	Native				
cf Clytia hemisphaerica	(Linnaeus, 1767)	Cnidaria	Native			1	1
cf Lovenella clausa	(Lovén, 1836)	Cnidaria	Native	1			
Cyanea lamarckii	Péron & Lesueur, 1810	Cnidaria	Native		1		
Diadumene cincta	Stephenson, 1925	Cnidaria	Non-native	1			
Metridium senile	(Linnaeus, 1761)	Cnidaria	Native	1	1	1	
Obelia dichotoma	(Linnaeus, 1758)	Cnidaria	Native			1	
Obelia longissima	(Pallas, 1766)	Cnidaria	Native	1	1	1	
Sagartia elegans	(Dalyell, 1848)	Cnidaria	Native			1	
Sagartia troglodytes	(Price in Johnston, 1847)	Cnidaria	Native		1		
Sagartiogeton undatus	(Müller, 1778)	Cnidaria	Native	1	1	1	
Austrominius modestus	(Darwin, 1854)	Crustacea	Non-native	1	1	1	
Balanus crenatus	Bruguière, 1789	Crustacea	Native	1	1	1	
Caprella mutica	Schurin, 1935	Crustacea	Non-native	1	1	1	
Carcinus maenas	(Linnaeus, 1758)	Crustacea	Native	1	1	1	

Crangon crangon	(Linnaeus, 1758)	Crustacea	Native			1	
Species	**Authority**	**Group**	**Origin**	**Area A**	**Area B**	**Area C**	**Area D**
Echinogammarus stoerensis	(Reid, 1938)	Crustacea	Native	1			
Hemigrapsus sanguineus	(De Haan, 1835)	Crustacea	Non-native		1	1	
Hemigrapsus takanoi	Asakura & Watanabe, 2005	Crustacea	Non-native	1	1	1	
Jassa marmorata	Holmes, 1905	Crustacea	Non-native	1	1		
Macropodia rostrata	(Linnaeus, 1761)	Crustacea	Native	1	1		
Melita nitida	Smith, 1873	Crustacea	Non-native			1	
Necora puber	(Linnaeus, 1767)	Crustacea	Native	1	1		
Palaemon longirostris	H. Milne Edwards, 1837	Crustacea	Native	1			
Pisidia longicornis	(Linnaeus, 1767)	Crustacea	Native		1		
Porcellana platycheles	(Pennant, 1777)	Crustacea	Native	1	1		
Semibalanus balanoides	(Linnaeus, 1767)	Crustacea	Native	1	1	1	
Mnemiopsis leidyi	A. Agassiz, 1865	Ctenophora	Non-native	1	1	1	1
Pleurobrachia pileus	(O. F. Müller, 1776)	Ctenophora	Native	1	1	1	
Ophiura albida	Forbes, 1839	Echinodermata	Native	1			
Ophiura ophiura	(Linnaeus, 1758)	Echinodermata	Native	1	1	1	
Abra alba	(W. Wood, 1802)	Mollusca	Native	1	1	1	
Corbula gibba	(Olivi, 1792)	Mollusca	Native	1	1	1	
Crassostrea gigas	(Thunberg, 1793)	Mollusca	Non-native	1	1	1	
Crepidula fornicata	(Linnaeus, 1758)	Mollusca	Non-native	1			
Ensis leei	Huber, 2015	Mollusca	Non-native	1			
Goniodoris castanea	Alder & Hancock, 1845	Mollusca	Native	1			
Limecola balthica	(Linnaeus, 1758)	Mollusca	Native	1			
Littorina littorea	(Linnaeus, 1758)	Mollusca	Native	1	1	1	
Littorina obtusata	(Linnaeus, 1758)	Mollusca	Native		1		
Mya arenaria	Linnaeus, 1758	Mollusca	Non-native	1	1		
Mytilus edulis	Linnaeus, 1758	Mollusca	Native	1	1	1	
Patella vulgata	Linnaeus, 1758	Mollusca	Native	1	1	1	
Peringia ulvae	(Pennant, 1777)	Mollusca	Native	1	1		
Ruditapes decussatus	(Linnaeus, 1758)	Mollusca	Native		1		
Spisula subtruncata	(da Costa, 1778)	Mollusca	Native	1	1		
Tritia reticulata	(Linnaeus, 1758)	Mollusca	Native	1		1	
Lineus longissimus	(Gunnerus, 1770)	Nemertea	Native		1		
Atherina presbyter	Cuvier, 1829	Pisces	Native			1	
Gobius niger	Linnaeus, 1758	Pisces	Native			1	
Pomatoschistus microps	(Krøyer, 1838)	Pisces	Native	1			
Leptoplana tremellaris	(Müller OF, 1773)	Platyhelminthes	Native	1			
Halichondria bowerbanki	Burton, 1930	Porifera	Native			1	
Halichondria panicea	(Pallas, 1766)	Porifera	Native		1	1	
Haliclona oculata	(Linnaeus, 1759)	Porifera	Native			1	
Ebria tripartita	(J.Schumann) Lemmermann, 1899	Protozoa	Native	1	1	1	
			Total number of species (220):	**160**	**141**	**134**	**2**
			Total number of non-native species (30):	**23**	**20**	**18**	**1**

4.1 Physical parameters

A total of 88 water samples were collected at 9 sampling locations in both spring and summer period to measure the physical water parameters.

The date of the inventory, the wind speed and direction, and the air temperature during the inventories done in the spring bloom and the late summer of 2016 in the Sloehaven are presented for each of the research areas in table 6. In research areas A to C water samples for measuring water parameters were taken at three sample locations. For each of these sample locations the geographical coordinates were noted (Tables 1-3). At each location the depth of the bottom was noted and the water parameters [1] turbidity in ntu, [2] temperature, [3] pH and [4] salinity (in ppt and PSU) were measured in the water samples in both spring (Table 7) and summer (Table 8).

Table 6. Survey dates and weather conditions during the spring and summer inventories for each research area (Fig. 1).

Area	Date	Wind Direction	Wind Speed	Air Temp
Area A	20-05-2016	235° (WSW)	2 BFT	8°C
Area A	05-09-2016	262°(W)	3 BFT	19°C
Area B	20-05-2016	235° (WSW)	2 BFT	8°C
Area B	05-09-2016	262° (W)	3 BFT	20°C
Area C	20-05-2016	235° (WSW)	2 BFT	8°C
Area C	05-09-2016	262°(W)	3 BFT	20°C
Area D	11-10-2016	45° (NE)	2 BFT	11°C

Table 7 Water parameter measurements at the research sites A to C (Fig. 1) during the sampling period in the spring of 2016.

Area	Sample loc.	Depth	Turbidity (ntu)	Water temp (°C)	pH	Salinity (ppt)	Salinity (PSU)
A	5	0,3	3,28	9,9	8,26	25,73	33,90
A	5	1	3,5	9,9	8,27	25,82	34,03
A	5	3 (bottom)	142	9,8	8,23	25,78	33,98
A	19	0,3	1,83	9,9	8,19	26,00	34,30
A	19	1	3,2	9,9	8,25	25,92	34,18
A	19	4	3,82	9,9	8,27	25,96	34,23
A	19	5	3,91	9,9	8,27	25,98	34,28
A	19	7	4,67	9,8	8,27	26,22	34,63
A	19	8 (bottom)	5,62	9,8	8,26	26,18	34,57
A	29	0,3	2,28	9,9	8,28	25,80	34,01
A	29	1	2,22	9,9	8,27	25,72	33,89
A	29	4 (bottom)	38,8	9,9	8,27	25,76	33,95
B	63	0,3	1,41	9,9	8,26	25,53	33,61
B	63	1	1,57	9,9	8,26	25,48	33,54
B	63	4	2,24	9,9	8,27	25,53	33,62
B	63	5	3,18	9,8	8,27	25,64	33,77
B	63	6,5 (bottom)	7,66	9,8	8,25	26,36	34,83
B	71	0,3	1,27	9,9	8,27	25,55	33,65
B	71	1	1,96	9,9	8,27	25,49	33,55
B	71	4	2,34	9,9	8,26	25,66	33,81
B	71	5	2,8	9,8	8,26	25,73	33,90
B	71	6,5 (bottom)	2,54	9,8	8,25	25,87	34,12
B	82	0,3	4,55	9,9	8,24	25,37	33,38
B	82	1	5,66	9,9	8,25	25,46	33,52
B	82	4	2,34	9,9	8,27	25,46	33,51
B	82	5	2,59	9,8	8,27	25,66	33,80
B	82	7	2,14	9,8	8,26	26,33	34,80
B	82	9,5 (bottom)	4,79	9,8	8,27	27,34	36,30
C	96	0,3	2,32	9,9	8,24	25,76	33,96
C	96	1	2,41	9,9	8,25	25,81	34,02
C	96	4	2,6	9,9	8,24	25,83	34,05
C	96	5	2,96	9,9	8,24	25,78	33,98
C	96	6,2 (bottom)	5,09	9,8	8,23	25,76	33,95
C	114	0,3	2,49	9,9	8,26	25,80	34,00
C	114	1	3,35	9,9	8,26	25,81	34,03
C	114	4	2,23	9,9	8,25	25,77	33,96
C	114	5	2,14	9,8	8,25	25,75	33,95
C	114	7 (bottom)	5,46	9,8	8,24	25,81	34,04
C	124	0,3	1,73	9,9	8,21	25,61	33,75
C	124	1	1,4	9,9	8,23	25,78	33,99
C	124	4	2,61	9,9	8,23	25,84	34,07
C	124	5	2,97	9,8	8,22	25,89	34,16
C	124	7	3,5	9,8	8,22	26,29	34,74
C	124	7,5 (bottom)	5,41	9,8	8,22	26,41	34,92

Table 8. Water parameter measurements at the research sites A to C (Fig. 1) during the sampling period in the late summer of 2016.

Area	Sample loc.	Depth	Turbidity (ntu)	Water temp (°C)	pH	Salinity (ppt)	Salinity (PSU)
A	19	0,3	3,00	21,0	7,90	20,49	26,26
A	19	1	3,72	21,0	8,05	20,63	26,46
A	19	4	3,81	21,0	8,08	20,77	26,65
A	19	7	4,60	20,8	8,10	20,78	26,68
A	19	10	4,83	20,6	8,10	21,13	27,18
A	19	13 (bottom)	5,36	20,5	8,10	21,88	28,25
A	29	0,3	2,69	20,9	8,08	21,19	27,26
A	29	1	3,46	20,9	8,08	21,14	27,19
A	29	4	3,83	20,8	8,09	21,27	27,37
A	29	6,5 (bottom)	20,40	20,5	8,10	21,53	27,74
A	5	0,3	6,00	21,1	8,12	20,88	26,82
A	5	1	7,12	21,0	8,13	20,85	26,77
A	5	4	6,98	20,8	8,13	20,92	26,87
A	5	5,5 (bottom)	71,50	20,0	8,11	20,99	26,98
B	82	0,3	2,52	21,0	8,12	21,00	26,98
B	82	1	4,85	21,0	8,13	20,99	26,96
B	82	4	2,15	20,8	8,11	21,06	27,06
B	82	7	4,61	20,3	8,11	21,33	27,45
B	82	10	9,79	20,0	8,13	22,05	28,49
B	82	10,5 (bottom)	46,90	20,0	8,16	22,16	28,64
B	71	0,3	3,03	21,0	8,11	21,03	27,01
B	71	1	3,74	21,0	8,11	20,94	26,89
B	71	4	2,31	20,8	8,09	21,01	27,00
B	71	7	4,03	20,5	8,09	21,21	27,29
B	71	9,5 (bottom)	49,10	20,4	8,09	21,79	28,12
B	63	0,3	3,03	21,0	8,12	21,09	27,11
B	63	1	5,80	21,0	8,11	21,03	27,03
B	63	4	8,85	20,8	8,12	21,03	27,03
B	63	6,5 (bottom)	15,90	20,5	8,10	21,39	27,54
B	96	0,3	4,82	22,0	8,08	21,14	27,18
B	96	1	2,79	22,0	8,08	21,07	27,08
B	96	4	3,03	21,8	8,07	21,09	27,11
B	96	7	6,67	21,5	8,08	21,37	27,52
B	96	8 (bottom)	22,50	21,0	8,07	21,58	27,82
C	114	0,3	1,55	21,5	8,08	21,06	27,08
C	114	1	2,76	21,5	8,04	21,10	27,13
C	114	4	2,96	21,0	8,07	21,15	27,21
C	114	7	3,94	21,0	8,08	21,46	27,64
C	114	8,5 (bottom)	23,84	21,0	8,07	21,53	27,74
C	124	0,3	1,92	21,0	8,08	21,20	27,28
C	124	1	1,99	21,0	8,05	21,17	27,23
C	124	4	2,37	20,8	8,07	21,17	27,23
C	124	7	3,76	20,8	8,06	21,27	27,37
C	124	8,7 (bottom)	8,53	20,5	8,07	21,36	27,49

4.2 Human pathogens

The results of the human pathogen analyses are presented in table 9. According to Regulation D-2 Ballast Water Performance Standard of the "Ballast water management convention" (International Maritime Organization; February, 2004) there should be less than 1 colony forming unit (cfu) per 100 ml of *Vibrio cholerae* (O1 and O139), less than 250 cfu per 100 ml of *Escherichia coli* and less than 100 cfu per 100 ml intestinal *Enterococci* in ballast water. These threshold values were not breached in the Sloehaven during the spring period sampling, when only one cfu *Enterococci* was scored in area B (Table 9). During the summer period, the *Enterococci* threshold was breached in research areas A and B with concentrations of respectively 608 and 506 cfu/100 ml. The other thresholds were not breached. In all three areas however, *Vibrio* species (*Vibrio spp*.) were found in high densities. In areas A, B and C values of respectively $5.3x10^4$, $2.3x10^4$ and $1.8x10^5$ cfu / 100 ml were recorded (Table 10). As *Vibrio cholerae* is known for its yellow colonies, all yellow *Vibrio* colonies on the growth media plates that appeared to have different morphologies (phenotype) were taken off the plates, grown over night on separate plates and analysed by VITEK ® MS to identify to the species. From these analyses it could be concluded that the *Vibrio* spp. in the Sloehaven do not concern *Vibrio cholerae*. The VITEK ® MS analyses indicated that the colonies concerned the species *Vibrio alginolyticus.*

Table 9. Human pathogens in the research areas A to C during the spring period sampling.

Area	*E. coli*	*Enterococci*	*Vibrio spp.*
Area A	0 cfu /100 ml	0 cfu /100 ml	0 cfu /100 ml
Area B	0 cfu /100 ml	1 cfu /100 ml	0 cfu /100 ml
Area C	0 cfu /100 ml	0 cfu /100 ml	0 cfu /100 ml

Table 10. Human pathogens in the research areas A to C during the late summer period sampling.

Area	*E. coli*	*Enterococci*	*Vibrio spp.*
Area A	0 cfu /100 ml	608 cfu /100 ml	$5.3x10^4$ cfu /100 ml
Area B	2 cfu /100 ml	506 cfu /100 ml	$2.3x10^5$ cfu /100 ml
Area C	14 cfu /100 ml	4 cfu /100 ml	$1.8x10^5$ cfu /100 ml

4.3 Plankton

4.3.1 Phytoplankton

The phytoplankton samples were taken in the research areas A to C in the Sloehaven during both sping and summer inventories. The species were identified by Koeman & Bijkerk BV (Table 11). In these samples 111 species were identified. Only two species, i.e. *Odontella sinensis* and *Thalassiosira punctigera* were non-native (Gómez & Souissi, 2010; Gómez, 2008).

4.3.2 Zooplankton

The zooplankton samples were taken in the research areas A to C in the Sloehaven during both sping and summer inventories. The species were identified by Koeman & Bijkerk BV. As many of the larval "zooplankton" stages like the nauplii and pluteus stages of related species look exactly the same, only two of the species could be identified to the species level (Table 12). Both concerned native species.

4.3.3 Larger zooplankton including gelatinous species

Samples were taken with a 500 µm zooplankton net in the three research areas A to C at three different locations in the Sloehaven during both sping and summer inventories. During the summer period, three additional samples were taken in research area D. In the samples 7 species were scored (Table 13) of which one concerns a non-native species, i.e. *Mnemiopsis leidyi.* It was recorded in all four research areas.

Table 11. The 111 phytoplankton species that were identified to the species level in the research areas A to C during both the spring and the late summer sampling period. The two non-native species are highlighed.

Species	Group	Origin	Spring			Summer		
			Area A	Area B	Area C	Area A	Area B	Area C
Cymbomonas tetramitiformis	Algea (Chlorophyta)	Native					1	
Mantoniella squamata	Algea (Chlorophyta)	Native			1			
Micromonas pusilla	Algea (Chlorophyta)	Native				1	1	1
Pyramimonas longicauda	Algea (Chlorophyta)	Native					1	
Mesodinium rubrum	Algea (Ciliophora)	Native	1	1	1	1	1	1
Leucocryptos marina	Algea (Cryptophyta)	Native					1	
Actiniscus pentasterias	Algea (Myzozoa)	Native				1		
Akashiwo sanguinea	Algea (Myzozoa)	Native				1	1	1
Archaeperidinium minutum	Algea (Myzozoa)	Native					1	1
Dinophysis acuminata	Algea (Myzozoa)	Native				1	1	1
Gonyaulax spinifera	Algea (Myzozoa)	Native						1
Gymnodinium galeatum	Algea (Myzozoa)	Native					1	1
Gymnodinium verruculosum	Algea (Myzozoa)	Native				1		1
Gyrodinium spirale	Algea (Myzozoa)	Native	1	1	1			
Heterocapsa lanceolata	Algea (Myzozoa)	Native	1			1		
Heterocapsa minima	Algea (Myzozoa)	Native	1	1	1	1	1	1
Katodinium glaucum	Algea (Myzozoa)	Native				1	1	1
Nematopsides vigilans	Algea (Myzozoa)	Native		1				
Noctiluca scintillans	Algea (Myzozoa)	Native					1	
Peridinium achromaticum	Algea (Myzozoa)	Native					1	
Prorocentrum micans	Algea (Myzozoa)	Native		1				1
Prorocentrum triestinum	Algea (Myzozoa)	Native				1	1	1
Protoperidinium bipes	Algea (Myzozoa)	Native	1	1				
Protoperidinium claudicans	Algea (Myzozoa)	Native				1	1	1
Protoperidinium conicum	Algea (Myzozoa)	Native			1			
Protoperidinium depressum	Algea (Myzozoa)	Native		1				
Protoperidinium excentricum	Algea (Myzozoa)	Native				1		
Protoperidinium leonis	Algea (Myzozoa)	Native				1	1	
Protoperidinium marie-lebouriae	Algea (Myzozoa)	Native				1		
Protoperidinium ovatum	Algea (Myzozoa)	Native	1	1				
Protoperidinium pentagonum	Algea (Myzozoa)	Native					1	
Protoperidinium steinii	Algea (Myzozoa)	Native				1		
Protoperidinium subinerme	Algea (Myzozoa)	Native	1	1	1			
Protoperidinium thorianum	Algea (Myzozoa)	Native	1					
Torodinium robustum	Algea (Myzozoa)	Native	1					
Warnowia polyphemus	Algea (Myzozoa)	Native				1		1
Actinoptychus octonarius	Algea (Ochrophyta)	Native		1		1	1	
Actinoptychus senarius	Algea (Ochrophyta)	Native	1	1	1	1	1	
Asterionellopsis glacialis	Algea (Ochrophyta)	Native	1		1			
Asteroplanus karianus	Algea (Ochrophyta)	Native		1				
Bacillaria paxillifera	Algea (Ochrophyta)	Native		1				
Bacteriastrum hyalinum	Algea (Ochrophyta)	Native						1
Biddulphia rhombus	Algea (Ochrophyta)	Native	1		1	1		
Brockmanniella brockmannii	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Cerataulina pelagica	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Cerataulus radiatus	Algea (Ochrophyta)	Native	1			1		
Ceratoneis closterium	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Chaetoceros affinis	Algea (Ochrophyta)	Native						1
Chaetoceros curvisetus	Algea (Ochrophyta)	Native					1	
Chaetoceros danicus	Algea (Ochrophyta)	Native		1		1	1	1
Chaetoceros debilis	Algea (Ochrophyta)	Native				1		1
Chaetoceros didymus	Algea (Ochrophyta)	Native	1			1	1	1
Chaetoceros pseudocurvisetus	Algea (Ochrophyta)	Native				1	1	1

Species	Group	Origin	Spring			Summer		
			Area A	Area B	Area C	Area A	Area B	Area C
Chaetoceros subtilis	Algea (Ochrophyta)	Native			1	1	1	
Chaetoceros teres	Algea (Ochrophyta)	Native						1
Coscinodiscus concinnus	Algea (Ochrophyta)	Native	1	1	1			
Coscinodiscus perforatus var. pavillardii	Algea (Ochrophyta)	Native			1			
Coscinodiscus radiatus	Algea (Ochrophyta)	Native	1	1	1	1	1	
Cymatosira belgica	Algea (Ochrophyta)	Native	1					
Dactyliosolen fragilissimus	Algea (Ochrophyta)	Native				1		
Dactyliosolen phuketensis	Algea (Ochrophyta)	Native				1	1	
Delphineis minutissima	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Dinobryon faculiferum	Algea (Ochrophyta)	Native						1
Ditylum brightwellii	Algea (Ochrophyta)	Native	1	1	1	1		
Eucampia zodiacus	Algea (Ochrophyta)	Native			1	1	1	1
Grammatophora marina	Algea (Ochrophyta)	Native				1		
Guinardia delicatula	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Guinardia flaccida	Algea (Ochrophyta)	Native	1		1	1	1	
Guinardia striata	Algea (Ochrophyta)	Native				1	1	1
Gyrosigma balticum	Algea (Ochrophyta)	Native				1		
Helicotheca tamesis	Algea (Ochrophyta)	Native	1	1	1			
Lauderia annulata	Algea (Ochrophyta)	Native				1		
Lennoxia faveolata	Algea (Ochrophyta)	Native					1	1
Leptocylindrus danicus	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Leptocylindrus minimus	Algea (Ochrophyta)	Native				1	1	1
Lithodesmium undulatum	Algea (Ochrophyta)	Native	1		1	1	1	1
Melosira moniliformis	Algea (Ochrophyta)	Native	1	1				
Membraneis challengeri	Algea (Ochrophyta)	Native	1			1	1	
Meuniera membranacea	Algea (Ochrophyta)	Native	1	1	1	1	1	
Minutocellus scriptus	Algea (Ochrophyta)	Native				1	1	1
Navicula distans	Algea (Ochrophyta)	Native	1					
Neocalyptrella robusta	Algea (Ochrophyta)	Native					1	
Nitzschia lorenziana var. incerta	Algea (Ochrophyta)	Native				1		
Odontella longicruris	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Odontella sinensis	Algea (Ochrophyta)	Non-native	1	1	1	1	1	1
Odontella turgida	Algea (Ochrophyta)	Native			1			
Paralia sulcata	Algea (Ochrophyta)	Native	1	1	1	1		
Plagiogrammopsis vanheurckii	Algea (Ochrophyta)	Native	1	1	1			
Pleurosigma formosum	Algea (Ochrophyta)	Native	1		1	1		
Podosira stelligera	Algea (Ochrophyta)	Native			1	1		
Pseudo-nitzschia americana	Algea (Ochrophyta)	Native				1		
Pseudo-nitzschia delicatissima	Algea (Ochrophyta)	Native	1	1	1			
Pseudo-nitzschia fraudulenta	Algea (Ochrophyta)	Native				1	1	1
Pseudo-nitzschia pseudodelicatissima	Algea (Ochrophyta)	Native				1		
Pseudo-nitzschia pungens	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Pseudo-nitzschia seriata	Algea (Ochrophyta)	Native	1					
Pseudopodosira westii	Algea (Ochrophyta)	Native		1				
Rhaphoneis amphiceros	Algea (Ochrophyta)	Native	1	1	1	1	1	
Rhizosolenia imbricata	Algea (Ochrophyta)	Native	1		1	1	1	1
Rhizosolenia setigera	Algea (Ochrophyta)	Native	1		1			1
Roperia tesselata	Algea (Ochrophyta)	Native	1					
Skeletonema costatum	Algea (Ochrophyta)	Native		1	1			
Thalassionema nitzschioides	Algea (Ochrophyta)	Native	1	1	1	1	1	1
Thalassiosira eccentrica	Algea (Ochrophyta)	Native	1					
Thalassiosira gravida	Algea (Ochrophyta)	Native	1	1	1	1		1
Thalassiosira punctigera	Algea (Ochrophyta)	Non-native	1	1	1	1		
Trigonium alternans	Algea (Ochrophyta)	Native				1	1	1
Tryblionella coarctata	Algea (Ochrophyta)	Native	1					1
Planktothrix agardhii	Bacteria (Cyanobacteria)	Native			1			
Ebria tripartita	Protozoa	Native				1	1	1
		Total	**49**	**39**	**43**	**64**	**52**	**46**

Table 12. Zooplankton recorded in samples from hauls with a 100 µm plankton net in the research areas A to C during the sampling periods in spring and summer 2016.

Species	Group	Origin	Spring			Summer		
			Area A	Area B	Area C	Area A	Area B	Area C
Noctiluca sp	Algea (Myzozoa)	-	1		1			
Magelona	Annelida	-	1		1			
Polychaeta	Annelida	-	1	1		1	1	1
Owenia mitraria (larvae)	Annelida	Native	1	1				
Oikopleura (Vexillaria) dioica	Appendicularia	Native	1	1	1			
Fritillaria	Appendicularia	-	1	1	1			
Ascidiella (larvae)	Ascidiacea	-					1	
Hydrozoa	Cnidaria	-						1
Balanidae (cypris larvae)	Crustacea	-	1				1	
Balanidae (nauplii)	Crustacea	-	1	1	1	1	1	1
Calanoides	Crustacea	-	1	1	1	1	1	1
Copepoda (nauplii)	Crustacea	-	1	1	1	1	1	1
Cyclopidina	Crustacea	-	1					
Decapoda	Crustacea	-		1				
Echinodermata (pluteus)	Echinodermata	-	1	1	1	1	1	1
Bivalvia (veliger)	Mollusca	-	1	1	1	1		1
Gastropoda	Mollusca	-		1				
Rotifera	Rotifera	-	1	1	1		1	1
		Total	**14**	**12**	**10**	**6**	**8**	**8**

Table 13. Gelatine zooplankton recorded in samples taken in the research areas A to D during the sampling periods in spring and summer 2016. Research area D was only sampled in the late summer. The non-native species is highlighted.

Species	Group	Origin	Spring			Summer			
			Area A	Area B	Area C	Area A	Area B	Area C	Area D
cf *Bougainvillia britannica*	Cnidaria	Native	1			1			
cf *Clytia hemisphaerica*	Cnidaria	Native			1				1
Cyanea lamarckii	Cnidaria	Native		1					
Lovenella clausa	Cnidaria	Native	1						
Mnemiopsis leidyi	Ctenophora	Non-native	1	1	1	1	1		1
Pleurobrachia pileus	Ctenophora	Native	1	1	1	1	1		
Atherina presbyter	Pisces	Native						1	
		Total	**4**	**3**	**3**	**3**	**2**	**1**	**2**

4.4 Traps

4.4.1 Chinese crab trap

In the summer of 2016 a total of nine Chinese crab traps were deployed in the Sloehaven for four days in the research areas A to C. With the Chinese crab traps in total 14 species were recorded (Table 14). Five of these species were non-native.

4.4.2 Gee's minnow trap

In the summer of 2016 a total of nine Gee's minnow traps were deployed in the Sloehaven for four days in the research areas A to C. With the Gee's minnow traps in total ten species were recorded (Table 15). Two of these species were non-native.

Table 14. Species found in the Chinese crab traps that were deployed in the research areas A to C in the late summer of 2016. They were baited and left in the water for four days. The five non-native species are highlighed.

Species	Group	Origin	Area A	Area B	Area C
Spirobranchus triqueter	Annelida	Native		1	1
Molgula manhattensis	Ascidiacea	Non-native	1	1	1
Conopeum reticulum	Bryozoa	Native	1	1	1
Scrupocellaria scruposa	Bryozoa	Native	1	1	1
Obelia longissima	Cnidaria	Native	1	1	1
Austrominius modestus	Crustacea	Non-native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Carcinus maenas	Crustacea	Native	1	1	1
Hemigrapsus sanguineus	Crustacea	Non-native		1	1
Hemigrapsus takanoi	Crustacea	Non-native	1	1	1
Necora puber	Crustacea	Native	1	1	
Mnemiopsis leidyi	Ctenophora	Non-native	1	1	1
Mytilus edulis	Mollusca	Native	1	1	1
Halichondria (Halichondria) panicea	Porifera	Native		1	1
		Total:	**11**	**14**	**13**

Table 15. Species found in the Gee´s minnow traps that were deployed in the research areas A to C in the late summer of 2016. They were baited and left in the water for four days. The two non-native species are highlighed.

Species	Group	Origin	Area A	Area B	Area C
Scrupocellaria scruposa	Bryozoa	Native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Carcinus maenas	Crustacea	Native	1	1	1
Hemigrapsus takanoi	Crustacea	Non-native	1	1	1
Macropodia rostrata	Crustacea	Native	1	1	
Necora puber	Crustacea	Native	1	1	
Palaemon longirostris	Crustacea	Native	1		
Mnemiopsis leidyi	Ctenophora	Non-native	1	1	1
Gobius niger	Pisces	Native			1
Pomatoschistus microps	Pisces	Native	1		
		Total:	**9**	**7**	**6**

Table 16. Species found on the fouling plates that were deployed during the sampling period in the spring The two non-native species are highlighed. of 2016 and checked in the late summer of 2016. The 15 non-native species are highlighted.

Species	Group	Origin	Area A	Area B	Area C
Ulva australis	Algea (Chlorophyta)	Non-native		1	
Ulva curvata	Algea (Chlorophyta)	Native	1		
Ulva prolifera	Algea (Chlorophyta)	Native	1		
Fucus vesiculosus	Algea (Ochrophyta)	Native	1	1	1
Hincksia granulosa	Algea (Ochrophyta)	Native		1	1
Hincksia sandriana	Algea (Ochrophyta)	Native		1	1
Aglaothamnion roseum	Algea (Rhodophyta)	Native	1		
Antithamnionella spirographidis	Algea (Rhodophyta)	Non-native	1		
Ceramium cimbricum	Algea (Rhodophyta)	Native		1	1
Ceramium virgatum	Algea (Rhodophyta)	Native	1		
Dasysiphonia japonica	Algea (Rhodophyta)	Non-native	1	1	1
Hypoglossum hypoglossoides	Algea (Rhodophyta)	Native	1		
Neosiphonia harveyi	Algea (Rhodophyta)	Non-native	1		
Polysiphonia elongata	Algea (Rhodophyta)	Native	1	1	1
Polysiphonia fucoides	Algea (Rhodophyta)	Native	1	1	1
Polysiphonia stricta	Algea (Rhodophyta)	Native		1	1
Pterothamnion plumula	Algea (Rhodophyta)	Native		1	1
Nereis pelagica	Annelida	Native	1		1
Neodexiospira brasiliensis	Annelida	Non-native			1
Serpula vermicularis	Annelida	Native	1	1	1
Spirobranchus triqueter	Annelida	Native		1	1
Ascidiella aspersa	Ascidiacea	Native	1	1	1
Botrylloides violaceus	Ascidiacea	Non-native	1	1	1
Botryllus schlosseri	Ascidiacea	Native	1	1	1
Ciona intestinalis	Ascidiacea	Native	1	1	1
Didemnum vexillum	Ascidiacea	Non-native		1	
Molgula manhattensis	Ascidiacea	Non-native	1	1	1
Perophora japonica	Ascidiacea	Non-native		1	
Styela clava	Ascidiacea	Non-native	1	1	1
Alcyonidioides mytili	Bryozoa	Native	1	1	1
Conopeum reticulum	Bryozoa	Native	1	1	1
Cryptosula pallasiana	Bryozoa	Native		1	1
Electra pilosa	Bryozoa	Native	1	1	1
Tricellaria inopinata	Bryozoa	Non-native	1	1	1
Metridium senile	Cnidaria	Native	1	1	1
Obelia longissima	Cnidaria	Native	1	1	1
Sagartia elegans	Cnidaria	Native			1
Austrominius modestus	Crustacea	Non-native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Caprella mutica	Crustacea	Non-native	1	1	1
Carcinus maenas	Crustacea	Native	1	1	1
Hemigrapsus takanoi	Crustacea	Non-native	1	1	1
Porcellana platycheles	Crustacea	Native	1	1	
Crassostrea gigas	Mollusca	Non-native	1	1	1
Mytilus edulis	Mollusca	Native	1	1	1
Lineus longissimus	Nemertea	Native		1	
Leptoplana tremellaris	Platyhelminthes	Native	1		
		Total:	**34**	**36**	**34**

4.5 Fouling plates

During the sampling period in the spring of 2016 a total of nine fouling plate constructions were deployed in the Sloehaven in the research areas A to C. These constructions were retrieved in September, 2016. In total 47 species were recorded (Table 16). Fifteen of these species concerned non-natives.

5.6 Scrape samples

In the summer of 2016 in total sixteen scrape samples were taken from floating docks, pilings and harbor walls in the Sloehaven in the research areas A to C. A total of 27 species were found using this method (Table 17). Thirteen of these species were non-native.

Table 17. Species found in the scrape samples taken in the late summer of 2016. The 13 non-native species are highlighted.

Species	Group	Origin	Area A	Area B	Area C
Aplidium glabrum	Ascidiacea	Non-native	1	1	1
Botrylloides violaceus	Ascidiacea	Non-native	1	1	1
Botryllus schlosseri	Ascidiacea	Native	1	1	1
Didemnum vexillum	Ascidiacea	Non-native	1	1	1
Molgula manhattensis	Ascidiacea	Non-native	1	1	1
Styela clava	Ascidiacea	Non-native	1	1	1
Alcyonidioides mytili	Bryozoa	Native	1	1	1
Bugulina stolonifera	Bryozoa	Non-native	1		
Conopeum reticulum	Bryozoa	Native	1	1	1
Scrupocellaria scruposa	Bryozoa	Native	1	1	1
Diadumene cincta	Cnidaria	Non-native	1		
Metridium senile	Cnidaria	Native	1	1	1
Obelia longissima	Cnidaria	Native	1	1	1
Austrominius modestus	Crustacea	Non-native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Caprella mutica	Crustacea	Non-native	1	1	1
Carcinus maenas	Crustacea	Native	1	1	1
Echinogammarus stoerensis	Crustacea	Native	1		
Hemigrapsus takanoi	Crustacea	Non-native	1	1	1
Jassa marmorata	Crustacea	Non-native	1	1	
Porcellana platycheles	Crustacea	Native	1	1	
Semibalanus balanoides	Crustacea	Native	1	1	1
Mnemiopsis leidyi	Ctenophora	Non-native	1	1	1
Crassostrea gigas	Mollusca	Non-native	1	1	1
Mytilus edulis	Mollusca	Native	1	1	1
Patella vulgata	Mollusca	Native	1	1	1
Halichondria (Halichondria) bowerbanki	Porifera	Native			1
		Total:	**26**	**23**	**22**

5.7 Dike fouling, littoral zone

In the summer of 2016 a total of 45 samples were taken in the littoral zones on dikes in the three research areas A to C in the Sloehaven. In the samples a total of 26 species were recorded (Table 18). Five of these species were non-native.

Table 18. Species recorded in the samples that were taken from the littoral zones on the dikes in the late summer of 2016. The five non-native species are highlighted.

Species	Group	Origin	Area A	Area B	Area C
Ulva intestinalis	Algea (Chlorophyta)	Native	1		
Ascophyllum nodosum	Algea (Ochrophyta)	Native	1	1	
Fucus serratus	Algea (Ochrophyta)	Native	1		
Fucus spiralis	Algea (Ochrophyta)	Native	1		1
Fucus vesiculosus	Algea (Ochrophyta)	Native	1	1	1
Chondrus crispus	Algea (Rhodophyta)	Native		1	1
Porphyra umbilicalis	Algea (Rhodophyta)	Native	1		
Serpula vermicularis	Annelida	Native	1	1	1
Conopeum reticulum	Bryozoa	Native	1	1	1
Actinia equina	Cnidaria	Native	1		
Austrominius modestus	Crustacea	Non-native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Carcinus maenas	Crustacea	Native	1	1	1
Hemigrapsus sanguineus	Crustacea	Non-native		1	1
Hemigrapsus takanoi	Crustacea	Non-native	1	1	1
Porcellana platycheles	Crustacea	Native	1	1	
Semibalanus balanoides	Crustacea	Native	1	1	1
Crassostrea gigas	Mollusca	Non-native	1	1	1
Crepidula fornicata	Mollusca	Non-native	1		
Littorina littorea	Mollusca	Native	1	1	1
Littorina obtusata	Mollusca	Native		1	
Mytilus edulis	Mollusca	Native	1	1	1
Patella vulgata	Mollusca	Native	1	1	1
Peringia ulvae	Mollusca	Native	1	1	
Ruditapes decussatus	Mollusca	Native		1	
Halichondria (Halichondria) panicea	Porifera	Native		1	1
		Total:	**21**	**20**	**16**

5.8 Petite ponar bottom sampling

In the summer of 2016 a total of 33 bottom samples were taken with a petite ponar in research areas A to D. In the petite ponar samples a total of 26 species were recorded (Table 19). Seven of these were non-native species. In research area D sediment samples could be taken, but no living organisms were found. This could be due to the very strong currents and the fact that the sample sites at research area D were located at great depth (30 - 55 meter).

Sediments quality (grain size) analyses were done on the samples taken with the bottom grab, i.e. the petite ponar. From these analyses it could be concluded that the sediments in the Sloehaven consist mostly of medium to fine sand (Table 20; Fig. 34).

Table 19. Species found in the bottom samples that were taken with a petite ponar in the summer of 2016. The seven non-native species are highlighted. In research area D three samples were taken. Altough these samples did contain sediment, no living organisms were present. Area D is therefore not included in this table.

Species	Group	Origin	Area A	Area B	Area C
Nephtys hombergii	Annelida	Native	1	1	
Pherusa flabellata	Annelida	Native	1	1	
Serpula vermicularis	Annelida	Native	1	1	1
Styela clava	Ascidiacea	Non-native	1	1	1
Conopeum reticulum	Bryozoa	Native	1	1	1
Scrupocellaria scruposa	Bryozoa	Native	1	1	1
Smittoidea prolifica	Bryozoa	Non-native		1	
Metridium senile	Cnidaria	Native	1	1	1
Obelia longissima	Cnidaria	Native	1	1	1
Sagartia troglodytes	Cnidaria	Native		1	
Sagartiogeton undatus	Cnidaria	Native	1	1	1
Austrominius modestus	Crustacea	Non-native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Carcinus maenas	Crustacea	Native	1	1	1
Jassa marmorata	Crustacea	Non-native	1	1	
Melita nitida	Crustacea	Non-native			1
Porcellana platycheles	Crustacea	Native	1	1	
Mnemiopsis leidyi	Ctenophora	Non-native	1	1	1
Ophiura ophiura	Echinodermata	Native	1	1	1
Abra alba	Mollusca	Native	1	1	1
Corbula gibba	Mollusca	Native	1	1	1
Crassostrea gigas	Mollusca	Non-native	1	1	1
Limecola balthica	Mollusca	Native	1		
Mytilus edulis	Mollusca	Native	1	1	1
Spisula subtruncata	Mollusca	Native	1	1	
Tritia reticulata	Mollusca	Native	1		1
		Total:	**23**	**23**	**18**

Table 20. Results of the sediments quality (grain size) analyses done on the samples taken with the bottom grab (Petite ponar). Each of the bottom samples that was taken, is divided in different fractions. The fractions highlighted in yellow illustrate the sediment size classes that combined represent > 50 % of the sample.

	Research Area A					Research Area B					Research Area C			
> 1.80 mm Fine gravel	7.9%	1.7%	5.9%	1.5%	0.8%	29.8%	0.9%	2.8%	1.5%	1.9%	0.0%	21.3%	0.0%	0.2%
1.80 - 0.50 mm Coarse sand	23.3%	10.8%	14.9%	5.6%	21.1%	19.9%	24.6%	25.2%	13.7%	25.8%	0.9%	10.7%	7.6%	1.5%
0.50 - 0.25 mm Medium sand	42.3%	32.2%	35.0%	42.4%	30.7%	25.5%	34.7%	31.2%	23.3%	31.6%	12.2%	37.1%	41.2%	83.6%
0.25 - 0.06 mm Fine Sand	23.6%	47.2%	34.5%	23.6%	35.3%	22.2%	33.3%	35.8%	50.4%	30.3%	85.3%	30.4%	38.6%	11.6%
< 0.06 mm Silt	2.9%	8.0%	9.7%	26.8%	12.2%	2.5%	6.5%	4.9%	11.0%	10.3%	1.5%	0.5%	12.6%	3.1%

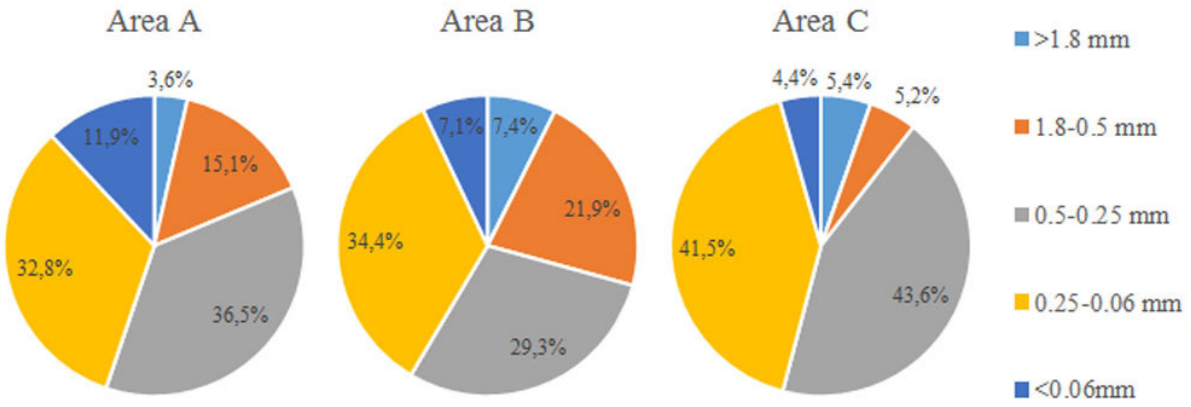

Fig 34. Results of the sediments quality (grain size) analyses done on the samples taken with the bottom grab (Petite ponar). Average sediment size compositions are illustrated in pie-diagrams for the research areas A to C.

5.9 Hand dredge sampling

In the late summer of 2016 (Table 6) a total of fourteen scrape samples were taken with a hand dredge in the Sloehaven in research areas A to D (Tables 1-4). In these samples a total of 20 species were recorded (Table 21). Six of the species were found to be non-native. At research area D no living species were found in the samples, although the dredge was filled with several kilograms of sand. This could be due to the relatively strong currents at this research area and the depth (30 - 55 meter).

Table 21. Species that were found in the hand dredge samples taken in research areas A to C. These samples were taken in the late summer of 2016. The six non-native species are highlighted. In research area D three samples were taken. Although each of these samples contained several kilograms of sand, no living organisms were present. Area D is therefore not included in this table.

Species	Group	Origin	Area A	Area B	Area C
Fucus vesiculosus	Algea (Ochrophyta)	Native	1	1	1
Hincksia granulosa	Algea (Ochrophyta)	Native		1	1
Hincksia sandriana	Algea (Ochrophyta)	Native		1	1
Ceramium cimbricum	Algea (Rhodophyta)	Native		1	1
Dasysiphonia japonica	Algea (Rhodophyta)	Non-native	1	1	1
Polysiphonia elongata	Algea (Rhodophyta)	Native	1	1	1
Polysiphonia fucoides	Algea (Rhodophyta)	Native	1	1	1
Polysiphonia stricta	Algea (Rhodophyta)	Native		1	1
Pterothamnion plumula	Algea (Rhodophyta)	Native		1	1
Ficopomatus enigmaticus	Annelida	Non-native	1		
Nephtys hombergii	Annelida	Native	1	1	
Conopeum reticulum	Bryozoa	Native	1	1	1
Scrupocellaria scruposa	Bryozoa	Native	1	1	1
Obelia longissima	Cnidaria	Native	1	1	1
Sagartiogeton undatus	Cnidaria	Native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Crangon crangon	Crustacea	Native			1
Pisidia longicornis	Crustacea	Native		1	
Mnemiopsis leidyi	Ctenophora	Non-native	1	1	1
Ophiura albida	Echinodermata	Native	1		
Ophiura ophiura	Echinodermata	Native	1	1	1
Abra alba	Mollusca	Native	1	1	1
Crassostrea gigas	Mollusca	Non-native	1	1	1
Ensis leei	Mollusca	Non-native	1		
Goniodoris castanea	Mollusca	Native	1		
Limecola balthica	Mollusca	Native	1		
Mya arenaria	Mollusca	Non-native	1	1	
Mytilus edulis	Mollusca	Native	1	1	1
Peringia ulvae	Mollusca	Native	1	1	
Spisula subtruncata	Mollusca	Native	1	1	
Tritia reticulata	Mollusca	Native	1		1
Halichondria (Halichondria) panicea	Porifera	Native		1	1
		Total:	**24**	**25**	**21**

5.10 Drop-down camera videos

In the summer of 2016 species were monitored with a drop-down camera in the Sloehaven in research areas A to C, at locations where the water visibility allowed it. In total five videos could be taken on which organisms were visible and identifiable. A total of 19 different species were recorded (Table 22). Seven of these species were found to be non-native.

Table 22. Species that were recorded with a drop-down camera in the summer of 2016 in the research area A to C. The seven non-native species are highlighted.

Species	Group	Origin	Area A	Area B	Area C
Ascidiella aspersa	Ascidiacea	Native	1	1	1
Botrylloides violaceus	Ascidiacea	Non-native	1	1	1
Ciona intestinalis	Ascidiacea	Native	1	1	1
Didemnum vexillum	Ascidiacea	Non-native	1	1	1
Diplosoma listerianum	Ascidiacea	Non-native			1
Styela clava	Ascidiacea	Non-native	1	1	1
Conopeum reticulum	Bryozoa	Native	1	1	1
Metridium senile	Cnidaria	Native	1	1	1
Obelia dichotoma	Cnidaria	Native			1
Obelia longissima	Cnidaria	Native	1	1	1
Sagartiogeton undatus	Cnidaria	Native	1	1	1
Austrominius modestus	Crustacea	Non-native	1	1	1
Balanus crenatus	Crustacea	Native	1	1	1
Carcinus maenas	Crustacea	Native	1	1	1
Mnemiopsis leidyi	Ctenophora	Non-native	1	1	1
Crassostrea gigas	Mollusca	Non-native	1	1	1
Mytilus edulis	Mollusca	Native	1	1	1
Halichondria (Halichondria) panicea	Porifera	Native		1	1
Haliclona (Haliclona) oculata	Porifera	Native			1
		Total:	**15**	**16**	**19**

6. Conclusion

In the spring and late summer of 2016 a survey was conducted in the Sloehaven, Vlissingen, following the HELCOM/OSPAR port survey protocol. A total of 336 samples were taken from 149 different sampling locations in four research areas. In these samples a total of 220 species were identified to the species level. Of these species 30 were non-native to the Netherlands. They are also non-native to NW Europe.

The HELCOM/OSPAR port survey protocol (HELCOM/OSPAR, 2013) stipulates that the presence of the non-native bacteria *Vibrio cholerae* in the port's water should be monitored. Although this species was not detected, *Vibrio alginolyticus* was recorded in the water samples taken during the survey. *Vibrio alginolyticus* is native to our waters and may concern a health issue in the port as it is known to be a human pathogen that can for example cause wound infections (Reilly *et al.*, 2011). The assessment of this risk was not the focus of the present survey however.

The non-native sea squirt *Didemnum vexillum* was also recorded in the port. This species was first recorded in the Netherlands in 1991. It remained rare until 1996 when suddenly its population rapidly expanded in the Oosterschelde and Grevelingen outcompeting various native species for space (Gittenberger, 2007). In 2009 it was first recorded, locally, in the Wadden Sea. In 2014 it had also become abundant there, at various sites in the northwestern part of the Wadden Sea (Gittenberger *et al.,* 2015). In 2014 it was recorded for the first time in the Westerschelde on a SETL-plate deployed from a floating dock in the port of Vlissingen (Gittenberger *et al*., 2017). The present survey revealed that in 2016 this non-native species was locally abundant and wide spread throughout the port of Vlissingen in various habitats (Fig. 33).

7. Literature

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