The new IMO Ballast Water Treatment Guidelines – Problems with Phytoplankton Cysts –

Shunji Sukizaki

Background

Around the beginning of the 20th century, marine organisms discharged in ballast water began to be suspected of adversely affecting the marine ecosystems in receiving waters (Hallegraeff and Bolch, 1992). At that time, countries probably affected by ballast water discharge ignored the potential effects because the number, size, and speed of vessels were very limited. However, as the size, speed, and travel frequency of vessels increased, so did the amount of discharged ballast water. Nowadays about 30 million tones of ballast water and 3,000 species of associated marine organisms are transported daily across international borders (Rakusuikai, 2001).

Many of the marine organisms transferred by discharged ballast water to new environments have adversely affected fishery resources and marine environments. Therefore, the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) has initiated a discussion about ballast water treatment (IMO, 2004).

Currently available technologies cannot kill or isolate marine organisms in ballast water without damaging or polluting the marine environment. Thus, the replacement of ballast water with seawater offshore (called "re-ballasting") is usually undertaken as a temporal countermeasure to prevent the introduction of species. However, re-ballasting at sea raises concerns about safety, extents travel time, and increases the running costs of vessels. Therefore, it is better to avoid offshore re-ballasting operations as much as possible. To overcome these problems, new methods are being sought to avoid introducing foreign marine organisms to the marine ecosystem of countries receiving ballast water. Experiments using ozone, cavitation, and other methods have been tested to kill marine organisms in ballast water, but treatment costs were high and treatment largely ineffective. Thus, a practical and economically feasible method has not been established.

Species and quantity of phytoplankton cysts in ballast-tank sediments

Vessels traveling between Australia and Japan usually fill ballast tanks with seawater pumped in at ports around Japan. After sailing for approximately two weeks, they arrive at ports in Australia. On the way to Australia, the ballast water from Japan is replaced with an intake of seawater from areas of the ocean where few organisms are present. Then, before they enter ports in Australia, the ballast water that was replaced offshore is discharged in the coastal areas of Australia.

Yoshida *et al.* (1996) studied temporal changes in phytoplankton in ballast water of bulk cargo vessels traveling between Port Kure in Japan and Port Olcot in Australia. The authors found that the density of phytoplankton was reduced to 1/10 after 8 days. Similarly, Gollasch *et al.* (2000) reported that phytoplankton in ballast water from Singapore to Colombo decreased to 1/10 after 8 to 10 days. They assumed that the significant decrease in phytoplankton in ballast water in such a short period of time could be attributed to 1) the lack of light, and 2) high water temperatures of more than 30° C when traveling across the equator (Gollasch *et al.*, 2000).

On the other hand, some phytoplankton species form cysts, when environmental conditions such as light and temperature deteriorate (Fig 1 and Fig 2). Once cysts are formed, their temperature tolerance increases. Furthermore, as they do not require light, they can settle and survive at the bottom of a ballast tank, where suspended solids contained in the ballast water settle down and form sediments. Phytoplankton that forms cysts includes toxic species, which can cause paralytic shellfish poisoning or red tides. Thus, if those cysts are released with ballast water, and if they are able to multiply, significant adverse effects on fishery resources and marine environments in the countries receiving the ballast water can be expected (Hallegraeff and Bolch, 1992).

Experiments on phytoplankton cysts were conducted on nine sediment samples collected from ballast tanks of four types of vessels: 1) container ship; 2) ore ship; 3) coal ship; and 4) woodchip ship. In sediments of all four types of ship diatom cysts were observed. The abundance of cells was about 200 per cm^3. Furthermore, many empty frustules of diatom were found in sediments even when no cysts were detected. Therefore, it was assumed that these were cells of phytoplankton transported in ballast water (Sukizaki *et al.*, unpublished data).

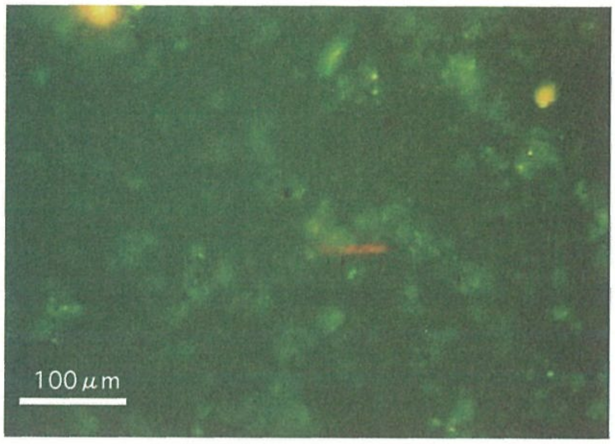

Figure 1　Cysts in ballast-tank sediments (Diatom)

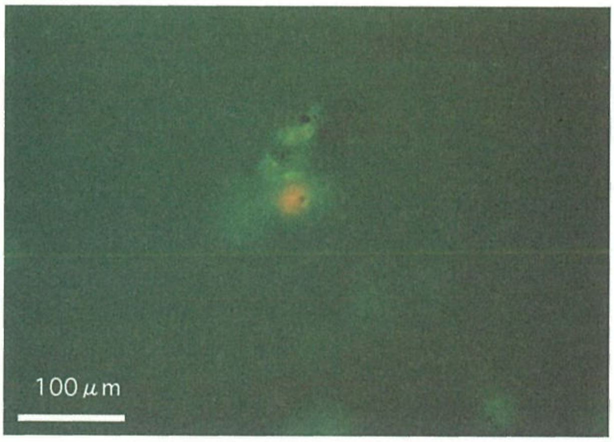

Figure 2　Cysts in ballast-tank sediments (Thalassiosiraceae)

According to an investigation of phytoplankton cysts in ballast tanks of 343 vessels entering 18 ports in Australia (Hallegraeff and Bolch, 1992), 65% of vessels had sediments at the bottom of their ballast tanks. In all those sediments cells or cysts of diatoms were found. Some of them were not indigenous to Australia. Also, in about 50% of those sediments, dinoflagellate cysts including *Alexandrium tamarense*, *Gonyaulax*, *Protoperidinium*, and *Scrippsiella* causing paralytic shellfish poisoning were found (Nagao *et al.*, 2001).

As a result of the IMO initiative for ballast water treatment, a new guideline has been adopted in

Table 1 New IMO Ballast Water Performance Standards

Organisms	Regulation of Ballast Water Manegement System
Plankton	① less than 10 viable organisms per cubic meter greater than or equal to 50 micrometers in minimum dimension. ② less than 10 viable organisms per milliliter less than 50 micrometers in minimum dimension and greater than or equal to 10 micrometers in minimum dimension.
Bacteria	less than the following concentrations of indicator microbes, as a human health standard: ① Toxicogenic *Vibrio cholerae* (serotypes O1 and O139) with less than 1 Colony Forming Unit (cfu) per 100 milliliters or less than 1 cfu per 1 gram (wet weight) of zooplankton samples. ② *Escherichia coli* less than 250 cfu per 100 millilitres. ③ Intestinal *Enterococci* less than 100 cfu per 100 millilitres.

February 2004. This guideline contains standards for the treatment of planktonic organisms and some microbes (Table 1), but does not address the problem of cysts contained in sediments. Since several investigators have found cysts (see above), treatment of phytoplankton cysts in ballast water is a very important issue.

References

Gollasch S., J. Lenz, M. Dammer and H-G. Andres (2000) Survival of tropical ballast water organisms during a cruise from the Indian Ocean to the North Sea. J. Plankton Res. 22, 923–937.

Hallegraeff G. M and C. J. Bolch (1992) Transport of diatom and dinoflagellate resting spores in ship's ballast water: implications for plankton biogeography and aquaculture. J. Plankton Res. 14, 1067–1084.

IMO (2004) International convention for the control and management of ship's ballast water and sediments, 2004

Nagao N., H. Hashimoto, M. Yoshida, and Y. Takasugi (2001) Germination factor and sea area disturbance of toxicity plankton cysts in Hiroshima Bay and Kure Bay. Proceedings of Coastal Engineering 48, 1081–1085. (In Japanese.)

Rakusuikai (2001) Possibility of plankton decentralization with ballast water. Rakusuikiyo, Vol. 1, 21–31. (In Japanese.)

Yoshida M, Y. Fukuyo, T. Murase and T. Ikegami (1996) On-board observation of phytoplankton viability in ship's ballast tanks under critical light and temperature conditions. eds. Yasumoto, T., Y. Oshima and Y. Fukuyo, In: Harmful and Toxic Algal Blooms. pp. 205–208.