Processing Wastewater From Two Mechanized Salmon Canneries

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Introduction

In 1972, Congress approved the Federal Water Pollution Control Act (PL 92-500) which enabled the Environmental Protection Agency (EPA) to establish guidelines and performance standards for seafood processing wastewater.

A survey was made of the industry and the results reported in a series of development documents (EPA, 1975). After considering the available information, the EPA recommended guidelines limiting the amount of 5-day biological oxygen demand (BOD_5), total suspended solids (TSS), and oil and grease (O&G) in wastewater discharged by mechanized salmon canneries. Performance standards for best practical control technology currently available (BPCTCA) and best available technology economically achievable (BATEA) were promulgated in the Federal Register (EPA, 1976).

This study was initiated in response to industry requests for information concerning treatment systems for fish-processing wastewater. The information published in the development documents (EPA, 1975) suggested that the amount of waste discharged for each unit of production varies daily and is different for each cannery. To select treatment systems which will comply with the EPA guidelines, it was necessary to determine the range, frequency, and causes for the variation in the amount of waste discharged by individual canneries.

Accordingly, intraday and daily variations in the composition of wastewater from two west coast mechanized salmon canneries were measured and compared. Relationships between the amount of processing waste discharged, daily production, water used, and the BOD_5, TSS, and O&G concentrations of the wastewater were determined. The long-term average and daily maximum discharge expected at each level of production were calculated and compared with the EPA recommended guidelines.

ABSTRACT—Wastewater discharged from seafood processing plants is subject to the Environmental Protection Agency regulations and guidelines. This study was performed to estimate the amounts and variability of waste loads from salmon canneries. The amount of 5-day biological oxygen demand, total suspended solids, and oil and grease discharged by two mechanized salmon canneries was determined. Variations in the composition of the processing wastewater, daily water use, and production levels are described. Both canneries complied with the EPA recommended effluent limitations more frequently as daily production increased.

Materials and Methods

Cannery Description

Two salmon canneries, designated as A and B, were evaluated during the 1976 fishing season. Both canneries used standard processing equipment, such as mechanical butchering machines, sliming tables, gang knives, and can-filling machines. The processing, canning, retorting, and wash-down procedures were similar to those observed elsewhere in the industry.

In both canneries, heads, tails, and viscera were collected before they entered the wastewater. Cannery A delivered this offal to local farmers who used it as a soil enhancer, while Cannery B used it in pet food production. Cannery B rendered some of the fish heads to recover salmon oil. Both canneries processed salmon roe as a by-product.

As is usual in mechanized salmon canneries, scraps accumulated on the floor in all the processing areas, especially at the butchering and can-filling machines. These wastes entered the wastewater when the plants were washed using high-pressure hoses. In addition, large amounts of waste were discharged at unscheduled intervals due to frequent spills, breakdowns, and the dumping of rendered fish heads and roe-processing brine.

Routine wash-down procedures were thorough at the end of the work day and superficial during lunch time and coffee breaks. Approximately the same amount of time, labor, and volumes of water were used to clean the equipment regardless of the duration or rate of production.

In both canneries, a series of flumes and floor drains, covered by grates having 2.54 cm (1 inch) openings, delivered wastewater from the work areas to an effluent collection sump. When full, the contents of the effluent collection sump were automatically pumped to a headbox located at the entrance to the wastewater treatment system being investigated. Wastewater in the headbox was well mixed and representative of the effluent subject to the EPA guidelines for point sources of discharge.

Sampling Techniques

Intraday grab samples were manually collected from the headbox. A table of random numbers (Youden and Steiner, 1975) was used to select time intervals between samples so that the probability

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of including variations in production, water use, or waste concentration (such as occur during lunch hour, spillage, or wash-down procedures) in each sample would be proportional to the frequency of occurrence.

Daily composite samples were obtained by combining the individual grab samples in proportion to the discharge rate measured at the time the samples were taken (Harris and Keffer, 1974).

Water used at Cannery A was measured by a rotary-style meter in the city water line. The flow rate of the wastewater, when samples were collected, was determined by measuring the time required to fill the 450 liter (119 gallon) effluent collection sump.

Wastewater from Cannery B flowed through a 45.7 cm (18 inch) H-flume before entering the collection sump. The height of the wastewater in the flume was continuously monitored by a Westmar[1] ultrasonic probe. The instantaneous flow rates and daily totals were recorded with a standard error less than ±1 percent. The accuracy of this method was confirmed by emptying a 7,571 liter (2,000 gallon) tank of water through the flume at a known flow rate.

Both canneries were plumbed so that only water used for production and wash-down procedures was included in the daily total. Water used for cooling retorts and other purposes not covered by EPA guidelines was not included in the totals.

Daily production was determined by totaling the weight of totes full of salmon purchased from the boats and processed on a particular day.

The average amount of water used by butchering machines, sliming tables, can fillers, and similar processes for each unit of production was estimated by the slope of the linear regression line which correlates daily water use and production. The amount of water used regardless of the amount of fish processed was estimated by extrapolating the ratio of daily water use and production to zero production.

[1]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

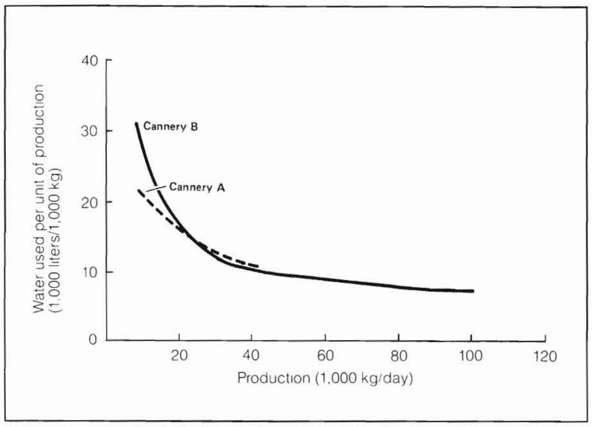

Figure 1.—Water used per unit of production as a function of daily production.

The amount of water used for each unit of production (flow ratio) was determined for each level of production. The flow ratio was multiplied by the analytical results to determine the waste discharged for each unit of production (EPA, 1975) and then by daily production to obtain the total discharge.

Analytical Techniques

All chemical and biological tests were made according to the methods described in the 14th edition of Standard Methods (APHA, 1975) or by the EPA (1974). Statistical quality control was employed when evaluating the data. Results were considered acceptable when duplicate analyses were within the 95 percent confidence intervals established for these tests (APHA, 1975; Youden and Steiner, 1975).

Total suspended solids (TSS) were separated from filterable residues (FR) by filtering aliquots of wastewater through a Gelman type A glass-fiber filter paper (EPA, 1974). The TSS retained by the filter paper was weighed after drying in an oven at 103°-105°C for 1 hour. The FR was determined by evaporating the filtered wastewater to a constant weight at 103°-105°C.

Total residues (TR) were measured by evaporating aliquots of wastewater to constant weights in an oven at 103°-105°C.

Values for total residues and filterable residues were reported after subtracting the sodium chloride (NaCl) content of the wastewater from the analytical results.

Results and Discussion

Water Used for Each Unit of Production (Flow Ratio)

Both canneries used water more efficiently as production increased. The average amount of water used for each unit of production (flow ratio) decreased as daily production increased (Fig. 1). The relative error of the flow ratio was ±11.8 percent at each level of production.

The amount of water used by the butchering machines, sliming tables, can fillers, and similar processes was proportional to the duration and rate of production. The average amount of water required for wash-down procedures and purposes other than production was relatively constant at all levels of daily production at both canneries (Fig. 2).

Analytical Results

The composition of the untreated wastewater from both canneries was very similar (Tables 1, 2). The concentration of waste in the samples from both canneries followed similar distribution curves at all levels of daily water use and production investigated. Although initially highly concentrated, the average composition of the wastewater during wash-down and production periods was similar.

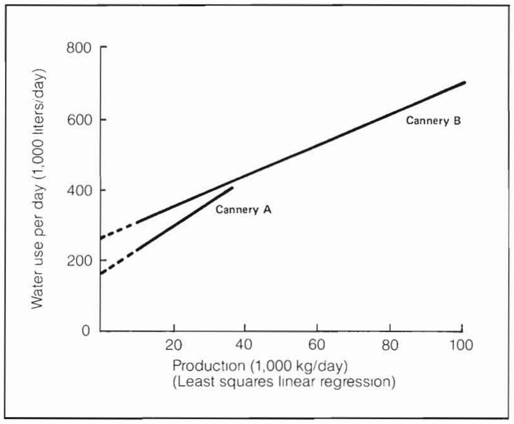

Figure 2.—Water used for each day's production at Canneries A and B. Data points omitted at the request of the canneries.

Table 1.—Intraday random samples—mechanized salmon processing canneries A and B.

				Waste concentration (mg/l)			
			No.[1] of samples	Daily	Daily	Observed	
Item	Cannery	Day	per day	mean	SD	Min.	Max.
TR	A	1	10	3,381	867	1,900	5,000
TR	A	2	30	1,986	645	956	3,146
TR	B	1	9	2,714	1,058	1,330	4,540
TR	B	2	25	3,921	1,114	1,690	5,560
TR	B	3	15	2,056	1,037	858	4,258
TR	B	4	30	3,790	4,024	38	10,066
TSS	A	1	10	1,680	383	1,062	2,067
TSS	A	2	30	959	339	395	1,595
TSS	B	1	10	1,936	566	1,062	2,585
TSS	B	2	9	1,924	979	995	2,590
TSS	B	3	20	2,906	1,375	1,595	6,174
TSS	B	4	28	2,404	807	1,225	3,235
FR	A	1	30	990	424	0	2,490
FR	B	4	22	1,522	615	150	3,380

[1]Results accepted when duplicate analyses were within the 95 percent confidence intervals established for these tests.

The analysis of numerous grab samples revealed rapid fluctuations in the waste loads (Fig. 3). The complexities of a salmon cannery, however, make it difficult to associate these fluctuations with any single event.

Statistical analysis of the data indicates a combined relative error due to sampling and analysis of approximately ± 8.7 percent for BOD_5, ± 6.3 percent for TSS, and ± 8.0 percent for O&G.

Table 2.—Daily composite samples—mechanized salmon processing canneries A and B.

				Waste concentration			
		No.[1] of samples				Observed	
Item	Unit	per day	Cannery	Mean	SD	Min.	Max.
BOD_5	mg/l	4	A	2,682	939	1,433	3,666
BOD_5	mg/l	12	B	2,490	901	1,347	3,970
TR	mg/l	4	A	3,198	760	2,090	3,760
TR	mg/l	14	B	3,607	1,036	2,720	5,660
TSS	mg/l	4	A	1,330	277	1,040	1,668
TSS	mg/l	13	B	1,575	719	460	2,735
FR	mg/l	4	A	1,868	587	1,050	2,429
FR	mg/l	13	B	2,020	752	867	3,348
O&G	mg/l	4	A	648	391	239	1,029
O&G	mg/l	10	B	687	475	246	1,653
TKN	mg/l	4	A	417	100	272	466
TKN	mg/l	10	B	388	152	280	641
COD	mg/l	4	A	4,462	1,247	2,928	5,782
COD	mg/l	10	B	5,348	2,268	3,434	9,900
$\frac{TSS}{TR}$	%	4	A	42.5	7.2	32.7	49.9
$\frac{TSS}{TR}$	%	13	B	43.6	15.4	16.4	67.9
$\frac{FR}{TR}$	%	4	A	57.5	7.2	50.1	67.3
$\frac{FR}{TR}$	%	13	B	56.4	15.4	32.1	83.6

[1]Results accepted when duplicate analyses were within the 95 percent confidence intervals established for these tests.

Waste Discharged for Each Unit of Production

Both canneries discharged less BOD_5, TSS, and O&G per unit of production on high-production days than on low-production days. Because the EPA effluent limitations (defined per unit of raw material processed) are the same for all levels of production, the untreated wastewater discharged by both canneries is below EPA recommended effluent limitations for BPTCA more frequently on high-production days than on low-production days (Fig. 4, 5).

The EPA limitations favored Cannery B (Table 3) which reported high-production days more frequently than Cannery A (Fig. 6). Cannery B, however, discharged more waste into the environment than Cannery A (Fig. 7).

Daily production levels are determined by the fishing intensity, weather conditions, and factors the canneries are unable to control. Quality would be lost if salmon were held to eliminate low-production days.

The relative errors for the determination of the amount of waste discharged for each limit of production were approximately ± 14.7 percent for BOD_5,

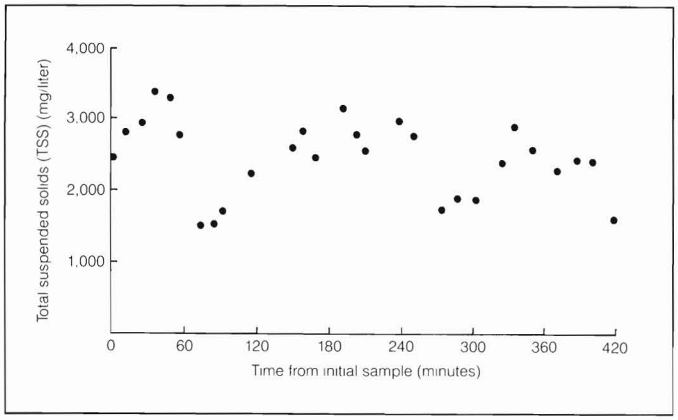

Figure 3. —Total suspended solids (TSS) concentration of intraday random samples from Cannery B, day 4.

Table 3.—Frequency of values less than EPA recommended effluent limitations for BPCTCA.

Item	Cannery	Daily max.	30-day avg.
BOD_5	EPA limit	N/A[1]	N/A
BOD_5	A	N/A	N/A
BOD_5	B	N/A	N/A
TSS[2]	EPA limit	44	26
TSS	A	76%	5%[3]
TSS	B	80%	40%
O&G[2]	EPA limit	29	11
O&G	A	95%[3]	76%
O&G	B	95%[3]	80%

[1] N/A = not applicable.
[2] Long-term estimates, in percent. EPA limits in pounds/1,000 pounds or kg/1,000 kg.
[3] Values of 5 percent and 95 percent represent the confidence interval justified by the data.

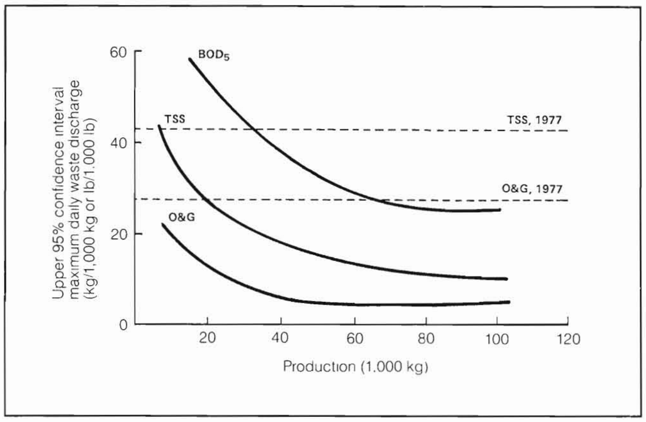

Figure 4. —Daily maximum waste discharge (upper 95 percent confidence interval vs. daily production and EPA guidelines for BPCTCA). Least squares regression curves fitting data for Canneries A and B.

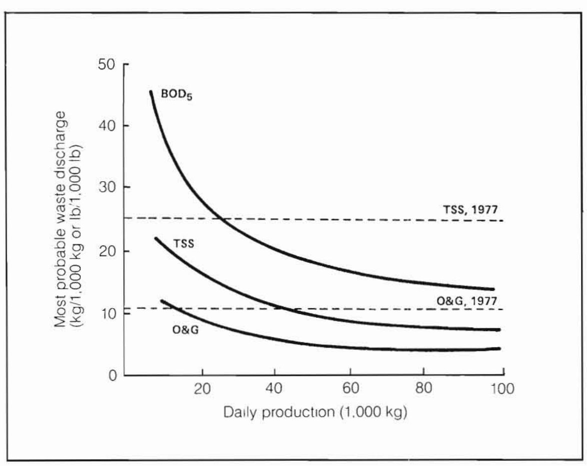

Figure 5. —Most probable waste discharge vs. daily production and EPA 30-day averages for BPCTCA. Least squares regression curve fitting data for Canneries A and B.

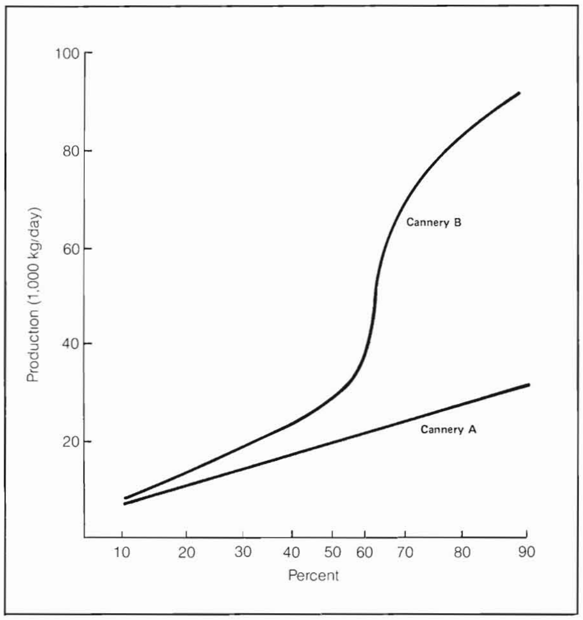

Figure 6.—The 1976 daily production at Canneries A and B. Frequency (percent) of values less than corresponding production.

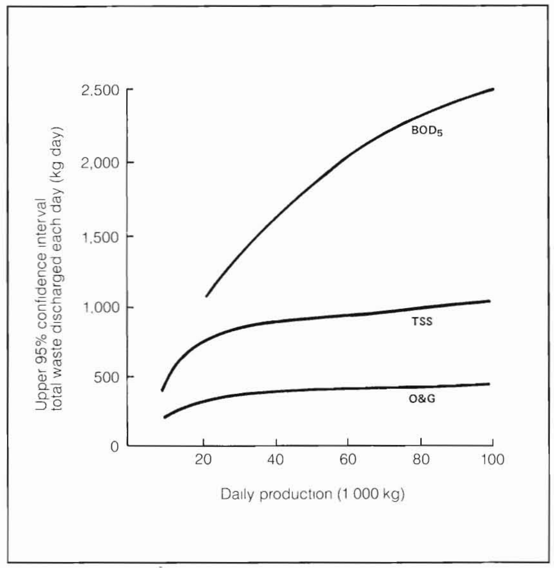

Figure 7.—Total waste discharged each day (upper 95 percent confidence interval) vs. daily production. Least squares regression curves fitting data for Canneries A and B.

±13.4 percent for TSS, and ±13.8 percent for O&G. At best, additional sampling would reduce but not eliminate sampling and analytical errors (Youden and Steiner, 1975).

Summary and Conclusions

Both canneries discharged less BOD_5, TSS, and O&G per unit of production as daily production increased. Values less than the EPA recommended effluent limitations became more frequent as production increased. The bias in favor of larger production is a strong case for basing guidelines on local environmental considerations rather than daily production values.

Variations in daily production, water use, and waste concentration values make it difficult to calculate precisely the amount of waste discharged for each unit of production. The relative errors for each of these measurements should be considered when enforcing guidelines.

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