

Salmon net pens in Puget Sound: Rules, performance criteria and monitoring.
An overview of Net pen permitting and monitoring in Washington State

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Net pen rules and site selection practices in Washington State have evolved considerably over the past 30 years since fish pens were first placed in Puget Sound. A few commercial or public agency operated pens began in the early 1970s, but site-locating practices were primarily driven by logical support considerations. Essentially there were no routine monitoring requirements for these pens, and most were relatively small operations located in shallow, protected waters. One exception was the extremely large array of pens in only moderate depths of Clam Bay Washington near Seattle, which had approximately 160 contiguous cages (Fig.1).



Figure 1: Aerial slide of Domsea Farms (in foreground) from late 1970s showing large size of pens (Photo courtesy of Pacific Aquaculture Caucus).

This pioneering effort was a landmark in its day, originating from the pilot scale studies of oceanographers Jon M. Lindbergh and Conrad V.W. Mahnken. Several studies focused on the extent of benthic impact from this early venture, which was relatively great, extending from 150 to 450 m (Weston and Gowen 1988). Other examples of less than optimum locations were common in the early days of pen culture (e.g., Fig. 2).

Figure 2: Pens located inside Shoal Bay at Lopez Island in 1980, with breakwater (upper left) partially preventing water circulation.



While studies of these sites helped with benthic impact model development, the environmental effects were not representative of typical pens used in the 1990s and currently in Puget Sound in terms of overall size or performance (e.g., food conversion ratios and management practices). As discussed below, impacts at existing net pens are now restricted to within a few 10s of meters of the cage perimeter and benthic life is much less affected (Fig. 3).



Figure 3. Pecten scallop growing at perimeter of pens near the San Juan Islands, typical of present day pens with strong currents and limited benthic impact.

Biologically, Puget Sound is a superior location to grow salmonids in pens, with optimum water temperatures, lack of parasitic sea lice, no problematic viruses and strong currents in many locations. However, there has been limited, although highly vocal and persistent opposition to net pens by a few shoreline residents. This review summarizes some milestones in the development of rules and regulations for pens in Puget Sound that were in part initiated by the growers themselves, through legislative action. The environmental scrutiny the process has received has been extraordinary, but appellants have never prevailed in any legal venue. This review is drawn from a more highly annotated version prepared and submitted for the JSA-EPA rule making process.

Interim Guidelines and PEIS

In the mid 1980s, amidst boom in Atlantic salmon culture worldwide, the Washington State Departments of Ecology and Fisheries commissioned a synthesis and review of the known effects of salmon net pen culture, which resulted in a milestone publication by Dr. Donald P. Weston of the University of Washington (Weston 1986). This document was widely acclaimed as the best-available review and interpretation of the literature at the time and is still a useful and pertinent document in many regards. Immediately after the issuance of the report, Dr. Weston, in concert with the state resources agencies and interested parties, prepared the *Interim Guidelines* (SAIC 1986), which helped guide agency management and monitoring efforts for nearly a decade. The Washington Department of Natural Resources very quickly adopted the *Interim Guidelines* as legal requirements of their aquatic lands leases. The requirements were detailed, but may be summarized as having the following primary attributes:

- Depth and velocity minimums were established, depending on size of annual fish production

- Pens could not be located near protected special habitats for fish & wildlife, invertebrates, (e.g., clam beds, herring spawning areas, marine bird and mammals)
- Pens were either not allowed in “nutrient-sensitive” areas subject to nitrogen-limitation of algal growth or strictly limited to minor production amount in transition areas.
- No un-pelletized (raw) feed or tributyltin net treatments were allowed
- Only non-lethal predator control was permitted
- Antibiotic use and fish transfer reports were requirements
- Hydrographic and bathymetric studies at proposed sites were required before initial permitting, although existing pens were allowed.
- Water column monitoring was required during the algal growing season and benthic sampling of infauna, chemistry and grain size were required along with SCUBA diving surveys for observation of waste feed, feces and bacterial growths.

There were no “end points” to this *Interim Guideline* monitoring, i.e., no threshold values or criteria were promulgated to determine if too much enrichment or impact was occurring. The idea was to amass a database so that future regulations could be based on more detailed fact. Over time, some of the sampling was found to be of little value, such as nutrient impact sampling, because the results were too variable and not really of consequence as commercial pens were all located in water naturally replete with nitrogen and phosphorus.

Subsequently, a Programmatic EIS for net pens was prepared by consultants for several state agencies under direction of the Washington Department of Fisheries. The work was peer-reviewed by leading fisheries and oceanographic authorities, included the best available technical information and was drawn in part from studies published in technical appendices (Parametrix 1991). The purpose of the PEIS was to clarify the known technical impacts of net pen rearing, to aid the site permitting and monitoring process. Aesthetic impacts were also considered in this effort.

NPDES Permit Development and Issuance

The first National Pollution Discharge Elimination System (NPDES) permits for net pens in Puget Sound were issued in 1996 by the Washington State Department of Ecology (Ecology). The development and issuance of these permits was actually the result of state legislature mandate, sponsored in part by the Washington Fish Growers Association. The growers recognized the need for actual performance standards for net pens, to end the debate about what was acceptable impact or effect. Washington State is also one of the few states that has a comprehensive marine sediment management rule; the net pen rules had to dovetail with the pre-existing rules for all industries but were encoded as a subset of the main rule due to the uniqueness of net pen effects (i.e., no toxins in the discharge, rapid recovery rates of the benthos after cessation of operation, etc.). These net pen rules were the result of three years of public hearings and work group meetings coordinated by the Washington Dept. of Ecology, in concert with the Treaty Indian Tribes, other state agencies, the salmon growing industry, other interested parties and NGOs through a group known as the Net Pen Advisory Workgroup (NPAW).

Initially Ecology and NPAW considered the use of numerical models to evaluate effects of the net pens. But the available models were either too complex or inexact, while extensive empirical data were available to characterize the effects. Accordingly, several consulting reports by State contractors were prepared to evaluate data that had been collected under the *Interim Guidelines* monitoring requirements. The consultants evaluated the entire database for monitoring that complied with all required quality control and quality assurance steps of EPA's Puget Sound protocols. Ecology's consultants described the types and distribution of impacts and made recommendations regarding rule endpoints, which stems from broader work done on a Puget Sound wide basis. Several findings were made by Ecology in review of the consultant's reports:

- Organic enrichment of sediments was the primary, measurable effect of salmon pens in Puget Sound. Water column data indicated no significant measurable effects on dissolved oxygen, ammonia or algae (also see Parametrix 1991, Rensel 1989). Most of Puget Sound is highly replete with dissolved macronutrients and light is considered the factor limiting algal production, except in some shallow, poorly flushed bays and inlets that should be avoided for any type of discharge.
- The extent of seabottom effects of salmon pens was limited in most cases to within 100' of the perimeter of the pens. Ecology elected to manage the pens by allowing a sediment impact zone within the "footprint" of the pens. Outside the 100' perimeter, performance standards would have to be met.
- The primary cause of the sediment effect was the natural decomposition and breakdown of the fish feces and waste food, mostly carbon compounds that are oxidized through bacterial decomposition. This process requires oxygen, but if the deposition rate exceeds the assimilation rate, the process may become anaerobic and slows down.
- Since carbon decomposition is known as the source of the oxygen demand in sediments below net pens, carbon monitoring was selected as a reasonable approach to grossly monitor conditions in the benthos. Total organic carbon (TOC) is measured from core samples of the upper 2 cm of sediment, after hydrolyzing carbonates from inorganic forms such as from bivalve shells. There are other means to estimate oxygen demand in sediments, but most are research tools, not well suited to routine monitoring needs as they have variable results that are more difficult to replicate.
- Carbon (TOC) data was available from a multitude of unaffected, reference sites throughout Puget Sound. This database was used to estimate background conditions, by parsing it into differing silt/clay content categories (e.g., finer sediments naturally have higher contents of carbon) within geographic subregions. By comparing to reference conditions, the relative "health" of the sea bottom at net pen sites could be estimated. Total Organic Carbon "Triggers" or endpoints were defined for each silt and clay category (Table 1) through this process.

Table 1. Total organic carbon trigger levels indexed to silt/clay content of the sediment. From the NPDES rule for net pens (NPDES Rule, Ecology 1996).

Category Number	Silt and Clay Percent in Sample	Total Organic Carbon, "Trigger" Criteria
1	0 –20%	0.5%
2	20-50%	1.7%
3	50-80%	3.2%
4	80-100%	2.6%

- Monitoring of sediment TOC is required at seven stations at each permitted net pen farm in Puget Sound. Four of these stations are located at a distance of 100' from the perimeter on each side of the farm. This distance was not selected arbitrarily, but was derived from observations of well-managed and sited farms in Puget Sound¹. Three replicate sediment samples are collected at each station (Fig. 4). No further monitoring is required if sediment TOC is not statistically elevated above the TOC trigger corresponding to the observed percent fines at each 100' station. If the measured TOC is significantly higher than the corresponding trigger value, then repeat sampling is required in the following summer with the collection of five replicates of benthic infauna samples at each station that may have failed the TOC trigger, as well as at a suitable reference location. Benthic infauna (i.e., invertebrate) enumeration analysis is required for any station at which elevated TOC is observed during the second round of sampling.

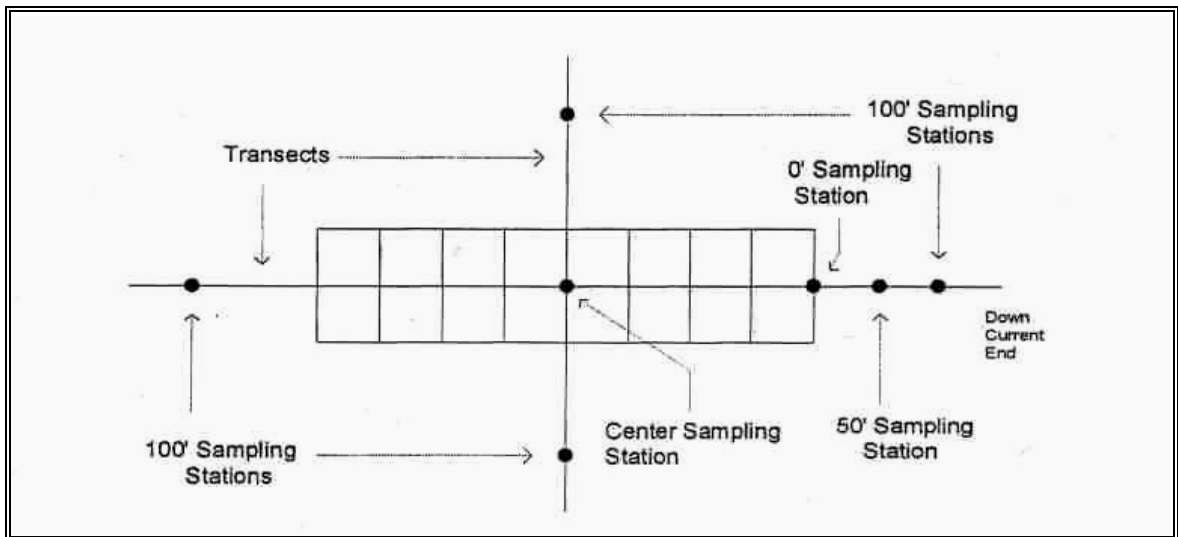


Figure 4. Benthic sampling stations and transects required by existing NPDES sampling protocols for Puget Sound net pens, typical.

¹ An appropriate distance for a sediment impact zone may vary in other locations of the US, depending on the available depths, currents and resources potentially at risk.

- Each farm is required to manage its production such that there are no significant negative effects on benthic resources beyond the boundary of this sediment impact zone. Washington State Administrative code states that biological resources in sediments are considered adversely impacted if the mean numbers of crustaceans, mollusks or polychaetes in the test sediment are reduced to significantly less than 50% of the number of animals belonging to the same taxa living in undisturbed reference sediment. A one tailed *t-test* at $\alpha = 0.05$ for five replicate samples is the basis of the test. The overall Puget Sound sediment standards are being revised and upgraded, with a probable shift to species diversity as an end point rather than species abundance (B. Betts, WDOE Sediment Management Unit supervisor, pers. comm.).
- Should any of the test stations around the pens have results showing a violation of the general benthic abundance rule mentioned above, the farm managers must prepare a plan showing how compliance will be achieved.
- Benthic conditions at each of the four orthogonal 100' SIZ stations must be photographically documented periodically and whenever sediment samples cannot be collected and analyzed in conformance with the requirements stipulated in the Puget Sound Protocols and the permits.

Current Status and Effectiveness of Existing NPDES Regulation

Net pens site locating and operation in Puget Sound has evolved and matured over the past three decades. Initially there were several poor sites located in shallow, poorly flushed and in some cases, nutrient sensitive waters but they no longer exist. The adoption of the Interim Guidelines began the push to more exposed, better-flushed sites and currently all commercial net pens are located in non-nutrient sensitive waters in Washington State (Rensel Associates and PTI 1991).

The existing NPDES permits have been in effect for about 4 years at this point. To date it has not been necessary for agencies to take action regarding unmet performance criteria. Net pen operators have dealt with the few stations that have not passed the test by altering their loading rates or pen configuration. Fish farmers have anticipated the need to make modifications prior to any regulatory action, as the defined performance criteria give them a known target to achieve. As a result of the increased interest in fish farm effects, fish farmers have also conducted additional voluntary studies to further characterize and understand their sites. For example, current meter and drifter surveys have been conducted at a number of sites that were in existence prior to the *Interim Guidelines*. These studies have furthered the understanding of relative site performance and effects.

A Washington State trial court has ruled that the operation of salmon net-pen farms in Puget Sound does not pose a significant risk to native salmon runs, water quality or sediment quality, and therefore does not violate water pollution laws. Judge Richard Strophy affirmed an earlier decision of Washington's Pollution Control Hearings Board to the same effect. The Board had conducted a five-week trial in 1997-98 in response to an appeal brought by the Marine Environmental Consortium and other groups against the State of Washington and two fish farming corporations. The effect of the court's decision is to uphold NPDES/waste discharge permits that the State had issued to the salmon farmers. The basis of the court's decision was a mass of scientific opinion and

data in the record, and evidence that the salmon farmers had initiated actions to reduce or eliminate fish escapements from their facilities. The industry now plans to move ahead and continue working cooperatively with the Washington Department of Ecology and other agencies to amend and reissue their permits.

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