ANL/ES-56
Volume I

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SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

Volume I. THE GREAT LAKES

by

Rajendra K. Sharma and Richard F. Freeman III

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

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ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

(in four volumes)

Volume I. THE GREAT LAKES

by

Rajendra K. Sharma
and
Richard F. Freeman III

Division of
Environmental Impact Studies

March 1977

SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

PROJECT LEADER
Rajendra K. Sharma

Volume I.
THE GREAT LAKES

Volume II.
INLAND WATERS

Volume III.
ESTUARIES AND COASTAL WATERS

Volume IV.
COMPOSITE DATA EVALUATION

EDITOR
Richard B. Keener

PREFACE

Information on fish impingement at water-intake structures is being collected on a routine basis by a number of utilities, most specifically in accordance with the technical-specifications requirement of the U. S. Nuclear Regulatory Commission (USNRC) and/or the requirement of Public Law 92-500, Section 316(b), promulgated by the U. S. Environmental Protection Agency (USEPA). However, to date there has been no attempt to disseminate, on a national basis, the data and experience gained from these individual collection efforts. The purpose of this survey has been to compile much of this information in a series of reports that will aid in planning improvements in the siting, design, and operation of cooling-water intakes and that will be of use to the utilities' biologists and engineers, to environmental investigators and consultants, and to the regulatory agencies--principally USNRC and USEPA.

A fish-impingement study was initiated with funding from the U. S. Energy Research and Development Administration (USERDA), beginning in FY 1975, as the Lake Michigan Fish Impingement Study. The scope of this initial study was to identify major factors responsible for fish impingement at cooling-water intakes of power plants located on Lake Michigan. Efforts to gather sufficient information for our data analysis were largely unsuccessful; data on the variables which could affect fish impingement were not available for most of the plants. The abundance and distribution of fish species in the water body in the vicinity of the site concurrent with the determination of fish impingement at intake screens were important parameters for our analysis, but this information was never adequate. Therefore, a meaningful analysis and interpretation to satisfy our original objective could not be made. Beginning in FY 1976, USNRC funded a survey of the fish-impingement problem in an endeavor to bring together fish-impingement data on a national basis. We considered it appropriate to merge these two projects to provide a more comprehensive presentation of information regarding fish impingement.

The survey has resulted in a four-volume series. Volume I covers power plants located on the Great Lakes, with emphasis on Lake Michigan. Volume II deals with power plants located on inland waters other than the Great Lakes, with emphasis on the Tennessee River and the Tennessee Valley Authority system. Volume III covers power plants located on estuaries and coastal waters. Volume IV in this series deals with

composite data evaluation, and highlights interplant comparisons among and within various ecosystems.

Comments are welcome, especially from the utilities whose data we have used, and may be directed to me.

Rajendra K. Sharma, Project Leader
Division of Environmental Impact Studies
Argonne National Laboratory
Argonne, Illinois 60439

ACKNOWLEDGMENTS

Acknowledgments are extended to the following:

- The funding agencies--USERDA and USNRC;
- The utilities whose data we have used in this study and are too numerous to list here;
- The regional USEPA offices, especially Regions I, IV, and V, who provided information that we could not procure directly from the utilities;
- I. P. Murarka and J. V. Tokar (ANL), who participated in an early phase (FY 1975) of the Lake Michigan Fish Impingement Study; and
- Those staff members of the Division of Environmental Impact Studies who from time to time were assigned to assist in the study.

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SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

Volume I. THE GREAT LAKES

Rajendra K. Sharma and Richard F. Freeman III

Abstract

Impingement of fish at cooling-water intakes of 20 power plants located on the Great Lakes has been surveyed and data are presented. Descriptions of site, plant, and intake design and operation are provided. Reports in this volume summarize impingement data for individual plants in tabular and histogram formats. Information was available from differing sources such as the utilities themselves, public documents, regulatory agencies, and others. Thus, the extent of detail in the reports varies greatly from plant to plant. Histogram preparation involved an extrapolation procedure that has inadequacies. The reader is cautioned in the use of information presented in this volume to determine intake-design acceptability or intensity of impacts on ecosystems. No conclusions are presented herein; data comparisons are made in Volume IV.

INTRODUCTION

Loss of fish at water-intake screens has been identified as one of the major impacts on aquatic biota resulting from operation of thermal power plants. Water used for condenser cooling must be screened of debris and aquatic biota to protect pumps and to prevent clogging of condenser tubes. Usually the water is screened through traveling screens having 3/8-inch-square mesh. The unidirectional flow of water into the intake results in accumulation of fish and debris on the screens. When screens are cleaned, fish and debris are washed off and are disposed of on land or returned to the source water body. Of those fish returned to the water, survival varies depending on design and operation of screening and fish-return systems. Generally, survival is low and can be assumed to be nil for most water intakes.

Impingement of fish is an unavoidable result of the screening of water taken from water bodies inhabited by fish. The problem has existed ever since water has been screened for irrigation and municipal, industrial, or other purposes. However, the focus on the issue has sharpened because of environmental awareness and because of the increase in cooling-water requirements at individual power plants, resulting in noticeable losses and public attention. The "Federal Water Pollution Control Act Amendments of 1972" (Public Law 92-500), administered by the U. S. Environmental Protection Agency (USEPA), requires under the provisions of Section 316(b) that the "... location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." Nuclear power plants are regulated by the U. S. Nuclear Regulatory Commission and their operation is conditioned by Environmental Technical Specifications. These specifications and administration of P.L. 92-500, Section 316(b) usually require collection of fish-impingement information so that the magnitude of the problem may be assessed and mitigative actions may be implemented where warranted. This information is collected and assessed on an individual-plant basis, and little or no flow of information regarding acquired data and experience passes between utilities and agencies concerned with the issue. Inasmuch as accurate predictions of the magnitude of impingement and the significance of such losses on aquatic biota may never be possible, dissemination of such information will play a significant role in providing insight into the problem and in providing bases for impact assessment and implementation of mitigative measures.

This study was designed to survey and catalog fish-impingement and related information available on various power plants in the United States. In order to limit the scope of the survey to a manageable project, information was sought on fossil power plants of 500 MWe or larger and on all nuclear power plants; however, wherever available, information on smaller fossil plants was included. In order to provide an allowance for similarity of impacts in a given ecosystem, the information was divided into three categories, each covered in a separate volume of the survey. This volume covers power plants located on the Great Lakes, with emphasis on Lake Michigan. Other volumes deal with plants on inland waters other than the Great Lakes and on estuaries and coastal waters.

A letter (Fig. 1) explaining the survey, together with a request for specific information (Fig. 2), was sent to all power companies that operate nuclear plants and operate fossil plants 500 MWe or larger in capacity. For information, copies were sent to the Regional Administrators of the ten regional offices of the USEPA. Where available, information was also retrieved from reports on fish impingement filed with the U. S. Nuclear Regulatory Commission. Although information on the nuclear power plants has been readily forthcoming, utilities were considerably reluctant to release information on fossil power plants prior to meeting 316(b) requirements. Therefore, the USEPA was asked to provide us with pertinent information where possible. We were unable to procure information on several plants because the 316(b) studies had not been completed or even initiated.

The status of 316(b) studies for all nuclear plants and fossil plants over 500 MWe is given in Table I. This table was compiled using information

gathered from telephone conversations, letters from the utilities, and other sources as indicated. The table covers 296 plants with a total generating capacity of 291.59 GWe, representing 80% of the 364.35 GWe generated in 1974 by thermal power plants in the United States.[1]

We have not undertaken nor do we recommend a sophisticated analysis of the data in this survey on an individual-plant basis. Fish-impingement data alone provide no basis for decisions on intake technology nor are they appropriate for determining significance of impacts. Volume IV in this series is intended to provide perspective on fish-impingement data by making interplant comparisons within and among various ecosystems. This effort does not employ sophisticated analyses; rather it is meant to portray the variability and presence or absence of trends in the information we have processed.

A map showing the locations of plants reported on in this volume is shown in Figure 3. An index of common names of all fishes referred to in this volume is given in Table II. It provides the scientific name of each fish, using a publication of the American Fisheries Society as authority.[2]

Information on each of the plants has been organized and presented in a standardized format. Individual plant reports vary in depth and extent of coverage depending on available information. Inasmuch as the volume of information and details that we obtained varied greatly, we used our discretion in selecting information that we thought was directly related to the problem of fish impingement. A brief description of the seven headings in the standardized format follows. Text is followed by references, figures, tables, and histograms as appropriate.

SITE CHARACTERISTICS

The plant location is described. Physical, chemical, and biological characteristics of the water body at the site are briefly described. Annual water-temperature range, flow rates or water currents past the site, water movement and turnover rates, dissolved oxygen, pH, salinity levels, and presence of dams or other structures upstream or downstream are described if information was available. Brief descriptions of fish fauna and seasonal distribution and abundance are given for some of the sites. A list of fish species captured in the vicinity of the site or impinged on the intake screens has usually been available. Reference to fishes in the individual plant reports is by common name only; scientific names can be noted by referring to the index provided in this introduction (Table II).

PLANT DESCRIPTION

Plant capacity is given in MWe. It is indicated whether the plant is nuclear or fossil and whether it is operated with a once-through or a closed-cycle cooling system. Also, the letter N or F in the title of each report denotes nuclear or fossil fuel, respectively. The designation of plant or station conforms to usage employed by the utility, if that usage was apparent.

INTAKE DESIGN AND OPERATION

When available, figures are included to show the overall site layout and location of intake with respect to the physical features of the site and the water body, a layout of the cooling system from intake to discharge, a close-in diagram of the intake forebay and pumps with details of such structures as the trash racks, deicing loops, traveling screens, screen-backwash systems, etc. When appropriate, figures of offshore intakes and special screening systems are also included. Intake design is described from the outermost trash racks or bars to the pumps. The intake operation is described in terms of flow rates, design or measured intake velocity at various points in the intake system, screen rotation and frequency of screen washing, sluice system and ultimate disposal of fish and debris, and operation of the deicing loop to prevent freezing of screens in winter.

IMPINGEMENT SAMPLING

There are large variations in methods of monitoring or sampling of fish impingement at intake screens. At some plants 24-hour collections are made every day, whereas at others sampling is performed for only a few hours during a month. When collections are large, a subsampling scheme is usually employed to estimate total impingement. There is a large variation in the type and amount of information recorded from these monitoring programs. The information may include size, weight, gonadal condition, sex identification, scale sample, and other parameters by species, or may include only numbers by major groups.

DATA AVAILABILITY

Only those dates for the data made available to us are given. It is conceivable that data for time periods in addition to those listed are available.

IMPINGEMENT DATA SUMMARY

Generally, data were available to us for each of the samples by species and numbers of each of the species. Important species (based on abundance) were identified for each of the sites, and data were processed for each of the samples to list numbers of important species individually and the total for all species including the important species. In order to present information on a uniform basis we selected a yearly histogram format. Simple proportional extrapolations were made to obtain daily and monthly estimates for each of the important species and the total for all species. These estimates were then plotted in a yearly histogram. The actual time period for sampling varied greatly from plant to plant and from month to month, and the fractional number at the bottom of each bar of the histogram indicates the number of days sampled per month. Thus, the original number of fish impinged during a sampling period can be readily back calculated. Absence of a number at the bottom of the histogram indicates that no sampling was done during that month. Absence of a histogram bar for a month when sampling is indicated

by a fractional number indicates that sampling was conducted but no fish were captured from the screens. In all extrapolations full-time operation of the station was assumed. We feel that no extrapolation scheme, no matter how sophisticated, can accommodate all of the vagaries of sampling schemes. In our opinion, simple extrapolation at least provides an opportunity to back calculate the original number impinged for a given sampling period.

When information was available for more than one year, an effort was made to plot histograms for a given species on the same page, thus providing easy comparison of annual fluctuations and seasonal trends. The impingement numbers are plotted on a logarithmic scale. There are scale changes from report to report, and sometimes within a report, depending on the number of fish killed. Thus, caution should be exercised in comparing heights of the bars; the vertical scale must be observed.

A summary table of fish impingement data is presented in each report. It contains information on the total number of fish impinged, and the number of fish of important species impinged, estimated for the number of months the sampling was conducted in a given year. Note that these estimates do not represent the number of fish killed per year; rather they indicate the estimated number of fish killed during the months the sampling was done.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Wherever used, devices such as air-bubble curtains, electric screens, reduction in intake velocity, and others are described and their success as reported by the utility or as described by other sources is included. Usually, the success of such devices has been judged subjectively, and no data are presented to substantiate the claims.

REFERENCES

1. "Steam-Electric Plant Factors." National Coal Association, Washington, DC. 1975.

2. R. M. Bailey et al. "A List of Common and Scientific Names of Fishes from the United States and Canada." American Fisheries Society, Special Publication No. 6, Third Edition. 1970.

ARGONNE NATIONAL LABORATORY

As part of a program to assess the environmental impacts of U.S. power plants, the Environmental Statement Project at Argonne National Laboratory is conducting a national survey on the impingement of fish at cooling water intakes, and we would appreciate your assistance.

Information on fish impingement is being collected on a routine basis by a number of companies, especially under provisions of the Technical Specifications requirement of the Nuclear Regulatory Commission and/or the Public Law 92-500, Section 316 (b), requirement of the Environmental Protection Agency. To date, however, there has been no attempt to disseminate, on a national basis, the data and experience gained from these individual collection efforts.

We intend to compile much of this information in a series of reports that we feel will aid in planning improvements in the design, siting, and operation of cooling water intakes and that will be of use to utility company biologists and engineers, to environmental investigators and consultants, and to regulatory agencies.

Enclosed is a list of the information we are requesting for each U.S. fossil-fuel station with a generating capacity of 500 MWe or greater and for each U.S. nuclear power plant. The list does look exhaustive, but we would appreciate receiving whatever information is available at this time. We intend to complete our study as soon as possible and would like to publish the reports in a timely fashion.

Please feel free to contact me for further information concerning the study or the data we are requesting. My phone number is (312) 739-7711, Ext. 2463.

Sincerely yours,

R. K. Sharma, Ph.D.
Fisheries Scientist - Ecologist
Environmental Statement Project

Enclosure

9700 South Cass Avenue, Argonne, Illinois 60439 · Telephone 312-739-7711 · TWX 910-258-3285 · WUX LB, Argonne, Illinois

Fig. 1. Explanatory Letter.

INFORMATION REQUESTED ON COOLING WATER INTAKES AND FISH IMPINGEMENT

1. Description of the intake site, including brief characteristics of the topography and the depth contours of the water body. (Please include any site parameters that you feel make it unique with respect to local fish populations.)

2. Description of the intake design from outermost bar racks to the circulating water pumps. Please provide dimensions where available and describe all structures in the intake forebays, skimmer wall, intake bays, number of bays, number and type of screens, and number of pumps. Also provide intake design drawings to show overall layout and details of the intake bays and screens.

3. Description of intake operational parameters, such as flow rate, intake velocity at outermost bar racks, summer and winter operation (if different), winter recirculation for de-icing, etc. Please include actual flow rate data for the dates of sampling, if available.

4. List of fish species present in the body of water, preferably by seasonal abundance.

5. Number of fish impinged, total and by species for each of the sampling dates, or by weekly or monthly summary tables.

6. Description of the fish impingement sampling program, frequency of sampling, subsampling procedures, etc.

7. Various intake design and operational modifications attempted by your company to reduce fish impingement and your comments regarding success of each modification in reducing fish impingement.

8. Any publications or reports prepared by your company that deal specifically with fish impingement problems.

Mail information to:

Dr. R. K. Sharma
Fisheries Scientist - Ecologist
Environmental Statement Project
Argonne National Laboratory
Argonne, Illinois 60439

Fig. 2. Information Request.

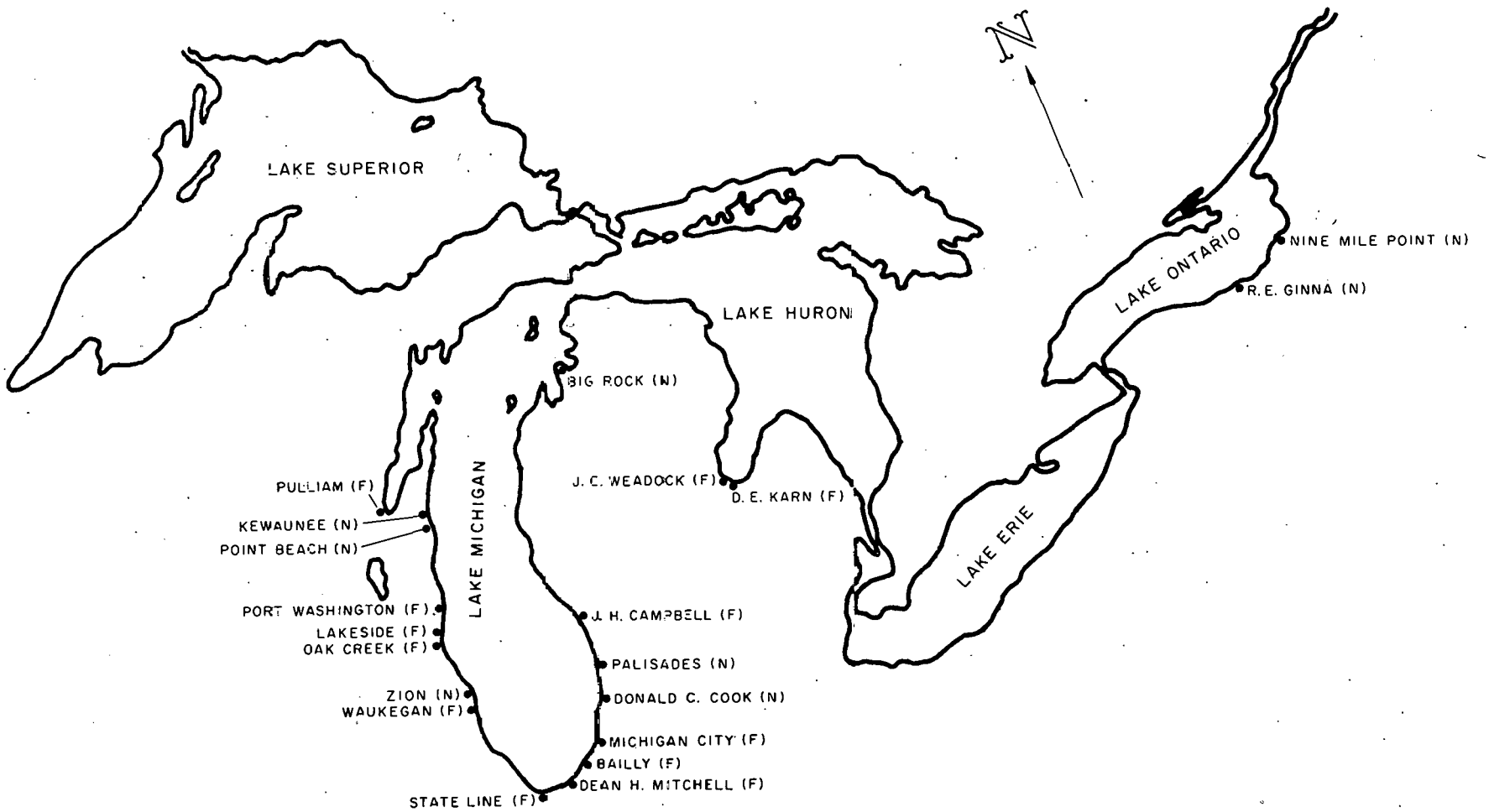


Fig. 3. Plant Locations, The Great Lakes.

Table I. The 316(b) Status (on 1 August 1976) of U. S. Power Plants (Fossil over 500 MWe, and Nuclear)

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
ALABAMA								
Alabama Power Co.								Data for Gaston and Gorgas were in a form not usable for the purpose of the survey.
Barry				X			1525	
E. C. Gaston		X		X			1880	
Gorgas		X		X			1341	
Green County				X			500	
Tennessee Valley Authority								
Browns Ferry	X						2304	
Colbert		X					1397	
Widows Creek	X						1978	
ALASKA								No fossil plants larger than 500 MWe; no nuclear plants.
ARIZONA								
Arizona Public Service Co.								
Four Corners					X		2234	Uses a cooling lake.
ARKANSAS								
Arkansas Power & Light Co.								
Arkansas Nuclear One	X						836	
Lake Catherine						X	756	
Robert Ritchie						X	900	
CALIFORNIA								
Los Angeles Dept. of Water & Power								
Haynes		X					1606	
Pacific Gas & Electric Co.								
Contra Costa	X		X				1260	No studies are being conducted for the fossil plants until 316(b) guidelines are issued by the EPA.
Diablo Canyon	X			X			2120	
Humboldt Bay	X		X				172	
Hunters Point	X		X				377	
Morro Bay	X		X				1002	
Moss Landing	X		X				2060	
Oleum	X		X				87	
Pittsburg	X		X				2002	
Potrero	X		X				323	
Sacramento Municipal Utility District								
Rancho Seco		X			X		913	Canal makeup water.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
CALIFORNIA (cont'd)								
San Diego Gas & Electric Co.								No utility response; information obtained from Calif Regional Water Qual Contl Bd, San Diego Region.
Encina			X				614	
South Bay			X				729	
Southern California Edison Co.								
Alamitos Bay			X				1950	
El Segundo			X				1020	
Etiwanda			X				904	
Huntington Beach			X				870	
Ormond Beach		X		X			1500	
Redondo Beach		X		X			1602	
San Onofre	X						430	
COLORADO								
Public Service Co. of Colorado								
Cherokee		X					710	
Fort St. Vrain		X	X				330	
CONNECTICUT								
Connecticut Yankee Atomic Power Co.								
Connecticut Yankee	X						600	
Northeast Utilities								Inadequate response from utility.
Middletown				X			837	
Millstone	X						1482	Information from NRC.
Montville				X			577	
United Illuminating Co.								
Bridgeport Harbor				X			600	A 316(b) report to be completed in Dec 76.
DELAWARE								
Delmarva Power & Light Co.								
Edge Moor	X						791	
DISTRICT OF COLUMBIA								
Potomac Electric Power Co.								No utility response.
Benning						X	684	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
FLORIDA								
Florida Power & Light Co.								No information on fossil plants was received.
Cape Canaveral			X				762	
Fort Myers			X				535	
Port Everglades			X				1214	
Riviera						X	692	
St. Lucie				X			1620	Only one St. Lucie unit (810 MWe) is fully operational.
Sanford			X				918	
Turkey Point	X				X		2321	
Florida Power Corp.								No utility response; permit for Anclote has been applied for - or study underway.
Anclote				X			556	
Crystal River	X						1782	
Gulf Power Co.								No utility response.
Crist				X			1045	316(b) demo approved.
Ellis			X				1000	316(b) propsl in prep.
Jacksonville Electric Authority								No utility response.
Northside			X				824	316(b) propsl in prep.
Orlando Utilities Comm.								No utility response.
Indian River			X				665	316(b) propsl in prep.
Tampa Electric Co.								No utility response.
Big Bend			X				891	316(b) propsl in prep.
F. J. Gannon						X	1062	
GEORGIA								
Georgia Power Co.								No utility response.
Bowen			X				2319	
Hammond			X				800	
Harllee Branch			X				1540	
Hatch		X					1581	Information from NRC.
J. McDonough						X	569	
Yates			X				1250	
HAWAII								No fossil plants larger than 500 MWe; no nuclear plants.
IDAHO						-		No fossil plants larger than 500 MWe; no nuclear plants.
ILLINOIS								
Central Illinois Light Co.								No utility response.
E. D. Edwards			X				725	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
ILLINOIS (cont'd)								
Central Illinois Public Service								No utility response.
Coffeen			X				1005	NPDES permit issued.
Meredosia				X			354	A 316(b) proposal has been submitted.
Commonwealth Edison Co.								
Dresden				X			1865	
Fisk						X	547	
Joliet						X	1787	
Kincaid						X	1319	
Powerton			X				893	
Ridgeland						X	690	
Quad Cities	X						1600	
Waukegan	X						933	
Will County			X				1269	
Zion	X						2196	
Electric Energy, Inc.								
Joppa		X					1041	
Illinois Power Co.								
Baldwin	X						1258	
Wood River	X						657	
Union Electric Co.								Inadequate response from utility.
Cahokia			X				304	
Venice			X				500	Sep 76 retirement.
INDIANA								
Commonwealth Edison Co.								
State Line	X						968	
Indiana-Kentucky Electric Corp.								
Clifty Creek	X						1290	
Indiana & Michigan Electric Co.								
Tanners Creek			X				1040	316(b) propsl in prep.
Indianapolis Power & Light Co.								No utility response.
Petersburg			X				650	316(b) proposals may
E. W. Stout						X	787	be in preparation.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
INDIANA (cont'd)								
Northern Indiana Public Service Co.								Inadequate response from utility.
Bailly	X						616	
Michigan City	X						736	
D. H. Mitchell	X						529	
Public Service Co. of Indiana, Inc.								Inadequate response from utility.
Cayuga						X	1025	
R. A. Gallagher				X			637	
Wabash River						X	881	
Southern Indiana Gas & Electric Co.								
Warrick			X				732	A 316(b) proposal may be in preparation.
IOWA								
Iowa Public Service Co.								
George Neal	X						496	
Iowa Electric Light & Power Co.								
Duane Arnold		X			X		529	
KANSAS								
Kansas City Power & Light Co.								Inadequate response from utility.
La Cygne						X	893	
Kansas Gas & Electric Co.								No utility response.
Gordon Evans						X	539	
Kansas Power & Light Co.								
Lawrence					X		613	Closed-cycle cooling.
KENTUCKY								
Big Rivers Electric Corp.								
Coleman			X				455	A 316(b) proposal may be in preparation.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
KENTUCKY (cont'd)								
Kentucky Power Co.								No utility response.
Big Sandy						X	1003	
Kentucky Utilities Co.								Inadequate response from utility.
E. W. Brown						X	706	
Ghent	X						525	
Green River	X						242	
Louisville Gas & Electric Co.								No utility response.
Cane Run			X				992	316(b) proposals may be in preparation.
Mill Creek			X				660	
Tennessee Valley Authority								
Paradise (A)	X						1408	Paradise uses cooling towers.
Paradise (B)	X						1150	
Shawnee		X					1750	
LOUISIANA								
Gulf States Utilities Co.								Inadequate response from utility.
R. S. Nelson						X	982	
Willow Glen	X						1586	
Louisiana Power & Light Co.								
Little Gypsy		X		X			1251	
Ninemile Point		X		X			1917	
Sterlington		X					523	
New Orleans Public Service, Inc.								No utility response.
Michoud						X	959	
MAINE								
Maine Yankee Atomic Power Co.								
Maine Yankee	X						855	
MARYLAND								
Baltimore Gas & Electric Co.								No utility response.
Calvert Cliffs	X						1690	A 316(b) propsl may be in prep for Wagner.
H. A. Wagner			X				990	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
MARYLAND (cont'd)								
Potomac Electric Power Co.								No utility response.
Chalk Point			X				708	NPDES permit appl may
Dickerson						X	570	be in prep for
Morgantown						X	1364	Chalk Point.
MASSACHUSETTS								
Boston Edison Co.								No utility response; information obtained
Mystic	X						1218	from EPA Region I.
New-Boston						X	718	
Pilgrim	X						655	
Canal Electric Co.								
Canal	X						1120	
New England Power Co.								
Brayton Point	X						1590	
Salem Harbor	X						775	
Yankee Atomic Electric Co.								
Yankee Atomic	X						185	
MICHIGAN								
Consumers Power Co.								316(b) demo approved
Big Rock	X						75	on 28 Jan 75.
J. H. Campbell	X						650	
B. C. Cobb	X						531	
D. E. Karn	X						530	Same as Big Rock.
Palisades	X						812	Same as Big Rock.
J. C. Weadock	X						615	Same as Big Rock.
Detroit Edison Co.								No utility response.
Conners Creek				X			460	316(b) demos approved
Monroe		X		X			3011	on 29 Jul 75 for
River Rouge				X			842	Conners Creek, River
St. Clair				X			1798	Rouge, St. Clair, &
Trenton Channel				X			700	Trenton Channel.
Indiana & Michigan Power Co.								
D. C. Cook	X						1100	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
MINNESOTA								
Minnesota Power & Light Co.								
Clay Boswell		X		X			462	
Northern States Power Co.								Inadequate response from utility; info obtained from Minn Pollut Cntl Board.
A. S. King		X					560	
Monticello		X					538	
Prairie Island	X						1040	
MISSISSIPPI								
Mississippi Power Co.								Inadequate response from utility.
Jack Watson						X	1012	
Mississippi Power & Light Co.								Inadequate response from utility.
G. Andrus			X				750	
Baxter Wilson		X					1328	
MISSOURI								
Associated Electric Cooperative, Inc.								
New Madrid			X				600	316(b) propsl in prep.
Kansas City Power & Light Co.								Inadequate response from utility.
Hawthorne		X		X			925	
Montrose					X		546	
Missouri Public Service Co.								No utility response.
Sibley						X	519	
Union Electric Co.								Inadequate response from utility.
Labadie			X				2220	NPDES permit appl may be in prep for Labadie.
Meramec						X	800	
Sioux						X	978	
MONTANA								No fossil plants larger than 500 MWe; no nuclear plants.
NEBRASKA								
Nebraska Public Power District								Information obtained from EPA Region VI.
Cooper	X						764	
Gerald Gentleman				X			650	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
NEBRASKA (cont'd)								
Omaha Public Power District								No utility response.
Fort Calhoun				X			481	
Nebraska City				X			575	
North Omaha				X			600	
NEVADA								
Southern California Edison Co.								Inadequate response from utility.
Mohave						X	1580	
NEW HAMPSHIRE								No fossil plants larger than 500 MWe; no nuclear plants.
NEW JERSEY								
Jersey Central Power & Light Co.								
Oyster Creek	X						670	
Public Service Electric & Gas Co.								No utility response.
Bergen			X				650	
Burlington			X		X		455	Partly closed-cycle.
Essex			X				700	
Hudson			X				1115	NPDES permit appls
Kearny			X				841	in prep for the
Linden			X				613	utility's plants
Mercer			X				653	except Burlington.
Seawaren			X				850	
NEW MEXICO								No fossil plants larger than 500 MWe; no nuclear plants.
NEW YORK								
Central Hudson Gas & Electric Corp.								Inadequate response from utility.
Danskammer Point			X				472	
Roseton					X		1140	Closed-cycle cooling.
Consolidated Edison Co. of New York, Inc.								Inadequate response from utility on all but Astoria &
Astoria	X						1625	Indian Point.
East River			X				454	
Hudson Ave.						X	700	316(b) proposals may
Indian Point	X						1158	be in prep for East
Arthur Kill			X				826	River & Arthur Kill.
Ravenswood						X	1726	
Waterside						X	593	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
NEW YORK (cont'd)								
Long Island Lighting Co.								
Northport	X						1158	
Niagara Mohawk Power Corp.								No utility response.
Dunkirk				X			640	
C. R. Huntley				X			830	
Nine Mile Point	X						642	
Orange & Rockland Utilities, Inc.								No utility response.
Bowline Point			X				1242	
Lovett					X		504	Closed-cycle cooling.
Rochester Gas & Electric Corp.								
Ginna	X						490	
NORTH CAROLINA								
Carolina Power & Light Co.								
Brunswick	X						1642	
Roxboro			X				1705	316(b) propsl in prep.
L. V. Sutton			X				554	316(b) propsl in prep.
Duke Power Co.								No utility response.
Allen	X						1140	
Belews Creek				X			1060	EPA is reviewing
Buck		X		X			364	applications from
Cliffside				X			770	the four plants
Marshall					X		2025	that indicate
Riverbend		X		X			631	"study underway."
NORTH DAKOTA								No fossil plants larger than 500 MWe; no nuclear plants.
OHIO								
Cincinnati Gas & Electric Co.								No utility response.
W. C. Beckjord				X			1168	
Cleveland Electric Illuminating Co.								No utility response.
Ashtabula			X				640	NPDES permit appls
Avon Lake			X				1275	may be in prep for
Eastlake			X				1045	the four plants.
Lake Shore			X				518	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
OHIO (cont'd)								
Columbus & Southern Ohio Electric Co.								
Conesville			X				1275	Appl may be in prep.
Ohio Edison Co.								
R. E. Burger		X					544	
Gavin			X				1300	Propsl may be in prep.
W. H. Sammis		X					1980	
Ohio Power Co.								No utility response.
Cardinal			X				1180	NPDES permit appls
Muskingum River			X				1467	may be in prep for
Philo			X				500	the three plants.
Ohio Valley Electric Corp.								No utility response.
Kyger Creek			X				1075	NPDES appl in prep.
Toledo Edison Co.								No utility response.
Bay Shore			X				639	
OKLAHOMA								
Oklahoma Gas & Electric Co.								No utility response.
Horseshoe Lake						X	949	
Mustang						X	505	
Seminole						X	1100	
Public Service Co. of Oklahoma								No utility response.
Northeastern						X	643	
OREGON								
Portland General Electric Co.								
Trojan	X						659	Closed-cycle cooling.
PENNSYLVANIA								
Allegheny Power Service Corp.								Inadequate response from utility.
Hatfield's Ferry					X		1728	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
PENNSYLVANIA (cont'd)								
Duquesne Light Co.								No utility response.
Cheswick						X	525	
Elrama						X	425	
Shippingport						X	100	
Metropolitan Edison Co.								
Three Mile Island	X						871	
Pennsylvania Electric Co.								No utility response.
Homer City						X	1320	
Shawville			X				640	Appl may be in prep.
Pennsylvania Power & Light Co.								No utility response.
Brunner Island						X	1559	
Conemaugh						X	1872	
Keystone						X	1872	
Montour						X	1642	
Philadelphia Electric Co.								Inadequate response from utility.
Eddystone			X				1090	
Peach Bottom	X						2130	
RHODE ISLAND								No fossil plants larger than 500 MWe; no nuclear plants.
SOUTH CAROLINA								
Carolina Power & Light Co.								
H. B. Robinson	X						839	
Duke Power Co.								Inadequate response from utility.
Oconee				X			2613	
South Carolina Electric & Gas Co.								
Canadys						X	490	
Wateree	X						772	Hot-wea cooling twrs.
A. M. Williams	X						633	Hot-wea cooling twrs.
SOUTH DAKOTA								No fossil plants larger than 500 MWe; no nuclear plants.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
TENNESSEE								
Tennessee Valley Authority								
T. H. Allen	X						990	
Bull Run		X					950	
Cumberland	X						2600	
Gallatin	X						1255	
Johnsonville		X					1485	
Kingston	X						1700	
John Sevier	X						847	
Watts Bar	X						240	
TEXAS								
Austin Electric Dept.								Utility not contacted.
Holly St.						X	555	
Central Power & Light Co.								No utility response.
Barney M. Davis	X						650	
L. C. Hill						X	545	
Nueces Bay						X	569	
Victoria						X	520	
Dallas Power & Light Co.								Inadequate response from utility.
Big Brown			X				1187	
Lake Hubbard			X				890	
Monticello			X				593	
Mountain Creek			X				928	
North Lake			X				700	
Gulf States Utilities Co.								
Lewis Creek		X		X			543	316(b) demo underway.
Sabine		X		X			1544	316(b) demo underway.
Houston Lighting & Power Co.								
Sam Bertron						X	751	
Cedar Bayou	X						2250	
Greens Bayou						X	741	
W. A. Parish						X	1119	
P. H. Robinson		X		X			2178	
Webster						X	550	
T. H. Wharton						X	562	
Lower Colorado River Authority								Utility not contacted.
Sam Gideon						X	565	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
TEXAS (cont'd)								
San Antonio Public Service Board								Utility not contacted.
Victor H. Braunig						X	885	
Sommers						X	872	
Southwestern Electric Power Co.								
Knox Lee		X	X				513	
Wilkes		X	X				879	
Texas Electric Service Co.								Inadequate response from utility.
Eagle Mountain		X					706	Impingement info was in a form not usable for the purpose of the survey.
Graham						X	635	
Handley		X					523	
Morgan Creek						X	848	
Permian Basin						X	702	
Texas Power & Light Co.								Inadequate response from utility.
Stryker Creek						X	675	
Tradinghouse Creek						X	1340	
Valley						X	1100	
UTAH								No fossil plants larger than 500 MWe; no nuclear plants.
VERMONT								
Vermont Yankee Nuclear Power Corp.								No utility response; some information obtained from NRC.
Vermont Yankee		X					563	
VIRGINIA								
Appalachian Power Co.								No utility response.
Clinch River						X	669	
Potomac Electric Power Co.								
Potomac River			X				486	
Virginia Electric & Power Co.								Inadequate response from utility.
Chesterfield			X				1481	
Portsmouth			X				650	
Possum Point			X				491	
Surry	X						1576	
Yorktown			X				1257	

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
WASHINGTON								
Pacific Power & Light Co.								No utility response.
Centralia						X	1330	
Washington Public Power Supply System								
Hanford	X						700	MWe quoted by a WPPSS representative.
WEST VIRGINIA								
Allegheny Power Service Corp.								Inadequate response from utility.
Fort Martin					X		1152	Both plants may have
Harrison					X		1368	off-stream cooling.
Appalachian Power Co.								No utility response.
J. E. Amos						X	2775	
Philip Sporn			X				1060	Propsl may be in prep.
Ohio Power Co.								No utility response.
Kammer						X	675	
Mitchell						X	1498	
Virginia Electric & Power Co.								Inadequate response from utility.
Mount Storm						X	1662	
WISCONSIN								
Dairyland Power Cooperative								
Genoa				X			360	
La Crosse	X						48	
Wisconsin Electric Power Co.								
Lakeside	X						310	
Oak Creek	X						1690	
Port Washington	X						400	
Wisconsin Michigan Power Co.								
Point Beach	X						1026	
Wisconsin Power & Light Co.								
Columbia					X		527	Uses a cooling lake.

Table I. Continued

State Utility Plant	Complete Data Available to Argonne National Laboratory	Incomplete Data Forwarded	No Impingement Information Available				Capability (MWe)	Comments
			No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status			
					Exempt	Unknown		
WISCONSIN (cont'd)								
Wisconsin Public Service Corp.								
Kewaunee	X						535	
Pulliam	X						393	
WYOMING								
Pacific Power & Light Co.								Inadequate response from utility.
Jim Bridger		X					2000	
Dave Johnston		X					750	

Data were compiled from: "Steam-Electric Plant Factors," National Coal Association, Washington, DC, 1975 Edition; "Inforum," Cumulative Index for September 1975-February 1976, Atomic Industrial Forum, Inc., Washington, DC, 1976; "Electrical World Directory of Electric Utilities," McGraw-Hill, Inc., 1975-1976, 84th Edition, 1975; individual utility responses; and other sources as given in the comments column.

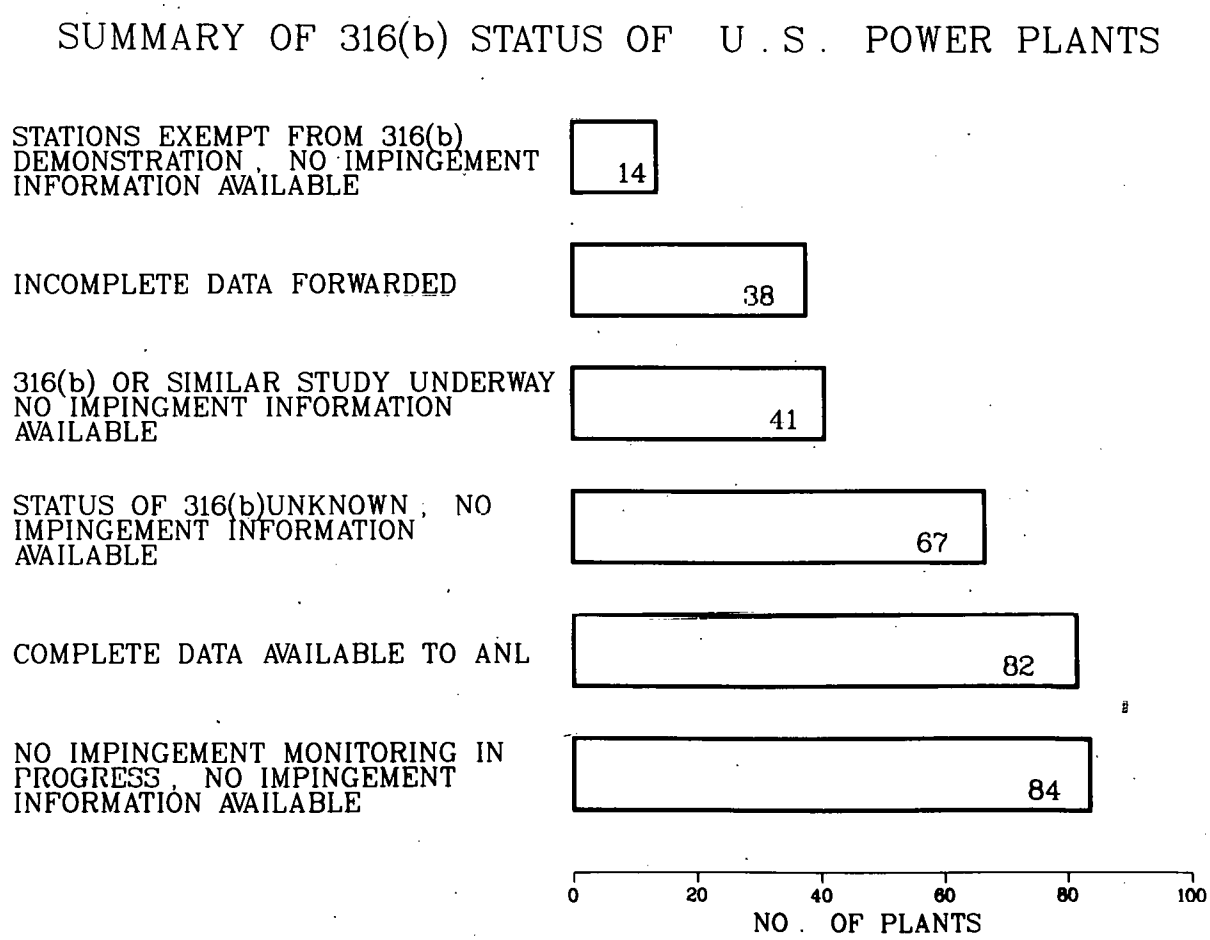


Table II. Index of Common Names Used in this Volume and the Corresponding Scientific Names

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
Atlantic salmon	*Salmo salar*
Bigmouth buffalo	*Ictiobus cyprinellus*
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis nigromaculatus*
Blacknose shiner	*Notropis heterolepis*
Bloater	*Coregonus hoyi*
Bluegill	*Lepomis macrochirus*
Bluntnose minnow	*Pimephales notatus*
Bowfin	*Amia calva*
Brook silverside	*Labidesthes sicculus*
Brook stickleback	*Culaea inconstans*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ictalurus nebulosus*
Brown trout	*Salmo trutta*
Burbot	*Lota lota*
Carp	*Cyprinus carpio*
Central mudminnow	*Umbra limi*
Channel catfish	*Ictalurus punctatus*
Chestnut lamprey	*Ichthyomyzon castaneus*
Chinook salmon	*Oncorhynchus tshawytscha*
Cisco or lake herring	*Coregonus artedii*
Coho salmon	*Oncorhynchus kisutch*
Common shiner	*Notropis cornutus*
Creek chub	*Semotilus atromaculatus*
Emerald shiner	*Notropis atherinoides*
Fathead minnow	*Pimephales promelas*
Freshwater drum	*Aplodinotus grunniens*
Gizzard shad	*Dorosoma cepedianum*
Golden redhorse	*Moxostoma erythrurum*
Golden shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Green sunfish	*Lepomis cyanellus*
Johnny darter	*Etheostoma nigrum*

Table II. Continued

Common Name	Scientific Name
Lake chub	*Couesius plumbeus*
Lake sturgeon	*Acipenser fulvescens*
Lake trout	*Salvelinus namaycush*
Lake whitefish	*Coregonus clupeaformis*
Largemouth bass	*Micropterus salmoides*
Logperch	*Percina caprodes*
Longear sunfish	*Lepomis megalotis*
Longnose dace	*Rhinichthys cataractae*
Longnose gar	*Lepisosteus osseus*
Longnose sucker	*Catostomus catostomus*
Mooneye	*Hiodon tergisus*
Mottled sculpin	*Cottus bairdi*
Muskellunge	*Esox masquinongy*
Ninespine stickleback	*Pungitius pungitius*
Northern hog sucker	*Hypentelium nigricans*
Northern pike	*Esox lucius*
Pirate perch	*Aphredoderus sayanus*
Pumpkinseed	*Lepomis gibbosus*
Quillback	*Carpiodes cyprinus*
Rainbow smelt	*Osmerus mordax*
Rainbow trout	*Salmo gairdneri*
River chub	*Nocomis micropogon*
Rock bass	*Ambloplites rupestris*
Round whitefish	*Prosopium cylindraceum*
Sauger	*Stizostedion canadense*
Sea lamprey	*Petromyzon marinus*
Shorthead redhorse	*Moxostoma macrolepidotum*
Shortnose gar	*Lepisosteus platostomus*
Silver lamprey	*Ichthyomyzon unicuspis*
Silver redhorse	*Moxostoma anisurum*
Silvery minnow	*Hybognathus nuchalis*
Slimy sculpin	*Cottus cognatus*
Smallmouth bass	*Micropterus dolomieui*
Spottail shiner	*Notropis hudsonius*
Steelhead	*Salmo gairdneri*
Stonecat	*Noturus flavus*
Stoneroller	*Campostoma anomalum*

Table II. Continued

Common Name	Scientific Name
Tadpole madtom	*Noturus gyrinus*
Threespine stickleback	*Gasterosteus aculeatus*
Trout-perch	*Percopsis omiscomaycus*
Walleye	*Stizostedion vitreum vitreum*
Warmouth	*Lepomis gulosus*
White bass	*Morone chrysops*
White crappie	*Pomoxis annularis*
White perch	*Morone americana*
White sucker	*Catostomus commersoni*
Yellow bullhead	*Ictalurus natalis*
Yellow perch	*Perca flavescens*

J. P. PULLIAM POWER PLANT (F)

SITE CHARACTERISTICS

The J. P. Pulliam Power Plant is located at the southern end of Green Bay at the confluence of the Fox River in the City of Green Bay, Wisconsin, as shown in Figure 1.

Green Bay is the most eutrophic and productive portion of Lake Michigan, averaging 50% of the annual commercial fish catch for the lake.[1] It is divided into a deep northern end which supports cold-water species and a shallow southern end characterized by warm-water species. The Fox River is a highly eutrophic river draining Lake Winnebago into Green Bay. Table I is a species list of fish found in Green Bay and the Fox River.

PLANT DESCRIPTION

The J. P. Pulliam Power Plant is a coal-fired facility consisting of eight generating units with a total gross output of 392.5 MWe. The plant utilizes once-through cooling.

INTAKE DESIGN AND OPERATION

Two sources of cooling water for the J. P. Pulliam Plant have been developed: a northern structure located on Green Bay and a southern structure located on the Fox River (Fig. 1). The northern structure consists of two intakes: one supplies Units 1, 2, and 3, while the second one supplies Units 4, 5, and part of 6. Water for these intakes is drawn from near the surface of Green Bay (within the 10-foot depth contour, at normal elevation). The Fox River water and the discharge water may also enter these intakes at times depending on flow rate and weather conditions. The intake structures are cribs housing a six-foot-diameter (Intake A) and an eight-foot-diameter (Intake B) intake pipe, trash rack, and rake for cleaning trash racks. The trash racks are vertical bars with six-inch gaps between bars. The area immersed at normal water level is eight feet wide and 10 feet (Intake A) and 18 feet (Intake B) high.

The south intake is a combined crib for two nine-foot-diameter pipes with trash racks of the same design as the other intakes (eight-inch spacing). The combined trash rack cross-sectional area at normal water level is 360 square feet. Water for the southern intakes is generally drawn from the Fox River, and supplies Units 7, 8, and part of 6.

All units receive water from a manifold-type system drawing water from the north and south intakes. A screen house consisting of a small forebay,

a trash rack with three-inch spacing, and traveling screens serves each unit (Fig. 2). Traveling screens are the conventional vertical type with 3/8-inch square openings.

Water is circulated through the plant at the total rate of 105,094 gpm. Condenser cooling uses 99,237 gpm. Current velocities based on the total rate were determined at the various intakes. The velocity at the intake servicing Units 1, 2, and 3 is about 6 fps, while the velocity at the remaining intakes is about 5.6 fps. There are eddies in each intake bay, and a reverse flow of 0.66 to 0.98 fps was detected near the surface in each intake bay.[1]

The deicing system consists of two pumps located in the discharge, rated at a capacity of 3824 gpm, and the recirculation piping for Units 7 and 8 (Fig. 2). Discharge water is piped from one pump to the deicing canal adjacent to the north intakes and from the other pump to the face of the south intake. Operation of the pumps is intermittent, depending on anchor ice.

IMPINGEMENT SAMPLING

Impingement sampling was conducted every fourth day from 1 April 1975 through 31 March 1976. At the beginning of each sampling period the traveling screens were washed and the fish discarded. The screens were then operated manually by personnel on each shift for 24 hours and all fish were retained for counting.

Fish collected were identified to species (usually sport fish) or family (suckers, bullheads, shiners, etc.), measured to the nearest centimeter total length, and weighed to the nearest five-gram increment. If the collection exceeded 40 fish, the total weight was recorded and the total number estimated using the mean weight of individually weighed fish.

DATA AVAILABILITY

Fish impingement data for the J. P. Pulliam Power Plant are available for April through December 1975 and January through March 1976.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the J. P. Pulliam Power Plant. These totals are summarized in Table II. Although bullheads were not identified to species, it is probable that they were black bullheads.[1]

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Each intake at the plant is equipped with an air-bubble curtain to deter fish from entering the intake. The curtain is operated continuously from April through October. It is felt that the curtain serves as a deterrent when operating, although no quantitative studies have been conducted to date.[2]

REFERENCES

1. J. P. Pulliam Power Plant 316(b) Demonstration. Prepared and submitted by Nalco Environmental Sciences of Northbrook, Illinois, to Wisconsin Public Service. May 1976.

2. Personal communication with Ed Newman of Wisconsin Public Service. 14 June 1976.

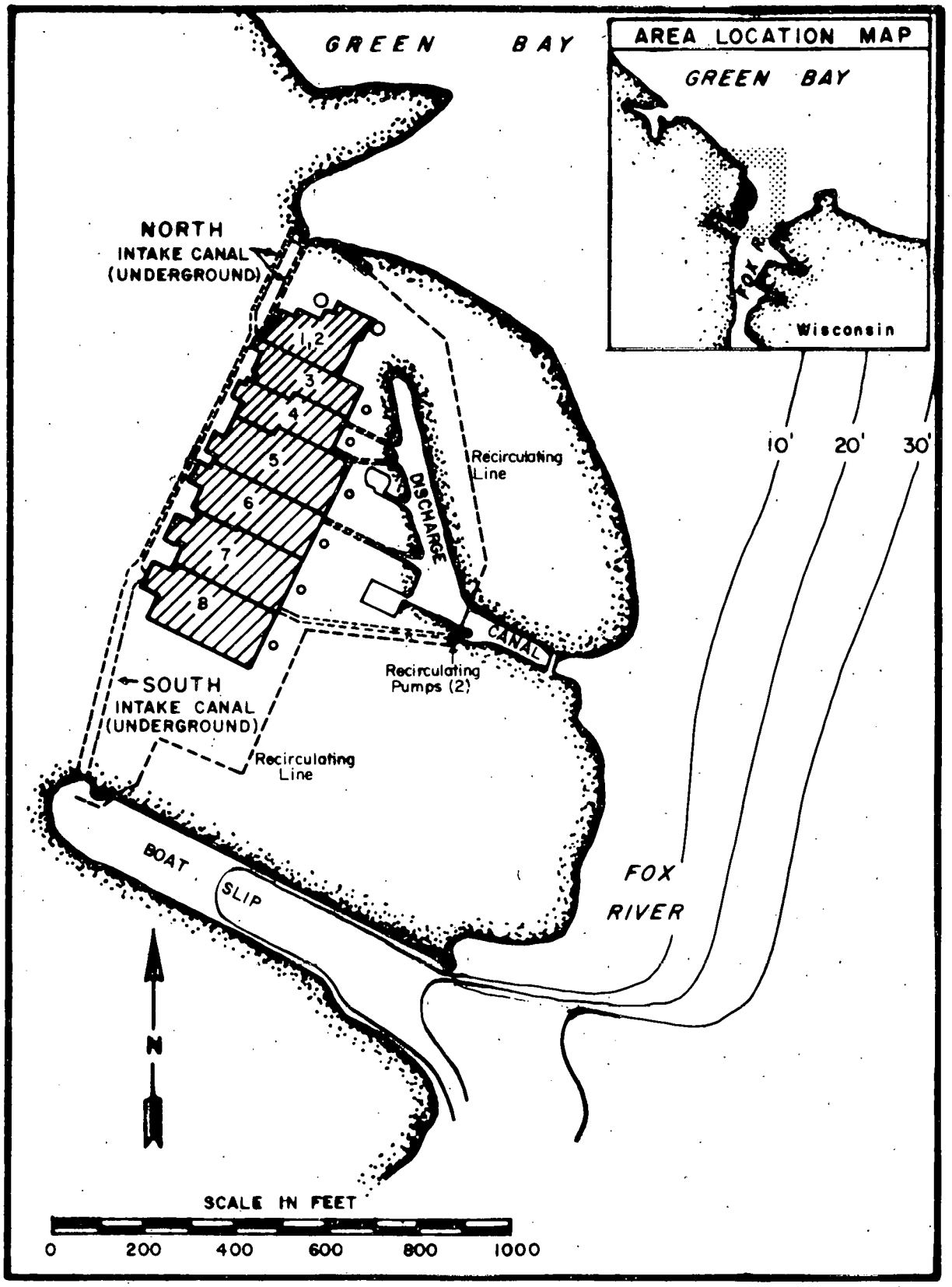


Fig. 1. Plant Location.

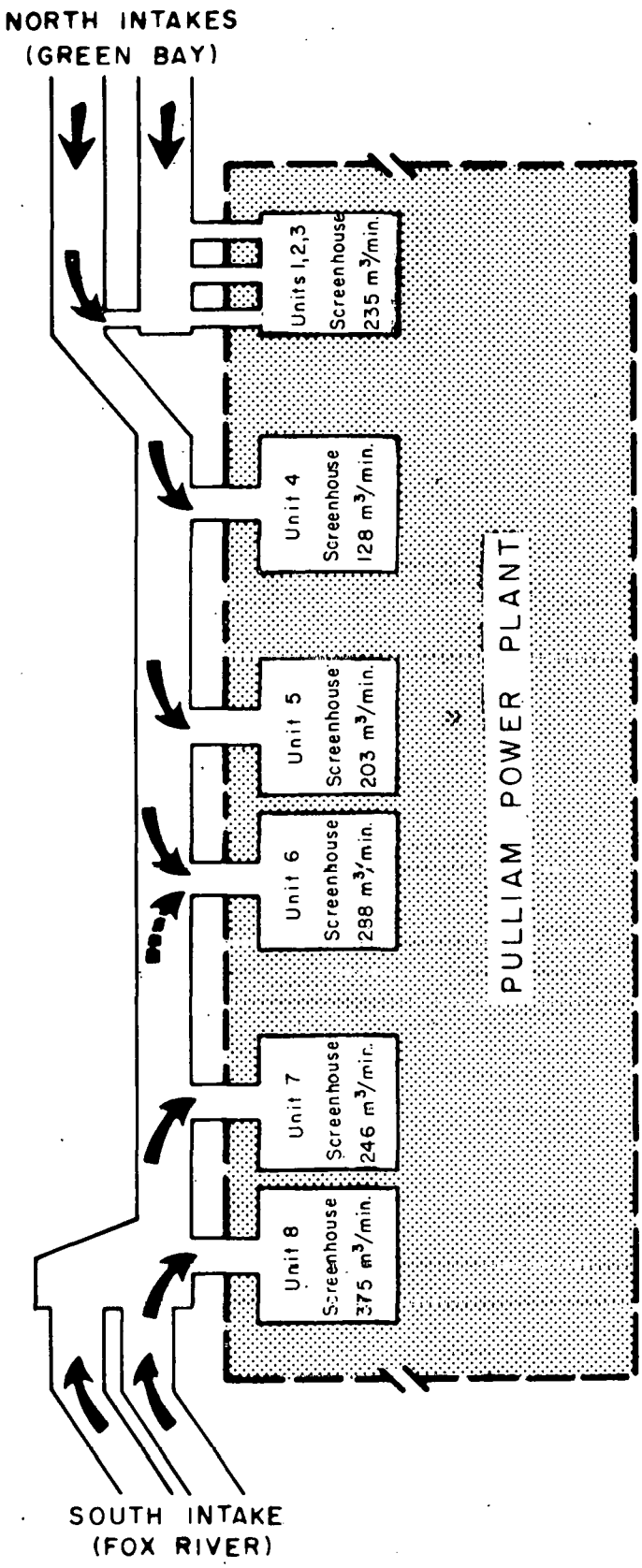


Fig. 2. Schematic Water-Flow Diagram.

Table I. Fishes of Green Bay and the Fox River in the Vicinity of Green Bay, Wisconsin

Lake sturgeon	Bigmouth buffalo
Longnose gar	Shorthead redhorse
Shortnose gar	Silver redhorse
Bowfin	Channel catfish
Alewife	Black bullhead
Gizzard shad	Brown bullhead
Mooneye	Yellow bullhead
Rainbow trout	Stonecat
Brown trout	Trout-perch
Brook trout	Burbot
Lake trout	Brook stickleback
Coho salmon	White bass
Chinook salmon	Largemouth bass
Rainbow smelt	Smallmouth bass
Northern pike	Bluegill
Muskellunge	Pumpkinseed
Carp	Green sunfish
Spottail shiner	Longear sunfish
Emerald shiner	Rock bass
Common shiner	Black crappie
Golden shiner	White crappie
Fathead minnow	Yellow perch
Quillback	Walleye
White sucker	Sauger
Longnose sucker	Logperch
	Johnny darter
	Freshwater drum

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Yellow Perch	Black Bullhead	Total
1975	9	514,295	100,366	29,101	664,734
1976	3	0	13,506	1,235	12,335

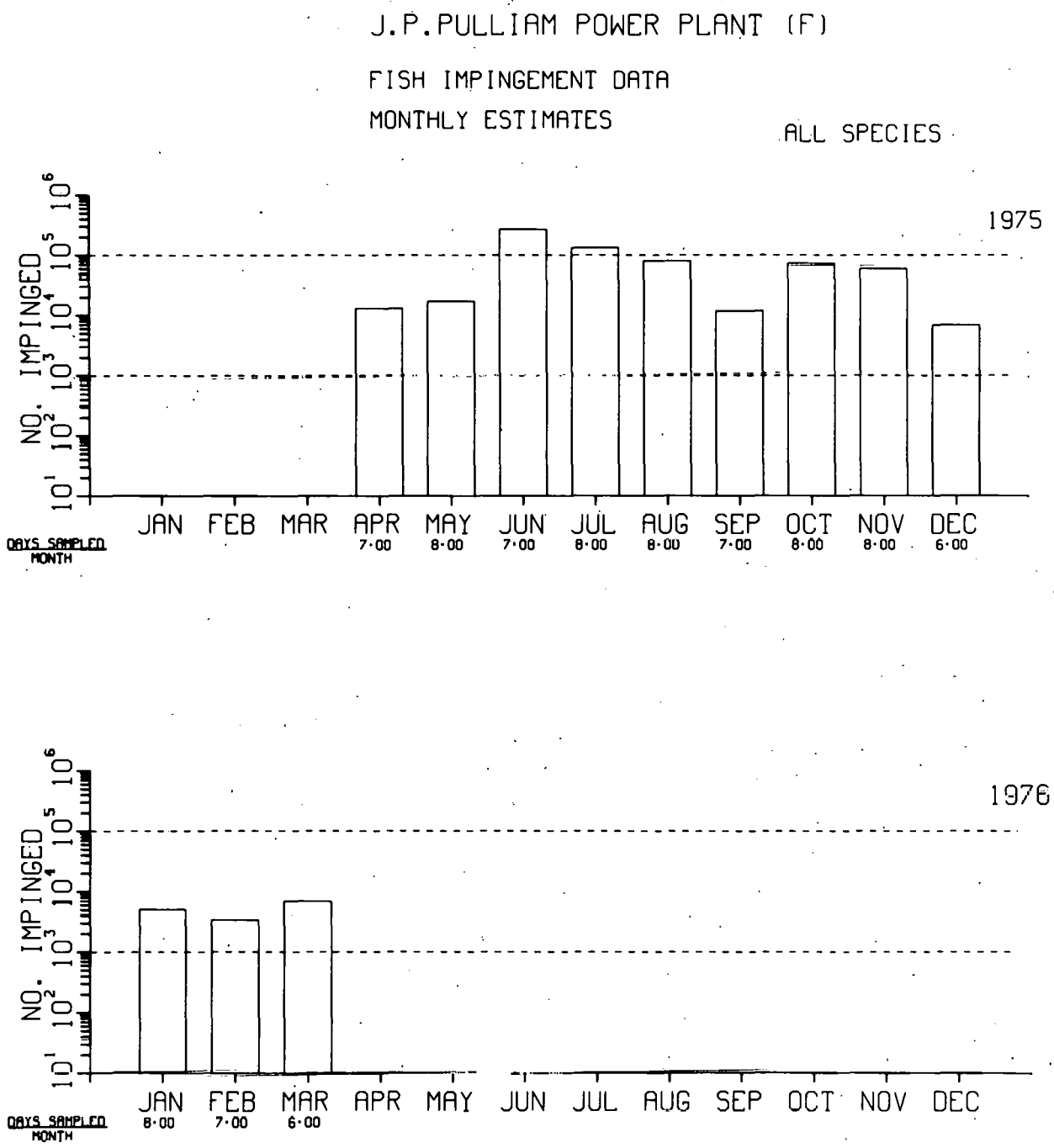


Fig. H1. Impingement Estimates.

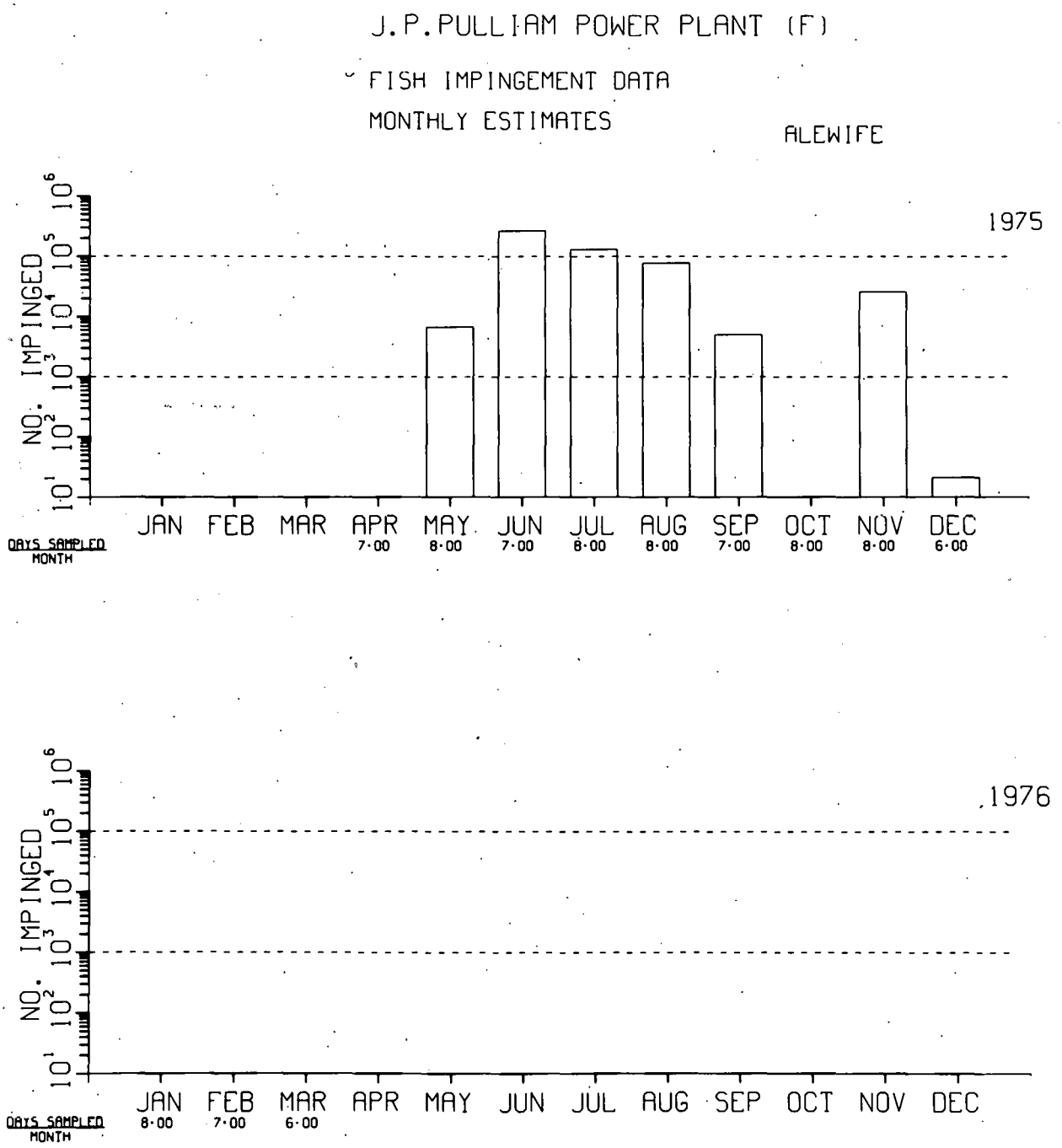


Fig. H2. Impingement Estimates.

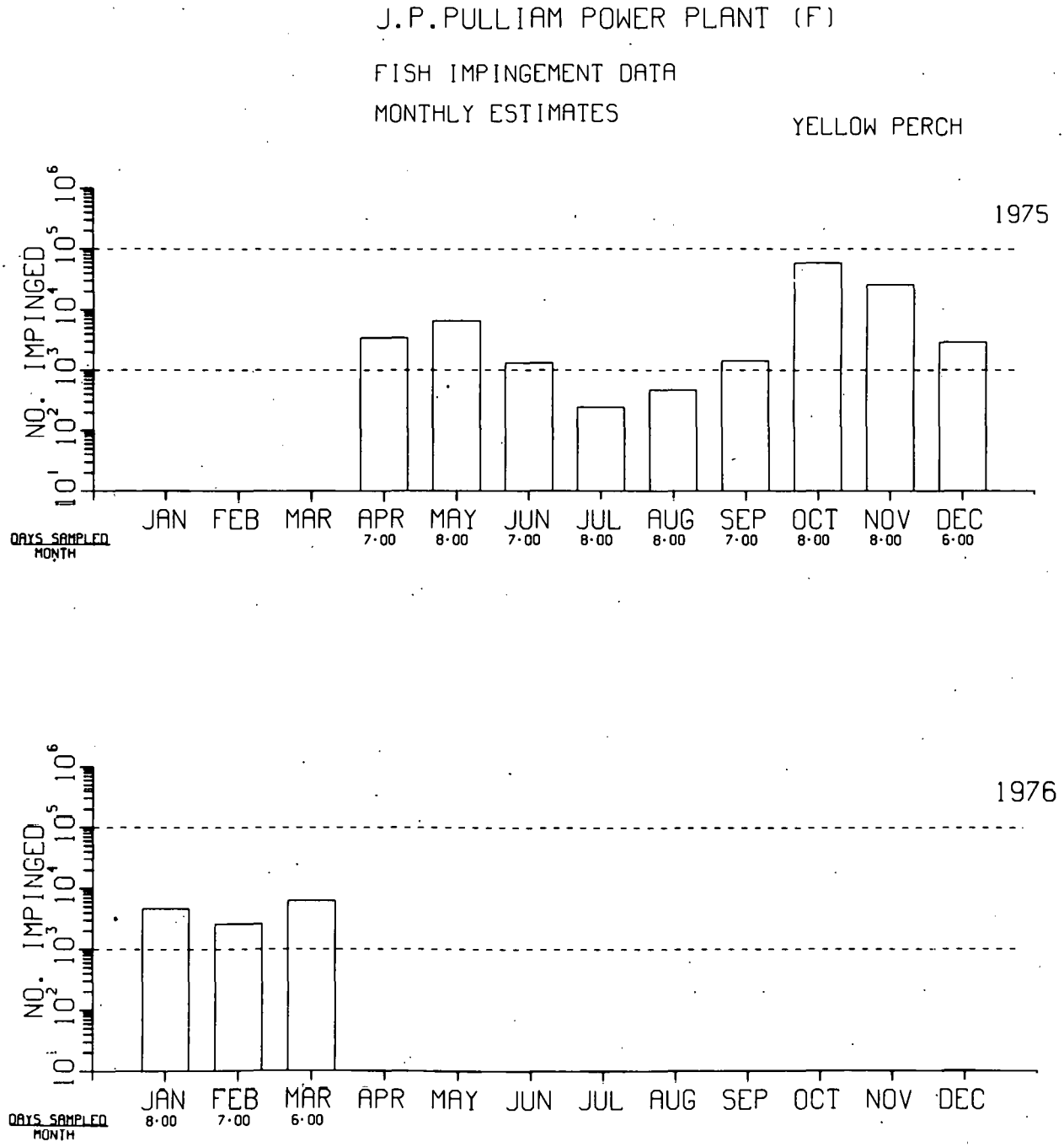


Fig. H3. Impingement Estimates.

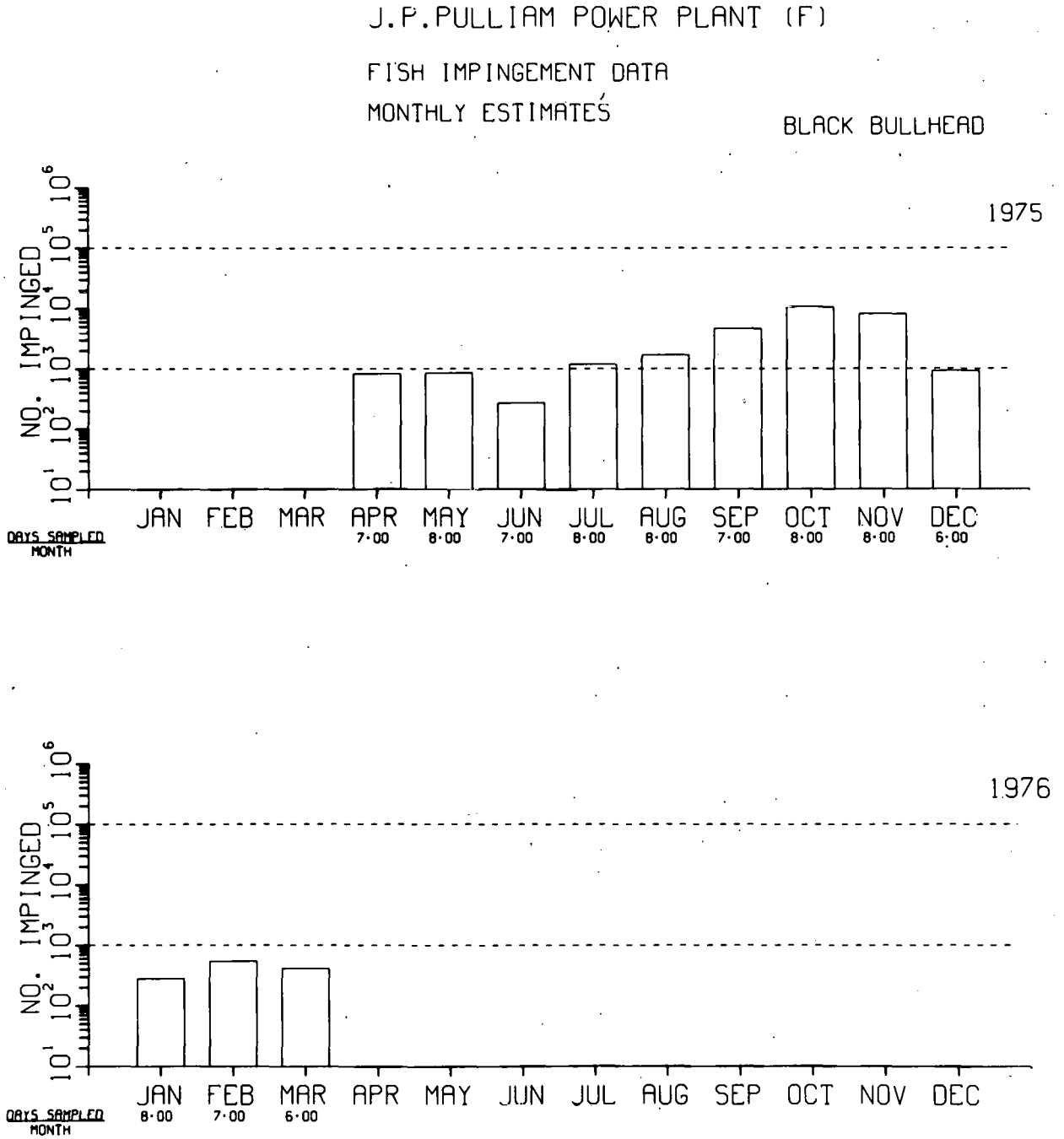


Fig. H4. Impingement Estimates.

KEWAUNEE NUCLEAR POWER PLANT (N)

SITE CHARACTERISTICS

The Kewaunee Nuclear Power Plant is located in east-central Wisconsin, on the west-central shore of Lake Michigan (Fig. 1).[1] The site occupies 907.57 acres. The shoreline along most of the site is characterized by steep, unstable bluffs. A short stretch of coastline with moderately flat, stable slopes is found near the center of the site and is protected from active erosion by a promontory extending into the lake.

In the area of the Kewaunee Plant, Lake Michigan is characterized by a shallow, gently sloping bottom. Fifteen hundred feet offshore at the water-intake site, water depth is only 15 feet; at a distance of 6000 feet offshore, water depth averages about 30 feet. The bottom sediments in the site region consist primarily of hard red clay with an overlay of fine to medium sand. There is heavy erosion of the shoreline in the general area of the site, and as a consequence there is little to no emergent vegetation along the shore and lake bottom.

Lake current patterns differ in the near-shore areas from the stronger currents that occur generally beyond the 30-foot depth contour. Seasonal water temperatures in the near-shore area range from near freezing in winter to 70°F in late August and September. Although a general warming trend occurs during summer, large fluctuations in water temperature occur within a period of a few days. These fluctuations are due to cold-water upwellings resulting when warmer surface waters are blown offshore. In general, the inshore areas (to a depth of about 30 feet) have greater temperature changes during the summer and early fall than do offshore areas. Good mixing in the near-shore areas is indicated by similar temperatures at different depths.

Table I is a species list of fish present in Lake Michigan in the vicinity of the Kewaunee Nuclear Power Plant.

PLANT DESCRIPTION

The Kewaunee Nuclear Power Plant has a pressurized water reactor designed to produce 540 MWe net. Condenser cooling water is supplied by a once-through cooling system.

INTAKE DESIGN AND OPERATION

The intake structure is located about 1600 feet from the shore where the lake depth is 15 feet. The inlet structure consists of three inverted cones

with 22-foot-diameter openings located one foot above the lake bottom. At full flow, the velocity at the intake mouth is about 0.9 fps. Water moves downward where the tapering of the cone is such that the velocity increases to about 11 fps within six feet, at which point the water enters a six-foot-diameter pipe for each cone. The three water inlets are connected to a single 10-foot-diameter pipe that connects to the screenhouse on shore. The three cones are 40 feet apart. The openings of the intake cones are protected with a metal grid with 12-inch-square openings, and an air-bubble screen around each of the cones.

The six-foot-diameter and 10-foot-diameter pipes are buried a minimum of three feet below the lake floor and coated inside and outside with asphaltum. The forebay water passes through four traveling screens (in parallel) with a mesh size of 3/8 inch.[2] The screen is rotated upward in a plane normal to the waterflow direction. The shelves are backwashed automatically, the debris being sluiced to a strainer basket, where it is collected and eventually removed for onsite burial. While the circulating-water pumps are operational, the water surface level in the basin is liable to be many feet below the lake surface level, which allows lake water to be drawn into the intake system by gravitational flow.

During the winter, to control ice formation within the system, the circulation flow is reduced to 287,000 gpm with a rise in temperature of the cooling water of about 29°F. Under this mode of operation, a portion of the discharge water is returned to the intake via a 10-inch recirculation line (Fig. 2). The normal flow rate at the main condenser is 413,000 gpm.[2]

IMPINGEMENT SAMPLING

Prior to 1 January 1975, the strainer basket was emptied whenever it became full. The contents were then sorted and the fish were identified, counted, and weighed. From 1 January to 1 April 1975, fish were identified, counted, and weighed on a daily basis. Sampling was conducted from two to seven days per week from 1 April 1975 through 31 March 1976.

DATA AVAILABILITY

Fish impingement data for the Kewaunee Nuclear Power Plant are currently available for all of 1974 except February, and January 1975 through March 1976.

IMPINGEMENT DATA SUMMUARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the Kewaunee Nuclear Power Plant. These totals are summarized in Table II. The source of data for 1974 and the first six months of 1975 was the NRC. A 316(b) study provided the remainder of the data.[3]

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

In order to discourage fish from entering the intake system at Kewaunee, an air-bubble screen has been installed around each intake cone. A value of 50% effectiveness for the screen has been assumed by the utility,[1] i.e. of the standing fish population around the inlet, one-half would avoid entering the intake as a result of its effectiveness.

REFERENCES

1. Summary of Recent Technical Information Concerning Thermal Discharges into Lake Michigan. Argonne National Laboratory, Center for Environmental Studies and Environmental Statement Project, Argonne, Illinois. August 1972.

2. "Final Environmental Statement for Kewaunee Nuclear Power Plant." USAEC Directorate of Licensing. Docket No. 50-305. December 1972.

3. "Section 316(b) Intake Study for Kewaunee Nuclear Power Plant," Nalco Environmental Sciences, Northbrook, Illinois. 1976.

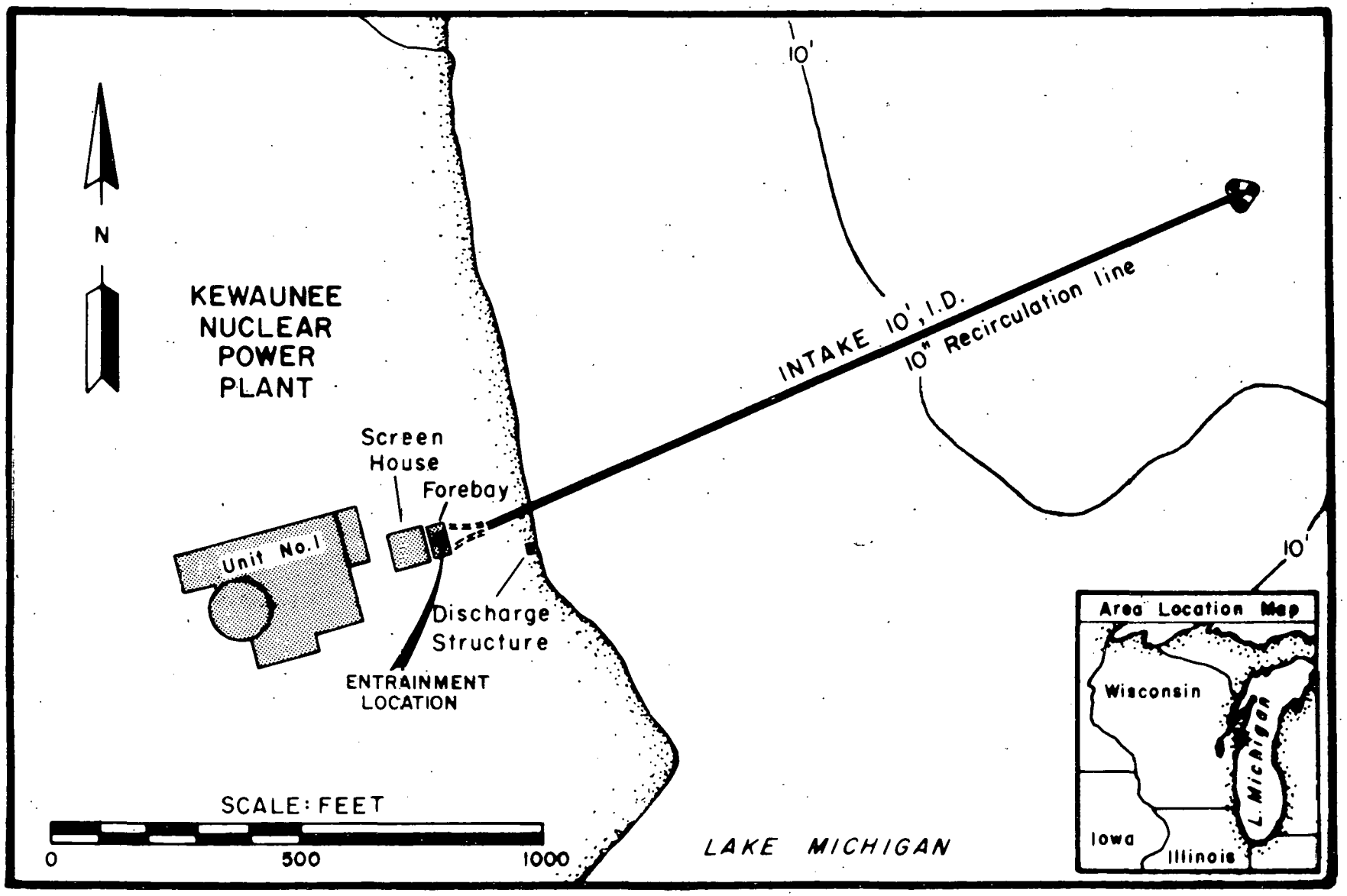


Fig. 1. Plant Location.

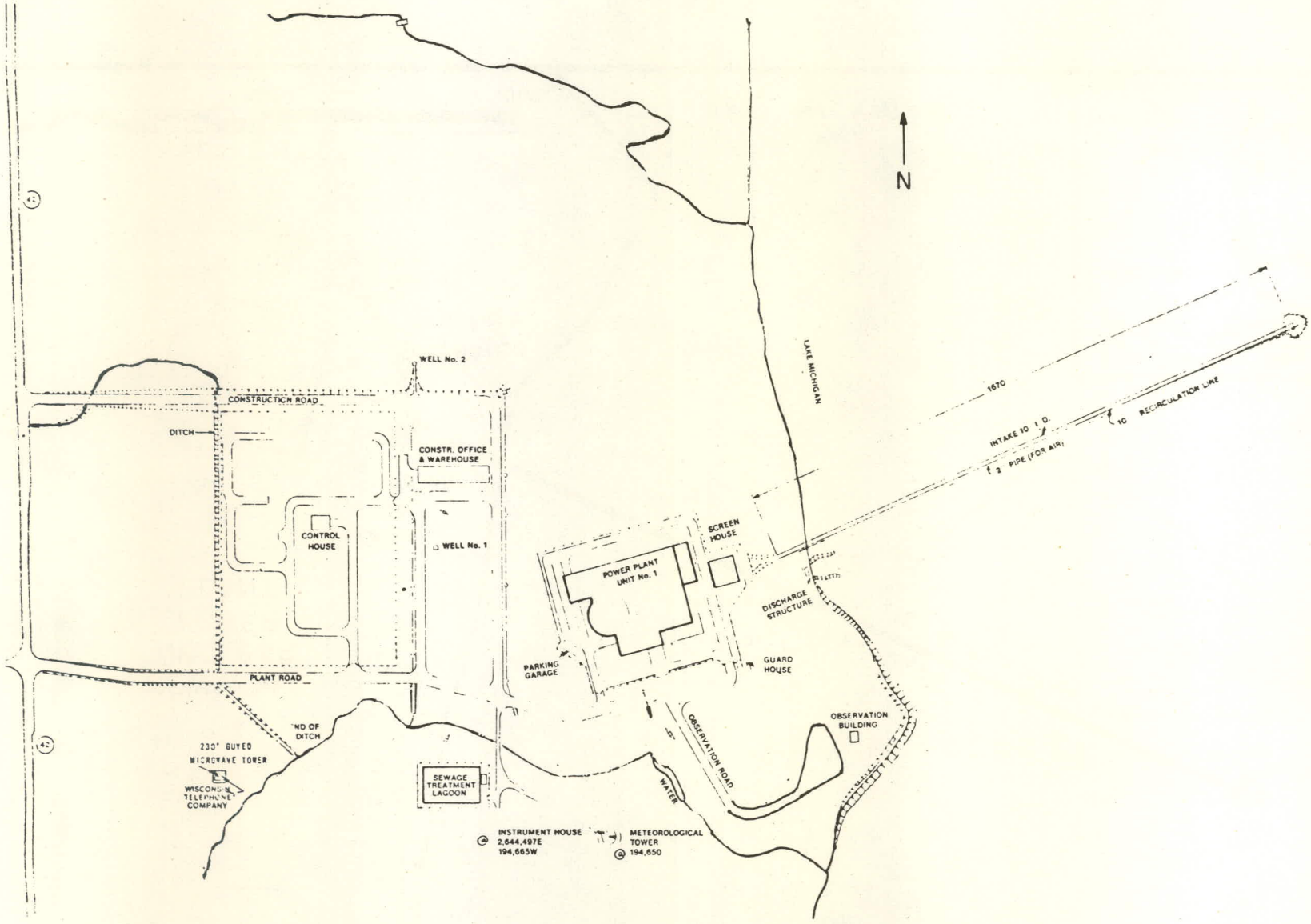


Fig. 2. Facilities Layout.

Table I. Fish Species in Lake Michigan near the Kewaunee Site

Alewife	White sucker
Rainbow smelt	Longnose dace
Lake trout	Spottail shiner
Brook trout	Fathead minnow
Rainbow trout	Lake chub
Bloater	Coho salmon
Round whitefish	
Slimy sculpin	
Yellow perch	
Longnose sucker	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Rainbow Smelt	Sucker	Total
1974	11	446,821	309,109	308	757,540
1975	12	179,907	16,146	1,048	210,479
1976	3	18	4,808	49	7,474

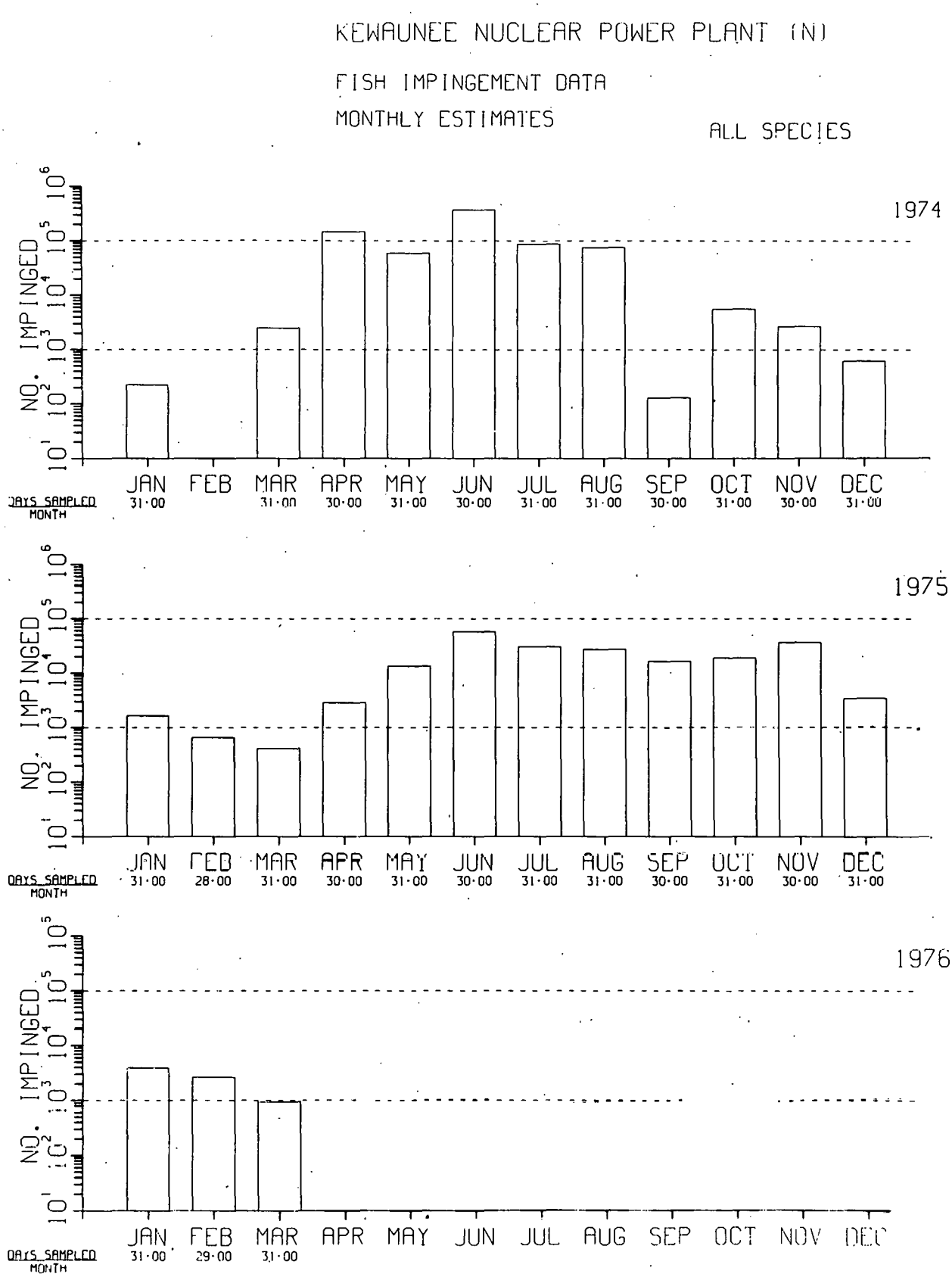


Fig. H1. Impingement Estimates.

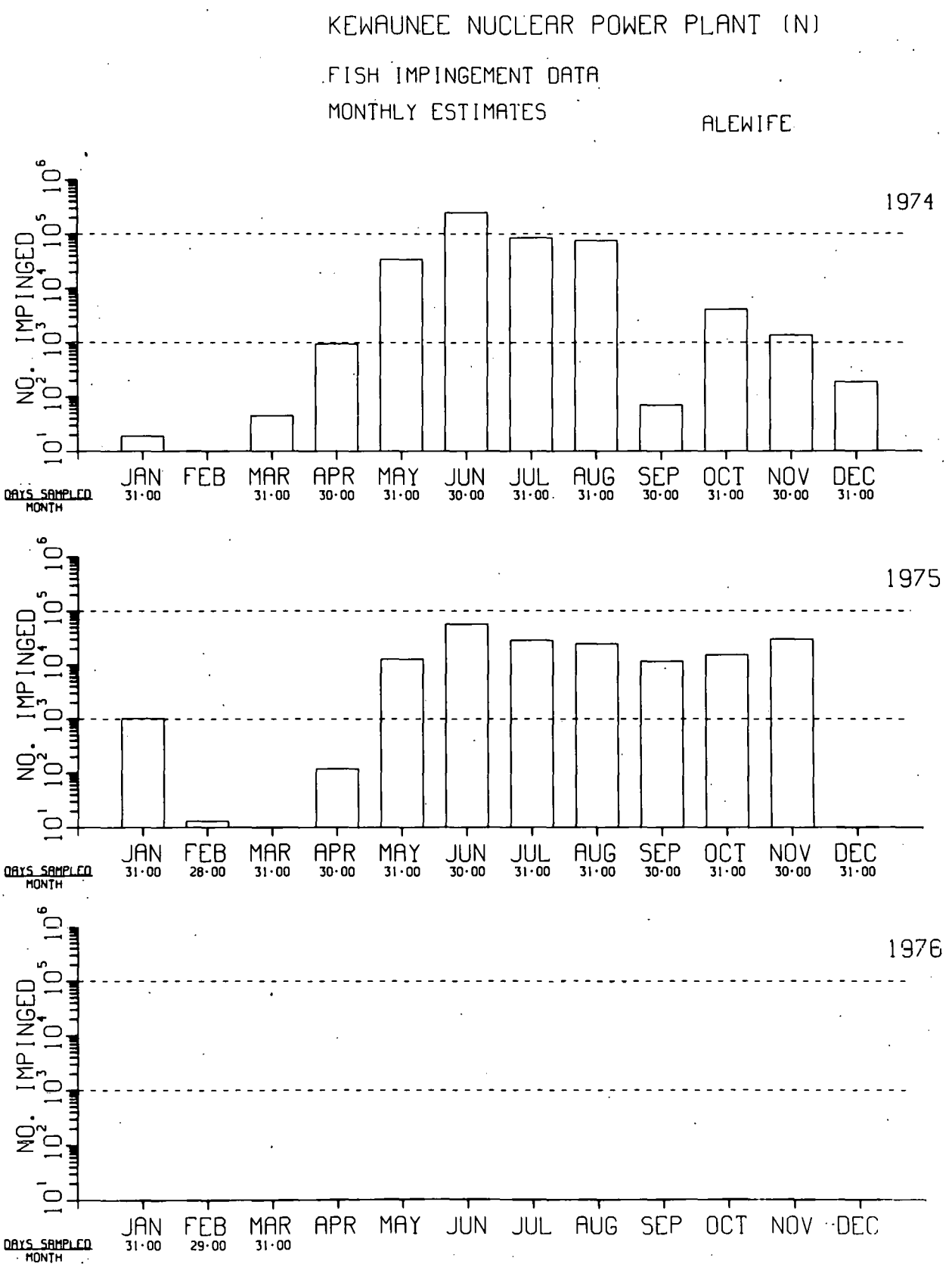


Fig. H2. Impingement Estimates.

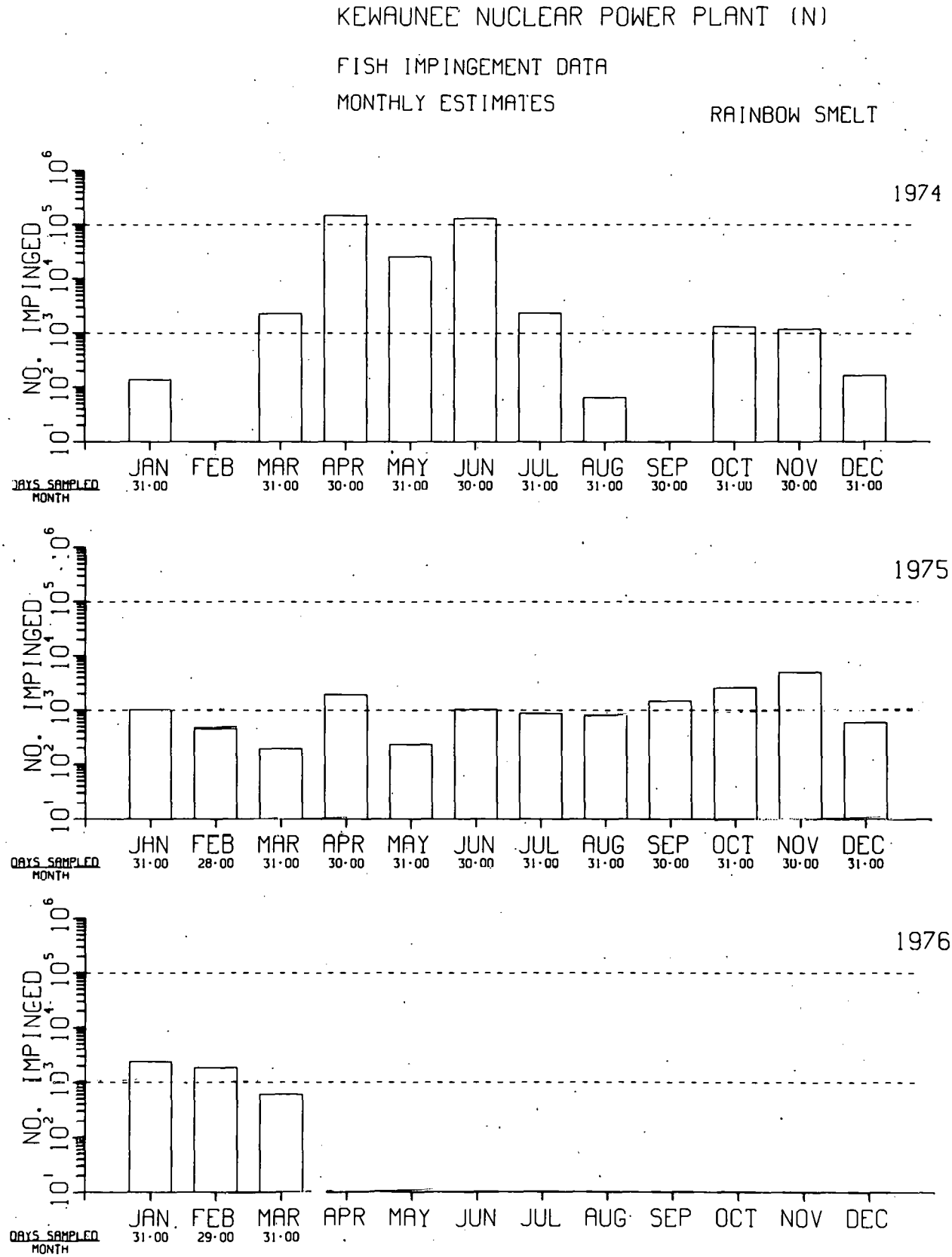


Fig. H3. Impingement Estimates.

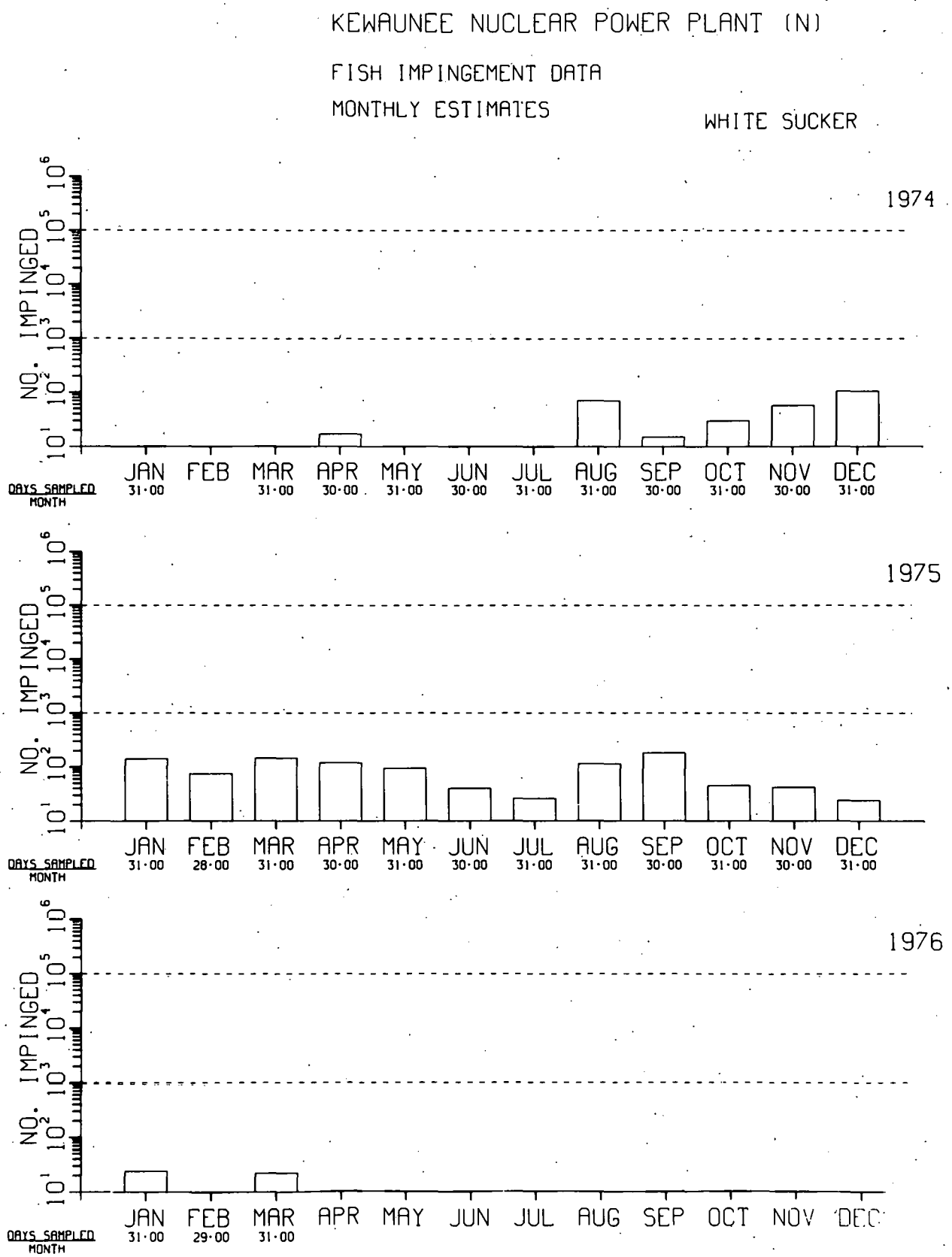


Fig. H4. Impingement Estimates.

POINT BEACH NUCLEAR PLANT (N)

SITE CHARACTERISTICS

The Point Beach Plant is located on the western shore of Lake Michigan about 30 miles southeast of Green Bay and about 90 miles north of Milwaukee, Wisconsin.[1] The site comprises 2065 acres extending about three miles parallel to the lakeshore (north-south) and about one mile inland.

The lake bottom has a gentle slope in the vicinity of the site. The progression of depth contours is uniform and 30-feet and 60-feet depths are reached at one to 1-1/2 miles and three to four miles offshore, respectively. As a result of extremes in climate, shoreline water temperatures are highly variable. During the winter, the lake surface is covered with floating block ice and the lake is stratified with colder, less dense water near the surface. During the summer months, surface-water temperatures rise to about 70°F (near equilibrium for this region). At this time stratification also occurs, the temperatures below the 10- to 50-foot depth remaining at about 50°F.

During the summer months of May through July, alewives are the most abundant fish in the beach zone. Carp are most commonly observed in the vicinity of the site. Smallmouth bass have been reported in the discharge flume, but trout and salmon, though abundant in the area, have not been observed near the discharge channel during the high-temperature period (> 72°F). A list of fishes collected at the intake screens is given in Table I.

PLANT DESCRIPTION

The plant consists of two identical pressurized water reactors, each to generate about 495 MWe net. The plant utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

The intake structure for the two units is located 1750 feet offshore at the 22 foot depth (Figs. 1 and 2). The intake structure--steel piling filled with limestone blocks--is in the form of a hollow cylinder (dike) standing upright on the lake bottom (Fig. 3). It has an outside diameter of 110 feet and an inside diameter of 60 feet. The top protrudes about 6.3 feet above the high-water level of the lake. Figure 3 shows the limestone blocks to be closely fitted, but in reality, they are staggered and somewhat more randomly oriented in the dike frame, with void spaces around them. There are 38 pipes, each with a 30-inch diameter, that penetrate the blocks in a ring at an elevation of five feet above the lake bottom. The outer ends of the pipes are covered with a bar grating having spacings of 1-3/16 by two inches to prevent

large fish or debris from entering the dike structure. Two 14-foot-diameter pipes buried beneath the lake bed connect the offshore dike structure to the intake bay located on shore. The intake bay has bar racks with two-inch spacings. For each of the two units, there are four vertical traveling screens with 3/8-inch wire mesh and two circulating-water pumps. Each traveling screen is 9.5 feet wide.

Water enters through the porous-dike structure and the 30-inch-diameter pipes located near the bottom of the structure at the rate of 770,000 gpm. After flowing to the onshore bay through the two 14-foot-diameter pipes, it passes through the bar racks and the traveling screens to the circulating-water pumps. Periodically, debris and fish are washed off the screens and sluiced into a strainer basket for counting and disposal. A common sluiceway returns wastewater to the Unit 2 discharge flume.

The intake velocity in the system at various locations is estimated to be as follows:

Interstices in the porous dike -- not measurable
30-inch diameter pipes in the porous dike -- 2 fps
Intake pipes (offshore to shore) -- 5.4 fps
Intake pipes (offshore to shore, winter) -- 6.4 fps
Traveling screens -- 1.1 fps

Because the intake water is drawn from the lower depths of the lake, it is often about 15°F cooler than the surface water. During winter, or whenever the intake-water temperature falls below 40°F, 108,000 gpm of the discharge water from either unit can be recirculated to the intake structure to prevent the formation of ice. This is accomplished by reversing the flow in one of the 14-foot-diameter intake pipes. At such times, the other pipe will maintain a higher intake flow of 428,000 gpm. Only one circulating-water pump is used on each unit during the recirculating mode of operation. Discharge and recirculation valves are positioned to maintain a minimum inlet-water temperature of about 40°F.

IMPINGEMENT SAMPLING

The traveling screens were rotated for 30 minutes during each eight-hour shift. For one shift per day (shift selected randomly for each day) a basket with openings of about 3/4-inch was installed in the bypass canal. All fish collected in this basket were identified and counted by species. On Wednesday of each week, regardless of shift, all of the fish in the basket were preserved and later identified, weighed, and measured. Effective 20 February 1975, the program has been designed to collect fish on every fourth day of plant operation for 24 hours or less each time.[2]

DATA AVAILABILITY

Fish impingement data are available for May through December 1973, all of 1974, and January through October 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Point Beach Nuclear Plant. Table II summarizes these totals.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The offshore intake with a porous dike acts as a barrier to fish. However, entrapment of fish in the structure cannot be completely avoided due to the use of the 30-inch-diameter pipes near the bottom of the dike.

REFERENCES

1. "Final Environmental Statement for Point Beach Nuclear Plant Units 1 and 2." USAEC Directorate of Licensing. Docket Nos. 50-266 and 50-301. May 1972.

2. First Quarterly Report - Intake Structure Monitoring Program - Point Beach Nuclear Plant. Wisconsin Electric Power Company. Milwaukee, Wisconsin. May 1975.

Fig. 1. Aerial View of Plant and Intake Well.

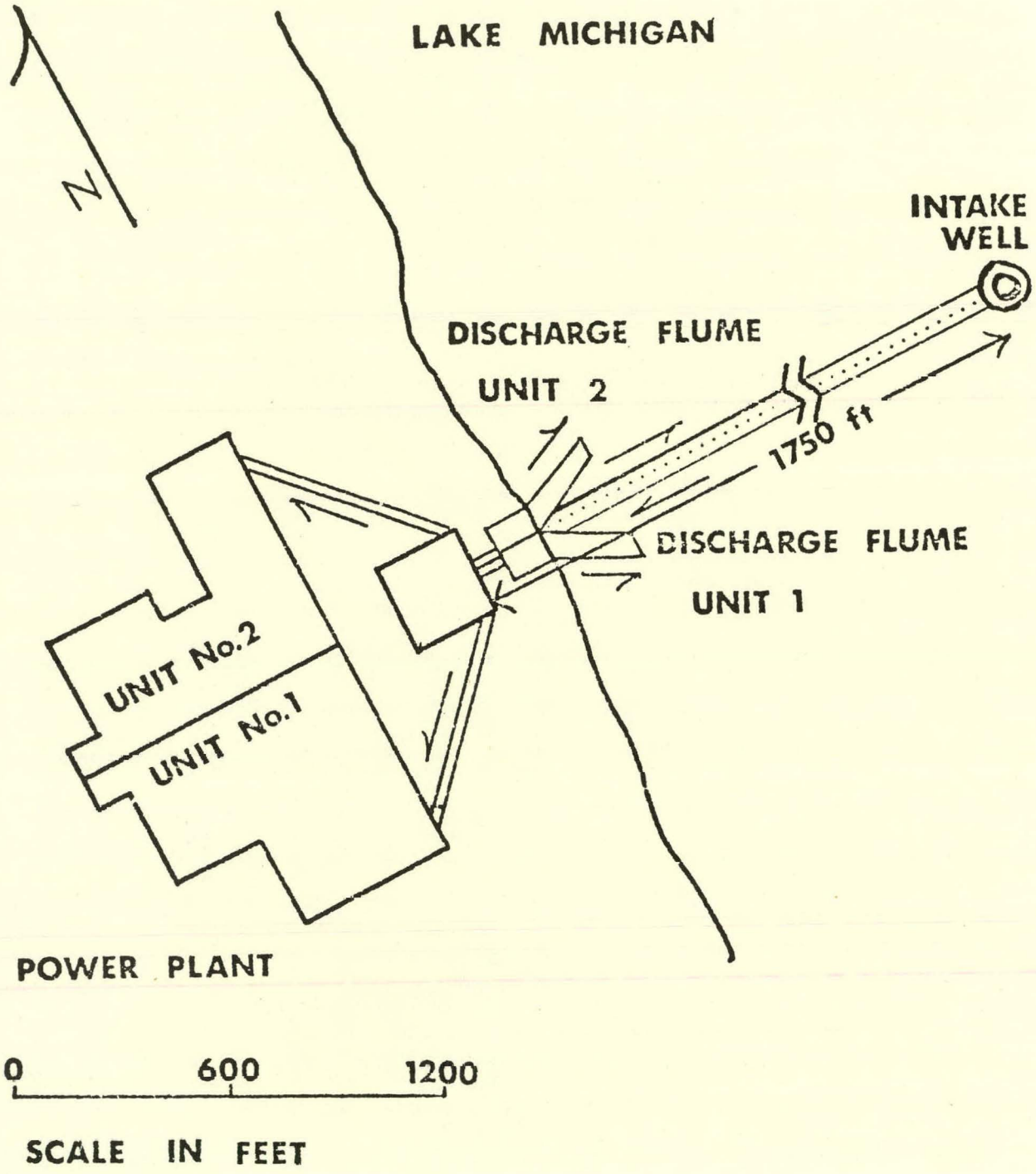


Fig. 2. Plan View Showing Intake and Discharge.

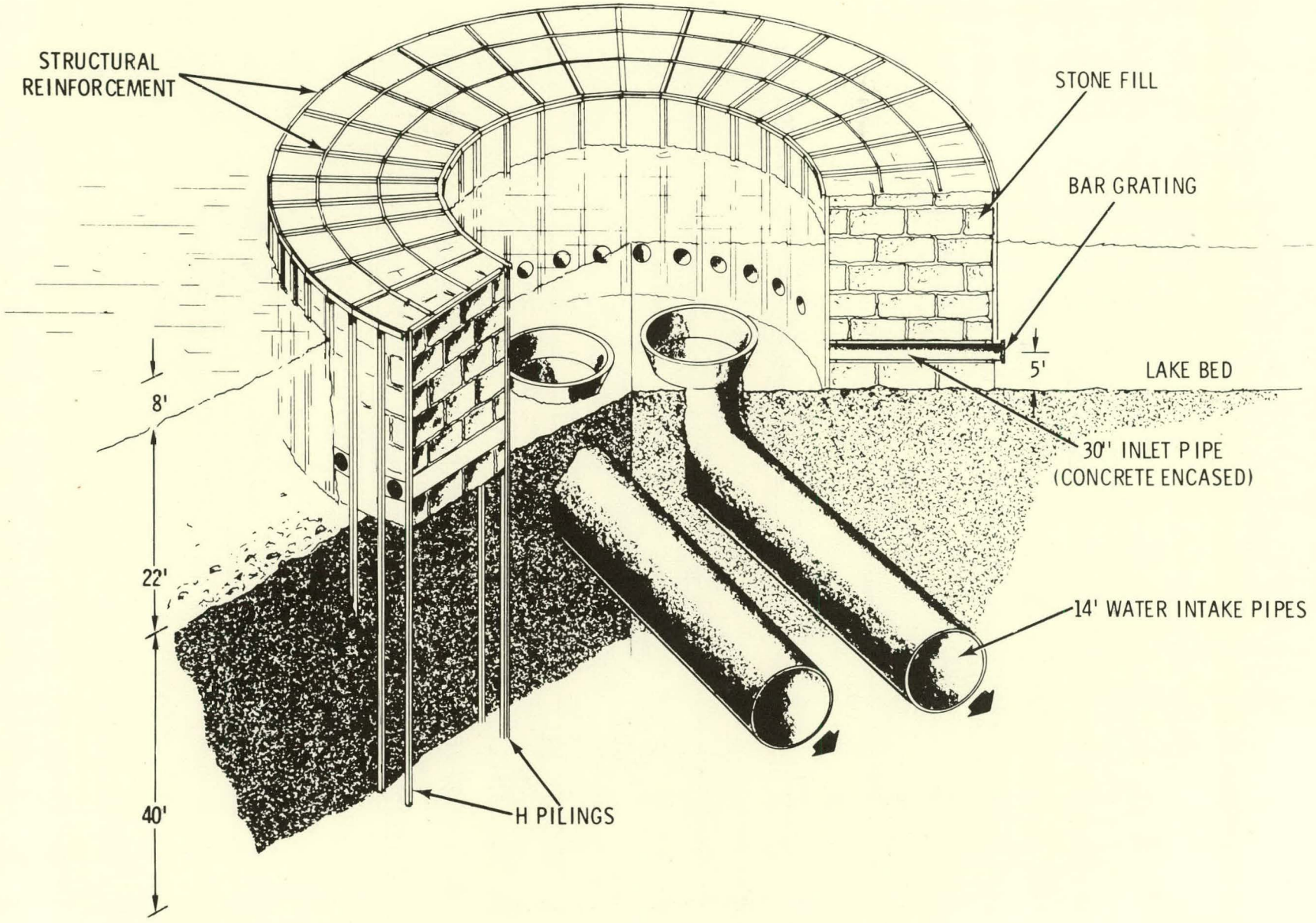


Fig. 3. Intake Structure.

Table I. Fish Species Collected at the Intake Screens

Rainbow smelt	Lake whitefish
Slimy sculpin	Lake trout
Yellow perch	Lake chub
Black bullhead	Longnose sucker
Gizzard shad	Largemouth bass
Rainbow trout	
White sucker	
Brown trout	
Coho salmon	
Carp	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Rainbow Smelt	Yellow Perch	Total
1973	8	268,628	30,467	914	301,106
1974	12	185,189	2,399	176	188,194
1975	10	703,912	19,133	104	725,275

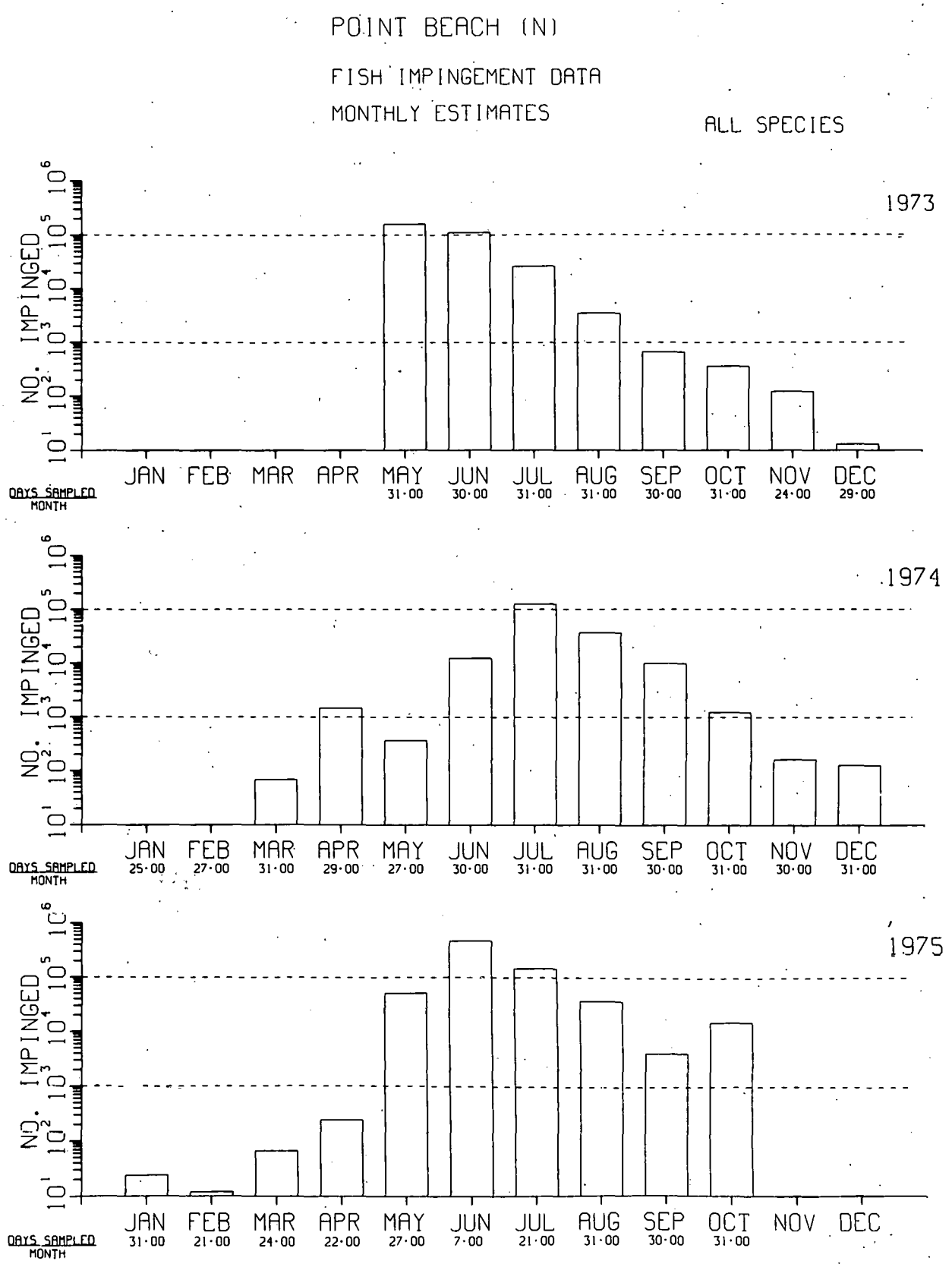


Fig. H1. Impingement Estimates.

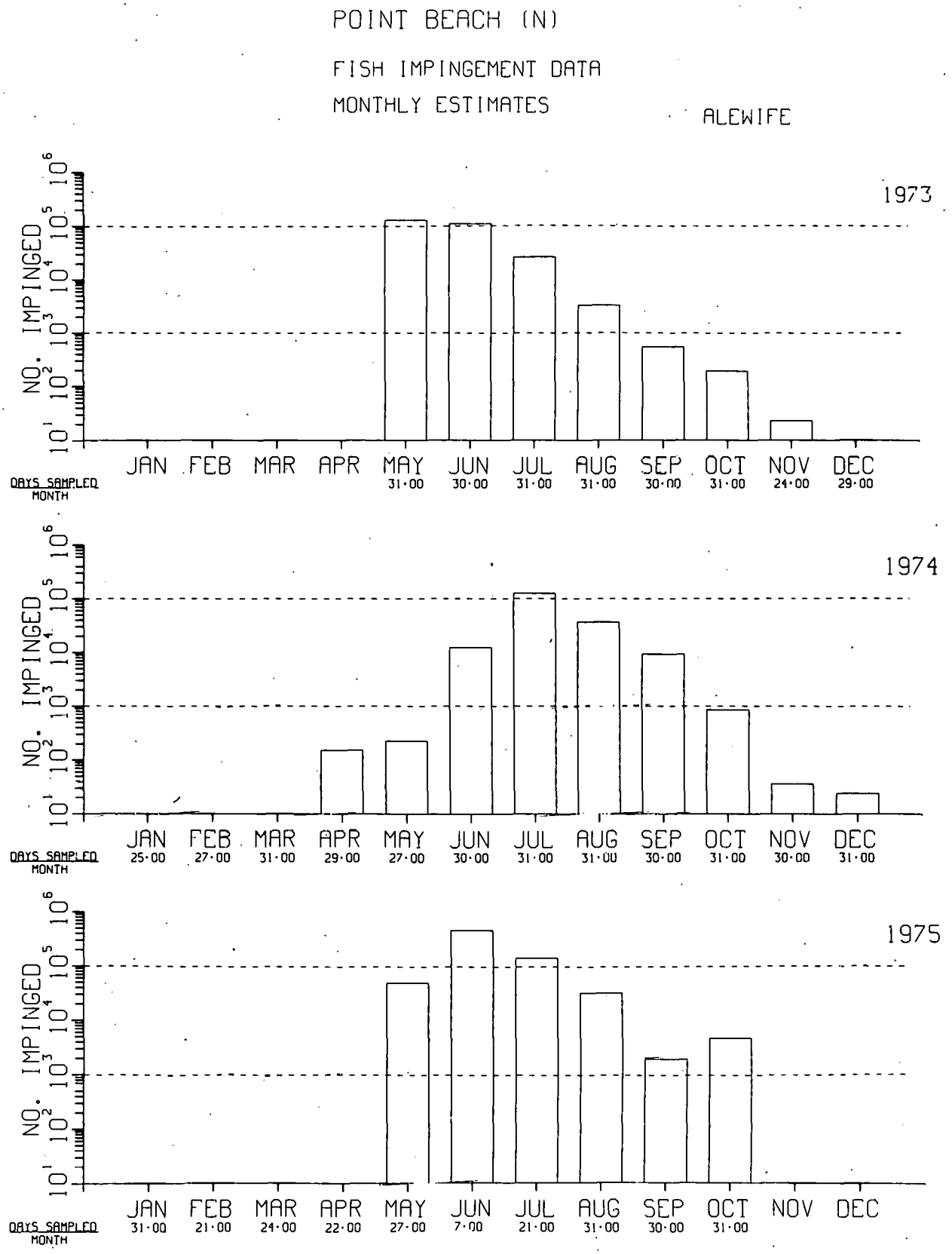


Fig. H2. Impingement Estimates.

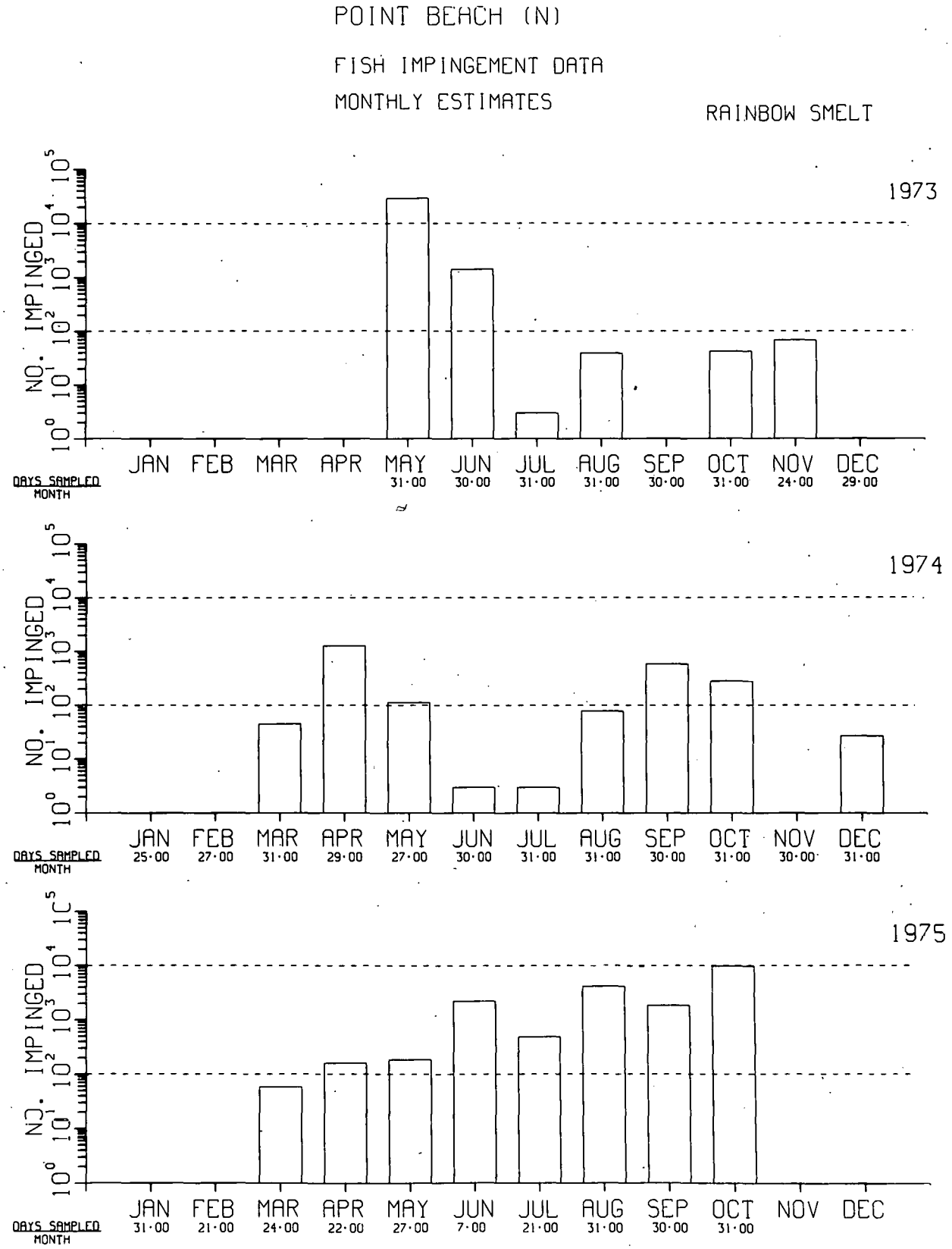


Fig. H3. Impingement Estimates.

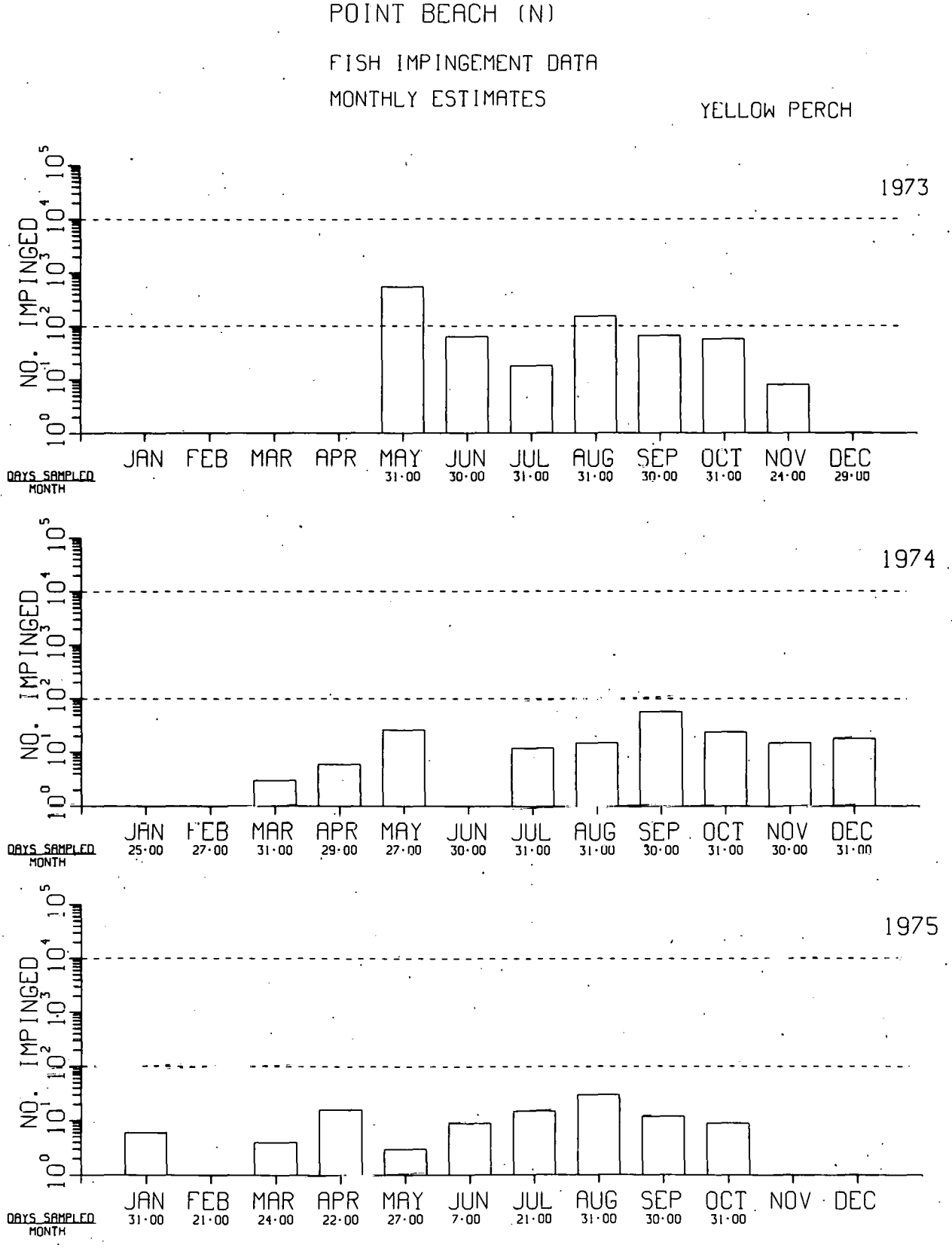


Fig. H4. Impingement Estimates.

PORT WASHINGTON POWER PLANT (F)

SITE CHARACTERISTICS

Port Washington Power Plant is situated on the western shore of Lake Michigan in the city of Port Washington, Wisconsin. Table I is a list of fishes found in the vicinity of the plant. At the time of this report, a description of the site in terms of aquatic habitat was not available.

PLANT DESCRIPTION

Port Washington Power Plant is a fossil-fueled facility consisting of five units, each rated at 80 MWe. Water for condenser cooling is withdrawn from Lake Michigan and the heated effluent is discharged to Port Washington Harbor.[1]

INTAKE DESIGN AND OPERATION

Water is withdrawn from Lake Michigan via an approach channel that extends lakeward for a distance of about 1200 feet, parallel to the south boundary of the coal dock (Fig. 1). The channel is about 75 feet wide and 12 feet deep at its mouth. A recirculation channel extends 300 feet from shore, parallel and adjacent to the intake channel. At the mouth of the recirculation channel, the intake-channel width and depth are reduced to 60 and 9.5 feet, respectively. Near the trash racks, the intake-channel depth increases to 20 feet, but steel-sheet piling reduces the width to 40 feet.

At the mouth of the approach channel, a vertical steel-bar trash rack prevents large debris from entering the intake tunnel. The steel bars are one inch wide with 5.5-inch gaps and extend to the bottom of the tunnel inlet.

The intake tunnel is a rectangular concrete conduit, 10 feet wide and 12 feet high (Fig. 2). The tunnel runs about 350 feet underground, expanding to a width of 65 feet to form a common bay ahead of the vertical traveling screens.

The screenwell contains six identical vertical traveling screens (Fig. 3). The screens are 8.5 feet wide and are built of 3/8-inch-square wire mesh. Debris is removed by a high-pressure (100 psig) wash at the upstream side of the screens.

Deicing is performed by recirculating heated effluent to the approach channel (Fig. 2). For its entire length, the 300-foot recirculation line runs parallel to the approach channel. It is separated from the approach

channel by steel pilings. In winter, 20% to 40% of the cooling water is recirculated to prevent buildup of ice in the approach channel and formation of frazzle ice on the trash racks and traveling screens. Such recirculation is necessary when the ambient lake temperature is below 40°F, which generally occurs from December to April.

Two circulating-water pumps, each with a capacity of 55,000 gpm, are associated with each of the five units. Maximum cooling-water volume is 550,000 gpm.

IMPINGEMENT SAMPLING

Impingement monitoring was scheduled to be performed during one operating day (not more than 24 hours) every week from 1 March 1975 through 29 February 1976. This schedule was met with one exception: debris load prevented sampling in the first week of January. Fifty-one impingement collections were made.

When the total number of smelt or alewife exceeded 100, a random sample of 100 fish was taken. The total weight for the species was divided by the sample weight to obtain an estimate of total number.

DATA AVAILABILITY

Impingement data for the Port Washington Power Plant are available for 3 March 1975 through 25 February 1976.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the Port Washington Power Plant. Table II summarizes these totals.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. Port Washington Power Plant - Intake Monitoring Studies. Wisconsin Electric Power Co. 1 June 1976.

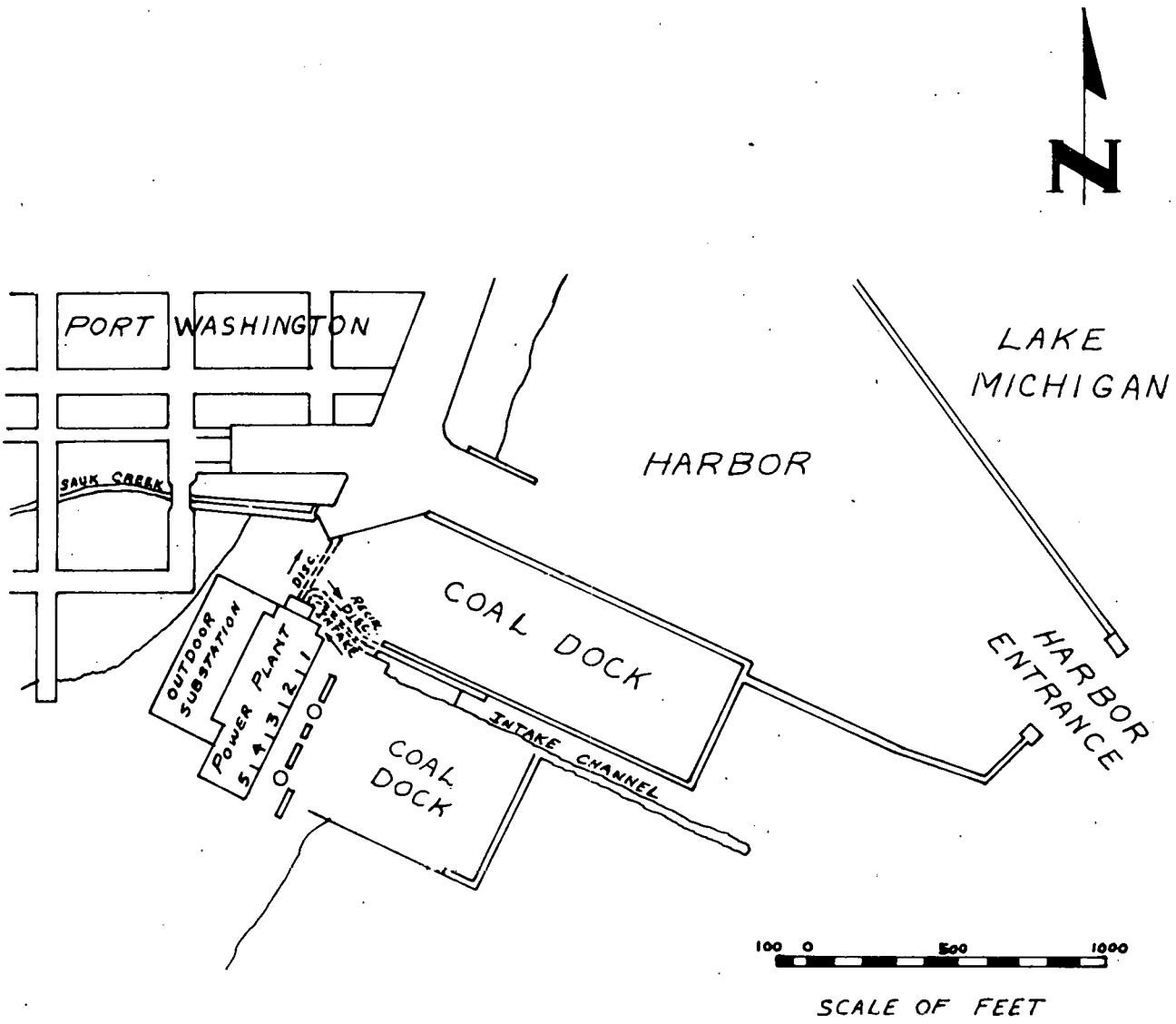


Fig. 1. Plant Layout.

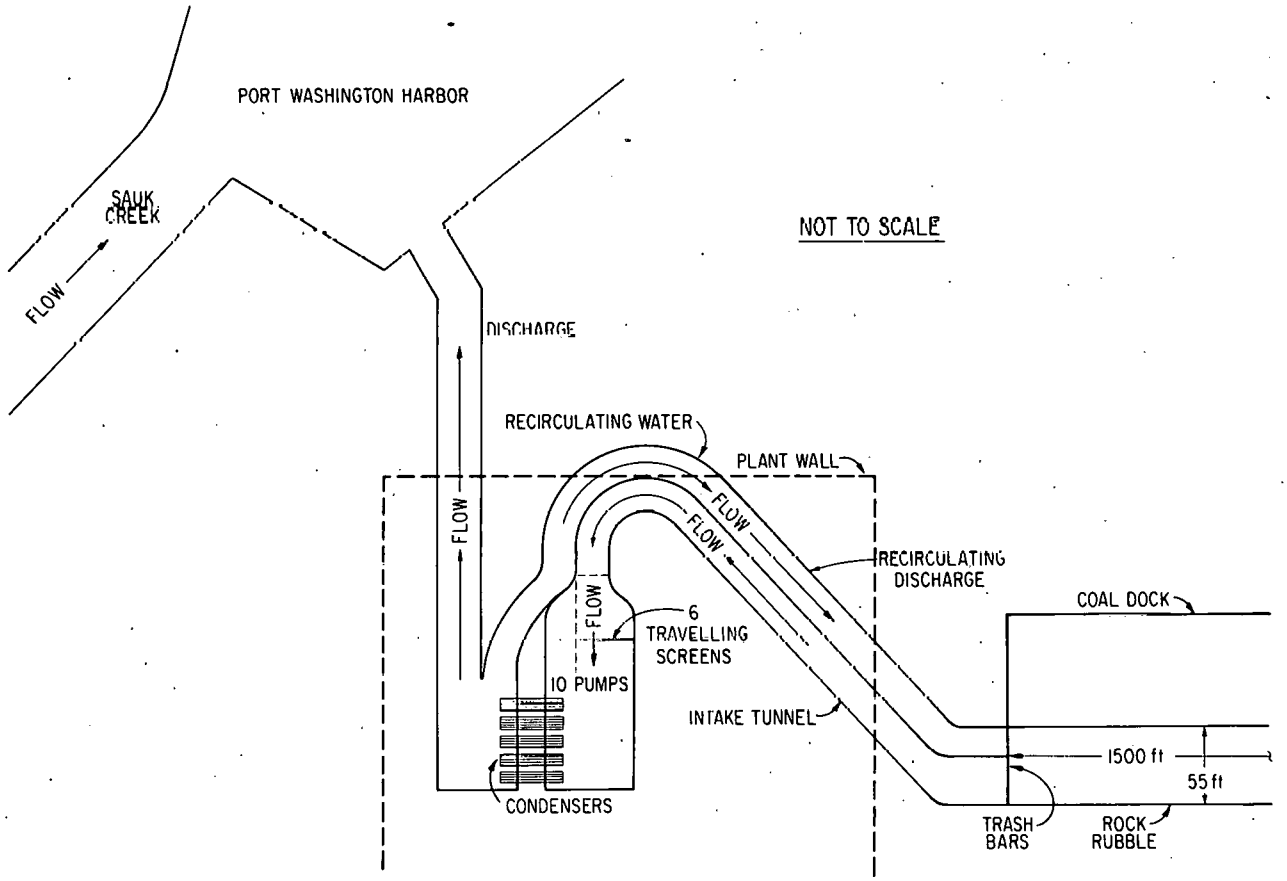


Fig. 2. Schematic of Intake and Discharge Systems.

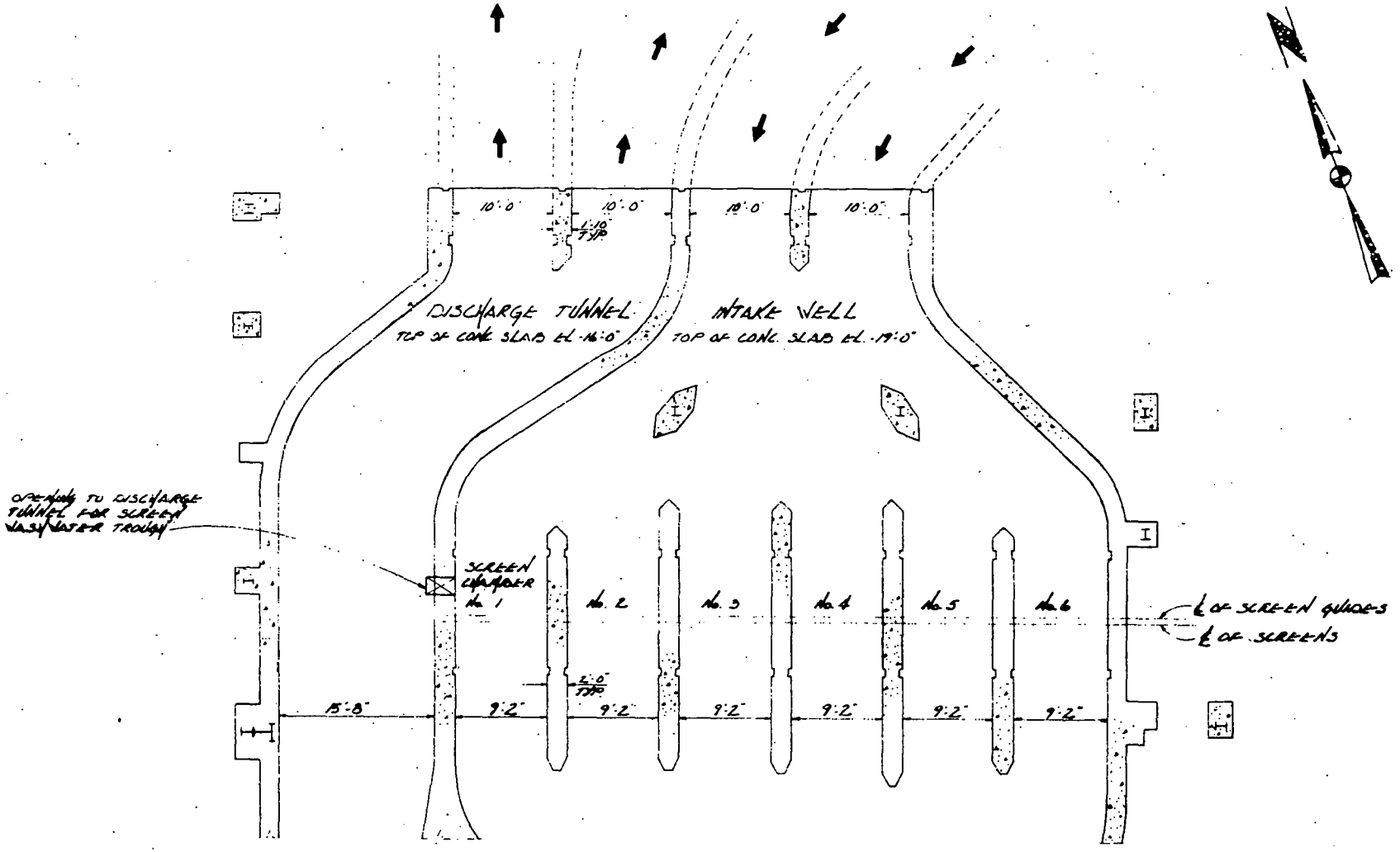


Fig. 3. Intake Screenwell.

Table I. Fishes Found in the Vicinity of the Plant

Rainbow trout	Largemouth bass
Atlantic salmon	Northern pike
Brown trout	Carp
Lake trout	Goldfish
Brook trout	Burbot
Chinook salmon	Shorthead redhorse
Coho salmon	Longnose sucker
Channel catfish	White sucker
Black bullhead	Trout-perch
Brown bullhead	Ninespine stickleback
Yellow bullhead	Brook stickleback
Lake whitefish	Slimy sculpin
Bloater	Longnose dace
Yellow perch	Lake chub
Bluegill	Spottail shiner
Pumpkinseed	Emerald shiner
Green sunfish	Gizzard shad
Black crappie	Johnny darter
White crappie	Creek chub
Rock bass	Fathead minnow
	Alewife
	Rainbow smelt

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Rainbow Smelt	Brown Trout	Total
1975	10	2,849,331	91,912	2,659	2,975,407
1976	2	721	928	70	2,691

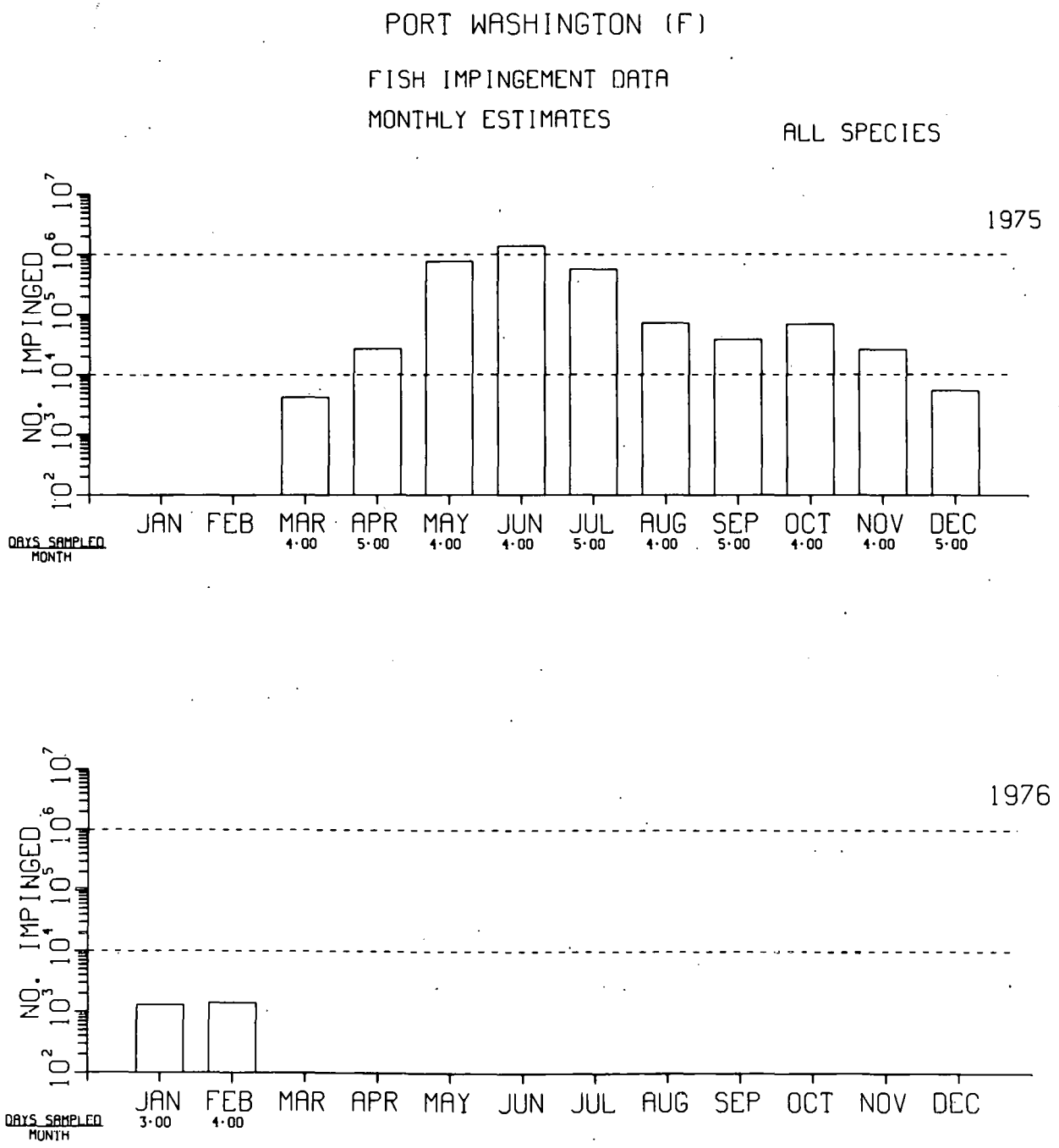


Fig. H1. Impingement Estimates.

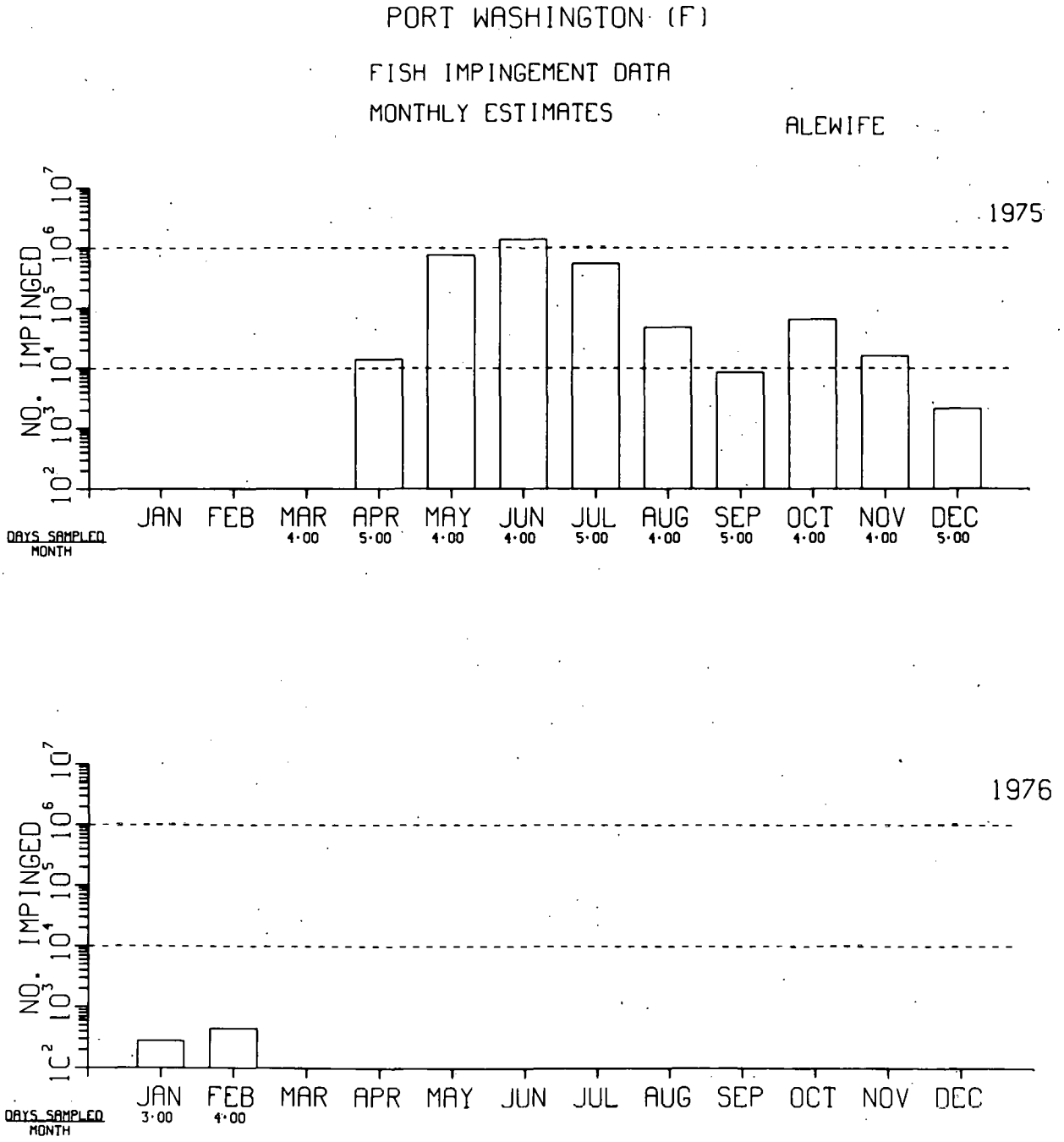


Fig. H2. Impingement Estimates.

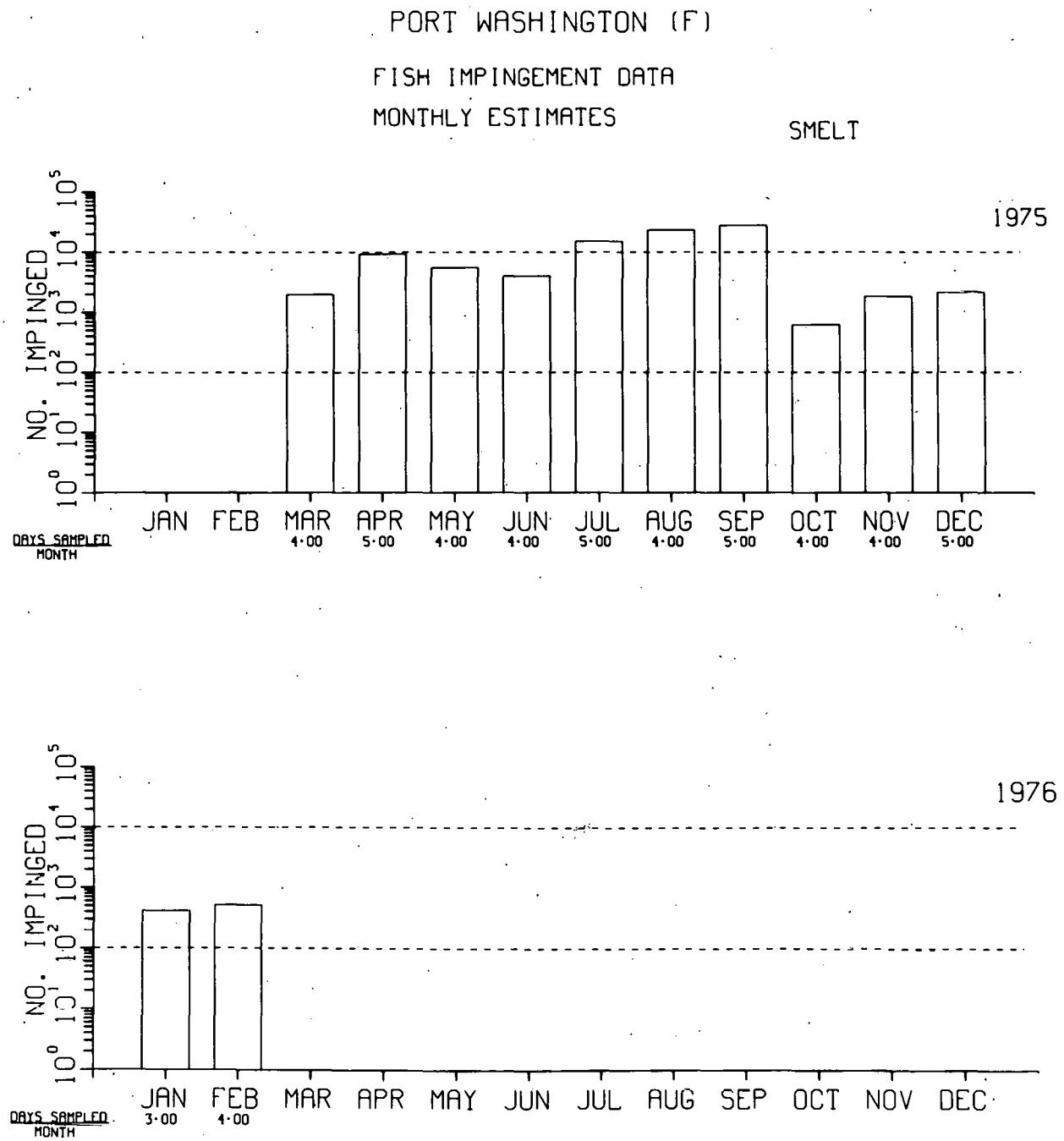


Fig. H3. Impingement Estimates.

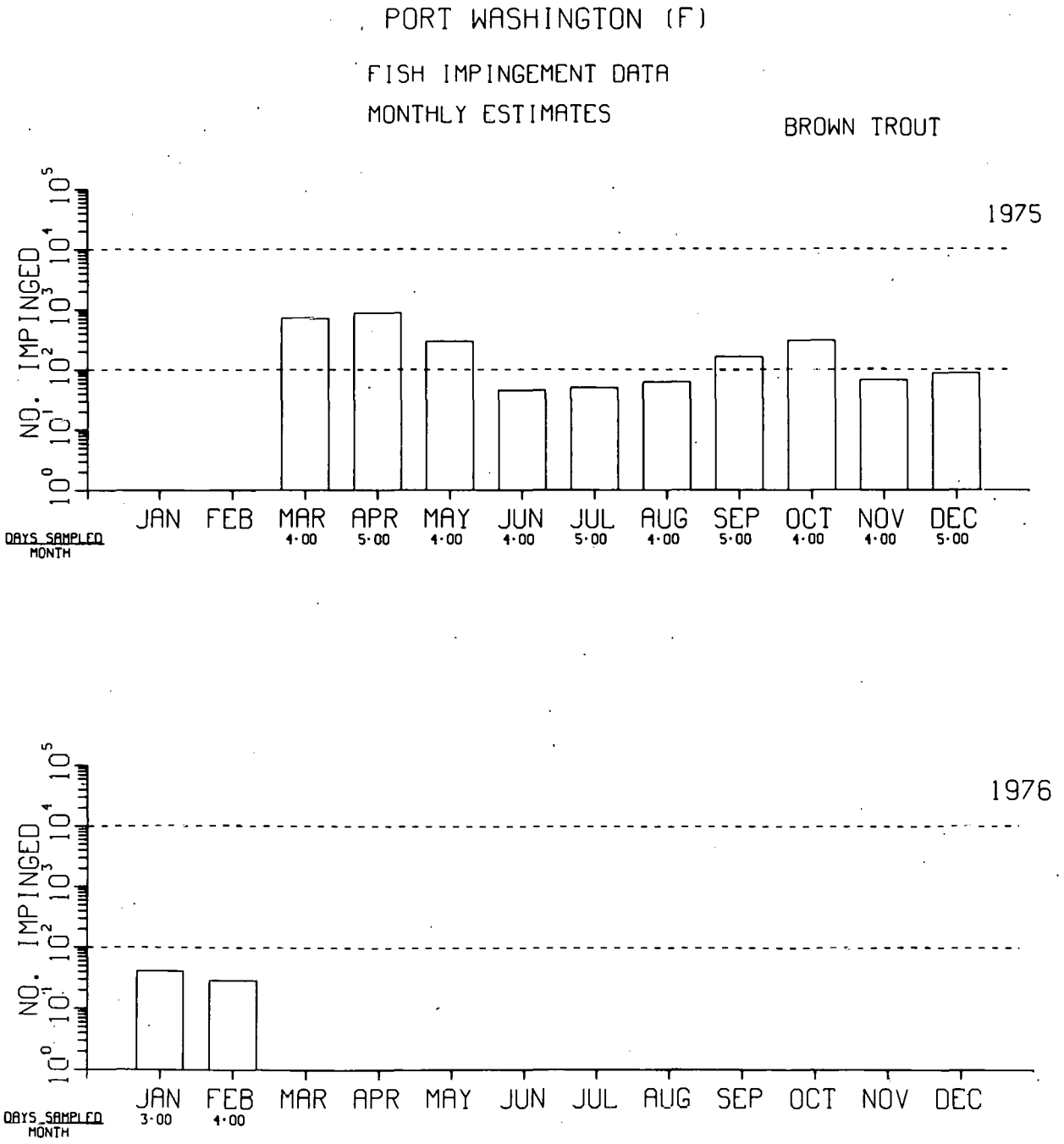


Fig. H4. Impingement Estimates.

LAKESIDE POWER PLANT (F)

SITE CHARACTERISTICS

The Lakeside Power Plant is situated on the southwestern shore of Lake Michigan, immediately south of Milwaukee, Wisconsin, in the village of St. Francis. At the time of this report a description of the site in terms of aquatic habitat was not available.

PLANT DESCRIPTION

Lakeside Power Plant is a fossil-fueled facility with a total generating capacity of 310 MWe. Water for condenser cooling is withdrawn from Lake Michigan and returned via two shoreline discharges located at the north and south ends of the intake pond.[1]

INTAKE DESIGN AND OPERATION

Water is withdrawn from Lake Michigan through a rubble-walled or "leaky-dam" intake pond of about five acres (Fig. 1). The rubble, consisting of large granite pieces, also serves as a breakwater to Lake Michigan waves.

Two adjacent shoreline intakes are located near the southwest corner of the pond (Fig. 2). The intakes are protected by vertical steel trash racks. Trash bars extend to the bottom of the intakes and are one inch wide with 5.5-inch gaps.

The two intake tunnels unite before again separating to extend to the north and south sides of the plant where, after screening, a single common well channels water to the condensers. The north tunnel is 10 feet in diameter, about 12 feet high, and about 600 feet long. The south tunnel is eight feet wide by 12 feet high and about 540 feet long. The north tunnel expands to a width of 45 feet ahead of five vertical traveling screens. The south tunnel widens to 31 feet to form a common bay ahead of three traveling screens.

The five identical traveling screens in the north bay are each six feet wide, and the three in the south bay are identical and each eight feet wide. All screens are constructed of 3/8-inch-square mesh. Debris is removed by a high-pressure (100-psig) wash at the upstream side of the screens.

The intake pond is about 18 feet deep at its western edge. Within the pond, observations indicate that depths range from six to 12 feet, averaging eight to nine feet.

The rubble mound operates as a "leaky dam" with water flowing through interstices. This serves as a partial barrier to fish penetration. Average velocities through the rubble range from 0.005 to 0.045 fps.

Deicing is performed by recirculating heated effluent to the intake pond. The heated effluent can be introduced into the pond at either the northwest or southwest end, or both. About 10% to 30% of the cooling water is so directed as to prevent buildup of ice in the intake pond and formation of frazzle ice on the trash racks and traveling screens. Recirculation is performed when ambient lake temperatures are below 40°F, which generally occurs from late December to early April. During that period, recirculation for deicing is performed almost continuously during plant operation.

The number of circulating-water pumps operating at the plant is dependent on unit operation and ambient water temperature; plant pumping rate is highly variable. At maximum, 12 pumps with a total capacity of 439,000 gpm can be operated.

IMPINGEMENT SAMPLING

Impingement monitoring was scheduled to be performed during one operating day (not more than 24 hours) every week from 1 March 1975 to 29 February 1976. Every attempt was made to accommodate this schedule. However, the plant was out of operation for extended periods. During some weeks, Lakeside Power Plant did not generate at all. At other times, it ran only one or two days a week, contingent on demand and fuel availability. These operations were not predictable, and assignment of personnel could not always be made in time to obtain useful data. Consequently, the schedule was modified to obtain as many days of monitoring as the limitations of plant operation and personnel availability would permit. During the sampling year, a total of 39 impingement collections were made.

DATA AVAILABILITY

Impingement data for the Lakeside Power Plant are available for 7 March 1975 through 6 February 1976.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the most abundant species as well as all species impinged at the Lakeside Power Plant. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

There are no additional devices reported to be in operation at the Lakeside Power Plant to reduce impingement except for the "leaky-dam" concept.

REFERENCE

1. "Lakeside Power Plant Final Report W.P.D.E.S. Intake Monitoring Studies." Wisconsin Electric Power Company. 1 June 1976.

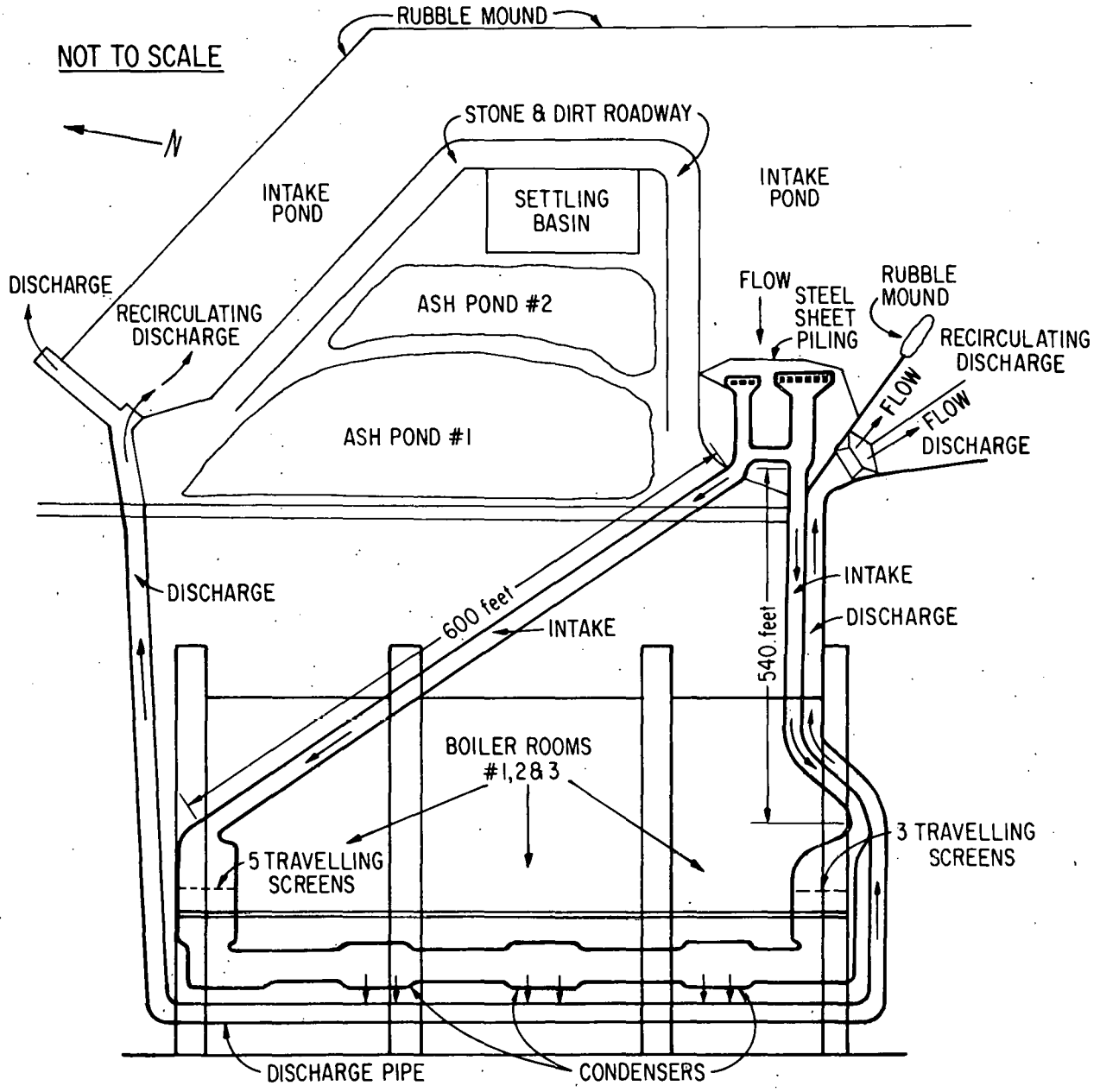


Fig. 1. Circulating-Water System.

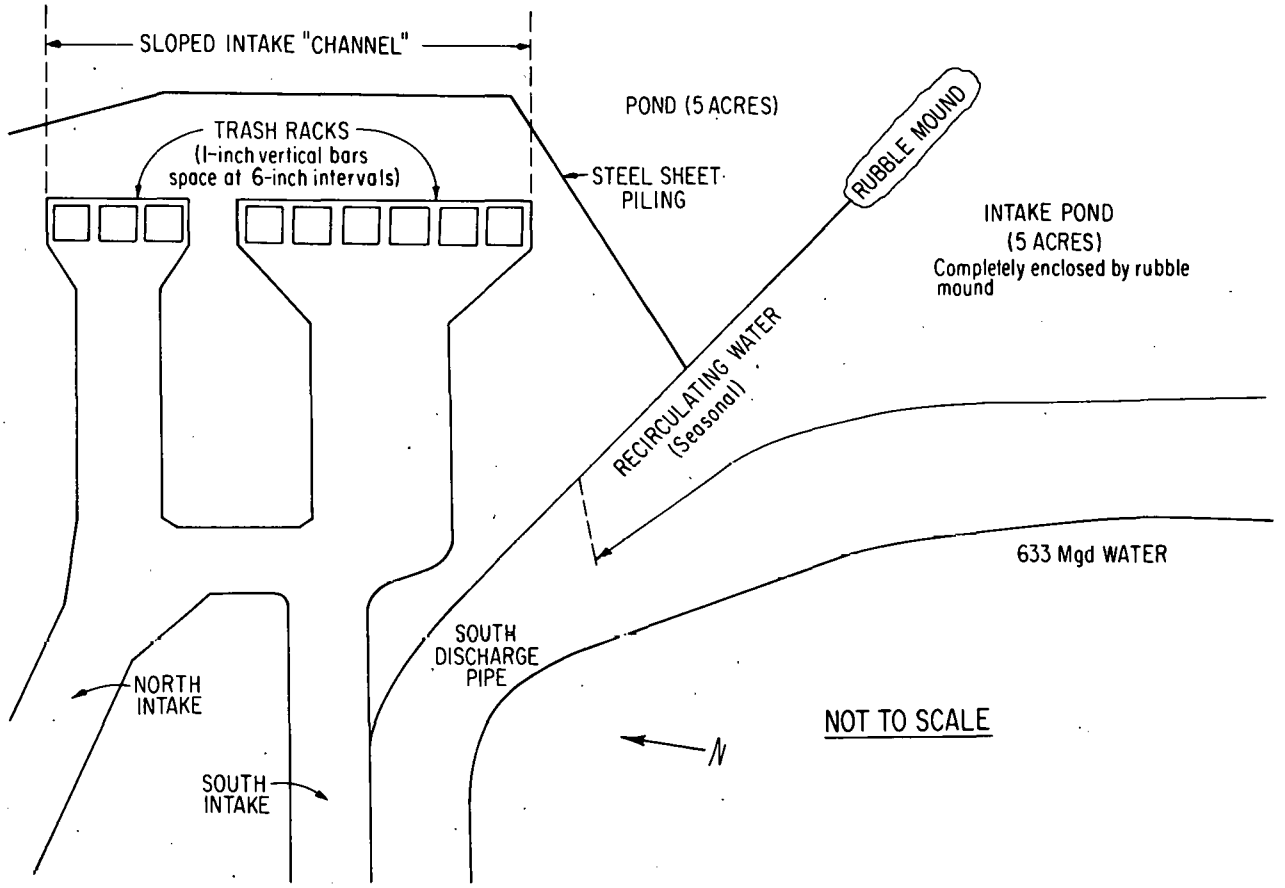


Fig. 2. Water Intakes.

Table I. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Slimy Sculpin	Spottail Shiner	Total
1974	9	113,546	1,179	65	114,951
1975	2	0	31	21	112

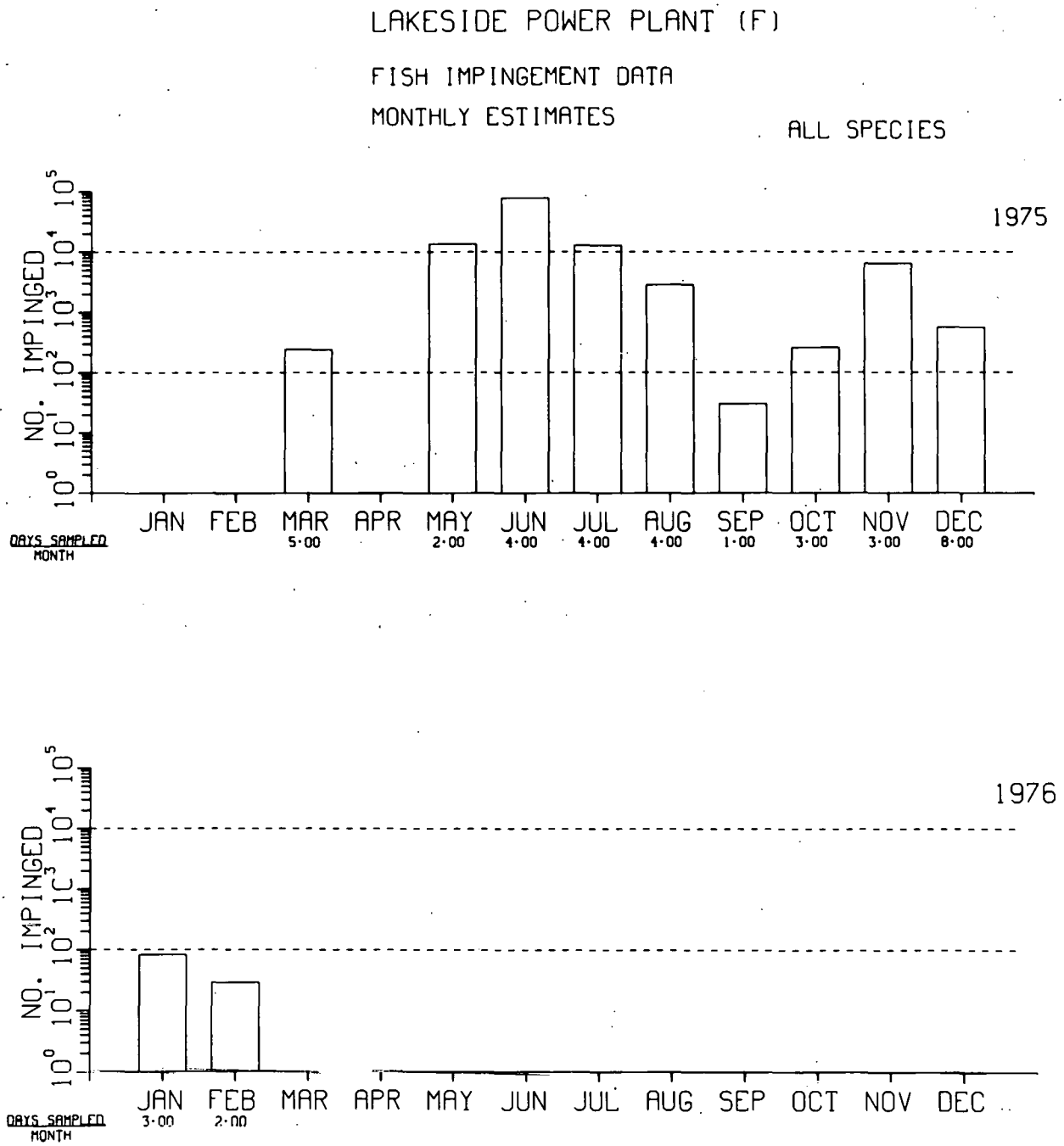


Fig. H1. Impingement Estimates.

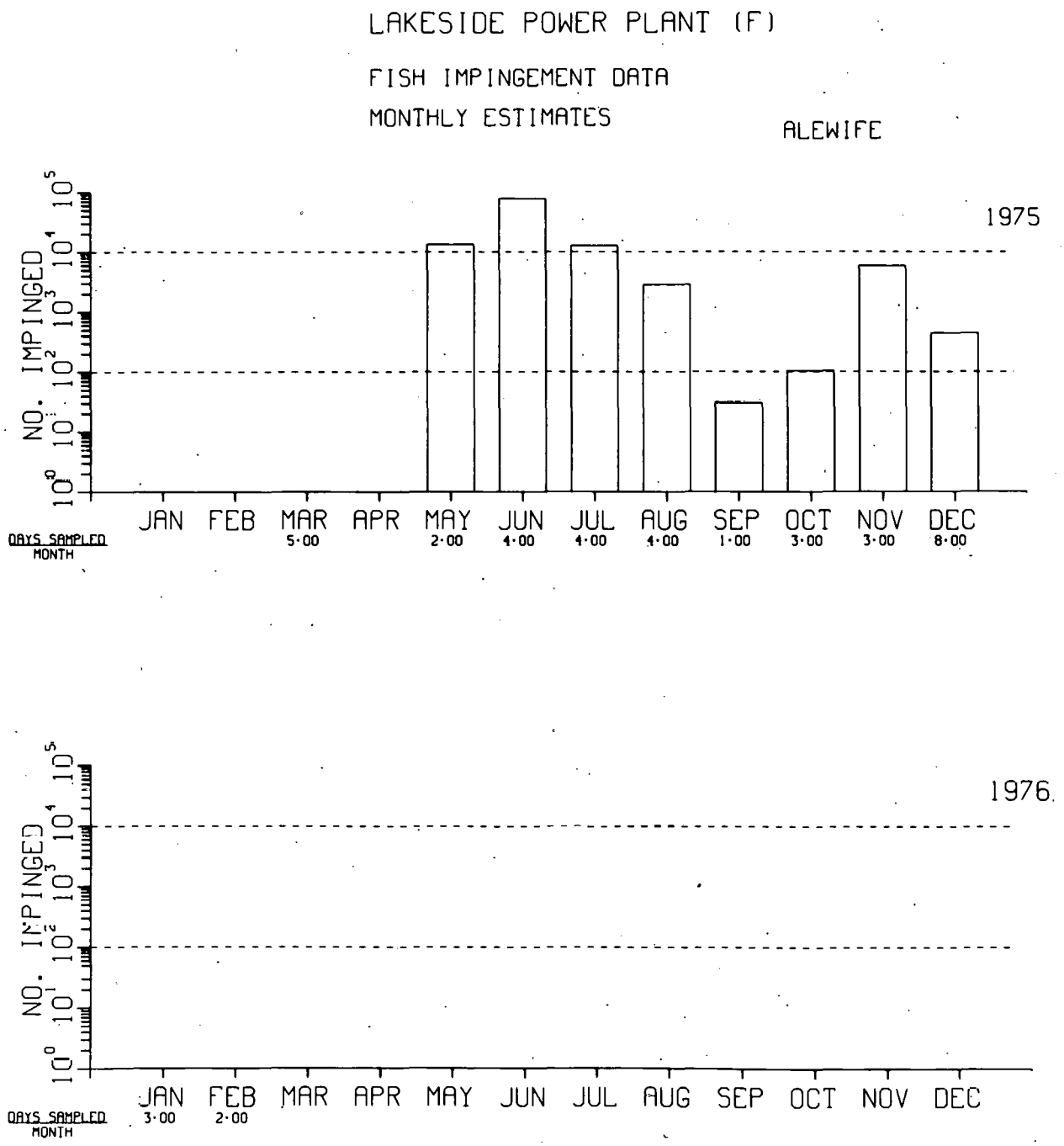


Fig. H2. Impingement Estimates.

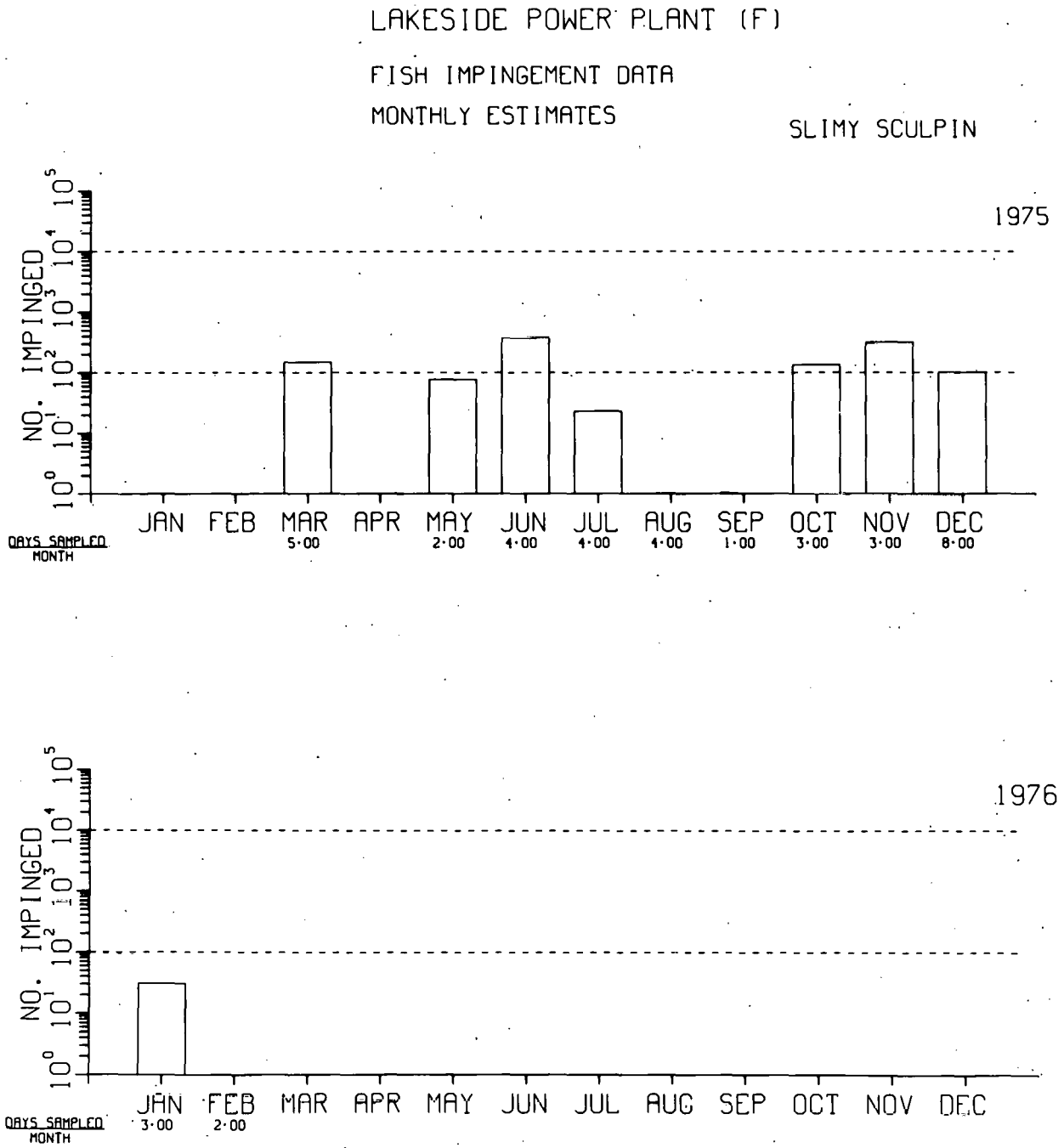


Fig. H3. Impingement Estimates.

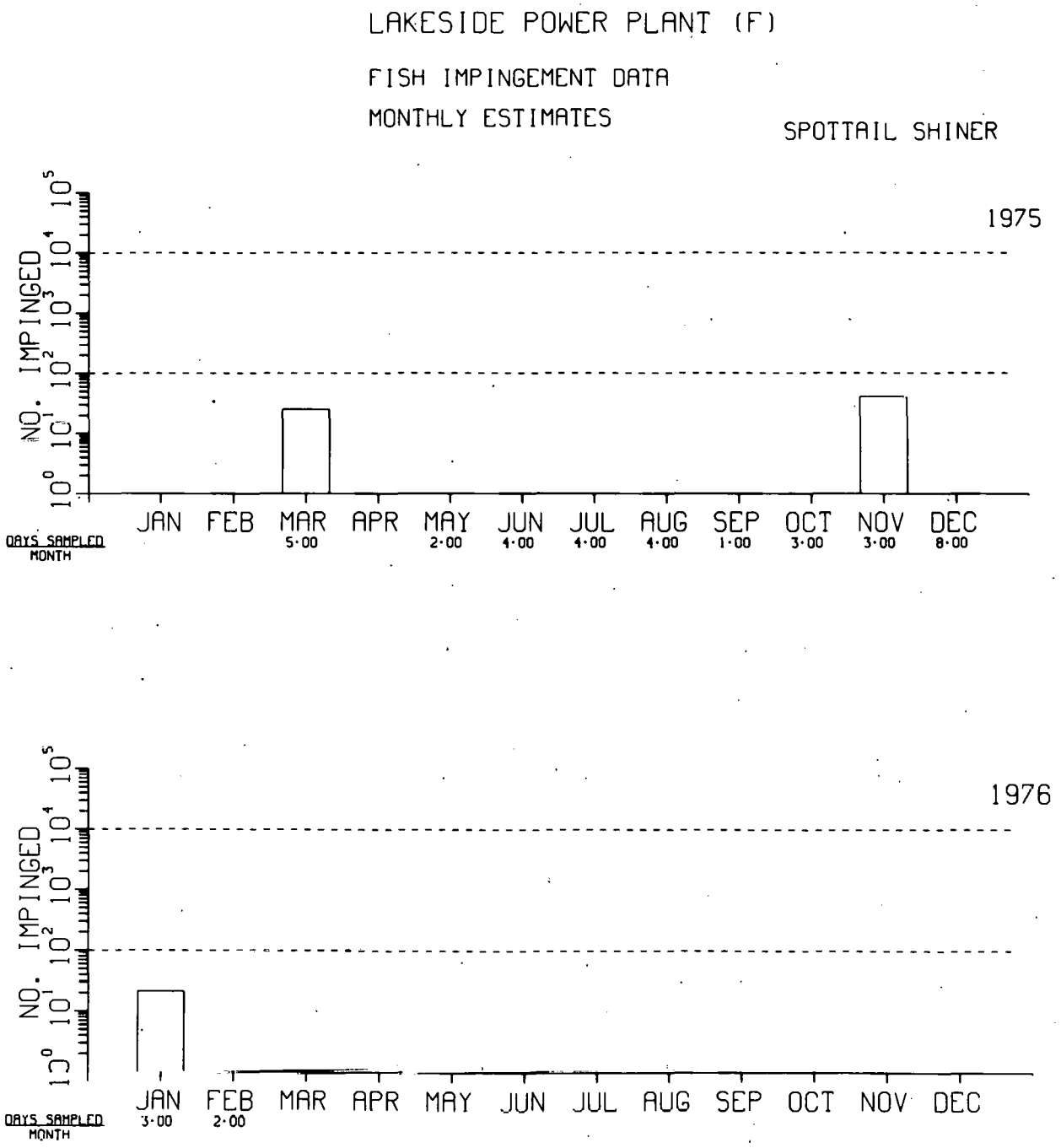


Fig. H4. Impingement Estimates.

OAK CREEK POWER PLANT (F)

SITE CHARACTERISTICS

Oak Creek Power Plant is situated on the southwest shore of Lake Michigan, about 12 miles south of Milwaukee.[1] Fishes observed in the plant vicinity are listed in Table I.

PLANT DESCRIPTION

The Oak Creek Power Plant actually consists of two smaller plants (Fig. 1). Units 1-4 are located in the North Plant and Units 5-8 are located in the South Plant. Units 1 and 2 are 120 MWe each, Units 3 and 4 are 130 MWe each, Units 5 and 6 are 275 MWe each, and Units 7 and 8 are 310 MWe each, for a total capacity of 1670 MWe. A once-through system is utilized for condenser cooling.

INTAKE DESIGN AND OPERATION

Cooling water for both the North and the South Oak Creek Plants is drawn from a common intake channel that is about 800 feet long and 250 feet wide (Fig. 1). The channel is formed by metal retaining walls and is periodically dredged to maintain a depth of 20 feet. Each plant has a separate intake on the common intake channel. Trash racks for both intakes are located at the shoreline. The trash-rack spacing is 6.5 inches and 3.0 inches for the North and South Plants, respectively. The width of the intakes is 41.5 feet for the North Plant and 60.8 feet for the South Plant. The vertical traveling screens are located about 60 feet downstream of the trash racks. Each of three screens at the North Plant is 10 feet wide and each of five at the South Plant is 11 feet wide. All screens have 3/8-inch-square mesh. Maximum cooling-water flow for all units for both plants is 1,228,000 gpm. Impinged fish and debris can be collected in a 3/8-inch-mesh wire basket placed in the washwater sluiceway. One of the water-intake structures is depicted in Figure 2.

Provisions exist for warm-water recirculation for deicing during winter. The estimated intake velocity at various locations is:

North Plant
- Intake opening -- 0.8 fps
- Traveling screens -- 0.8 fps

South Plant
- Intake opening -- 2.7 fps
- Traveling screens 1.2 fps

IMPINGEMENT SAMPLING

The Oak Creek Power Plant fish- and debris-screen study was initiated on 1 January 1973. A small basket with 3/8-inch openings was placed in the screen-wash-bypass trough in the north pumphouse for a period of 30 minutes during each shift. The sample was bagged, identified, and frozen until it was processed. The sampling period varied depending on the screen-wash load.

A second series of fish-sampling programs at the intake screens was initiated on 28 February 1975. The fish-collection procedure was the same; however, fish were collected on every fourth day of plant operation (not more than 24 hours). The amount of sampling time was expressed in minutes. These values were converted to total 24-hour periods to get the total number of days sampled per month.

DATA AVAILABILITY

Fish impingement data are available for April through October 1973 and February through October 1975. The source for the 1973 data was the Nuclear Regulatory Commission, whereas the 1975 data were obtained from the utility.[1]

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the North Plant. These totals are summarized in Table II. All impingement collections were made at the North Plant pumphouse because there is no room to insert a collection device in the sluiceway at the pumphouse for the South Plant.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. First, Second, and Third Quarterly Reports on the Intake-Structure Monitoring Program. Wisconsin Electric Power Company, Green Bay, Wisconsin. May, August, and November 1975.

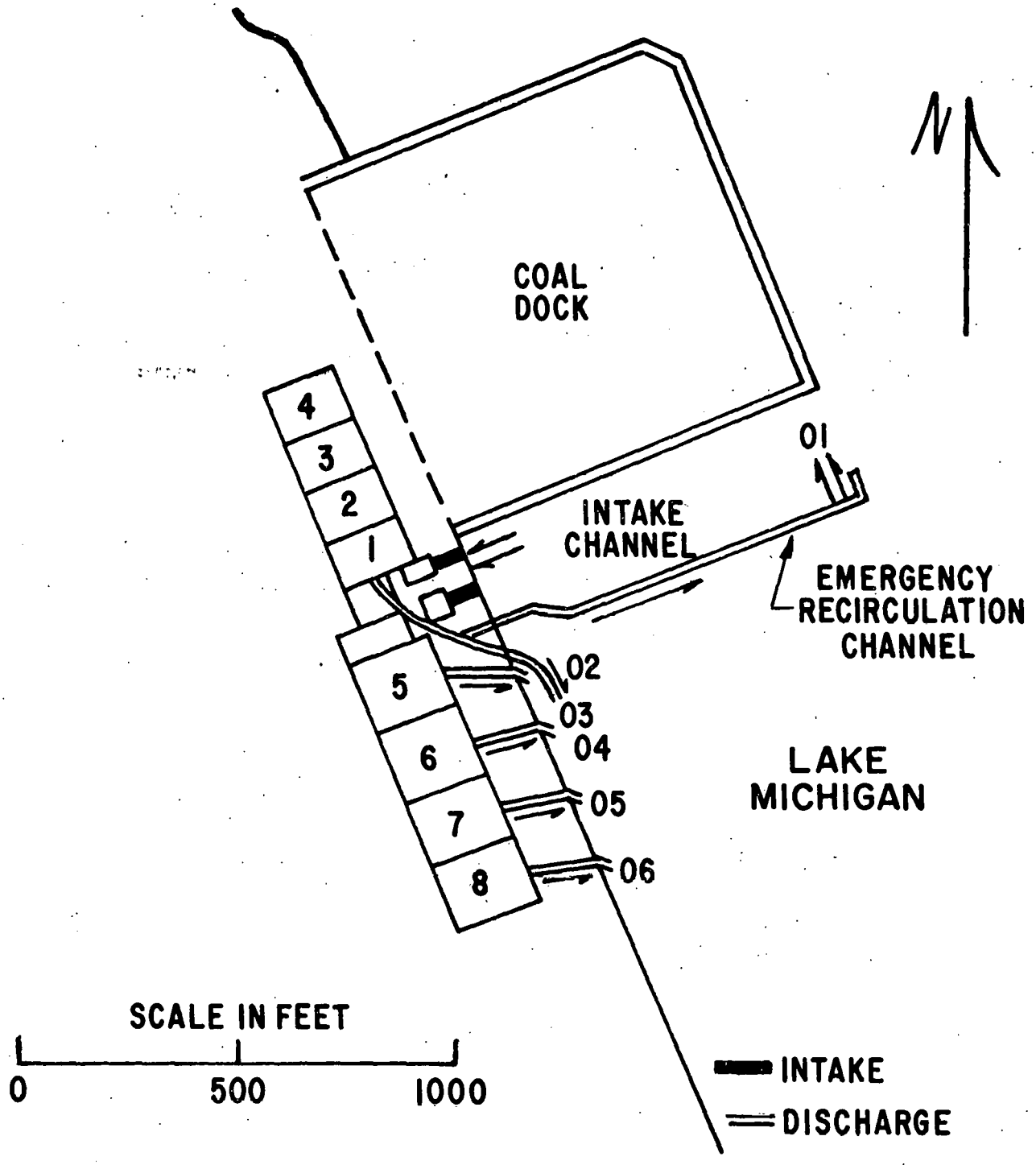


Fig. 1. Site Plan.

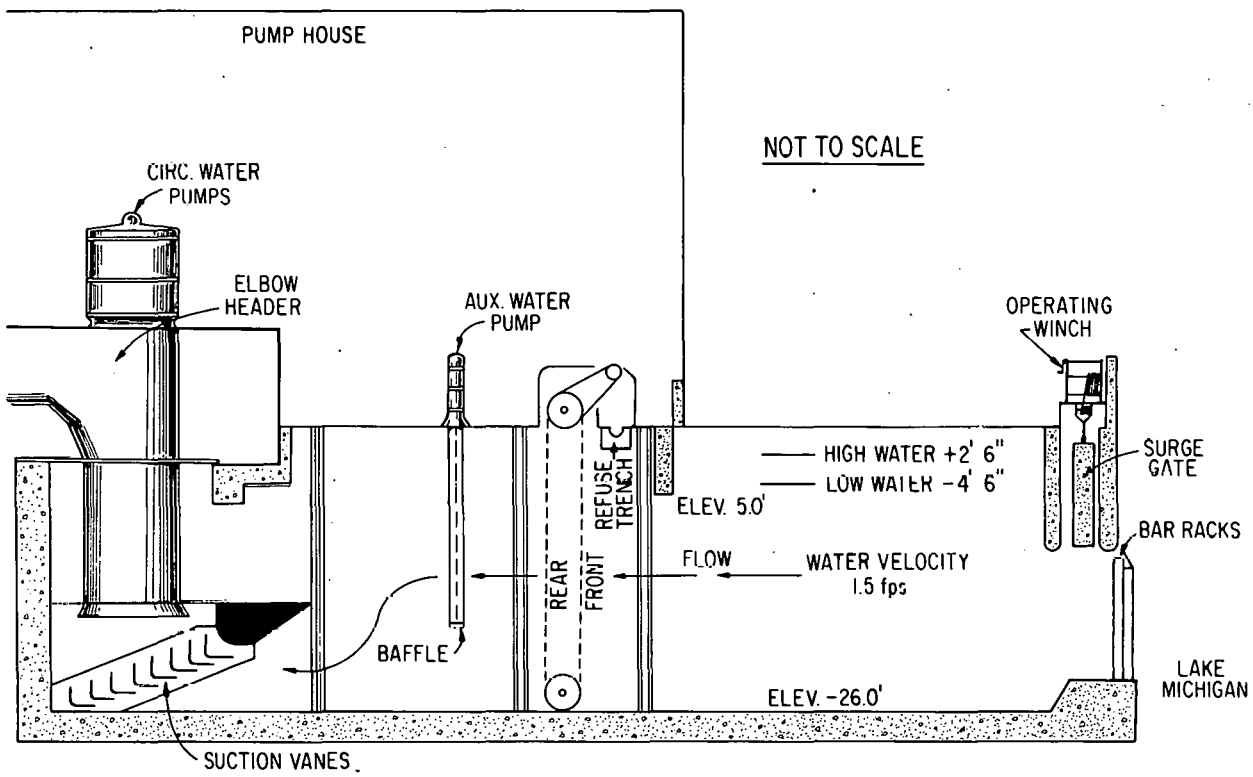


Fig. 2. Water-Intake Structure.

Table I. Fishes Observed at the Plant

Alewife	Rainbow trout
Rainbow smelt	White sucker
Yellow perch	Brown trout
Ninespine stickleback	Bluegill
Trout-perch	Carp
	Longnose dace
	Lake chub
	Mottled sculpin

Table II. Summary of Fish Impingement Data at the North Plant

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Rainbow Smelt	Yellow Perch	Total
1973	7	6,253	2,157	5	8,497
1975	9	834,639	176,253	612	1,022,571

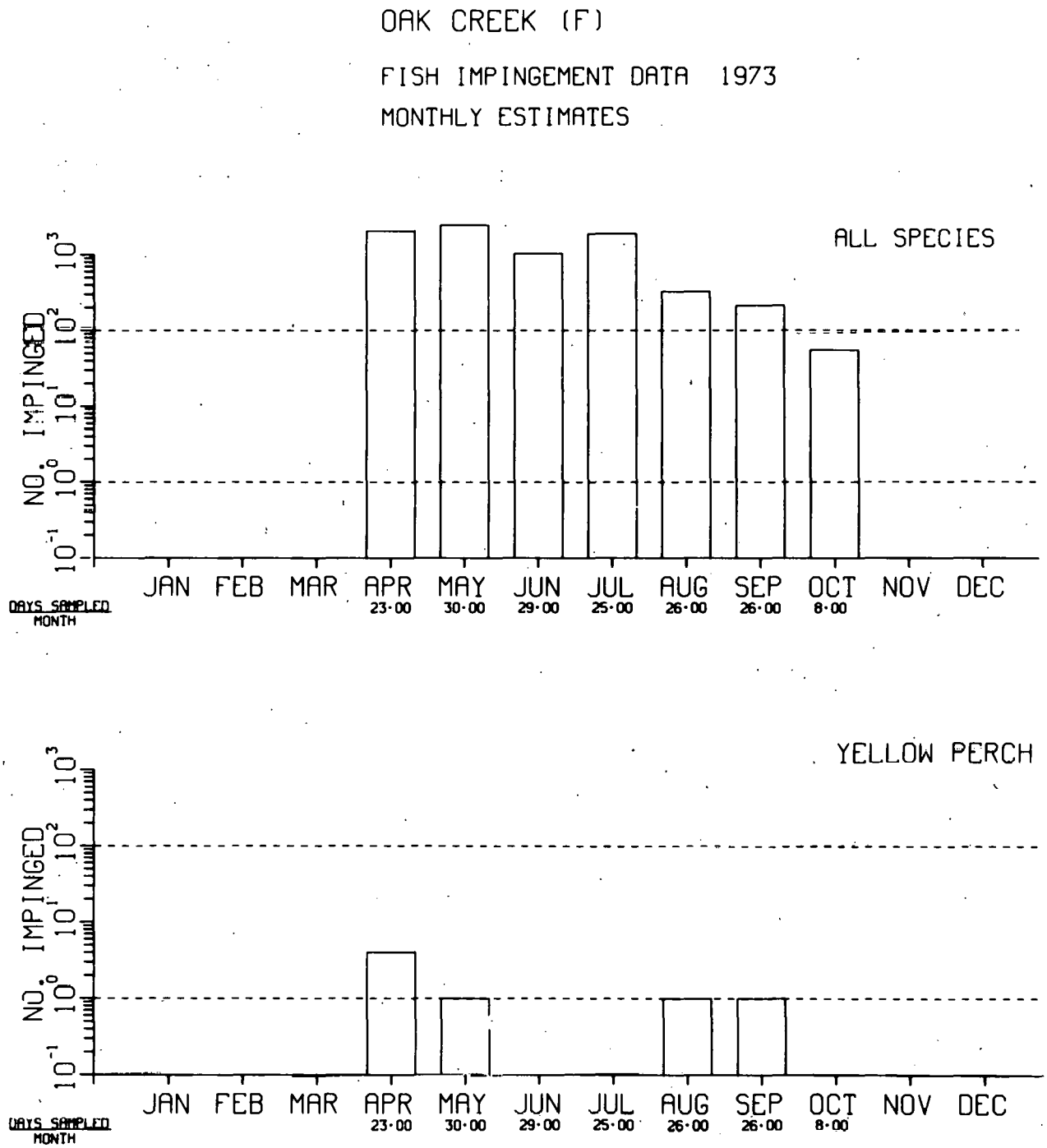


Fig. III. Impingement Estimates.

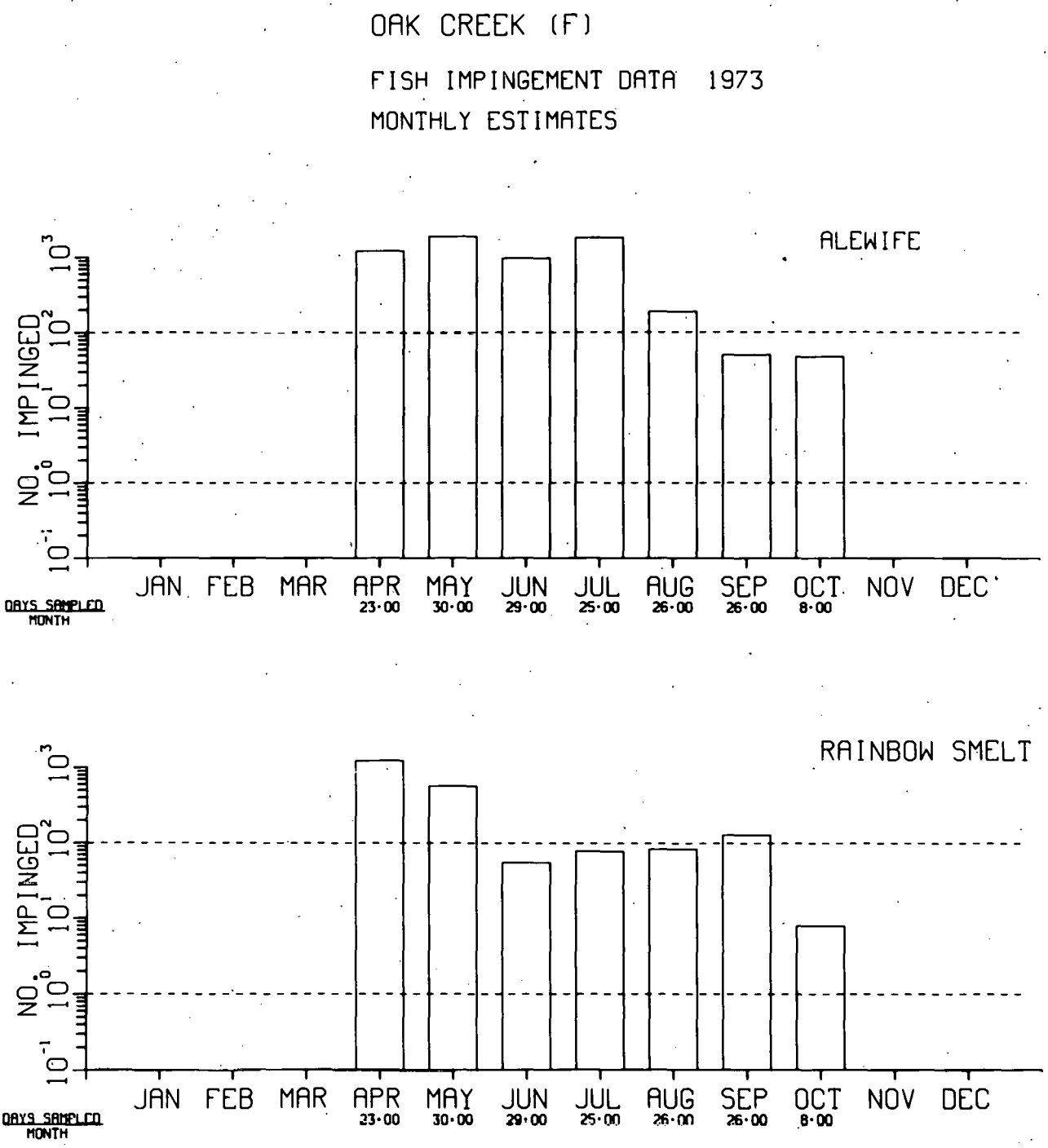


Fig. H2. Impingement Estimates.

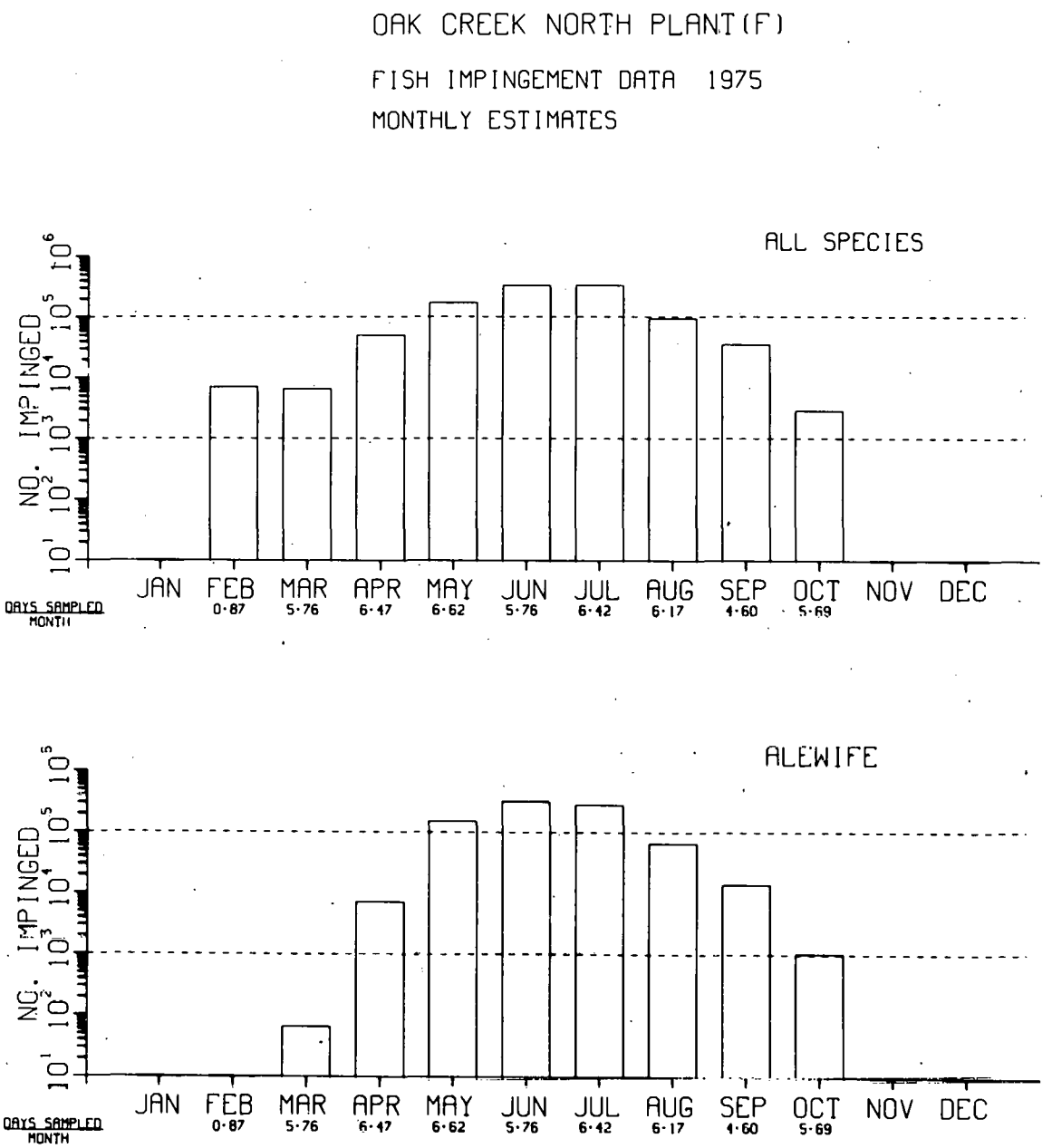


Fig. H3. Impingement Estimates.

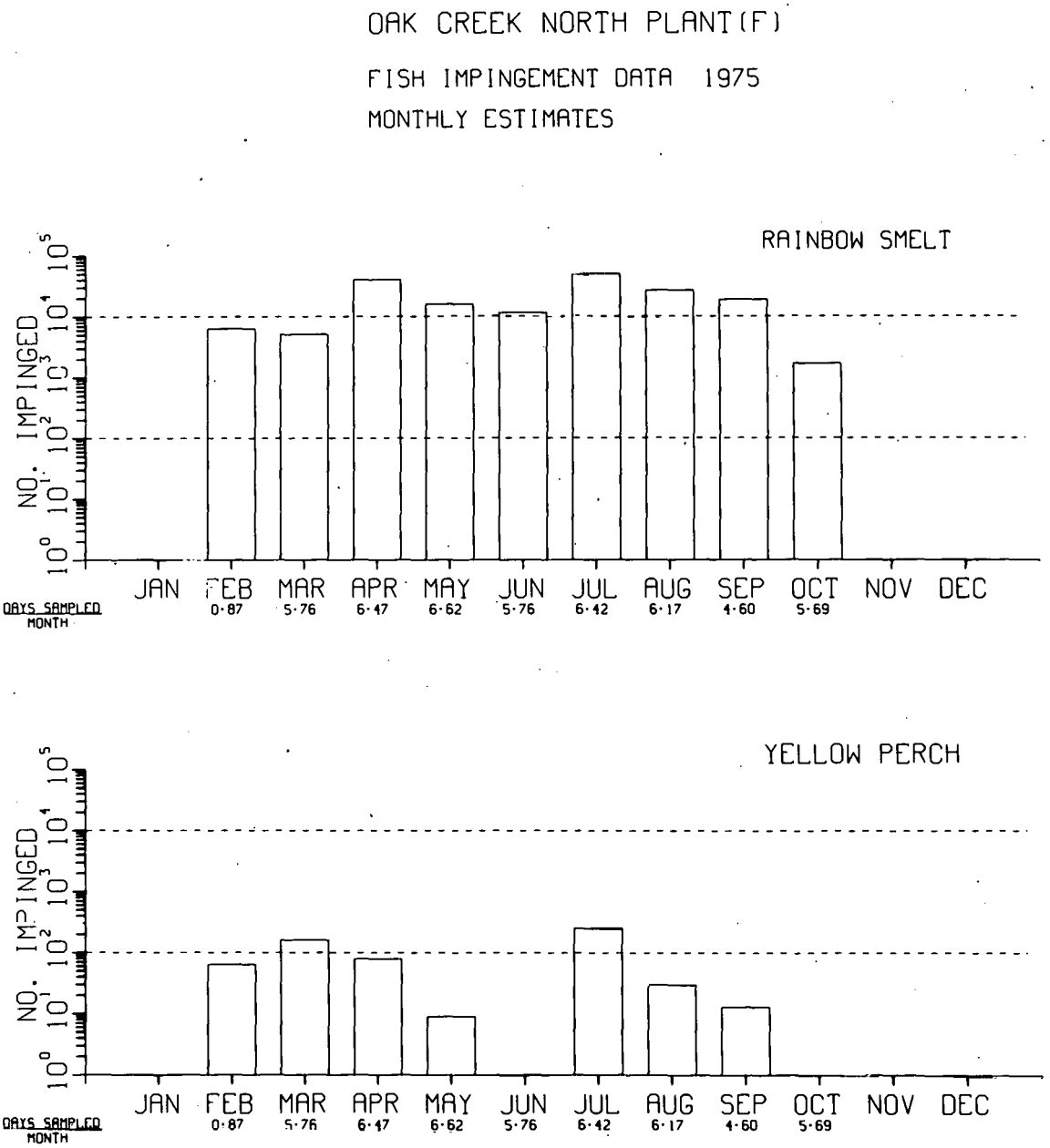


Fig. H4. Impingement Estimates.

ZION NUCLEAR POWER STATION (N)

SITE CHARACTERISTICS

The Zion Nuclear Power Station is located on a 250-acre site in the extreme northeastern edge of the city of Zion, Lake County, Illinois.[1] The site fronts on Lake Michigan and includes about 2000 feet of shoreline. The station primarily affects the beach-water zone, which extends out to the 30-foot depth contour. Both the intake and discharge structures of the plant are within this area.

At the depths where the intake structure is located, prevailing wind-driven currents are parallel to the shoreline. Current drogue measurements at the site range from 0.07 to 1.09 fps, with the most common range being 0.2 to 0.5 fps.[2] The waters are frequently turbid because of wave action on the bottom sediments. Water temperature at the site ranges from 32°F to 82°F, and the water occasionally may be covered with ice from January through March.

The site area is periodically subject to heavy wave action and this, in addition to the lack of a suitable type of bottom, is not conducive to spawning for most fish species. Studies conducted by the Industrial Bio-Test Laboratories for the Commonwealth Edison Company have shown that alewives and rainbow smelt use the site area for spawning and nursery. Spawning by alewives from mid-June through mid-August and by rainbow smelt in April and May has been reported. Young-of-the-year of both species are present in the site area through October. Eight species of larval and juvenile fish and seven species of fish eggs have been reported in these studies.

The species of fish captured by all methods during the sampling period of July 1973 to June 1974 are listed in Table I. All six major species in the area (coho salmon, yellow perch, lake trout, bloater, rainbow smelt, and alewife) have been reported to abandon the area in waters shallower than 60 feet during winter (trawl and gill-net data). Peak abundance of bloaters and yellow perch occurs in the offshore area in the fall, and movement of coho salmon in the inshore area has been reported to occur during spring. During spring, summer, and fall there is a general movement of alewives and rainbow smelt throughout the area, the latter preferring deeper waters (30 to 60 feet) in the fall. Bloaters are abundant in shallow waters (12 to 24 feet) during spring and in deeper water (30 to 60 feet) during summer, declining markedly during fall in both zones. Considerable numbers (76,157) of chinook salmon have been reported in seine catches from inshore waters in the Zion area. The seasonal abundance of various species is represented in Figure 1 (from the Zion Annual Monitoring Report for 1973-1974).[2]

PLANT DESCRIPTION

The Zion Nuclear Power Station consists of two units. Each unit utilizes a pressurized water reactor to generate about 1100 MWe gross. A once-through system is utilized for condenser cooling.

INTAKE DESIGN AND OPERATION

The intake structure for the station is located 2600 feet offshore (Fig. 2). The top of the vertical inlet pipes is at an elevation of 560.7 feet, which is about 17 feet below normal lake level. There are two large-diameter pipes near the center of the intake structure and 45 small-diameter ports spaced around its periphery (Figs. 3 and 4). Each of the two large pipes has a conical entrance 24 feet in diameter flaring into it. The pipes are spaced 27 feet apart, equidistant from the center line. A velocity cap is located above the large inlet pipes to prevent vortex formation in the inlet water. The top of the velocity cap is at an elevation of 568.5 feet, which is about nine feet below normal lake level. The effective vertical clearance for lateral water flow between the underside of the roof structure and the top of the large intake pipes is about 5.5 feet. The intake annulus is located about four feet above the lake bottom. The 45 small-diameter ports around the periphery of the intake are connected to an annular plenum (thawing box), and then to a third intake pipe (this system performs a deicing function during winter and is described later).

All three 16-foot-diameter intake pipes lead to the forebay at the shore. The bar racks are located at the upstream end of the forebay. They consist of bars with a cross section of 0.5 × 5.0 inches, spaced vertically on 2.5-inch centers, resulting in nominal two-inch openings between the bars. Twelve conventional vertical traveling screens are located behind the bar racks. The traveling screens are constructed of 12-gauge wire mesh with 3/8-inch-square openings. There are a total of six circulating-water pumps located in the pumpwell behind the traveling screens. A sluice is located in front of the traveling screens and slopes into a trash bin (Fig. 5).

From about mid-March to mid-November, depending on weather and accessibility for maintenance, the offshore intake is surrounded with one-by-one-inch diagonal-mesh nets, with strands coated to prevent gillnetting. The nets are intended to prevent the intake entrapment of adults of the larger fish species.

The water enters through the outermost diagonal-mesh nets (when in position) into the offshore intake structure through two pipes and through the 45 peripheral ports that lead to the third intake pipe. It flows by gravity through intake pipes to the forebay on the shore. Here it passes through the bar racks and then through the traveling screens to the circulating-water pumps. Debris and fish, washed off periodically from the screens, are sluiced into the trash basket for counting and removal. The maximum condenser flow rate is 1,530,000 gpm.

The intake velocity in the system at various locations is estimated to be as follows:

Outermost diagonal-mesh net	0.30 fps
Offshore intake opening (non-winter)	2.47 fps
Offshore intake opening (winter)	3.70 fps
Intake pipes (offshore to shore)	5.60 fps
Bar racks (on shore)	1.20 fps
Traveling screens	2.00 fps

During the winter, operation of the cooling system is altered to prevent ice collection or formation at the intake structure and the screens. Part of the discharge water is recirculated to the intake opening by flow reversal in the central 16-foot-diameter intake pipe. This flow passes through the thawing box and is discharged vertically upward through the 45 ports around the periphery of the thawing box (Fig. 3). The maximum amount of warm water that can be returned to the intake is 750,000 gpm or 50% of the entire intake flow. Most of this warm-water discharge is drawn into the other two large intake pipes. It is possible that some of this discharge can escape and establish a thermal gradient around the intake structure.

IMPINGEMENT SAMPLING

The traveling screens were monitored on a daily basis from July 1973 through December 1974 and on every fourth day from January 1975. These 24-hour collections were identified to species, weighed, and measured. For more than 30 fish of a given species, a subsampling procedure was used. Total weight was recorded for all individuals of a species and a random subsample of 30 fish was weighed and measured separately. The total number was then estimated on the basis of the number-to-weight ratio in the subsample.

DATA AVAILABILITY

Fish impingement data are available for September 1973 through December 1975, with the exception of January 1974.

IMPINGEMENT DATA SUMMARY

Figures H1 through H5 are histograms representing the four most abundant species as well as all species impinged at the Zion Nuclear Power Station. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Depending on weather and accessibility the offshore intake is surrounded with one-by-one-inch diagonal-mesh nets, with strands coated to prevent gill-netting, from mid-March to mid-November. These nets supposedly preclude the possibility of entrapment of adults of larger species.

REFERENCES

1. "Final Environmental Statement for Zion Nuclear Power Station Units 1 and 2." USAEC Directorate of Licensing. Docket Nos. 50-295 and 50-304. December 1972.

2. "Operational Environmental Monitoring in Lake Michigan near the Zion Station - July 1973 through June 1974." Vol. III. Industrial Bio-Test Laboratories, Inc., Northbrook, Illinois. October 1974.

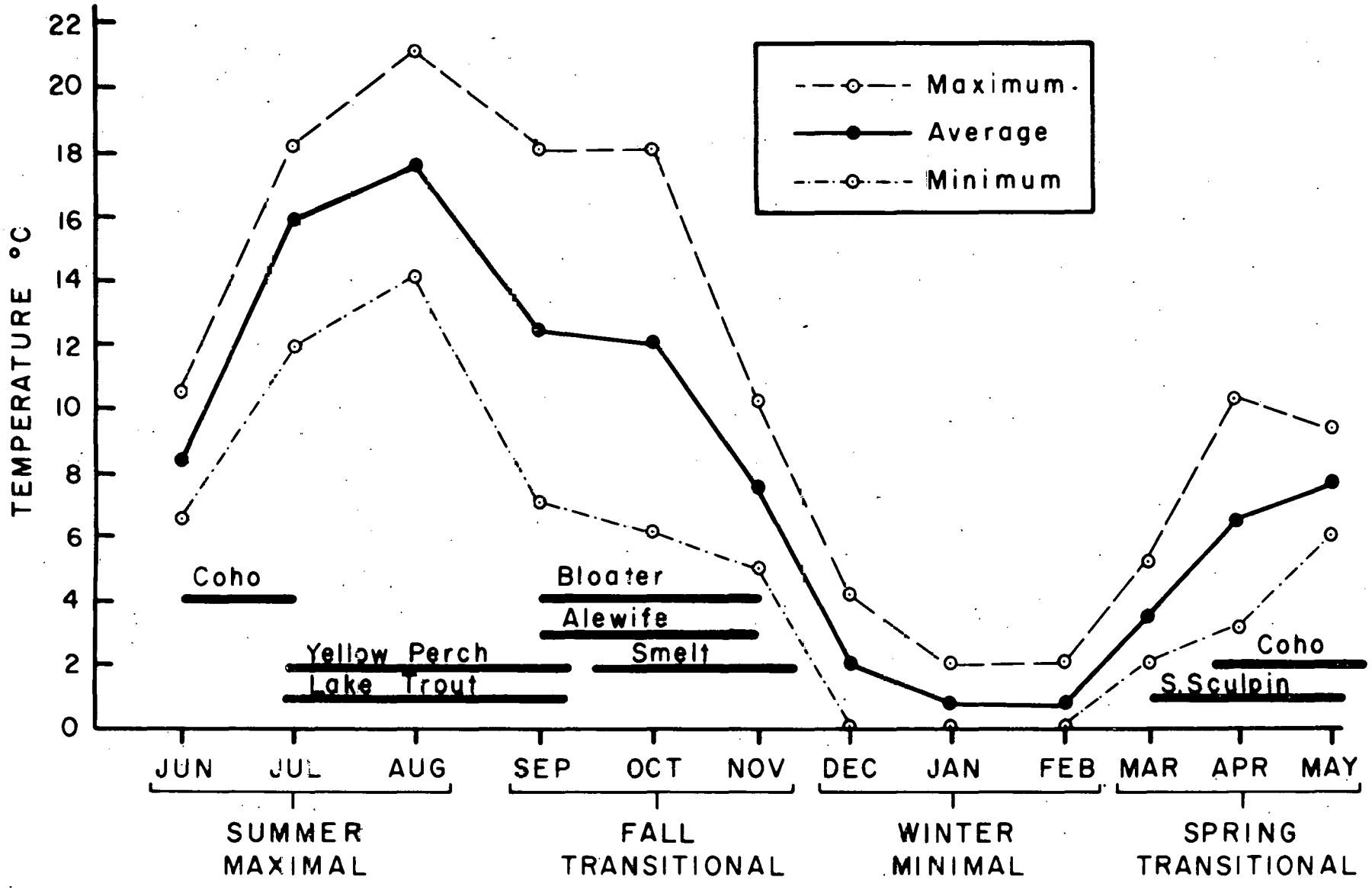


Fig. 1. Bottom Temperatures at All Trawl Locations, and Seasonal Abundance of Important Species, July 1973 to June 1974.

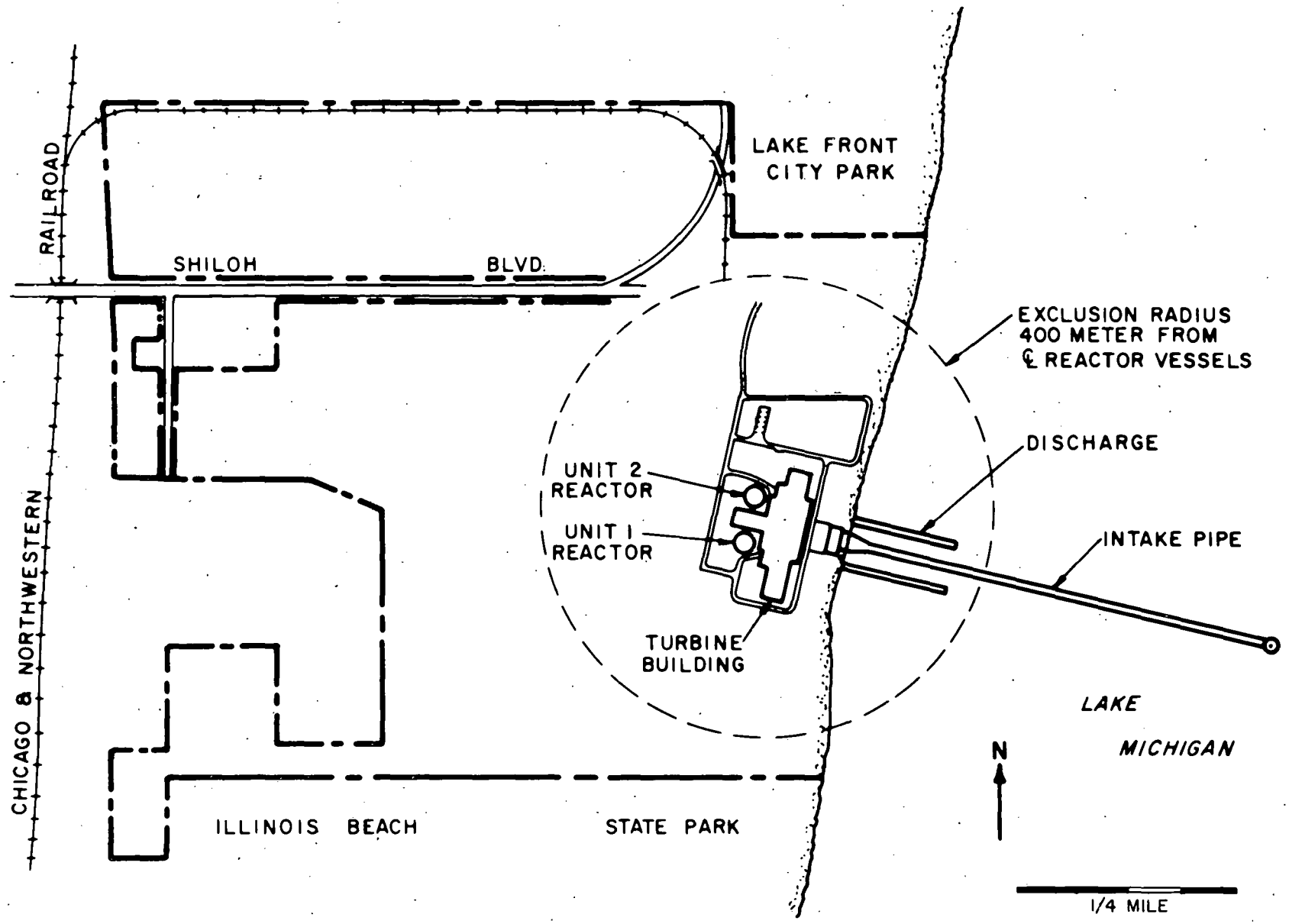


Fig. 2. Station Layout Showing Intake and Discharge.

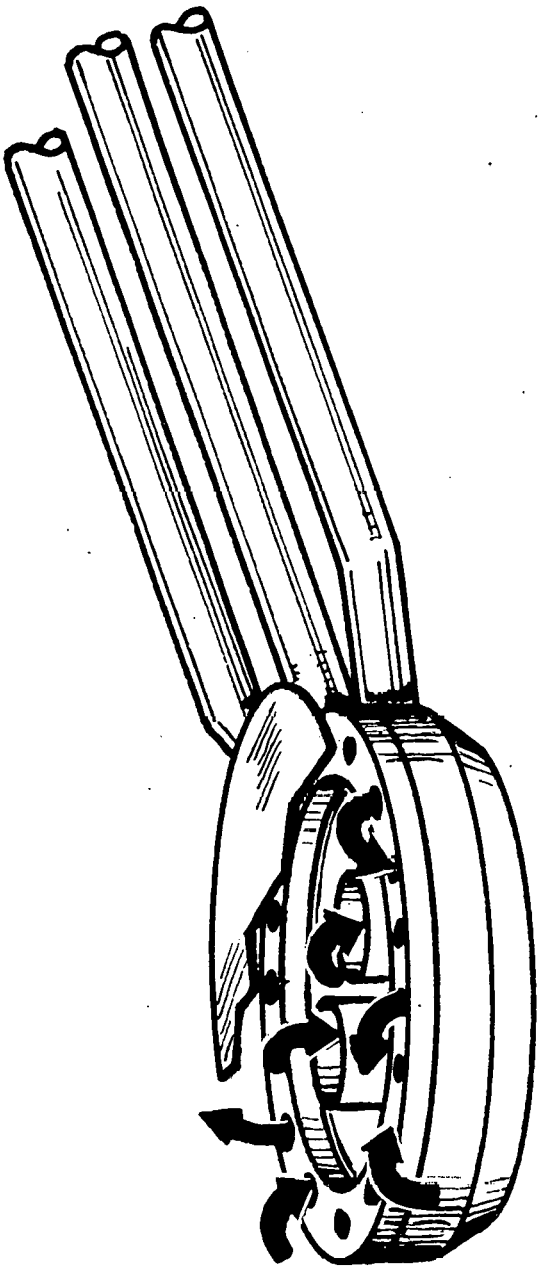
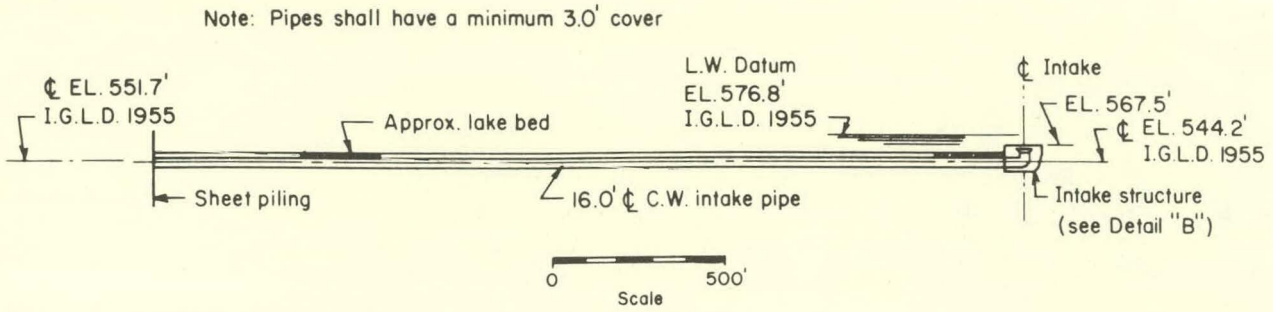


Fig. 3. Cooling-Water Intake Structure.



16.0 ft. is outside diameter of intake pipes

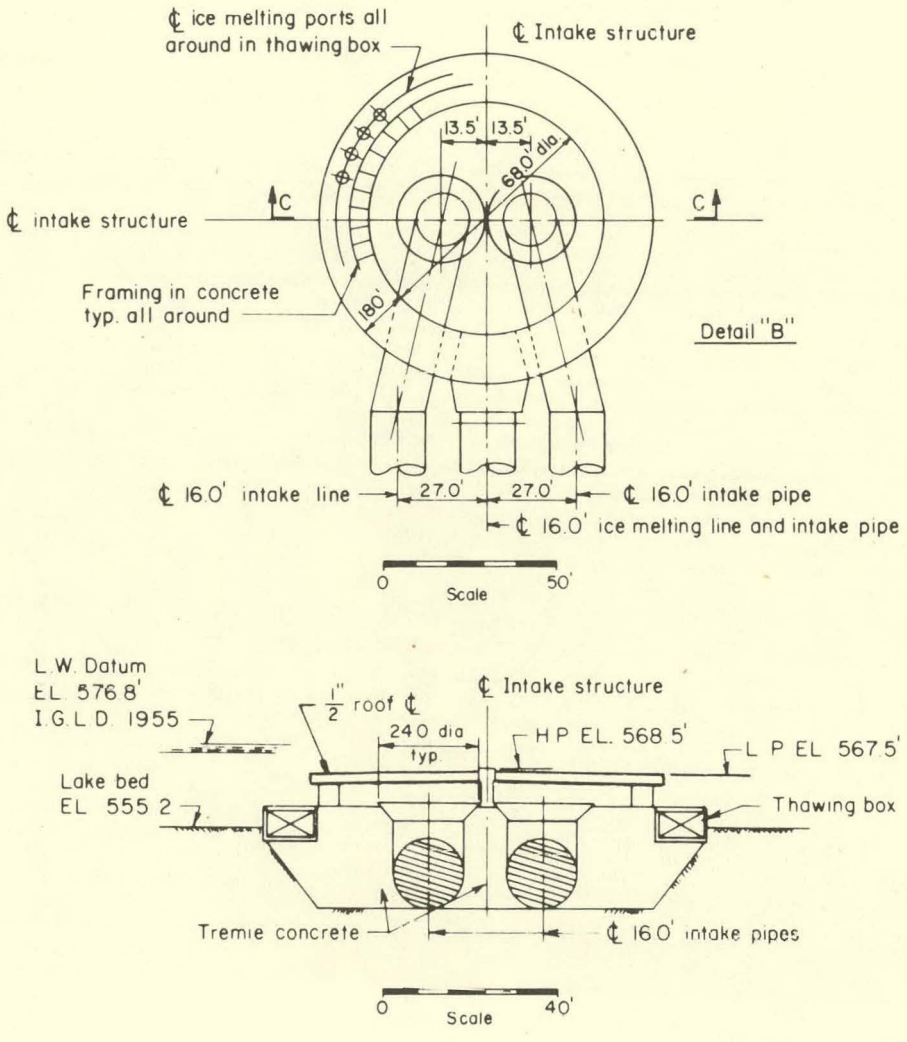


Fig. 4. Detail of Intake Structure and Pipes.

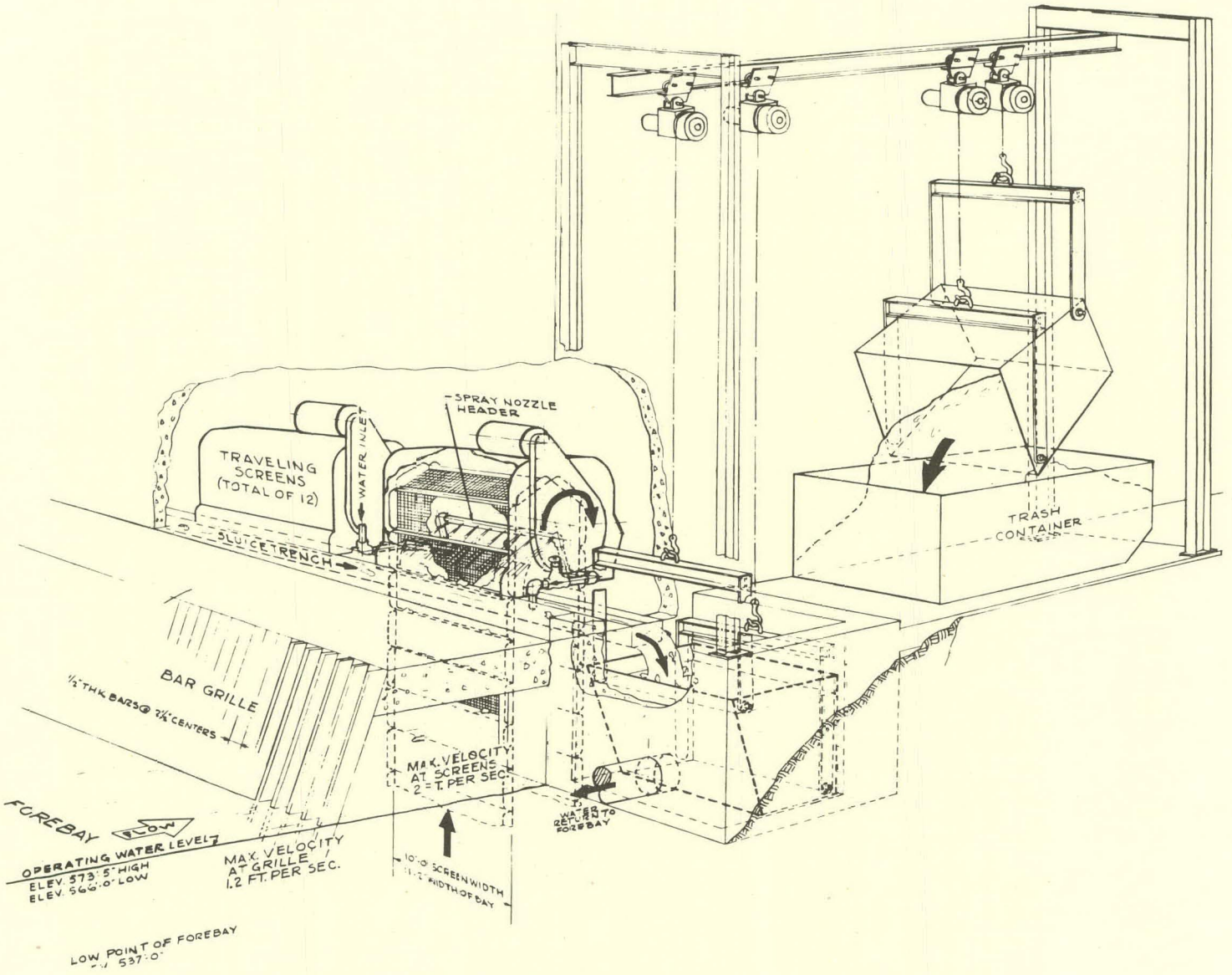


Fig. 5. Onshore Water-Intake Detail.

Table I. Fish Species Collected from July 1973 to June 1974

Alewife	Longnose dace
Rainbow smelt	Fathead minnow
Bloater	Golden shiner
Lake whitefish	Central mudminnow
Cisco or lake herring	Gizzard shad
Lake trout	Yellow perch
Brown trout	Slimy sculpin
Rainbow trout	Trout-perch
Coho salmon	Ninespine stickleback
Chinook salmon	Brook stickleback
Longnose sucker	Burbot
White sucker	Largemouth bass
Carp	White crappie
Spottail shiner	Black bullhead
Emerald shiner	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		Alewife	Rainbow Smelt	Slimy Sculpin	Spottail Shiner	Total
1973	4	138,490	13,559	1,023	1,202	154,228
1974	11	1,439,329	189,014	3,840	571	1,671,652
1975	12	19,135,638	39,293	295	379	19,177,306

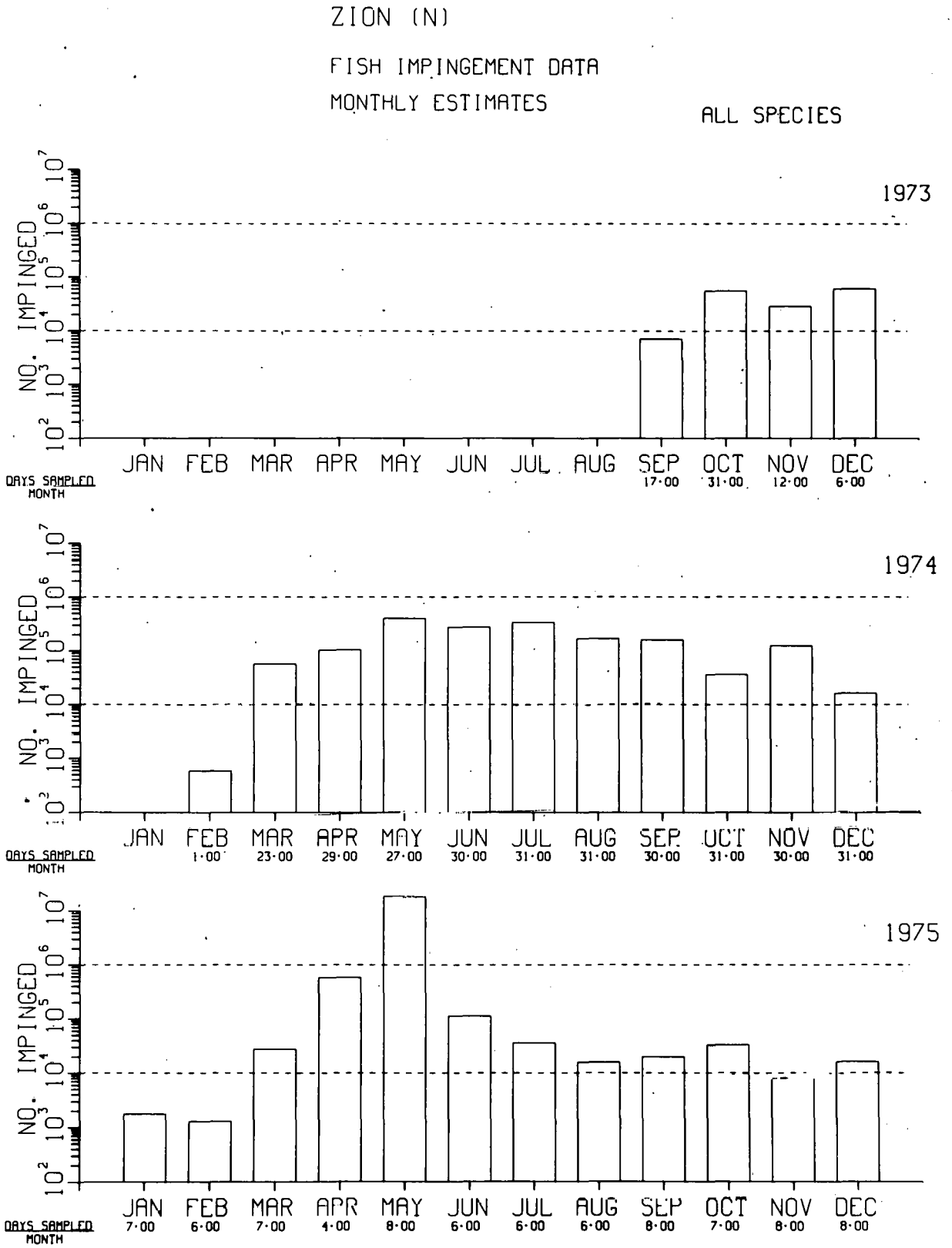


Fig. H1. Impingement Estimates.

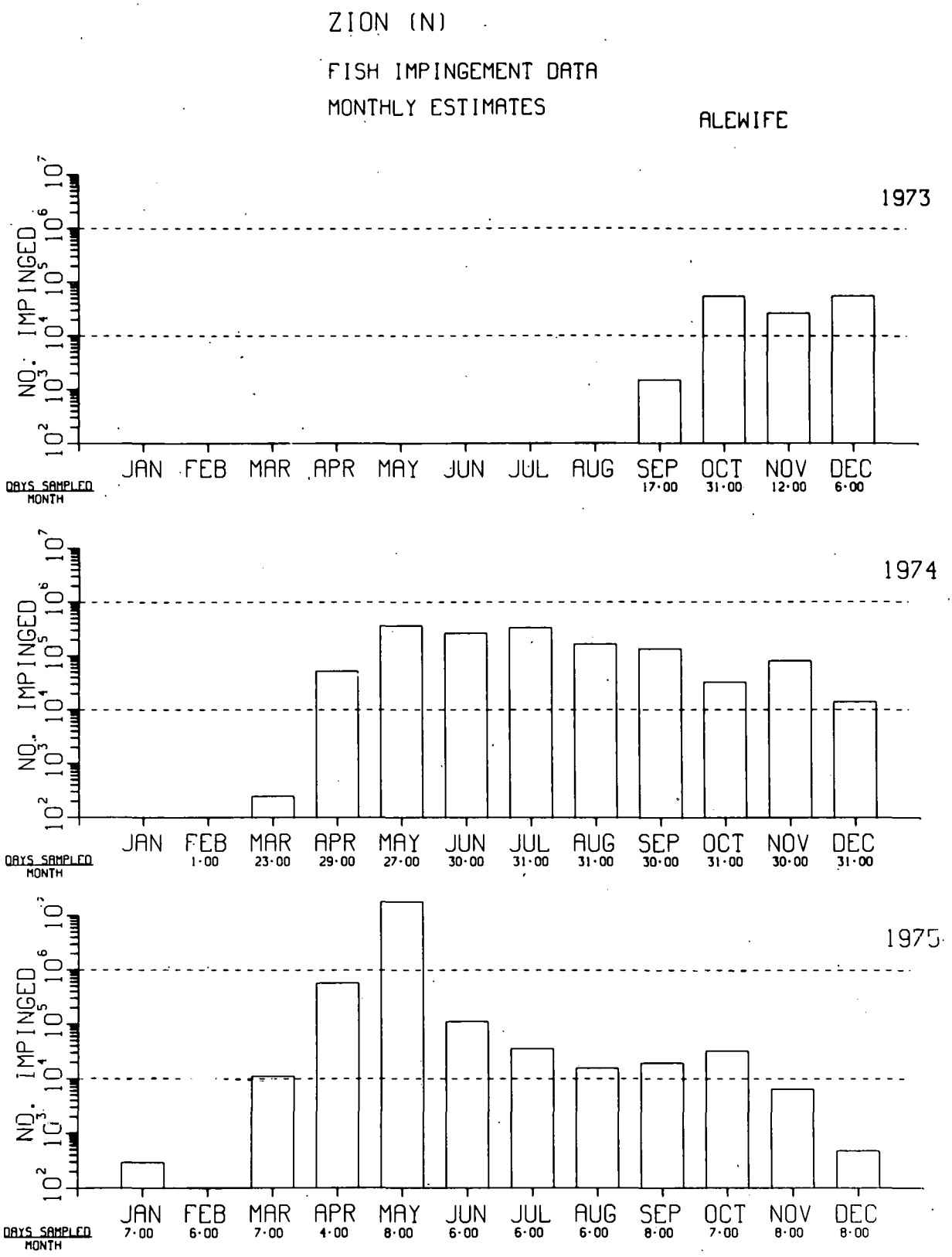


Fig. H2. Impingement Estimates.

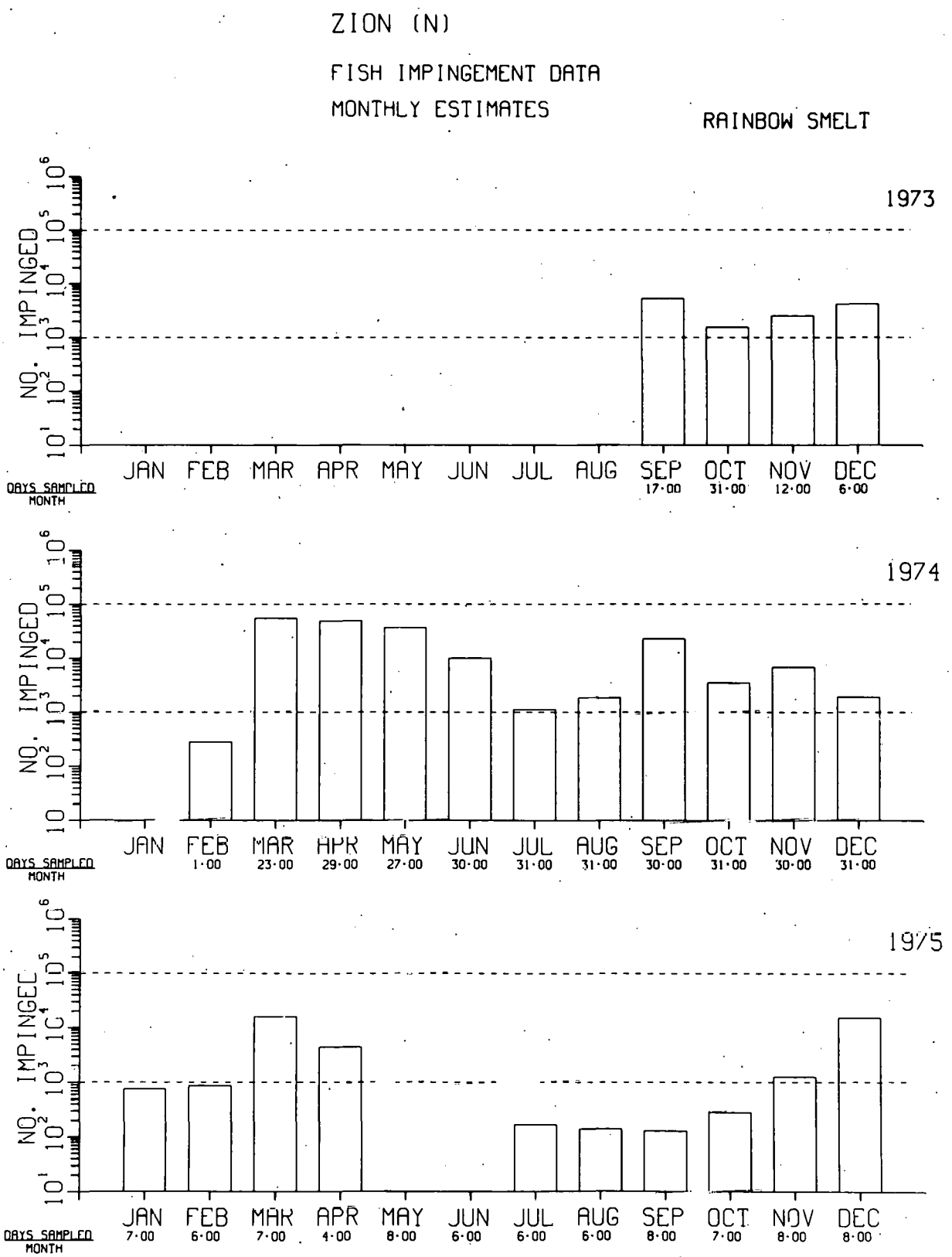


Fig. H3. Impingement Estimates.

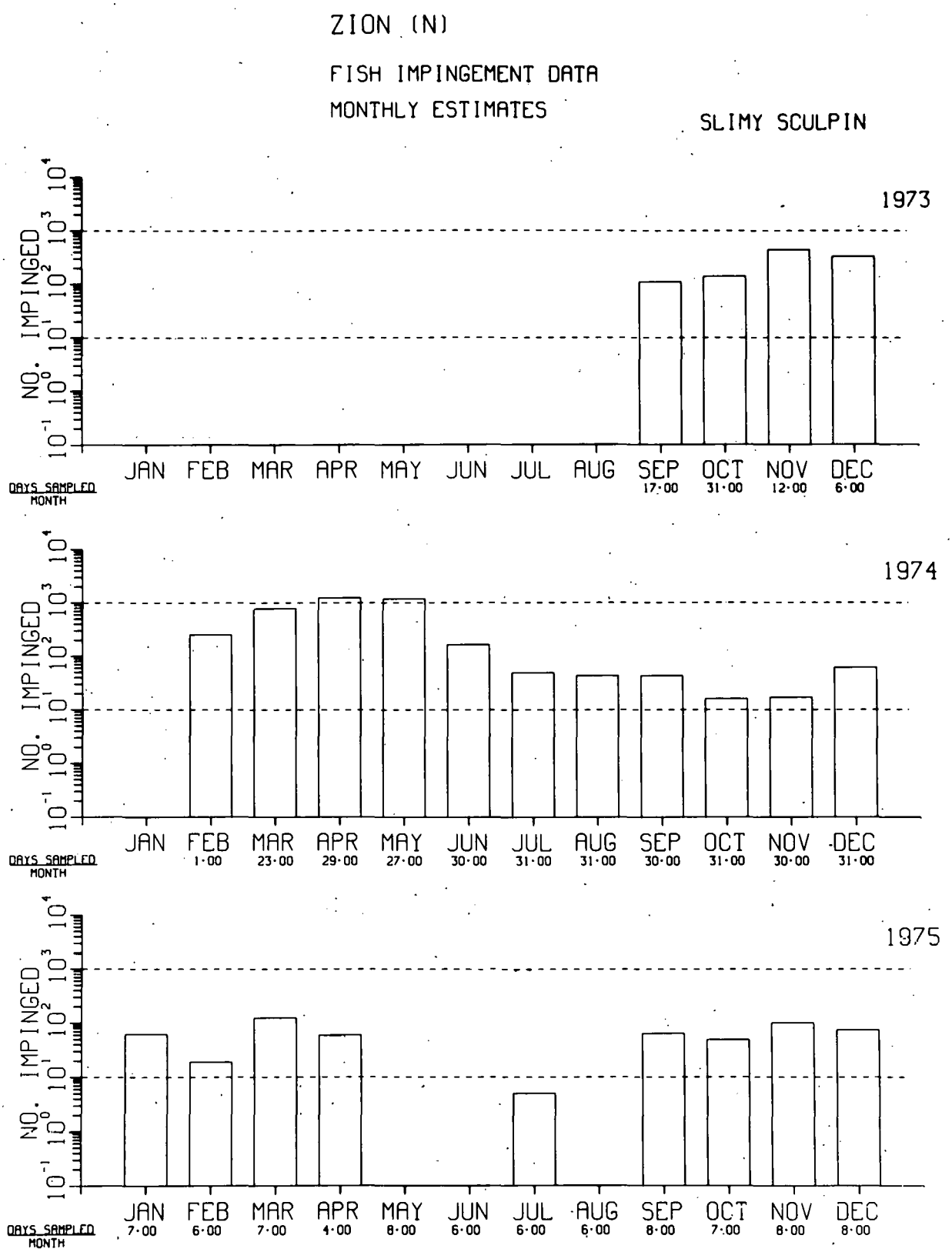


Fig. H4. Impingement Estimates.

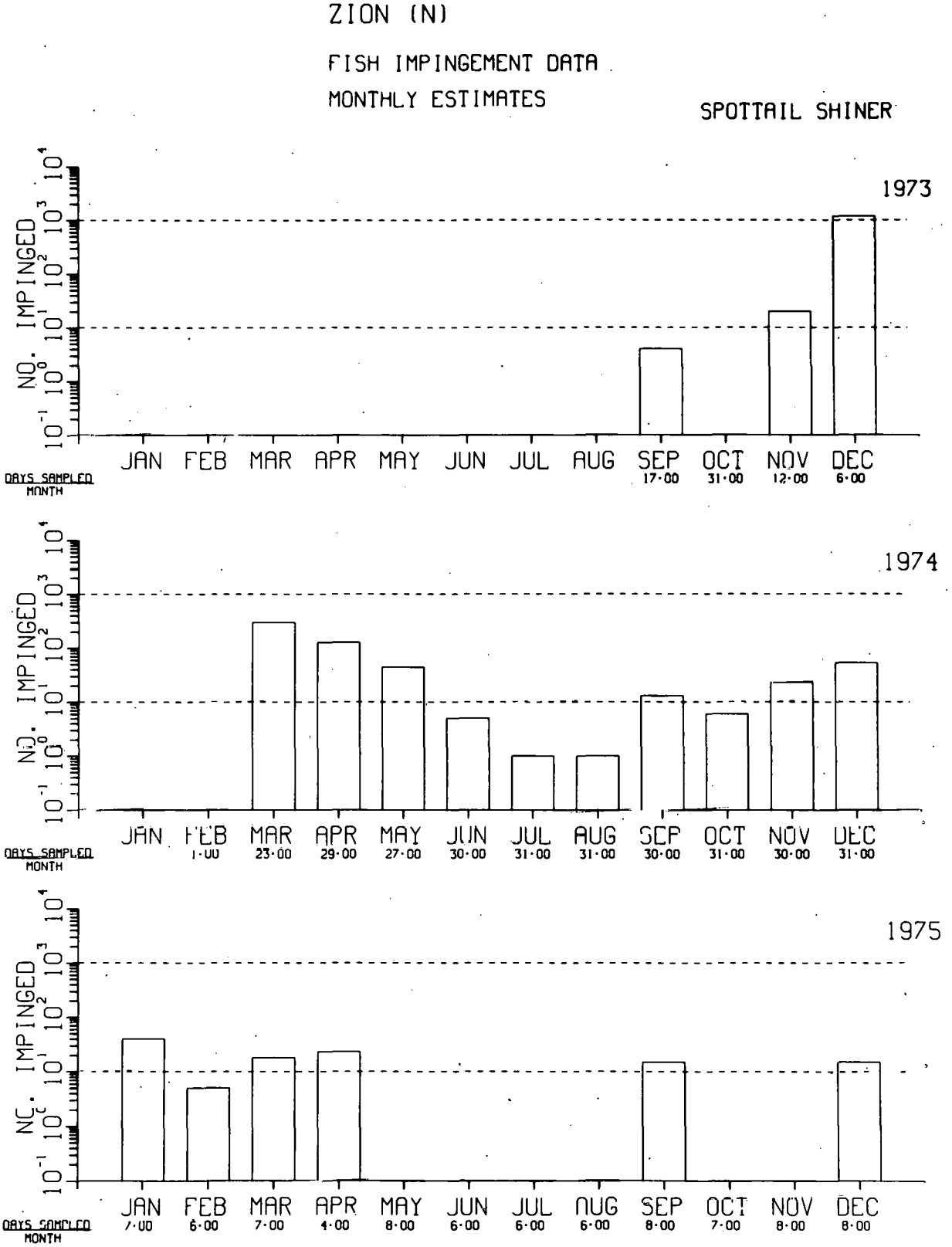


Fig. H5. Impingement Estimates.

WAUKEGAN GENERATING STATION (F)

SITE CHARACTERISTICS

The Waukegan Generating Station is located on the southwest shore of Lake Michigan in Waukegan, Illinois. The shoreline in the vicinity of the station is uniform with no harbors or bays. Bottom contours are even and the slope is gradual. Bottom sediments are characterized by fine sand near the shore with percentages of silt and clay generally increasing with depth.[1] At the time of this report, a list of fish species found in the vicinity of the plant was not available.

PLANT DESCRIPTION

The Waukegan Generating Station consists of four fossil-fueled units. The gross power ratings of the four units are given in Table I. The station utilizes once-through cooling with water being drawn directly from Lake Michigan.

INTAKE DESIGN AND OPERATION

Water used for condenser cooling at the Waukegan Generating Station is withdrawn from Lake Michigan via an intake canal (Fig. 1). The water passes through 14 traveling screens that have 3/8-inch mesh. Calculated velocities through the screens are given in Table I.[2] There are ten circulating-water pumps. Condenser flow rates for the various units are given in Table I.

IMPINGEMENT SAMPLING

The traveling screens at the Waukegan Generating Station were monitored for impinged fish over a 24-hour period every fourth day beginning 12 May 1975.[3] Forty-eight hours prior to the impingement count, the chlorinating system was shut off to insure that fish present in the intake canal were not stunned by the presence of chlorine. All fish collected were identifed to species, weighed, and measured. If more than 50 fish of a given species were found, a total weight was noted and a random subsample of 50 fish was removed. The fish in this subsample were then weighed and measured separately. An estimated total number was then calculated.

DATA AVAILABILITY

Fish impingement data for the Waukegan Generating Station are available for May through December 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 and H2 are histograms representing the three most abundant species as well as all species impinged at the Waukegan Generating Station. Table II summarizes these totals.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The Waukegan Generating Station employs a fish net from April through October to discourage large fish from entering the intake canal. The net has a mesh size of about one inch.[2]

REFERENCES

1. "Operational Environmental Monitoring in Lake Michigan near Zion Station, July 1975 through December 1975." Vol. 1. Nalco Environmental Sciences, Northbrook, Illinois. 13 February 1976.

2. Personal communication with David Moskovitz of Commonwealth Edison Co. 7 June 1976.

3. "316(b) Studies at Waukegan Generating Station, April-June 1975." Nalco Environmental Sciences, Northbrook, Illinois. 18 July 1975.

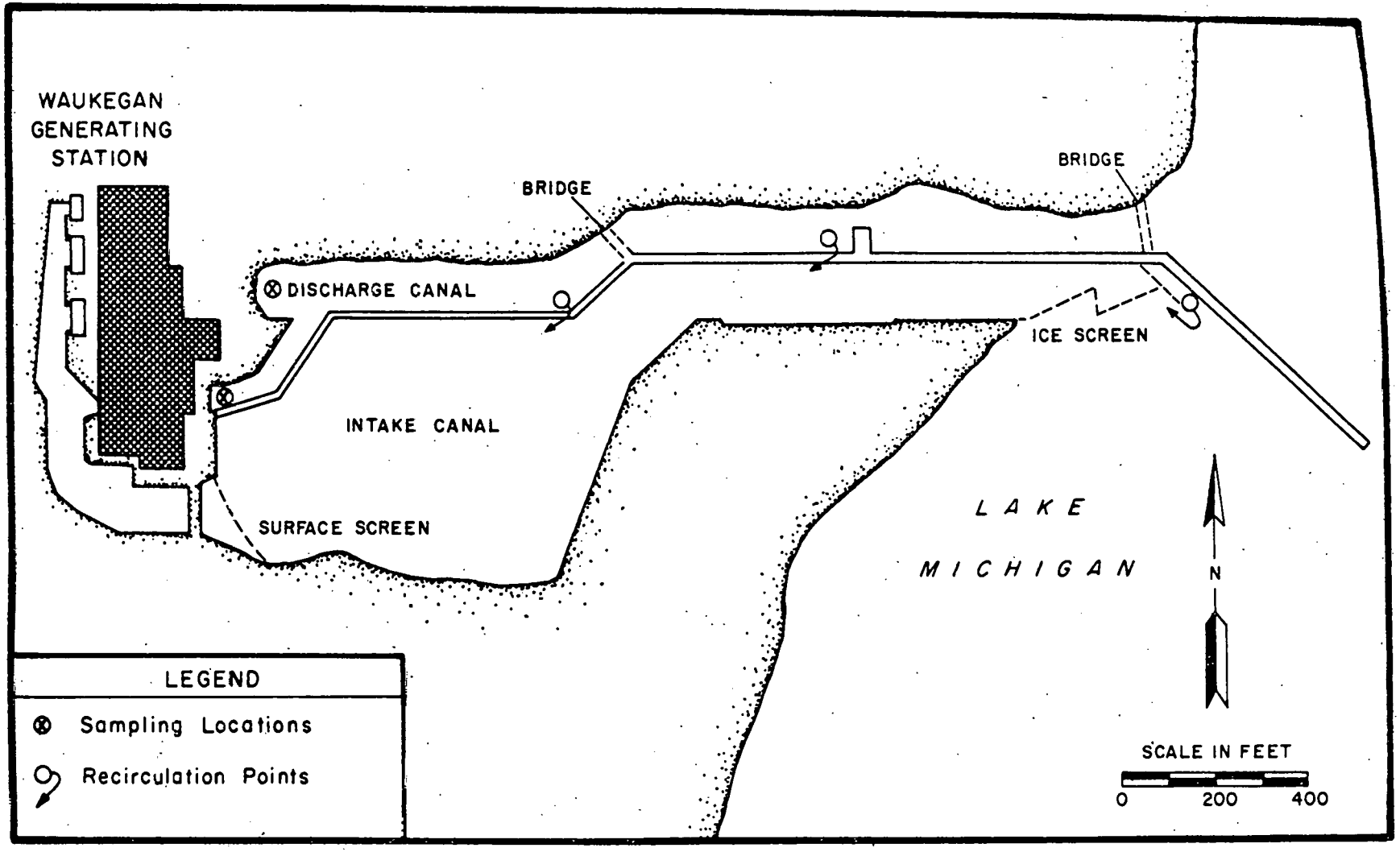


Fig. 1. Station Plan Showing Intake and Discharge Canals.

Table I. Power Ratings and Cooling-System Parameters

Unit	Gross Power (MWe)	Water Velocity at Screens (fps)	Condenser Flow Rate
5	135	2.0	131,956 gpm
6	100	1.7	112,208 gpm
7	335	2.3	255,834 gpm
8	323	2.1	219,827 gpm
Total	893		719,925 gpm

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Rainbow Smelt	Gizzard Shad	Total
1975	8	689,827	3,404	4,157	699,138

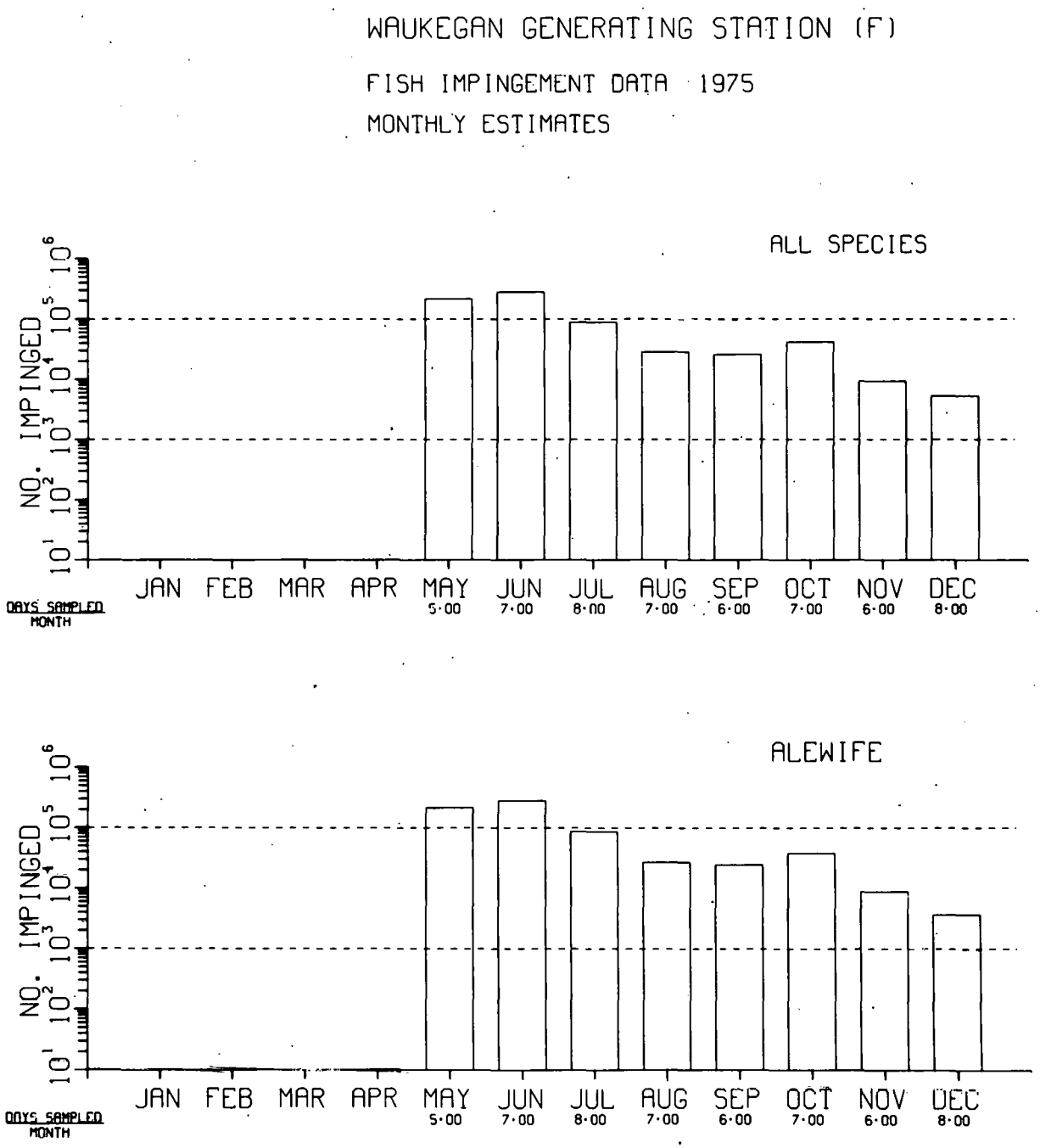


Fig. H1. Impingement Estimates.

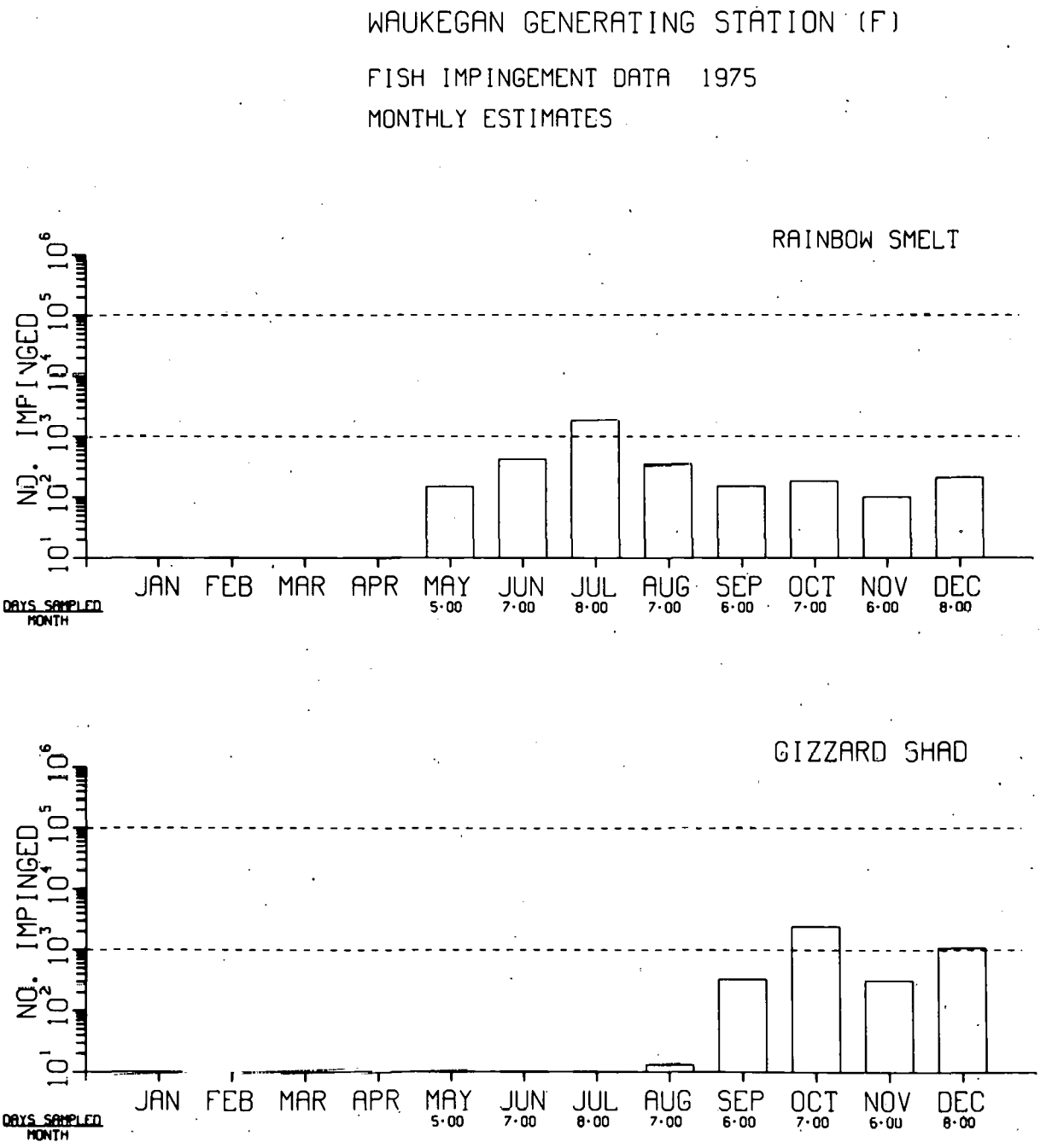


Fig. H2. Impingement Estimates.

STATE LINE GENERATING STATION (F)

SITE CHARACTERISTICS

The State Line Generating Station is located on the extreme southwestern tip of Lake Michigan in Hammond, Indiana (Fig. 1).[1] Table I is a list of fishes impinged at the station.

PLANT DESCRIPTION

The station consists of four units with a total load capacity of 972 MWe and utilizes once-through cooling.

INTAKE DESIGN AND OPERATION

Condenser cooling water is withdrawn from Lake Michigan through a granite-block leaky-dam breakwater into an intake forebay. The cooling-water discharge into Lake Michigan flows through a leaky dam also.

A schematic diagram of the trash barrier, sluice, and collection basket of the State Line Station is shown in Figure 2. Water is withdrawn from the intake forebay by way of gates that open into small embayments in front of the traveling screens. Trash racks, consisting of metal bars about three inches apart, protect the screens from heavy debris. The screens consist of wire gridwork with seven-inch by 3/8-inch openings. There are ten screens in the crib house, five for Units 2 and 3 and five for Units 1 and 4. When activated, the screens travel vertically on a continuous belt, lifting impinged materials into a sluiceway, through which they are carried to a trash collection basket and removed to appropriate dumping sites. The trash collection basket is constructed of a steel grid with a mesh aperture of about four inches by 3/8 inch.

The embayments in front of the trash racks are equipped with compressed-air hoses that are periodically activated to clean this area. Each unit has two circulating-water pumps. The eight pumps have a total rated flow of 829,976 gpm.

An ice-tempering recirculation canal is separated from the intake forebay by a steel curtain. This curtain is pierced in various places, and a small amount of discharge water is continuously recirculated into the intake forebay. To alleviate icing, a gate provides for larger amounts of water to be recirculated when the intake-water temperature is below 38°F.

Results of current-velocity measurements indicated that water does not pass through each screen at the same rate. Generally, at surface and bottom levels, current velocities were less than 0.5 fps, whereas mid-depth velocities ranged from 0.8 to 1.8 fps. Surface and mid-depth velocities at the southernmost screen were measured to be 1.6 to 2.0 fps. A strong eddy or whirlpool has frequently been observed at that point adjacent to the crib-house wall in the intake forebay; however, it has never been noted that more fish are impinged on this particular screen. Except in the one instance when current velocity was as high as 2.0 fps, it was otherwise sufficiently low that escape would be possible for most healthy fish with unobstructed access back to the forebay.

IMPINGEMENT SAMPLING

The traveling screens at the State Line Generating Station were monitored for impinged fish over a 24-hour period every fourth day beginning 5 April 1975. Fish were sorted by species. When the number of fish of a given species was less than 50, all fish were individually weighed and measured. When the number of fish of a given species exceeded 50, the total species weight was determined, a random sample of 50 fish was taken, and the fish were weighed and measured individually. A mean weight of fish of each species was derived from the subsample and the total number of fish was estimated by dividing the total weight by the mean weight.

Dead and decomposing fish were removed from the samples, and were not regarded as having been impinged during the 24-hour sampling period.

DATA AVAILABILITY

Fish impingement data are available for April through December 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 and H2 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the State Line Generating Station in 1975. The totals were arrived at by simple extrapolation of the figures obtained during the sampling periods. Table II summarizes this information.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The State Line Generating Station does not employ any additional devices for minimizing fish impingement except for the granite-block leaky dam in front of the intake forebay.

REFERENCE

1. "316(b) Studies at State Line Generating Station, October-December 1975." Nalco Environmental Sciences, Northbrook, Illinois. 27 January 1976.

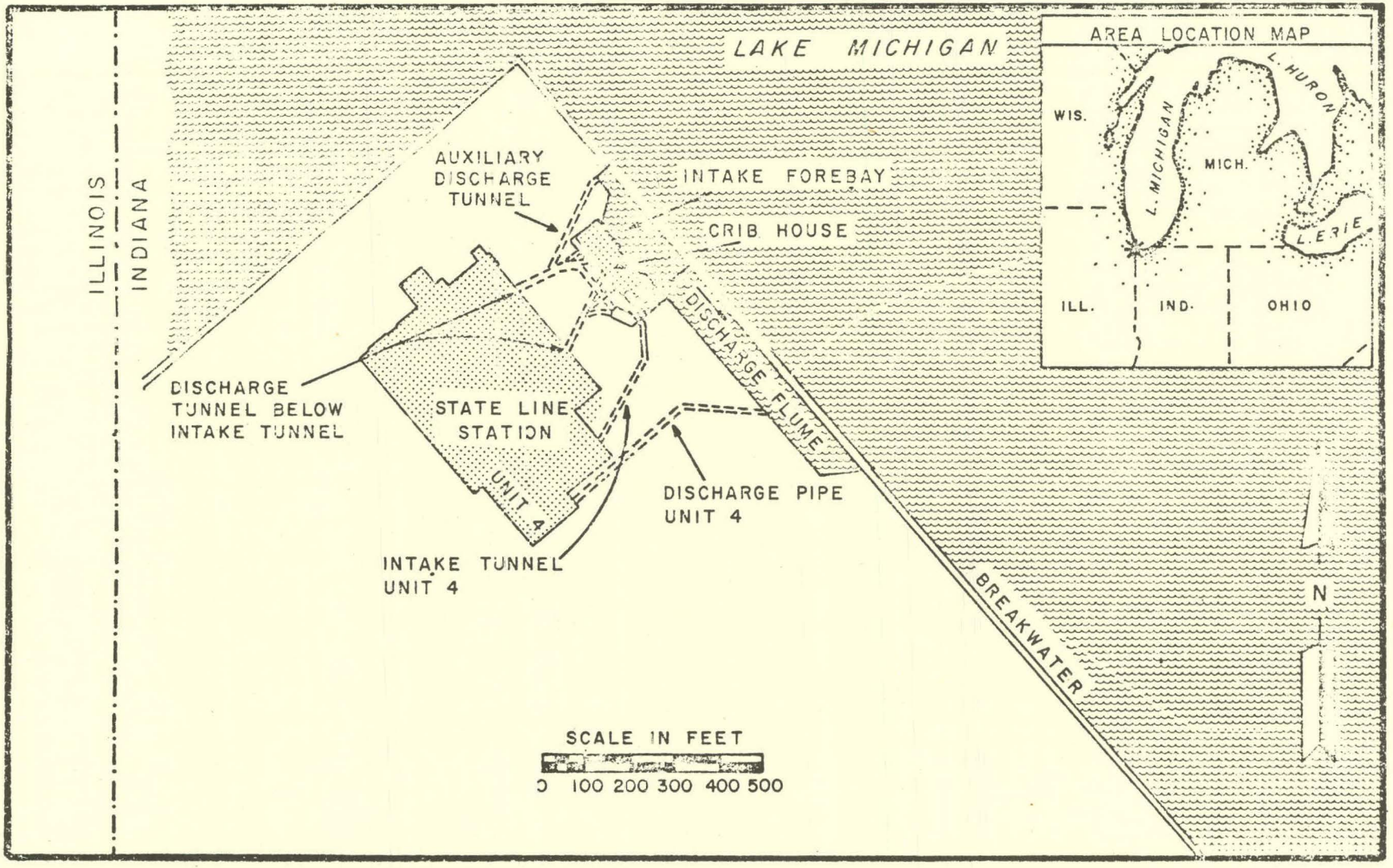


Fig. 1. Station Location and Plot Plan.

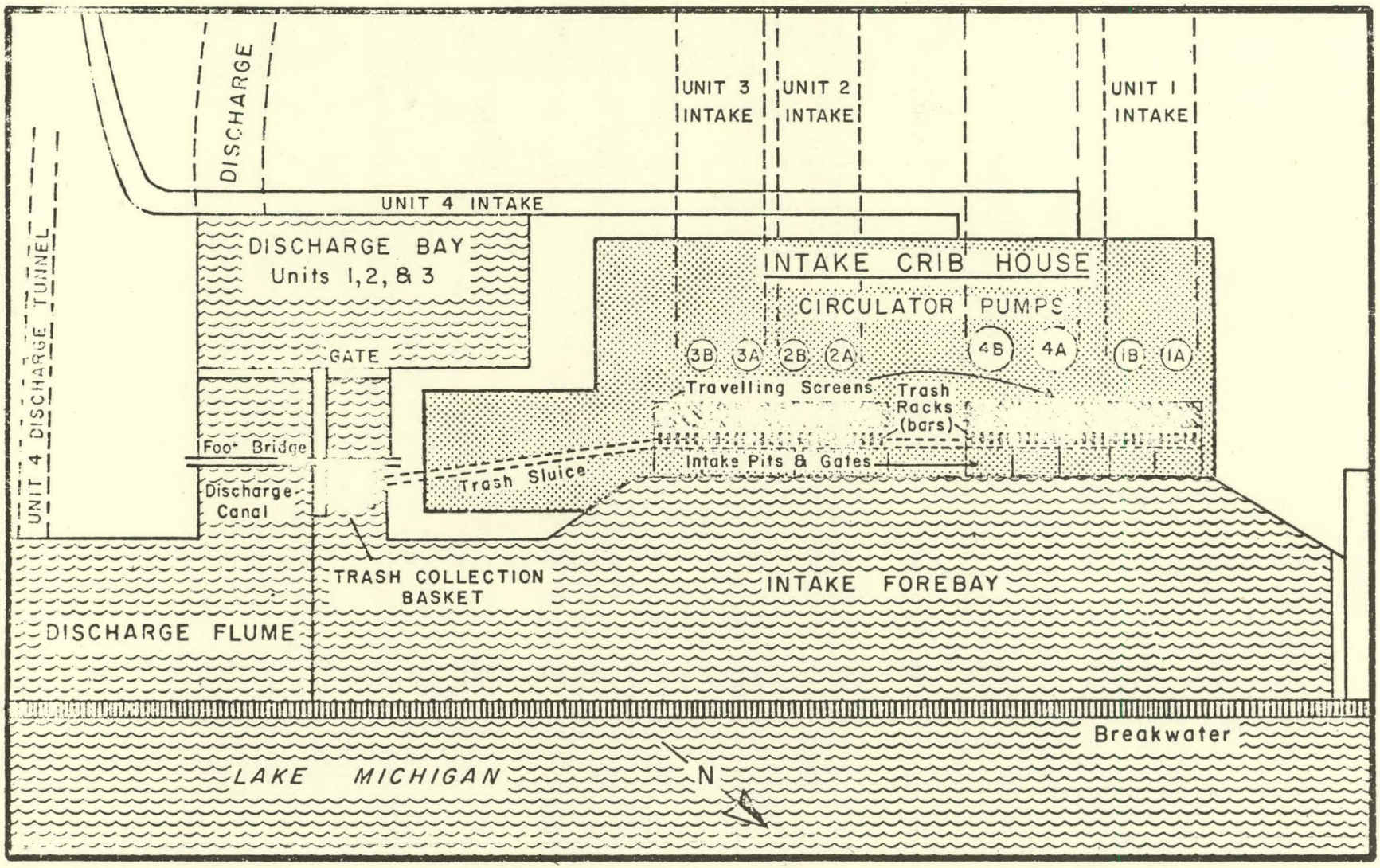


Fig. 2. Schematic of Intake and Discharge.

Table I. Fishes Impinged at the Station

Alewife	Black crappie
Rainbow smelt	Lake trout
Gizzard shad	Green sunfish
Yellow perch	Goldfish
Spottail shiner	Fathead minnow
Slimy sculpin	Bluegill
Brown trout	Largemouth bass
Trout-perch	Golden shiner
Ninespine stickleback	Silvery minnow
Carp	Smallmouth bass
Coho salmon	Brown bullhead
Emerald shiner	Chinook salmon
Rainbow trout	Johnny darter
Black bullhead	
Pumpkinseed	

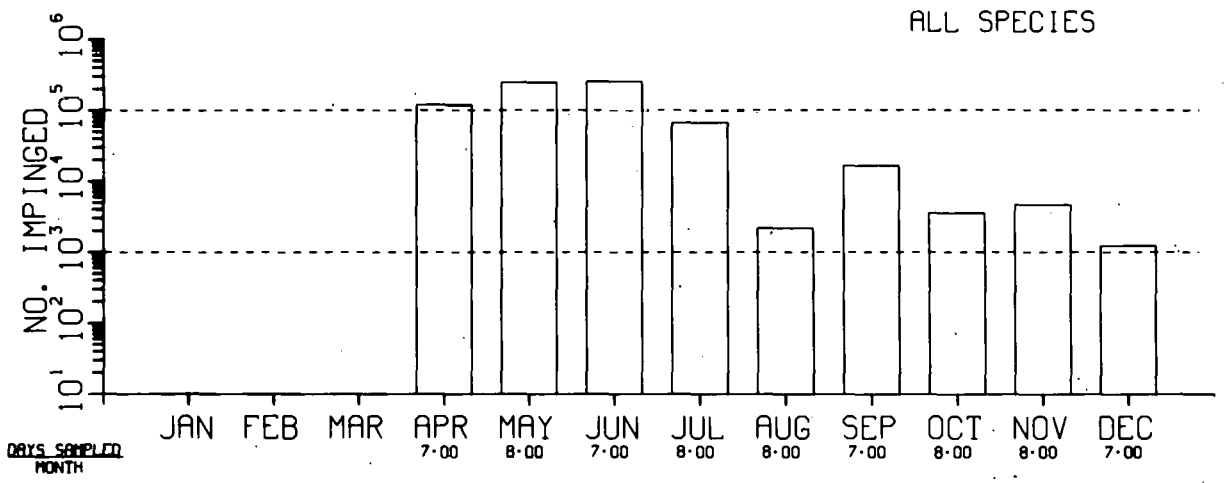
Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Gizzard Shad	Spottail Shiner	Total
1975	9	692,004	19,308	3,641	718,731

STATE LINE GENERATING STATION (F)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



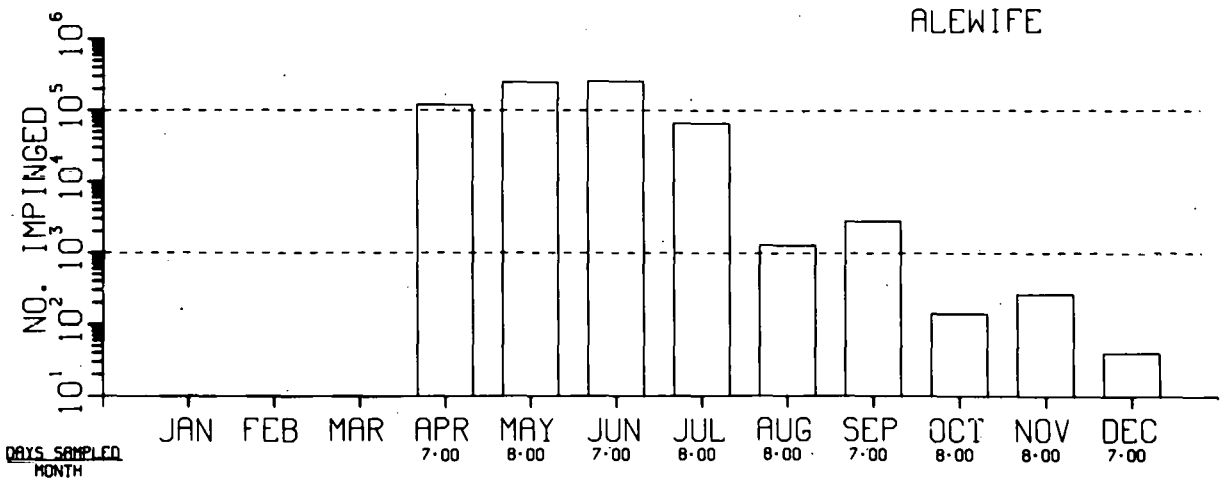


Fig. H1. Impingement Estimates.

STATE LINE GENERATING STATION (F)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES

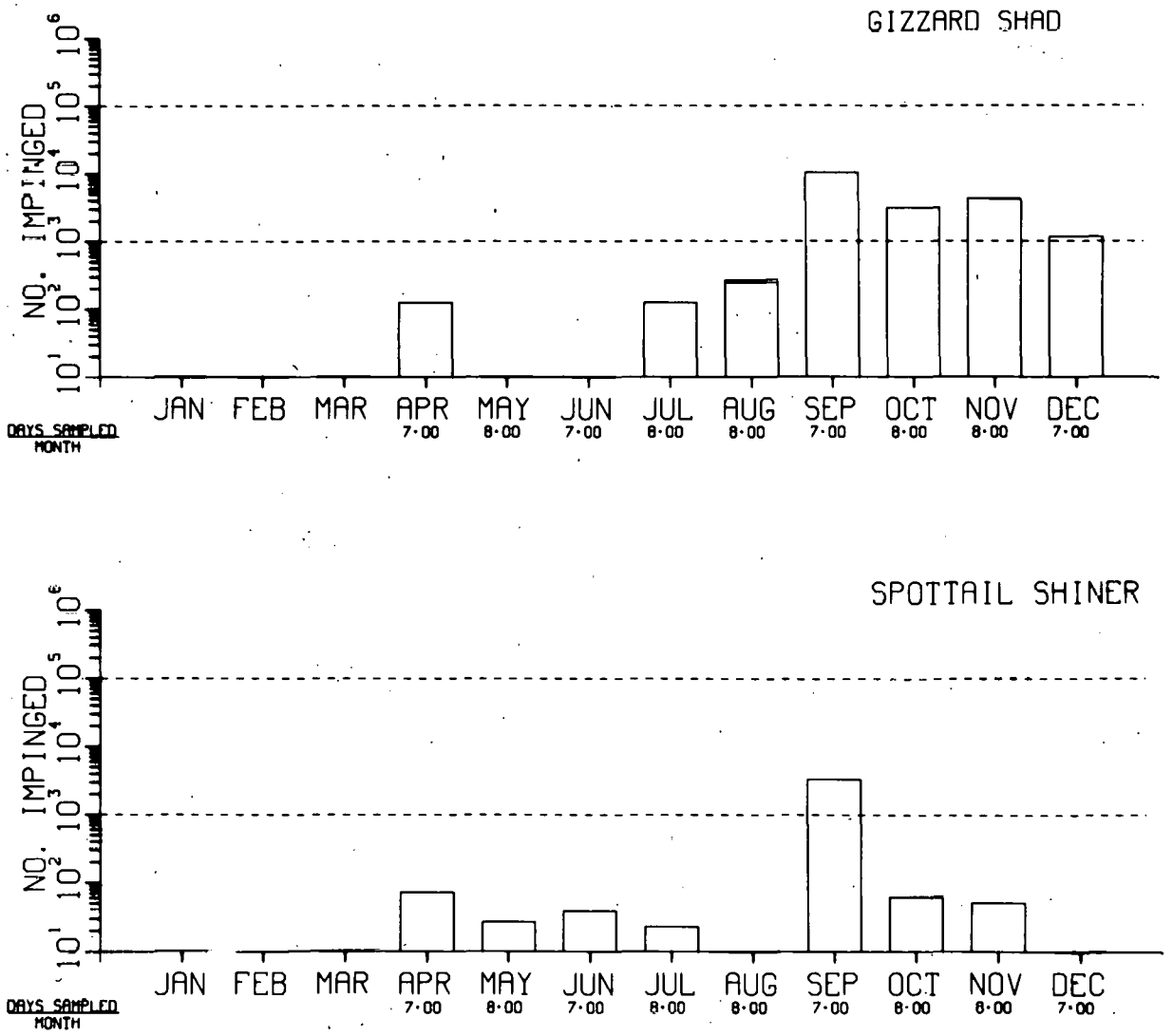


Fig. H2. Impingement Estimates.

DEAN H. MITCHELL STATION (F)

SITE CHARACTERISTICS

The Dean H. Mitchell Station is located on a 100-acre tract of land in Lake County, Indiana. It is situated on the southeast shore of Lake Michigan. Land-fill activity in the general vicinity of the station over the past 70 years has infringed on the lake to the extent that normally biologically productive areas are virtually absent. At the time of this report, a list of fishes found in the vicinity of the station was not available.

PLANT DESCRIPTION

The Dean H. Mitchell Station is composed of three units (Units 4, 5, and 6) that generate 138.1 MWe each, another unit (Unit 11) that generates 115.1 MWe, and three gas-turbine units that generate 17.4 MWe each, for a combined total of 581.6 MWe. Once-through cooling is utilized at the station.

INTAKE DESIGN AND OPERATION

Condenser cooling water is obtained from Lake Michigan via an intake canal. The intake crib itself is a steel and limestone-block structure extending 125 feet from the shore into Lake Michigan (Fig. 1). The large rocks allow a considerable amount of water to pass through. Plant personnel have estimated that 15% of the area of the intake structure is open to the passage of water.[1] Cooling water also enters through nineteen 36-inch-diameter pipes that vary in depth from five to 20 feet below the surface. To prevent freezing at the intake crib, discharge water is recirculated through a six-foot-diameter pipe into the intake-crib area. The intake forebay is equipped with trash racks, the bars being spaced 2-7/8 inches apart. Each unit has two traveling screens with openings that are 3/16 by 22-1/2 inches. The circulating-water pumps and condensers are further protected by electric screens consisting of three-inch-diameter pipes about 18 inches apart, which are intended to ward off fish (Fig. 2).

Intake parameters are presented in Table I.[1] These velocities are calculated values and will vary in magnitude with changes in lake level. Maximum condenser flow rate is 413,668 gpm.

IMPINGEMENT SAMPLING

The traveling screens and trash racks at the station were monitored for impinged fish over 24-hour periods from May 1975 through April 1976.[2] When

the number of fish of a given species exceeded 100, the total species weight was determined. A random subsample of 100 was taken and each fish was weighed individually. A mean weight of fish of each species was derived from the subsamples and the total number of fish was estimated. These total fish numbers and weights were then extrapolated to monthly total estimates.

DATA AVAILABILITY

Fish impingement data are available for 3 May 1975 through 27 April 1976.[2]

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the Dean H. Mitchell Station. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

At the time of this report, no information was available on the operation or effectiveness of the electric screen in reducing numbers of fish impinged.

REFERENCES

1. Section 316(a) Demonstration for the Dean H. Mitchell Station. Nalco Environmental Sciences, Northbrook, Illinois. 3 May 1976.

2. Section 316(b) Demonstration for the Dean H. Mitchell Station. Nalco Environmental Sciences, Northbrook, Illinois. 15 June 1976.

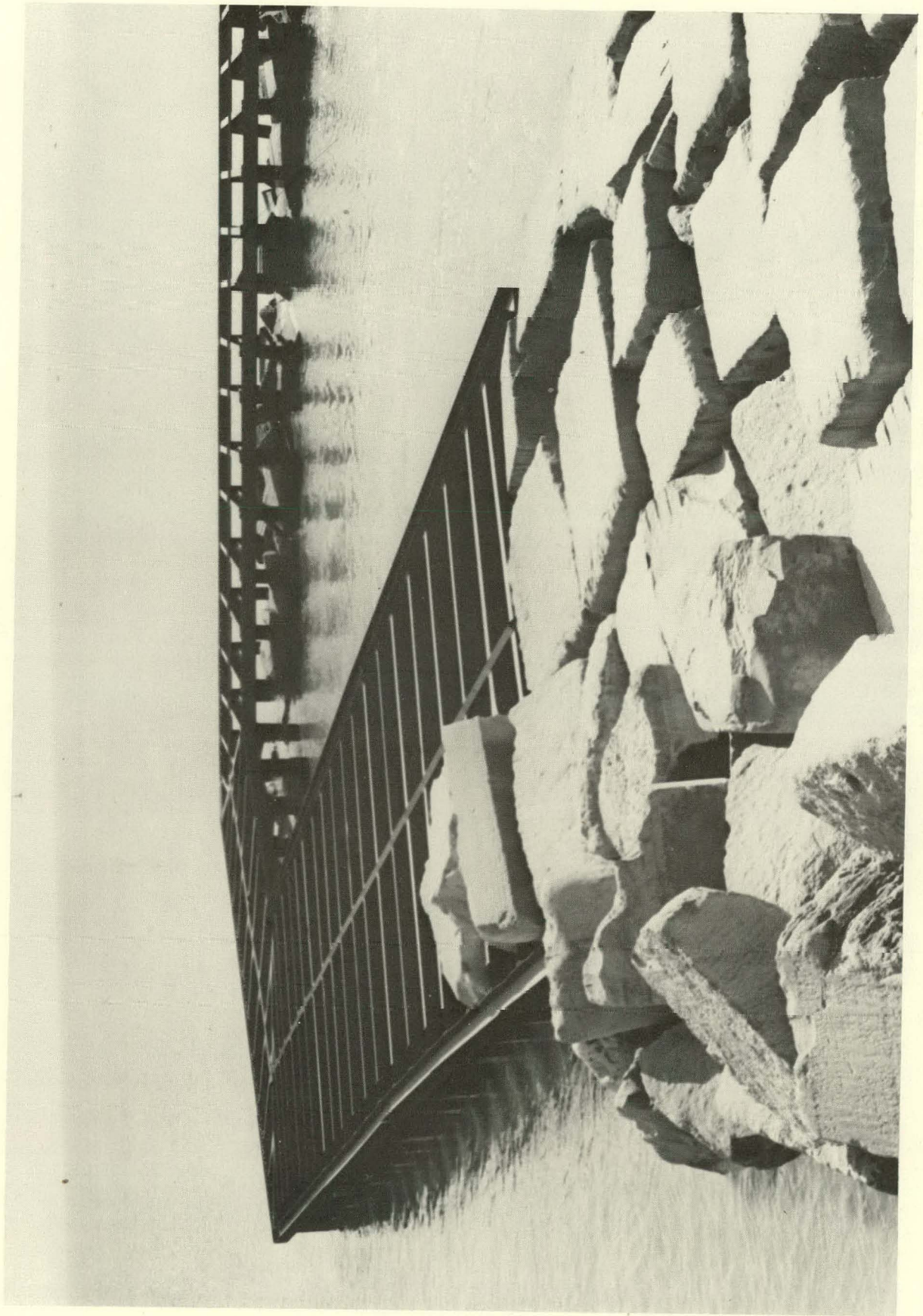


Fig. 1. Intake Crib.

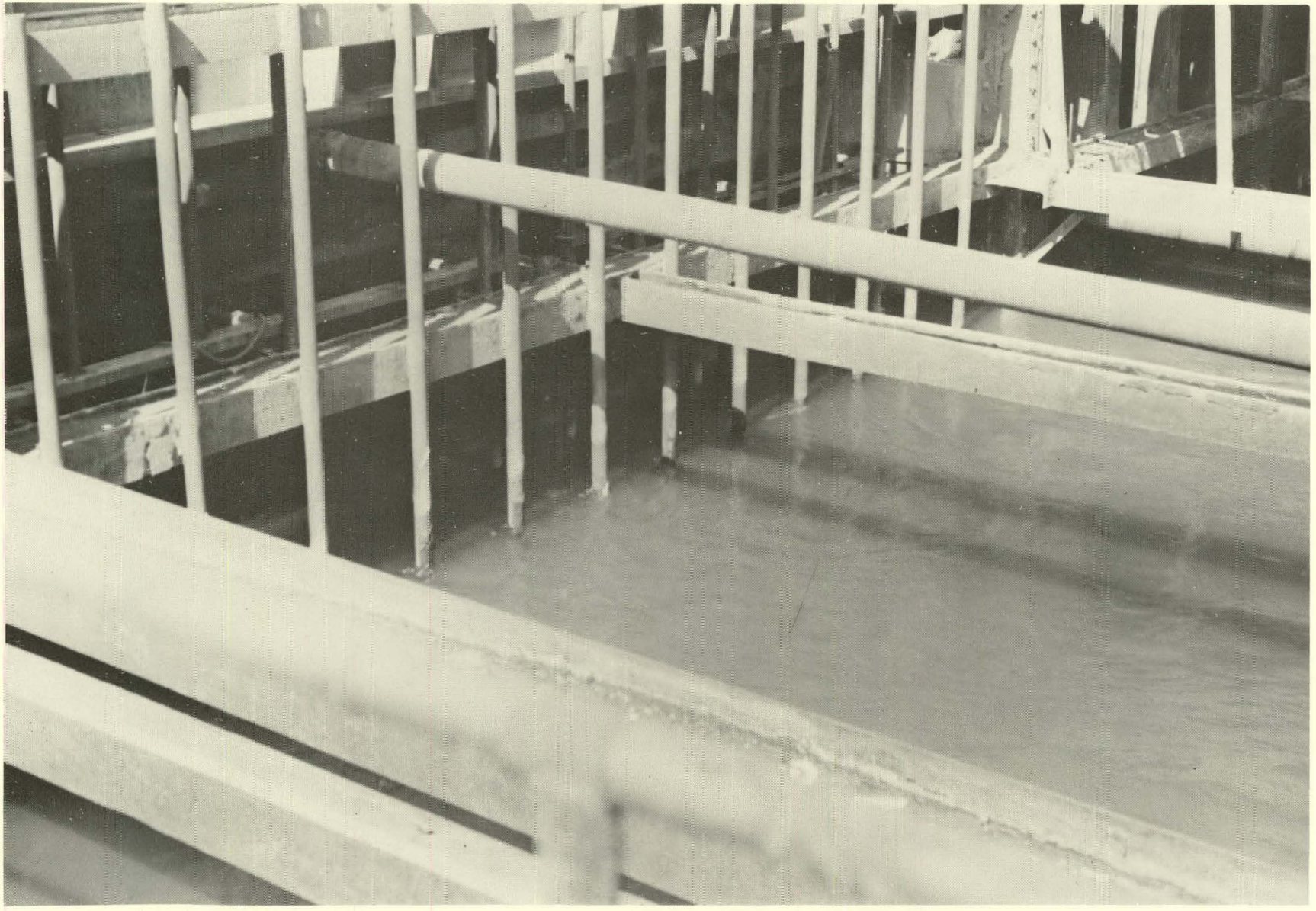


Fig. 2. Electric Fish Screen.

Table I. Intake Parameters

	Percent Total Flow[a]							
	100	88	76	64	53	41	28	16
Number of main circulating-water pumps in operation	8	7	6	5	4	3	2	1
Combined flow through condensers (gpm)	425,580	374,780	323,980	273,180	226,680	173,680	120,680	67,680
Velocity[b] at intake - no recirculation (fps)	1.35	1.19	1.03	0.86	0.72	0.55	0.37	0.22
Velocity[b] at intake - recirculation (fps)	1.11	0.96	0.82	0.68	0.56	0.42	0.29	0.16

[a]Includes five low-head service pumps in operation.

[b]Calculated for mean-low-water data (576.8 ft MSL).

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Gizzard Shad	Yellow Perch	Total
1975	8	149,916	2,023	493	153,191
1976	4	3,049	1,064	35	4,323

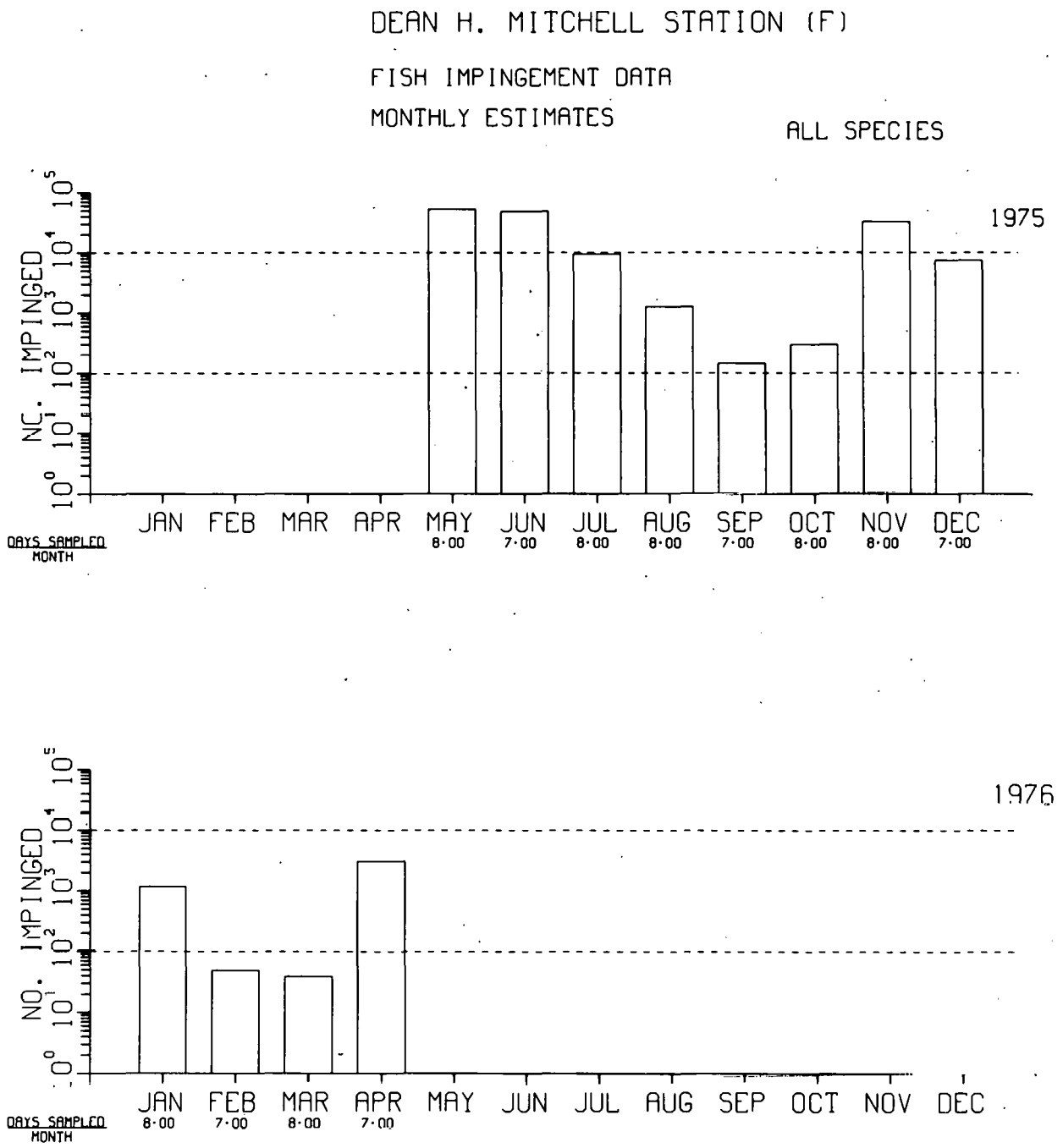


Fig. H1. Impingement Estimates.

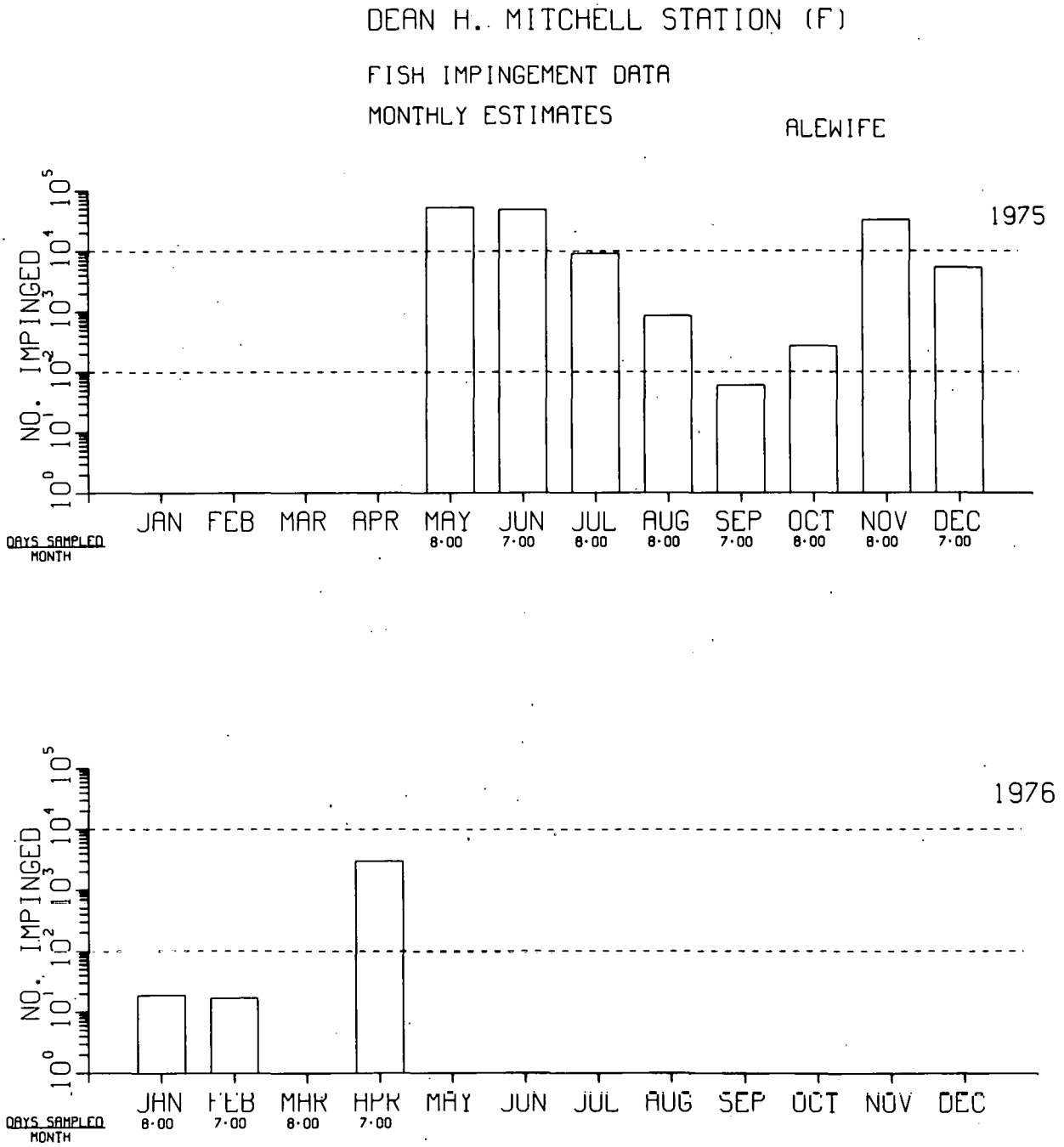


Fig. H2. Impingement Estimates.

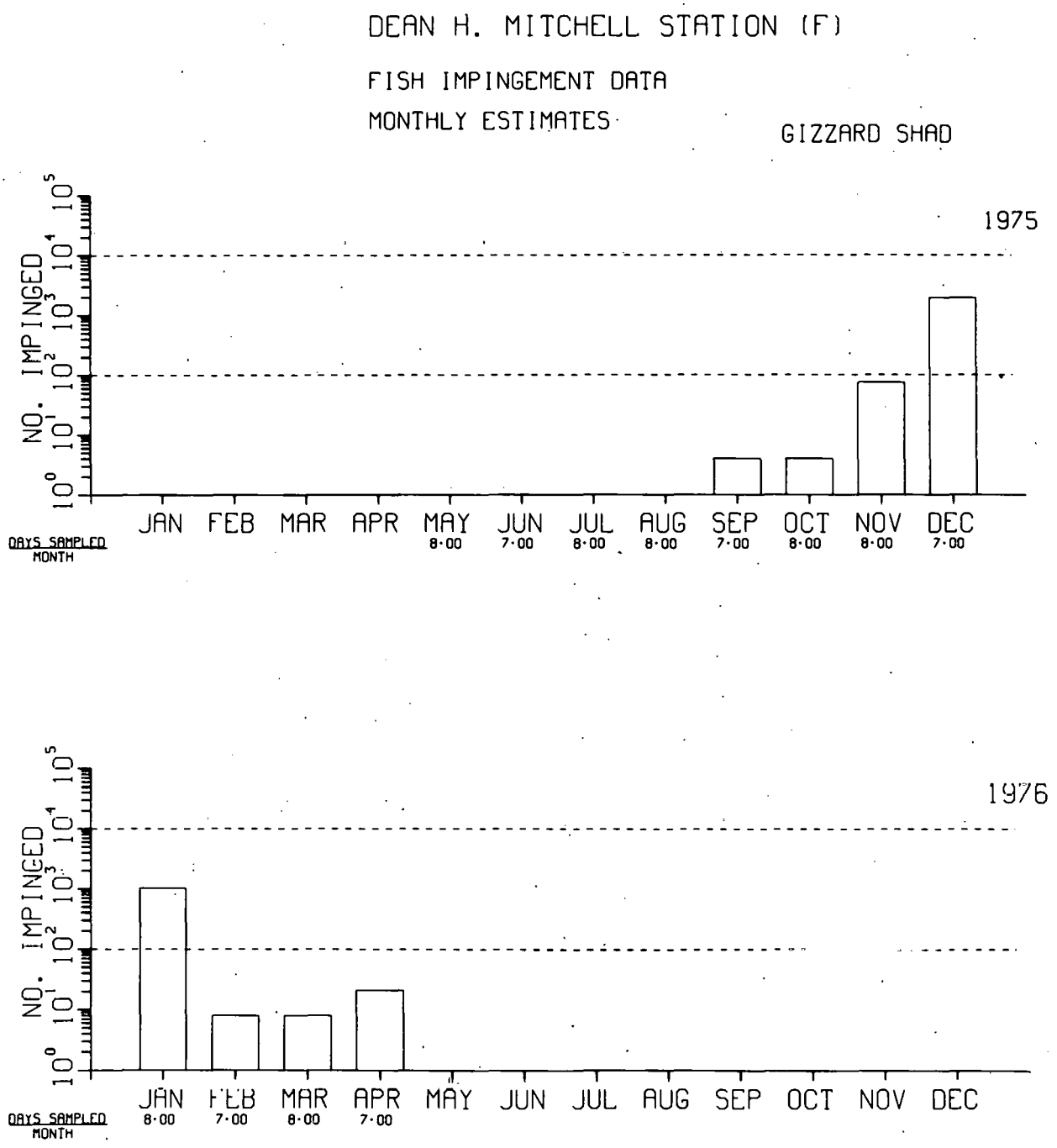


Fig. H3. Impingement Estimates.

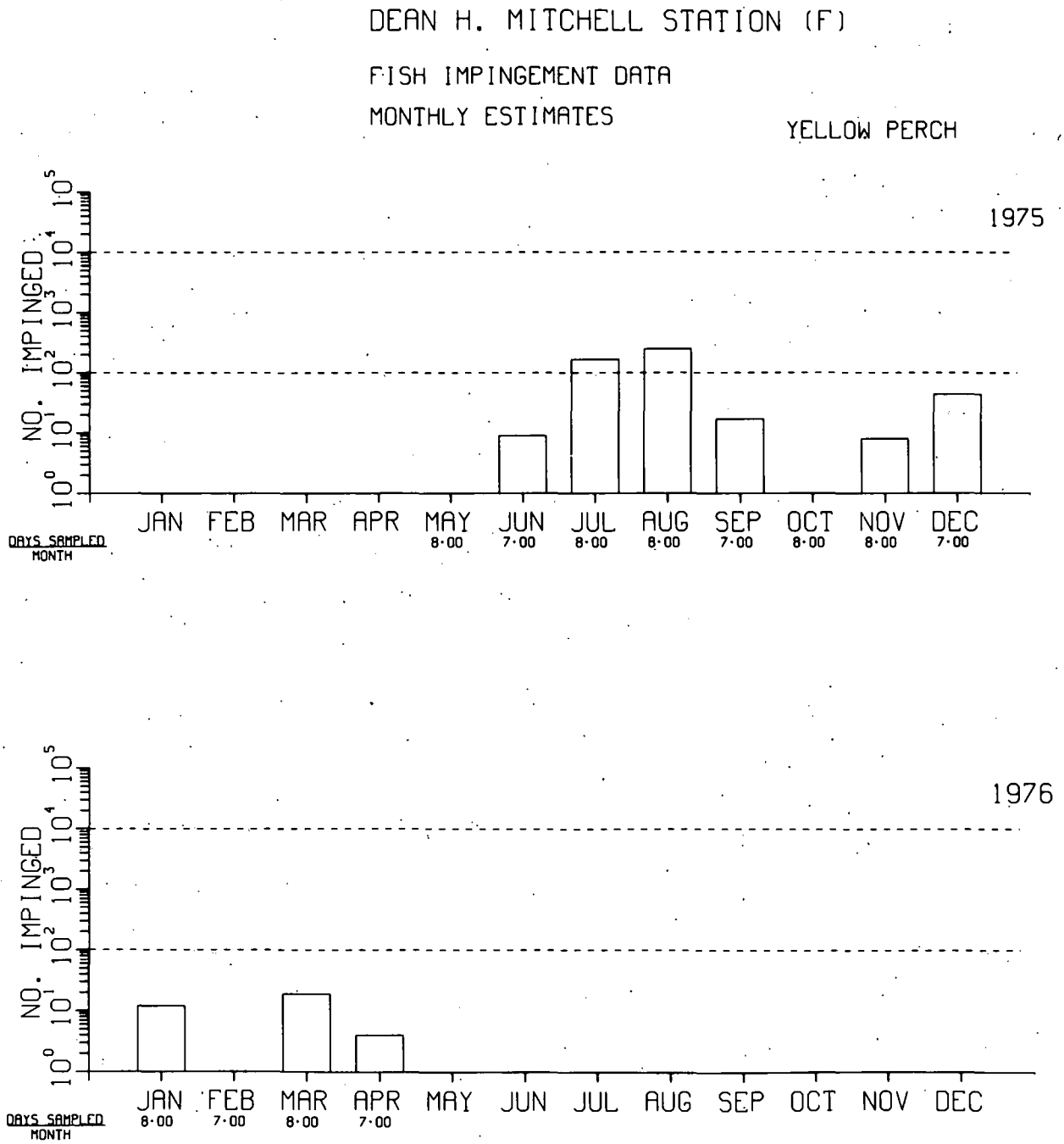


Fig. H4. Impingement Estimates.

BAILLY GENERATING STATION (F)

SITE CHARACTERISTICS

The Bailly Generating Station is located on the southeast shore of Lake Michigan. The site occupies 350 acres in Westchester Township of Porter County, Indiana. The shoreline at the station is gently sloping and composed of naturally deposited sand. Water temperature ranges from 32.8°F in winter to 65.5°F in summer.[1] A list of the important fishes found in the vicinity of the station was not available at the time of this report.

PLANT DESCRIPTION

Bailly Generating Station consists of two coal-fired units (Units 7 and 8). Unit 7 generates 194 MWe and Unit 8 generates 422 MWe, for a total of 616 MWe. The station utilizes once-through cooling, the water being drawn from Lake Michigan.

INTAKE DESIGN AND OPERATION

Condenser cooling water is drawn from Lake Michigan through a doughnut-shaped structure located 1500 feet offshore. The structure consists of two concentric circles, the diameter of the larger one being 110 feet and the smaller one 60 feet (Fig. 1). The circles are constructed of H-pilings that are driven 24 to 41 feet into the lake bottom. The pilings extend eight feet above the surface and are spaced four to five feet apart. The space between the circles is filled with rocks weighing from three to ten tons each. Twenty-six 36-inch-diameter pipes placed around the periphery draw water into the structure at the bottom. Voids between the rocks and the pipes at the bottom allow sufficient passage of water. A sheet-piling wall divides the inner circle into equal halves. Each half contains a 14-foot-diameter pipe that conducts cooling water to the pumphouse. Deicing is accomplished by partial diversion of discharge water. This intake design is similar to that of the Point Beach Nuclear Plant.

Each unit utilizes two condenser pumps. The pumps for Unit 7 have a capacity of 70,500 gpm each and the pumps for Unit 8 have a capacity of 83,380 gpm each, for a maximum condenser flow rate of 307,760 gpm.[2] Each unit has two sets of traveling screens having 3/8-inch-square mesh.

Intake velocities at such locations as the offshore structure, the trash bars, and the traveling screens are unavailable.

IMPINGEMENT SAMPLING

Fish impingement sampling was scheduled every fourth day for a 24-hour period. When quantities became too large for individual counting, subsamples were weighed and the corresponding weight converted to numbers of fish.

DATA AVAILABILITY

Data are available for February through September 1974.

IMPINGEMENT DATA SUMMARY

Figures H1 and H2 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the Bailly Generating Station. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Except for the rock-filled offshore intake structure, there are no devices reported to be in operation at the Bailly Generating Station to minimize fish impingement.

REFERENCES

1. "Final Environmental Statement, Bailly Generating Station, Nuclear-1." USAEC Directorate of Licensing. Docket No. 50-367. February 1973.

2. Personal communication with Terry Virnig of Northern Indiana Public Service Company. 4 May 1976.

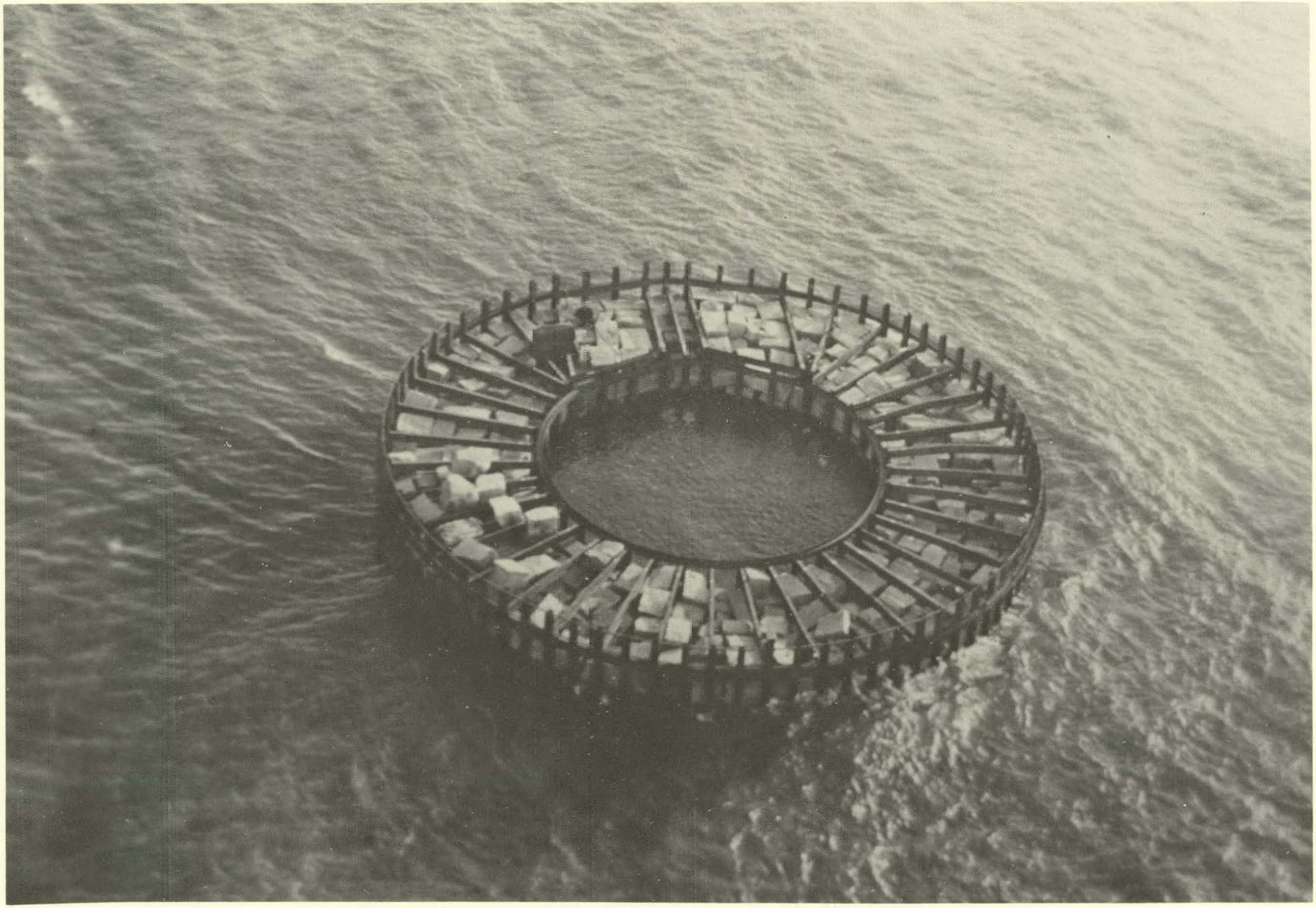


Fig. 1. Intake Structure.

Table I. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Yellow Perch	Rainbow Smelt	Total
1974	8	30,654	51	32	30,829

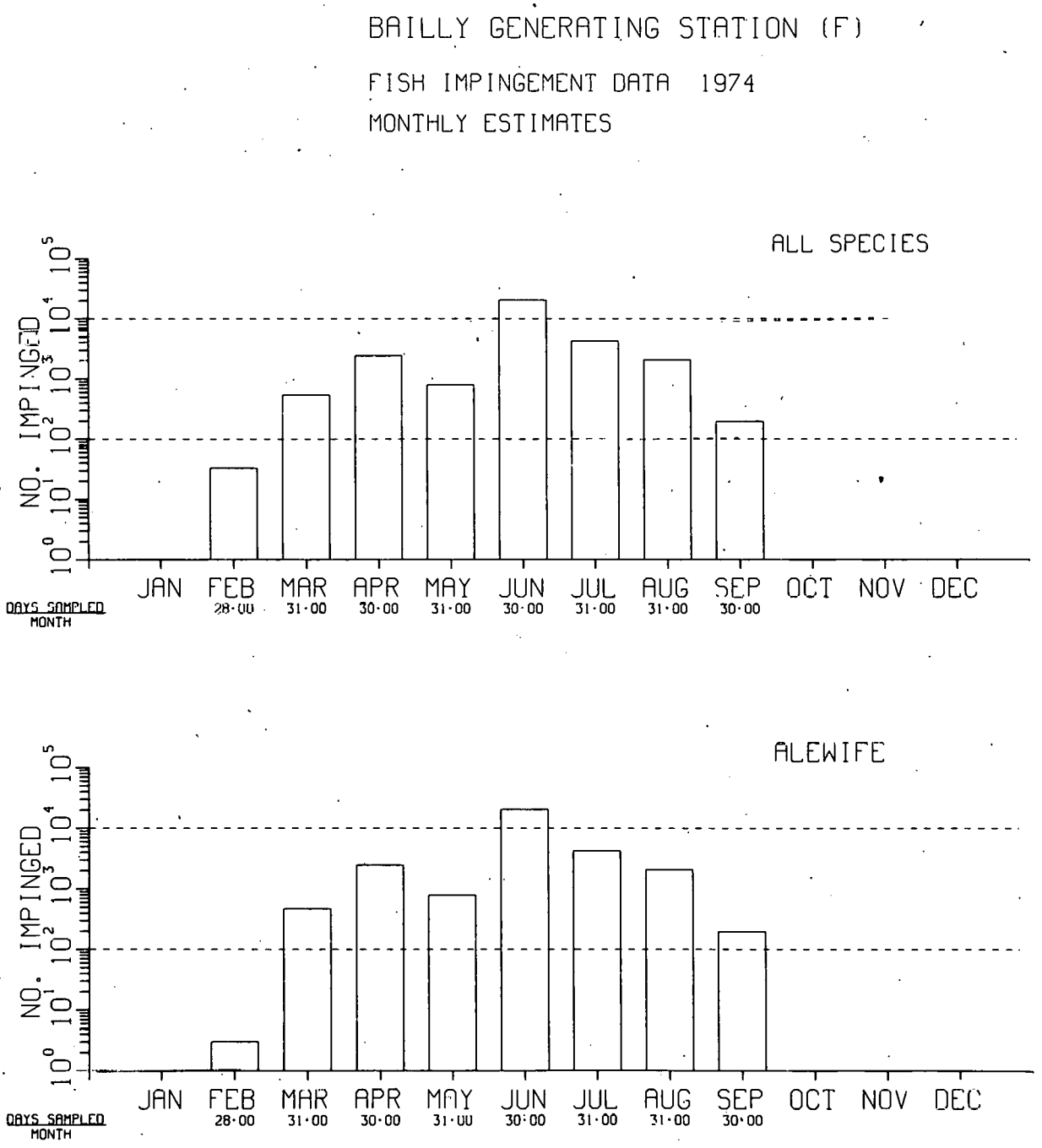


Fig. H1. Impingement Estimates.

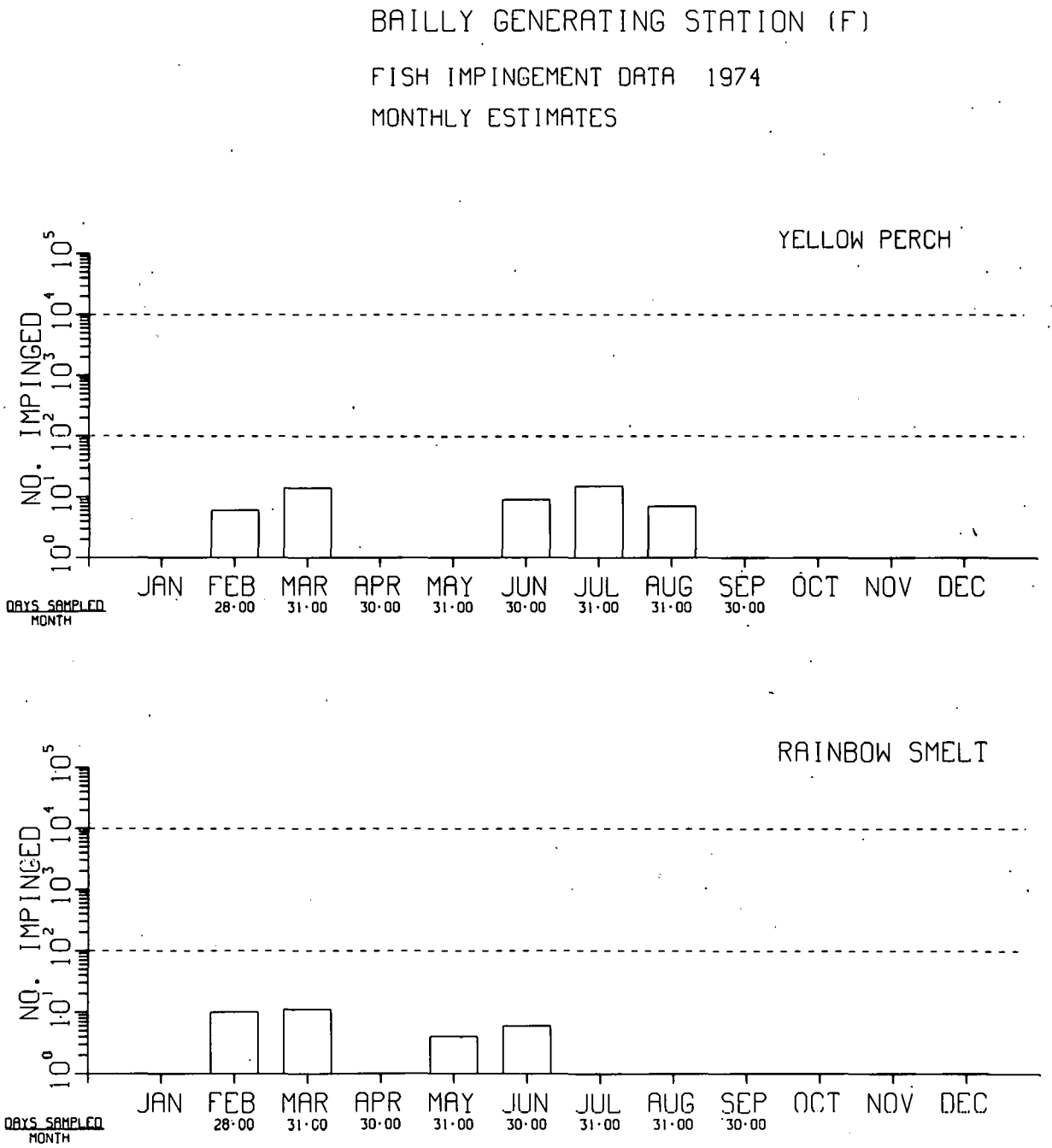


Fig. H2. Impingement Estimates.

MICHIGAN CITY GENERATING STATION (F)

SITE CHARACTERISTICS

The Michigan City Generating Station is located at the Lake Michigan shore and the mouth of Trail Creek in LaPorte County, Indiana. The shoreline is comprised of a sheet-piling dock wall at the site. Trail Creek is 375 feet wide and 15 feet deep. A list of fishes found in the vicinity of the Michigan City Generating Station was unavailable at the time of this report. Figure 1 is an aerial view of the station area.

PLANT DESCRIPTION

The Michigan City Generating Station is a four-unit fossil-fueled station (Units 1-3 and 12) generating about 736 MWe. Condensers for Units 1-3 are cooled by a once-through system using water drawn from Trail Creek. Condensers for Unit 12 are cooled using a natural-draft cooling tower with blowdown water being taken from the intake canal for Unit 3.

INTAKE DESIGN AND OPERATION

The station utilizes two intakes, both of which are located on Trail Creek. The intake for Units 1 and 2 is 28.5 feet wide, whereas the intake for Unit 3 is 28.0 feet wide. Each unit utilizes two identical circulating-water pumps as well as two sets of traveling screens. The maximum flow of water through the intake bay for Units 1 and 2 is 160,000 gpm, and 140,000 gpm is the maximum flow through the Unit 3 intake bay. At times of low flow, the entire flow of Trail Creek may be diverted through the plant. Intake velocities at various locations are unavailable.

Winter deicing results indirectly from the use of air-bubble screens in front of each intake bay. These are discussed in greater detail later.

IMPINGEMENT SAMPLING

For each unit on each day, the traveling screens were operated at least twice every shift. The fish were identified, counted, and weighed. When quantities became too large to count, the total impingement number was determined by subsampling.[1]

DATA AVAILABILITY

Fish impingement data for the Michigan City Generating Station are available for April 1973 through December 1974.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing total numbers of the three most abundant species as well as all species impinged at the station. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

An air-bubble screen has been placed in front of each intake bay. Each screen is made of 3/4-inch pipe. Two 20-foot-long pipes divided into 10-foot lengths make up the base. The holes in the pipes are 3/32 inch in diameter and are placed three inches apart. Each system utilizes 80 pounds of pressure.

In addition, both intake bays utilize electric shockers (Fig. 2). There are three electrodes per bay, each 19-1/4 feet long. The electrodes are 29 inches apart and 21 inches from either end. There are 30-inch spaces between electrodes and grizzlies. Each bay has 24 grizzlies, which are spaced four inches apart. The electrodes are placed eight inches above the harbor bottom.[1]

At the time of this report, no studies had been conducted to determine the effectiveness of either one of these two systems in reducing fish impingement at the Michigan City Generating Station.

REFERENCE

1. Personal communication with Terry Virnig of Northern Indiana Public Service Company. 4 May 1976.

Fig. 1. Aerial View Showing Part of the Station and Trail Creek.

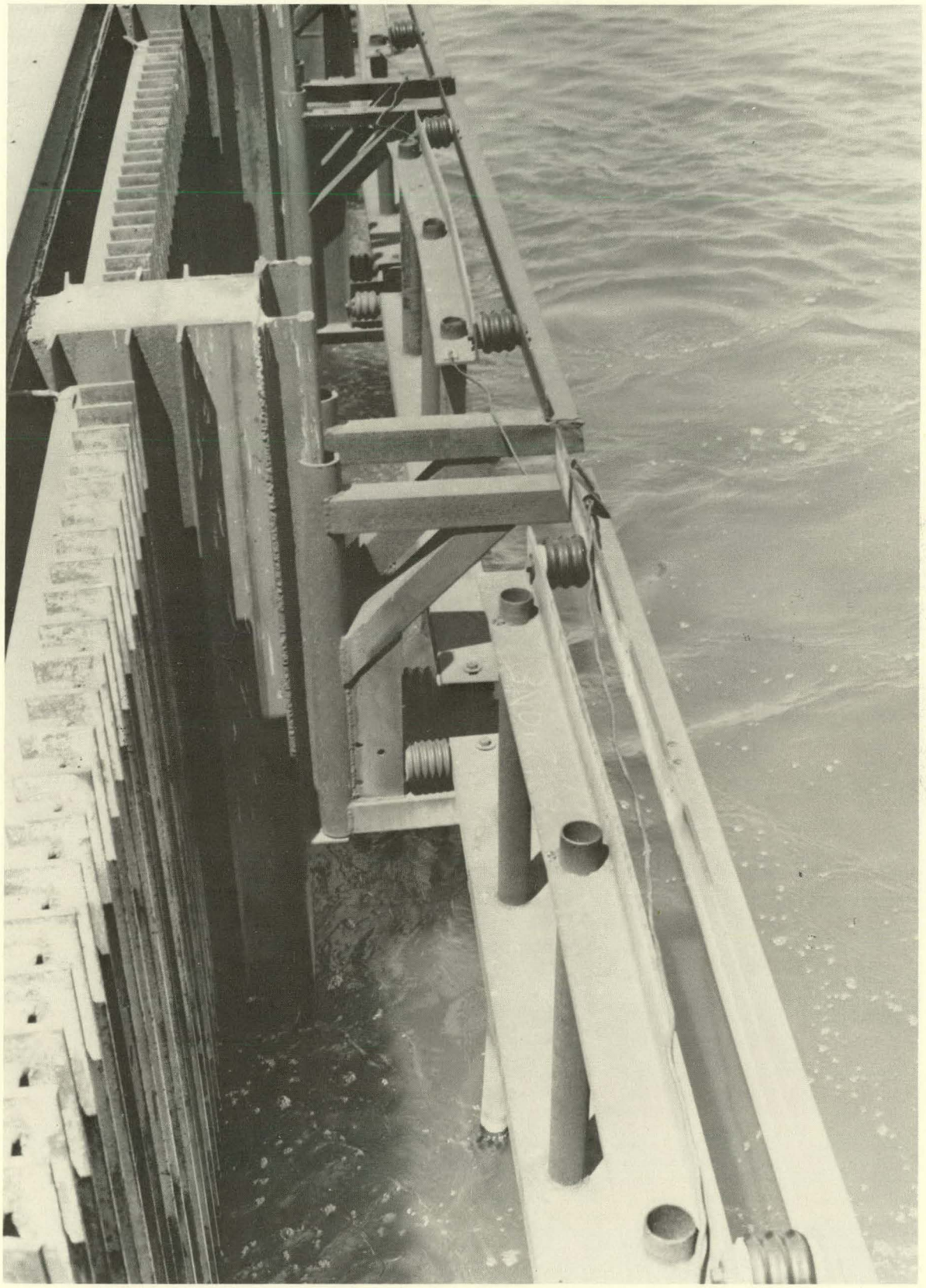


Fig. 2. Electric Fish Shockers.

Table 1. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Yellow Perch	Northern Pike	Total
1973	9	357,095	50	15	357,237
1974	12	172,926	21	33	173,034

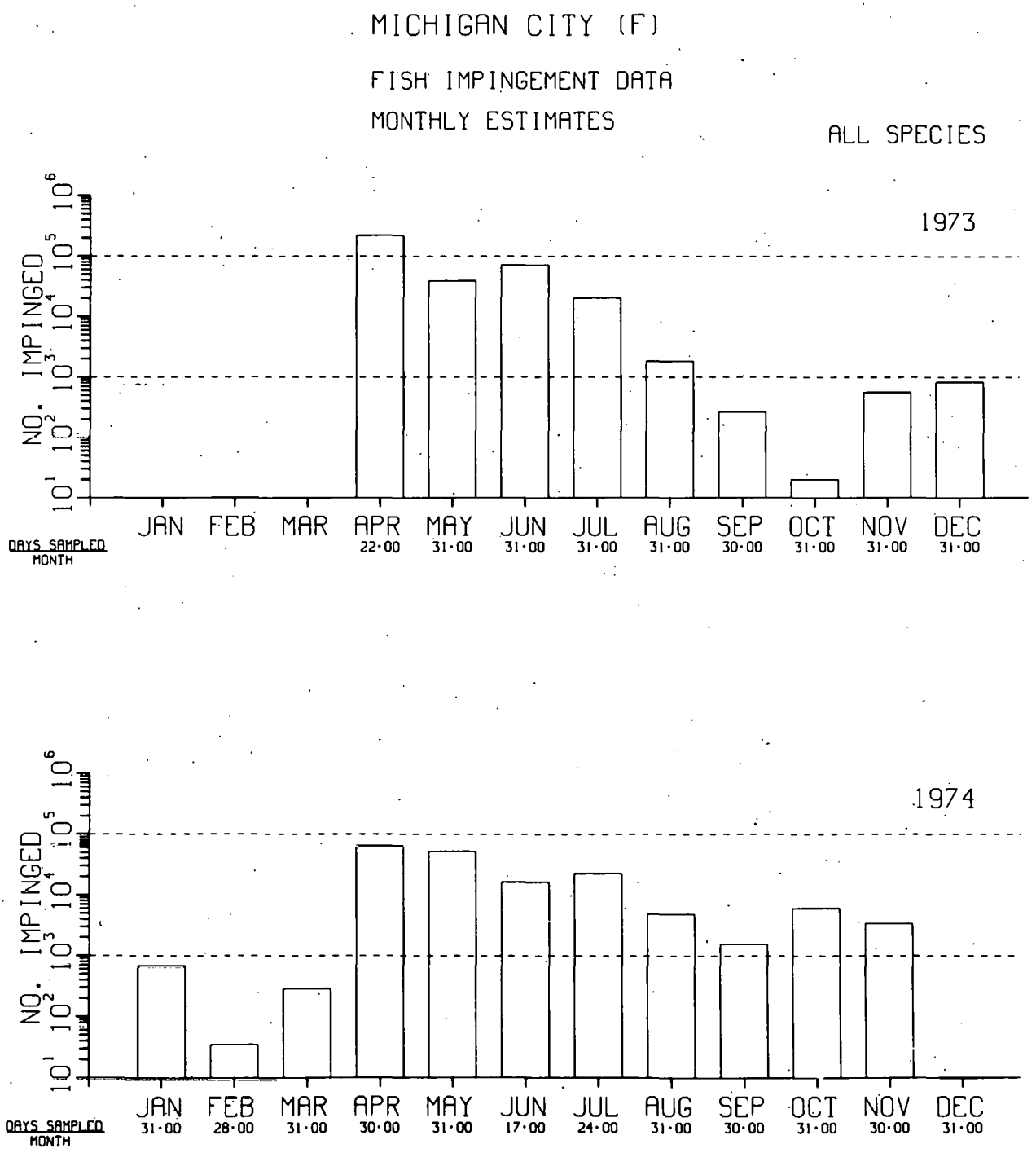


Fig. H1. Impingement Estimates.

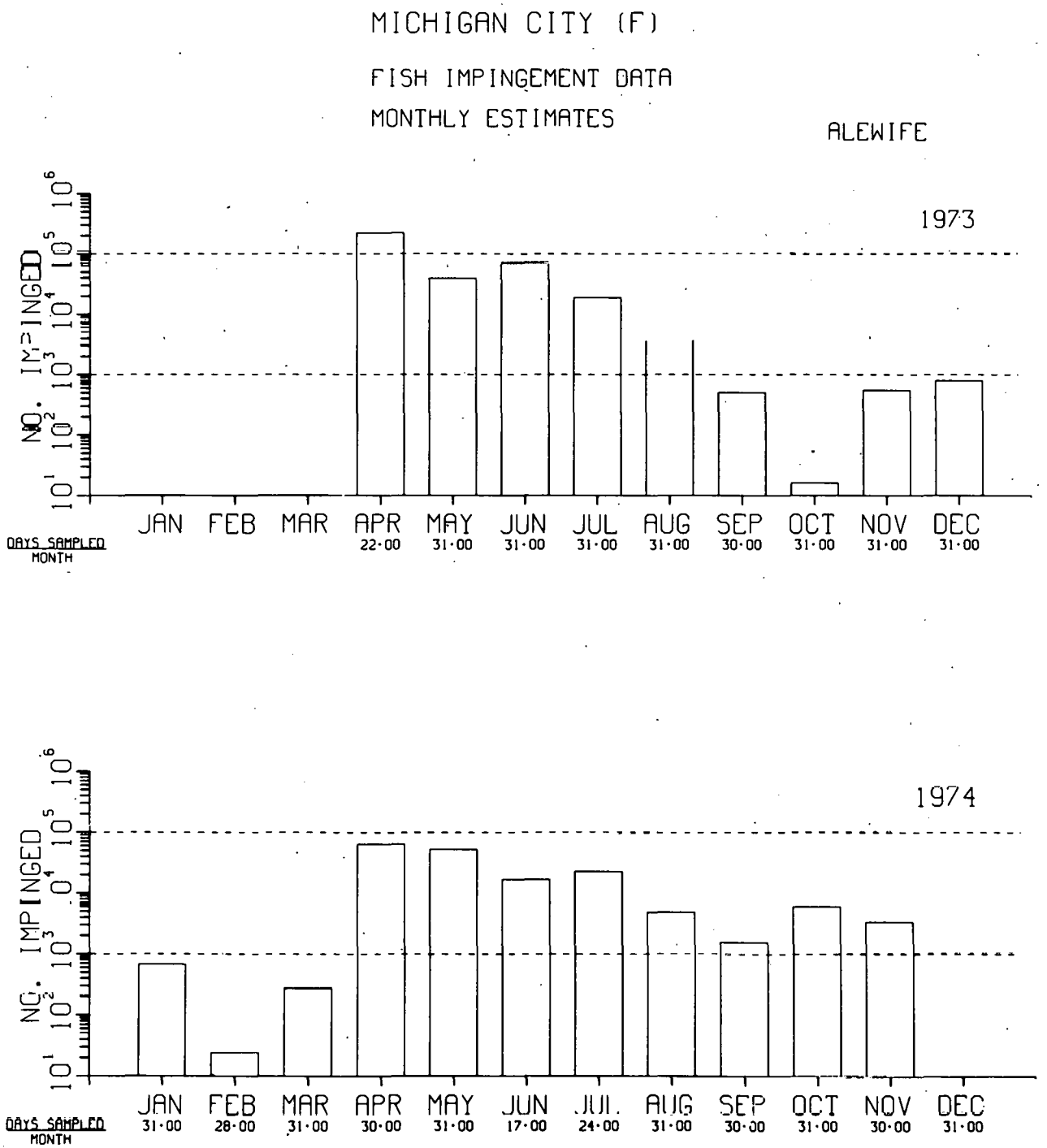


Fig. H2. Impingement Estimates.

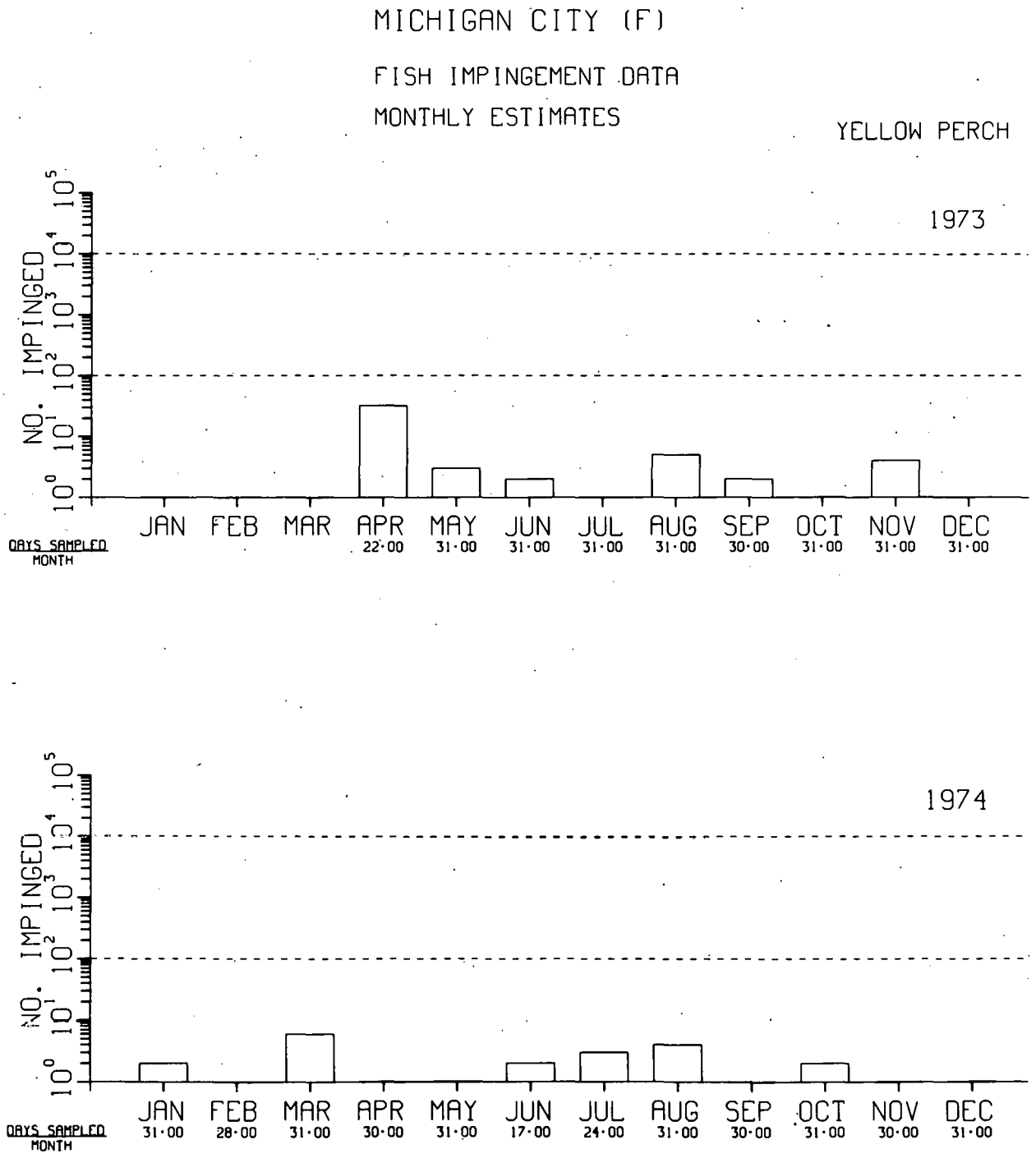


Fig. H3. Impingement Estimates.

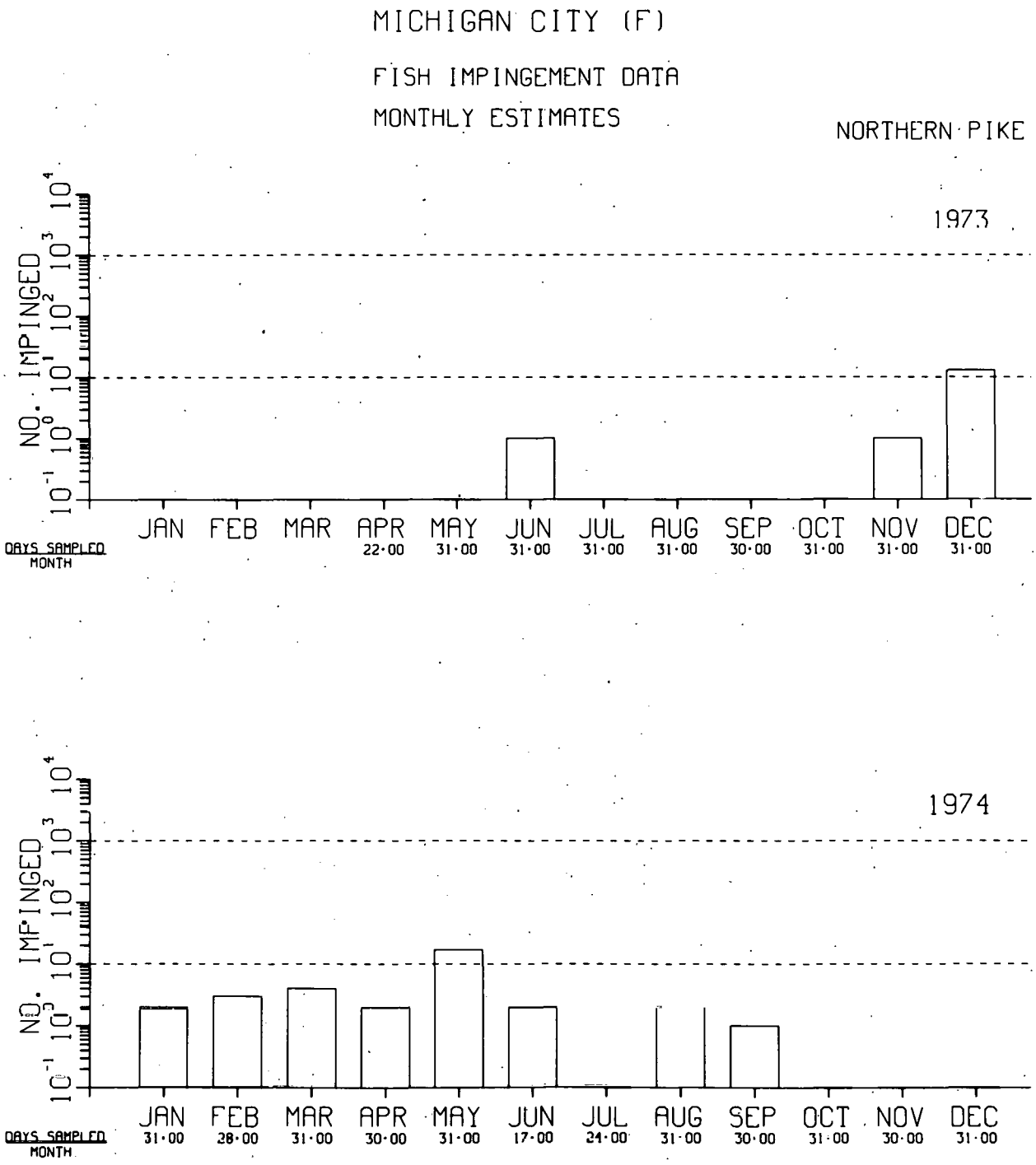


Fig. H4. Impingement Estimates.

DONALD C. COOK NUCLEAR POWER PLANT (N)

SITE CHARACTERISTICS

The Donald C. Cook Nuclear Power Plant, located on the eastern shore of Lake Michigan, occupies a 650-acre site in Lake Township, Berrien County, Michigan, and is about two miles northeast of Bridgman, Michigan.[1] The site includes 4350 feet of shoreline and is contiguous to residential Rosemary Beach on the north and to land zoned for agriculture on the south.

The average fetch of Lake Michigan in this area is 140 to 160 nautical miles. There are two relatively stable sandbars located about 450 and 1000 feet from the water's edge, with a depth between them that varies from five to 13 feet. Due to shoreline "runup" and the offshore sandbars, waves in excess of three or four feet are rarely expected.[1] The station was designed to accommodate a seiche with an amplitude up to 11 feet above the high-water level (protection to 594.6 feet MSL).

The 30-foot depth contour lies about one-half mile off shore. The major surface-water currents along the shore, at the plant, flow north or south under the influence of surface winds. Only preliminary measurements of the behavior of along-shore currents have been made. The mean surface-water temperature of the lake at the plant ranges between 32°F from December through February and 70°F to 77°F in July and August.

PLANT DESCRIPTION

The Donald C. Cook Nuclear Plant consists of two units. Each one employs a pressurized water reactor that generates about 1100 MWe gross. The plant utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

Cooling water for the station is drawn through three intake cribs located about 2250 feet off shore in 24 feet of water (Figs. 1 and 2). The intake cribs consist of smoothly rounded intake elbows set in the lake bottom, surrounded by sacked concrete and riprap to prevent erosion. Each elbow is surrounded by an octagonal heavy-structural-steel frame. The steel frame is provided with bar racks and guides on all sides. The bar racks and guides form an eight-by-eight-inch grill; the top of the structural frame is provided with a steel-plate roof to prevent vortex formation. The trash racks are composed of 3/4-inch-thick by four-inch-deep bars on three-inch centers, providing openings of 2-5/8 inches. The traveling screens have 3/8-inch-square openings.

Water is pumped through three submerged parallel pipes to the screenhouse located on the beach in front of the station. The maximum condenser flow rate for the two units is 1,645,000 gpm. The screenhouse is common to both reactors. Intake velocities in the system at various locations are estimated to be as follows:

Eight-by-eight-inch intake grills -- 1.27 fps
Eight-by-eight-inch intake grills (deicing) -- 1.9 fps
In the intake pipes -- 6.0 fps
Through the trash racks -- 1.0 fps
Through the traveling screens (at lowest expected level in screenhouse forebay) -- 2.0 fps

During winter deicing operation, cooling water is drawn through two, rather than three, intake pipes and heated discharge water is pumped back through the third pipe. This increases the intake velocity by 50% to 1.9 fps, as indicated in the preceding figures.

Total cooling-water transit time from intake to discharge is about ten minutes; transit time through the condenser is about six seconds. Debris caught on the traveling screens is washed off by water sprays, which flush it into troughs to be disposed of off-site.

IMPINGEMENT SAMPLING

Impingement samples were taken on a 24-hour continuous-sampling basis.

DATA AVAILABILITY

Fish impingement data are available for January through September 1975, with the exception of June.

IMPINGEMENT DATA SUMMARY

Figures H1 and H2 are histograms representing the four most abundant species as well as all species impinged at the Donald C. Cook Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. "Final Environmental Statement, Donald C. Cook Nuclear Plant Units 1 and 2." USAEC Directorate of Licensing. Docket Nos. 50-315 and 50-316. August 1973.

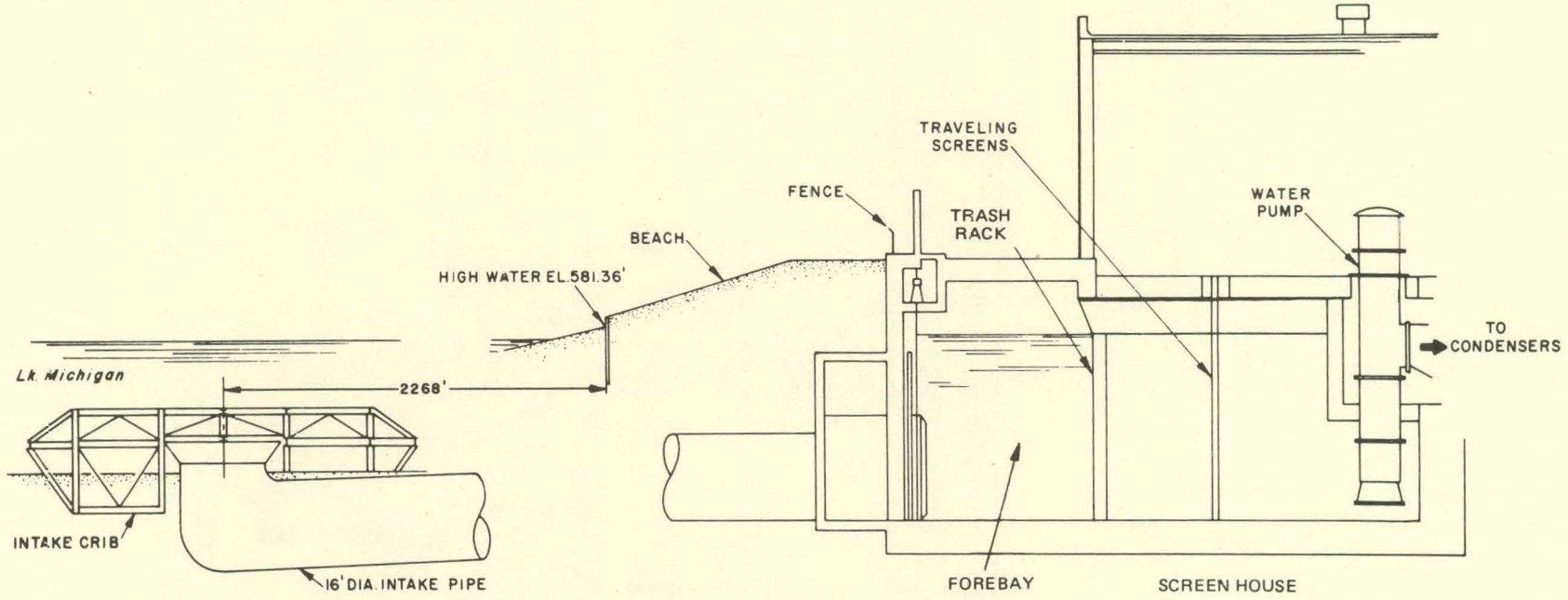


Fig. 1. Intake Crib and Screenhouse.

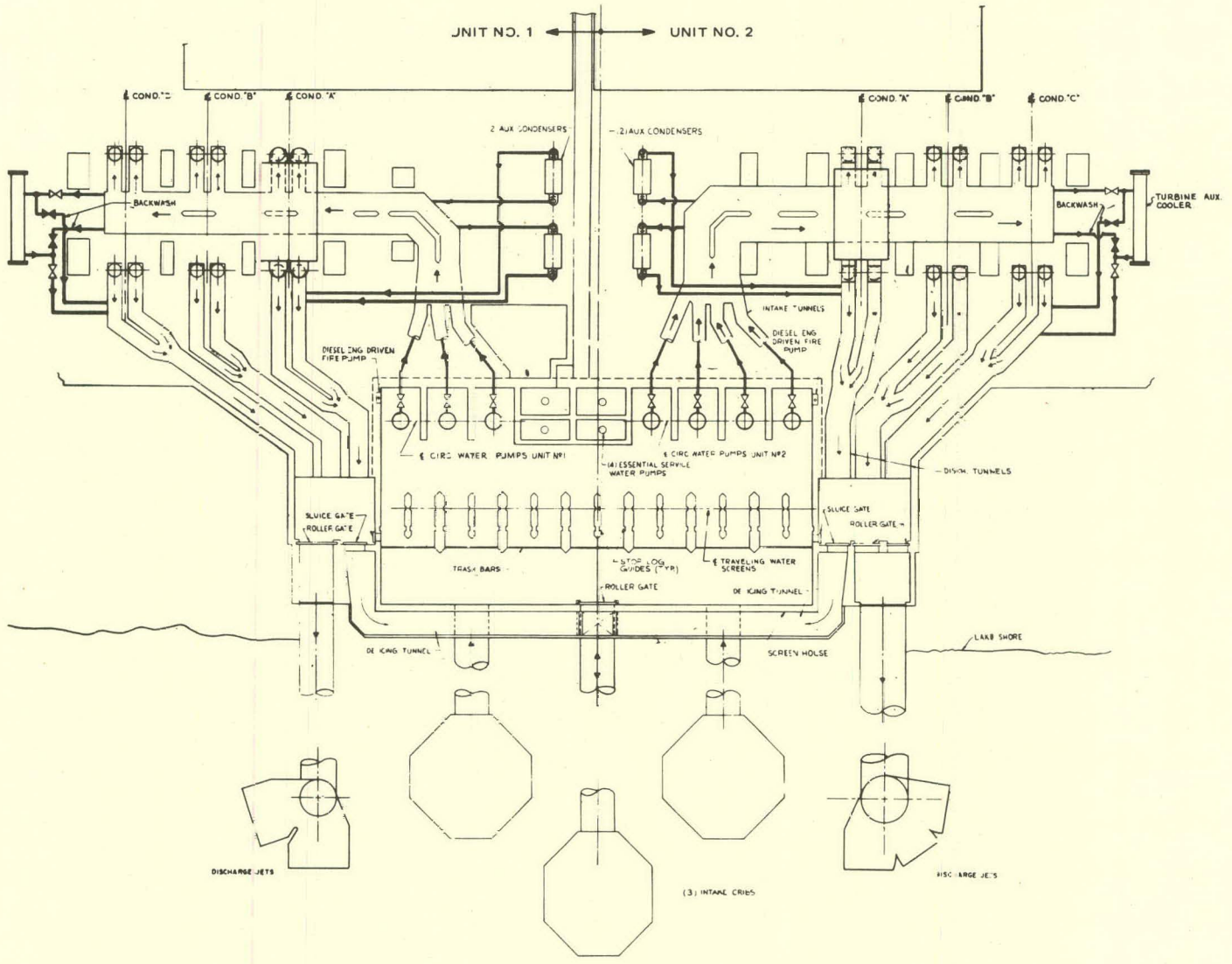


Fig. 2. Condenser Cooling-Water System.

Table I. Fishes Collected at the Plant

Lake sturgeon	Northern pike
Longnose sucker	Burbot
White sucker	Ninespine stickleback
Quillback	Black bullhead
Smallmouth bass	Channel catfish
Green sunfish	Rainbow smelt
Pumpkinseed	Yellow perch
Black crappie	Johnny darter
Alewife	Walleye
Gizzard shad	Trout-perch
Lake whitefish	Rainbow trout
Bloater	Brown trout
Cisco or lake herring	Lake trout
Mottled sculpin	Coho salmon
Slimy sculpin	Chinook salmon
Carp	Central mudminnow
Spottail shiner	
Emerald shiner	
Longnose dace	
Lake chub	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		Yellow Perch	Slimy Sculpin	Alewife	Spottail Shiner	Total
1975	8	3,149	6,265	85,888	3,347	102,894

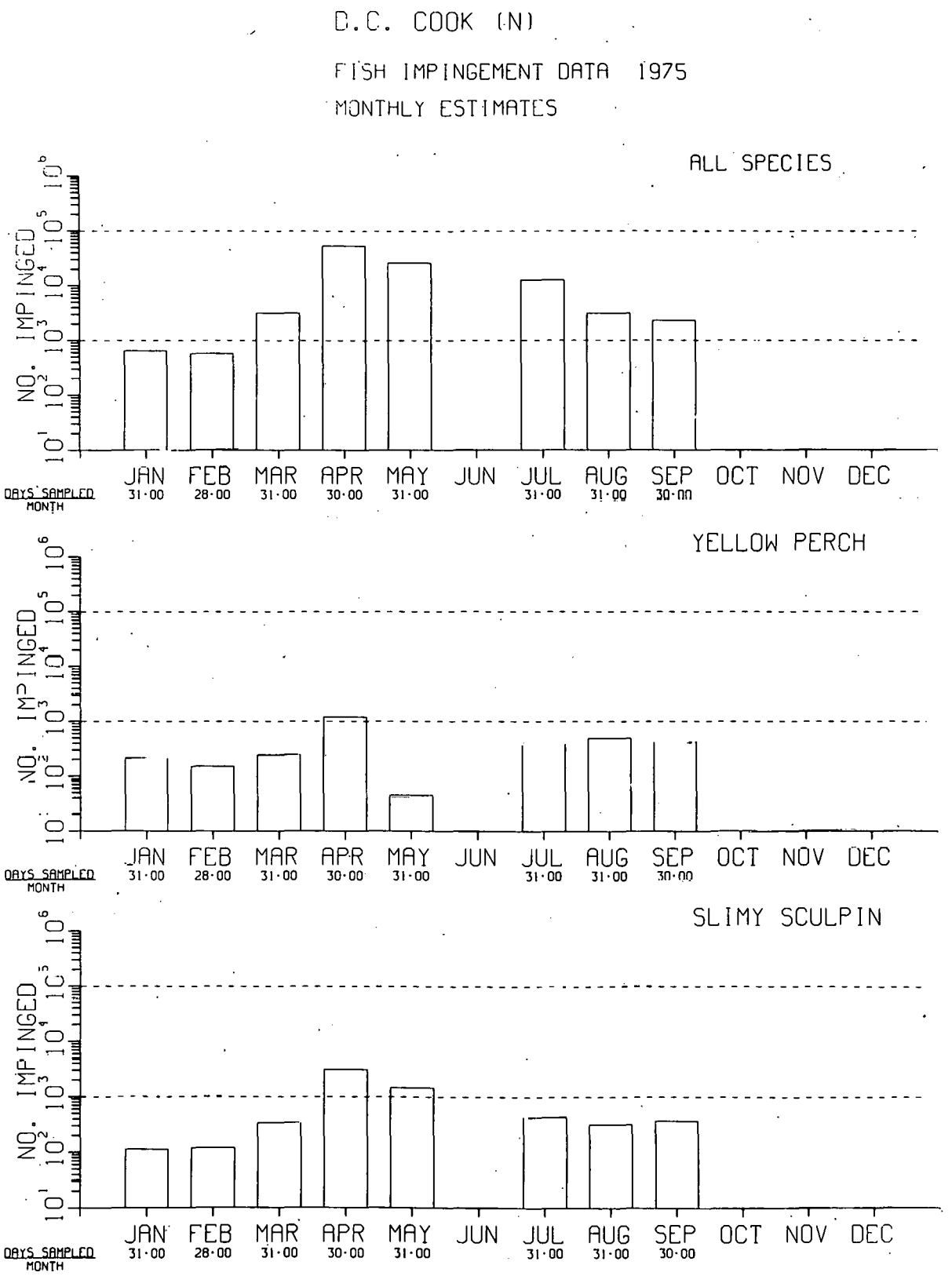
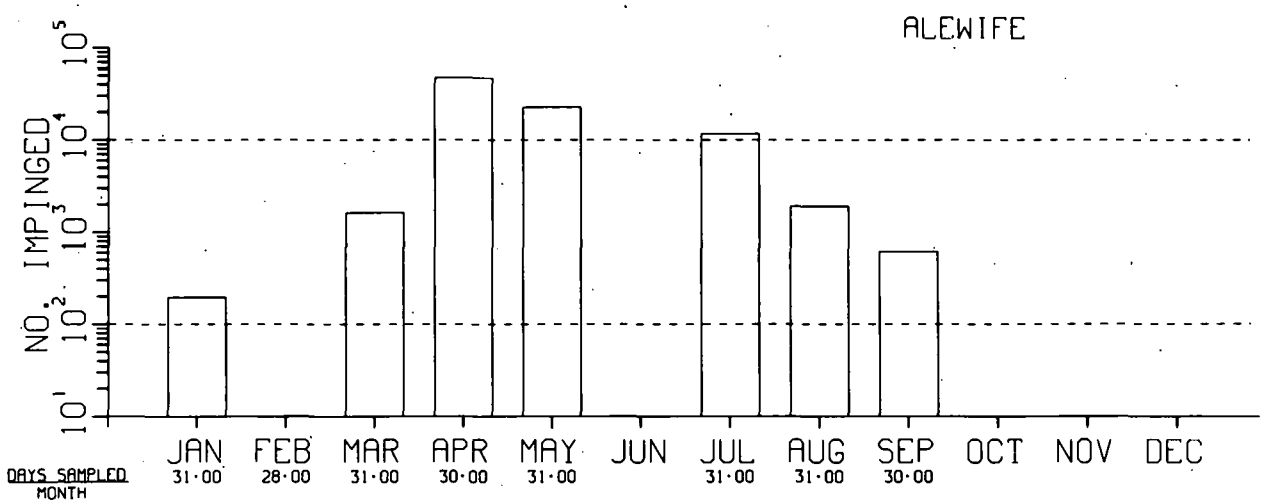


Fig. H1. Impingement Estimates.

D.C. COOK (N)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



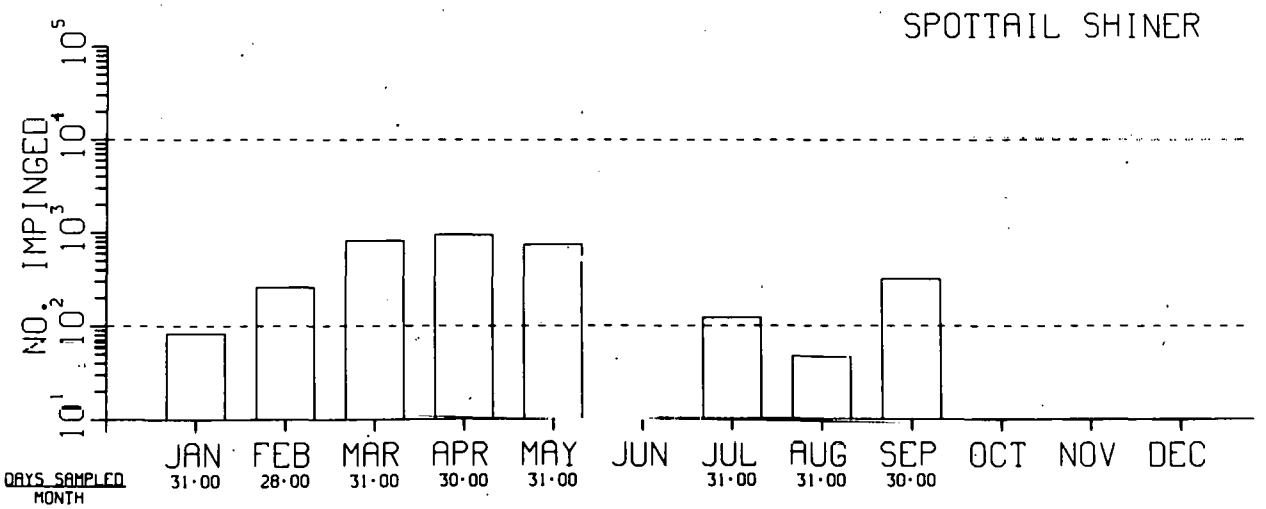


Fig. H2. Impingement Estimates.

PALISADES NUCLEAR GENERATING PLANT (N)

SITE CHARACTERISTICS

The Palisades Nuclear Plant is located on the southeast shore of Lake Michigan in Van Buren County, Michigan (Fig. 1).[1] Lake Michigan is dimictic, with overturns, or nearly complete circulation, occurring in early winter and early spring every year in the southern basin. During this circulation period, about one month in duration, the lake is isothermal and water in the southern basin is mixed from top to bottom. As air temperatures decrease in late December and early January, the shallow inshore waters, from the shoreline to the 100-foot depth contour, cool faster and reach temperatures below that of maximum density, whereas the offshore deep waters are above 39.2°F and continue to mix. As cooling and mixing of the water in winter continues, offshore waters cool to the temperature of maximum density and become nearly isothermal at about that temperature. Ordinarily, there is an intermittent ice cover extending one to two miles from shore in the southern basin; the rest of the basin remains ice free.

In early spring, warming of surface waters results in the shallow inshore waters heating up faster than offshore waters. As the inshore waters reach temperatures above that of maximum density, mixing within this zone occurs. As heating and mixing of surface waters continue, vertical thermal stratification is established across the entire lake in summer. Average water temperature at the intake, in 1975, ranged from a low of 39.5°F in January to a high of 64.8°F in July.

Table I is a list of fishes found in the vicinity of the Palisades Nuclear Plant.

PLANT DESCRIPTION

The Palisades Nuclear Generating Plant has a pressurized water reactor to generate 715 MWe. The closed-cycle circulating-water system uses two mechanical-draft cooling towers, each with 18 cells.

INTAKE DESIGN AND OPERATION

Water for the service-water system (20,000 gpm maximum) and for blowdown dilution (60,000 gpm maximum) is taken from Lake Michigan through an intake crib 20 feet below the lake surface, six feet from the lake bottom, and 3300 feet from the shoreline (Fig. 2). The crib is 57 feet square and 12 feet high with a steel velocity cap on top and two-inch vertical bars spaced about 11 inches apart around the sides. Water flows horizontally between the

vertical bars at a calculated maximum velocity of 0.098 fps and subsequently through an 11-foot-diameter intake pipe at a calculated maximum velocity of 2.13 fps. The pipe transports the water to the intake forebay, which is equipped with trash racks and traveling screens. The trash racks, which serve to remove large material from the water, consist of a grating with vertical bars having centers spaced at about one inch. Two vertical traveling screens with 3/8-inch wire mesh are installed ahead of the service-water and blowdown-dilution pumps to provide additional filtering of small fish and debris. Material impinged on the traveling screens is backwashed to a wire collection basket and disposed of as solid waste.

IMPINGEMENT SAMPLING

The two traveling screens were operated simultaneously with time intervals between screen operations recorded. The intervals used in calculating the number of hours between actual screen counts were determined by the established plant schedule and information obtained from plant personnel. During screen washing, fish were collected either by hand from each screen panel or by wire collection baskets in the sluiceway. After collection, the fish were identified, weighed, and measured.[2]

Estimates of potential numbers and weights of fish impinged were made by comparing the cumulative impingement times represented by the screen counts with the total impingement time in the sampling period, and then multiplying the actual number or weight by the appropriate factor. Extrapolations of potential numbers of fish impinged were calculated for each species on a weekly basis using the following formula:

$$P_i = \frac{A_i}{\frac{H_i}{(\frac{}{c})}}$$

Where: P_i = Potential number of fish impinged per week.
A_i = Actual number of fish impinged per screen count.
H_i = Number of hours sampled per week.
c = Constant (number of hours per week = 168).

It was assumed that the fish collected were representative of the natural populations and that impingement occurred at a uniform rate. Calculations based on weekly impingement extrapolations reflect the seasonal occurrence of fish in the area.[2]

DATA AVAILABILITY

Fish impingement data for the Palisades Nuclear Generating Plant are available for 21 March 1974 through 25 March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the Palisades Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Final Environmental Statement, Palisades Nuclear Generating Plant." USAEC Directorate of Licensing. Docket No. 50-255. June 1972.

2. "Section 316(b) Intake Study - Palisades Nuclear Plant." Consumers Power Company, Jackson, Michigan. August 1976.

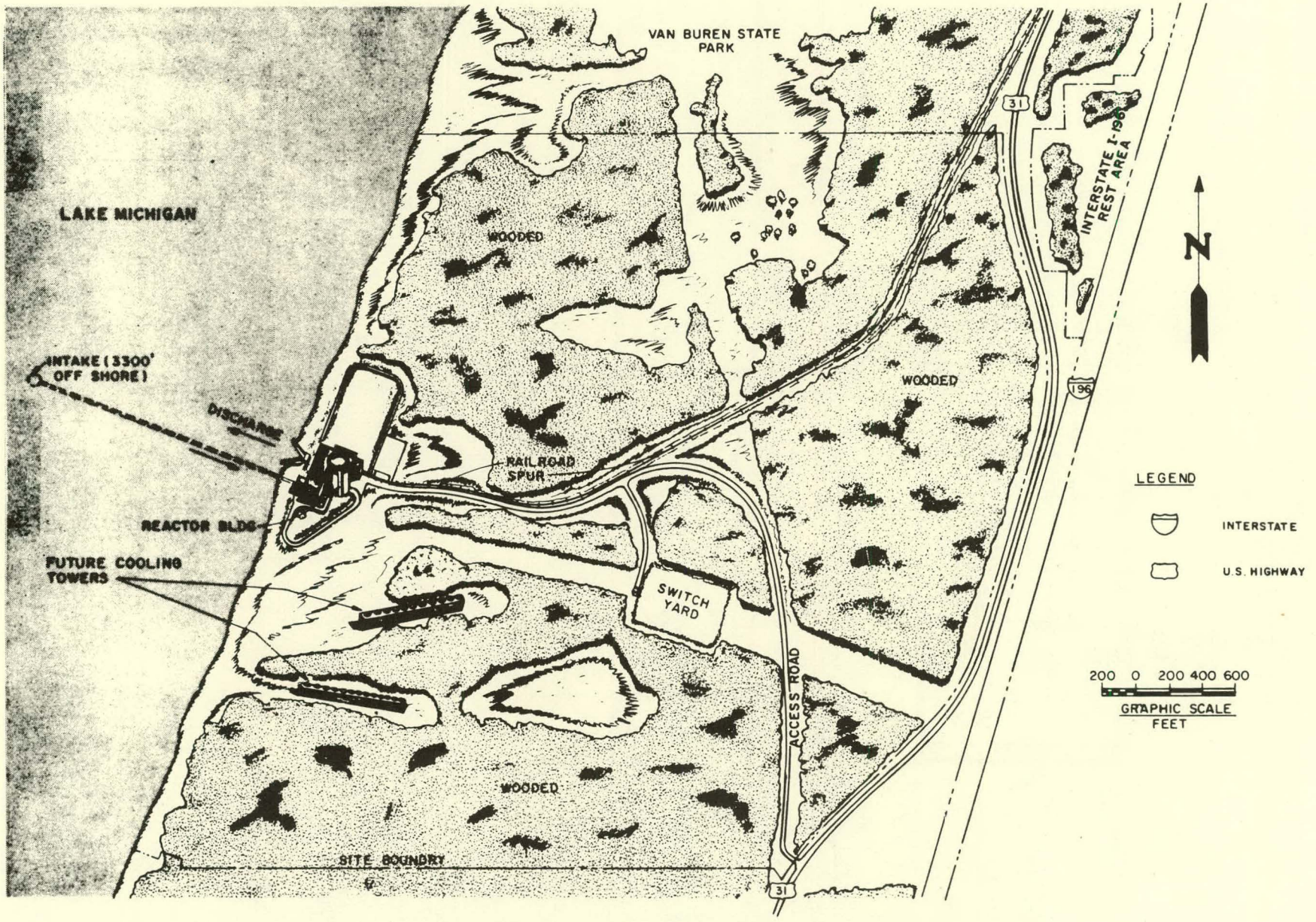


Fig. 1. The Plant Site.

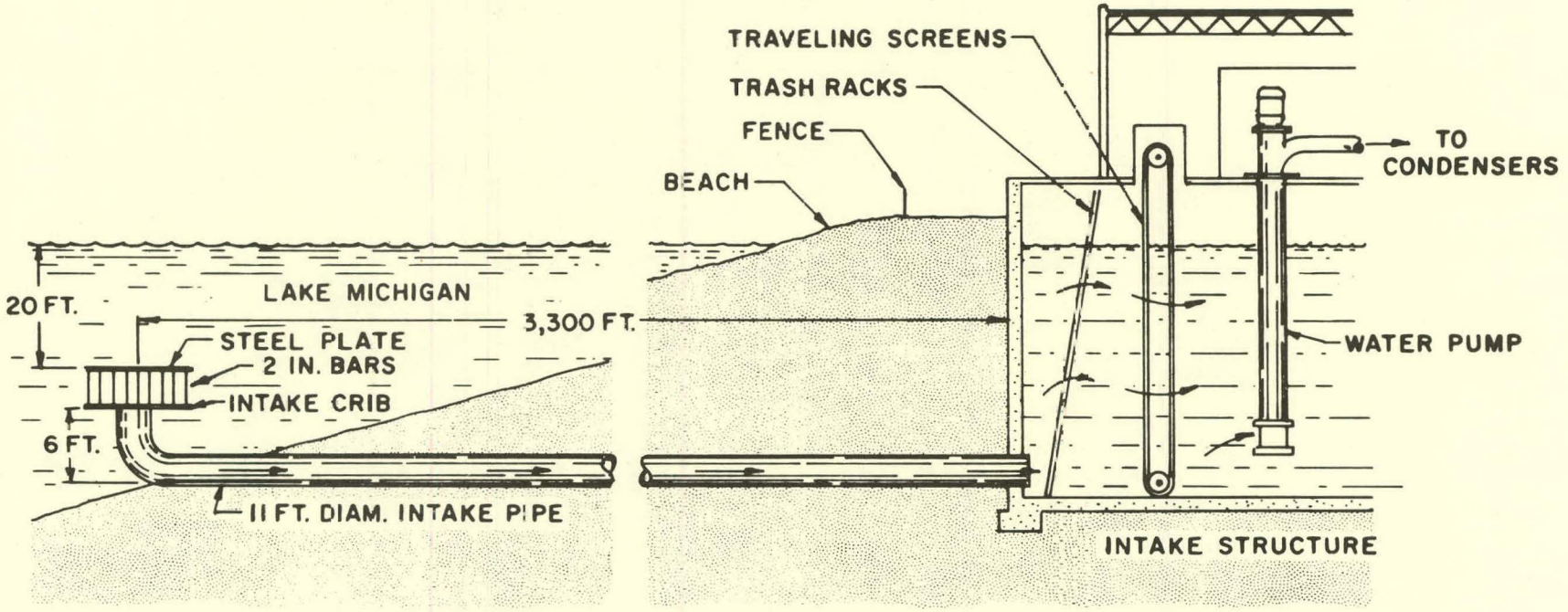


Fig. 2. Schematic of the Water-Intake System.

Table I. Fishes Collected in Lake Michigan by Seining, Gillnetting, and Trawling near the Plant

Alewife	Channel catfish
Lake whitefish	Northern pike
Cisco or lake herring	Round whitefish
Bloater	Johnny darter
Yellow perch	Emerald shiner
Rainbow smelt	Bluegill
Longnose dace	Mottled sculpin
Trout-perch	Common shiner
Spottail shiner	Burbot
Lake trout	Black bullhead
Coho salmon	Carp
Chinook salmon	Quillback
Longnose sucker	Smallmouth bass
White sucker	Slimy sculpin
Golden redhorse	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Slimy Sculpin	Alewife	Spottail Shiner	Total
1974	10	5,887	1,116	49	7,220
1975	3	51	71	47	217

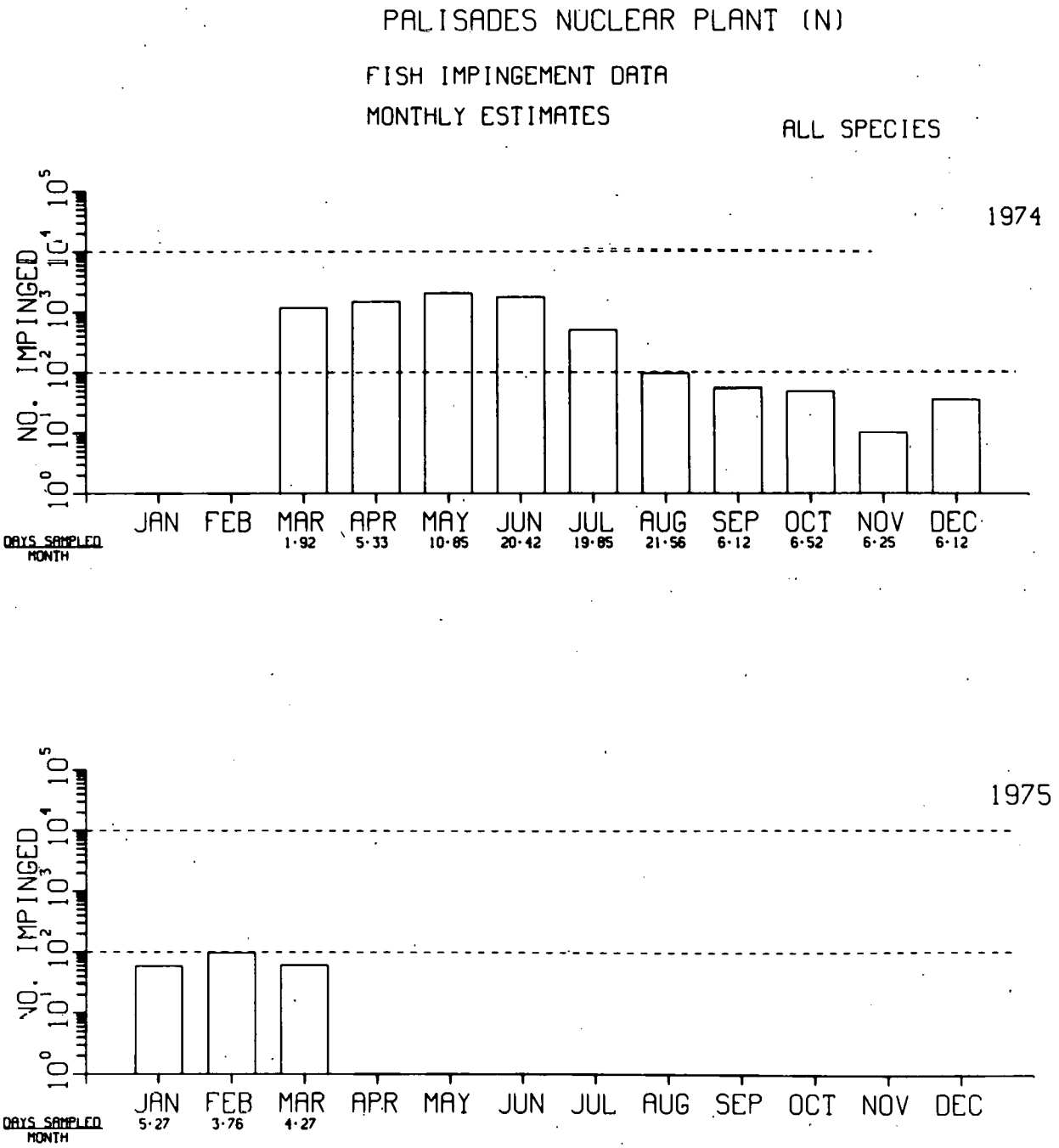


Fig. H1. Impingement Estimates.

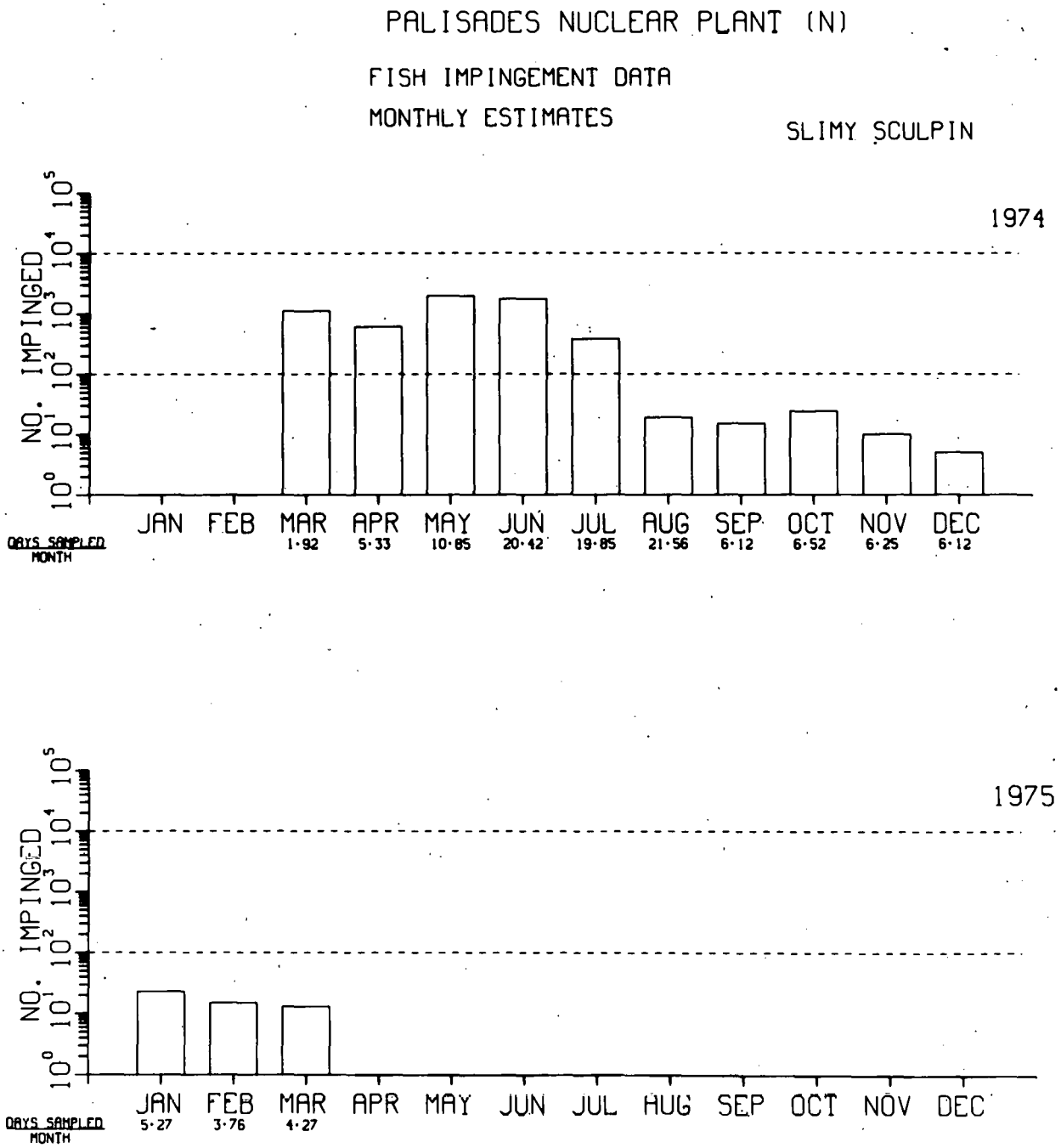


Fig. H2. Impingement Estimates.

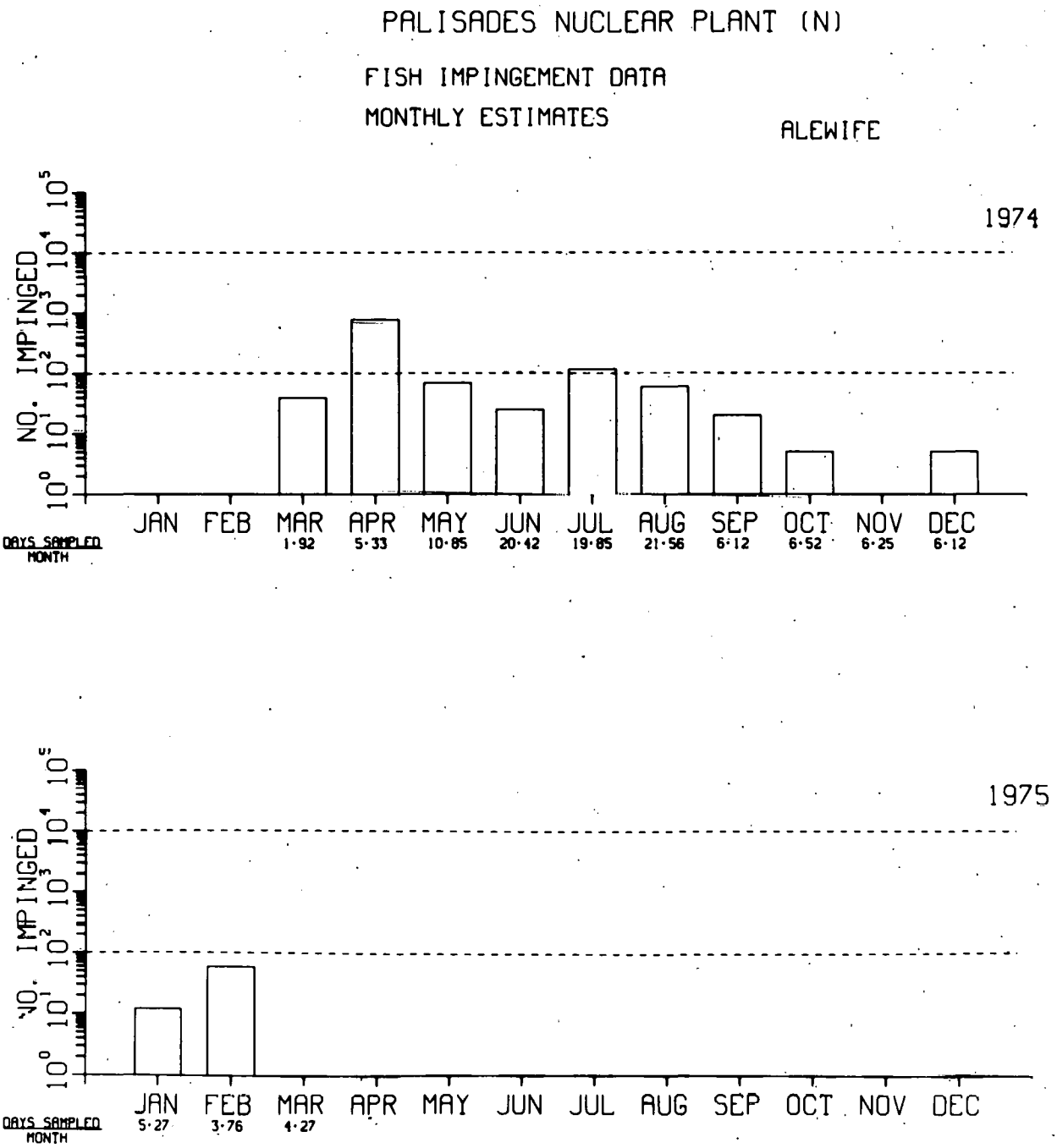


Fig. H3. Impingement Estimates.

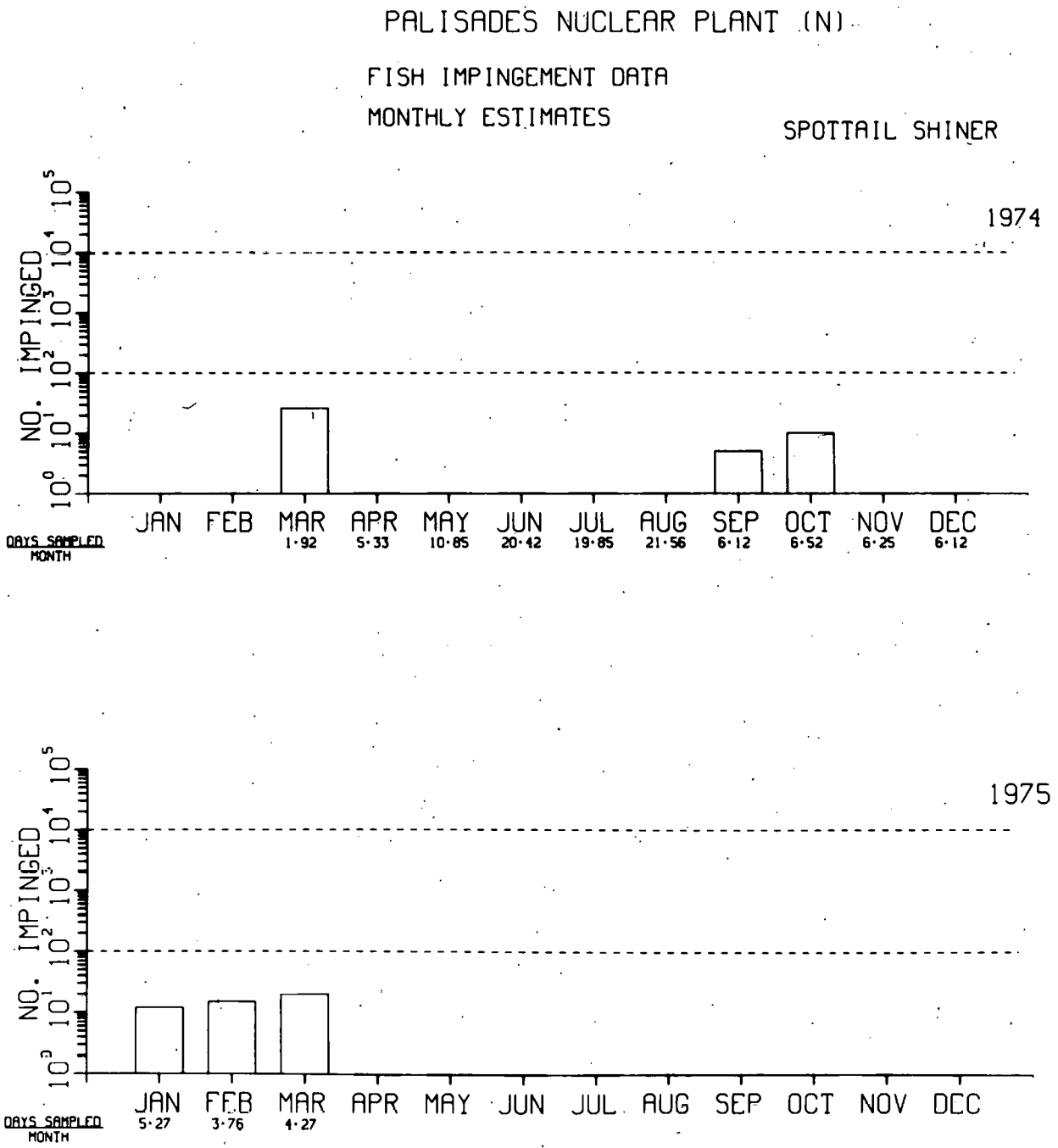


Fig. H4. Impingement Estimates.

J. H. CAMPBELL PLANT (F)

SITE CHARACTERISTICS

The J. H. Campbell Plant is located on the southeast shore of Lake Michigan in Port Sheldon Township, Ottawa County, Michigan. The plant property is bounded by Lake Michigan on the west and Pigeon Lake on the south (Fig. 1).[1]

Pigeon Lake is the natural outlet of Pigeon River into Lake Michigan. The flow of the Pigeon River at its mouth has been reversed and the natural runoff empties into Lake Michigan about 3300 feet north of the previous channel, after it passes through the plant cooling system. The interface between Pigeon Lake and Lake Michigan has been physically modified by the construction of rock jetties projecting about 1200 feet into Lake Michigan on both sides of the channel. Water temperature ranges from an average monthly high of 75°F in August to an average monthly low of 39°F in January.

Table I is a list of fishes found in the vicinity of the J. H. Campbell Plant.

PLANT DESCRIPTION

The J. H. Campbell Plant is a coal-fired electric generating facility consisting of two units. The gross output of Unit 1 is 275 MWe, and of Unit 2 is 372 MWe, for a combined output of 647 MWe.

INTAKE DESIGN AND OPERATION

Condenser cooling water for the plant is obtained from Pigeon Lake and Lake Michigan via an intake channel connecting the intake structure and the north shore of Pigeon Lake (Fig. 1). The intake structure is located on the east side of the forebay at the north end of the intake channel. Trash bars spaced on 2-3/8-inch centers are located at the face of the screenhouse. Two vertical traveling screens per unit are located in the screenhouse. Cooling water for Unit 1 is provided by two 60,000-gpm pumps, and for Unit 2 by two 90,000-gpm pumps, yielding a maximum condenser flow rate for the plant of 300,000 gpm.

As water is pumped into the plant, fish and debris not diverted or stopped by the trash bars are collected on the traveling screens. The screens are run automatically, with operation determined by a timer or head loss across the screens, or manually depending on service requirements. Standard procedure is to operate the traveling screens automatically at least once per

eight-hour shift. As the screen panels travel out of the water, impinged fish and debris are washed off by spray nozzles delivering water at about 100 psi, are carried to the discharge duct of Unit 1 via a sluiceway, and from there enter Lake Michigan via the discharge channel. After passage through the condensers, the cooling water is discharged to Lake Michigan via this same discharge channel, which is about 3600 feet long, 70 feet wide, and 12 to 15 feet deep.

Because winter icing conditions can restrict flow through the Pigeon Lake jetties, a warm-water recirculation system exists for pumping water from the discharge channel to the north jetty. The system consists of a two-speed pump that recirculates water at the rate of either 35,000 gpm or 70,000 gpm, depending on water temperature and icing conditions. Pumping normally begins when the inlet temperature drops below 39°F.

IMPINGEMENT SAMPLING

Impingement sampling at the J. H. Campbell Plant was conducted at least once every four days for a period of 24 hours. The two traveling screens were operated either singly or together, depending on the number of fish impinged and the time available at various intervals during the week. Time intervals between screen operations were used in calculating the number of hours between actual screen counts. These intervals were determined by the established plant schedule and information obtained from the shift supervisor or individual screen operators.

DATA AVAILABILITY

Fish impingement data for the J. H. Campbell Plant are available for January 1974 through March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing extrapolated totals for the three most abundant species as well as all species impinged at the J. H. Campbell Plant. These totals are summarized in Table II.

A statistical comparison of the occurrence of fish on the traveling screens showed a significant difference between screens 1 and 2 ($Z = 2.97$). A comparison of the ranked sums showed that screen 2 impinged significantly greater numbers of fish than screen 1. The reason for this may have been the greater circulating-water flow and resultant higher maximum intake velocity at Unit 2 (1.36 fps, calculated) than at Unit 1 (0.91 fps, calculated).

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. "Section 316(b) Intake Study - J. H. Campbell Units 1 and 2." Consumers Power Company, Jackson, Michigan. March 1976.

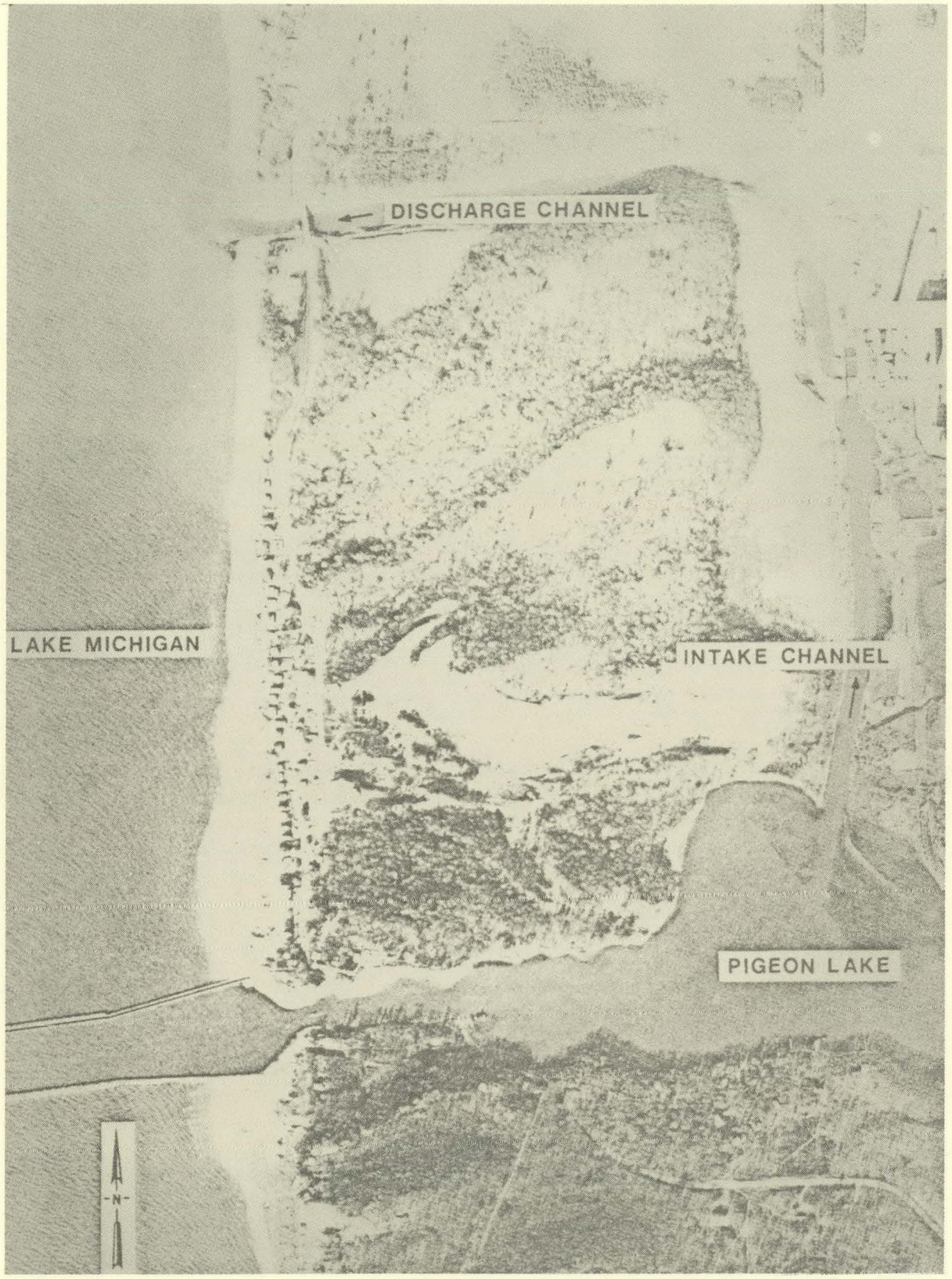


Fig. 1. Aerial View of Lakes and Channels.

Table I. Fishes Collected from January 1974 to March 1975

Chestnut lamprey	Shorthead redhorse
Sea lamprey	Northern hog sucker
Longnose gar	Black bullhead
Bowfin	Yellow bullhead
Alewife	Brown bullhead
Gizzard shad	Channel catfish
Coho salmon	Tadpole madtom
Chinook salmon	Burbot
Lake trout	Ninespine stickleback
Rainbow smelt	Yellow perch
Trout-perch	Rock bass
Central mudminnow	Warmouth
Northern pike	Green sunfish
Stoneroller	Pumpkinseed
Goldfish	Bluegill
Carp	Smallmouth bass
River chub	Largemouth bass
Golden shiner	White crappie
Emerald shiner	Black crappie
Blacknose shiner	Johnny darter
Common shiner	Logperch
Spottail shiner	Walleye
Bluntnose minnow	Pirate perch
Longnose sucker	Freshwater drum
White sucker	Slimy sculpin
	Brook silverside

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Gizzard Shad	Spottail Shiner	Total
1974	12	143,419	71,122	2,500	229,248
1975	3	0	34,633	635	39,420

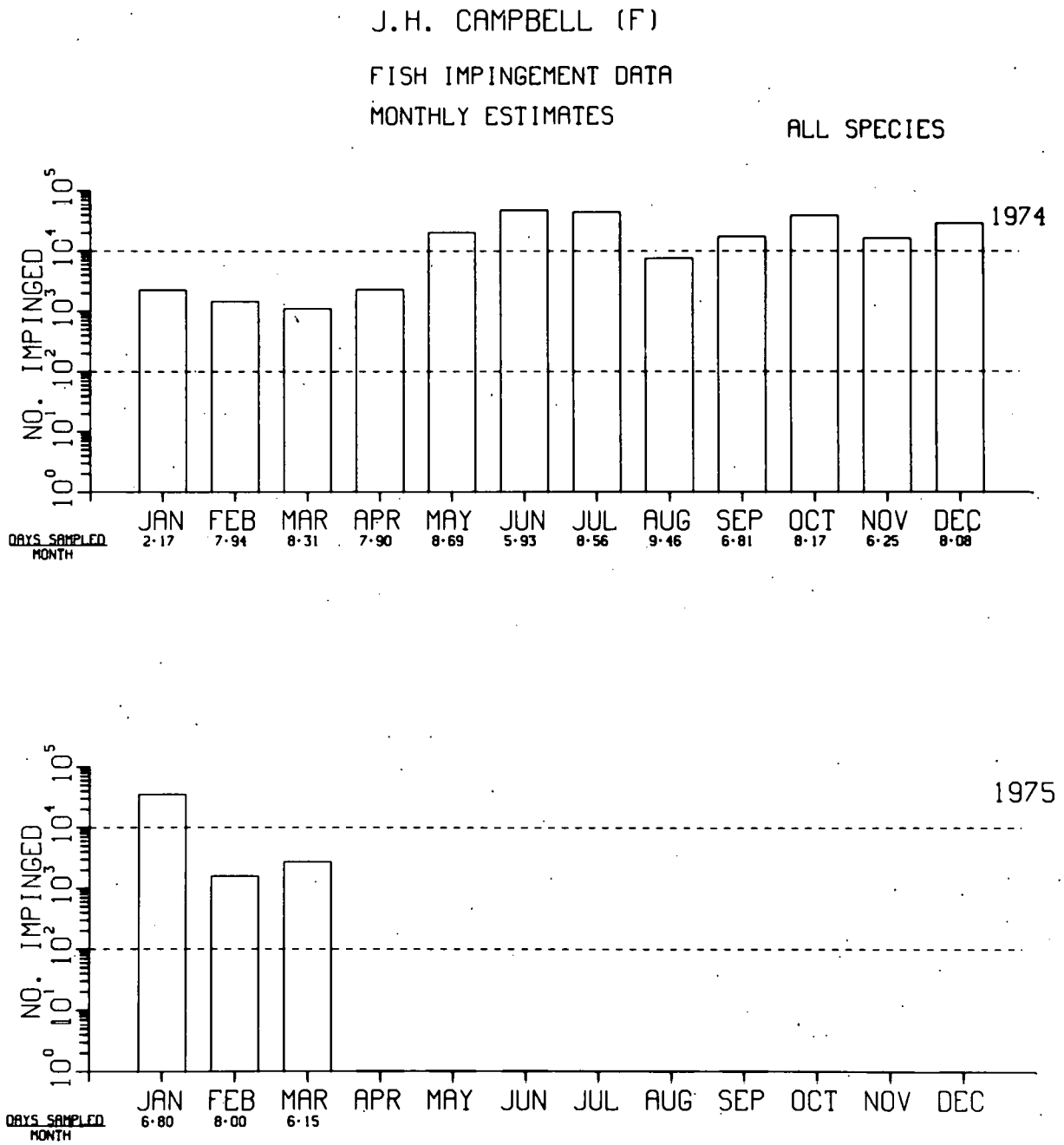


Fig. H1. Impingement Estimates.

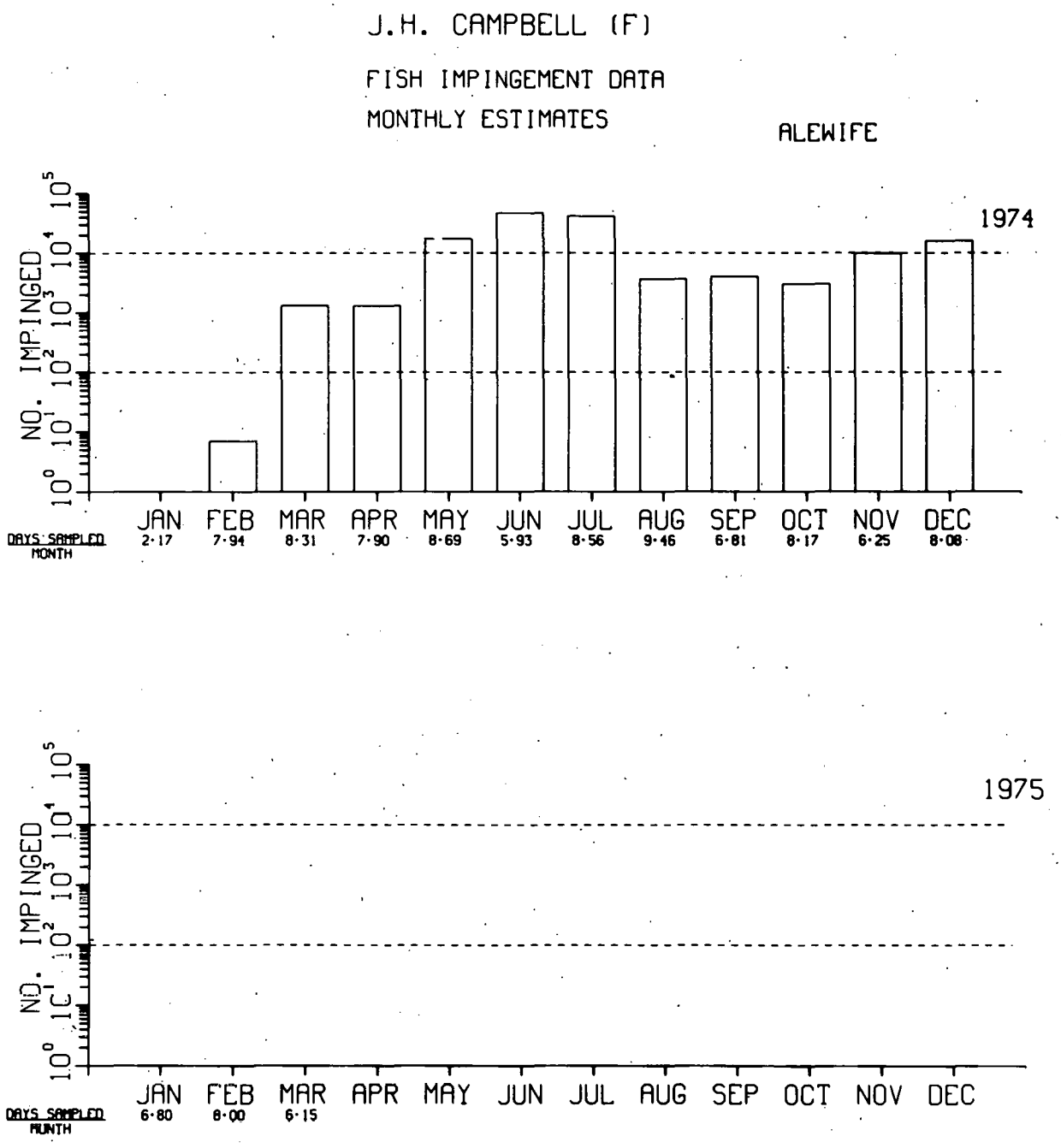


Fig. H2. Impingement Estimates.

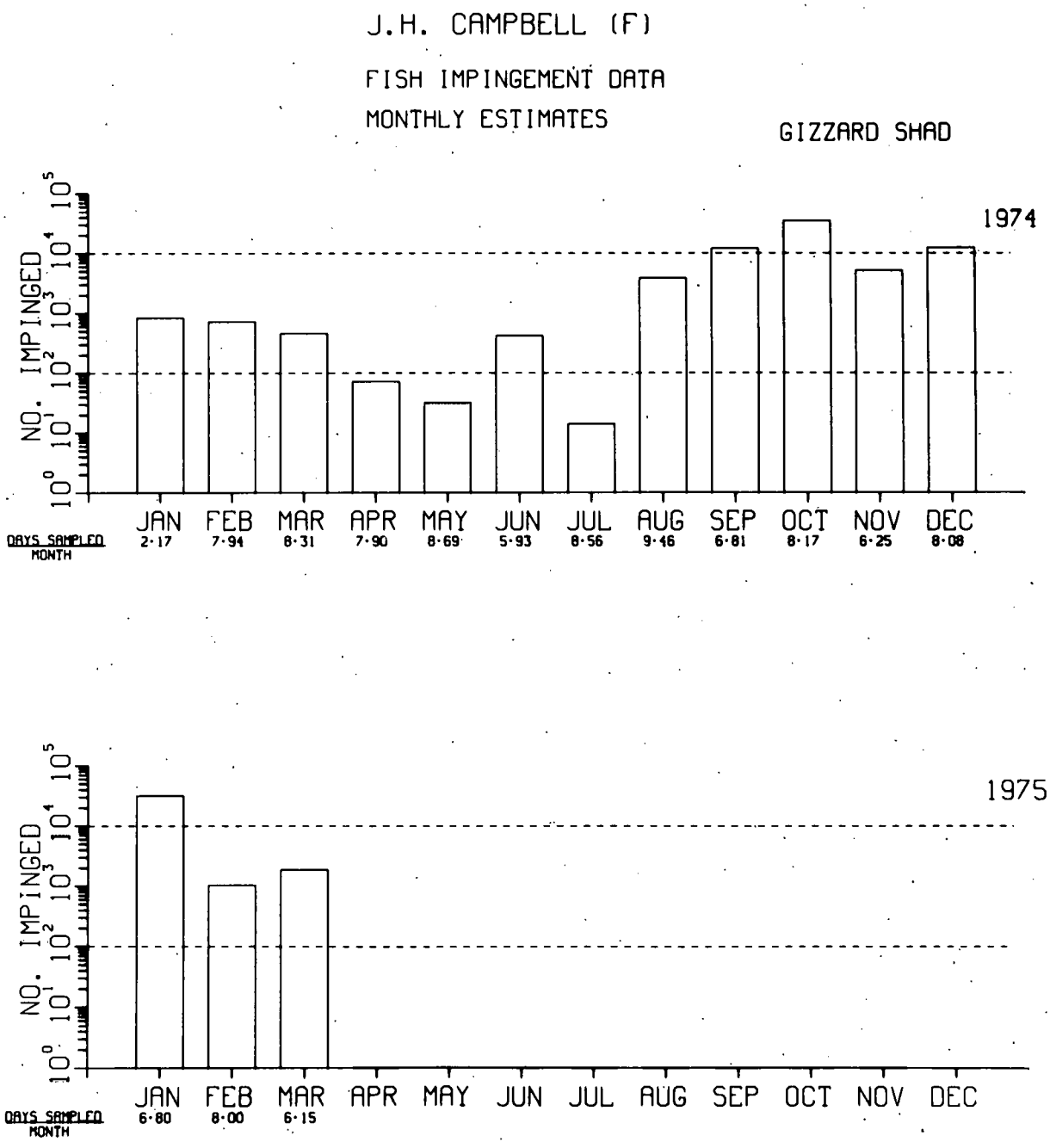


Fig. H3. Impingement Estimates.

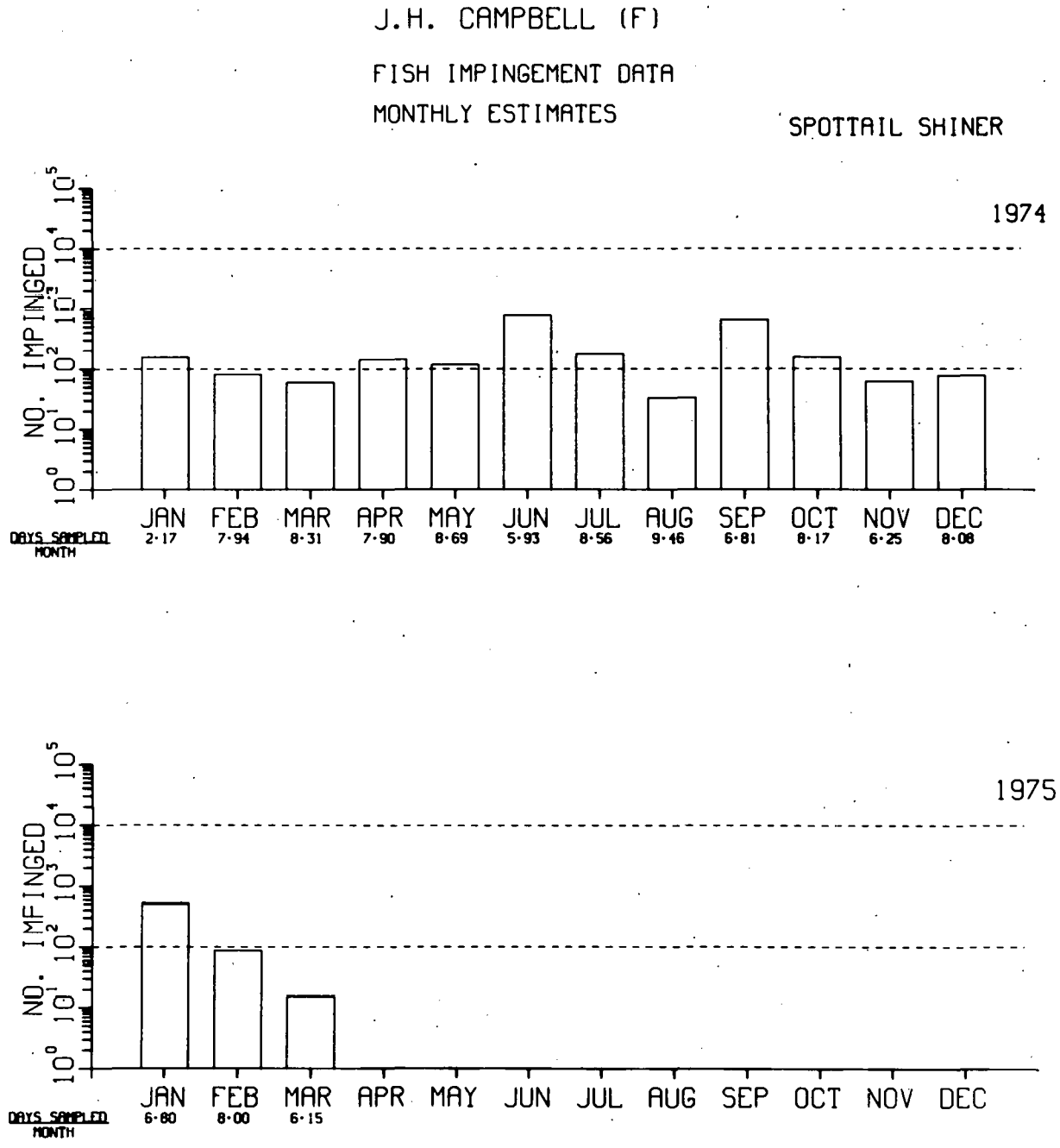


Fig. H4. Impingement Estimates.

BIG ROCK NUCLEAR PLANT (N)

SITE CHARACTERISTICS

The Big Rock Nuclear Plant is located on the northwest coast of the Lower Peninsula of Michigan about 5-1/2 miles northeast of Charlevoix in Hayes Township, Charlevoix County (Fig. 1).[1] A list of fishes found in the vicinity of the plant was not available at the time of this report.

PLANT DESCRIPTION

The Big Rock Nuclear Plant uses a 75-MWe boiling water reactor. It utilizes a once-through cooling system.

INTAKE DESIGN AND OPERATION

Condenser cooling water for the plant is withdrawn from Lake Michigan via a submerged 72-inch intake pipe that extends about 1500 feet offshore. The top of the 21.5-foot-diameter intake crib is located about 27 feet below the lake surface and is about seven feet above the lake bottom. The perimeter of the crib is constructed of two-by-two-inch vertical wooden slats on centers of about 12 inches. Water flows horizontally between the vertical slats at a calculated maximum velocity of 0.24 fps and subsequently through the 72-inch-diameter intake pipe at a calculated maximum velocity of 5.4 fps. The pipe transports the water to the intake forebay, which is equipped with trash racks and traveling screens. The trash racks consist of a grating with vertical bars spaced on 2-1/4-inch centers. Two vertical traveling screens constructed of 3/8-inch wire mesh are installed ahead of the circulating-water pumps. The calculated maximum flow through clean screens is 1.74 fps. Material impinged on the traveling screens is backwashed to the discharge channel. After passage through the plant, condenser cooling water is discharged to Lake Michigan through a short shoreline-discharge channel. There are two circulating-water pumps that provide a total flow rate of 48,000 gpm.[2]

IMPINGEMENT SAMPLING

The Big Rock Nuclear Plant intake study was initiated on 7 February 1974 and completed on 26 March 1975, covering 59 weeks. A total of 323 screen counts was made. These counts quantified fish impingement for 26.2% of the time during the 59-week period.

DATA AVAILABILITY

Fish impingement data for the Big Rock Nuclear Plant are available for 15 February 1974 through 26 March 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the Big Rock Nuclear Plant. These totals are summarized in Table I.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. Section 316(b) intake study at the Big Rock Nuclear Plant. Consumers Power Company, Jackson, Michigan. July 1976.

2. Personal communication with Rick Skimer of Consumers Power Company. 10 August 1976.

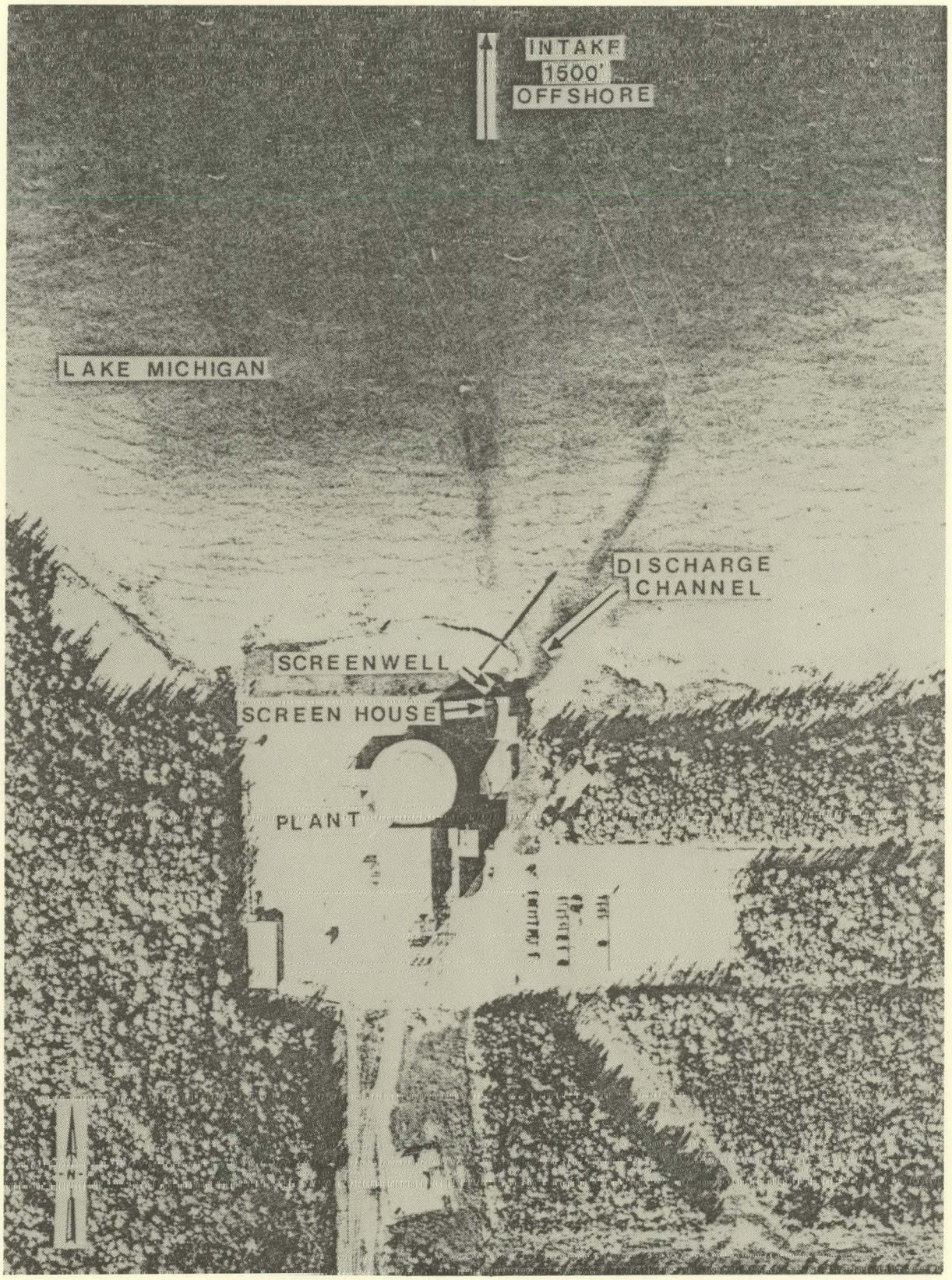


Fig. 1. Aerial View of the Plant.

Table T. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Rainbow Smelt	Lake Chub	Total
1974	11	393	514	138	1,265
1975	3	0	0	6	73

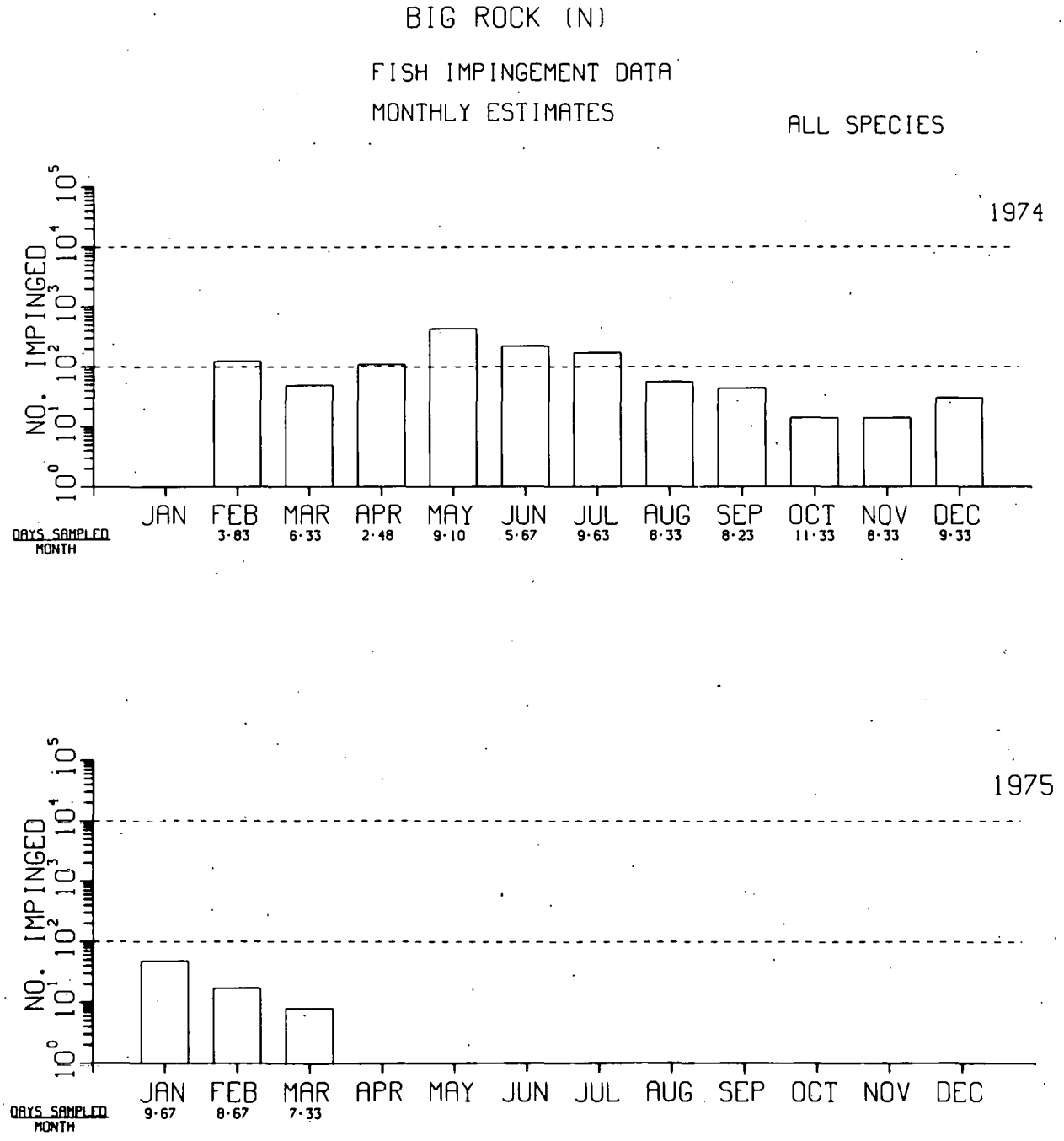


Fig. H1. Impingement Estimates.

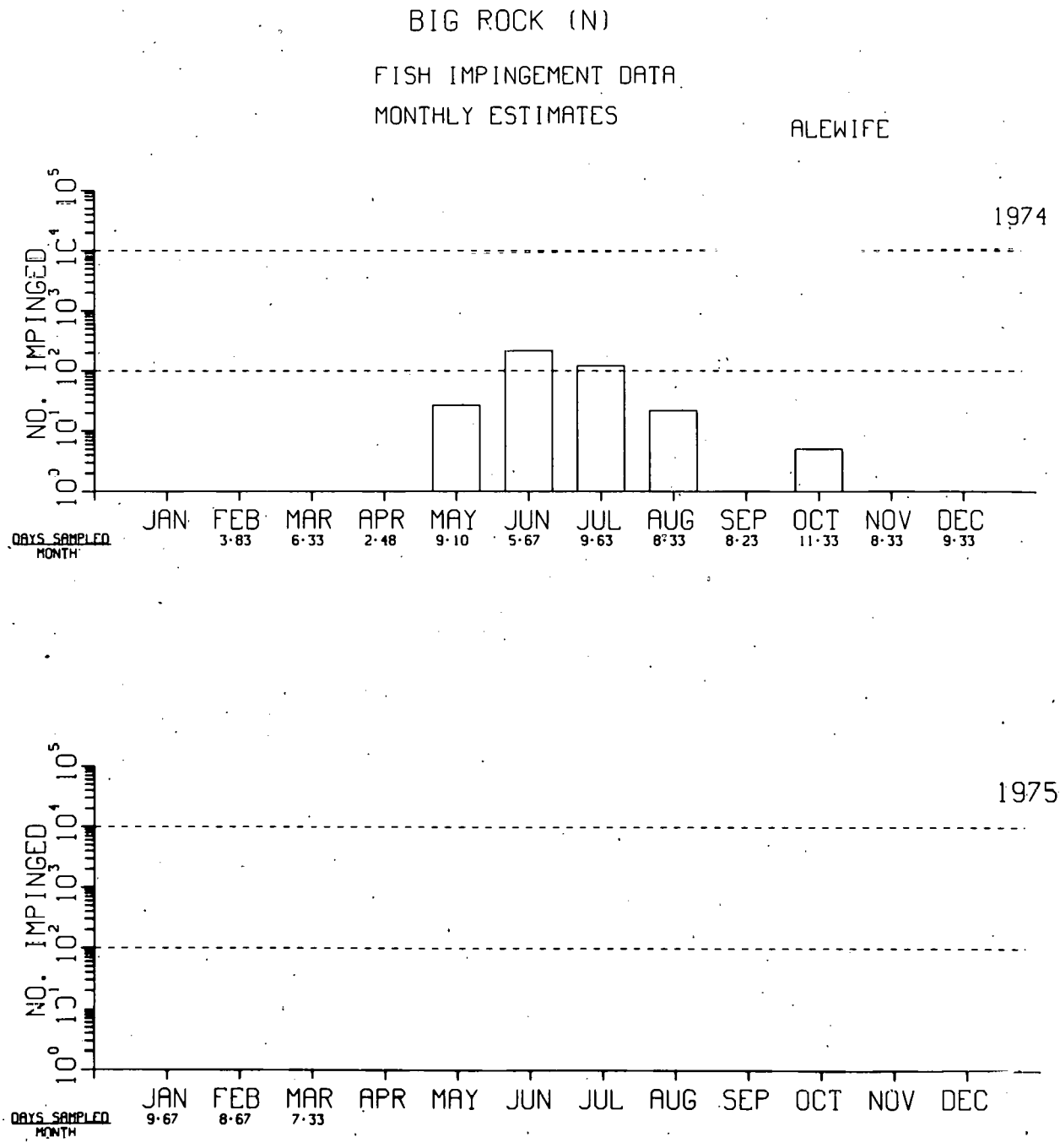


Fig. H2. Impingement Estimates.

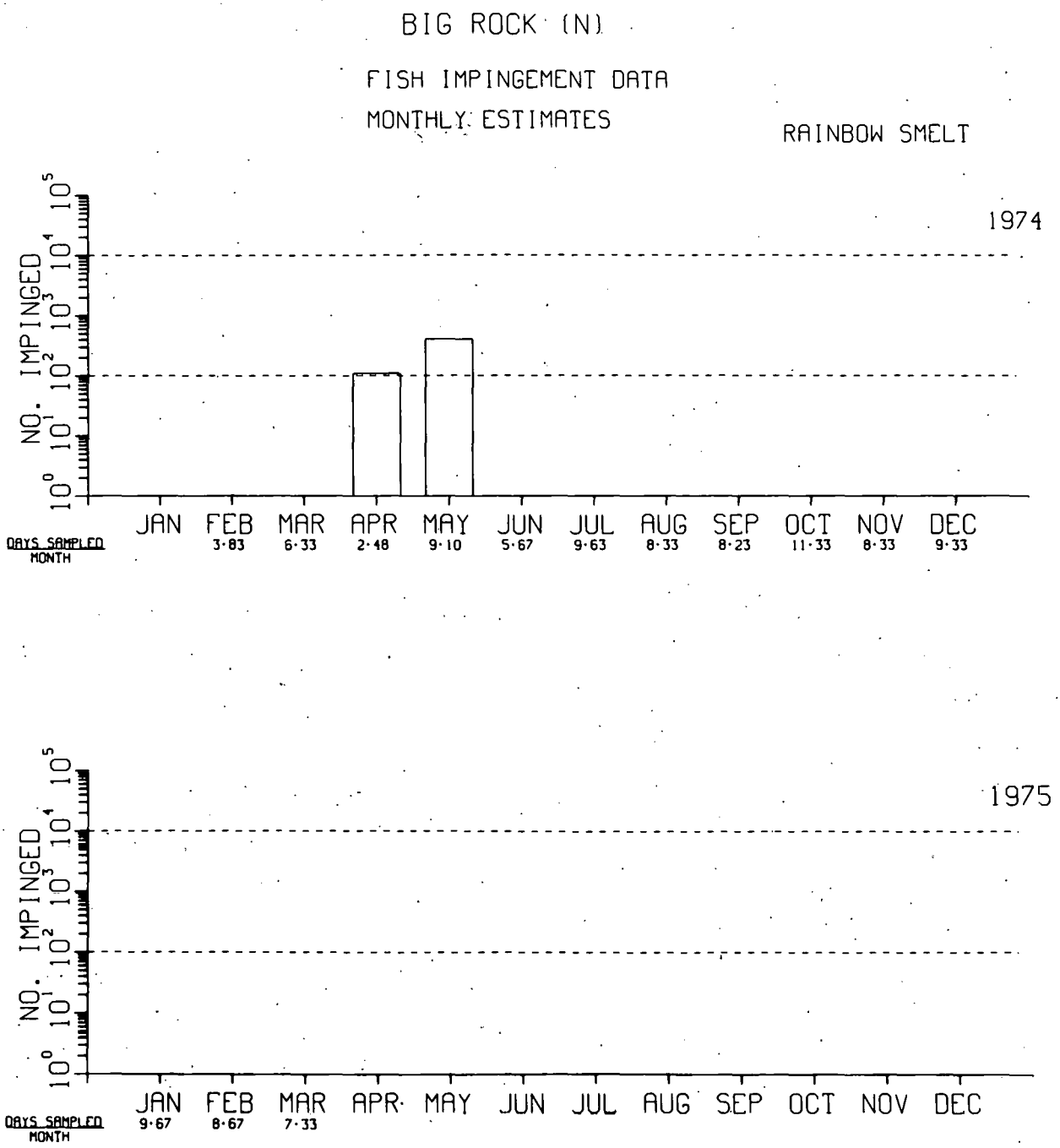


Fig. H3. Impingement Estimates.

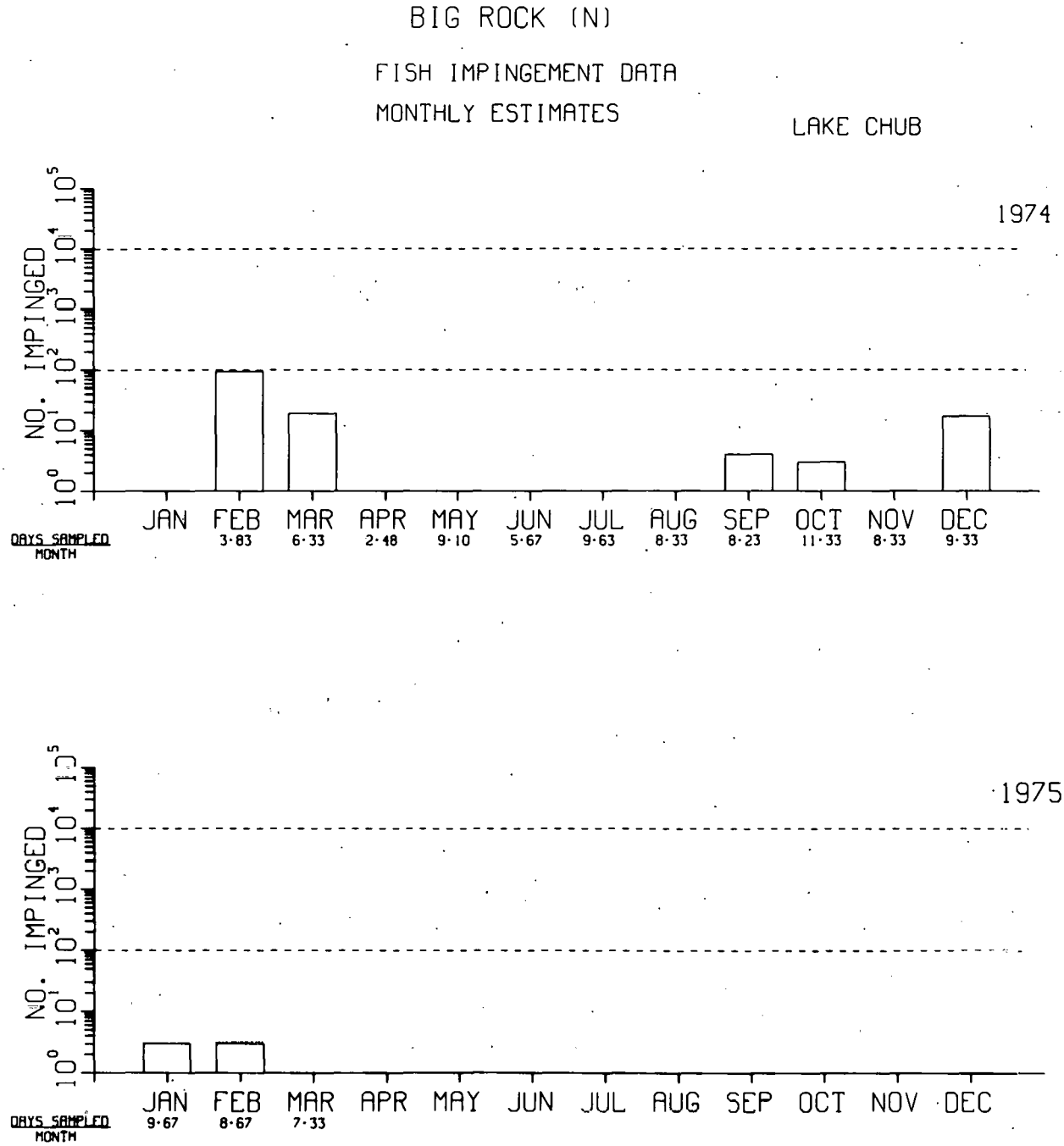


Fig. H4. Impingement Estimates.

D. E. KARN AND J. C. WEADOCK PLANTS (F)

SITE CHARACTERISTICS

The D. E. Karn and J. C. Weadock Plants are located at the mouth of the Saginaw River, about four miles northeast of Bay City, Michigan (Fig. 1).

The Saginaw River drainage basin consists of 6222 square miles although it drains directly only 246 square miles. It is 22 miles long, formed by the confluence of the Shiawassee, Tittabawassee, and Cass Rivers. The river is dredged and used as a commercial waterway, and receives numerous industrial and municipal effluents. It moves slowly, having a gradient of no more than one foot per mile along its entire length. The mean flow is 1,391,376 gpm. In drought (flows of 157,091 gpm or less), the flow velocity may be 0.03 fps. The level of the river can be changed quite quickly as a result of northeast or southwest winds on Saginaw Bay. Reversals in river flow occur quite frequently.

Saginaw Bay is a shallow inland extension of the western shore of Lake Huron. The bay is 26 miles wide at its mouth and 51 miles long. Its narrowest width is 13 miles. A shoal between Sand Point and Charity Island divides the bay at this point into inner and outer bays. The inner bay is divided longitudinally by the Coryeon Reef, a sand and gravel bar about nine feet below the surface, separating the eastern one-third from the western two-thirds. The inner bay is shallow, with a mean depth of 15 feet and a maximum depth of 46 feet. The bay on the eastern side of Coryeon Reef is 16 feet deep and, on the west, drops down to the old Huronian Riverbed, which is dredged for a shipping channel extending from the Saginaw River (depth, 27 feet). The outer bay has a mean depth of 48 feet and a maximum depth of 133 feet. The majority of the sediments are composed of sand, gravel, quartz, and silt, which are shifted about by currents. The dredged shipping channel contains high quantities of mud and silt. The prevailing current is counterclockwise; water from Lake Huron enters the bay along the northwest shore and leaves along the eastern shore. Winds affect the surface, and flow reversals occur in shallow areas of the bay.

Deep-water temperature remains at or near 39°F all year, but that of the shallow waters changes considerably during the year. In spring, the entire water mass warms from 34°F to 39°F and produces a vertically homothermous state. As the year advances, the shallow waters warm rapidly. A temporary stratification occurs in the shallow bay but only the deeper parts of the bay contain a well-formed thermocline.

A list of fishes present in the vicinity of the plants is not currently available; however Table I is a list of fishes collected during the Karn intake study of January 1974 to January 1975.

PLANT DESCRIPTION

The D. E. Karn Plant is a two-unit fossil-fueled facility with a total generating capacity of 550 MWe. The J. C. Weadock Plant is an eight-unit fossil-fueled facility with a generating capacity of 679 MWe. Both plants utilize once-through cooling.

INTAKE DESIGN AND OPERATION

Condenser cooling water for the D. E. Karn Plant is obtained from the mouth of the Saginaw River via a 2400-foot intake channel (Fig. 2).[1] The intake structure is located on the east side of a forebay at the south end of the intake channel. Vertical iron trash bars spaced on two-inch centers are located at the face of the screenhouse. There are two traveling screens, each of which is two feet by 8.5 feet with 3/8-inch mesh. The screens are run automatically, with operation determined by a timer or head loss across the screens, or manually, depending on service requirements. Standard procedure is to operate the traveling screens automatically at least once every eight-hour shift. Each unit utilizes two 75,000-gpm circulating-water pumps for a total capacity of 300,000 gpm.

Condenser cooling water for the J. C. Weadock Plant is obtained from the Saginaw River via shoreline intake structures located on the east riverbank, south of the D. E. Karn Plant intake channel (Fig. 2).[2] Vertical iron trash bars spaced on two-inch centers are located at the face of each of the four screenhouses. Each screenhouse serves two generating units. Two vertical traveling screens are located in each screenhouse. The screens are made of 3/8-inch wire mesh. The screen panels measure two feet by 4.25 feet for Units 1-3, two feet by 5.25 feet for Units 4-6, and two feet by 8.5 feet for Units 7 and 8. Screen operation is the same as that at the D. E. Karn Plant.

Units 1 and 2 each utilize two 21,900-gpm pumps, Units 3 and 4 each utilize two 26,000-gpm pumps, Units 5 and 6 each utilize two 27,250-gpm pumps, and Units 7 and 8 each utilize two 60,000-gpm pumps. Total capacity is 540,600 gpm.

Because winter icing conditions can cause restriction of flow through the trash bars, warm water is recirculated to the area in front of the trash bars from November through March at the D. E. Karn Plant and December through March at the J. C. Weadock Plant. Recirculation, at rates of about 1000 gpm at Karn and 400 gpm at Weadock, begins when the inlet temperature drops below 39°F.

IMPINGEMENT SAMPLING

At the D. E. Karn Plant, 145 screen counts were made on 119 days between 15 January 1974 and 9 January 1975. These counts quantified fish impingement for 15.5% of the time during the 52-week period with time periods sampled representing both day and night. At the J. C. Weadock Plant, 202 screen counts were made on 140 days between 15 January 1974 and 14 January 1975. These counts quantified fish impingement for 15.8% of the time during the 53-week period.

DATA AVAILABILITY

Impingement data for the Karn Plant are available from 15 January 1974 through 9 January 1975, and for the Weadock Plant from 15 January 1974 through 14 January 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the total numbers of the three most abundant species as well as all species impinged at the D. E. Karn Plant. These totals are summarized in Table II. Figures H5 through H8 are histograms representing the three most abundant species as well as all species impinged at the J. C. Weadock Plant. These totals are summarized in Table III.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited at either plant.

REFERENCES

1. Section 316(b) intake study for the D. E. Karn Plant, Units 1 and 2. Consumers Power Company, Jackson, Michigan. July 1976.

2. Section 316(b) intake study for the J. C. Weadock Plant. Consumers Power Company, Jackson, Michigan. July 1976.

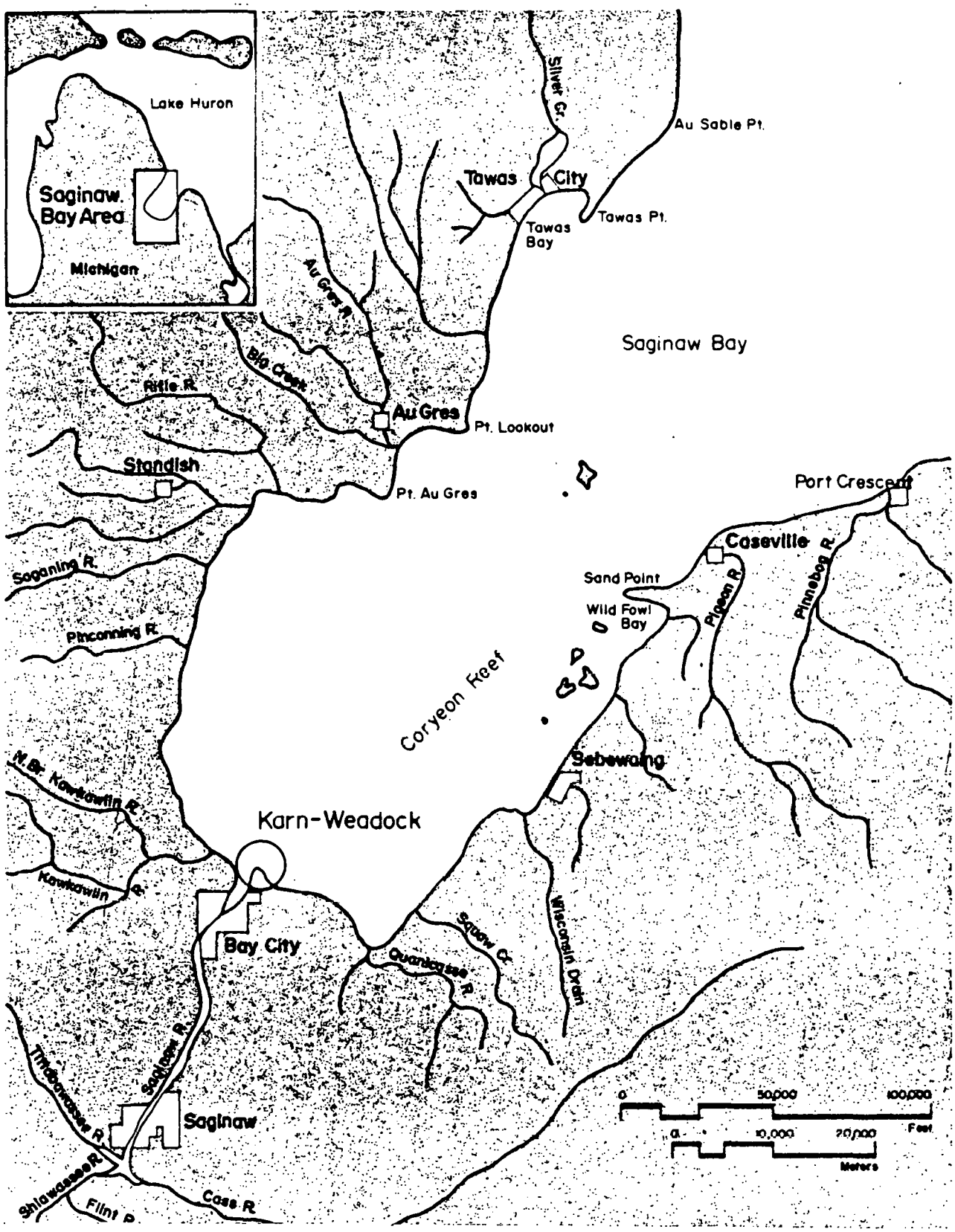


Fig. 1. Location of the Plants.

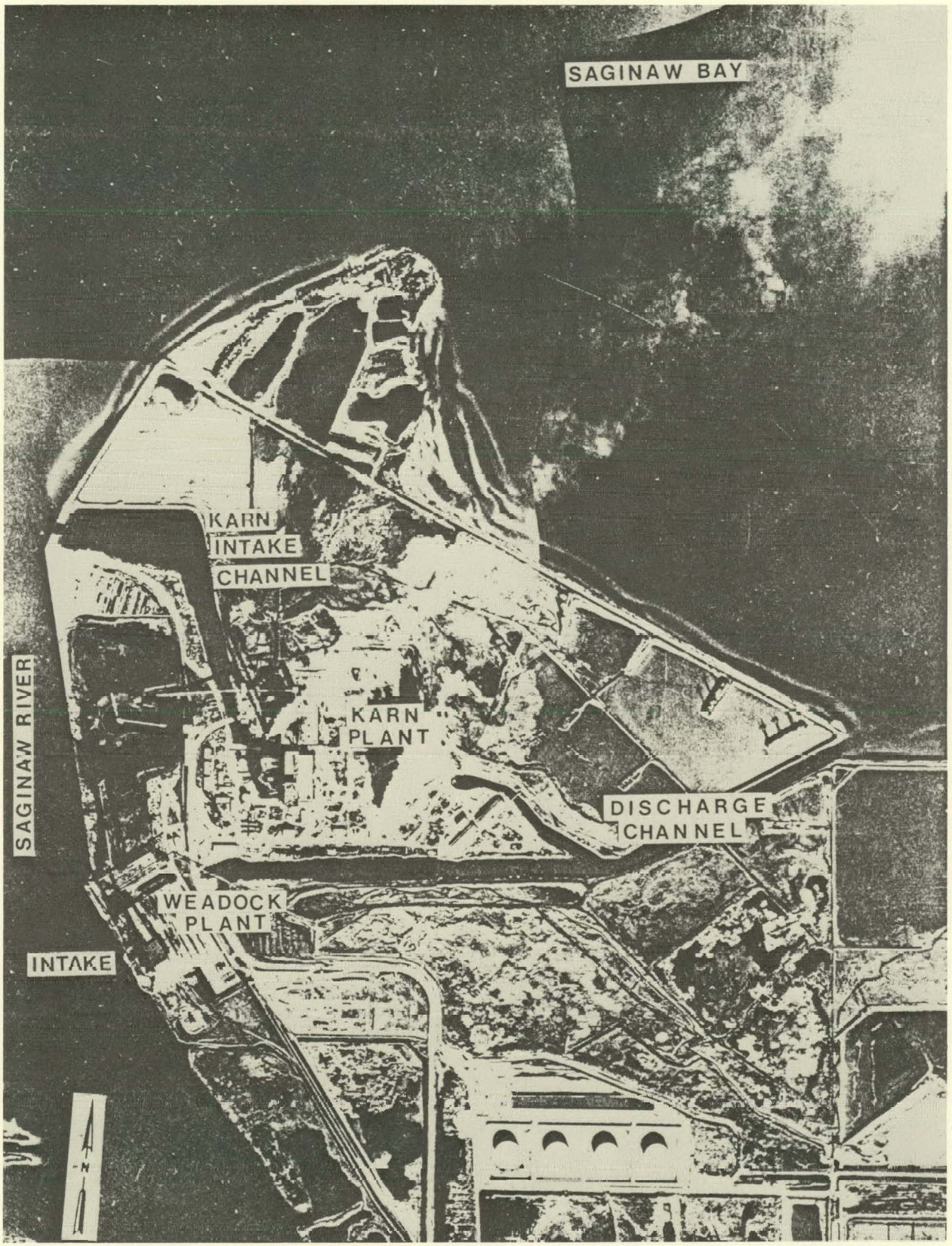


Fig. 2. Aerial View of the Site.

Table I. Fishes Collected during the Karn Intake Study of January 1974 to January 1975

Silver lamprey	Spottail shiner
Sea lamprey	River chub
Longnose gar	White sucker
Bowfin	Golden redhorse
Alewife	Black bullhead
Gizzard shad	Yellow bullhead
Central mudminnow	Brown bullhead
Steelhead	Channel catfish
Coho salmon	Trout-perch
Rainbow smelt	Yellow perch
Northern pike	Rock bass
Goldfish	Pumpkinseed
Carp	Bluegill
Golden shiner	Smallmouth bass
Emerald shiner	White crappie
	Black crappie
	Freshwater drum
	White bass
	Slimy sculpin

Table II. Summary of Fish Impingement Data at the D. E. Karn Plant

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Yellow Perch	Spottail Shiner	Total
1974	12	409,099	165,758	106,871	883,334
1975	1	216,376	198	1,269	218,737

Table III. Summary of Fish Impingement Data at the J. C. Weadock Plant

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gizzard Shad	Yellow Perch	Spottail Shiner	Total
1974	12	552,429	181,949	127,392	877,201
1975	1	999,626	558	2,263	1,008,678

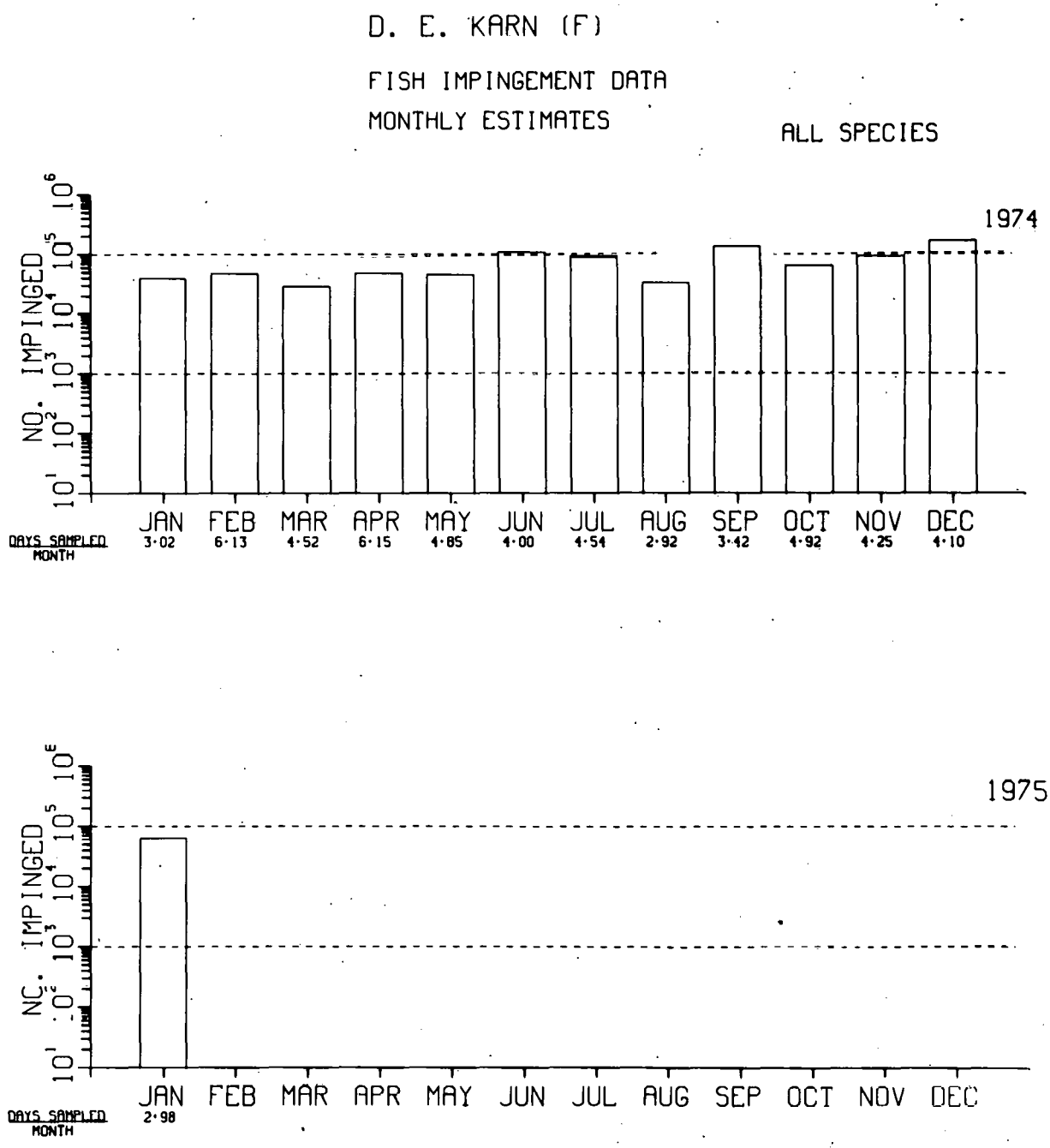


Fig. H1. Impingement Estimates.

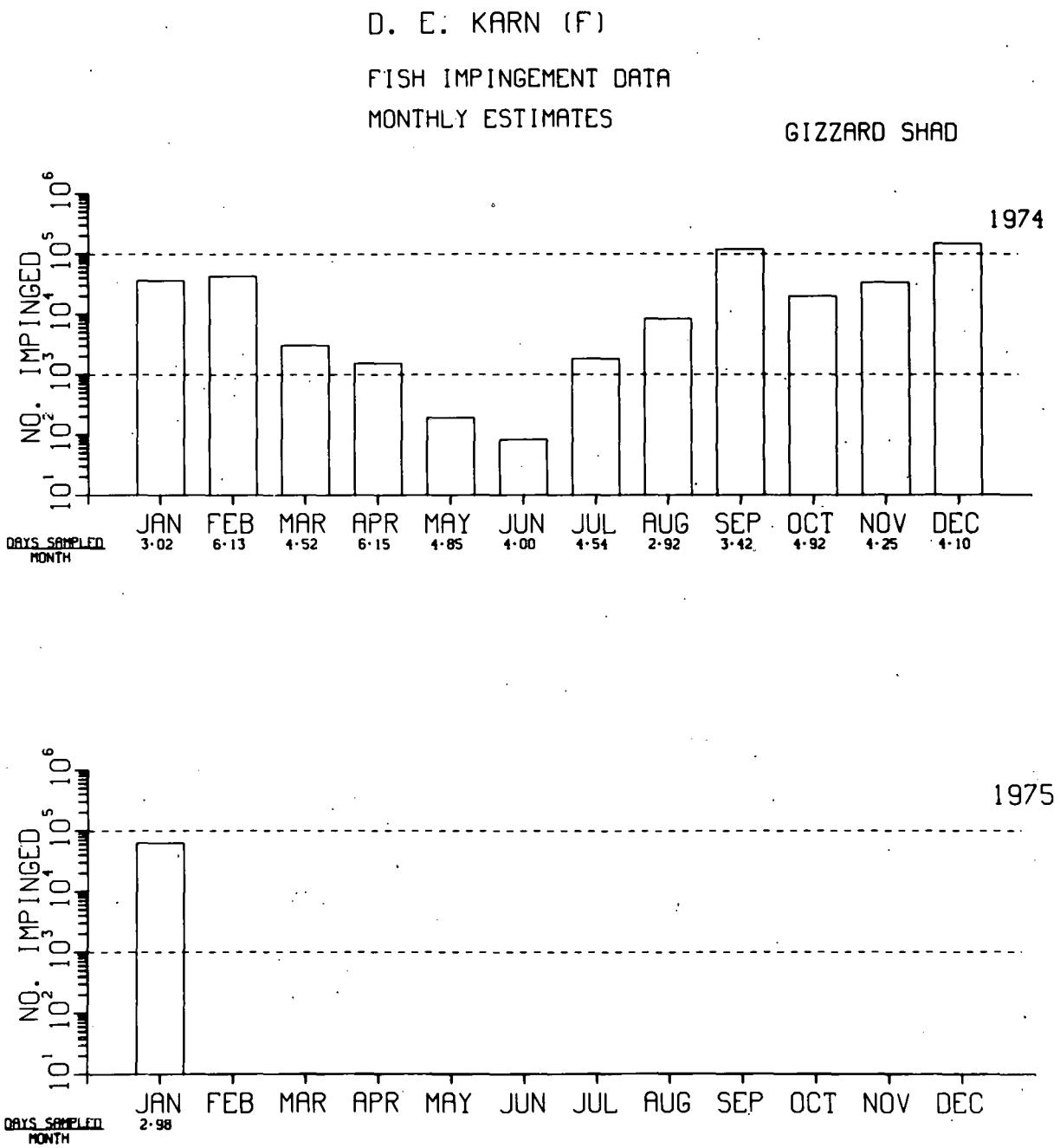


Fig. H2. Impingement Estimates.

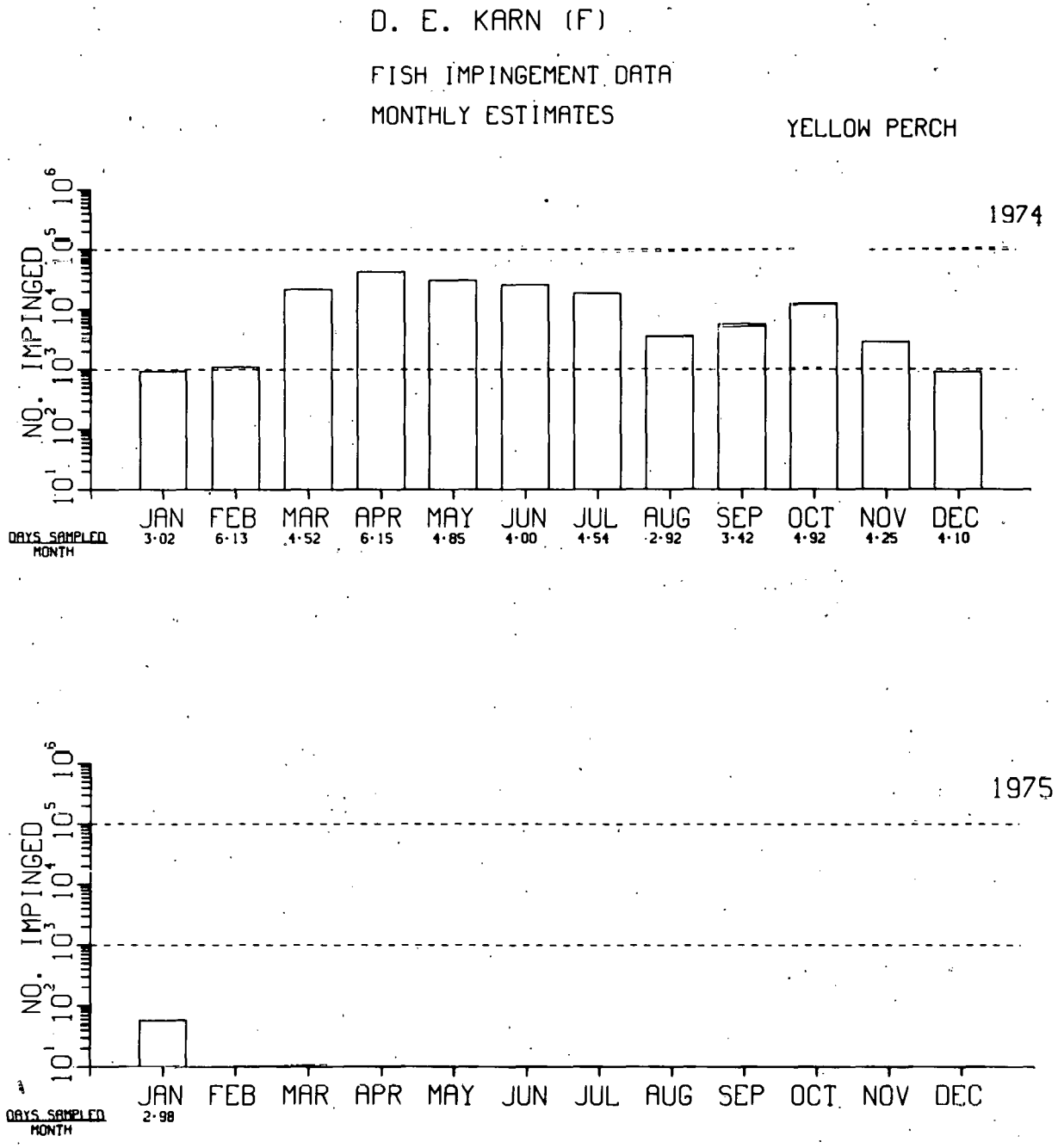


Fig. H3. Impingement Estimates.

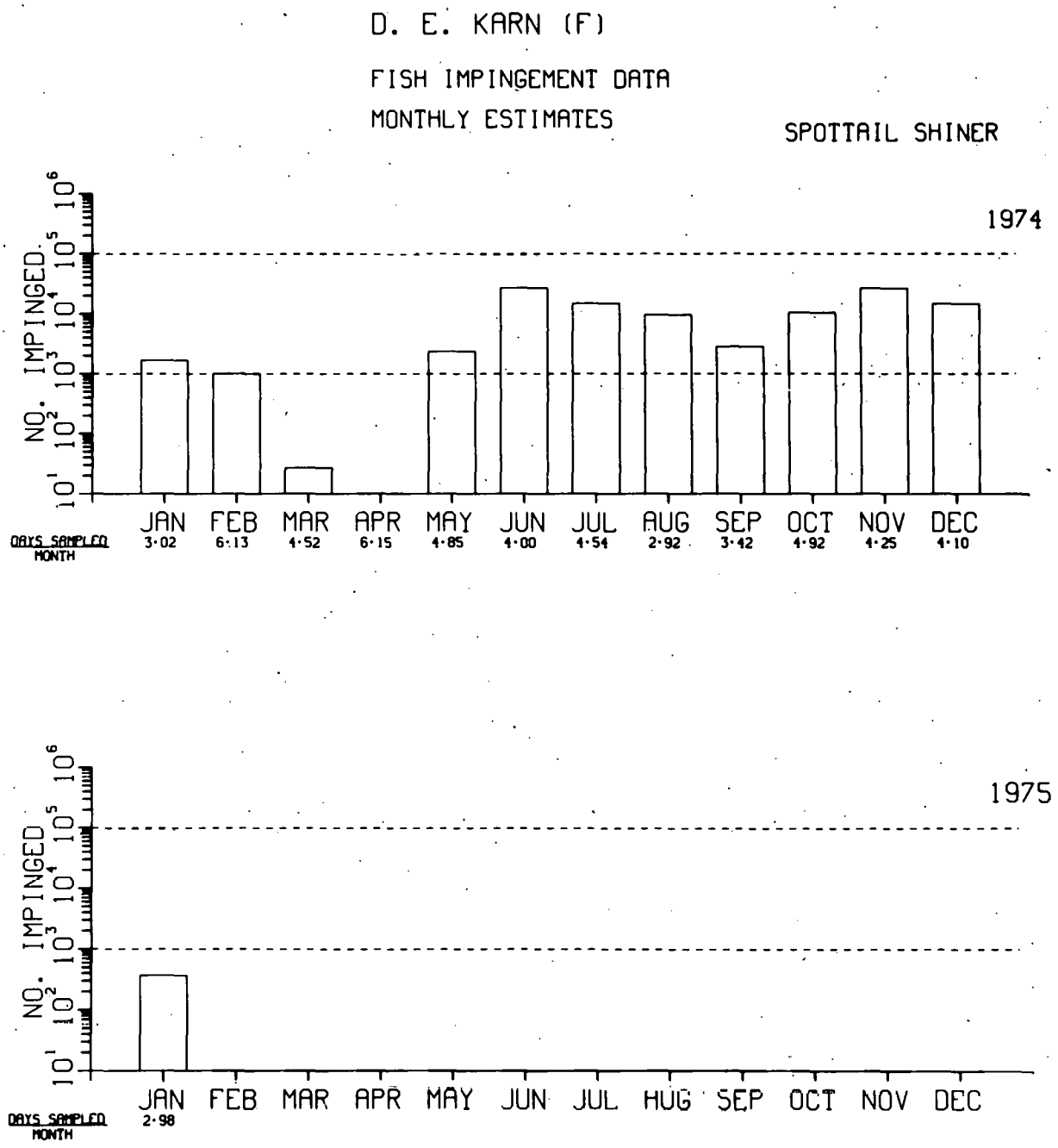


Fig. H4. Impingement Estimates.

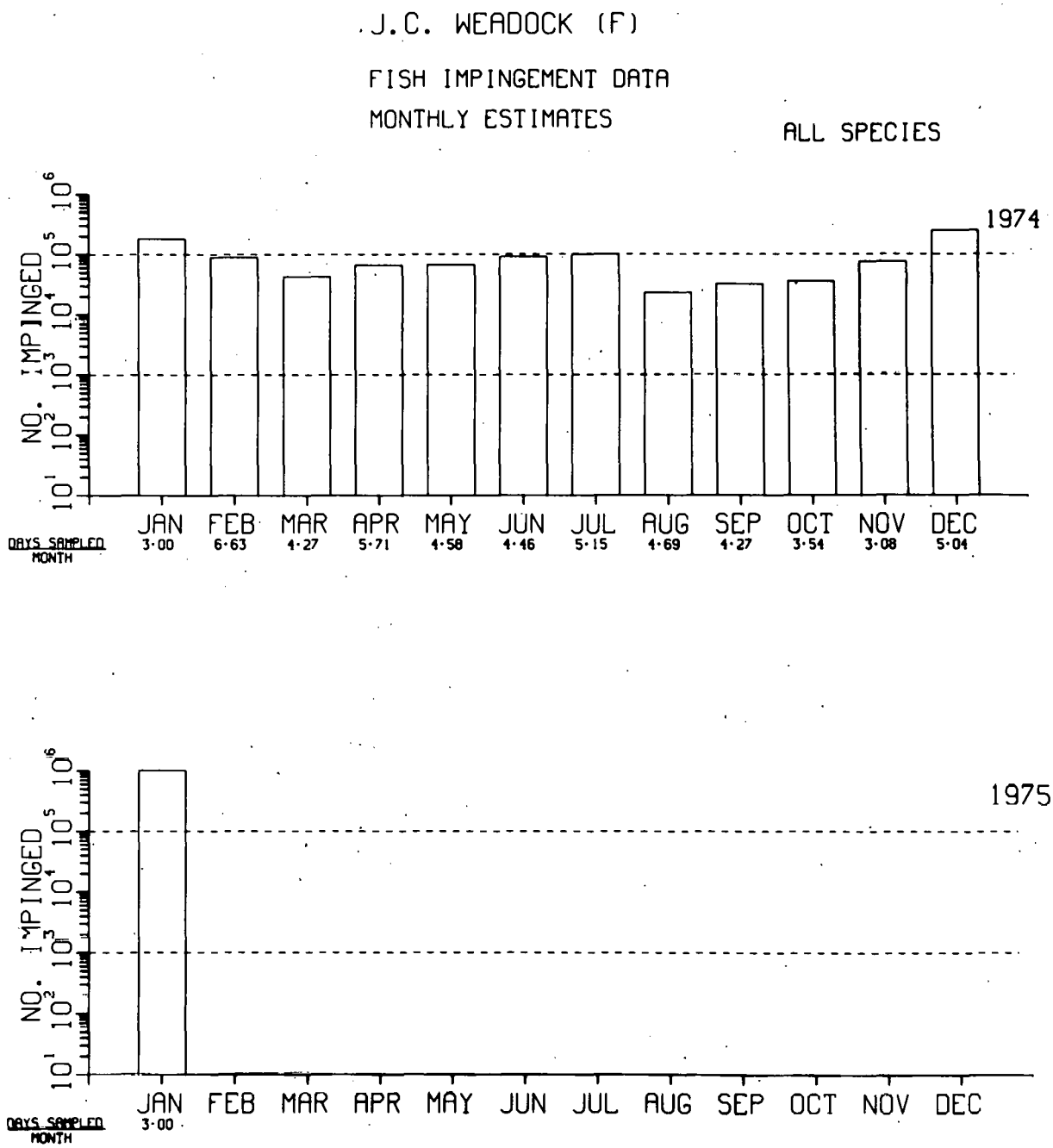


Fig. H5. Impingement Estimates.

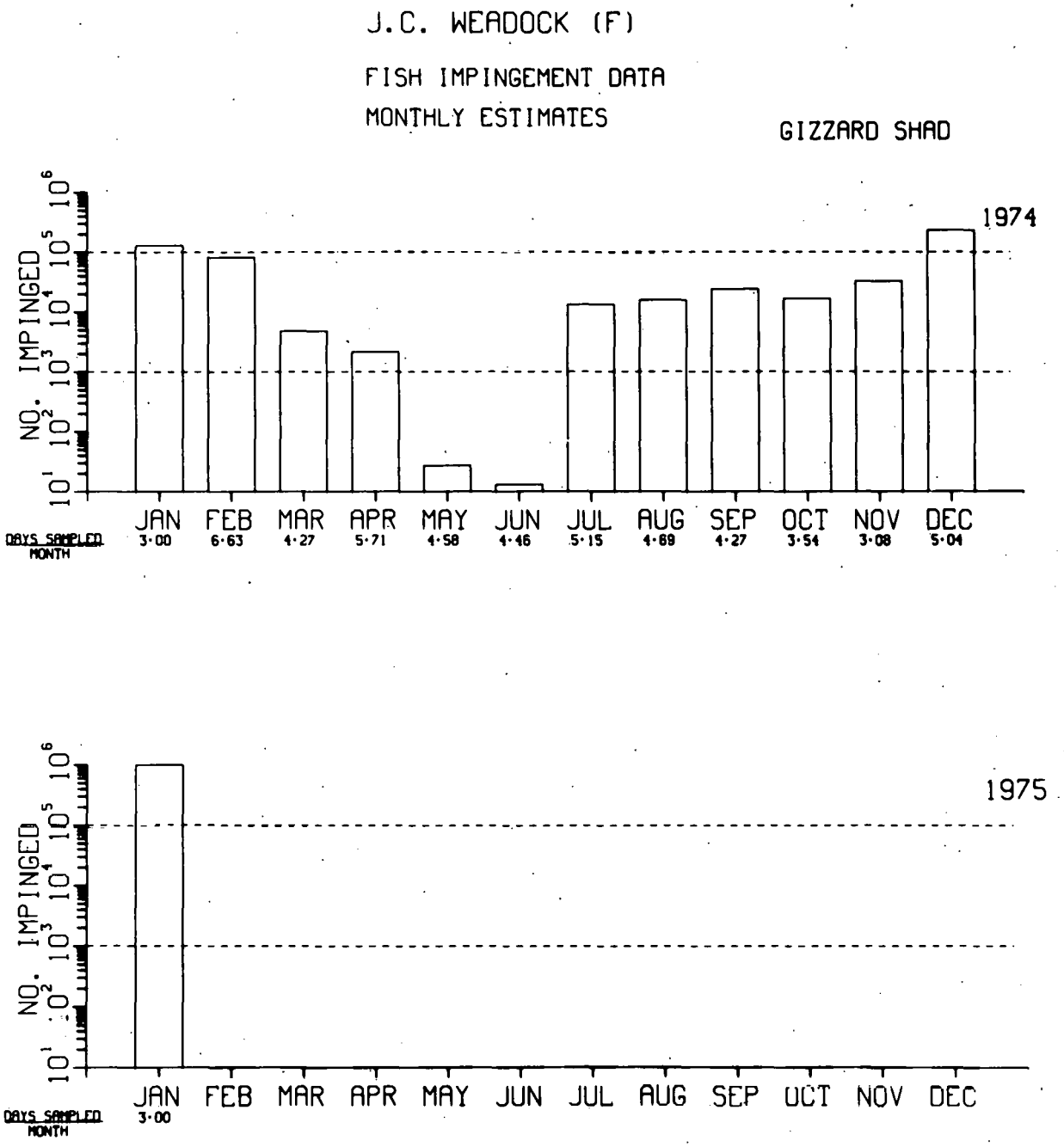


Fig. H6. Impingement Estimates.

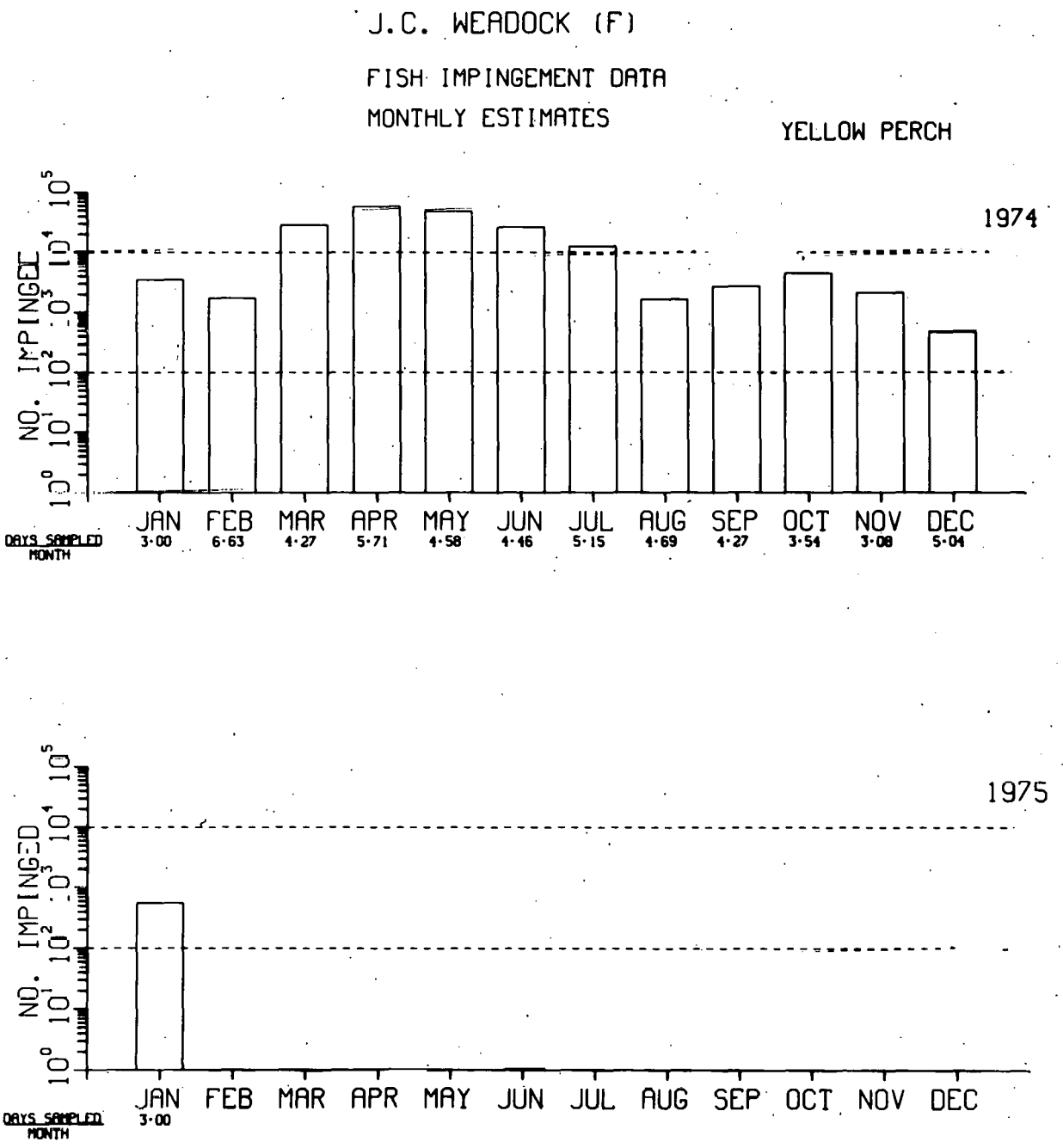


Fig. H7. Impingement Estimates.

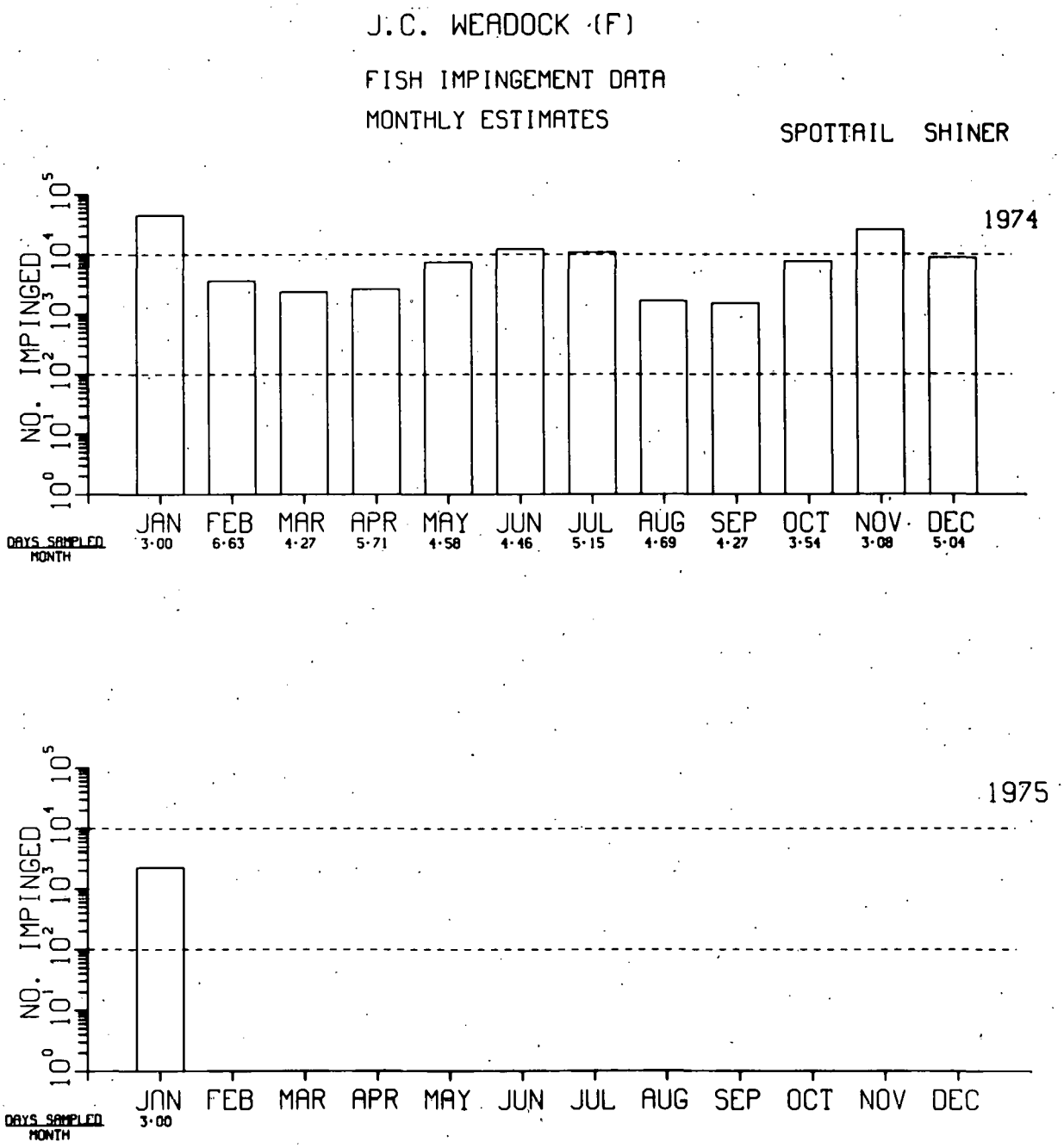


Fig. H8. Impingement Estimates.

R. E. GINNA NUCLEAR POWER PLANT (N)

SITE CHARACTERISTICS

The R. E. Ginna Power Plant is in the northwest corner of Wayne County, New York, on the southern shore of Lake Ontario.[1] The shoreline near the site is high and rocky with no inlets. The lake bottom at the site is composed of fine-to-coarse shale with some cobble-like rock. Farther offshore the composition tends to become bedrock and boulders with isolated areas of sand patches between rocky areas. On an annual basis, water temperature ranges from 32°F to 64°F.

Table I is a list of fishes present in Lake Ontario in the vicinity of the R. E. Ginna Plant.

PLANT DESCRIPTION

The R. E. Ginna Nuclear Power Plant Unit 1 uses a pressurized water reactor to produce 420 MWe net. A once-through system is utilized for condenser cooling.

INTAKE DESIGN AND OPERATION

Condenser cooling water is withdrawn from Lake Ontario through eight ports (17.3 feet wide by 10 feet high) of a submerged octagonal intake structure that lies about 3100 feet offshore in about 33 feet of water (Fig. 1). Each port is screened for large debris with 3/4-inch-diameter bars spaced at 10-inch intervals. These screens are capable of heating the water to 2°F above ambient temperature to prevent accumulation of fragile ice. The water flows by gravity through a 10-foot-diameter concrete-lined tunnel into the screenhouse, where it passes through a coarse trash screen and a fine-mesh traveling screen before being pumped through the condenser-cooling and service-water systems. The water from these two systems is combined and released to a discharge canal that opens into Lake Ontario at the shoreline. Maximum condenser flow rate is 381,000 gpm.

IMPINGEMENT SAMPLING

Impingement studies at the plant were conducted by collecting the fish impinged during consecutive four-hour periods over 24 hours. One hundred twenty-three 23-hour samples were taken from January 1973 through December 1974. There were 39 studies in 1973 and 84 in 1974.

DATA AVAILABILITY

Fish impingement data for the R. E. Ginna Nuclear Power Plant are available for all of 1973 and 1974.

IMPINGEMENT DATA SUMMARY

Figures H1 through H4 are histograms representing the three most abundant species as well as all species impinged at the R. E. Ginna Nuclear Power Plant. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINCEMENT

Fish are discouraged from entering the discharge canal and screenhouse by an electric fish screen (0.3 volt per inch between each electrode) located on the lake side of the recirculation-water weir (Fig. 1).

REFERENCE

1. "Final Environmental Statement, R. E. Ginna Nuclear Power Plant - Unit 1." USAEC Directorate of Licensing. Docket No. 50-244. December 1973.

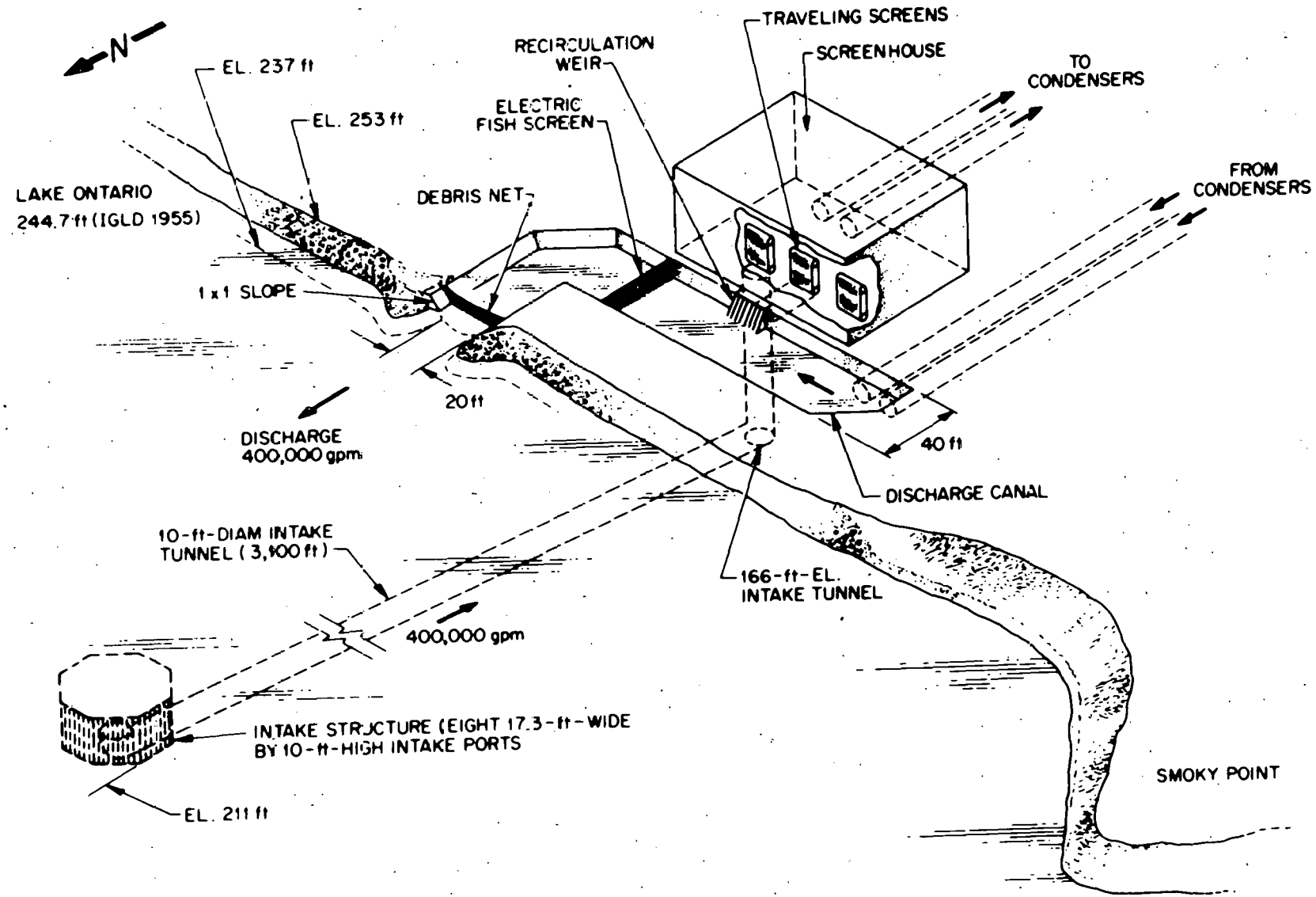


Fig. 1. Intake Structure, Screenhouse, and Discharge Canal.

Table I. Fishes Reported in Lake Ontario at the Site

Sea lamprey	Common shiner
Longnose gar	Spottail shiner
Bowfin	White sucker
American eel	Brown bullhead
Alewife	Channel catfish
Gizzard shad	Stonecat
Coho salmon	Threespine stickleback
Rainbow trout	White perch
Brown trout	White bass
Rainbow smelt	Rock bass
Northern pike	Pumpkinseed
Goldfish	Bluegill
Lake chub	Smallmouth bass
Carp	Largemouth bass
Emerald shiner	Black crappie
	Yellow perch
	Walleye
	Freshwater drum
	Slimy sculpin

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Alewife	Rainbow Smelt	Spottail Shiner	Total
1973	12	2,206,036	206,508	30,277	2,499,918
1974	12	2,361,463	119,729	8,401	2,591,936

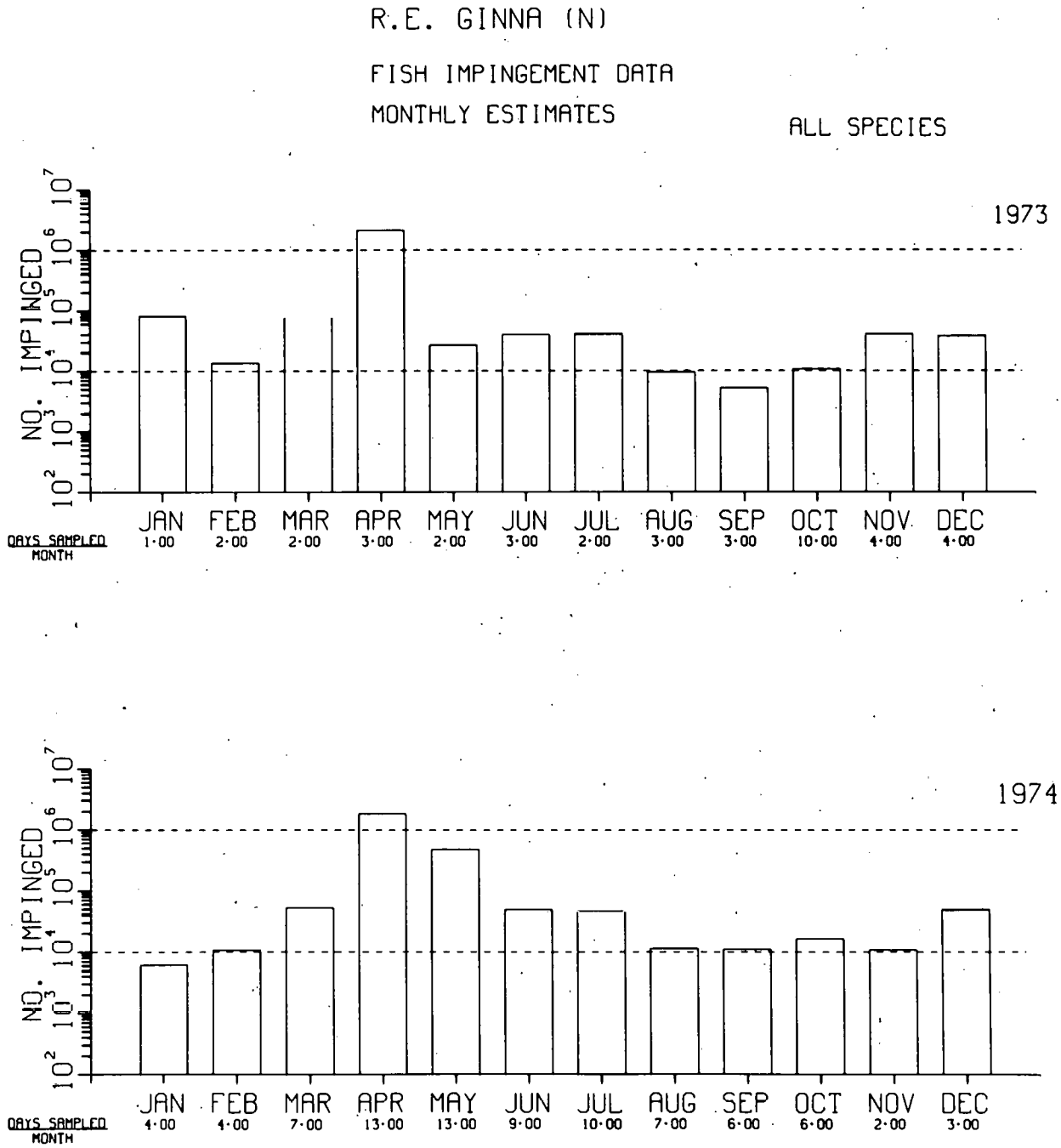


Fig. H1. Impingement Estimates.

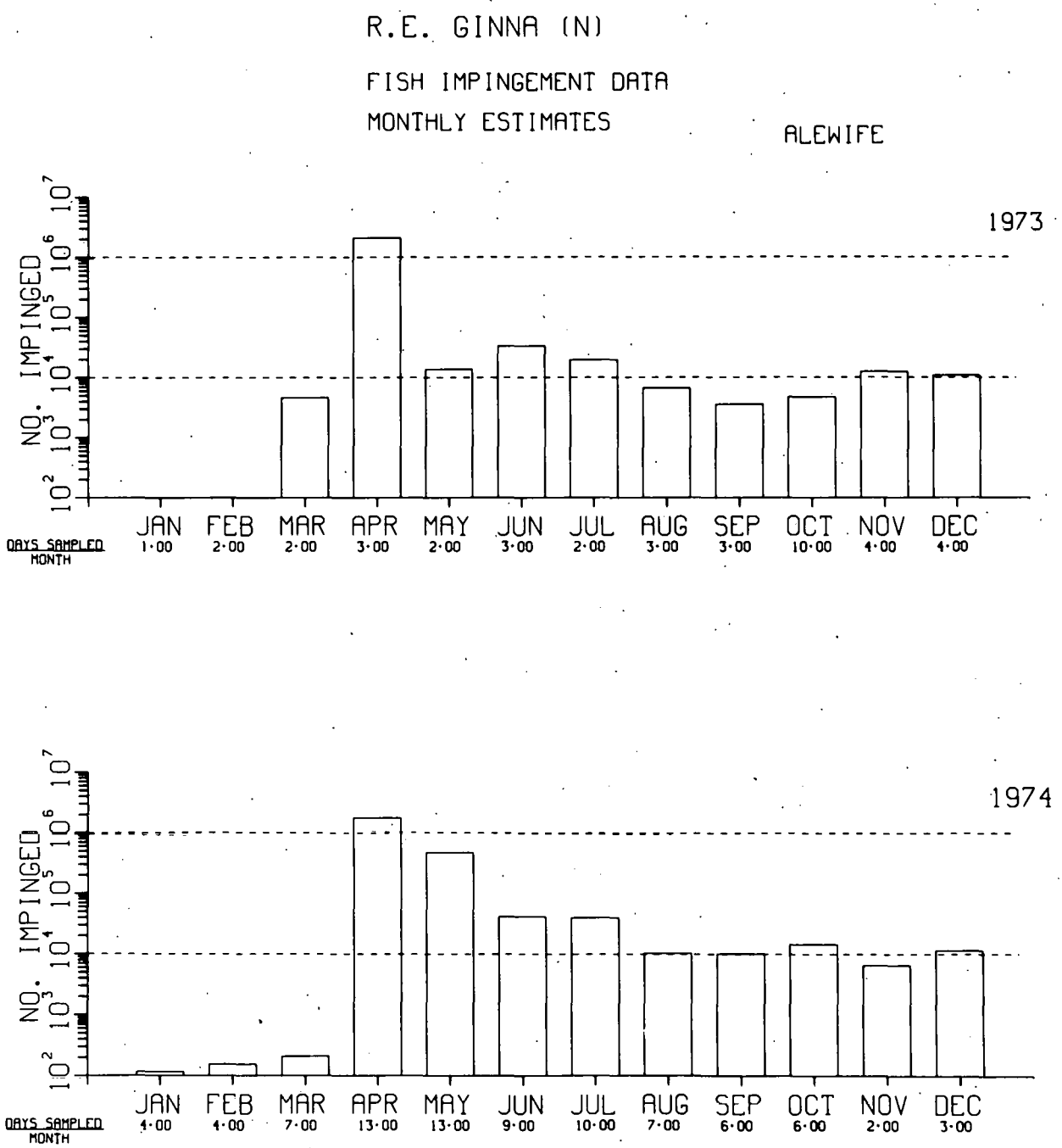


Fig. H2. Impingement Estimates.

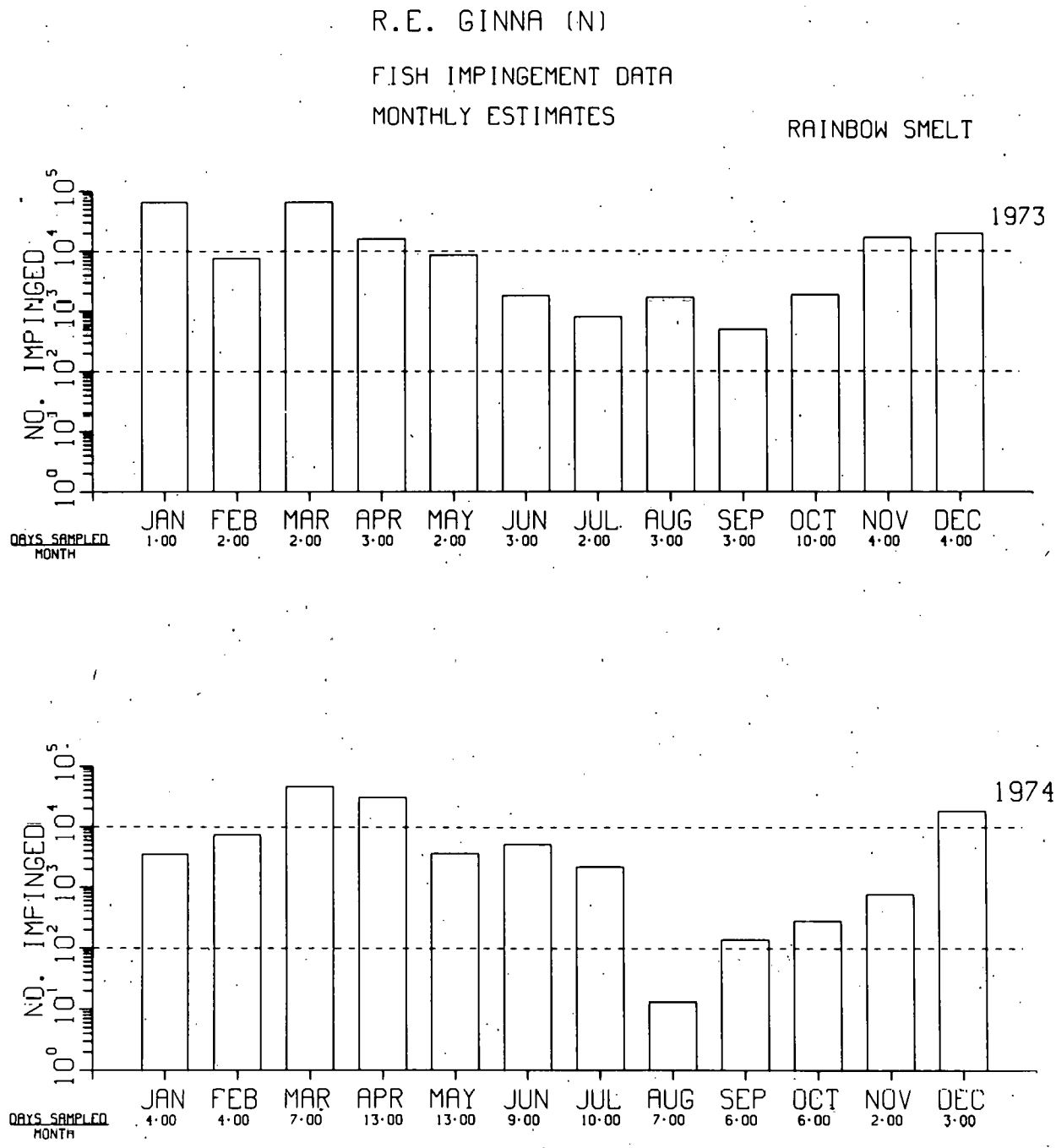


Fig. H3. Impingement Estimates.

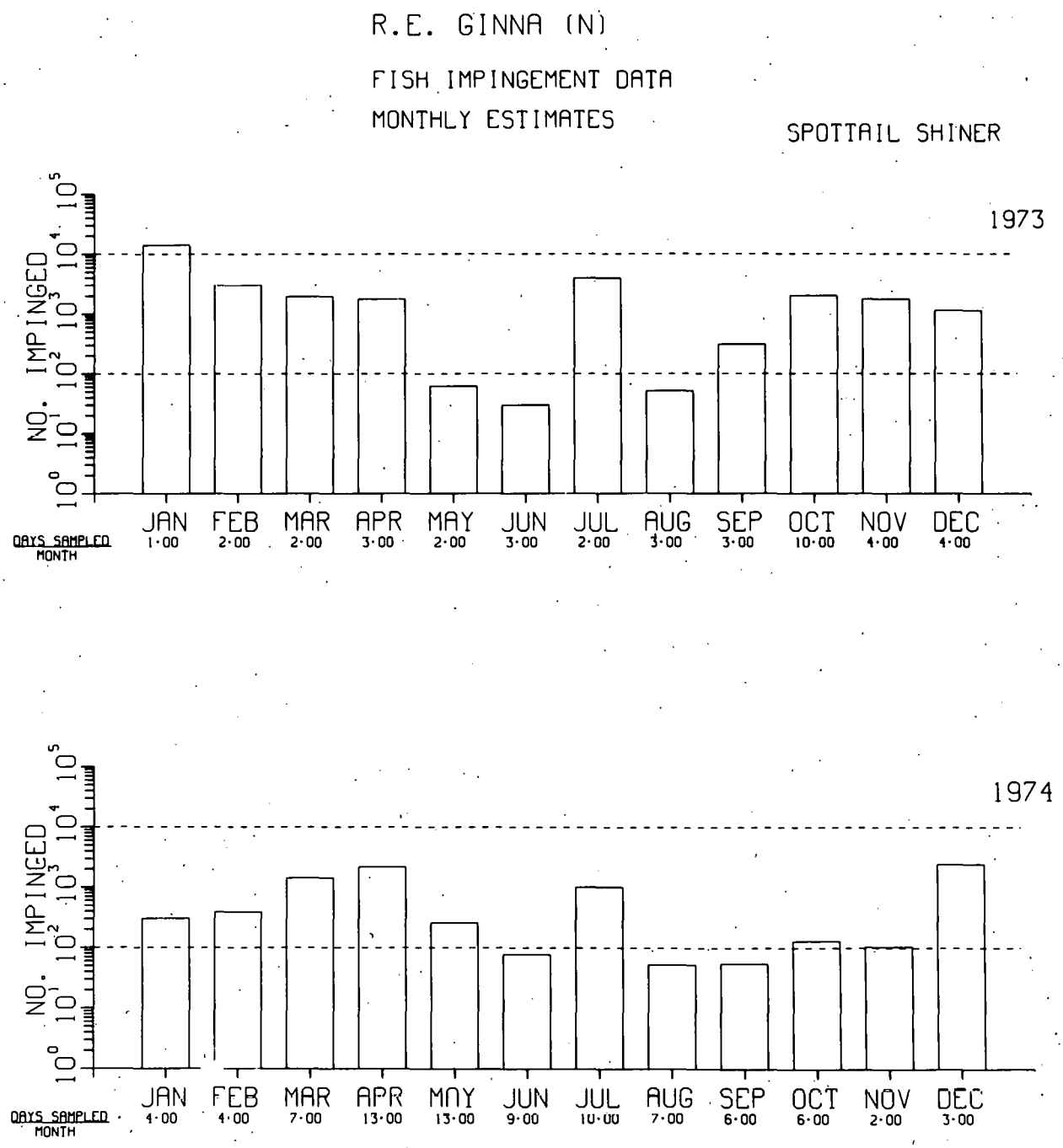


Fig. H4. Impingement Estimates.

NINE MILE POINT NUCLEAR STATION (N)

SITE CHARACTERISTICS

The Nine Mile Point Nuclear Station is located on a 900-acre site on the south shore of Lake Ontario in Oswego County, New York.[1] The lake bottom near the site is rocky and the bedrock out to the 15-foot depth is relatively free of overburden because of heavy wave activity, whereas the bedrock in deeper waters is covered with a loose overburden. The shoreline in the area is abrupt, and there are no beaches.

Table I is a list of fishes found in Lake Ontario in the vicinity of the station.

PLANT DESCRIPTION

The Nine Mile Point Nuclear Station has a single boiling water reactor to generate a net electrical output of 610 MWe. The station utilizes a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

Cooling water is drawn from Lake Ontario into a hexagonal intake structure located about 850 feet from the shoreline in about 18 feet of water. Six water inlets, one on each side of the structure and each 5 feet high by 10 feet long, are protected by galvanized-steel racks to prevent the entrance of debris into the water system. This type of design provides for water to be drawn equally from all directions with a minimum of disturbance and no vortex at the surface. With all pumps in operation, the water velocity at the intake is about two fps.

From the intake structure, the water flows at eight fps (maximum) through a concrete-lined tunnel with a diameter of about ten feet to the screenwell and pumphouse (Figs. 1 and 2). From three separate but interconnected bays in the screenwell, two circulating-water pumps with a total capacity of 250,000 gpm draw the water through trash racks and traveling screens at 0.85 fps (maximum) (Fig. 3).

IMPINGEMENT SAMPLING

During January and February of 1973, samples were collected hourly for a 24-hour period every other week. From March through December 1973, samples were collected hourly for a 24-hour period every week.

During 1974, a 24-hour composite sample was collected each Monday and Friday and samples were collected hourly during a 24-hour period each Wednesday. During periods of increased impingement rates (more than 20,000 fish in a 24-hour period), the frequency of sampling was increased by instituting daily sampling in addition to the regularly scheduled three-day-per-week program. This practice was continued until the number of fish collected daily fell below 20,000.[2]

During 1975, sampling was conducted in the same manner as it was done in 1974.[3]

DATA AVAILABILITY

Fish impingement data for the Nine Mile Point Nuclear Station are available for January 1973 through December 1975.

IMPINGEMENT DATA SUMMARY

Figures H1 through H5 are histograms representing the four most abundant species as well as all species impinged at the Nine Mile Point Nuclear Station. These totals are summarized in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Final Environmental Statement, Nine Mile Point Nuclear Station Unit 2." USAEC Directorate of Licensing. Docket No. 50-410. June 1973.

2. "Nine Mile Point Aquatic Ecology Studies - 1974." Niagara Mohawk Power Corporation and Power Authority of the State of New York. December 1975.

3. "Nine Mile Point Aquatic Ecology Studies - 1975." Niagara Mohawk Power Corporation and Power Authority of the State of New York. May 1976.

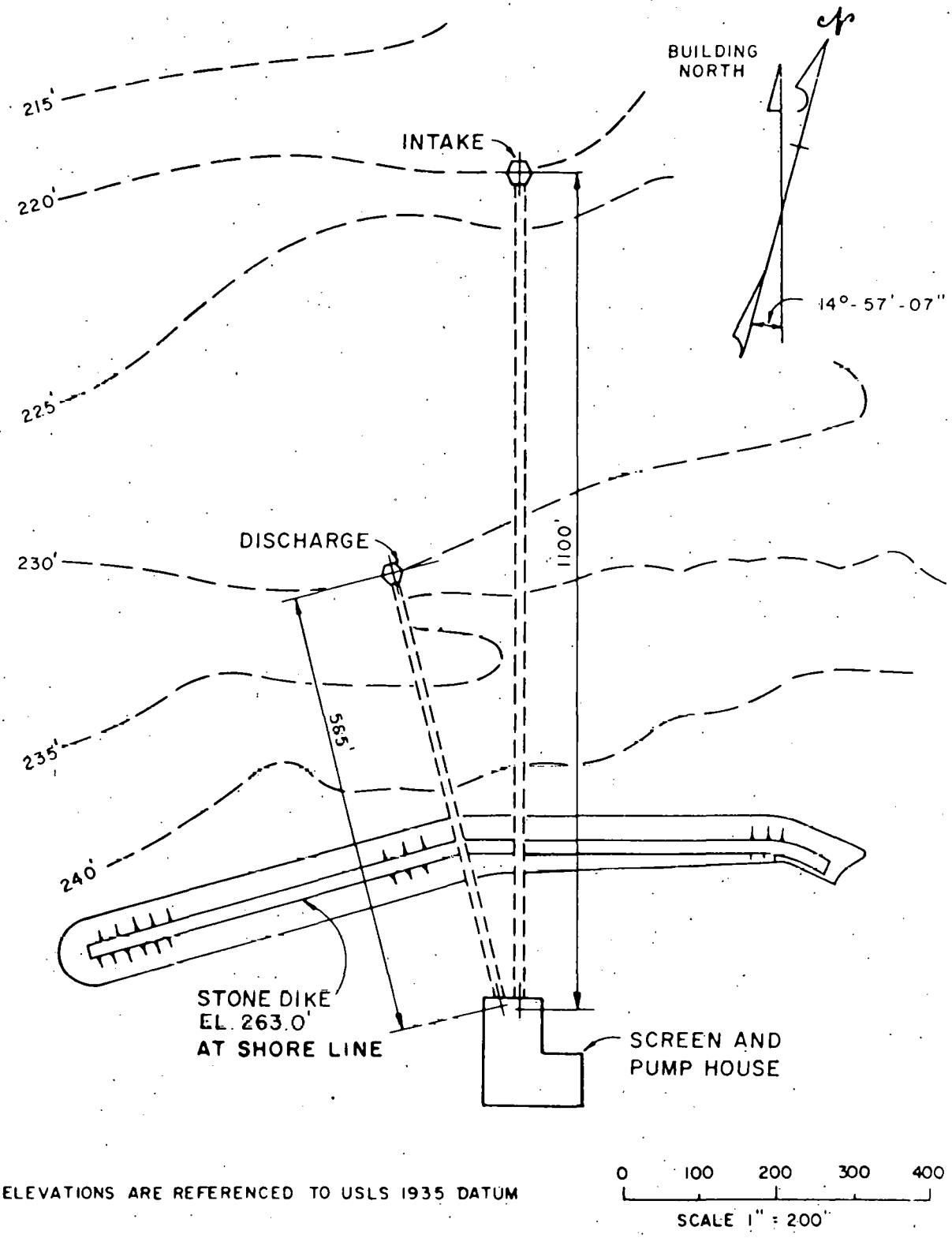


Fig. 1. Circulating-Water System, Plan View.

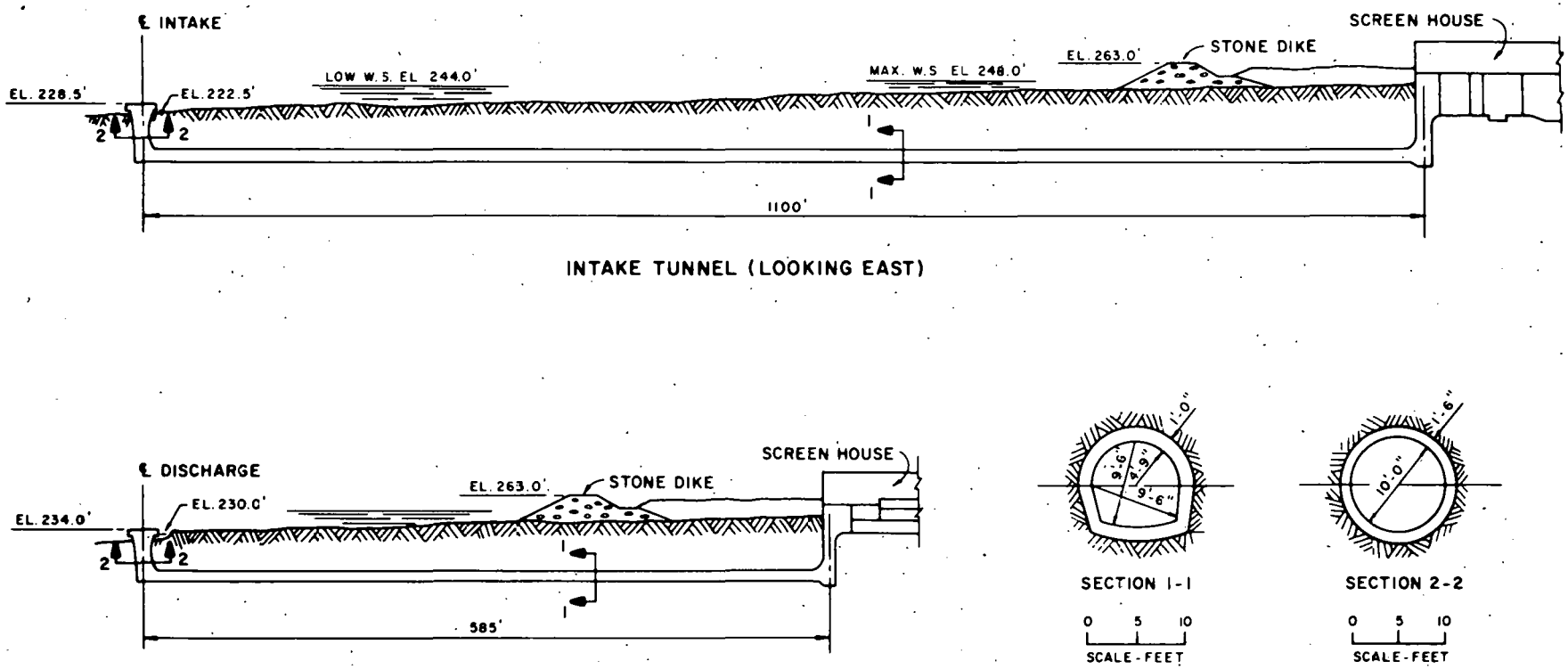


Fig. 2. Circulating-Water System, Elevation View.

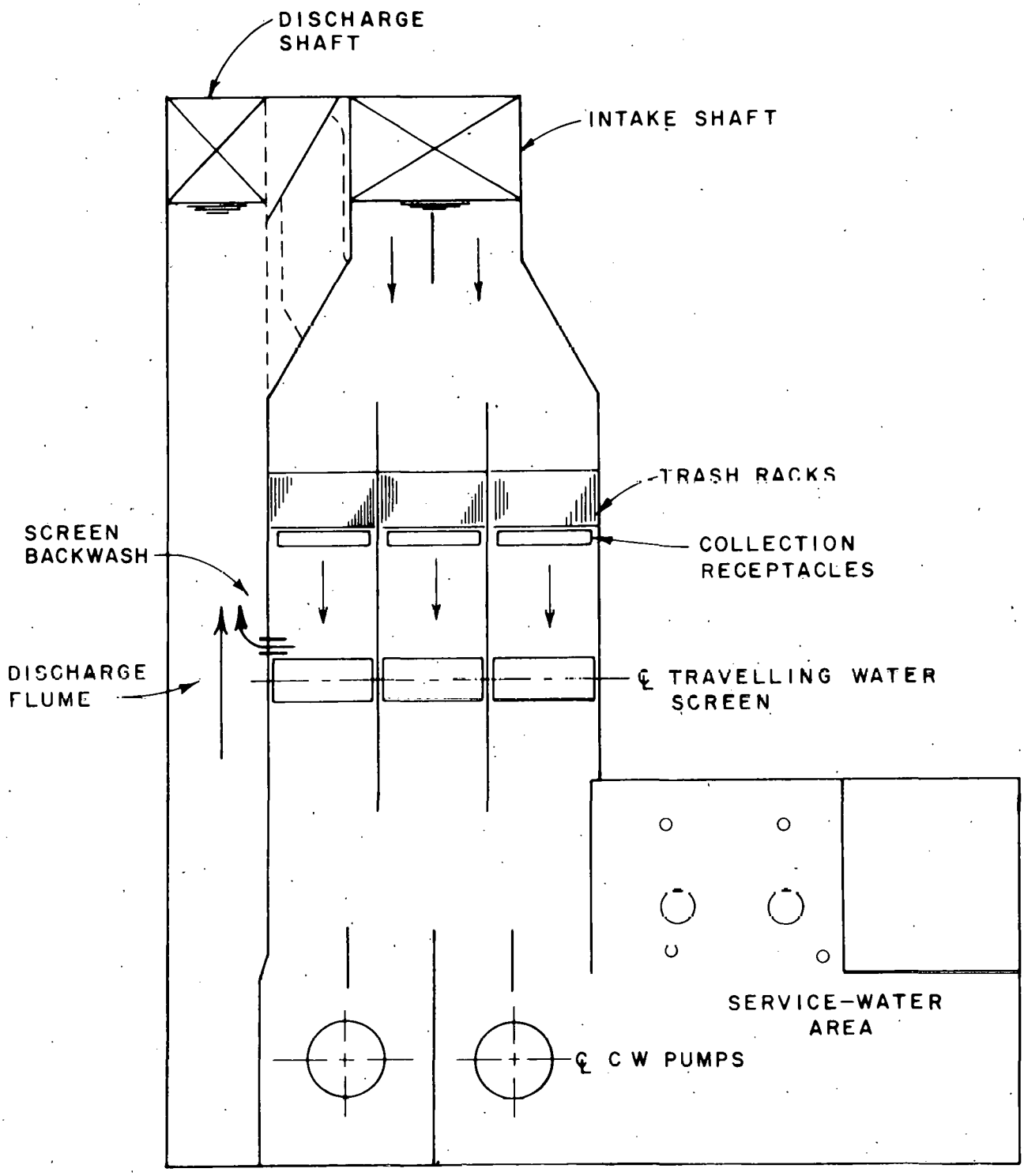


Fig. 3. Schematic of the Screenwell.

Table I. Fishes Found in the Station Area

Alewife	Rainbow smelt
Yellow perch	Gizzard shad
White perch	White bass
Rock bass	Bowfin
Smallmouth bass	Black crappie
Bluegill	Spottail shiner
Brown bullhead	Mottled sculpin
Carp	Northern pike
Coho salmon	White sucker
Walleye	Lake whitefish

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		Alewife	Rainbow Smelt	Spottail Shiner	Mottled Sculpin	Total
1973	12	4,931,566	116,277	683	2,946	5,079,603
1974	12	2,001,698	83,771	7,468	4,405	2,120,761
1975	12	780,738	65,570	1,892	2,996	970,321

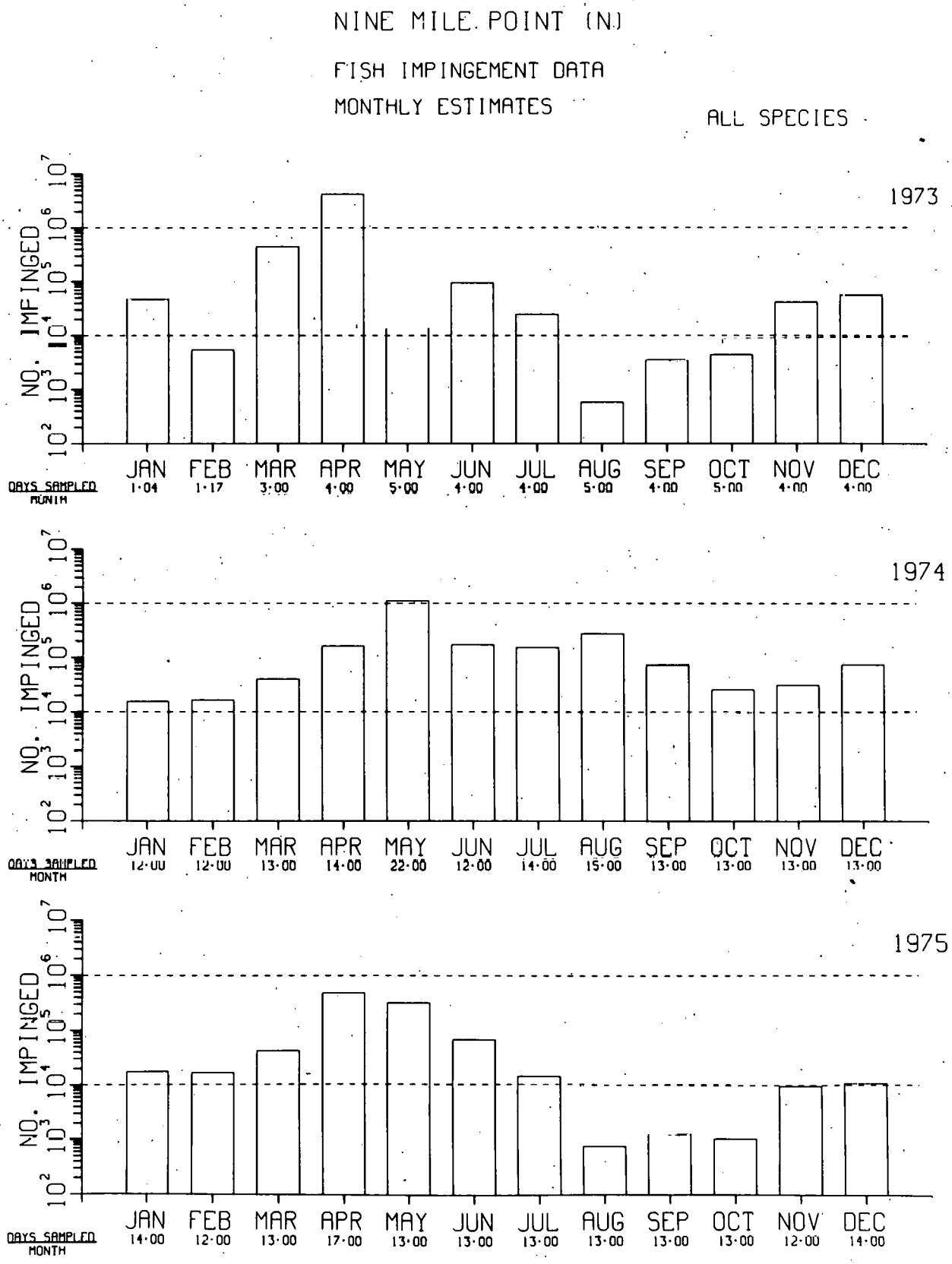


Fig. H1. Impingement Estimates.

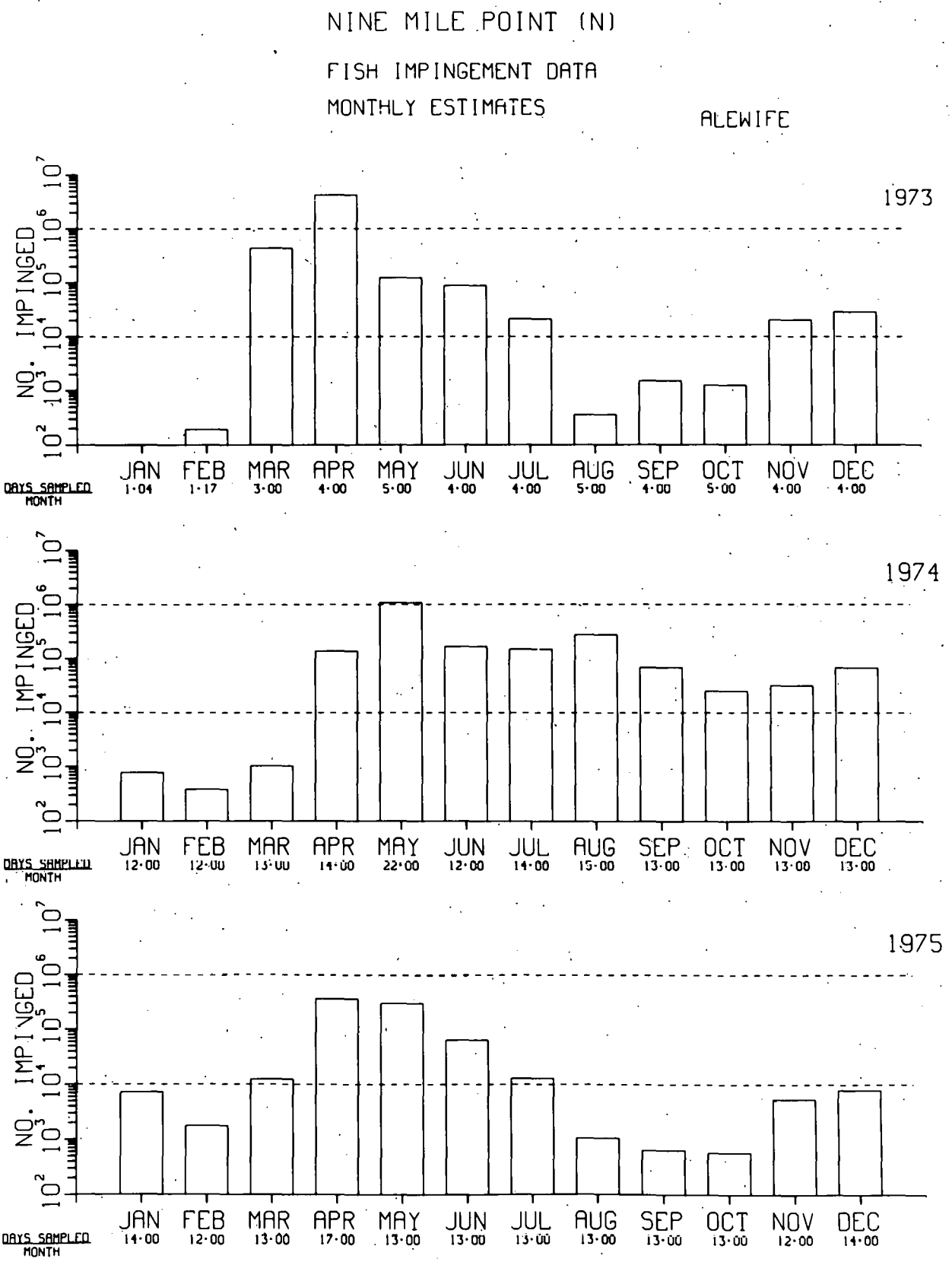


Fig. H2. Impingement Estimates.

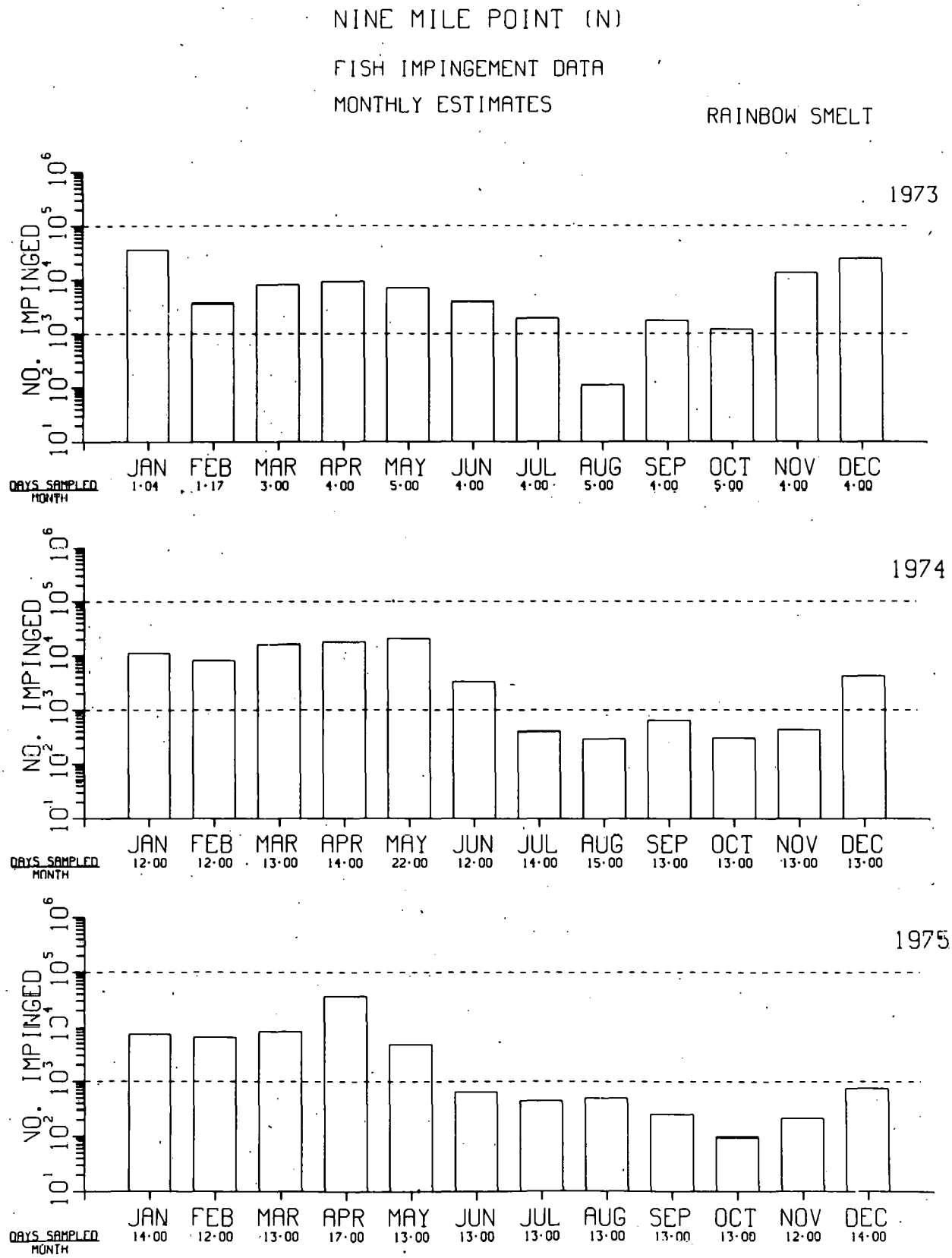


Fig. H3. Impingement Estimates.

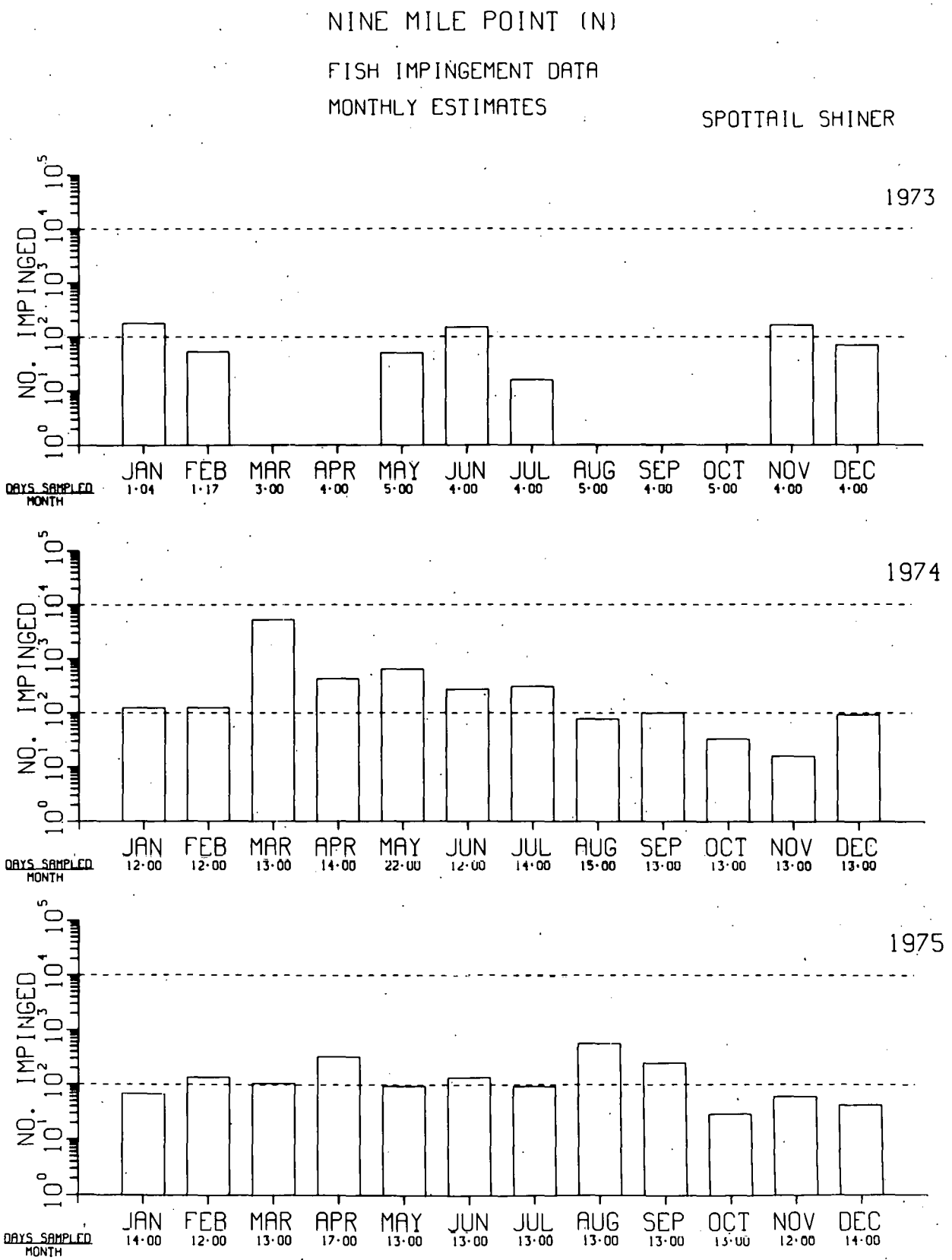


Fig. H4. Impingement Estimates.

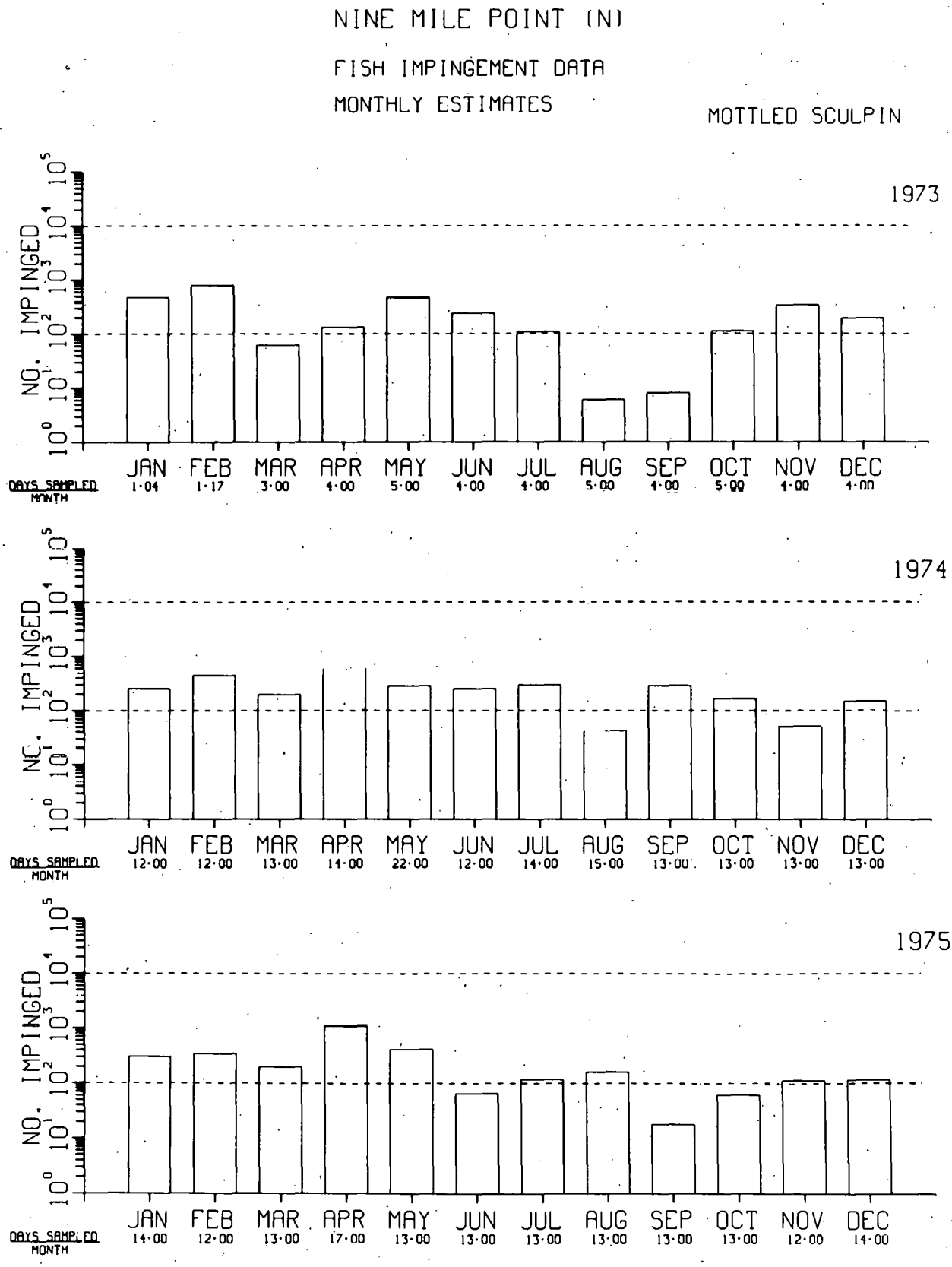


Fig. H5. Impingement Estimates.

SUMMARY

This volume covers 20 power plants located on the Great Lakes. Site characteristics, plant description, intake design and operation, impingement sampling, data availability, and design and operational features to minimize fish impingement are described for each of the plants. An impingement-data summary for each plant is presented in a summary table and in a yearly histogram format in each report.

The fish-impingement monitoring programs and availability of related information vary widely. Therefore, presentation of information in a standardized format has been rather difficult. The amount of detail presented here varies greatly from plant to plant because we had to rely on information from differing sources such as that available only in public documents or in other cases forwarded to us by the utility. We are fully aware of the inadequacies in the use of simple extrapolation for preparation of yearly histograms.

We caution the reader in use of this information alone in determining adequacy of intake designs or severity of impacts on ecosystems. Fish-impingement data alone provide no basis for decisions on intake technology nor are they appropriate for determining significance of impacts. We have avoided drawing any conclusions from the information presented in this volume. Interplant comparisons of fish-impingement data within and among various ecosystems are presented in Volume IV of this series.

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