Methods to restrict the invasion of alien species

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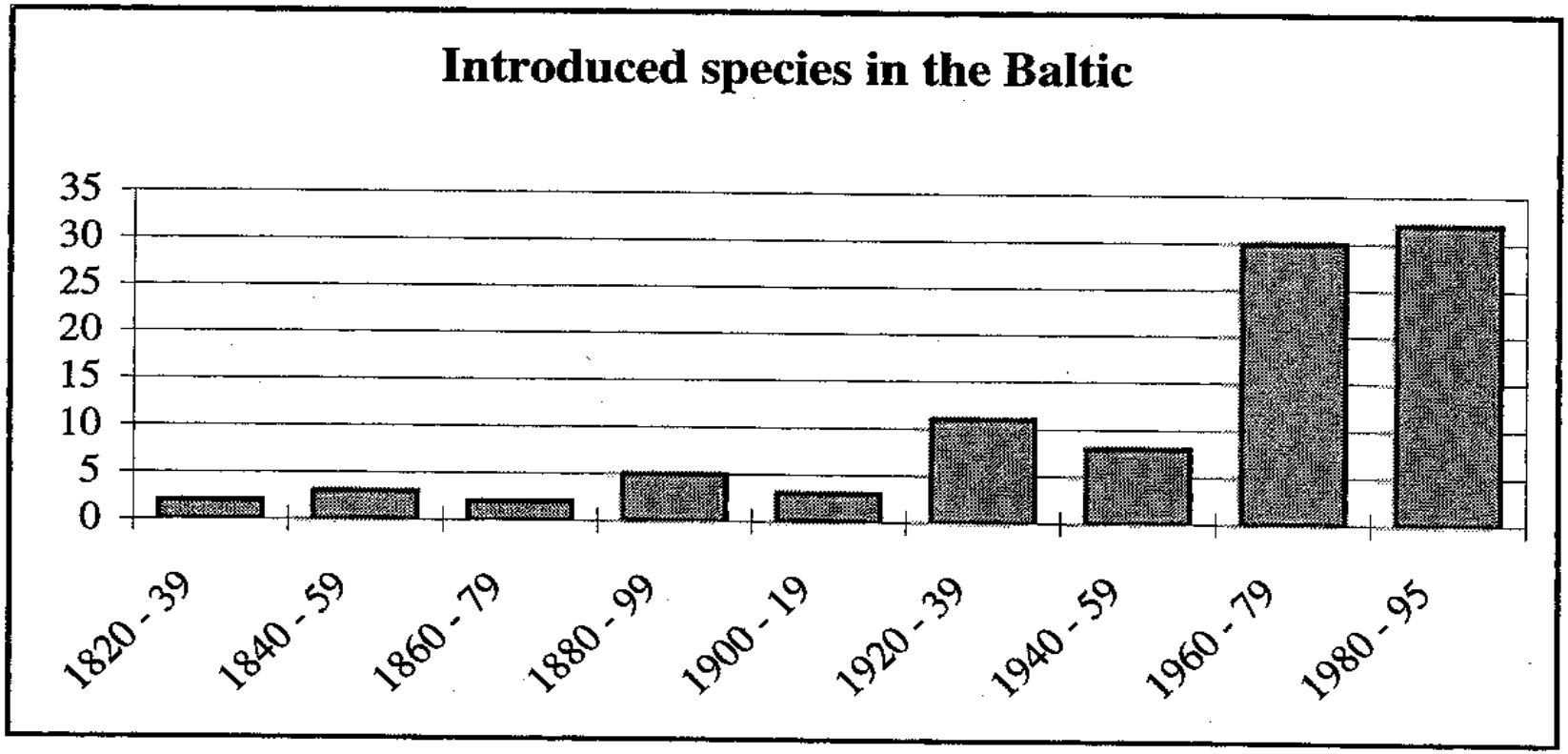
Aliens / Non-Indigenous Species

- Tentative figures obtained during the study indicate high numbers of invaders in the Baltic Sea (> 105 species of which some 70 established) in relation to its low number of native species of plants and animals.

- For British waters, it was estimated that about 55% of primary introductions of all NIS had probably been introduced in association with shipping.

- In the Black Sea and the Sea of Azov there are more than 45 NIS recorded of which 16 are of North American origin.

Introduced species in the Baltic, Gollasch & Leppäkoski, 1999:



Increasing trend in the future ?

higher frequency of ship visits, rapid turn-around times in port and changes in trading patterns ,

new trading links resulting in imports from new port regions,

more berths available in ports where there are marine conditions and construction of new ports ,

better management of water quality in port regions leading to better conditions for imported organisms in ballast water to become established,

the expansion of exotic species ranges elsewhere ,

the widespread interest in gardening and aquarium species ,

with the development of new aquaculture products ,

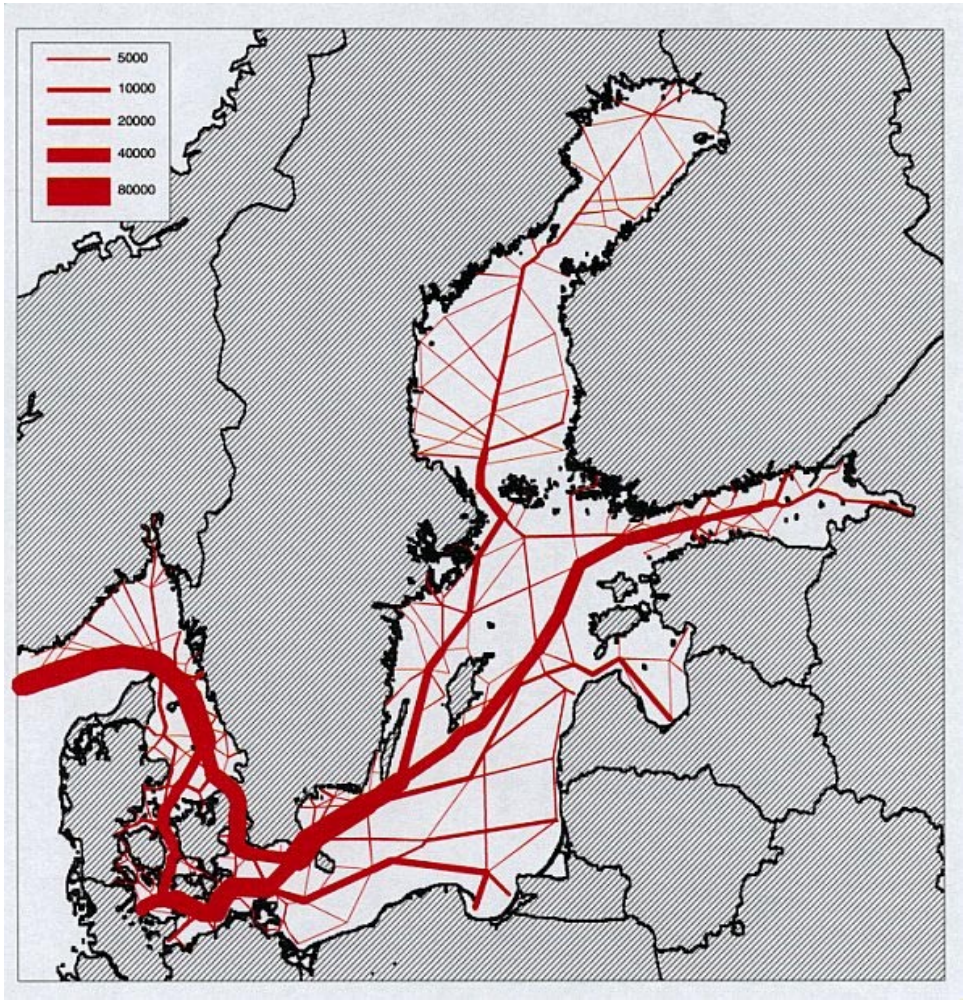
predictions of mean annual temperature increases will provide important changes,

the planned banning of some toxic ships antifoulants ,

environmental pollution and habitat destruction provide new conditions .

Annual Ship Traffic (No. of movements) projected to year 2017, all ship categories

Source: Tacis, 1998: Existing and Future Shipping through the Baltic Sea.



IMO

- MEPC Commitee work,
- Diplomatic Conference 2004,
- only recommendation is the exchange in the open sea (strenght, stability,slamming, stiffness, exchange-manual onboard etc..)
- Question of definitions,
- testing protocolls,
- killing rates,
- 95 % mortality of what ?,
- Basic principle: onboard threatment must be a part of normal ship design,
- monitoring possibilities,
- safe systems,
- sample taking,

Onboard testing facilities

- Filtering
- Cyclone, centifuge,
- problems: blockages, turbidity, sediments, ballast water volumes, corrosion ? Price !!
- Poisons,
- Deoxygenation (biol. & chem.)
- Oxygenation (hydroperoxid, O3),
- Electro-ionisation,
- Ultrasonic,
- Thermal treatment
- Combined systems

MARTOB

- EU project entitled “On Board Treatment of Ballast Water (Technologies Development and Applications) and Application of Low-Sulphur Marine Fuel.”

- The main objectives of the project are to investigate methodologies and technologies for preventing the introduction of non-indigenous species through ships’ ballast water.

- In addition to the Ballast Water treatment issues also the low sulphur fuels are studied in terms of assessment of the financial, technical and operational effects of a sulphur cap on marine bunker fuel in European waters.

Objectives

- The general objectives of the laboratory test phase were the following:

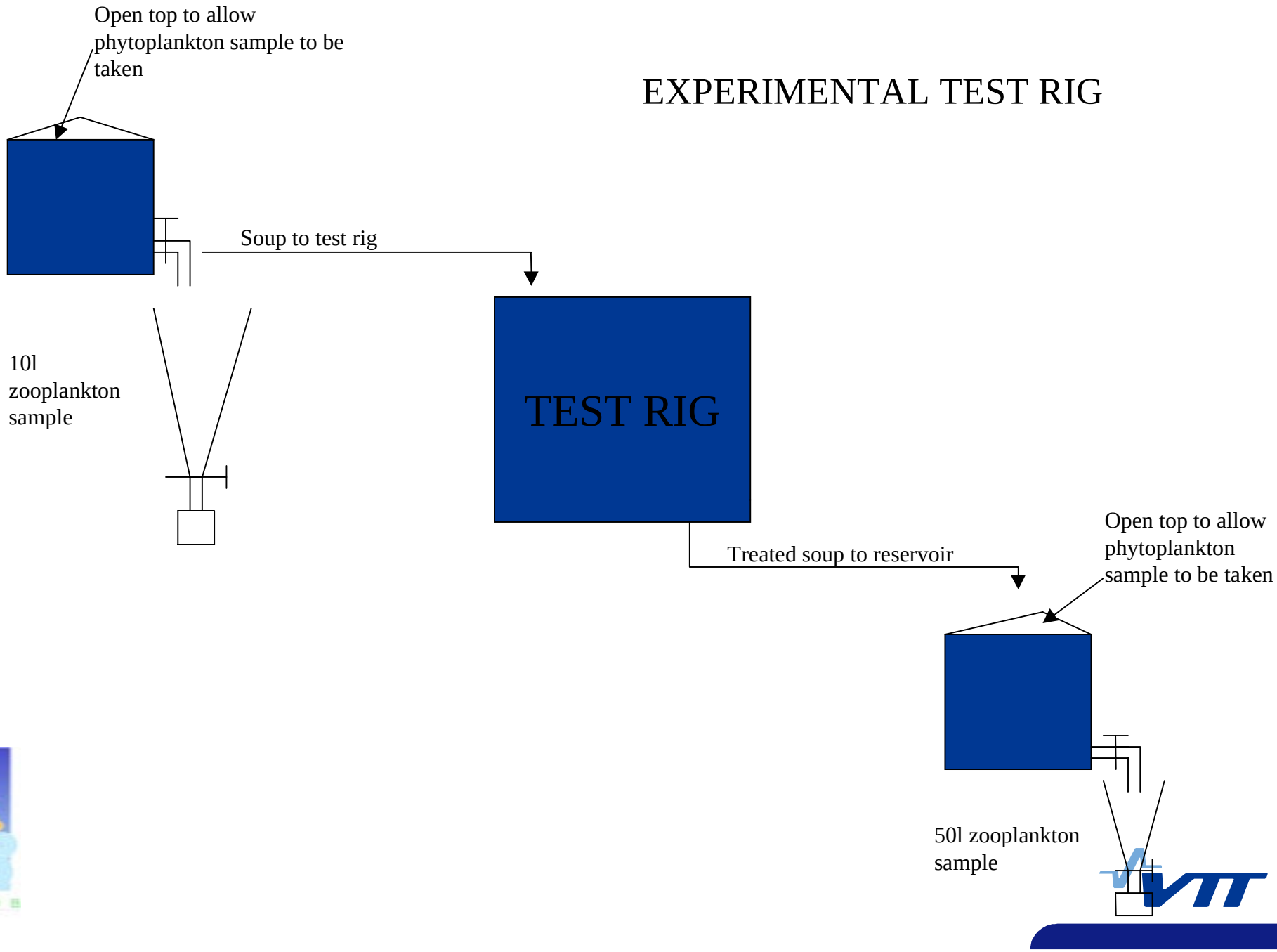
- - to design and develop the proposed treatment methods in laboratory scale and with computer simulation,
- - assessment of environmental, biological, economical, risk and safety aspects,
- - evaluation of subsequent long-term effect of the individual methods on the marine eco-systems.

MARTOB

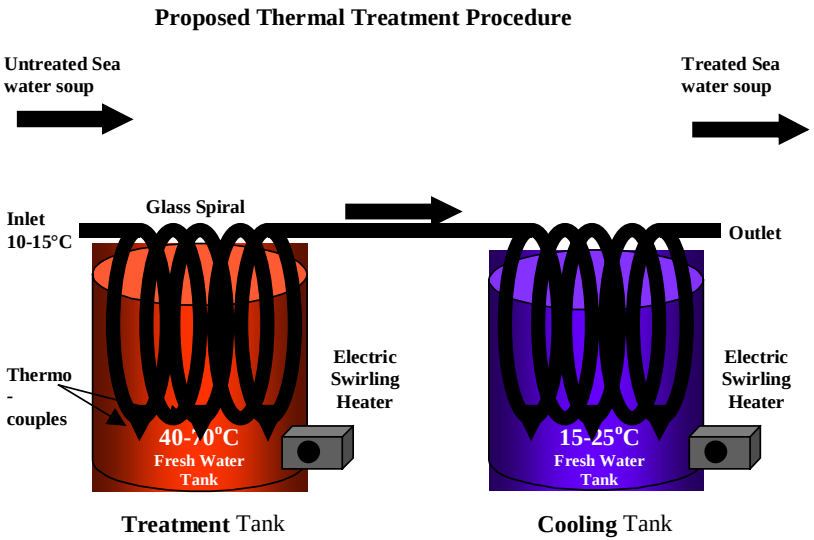
Tests trials in Newcastle, UK

- early June 2002,
- facilities provided by University of Newcastle,
- high temperature heat treatment (University of Newcastle), oxicide treatment (TNO), ultraviolet, ultrasound and ozone methods (VTT), de-oxygenation (SINTEF), Advanced Oxidation Method (BenRad) and combinations of technologies as hurdle technology (BERSON).
- artificial sea water, “Martob Soap”, de-ionised water + salt
- salinity 33-35 ppt, pH ~ 8,3, T = 10-15 ^{o}C
- *Nereis virens, Acartia tonsa, Tisbe battagliai, Alexandrium tamarense, Thalassiosira pseudonana* as target organisms,
- each test run was carried out only once (no repetition),
- corrosion assessment included

EXPERIMENTAL TEST RIG



Thermal Treatment Procedure by UNEW



- The design objective was to integrate a two stage heating system (pre-heating and high temperature heating systems) with existing ballast and cooling systems.
- Vourdachas, A. & Meshabi, E. 2002. Design and effectiveness of a high temperature thermal treatment for ballast water. ENSUS 2002 Conference.

Biological de-oxygenation
by Sintef

- The de-oxygenation technique is based on the theory that addition of nutrients to ballast water will lead to a rapid bacterial growth that will consume the oxygen in the water. The resulting anoxic conditions will kill most higher organisms.
- Josefsen, K. & Marjussen, S. 2002. Biological de-oxygenation of ballast water. ENSUS 2002 Conference. 16-18.12.2002. University of Newcastle, UK

UV Treatment by VTT & Berson

- Ultraviolet (UV) lamps are used to irradiate the organisms in the ballast water. The UV radiation will induce photochemical changes in the organism; i.e. it will break the chemical bonds in DNA.
- This can lead to problems should the organisms survive, as it may carry mutations. Furthermore, there is a requirement for pre-treatment of the ballast water, as the performance of the system decreases with the turbidity of the water.
- Ultraviolet Treatment is well established and proven as a disinfectant in the wastewater treatment sector.

US Treatment by VTT &Acomarin LtD

- Ultrasound is generated by a transducer, which converts mechanical or electrical energy into high frequency vibration.
- The ultrasound generates cavitation in liquid (in this case ballast water), which can lead to the cells of organisms rupturing. It has been shown to be effective with bacteria, plankton and other larger organisms.
- Ultrasonic treatment has been successfully used in water treatment and the food industry to control micro-organisms.

Ozone Treatment by VTT

- The ozonation system introduces ozone into the ballast water. As ozone is unstable under ambient conditions it must be generated *in situ*.
- Ozone has been used in onshore applications, such as swimming pools, disinfecting drinking water and controlling microbiological contamination in various areas.
- In these applications it has proven to be very effective and a more powerful biocide than chlorine, which has traditionally been used. Ozone is toxic and therefore it will have to be used with care. There is also concern that it may cause increased corrosion .

Oxicide method (electrochemical treatment) by TNO

- The Oxicide method is an electrochemical method, which generates hydrogen peroxide from the oxygen present in the ballast water.
- This decline in the concentration of oxygen and the presence of hydrogen peroxide is enough to significantly reduce the number of organisms present in the water.
- It also decomposes in water and will therefore not cause any problems to the environment. Hydrogen peroxide is an irritant and it will have to be used with care and it could possibly lead to increased corrosion.

an Advanced Oxidation Technology (AOT) by BenRad

- The Swedish BenRad equipment tested during the laboratory trials is based on an Advanced Oxidation Technology (AOT) consisting of a combination of ozone (O_3), two UV systems with different wavelength spectra and two different catalysts.
- The unique combination is designed to generate large amounts of radicals, mainly hydroxyl radicals, within the reactor. It is these radicals that destruct / eliminate the microorganisms
- The maximum flow for the testing device is 1,8 m^3/h.

Techniques	**Total costs in Euro per m^3 ballast water**
Methods that have been used or tested at large scale	
Sequential methods	0.014 – 0.30
Flow-through method	0.019 – 0.171
Brazilian Dilution method	0.156
Thermal treatment	0.031 – 0.050
Filtration	0.065 – 0.177
Hydrocyclone	0.059 – 0.241
Ultraviolet irradiation	0.090 – 0.287
UV/Filtration	0.154 – 0.464
UV/hydrocyclones	0.149 – 0.528
Methods in experimental phase	
Hydrogen peroxide	0.132 – 22.06
Glutaraldehyde	0.61 – 6.04
Chlorine	0.0871 – 4.36
Ozone	Not available
Sodium hypochlorite	0.046 – 0,185
Electric pulse	0.016
Use of fresh or treated water (Alternative water supply)	0.038 – 0.66
Land based treatment	0.1875 – 8.30

Hurdle Technologies by Berson

- Hurdle technology uses a combination of two or more treatment methods to reduce the number of micro-organisms present.

- - mechanical pretreatment (filtration or multicyclones) in combination with UV or oxidation techniques (ozone, Oxicide)
- - oxidation techniques (ozone, Oxicide) and UV
- - deoxygenation and (low) thermal treatment
- - (low) thermal treatment and UV.
- - (low) thermal treatment and oxidation.

Installation of large scale test systems , year 2003.

Large/full scale test trials onboard a ship:

- heat treatment (University of Newcastle)
- de-oxygenation (SINTEF)
- Advanced Oxidation Method (BenRad).

- Other partners continue the development :
- Example: on-shore tests
- Ozone (VTT)
- US (VTT),
- UV(VTT).