
Economic Impact of Zebra Mussels - Results of the 1995 National Zebra Mussel Information Clearinghouse Study

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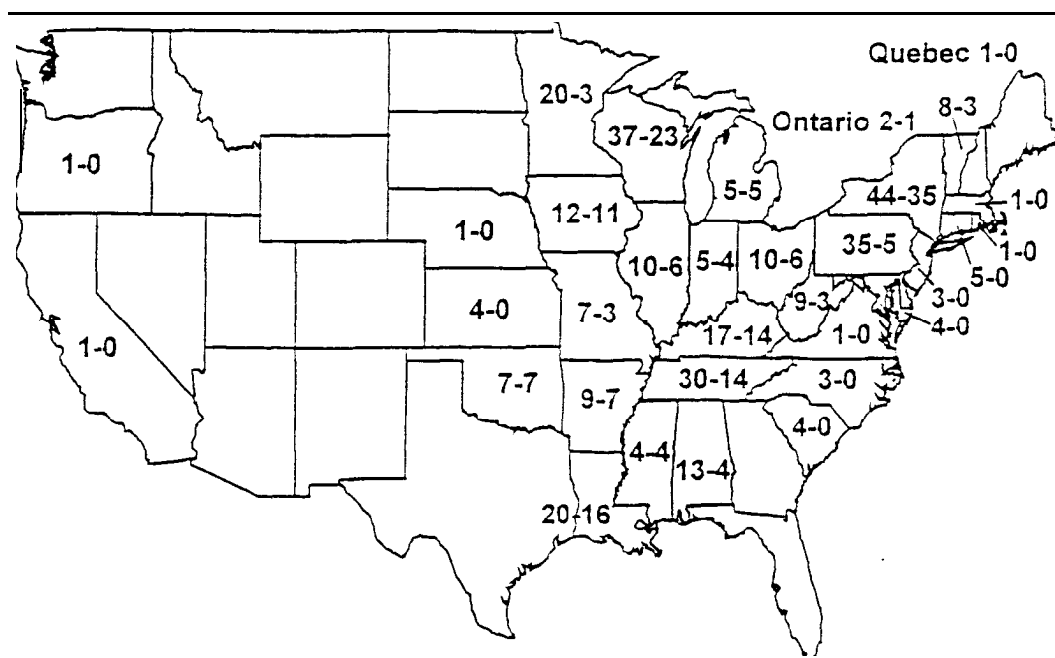
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INTRODUCTION

Raw water-dependent infrastructure, including electric power generation stations, drinking water treatment plants, industrial facilities, navigation lock and dam structures, and other facilities throughout much of the eastern half of North America, have been significantly impacted by zebra mussels. While the mussel's physical impacts upon infrastructure are well

known, their economic impacts are less understood. This study, undertaken by New York Sea Grant and the National Zebra Mussel Information Clearinghouse, addressed the economic impact of the zebra mussel throughout its North American range, as well as regions proximate to that range but not yet known to be infested.

A detailed survey was mailed to a random sample totaling 766 infrastructure owners/operators throughout a 35 state /3 province range. From this mailing, 436



First number represents facilities reporting zebra mussel-related economic impacts, second number represents number of zebra mussel infested facilities in that state.

Category	Number Responding	Number With Expenditures	Number Infested	Expenditures (Total)	Expenditures (Infested)	% Total
Non-Navigation Canal	1	0	0	\$0	\$0	0.000%
Aquarium Theme Parks	1	0	0	\$0	\$0	0.000%
Sewage Treatment Plants	1	0	0	\$0	\$0	0.000%
Golf Courses	2	1	0	\$750	\$0	0.001%
Marinas	2	2	2	\$7,500	\$7,500	0.011%
Recreation Facilities	1	1	0	\$20,000	\$20,000	0.029%
Institutions	2	2	1	\$20,000	\$25,000	0.039%
Impoundments/Reservoirs	9	9	0	\$27,100	\$0	0.039%
Hatcheries/Aquaculture	3	3	2	\$88,000	\$73,000	0.127%
Navigation Locks	58	56	28	\$484,800	\$411,700	0.702%
Shippin/Navigation	1	1	1	\$563,000	\$563,000	0.815%
Scenic Riverways	1	1	0	\$723,00	\$0	1.047%
Agencies	5	5	0	\$4,574,000	\$4,574,000	6.622%
Industries	56	35	22	\$5,846,000	\$3,747,500	8.464%
Water Treatment	160	100	38	\$21,435,610	\$6,516,910	31.034%
Electric Power Generation	133	123	80	\$35,274,020	\$30,064,100	51.070%
	436	339	174	\$69,070,780	\$46,031,710	100.000%

Table 1. Total reported expenditures on zebra mussel-related activities. 1989-1995, including number of facilities responding, number of facilities with expenditures, number of facilities infested at the time of the study, total expenditures, expenditures at infested facilities, and percent of total economic impact by water use category.

usable responses were received, a 56.92% return rate. Three hundred thirty nine facilities reported expending funds related to zebra mussel impacts (see Map). Information solicited included; facility type and location; source water body; degree of facility water use; types of zebra mussel-related impacts; zebra mussel monitoring and control activities; and, 13 categories of zebra mussel-related annual costs from 1989 through 1995.

Three hundred thirty nine facilities reported total zebra mussel-related expenses of \$69,070,780, with a minimum reported expenditure of \$400, a maximum expenditure of \$5,953,000, and a mean expenditure of \$205,570 per facility (see Table and Figure 1). The big spender was nuclear power plants with a mean expenditure of \$786,670 per facility, accounting for 26.2% of the total reported zebra mussel impact. Other major water user categories included; drinking water treatment facilities, with a mean expenditure of

\$214,360 (31.03% of total reported impact); fossil fuel electric generating facilities, with a mean expenditure of \$145,620 per facility (16.02% of the total reported impact); and, industrial facilities, with a mean expenditure of \$167,030 per facility (8.46% of the total reported impact). Total annual expenditures increased from 1989 (\$234,140) to 1995 (17,751,000) as the mussel's North American range and the number of facilities affected increased (Figure 2).

RESULTS

No zebra mussel-related expenses were reported for non-navigation water transport canals, aquarium theme parks, or sewage treatment facilities. Two noninfested golf courses reported total monitoring expenses of \$750 from 1993 through 1995. Two infested marinas, one on Lake Champlain and one on

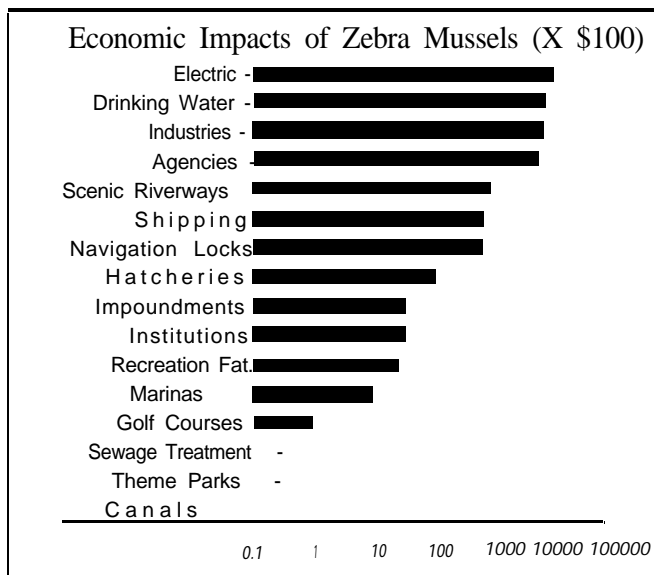


Figure 1. Summary of total zebra mussel economic impacts by water use category. Note logarithmic scale.

the Niagara River, reported total zebra mussel-related expenses of \$7,500. One public recreation area on an infested public impoundment reported \$20,000 of zebra mussel-related expenditures, mostly for monitoring and planning. Two institutions, a university campus on Lake Michigan and a residential care facility on Lake Champlain, reported total zebra mussel-related expenses of \$27,000; \$2,000 for monitoring and \$25,000 for prevention. Nine noninfested public impoundments in three states reported total zebra mussel-related monitoring expenses of \$27,100. Three fish hatcheries in three states reported zebra mussel-related expenses of \$88,000 from 1993 through 1995, of which \$73,000 was spent at two infested facilities. The uninfested facility uses ponds as its water source, one infested facility uses the Mississippi River, the other infested facility uses Lake Champlain. There was \$67,000 spent on preventive measures, \$15,000 on research, \$5,000 on planning and engineering, and

\$1,000 on monitoring.

Responses were received from 58 public navigation lock facilities (28 of which are infested) in 10 states. The facilities are on the Allegheny, Arkansas, Cumberland, Mississippi, Monongahela, Ohio, and Verdigris Rivers and their tributaries. Fifty-six of the facilities reported total cumulative zebra mussel-related expenses of \$484,800 from 1991 through 1995, \$441,700 (91.11%) at infested facilities, \$43,100 at uninfested facilities. Navigation locks represent 13.9% of facilities responding to the survey, 15.7% of infested facilities, and 16.5% of facilities reporting zebra mussel-related expenses, yet locks accounted for only 0.7% of the total reported seven year zebra mussel economic impact. For this reason, any aggregate figure for all water user categories, including navigation locks, which shows an average per facility zebra mussel-related expense will be skewed toward the low end of the scale.

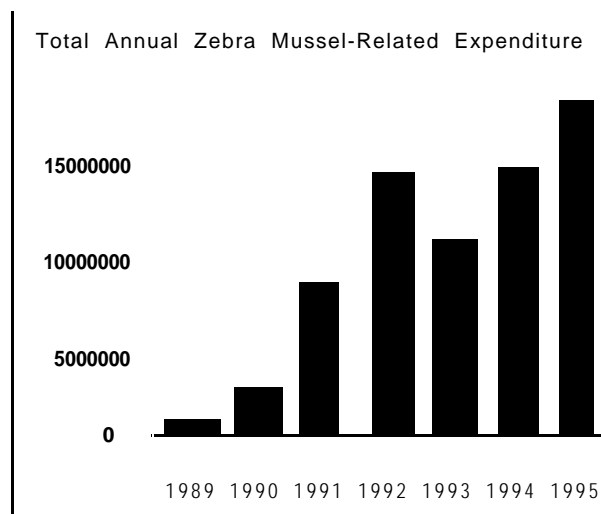


Figure 2. Total annual zebra mussel-related expenditures for all water user categories.

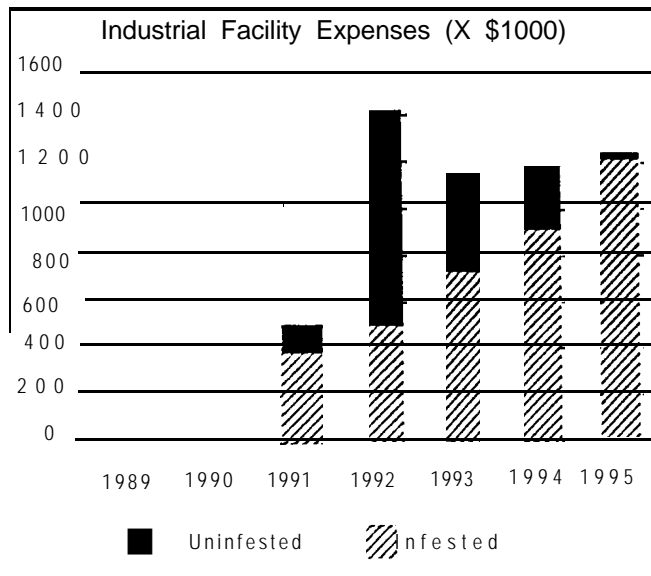


Figure 3. Industrial facility expenses at infested and uninfested facilities (in \$1000s)

Fifty-six locks spent an average of \$3,416 each on monitoring, ranging from \$400 to \$31,000, accounting for \$191,300 (39.5%) of reported navigation lock expenses. The second largest expense category was facility retrofit, with two locks spending \$100,000. One facility spent \$75,000 on mechanical controls; two locks spent \$36,000 on staff training; and three locks spent \$34,000 on planning and engineering expenses. Several facilities were expected to close for several days in late 1995 for mechanical removal of mussels - \$32,000 revenue was expected to be lost during these closures. Other expenses included nonchemical controls, research, and prevention.

One response was received from a shipping related entity with numerous vessels on the Arkansas, Hudson, Illinois, Mississippi, Ohio, Tennessee, and Missouri

Rivers and the Great Lakes. Vessels were reported to have been infested since 1990; \$563,000 worth of zebra mussel-related expenses were incurred in all categories. The single largest category of expense, \$220,000 (39.08%), was for vessel retrofit, followed by \$99,000 (17.58%) for nonchemical treatments and \$92,000 (16.34%) for lost production/use. Other expense categories included; mechanical treatment, planning and engineering, training, research, prevention, monitoring, chemical controls, and tiltration. It was reported that all new vessels are being constructed with zebra mussel-proofing measures "built in."

A National Scenic Riverway reported that it was not yet infested but was proactive in its response to zebra mussels, implementing a monitoring and user education programs, signage, boat inspections, and boat

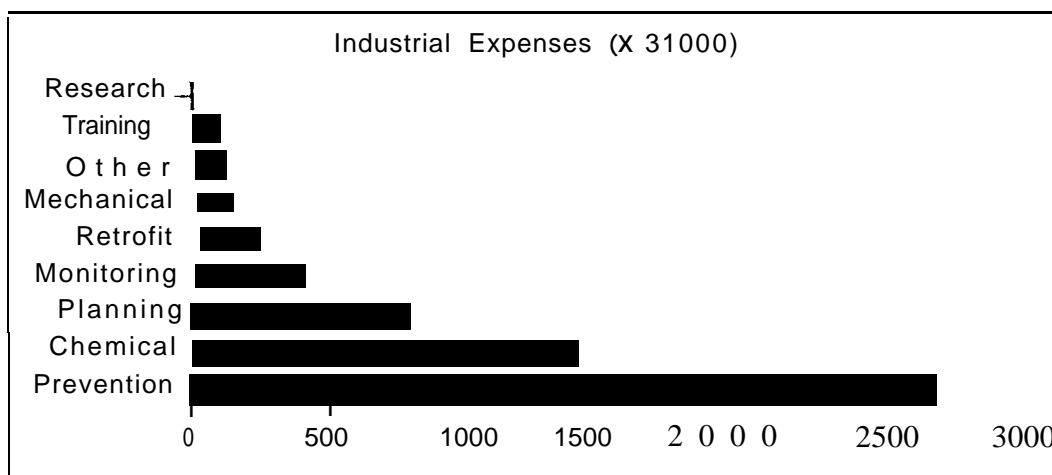


Figure 4. Industrial expenses by category (in \$1000s).

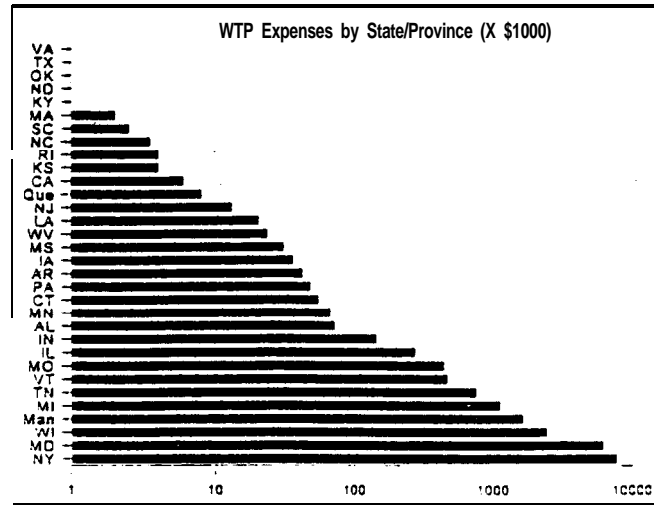


Figure 5. Water treatment plant expenditures (by state/province, in \$1000s), 1989-1995 inclusive. (Note: logarithmic scale)

cleaning stations at access points. The facility spent \$723,000 on monitoring, planning, prevention, research, and training activities from 1992 through 1995.

Five government agencies (two federal, three state) verbally reported incurring \$4,574,000 of zebra mussel-related expenses from 1991 through 1995, 6.62% of the total reported economic impact. In all cases, the money was spent on mussel control research.

Fifty-six industries in 13 states and one province responded, 22 (39.29%) of which reported that they are infested. No industrial expenses were reported for 1989. Thirty-five (62.5%) of the industries reported a cumulative total zebra mussel-related expense of \$5,846,000 from 1990 through 1995; \$3,747,500 (64.1%) at infested facilities, \$2,098,500 at uninfested facilities (Figure 3). Industrial expenses represented

8.46% of total reported zebra mussel economic impacts.

The largest number of responses from a single geographic region came from 18 facilities on the Mississippi River with a total expense of \$753,000 (12.88% of industrial expenditures); seven facilities drawing their water from the Great Lakes reported \$2,815,000 of expenditures (48.15%). This disparity in impact can be attributed to the Great Lakes facilities becoming infested much earlier than those on the Mississippi. Expenses generally increased from 1991, with the exception of 1992 which, at \$1,423,500, was the second highest annual expenditure, 1992 was also the only year in which expenditures at uninfested facilities (\$924,000) exceeded those at infested facilities (\$499,500).

Eight industries (five of which are infested) spent

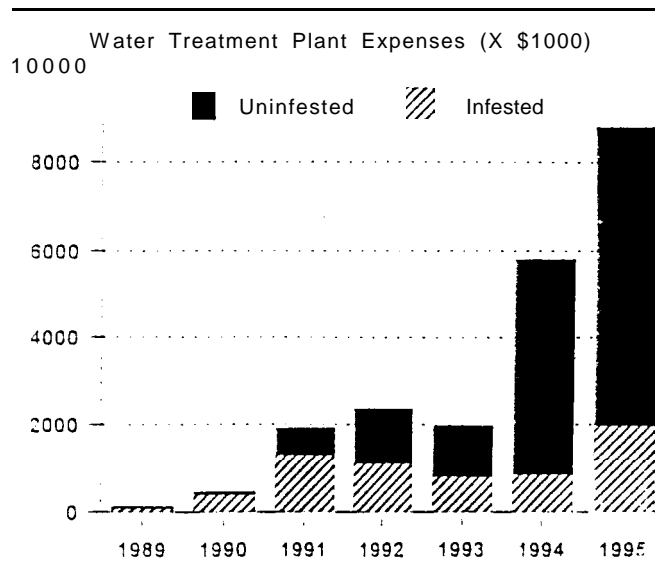


Figure 6. Water treatment plant expenses at infested and uninfested facility (in \$1000s) by year.

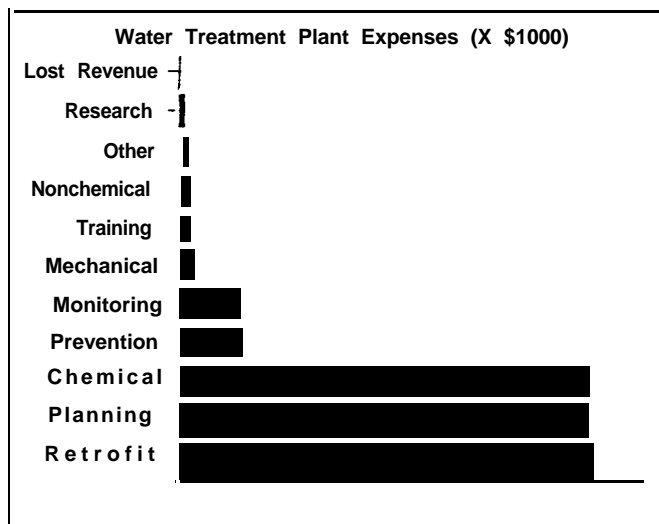


Figure 7. Water treatment plant expenses by category (in \$1000s).

a total of \$2,657,000 (a mean expenditure of \$332,125 per facility) on preventive measures, accounting for 45.45% of the total reported industrial expenses, the largest single expense category (Figure 4). These expenditures, however, were very unevenly distributed, ranging from \$4,000 to \$1,500,000 at facilities with water use capacities ranging from 4 million gallons per day (mgd) to 300 mgd (mean capacity = 60.3 mgd): Excluding two facilities that plot as outliers, the mean industrial prevention expense at facilities with water use capacities between 4,000 and 50,000 mgd was \$92,833.

The second largest expense category was chemical control measures. Seventeen industries with water use capacities ranging from 4 to 300 mgd (mean capacity = 51.5 mgd) spent a total of \$1,358,000 (mean expenditure of 579,882 per facility), 23.2% of the total industrial expenditure. Twenty one industries with

water use capacities ranging from 3 to 94 mgd spent a total of \$781,000 (-mean expenditure of \$37,190 per facility) on planning related expenditures. Twenty eight facilities spent a total of \$401,500 (mean = \$14,393) on monitoring activities. Five facilities spent a total of \$241,000 (mean = \$48,200) on retrofit of existing plant. Eight facilities spent an average of \$20,250 for a total of \$162,000 on mechanical control alternatives. Two facilities spent a total of \$128,000 on other (thermal and coatings) control technologies. Sixteen facilities spent a total of \$102,500 (mean = \$6,406) on staff training, and two facilities spent a total of \$15,000 on research activities. No funds were spent on lost production, filtration, or nonchemical, nonmechanical control techniques.

Responses were received from 160 drinking water treatment plants (WTPs) in 30 states and two provinces.

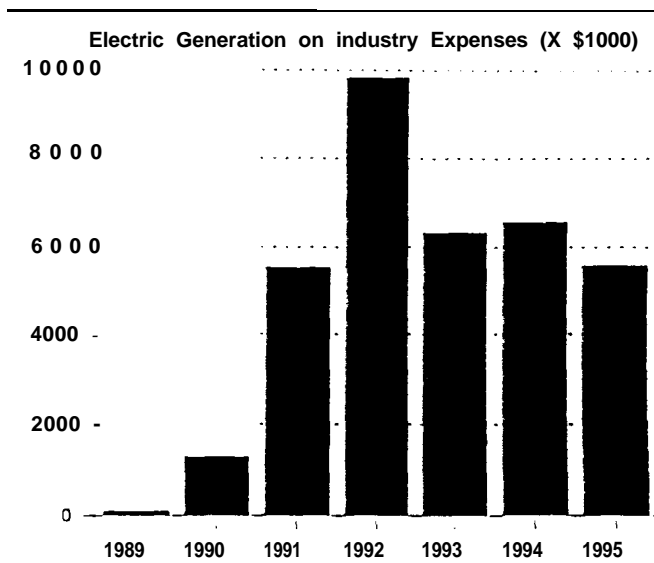


Figure 8. Electric generation industry expenditures (in \$1000s) by year.

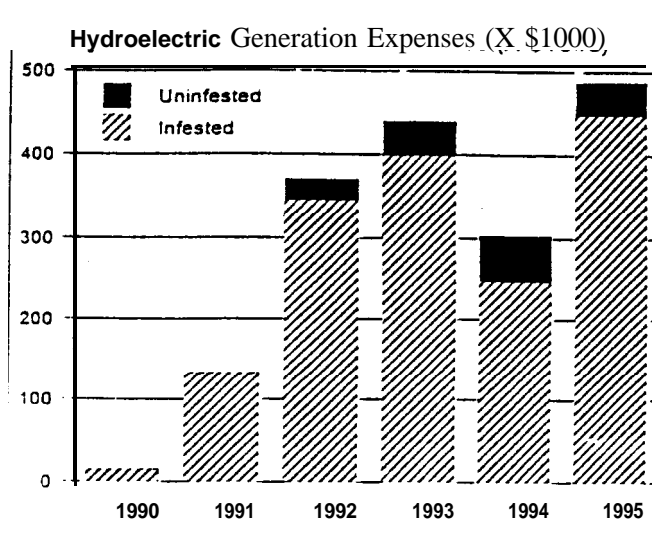


Figure 9. generation expenses (in \$10000s) at infested and uninfested facilities. by year.

There were 100 facilities with a combined water usage of 5,677,440 mgd (62.5% of all WTPs responding to the survey) that reported they had spent a combined total of \$21,445,610 on zebra mussel related activities. 31.05% of the total reported zebra mussel economic impact. The state with the greatest number of water treatment plants responding was Alabama with 27 responses, one of which was infested. New York had the second largest response, 21, of which 15 are infested. The states/provinces which spent the greatest amount of money on zebra mussel related activities at WTPs were: New York (\$7.63 million, 35.6% of all WTPs), Maryland (\$6.11 million, 28.5%), and Wisconsin (\$2.43 million, 11.3%) (Figure 5). Water treatment plant expenses began in 1989 in the Great Lakes region, with seven facilities reporting a total

expenditure of \$106,140 compared to three non-Great Lakes facilities spending a total of only \$16,000. Both the number of impacted plants and total expenditures increased on a yearly basis with the Great Lakes outpacing other regions of the country until 1994, when 49 non-Great Lakes facilities spent a combined total of \$3,483,300 compared to 31 Great Lakes facilities spending \$2,331,800. Over the entire period, Great Lakes facilities spent a total of 511,717,900 (54.64% of WTP expenditures), while non-Great Lakes facilities spent \$9,727,700.

From 1989 through 1991 the majority of WTP expenditures were spent responsively by infested facilities. This changed in 1992 when proactive expenditures at noninfested facilities began to exceed those at infested plants. This trend was very evident

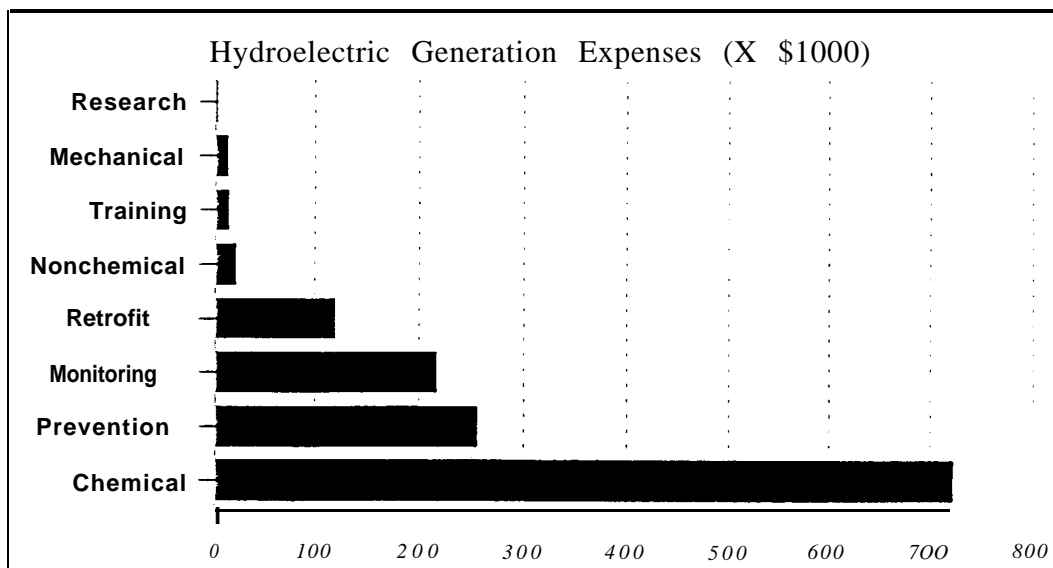


Figure 10. Hydropower facility expenses by category (in \$1000s).

representing 23,700 megawatts (33.17% of all fossil fuel costs, 10.41% of all reported power plant expenses), with 26 facilities utilizing oxidizing chemicals, 10 using molluscicides, and 10 using both oxidizing chemicals and molluscicides (Figure 12). The mean per plant chemical control expense was \$101,960. The second greatest expense, \$3,329,000 (30.08% of all fossil fuel costs, 9.44% of all power plant costs) was for retrofit projects at 20 facilities representing 10,323 megawatts (for chemical injection systems, cathodic protection systems, and waste heat recirculation replumbings), with a mean expenditure of \$165,450. This was followed by \$1,054,100 for monitoring expenses at 70 facilities (48539 megawatts, a mean expenditure of \$15,060, 9.52% of fossil fuel expenses, 3.0% of all power plant expenses). Other major expense categories were planning and engineering, research, and lost production (\$475,000 at six facilities).

Responses were received from 23 nuclear power plants in 15 states and one province (representing a total generating capacity of 28.896 megawatts). Of these, 12 (15,877 megawatts) reported that they are infested by zebra mussels. All of the nuclear facilities reported spending money on zebra mussel related activities. Sixteen responses were from facilities located in the Great Lakes. Nuclear power plant expenditures totaled \$18,093,400, 51.29% of the total electric generation industry impact (26.2% of the total reported zebra mussel economic impact), making this the largest water user category impact in the study. Of this, \$17,607,900 (97.32% of nuclear expenses, 49.92% of the total electric industry cost) was spent at facilities that are infested by mussels, with the remaining \$485,500 spent at uninfested facilities (Figure 13). The mean per facility expenditure was \$786,670.

The largest nuclear plant expense was \$5,303,000 for facility retrofit at six plants with a total generating capacity of 6,209 megawatts (29.31% of all nuclear costs, 15.03% of all power plant expenses, 7.68% of all reported zebra mussel expenses). In each case, the retrofit was installation of source-end-of-pipe oxidizing chemical injection systems at an average of \$883,800 per plant (Figure 14). The next largest category was \$5,211,500 at 13 facilities (16,827 megawatts) for chemical control activities, an average of \$400,900 per plant (28.8% of all nuclear expenses, 14.77% of all power plant costs, 7.55% of total reported expenditures). Five of the facilities reported using oxidizing chemicals, one uses molluscicides, and seven use both oxidizing chemicals and molluscicides. In addition, several other facilities also reported using chemical controls but did not quantify those expenses: two reported using oxidizing chemicals, one molluscicides, and three use both oxidizing chemicals and molluscicides. The third major expense category, \$3,422,000 (18.86% of all nuclear plant costs, 9.67% of all power plant costs, 4.94% of all reported costs) was for prevention projects at three plants, in all cases chemical injection systems, at an average of \$1,137,300 per plant. It should be noted here that these facilities considered the chemical control systems to be a prevention expense, and did not include it in their retrofit costs; it could be argued that these expenses were, in fact, a retrofit expense, which would increase retrofit to 48.17% of all nuclear facility expenditures (12.62% of all reported zebra mussel expenditures). Other major expenditures included: \$1,580,000 at 10 facilities for planning and engineering expenses; \$1,371,000 at five facilities for mechanical control activities; and, \$968,900 for monitoring activities at 21 facilities.

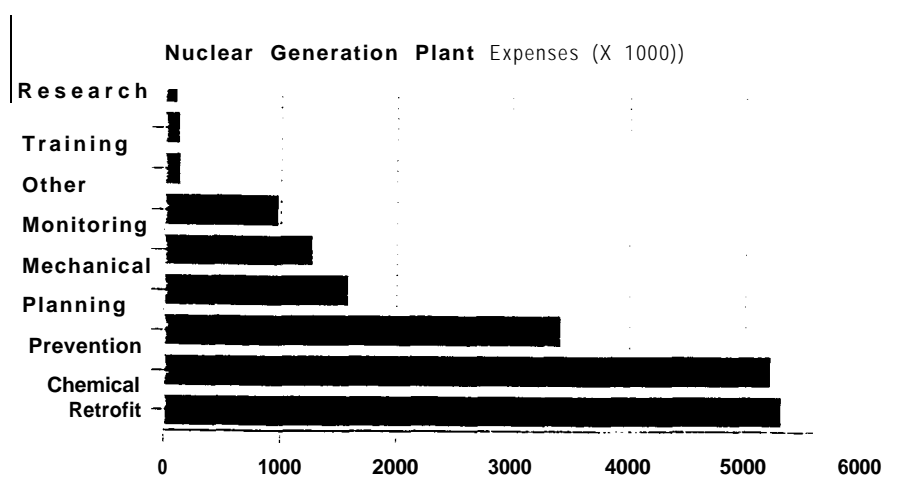


Figure 14. Nuclear generating station expenses (in \$1000s) by category.