Fish, Money, and Science in Puget Sound

Perhaps the national dilemma of solid waste disposal has been blown out of proportion. Marcia Barinaga (News & Comment, 9 Feb., p. 631) equates the amount of feces and uneaten food produced by a 2-acre salmon farm—100,000 kilograms annually—with the organic waste produced by a town of 10,000 people.

I have calculated that food wastes and wastewater from 10,000 people annually amount to more than 400,000 kilograms of organic, dry mass (*1*). Humans also produce other classes of organic wastes, such as paper, cardboard, textiles, garden trimmings, and wood. These wastes contribute a whopping 2,700,000 kilograms of dry matter annually. While "50,000 to 100,000 salmon concentrated in a 2-acre farm" may not represent the "cleanest industry," the fish actually produce less organic waste than 320 people.

The mass of feces and uneaten food from *all* of the salmon farms, which comprise "23 of Puget Sound's 3 million acres," is roughly equivalent to the mass of organic waste from a town of fewer than 4000. Producing "several thousand tons of fish per year" has costs, but these costs seem reasonable when they are accurately identified.

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Barinaga's article about salmon farming suggests that several negative biological impacts are occurring in Puget Sound. The issues discussed in the article have been raised for the past 5 years and have been addressed in scientific, legal, and political forums in Washington State. Numerous scientific papers have been gathered during the preparation of several documents, including a "programmatic environmental impact statement" (*1*). This information, together with 20 years of marine salmon farming experience in the state and more than 100 years of public and private hatchery experience, leads to the conclusion that salmon farming is a reasonable activity when sited and managed correctly. The state departments of ecology, fisheries, natural resources, and agriculture have taken extremely conservative positions in order to avoid errors and prevent impacts that may have occurred in other countries where there is salmon farming.

The Working Group on the Environmental Impact of Mariculture, International Council for the Exploration of the Sea, has stated (*2*) that farm wastes cannot be compared with human sewage. The often used term, "person equivalence" is misleading because of the different N,P,C-ratios and the different relationships between solid components and the nutrient load. Donald Weston has explained (*3*) why salmon farm effluents are different from sewage treatment plant effluents. The use of the biochemical-oxygen-demand unit as a measure of pollutant effects of a fish farm gives an erroneous evaluation of the biological impact when compared with that of sewage, according to Ervik *et al.* (*4*). Brown *et al.* (*5*) found that the dispersal and impact of salmon farm effluent was far less than that of sewage treatment plants or pulp mills. Salmon farms in Washington State are sited through the State Environmental Protection Act with the use of established criteria that limit organic inputs and minimize impacts. It is also important to note that "algae (bloom)

was a recurring problem in Canada" long before fish were farmed in those waters.

The "new diseases" question is as important to farmed fish as it is for wild or hatchery stocked fish. Washington State fish health protection regulations, which are applied to aquaculture, are among the most restrictive in the nation. The discovery of viral hemorrhagic septicemia virus in 1989 in returning stocks of Pacific salmon led to an exhaustive examination of the problem. European experts and federal, state, and tribal scientists could not determine the source, but found no evidence that farmed fish were responsible. It should be noted that no disease has occurred and that all mortalities have resulted from destruction of fish at public and tribal hatcheries, in an effort to contain the virus.

Three antibiotics may be used in fish farming in the United States. Antibiotics are expensive to administer, and fish farms primarily use them at or after smolts enter seawater from freshwater hatcheries. The young fish are physically stressed and subject to disease from pathogens found normally in the marine environment. The entire farm is not necessarily treated, since the older, larger fish have developed some resistance. The issue of the persistence of antibiotics in farm sediment is based on the data from one Norwegian paper (*6*). Temperatures, depths, currents, fish densities, or the dosages, frequencies, or applications of antibiotics used at the three farms studied were not included in the paper. Twenty years of farming at the Washington Clam Bay site (with sediment accumulation) does not indicate that antibiotic therapy has caused alteration of bacterial populations. A 1988 Food and Drug Administration study of three farms, including Clam Bay, showed that no antibiotics in shellfish were found, no antibiotic residues were found in the sediments, and there was no selection for pathogens at the farm sites (*1*, p. 55). In addition, Lee Harrell, a pathologist with the National Marine Fisheries Service, adjacent to the Clam Bay site, has diagnosed thousands of cases of vibriosis in salmon. His lab has not reported an oxytetracycline-resistant strain of *Vibrio anguillarum* since 1973, when data collection began. T. Aoki, an authority on the plasmid transfer of resistant fish pathogens, states (7) that it is not a human health problem. He has found that the properties of R-plasmids detected from fish pathogens are different from those of R-plasmids from human or domestic animal pathogens (7).

I invite the readers of *Science* to review published papers and the 1990 Final Programmatic Environmental Impact Statement prepared by the Washington Department of Fisheries (*1*) before reaching any conclusions about the environmental impact of salmon farming.

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