DNV·GL

Certificate No:
TAP00001U4

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Ballast Water Management System

with type designation(s)
Oceansaver BWTS MKIIB

Issued to
TeamTec Oceansaver AS
Tvedestrand, Norway

is found to comply with
DNV GL rules for classification – Ships
DNV GL class programme DNVGL-CP-0209 – Type approval – Ballast water management systems
Resolution MEPC.169(57)
IMO Resolution MEPC.300(72) - Code for Approval of Ballast Water Management Systems (BWMS Code)

Application :

This is to certify that the Ballast Water Management System listed above has been examined and tested in accordance with the requirements of the specifications contained in the BWMS Code and DNV GL Rules stated above. This Certificate is valid only for the Ballast Water Management System referred to above.

System Design Limitations / Limiting Operating Conditions imposed are described in this document.

For the compliance with the BWMS Code, the Certificate is issued on behalf of the Norwegian Maritime Authority.

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV GL, unless otherwise instructed by relevant Maritime Administrations.

Issued at **Høvik** on **2020-01-15**
This Certificate is valid until **2025-01-14**.
DNV GL local station: **Kristiansand**

for **DNV GL**

Approval Engineer: **Ingrid Sigvaldsen**

Dag Sæle-Nilsen
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

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Job Id: **262.1-019254-2**
Certificate No: **TAP00001U4**

Name of ballast water management system (BWMS)
Oceansaver Ballast Water Treatment System MKIIB (TTO BWTS MKIIB)

Ballast water management system manufactured by
TeamTec Oceansaver AS

Place of production
TeamTec Oceansaver Systems AS, Risør, Norway

Type and model designations
C2E-200A-5/10, C2E-400A-5/10, C2E-600A-5/10, C2E-800A-5/10, C2E-1000A-5/10, C2E-1200A-10/15, C2E-1400A-10/15, C2E-1600A-10/15, C2E-1800A-10/15, C2E-2000A-10/15, C2E-2200A-15/20, C2E-2400A-15/20, C2E-2600A-15/20, C2E-2800A-15/20, C2E-3000A-15/20, C2E-3200A-20/25, C2E-3400A-20/25, C2E-3600A-20/25, C2E-3800A-20/25, C2E-4000A-20/25 C2E-4500A-25/30, C2E-5000A-25/30, C2E-5500A-25/35, C2E-6000A-25/35, C2E-6600A-35/40 and C2E-7200A-35/40

Equipment / Assembly drawings
The ballast water treatment system shall be installed in accordance with the relevant documents listed below.

Description	Title	Drawing no.	Rev.
Piping and instrumentation diagram (P&ID)	System Pipe and Instrument Diagram TTO BWTS MKIIB	501964	Rev.01, dated 14.05.2019
Electrical wiring diagram	OS BWTS MKII Electrical Wiring Diagram	99999-EWD-02	Rev.03, dated 20.08.2019
Component list	Scope of Supply TTO BWTS MKIIB	501964-SOS	Rev.01, dated 14.05.2019
General arrangement drawing	General Arrangement Drawing TTO BWTS MKIIB	501964-GA	Rev.02, dated 22.08.2019
Component list for hazardous installation	EX Certificate for USCGFLAG TTO BWTS MKIIB	501964-EX	Rev.05, dated 23.06.2019

Other equipment manufactured by
The Oceansaver BWTS MKIIB applies one of the following self-cleaning filters:

- Filtersafe filter with a 40 µm mesh
- MossHydro filter with 40 µm mesh

Treatment Rated Capacity
200 - 7200 m^3/h

Product description

Treatment sequence:

- Ballast water uptake: Filtration and injection of active substances generated by electrodialysis.
- Ballast water discharge: Neutralization.

System design limitations - Water quality parameters

Temperature and salinity

Temperature and salinity of the ballast water are not a limiting condition for the ballast water treatment system.

System design limitations - Operational parameters

Feed water to the electrodialysis unit

The system is arranged to give alarm in case the salinity is lower than 20 PSU in the feed water to the electrodialysis C2E cell. For treatment of ballast water with a salinity of less than 20 PSU, the feed water shall be sourced from a dedicated seawater storage tank. The arrangement and details of the saline water source must be approved on a case by case basis.

The temperature of the feed water to the electrolysis unit shall be ≥17°C and shall as necessary be heated to above 17°C by use of a heat exchanger.

The feed water to the electrodialysis unit shall be pre-filtered water.

Holding time

The Oceansaver BWTS MKIIB has demonstrated performance to the discharge standard with a minimum holding time between intake and discharge of 24 hours in land-based testing. A minimum holding time of 24 hours is required for the Oceansaver BWTS MKIIB.

Dosing

The control equipment is designed to ensure a dosage providing a target initial TRO level in the ballast tanks at minimum 1.7 mg/L in brackish and marine water and minimum 2.0 mg/L in fresh water, measured as TRO in-line between 1.7 mg/L and 10 mg/L depending on measured immediate oxidant demand (IOD)).

Treatement rated capacity (TRC) – Electrodialysis C2E cell

The number of C2E cells can be adjusted to accommodate higher or lower flow rates, as given in the following tables to this certificate.

The feed water flow shall be 1.6% ±0.8% of the TRC given for a specific model.

Treatment rated capacity (TRC) - Filter

A filter shall be selected to meet the vessel's ballast flow capacity. Approved filters and capacities are given in the following tables. In case one BWTS model shall serve two or three ballast water lines, each with a filter, a smaller filter with sufficient TRC can be selected.

Treatment rated capacity (TRC) - Neutralization

The neutralization unit has two steps and can neutralize up to 1.6 times the BWTS model TRC in order to facilitate gravity discharge.

TRC related to each electrodialysis unit (C2E cell)

C2E cell	Maximum current (A)	TRC (m^3/h)
C2E-200A-5/10	200	200
C2E-400A-5/10	400	400
C2E-600A-5/10	600	600
C2E-800A-5/10	800	800
C2E-1000A-5/10	1000	1000
C2E-1200A-10/15	1200	1200
C2E-1400A-10/15	1400	1400
C2E-1600A-10/15	1600	1600
C2E-1800A-10/15	1800	1800
C2E-2000A-10/15	2000	2000
C2E-2200A-15/20	2200	2200
C2E-2400A-15/20	2400	2400
C2E-2600A-15/20	2600	2600

C2E cell	Maximum current (A)	TRC (m^3/h)
C2E-2800A-15/20	2800	2800
C2E-3000A-15/20	3000	3000
C2E-3200A-20/25	3200	3200
C2E-3400A-20/25	3400	3400
C2E- 3600A-20/25	3600	3600
C2E-3800A-20/25	3800	3800
C2E-4000A-20/25	4000	4000
C2E-4500A-20/25	4500	4500
C2E-5000A-25/30	5000	5000
C2E-5500A-25/20	5500	5500
C2E-6000A-25/35	6000	6000
C2E-6600A-35/40	6600	6600
C2E-7200A-35/40	7200	7200

TRC related to each MossHydro filter

MossHydro (single screen)	Size	TRC (m^3/h)
MH 0.2 V/H	DN80	50
MH 0.3 V/H	DN80	69
MH 0.4 V/H	DN100	100
MH 0.6 V/H	DN150	150
MH 1.0 V/H	DN200	250
MH 1.2 V/H	DN200	290
MH 1.4 V/H	DN200	330
MH 1.7 V/H	DN250	425
MH 2.0 V/H	DN250	500
MH 2.3 V/H	DN250	580
MH 3.0 V/H	DN300	660
MH 3.5 V/H	DN350	830
MH 4.0 V/H	DN350	1000
MH 4.5 V/H	DN350	1130
MH 5.4 V/H	DN400	1350
MH 6.0 V/H	DN400	1500

MossHydro (multiple screen)	Size	TRC (m^3/h)
MH 5.0 V/H	DN400	1250
MH 6.0 V/H	DN400	1500
MH 7.0 V/H	DN500	1750
MH 8.0 V/H	DN500	2000
MH 9.0 V/H	DN500	2250
MH 10.0 V/H	DN600	2500
MH 12.0 V/H	DN600	3000
MH 13.0 V/H	DN600	3250
MH 14.0 V/H	DN700	3500
MH 15.0 V/H	DN700	3750
MH 16.0 V/H	DN700	4000
MH 18.0 V/H	DN700	4500

TRC related to each Filtersafe filter

Filtersafe BS (1)	Size	TRC (m^3/h)	Filtersafe BS (1)	Size	TRC (m^3/h)
BS-025	DN50-100	50	BS201-T	DN250-350	600
BS-050	DN80-150	125	BS300	DN250-350	750
BS-070	DN150-200	180	BS300-T	DN300-400	900
BS-100	DN150-200	250	BS400	DN300-400	1000
BS-100-T	DN200-250	300	BS400-T	DN300-400	1200
BS0150	DN200-250	375	BS603	DN400-450	1500
BS0150-T	DN200-300	450	BS603-T	DN400-450	1800
BS200	DN250-350	500	BS804	DN450-500	2000
BS200-T	DN250-350	600	BS804-T	DN450-500	2400
BS031	DN50-100	75	BS1004	DN500-600	2500
BS061	DN80-150	150	BS1004-T	DN500-600	3000
BS061-T	DN80-150	180	BS1204	DN500-600	3000
BS101	DN150-200	250	BS1204-T	DN500-600	3600
BS101-T	DN200-250	300	BS1206	DN500-600	3000
BS151	DN200-300	375	BS1206-T	DN500-600	3600
BS151-T	DN250-350	450	BS1406	DN500-600	3500
BS201	DN250-350	500	BS1406-T	DN500-600	4200

(1) The BS filter can be installed horizontal (H) or vertical (V) and the filter model will be designated with the suffix H or V. Filter models with suffix -T has higher TRC as it is a turbo filter.

Pressure
The minimum/maximum pressure and the differential pressure triggering backflushing are listed below.

Filter type	Maximum inlet pressure (back-pressure)	Differential pressure triggering backflushing	Maximum operating pressure
Filtersafe	1.6 bar	0.5 bar	6 bar
MossHydro	1.6 bar	0.5 bar	6 bar

Control and monitoring equipment

Software version

The Oceansaver BWTS MKIIB is type approved with the system control software version 01.yy. Any changes to the software are to be recorded as long as the system is in use onboard. The records of all changes are to be forwarded to DNV GL for evaluation. Major changes in the software, which can alter the performance of the system require approval. Testing of the application functions of the revised software may be required.

Safety measures

The Oceansaver BWTS MKIIB is type approved with the following instruments for monitoring the safe operation of the BWTS:

- Hydrogen gas sensor in the C2E compartment (IA951)
- Water leakage detection in drip tray under the C2E cell (LS958)
- Liquid/gas low level and high-level sensor in the 2-phase separator (LS955, LS956, LS957)
- Air flow sensor in the ventilation duct (FS979)
- H2 gas sensor in the gas ventilation duct (HS01), arranged with independent shutdown functionality (1XXIA952)
- Pressure sensor upstream and downstream of the C2E cell (PT941, PT942, PT944), PT941 arranged with independent shutdown functionality
- Flow sensor upstream and downstream of C2E cell (FM952, FM953, FM954)
- Exhaust fans arranged with redundancy and emergency power supply

Flow/ pressure control valve

A control valve shall be included in the assembly to adjust the flow to keep a sufficient system pressure in order to accommodate for the pressure needed to backwash the filter. The control valve shall reduce flow if required in order to maintain required concentration of TRO levels as specified in this certificate.

Electrical and electronic equipment

The Oceansaver BWTS MKIIB is type approved with the electrical and electronic components (including the above listed instruments for monitoring safe operation of the BWTS) indicated on the P&IDs and specified on the component list (501964-SOS). Except for the components listed below, alternate models to one specified on the component list (C501964-SOS) may be used provided that information regarding the selected components are part of the documentation related to the specific installation, by providing either a reference to valid type approval certificate or technical documentation demonstrating that the selected component was subject to environmental testing as per IACS UR E10.
For the following electrical and electronic components, the models specified below and in the component list (501964-SOS) shall be used:

Tag id	Component name	Manufacturer	Model
IAx40	TRO meter	HF Sientific	CLX XT or CLX EX
EL101	Control cabinet	Insta/IMS	Main control cabinet MKII
ER976	Rectifier	Kraft Powercon	Flexkraft module 29370 / 292462
		AEG	Thyrobox BWT G48/3000
EL992	C2E power distribution cabinet	Insta/IMS	EL992
EL104	Independent SD cabinet	IMS	EL104
EL993	Interface cabinet	Insta/IMS	EL993

Hazardous area/ Ex-proof

The Oceansaver BWTS has been evaluated and found to be in compliance with DNV GL Rules Pt.4 Ch.8 Sec.11 for hazardous area installations. The Oceansaver BWTS MKIIB with the required sensors can be located in hazardous area zone 1 IIB H2, but the electrical supply and control systems are to be located in safe zone. Ex-certification is not covered by this Certificate.

Ex-installations and application in hazardous area are to be approved in each case according to the Rules and Ex-certification / Special Condition for Safe Use listed in valid Ex-Certificate issued by a notified/recognized Certification Body.

Documents approval

The following documentation is to be submitted for each BWTS installation:

- Power supply arrangement (including power supply to exhaust fans)
- Piping and Instrumentation Diagram (P&ID) of the ballast system including the treatment system installation
- Commissioning procedure
- Interface description specifying external signals including alarms for failure
- List of Ex-equipment according to Pt.4 Ch.8 Sec.11 for components in possible contact with hydrogen gas (exhaust fans, air flow sensor, Hydrogen gas sensor)
- List of Ex-equipment according to Pt.4 Ch.8 Sec.11 if the system is to be installed in hazardous area zone

Type Approval documentation

Biological test reports

- DHI: Biological efficacy performance evaluation of Ballast Water Management Systems in land-based test, Test plan: Oceansaver, Rev. Final, dated 2015-04-24.
- DHI: Performance evaluation in land-based test facility, Oceansaver, Chemical treatment with two mechanical filter options: Filtersafe and MossHydro, Rev. Final, dated 2016-07-19
- DHI: Biological efficacy performance evaluation of Ballast Water Management Systems in shipboard test, Test plan: Oceansaver, Rev. Final, dated 2015-06-25
- DHI: Performance evaluation of Ballast Water Management System in shipboard test, Oceansaver, Mechanical filtration and chemical treatment, Rev. Final, dated 2016-09-13
- DHI: Oceansaver Ballast Water Treatment System MKII, Whole effluent toxicity test of the effluent from the Oceansaver Ballast Water Treatment System MKII, brackish, marine and fresh water, Rev. Final, dated 2016-08-24
- NIVA: Land based testing of The Oceansaver Ballast Water Management System RII (OS BWMS RII). Rev. Final, dated 2011-10-13.
- Basic Approval, Report of the Marine Environmental Protection Committee, MEPC 57/21 dated 2008-04-07
- Final Approval, Report of the Marine Environmental Protection Committee, MEPC 58/23 dated 2008-10-10
- Sheila Ann: Maintenance log from shipboard test period

Environmental test reports

- DELTA: Test for Marine Type Approval of Control cabinet for filter and Operator panel/junction box, DANAK-19/16541
- Applica: Technical Report, DNV GL, EMC and Environmental testing of Oceansaver BWTS, 20633, Rev. 1
- Applica: Technical Report, Kraft Powercon, Type testing of FlexKraft Marine 9R, 20825, Rev. 2
- Oceansaver: Bill of material, EL-104 Safety Cabinet

System description documentation

- Oceansaver: Operation, Maintenance and Safety Manual, OS BWTS MKIIB, Rev. 2.0
- Oceansaver: Filters used in the Oceansaver BWTS MKII
- Oceansaver: Anolyte Flow Control, Rev. 02
- Oceansaver: TTO BWTS MKII, Risk assessment, Doc. No. 501964, Rev. 06
- Oceansaver: TTO BWTS MKII, Hydrogen Management System, Doc. No. OS-HMS-07, Rev. 07
- Oceansaver: GA – Hydrogen Management System, Drw. No. 501690, Rev. A
- Oceansaver: 501964-EX, EX Certificate for USCGFLAG TTO BWTS MKIIB, Rev. 05
- DNV GL Type Approval Certificate Amendment – Treatment Chemical Injection, Mixing, and Sampling Technical Information, Rev. 03

Tests carried out

- Land-based testing using model C2E-200A-5/10-17/5 in accordance with Resolution MEPC.279(70) and 46CFR 162.060-26
- Shipboard testing using model C2E-L4000-20/25-17/5 in accordance with Resolution MEPC.279(70) and 46 CFR 162.060-28
- Function tests of the control and automation system witnessed by DNV GL
- Environmental testing in accordance with Environmental test specification for instrumentation and automation equipment, DNV Standard for Certification No. 2.4 (April 2006) and Resolution MEPC.279(70)
- Land-based testing for alternate filters in accordance with Resolution MEPC.279(70) and 46 CFR 162.060-26 but limited to 3 test cycles in each salinity.

Marking of product

For the traceability of this type approval, each treatment system is to be marked with:

- Manufacturer's name or trade mark
- Type designation
- Serial number

Periodical assessment

For retention of the Type Approval, DNV Surveyor shall perform periodical assessments to verify that the conditions of the TA are not altered since the Certificate was issued.

The scope of periodical assessment includes:

- Review of the TA documentation and verification that the documentation is still used as basis for the production.
- Review of possible changes in design, material and performance of the product.
- Verification of the company's production and quality systems ensuring continued consistent
- production of the type approved products to the required quality.
- Verification that the product marking for identification and traceability to the TA Certificate is not altered.

Copy of the type approval certificate

A copy of this type approval certificate shall be carried on board a vessel fitted with this Ballast Water Management System at all times. A reference to the test protocol and a copy of the test results should be available for inspection on board the vessel.

ANNEX: SUMMARY OF TESTING

Land-based testing

Table 1 Test water conditions and operational parameters in land-based testing of the Oceansaver BWTS MKIIB C2E-200A-5/10-17/5 with a TRC of 200 m³/h and with one C2E cell and one Filtersafe filter at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, during the period of April 2015 to December 2015.

Test cycle	**Water temp.** [°C]	**Salinity** [PSU]	**DOC** [mg/L]	**POC** [mg/L]	**TSS** [mg/L]	**Holding time** [days]	**TRO Cl_2** [mg/L]	**Average flow rate after filter** [m³/h]	**Average electrolyse current** [A]
B-1	10	21	6.9	6.7	57	1	2.3	199	117.57
B-2	12	19	7.0	7.8	56	1	2.6	202	119.64
B-3	12	19	7.0	7.8	56	1	2.7	198	106.62
B-4	13	19	6.7	7.4	61	1	2.5	199	115.75
B-5	13	19	6.7	7.4	61	1	2.9	198	114.54
M-1	15	35	7.0	8.0	40	1	2.6	199	122.33
M-2	17	34	6.9	8.0	42	1	2.5	198	118.73
M-3	17	34	6.9	8.0	42	1	3.1	196	118.90
M-4	18	34	6.3	8.1	43	1	3.4	175	187.76
M-5	18	34	6.3	8.1	43	1	3.3	177	182.46
F-1	18	0.42	7.2	7.3	60	1	5.6	150	197
F-2	17	0.37	7.3	7.0	66	5	6.3	136	197
F-3	17	0.37	7.3	7.0	66	5	7.0	135	197
F-4	15	0.34	7.1	7.7	59	5	5.1	180	197
F-5	15	0.34	7.1	7.7	59	5	6.0	170	197
F-6	9.6	0.32	7.4	8.1	63	1	7.1	170	197
F-8	11	0.32	6.7	6.3	63	1	6.9	141	197
F-9	11	0.37	6.7	6.3	63	1	7.1	137	197

Table 2 Average numbers of live organisms in inlet and treated discharge water during land-based testing of the Oceansaver BWTS MKIIB C2E-200A-5/10-17/5 with a TRC of 200m³/h and with one C2E cell and one Filtersafe filter at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, during the period of April 2015 to December 2016. Live organisms ≥10 and <50 µm were quantified by microscopy counting after staining with CMFDA/FDA. All counts of pathogenic bacteria (*E. coli, Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

Test cycle	inlet water		treated discharged water			
	≥50 µm [org/m³]	**≥10-<50 µm** [org/mL] **(FDA/CMFDA)**	**≥50 µm** [org/m³]		**≥10-<50 µm** [org/mL] **(FDA/CMFDA)**	
			Treated	**Control**	**Treated**	**Control**
B-1	207,951	2,191	4.0	61,290	0.56	1,490
B-2	672,524	2,388	0.33	327,182	0.11	1,927
B-3	672,524	2,388	0.67	327,182	0.11	1,927
B-4	239,191	1,947	3.3	109,494	0.44	605
B-5	239,191	1,947	6.7	109,494	0.22	605
M-1	205,229	4,186	0	45,988	0	2,067
M-2	182,023	2,753	0	37,114	3.4	1,787
M-3	182,023	2,753	0	37,114	3.8	1,787
M-4	147,714	1,889	0.67	36,058	1.6	1,608
M-5	147,714	1,889	0.33	36,058	2.7	1,608
F-1	540,333	20,602	0	212,002	1.0	1,260
F-3	397,102	26,971	0.94	280,230	2.4	2,663
F-4	221,378	22,939	4.6	141,932	4.6	2,733
F-5	227,378	22,939	1.7	141,932	5.4	2,733
F-6	63,042	36,444	0	49,478	3.2	4,354
F-7	63,042	36,444	0	49,478	4.8	4,354
F-8	213,023	20,573	0	98,006	1.2	2,317
F-9	213,023	20,573	0.33	98,006	1.3	2,317

Table 3 Test water conditions and operational parameters in additional land-based testing of the Oceansaver BWTS MKIIB C2E-200A-5/10-17/5 with a TRC of 200 m³/h and with one C2E cell and one MossHydro filter at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, during the period of October 2015 to December 2016.

Test cycle	**Water temp.** [°C]	**Salinity** [PSU]	**DOC** [mg/L]	**POC** [mg/L]	**TSS** [mg/L]	**Holding time** [days]	**TRO Cl_2** [mg/L]	**Average flow rate after filter** [m³/h]	**Average electrolyse current** [A]
B-6	11	19	6.8	7.9	55	1	2.6	198	123.84
B-7	11	19	6.8	7.9	55	1	2.9	198	106.6
B-8	11	19	6.9	8.8	58	1	2.5	199	119
M-6	7.4	32	6.2	8.5	47	1	3.4	199	124.2
M-7	7.4	32	6.2	8.5	47	1	2.9	196	128.6
M-8	8.1	34	6.3	8.1	48	1	3.1	196	121.17
F-7	9.6	0.32	7.4	8.1	63	1	6.2	174	197

Test cycle	**Water temp.** [°C]	**Salinity** [PSU]	**DOC** [mg/L]	**POC** [mg/L]	**TSS** [mg/L]	**Holding time** [days]	**TRO Cl_2** [mg/L]	**Average flow rate after filter** [m^3/h]	**Average electrolyse current** [A]
F-10	9.1	0.34	7.7	7.9	58	1	4.1	163	197
F-11	9.3	0.34	7.7	7.9	58	1	6.8	133	197
F-12	9.3	0.35	6.8	7.6	73	1	6.6	140	197

Table 4 Average numbers of live organisms in inlet and treated discharge water during land-based testing of the Oceansaver BWTS MKIIB C2E-200A-5/10-17/5 with a TRC of 200m³/h and with one C2E cell and one MossHydro filter at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, during the period of April 2015 to December 2016. Live organisms ≥10 and <50 µm were quantified by microscopy counting after staining with CMFDA/FDA. All counts of pathogenic bacteria (*E. coli, Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

Test cycle	**inlet water**		**treated discharged water**			
	≥50 µm [org/m^3]	**≥10-<50 µm** [org/mL] **(FDA/CMFDA)**	**≥50 µm** [org/m^3]		**≥10-<50 µm** [org/mL] **(FDA/CMFDA)**	
			Treated	**Control**	**Treated**	**Control**
B-6	154,893	3,327	1.7	40,788	2.2	3,493
B-7	154,893	3,327	0	40,788	1.3	3,493
B-8	190,712	1,763	0.67	93,675	4.7	1,660
M-6	165,170	2,390	1.0	81,887	1.3	1,510
M-7	165,170	2,390	0	81,887	0.44	1,510
M-8	176,956	1,679	0	71,148	0.44	1,677
F-10	194,588	20,573	0	149,176	2.3	4,222
F-11	194,588	22,211	0	149,176	1.3	4,222
F-12	131,597	11,623	0	72,682	4.2	4,413

Shipboard testing

Table 5 Test water conditions and operational parameters in shipboard testing of the Oceansaver BWTS MKIIB C2E-L4000-20/25-17/5 with one C2E cell and Filtersafe filters installed in parallel on board the bulk carrier SHEILA ANN (IMO No. 9138094) during the period of July 2015 to May 2016.

Test cycle	Water temp. [°C]	Salinity [PSU]	Holding time [hours]	Average flow rate after filter [m^3/h]	Average electrolyse current [A]
1	27	35	16	-	2.2-4.3
4	9.9	27	22	1,780	2.0-5.8
5	9.7	27	221	1,774	2.1-5.7
6	19	35	20	1,735	1.9-6.3
7	17	24	153	1,726	2.6-5.2
8	24	38	29	1,797	2.8-3.7

Table 6 Average numbers of live organisms in inlet and treated discharge water during shipboard testing of the Oceansaver BWTS MKIIB C2E-L4000-20/25-17/5. Live organisms ≥10 and <50 µm were quantified by microscopy counting after staining with CMFDA/FDA. All counts of pathogenic bacteria (*E. coli, Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

Test cycle	≥50 µm [org/m^3]		≥10-<50 µm [org/mL] (FDA/CMFDA)	
	Influent water	Treated discharge	Influent water	Treated discharge
1	43,018	5.7	24*	1.9
4	6,547	0	209	3.0
5	4,531	0.22	139	0.17
6	9,000	8.8	201	0.67
7	60,762	0	844	5.1
8	19,240	0.27	146	2.8

*Invalid test cycle that meets the D-2 standard and starts the six-month shipboard test period.

Supporting data for evaluation of regrowth in marine and brackish water

Table 7 Results from land-based testing of Oceansaver BWTS MKIIB at NIVA in 2011. Test cycles were performed with fresh-, marine and brackish water quality and a hold time of 5 days. Test conditions: Temp: 4.3-10.3 °C., Live organisms ⩾10 and <50 µm in discharge water were quantified based on microscope counts after CFDA staining.

Test cycle	inlet water			treated discharged water			
	Salinity [PSU]	≥50 µm [org/m³]	≥10-<50 µm [org/mL] (CFDA)	≥50 µm [org/m³]		≥10-<50 µm [org/mL] (CFDA)	
				Treated	Control	Treated	Control
1	21.4	251,029	1,366	1.3	67,550	0.7	1,685
2	21.3	221,346	1,452	5.7	29,538	<0.2	882
4	21.4	210,988	1,366	3.7	60,754	<0.2	933
5	21.4	165,842	1,201	1.3	52,733	0.4	1,175
6	20.8	214,675	2,610	4.7	24,607	<0.2	1,953
7	32.2	173,542	2,999	1.0	47,539	<0.2	2,265
8	32.2	223,025	1,193	2.3	51,722	0.2	908
9	32.8	174,117	1,495	1.0	38,133	<0.2	1,625
10	32.7	161,379	2,273	1.0	28,907	0.7	1,305
11	32.2	176,600	1,158	1.7	81,904	<0.2	795