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co-organised by Ruđer Bošković Institute and University of Dubrovnik
with the participation of: IAEA

Sediment in the ship's ballast water tank: A forgoten problem

Conference theme:
8. BALLAST WATER AND SEDIMENTS – BNW CONVENTION

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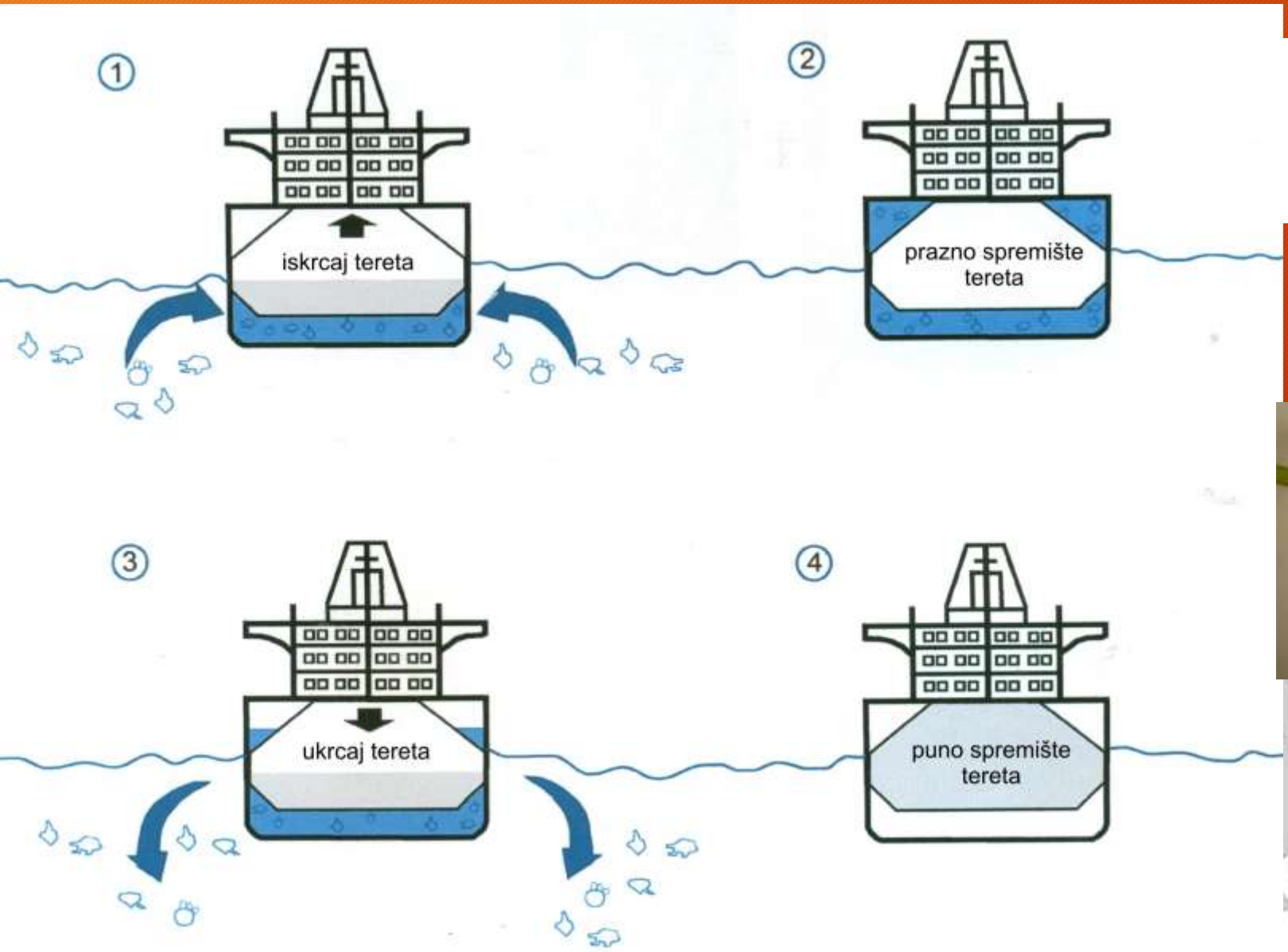
Sediment in the ship's ballast water tank: A forgoten problem



Sediment in the ship's ballast water tank: A forgoten problem

Ballast water release in the port while loading the cargo

Hamer J.P. (2002) Ballast Tank Sediments. In: Leppäkoski E., Gollasch S., Olenin S. (eds) Invasive Aquatic Species of Europe. Distribution, Impacts and Management. Springer, Dordrecht

When a vessel takes on ballast water in shallow areas, resuspended sediment and the associated benthic organisms and resting stages are also taken on board. Once inside a ballast tank, the sediments settle out of suspension and begins to accumulate. The volume of accumulated sediment present in a tank is a result of the ships ballast management practices, the type of ballast tanks involved and the time since the tanks were last cleaned in dry dock.

During a ballast water sampling programme carried out in England and Wales, numerous dedicated ballast tanks of ships in dry dock (ferry, container, cruise ships) were entered and the sediment sampled (Lucas et al. 1999). The volumes of accumulated sediment were found to vary considerably within ballast tanks, between ballast tanks and between ships.

Sediment accumulations varied from a few cm to more then 30 cm depth which translate to 10's and even 100's of tons of sediment in the ballast tanks of larger vessels. Although the sediment type varied between ships, most of the sediment found was fine mud with a mean particle size of < 20 μm.

Sediment in the ship's ballast water tank: A forgoten problem

Global ports are hubs for industrial activities and trade. In consequence, sediments and water in these areas are often contaminated by an array of chemicals.

Sediments also harbour both living, active stages and various diapausing or resting stages of biota. International shipping activities move sediments containing these biotic stages around the world, possibly resulting in biological contamination of port areas.

Presence of sediments in ballast waters imposes the limits on applicability of ballast waters treatment systems.

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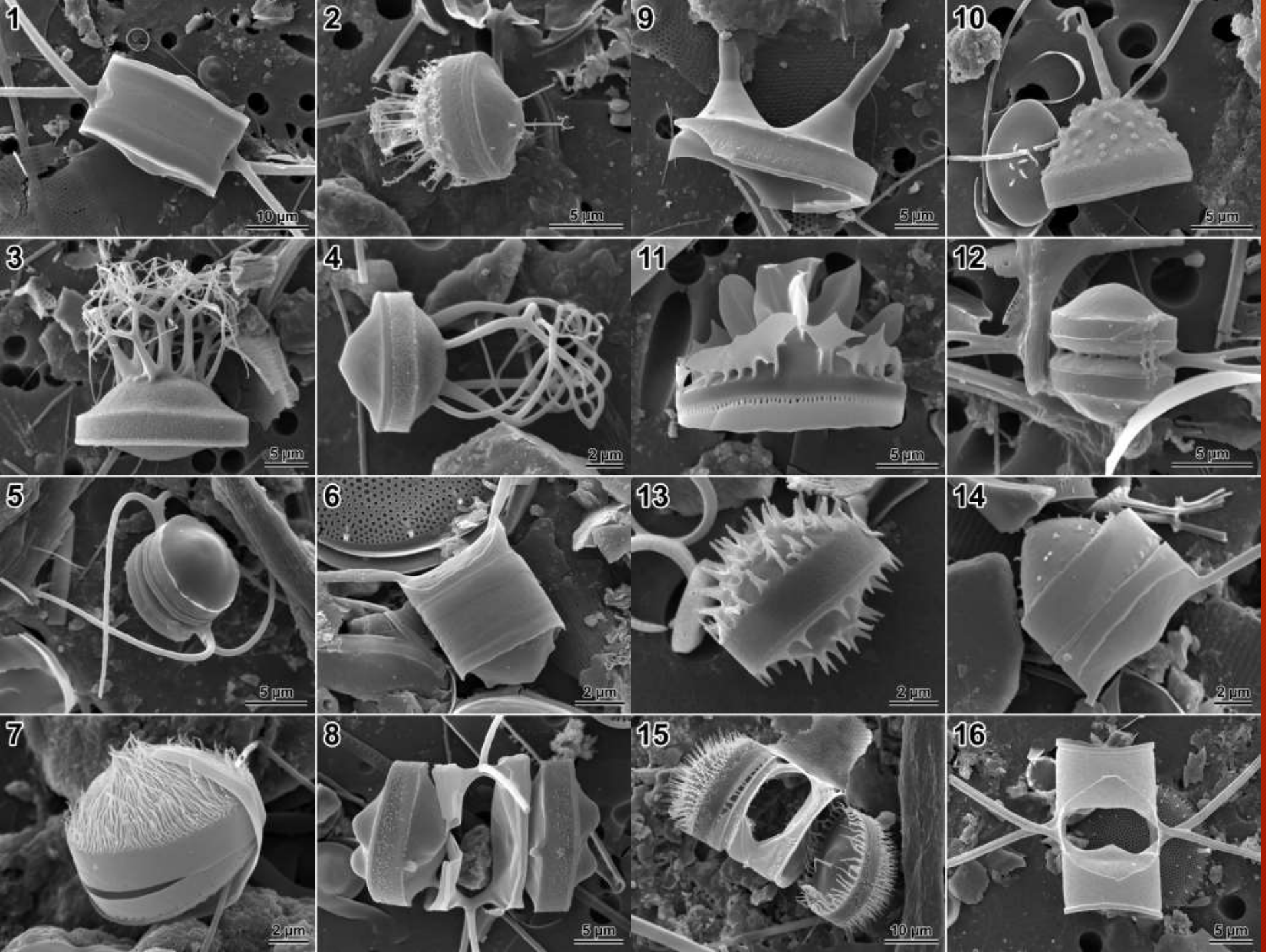


SEM pictures by
Dr. James M. Ehrman,
Digital Microscopy Facility,
Mount Allison University,
Sackville, Canada.

1 – C. didymus;
2 – C. cf. affinis;
3, 4 – C. diadema;.
5 – C.cinctus;
6 – C. ceratosporus;
7 – C. cf. compressus var. hirtisetus;
8 – C. debilis.
9 – C. lorenzianus;
10 – C. cf. diadema;
11 – Spore no.1., similar to C. Coronatus;
12 – C. furcillatus;
13 – C. cf. socialis var. radians;
14 – C. cf. similis;
15 – C. cf. hispidus;
16– C. lorenzianus/C. decipiens?

Several systems for the treatment of ballast waters use a combination of two or three techniques, filtration being usually the first and/or the last step.

Presence of sediments in ballast waters imposes the limits on applicability of these methods.

For example, systems with UV irradiation cannot eliminate all organisms present in ballast waters because of inability to deliver a stable lethal dose to ballast waters of variable quality.

The presence of sediments drastically reduces the effectiveness of UV irradiation because the sediment particles protect small organisms from exposure to irradiation.

Sediment in the ship's ballast water tank: A forgoten problem

- On 8. September 2017. the International Maritime Organization's (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM) Convention has entered into force.
- It deals with one of the greatest threats to coastal and marine environments around the world: aquatic invasive alien species (IAS).
- Although the control of IAS through treatment of ballast water is appropriately dealt in the Convention and its implementation, the problems generated by sediments are not treated in such a manner.

Sediment in the ship's ballast water tank: A forgoten problem

Although the control of IAS through treatment of ballast water is appropriately dealt in the Convention and its implementation, the problems generated by sediments are not treated in such a manner.

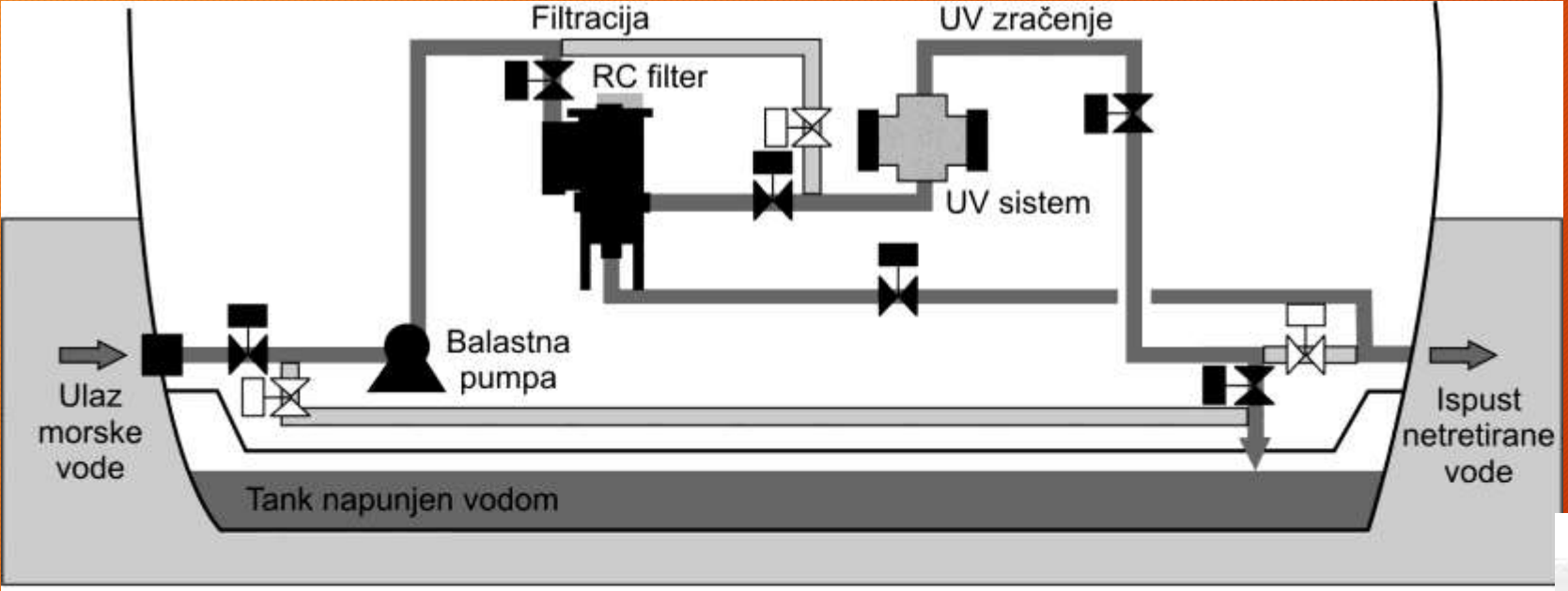
For example, Convention's Guideline G1, which addresses sediments does not set out definite treatment procedures or discharge standards, asking only that the applied procedure should avoid unwanted side effects.

- As a result, ship operators have devised their own method: they dump it at sea, at least 200 miles offshore and in at least 200m of water.

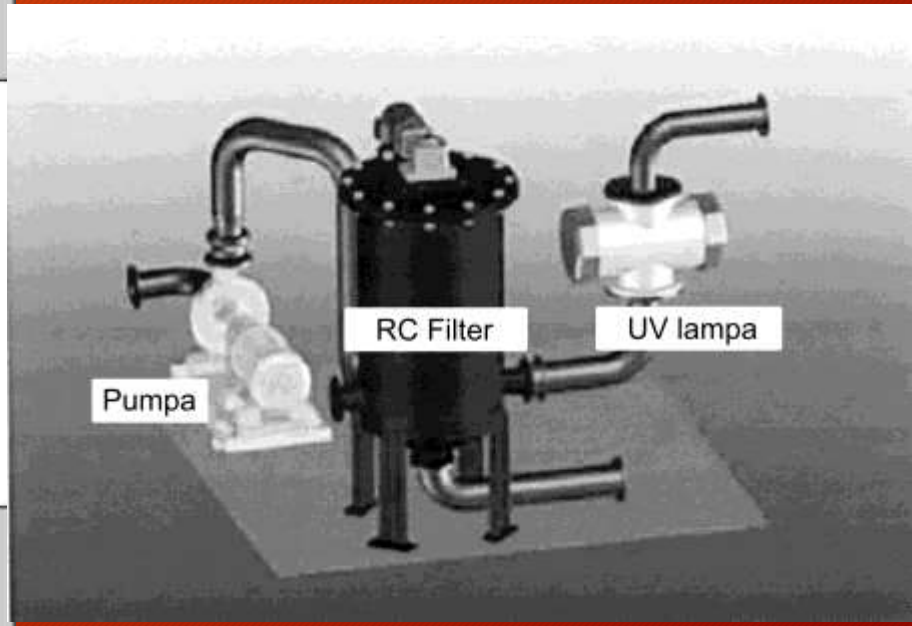
Sediment in the ship's ballast water tank: A forgoten problem

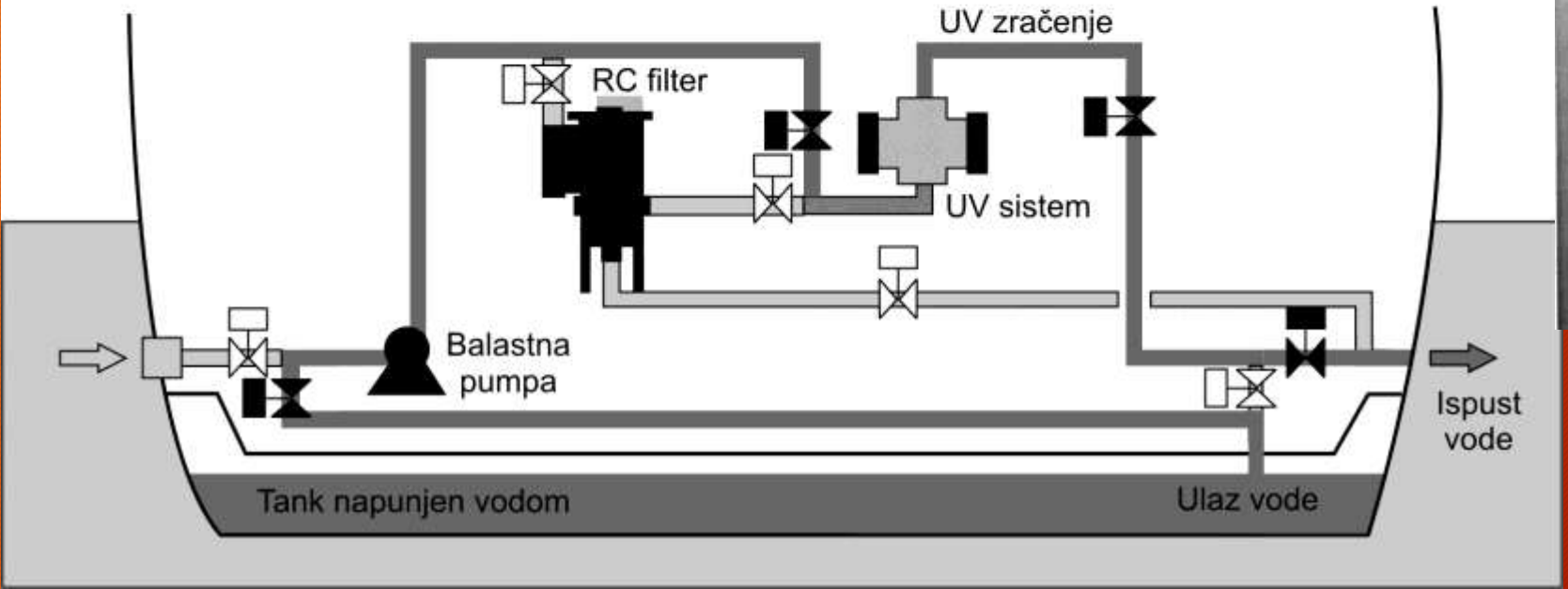
- Regulation B-5 Sediment Management for Ships states that all ships shall remove and dispose of sediments from spaces designed to carry ballast water in accordance with the provisions of the ship’s Ballast Water management plan.

- New ships should be designed and constructed with a view to minimize the uptake and undesirable entrapment of sediments, facilitate removal of sediments, and provide safe access to allow for sediment removal and sampling, taking into account guidelines developed by IMO.



ECOMARINE UV SYSTEM





IMO Convention Ballast Water Management (2004) defines the role of ports i.e. the port country, (Port States, PS). PS must be ready and possess the adequate equipment to be able to determine the ship compliance with the Convention. This could be done by inspection of documents but also by testing the samples.

Dutch company DAMEN

http://Ddamenballastwatertreatment.com

Inside a ballast tank. Stephan Gollasch, GoConsult. In Raf. Waite and Sweat, GloBallast Monograph Series No.23, 2017.

The composition of ballast sediments varies among ships, depending greatly on the sediment content of the ballast water taken up and the condition of the tank itself. In general, ballast sediments contain eight major constituents:

1. Clay: particles 2 µm or less
2. Silt: particles 2 – 63 µm
3. Sand: particles 63 µm – 2 mm
4. Larger soil particles: over 2 mm
5. Products of corrosion processes in the tanks and associated piping
6. Parts of protective coatings
7. Non-living organic material
8. Living organisms

Sediment in the ship's ballast water tank: A forgoten problem

In addition, under Article 5 of BWM Convention Sediment Reception Facilities, Parties undertake to insure that ports and terminals where cleaning or repair of ballast tanks occurs have adequate facilities for the reception of sediments.

Sediment in the ship's ballast water tank: A forgoten problem

Increased interest

Recently, we have witnessed the increased interest in ballast tank sediments. There is a number of published technical and scientific papers, discussions and commentaries.

Bailey et al., 2003

Bailey et al. (2003). Viability of invertebrate diapausing eggs collected from residual ballast sediment. Limnology and Oceanography 48: 1701-1710.

Viability of diapausing eggs was explored under light and dark conditions using sediment collected from eleven tanks on nine vessels operating on the Great Lakes. Seventeen cladoceran, copepod, and rotifer taxa were identified. Four of the species hatched have not yet been reported as established in the Great Lakes. Egg viability for individual species varied from 0% to 92%.

Bailey et al., 2005

Bailey et al. (2005). Invertebrate resting stages in residual ballast sediment of transoceanic ships. Canadian Journal of Fisheries and Aquatic Sciences 62: 1090-1103.

Although ballast water exchange regulations were implemented in 1993 to reduce propagule loads, new NIS continue to be discovered. A possible explanation for this trend is the importance of alternative vectors, such as residual ballast of ships claiming "no ballast on board".

Sediment in the ship's ballast water tank: A forgoten problem

Bailey et al., 2005

Bailey et al., (2005). In situ hatching of invertebrate diapausing eggs from ships' ballast sediment. Diversity and Distributions 11: 453-460.

Hatching was observed on every ship, although not from all sediments on all ships. Overall hatch rates were very low (0.5 individuals per 500 g sediment), typically involving activation of < 0.05% of total eggs present. Five species of rotifers and copepod nauplii were hatched from ballast sediments, although only one or two species typically hatched from any one sediment.

However, as reproduction may occur in tanks, and non-indigenous species may be involved in numerous introduction events, the risk posed by this vector is small but potentially important.

Bailey et al., 2007

S.A.Bailey et al. (2007). Sediments in ships: biota as biological contaminants. *Aquatic Ecosystem Health and Management* **10**:93-100.

They studied active and resting stages of invertebrates contained in ballast sediment of transoceanic vessels operating on the North American Great Lakes to determine if ballast sediments could serve as a vector.

A cumulative total of 160 species were identified, including 22 freshwater species not recorded from the Great Lakes' basin of nonindigenous species.

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Mimura et al., 2008

Mimura, H., Okuyama, S. & Ishida, H. (2008). Changes in marine bacterial populations in ballast water and sediment of a LNG carrier bound for Qatar from Japan. Proceedings of the Japan Navigation Association 118: 123-133.

離岸流音響観測装置で検出された沖向きの強い流れは離岸流か?
中埜岩男, 石田廣史, 出口一郎
海洋音響学会研究発表会講演論文集

These results indicate that the ballast water exchange in the high seas is not effective as for the reduction of marine bacterial populations in ballast water.

Their results show the importance of management of sediment in ballast tanks as well as ballast water of ocean going vessels

Sediment in the ship's ballast water tank: A forgoten problem

V.Valkovic and J.Obhodas., 2015

V.Valkovic and J.Obhodas. (2015) 9th International SedNet Conference 23-26 Sept. Cracow Polland.

The accumulation of sediments derives from the obstruction of the scallops in the tanks' structures, and by the non-direction of sediments towards the BW suction bell.

N.Pereira, 2013

N.Pereira (2013) Ship Ballast Tank Sediment Reduction Methods. *Naval Engineers Journal* **125-2(2)** : 127-134.

This paper proposes modifications in the deballasting systems of ships that can be implemented in either existing ships or incorporated in new construction. The proposed alterations ensure the structural and operational integrity of ships, as well as facilitating the flow and subsequent removal of sediments from within the ballast tanks.

S.Gollash, 2017

S. Gollasch (2017) *https://www.ballastwatermanagement.co.uk/news/view,sediments-the-forgotten-aspect-of-ballast-treatment_46837.htm*

An awareness campaign is needed to explain the problems caused by risks of introducing species and contaminants when sediment is release.d in water.

If the sediment is not removed from ballast water tanks and a BWMS is installed, it cannot be guaranteed that the D2 standard will be met on discharge

TRIMIS: Transport Research and Innovation Monitoring and Information System

BaWaPla

FP6-2005-TRANSPORT-4

PROJECT (2006-2009):

BaWaPla (Sustainable Ballast Water Management Plant)

FlowSafe

INVESTMENT PROJECT EIPP-20170362

FlowSafe (Start date: January 2018)

The FlowSafe modular electro-chlorination Ballast Water Management System provides a unique and safe solution giving greater flexibility on installation, overall reduced costs and energy consumption.

FlowSafe Ballast Water Management System uses a combination of two methods of treatment giving optimum results in a marine environment. Both Solutions meet current and future legislations in our changing world.

The first is by using a low energy frequency Sea Water Conditioning Unit on the main ballast water fill line eliminating the need for filtration.

The second is the production of concentrated sodium hypochlorite from sea water using a high capacity electro-activation cell.

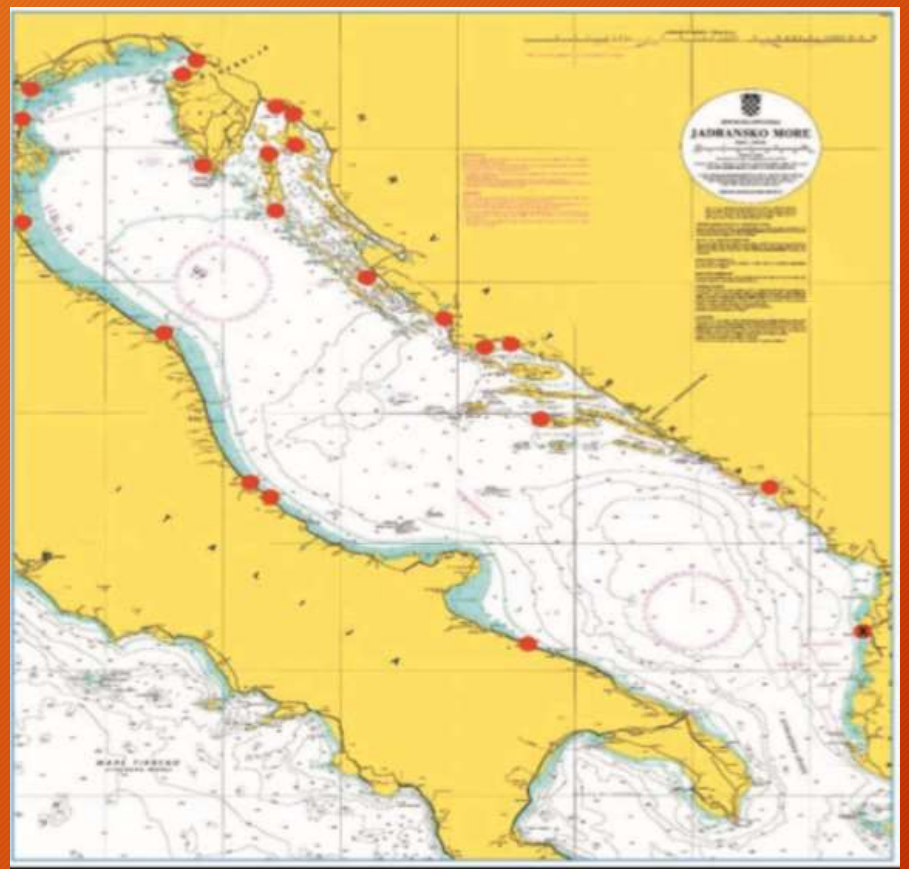
BALMAS

BALMAS project (2013-2016)

see next slide!

EC contribution: BALMAS - Ballast water management for Adriatic Sea protection

Locations of shipyards studied in the BALMAS project (2013-2016)



BALMAS project integrates all necessary activities to enable a long-term, environmentally efficient, and financially and maritime transport sustainable implementation of BWM (Ballast Water Management) measures in the Adriatic.
The only publication we found:

Maglić et al., 2016

Maglic et al. (2016). Ballast water sediment elemental analysis. Marine Pollution Bulletin **103** : (1-2)

No significant abundance of heavy metals was found in the sediment samples.

The results indicate that the sediment samples mostly consisted of compounds that originated from the deterioration of tank plates, tank coating residues and ballast operations such as clay, silt, sand and organic materials.

Significant drawbacks of using X-ray photoelectron spectroscopy (XPS) and secondary ion mass spectroscopy (SIMS) for the routine analysis of sediment composition as a decision supporting tool for ballast water and sediment management.

EMSA

European Maritime Safety Agency

EU action:

At present there is no direct EU Law on Ballast Water, however Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species recognises the BWM Convention as one of the possible management measures for invasive species of concern. The level of Invasive Alien Species and their environmental impact is also one of the many descriptors for assessing Good Environmental Status under the Marine Strategy Framework Directive.

EMSA's role:

EMSA has completed a 14 point Action programme to help the EU Member States implement the BWM Convention and contribute to the advanced work being undertaken on this issue in the Regional Sea Committees around Europe. EMSA continue to provide the EC and the MS with technical support on this issue when requested.

EMSA recent involvement:

EMSA monitors and examines international, regional and sub-regional developments in this field in order to enable the Member States and the Commission to identify any need for further action at EU-level to:

- promote the effective management of ballast water on board ships in European waters; and,

- to ensure a coherent approach within different European regions.

Thomas Waite and Holly Sweat: GloBallast Monograph Series No.23, 2017, London, UK.

SUMMARY OF FINDINGS

- Shipyards that currently offer ballast tank cleaning services have no experience with procedures to handle the sediments in line with the BWM Convention (invasive species).
- Sediment volumes in ships' ballast tanks are highly variable, but ballast tank cleaning services are not often requested in existing shipyards.
- Most existing shipyards contract out ballast tank services to specialized companies who provide the temporary labor force to remove sediments from ships.
- Most sediment material found in ships' ballast tanks is composed of fine-grain particles (< 35 µm). Therefore, utilizing filtration as a BWM treatment scheme will not preclude sediment accumulation in ballast tanks unless the filters can remove particles less than approx. 35 µm.
- Most routine cleaning of ballast tanks (light sediment build-up) is performed by ships' crews while at sea using some form of hydraulic washing.
- Most heavy ballast sediment removal in shipyards is performed using manual labor, i.e. physically digging out sediments and hauling them off the ship.
- One solution to reduce sediment build-up in ballast tanks for ships that ballast in shallow water areas is to move the water chests higher in the ship.

Options for the Disposal of Sediments

The options for disposal of sediments collected at a reception facility are limited by article 5 of the Convention. Disposal of this material will be in reference to the goal of preventing transfer of unwanted species, principally into the aquatic environment.

Therefore “disposal” refers to either rendering the sediments free of active biological agents, or placing the sediments in an isolated area where propagation of unwanted species is not possible.

- Ballast tank sediments management schemes must be included in a ship’s overall Ballast Water Management Plan as per regulation B-5 of the Convention.
- Sediments management schemes are only applicable when ships are in Party-identified ship repair yards. Treatment or removal of ballast tank sediments is *not* required during normal ballasting and de-ballasting operations.
- The Convention requires Member States to identify reception facilities for ballast tank *sediments removal/treatment only*. These are usually located in shipyards that provide ballast tank cleaning services. The Convention does not require Member States to create reception facilities for ballast water.

Published in 2017
by GloBallast Partnerships
Project Coordination Unit
International Maritime
Organization 4 Albert
Embankment, London
SE1 7SR United Kingdom

SEDIMENT MENAGEMENT

Disposal Requirements

1. *Free of active biological agents.*
2. *Chemical composition: No chemical elements in toxic range (< Class 3)*

Storage Requirements

3. *Placing sediments in an isolated area where propagation of unwanted species is not possible.*

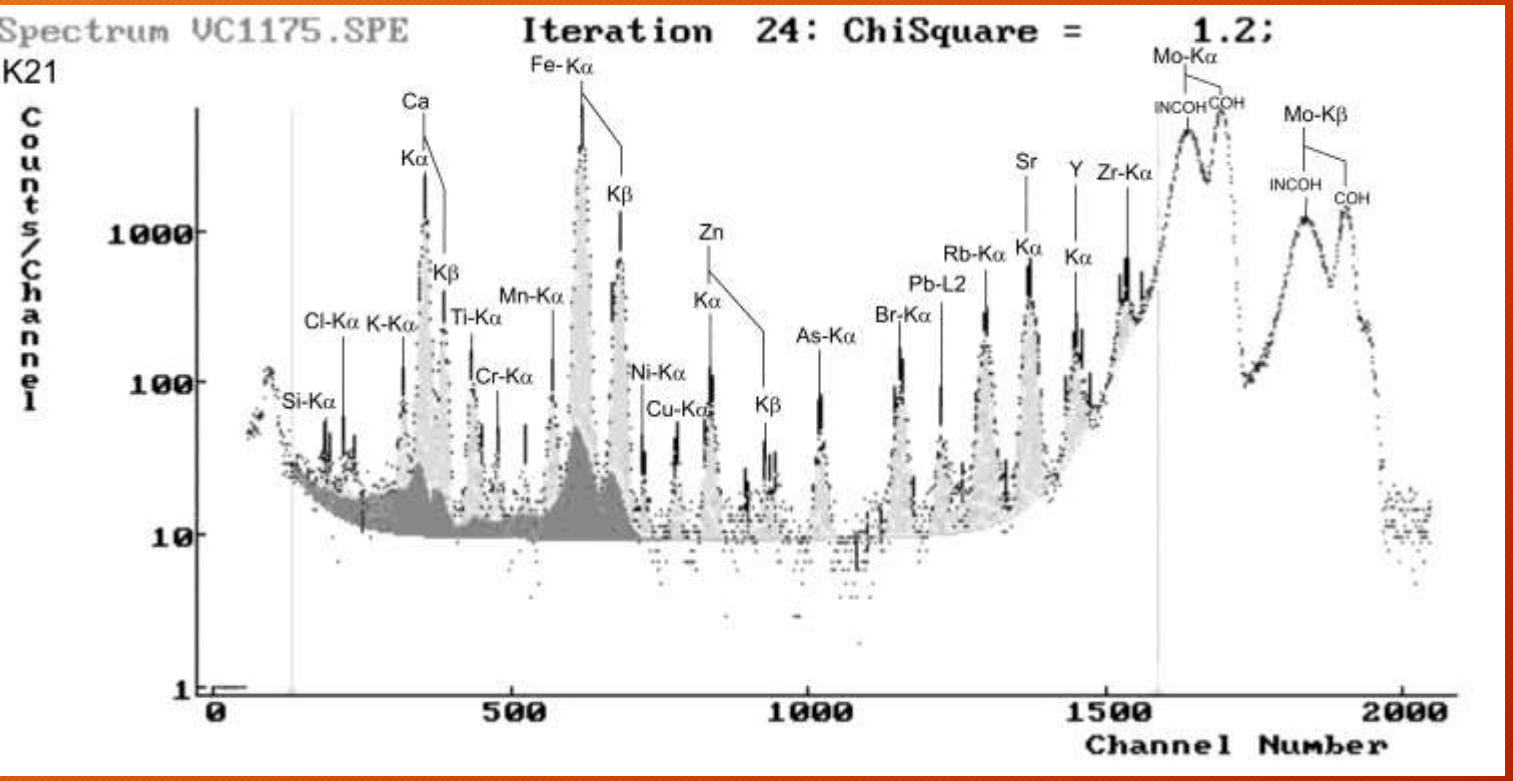
*Sediment classification and proposed disposal

Metals	Class 1	Class 2	Class 3	Class 4	Class 5
As	< 20	[20 - 50]	[50 - 100]	[100 -500]	> 500
Cd	< 1	[1 -3]	[3 -5]	[5 - 10]	> 10
Cr	< 50	[50 - 100]	[100 - 400]	[400 - 1000]	>1000
Cu	< 35	[35 - 150]	[150 - 300]	[300 - 500]	> 500
Hg	< 0,5	[0,5 - 1,5]	[1,5 - 3,0]	[3,0 - 10]	> 10
Pb	< 50	[50 - 150]	[150 - 500]	[500 - 1000]	> 1000
Ni	< 30	[30 - 75]	[75 - 125]	[125 -250]	> 250
Zn	< 100	[100 - 600]	[600 - 1500]	[1500 - 5000]	> 5000
Description of material	Clean material	Traces of contamination	Small contamination	Contaminated material	Very contaminated material
Disposal	Aquatic environment & Beaches	Aquatic environment	Aquatic environment (Mandatory monitoring)	Disposal on land (Special monitoring)	Disposal on land (Special treatment)

*) We propose the use of Portuguese Directive as elaborated in Caeiro et al. 2005. Ecological Indicators 5: 151-169.

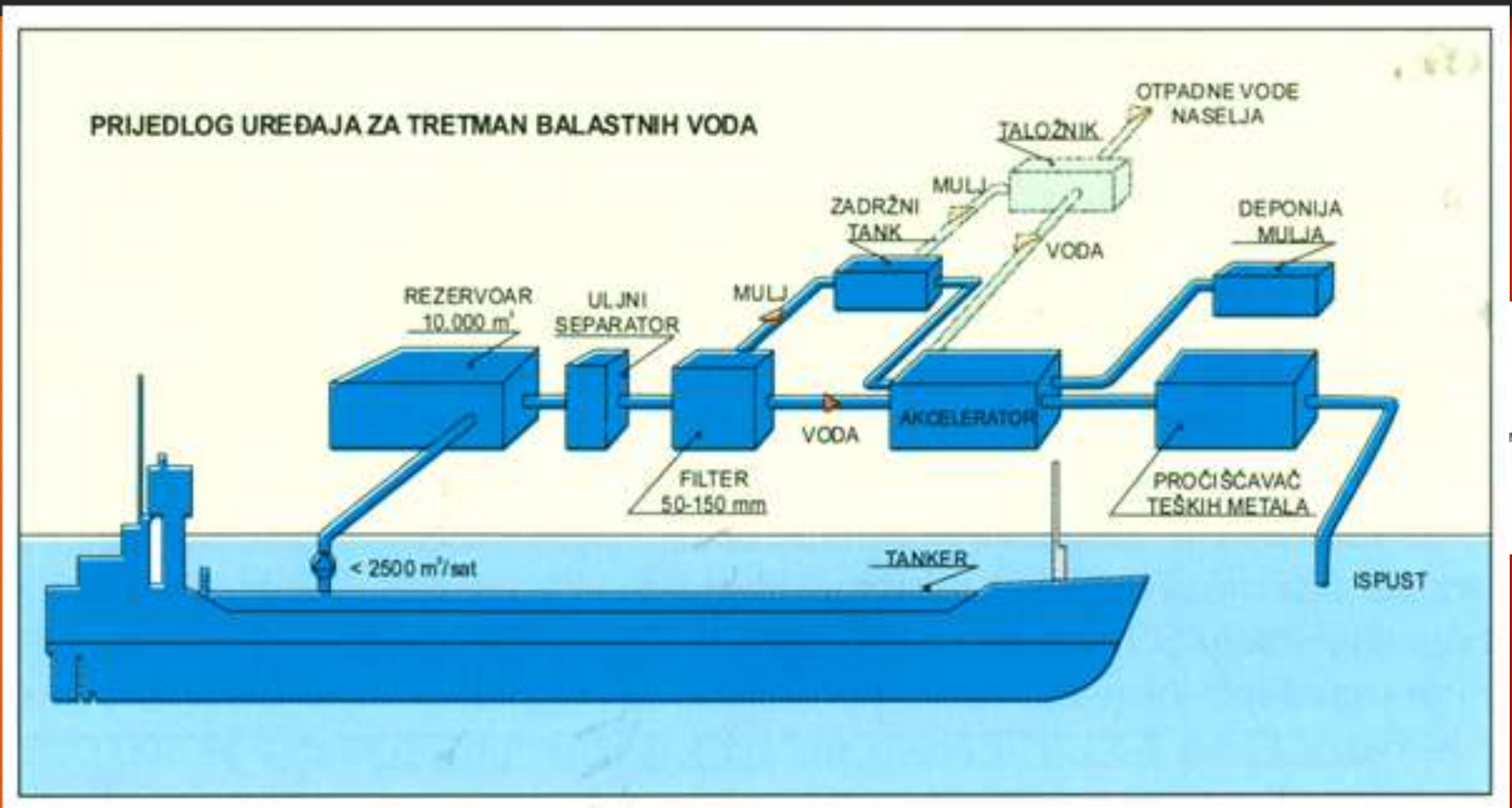
Sediment analysis

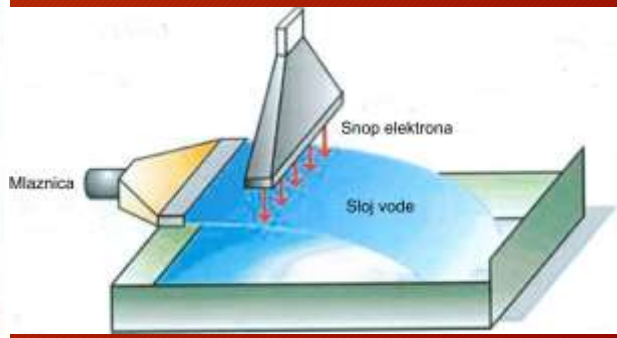
Sediment sample x-ray spectrum



Qualitest Inc.

Sediment in the ship's ballast water tank: A forgoten problem





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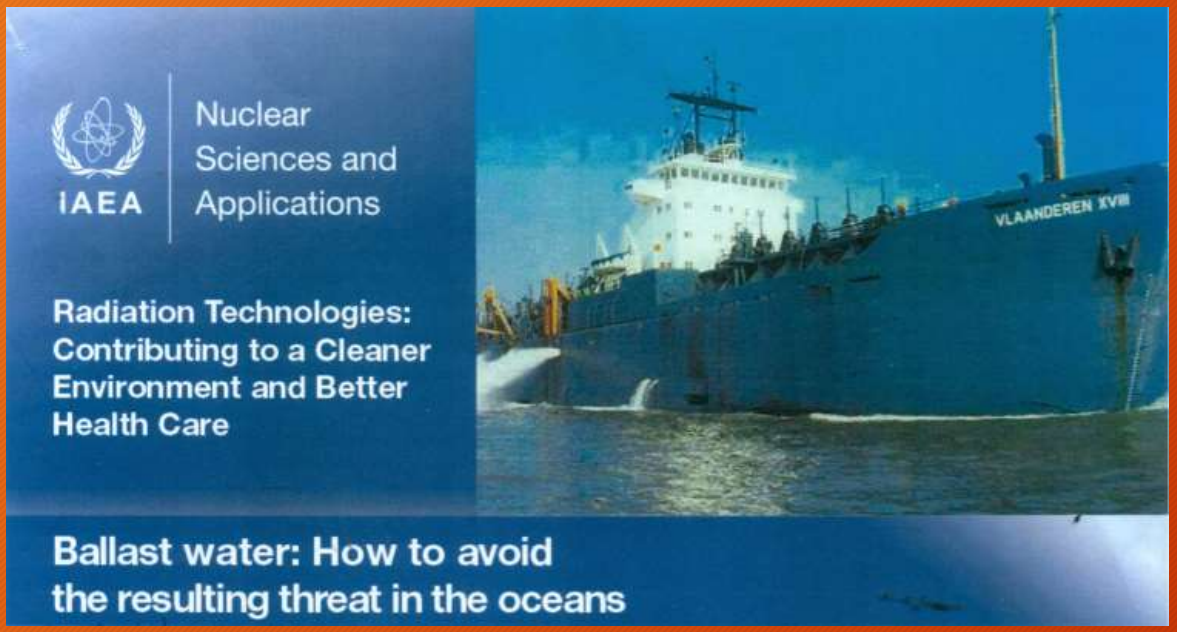
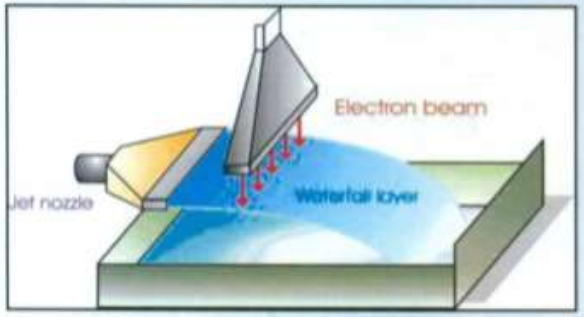


Ballast water treatment using electron beam technology

Radiation technology is a well proven and effective method used by the medical industry to sterilize medical products. This technology using electron beam radiation technology can remove various contaminants from the ballast water. The patented technology utilizes injecting high energy electron beams directly into ballast water to generate highly reactive species in the ballast water that rapidly damage and destroy the cells of harmful marine organisms, including viruses, bacteria and red algae within a short time, thus making it possible to remove various contaminants from the ballast water in a simpler manner. As the contaminants of the ballast water are removed by continuously irradiating with the electron beams, the treatment time for removing the contaminants from the ballast water can be reduced and the additional oxidative degradation of refractory organic matter can also be achieved, thus greatly increasing the efficiency of treatment of the ballast water.



Advantages of the technology:

- It is based on a simple, highly effective and well proven process used for sterilization of medical devices;
- The technology can be adapted to suit the varying levels of treatment required;
- It does not require any additional chemicals to be added;
- It is based on an ON/OFF system of treatment.

Thank you
for
your attention!