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Editorial

The Use of Copper Alloy in Aquaculture Fish Net Pens: Mechanical, Economic and Environmental Advantages

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Aquaculture industry is among the fastest-growing animal food-producing sectors in the world. In 2014, fish harvested from aquaculture amounted to 73.8 million tonnes, with an estimated first-sale value of US$160.2 billion (FAO, 2016). Maximize production should be followed by sustainable management of the aquatic environment and more environmentally friendly practices. A common issue with the conventional nylon (or other polymer) mesh nets of the fish cages is the attachment of algae (biofouling) a short time after the installation of the fish cages. The aquaculture plastic nets are susceptible to the development of biofouling (Greene and Grizzle, 2007). The biofouling development on the nets reduced the water flow inside the fish cages (Bakus et al., 1986; Fredriksson et al., 2003; Braithwaite and McEvoy, 2005; Lader et al., 2008; de Nys and Guenther, 2009). Fish farmers must change polymer nets frequently, clean them in situ, or use antifouling coatings. These actions increase significantly the operating costs of fish farming (Solberg et al., 2002; Braithwaite et al., 2007). The active ingredients of the antifouling coating are, among else, copper oxide, cadmium and zinc (Solberg et al., 2002; Braithwaite et al., 2007). These chemicals are discarded over time (10-12 months) into the water producing that way toxic effects in the water column and in the sediment under the cages, where the chemicals elements tend to accumulate. The maintenance of conventional nets with copper based anti-fouling paints may result in unpredictable incidents of significant copper release (Kalantzi et al., 2016). Concern about the effect of copper in the marine environment (water column and sediment) near fish farms is primarily based on the use of antifouling coatings and their effect on the benthic environment. The use of solid copper mesh avoids this issue because the cupric ions are dispersed rapidly in seawater and do not reach the benthic environment in a bioavailable form (Dwyer and Stillman, 2009). Ayer et al. (2016) suggest that use of copper alloy mesh systems could result in significant reductions in metal emissions to water. According to Yigit et al. (2016) trace metals in fish grown in copper alloy mesh cage were below the upper limits for human consumption, supporting the use of copper alloy mesh nets in cage farming.

The use of copper alloy mesh materials in net pen containment is a promising practice for reducing the disadvantages caused by conventional nets. The fish net pens made of copper alloy appear to have comparative mechanical, economic and environmental advantages over the conventional polymer ones (Chambers et al., 2012; Aufrecht et al., 2013; Drach, 2013; González et al., 2013; Ayer et al., 2016; Efstathiou et al., 2016; Kalantzi et al., 2016; Yigit et al., 2016; Buyukates et al., 2017). Copper alloy fish nets have higher structural stability. Their higher weight and resistance to deformation assures that there is sufficient pen volume available for fish, even under the presence of strong waves and currents, preventing that way crowding and fish stress. When copper alloy fish nets are introduced into seawater they develop an adherent protective patina layer. That layer inhibits corrosion and resists the attachment of fouling organisms (Chambers et al., 2012; Aufrecht et al., 2013; Drach, 2013). A clean net maintains water movement through the cage for optimal fish health. Moreover, net cleaning is expensive, time consuming and stressful to the fish. In addition, the absence of biofouling in copper alloy net pens eliminates growth environment for pathogens and parasites near fish, resulting to the reduction of diseases and parasites infection to the farmed fish. Therefore, there is a reduction on the use of formalin and antibiotics (Dwyer and Stillman, 2009; Efstathiou et al., 2016). In Japan and Tasmania, fish farmers using copper

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alloy mesh for yellowtail and *salmon salar* respectively do not use antibiotics or chemical treatments to maintain healthy fish (Dwyer and Stillman, 2009).

There is concern that escaped fish from aquaculture net pens can damage wild fish through genetic contamination, and by transferring parasites and diseases to wild stocks. The higher mechanical strength of the copper alloy fish net pens prevents the loss of fish through escapes (Dwyer and Stillman, 2009; Drach, 2013). The strength of copper netting also deters predators such as seals and sharks (Chambers et al., 2012). Lastly, at the end of the copper netting shelf life, it can be sold back to the manufacturer and recycled into another copper net or product.

Copper alloy mesh always remains open for water flow and improved oxygenation to improve fish health, growth rate and lower mortality rates (Dwyer and Stillman, 2009; González et al., 2013; Efstathiou et al., 2016). Higher food conversion rate and lower mortality reduces food consumption for production of same biomass. Dwyer and Stillman (2009) reported that the food conversion rate can be improved by 15% and the growth time to harvest can be reduced by several months. According to González et al. (2013) copper alloy net pens obtained 20% higher survival rates and 10% lower cumulative EFCR than nylon nets on average. These are strong indicators of healthy fish.

However, some risks regarding the use of copper nets should be taken into consideration. For example, it is known that copper pipes offer better microbial protection in drinking water distribution systems (Berry et al., 2006) but the possible increase of metal resistant bacteria (Calomiris et al., 1984) should be evaluated. In addition, the prolonged use of these nets without the appropriate temporal monitoring could induce environmental risks from heavy metals release in the environment. A possibility would be the application of simple active biomonitoring procedures (Tsangaris et al., 2011) like the use of caged mussels in the aquaculture installations.

In summary, copper alloy mesh nets can be an alternative to the conventional nylon (or other polymer) mesh nets for the fish cages but continues assessment and environmental monitoring is needed when they are in use. The best management strategy for fish farms is to take advantage of technological advances to reduce production costs and to develop more environmentally friendly practices, coupled with research and monitoring for a sustainable future for aquaculture.

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