

# Salmon Pen Aquaculture on the Maine Coast: Environmental Points for Consideration

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1. Siting of salmon pen aquaculture in inshore waters of the Maine coast should include consideration of how *well flushed* the particular site is. That is, it is important that the *exchange rate*, of waters in the embayment with waters outside the embayment, be known in order to predict the potential for nutrient enrichment. This becomes especially important when considering the addition of artificial sources of nutrients to coastal environments, such as those associated with urban development or fish farms.

2. Of the carbon and nitrogen content of food ingested by a fish, only a fraction is incorporated into the fish by way of growth; about 70% is released into the holding waters as a byproduct of natural physiological processes (Fig. 1). *Note:* processes shown in Figure 1 include only materials that are *ingested* by a fish; food that is added to the system, but which is not ingested, will also contribute nitrogen to the environment.

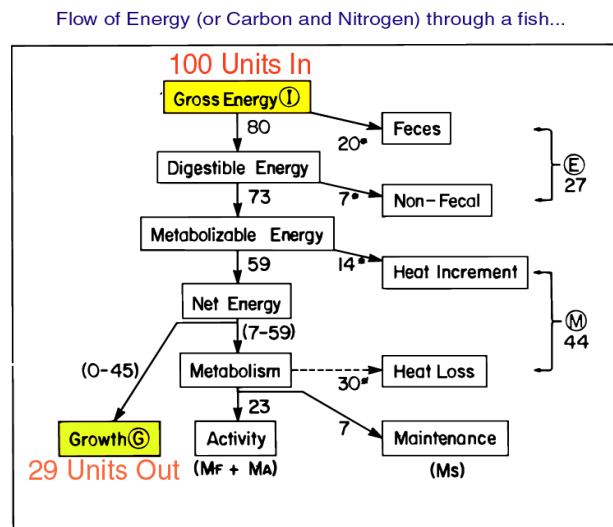
Examples:

A. Wolloughby (1999) reports that ca. 50 kg of nitrogen per year is released for each metric ton (1000 kg) of fish.

Therefore: 1 million salmon weighing 5 kg each (ca. 11 lbs), or 5,000 MT, will discharge about 250 MT of nitrogen per year, or ca. 700 kg nitrogen per day.

B. Brett and Groves (1979) report that nitrogen excretion by salmon is about 100 mg N per kg per day. For 1 million 5 kg fish, this is about 500 kg nitrogen per day.

These two estimates are not far apart. Thus, as a simplified example, we can assume that something on the order of 500 to 700 kg nitrogen per day will be discharged into holding waters for a salmon farm with 1 million 5 kg fish.



**Figure 1.** From Brett and Groves (1979). Flows of energy through a fish; pathways are the same for the elements carbon and nitrogen.

4. How much nitrogen release is OK?

This depends on the flushing rate of the embayment in question, which in turn will dictate how much nitrogen will accumulate. A site that has a rapid flushing rate may accumulate negligible stocks of nitrogen, but the opposite scenario is also true.

5. What *is* this nitrogen that is released by fish, and *where does it go* if it is not flushed out of the system?

Fish metabolically release dissolved nitrogen in both organic (urea) and inorganic (ammonium) forms. Both of these forms are readily taken up and utilized by microalgae (phytoplankton) for growth. Two resulting possibilities should be of particular concern:

- Microalgae may “recycle” the nitrogen many times (especially ammonium), potentially leading to greater primary production of organic carbon than one might initially expect. That organic carbon then will either be flushed from the system, buried in the bottom sediments, or respired (decomposed) which consumes oxygen in the process.
- The particular species of microalgae present may be dictated by the proportion of dissolved nitrogen to other nutrients, especially silicate and phosphate. Altered ratios of these nutrients may create the potential for “harmful algal blooms” such as those responsible for PSP.

Brett, J.R. and T.D.D. Groves. (1979) Physiological energetics. Pp. 279-344, In: Hoar, W.S., D.J. Randall and J.R. Brett (eds) *Fish Physiology*. Academic Press, NY.

Willoughby, S. (1999) *Manual of Salmonid Farming*. 329 p. Oxford ; Malden, MA : Fishing News Books.