Aquaculture and Animal Pathogens in the Marine Environment with Emphasis on Marine Shrimp Viruses

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19.1. INTRODUCTION

The Oxford English Dictionary defines agriculture as “The science and art of cultivating the soil; including the allied pursuits of gathering in the crops and rearing live stock”. Modifying the OED definition by replacing “soil” with “Earth’s surface” makes aquatic agriculture—or in shorthand “aquaculture”, the fastest growing sector of agriculture (FAO, 2002). A characteristic that sets the aquaculture industry apart from terrestrial livestock production is the rearing of species that are also natural resources. Although the spread of a terrestrial livestock pathogen serves as a primary concern to the livestock industry, dissemination of an aquaculture pathogen concerns commercial fisheries, recreational fisheries, and a wider environmental community. A converse concern is also felt by the aquaculture community; pathogens in natural populations may spread more easily into the aquaculture industry because of the shared host species.

As human population size and wealth have grown, so has demand for seafood. Expansion of marine aquaculture meets much of the new demand. According to the data in the FAO database FishStat, the capture fishery sector of seafood production has been level since the 1980s; however, mariculture has continued an 8% per annum exponential growth rate that began in the 1950s (Fig. 19.1). Further, the percentage of marine seafood coming from mariculture has increased steadily over that time and now approaches 25%.

Given that a population (either wild or cultured) carries a pathogen, the probability of transferring that pathogen to the other population increases as the number of effective contacts between those two populations increases. An effective contact is one that carries with it some non-zero probability of transmission-of-infection. One correlate to the growth of marine aquaculture is increased contacts between wild and cultured host populations. More contacts presently occur because of an increase in cultured animals inhabiting the environment and therefore more opportunities for contact between wild and cultured animals. Effective contact can occur between cultured animals and local populations during fish rearing or more distant populations after harvest.

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Locally, the number and kind of contacts is a function of the specific rearing practice. Farming of marine organisms occurs in a variety of ways, but all the cases can be categorized into one of three broad groupings relating to proximity of wild counterparts; (1) in the natural habitat, (2) in the coastal zone, or (3) in the inland zone. In the natural habitat, organisms are cultured in situ and may be in the water column or on the bottom suspended in cages, trays, or nets, or attached to artificial substrate. In the case of ocean ranching, organisms are not contained at all, but young are released into the environment, allowed to range freely, grow, and be re-harvested—an interesting hybrid between aquaculture and fisheries. Wild organisms can make direct contact with free-ranging ranched organisms, with cultured animals that have escaped from their culture unit, or, if small enough, wild organisms may actually enter the rearing unit. Direct physical contact may not be required and effective contacts can occur with the rearing unit itself or with dispersing contaminated waste. Often, wild organisms will be attracted to in situ culture units because food is available from dietary commercial feed or prey organisms colonizing the rearing units. In the coastal zone, organisms are grown in earthen ponds or tanks located near the open ocean or estuary from which culture water is obtained. The natural water is not only the source of new culture water but is also the repository for wastewater discharge, and effective contacts may occur with the wastewater. Inland, as in the coastal zone, ponds or tanks are used; however, inland facilities are located some distance away from the open ocean or estuary. The water source inland usually consists of saline groundwater, and wastewater is often disposed into rivers and streams, or if the saline content is low enough, it is used for irrigation. Likelihood of effective contacts with wild marine or estuarine organisms is dependent on the distance inland. However, novel contacts may be made between non-marine or non-estuarine organisms and wastewater effluent and may increase the likelihood of an emerging disease in an unusual wild host.

In addition to increasing the number of contacts between cultured and wild populations, the growth of mariculture also has changed the spatial distribution of contacts. Mariculture grows not only by an increase in the density of culture operations in locations where farming already exists, it also grows by expansion into areas where mariculture has not previously taken place. Pathogen range-extension can follow culture activities if the culture-species carries a pathogen into areas inhabited by uninfected susceptible populations of either conspecific or