

Comparison of Fish Impingement at the Palisades Nuclear Power Plant for Once-Through and Closed Cycle Cooling

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Abstract

Two studies of fish impingement were conducted at the Palisades Nuclear Power Plant. The first (May 16, 1972 to October 25, 1973) during once-through-cooling and a second (March 10, 1974 to March 29, 1975) during closed cycle cooling using mechanical draft cooling towers.

The Palisades facility, which has an ultimate electrical output up to 821 megawatts, began operations in early 1972. The cooling water intake is submerged 1006 meters offshore at a minimum depth of about 7.6 meters. The heated discharge enters the lake directly at the shoreline. The total flow rate was about 30686 liters/sec during once-through-cooling and 4644.5 liters/sec during closed cycle cooling.

From May 16, 1972 to October 25, 1973 daily records showed a total of 651,712 fish weighing 19842.2 kilograms were impinged on the traveling screens. Of these totals, alewife (*Alosa pseudoharengus*), slimy sculpin (*Cottus cognathus*), spottail shiner (*Notropis hudsonius*), and perch (*Percha flavescens*) made up 58.6, 27.5, 7.2, and 4.4 percent, respectively, of the total number. Coregonoids and salmonids, and smelt, *Osmerus mordax* made up 0.2 and 1.0 percent of the total respectively.

The fish appeared seasonally on the screens with none of the 37 recorded species being collected regularly. In addition, 4,768 crayfish, *Orconectes propinquis* were counted, mostly during late spring and early summer.

Results from the March 10, 1974 to March 29, 1975 study showed 2724 individuals weighing 25 kg were impinged during 111 screen counts which represented 31.3 percent of the total number of hours the screens were operated. Slimy sculpin and alewife made up 85.8 and 11.4 percent respectively of the total, with seven other species comprising the additional 2.8 percent. Extrapolation of the data (based upon weekly screen counts) showed that potentially 7488 fish weighing 68 kg could have been impinged. An additional 8096 crayfish were impinged and extrapolation show that potentially 10,218 could have been impinged.

The change from once-through-cooling to closed cycle cooling resulted in a significant decrease in the total number, weight, and number of fish species impinged at the Palisades Plant resulting in a reduction of biomass removed from the inshore area Lake Michigan near South Haven.

Introduction

This paper compares the results of fish impingement rates at the Palisades Nuclear Generating Plant. The data were collected for 75 weeks (May 16, 1972 to October 25, 1973) during once-through-cooling as part of a total environmental study (Consumers Power Co., 1975) and for 54 weeks (March 10, 1974 to March 29, 1975) during closed-cycle-cooling with mechanical draft cooling towers.

Description of the Plant and Study Area

The plant is located in Van Buren County on a 197 hectare site on the eastern shore of Lake Michigan in the southwestern part of Mich-

igan. The site is approximately 7 kilometers south of South Haven and 26 kilometers north of Benton Harbor and St. Joseph.

The Palisades facility, has rated capacity of about 700 megawatts electric (MWe) with an ultimate electrical output up to 821 MWe. The plant utilized a pressurized water nuclear reactor system and the steam was condensed by means of a once-through condenser cooling system using Lake Michigan water to dissipate the waste heat. The waste heat at rated capacity increased the cooling water temperature a maximum of 19°C above ambient at the intake. Cooling water is taken from Lake Michigan through an intake crib located 6.1 meters below the lake's surface, 1.8 meters from the lake bottom, and 1000 meters from the shoreline. The crib is a 17.4 meters wide, 17.4 meters long, 3.7 meters high box with a steel plate for its top and 0.05 meter vertical bars spaced 0.25 meters apart around the sides. Water flows horizontally between the vertical bars at a measured velocity of 0.21-0.29 m/sec and subsequently is diverted to a 3.4 meter intake pipe rated at 2.9 m/sec at full-flow conditions.

The heated discharge entered Lake Michigan directly at the shoreline. The total flow rate through the once-through cooling system was about 30686 liters/sec. This cooling system was used until completion of mechanical draft evaporative cooling towers in early 1974. These towers converted the circulating water system to essentially closed cycle cooling with a 98.5 liters/sec blowdown discharged at the shoreline to the lake. This blowdown, when diluted by 4546 liters/sec will be no more than 3°C above ambient lake temperature.

Methods

The plant intake water flows through 0.95 cm mesh traveling screens. During the 1972-73 study the screens were usually run twice per 24-hour period, except during heavy runs of fish when they were run continuously. All fish impinged were sluiced into a collection basket, identified, counted, and weighed on a daily basis. During the 1974-75 study, 111 screen counts were conducted during the 54 weeks. A screen count entailed running the screens until all impinged fish had been sluiced off into the basket. The time span between successive runs was documented to make the screen counts a representative as possible of variations in diurnal and nocturnal fish movement. These data were then extrapolated for each week of the survey period and a potential number of fish impinged was calculated based upon the percent of time covered between counts for each week.

Fish Impingement During Closed Cycle Cooling

Table 2 shows the actual and potential number and weight of the fish impinged from March 10, 1974 to March 29, 1975. Nine species totaling 2724 individuals, weighing 25 kg were collected in 111 screen counts covering a total of 2839 hours between screen runs at the plant. These counts covered 31.3 percent of the total time fish could have been impinged.

Slimy sculpin and alewife comprised 85.8 and 11.4 percent of the total respectively. The other 7 species combined made up the additional 2.8 percent with spottail shiners and smelt being the next most frequently collected. If we extrapolate the actual number of fish collected by the percent time covered per week (assuming the rate and numbers of fish impinged would be constant over the time intervals not covered) a potential 7,488 fish could have been impinged.

The actual weight of the fish impinged was 25 kg. If this weight is extrapolated it would show 68 kg of fish could have potentially been impinged for the 54 weeks.

In addition to the fish being impinged, a single species of crayfish, *Orconectes propinquis* was also impinged during the summer months (June to September). During the May 16, 1972 to October 25, 1973 study 4768 crayfish were impinged, as compared to an actual number of 8096 and a potential number of 10,218 impinged during the latter study. Scuba diving observations near the intake showed this species inhabited the area surrounding the intake crib, indicating the intake crib and associated rip-rap act as a habitat for the crayfish during March through October. The majority of these crayfish were sluiced off alive and in good condition.

Fish Impingement During Once-Through Cooling

Table 1 shows the total number, weight and period of greatest impingement from May 16, 1972 to October 25, 1973. A total of 651,712 fish weighing 19842.2 kilograms were impinged on the screens. Of this total, four species of fish, alewife, slimy sculpin, spottail shiner, and perch made up 58.6, 27.5, 7.2, and 4.2 percent respectively of the total number of fish, and 62.8, 5.8, 4.3, and 18.1 percent respectively of the total weight of fish. Longnose sucker, burbot, and white sucker made up 3.7, 1.7, and 1.4 percent respectively of the total weight of fish although combined they made up less than .003 percent of the total number of fish. The most numerous groups of fish appeared in the vicinity of the plant intake on a seasonal basis.

Except for perch, the number of game fish impinged was small in comparison to nongame fish in the collections. The salmonids (steelhead, coho, chinook, lake trout, and brown trout) totaled 139 individuals weighing 72.6 kilograms while coregonids (cisco, lake whitefish, round whitefish and bloaters) totaled 551 individuals, weighing 55.8 kilograms. The majority of coregonids were impinged on just a few days and these usually followed an upwelling in the lake. The only other game fish were smelt, totaling 7565 individuals, weighing 193.7 kilograms and northern pike totaling 18 individuals, weighing 6.8 kilograms.

The condition of the impinged fish varied from excellent to battered, dead or decomposed. The majority (over 50 percent) of the fish showed signs of physical damage including descaling, hemorrhaging, cuts, and gouges. It is doubtful that many of the fish in this condition could have survived if put back into the lake, considering the possibility of increased infection and predation pressures.

TABLE 1. Total number of fish collected daily from traveling screens at the Palisades Nuclear Power Plant from May 16, 1972 to October 25, 1973.

Species	Total Number	Total Number %	Total Weight (Kilograms)	Total Weight %	Greatest Impingement	Period of Greatest Impingement
Alewife— —adult	339,807 42,565	52.1 6.5	12,464.0	62.8	October, 1972; October, 1973 April, 1973	October, 1972; October, 1973 April, 1973
Slimy Sculpin	178,376	27.5	1,146.0	5.8	March-April-May	March-April-May
Spottail Shiner	46,897	7.2	854.9	4.3	October-April, 1973; * Dec. (esp.)	October-April, 1973; * Dec. (esp.)
Perch— —adult	27,330 1,084	4.2 *	3,589.6	18.1	October-December, esp. Dec., 1972	October-December, esp. Dec., 1972
Smelt— —adult	6,691 874	* *	193.7	1	April-May, 1973	April-May, 1973
Trout— —perch	3,485 1,294	* *	62.6	*	June-August, 1973	June-August, 1973
Longnose Sucker	519	*	732.4	3.7	April-June, 1973; May, 1972	April-June, 1973; May, 1972
Bloater	493	*	46.3	*	June, 1973	June, 1973
Burbot	409	*	344.7	1.7	May-August, 1972 and 1973	May-August, 1972 and 1973
Nine-spine Stickleback	395	*	2.3	*	December-March, 1973	December-March, 1973
White Sucker	167	*	283.4	1.4	April-June, 1972, 1973	April-June, 1972, 1973
Channel Catfish	81	*	20.0	*	December-January, 1973	December-January, 1973
Lake Trout	76	*	41.3	*	January-March, 1973	January-March, 1973
Black Bullhead	28	*	3.2	*	April-June, 1972	April-June, 1972
Chinook Salmon	28	*	12.2	*	June-July, 1973 (young)	June-July, 1973 (young)
Lake Whitefish	28	*	7.7	*	August, 1973	August, 1973

Results and Discussion

The change from a once-through-cooling system to an essentially closed-cycle cooling system has significantly reduced the total number, weight and numbers of fish species impinged on the traveling screens at the Palisades Nuclear Power Plant. Based upon the potential number of fish impinged the reduction has been over 95 percent.

In both studies the largest number of fish by species were alewife and slimy sculpin, neither of which is considered economically important to the sport or commercial fishing industry. Both are considered forage fish, especially to the salmon and lake trout which supply the majority of the sport fishing in this area of the lake.

Without knowing the magnitude of the lake-wide populations it is difficult to say if this reduction in biomass is significant to the lake, but as indicated by the data closed-cycle cooling impinges fewer fish than once-through cooling.

TABLE 2. *Actual and potential number of fish impinged on the traveling screens at the Palisades Nuclear Power Plant from March 10, 1974 to March 29, 1975.*

Species	Actual Total Number	% Total Number	Potential Total Number	Actual Total Weight (kg)	% Total Weight	Potential Total Weight (kg)
Slimy Sculpin	2342	85.8	6510	11.6	46.6	31.4
Alewife: young	2	*	6			
adult	312	11.4	787	12.3	49.3	33.4
Spottail shiner	17	*	49	0.34	*	1.0
Smelt: young	9	*	27			
adult	6	*	17	0.23	*	0.7
Perch: young	9	*	26			
adult	4	*	12	0.23	*	0.7
Ninespine stickleback	9	*	24			
Trout perch	7	*	18	0.11	*	0.3
Gizzard shad	5	*	13	0.11	*	0.3
Channel catfish	2	*	5	0.06	*	0.2
Totals	2724		7488	25	*	68.0

* Indicates less than one percent of total.

Literature Cited

CONSUMERS POWER COMPANY. 1975. Summary of the Effects of Once-Through Cooling at the Palisades Nuclear Power Plant. Consumers Power Company, Jackson, Michigan.