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Antibiotic Use in Finfish Aquaculture: Modes of Action, Environmental Fate, and Microbial Resistance

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Abstract Various antibiotics have been used over the past 20 years and continue to be registered for use in finfish aquaculture in the United Kingdom, Norway, Ireland, and Canada. These include β-lactam (Amoxicillin), macrolide (Erythromycin), phenicols (Florfenicol), quinolones (Oxolinic acid, Piromidic acid, Naladixic acid, Flumequine), fluoroquinolone (Sarafloxacin), sulphonamides (potentiated sulphonamides), and tetracyclines (Oxytetracycline). Vaccines have largely replaced antibiotics as a means for controlling bacterial pathogens in cultured finfish but these anti-microbial agents continue to be applied to control disease in both hatcheries and grow-out stock. Bacterial strains resistant to specific antibiotics used in aquaculture have been cultured from mixed microbial communities in sediments after treatments of cultured fish stocks with antibiotics cease. This chapter considers modes of action, factors affecting environmental

persistence and ecological aspects of antibiotic resistance of the major antibiotics currently used in finfish aquaculture in Canada and Europe.

Keywords Antibiotic resistance · Disease control · Microbial infection · Salmon aquaculture · Waste feed and feces

1 Introduction

The high biomass of finfish cultured within the restricted volume of netpens creates the potential for microbial and parasitic infections. The risk is so great that animal health management is a central husbandry requirement in all finfish aquaculture operations [1, 2]. Although the development of standard codes of practice, improved biosecurity and the use of vaccines have resulted in reduced use of antibiotics from levels used a decade ago [3–8], chemotherapeutants continue to be used. Diseases and infections will always need to be controlled to ensure maximum production [1]. Here we review various antimicrobial agents used to control infectious bacterial diseases in finfish aquaculture. Mode of action, persistence, and concerns surrounding the development of antibiotic resistance as they relate to environmental and human health are presented.

2 Types of Antibiotics

A small number of antibiotics are registered for legal use in the finfish aquaculture industry in Canada and Northern Europe (Table 1).

2.1 β-Lactams

β-Lactam antibiotics such as Amoxicillin (Fig. 1) interfere with the enzymatic cross-linking (i.e. transpeptidases and carboxypeptidases) of the cell wall in actively growing bacteria. The activity of β-lactams depends on the affinity for the target, permeability constraints such as bacterial capsule and peptidoglycan, and the stability of β-lactamases. β-Lactamases can be regulated by constitutive or inducible mechanisms [9, 10]. Amoxicillin is typically used for the control of furunculosis in salmonids caused by *Aeromonas* sp. It is administered orally in medicated feed at a dose of 80–160 mg kg^{-1} body weight d^{-1} for a standard period of 10 days [11]. The withholding period for β-lactam antibiotics in the United Kingdom is 40–150 degree days in Atlantic salmon (*Salmo salar*). Environmental concerns with respect to persistence of the β-