A brief overview of potential harmful effects to marine ecosystems of ship-associated technology

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The potential environmental impact of shipping includes a number of well-known issues such as greenhouse gas and other atmospheric emissions, sound pollution, accidental oil and chemical spills, ballast water pollution and associated introduction of alien species. Other demonstrated threats to the marine environment are measures taken and technologies applied to combat ship hull bio-fouling and ballast tank corrosion. Marine bio-fouling is a highly complex process and can involve a wide variety of up to 4000 different species. Typically, the process can be divided into two main stages: micro- and macro-fouling. During micro-fouling, a biofilm is formed and bacteria start to adhere. Larger organisms, such as macro-algae and various sessile invertebrates, subsequently start to attach: i.e. the macro-fouling phase. To prevent fouling – which is essential with respect to the ship's fuel consumption – vessel operators have typically relied on antifouling coating/paint to prevent or slow down the growth of organisms on the ship's exterior. To date, the working principle of most of the paint systems applied commercially is based on the slow release of toxic substances in time. These so-called "self-polishing" coatings indeed slowly erode in time releasing toxic compounds such as – the now banned – TBT and cuprous oxide (still in use) into the surrounding environment. As such, these and other toxic substances do not only kill "fouling" organisms but may also adversely affect many other species in the receiving ecosystem. Indeed, the impact of these substances on natural systems may be considerable. For example, for tributyltin (TBT) it was shown that it induced sex changes in a number of snail species and it was also linked to whale beachings. With the ban of TBT formulations, most contemporary marine antifouling paints contain a copper (I)-based biocidal pigment, or the less potent zinc oxide. These formulations are often further enhanced by the addition of one or more booster biocides such as Igarol 1051, diuron and Sea-nine 211. In this paper, the principles of how to assess the risks (to the marine environment) of antifouling coatings, i.e. the comparison of the measured/expected environmental concentrations with the "safe concentration for the ecosystem", will be discussed. The method(s) will be illustrated by assessing the relative risks of some "old" and "new" antifouling paints. Finally, a brief overview of innovative, environmentally friendly, antifouling technologies - not involving the use of toxic substances, but - based on an improved understanding of the biological principles of the bio-fouling process will be given.