Task 6.3: Biological de-oxygenation review

Executive Summary

Most higher aquatic organisms require a steady supply of oxygen and will die if deprived of oxygen for an extended period. The idea behind biological deoxygenation is to stimulate the growth of the indigenous bacteria in the ballast water by adding a nutrient solution to the water. The resulting bacterial growth will consume the oxygen and make the water anoxic.

The biological de-oxygenation studies in MARTOB include a literature review, laboratory experiments to develop a suitable nutrient solution, meso-scale studies in Newcastle to test the biological killing efficiency under laboratory conditions, and sea trials onboard the car carrier M/S Don Quijote to test the method in full scale under real working conditions. In addition, economical and environmental aspects as well as ship and crew safety has been evaluated. This report summarizes the results of the studies and draws some conclusions regarding further studies.

Biological de-oxygenation can be used to make ballast water anoxic onboard ships. The potential threat of hydrogen sulphide formation can be controlled by the composition of the nutrient solution. The treatment costs are low. For a ship of approx. 15 000 ton deadweight with a need to treat 2000 m3 ballast water per voyage and 50 trips per year, the total cost was estimated to €0.10 per m3 treated water of which 3/4 was capital costs. The space requirement was estimated to 2-3 m3 with a "footprint" of about 1 m2 and a maximum weight of 2.6 tons.

Biological de-oxygenation is not suited for short voyages. The de-oxygenation process takes from 4 days or more at ballast water temperatures below 5 ºC to less than 1 day at temperatures above 20 ºC. In addition the water should be kept anoxic for at least 3 days, giving a total treatment time of 4-9 days.

The overall killing efficiency of de-oxygenation is limited. Even for zooplankton, for which the treatment is fairly efficient (~99 % kill rate), it is doubtful if the new IMO standard of less than 10 living organisms per m3 can be consistently achieved. The treatment seems to have limited effect on phytoplankton and may at best reduce their viability by 90 % compared to no treatment. This is not enough to ensure that the IMO standard (<10 viable cells/ml) is achieved even at moderately high phytoplankton densities. The effect on the indicator bacteria in the IMO standard (E. coli, intestinal enterococci, V. cholerae) has not been studied.

Because of the low killing efficiency, biological de-oxygenation is not likely to be suited as a stand alone ballast water treatment technique. It may be used in combination with other treatments, preferably methods that are most efficient towards phytoplankton and bacteria, or in combination with ballast exchange to enhance the effect of this treatment. The latter combination is based on the fact that the method should be relatively easy to implement on existing ships.