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131

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER, NO. 131
"THE SIGNIFICANCE OF IMPINGEMENT AND ENTRAINMENT IMPACTS ON HUDSON RIVER WHITE PERCH"

Introduction

In response to user need letter NRR-78-2, the Office of Nuclear Regulatory Research funded a project to evaluate the significance of impingement and entrainment impacts on Hudson River white perch from the operation of Indian Point Nuclear Generating Station Units 2 and 3 and other power plants on the Hudson River. These impacts were observed at both nuclear and non-nuclear power plants and are primarily influenced by the volume of water used and the site characteristics. This three year project, begun in 1978, was conducted by Drs. Webb Van Winkle and Lawrence W. Barnthouse of Oak Ridge National Laboratory and is now completed. The results demonstrate the difficult task of assessing and predicting long-term fishery population impacts given an observed level of power plant induced fish mortality and suggest the importance of site characteristics in influencing the level of observed impact. The developed techniques will aid in evaluating potentially adverse short-term impacts on fishery resources during future license reviews, but the state-of-the-art is such that definitive statements about the long-term impact on fishery resources from nuclear power plants cannot be made. However, the researchers of this work believe, based on their professional experience, that the observed impacts are sufficiently large to warrant mitigative actions aimed at reducing the level of power plant imposed mortality to protect the long-term productivity of the Hudson River white perch fishery resource. This conclusion is directly opposite to that reached by the utility and their consultant on this issue.

Although the U.S. Environmental Protection Agency assumed the responsibility of determining the need for mitigative measures to reduce fishery impacts at the Indian Point Nuclear Generating Station, this case identified the NRC staff's lack of ability to make and defend accurate assessments of these types of impacts during licensing reviews as required by the National Environmental Policy Act of 1969 (NEPA). The purpose of this work was to provide techniques and information of generic applicability to future licensing reviews for use in increasing the accuracy, confidence, and efficiency with which fishery resource impact issues are handled in environmental reviews of nuclear power plant license applications.

This project included a series of analyses of the magnitude and biological significance of the impingement and entrainment of white perch at the Indian Point Nuclear Generating Station and other Hudson River power plants. Included in these analyses were evaluations of the following:

1. Two independent lines of evidence relating to the magnitude of impingement impacts on the Hudson River white perch population.

2. The additional impact caused by entrainment of white perch.

3. Data relating to density-dependent growth among young-of-the-year white perch.

4. The feasibility of performing population-level analyses of impingement impacts on white perch populations of the Chesapeake Bay and the Delaware River.

5. The feasibility of using simple food chain and food web models to evaluate community-level effects of impingement and entrainment.

<u>Results</u>

A summary of the results developed during this project are contained in Reference 1. The principal findings are described below according to the project tasks.

1a. Analysis of Impingement Rates

Regression analyses were used to examine the trend of white perch impingement levels as an index of year-class strength for all Hudson River power stations over the 1972-1977 time period. These analyses could not identify any significant trends in the year-class strengths, but because of the limited data availability (5-6 years) these analyses were not very powerful. As described further in Reference 2, an analysis of the minimum detectable differences in the annual impingement rates and the number of years required to detect a specific reduction in the index indicated that for the Hudson River data a very long time series of data is required to detect even large (50%) reductions in population sizes. The baseline data variability is so great in this case that more than 50 years of data would be required to detect an actual 50% reduction in mean year-class strength given a statistical power of only 50%. Analyses were also conducted on the impingement rate and beach seine data to examine the correlation between these two year-class strength indices. The correlations were not statistically significant, indicating that at least one index is not a good year-class strength index, but the data were not available to determine which index was more accurate.

1b. The Impact of Impingement on the 1974 and 1975 White Perch Year Classes

The analytical technique described in Reference 3 based on conditional mortality rates was used to assess the impingement impact on the white perch population. A more complete description of these analyses is found in Reference 2. These analyses indicate that the impingement at all the Hudson River plants resulted in a probable 20% reduction in the size of the 1974 year-class and a probable 15% reduction in abundance of the 1975 year-class. The impingement observed at Indian Point Units 2 and 3 was greater than all the other Hudson River plants combined and accounted for most of the total. The majority of the impacts occurred during the winter and spring at Indian Point which is due primarily to the fall migration of white perch to the lower and middle estuary where Bowline, Lovett, and Indian Point are located and where these fish remain during the winter. The increased impingement at Indian Point is also related to the presence of high concentrations of white perch in the vicinity of the salt front, which fluctuates above and below the plant during the winter. The mobility of the fish is decreased during the winters and leads to increased vulnerability of yearling and older specimens resulting in substantially greater population impacts.

2. The Impact of Entrainment on the 1974 and 1975 White Perch Year-Classes

The methodology used to evaluate the entrainment impacts on the Hudson River white perch can be found in Reference 4. This analysis indicates that fractional reductions in abundance were between 10.9 and 11.7 percent for the 1974 year-class and between 13.0 and 13.6 for the 1975 year-class, above that calculated due to impingement. These figures are for all the Hudson River plants and the separate impact of the Indian Point Station was not determined.

3. Evaluation of Data Relating to the Existence of Density-Dependent Growth in the Hudson River White Perch Population

Long-term projections of population abundances were impossible to make because the operation of compensatory mechanisms may, in principal, offset much of the mortality caused by impingement and entrainmemt. Reference 5 contains a detailed evaluation of an analysis performed by a utility consultant demonstrating the existence of density-dependent growth (one type of compensatory mechanism) in Hudson River white perch. The evaluation by ORNL concludes that the available data are not sufficient to demonstrate the occurrence or absence of density-dependent growth in this population. The correlations between growth and abundance identified by the consultant may have been spurious due to biased data, but even if they are real correlations they are not proof that growth is functionally related to density, according to the investigators.

Also, the data necessary to quantify the magnitude of any compensation is not presently available and may not be developed soon because of the complexity of the issue. However, the utility industry through EPRI is developing a research program to begin to address this issue.

4. Data and Information from other Water Bodies

Attempts to assess the impacts on Chesapeake Bay and Delaware River white perch due to Calvert Cliffs, Surry, and Salem Nuclear Power Stations were unsuccessful. The impingement levels at Calvert Cliffs were too low to make an analysis worthwhile and the time series of impingement data from both Surry and Salem were too short to provide meaningful results. A five year data set is recommended as a minimum for useful analysis. Also, there were no good indices of white perch year-class strength in the areas of interest.

5. Multipopulation Modeling

Loop-analysis techniques were used to investigate the multipopulation level impacts of white perch power plant related mortality. This analysis is described in Reference 6. The results were generally similar to the ecosystem responses that would be expected based on an intuitive understanding of the Hudson River aquatic ecosystem. This technique is best suited for deriving hypotheses and interpreting experimental results. It may be useful for determining critical ecosystem relationships that should be the focus of preoperational monitoring at power plant sites.

These results have been used by the NRC and the EPA for developing testimony in the Indian Point hearings, and formed a partial basis for determining the mitigative requirements placed on the licensee by the EPA.

Evaluation

This work represents one of the most comprehensive analyses of impacts on a fishery resource due to a nuclear power plant. The results have been reviewed by other federal agencies, used during ajudicatory hearings, and parts have received peer review during presentations at professional meetings and publication in refereed journals.

These results demonstrate the difficult task of assessing and predicting the significance of impacts on fishery resources from nuclear power plant operations. This difficulty is generally the result of the following: 1) large natural variability in annual fish abundance data, 2) the lack of reliable and accurate year-class strength indices, and 3) a lack of understanding of the quality and quantity of compensatory mechanisms that may act to offset observed losses. These factors will make it impossible to definitively predict the long-term impacts on fishery resources from similarly sited and designed facilities, but impacts of the magnitude observed at Indian Point can be expected to cause considerable controversy during future licensing reviews due to the uncertainty of these long-term predictions. These results and analytical techniques will be useful during future environmental reviews for identifying potentially adverse impacts on fishery resources that may be expected at similar sites and from similar designs. This will aid in better characterizing the magnitude and cost of these adverse impacts for factoring into the NEPA cost-benefit analysis of alternative sites and designs for particular facilities.

Additional information on this work may be obtained from Mr. Paul Hayes (427-4318) of the Siting and Environmental Branch, DHSWM.

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

REFERENCES

1. NUREG/CR-2311, "The Impact of Impingement on the Hudson River White Perch Population: Final Report," Barnthouse, et al., February 1982.

2. NUREG/CR-1100, "Evaluation of Impingement Losses of White Perch at the Indian Point Nuclear Station and other Hudson River Power Plants," Van Winkle, et al., June 1980.

3. NUREG/CR-0639, "An Empirical Model of Impingement Impact," Barnthouse, et al., February 1979.

4. NUREG/CR-2220, Vol. 1, "The Impact of Entrainment and Impingement on Fish Populations in the Hudson River Estuary," Boreman, et al., January 1982.

5. NUREG/CR-1242, "Methods to Assess Impacts on Hudson River White Perch: Report for the Period October 1, 1978 to September 30, 1979," Barnthouse, et al., May 1980.

6. NUREG/CR-2250, "Modeling Power Plant Impacts on Multipopulation Systems: Application of Loop Analysis to the Hudson River White Perch Population," L. W. Barnthouse, December 1981.

Summary

A series of analyses were conducted on licensee acquired date in an attempt to determine the significance of nuclear power plant imposed impingement and entrainment impacts on Hudson River, Delaware River, and Chesapeake Bay white perch fisheries. These analyses will provide the staff with better analytical tools and information when addressing the question of nuclear power plant impacts on fishery resources during future reactor license environmental reviews. The results identified the critical nature of three basic factors affecting attempts to definitively predict the long-term impacts on fishery resources. These factors are: 1) the large natural variability in annual fish abundance data, 2) the lack of reliable and accurate year-class strength indices for the area of interest, and 3) a lack of understanding of the quality and quantity of compensatory mechanisms that may act to offset observed losses. Using the developed analytical techniques the studies indicate a probable reduction of 20% and 15% in the size of the 1974 and 1975 Hudson River white perch year-classes, respectively, due to impingement at all Hudson River power plants with Indian Point accounting for the majority of the impacts. Entrainment impacts were calculated to be responsible for an additional abundance reduction of the 1974 and 1975 year-classes of approximately 10% to 14%. Although the state-of-the-art can not support a definitive analysis of the long-term significance of these levels of impact, the researchers believe that these levels are sufficiently large to warrant mitigative actions aimed at reducing the level of power plant imposed mortality to protect the long-term productivity of the Hudson River white perch fishery resource. The developed analytical techniques will be useful during future environmental reviews for better characterizing the magnitude and cost of projected adverse impacts on fishery resources from particular facilities.

the magnitude observed at Indian Point can be expected to cause considerable controversy during future licensing reviews due to the uncertainty of these long-term predictions. These results and analytical techniques will be useful during future environmental reviews for identifying potentially adverse impacts on fishery resources that may be expected at similar sites and from similar designs. This will aid in better characterizing the magnitude and cost of these adverse impacts for factoring into the NEPA cost-benefit analysis of alternative sites and designs for particular facilities.

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Original Signed by

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for Robert B. Minogue, Director
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NOTE: Dr. Phillip R. Reed was the project manager for the majority of this project.

NRR agreed that the results of this work warranted the preparation of a RIL at this time.

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