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SURVEY OF FISH IMPINGEMENT AT POWER PLANTS IN THE UNITED STATES

Volume III. ESTUARIES AND COASTAL WATERS

by

Richard C. Stupka and Rajendra K. Sharma

U of C-AUA-USERDA

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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 III. ESTUARIES AND COASTAL WATERS

by

Richard C. Stupka
and
Rajendra K. Sharma

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 III. ESTUARIES AND COASTAL WATERS

Richard C. Stupka and Rajendra K. Sharma

Abstract

Impingement of fish at cooling-water intakes of 32 power plants located on estuaries and coastal waters 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 estuaries and coastal waters. Other volumes deal with plants on the Great Lakes and on inland waters other than the Great Lakes.

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.

UofC-AUA-USERDA

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.

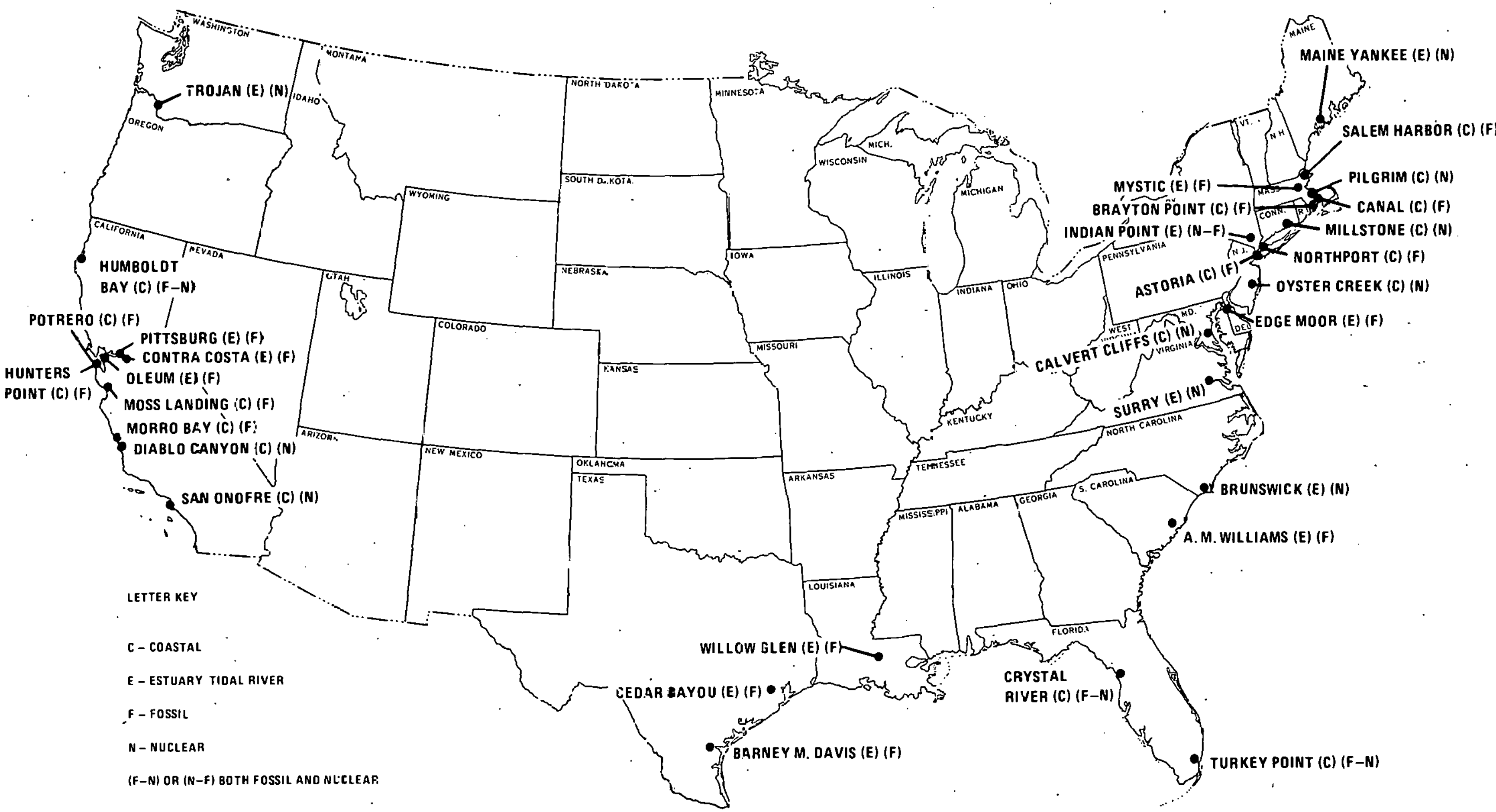


Fig. 3. Plant Locations, Estuaries and Coastal Waters.

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	316(b) Status: Unknown		
ALABAMA								
Alabama Power Co.								Data for Gaston and Gorgas were in a
Barry				X			1525	form not usable for
E. C. Gaston		X		X			1880	the purpose of the
Gorgas		X		X			1341	survey.
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
Diablo Canyon	X			X			2120	conducted for the
Humboldt Bay	X		X				172	fossil plants until
Hunters Point	X		X				377	316(b) guidelines
Morro Bay	X		X				1002	are issued by the
Moss Landing	X		X				2060	EPA.
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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			377	
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: No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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 be in preparation.
E. W. Stout						X	787	

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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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						1386	
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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 in prep for the utility's plants except Burlington.
Kearny			X				841	
Linden			X				613	
Mercer			X				653	
Seawaren			X				850	
NEW MEXICO								No fossil plants larger than 500 MWe; no nuclear plants.
NEW YORK								
Central Hudson Cas & 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 & Indian Point.
Astoria	X						1625	
East River			X				454	
Hudson Ave.						X	700	316(b) proposals may be in prep for East River & Arthur Kill.
Indian Point	X						1158	
Arthur Kill			X				826	
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	No Impingement Information Available: 316(b) Status: Exempt	No Impingement Information Available: 316(b) Status: Unknown	Capability (MWe)	Comments
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: No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	316(b) Status: Exempt	316(b) Status: Unknown	Capability (MWe)	Comments
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: No Impingement Monitoring in Progress	No Impingement Information Available: 316(b) or Similar Study Underway	No Impingement Information Available: 316(b) Status: Exempt	No Impingement Information Available: 316(b) Status: Unknown	Capability (MWe)	Comments
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 off-stream cooling.
Harrison					X		1368	
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: No Impingement Monitoring in Progress	316(b) or Similar Study Underway	316(b) Status: Exempt	Unknown	Capability (MWe)	Comments
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.

SUMMARY OF 316(b) STATUS OF U.S. POWER PLANTS

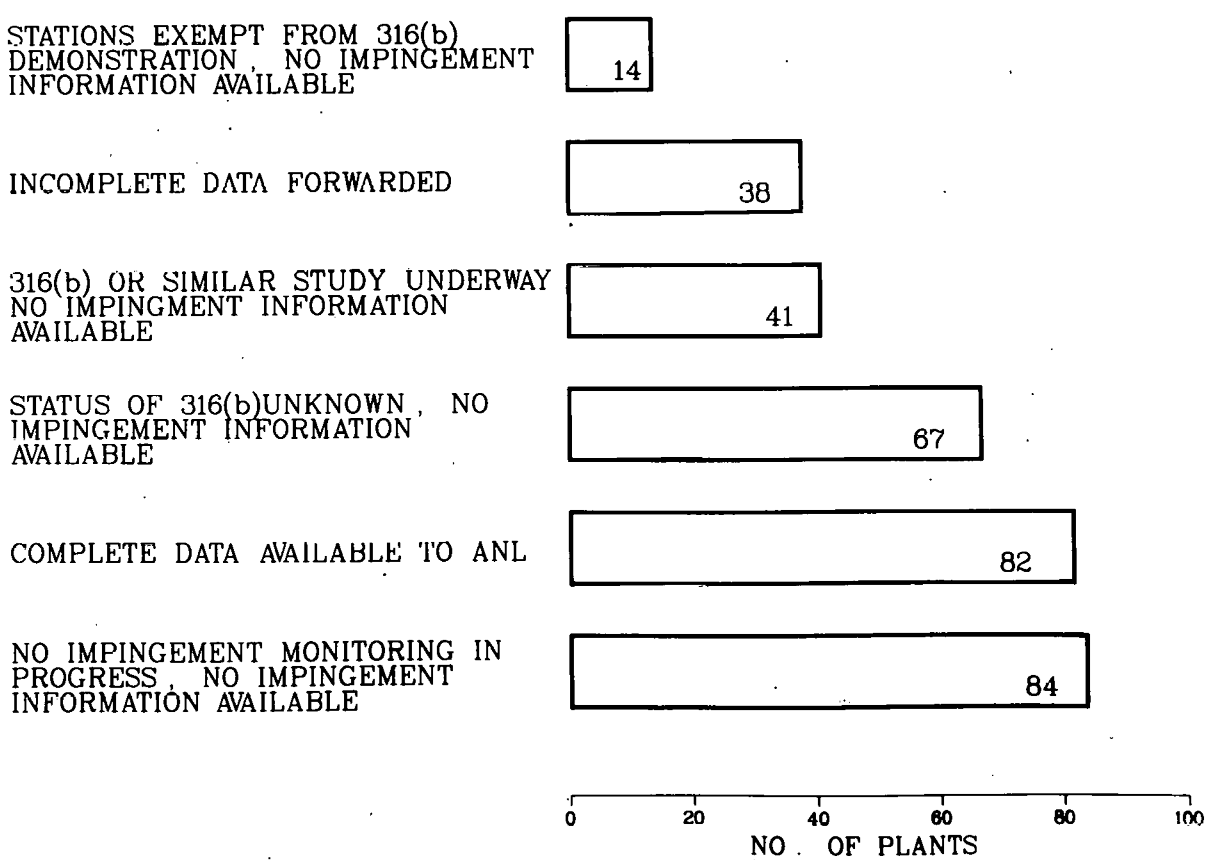


Table II. Index of Common Names Used in this Volume and the Corresponding Scientific Names

Common Name	Scientific Name
African pompano	*Alectis crinitus*
Alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
American sand lance	*Ammodytes americanus*
American shad	*Alosa sapidissima*
Arrow goby	*Clevelandia ios*
Atlantic bumper	*Chloroscombrus chrysurus*
Atlantic cod	*Gadus morhua*
Atlantic croaker	*Micropogon undulatus*
Atlantic cutlassfish	*Trichiurus lepturus*
Atlantic guitarfish	*Rhinobatos lentiginosus*
Atlantic herring	*Clupea harengus harengus*
Atlantic mackerel	*Scomber scombrus*
Atlantic menhaden	*Brevoortia tyrannus*
Atlantic midshipman	*Porichthys porosissimus*
Atlantic moonfish	*Vomer setapinnis*
Atlantic needlefish	*Strongylura marina*
Atlantic salmon	*Salmo salar*
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*
Atlantic silverside	*Menidia menidia*
Atlantic spadefish	*Chaetodipterus faber*
Atlantic stingray	*Dasyatis sabina*
Atlantic sturgeon	*Acipenser oxyrhynchus*
Atlantic thread herring	*Opisthonema oglinum*
Atlantic threadfin	*Polydactylus octonemus*
Atlantic tomcod	*Microgadus tomcod*
Atlantic torpedo	*Torpedo nobiliana*
Ballyhoo	*Hemiramphus brasiliensis*
Banded blenny	*Paraclinus fasciatus*
Banded drum	*Larimus fasciatus*
Banded killifish	*Fundulus diaphanus*
Banded rudderfish	*Seriola zonata*
Bandtail puffer	*Sphoeroides spengleri*
Bank cusk-eel	*Ophidion holbrooki*
Bantam sunfish	*Lepomis symmetricus*
Barbfish	*Scorpaena brasiliensis*
Barndoor skate	*Raja laevis*
Barred pipefish	*Syngnathus auliscus*
Barred sand bass	*Paralabrax nebulifer*
Barrelfish	*Hyperoglyphe perciformis*
Bat ray	*Myliobatus californica*
Batfish	*Ogcocephalus* sp.
Bay anchovy	*Anchoa mitchilli*
Bay blenny	*Hypsoblennius gentilis*
Bay pipefish	*Syngnathus griseolineatus*
Bay whiff	*Citharichthys spilopterus*

Table II. Continued

Common Name	Scientific Name
Bayou killifish	*Fundulus pulvereus*
Bigeye	*Priacanthus arenatus*
Bigeye scad	*Selar crumenophthalmus*
Bighead searobin	*Prionotus tribulus*
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis nigromaculatus*
Black croaker	*Cheilotrema saturnum*
Black drum	*Pogonias cromis*
Black grouper	*Mycteroperca bonaci*
Black perch	*Embiotoca jacksoni*
Black sea bass	*Centropristis striata*
Blackcheek tonguefish	*Symphurus plagiusa*
Blackedge moray	*Gymnothorax nigromarginatus*
Blackeye goby	*Coryphopterus nicholsi*
Blacksmith	*Chromis punctipinnis*
Blacktip shark	*Carcharhinus limbatus*
Blackwing searobin	*Prionotus salmonicolor*
Blotched cusk-eel	*Ophidion grayi*
Blue catfish	*Ictalurus furcatus*
Blue runner	*Caranx crysos*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Bluegill	*Lepomis macrochirus*
Bluespotted cornetfish	*Fistularia tabacaria*
Bluespotted searobin	*Prionotus roseus*
Bluespotted sunfish	*Enneacanthus gloriosus*
Bluestriped grunt	*Haemulon sciurus*
Bluntnose jack	*Hemicaranx amblyrhynchus*
Bluntnose stingray	*Dasyatis sayi*
Bonnethead	*Sphyrna tiburo*
Bowfin	*Amia calva*
Bridle shiner	*Notropis bifrenatus*
Broad flounder	*Paralichthys squamilentus*
Bronze cardinalfish	*Astrapogon alutus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ictalurus nebulosus*
Brown smoothhound	*Mustelus henlei*
Brown trout	*Salmo trutta*
Butterfish	*Peprilus triacanthus*
Cabezon	*Scorpaenichthys marmoratus*
Calico rockfish	*Sebastes dalli*
California butterfly ray	*Gymnura marmorata*
California clingfish	*Gobiesox rhessodon*
California corbina	*Menticirrhus undulatus*
California halfbeak	*Hyporhamphus rosae*
California halibut	*Paralichthys californicus*
California killifish	*Fundulus parvipinnis*

Table II. Continued

Common Name	Scientific Name
California moray	*Gymnothorax mordax*
California needlefish	*Strongylura exilis*
California scorpionfish	*Scorpaena guttata*
California tonguefish	*Symphurus atricauda*
Carp	*Cyprinus carpio*
Chain pickerel	*Esox niger*
Chain pipefish	*Syngnathus louisianae*
Channel catfish	*Ictalurus punctatus*
Cheekspot goby	*Ilypnus gilberti*
Chinook salmon	*Oncorhynchus tshawytscha*
Chiselmouth	*Acrocheilus alutaceus*
Chub mackerel	*Scomber japonicus*
Chum salmon	*Oncorhynchus keta*
Clearnose skate	*Raja eglanteria*
Clown goby	*Microgobius gulosus*
C-O sole	*Pleuronichthys coenosus*
Cobia	*Rachycentron canadum*
Code goby	*Gobiosoma robustum*
Coho salmon	*Oncorhynchus kisutch*
Common shiner	*Notropis cornutus*
Conger eel	*Conger oceanicus*
Coralline sculpin	*Artedius corallinus*
Cowfish	*Lactophrys* sp.
Creek chubsucker	*Erimyzon oblongus*
Crested blenny	*Hypleurochilus geminatus*
Crested cusk-eel	*Ophidion welshi*
Crevalle jack	*Caranx hippos*
Cunner	*Tautogolabrus adspersus*
Cutthroat trout	*Salmo clarki*
Darter goby	*Gobionellus boleosoma*
Deepbody anchovy	*Anchoa compressa*
Deepwater blenny	*Cryptotrema corallinum*
Diamond turbot	*Hypsopsetta guttulata*
Dusky anchovy	*Anchoa lyolepis*
Dusky pipefish	*Syngnathus floridae*
Dusky shark	*Carcharhinus obscurus*
Dwarf perch	*Micrometrus minimus*
Dwarf seahorse	*Hippocampus zosterae*
Eastern mudminnow	*Umbra pygmaea*
Emerald parrotfish	*Nicholsina usta*
Emerald shiner	*Notropis atherinoides*
English sole	*Parophrys vetulus*
Eulachon	*Thaleichthys pacificus*

Table II. Continued

Common Name	Scientific Name
Fallfish	*Semotilus corporalis*
Fantail mullet	*Mugil trichodon*
Fat sleeper	*Dormitator maculatus*
Feather blenny	*Hypsoblennius hentzi*
Flat bullhead	*Ictalurus platycephalus*
Flier	*Centrarchus macropterus*
Florida blenny	*Chasmodes saburrae*
Florida pompano	*Trachinotus carolinus*
Flyingfish	*Cypselurus* sp.
Fourbeard rockling	*Enchelyopus cimbrius*
Fourspine stickleback	*Apeltes quadracus*
Fourspot flounder	*Paralichthys oblongus*
Freckled blenny	*Hypsoblennius ionthas*
Freshwater drum	*Aplodinotus grunniens*
Frillfin goby	*Bathygobius soporator*
Fringed filefish	*Monacanthus ciliatus*
Fringed flounder	*Etropus crossotus*
Fringed pipefish	*Micrognathus crinigerus*
Gafftopsail catfish	*Bagre marinus*
Gag	*Mycteroperca microlepis*
Garibaldi	*Hypsypops rubicunda*
Giant kelpfish	*Heterostichus rostratus*
Giant sea bass	*Stereolepis gigas*
Gizzard shad	*Dorosoma cepedianum*
Golden shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Goldspotted killifish	*Floridichthys carpio*
Goosefish	*Lophius americanus*
Grass pickerel	*Esox americanus vermiculatus*
Grass porgy	*Calamus arctifrons*
Gray smoothhound	*Mustelus californicus*
Gray snapper	*Lutjanus griseus*
Gray triggerfish	*Balistes capriscus*
Green goby	*Microgobius thalassinus*
Green sunfish	*Lepomis cyanellus*
Grey trout	*Cynoscion regalis*
Grubby	*Myoxocephalus aenaeus*
Guaguanche	*Sphyraena guachancho*
Gulf butterfish	*Peprilus burti*
Gulf flounder	*Paralichthys albigutta*
Gulf killifish	*Fundulus grandis*
Gulf kingfish	*Menticirrhus littoralis*
Gulf menhaden	*Brevoortia patronus*
Gulf pipefish	*Syngnathus scovelli*
Gulf toadfish	*Opsanus beta*

Table II. Continued

Common Name	Scientific Name
Haddock	*Melanogrammus aeglefinus*
Halfbeak	*Hyporhamphus unifasciatus*
Harvestfish	*Peprilus alepidotus*
Hickory shad	*Alosa mediocris*
Hogchoker	*Trinectes maculatus*
Horn shark	*Heterodontus francisci*
Horse-eye jack	*Caranx latus*
Houndfish	*Tylosurus crocodilus*
Inshore lizardfish	*Synodus foetens*
Irish pompano	*Diapterus olisthostomus*
Jack mackerel	*Trachurus symmetricus*
Jacksmelt	*Atherinopsis californiensis*
Johnny darter	*Etheostoma nigrum*
Kelp bass	*Paralabrax clathratus*
Kelp perch	*Brachyistius frenatus*
Kelp pipefish	*Syngnathus californiensis*
Kelp rockfish	*Sebastes atrovirens*
Killifish	*Fundulus* sp.
King mackerel	*Scomberomorus cavalla*
Ladyfish	*Elops saurus*
Lane snapper	*Lutjanus synagris*
Largemouth bass	*Micropterus salmoides*
Largescale sucker	*Catostomus macrocheilus*
Least puffer	*Sphoeroides parvus*
Leatherjacket	*Oligoplites saurus*
Leopard searobin	*Prionotus scitulus*
Leopard shark	*Triakis semifasciata*
Lined seahorse	*Hippocampus erectus*
Lined sole	*Achirus lineatus*
Little skate	*Raja erinacea*
Longfin smelt	*Spirinchus thaleichthys*
Longhorn sculpin	*Myoxocephalus octodecemspinosus*
Longjaw mudsucker	*Gillichthys mirabilis*
Longnose gar	*Lepisosteus osseus*
Longnose killifish	*Fundulus similis*
Longspine porgy	*Stenotomus caprinus*
Lookdown	*Selene vomer*
Lumpfish	*Cyclopterus lumpus*
Midshipman	*Porichthys* sp.
Mosquitofish	*Gambusia affinis*
Mottled mojarra	*Eucinostomus lefroyi*
Mountain whitefish	*Prosopium williamsoni*
Mud sunfish	*Acantharchus pomotis*
Mummichog	*Fundulus heteroclitus*

Table II. Continued

Common Name	Scientific Name
Naked goby	*Gobiosoma bosci*
Ninespine stickleback	*Pungitius pungitius*
Northern anchovy	*Engraulis mordax*
Northern kingfish	*Menticirrhus saxatilis*
Northern pipefish	*Syngnathus fuscus*
Northern puffer	*Sphoeroides maculatus*
Northern ronquil	*Ronquilus jordani*
Northern sand lance	*Ammodytes dubius*
Northern searobin	*Prionotus carolinus*
Northern sennet	*Sphyraena borealis*
Northern squawfish	*Ptychocheilus oregonensis*
Northern stargazer	*Astroscopus guttatus*
Ocean pout	*Macrozoarces americanus*
Ocellated flounder	*Ancylopsetta quadrocellata*
Ocellated frogfish	*Antennarius ocellatus*
Olive rockfish	*Sebastes serranoides*
Onespot fringehead	*Neoclinus uninotatus*
Opaleye	*Girella nigricans*
Orange filefish	*Aluterus schoepfi*
Orangespotted sunfish	*Lepomis humilis*
Oyster toadfish	*Opsanus tau*
Pacific angel shark	*Squatina californica*
Pacific barracuda	*Sphyraena argentea*
Pacific bonito	*Sarda chiliensis*
Pacific electric ray	*Torpedo californica*
Pacific lamprey	*Entosphenus tridentatus*
Pacific staghorn sculpin	*Leptocottus armatus*
Paddlefish	*Polyodon spathula*
Painted greenling	*Oxylebius pictus*
Peamouth	*Mylocheilus caurinus*
Permit	*Trachinotus falcatus*
Pigfish	*Orthopristis chrysoptera*
Pile perch	*Rhacochilus vacca*
Pinfish	*Lagodon rhomboides*
Pirate perch	*Aphredoderus sayanus*
Planehead filefish	*Monacanthus hispidus*
Polka-dot batfish	*Ogcocephalus radiatus*
Pollock	*Pollachius virens*
Prickly sculpin	*Cottus asper*
Pumpkinseed	*Lepomis gibbosus*
Queenfish	*Seriphus politus*
Radiated shanny	*Ulvaria subbifurcata*
Rainbow smelt	*Osmerus mordax*
Rainwater killifish	*Lucania parva*

Table II. Continued

Common Name	Scientific Name
Red drum	*Sciaenops ocellata*
Red grouper	*Epinephelus morio*
Red hake	*Urophycis chuss*
Red shiner	*Notropis lutrensis*
Red snapper	*Lutjanus campechanus*
Redbreast sunfish	*Lepomis auritus*
Redear sunfish	*Lepomis microlophus*
Redfin needlefish	*Strongylura notata*
Redfin pickerel	*Esox americanus americanus*
Redside shiner	*Richardsonius balteatus*
River carpsucker	*Carpiodes carpio*
Rock bass	*Ambloplites rupestris*
Rock gunnel	*Pholis gunnellus*
Rock sea bass	*Centropristis philadelphica*
Rock wrasse	*Halichoeres semicinctus*
Rockpool blenny	*Hypsoblennius gilberti*
Rough ronquil	*Rathbunella alleni*
Rough silverside	*Membras martinica*
Roughtail stingray	*Dasyatis centroura*
Round herring	*Etrumeus teres*
Round stingray	*Urolophus halleri*
Rubberlip seaperch	*Rhacochilus toxotes*
Sailfin eel	*Letharchus velifer*
Sailfin molly	*Poecilia latipinna*
Salema	*Xenistius californiensis*
Sand perch	*Diplectrum formosum*
Sand roller	*Percopsis transmontana*
Sand seatrout	*Cynoscion arenarius*
Sand tiger	*Odontaspis taurus*
Sarcastic fringehead	*Neoclinus blanchardi*
Sargo	*Anisotremus davidsoni*
Scaled sardine	*Harengula pensacolae*
Scrawled cowfish	*Lactophrys quadricornis*
Scrawled filefish	*Aluterus scriptus*
Sculpin	*Myoxocephalus* sp.
Scup	*Stenotomus chrysops*
Sea catfish	*Arius felis*
Sea lamprey	*Petromyzon marinus*
Sea raven	*Hemitripterus americanus*
Seaboard goby	*Gobiosoma ginsburgi*
Seahorse	*Hippocampus* sp.
Seasnail	*Liparis atlanticus*
Señorita	*Oxyjulis californica*
Shadow goby	*Quietula y-cauda*
Sharksucker	*Echeneis naucrates*
Sharptail goby	*Gobionellus hastatus*
Sheepshead	*Archosargus probatocephalus*

Table II. Continued

Common Name	Scientific Name
Sheepshead minnow	*Cyprinodon variegatus*
Shiner perch	*Cymatogaster aggregata*
Short bigeye	*Pristigenys alta*
Shorthorn sculpin	*Myoxocephalus scorpius*
Shortnose gar	*Lepisosteus platostomus*
Shortnose sturgeon	*Acipenser brevirostrum*
Shovelnose guitarfish	*Rhinobatos productus*
Shrimp eel	*Ophichthus gomesi*
Silver hake	*Merluccius bilinearis*
Silver jenny	*Eucinostomus gula*
Silver perch	*Bairdiella chrysura*
Silver seatrout	*Cynoscion nothus*
Silvery minnow	*Hybognathus nuchalis*
Skilletfish	*Gobiesox strumosus*
Skipjack herring	*Alosa chrysochloris*
Slippery dick	*Halichoeres bivittatus*
Slough anchovy	*Anchoa delicatissima*
Smallmouth bass	*Micropterus dolomieui*
Smallmouth flounder	*Etropus microstomus*
Smooth butterfly ray	*Gymnura micrura*
Smooth dogfish	*Mustelus canis*
Smooth flounder	*Liopsetta putnami*
Smooth puffer	*Lagocephalus laevigatus*
Smooth ronquil	*Rathbunella hypoplecta*
Smoothhead sculpin	*Artedius lateralis*
Snook	*Centropomus undecimalis*
Sockeye salmon	*Oncorhynchus nerka*
Southern flounder	*Paralichthys lethostigma*
Southern hake	*Urophycis floridanus*
Southern kingfish	*Menticirrhus americanus*
Southern puffer	*Sphoeroides nephelus*
Southern sea bass	*Centropristis melana*
Southern spearnose poacher	*Agonopsis sterletus*
Southern stargazer	*Astroscopus y-graecum*
Southern stingray	*Dasyatis americana*
Spanish mackerel	*Scomberomorus maculatus*
Speckled sanddab	*Citharichthys stigmaeus*
Speckled worm eel	*Myrophis punctatus*
Specklefin midshipman	*Porichthys myriaster*
Spiny dogfish	*Squalus acanthias*
Spinycheek sleeper	*Eleotris pisonis*
Spot	*Leiostomus xanthurus*
Spotfin croaker	*Roncador stearnsi*
Spotfin mojarra	*Eucinostomus argenteus*
Spottail pinfish	*Diplodus holbrooki*
Spottail shiner	*Notropis hudsonius*
Spotted burrfish	*Chilomycterus atinga*
Spotted gar	*Lepisosteus oculatus*

Table II. Continued

Common Name	Scientific Name
Spotted hake	*Urophycis regius*
Spotted kelpfish	*Gibbonsia elegans*
Spotted sand bass	*Paralabrax maculatofasciatus*
Spotted seatrout	*Cynoscion nebulosus*
Spotted spoon-nose eel	*Mystriophis intertinctus*
Spotted sunfish	*Lepomis punctatus*
Spotted whiff	*Citharichthys macrops*
Star drum	*Stellifer lanceolatus*
Starry flounder	*Platichthys stellatus*
Steelhead	*Salmo gairdneri*
Striped anchovy	*Anchoa hepsetus*
Striped bass	*Morone saxatilis*
Striped blenny	*Chasmodes bosquianus*
Striped burrfish	*Chilomycterus schoepfi*
Striped kelpfish	*Gibbonsia metzi*
Striped killifish	*Fundulus majalis*
Striped mullet	*Mugil cephalus*
Striped searobin	*Prionotus evolans*
Striped seasnail	*Liparis liparis*
Summer flounder	*Paralichthys dentatus*
Sunfish	*Lepomis* sp.
Tautog	*Tautoga onitis*
Tessellated darter	*Etheostoma olmstedi*
Threadfin shad	*Dorosoma petenense*
Threespine stickleback	*Gasterosteus aculeatus*
Tidewater silverside	*Menidia beryllina*
Timucu	*Strongylura timucu*
Topsmelt	*Atherinops affinis*
Treefish	*Sebastes serriceps*
Tripletail	*Lobotes surinamensis*
Vermilion rockfish	*Sebastes miniatus*
Violet goby	*Gobioides broussonneti*
Walleye surfperch	*Hyperprosopon argenteum*
Warmouth	*Lepomis gulosus*
Weakfish	*Cynoscion regalis*
Web burrfish	*Chilomycterus antillarum*
Whip eel	*Bascanichthys scuticaris*
White bass	*Morone chrysops*
White catfish	*Ictalurus catus*
White crappie	*Pomoxis annularis*
White croaker	*Genyonemus lineatus*
White grunt	*Haemulon plumieri*
White hake	*Urophycis tenuis*
White mullet	*Mugil curema*
White perch	*Morone americana*

Table II. Continued

Common Name	Scientific Name
White seabass	*Cynoscion nobilis*
White seaperch	*Phanerodon furcatus*
White sturgeon	*Acipenser transmontanus*
White sucker	*Catostomus commersoni*
Whitebelly rockfish	*Sebastes vexillaris*
Whitespotted soapfish	*Rypticus maculatus*
Windowpane	*Scophthalmus aquosus*
Winter flounder	*Pseudopleuronectes americanus*
Winter skate	*Raja ocellata*
Wooly sculpin	*Clinocottus analis*
Wrymouth	*Cryptacanthodes maculatus*
Yellow bass	*Morone mississippiensis*
Yellow bullhead	*Ictalurus natalis*
Yellow perch	*Perca flavescens*
Yellowfin croaker	*Umbrina roncador*
Yellowfin fringehead	*Neoclinus stephensae*
Yellowfin mojarra	*Gerres cinereus*
Yellowtail	*Seriola dorsalis*
Yellowtail flounder	*Limanda ferruginea*

MAINE YANKEE POWER PLANT UNIT 1 (N)

SITE CHARACTERISTICS

The plant is located four miles south of the town of Wiscasset, Lincoln County, Maine.[1] The site comprises 740 acres bounded by the Back River on the east, by the mainland on the north, by Birch Point Road on the west, and by Montsweag Bay on the south (Fig. 1). The plant proper occupies 30 acres and is situated on the southern point of a peninsula known as Bailey Point. Bailey Point is a ridge of bedrock running northeast to southwest. The general elevation varies from zero to 40 feet MSL. The graded elevation of the plant is 20 feet MSL.

The tidal waters around Bailey Point are part of the Sheepscot River Estuary. The Back and Sheepscot Rivers in the vicinity of the plant are tidally influenced portions of an estuarine system. The maximum depth at the plant is 36 feet at mean low water. Upstream, the channel of the Back River narrows from 1500 feet to 500 feet; however, an artifical causeway was constructed in 1950 and further reduced this to 45 feet. This restricted tidal movements in the estuary and impeded water recirculation and mixing around Bailey Point. The causeway was removed in 1974 by the utility to promote recirculation around Bailey Point (Fig. 2).

The average tidal range in the estuary is 8.5 feet. The total average flow into and out of Montsweag Bay and the Back River with the causeway in place was 21,000 acre-feet. Slightly more than one-half of the total volume of water in the area is removed and replaced by tidal action twice each day. Bailey Cove, located immediately west of Bailey Point, receives the discharge from the plant. This small embayment is in the intertidal zone and has a surface area of 80 acres. At ebb tide nearly all of the bottom is exposed.

Thermal stratification occurs during most of the year. This vertical stratification is weak, however, and the temperature gradient seldom exceeds 7°F. In the severe winter months, ice usually forms on the surface of the Back River in the vicinity of the plant. The salinity stratification is more pronounced and consistent, with the more saline water from Montsweag Bay underriding the Back River flow during flood tide and maintaining high salinity in the lower strata of the bay during ebb tide where the less saline surface water mixes with it.

Thirty-one species of fish (Table I) were reported to be in the Back River and Montsweag Bay in the utility's semiannual report.[2] Their abundances during the sample years is also discussed in the report. The most abundant demersal fishes in the area are the Atlantic tomcod, winter flounder, smooth flounder, white hake, and grubby. No commercial and little sport fishing is done in the area. Although a small run of Atlantic salmon spawns in the

Sheepscot River, no conclusion regarding the use of the Back River by smolts returning to sea has been reached. The relative abundance of the principal species sampled is listed in Table II. Nine species showed marked fluctuations in relative abundance.

PLANT DESCRIPTION

The plant has a pressurized water reactor rated at 855 MWe. The plant employs once-through cooling, with intake from the Back River and discharge into Bailey Cove.

INTAKE DESIGN AND OPERATION

Water is drawn into the plant by means of four, one-quarter-capacity circulating-water pumps. Debris is prevented from entering the cooling system first by a bar rack with a 2-1/8" spacing followed by four Monel traveling screens with 3/8" openings (Fig. 3). The flow rate is constant both in summer and winter at 450,000 to 490,000 gpm. Intake velocities reach 1.2 to 2.0 fps when the flow is 342,000 gpm. No warm-water recirculation is necessary for deicing. An overall view of the intake and discharge locations at Maine Yankee is shown in Figure 2. In June 1975, a multiport-diffuser discharge system began operation. The flow rate at Maine Yankee remains constant regardless of the plant's electrical output. This results in a highly variable ΔT across the condensers and a constant intake velocity, as well as a constant rate of impingement regardless of the plant's operating factor.

IMPINGEMENT SAMPLING

The impingement sampling approved by the NRC (then the AEC) requires documentation by type, number, and frequency of fish entrapped on the screens during a 24-hour period.[3] The utility complied, doing sampling once per week. However, the data were presented in such a way in the semiannual reports that only six-month totals could be derived for each of the three most numerous species impinged and for the total impingement in 1974. Monthly totals for the remaining years are presented.

DATA AVAILABILITY

Data are available for October through December 1972, and two six-month totals are given for 1974. Monthly totals are again given for January through April 1975. Data for 1973 are unavailable.

IMPINGEMENT DATA SUMMARY

Table III presents a summary of fish impingement at the plant. The three most numerous species in 1972 and 1974 were the threespine stickleback, smooth flounder, and rainbow smelt. In 1975, flounder was replaced by the Atlantic menhaden as third most numerous species with 20,097. It is not certain that the numbers for 1972 and 1975 are representative, as they represent only three and four months of sampling, respectively. Histograms of monthly impingement estimates are shown in Figures H1 through H4. Histograms are not presented for 1974 because only six-month totals are available.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

No special design features have been used at the plant to reduce fish impingement. Improvements in the handling of impinged fish have reportedly resulted in high survival rates for smooth flounder and winter flounder when they are returned to the river. These methods employ a series of holding tanks leading to a fish sluiceway that empties back into the river. Because all impingement data were obtained before the artificial causeway was removed, it is not known what effect, if any, the removal had on fish impingement.

REFERENCES

1. "Final Environmental Statement, Maine Yankee Atomic Power Station." USAEC Directorate of Licensing. Docket No. 50-309. July 1972.

2. Maine Yankee Atomic Power Company. Semiannual Report Number 6. January-June 1975.

3. Operating License for Maine Yankee Atomic Power Station, DPR-21. USAEC Directorate of Licensing. September 1972.

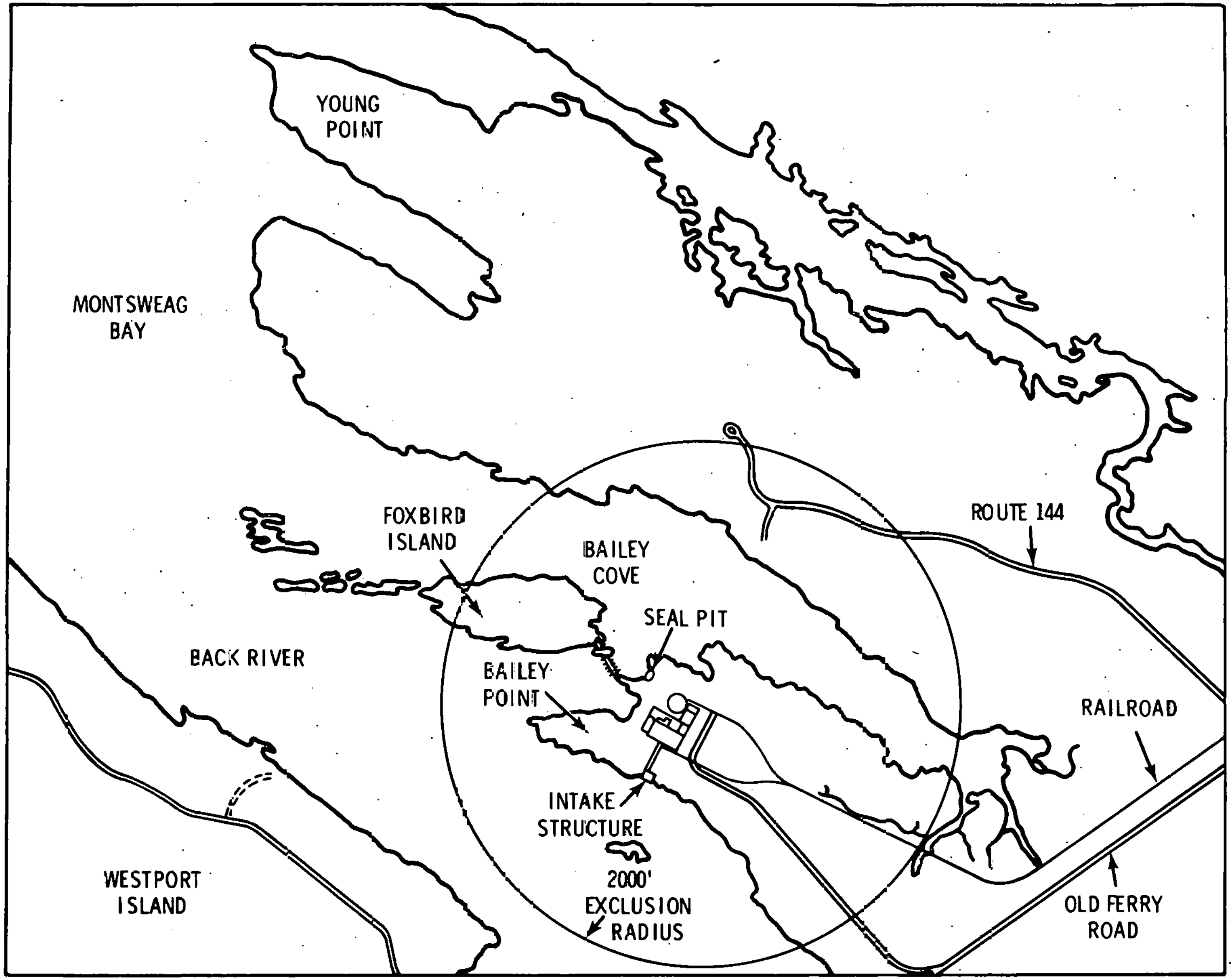


Fig. 1. Site Plan.

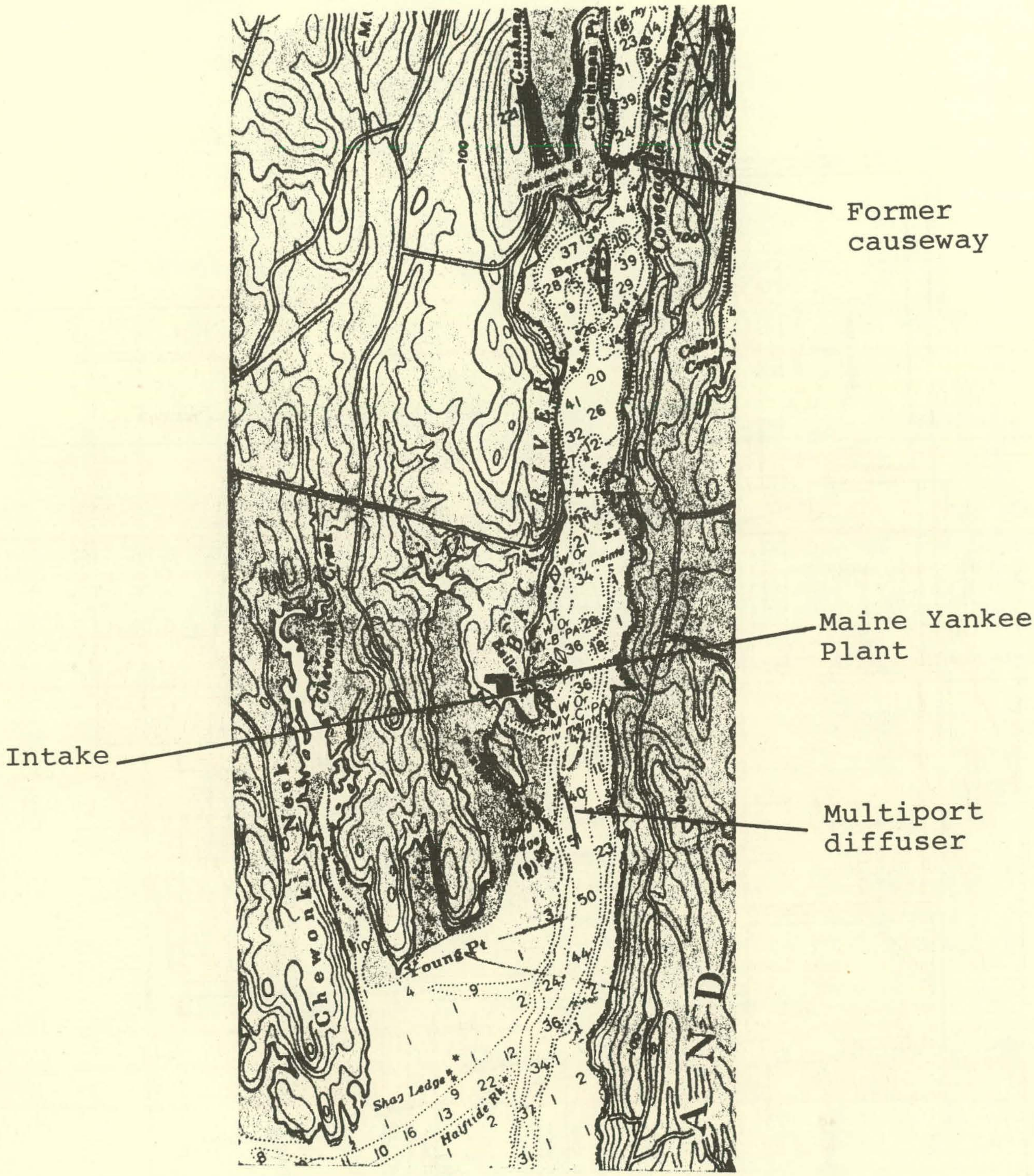


Fig. 2. Back River and Former Causeway.

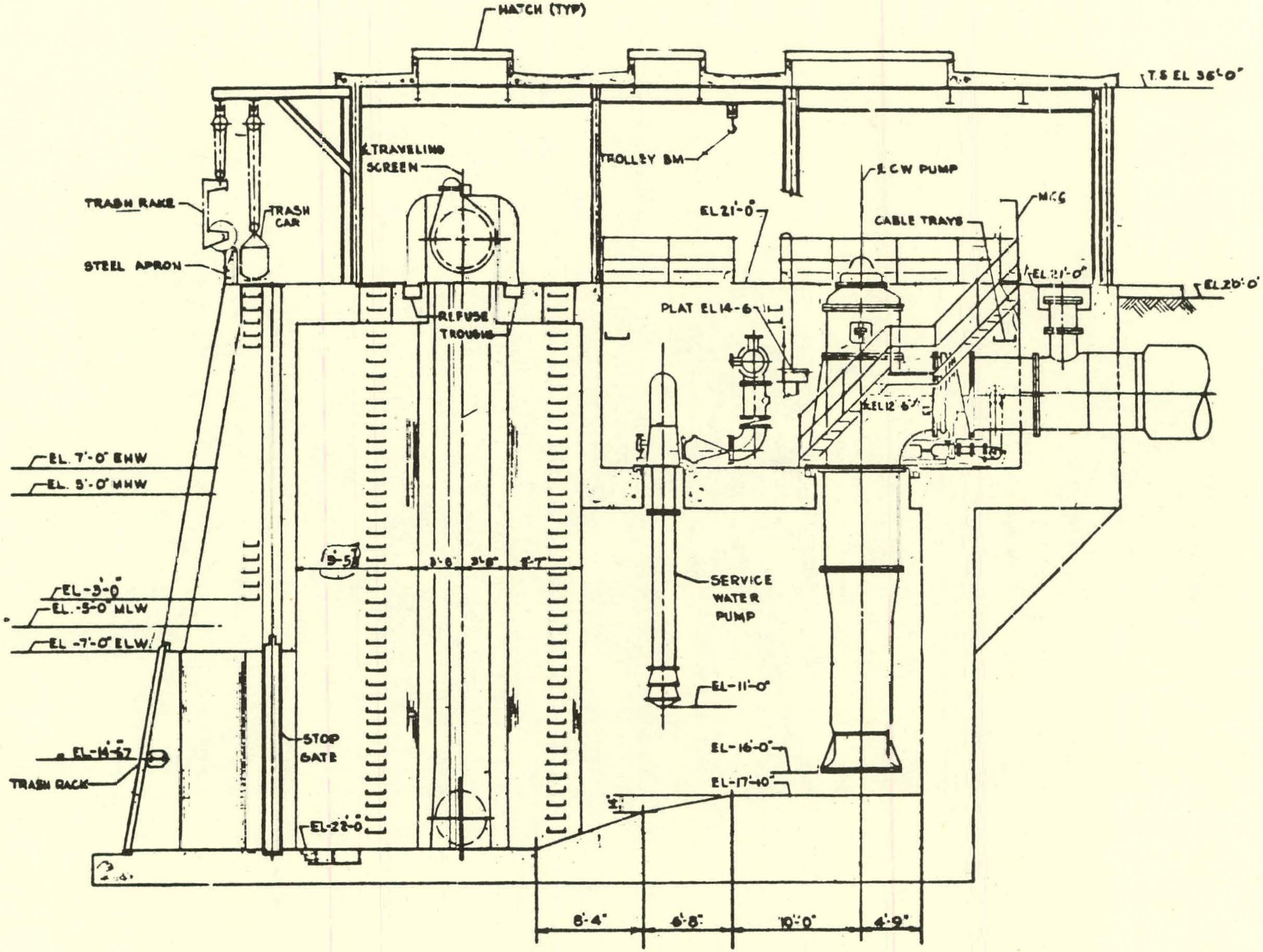


Fig. 3. Intake Structure.

Table I. Fishes of the Back River-Montsweag Bay Area (January 1973-June 1975)

Blueback herring	Striped bass
Hickory shad	Grubby
Alewife	Longhorn sculpin
American shad	Shorthorn sculpin
American eel	Rainbow smelt
Atlantic menhaden	Butterfish
Atlantic herring	Pollock
Atlantic cod	Bluefish
Threespine stickleback	Winter flounder
Sea raven	Little skate
Smooth flounder	Atlantic salmon
Ocean pout	Atlantic mackerel
Silver hake	Windowpane
Atlantic tomcod	Spiny dogfish
White perch	Red hake
	White hake

Table II. Seasonal Abundance of Selected Species

Species	Relative Seasonal Abundance			
	Spring	Summer	Fall	Winter
Alewife	C	P	P	
Atlantic menhaden	C	P	A	P
Smooth flounder	P	C	P	A
Atlantic tomcod	A	P	C	C
White perch	P		P	C
Rainbow smelt	P	P	P	A
Winter flounder	A	C	C	C
Windowpane	P	P	C	P
White hake	C	P	P	P

P - Present.

C - Common.

A - Abundant.

Table III. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Threespine Stickleback	Smooth Flounder	Rainbow Smelt	Total
1972	3	339,667	65,068	23,722	447,191
1973			No data available		
1974	12	3,460,820	3,315,073	2,003,179	11,134,394
1975	4	76,265		22,898	119,260

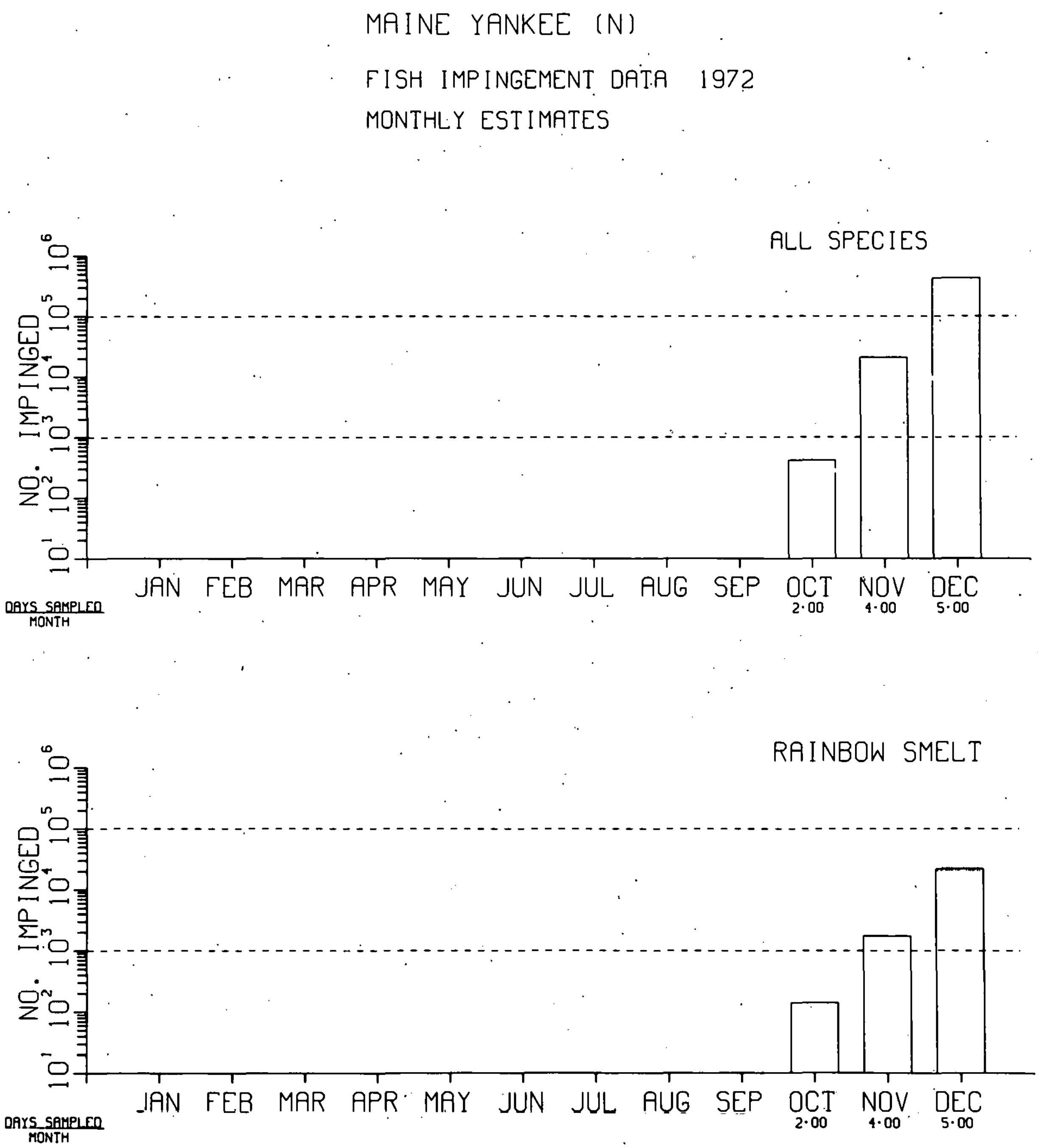
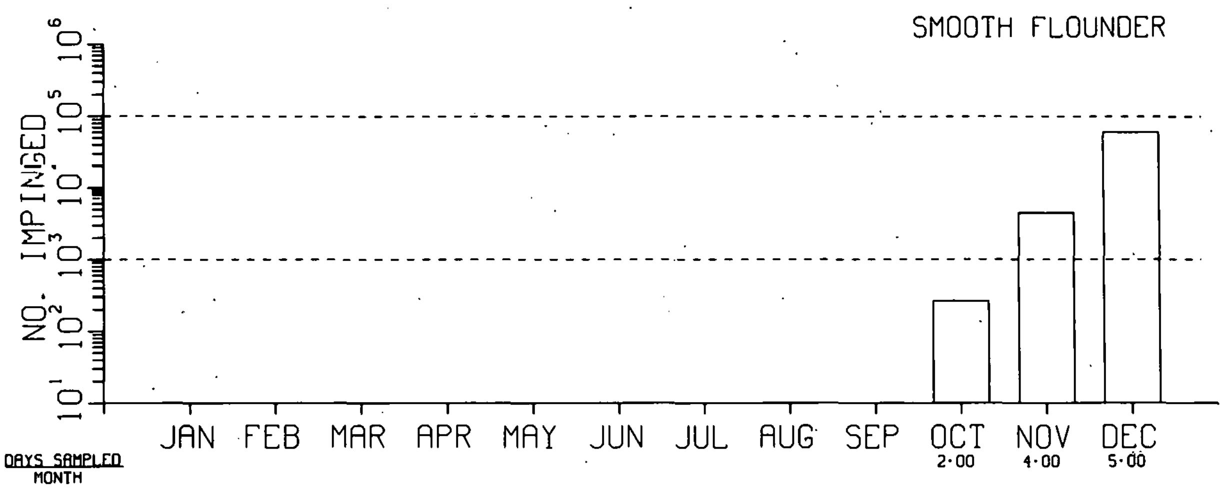


Fig. H1. Impingement Estimates.

MAINE YANKEE (N)

FISH IMPINGEMENT DATA 1972

MONTHLY ESTIMATES



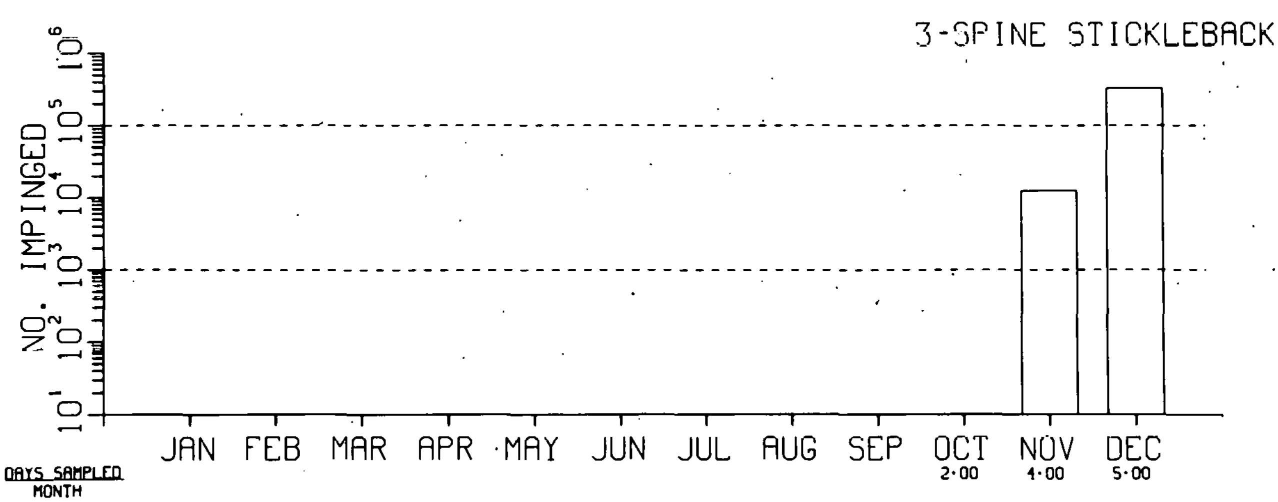
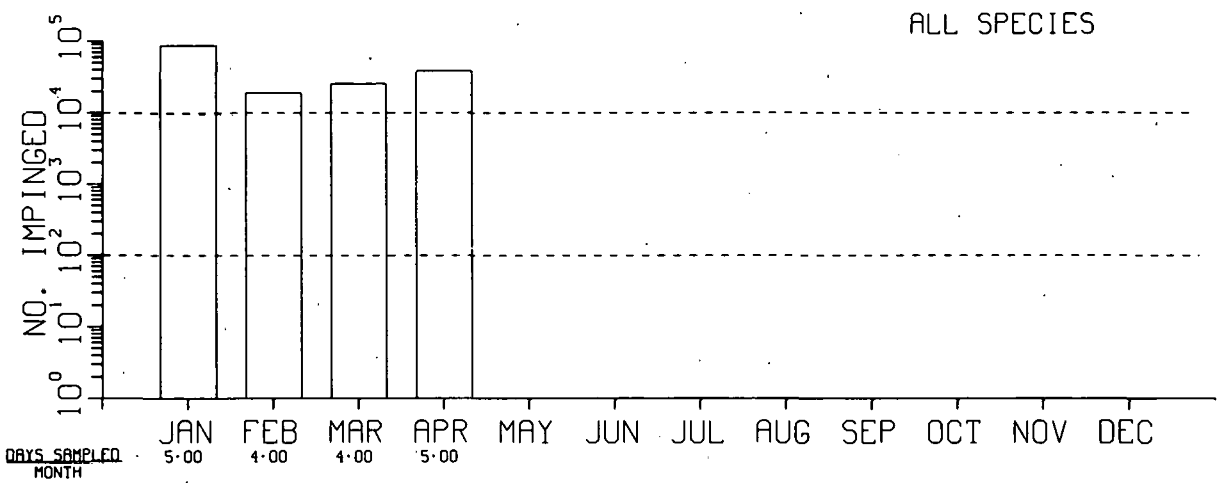


Fig. H2. Impingement Estimates.

MAINE YANKEE (N)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



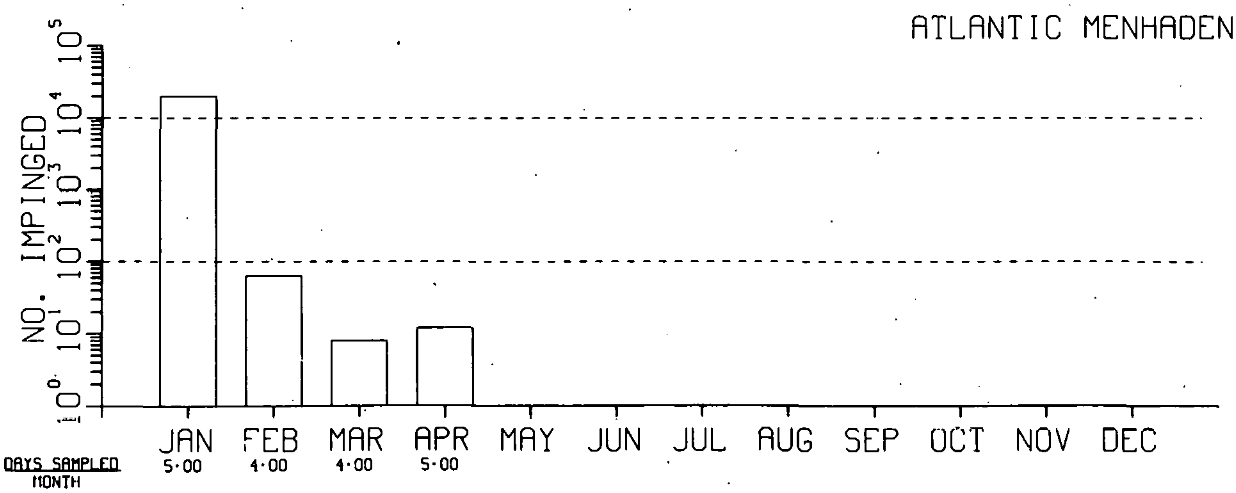


Fig. H3. Impingement Estimates.

MAINE YANKEE (N)

FISH IMPINGEMENT DATA 1975
MONTHLY ESTIMATES

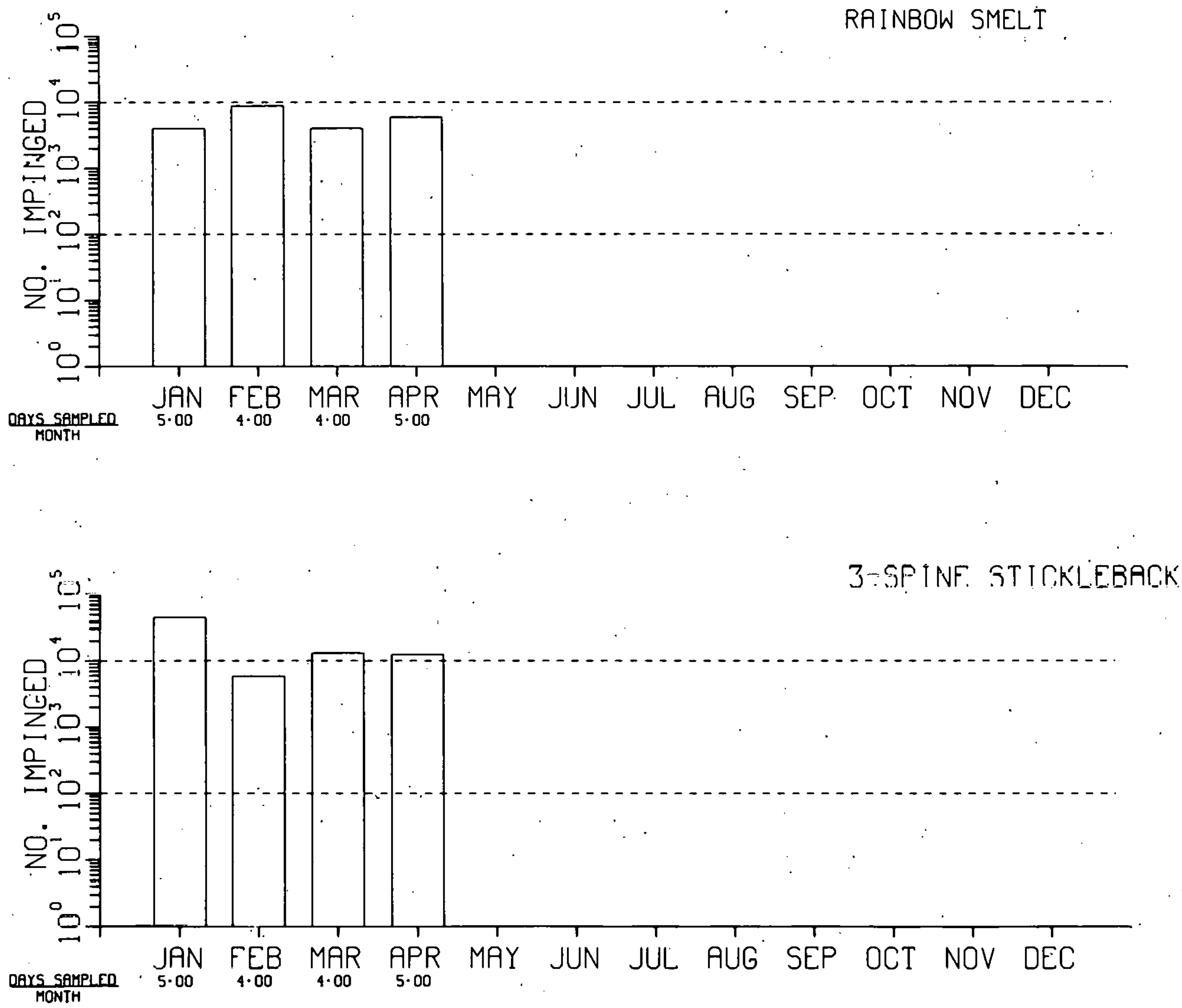


Fig. H4. Impingement Estimates.

SALEM HARBOR POWER PLANT UNITS 1-4 (F)

SITE CHARACTERISTICS

The Salem Harbor Plant is located on the Atlantic Ocean in Salem, Massachusetts, on the west side of inner Salem Harbor about 12 miles northeast of Boston Harbor and 11 miles southwest of Cape Ann.[1] The inner harbor averages about 0.75 miles in width and about 1.5 miles in length from the entrance at Nagus Head (Fig. 1).

Salem Harbor is part of a larger harbor referred to as the Beverly-Salem Harbor. This larger waterbody has a total surface area of 12.5 square miles at mean low water. The mean tidal amplitude at the harbor entrance is 9.0 feet. The total volume of water in Beverly-Salem Harbor is 62.7 billion cubic feet at mean low water. The maximum depth is 73.0 feet and the average depth is 29.7 feet. Surface water temperature varies from a low of 29°F to a high of 72°F. Salinity varies from 30.5 to 33.5 ppt. The largest river flowing into the harbor is the Danvers River, which flows easterly into Beverly Harbor at Tucks Point and has a drainage area of 35 square miles. Two smaller streams, Chub Creek and Foust River, flow into Beverly and Salem Harbors, respectively. The harbor complex is a typical coastal environment formed by the general bay area and the Danvers River Estuary.

A diverse fauna is found in the bay area (Table I). Of the species caught during the State run survey in 1965, winter flounder was the most dominant species present in the harbor.

PLANT DESCRIPTION

The four-unit plant is located on 60 acres of land fronting Salem Harbor. It is an oil-fired facility. Units 1 and 2 are rated at 80 MWe each. Units 3 and 4 are rated at 150 and 465 MWe, respectively. The plant employs once-through cooling. The site has been used for power production since 1952.

INTAKE DESIGN AND OPERATION

Water for cooling is taken from Salem Harbor at the maximum rate of 440,000 gpm. Water is taken into three separate intake bays, through associated trash bars and screens, and pumped by six circulating-water pumps (two for each intake bay) to the condensers. Pump capacity is about 73,000 gpm each. Maximum water velocity is 1.47 fps at Unit 4. A dredged basin is maintained in front of the screenwells. The number of screens and the mesh size were not given.

IMPINGEMENT SAMPLING

The sampling schedule is variable. Sampling is usually conducted randomly for two hours at a time. Data are reported quarterly in reports that list the number of random-sample hours, the fish species, numbers, and dates that the samples were taken. Exceptions were made to this routine, early in the study, when daily collections were made to determine the extent of the impingement.

DATA AVAILABILITY

Data are available on a quarterly basis from 1972 to 1975. Complete reports are available for the years 1972,[2] 1973,[3] 1974,[4,5] and the first three months of 1975.[5]

IMPINGEMENT DATA SUMMARY

Where data are reported in daily summaries, monthly totals were extrapolated. Where random, hourly samples were taken, impingement numbers were estimated using the total number of hours during which sampling was done. Four species encountered the highest impingement rates throughout the study. The first, Atlantic menhaden, was noted only in 1972 because of an unusually large kill at this station. The other three were winter flounder, northern pipefish, and threespine stickleback. Figures for the years 1972 to 1975 are presented in Table II. These data do not include impingement at Units 1 and 2. Histograms shown in Figures H1 through H6 summarize the monthly totals for the three most numerous species and the total fish impinged at Units 3 and 4.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited. In the fish-analysis program, survival rates on a species-specific basis tended to vary from 40% to 60% during analysis of the random samples.

REFERENCES

1. "Environmental Report, Salem Harbor Steam-Electric Generating Station." New England Power Company. October 1971.

2. A. P. Chesmore and D. J. Brown. "Biological Investigations of the Effects of Electrical Power Generation on Marine Resources in Salem Harbor." Progress Reports 2-5. Mass. Dep. Nat. Resour., Div. Mar. Fish. 1972.

3. A. P. Chesmore, D. J. Brown, B. A. Ketschke, and E. M. Swain. "Investigations of the Effects of Electrical Power Generation on Marine Resources in Salem Harbor." Progress Reports 6-9. Mass. Dep. Nat. Resour., Div. Mar. Fish. 1973.

4. C. O. Anderson, D. J. Brown, B. A. Ketschke, and E. M. Swain. "Investigations of the Effects of Electrical Power Generation on the Marine Resources in Salem Harbor." Progress Reports 10-12. Mass. Dep. Nat. Resour., Div. Mar. Fish. 1974.

5. C. O. Anderson, D. J. Brown, B. A. Ketschke, and E. M. Elliot. "Investigations of the Effects of Electrical Power Generation on Marine Resources in Salem Harbor." Semiannual Report Number 1A. Mass. Dep. Nat. Resour., Div. Mar. Fish. 1975.

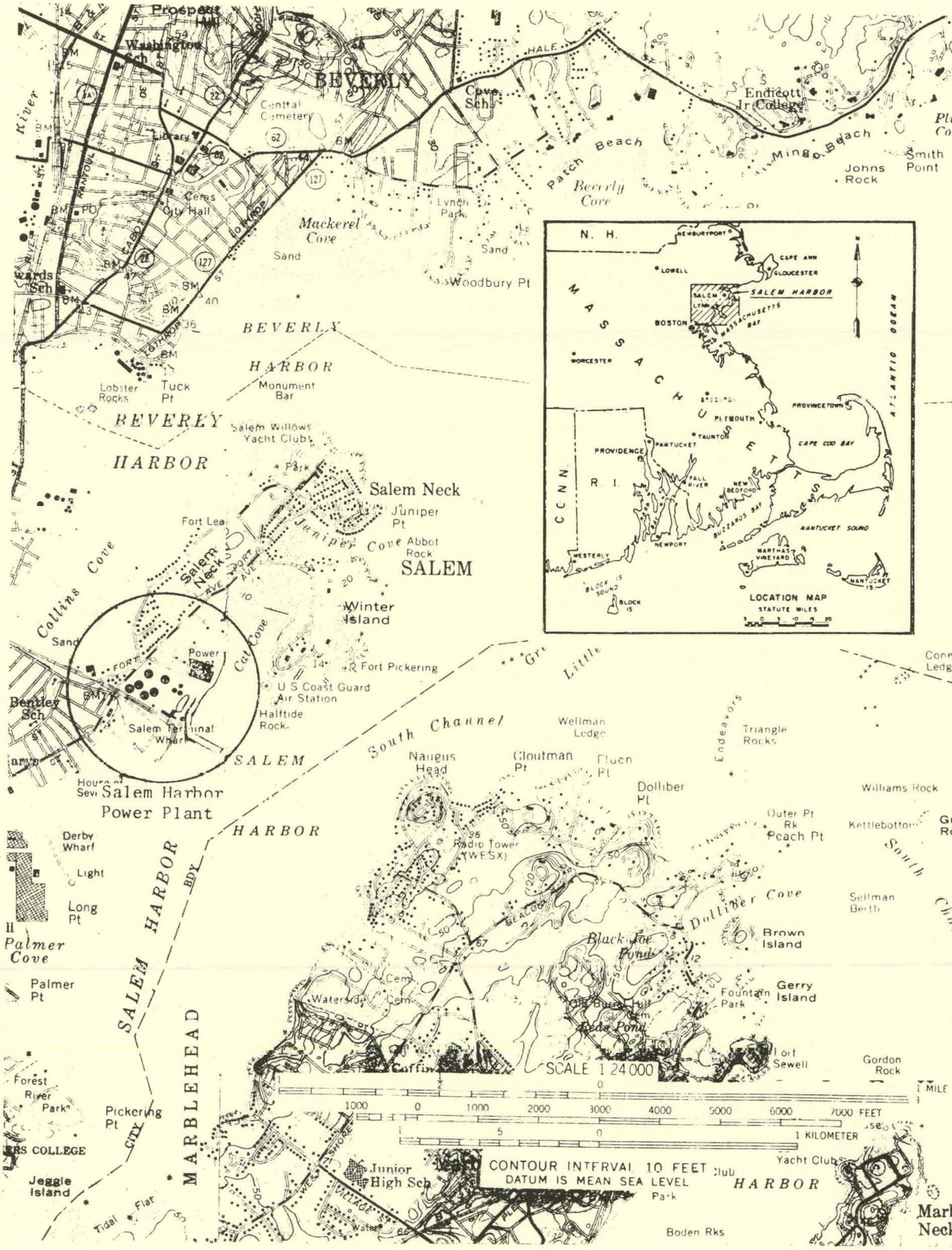


Fig. 1. Plant Location.

Table I. Fishes Collected in the Beverly-Salem Harbor Area in 1965

Spiny dogfish	White hake
Little skate	Fourspine stickleback
Winter skate	Threespine stickleback
Blueback herring	Ninespine stickleback
Atlantic herring	Northern pipefish
Rainbow smelt	Cunner
American eel	Sea raven
Mummichog	Longhorn sculpin
Striped killifish	Lumpfish
Atlantic cod	Seasnail
Haddock	Ocean pout
Silver hake	Atlantic silverside
Atlantic tomcod	Windowpane
Pollock	Yellowtail flounder
Red hake	Winter flounder
	Goosefish

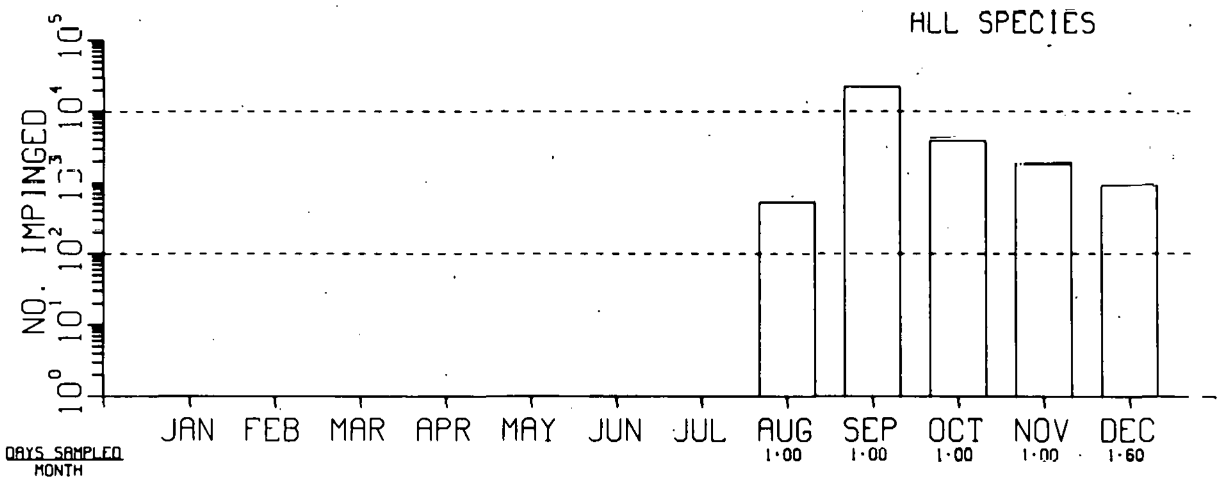
Table II. Summary of Fish Impingement Data at Units 3 & 4

		Estimated No. of Fish Impinged during Months Sampled				
Year	No. of Months Sampled	Atlantic Menhaden	Winter Flounder	Northern Pipefish	Threespine Stickleback	Total
1972	5	21,900	1,502	941		29,373
1973	12		3,036	355	1,820	5,913
1974	11		1,162	140	3,882	18,284
1975	3		280	92	193	1,599

SALEM HARBOR STATION (F)

FISH IMPINGEMENT DATA 1972

MONTHLY ESTIMATES



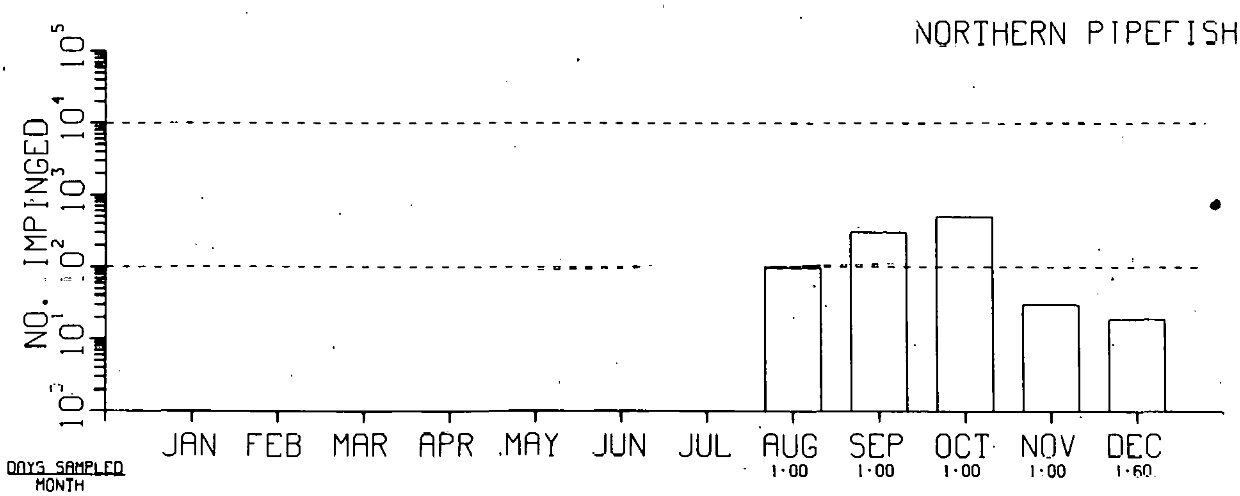


Fig. H1. Impingement Estimates.

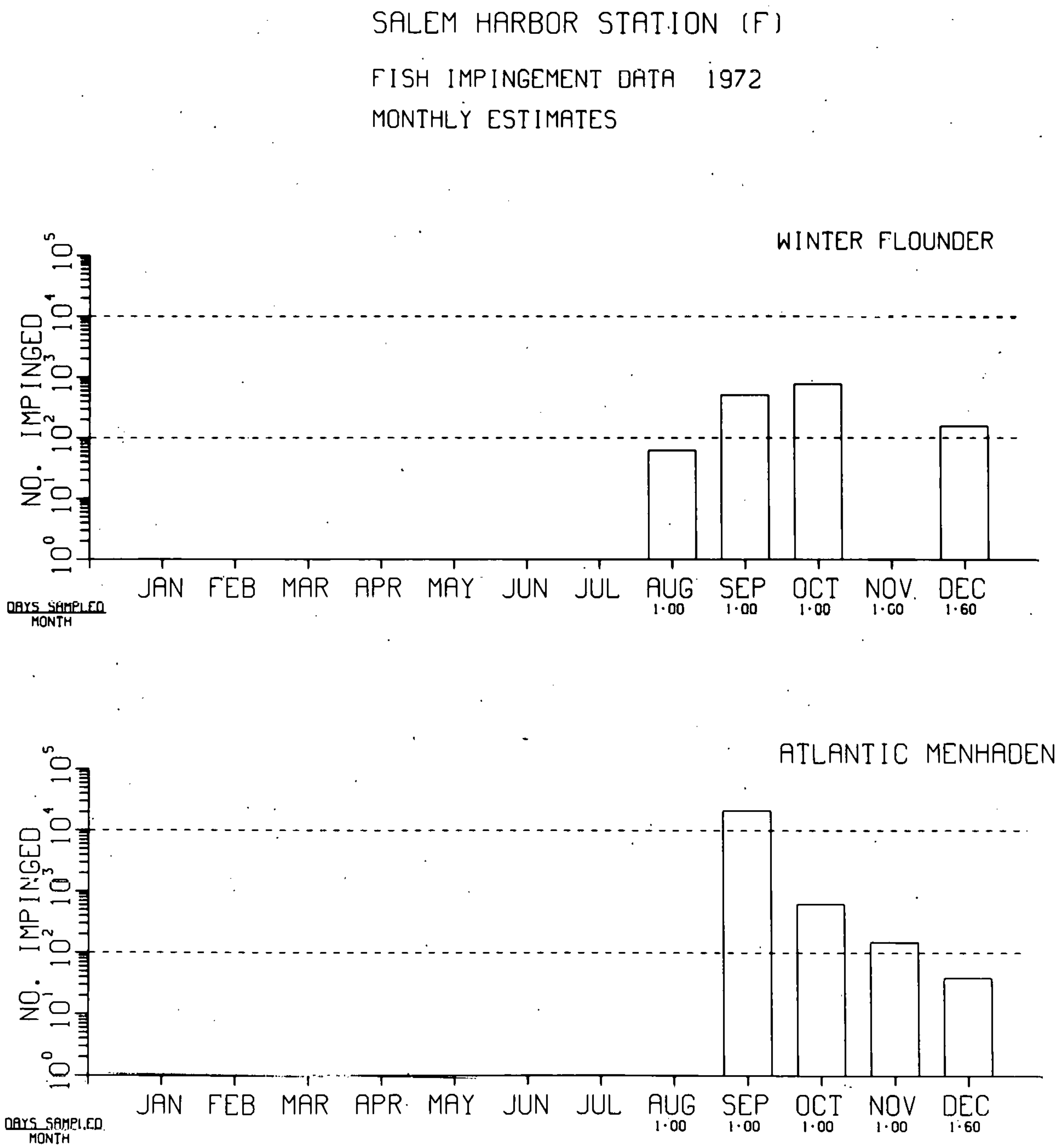


Fig. H2. Impingement Estimates.

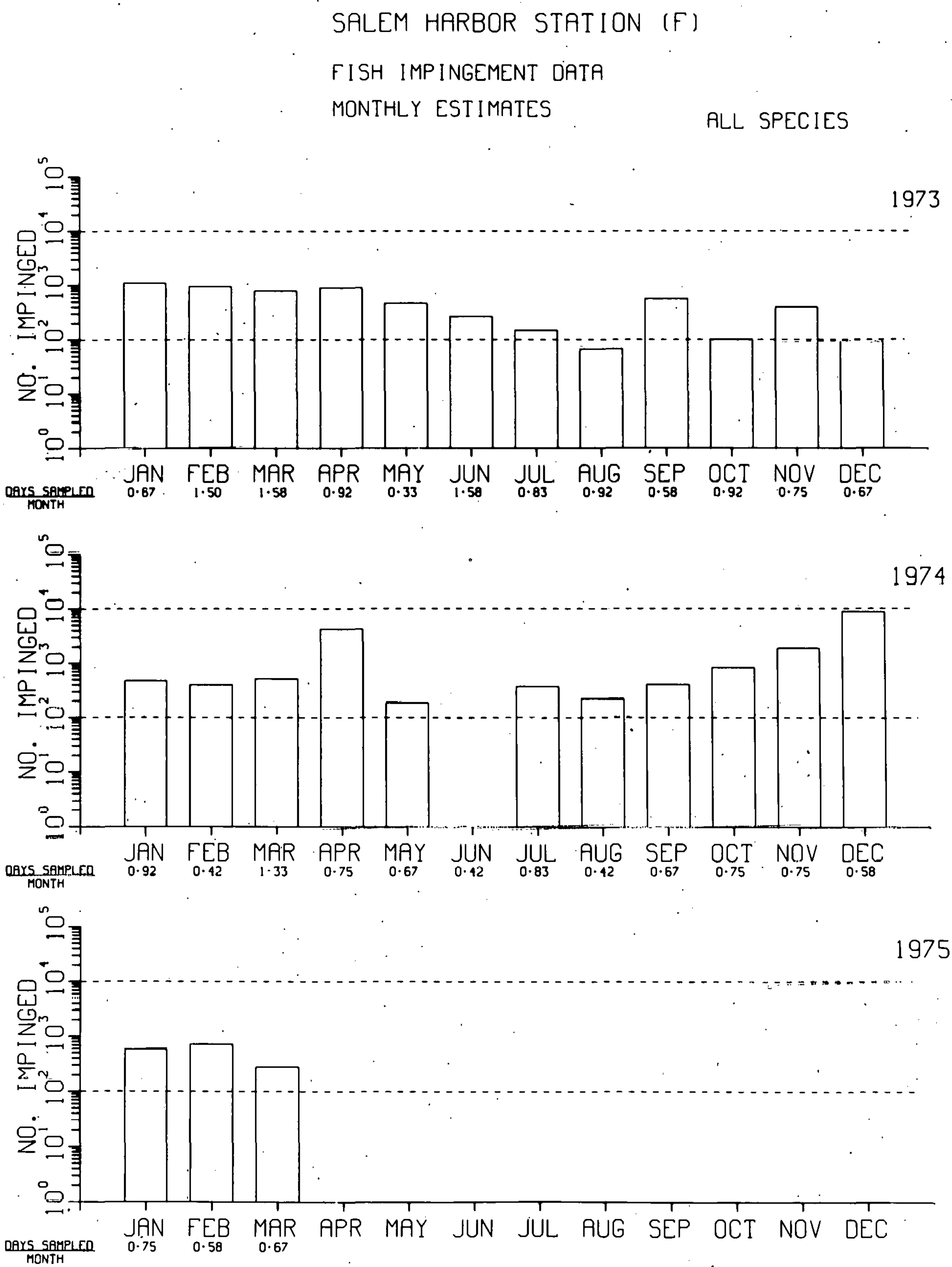


Fig. H3. Impingement Estimates.

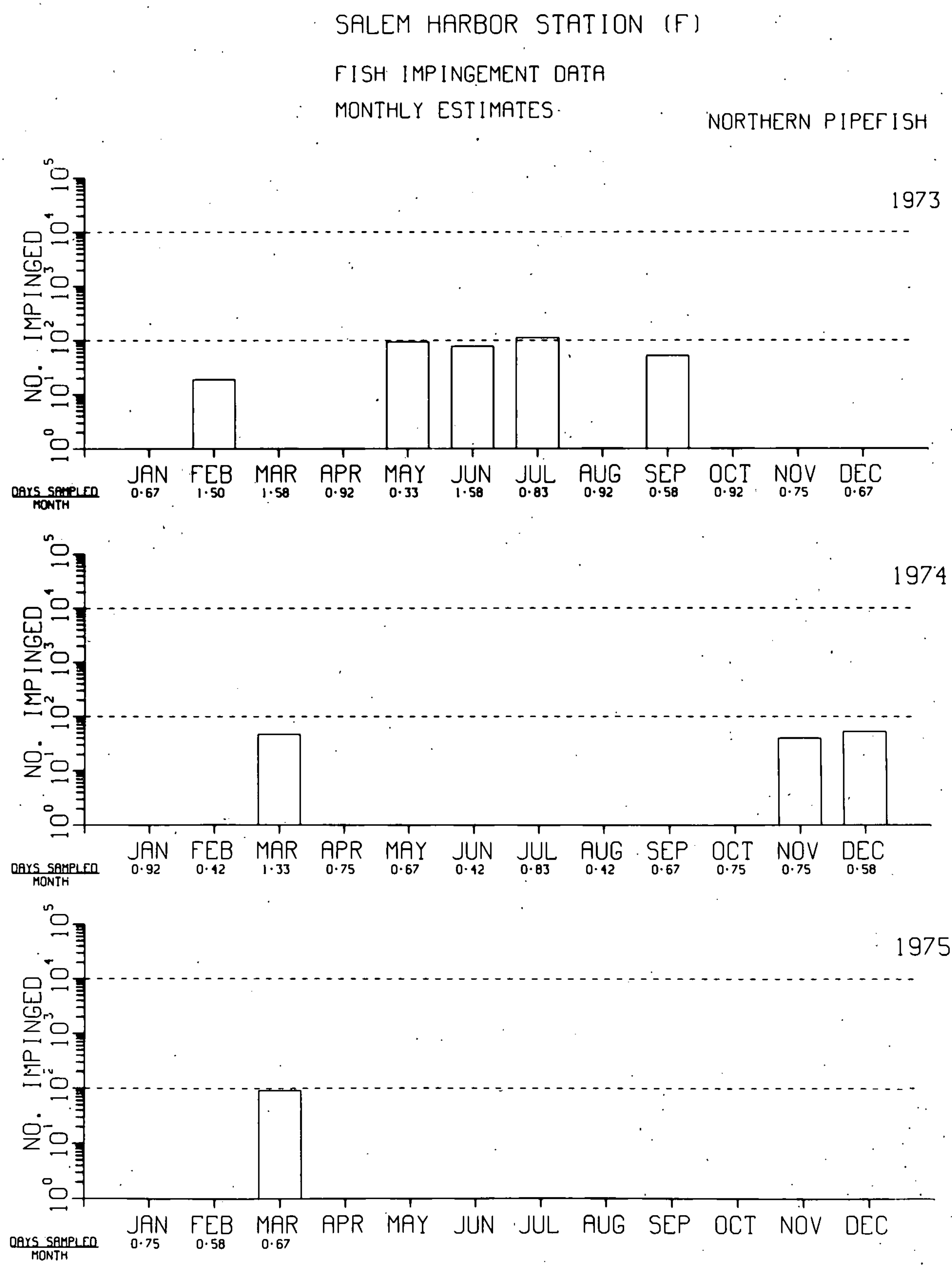


Fig. H4. Impingement Estimates.

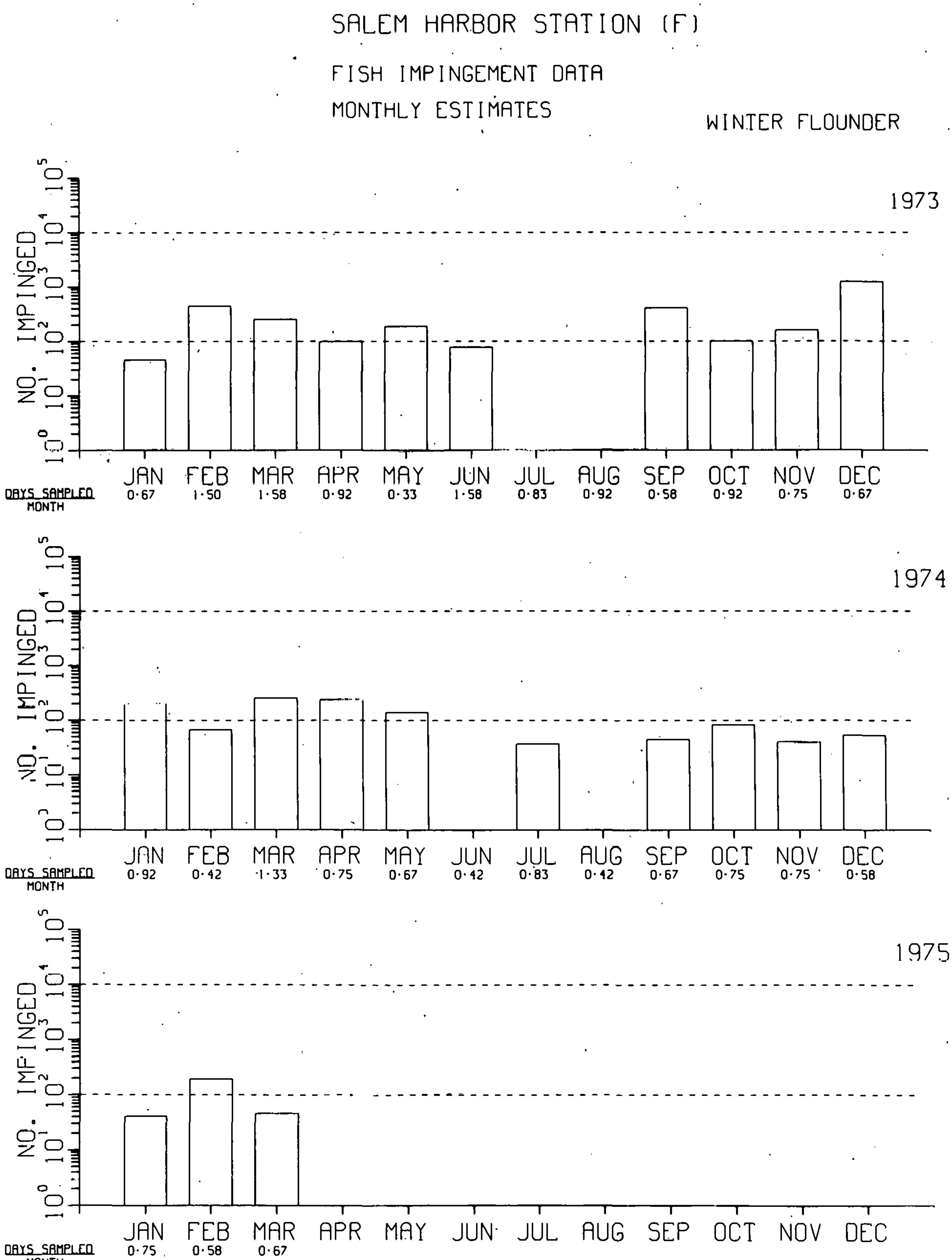


Fig. H5. Impingement Estimates.

SALEM HARBOR STATION (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

THREESPINE STICKLEBACK

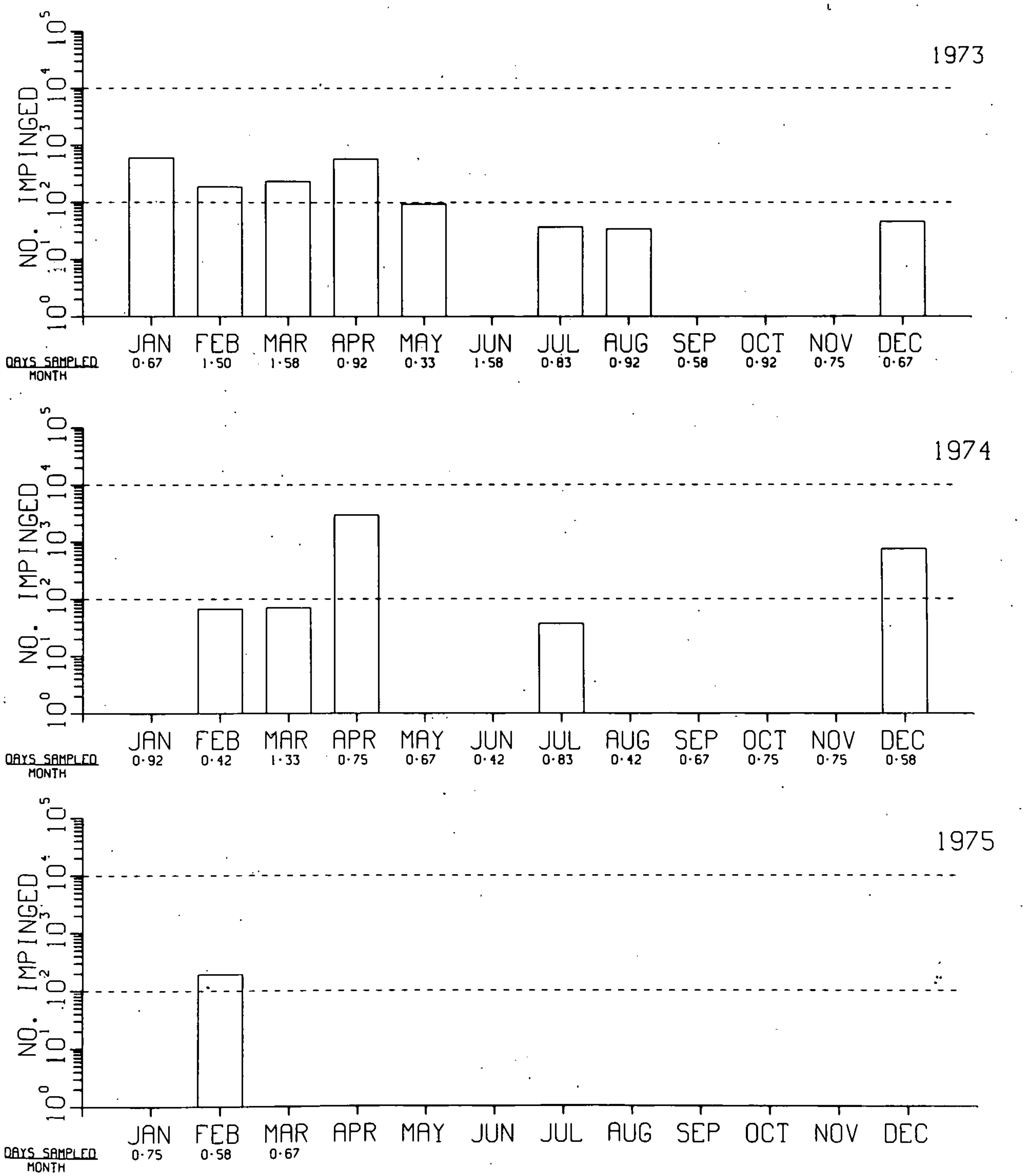


Fig. H6. Impingement Estimates.

MYSTIC ELECTRIC GENERATING STATION UNITS 1-7 (F)

SITE CHARACTERISTICS

The Mystic Station complex is situated on a 42-acre site in the city of Everett, Massachusetts. The station is located on the north bank of the Mystic River, about two miles upstream from the point where the river flows into Boston Harbor (Fig. 1).[1]

The river in the vicinity of the plant is 400 feet wide, with a depth varying from zero to 30 feet at mean low water. The Amelia Earhart Lock and Dam is located about 0.5 mile upstream from the station, and this structure effectively bounds the saltwater portions of the river. The presence of the dam also makes the tidal flows the only important water movement at the site. Mean tidal flows are 480,000 gpm with a tidal range of 6.0 to 13.5 feet. The mean is 9.4 feet.

Summer temperatures in the river reach a mean high of 62.6°F in August. Salinity (as total chloride) is 17,000 mg/liter, and the pH varies from 6.7 to 7.2.

The site is fairly diverse biologically, with 25 species of fish observed at the station. A list is presented in Table I.

PLANT DESCRIPTION

The station includes seven oil-fired units of varying electrical capability. Units 1-3 have a generating capacity of 50 MWe each and Units 4-6 generate 156 MWe each, for a combined capacity of 618 MWe. Unit 7, at 600 MWe, has recently been added. All units employ once-through cooling with water taken from the Mystic River. An overall plan of the site is shown in Figure 2.

INTAKE DESIGN AND OPERATION

Units 1-6 use 374,000 gpm and Unit 7 uses an additional 310,000 gpm of water for cooling. The intakes are submerged and the shoreline screenwells for all units are contiguous. No specifics are given for Units 1-6, but the Unit 7 intake has been described in detail.[1] Figure 3 depicts the intake structure for Unit 7. The two screenwells for Unit 7 contain stoplogs, bar racks, curtain walls, and traveling screens. For each screenwell there is a vertical-column circulating-water pump rated at 155,000 gpm. The distances from the front of the screenwell to the curtain wall and traveling screens are 11.5 feet and 25.5 feet, respectively. Detailed information on intake velocities at three places in all the screenwells is presented in Table II.

IMPINGEMENT SAMPLING

Impingement sampling at the Mystic Station was divided so that Units 1-5 were sampled together and Units 6 and 7 were sampled individually. Sampling was carried out on a daily basis, but the number of days that sampling was done in each month varied widely. Plant flow and other plant parameters were monitored concurrently. The number of winter flounder, alewives, American smelt, Atlantic herring, Atlantic cod, and miscellaneous finfish were computed and extrapolated to obtain the mean number of fish per day.

DATA AVAILABILITY

Total yearly numbers for the three most numerous species and for total fish impinged are available for 1971 through 1975. In addition, monthly data are available for Units 1-6 from August 1971 to August 1972, and for Unit 4 and Unit 7 from June to December 1975.

IMPINGEMENT DATA SUMMARY

Tabulated impingement data for Mystic Units 1-7 are presented in Table III. In each case, monthly and yearly totals were generated from the estimates of mean fish per day given in the Final Environmental Statement[1] and not from the original data. The 1975 data for Units 1-6 are misleading because all units but Unit 4 have been out of service since May 1975. Also, because Units 1-3 have been retired permanently since October 1975, the overall impingement at the station will be somewhat reduced. Unit 6 has higher impingement values than Units 1-5 even though less water is screened. Unit 6 also has higher velocities at the curtain wall. Histograms of monthly impingement estimates are shown in Figures H1 through H12.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Two main design alterations have been employed to reduce fish impingement. Stoplogs have been installed to reduce the influx of benthic fishes such as winter flounder. The curtain walls have been raised 7.0 feet in order to reduce water velocities under the curtain wall. The effect of these two measures is currently being evaluated.

REFERENCE

1. "Final Environmental Statement - Addition of Unit Number 7 - Mystic Electric Generating Station, Everett Massachusetts," Prepared by U. S. Army Engineer Division (New England) Waltham, Massachusetts. November 1973.

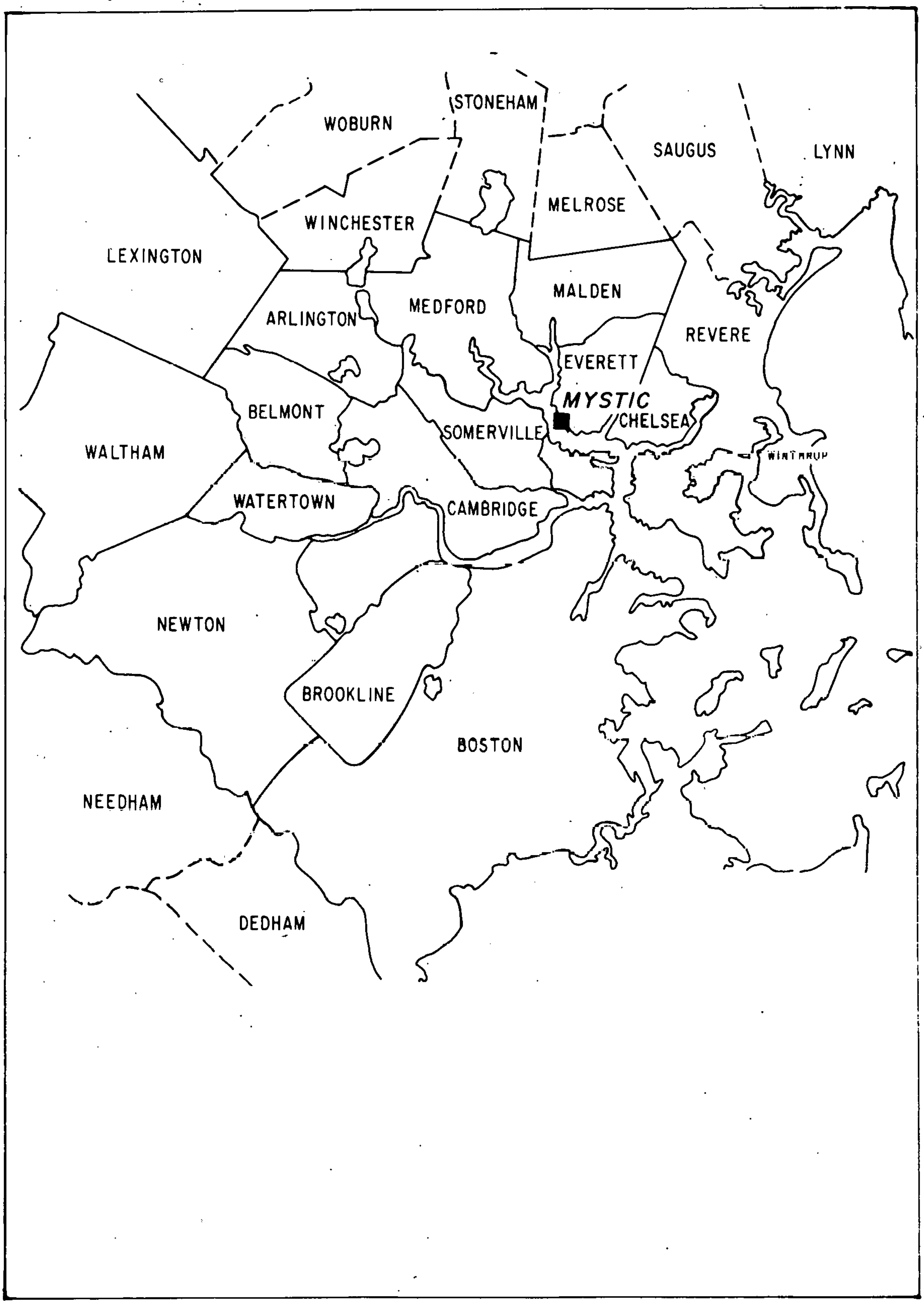


Fig. 1. Station Location.

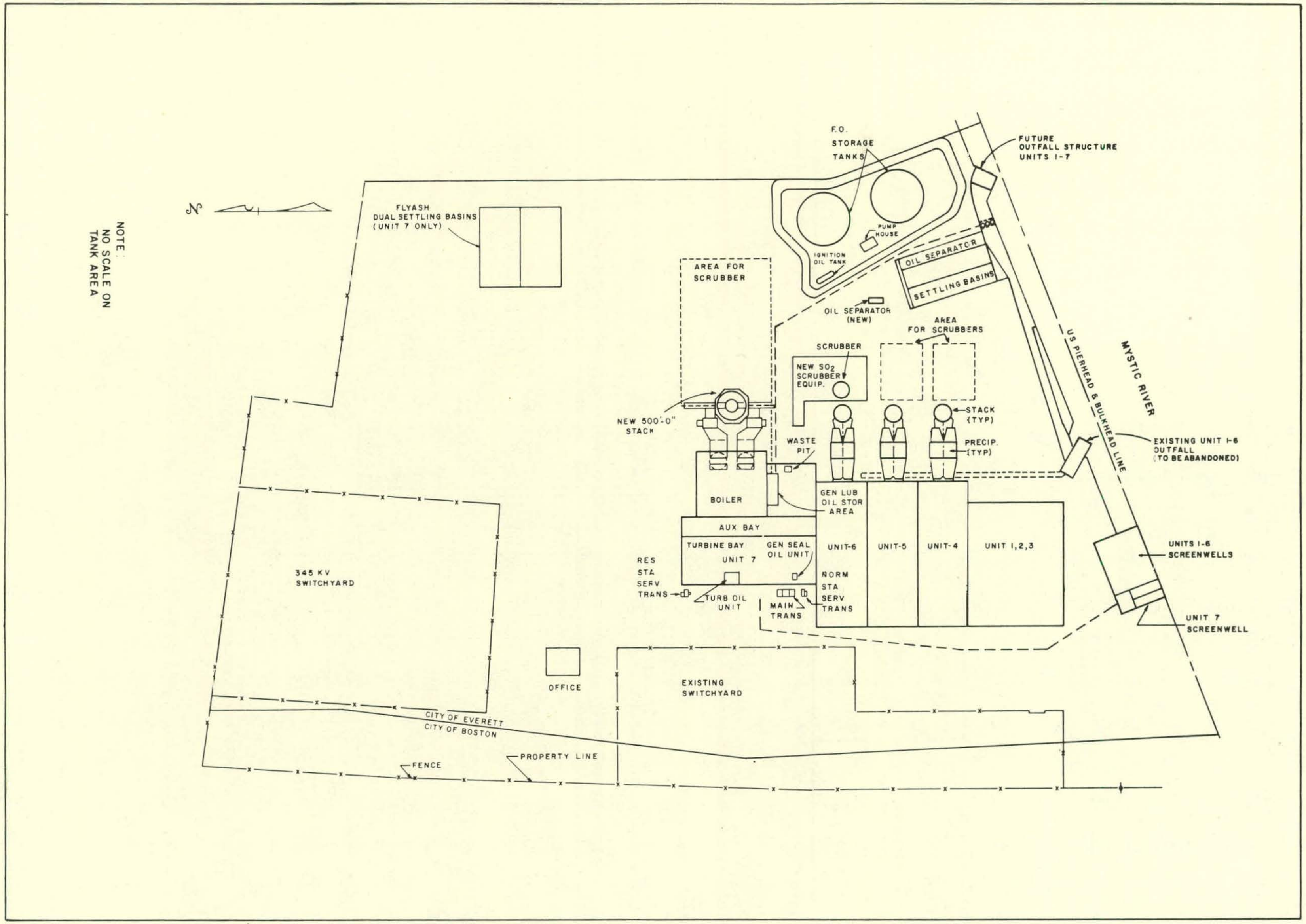


Fig. 2. Site Plan.

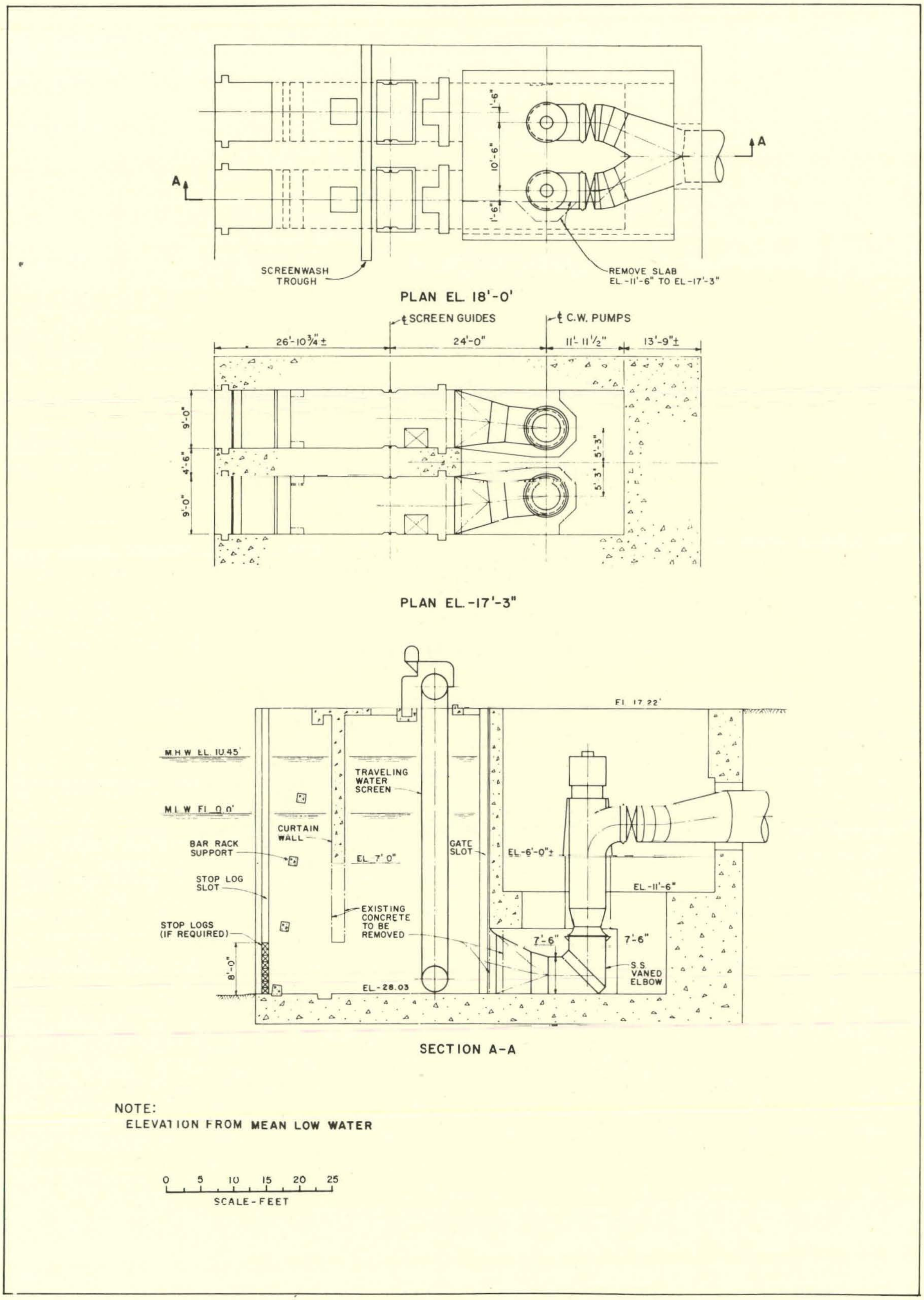


Fig. 3. Circulating-Water Intake, Unit 7.

Table I. Fishes Observed at the Station

Blueback herring	Pollock
Alewife	Butterfish
American eel	Bluefish
Fourspine stickleback	Northern searobin
Atlantic menhaden	Winter flounder
Atlantic herring	Atlantic mackerel
Killifish	Windowpane
Atlantic cod	Northern pipefish
Ocean pout	Cunner
Silver hake	Red hake
Atlantic tomcod	
White perch	
Striped bass	
Sculpin	
Rainbow smelt	

Table II. Current at Various Screenwell Locations (fps)

Location	Unit No. 1-3	Unit No. 4-5	Unit No. 6	Unit No. 7
Mouth of Screenwell Bay	0.325	0.604	0.67	1.28
Curtain Wall	0.65	1.21	2.35	1.77
Traveling Screen	0.49	0.67	0.67	1.28

Table III. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Winter Flounder	Rainbow Smelt	Alewife	Total
Units 1-5					
1971	0.73	1,649	573	4,767	10,939
1972	2.1	1,588	3,060	1,373	7,569
1973	1.93	2,577	409	409	5,694
1974	1.63	1,902	1,201	2,081	9,388
1975[a]	0.87	1,799	164	0	2,873
Unit 6					
1971	0.67	17,816	3,497	11,636	38,935
1972	2.2	7,192	10,061	2,807	23,226
1973	1.6	4,752	829	584	9,808
1974	1.2	2,383	1,175	989	7,961
1975[a]	0.06	3,741	1,551	0	7,665
Unit 7					
1975	0.93	29,897	17,739	7,088	69,981

[a]Units 1-3 have been out of service since May 1975 and were retired in October 1975. Units 5 and 6 have also been out of service since May 1975.

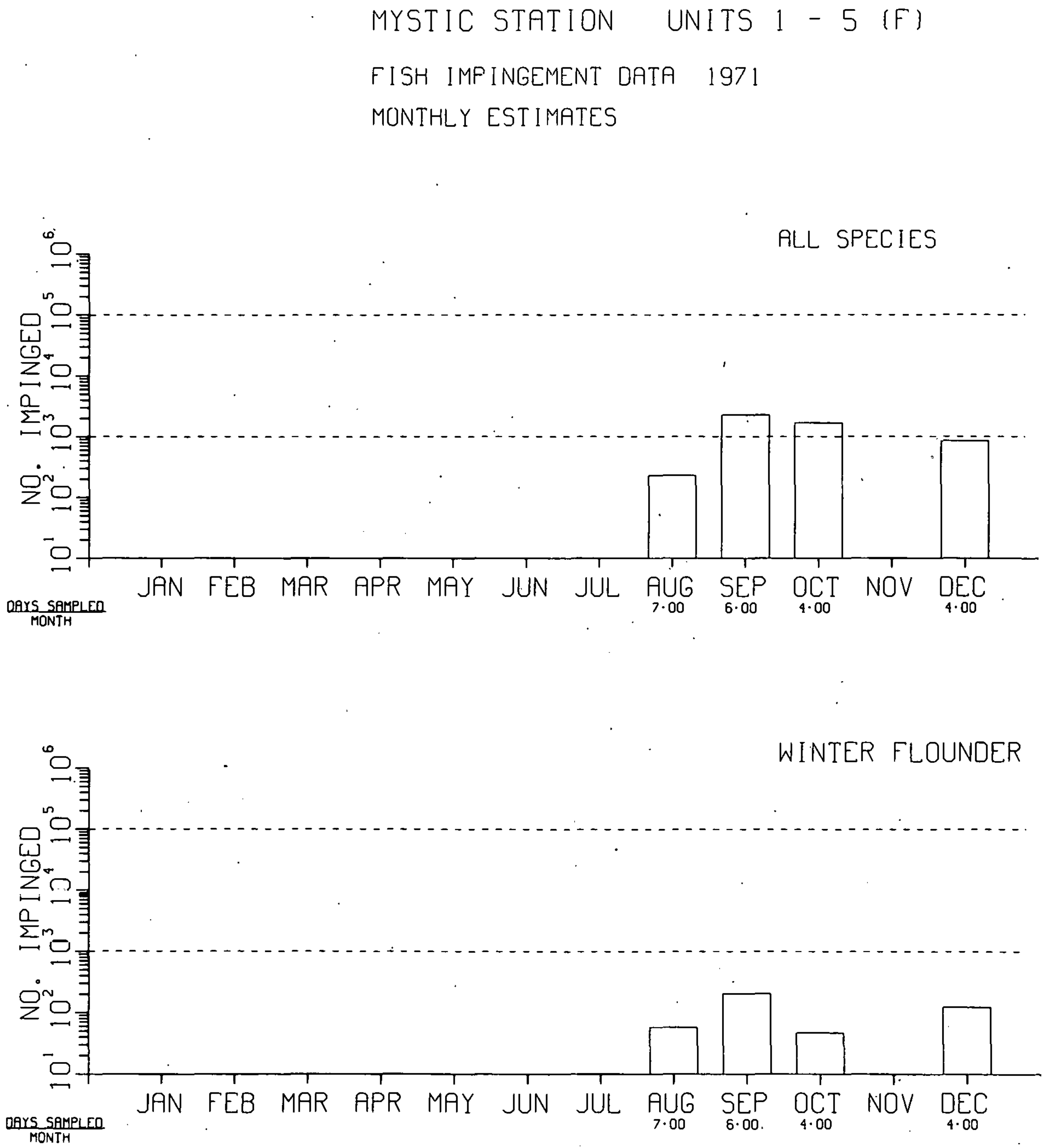
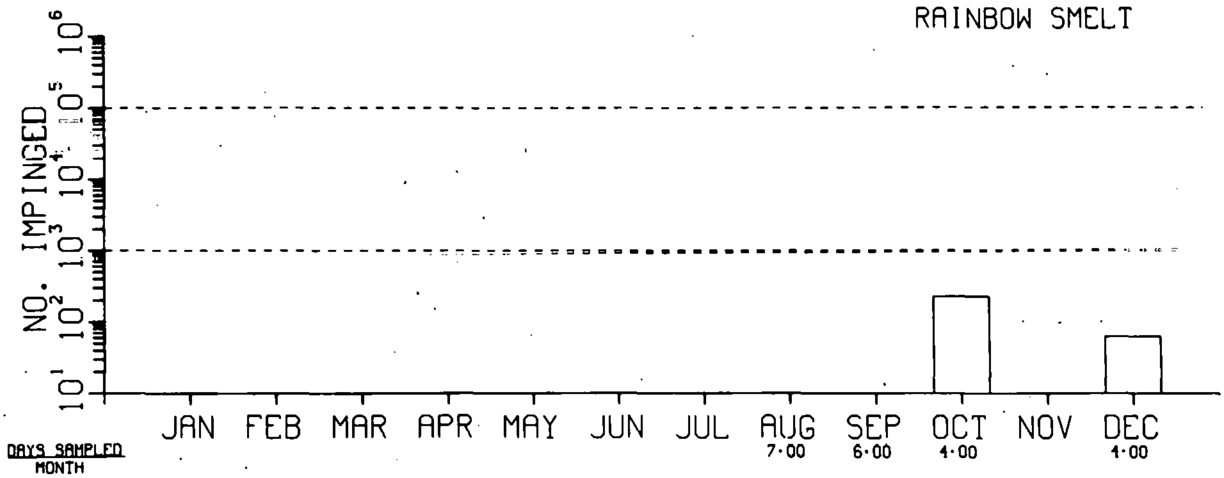


Fig. H1. Impingement Estimates.

MYSTIC STATION UNITS 1 - 5 (F)

FISH IMPINGEMENT DATA 1971

MONTHLY ESTIMATES



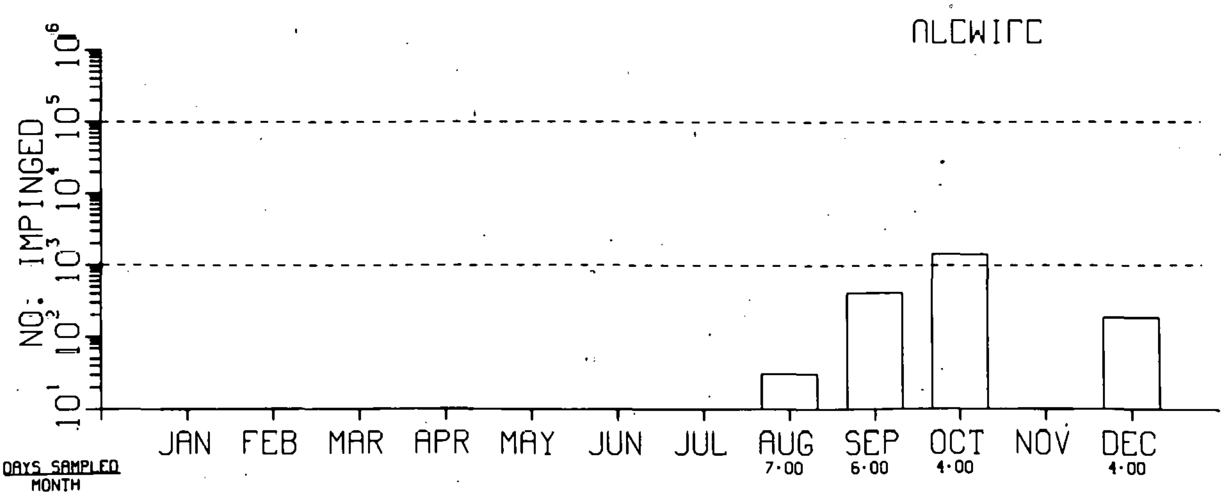
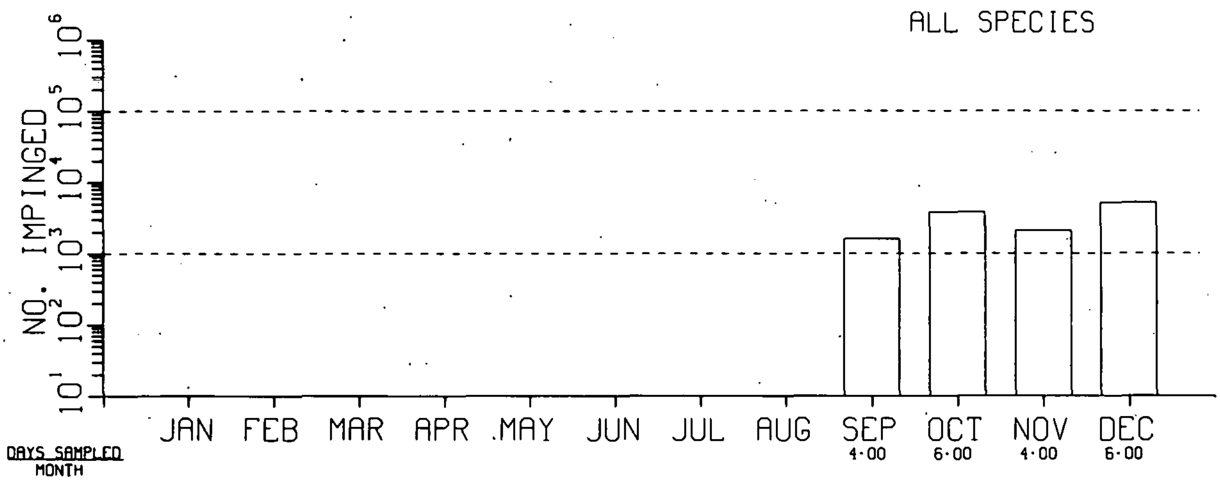


Fig. H2. Impingement Estimates.

MYSTIC STATION UNIT 6 (F)

FISH IMPINGEMENT DATA 1971

MONTHLY ESTIMATES



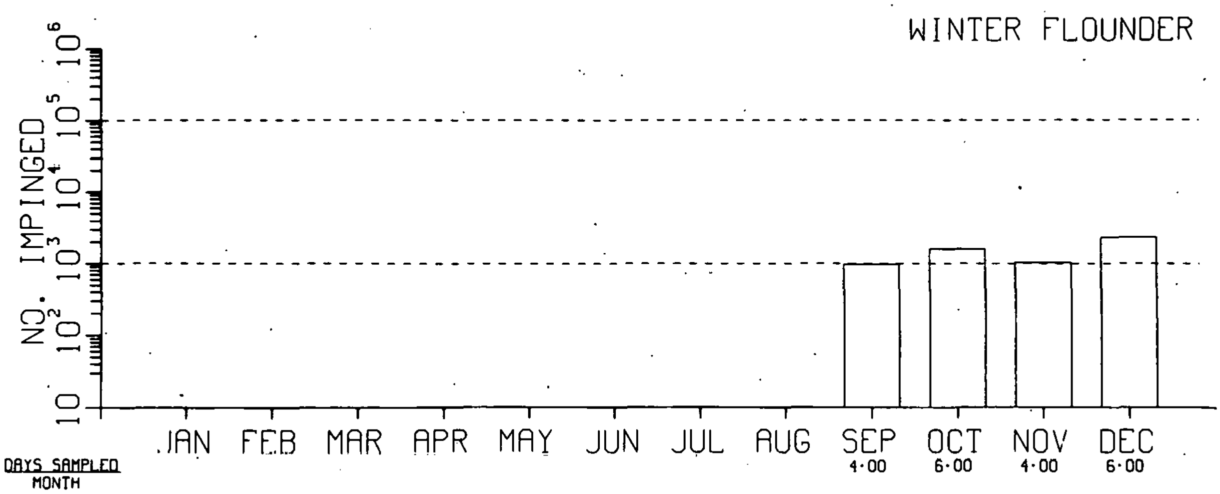


Fig. H3. Impingement Estimates.

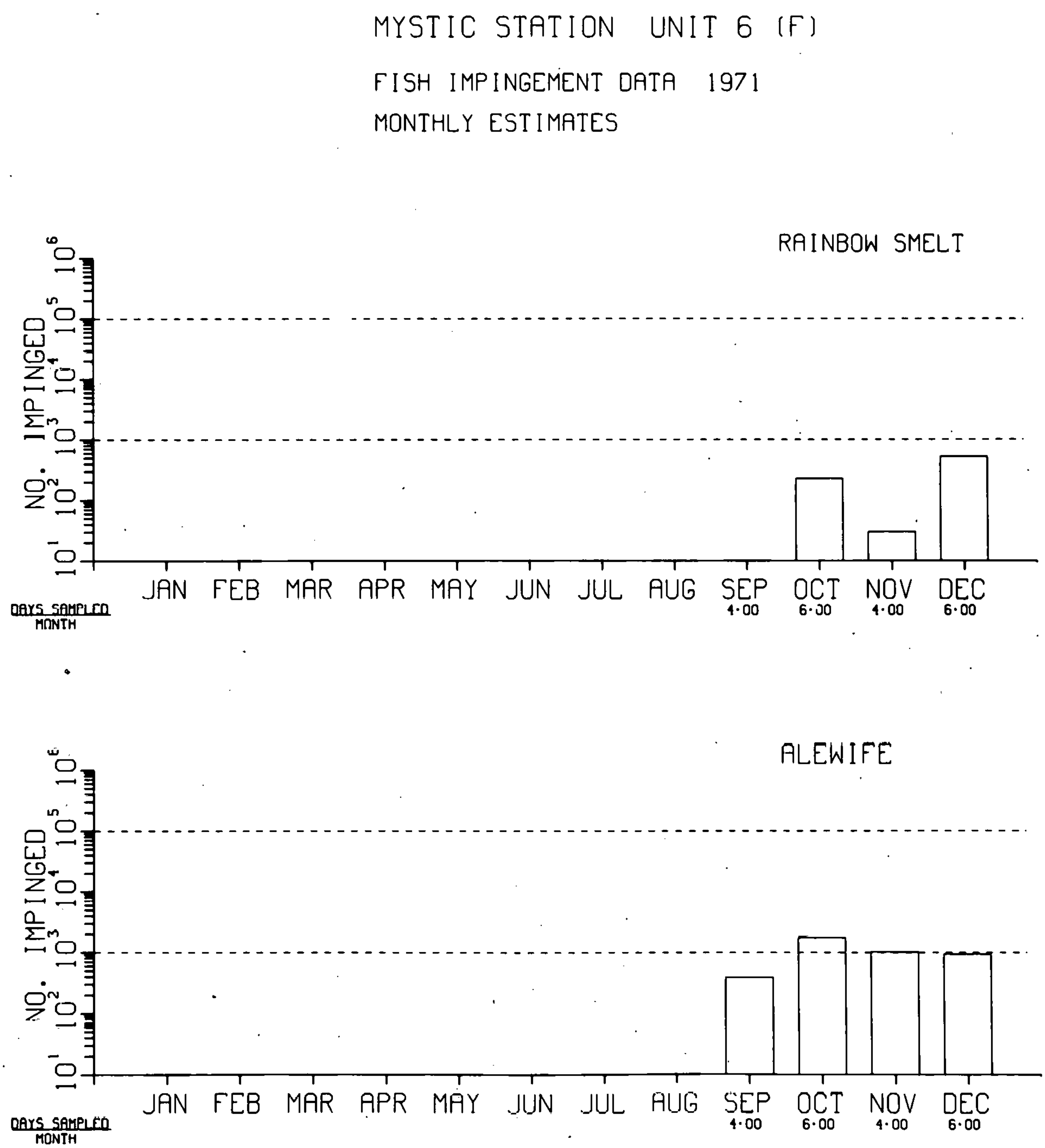


Fig. H4. Impingement Estimates.

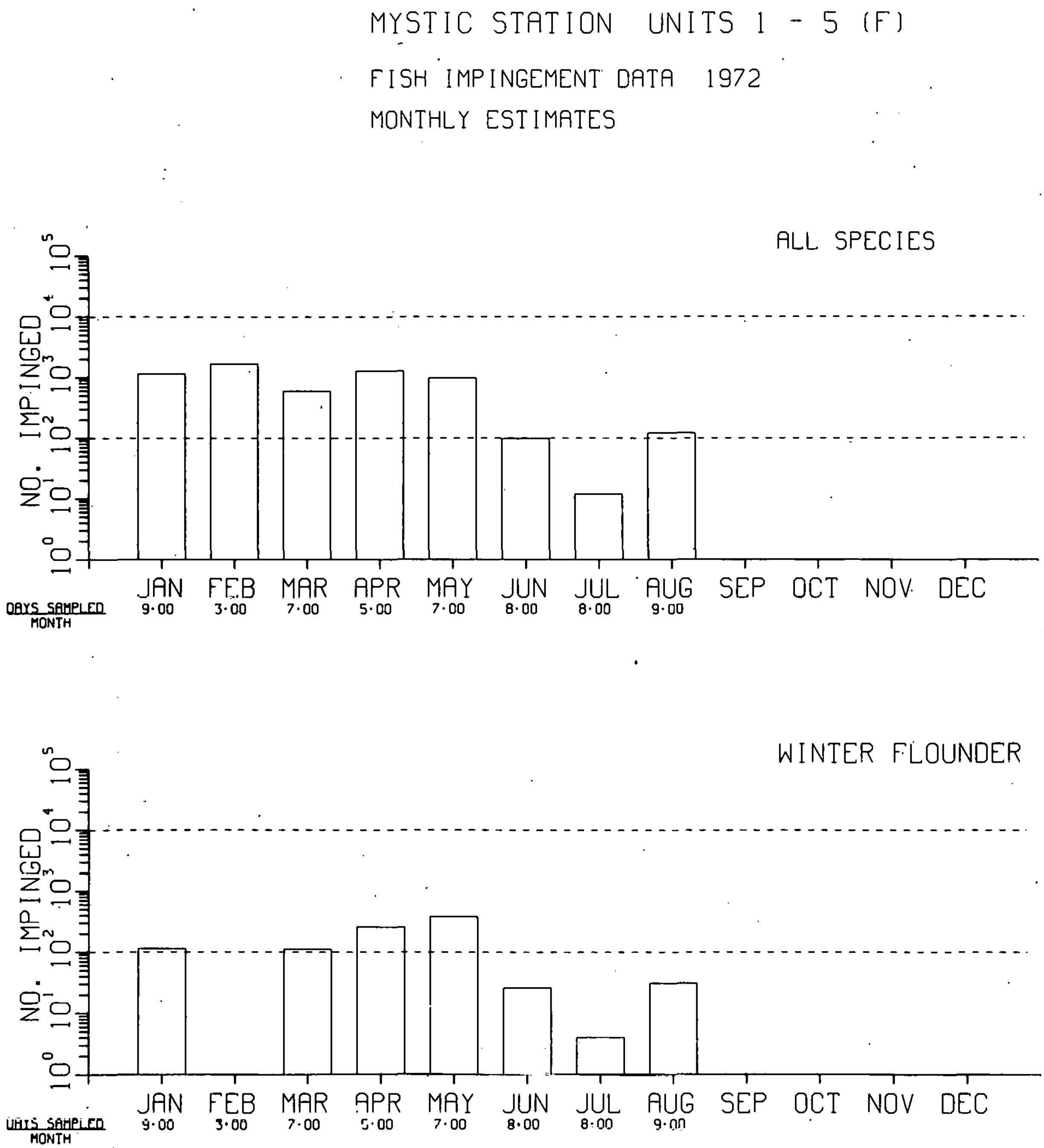
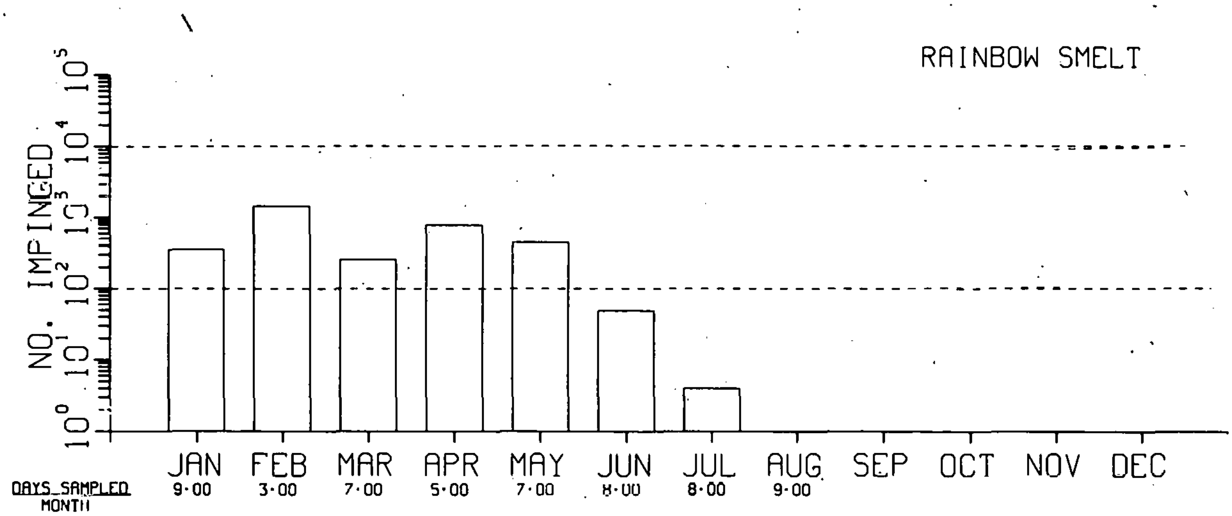


Fig. H5. Impingement Estimates.

MYSTIC STATION UNITS 1 - 5 (F)

FISH IMPINGEMENT DATA 1972

MONTHLY ESTIMATES



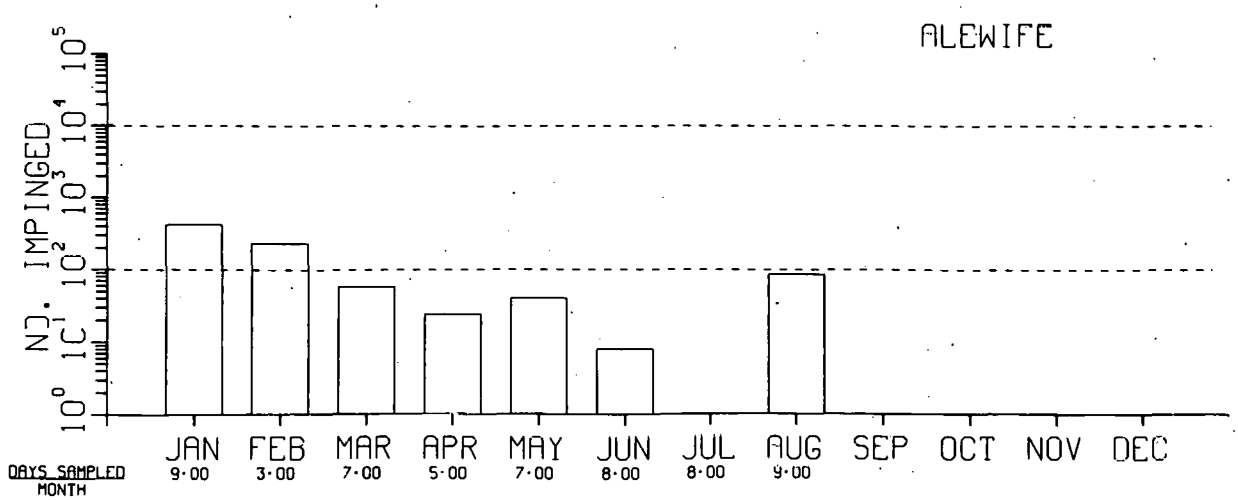


Fig. H6. Impingement Estimates.

MYSTIC STATION UNIT 6 (F)

FISH IMPINGEMENT DATA 1972

MONTHLY ESTIMATES

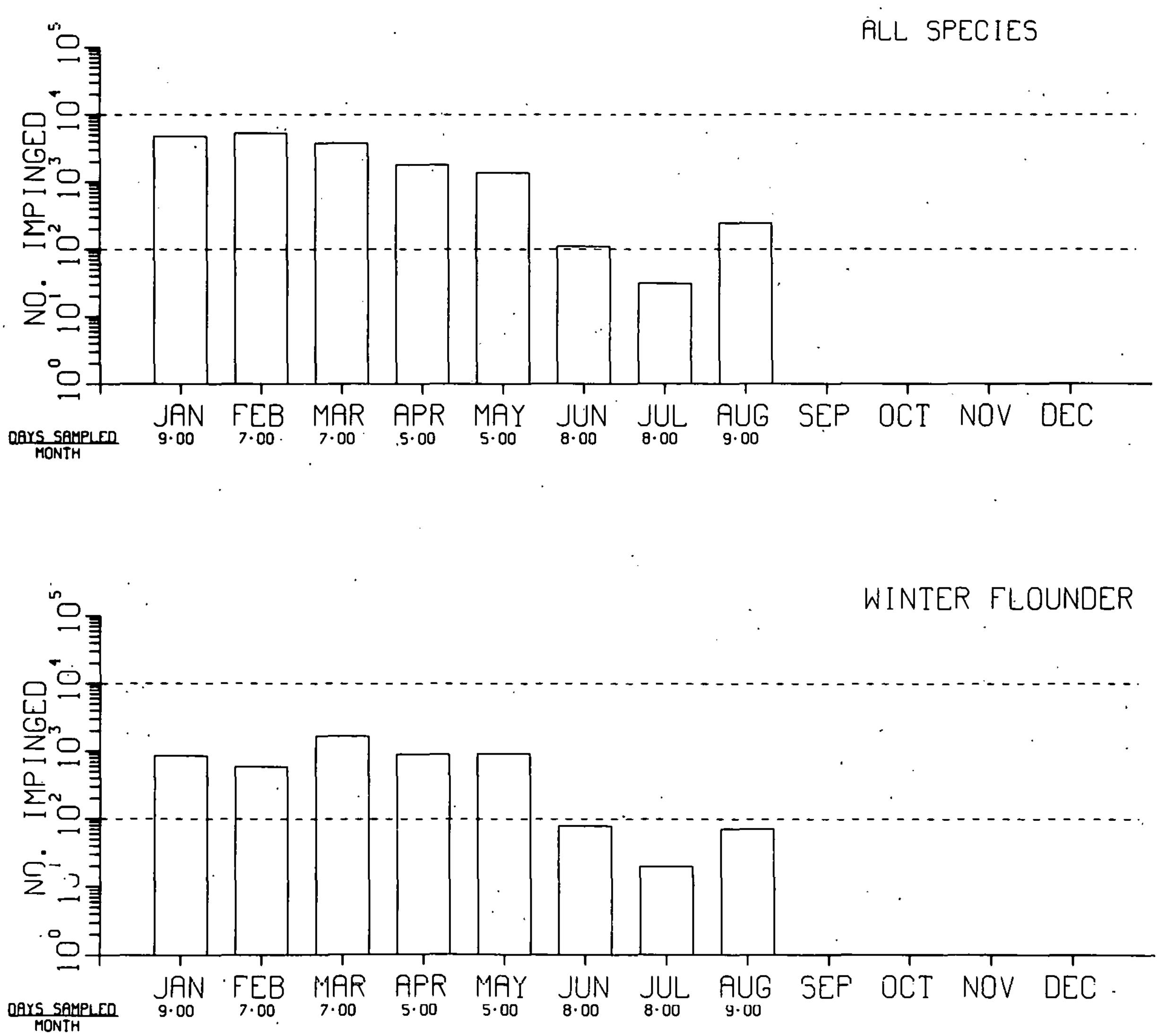
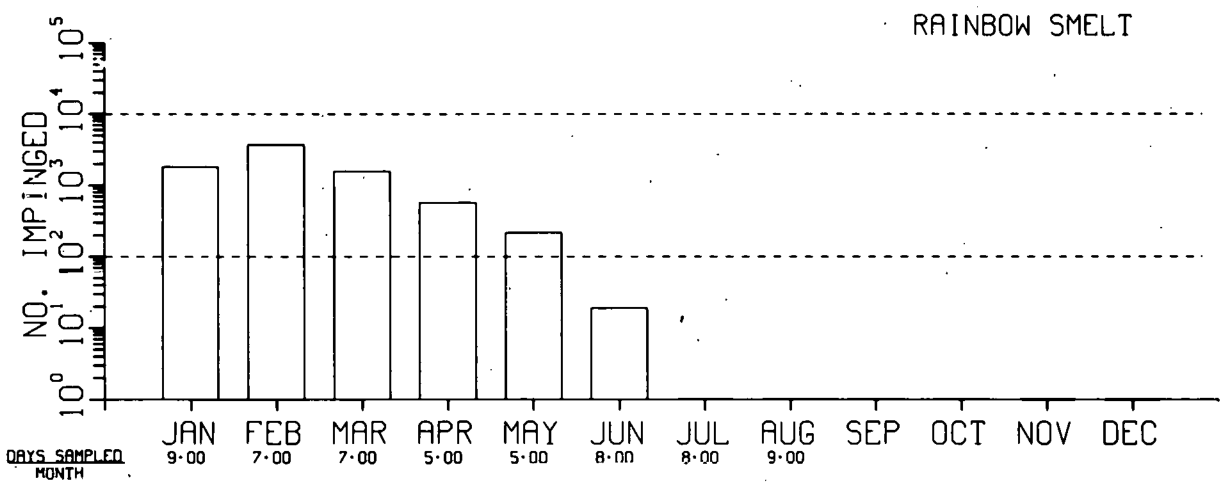


Fig. H7. Impingement Estimates.

MYSTIC STATION UNIT 6 (F)

FISH IMPINGEMENT DATA 1972

MONTHLY ESTIMATES



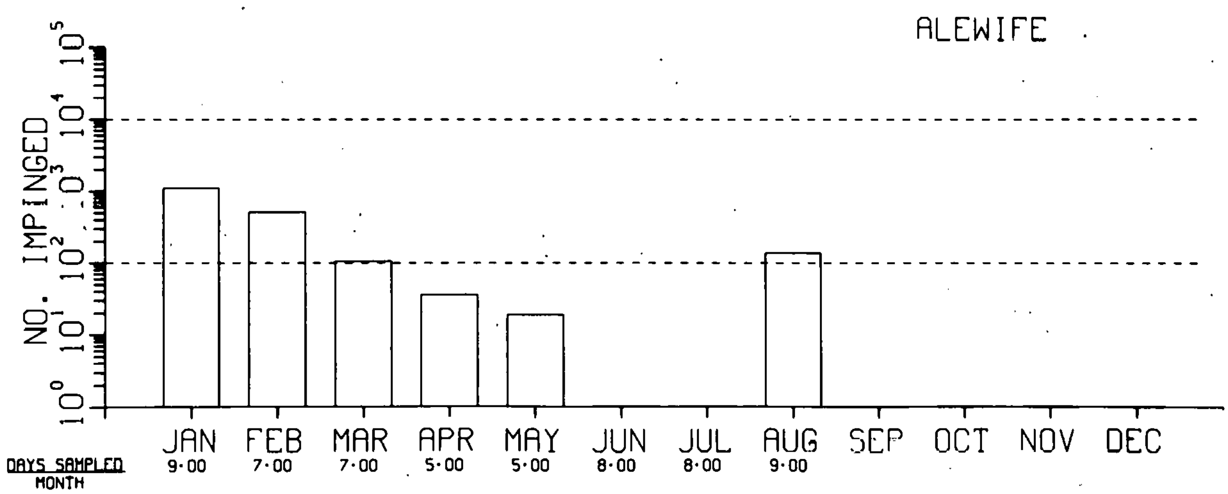


Fig. H8. Impingement Estimates.

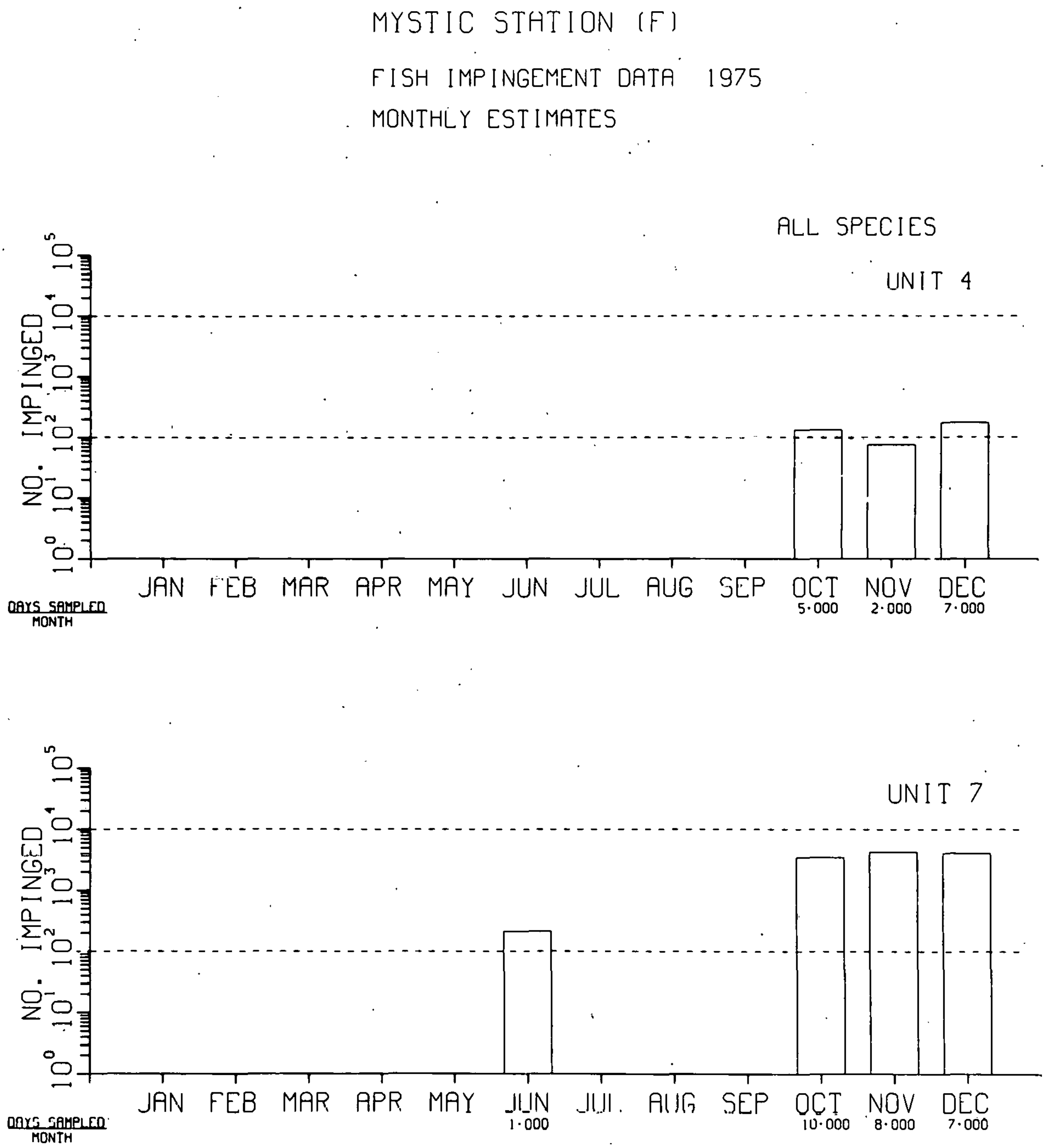


Fig. H9. Impingement Estimates.

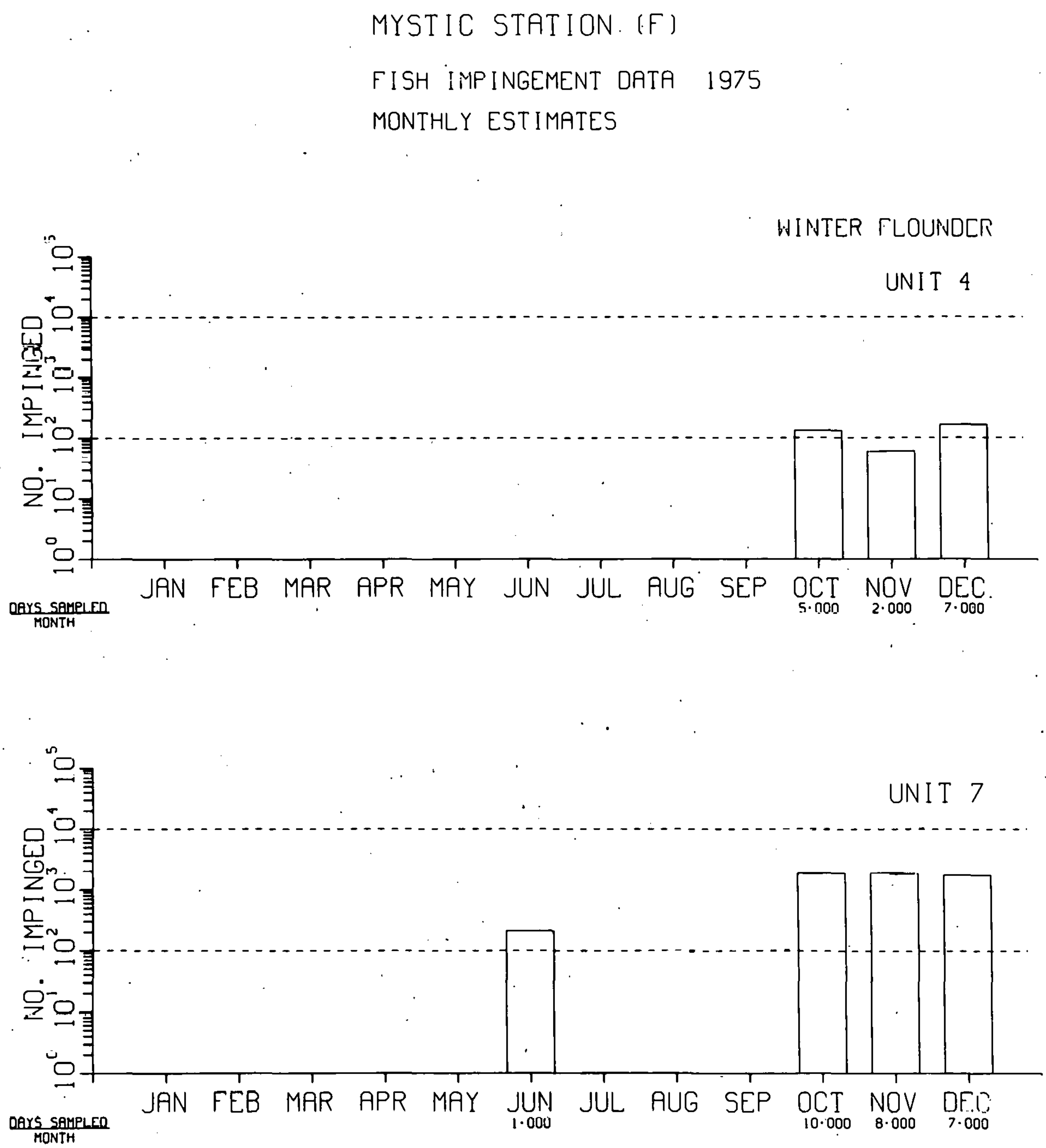


Fig. H10. Impingement Estimates.

MYSTIC STATION (F)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES

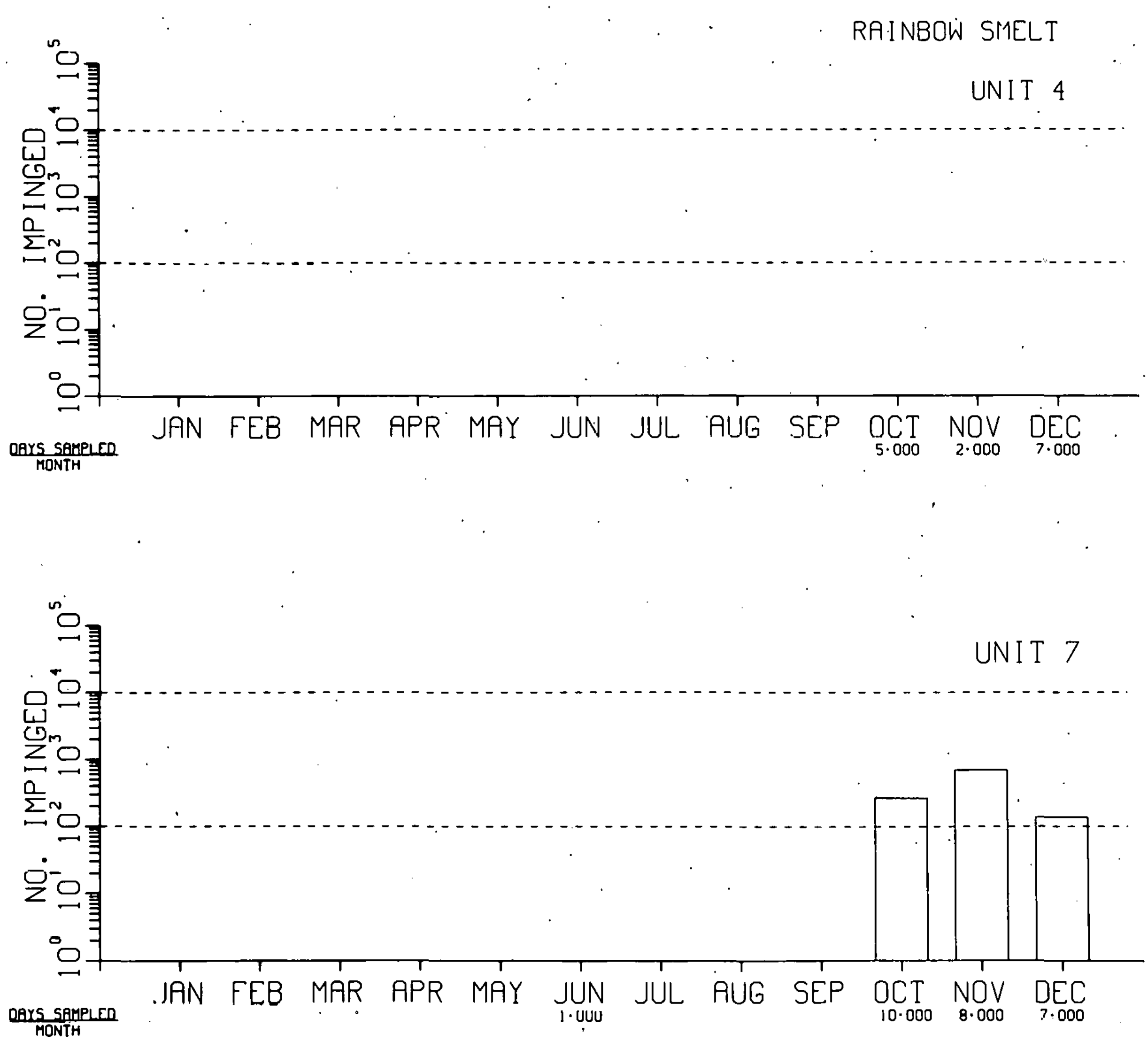


Fig. H11. Impingement Estimates.

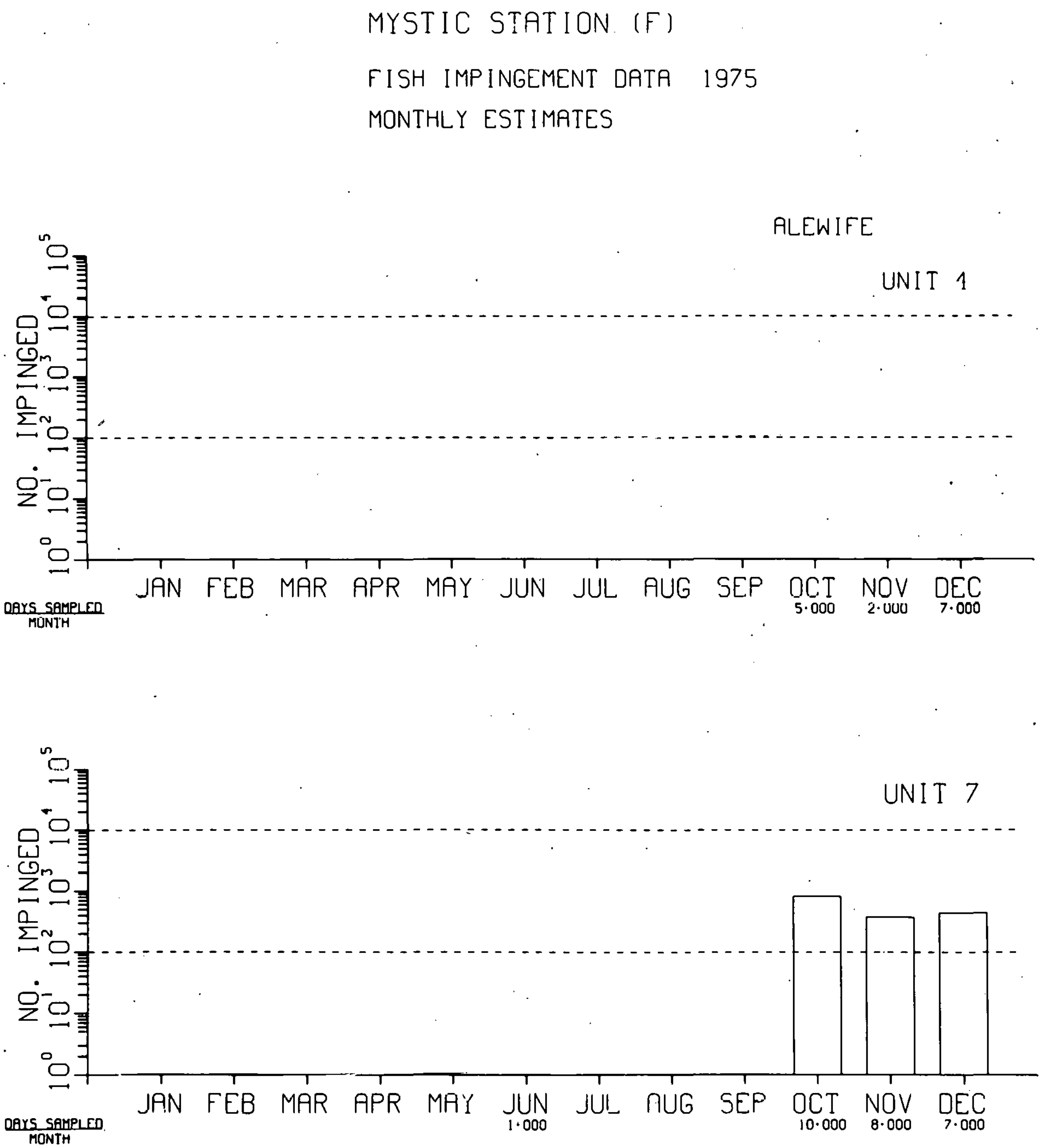


Fig. H12. Impingement Estimates.

PILGRIM POWER STATION UNIT 1 (N)

SITE CHARACTERISTICS

The Pilgrim Station site is located on the western shore of Cape Cod Bay in the Town of Plymouth, Plymouth County, Massachusetts (Fig. 1).[1] The site occupies 517 acres and runs along a rocky shoreline of Cape Cod Bay. Sixty percent of the area within a 50-mile radius of the plant is open water. The nearest population center is Brockton, located 23 miles west-northwest of the plant.

Cape Cod Bay has a surface area of about 430 square nautical miles (365,000 acres). Depth from the shoreline increases rapidly at the site to 180 feet MSL at the mouth of the Bay. The volume of water in the Bay is about 1.6×10^{12} cubic feet. Net movement of water at the site is southeasterly and averages less than 0.1 knot over its entire depth. There is a counter-clockwise circulation of water in the Bay, but this is reduced near the plant by the presence of offshore submarine ledges. Tidal exchange, general circulation, and wind-induced motion account for a daily renewal of 10% of the Bay volume.

Seasonal temperature fluctuations of the water exhibit a typical annual cycle. In August, the temperature range of the Bay is 42°F to 73°F with a mean of 65°F. Low temperatures occur between December and April and range between 30°F and 40°F. A weak thermocline with a ΔT of 10°F from surface to bottom is often present during the warm months of the year.

A list of the fishes collected in the vicinity of the site is presented in Table I. The Bay is a well-used fishery, and several species of benthic fishes including cod, haddock, winter flounder, and hake are harvested as close as three miles from shore from 1 April to 1 November. Some winter trawling for winter flounder also occurs near the station.

PLANT DESCRIPTION

The unit is a boiling water reactor with a net power output of 655 MWe. The station employs once-through cooling and uses 320,000 gpm for cooling and service water from Cape Cod Bay. The ΔT across the condensers is 29°F. A schematic of the circulating-water system, including the intake and discharge, is shown in Figure 2.

INTAKE DESIGN AND OPERATION

Intake water passes between the two breakwaters and through the dredged channel. The depth of the channel is maintained at -24 feet MSL. At the intake structure, water passes under a skimmer wall at a depth of -12 feet MSL (Fig. 3). Trash racks downstream of the curtain wall stop debris larger than three inches in diameter. Traveling screens are equipped with 3/8-inch-square mesh.

There are four traveling screens in parallel, two for each of the two circulating-water pumps. The intake structure is divided into three bays, one for each of the circulating-water pumps and one for the five service-water pumps (Fig. 3). Each circulating-water pump has a capacity of 155,500 gpm. Water velocity at the traveling screens is about 1.0 fps.

IMPINGEMENT SAMPLING

The screen-wash monitoring program instituted sampling at one day a week and divided the day into three eight-hour periods.[2] A metal trap was placed in the sluiceway to catch fish washed off the screens. The screens were rotated just prior to placing the trap and prior to its removal. The screens were run during the sampling as necessary. A continuous 24-hour sample was included when large numbers of fish were impinged. The actual program, as carried out by the utility, involved sample periods of eight days a month most of the time. The number of days sampled each month ranged from two to ten. Sampling error sometimes occurred when the trap became clogged and overflowed resulting in a loss of part of the sample.

DATA AVAILABILITY

Data are available for 1973, 1974 (except April to July when the plant was shut down), and January to June 1975.

IMPINGEMENT DATA SUMMARY

Data for Pilgrim Unit 1 are summarized in Table II. The three most numerous species impinged were Atlantic silverside, rainbow smelt, and unidentified herring--Family Clupeidae. Histograms summarizing the yearly data by month are presented in Figures H1 through H4.[3-5]

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Holes in the skimmer wall were provided just below the mean-low-water level to facilitate the escape of fish from the intake forebay (Fig. 3). No other special features are employed to minimize impingement. The station, according to utility surveys, is located favorably on the Bay with respect to fish populations.

REFERENCES

1. "Final Environmental Statement, Pilgrim Unit 1." USAEC Directorate of Licensing. Docket Number 50-293. May 1972.

2. Boston Edison Company. "First Semiannual Operating Report." 1 July-31 December 1972.

3. Boston Edison Company. "Third Semiannual Operating Report." January-December 1973.

4. Boston Edison Company. "Fifth Semiannual Operating Report." January-December 1974.

5. Boston Edison Company. "Sixth Semiannual Operating Report." January-June 1975.

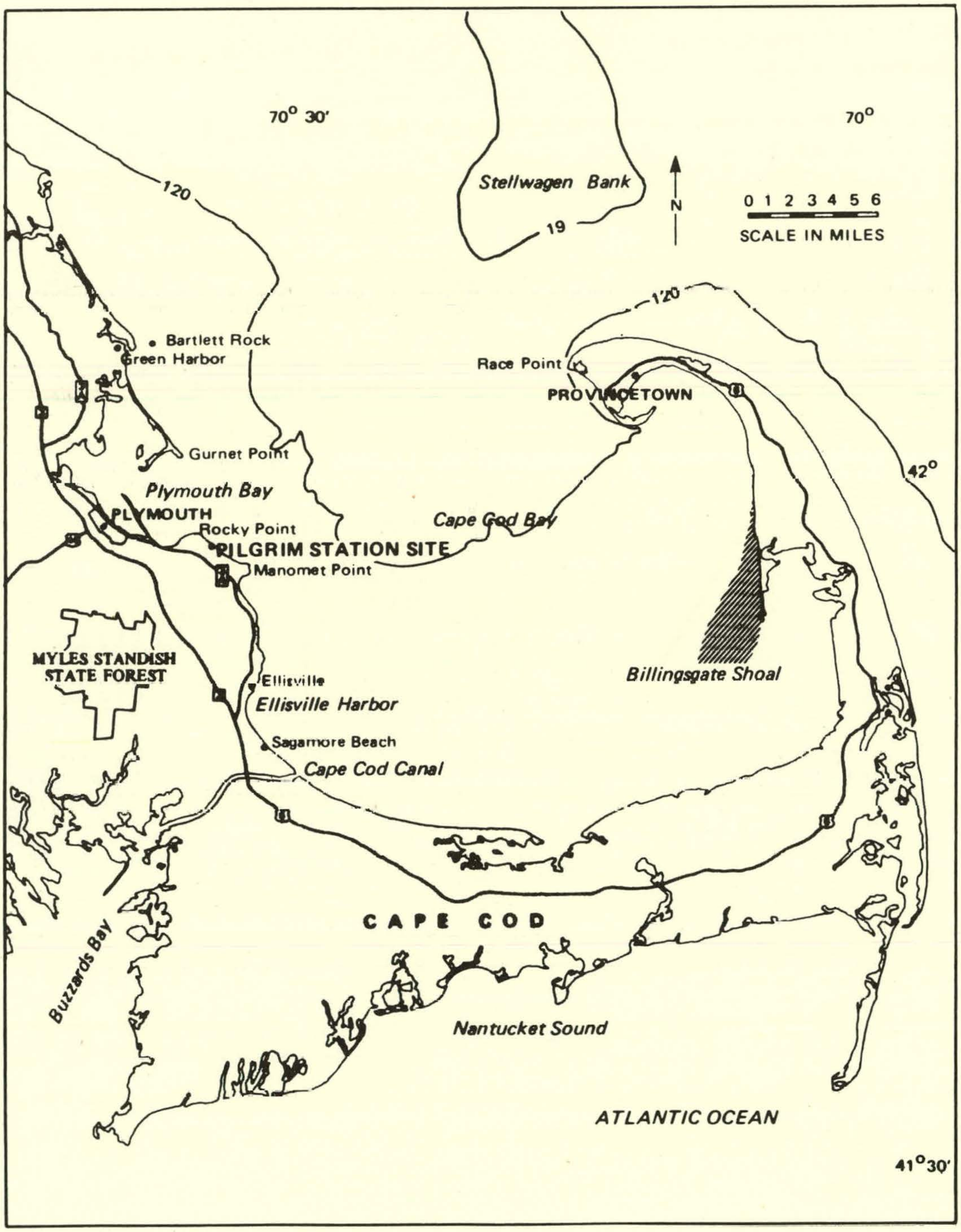


Fig. 1. Station Location.

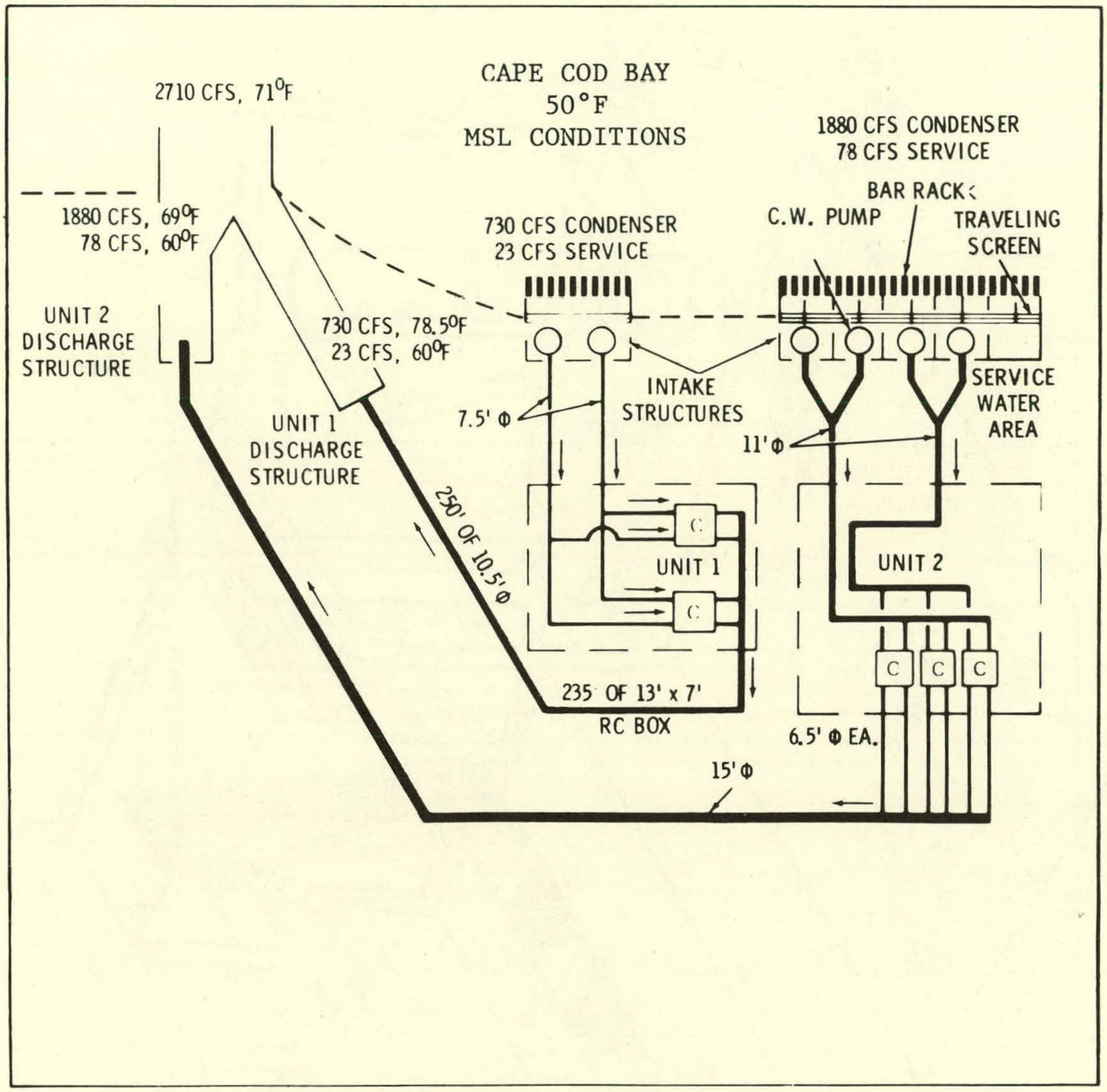


Fig. 2. Circulating-Water System Schematic.

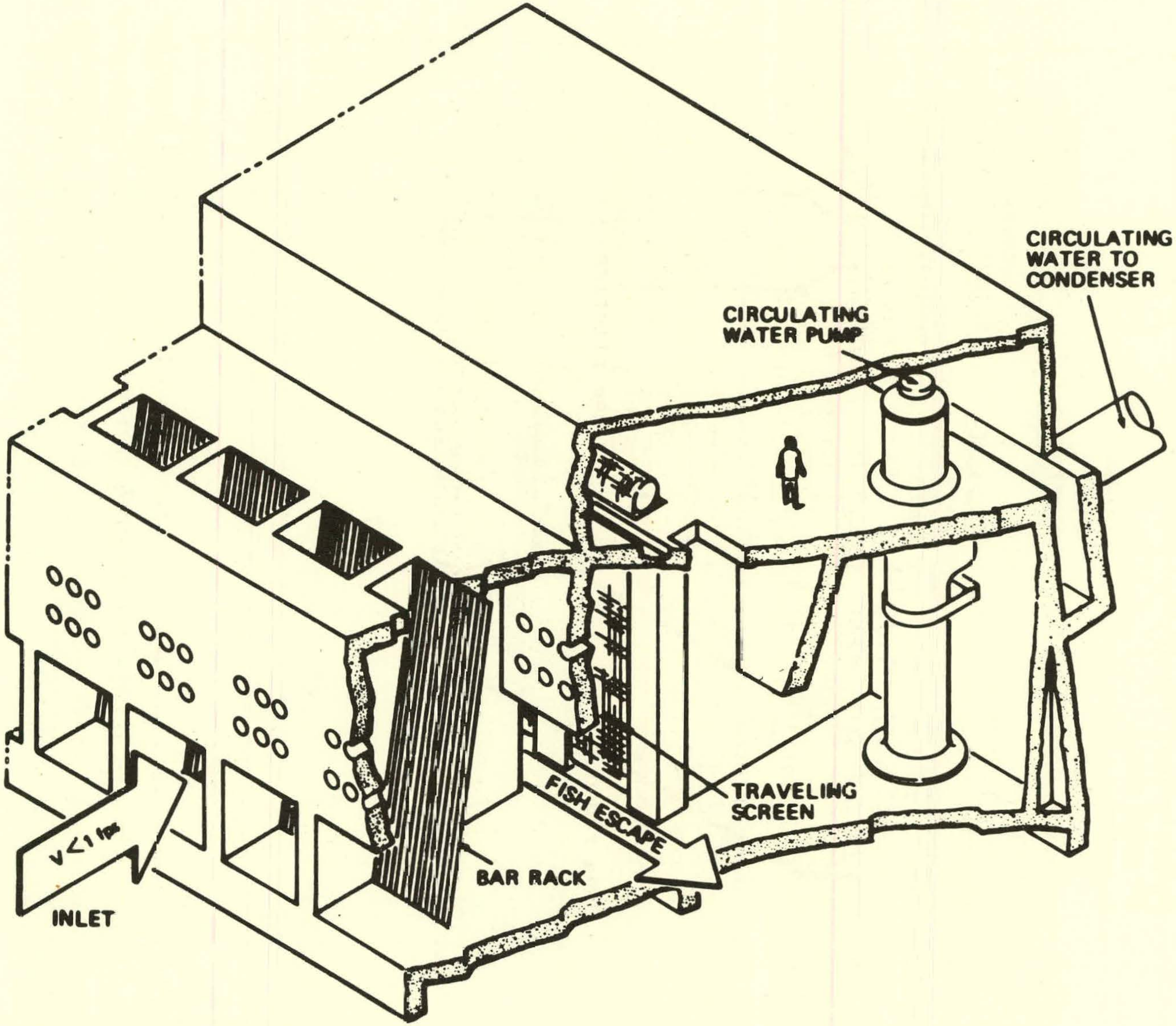


Fig. 3. Intake Structure.

Table I. Fishes Taken in the Vicinity of Unit 1

Spiny dogfish	Gray triggerfish
Smooth dogfish	Planehead filefish
Atlantic herring	Lumpfish
Rainbow smelt	Seasnail
Atlantic silverside	Rock gunnel
Butterfish	Pollock
Lookdown	Shorthorn sculpin
Atlantic mackerel	Striped searobin
Bluefish	Northern kingfish
Atlantic cod	Hickory shad
Red hake	Atlantic tomcod
Cunner	Silver hake
Tautog	Striped bass
Scup	Atlantic menhaden
Winter flounder	Blueback herring
Yellowtail	Alewife
Windowpane	Northern pipefish
Fourspot flounder	Striped seasnail
Longhorn sculpin	Grubby
Sea raven	Orange filefish
	Northern searobin
	Ocean pout
	Northern puffer
	Goosefish

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled: Atlantic Silverside	Rainbow Smelt	Family Clupeidae	Total
1973	12	2,200	815	7,412	12,452
1974	7	18	115	2,723	3,217
1975	6	418	0	82	676

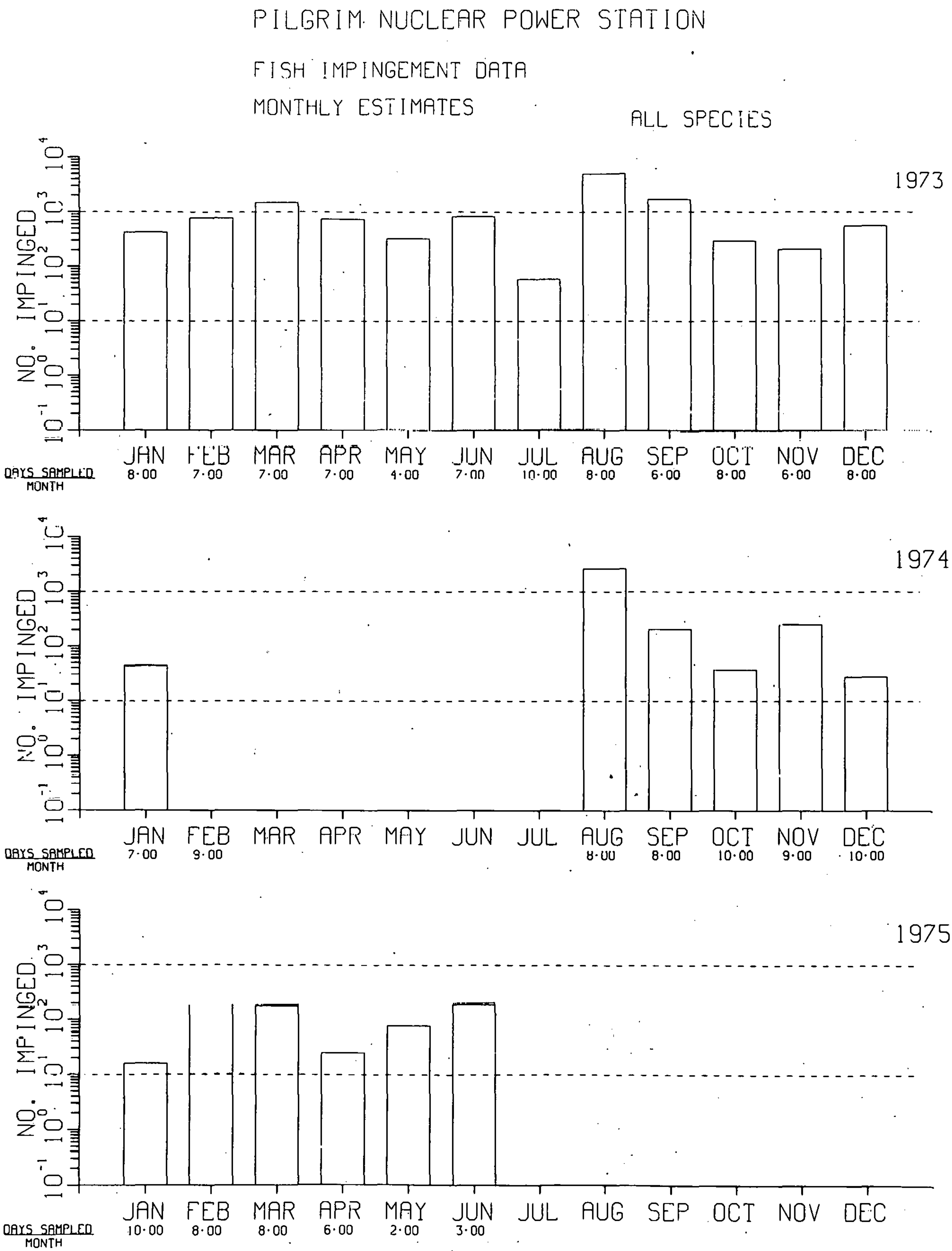


Fig. H1. Impingement Estimates.

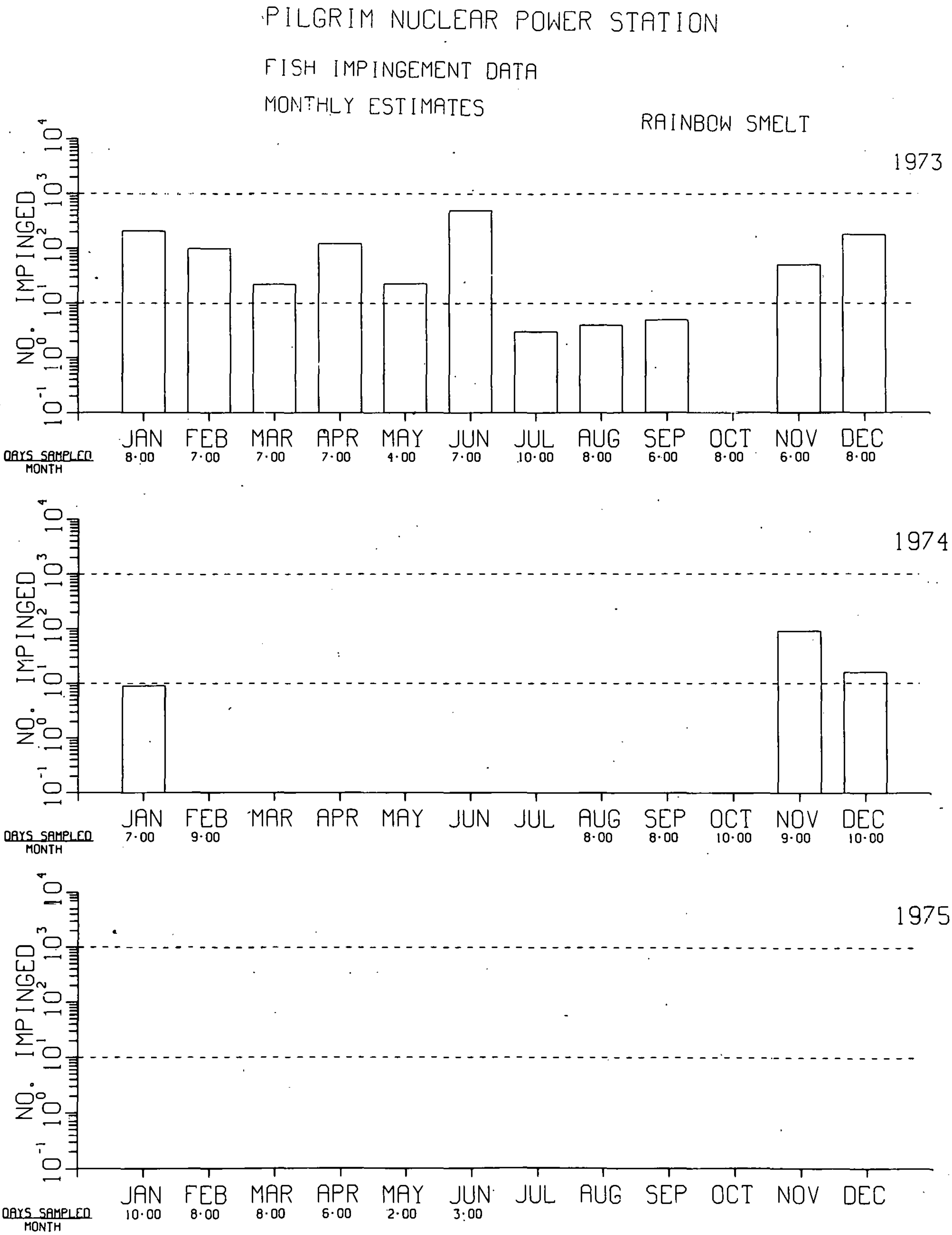


Fig. H2. Impingement Estimates.

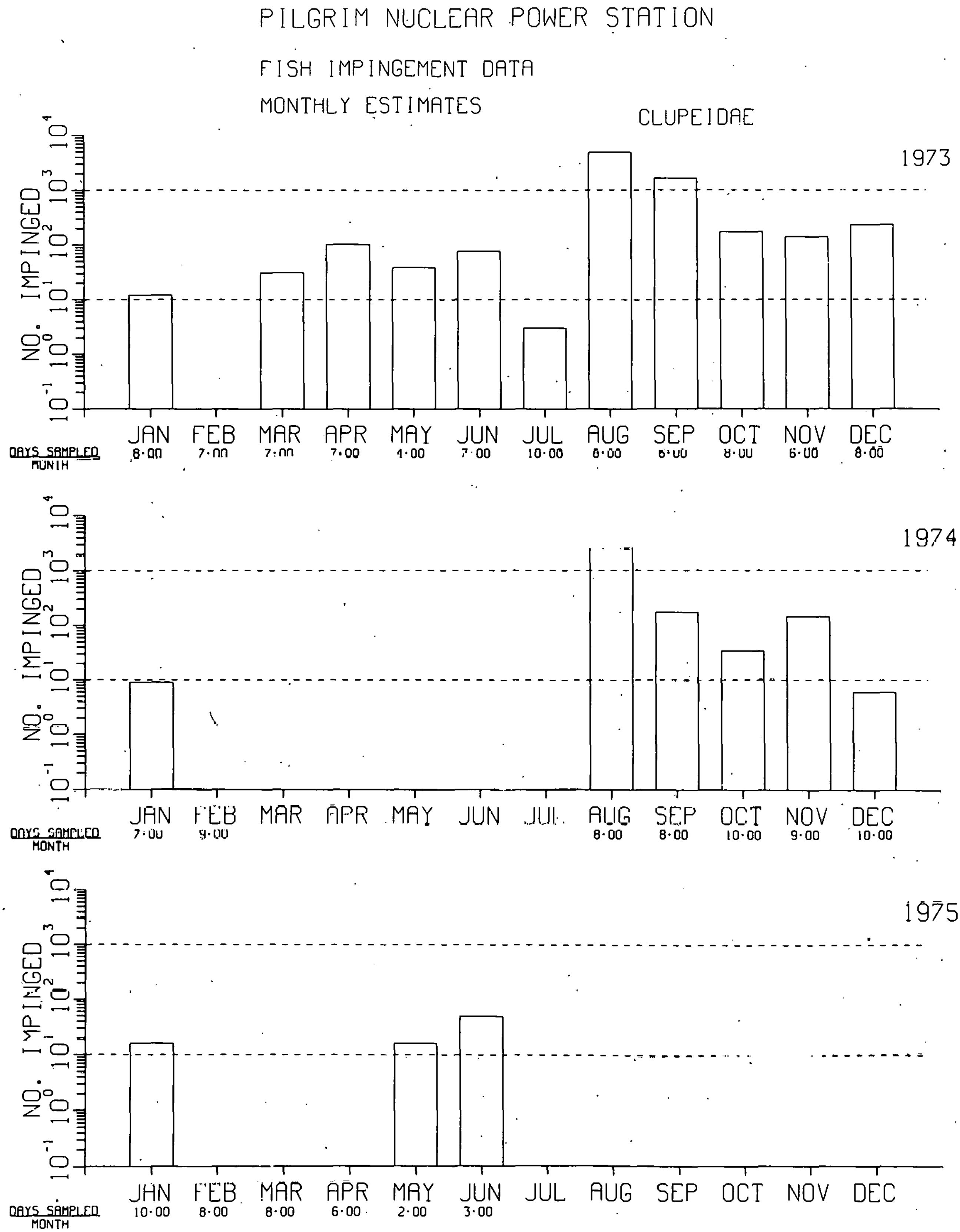


Fig. H3. Impingement Estimates.

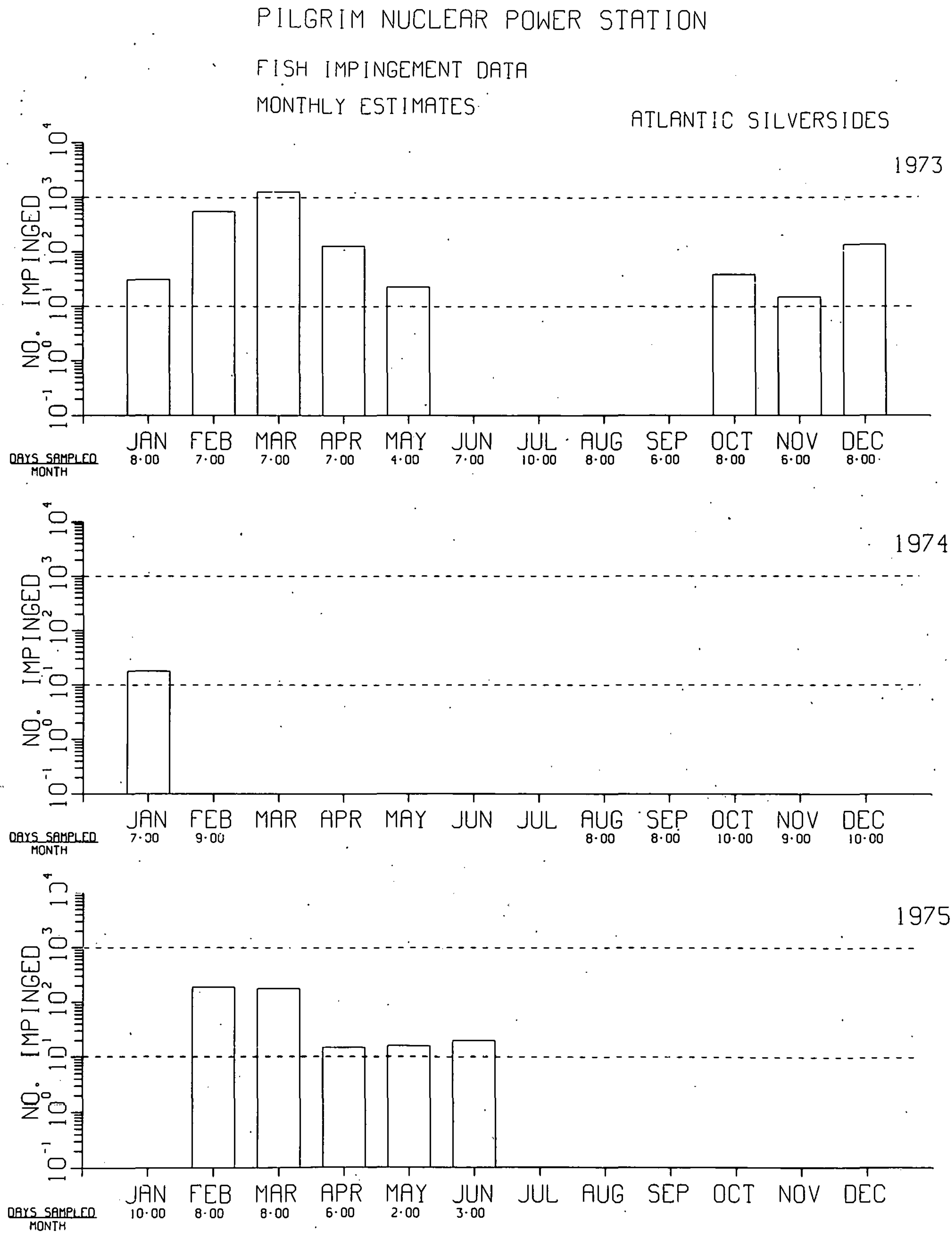


Fig. H4. Impingement Estimates.

CANAL PLANT UNITS 1 AND 2 (F)

SITE CHARACTERISTICS

The Canal Plant is jointly owned by the Canal and the Montaup Electric Companies and is located in Sandwich, Massachusetts.[1] The plant is situated on the south bank of the Cape Cod Canal, which connects Cape Cod Bay with Buzzards Bay to the southwest (Fig. 1). The canal is seven miles long and is trapezoidal in cross section, measuring 480 feet wide at its prism line. Its depth typically ranges between 35 and 40 feet below mean low water.

Cape Cod Canal is noted for its unusual flows and velocities that result from differences in tidal phase and amplitude between Buzzards Bay to the west and Cape Cod Bay to the east. High tide occurs about three hours earlier than in Cape Cod Bay, and the mean tidal ranges at the east and west canal entrance are 8.7 feet and 3.5 feet, respectively. Because the water at the east end alternately rises above and falls below the water at the west end, currents are reversed every six hours. These currents generally shift east when flooding and west when ebbing. The maximum velocities associated with eastward and westward tidal flows are 4.25 fps and 4.45 fps, respectively. The canal is completely flushed during each tidal cycle. This respresents the movement of at least 570,000,000 cubic feet of water.

Yearly water temperatures in the canal averaged 47.6°F over the 12-year period from 1955 to 1966. Mean maximum and minimum temperatures during that time occurred during August and February and were 68.7°F and 30.6°F, respectively. Salinities are quite uniform because of the high water exchange in the canal, and average 31.5 ppt.

In spite of the large water exchange in the canal, a diverse ichthyofauna is present. The canal joins two bodies of water with distinctly different temperature regimes and consequently supports components of two different faunal assemblages (Table I).

PLANT DESCRIPTION

The Canal Plant consists of two 560-MWe oil-fired units with two separate intakes and a common discharge. Once-through cooling is employed, utilizing a total of 358,000 gpm from Cape Cod Canal. Unit 1 began operation on 1 July 1968 and Unit 2 commenced operation on 1 February 1976.

INTAKE DESIGN AND OPERATION

An overall view of the circulating-water system at Canal Units 1 and 2 is shown in Figure 2. Both intakes consist of flumes, or dredged intake

2

channels, extending into the canal perpendicular to the shoreline. Water velocity is 1.02 fps at the entrance, 2.10 fps in the center of the flume, and 0.74 fps in front of the traveling screens. Water velocities through the screens vary from 0.43 fps to 0.94 fps depending on the water level. Each screenwell (Fig.3) consists of a two-celled structure with concrete floors and steel sheet pile walls. Each of the five cells has a trash rack, a traveling screen with 3/8-inch mesh, and a mixed-flow circulating-water pump rated at 95,500 gpm. A nine-foot fish sill has been installed at the bottom of the screenwell for Unit 2 to prevent the entrance of bottom-dwelling fishes.

IMPINGEMENT SAMPLING

Sampling was done as part of the Canal Plant's NPDES permit requirement. Tests at Unit 1 began on 24 June 1975, with preoperational testing at Unit 2 commencing 26 June 1975. Only one circulating-water pump was running at Unit 2 during these preoperational studies. Unit 1 always had full water flow when the tests were run. Sampling varied from two to seven days per month. The number of hours sampled per day varied randomly from two to five.

DATA AVAILABILITY

Data are available from 24 June 1975 to 21 January 1976.

IMPINGEMENT DATA SUMMARY

Data were extrapolated to 24 hours continuous sampling. Data for each unit were calculated independently and the totals summed to avoid error due to different sampling times that occurred at the two units. Table II summarizes data on the three most numerous species impinged--cunner, blueback herring, and alewife. Histograms that summarize the fish impingement by month for 1975 are shown in Figures H1 and H2.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

An experimental bottom sill has been placed in the screenwell of Unit 2 to reduce the impingement of bottom-dwelling fishes. If successful, the sill will be added to the Unit 1 screenwell as well. No other methods were cited.

REFERENCES

1. "Canal Unit Number 2 Environmental Impact Statement." Canal Electric Company and Montaup Electric Company. Circa 1970.

2. "Entrapment Study." First Semiannual Report, 24 June 1975 to 21 January 1976. Canal Electric/Montaup Electric Company. 22 January 1976.

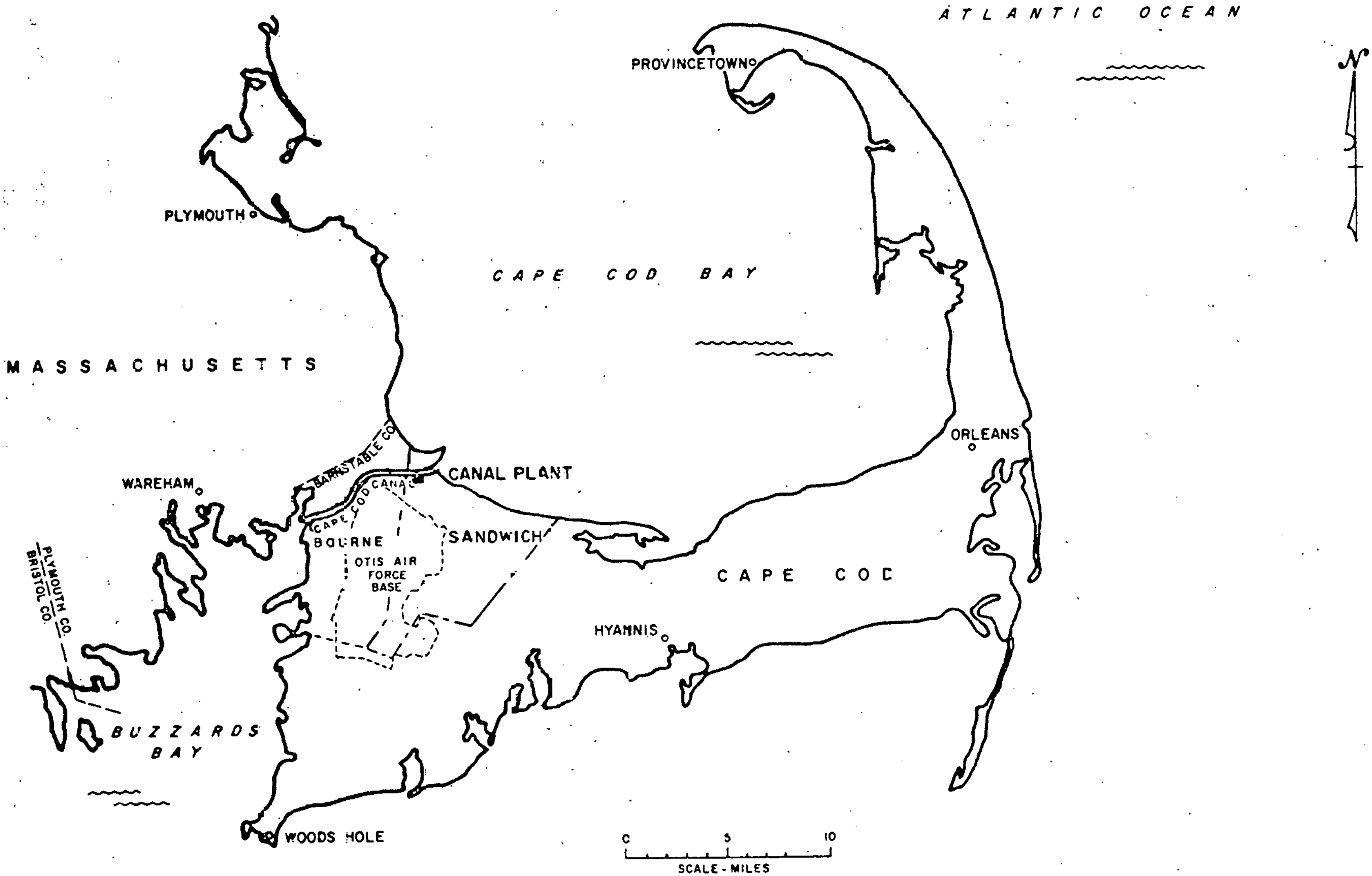
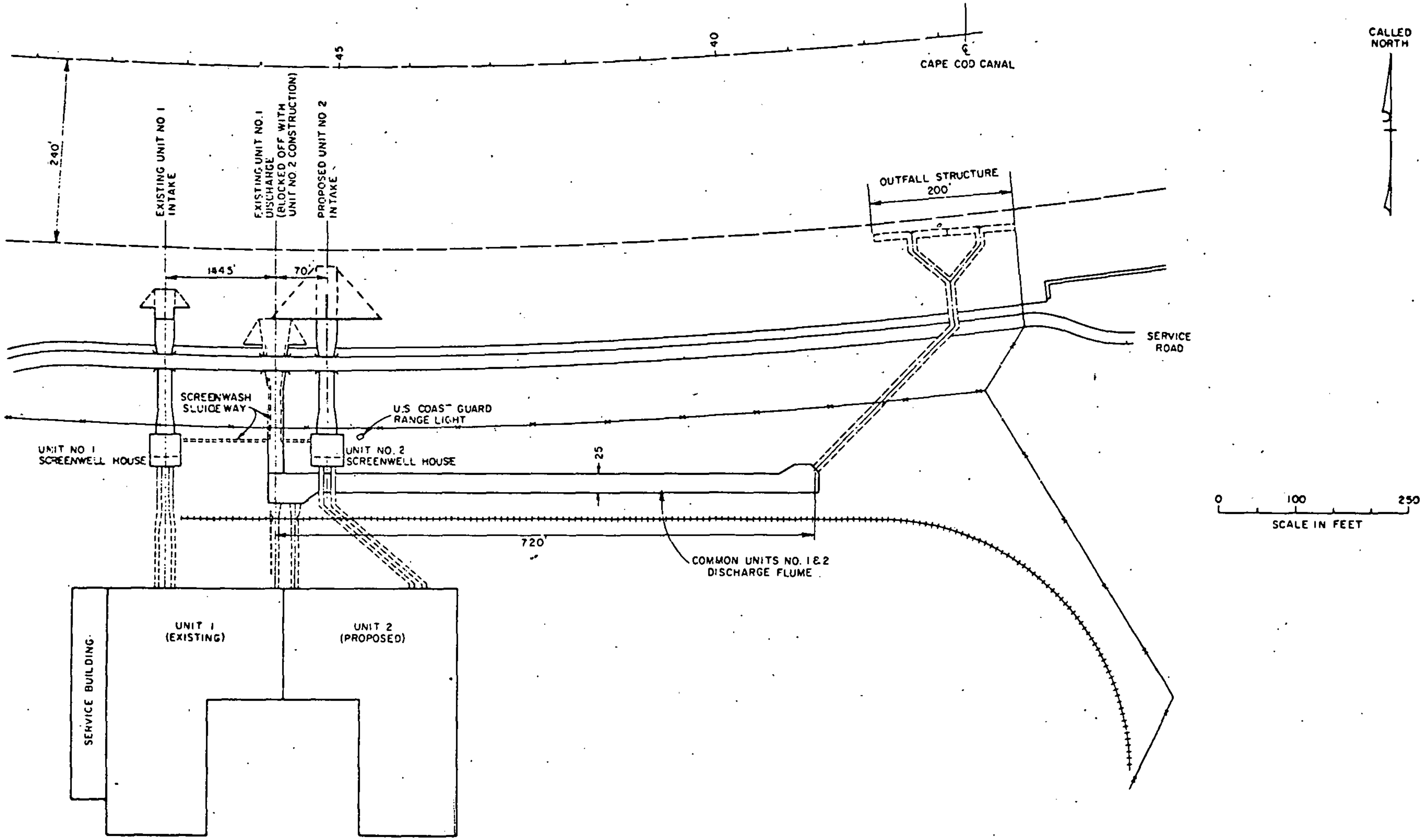


Fig. 1. Plant Location.



CANAL

Fig. 2. Circulating-Water System.

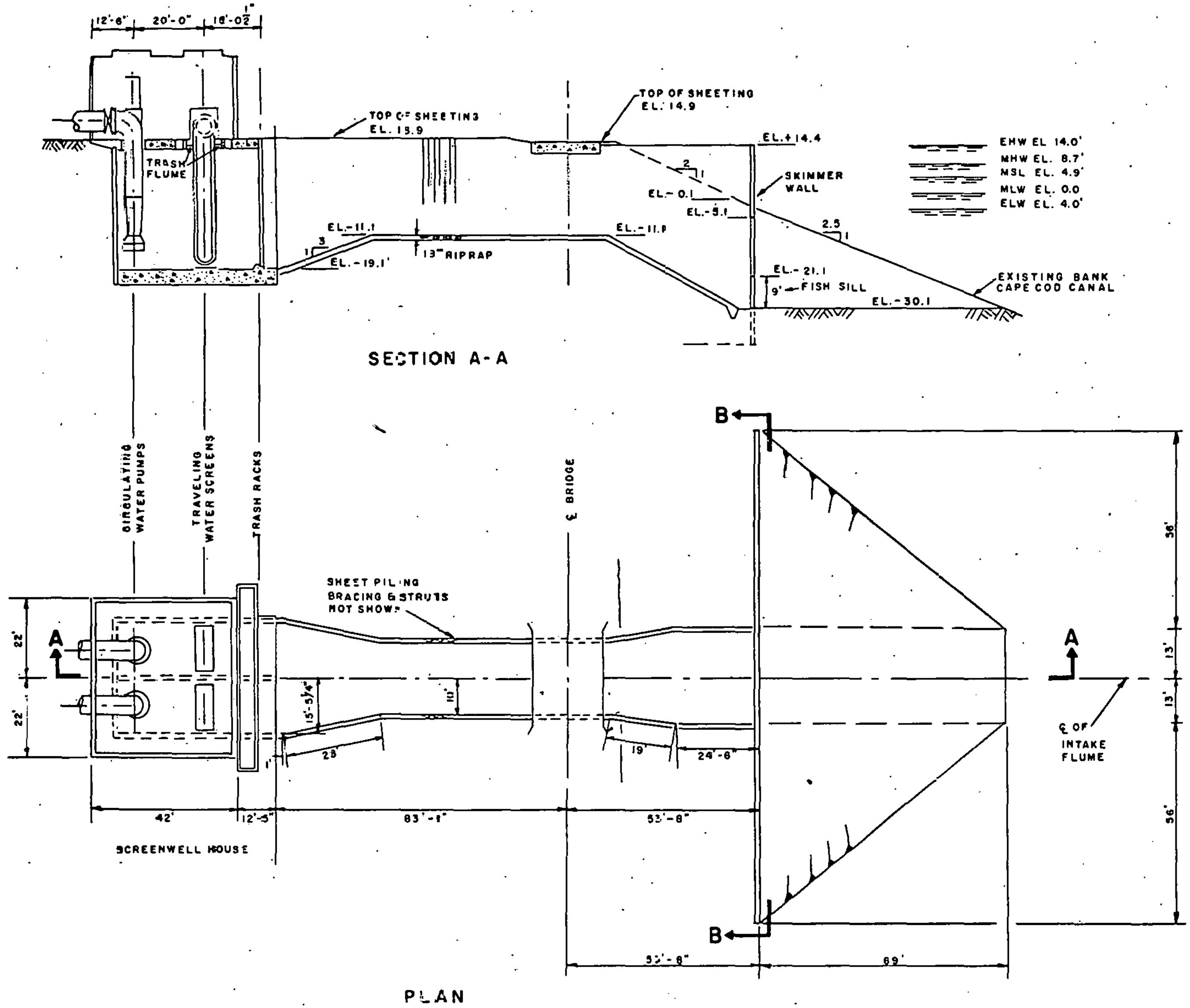


Fig. 3. Screenwell.

Table I. Fishes Recorded in the Cape Cod Canal

Spiny dogfish	Bluefish
Atlantic torpedo	Blue runner
Barndoor skate	Banded rudderfish
Winter skate	Scup
American eel	Tautog
Blueback herring	Cunner
Alewife	Radiated shanny
Atlantic menhaden	Rock gunnel
Atlantic herring	Northern sand lance
Rainbow smelt	Atlantic mackerel
Goosefish	Chub mackerel
Fourbeard rockling	Barrelfish
Atlantic cod	Northern searobin
Atlantic tomcod	Sea raven
Pollock	Grubby
Red hake	Longhorn sculpin
Mummichog	Shorthorn sculpin
Atlantic silverside	Lumpfish
Northern pipefish	Seasnail
Striped bass	Wrymouth
	Windowpane
	Yellowtail flounder
	Winter flounder
	Northern puffer

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Cunner	Blueback Herring	Alewife	Total
1975	7	4,523	954	3,186	11,843

CANAL PLANT UNITS 1 AND 2

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES

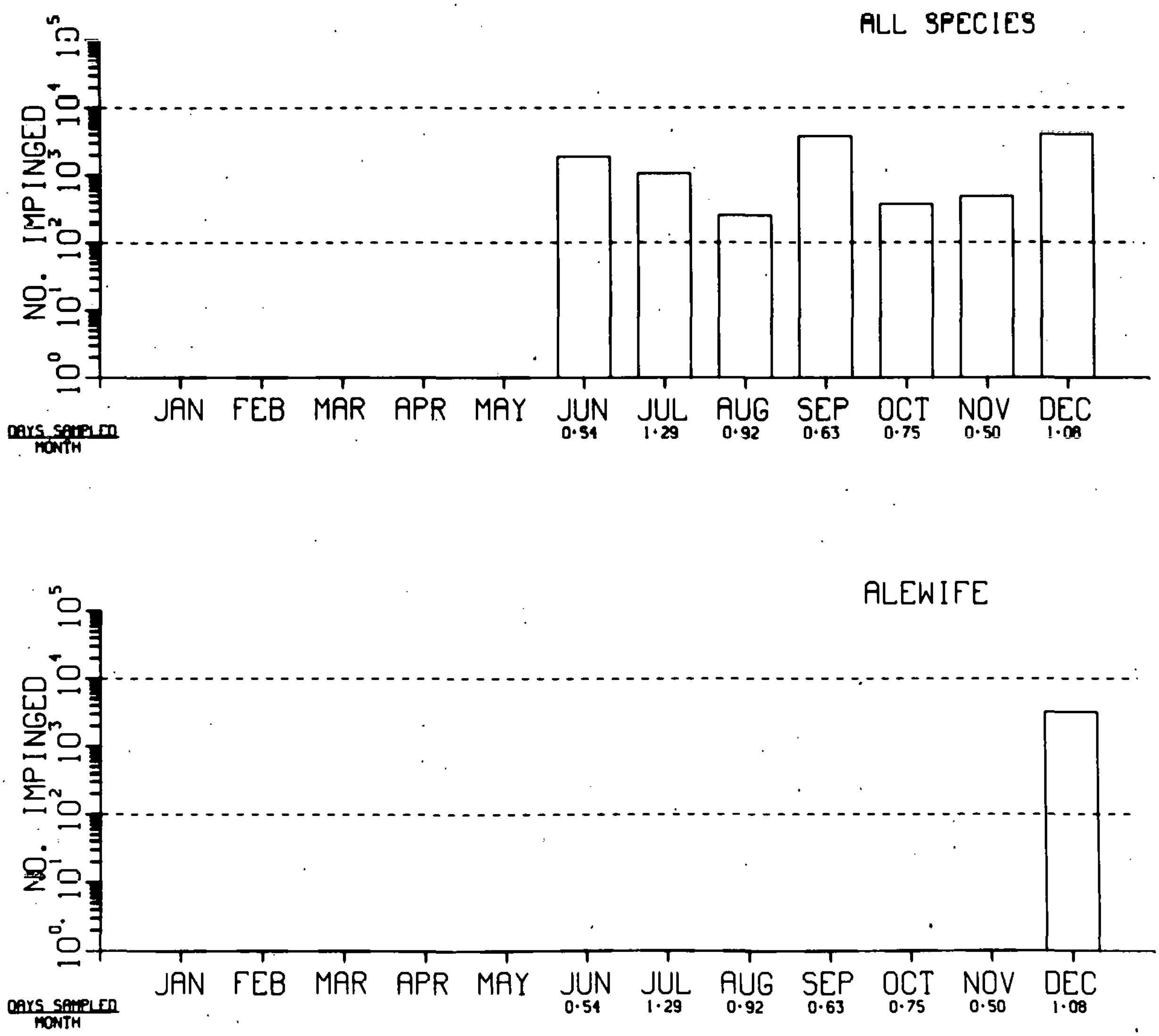
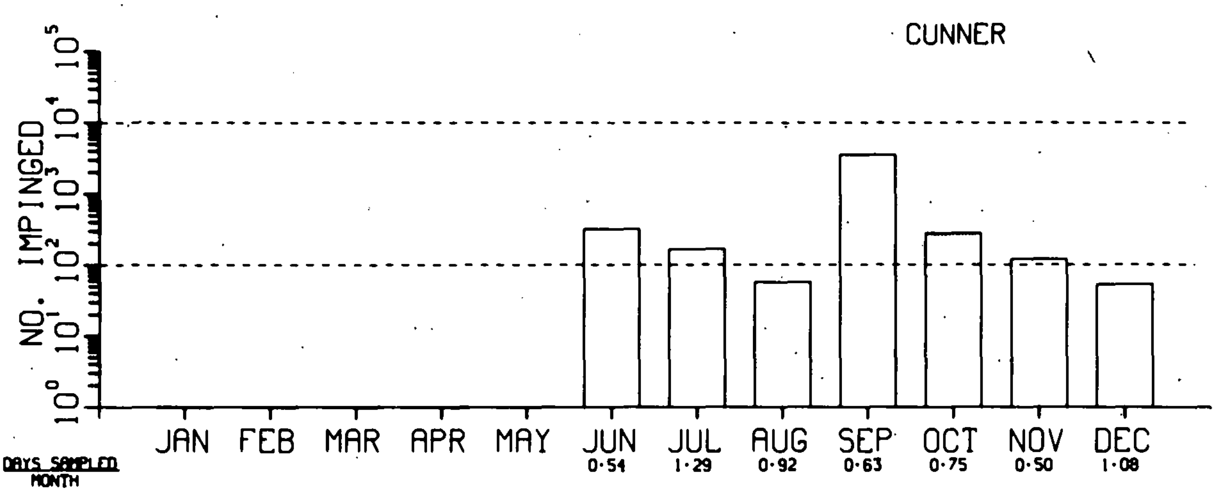


Fig. H1. Impingement Estimates.

CANAL PLANT UNITS 1 AND 2

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



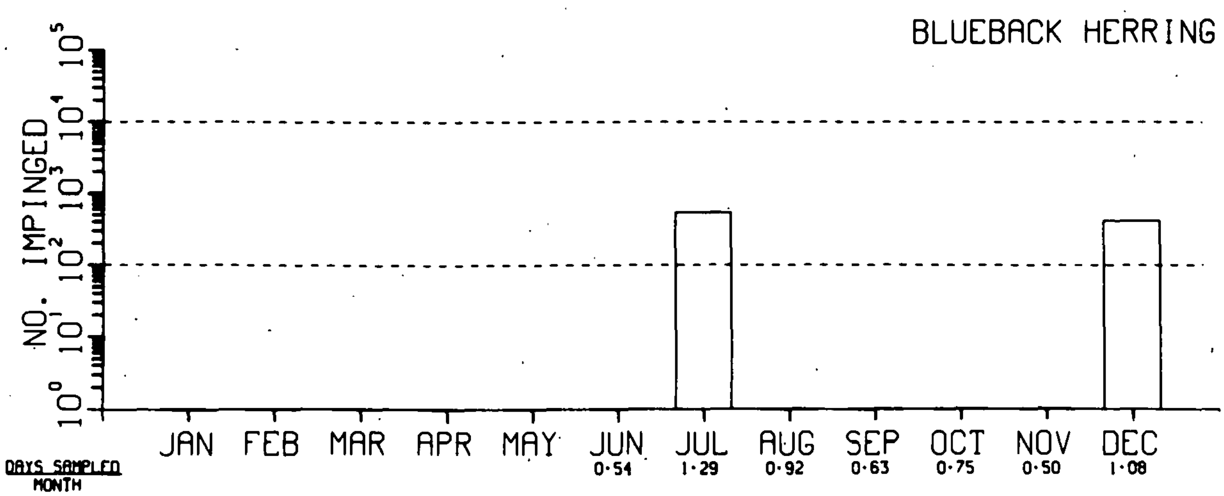


Fig. H2. Impingement Estimates.

BRAYTON POINT STATION UNITS 1-4 (F)

SITE CHARACTERISTICS

Brayton Point Station is located on a 250-acre site in Somerset, Massachusetts, at the confluence of the Lee and Taunton Rivers where they empty into Mount Hope Bay[1] (Fig. 1). Mount Hope Bay lies at the far northeastern corner of Narragansett Bay, which is located principally in Rhode Island.

The plant is located at the south end of a peninsula known as Brayton Point. In addition to the Taunton and Lee Rivers, drainage from the Cole, Kickamuit, and Quequechan Rivers, and tidal influx from the Sakonnet River and Narragansett Bay, make up the Mount Hope Bay system. The total surface area of Mount Hope Bay is 16.7 miles. For purposes of this report, Brayton Point will be treated as a coastal-zone plant, because salinities are always 75% to 85% of normal oceanic values (average 23.7 ppt). Water temperatures range from 72°F to 83°F in the summer.

Ichthyofauna in Mount Hope Bay is fairly diverse. Fifty species of fish were captured in the Brayton Point area during the ecological surveys.[1] Of these, nine species were shallow-water fishes, 17 species were demersal, and 24 species were pelagic (Table 1).

PLANT DESCRIPTION

Brayton Point is a four-unit oil-fired facility rated at a total of 1590 MWe. Units 1 and 2 are rated at 250 MWe each, and Unit 3 is rated at 652 MWe. The station employs once-through cooling. Unit 4 is rated at 465 MWe and employs closed-cycle cooling (spray canals) and derives its makeup water from the Unit 3 intake structure (Fig. 2).

INTAKE DESIGN AND OPERATION

The three intakes for the four units constitute a structure 140 feet wide with openings 20 feet below mean low water. Intake velocities at the trash racks are 1.36 fps for Units 1 and 2 and 1.56 fps for Unit 3. Six circulating-water pumps draw water through traveling screens with 3/8-inch mesh at the rate of 630,000 gpm, which includes 10,000 gpm makeup water for Unit 4. Screens are rotated intermittently to remove debris. Fixed screens are set in place on the trash bars from May to November to prevent the impingement of horseshoe crabs. It is not known whether this took place every year. A side view of the intake forebay for Units 3 and 4 is shown in Figure 3.

IMPINGEMENT SAMPLING

The first record of impingement sampling is for 1971, when data on impingement with and without fixed screens are given for Units 1-3 in the Environmental Impact Statement for the proposed Unit 4. Sampling schemes varied from three days per week to continuous sampling, but in all cases the numbers obtained were extrapolated to yield projected weekly totals. If large numbers of fish were obtained, as was the case with Atlantic menhaden, volumetric subsampling was used. Each year the fixed screens were remounted in May, and impingement totals on those screens were added to those on the traveling screens.

DATA AVAILABILITY

Data are available from May 1971 through January 1975.[2-15] Fixed and traveling-screen data have been combined by month to determine total impingement.

IMPINGEMENT DATA SUMMARY

Data are summarized in Table II. In 1971 the threespine stickleback was the third most numerous species, but was replaced thereafter by winter flounder. The other two most numerous species were Atlantic menhaden and Atlantic silverside. Periodic large numbers of alewife, silver hake, white hake, tautog, and windowpane have also been reported. Histograms summarizing the monthly impingement totals for Brayton Point are presented in Figures H1 through H6. Data for 1975 are not included in the histograms because only one month was sampled. Totals for 1975 appear in Table II.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The intake channel was widened in order to reduce the intake velocity from 1.5 fps to 0.7 fps at the trash bars. No evaluation of this measure is currently available.[1] Unit 4 employs closed-cycle cooling (spray canals).

REFERENCES

1. "Final Environmental Statement, Addition of Unit Number 4, Brayton Point Generating Station, Somerset, Massachusetts." U. S. Corps of Engineers. August 1973.

2. "Brayton Point Investigations, Quarterly Progress Report, August-October 1971." Marine Research, Inc., Marion, Mass. 19 November 1971.

3. "Brayton Point Investigations, Quarterly Progress Report, November 1971-January 1972." Marine Research, Inc., East Wareham, Mass. 21 February 1972.

4. "Brayton Point Investigations, Quarterly Progress Report, February-April 1972." Marine Research, Inc., East Wareham, Mass. 16 June 1972.

5. "Brayton Point Investigations, Quarterly Progress Report, May-July 1972." Marine Research, Inc., East Wareham, Mass. 12 October 1972.

6. "Brayton Point Investigations, Quarterly Progress Report, August-October 1972." Marine Research, Inc., East Wareham, Mass. 4 January 1973.

7. "Brayton Point Investigations, Quarterly Progress Report, November 1972-January 1973." Marine Research, Inc., East Wareham, Mass. 13 April 1973.

8. "Brayton Point Investigations, Quarterly Progress Report, February-April 1973." Marine Research, Inc., East Wareham, Mass. 31 July 1973.

9. "Brayton Point Investigations, Quarterly Progress Report, May-July 1973." Marine Research, Inc., East Wareham, Mass. 15 November 1973.

10. "Brayton Point Investigations, Quarterly Progress Report, August-October 1973." Marine Research, Inc., East Wareham, Mass. 28 February 1974.

11. "Brayton Point Investigations, Quarterly Progress Report, November 1973-January 1974." Marine Research, Inc., East Wareham, Mass. 20 May 1974.

12. "Brayton Point Investigations, Quarterly Progress Report, February-April 1974." Marine Research, Inc., East Wareham, Mass. 26 August 1974.

13. "Brayton Point Investigations, Quarterly Progress Report, May-July 1974." Marine Research, Inc., Falmouth, Mass. 31 December 1974.

14. "Brayton Point Investigations, Quarterly Progress Report, August-October 1974." Marine Research, Inc., Falmouth, Mass. 7 March 1975.

15. "Brayton Point Investigations, Quarterly Progress Report, November 1974-January 1975." Marine Research, Inc., Falmouth, Mass. 30 June 1975.

Fig. 1. Station Location.

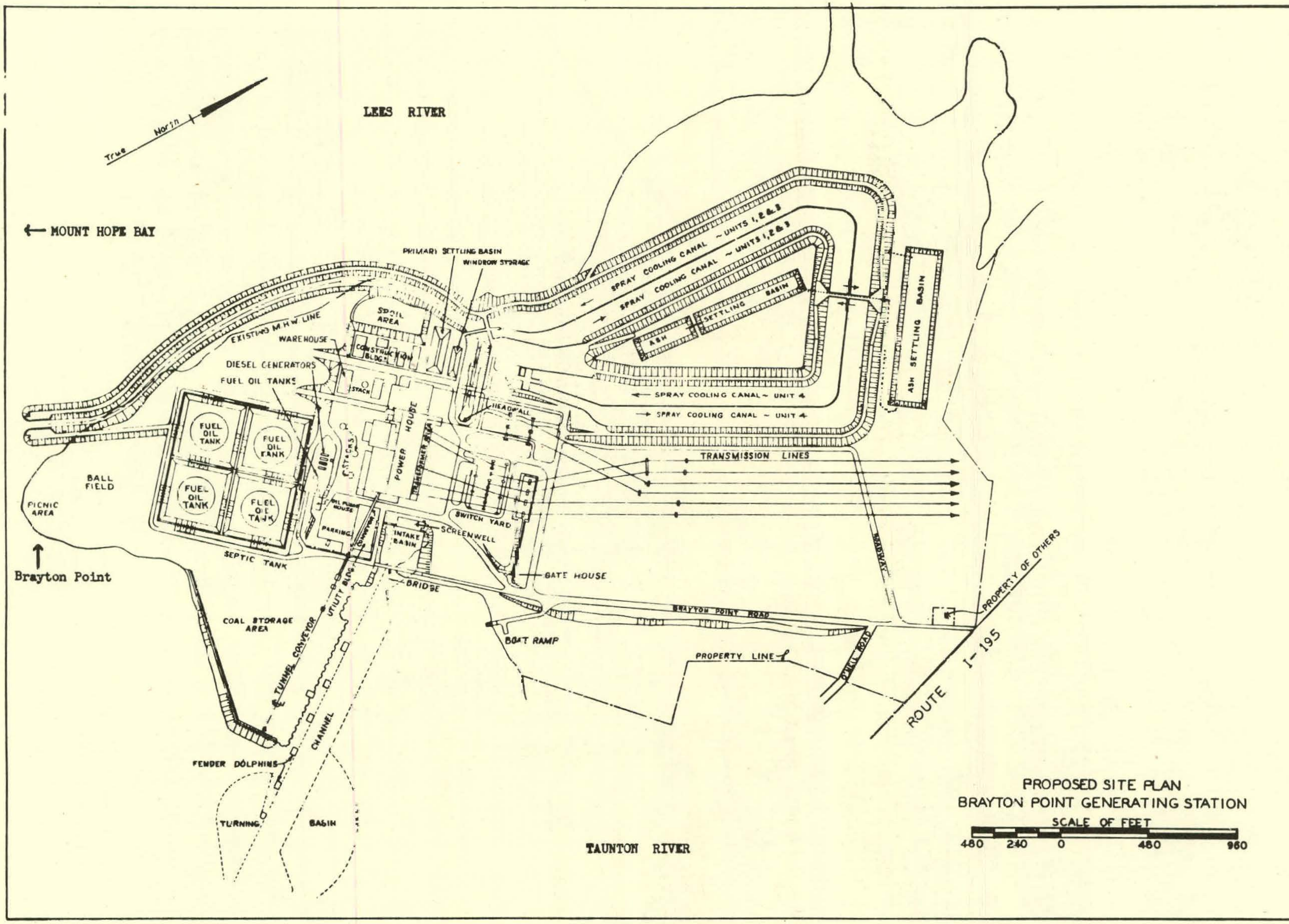


Fig. 2. Site Plan.

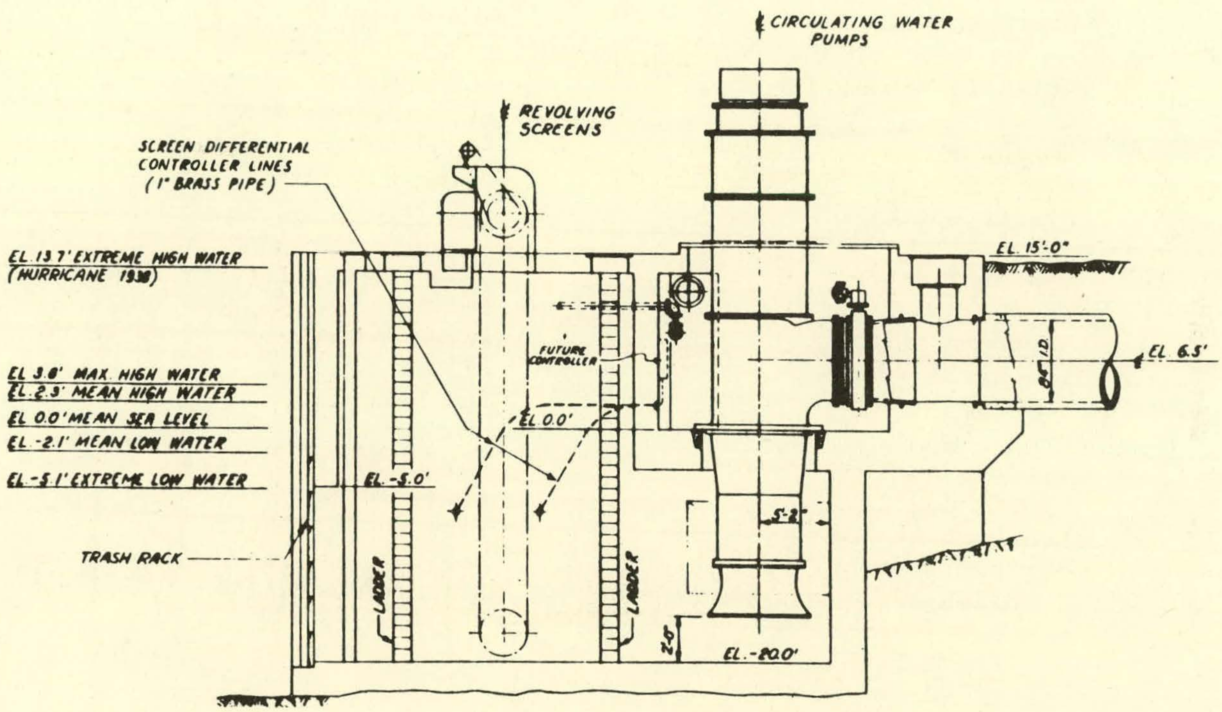


Fig. 3. Intake Forebay for Units 3 & 4.

Table I. Finfish Identified in the Station Area

Atlantic silverside	Atlantic tomcod
Mummichog	Alewife
Striped killifish	Atlantic menhaden
Fourspine stickleback	Blueback herring
Ninespine stickleback	Northern kingfish
Threespine stickleback	Bluefish
Tidewater silverside	Crevalle jack
Sheepshead minnow	Weakfish
Blue runner	Scup
Northern pipefish	White perch
Atlantic needlefish	Striped bass
Cunner	Atlantic herring
Hogchoker	Round herring
American eel	Striped mullet
Oyster toadfish	Spot
Winter flounder	Butterfish
Northern searobin	Permit
Northern puffer	Rainbow smelt
Tautog	Silver hake
Lookdown	Red hake
Windowpane	Bay anchovy
Smooth dogfish	Bigeye scad
Longhorn sculpin	Planehead filefish
Striped searobin	African pompano
Lumpfish	Atlantic moonfish

Table II. Summary of Fish Impingement Data for Units 1-3

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		Threespine Stickleback	Atlantic Menhaden	Atlantic Silverside	Winter Flounder	Total
1971	2	855	501,726	1,025		508,861
1972	12		238,778	42,405	20,491	355,566
1973	12		11,634	2,096	19,335	63,663
1974	12		11,666	3,780	16,119	53,054
1975	1		342	50	735	2,509

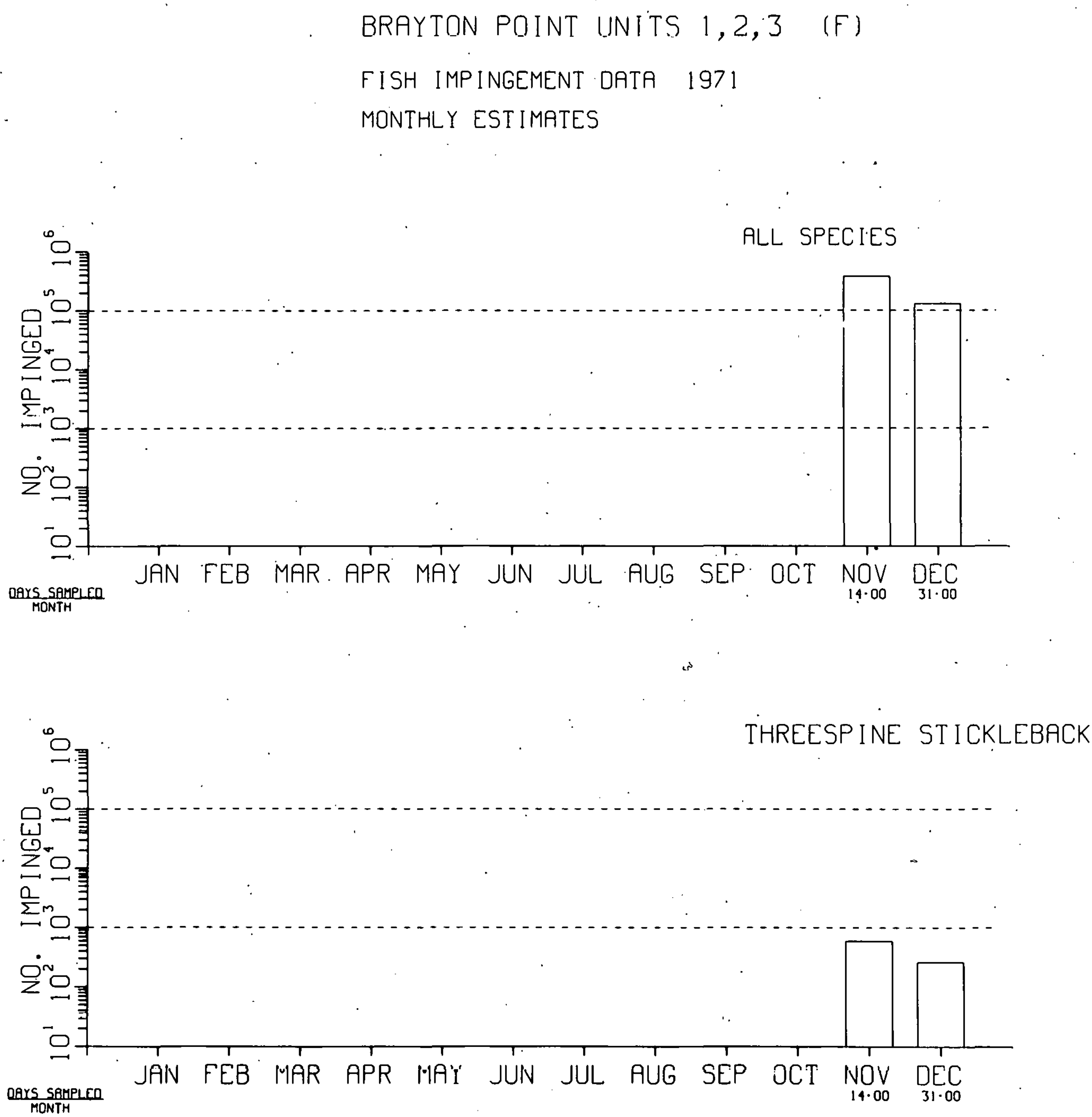


Fig. H1. Impingement Estimates.

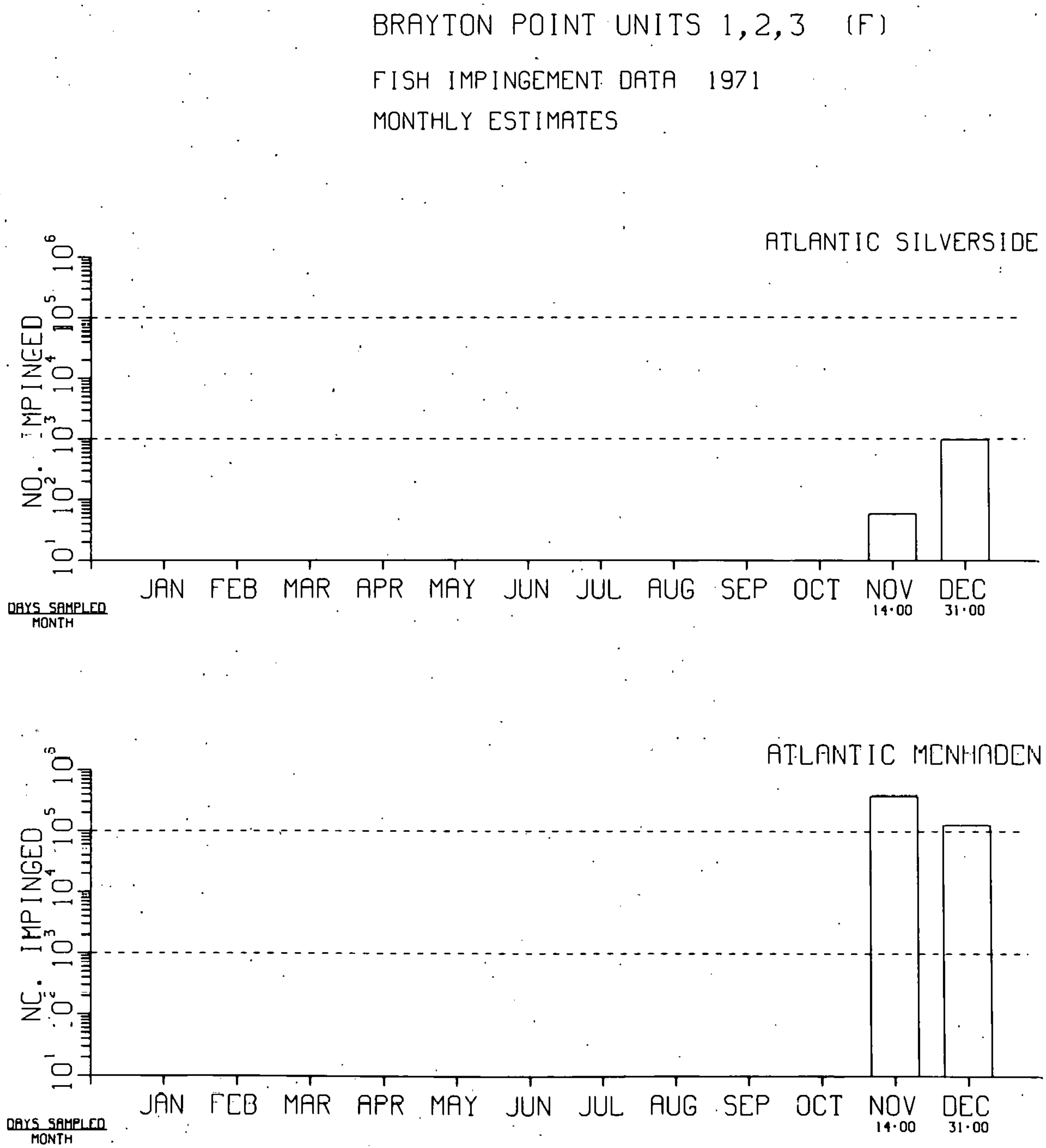


Fig. H2. Impingement Estimates.

BRAYTON POINT UNITS 1,2,3 (F)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

ALL SPECIES

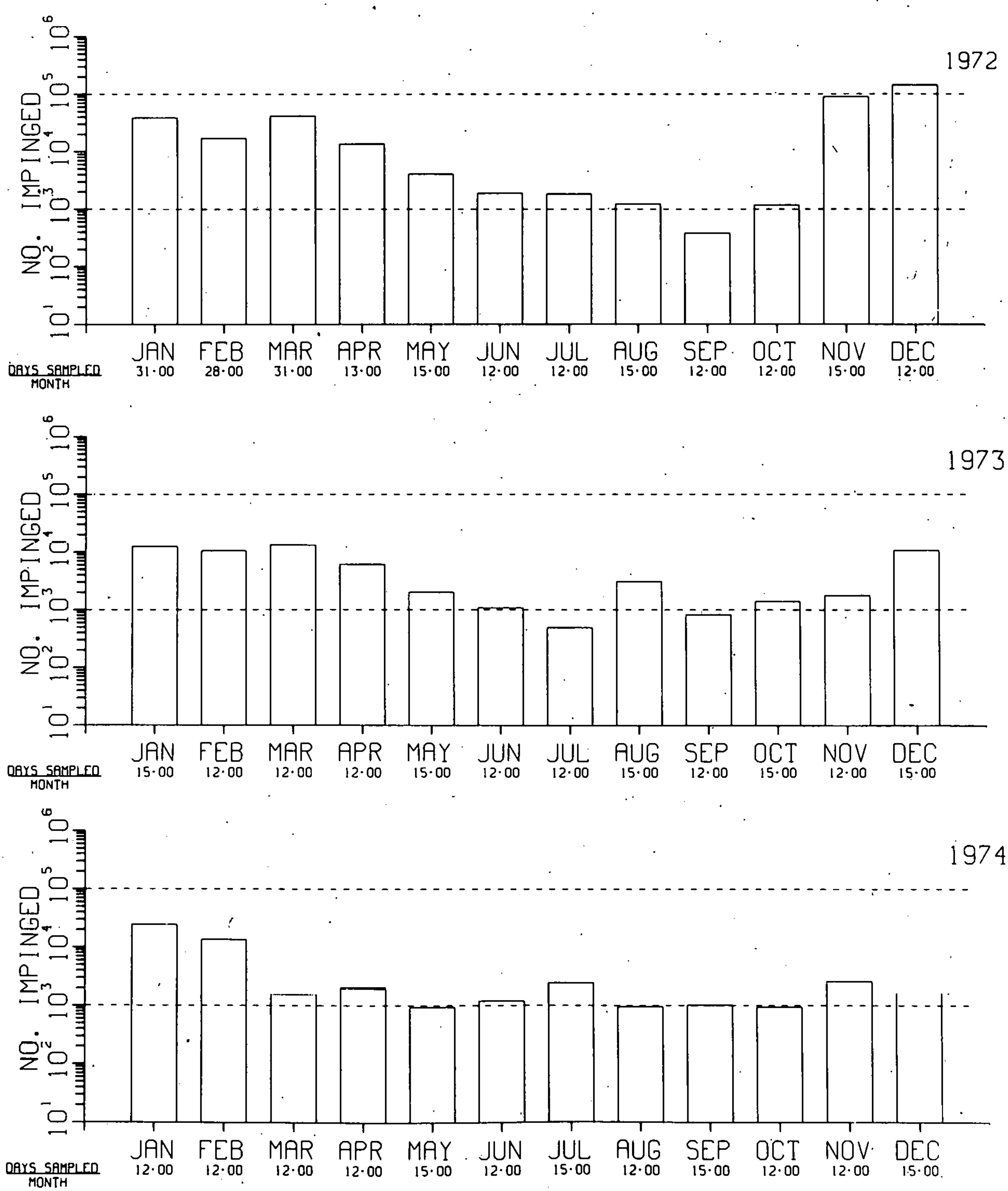


Fig. H3. Impingement Estimates.

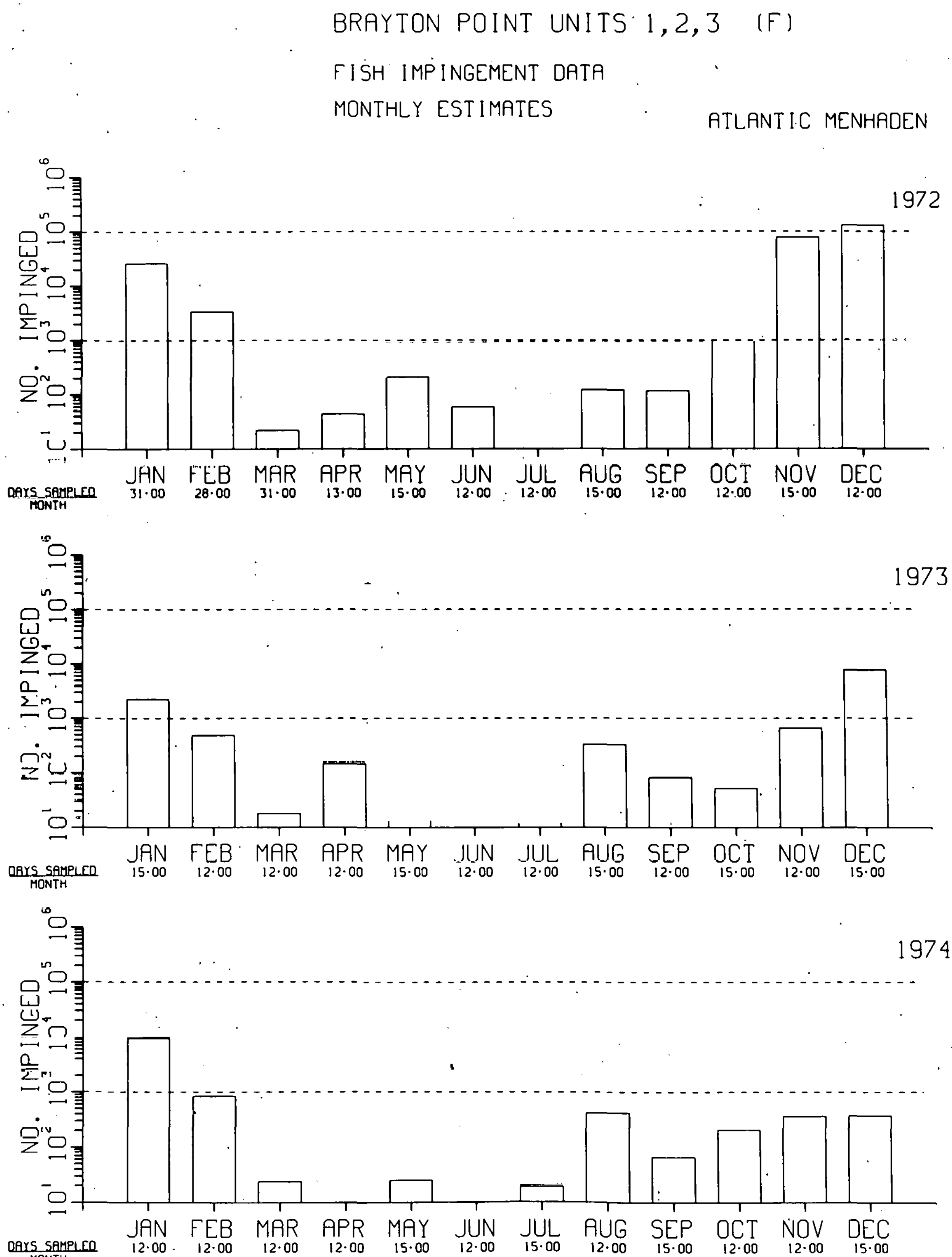


Fig. H4. Impingement Estimates.

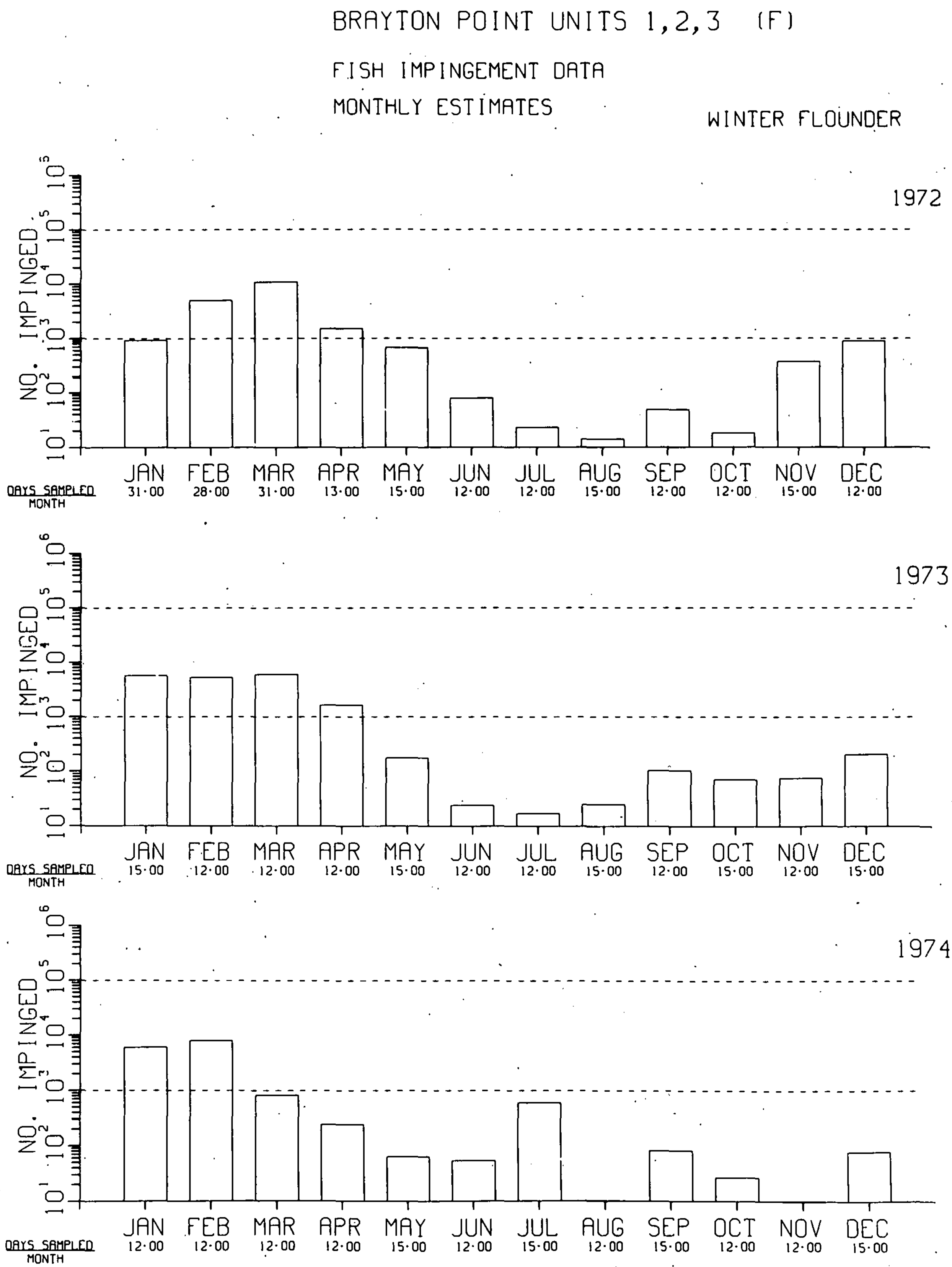


Fig. H5. Impingement Estimates.

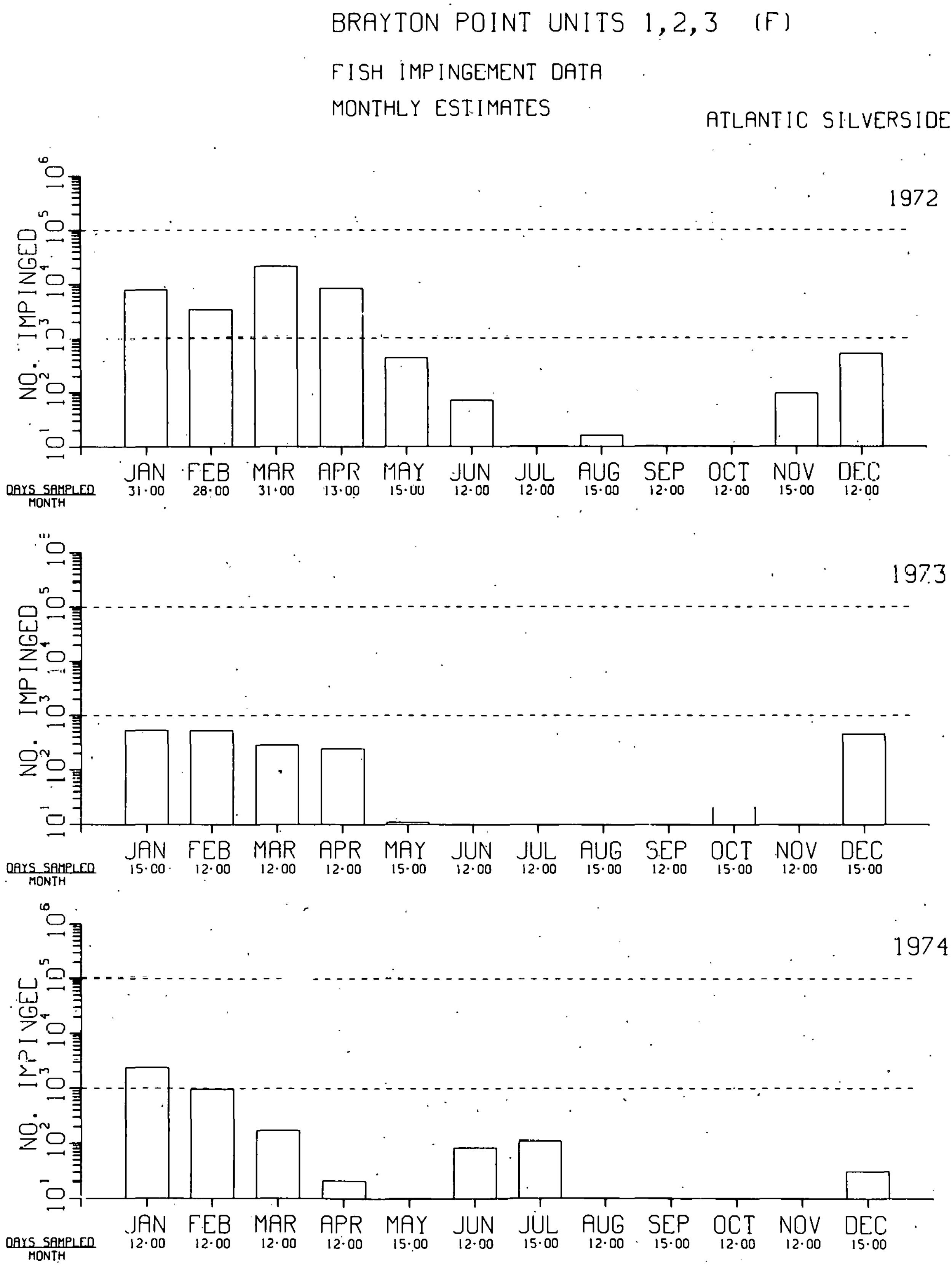


Fig. H6. Impingement Estimates.

MILLSTONE NUCLEAR POWER STATION UNITS 1 AND 2 (N)

SITE CHARACTERISTICS

The Millstone Nuclear Power Station is located in Waterford, Connecticut, on the north shore of Long Island Sound.[1] The main station complex is located on a peninsula jutting into the Sound and bounded on the west by Niantic Bay, from which it draws its cooling water (Fig. 1). A quarried bay to the southwest of the plant receives the discharge, which eventually empties into Twotree Island Channel (Fig. 2). This location is 3.2 miles west-southwest of New London and 40 miles southeast of Hartford, Connecticut. The site occupies about 500 acres of land.

The tide in Long Island Sound near Millstone Point ebbs and flows twice daily with a mean range of 2.7 feet and a spring range of 3.2 feet. This tidal influence creates strong offshore currents averaging 0.857 fps. This average tidal velocity corresponds to a mean tidal flow of 56.6×10^6 gpm in Twotree Island Channel.

Surface temperature of the water at Millstone Point was monitored from 1966 to 1970. It varied from 31°F to 36°F in January and February to 75°F in July and August. There was no significant horizontal variation in temperature or salinity with depth at any location sampled around Millstone Point. This indicates very thorough mixing by mechanical turbulence.

A list of fishes impinged at the intake screens of Unit 1 is given in Table I. In all, 70 species are represented, and probably comprise most of the species found at the site and in the immediate environs.

PLANT DESCRIPTION

The station includes two light water reactors of different designs. Unit 1 is a boiling water reactor rated at 652 MWe. Unit 2 is a pressurized water reactor and is rated at 830 MWe. A once-through cooling system is used. Major components of the system and their spatial relationship to the rest of the plant are shown in Figure 2.

INTAKE DESIGN AND OPERATION

The intake structure for Unit 1 contains four circulating-water pumps supplying cooling water at 448,800 gpm to the condensers (Fig. 3). In addition, four one-third-capacity service-water pumps rated at 10,000 gpm each furnish auxiliary water. They are located in the outer bay of the five-bay intake structure. The outermost feature of the intake is the curtain wall, which is followed by bar racks and traveling screens (Fig. 3). The number of traveling screens is not given. The water velocity approaching the screens ranges from 0.5 to 0.9 fps, whereas the water velocity through the screens is 2.0 fps.

The water intake for Unit 2 is identical in structure to that of Unit 1, but not so in design or operational parameters. The circulating-water pumps supply 585,600 gpm cooling water to the condensers. In addition, three one-half-capacity service-water pumps rated at 12,000 gpm each provide auxiliary water. The water velocity in the dredged channel in front of the intake is 0.5 fps. The water velocity through the traveling screens is estimated at 1.66 fps. Natural recirculation from the discharge does not exceed 2.5% according to tracer-dye studies.

IMPINGEMENT SAMPLING

The AEC environmental technical specifications for Millstone Units 1 and 2 provide for impingement sampling on a daily basis.[2] Data exist for Unit 1 but not for Unit 2. Two daily counts encompassing the previous 12-hour catch were made daily. Organisms collected were counted and measured.

DATA AVAILABILITY

Data for Unit 1 are available for 1972, 1973, and 1974.[3]

IMPINGEMENT DATA SUMMARY

Table II summarizes the yearly totals for the three most numerous species and the total species counts for 1972, 1973, and 1974. There were five most numerous species taken in the three-year study. The threespine stickleback and the grubby were also impinged to the same degree as the windowpane, but not in the same years. The total impingement of 65,109 over the three-year study included 72 species of fish. Histograms for the yearly data are presented in Figures H1 through H6.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

A cofferdam-like structure is present at the intakes and it is suggested that this may provide a calm-water area in which fish may congregate, which is a disadvantage in preventing impingement. Low water velocities, elimination of shoreline recesses, and lateral exit passages are design measures that seek to minimize the impact of impingement. Ideas such as electric shocking fences and booms with nets have been proposed, but none have been used at the station.

REFERENCES

1. "Final Environmental Statement, Millstone Units 1 and 2." USAEC Directorate of Licensing. Docket Nos. 50-245 and 50-336. June 1973.

2. Provisional Operating License for Millstone Units 1 and 2, DPR-21. USAEC Directorate of Licensing. October 1970.

3. "Summary Report of Ecological and Hydrographic Studies at Millstone Units 1 and 2, May 1966 to December 1974." Millstone Power Co. 1975.

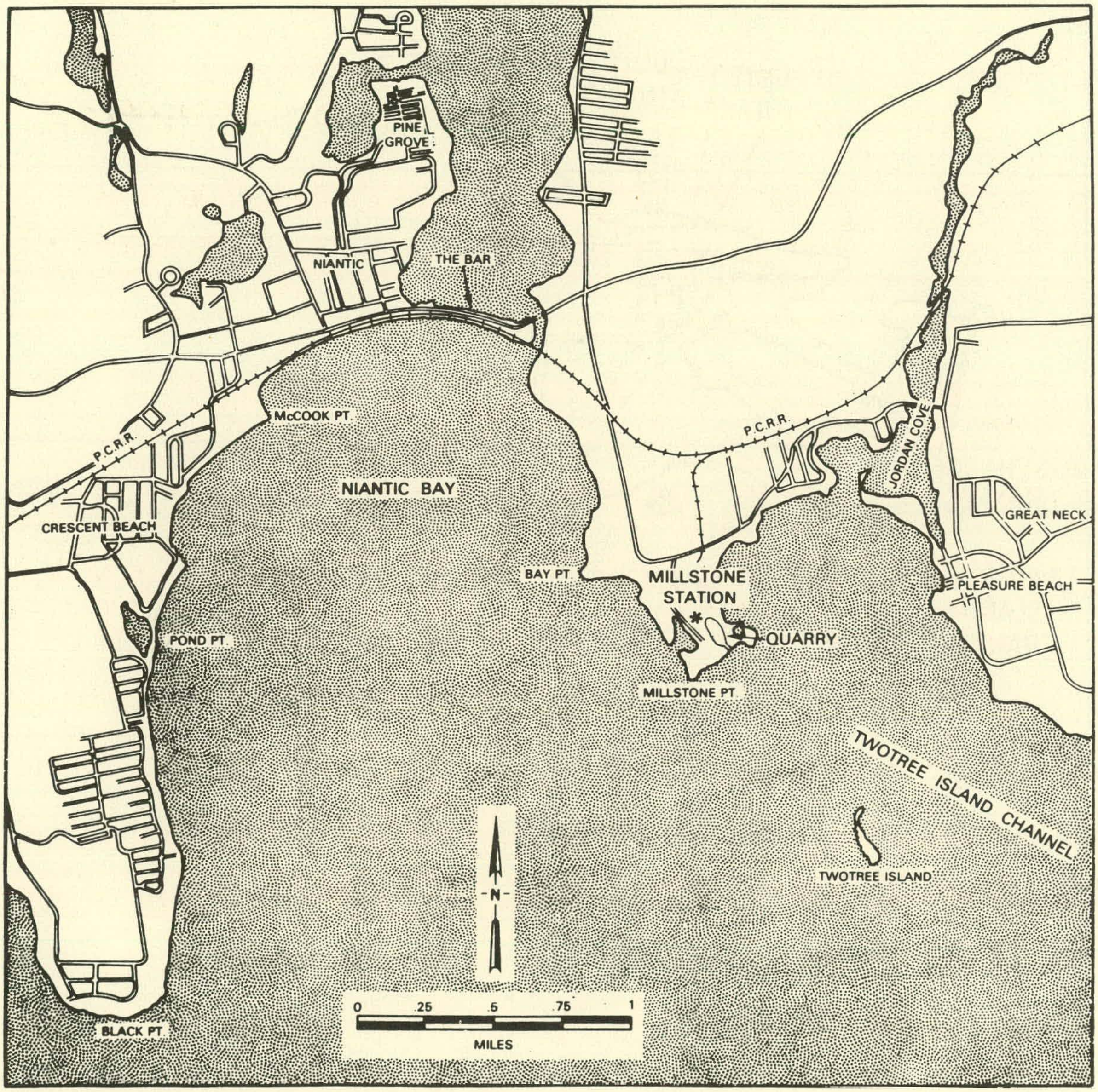


Fig. 1. Station Location.

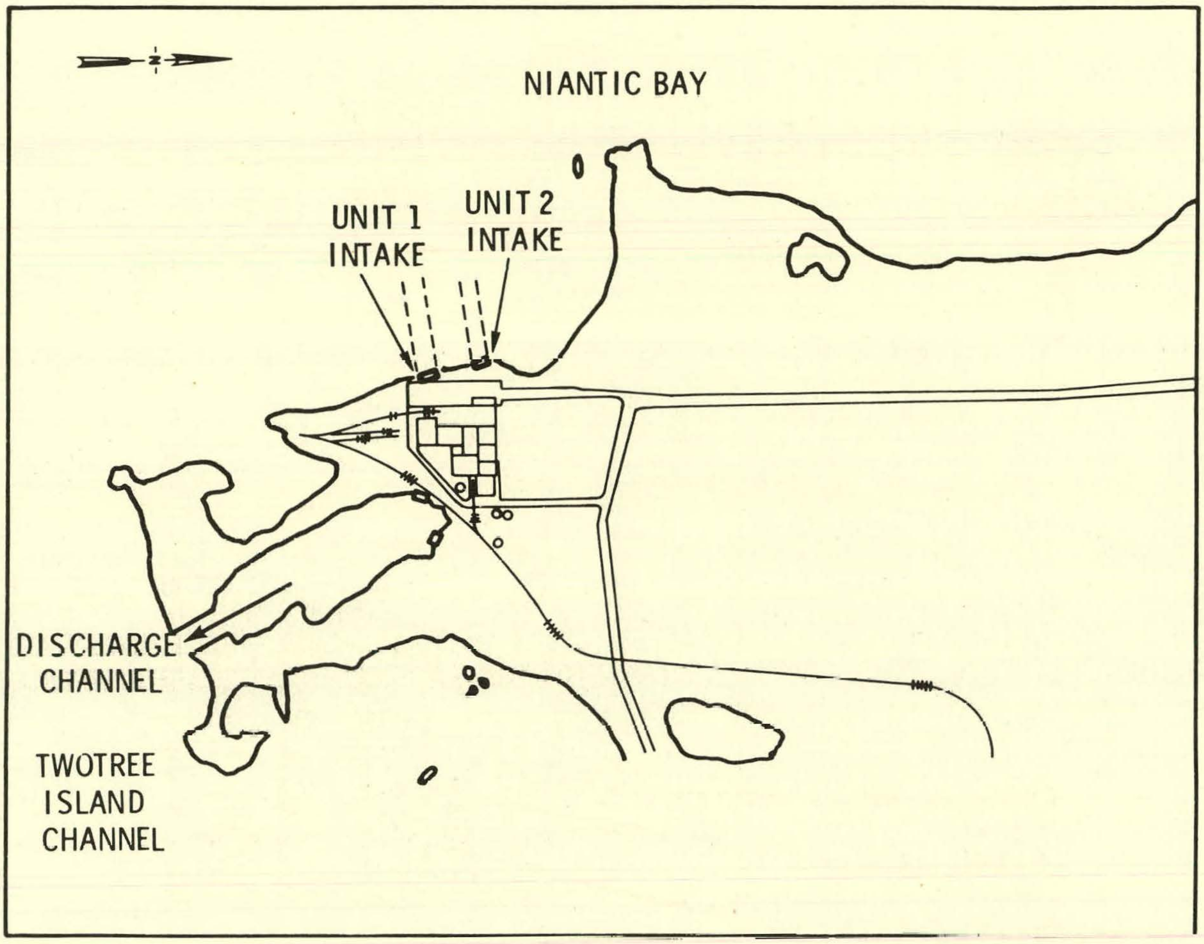


Fig. 2. Circulating-Water Intake and Discharge Locations.

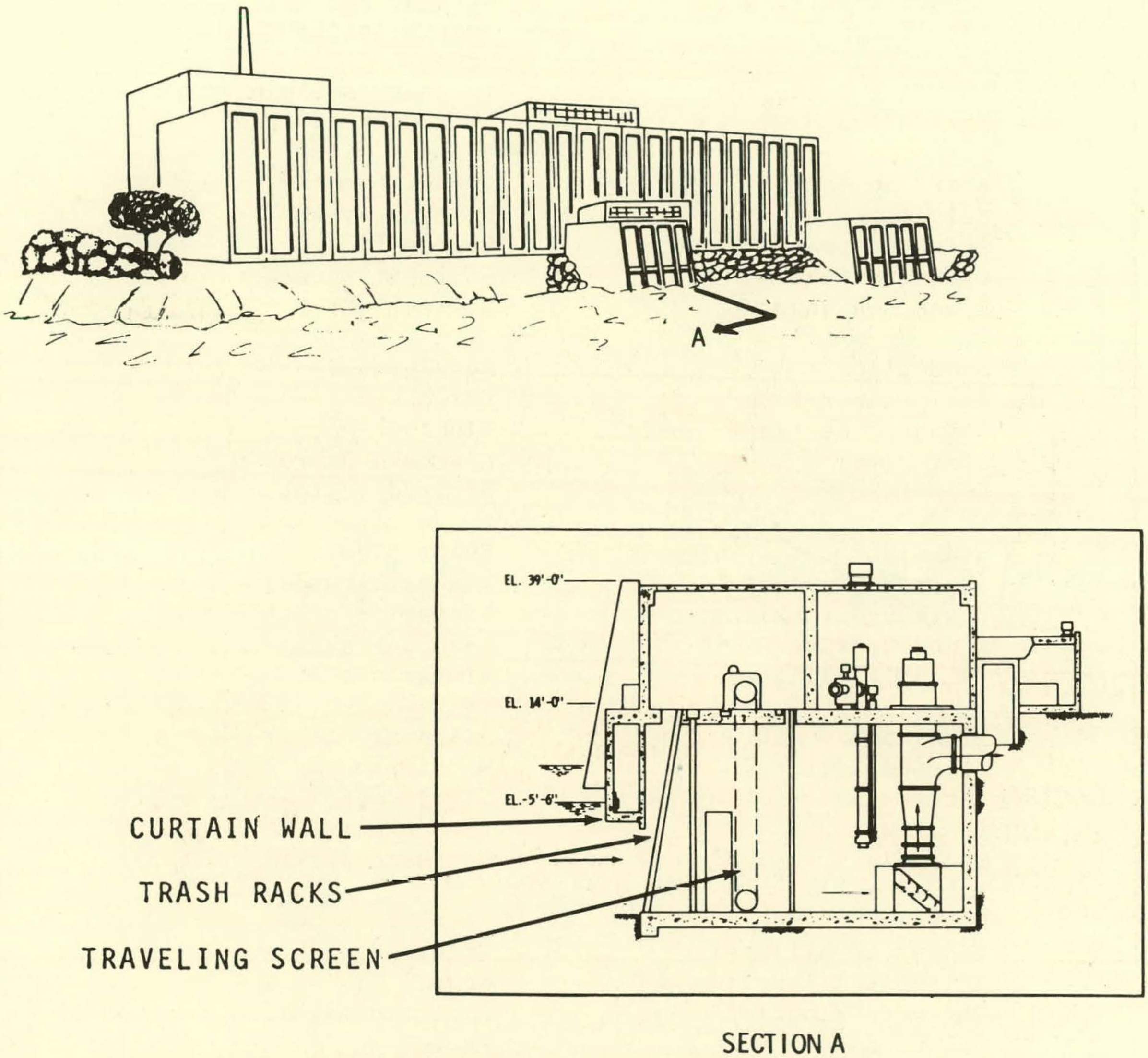


Fig. 3. Circulating-Water Intake Structures for Units 1 and 2.

Table I. Fishes Impinged on Screens at Unit 1

Blueback herring	Striped mullet
Alewife	Smooth dogfish
Trumpetfish	Grubby
American sand lance	Longhorn sculpin
Striped anchovy	Shorthorn sculpin
American eel	Oyster toadfish
Silver perch	Rainbow smelt
Atlantic menhaden	Summer flounder
Crevalle jack	Fourspot flounder
Black sea bass	Butterfish
Sand tiger	Rock gunnel
Striped burrfish	Pollock
Atlantic herring	Bluefish
Conger eel	Northern searobin
Lumpfish	Striped searobin
Weakfish	Short bigeye
Sheepshead minnow	Winter flounder
Fourbeard rockling	Ninespine stickleback
Round herring	Barndoor skate
Banded killifish	Winter skate
Mummichog	Atlantic mackerel
Striped killifish	Windowpane
Threespine stickleback	Bigeye scad
Sea raven	Lookdown
Goosefish	Northern puffer
Ocean pout	Northern sennet
Tidewater silverside	Spiny dogfish
Atlantic silverside	Scup
Northern kingfish	Northern pipefish
Silver hake	Tautog
Atlantic tomcod	Cunner
Atlantic croaker	Hogchoker
Planehead filefish	Red hake
White perch	White hake
Striped bass	Atlantic moonfish

Table II. Summary of Fish Impingement Data at Unit 1

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Atlantic Menhaden	Winter Flounder	Windowpane	Total
1972	12	2,022	1,910	1,555	15,641
1973	12	1,447	6,155	715	30,412
1974	12	190	3,718	213	19,056

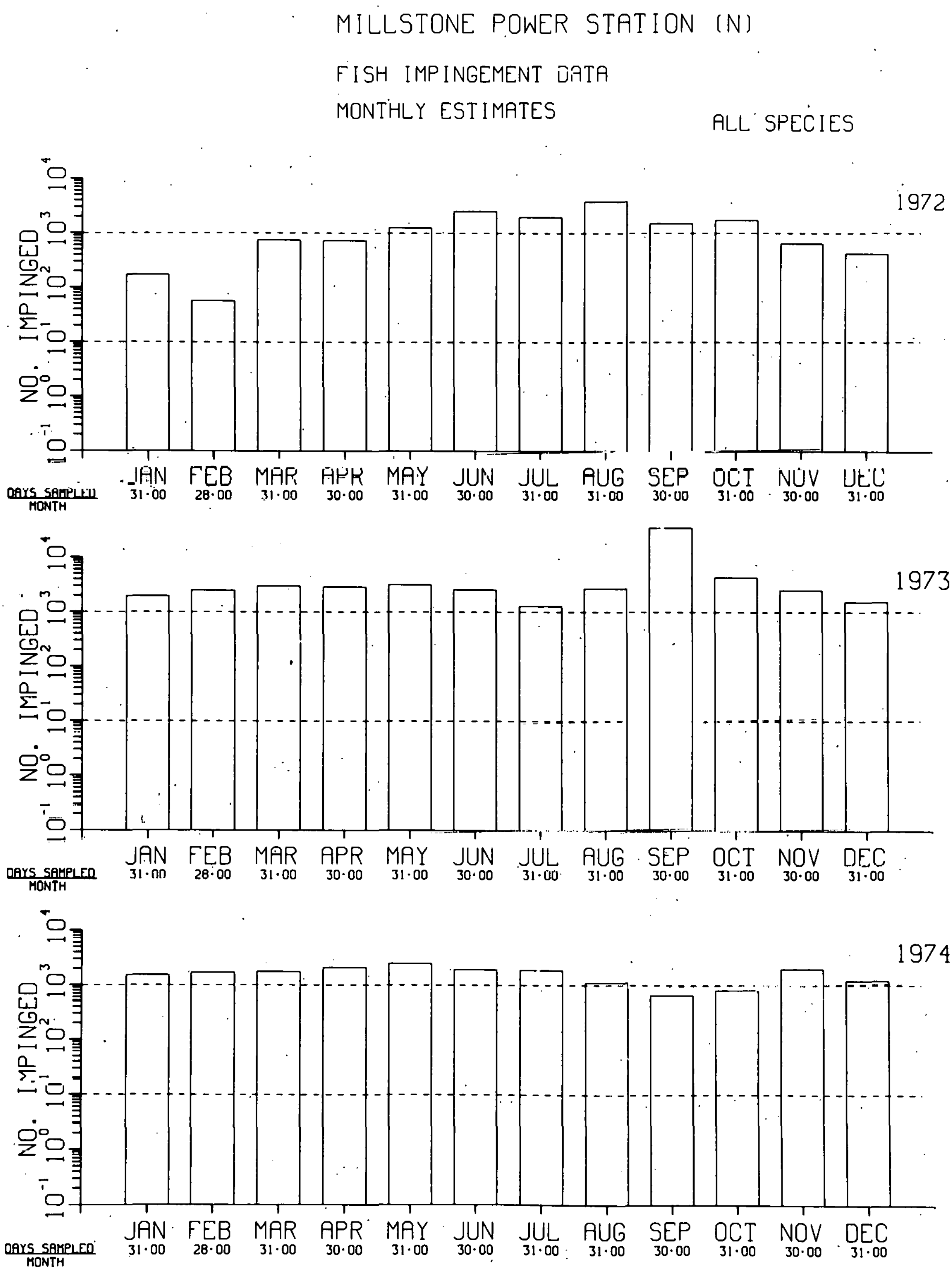


Fig. H1. Impingement Estimates.

MILLSTONE POWER STATION (N)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

ATLANTIC MENHADEN

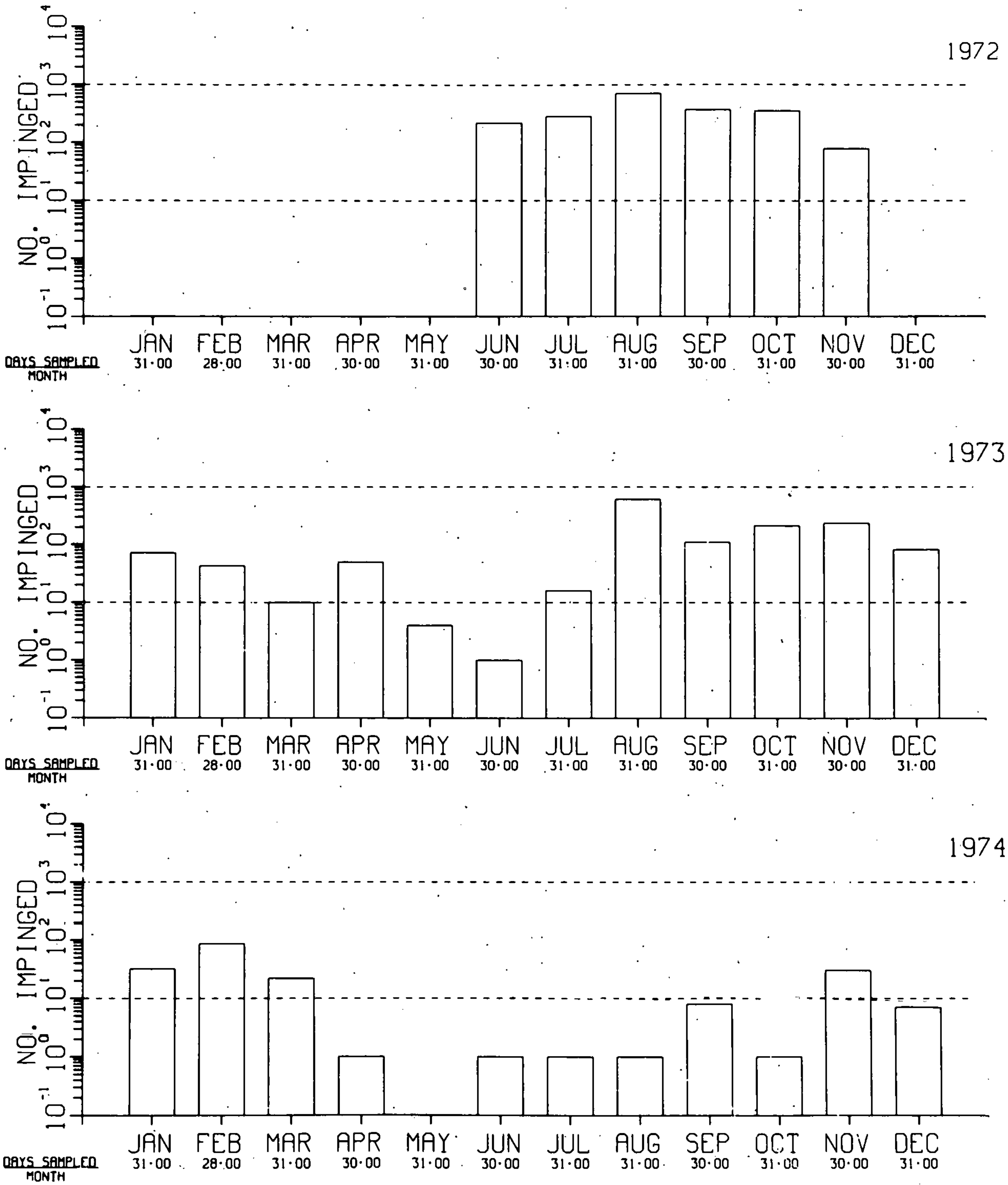


Fig. H2. Impingement Estimates.

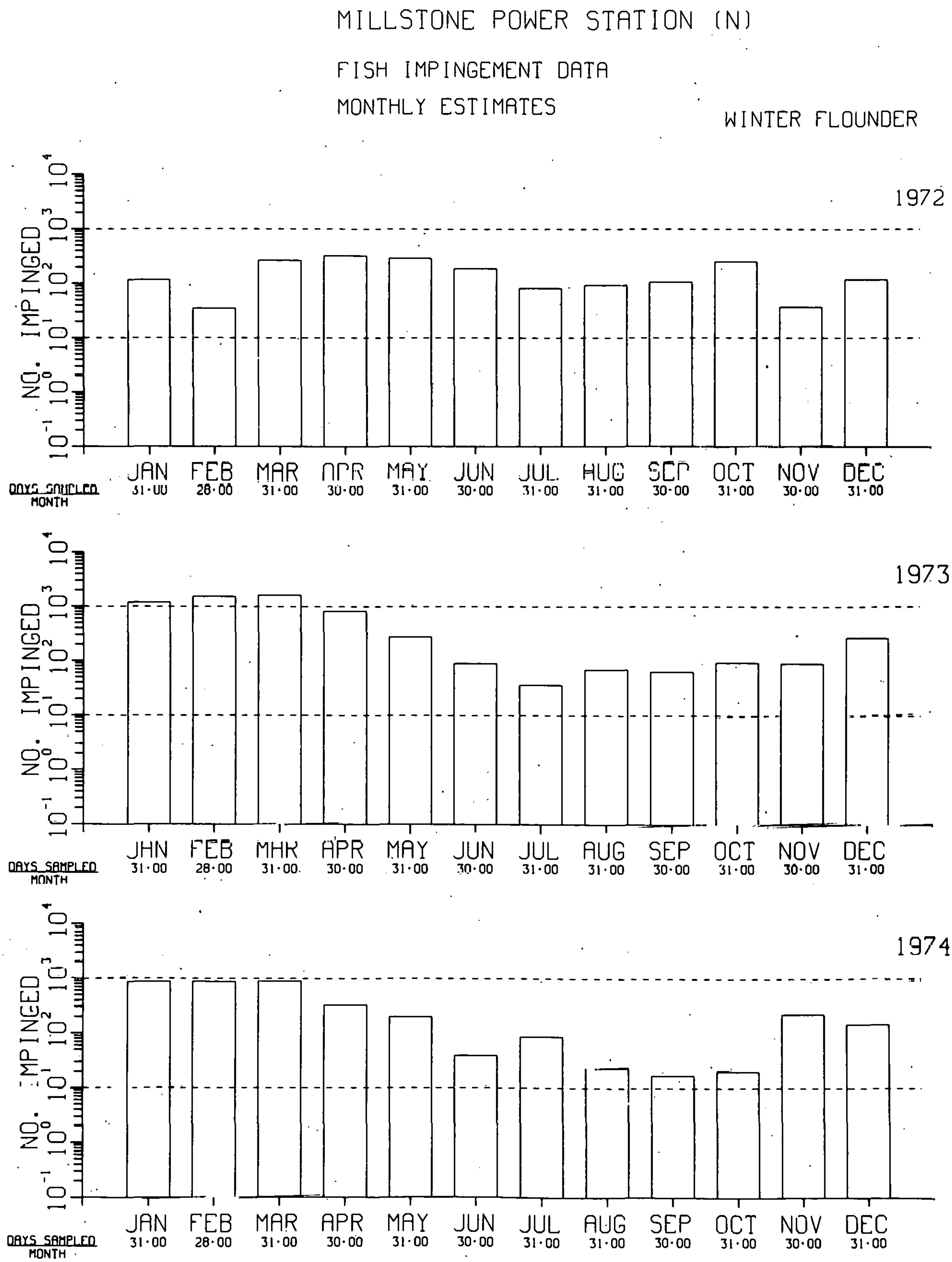


Fig. H3. Impingement Estimates.

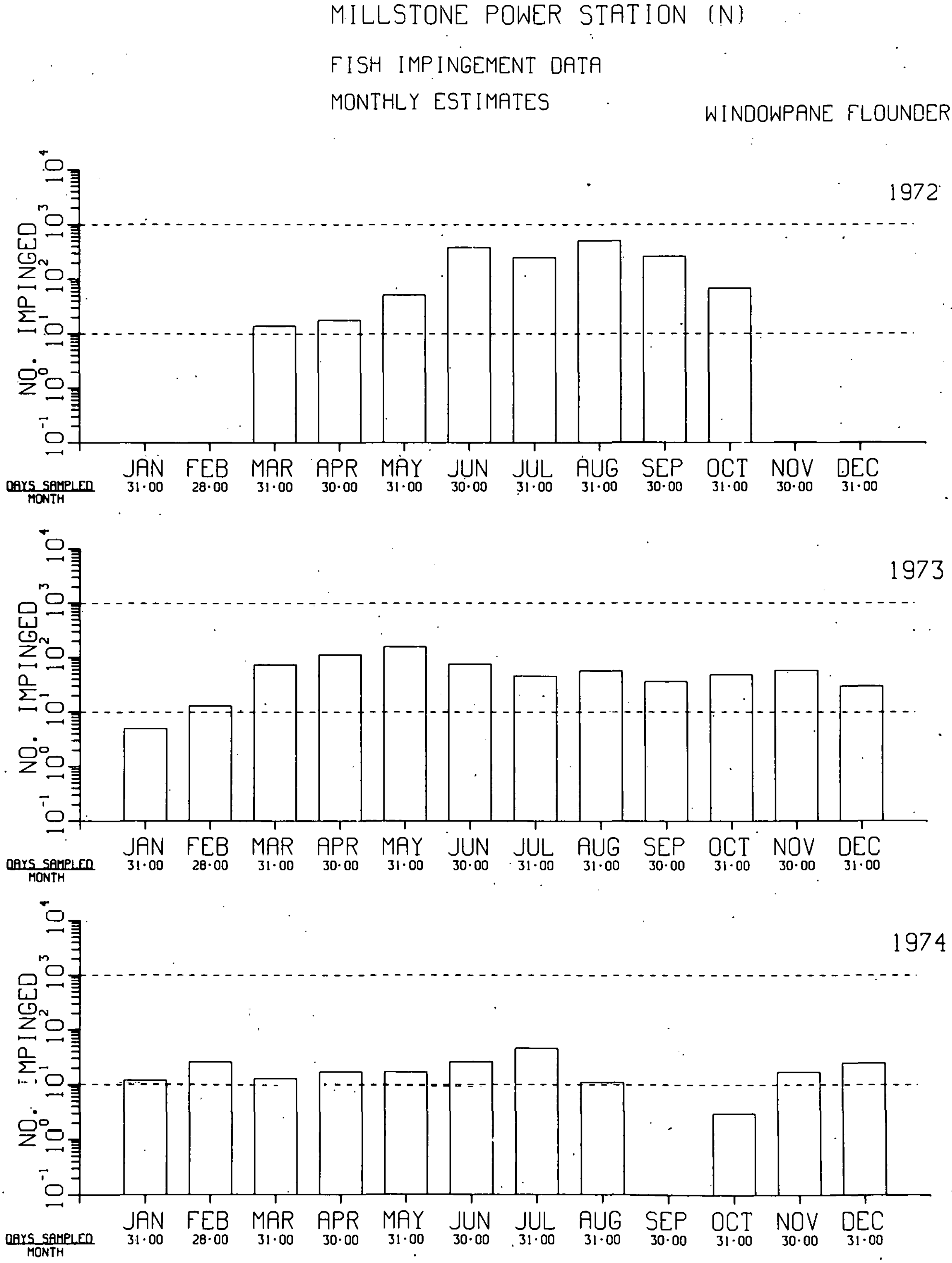


Fig. H4. Impingement Estimates.

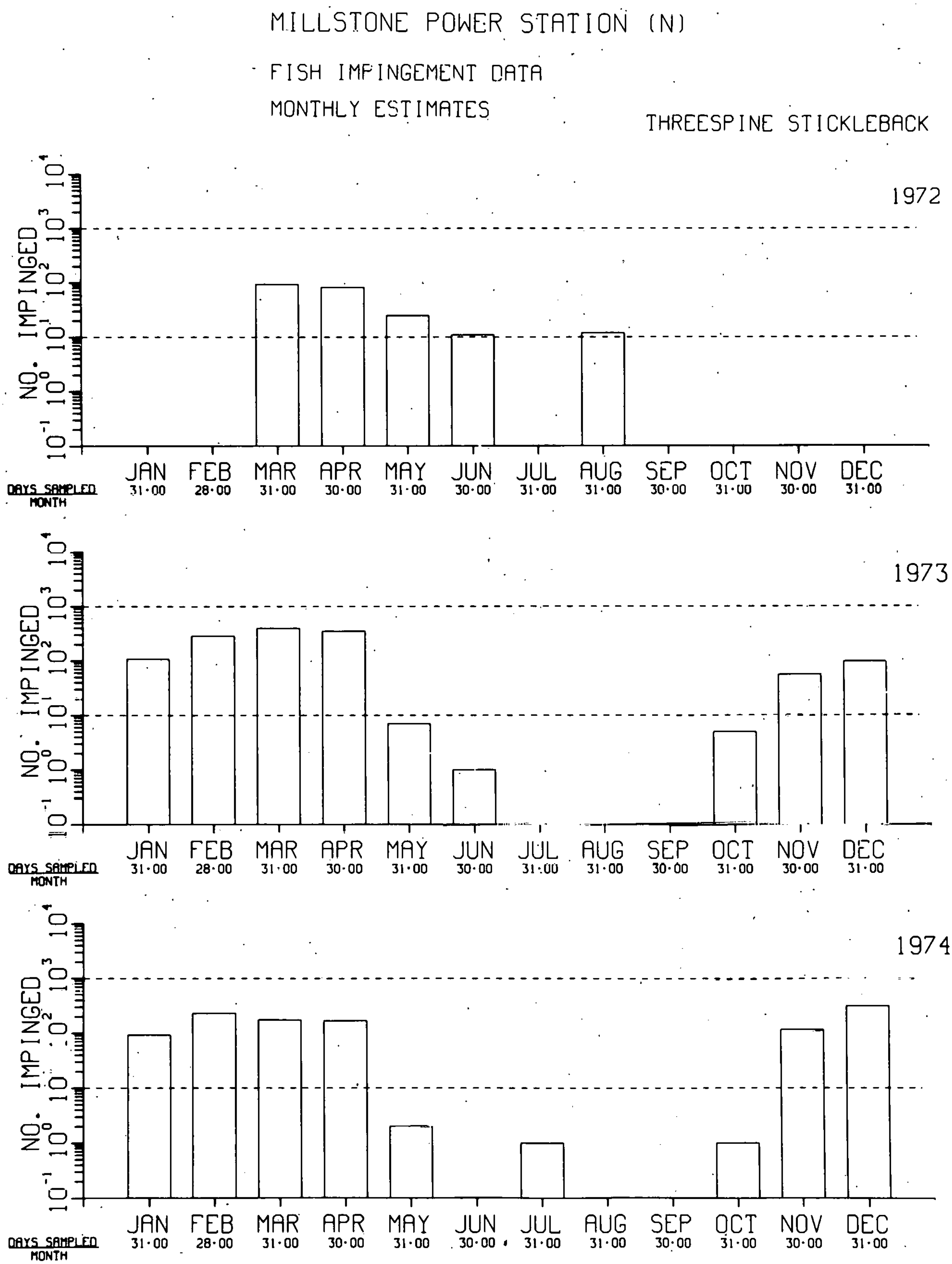


Fig. H5. Impingement Estimates.

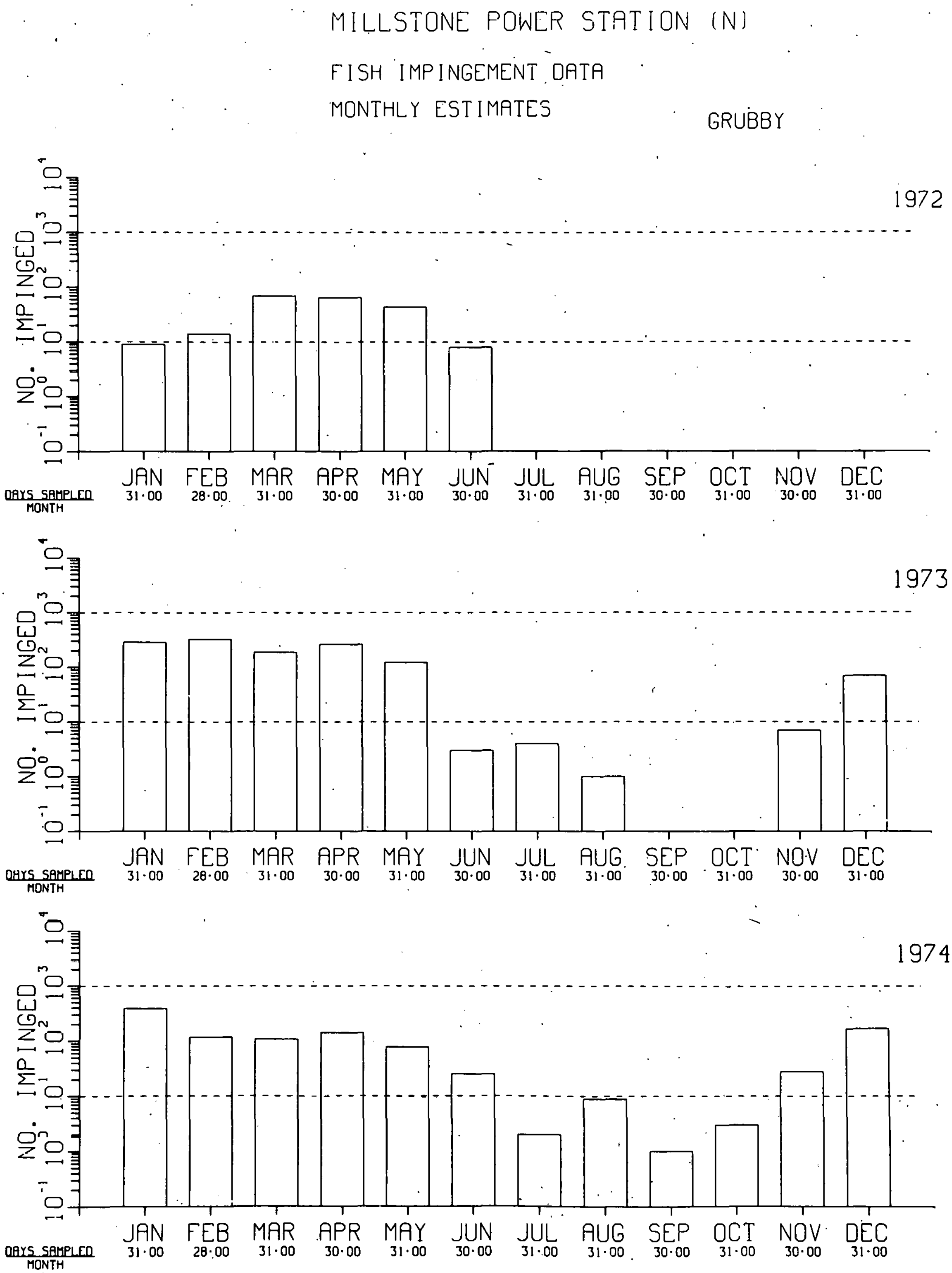


Fig. H6. Impingement Estimates.

INDIAN POINT POWER PLANT UNITS 1-3 (N-F)

SITE CHARACTERISTICS

The 239-acre site is located on the east bank of the Hudson River, 24 miles north of the New York City limits at Indian Point, Village of Buchanan, Westchester County, New York (Fig. 1).[1] The site is located at the inside of a large bend in the river. The minimum elevation at the site is 15 feet MSL. The site fronts the river channel where the intake structures are located flush with the riverbank (Fig. 2).

The Hudson River varies from 4000 to 5000 feet in width and has a maximum depth of about 85 feet in the vicinity of the site. The cross-sectional area of the river at the plant is 140,000 square feet. The average freshwater flow in the river is about 9,000,000 gpm, with maximum and minimum flows of 13,000,000 and 1,300,000 gpm, respectively. The Hudson is under tidal influence throughout most of its length. Tidal mixing brings salt water upstream above Indian Point during much of the year. The extent of the saltwater intrusion depends on the freshwater flow, and may actually be pushed downstream to the mouth of the river during the high flows associated with spring runoff. However, the tidal ebb and flow has a large effect, when compared with this runoff, on the volume and chemistry of the water flowing past the Indian Point site. Ebb flows reach 160,000,000 gpm and flood flows reach 120,000,000 gpm. The saline region of the Hudson River a partially stratified estuary. The water body in the vicinity of the site is characterized by both vertical and longitudinal salinity gradients, the exact nature and distribution of which depend on the downstream freshwater flow. Water temperature ranges from a low of 32°F to 34°F in January-March to a high of 81°F in August. Vertical and horizontal temperature variations show little difference with temperature gradients of 2.5°F and 2.0°F, respectively.

The estuarine nature of the river provides habitat for a rich biota. Table I is a list of the fishes identified in collections from the Hudson River at Indian Point. A notable characteristic is a high seasonal fluctuation in population of some species. Among those species exhibiting such fluctuation are the white perch, tomcod, bay anchovy, hogchoker, white catfish, blueback herring, alewife, pumpkinseed, johnny darter, spottail shiner, and weakfish, to name a few. In addition, the estuarine environment in the Lower Hudson River is an essential pathway to and from spawning grounds for migratory species. Numerous other species utilize the very diverse habitats of the estuarine environment for spawning and as a nursery. The most important commercial species using the river for this purpose is the striped bass.

PLANT DESCRIPTION

The Indian Point Plant (Fig. 3) consists of three separate units. Unit 1, a combined nuclear and oil-fired unit, has a total electrical output of 285 MWe. It utilizes once-through cooling at a maximum flow of 319,000 gpm. Units 2 and 3 are pressurized water reactors. Unit 2 has a net electrical output of 873 MWe and utilizes once-through cooling at a maximum capacity of 840,000 gpm. Unit 3 generates 965 MWe and has just begun service. It also utilizes once-through cooling with a flow rate similar to that of Unit 2.[2]

INTAKE DESIGN AND OPERATION

The intakes are arranged in the following sequence from north to south: Unit 2, Unit 1, Unit 3 (Fig. 2). Unit 1 is serviced by the central and smallest intake structure, which is located at the north end of a 247-foot-long wharf placed parallel to the shoreline directly in front of the reactor building. The intake consists of four bays, each 11.2 feet wide with the bottoms 26 feet below mean low water. A skimmer wall limits the openings to 20.5 feet, or 5.5 feet below mean low water. Each of the four bays contains in sequence, a stoplog gate, deicing header, trash rack, traveling screen, chlorination system, and circulating-water pumps. A fine fixed screen with 3/8-inch openings was added in 1967 to cover the opening of each bay. The total flow for Unit 1 is 319,000 gpm with a water velocity of 1.4 fps at the mouth of the intake.[3] The intake for Unit 2 is larger than that for Unit 1, containing six main intake channels for six circulating-water pumps and a divided service-water intake channel. A drawing of the structure is shown in Figure 4. Each large pump has a capacity of 140,000 gpm, for a total screening capacity of 840,000 gpm. There are six service-water pumps that provide a total flow of 30,000 gpm. Each bay opening is 13.3 feet wide by 26 feet deep, with the top one foot below the mean low water of the river. This skimmer wall removes floating debris. A trash rack composed of vertical steel bars 1/2 inch by three inches on 3-1/2-inch centers is located 12.3 feet from the river's edge in each of the seven bay openings to protect the pumps from large debris. Behind the trash rack is an optional fixed fine-mesh screen followed by the 3/8-inch traveling screen. A deicing spray header is located just ahead of all the screens so that heated water from the discharge canal can be recirculated at 160,000 gpm to deice the screens in winter. Maximum velocities are 0.8 fps through the main openings, 1.0 fps through the trash bars, 1.3 fps through the fixed fine-mesh screens (when present), and 2.0 fps through the traveling-screen panels. The intake structure for Unit 3 is identical to that for Unit 2.

IMPINGEMENT SAMPLING

Data collected at Indian Point since 1965 provide the most complete record of fish impingement that exists to date, for any power plant. The methods of collection varied and improved through the years, but nearly all of the data are the result of continuous sampling for 24-hour periods. The environmental technical specification states that the number and total weight of fish from each traveling screen shall be monitored on a daily basis. Where subsampling is done, the subsample must contain 5000 fish and size ranges must be delineated for the most numerous species. White perch, striped bass, and Atlantic tomcod are to be monitored during the spawning season. These specifications went into effect in 1971 with the operating license for Unit 2.[4] Prior to that, only total numbers were given for Unit 1.

DATA AVAILABILITY

Impingement data are available for the years and months outlined in Table II. Quantitative data for all years except 1968, 1969, and 1971 exist for Indian Point. These data, plus data for miscellaneous months from 1972 through 1975, were not made available to the authors by the utility.[5,6]

IMPINGEMENT DATA SUMMARY

The highly seasonal nature of abundance for many species at Indian Point makes the determination of "important" species difficult. The abundance changed from year to year for various species, and therefore several species are included. It is felt that they constitute a reasonably comprehensive sample of those species that are impinged seasonally in high numbers as well as those that are impinged in large numbers throughout most of the year.

A number of species have undergone notable fluctuations in number impinged; they are alewife, hogchoker, white catfish, blueback herring, pumpkinseed, johnny darter, spottail shiner, and weakfish. Large numbers of two fish, striped bass and rainbow smelt, were observed only on an irregular basis. The three fish found to be most numerous in the samples were white perch, Atlantic tomcod, and bay anchovy. Table III summaries impingement data for the last-named five species, where available since 1971. Extrapolated monthly impingement totals are summarized in Figures H1 through H18.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The utility has tried numerous mitigative measures to reduce the number of fish impinged at Indian Point. Starting in 1963, air-bubble screens, pneumatic sound, and smaller-mesh mechanical barriers were employed with little or no success. Moving the point of addition of sodium hypochlorite to a location behind the screens stopped the impingement of larger fishes. Fixed screens at the mouth of the intake were found to kill large numbers of fish outside the intake, thus simply moving the problem away from the traveling screens. Since 1972, the utility has been under a consent decree from the New York State Department of Environmental Conservation that requires it to employ the air-bubble screens 100% of the time and reduce the intake flow rate by 40% whenever the water temperature is less than 40°F.[7] Reducing the water velocity is the only measure that has effectively reduced the rate of fish impingement at Indian Point. To achieve a reduction in water velocity at the intakes permanently, protective screened bays may be employed in the future to reduce fish kills at the plant.

REFERENCES

1. "Final Environmental Statement, Indian Point Nuclear Generating Plant Unit No. 2." Vol. 1. USAEC Directorate of Licensing. Docket No. 50-247. September 1972.

2. "Final Environmental Statement, Indian Point Nuclear Generating Plant Unit No. 3." Vol. 1. USNRC Office of Nuclear Reactor Regulation. Docket No. 50-286. February 1975.

3. "Indian Point Impingement Study Report for the Period 15 June 1972 through 31 December 1973." Prepared for Consolidated Edison Company of New York, Inc., by Texas Instruments, Inc., Ecological Services. December 1974.

4. Operating License for Indian Point Unit 2, DPR-26, Section 4.2.1a. USAEC Directorate of Licensing. October 1971.

5. Monthly Fish Impingement Reports, 1974 and 1975. Consolidated Edison Company of New York, Inc.

6. Personal communication with John Jannarone of Consolidated Edison Company of New York, Inc. 14 May 1976.

7. Personal communications with Robert Goldstein of Consolidated Edison Company of New York, Inc. April-May 1976.

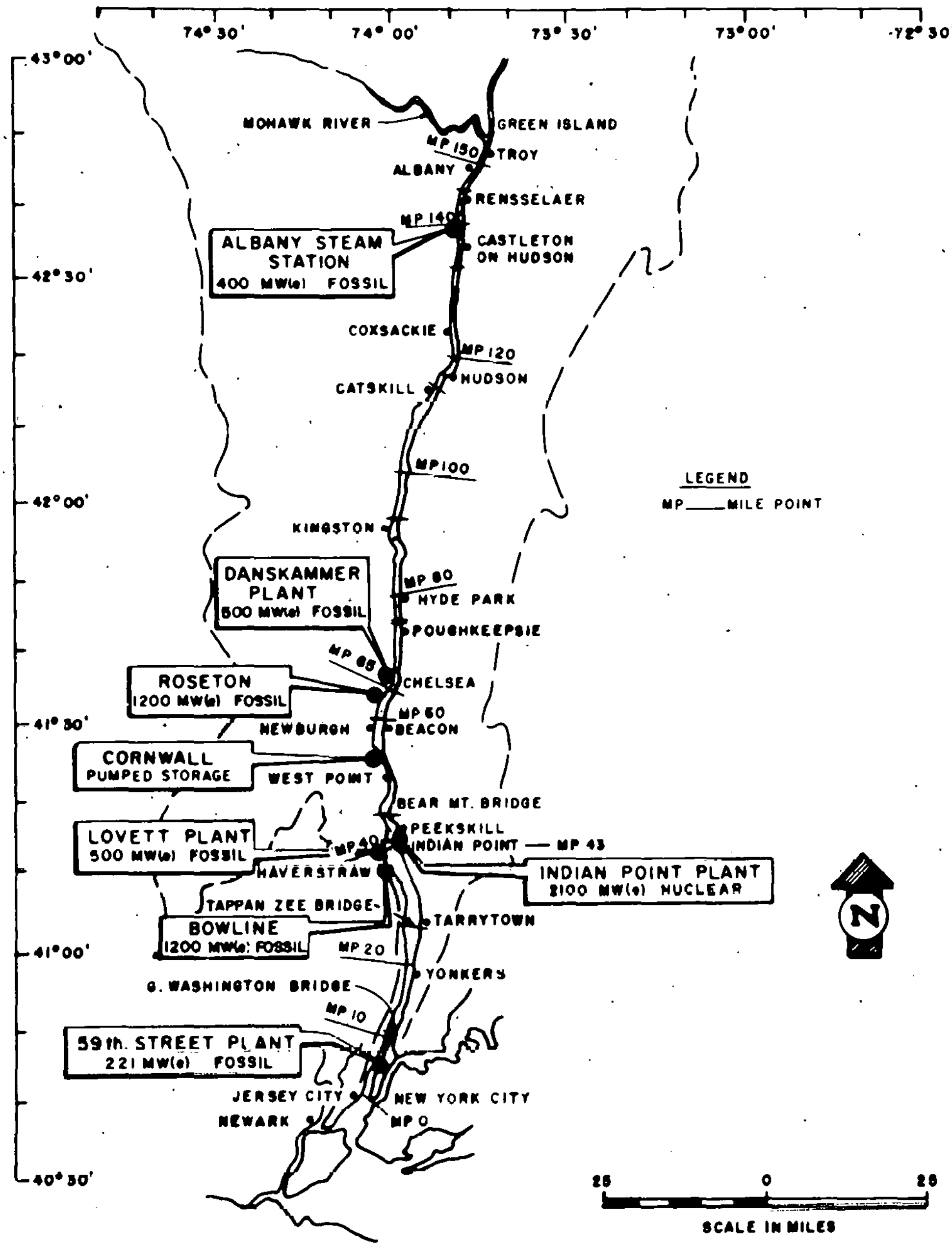


Fig. 1. Plant Location.

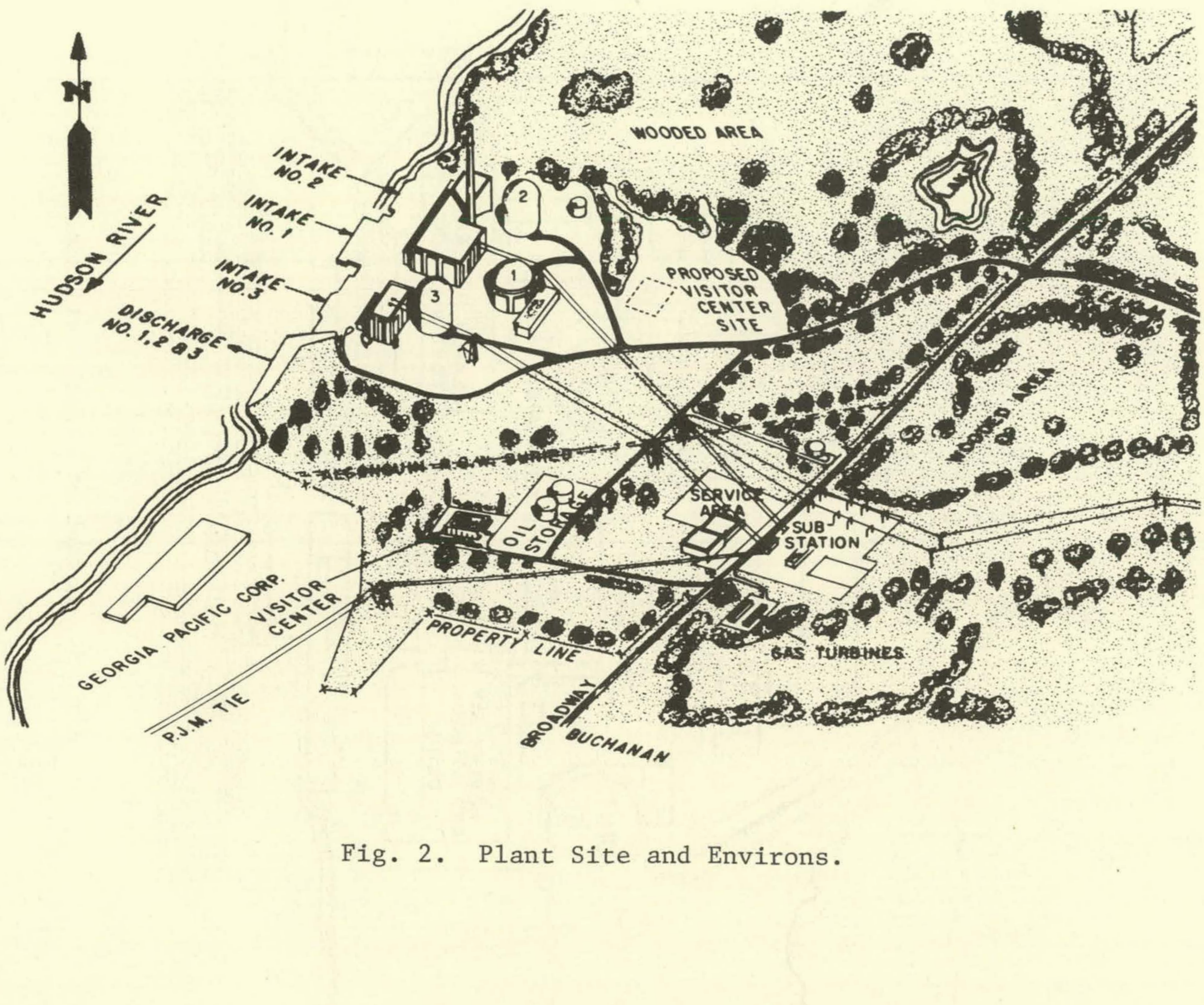


Fig. 2. Plant Site and Environs.

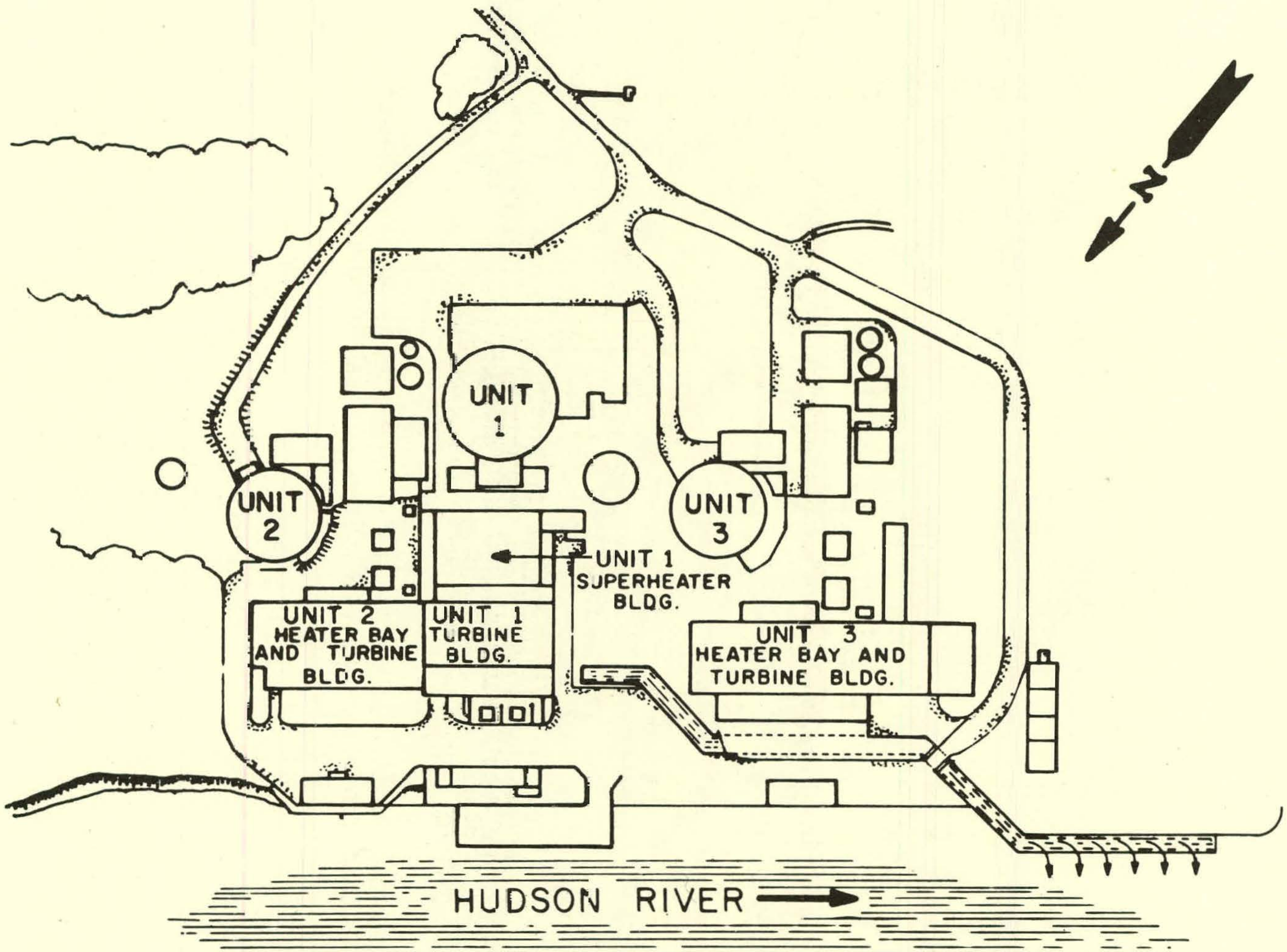


Fig. 3. Layout of Plant Facilities.

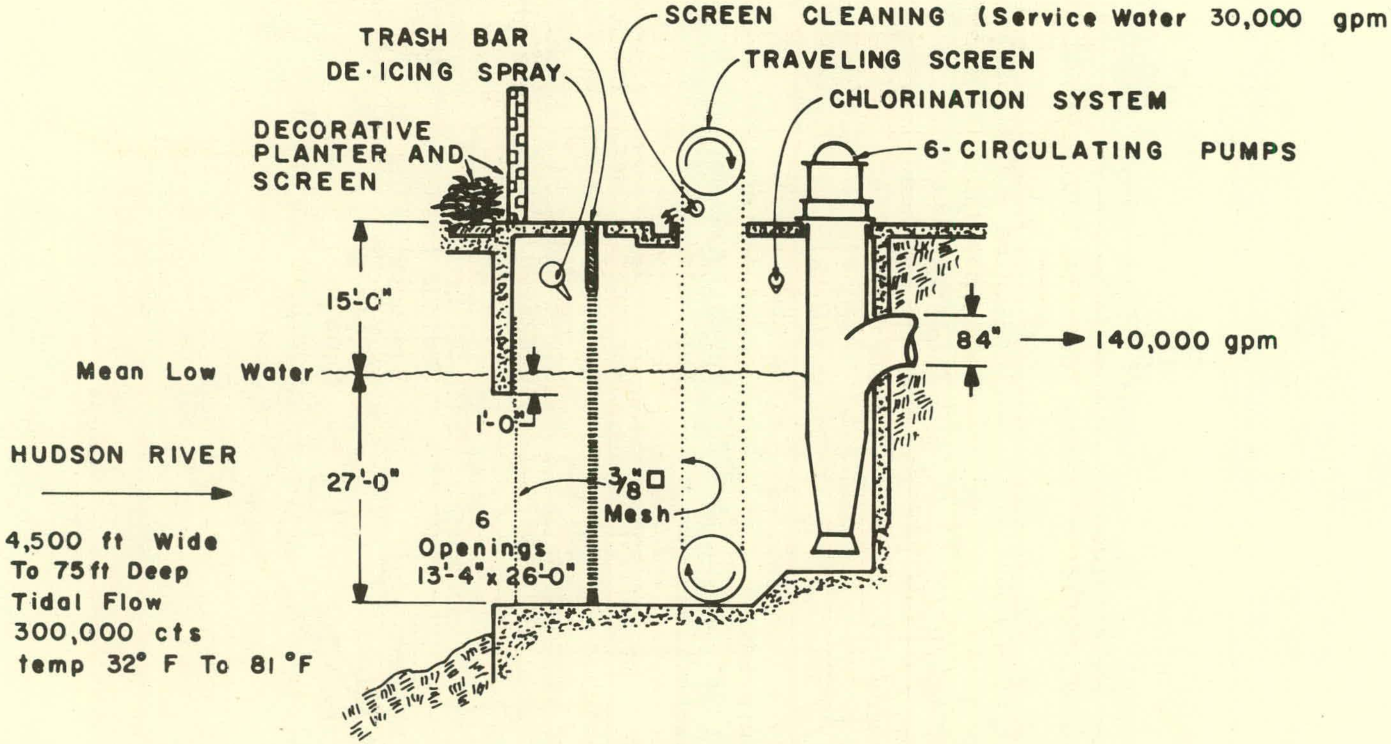


Fig. 4. Intake Structure for Unit 2.

Table I. Fishes Identified in Collections from the Hudson River in the Vicinity of Units 1-3

Shortnose sturgeon	Grass pickerel
Atlantic sturgeon	Silver hake
American eel	Atlantic tomcod
Tidewater silverside	Red hake
Atlantic silverside	Fourspine stickleback
Atlantic needlefish	Threespine stickleback
Crevalle jack	White catfish
White sucker	Black bullhead
Redbreast sunfish	Brown bullhead
Pumpkinseed	Striped mullet
Bluegill	White mullet
Smallmouth bass	Rainbow smelt
Largemouth bass	Johnny darter
Black crappie	Tessellated darter
Blueback herring	Yellow perch
Alewife	Winter flounder
American shad	Bluefish
Atlantic menhaden	Brown trout
Gizzard shad	Weakfish
Goldfish	White perch
Carp	Striped bass
Golden shiner	Hogchoker
Emerald shiner	Pinfish
Common shiner	Scup
Spottail shiner	Northern pipefish
Fallfish	
Banded killifish	
Mummichog	
Bay anchovy	
Chain pickerel	

Table II. Impingement Data Availability for Units 1 and 2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1965			X	X		X	X	X	X	X	X	
1966				X	X	X	X	X	X	X	X	X
1967	X	X	X					X				
1968												
1969												
1970	X	X	X	X	X	X						
1971												
1972					X	X	X	X	X	X	X	X
1973	X	X	X	X	X	X	X	X	X	X	X	X
1974	X	X	X	X	X	X	X			X		
1975				X	X	X		X	X	X	X	X

Table III. Summary of Fish Impingement Data at Units 1 and 2

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled					
		White Perch	Atlantic Tomcod	Bay Anchovy	Striped Bass	Rainbow Smelt	Total
1971	No data available						
1972	8	27,514	48,739	13,629			97,990
1973	12	78,903	28,210	11,853			133,045
1974	8	328,389	238,600	44,753	4,894		564,589
1975	8	205,575	69,343	87,808		7,757	580,350

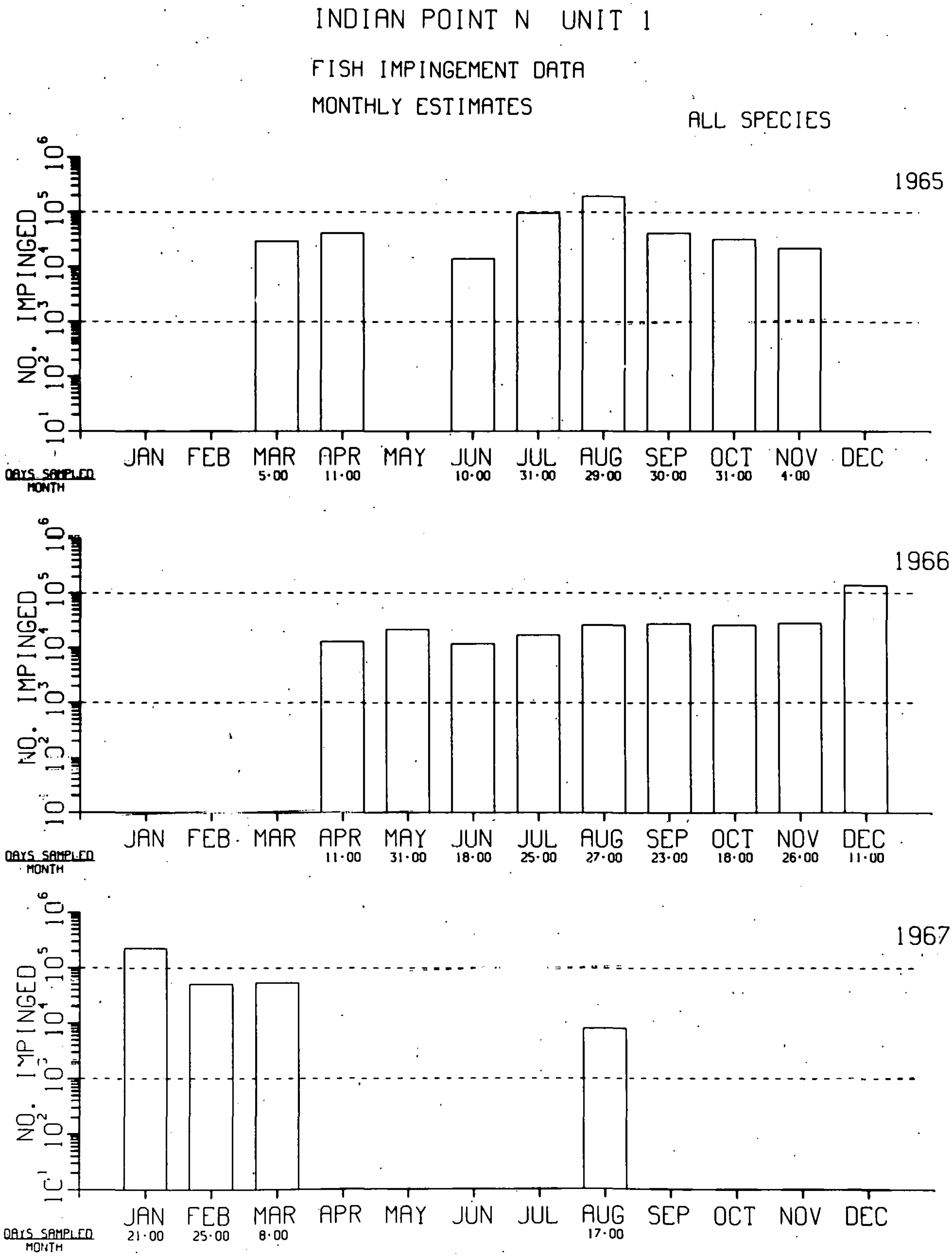


Fig. H1. Impingement Estimates.

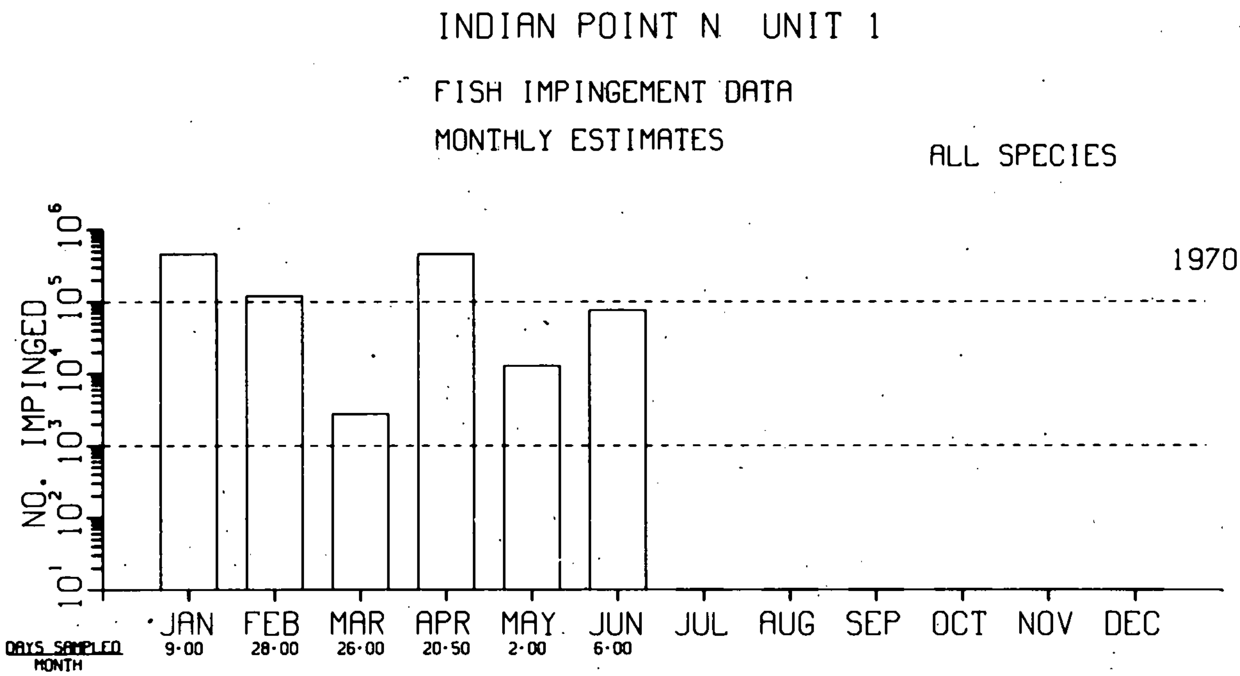


Fig. H2. Impingement Estimates.

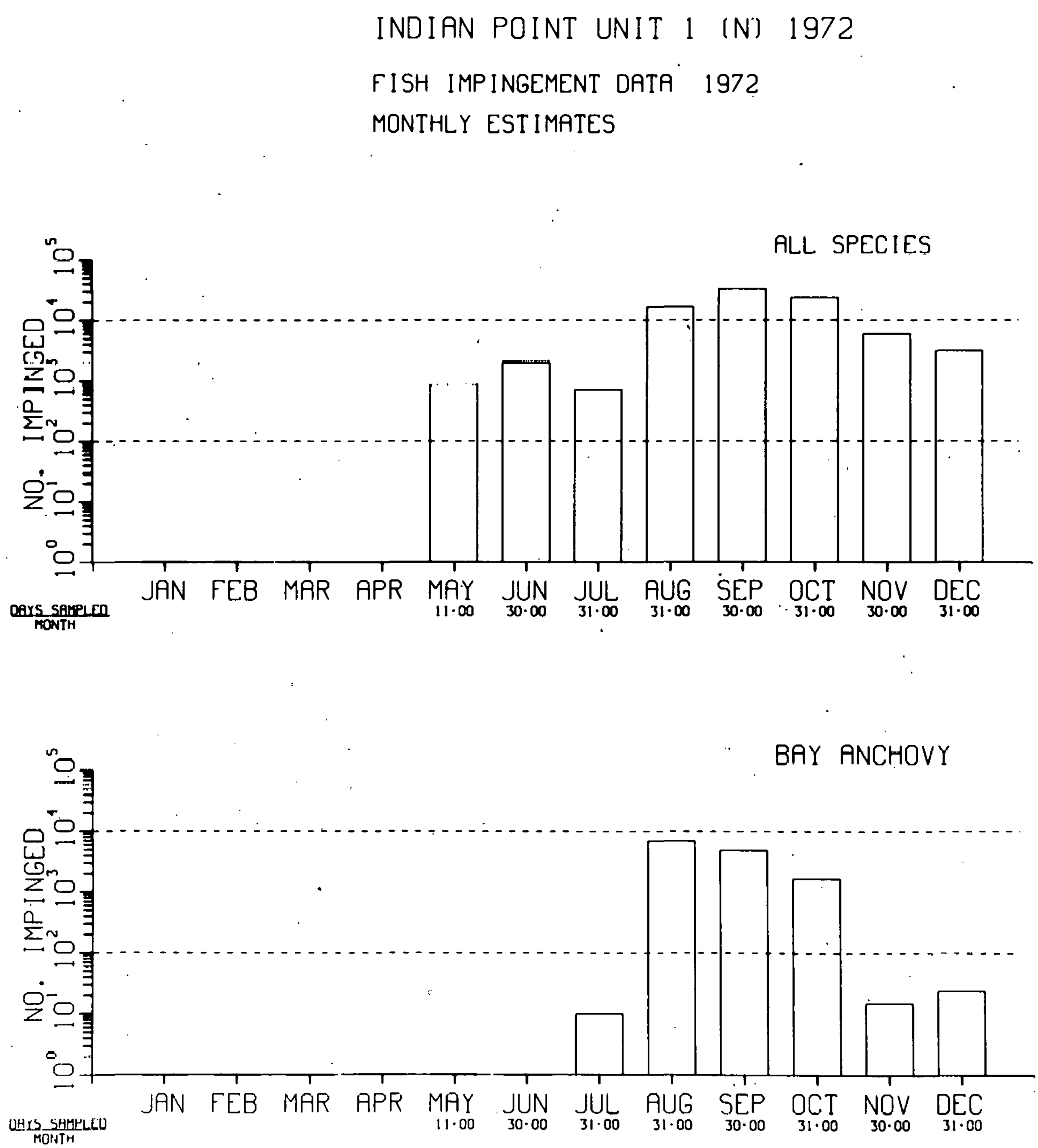


Fig. H3. Impingement Estimates.

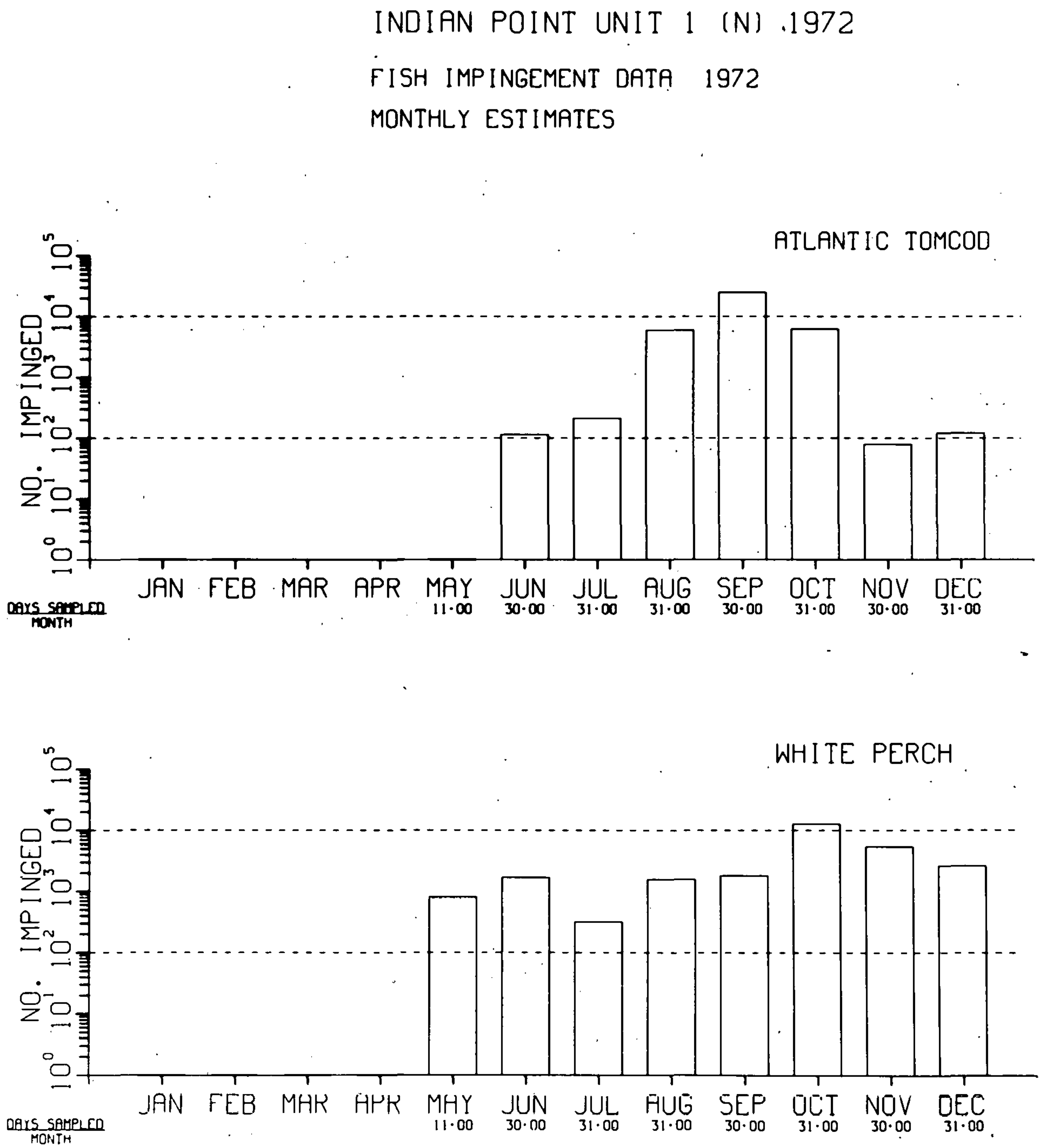


Fig. H4. Impingement Estimates.

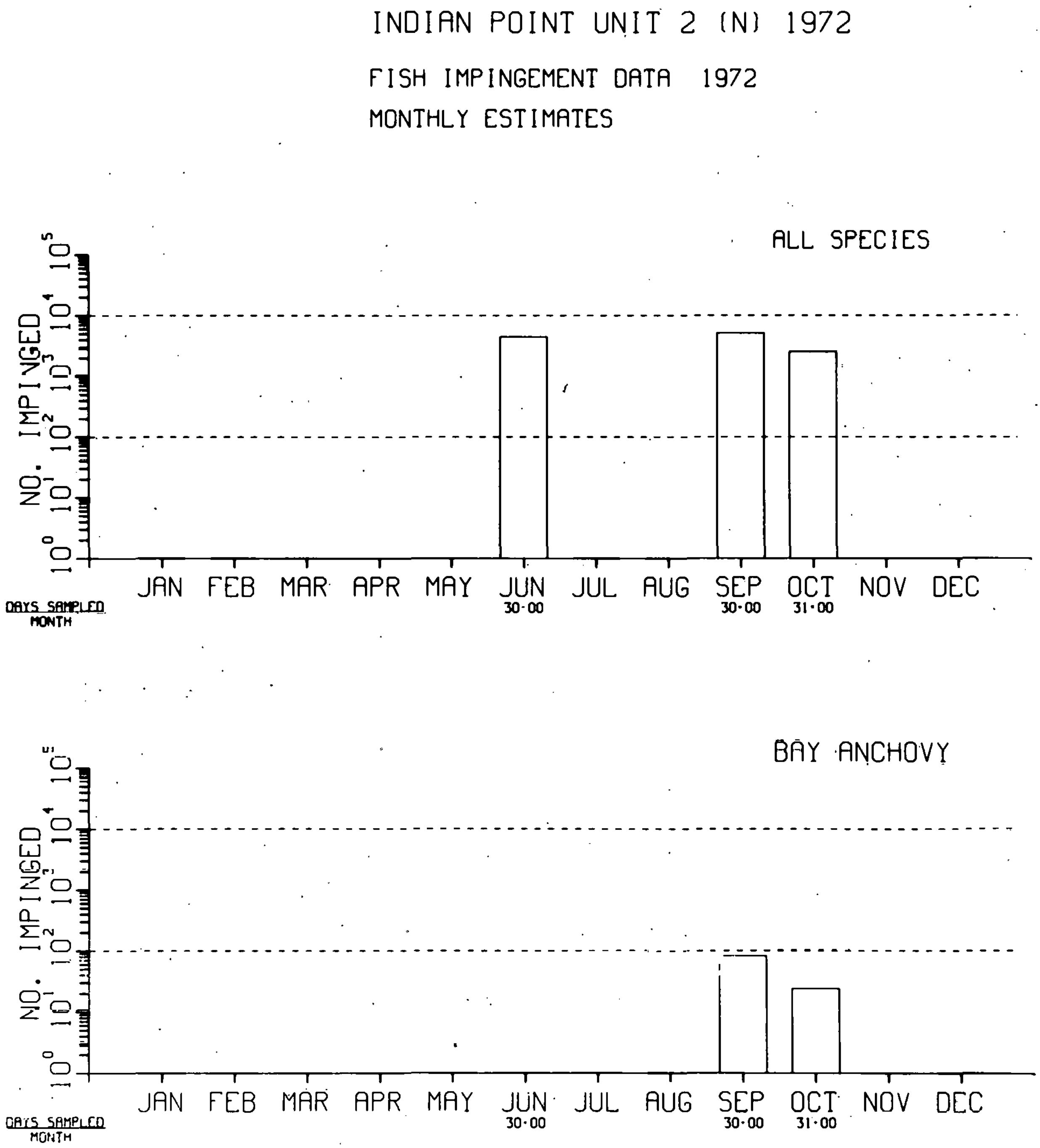
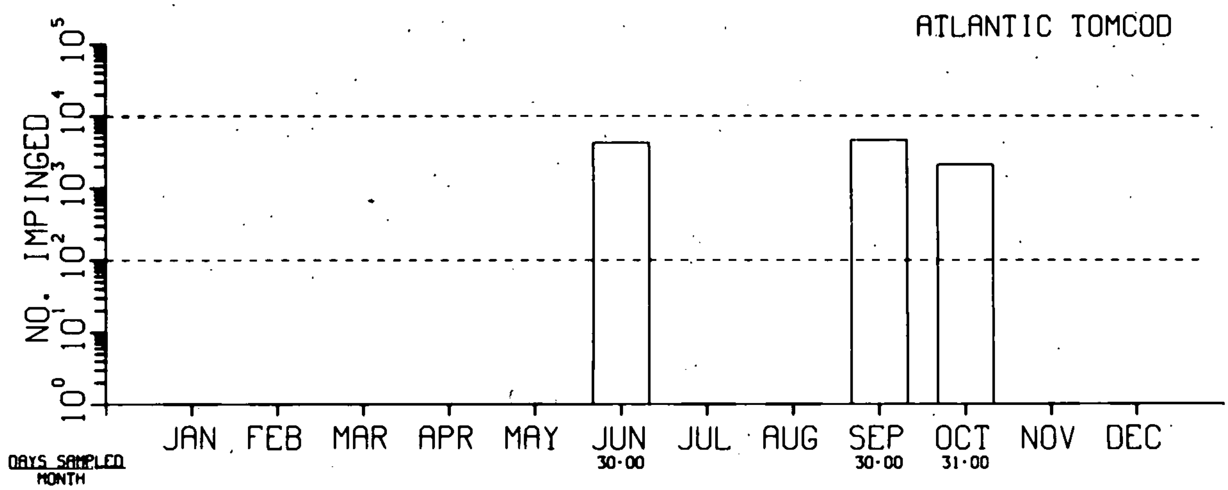


Fig. H5. Impingement Estimates.

INDIAN POINT UNIT 2 (N) 1972

FISH IMPINGEMENT DATA 1972

MONTHLY ESTIMATES



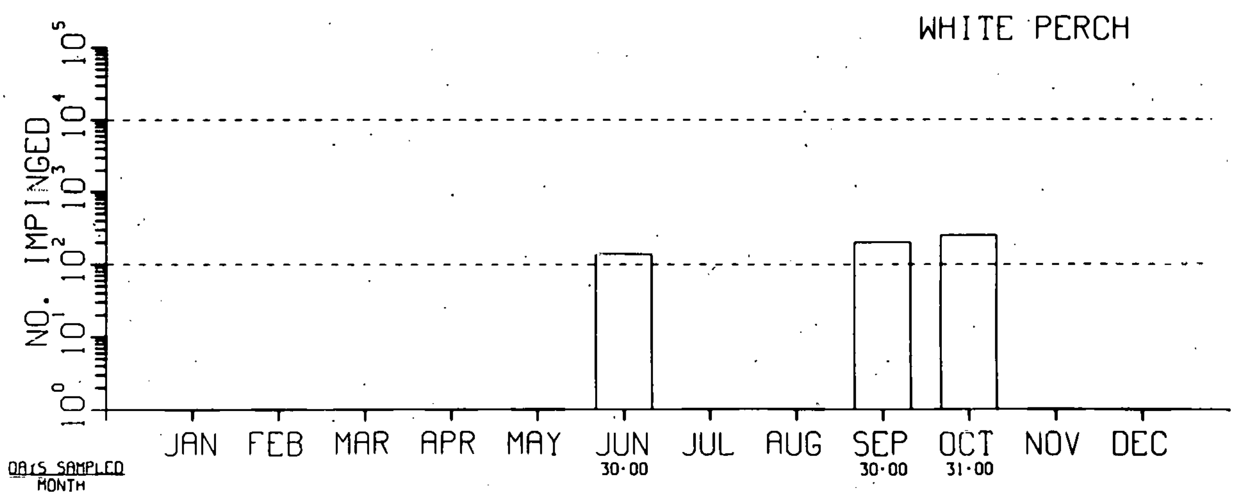


Fig. H6. Impingement Estimates.

INDIAN POINT UNIT 1 (N) 1973

FISH IMPINGEMENT DATA 1973

MONTHLY ESTIMATES

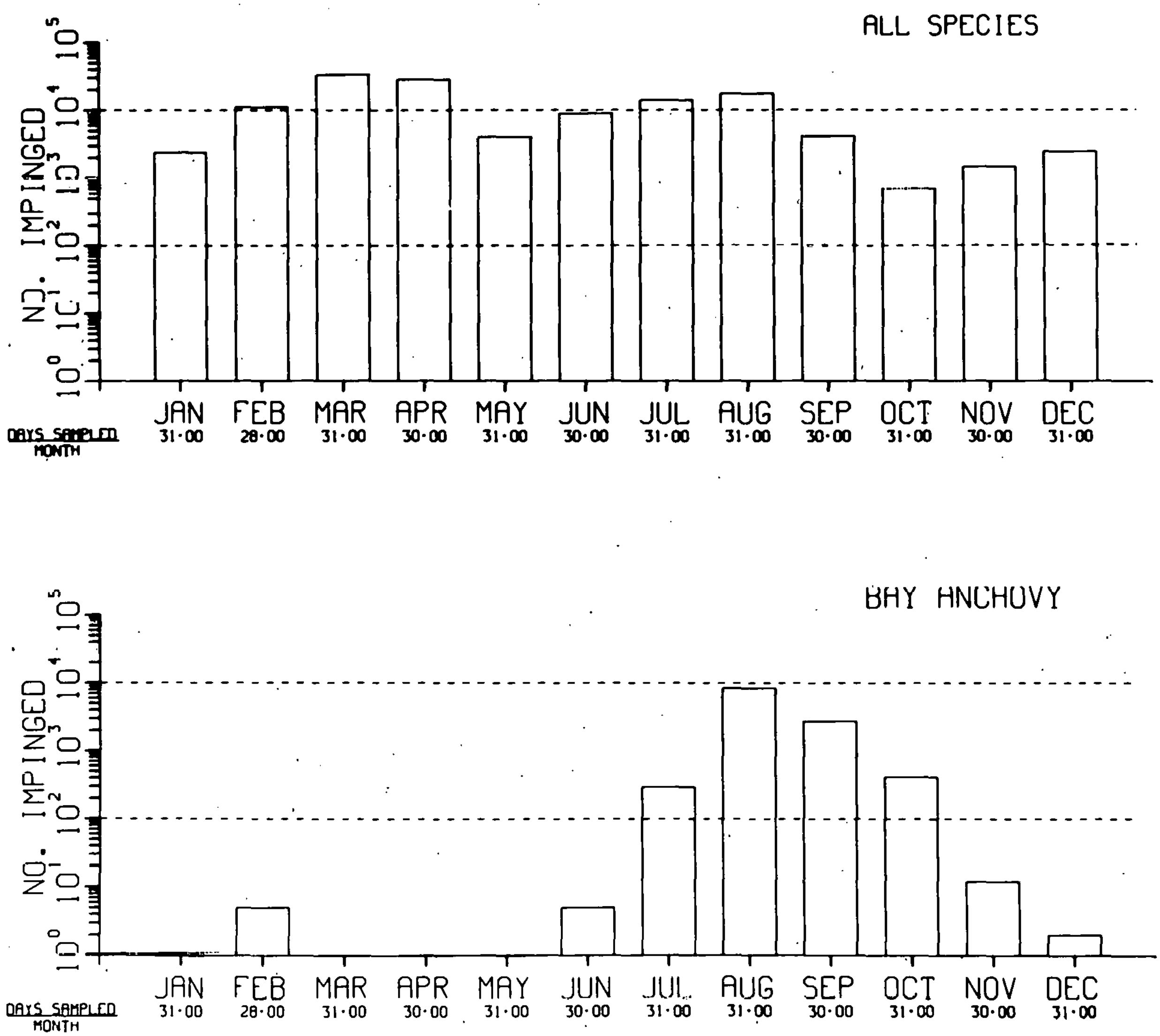


Fig. H7. Impingement Estimates.

INDIAN POINT UNIT 1 (N) 1973

FISH IMPINGEMENT DATA 1973

MONTHLY ESTIMATES

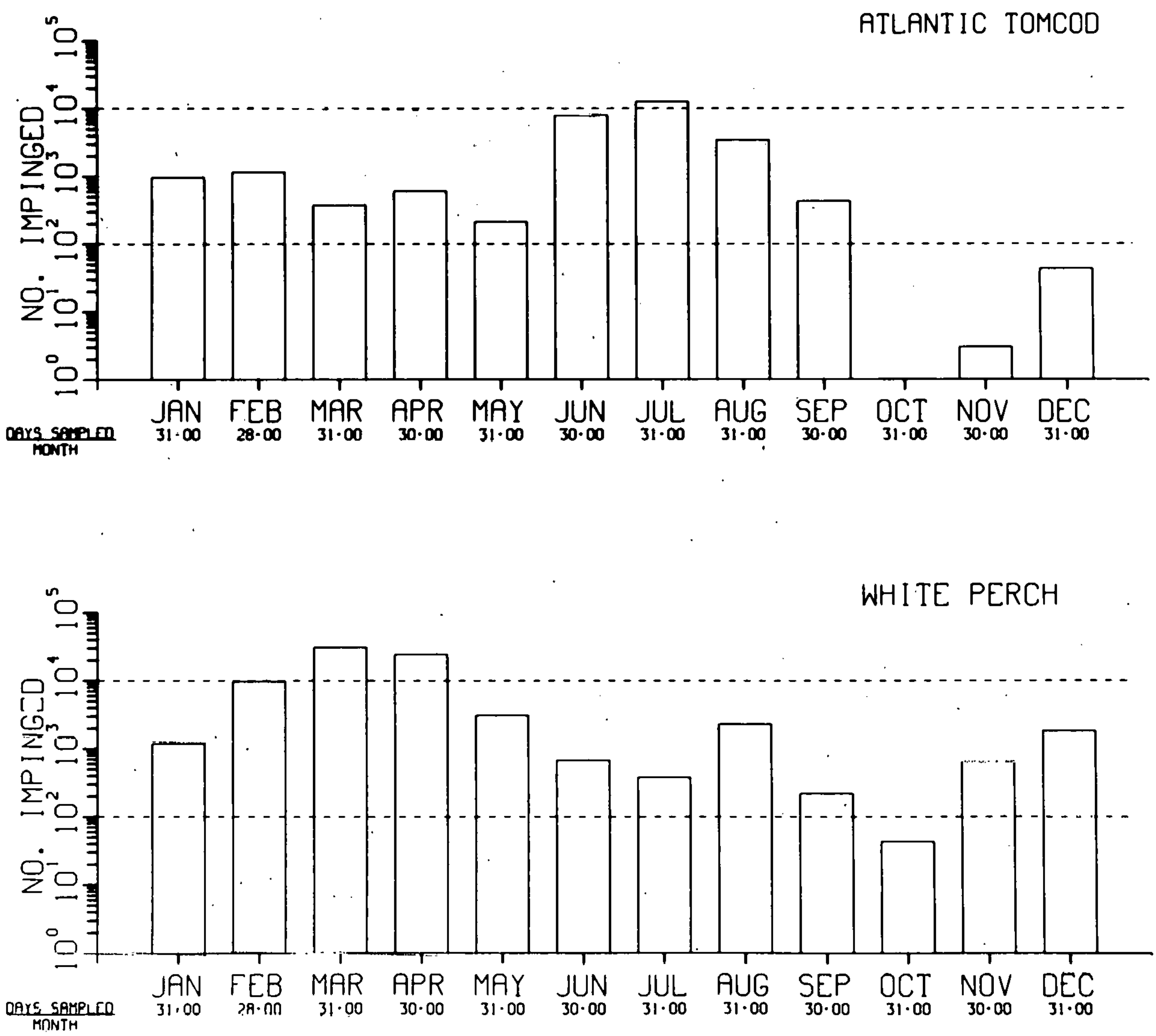


Fig. H8. Impingement Estimates.

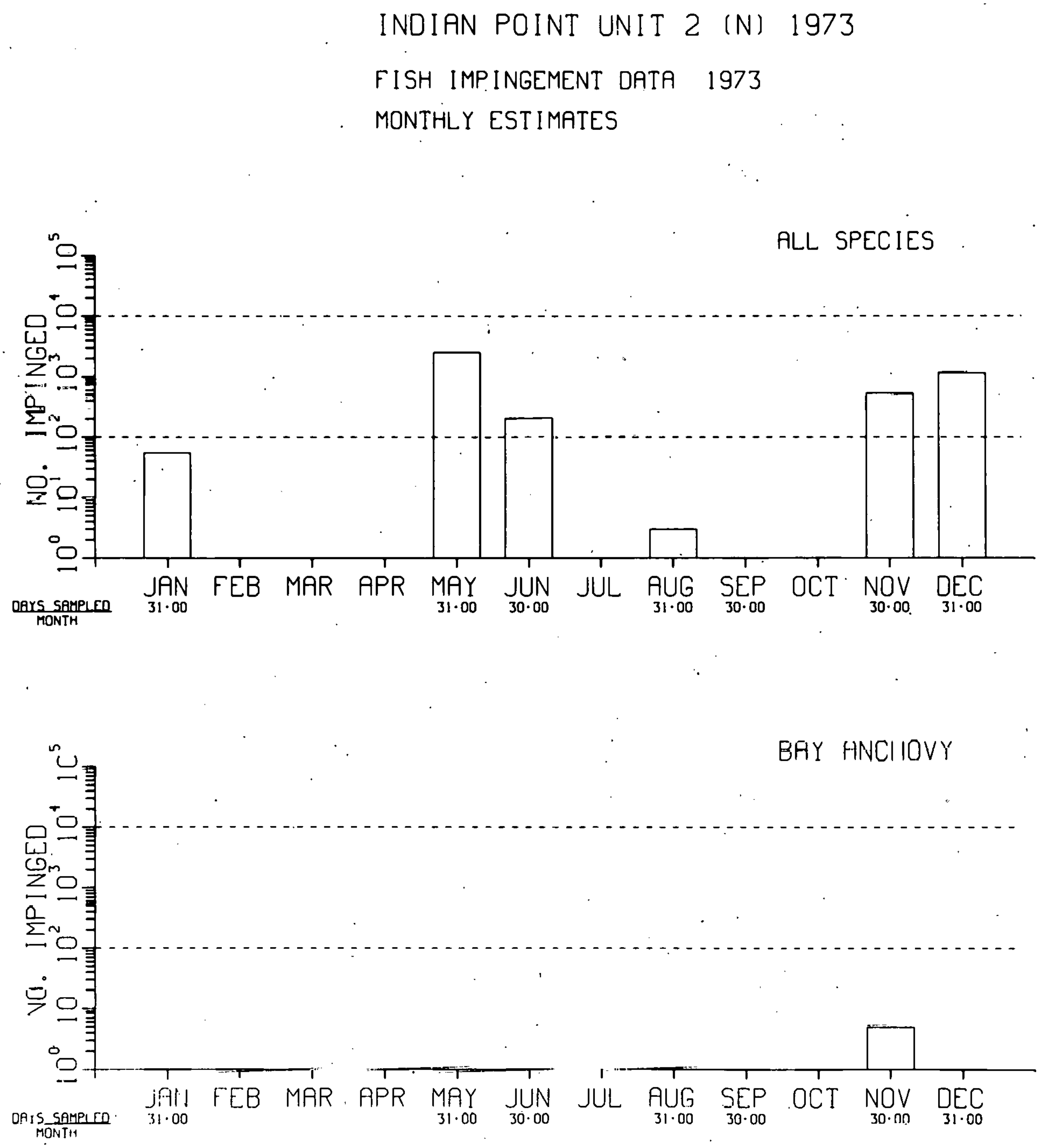


Fig. H9. Impingement Estimates.

INDIAN POINT UNIT 2 (N) 1973

FISH IMPINGEMENT DATA 1973

MONTHLY ESTIMATES

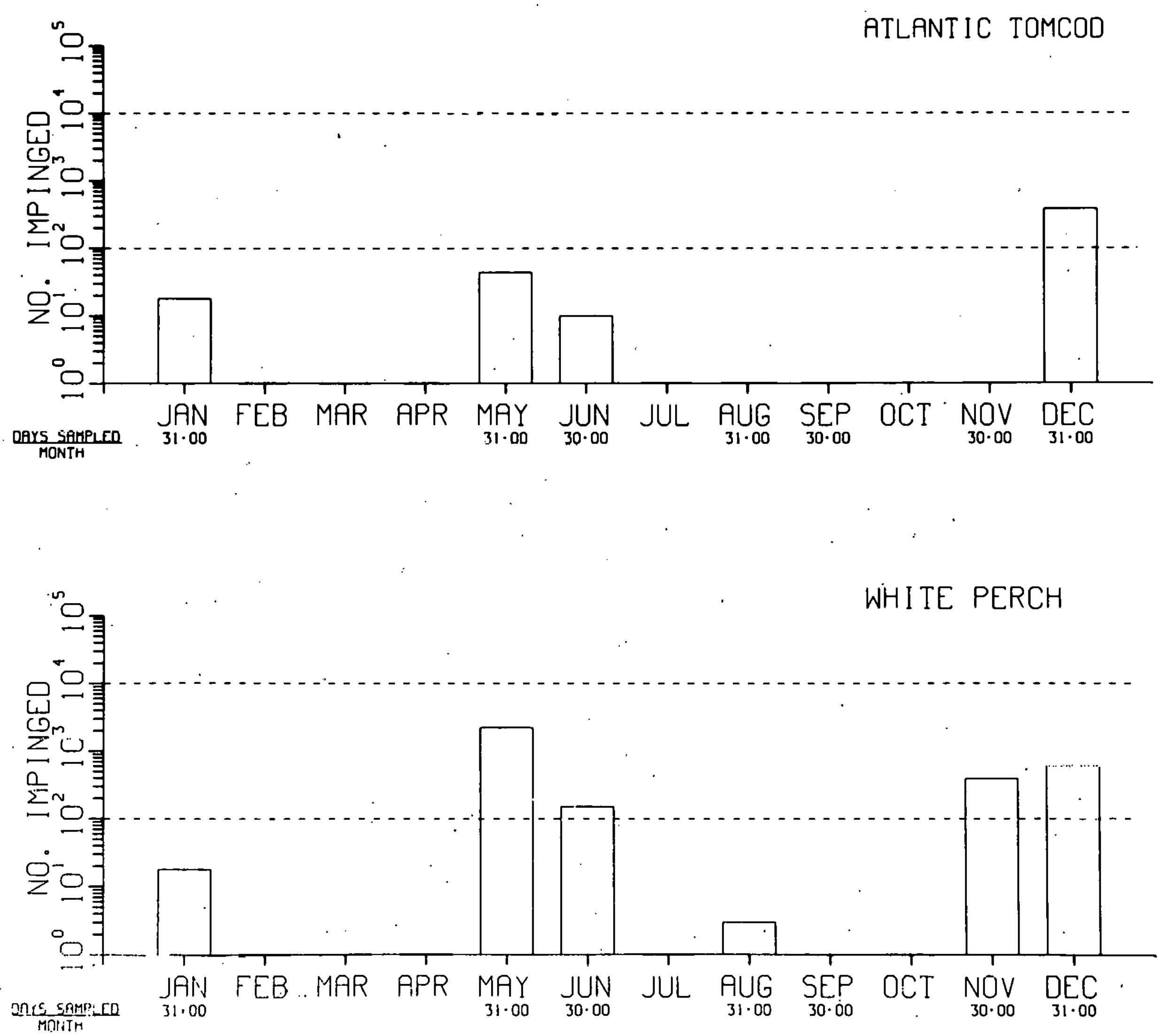


Fig. H10. Impingement Estimates.

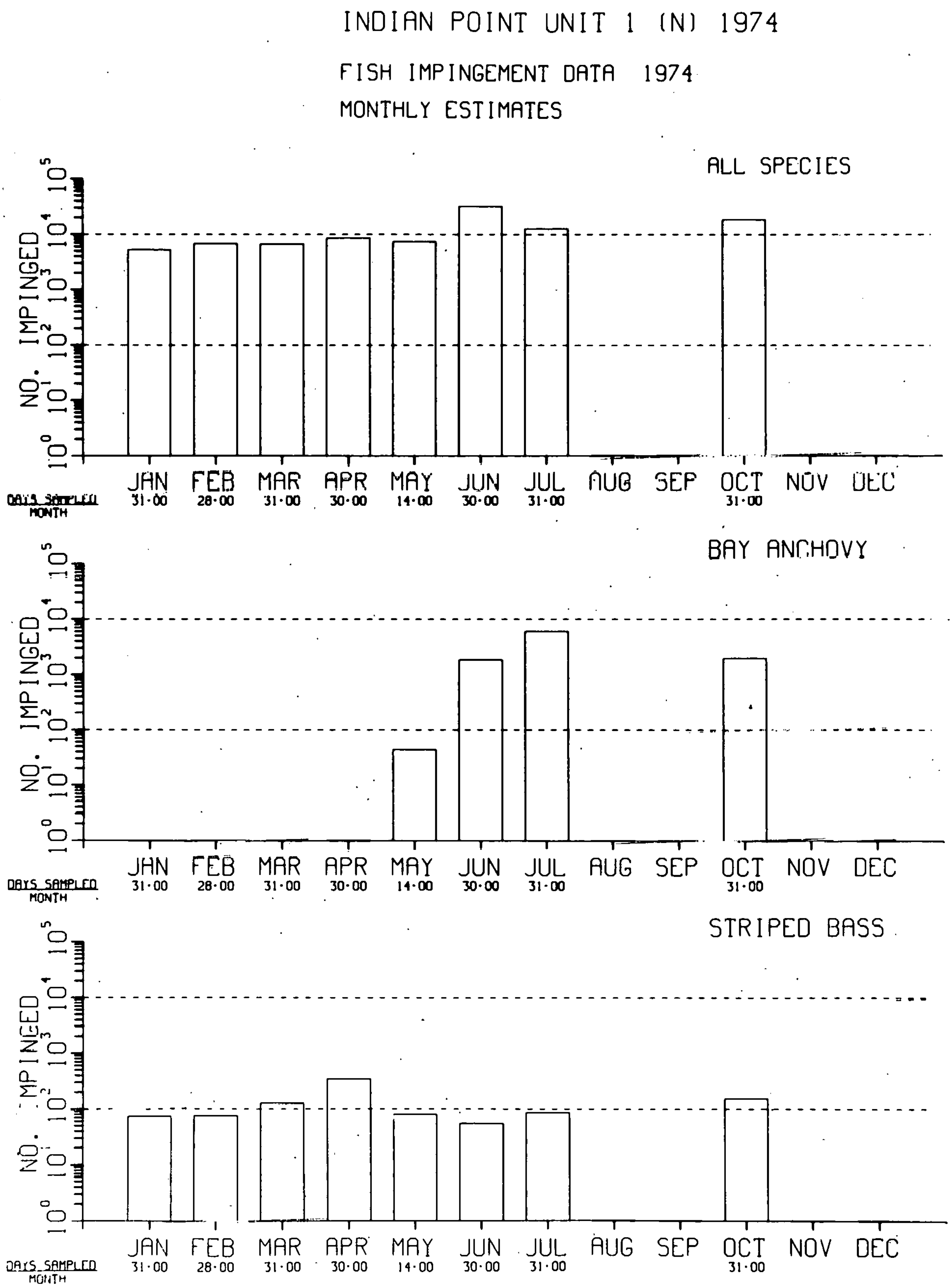


Fig. H11. Impingement Estimates.

INDIAN POINT UNIT 1 (N) 1974

FISH IMPINGEMENT DATA 1974

MONTHLY ESTIMATES

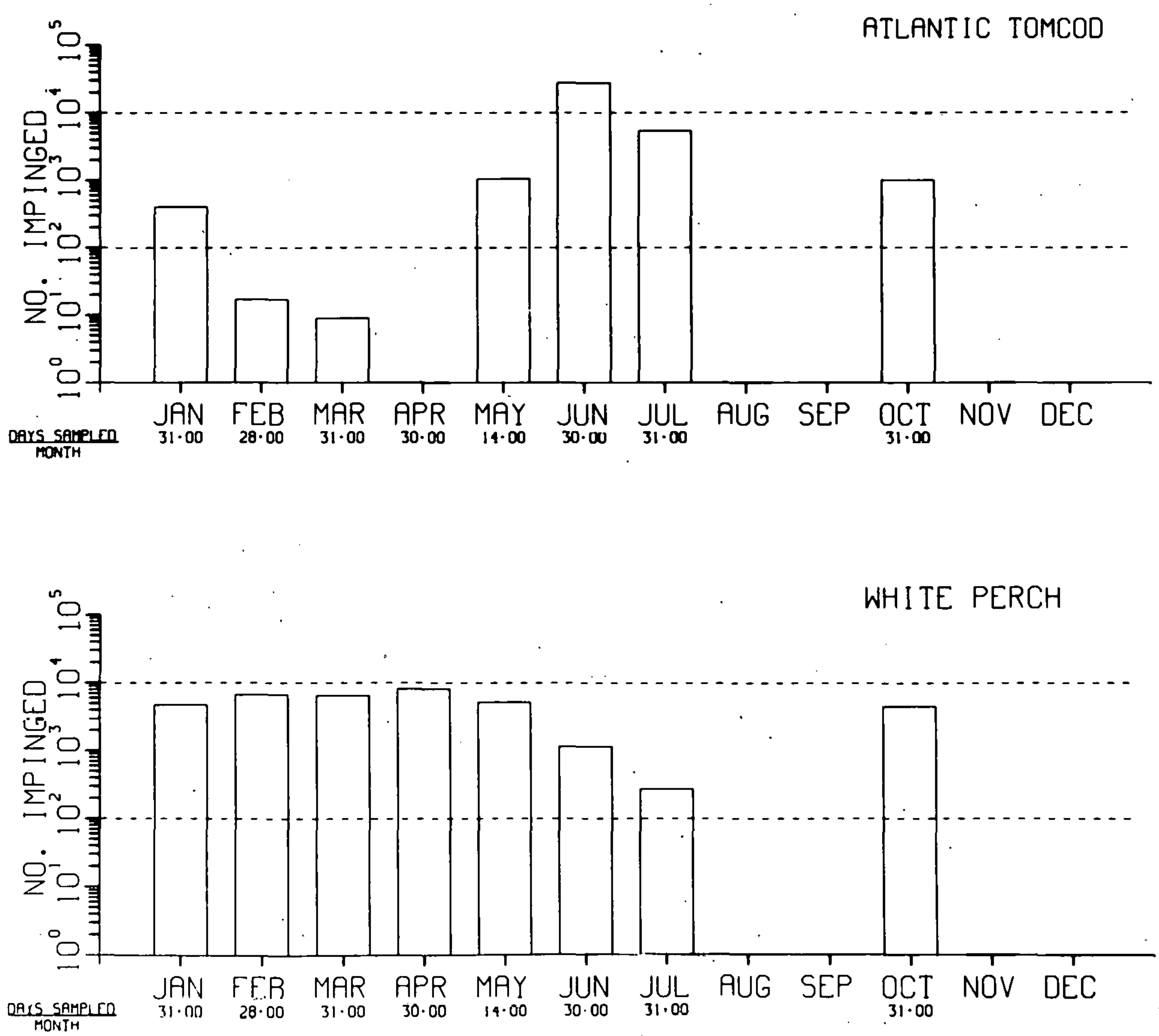


Fig. H12. Impingement Estimates.

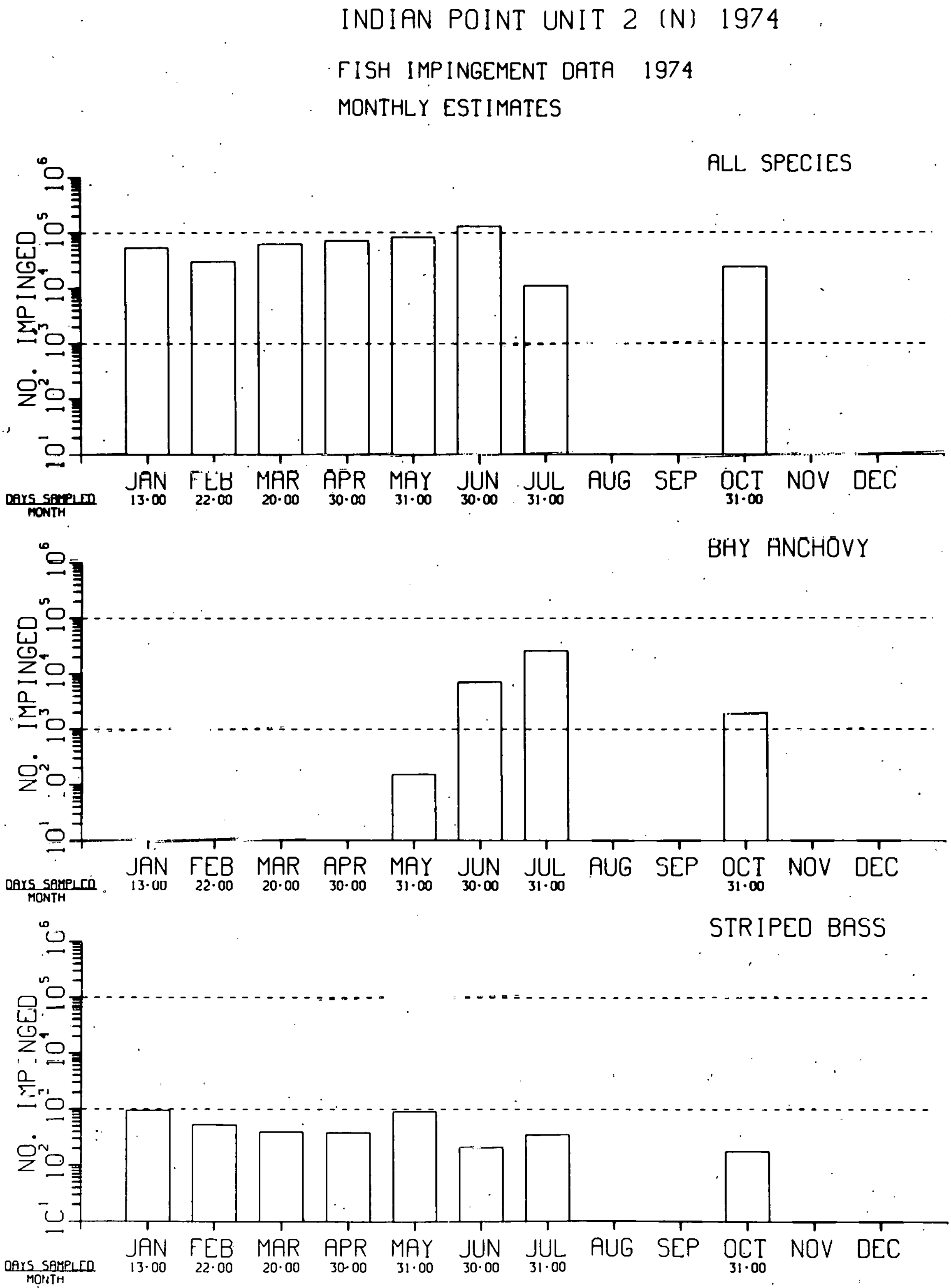
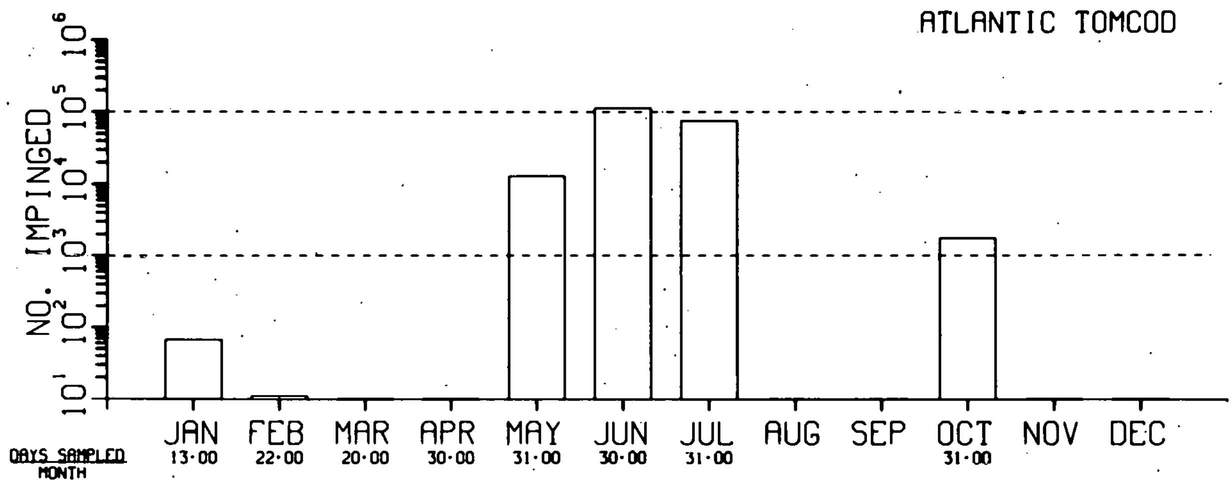


Fig. H13. Impingement Estimates.

INDIAN POINT UNIT 2 (N) 1974

FISH IMPINGEMENT DATA 1974

MONTHLY ESTIMATES



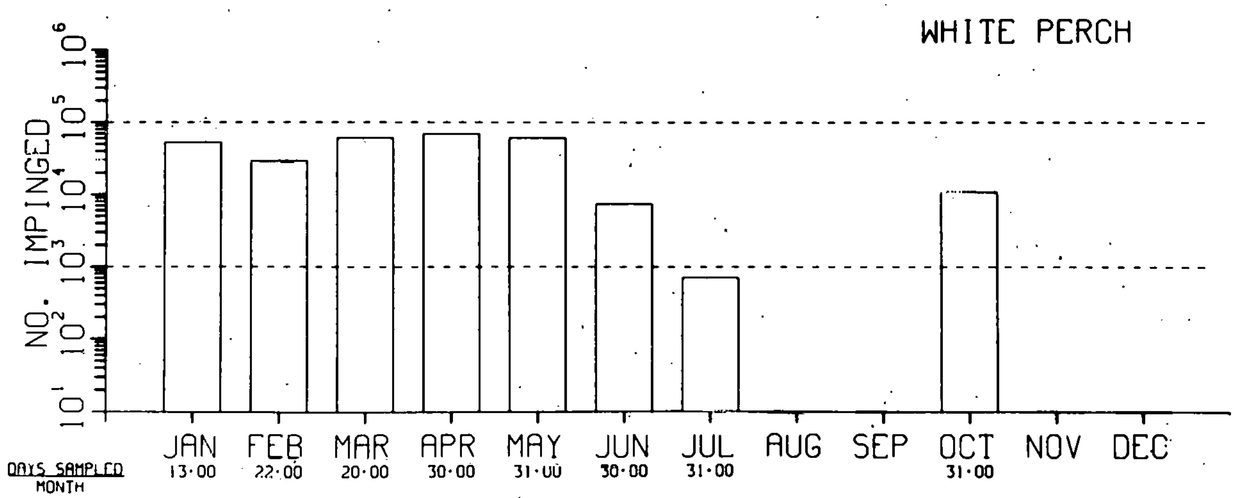


Fig. H14. Impingement Estimates.

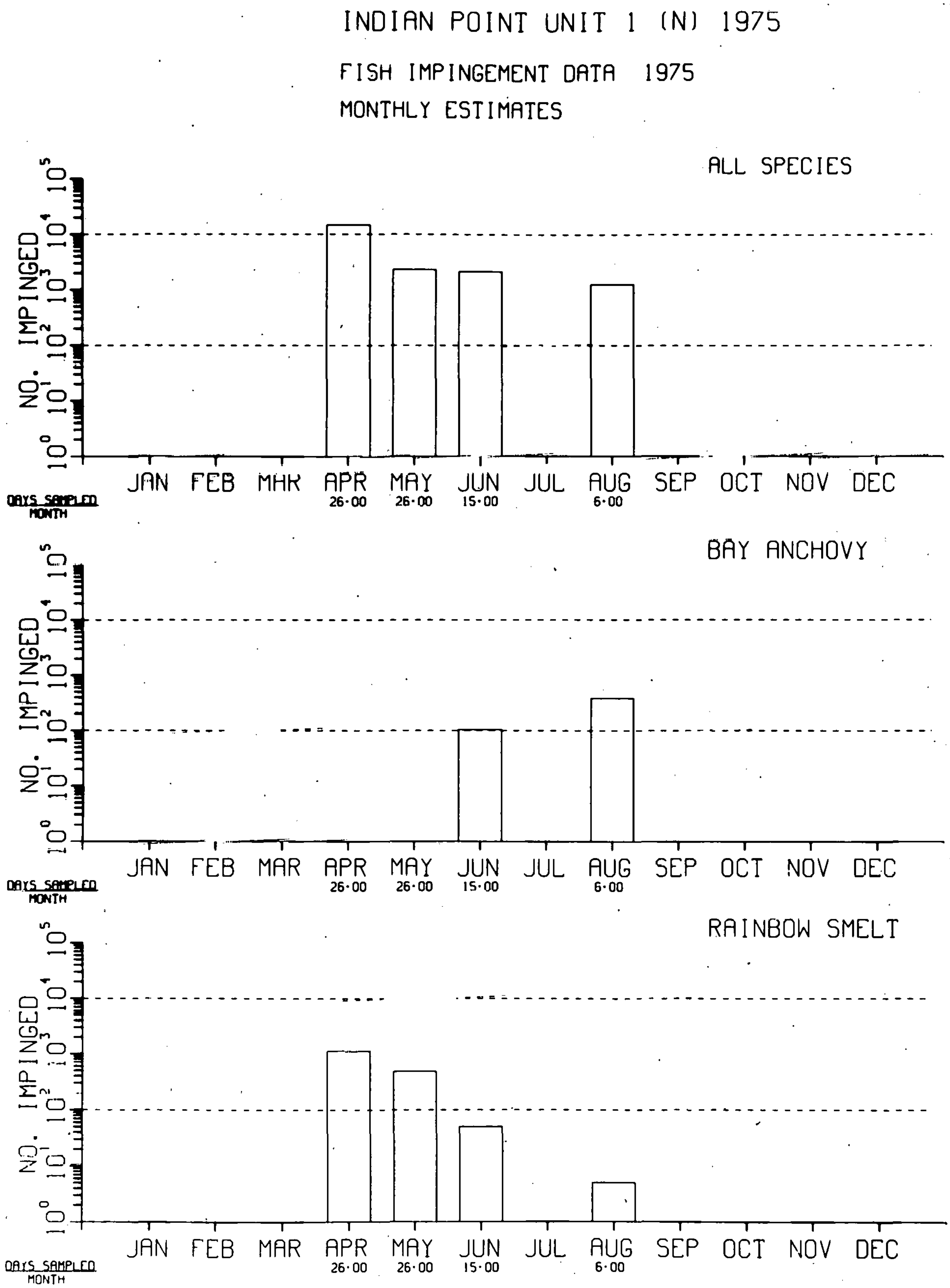
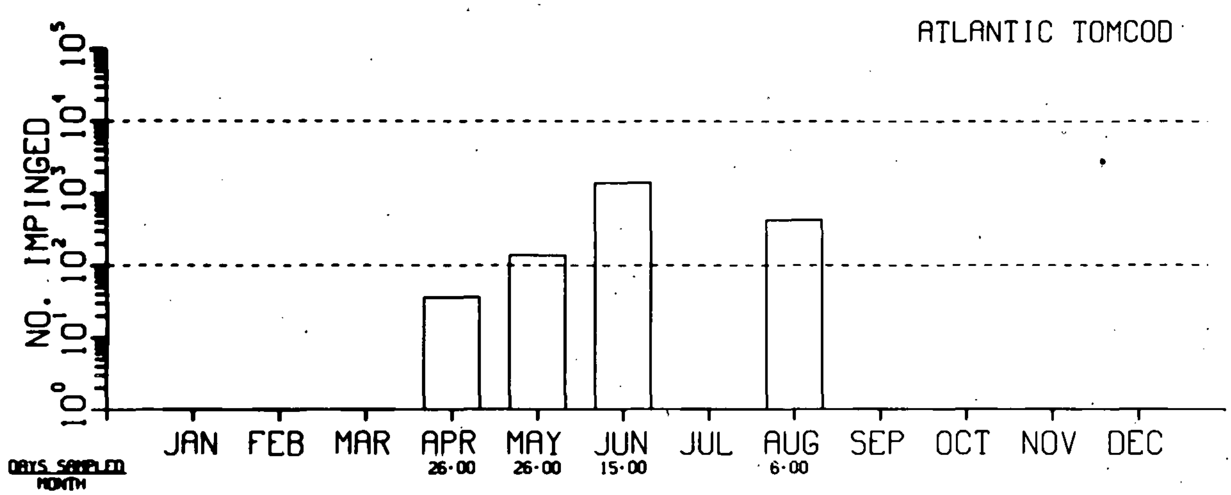


Fig. H15. Impingement Estimates.

INDIAN POINT UNIT 1 (N) 1975

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



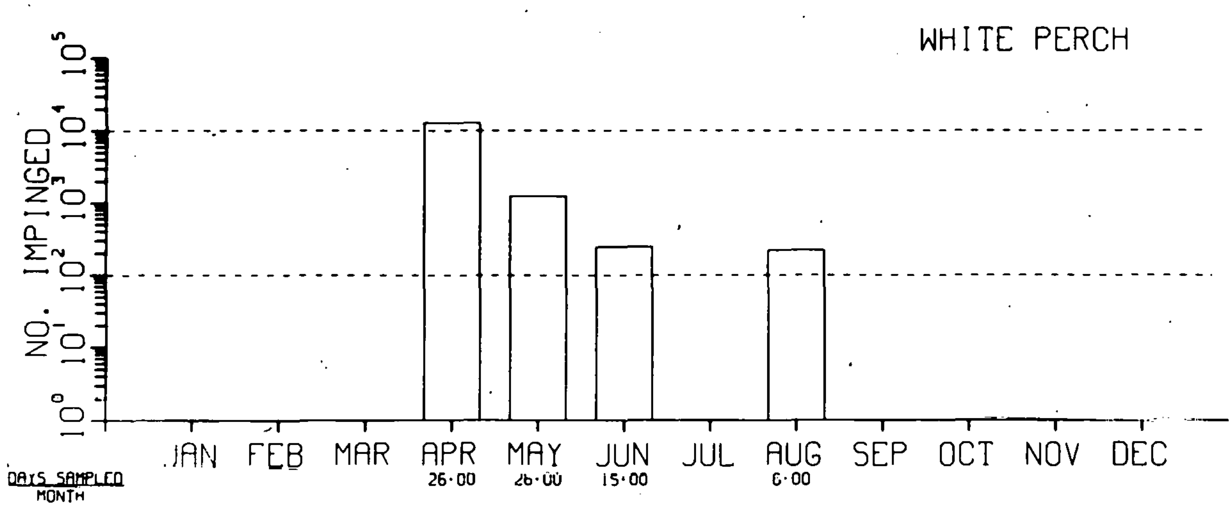


Fig. H16. Impingement Estimates.

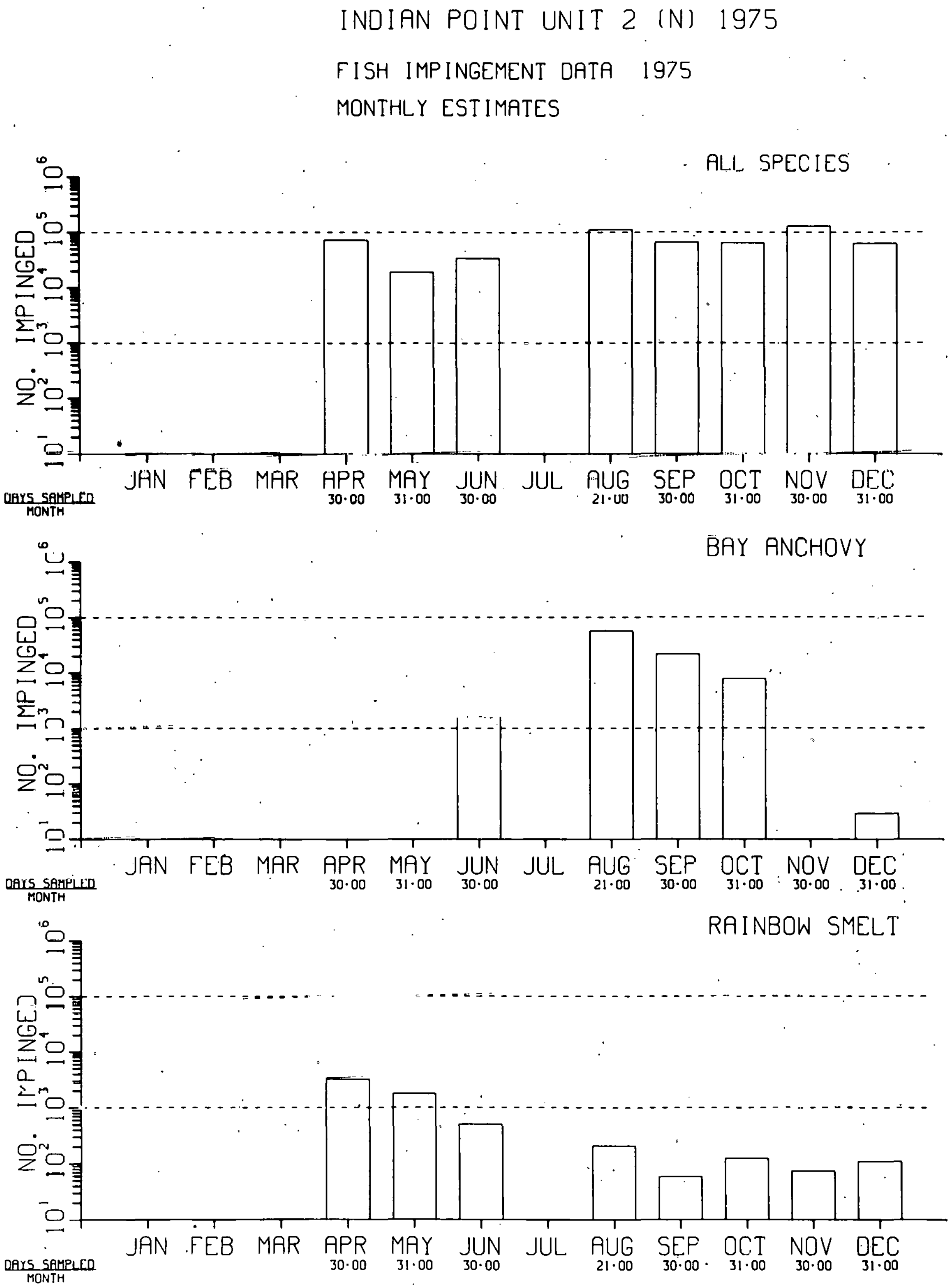


Fig. H17. Impingement Estimates.

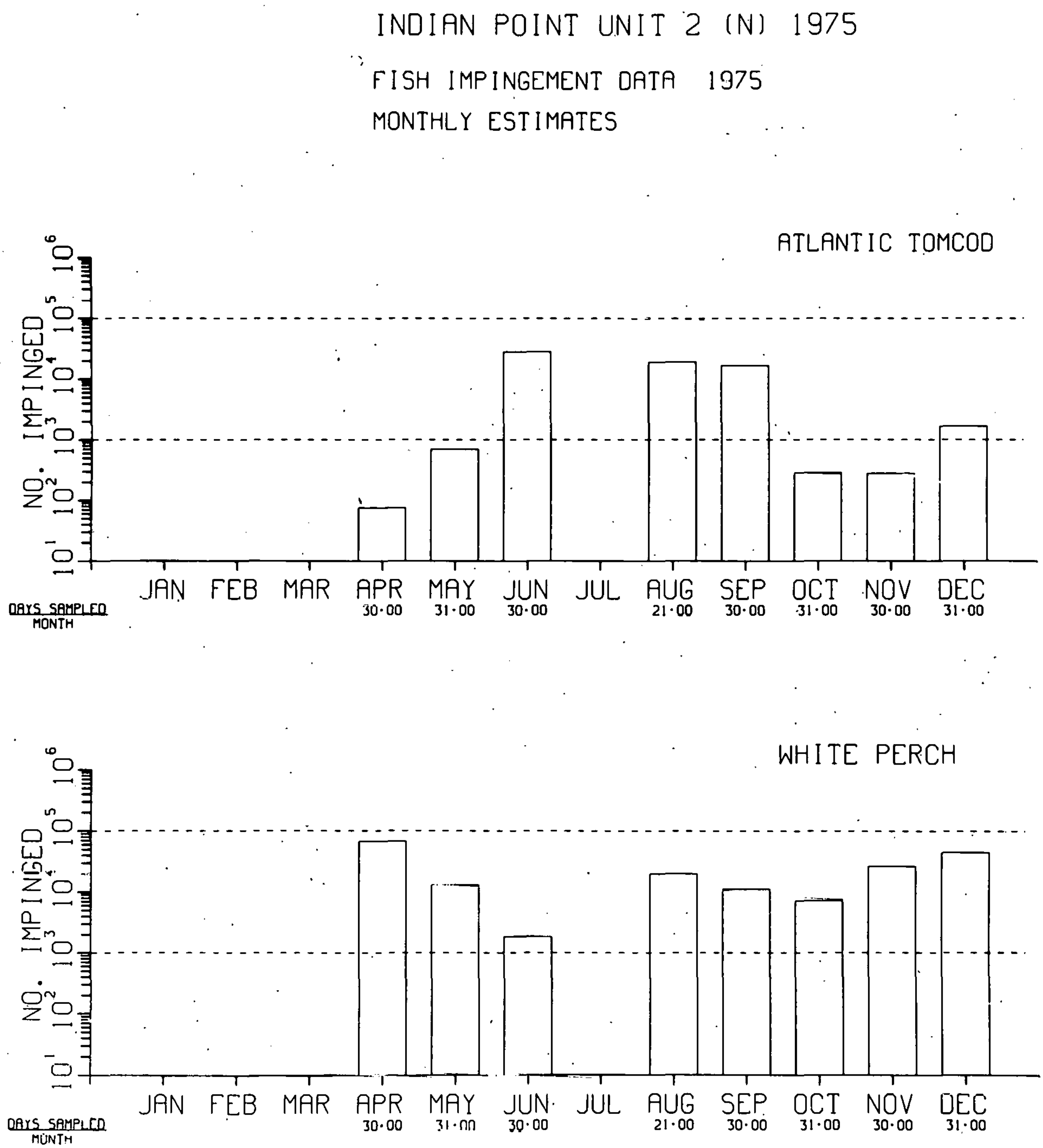


Fig. H18. Impingement Estimates.

NORTHPORT POWER STATION (F)

SITE CHARACTERISTICS

The Northport Power Station is located on an intake lagoon on the southern shore of Long Island Sound in Huntington, Long Island (Fig. 1). Three units are in operation and a fourth is under construction. The site is situated about 40 miles east of New York City.[1]

Cooling water is withdrawn from Long Island Sound through an intake canal and two jetties that protrude into the sound. The depth of the canal is 15 feet below mean low water in the 150-foot-wide channel at the mouth of the jetties and 20 feet below mean low water in the 200-foot-wide channel in front of the intake structures.

A list of 34 fish species at the Northport Power Station is presented in Table I. This list suggests that a reasonably large variety of fish frequent the quiet waters of the intake-canal area.

PLANT DESCRIPTION

Northport is an oil-fired facility consisting of three units with a maximum net capacity of 386 MWe each, for a total of 1158 MWe. A fourth unit is under construction. The plant employs once-through cooling, and the heated effluent is discharged to an adjacent canal where an oyster farm is situated (Fig. 1).

INTAKE DESIGN AND OPERATION

The intake structures for the three units are located on the eastern side of the lagoon. Those for Units 1 and 2 are paired, and the intake for Unit 4 will be paired with that for Unit 3 upon its completion in 1977 (Fig. 2). Each unit has two circulating-water pumps and two traveling screens equipped with 3/8-inch mesh. The screens and screenwash sprays are normally operated on a continuous basis. The total volume of water pumped by the three units is 469,000 gpm (148,000 gpm each for Units 1 and 2 and 173,000 gpm for Unit 3). Velocities under the curtain wall are 1.28 fps for Units 1 and 2 and 1.51 fps for Unit 3. Velocities at the traveling screens are 0.69 fps for Units 1 and 2 and 0.81 fps for Unit 3. No deicing procedures were outlined.

IMPINGEMENT SAMPLING

The intake screens are sampled for a total of 80 hours on Monday through Thursday of each week. Sampling baskets of 1/4-inch mesh were placed in the screenwash sluiceway and all fish collected were returned to the lab for analysis. Uninjured fish were returned to Long Island Sound. Monthly tables were prepared for each unit and included (1) number of fish, (2) number of fish/hour, (3) number of pounds, and (4) number of pounds/hour.

DATA AVAILABILITY

Data are available for all three units for 27 January 1975 through 28 January 1976.

IMPINGEMENT DATA SUMMARY

The three most numerous species impinged at Northport Units 1-3 from February to July 1975 were winter flounder, Atlantic menhaden, and Atlantic silverside. Data were independently extrapolated by combining the three units and using the average number of hours sampled in any given month to derive hypothetical impingement figures for the months sampled.. A summary of the fish impingement data is presented in Table II. During the months of July 1975 through January 1976, a radical species shift took place with four new species, striped searobin, cunner, butterfish, and red hake, dominating the collection from the screens. Because the numbers were taken from raw data, a standard monthly sample time of 320 hours, or 13.3 days per month was chosen. This could result in an underestimate due to variable downtime on each of the units. Histograms of monthly impingement estimates are shown in Figures H1 through H4.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

No special features were cited. In fact, measured intake velocities were lower than water currents in the lagoon. Calmer water near the intake attracts fish and may mitigate against their return to open water.

REFERENCE

1. A. C. Gross and E. R. Fairfield. "Fish Impingement at Northport Power Station." Six-Month Progress Report. Long Island Lighting Company, Environmental Engineering Department. 1975.

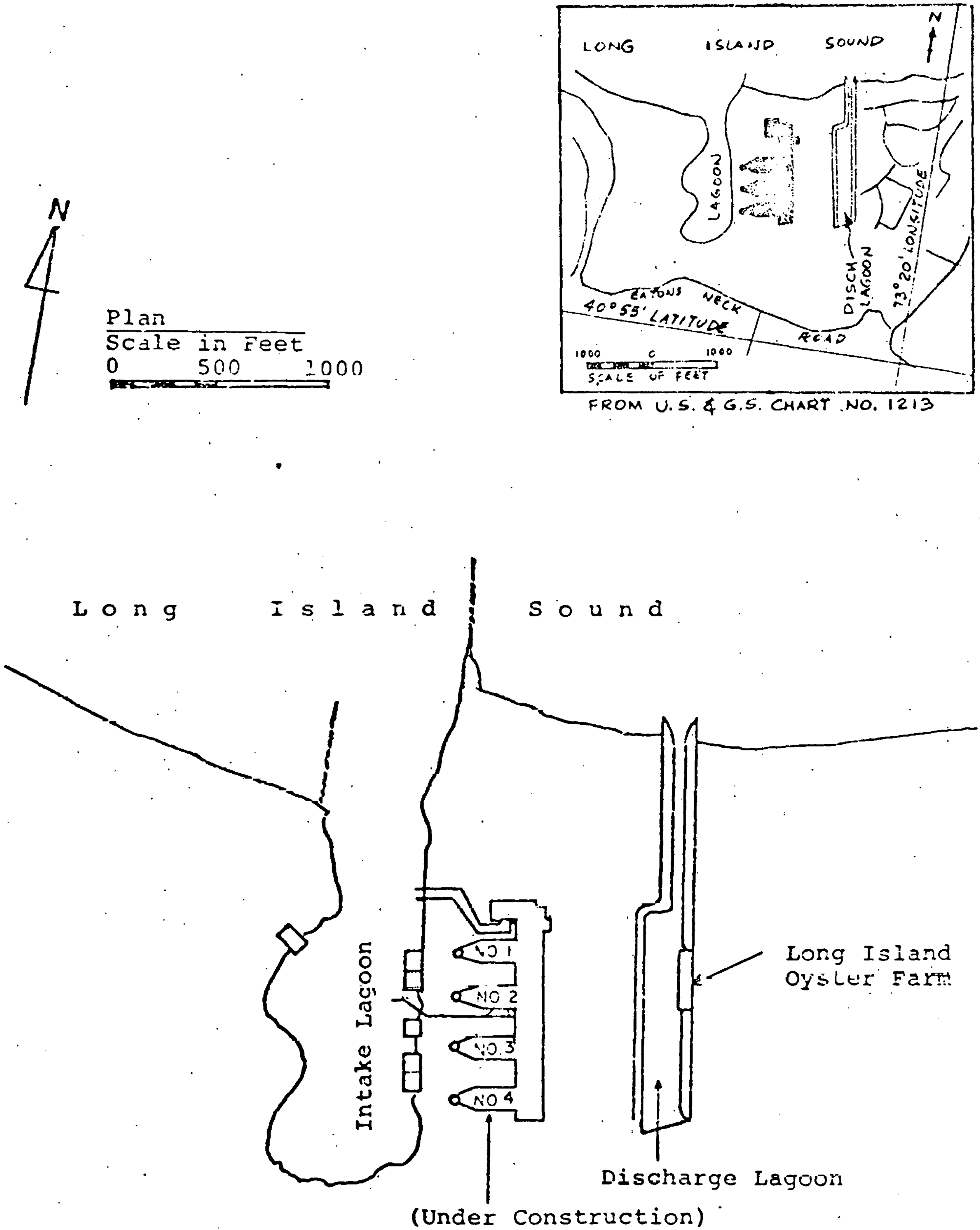


Fig. 1. Site Plan and Location.

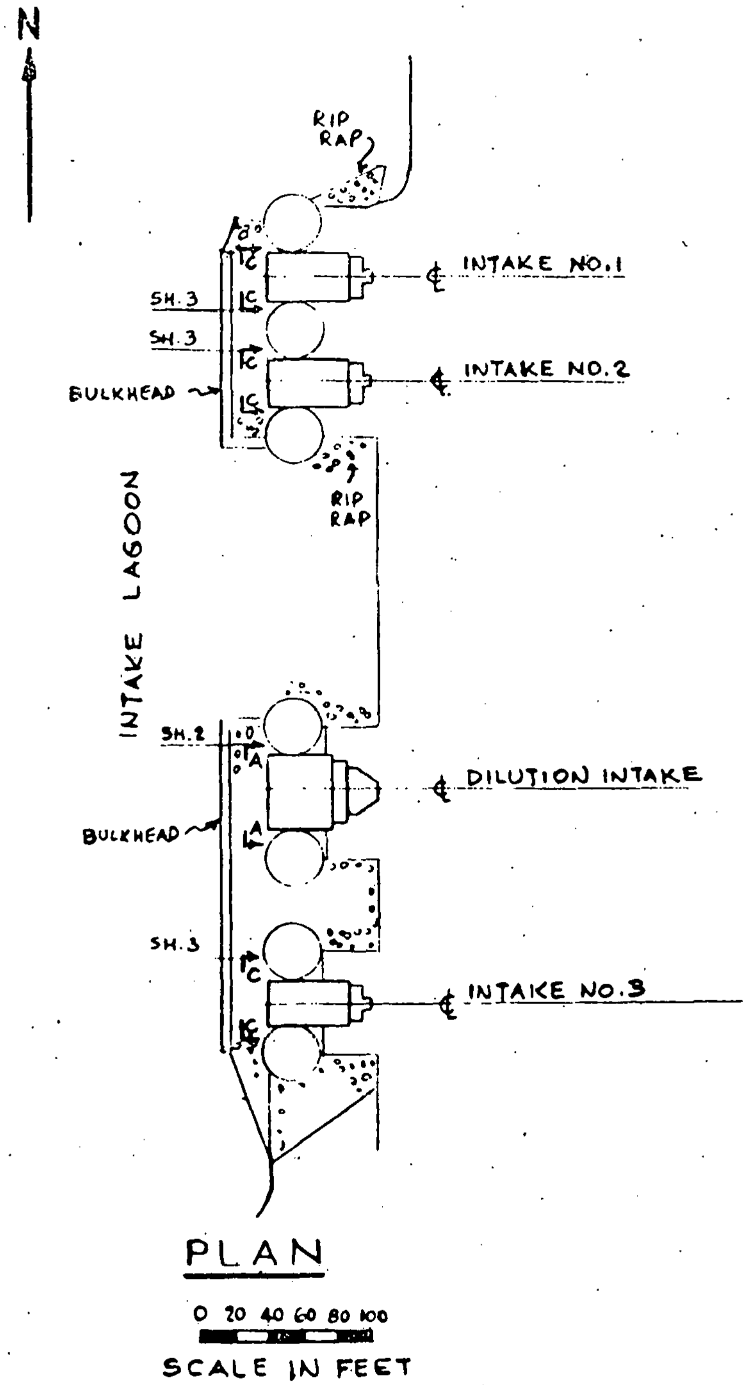


Fig. 2. Intake Structures.

Table I. Fishes Impinged at the Station

American sand lance	Bluefish
American eel	Northern searobin
Atlantic menhaden	Striped searobin
Black sea bass	Winter flounder
Weakfish	Little skate
Smallmouth flounder	Brook trout
Mummichog	Windowpane
Striped killifish	Lookdown
Spot	Northern puffer
Yellowtail flounder	Scup
Atlantic silverside	Northern pipefish
Northern kingfish	Tautog
Silver hake	Cunner
Summer flounder	Hogchoker
Striped mullet	Red hake
	Smooth dogfish
	Grubby
	Oyster toadfish
	Butterfish

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Atlantic Menhaden	Winter Flounder	Atlantic Silverside	Total
1975	11	840	3,784	3,941	17,269
1976	1	21	237	495	1,811

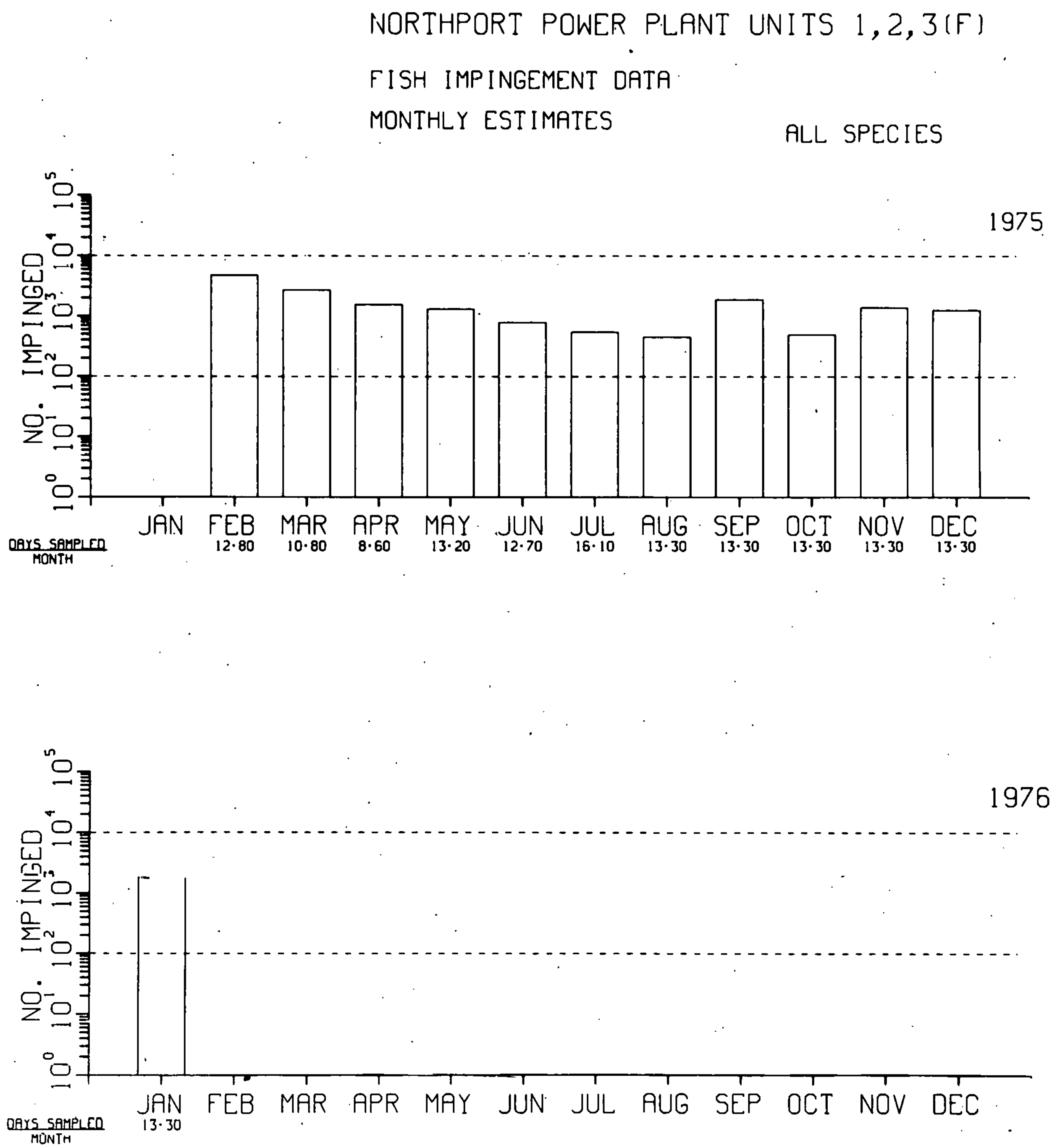


Fig. H1. Impingement Estimates.

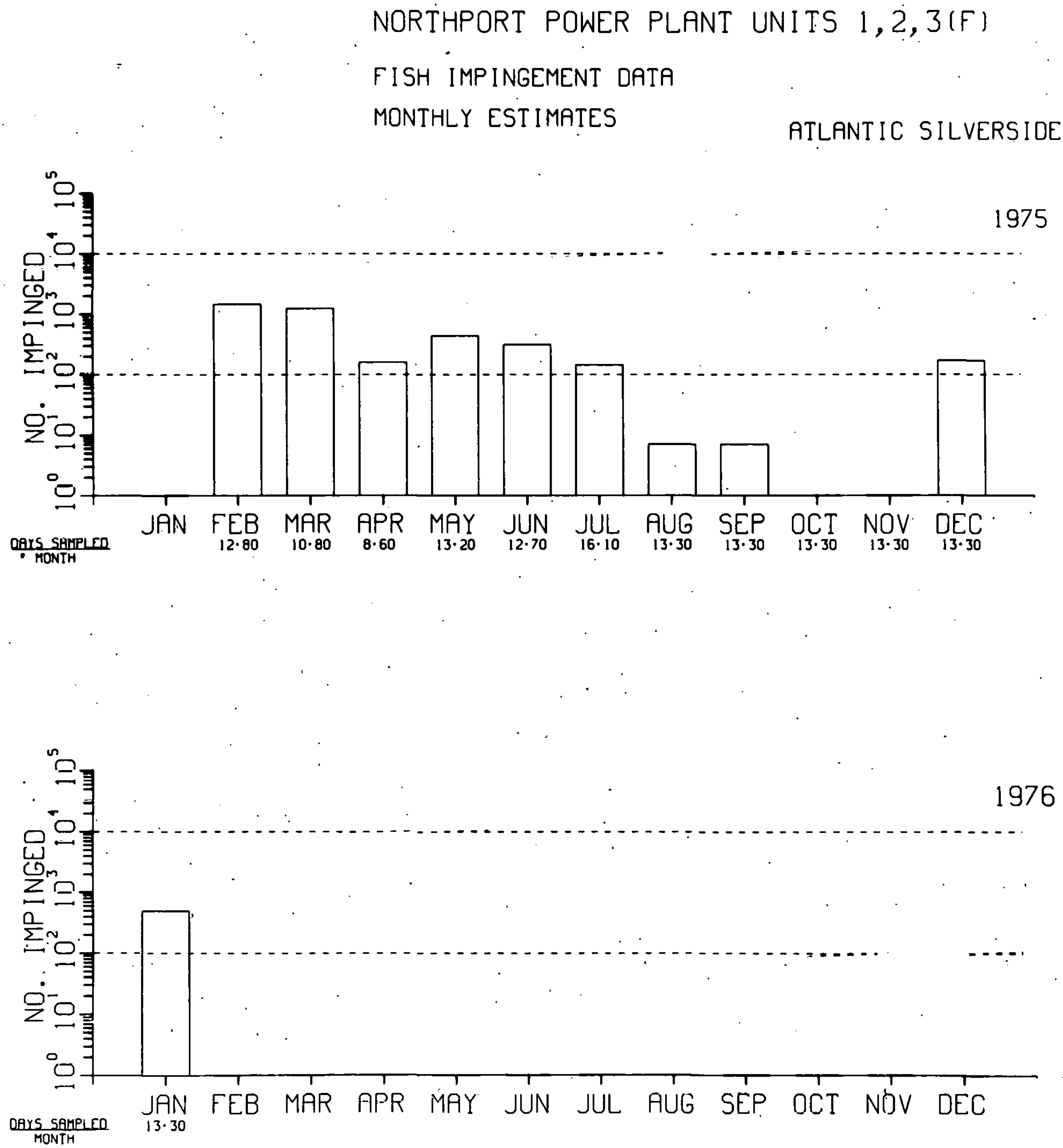


Fig. H2. Impingement Estimates.

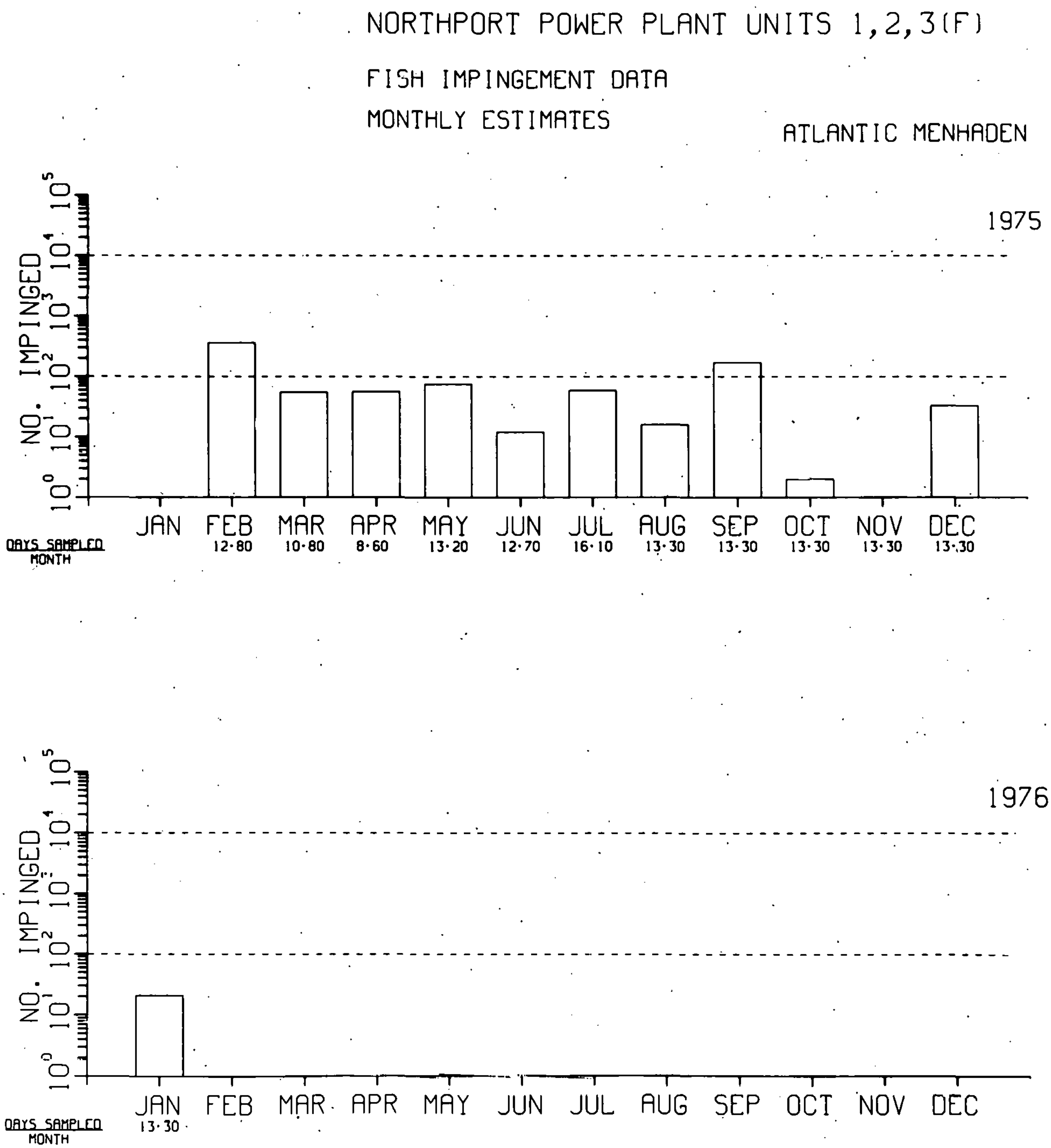


Fig. H3. Impingement Estimates.

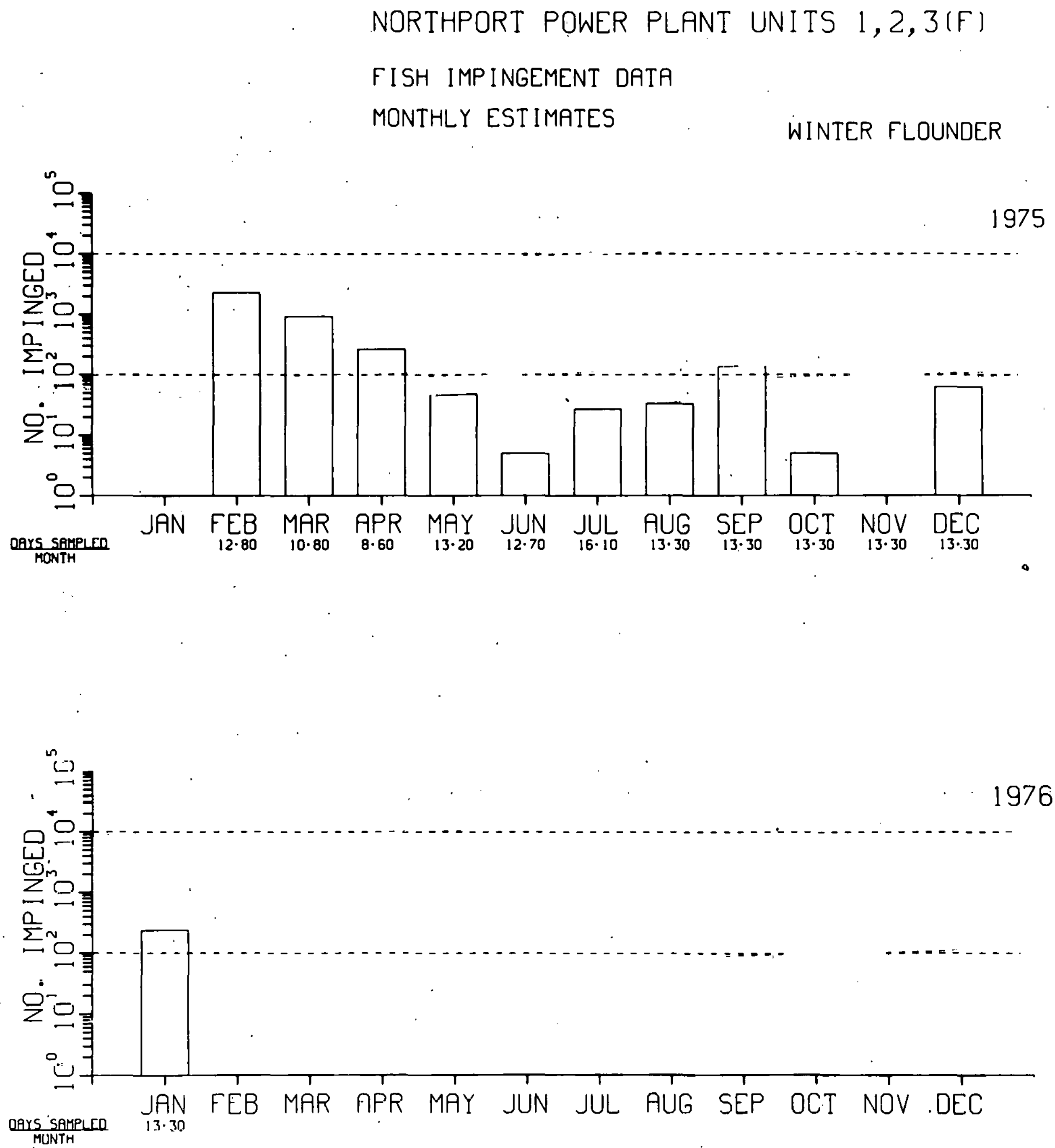


Fig. H4. Impingement Estimates.

ASTORIA GENERATING STATION UNITS 1-5 (F)

SITE CHARACTERISTICS

Astoria is a five-unit steam-electric generating station, located on the East River in New York City, New York.[1] The location of the station with respect to the surrounding aquatic environment is shown in Figure 1. The East River is a relatively short stretch of water that connects Lawrence Bay and Long Island Sound to the northeast with New York Bay to the southwest. Maximum tidal velocity in the river occurs on the ebb tide and averages 7.6 fps. The channel in front of the plant is 75 feet deep. Average water temperature varies from a low of 38°F in February to a high of 75°F in August. Salinity varies widely and in a random fashion, with values ranging from 8000 to 18,000 mg/liter.

Thirty-seven species of fish were impinged at Astoria during the study period (Table I). A biological survey of the East River conducted in 1970 shows that no resident fish populations exist in the river.[2] Their presence is transitory, and fish impinged at Astoria may be taken mostly from populations in Long Island Sound, the Hudson River Estuary, and inshore areas of the Atlantic Ocean.

PLANT DESCRIPTION

Units 1-5 are oil-fired facilities having a total capacity of 1625 MWe. The station employs once-through cooling. The East River provides cooling water and receives effluents.

INTAKE DESIGN AND OPERATION

Figure 2 is a schematic diagram of the three intake structures at the Astoria Generating Station. The structure for Units 1 and 2 has one wash trough. It has a combined total of seven traveling screens and four circulating-water pumps, is the southernmost intake, and lies closest to the discharge. The intake for Units 3 and 4 is located in the next screen building to the north. There are six traveling screens and two pumps for each unit. The screenhouse for Unit 5 has four traveling screens and two circulating-water pumps, and is farthest from the discharge. All of the structures extend to a depth of 25 to 30 feet below mean low water. Total circulating-water flow to the station is 1,476,000 gpm. A maximum intake velocity of 0.87 fps occurs at the intake for Units 3 and 4. No special operational modes for winter deicing were mentioned.

In addition to the traveling screens, fixed screens of 1/2-inch mesh are attached to trash bars. They are designed to keep debris and larger organisms from entering the station water systems. These fixed screens are not cleaned on a regular basis and could not be observed when in place, and it is not certain whether large fish were impinged on them, or exactly in what way they affected impingement at Astoria.

IMPINGEMENT SAMPLING

Organisms impinged on the traveling screens were collected from trough sluiceways at points indicated by + in Figure 2. During each continuous 12-hour sampling period, each of the operating units was sampled twice for one hour. At the time of collection, the station operating characteristics were noted. Sampling time totaled 0.12 days per month.

DATA AVAILABILITY

Data were combined for all units and are available for October and November of 1971, and all of 1972.

IMPINGEMENT DATA SUMMARY

Table II summarizes the yearly totals for five species of fish impinged to varying degrees over the 14 months in which sampling took place at Astoria. These species include the striped searobin, Atlantic silverside, blueback herring, Atlantic menhaden, and alewife.

Because there are no resident fish populations in the East River, the rate of impingement is highly variable, as evidenced by Table II. There were 269,000 fish taken in two months in 1971, whereas in 1972 only 215,000 were impinged in 12 months. Monthly impingement totals are summarized in Figures H1 through H4.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

No measures have been reported taken to minimize fish impingement other than maintaining a low intake velocity and having a "favorable position in the East River." The position may be favorable because of the absence of any permanent fish population at that point, the presence of which would increase impingement at the plant.

REFERENCES

1. "A Study of Impinged Organisms at the Astoria Generating Station." Quirk, Lawler, and Matusky, Engineers. Project Number 115-16, for Consolidated Edison Company of New York, Inc. September 1973.

2. A. Perlmutter. "Ecological Studies Related to the Proposed Increase in Generating Capacity at the Astoria Power Station of Consolidated Edison, 1970." 34 pp. 1971.

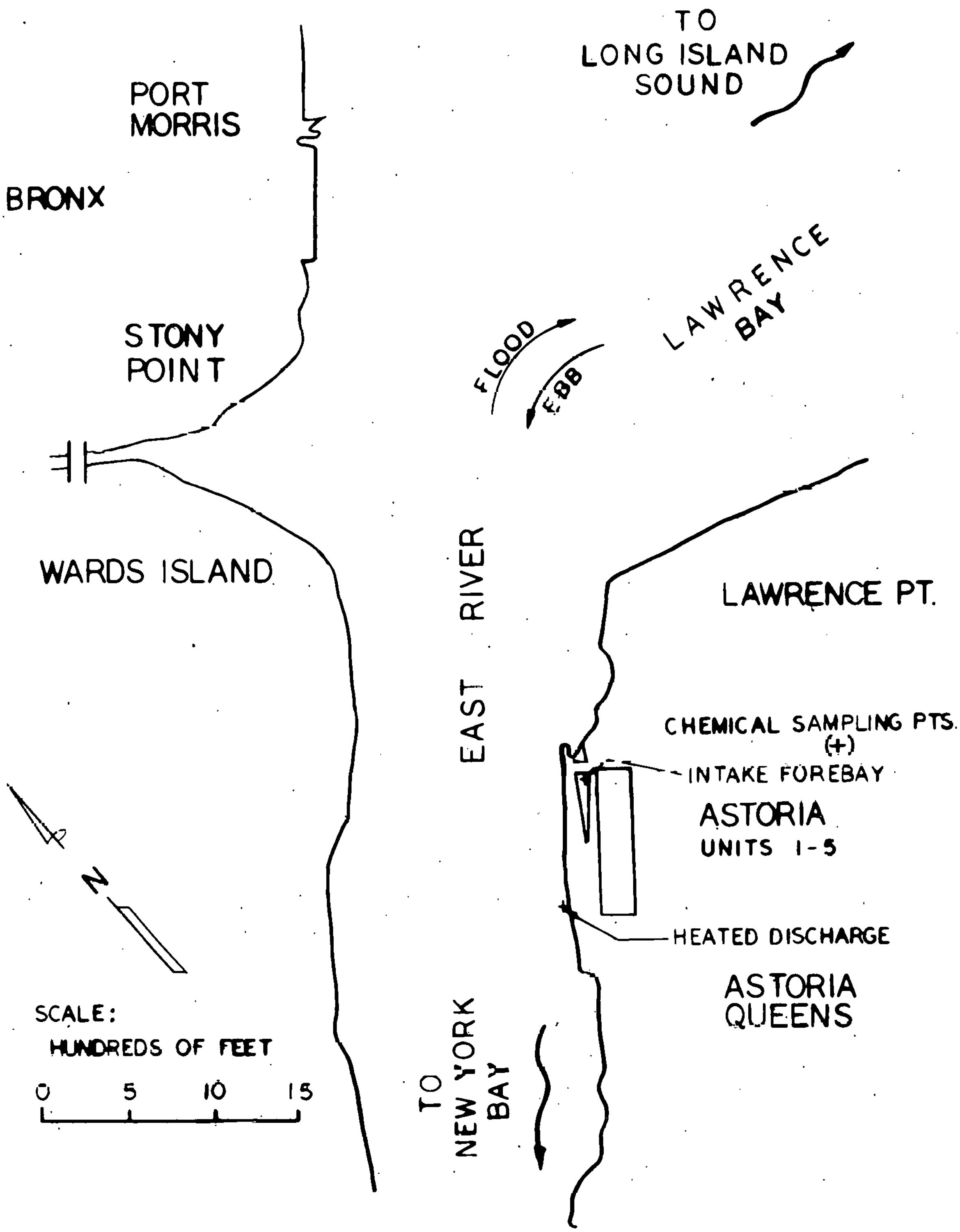


Fig. 1. Station Location.

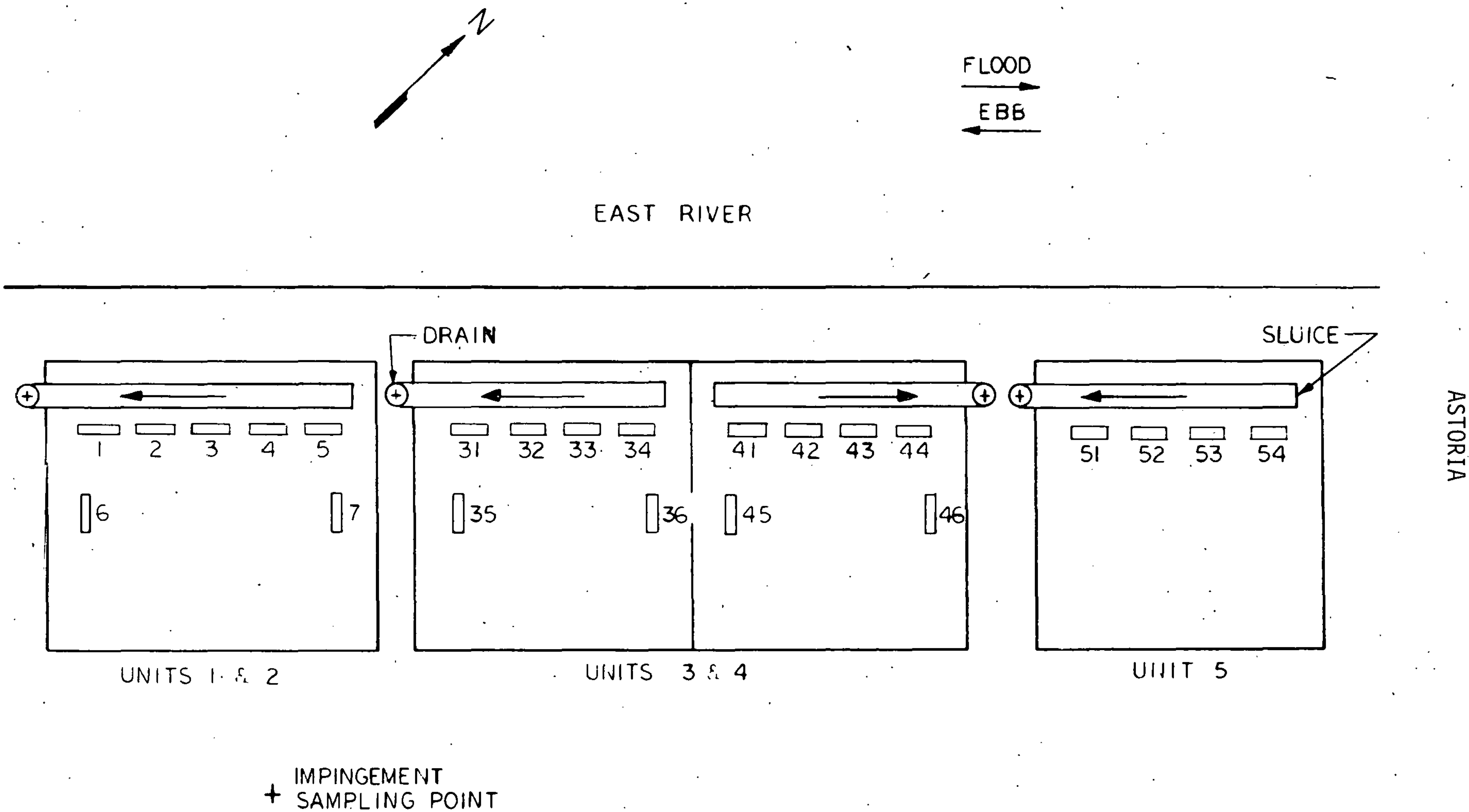


Fig. 2. Water-Intake Schematic.

Table I. Fish Species Impinged at the Intakes

Alewife	Pollock
American eel	Longspine porgy
American shad	Red hake
Atlantic silverside	Rock sea bass
Bay anchovy	Seahorse
Blueback herring	Silver hake
Bluefish	Spotted hake
Blue runner	Striped bass
Butterfish	Striped searobin
Cunner	Threespine stickleback
Fourbeard rockling	Atlantic tomcod
Fourspot flounder	Weakfish
Grubby	White hake
Gulf flounder	White perch
Lookdown	Windowpane
Atlantic menhaden	Winter flounder
Atlantic moonfish	Yellowtail flounder
Northern pipefish	
Northern puffer	
Northern searobin	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled					
		Striped Searobin	Atlantic Silverside	Blueback Herring	Atlantic Menhaden	Alewife	Total
1971	2	217,284	17,046	5,514	186	Not sampled	268,542
1972	12	Not sampled	3,834	71,628	21,984	52,404	215,016

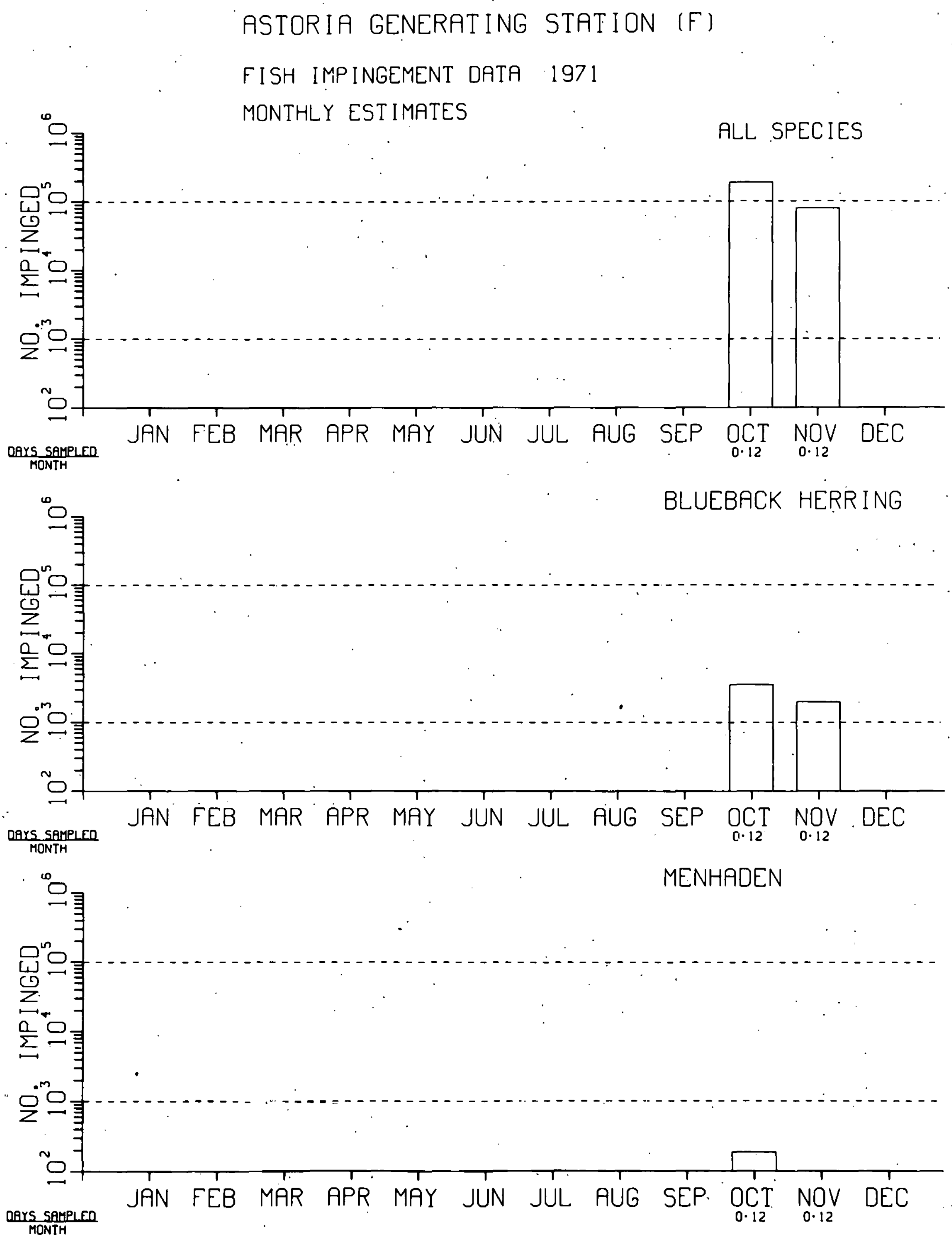
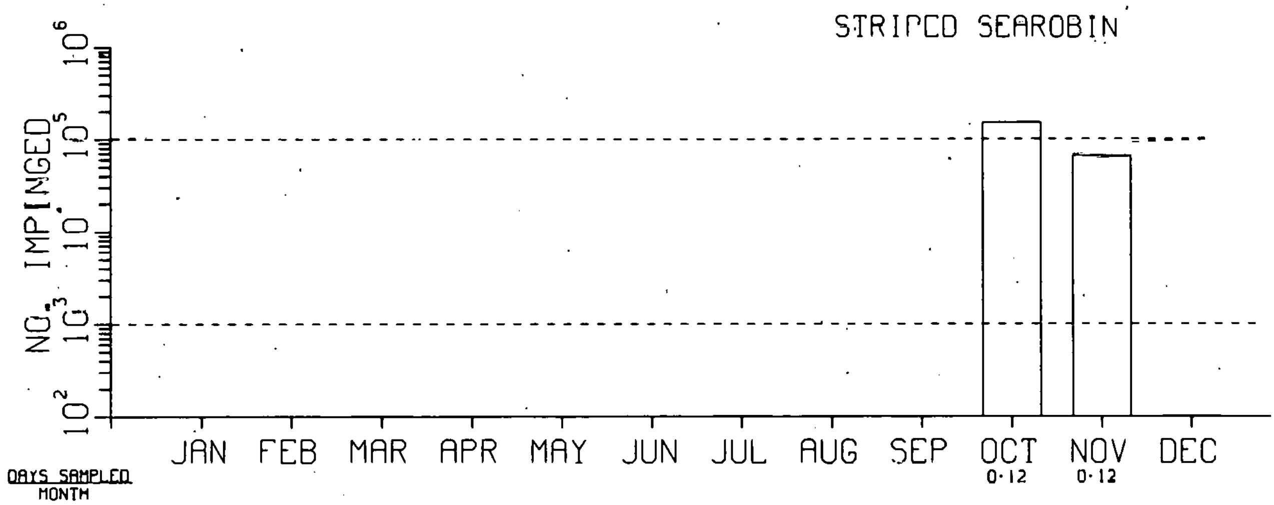


Fig. H1. Impingement Estimates.

ASTORIA GENERATING STATION (F)

FISH IMPINGEMENT DATA 1971

MONTHLY ESTIMATES



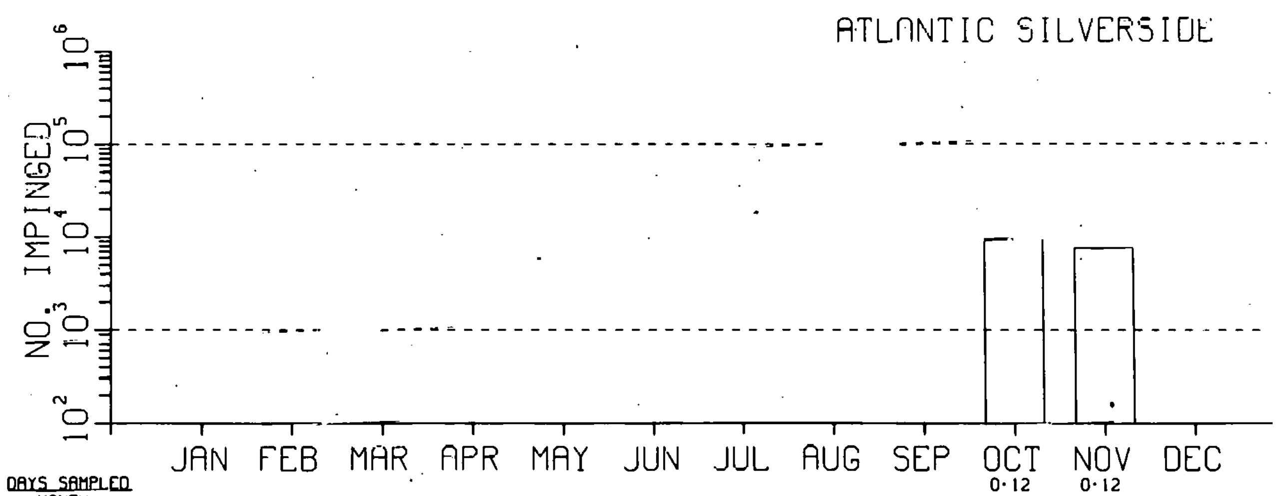


Fig. H2. Impingement Estimates.

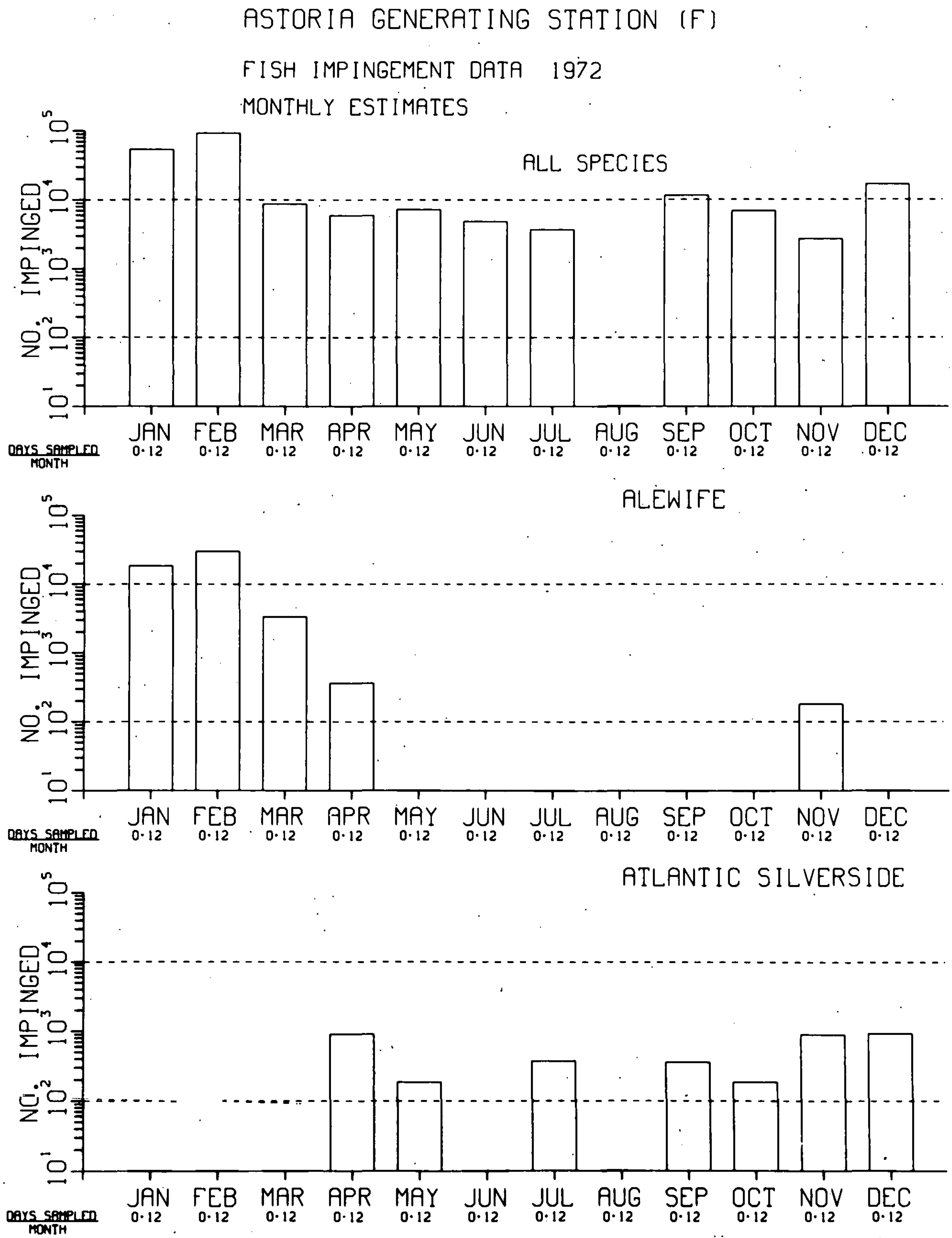


Fig. H3. Impingement Estimates.

ASTORIA GENERATING STATION (F)

FISH IMPINGEMENT DATA 1972

MONTHLY ESTIMATES

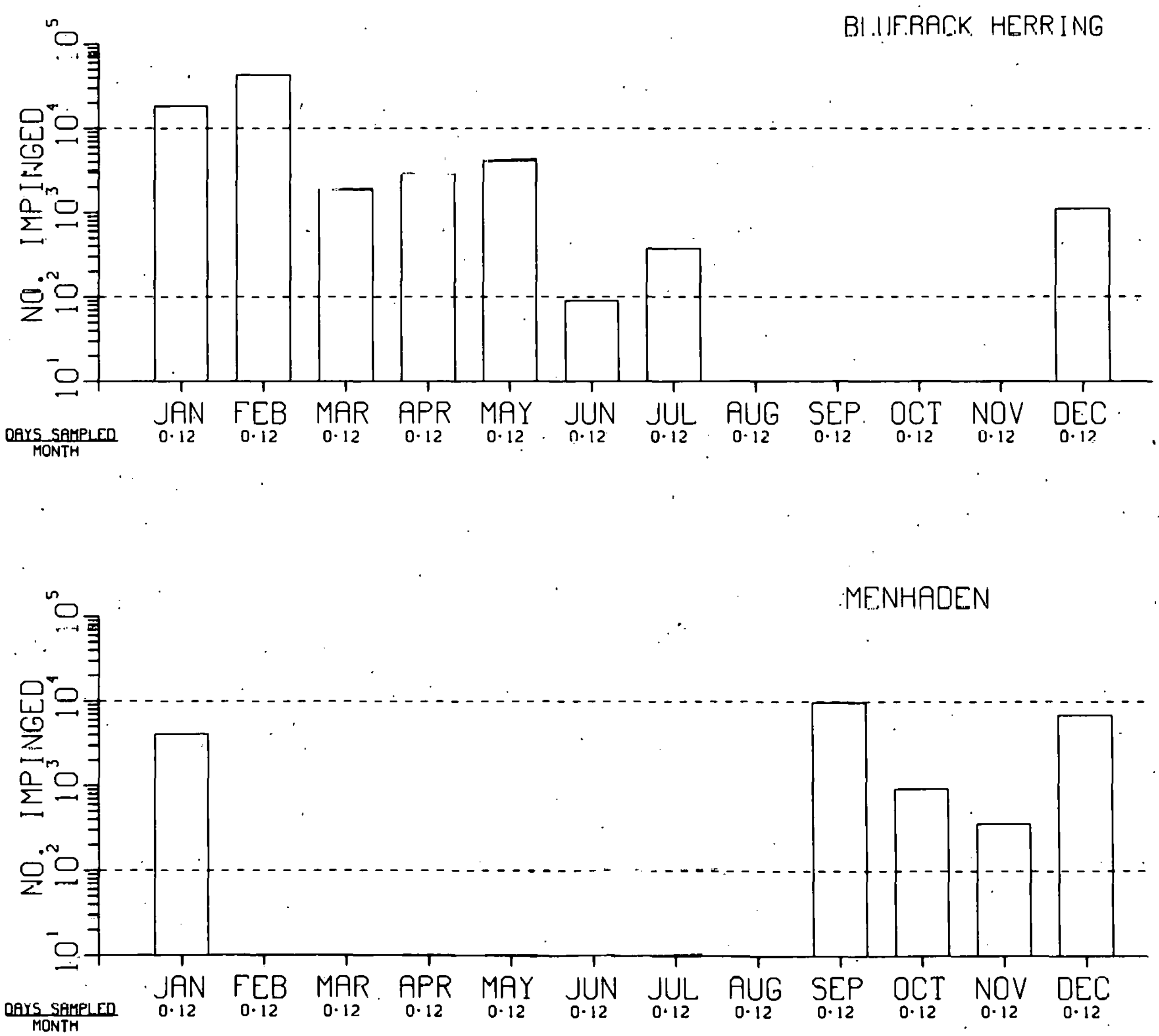


Fig. H4. Impingement Estimates.

OYSTER CREEK GENERATING STATION (N)

SITE CHARACTERISTICS

The Oyster Creek Nuclear Generating Station is located in Ocean County, New Jersey, two miles inland from Barnegat Bay.[1] The 1516-acre site is 60 miles south of Newark, nine miles south of the Toms River, and 35 miles north of Atlantic City (Fig. 1). The site is part of the New Jersey shore area and includes its typically flat topography and extensive freshwater and saltwater marshlands. In addition, Barnegat Bay is part of the intercoastal waterway. The site is bounded on the north by the South Branch of the Forked River, and while Oyster Creek partly makes up the southern boundary.

Barnegat Bay is a shallow, irregular tidal basin enclosed by the mainland on the west and separated from the Atlantic Ocean on the east by a barrier beach extending 30 miles from Point Pleasant on the north to Manahawkin Causeway on the south.[2] The width of the bay is about four miles, and its maximum depth is 20 feet at mean low water. The mean depth is generally less than ten feet. Water volume in the bay is about 8.5×10^9 cubic feet. The barrier beach and the shallowness of the bay tend to minimize tidal fluctuations, which generally vary from 0.5 to 0.8 feet. Most of this tidal water enters and leaves the bay via Barnegat Inlet, directly east of the site. Inflowing water from small coastal streams locally diversifies the weak current system. The average salinity of the bay is 25 ppt. This is 30% less than normal, and is accounted for by the large number of streams in the area as well as groundwater seepage. The average temperature of Barnegat Bay is well over 70°F during the summer.

The fish fauna of the area is diverse, with 74 species of fish identified during trawling operations in the bay (Table I). The most abundant species in terms of sport or commercial fisheries are Atlantic silverside, tidewater silverside, winter flounder, fourspine stickleback, northern pipefish, silver perch, and bay anchovy. The sampling was extensive and the time of year in which most species were found in the bay is also recorded in Table I.

PLANT DESCRIPTION

The station utilizes a single boiling water reactor rated at 670 MWe. It employs a once-through system for condenser cooling.

INTAKE DESIGN AND OPERATION

The flow characteristics of the intake and discharge at the Oyster Creek Station are shown in Figure 2. Water for cooling is drawn from Barnegat Bay through the South Branch of the Forked River to an artificial canal that has a total length of five miles. Discharged cooling water is pumped to Oyster Creek on the south and ultimately empties back into Barnegat Bay. During the summer, bypass pumps divert a large quantity of cooling water directly into the discharge flume to reduce the effluent-water temperature below 95°F. The average depth of the intake and discharge canal is about ten feet, and its width is always greater than 150 feet except at the Highway 9 bridges. The maximum flow velocity in both canals is 2.0 fps (with dilution-flow in operation). This represents a flow of 1,250,000 gpm. Without dilution-flow the velocity is decreased to 1.0 fps. Theoretical intake velocity at the traveling screens is 1.7 fps at normal water level and 2.3 fps at low water level. Actual measurements at the opening of each bay averaged 0.35 fps.

The intake structure has two forebays, each of which contains trash racks and three traveling screens, a chamber for two emergency service-water pumps, one service-water pump, one screen-wash system, and a separate chamber for each of two circulating-water pumps. The arrangement of stoplogs shown in Figure 3 allows screenwells or pumpwells to be dewatered individually without interruption of the water supply to any of the other pumps. A recirculation tunnel from the circulating-water discharge provides heated water through six hand-operated sluice gates to prevent icing during cold weather.

Each traveling screen consists of screen panels attached to two continuous chains riding on head-and-foot sprockets. The screens are equipped with 3/8-inch mesh openings and travel at a rate of ten feet per minute. A spray pipe with nozzles within the head assembly washes accumulated debris into a sluiceway. Two half-capacity screen-wash pumps discharge into a common header to the six spray pipes. Normal plant operation involves a screen wash every two hours for ten minutes, or sooner if screen clogging occurs. Differential pressure across the screen is sensed by special controllers, which start the screen-wash cycle if head loss in either section of the intake structure is above a preset value. The screen-wash cycle continues until the head loss decreases to normal. Fish, aquatic plants, and trash accumulating on the screens are carried together by a flume to the discharge canal.

As shown in Figure 3, there are four circulating-water pumps, each rated at 115,000 gpm. Two service-water pumps are rated at 6000 gpm each, but only one operates at any one time; the other is a backup pump. Thus, the maximum plant capacity for pumping screened water is 466,000 gpm. In addition, the dilution-system pumps are periodically operational, but are protected only by trash racks. They are low-speed, axial-flow pumps with seven-foot-diameter impellers and, according to the applicant, "damage to fish has not been a problem."

IMPINGEMENT SAMPLING

Fish impingement was monitored during two widely spaced time periods: April through July 1971, and August 1975 through August 1976. Data for the first five months of the latter program are available.

Impingement sampling involved the collection of two hours' accumulated fish and debris for each sample. Each set of 12 samples was considered to be a 24-hour sample when extrapolating the numbers of fish to continuous sampling. Sampling in the 1975 study occurred three days per week and ran for a total of 48 hours, 12 hours on the first and third days and 24 hours on the second day.[3] Subsamples were taken every two hours and a total of 370 such collections were made from 7 September to 27 December 1975.

DATA AVAILABILITY

Data are available for April through July 1971 and September through December 1975.

IMPINGEMENT DATA SUMMARY

Five different species were included in the three most numerous species impinged over the two study years when sampling was done. These are Atlantic silverside, winter flounder, northern pipefish, bay anchovy, and blueback herring. Because only four months of data are available from each year, the data may not reflect either actual numbers impinged or any seasonal variations that may exist. Summaries of the data for each species are presented in Table II. Monthly totals are given for the species and total fish in Figures H1 through H4.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

No measures were reported to have been taken to reduce fish impingement at this station.

REFERENCES

1. "Final Environmental Statement for Oyster Creek Nuclear Generating Station." USAEC Directorate of Licensing. Docket No. 50-219. December 1974.

2. "Cooling Water Intakes and Impingement of Fin and Shellfish at the Oyster Creek Nuclear Generating Station of JCP&L." Prepared by Michael B. Roche of the Jersey Central Power & Light Co. for Argonne National Laboratory. June 1976.

3. D. L. Thomas and G. J. Miller. "Impingement Studies at the Oyster Creek Generating Station." Icthyological Associates, Inc., Absecon, New Jersey. Presented at the Third National Workshop on Entrainment and Impingement, New York City, NY, 2-4 February 1976.

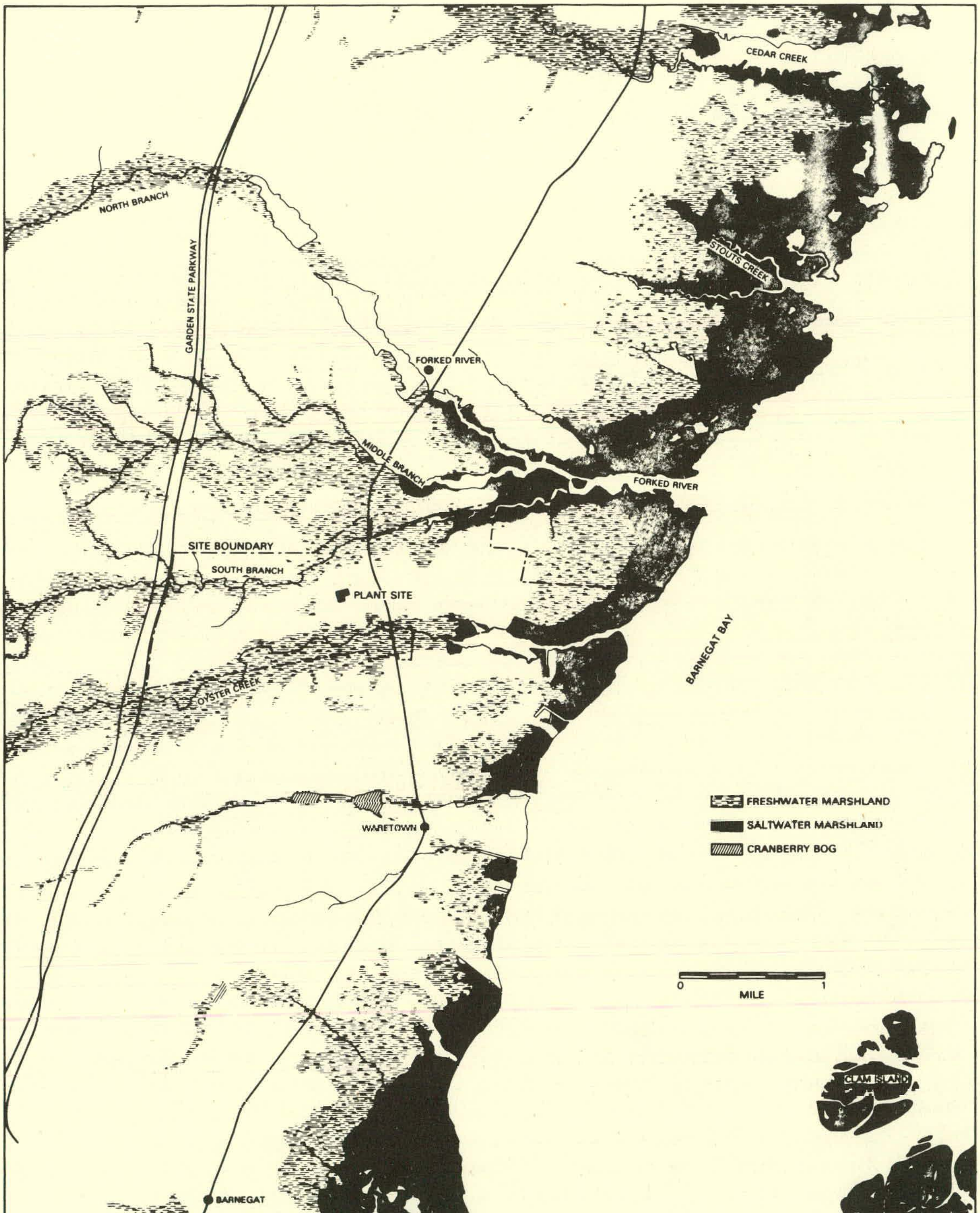


Fig. 1. Station Location.

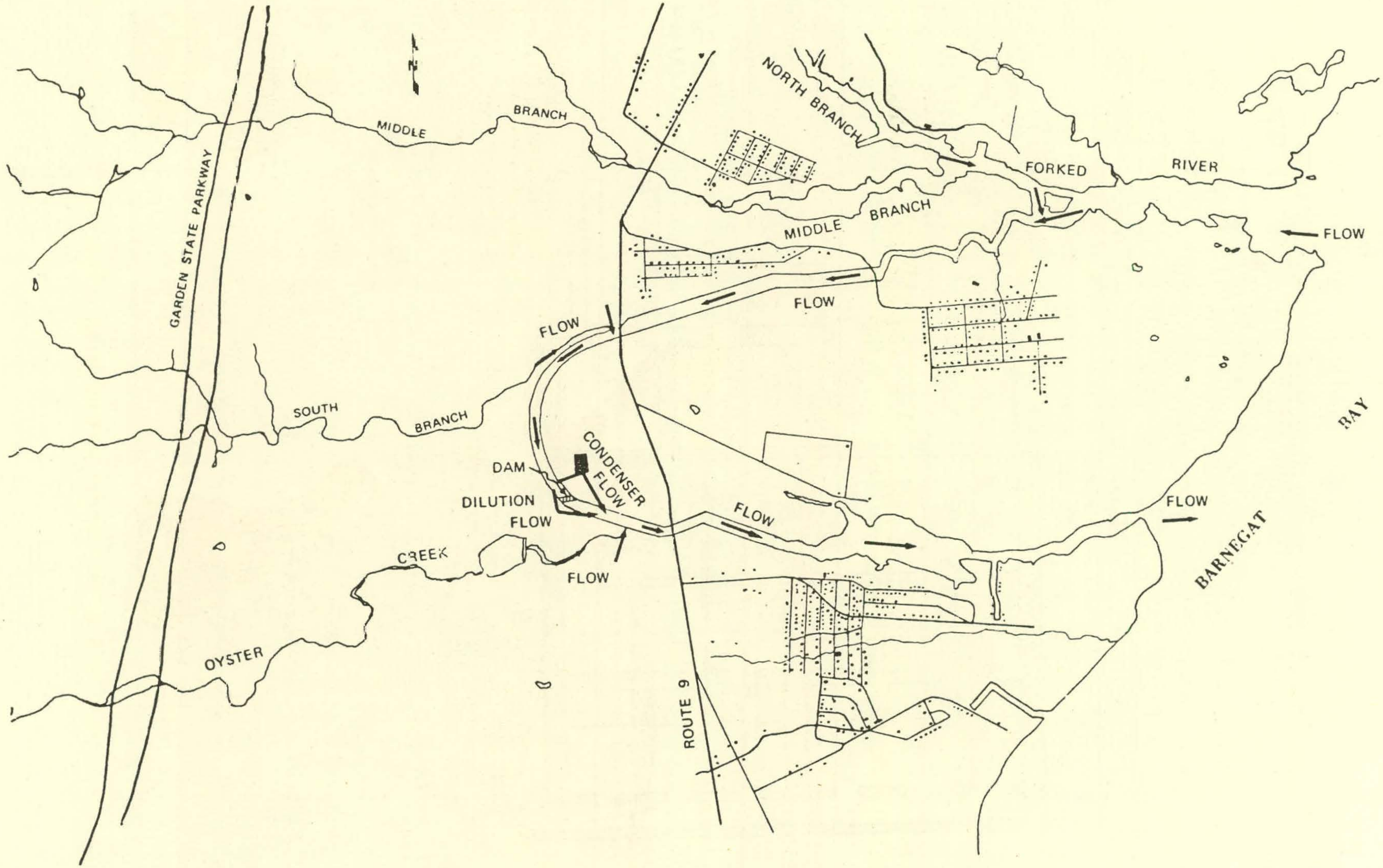


Fig. 2. Intake and Discharge Flow Characteristics.

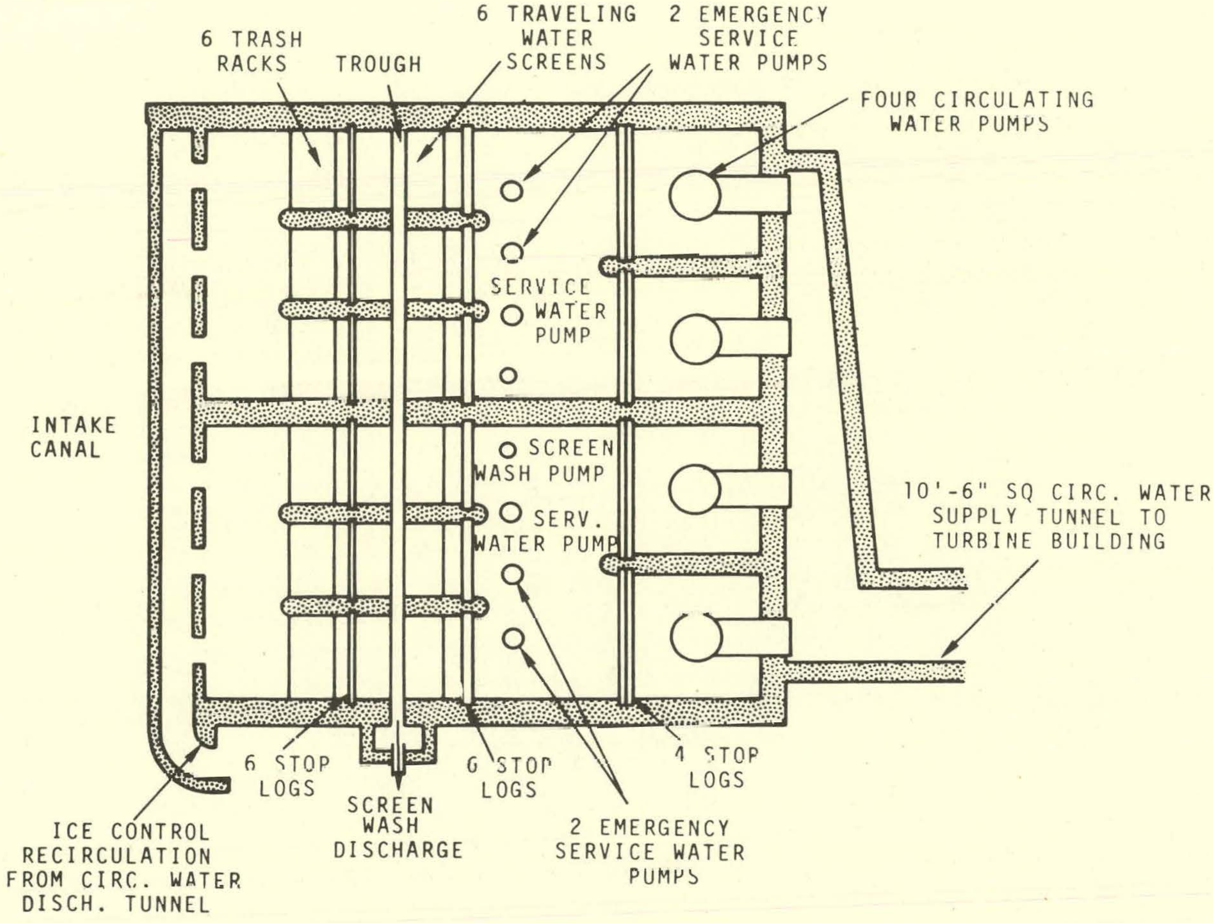


Fig. 3. Plan of Intake Structure at Centerline of Recirculation Tunnel.

Table I. Fish Species Found in Barnegat Bay and Surrounding Freshwater Streams

Common Name	Months in Residence[a]
Chain pickerel	Dec
Redfin pickerel	U
Yellow bullhead	U
Creek chubsucker	U
Pirate perch	U
Mud sunfish	U
Orangespotted sunfish	U
Golden shiner	Jun
Alewife	Mar-Aug
American eel	P
American shad	May
Atlantic herring	Dec-Jul
Atlantic menhaden	Aug-Feb
Atlantic needlefish	May-Oct
Round herring	U
Atlantic silverside	P
Banded killifish	P
Bay anchovy	Apr-Oct
Black drum	Sep-Oct
Blueback herring	Feb-Nov
Bluefish	Jun-Oct
Gulf butterfish	U
Crevalle jack	Jun-Oct
Cunner	May-Oct
Fourspine stickleback	P
Gizzard shad	Mar
Grubby	Oct-Jan & Jul
Hogchoker	Jun-Aug
Horse-eye jack	U
Lookdown	Jul-Sep
Mummichog	P
Naked goby	Mar & Nov
Northern kingfish	Jun-Oct
Northern pipefish	P
Northern searobin	Jun-Oct
Oyster toadfish	May-Dec
Pollock	Apr
Red grouper	Aug
Roughtail stingray	U
Sheepshead minnow	Oct-Apr & Aug

Table I. Continued

Common Name	Months in Residence[a]
Shorthorn sculpin	U
Silver perch	May-Oct
Smallmouth flounder	Jul-Aug
Spot	Jul-Sep
Spotted burrfish	U
Lined seahorse	Jul
Red hake	U
Striped bass	Mar
Striped blenny	May-Nov
Striped burrfish	Apr-Oct
Striped killifish	P
Striped mullet	Jul-Oct
Summer flounder	May-Jul
Tautog	Feb-Dec
Threespine stickleback	P
Tidewater silverside	P
Weakfish	Sep
White mullet	Jul-Sep
White perch	Mar-Nov
Windowpane	Mar-Jul
Winter flounder	P
Northern puffer	May-Oct
Rainwater killifish	P
Atlantic moonfish	Jun-Sep
Permit	Jul
White hake	May
Pinfish	Jul-Aug
Planehead filefish	Jul
Butterfish	Sep
Northern stargazer	Aug
Gray snapper	Oct
Bigeye	Apr
Halfbeak	Jun-Oct
American sand lance	Feb & Apr

[a]U - Unknown.
P - Permanent resident.

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Atlantic Silverside	Winter Flounder	Northern Pipefish	Bay Anchovy	Blueback Herring	Total
		Estimated No. of Fish Impinged during Months Sampled					
1971	4	919	6,427	2,261			27,731
1975	4	27,419			20,355	20,581	138,140

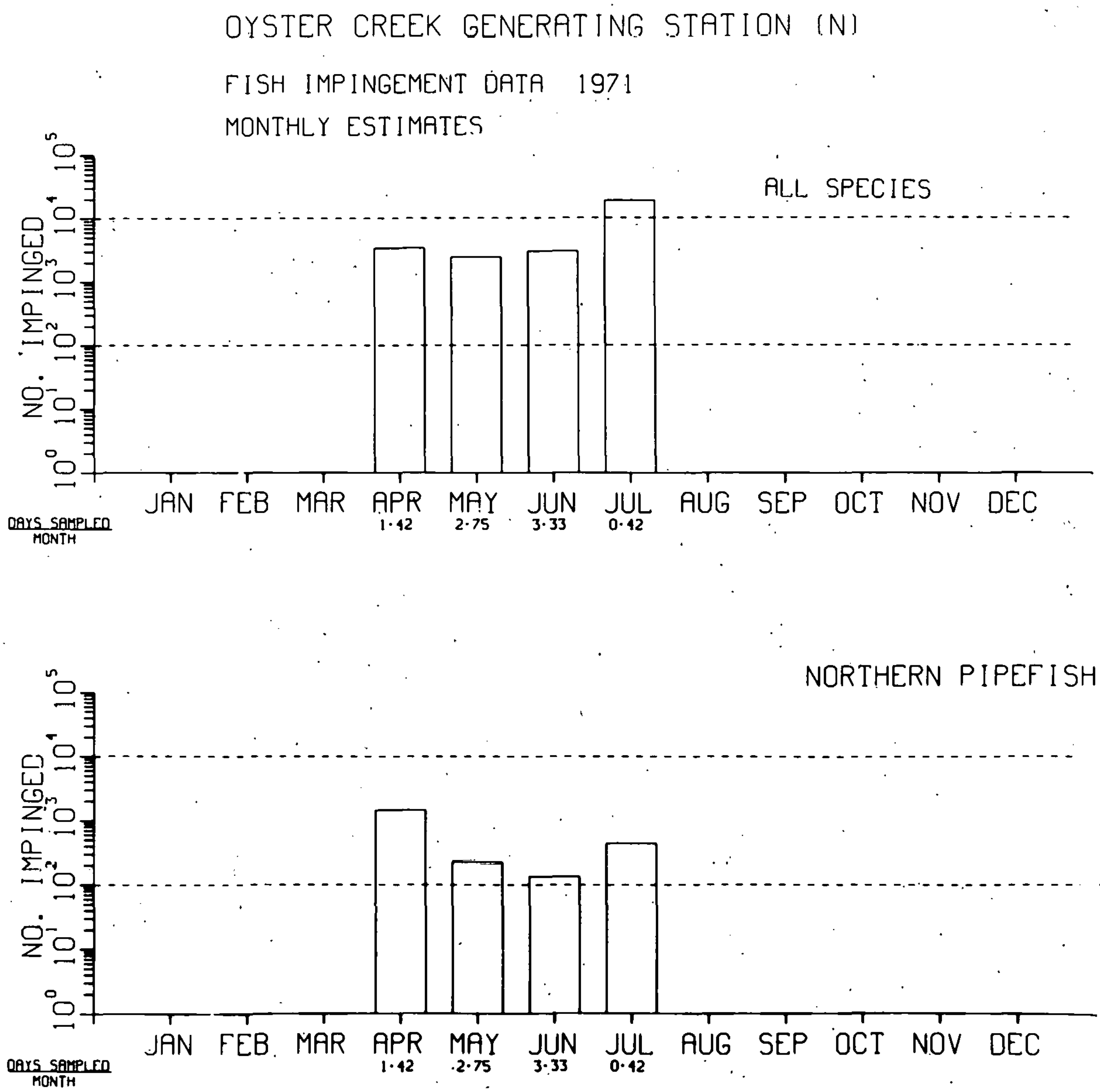
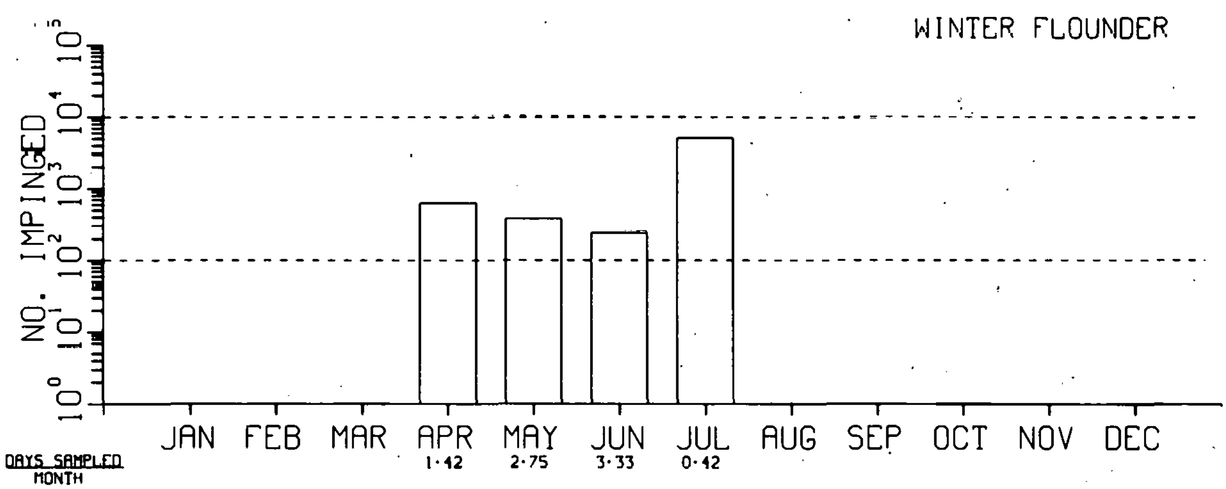


Fig. H1. Impingement Estimates.

OYSTER CREEK GENERATING STATION (N)

FISH IMPINGEMENT DATA 1971

MONTHLY ESTIMATES



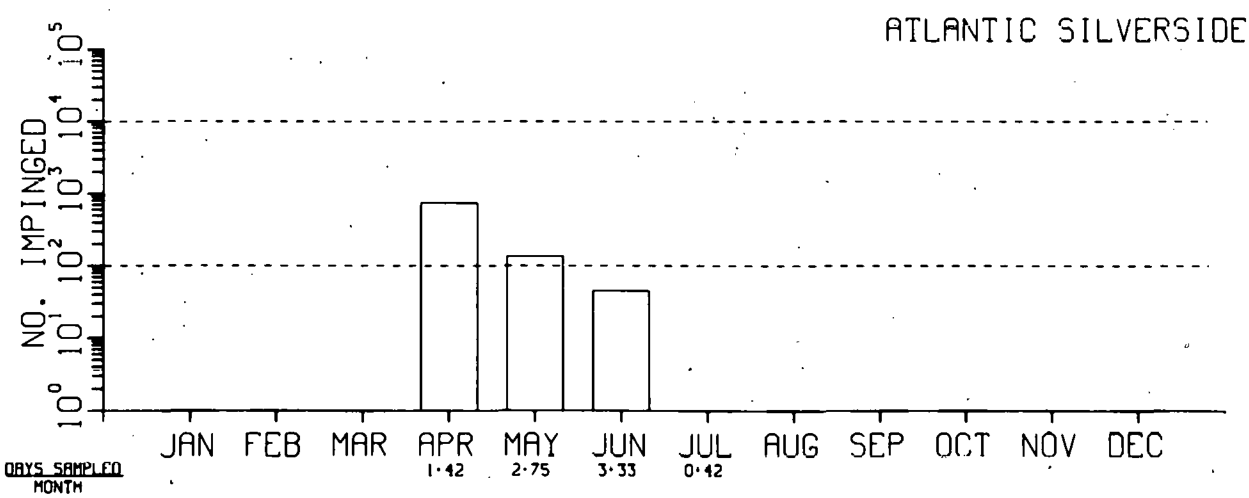


Fig. H2. Impingement Estimates.

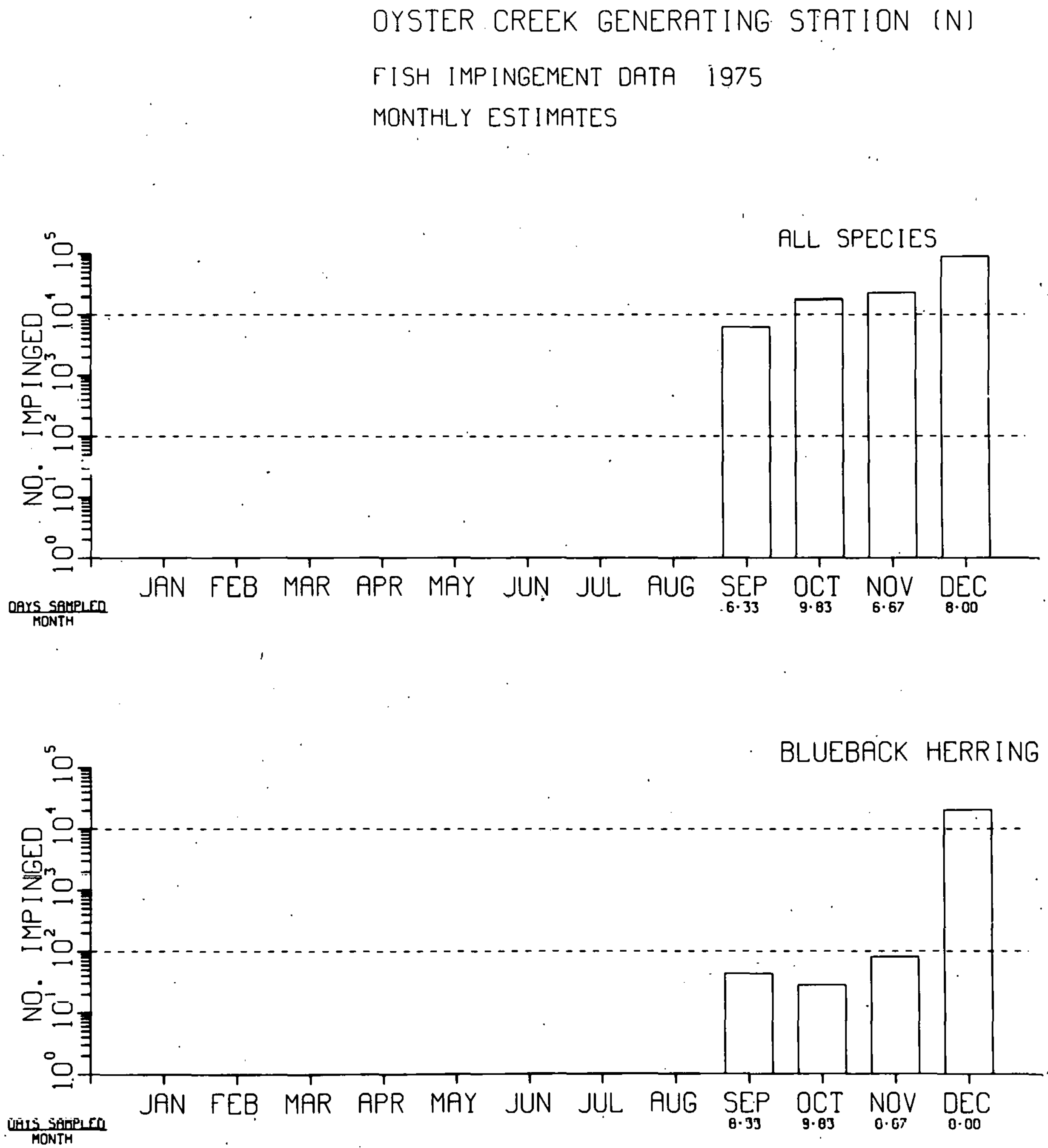


Fig. H3. Impingement Estimates.

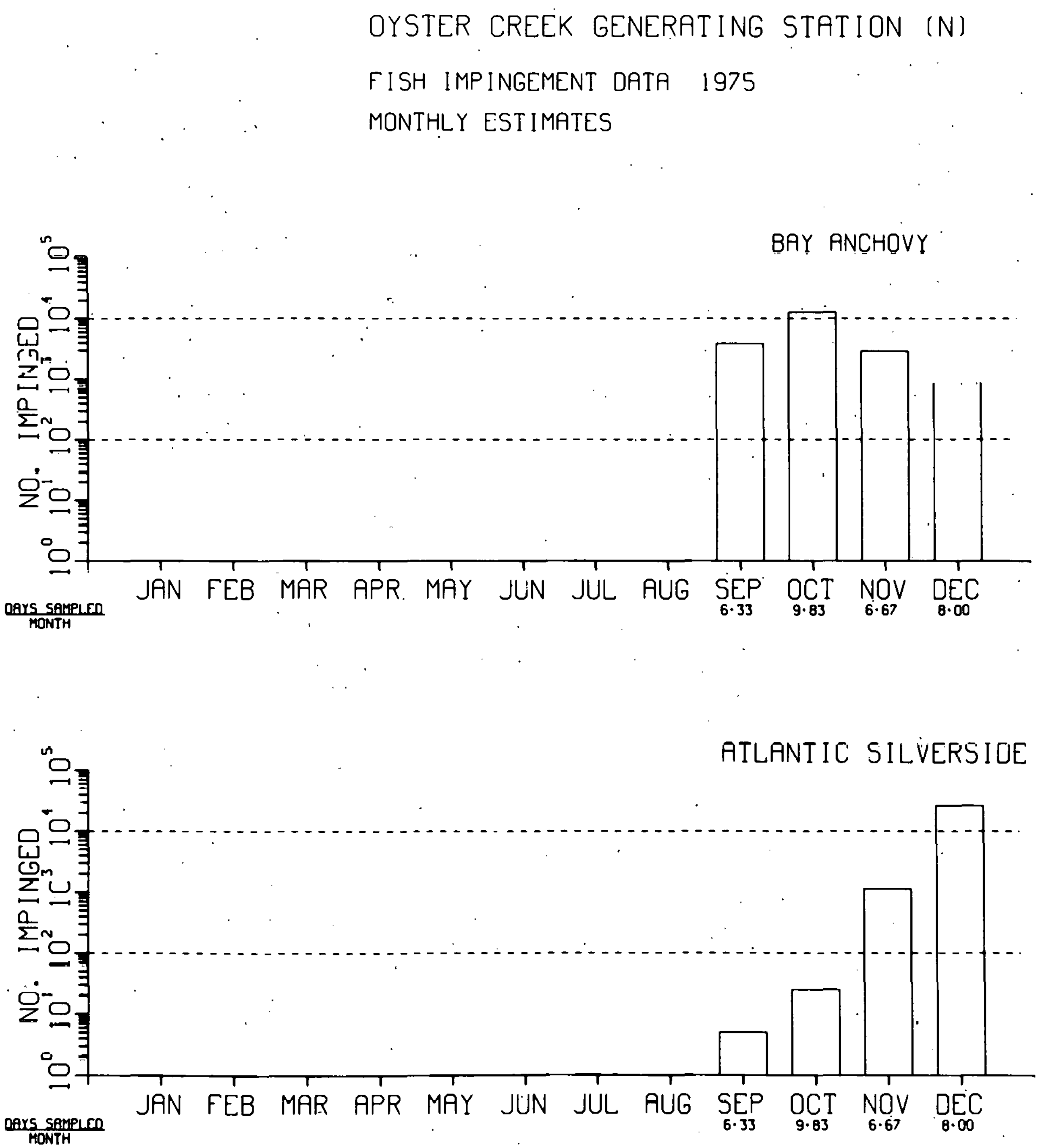


Fig. H4. Impingement Estimates.

EDGE MOOR POWER STATION UNITS 1-5 (F)

SITE CHARACTERISTICS

The Edge Moor Power Station is located in Wilmington, Delaware just north of the confluence of Shellpot Creek and the Delaware River (Fig. 1). The station location and nearby landmarks are shown in Figure 2.

The Delaware River in the vicinity of the power station is about 1.5 miles wide and its depth at mean low water ranges from more than 40 feet in the shipping channel to one foot on Cherry Island Flats. The shipping channel is about 0.1 mile from, and parallel to, the Delaware shore. Cherry Island Flats lies west of a secondary channel that is more than 20 feet deep at mean low water. The Christina River, which is slightly less than 0.25 mile wide, enters the Delaware River south of Cherry Island. There are three other creeks in the vicinity. They are Shellpot Creek (south of the station), Stoney Creek (two miles north of the station), and Brandywine Creek (south and west of the station and the Delaware River).

The Delaware River in this region is estuarine and has a mean tidal amplitude of 5.7 feet. The maximum tidal range is about 12 feet in the spring. The flow measured at Trenton, New Jersey, is 5,242,000 gpm and increases to 6,700,000 gpm near Rudy Island. The tidal flow is about 180,000,000 gpm on flood tide and 220,000,000 gpm on ebb tide. Currents are generally strongest in the main channel except during tidal changes, when maximum movement is to either side of the channel. Velocities during tidal cycles reach four to six fps.

A list of fishes impinged on the screens at the station is given in Table I.

PLANT DESCRIPTION

The station consists of five oil-fired steam-electric generating units. Units 1-4 have operated since the 1950s and 1960s and have a combined generating capacity of 391 MWe. Unit 5 has a capacity of 400 MWe and began operation in August 1973. The station employs once-through cooling with water taken from the Delaware River Estuary.

INTAKE DESIGN AND OPERATION

Water for condenser cooling is drawn from the Delaware River. Bankside intakes have vertical traveling screens and large circulating-water pumps, and also smaller in-plant cooling and fire pumps (Fig. 3). Trash bars five inches apart across the entire width of the entrance to the cooling system, and 3/8-inch mesh traveling screens 10 to 20 feet behind the bars, prevent debris and organisms that are too large to penetrate the screens from clogging the water pumps and condensers. The intake velocity at the screens is 1.0 fps. Intake velocities at the mouths of the bays range from 0.5 fps to 1.16 fps.

The pumps for the condenser-cooling-water systems of the five units of the station are located in three screenhouses. One is for Units 1 and 2 and has four traveling screens, another serves Units 3 and 4 and has five traveling screens, and the third one is for Unit 5 and has eight traveling screens. Each intake for the five units has two large circulating-water pumps, one in-plant cooling pump, and one fire pump. The maximum water flow rate at the station is 752,100 gpm, although the amount of water pumped varies considerably with ambient water temperature.

IMPINGEMENT SAMPLING

Samples were taken on Mondays and Fridays, usually in the morning, with 1/16-inch mesh nets secured in the screen washwater basins of each pump. On each sampling date, impinged fishes from all screens of Units 1-4 and from four alternate screens of the eight screens of Unit 5 were collected concurrently for 30 minutes ± 10 minutes while the screens were rotated and cleaned. Prior to sampling, all screens were rotated and cleaned so that only those fish impinged during the 30-minute sampling period were counted.

Twenty-four-hour surveys were conducted monthly beginning in April to determine tidal and diurnal variations in numbers of impinged fishes. Samples were taken at three-hour intervals with methods described for the weekly collections.

DATA AVAILABILITY

Data are available for all three screenhouses for 1974. From January to May, data for Units 1-5 are broken down by screenhouse. From June to December, data for all units are grouped together.

IMPINGEMENT DATA SUMMARY

Four species of fish - white perch, silvery minnow, American eel, and blueback herring - were impinged in sufficiently large numbers at the station to warrant inclusion in Table II. Figures H1 through H5 summarize the impingement data that are broken down by screenhouse. Figures H6 and H7 show the combined data for all units at the station.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCE

1. T. L. Preddice. "An Ecological Study of the Delaware River in the Vicinity of the Edge Moor Power Station." Prepared for the Delaware Power Corporation by Ichthyological Associates, Inc. 1975.

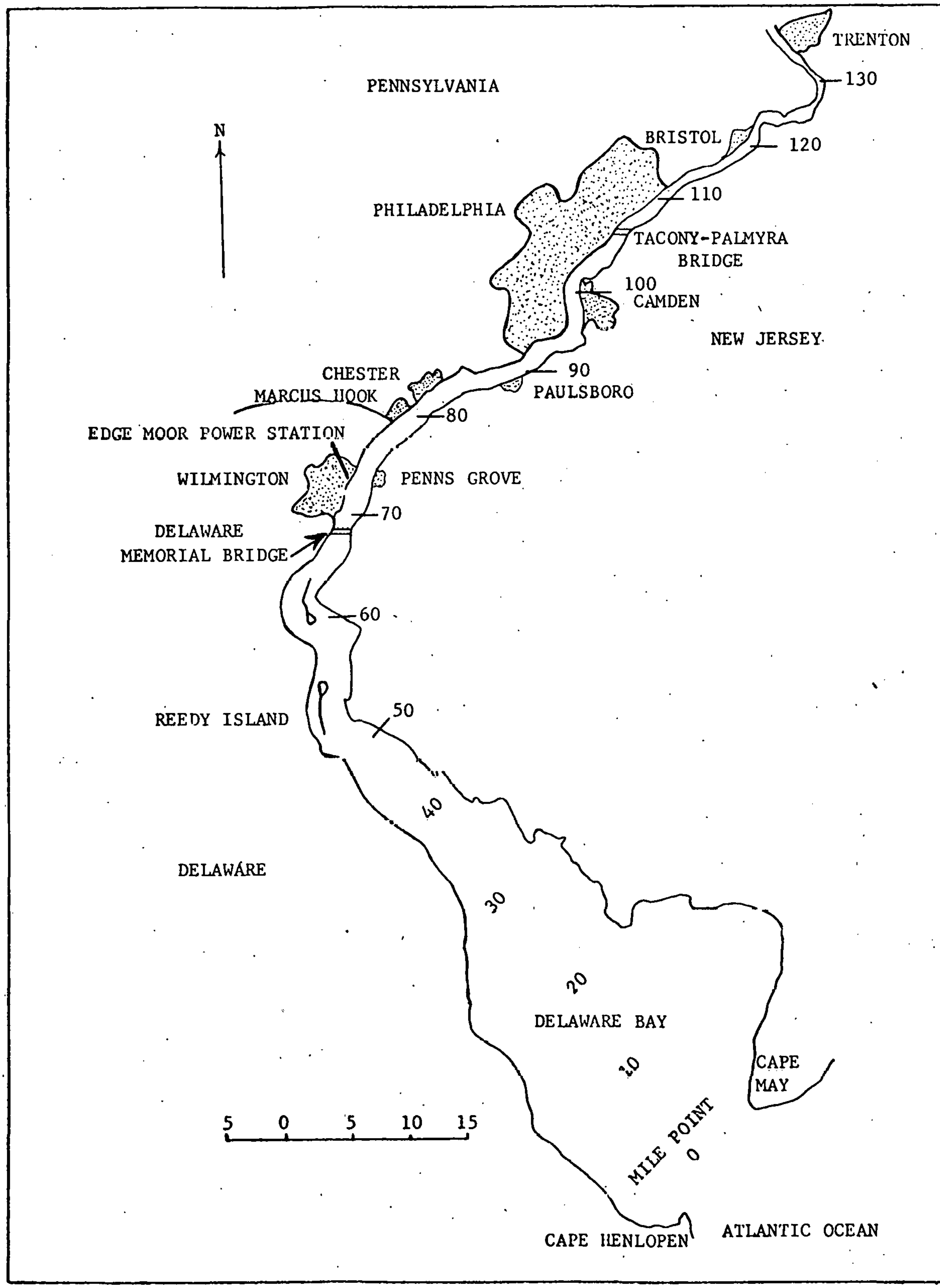


Fig. 1. Station Location.

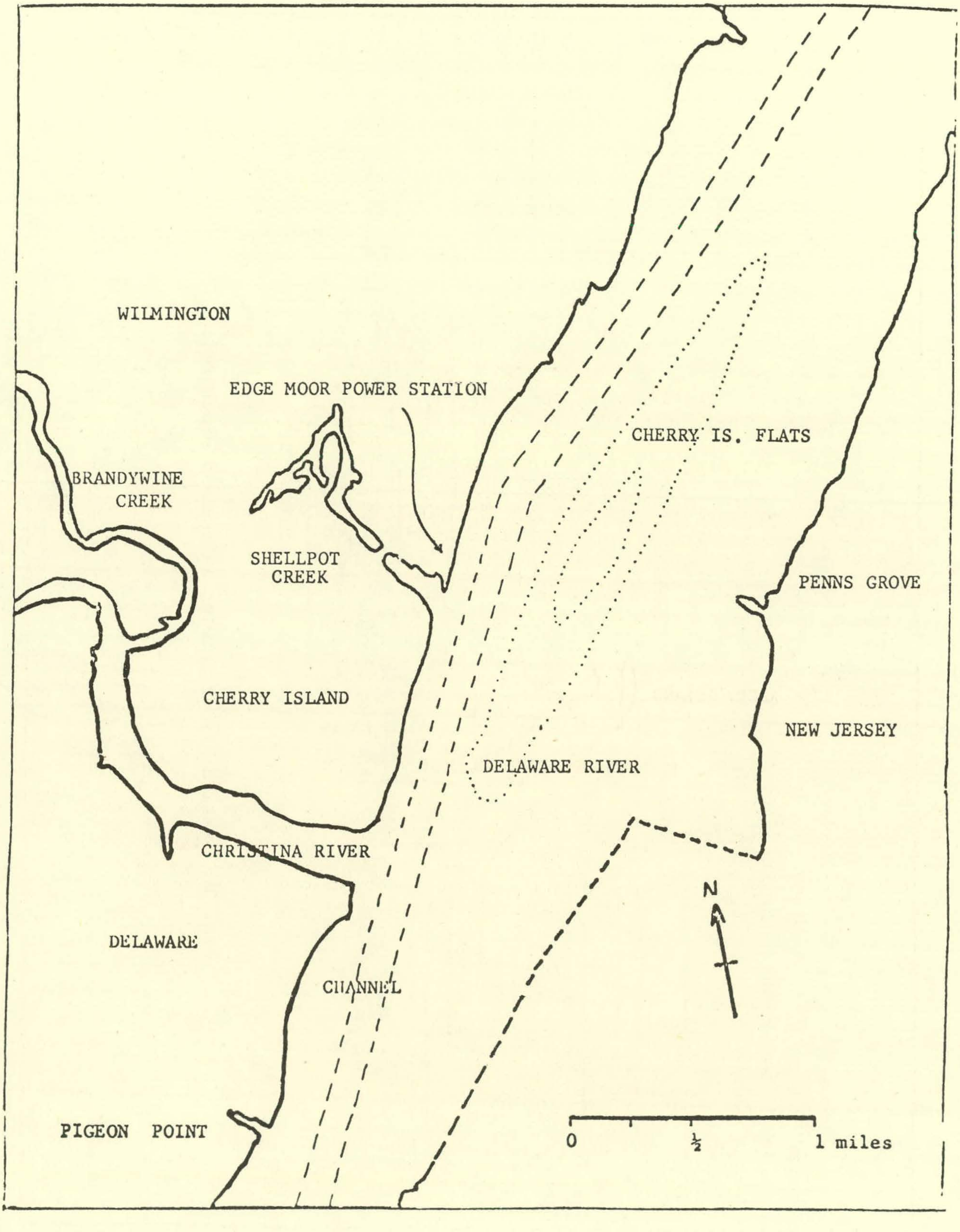


Fig. 2. Landmarks in the Vicinity of the Station.

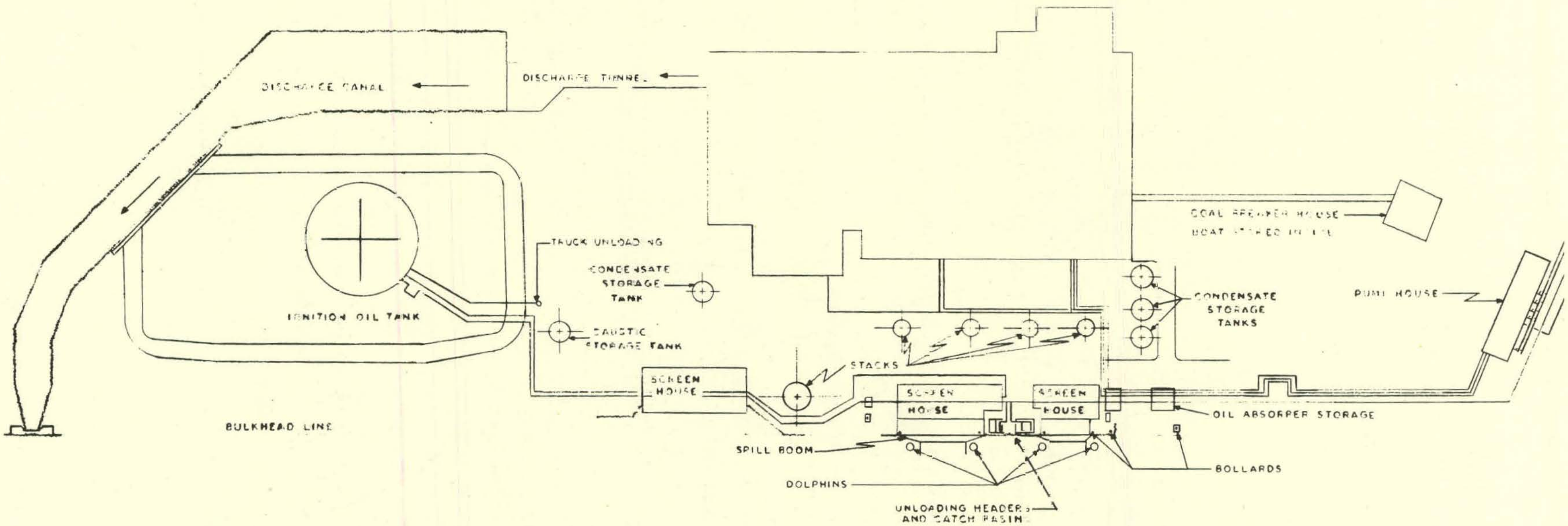


Fig. 3. Station Layout Showing Intake and Discharge.

Table I. Fishes Impinged on the Screens at the Station

American eel	Mummichog
Blueback herring	Threespine stickleback
Alewife	White perch
Gizzard shad	Pumpkinseed
Bay anchovy	Bluegill
Goldfish	Black crappie
Carp	Yellow perch
Silvery minnow	Atlantic croaker
White catfish	
Brown bullhead	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled				
		White Perch	Silvery Minnow	American Eel	Blueback Herring	Total
1974	12	319,255	73,354	19,088	26,046	942,293

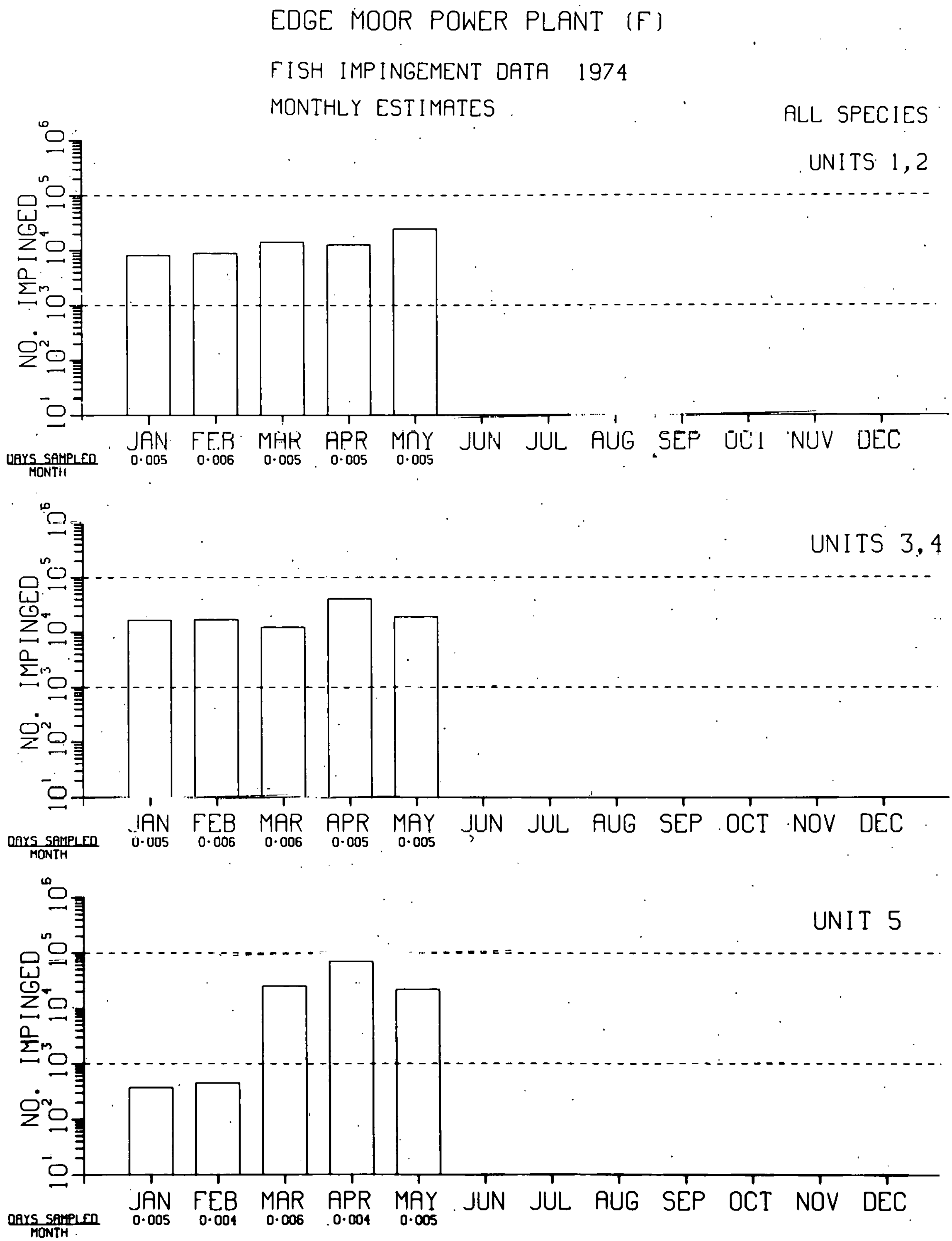


Fig. H1. Impingement Estimates.

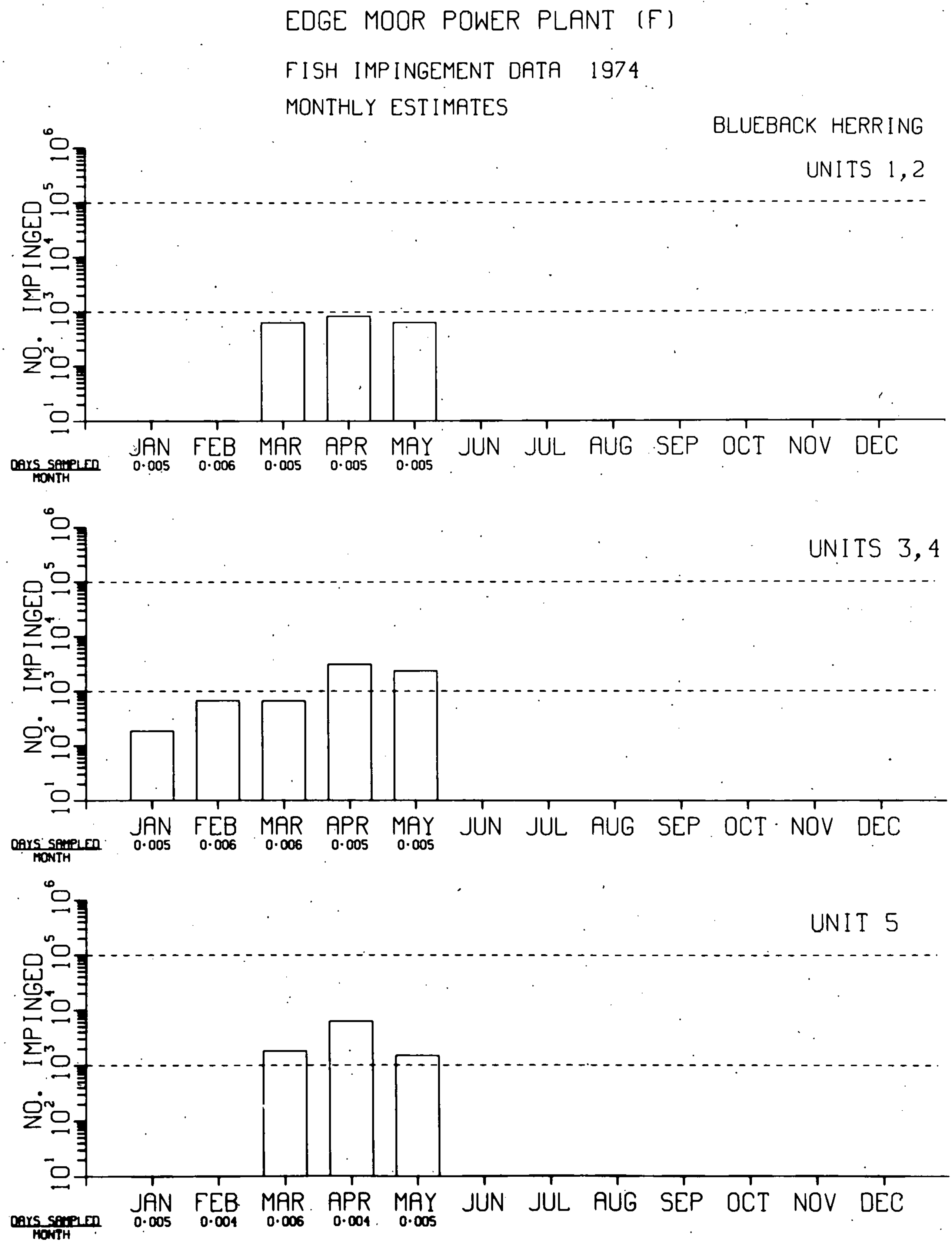


Fig. H2. Impingement Estimates.

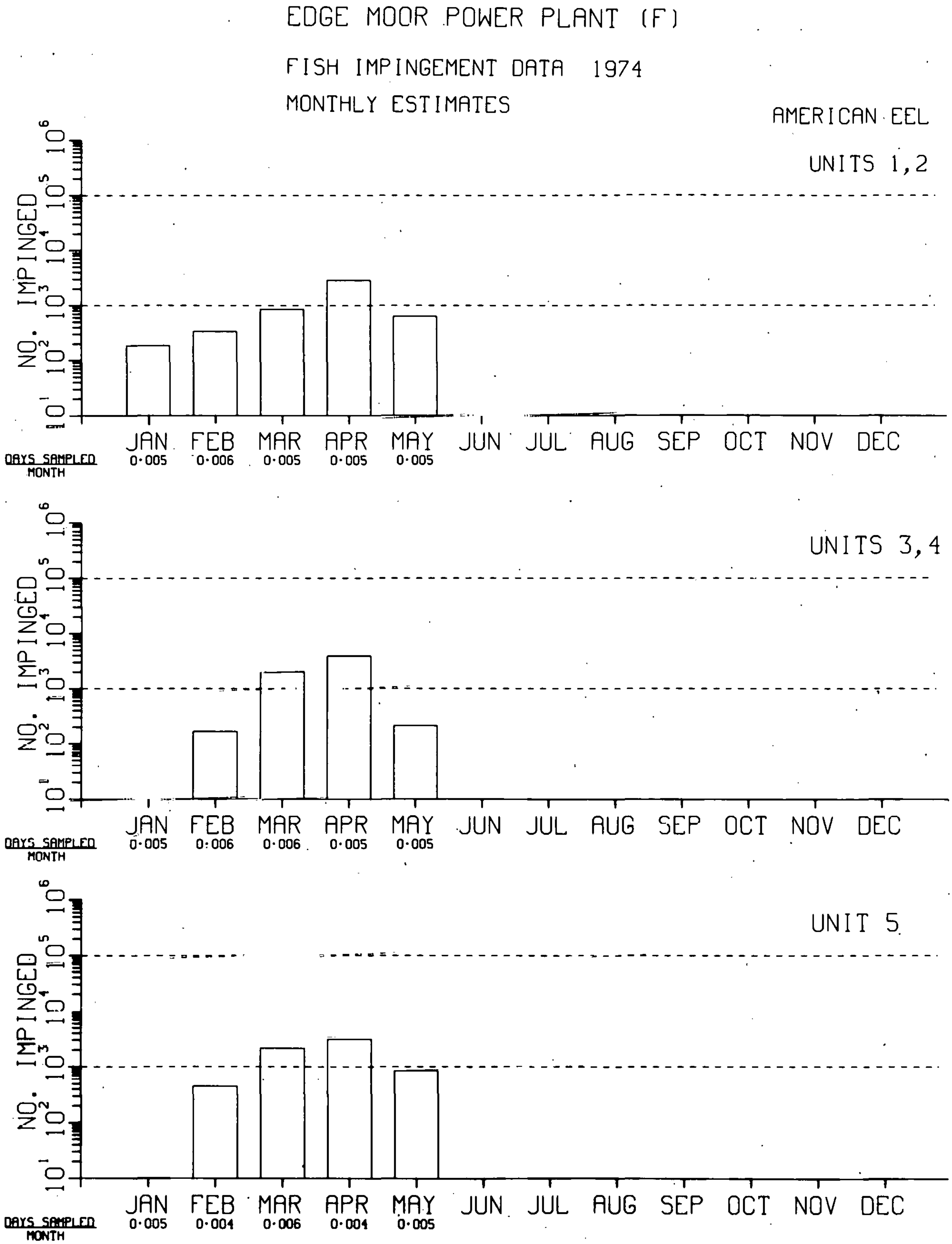


Fig. H3. Impingement Estimates.

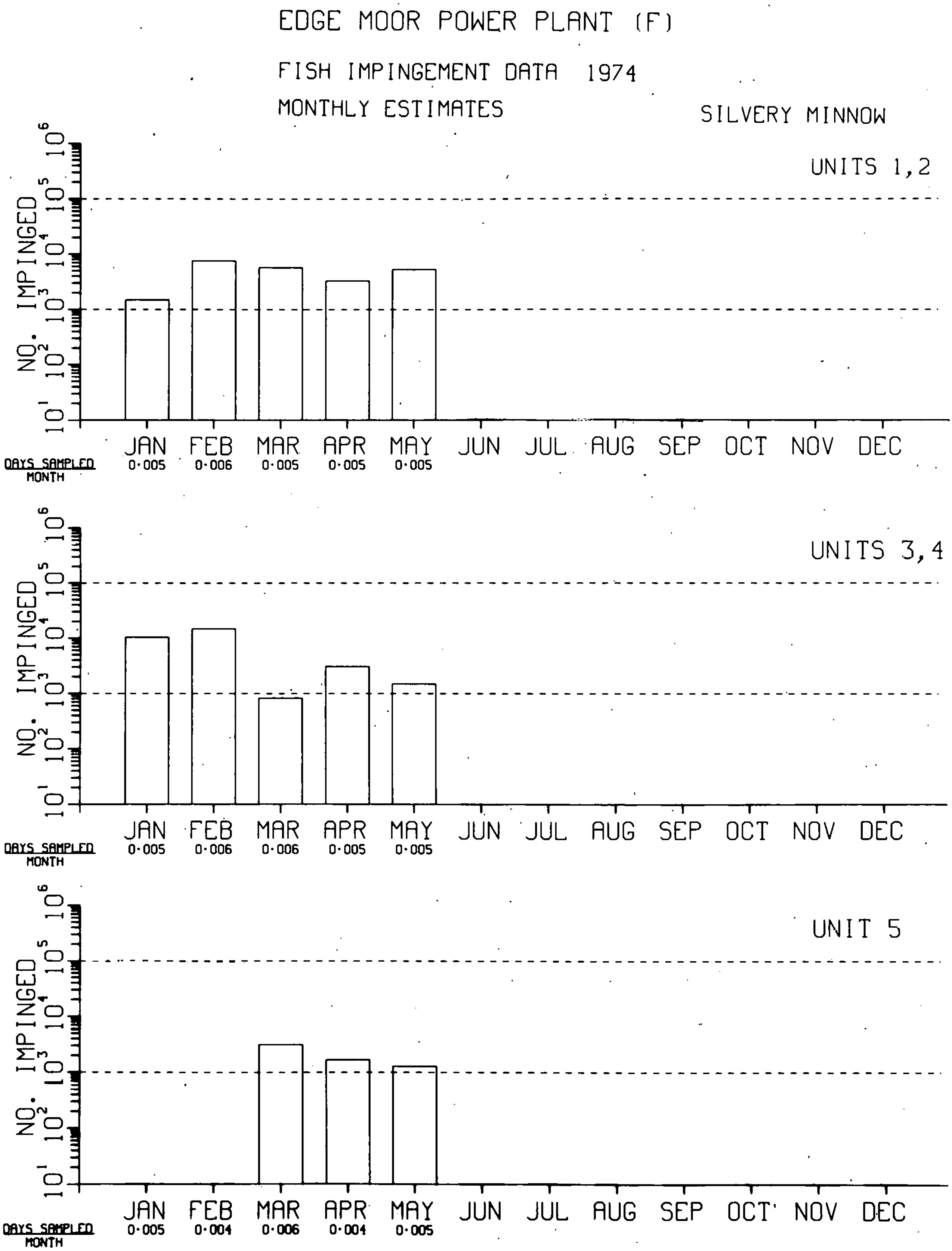


Fig. H4. Impingement Estimates.

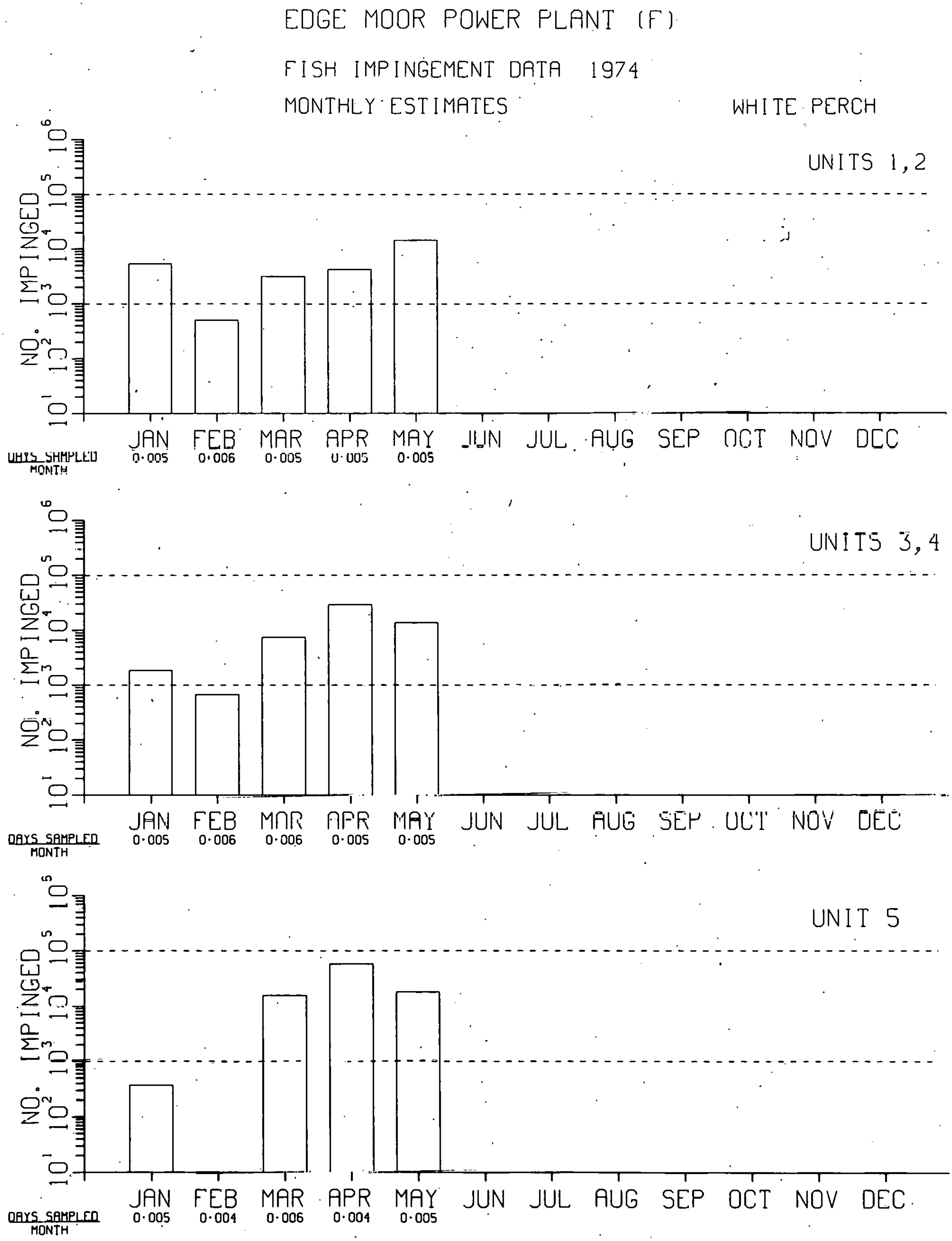


Fig. H5. Impingement Estimates.

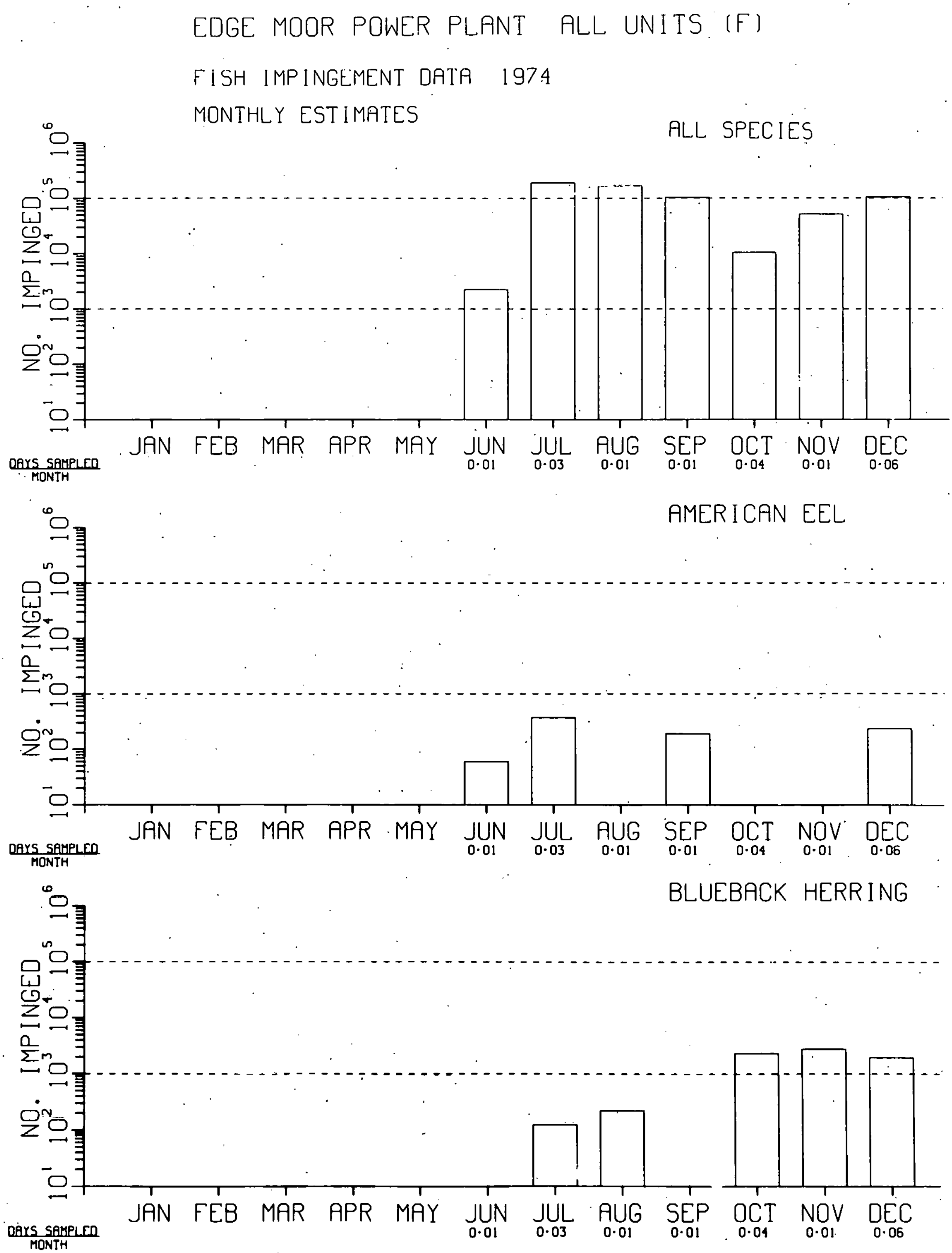
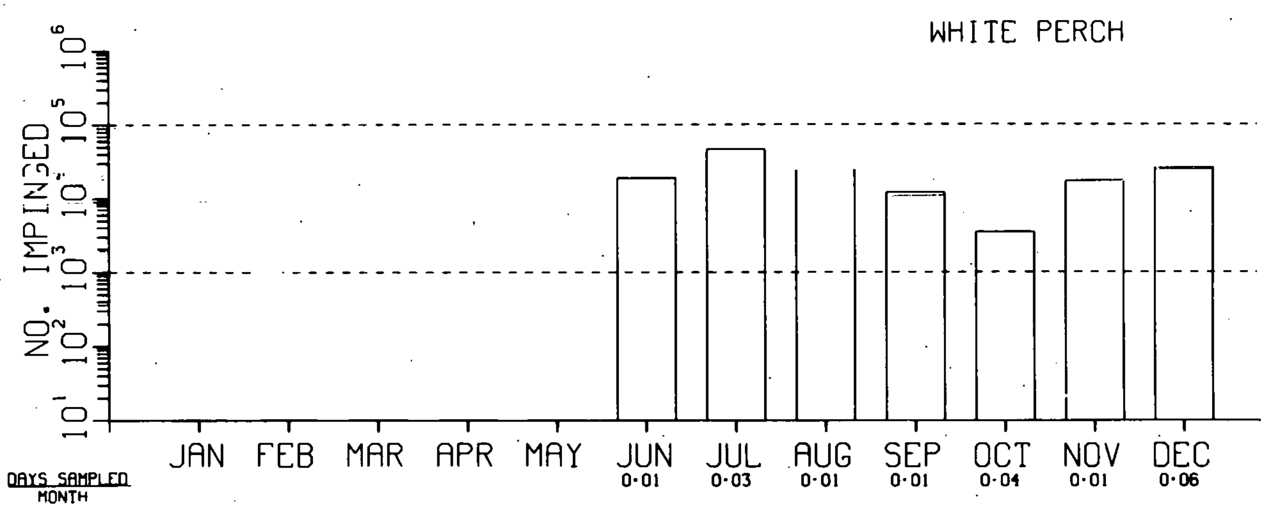


Fig. H6. Impingement Estimates.

EDGE MOOR POWER PLANT ALL UNITS (F)

FISH IMPINGEMENT DATA 1974

MONTHLY ESTIMATES



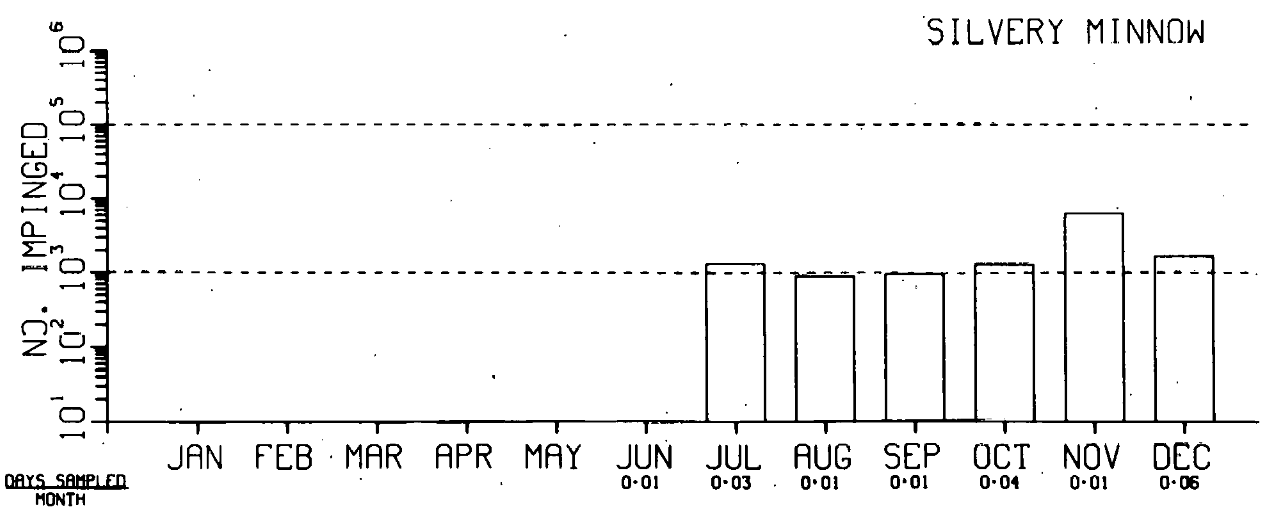


Fig. H7. Impingement Estimates.

CALVERT CLIFFS NUCLEAR POWER PLANT UNITS 1 AND 2 (N)

SITE CHARACTERISTICS

The Calvert Cliffs Nuclear Power Plant is located on an excavated section of the Calvert Cliffs in Calvert County, Maryland.[1] The site occupies 1735 acres and is situated geographically halfway between the mouths of the Chesapeake Bay and the Susquehanna River. Its elevation varies from zero to 137 feet MSL, with an average elevation of 100 feet. The site's bay frontage, as well as several of the small interior streams, are characterized by nearly perpendicular natural sea walls produced by wave, wind, and frost action. The site and nearby major population centers are shown in Figure 1.

In the vicinity of Calvert Cliffs, Chesapeake Bay slopes gently to a depth of 35 feet, levels off to the center of the bay, and then drops off sharply to 110 feet. The bay is six miles wide at the plant site. However, its width varies from three to 35 miles with a mean width of 15 miles. The total length of the bay is 195 miles.

Salinity and current patterns in Chesapeake Bay are complex and fluctuate primarily in response to five factors: (1) tides, which range from one to two feet, generating one- to two-knot midchannel currents (current velocities are higher at constructed portions of the bay such as the plant site); (2) influx of fresh water from streams and rivers, where lack of chemical mixing results in a net transport of water out of the bay; (3) net flow of denser water (below 20 feet) up the bay; (4) rotation of the earth; and (5) weather, which causes unpredictable current and salinity patterns for short periods of time. Surface temperature of the bay waters varies from near freezing in the winter to 86.5°F in July. At the latter temperature, thermal stratification becomes pronounced in the center of the bay, and a temperature gradient of 15°F at the 35-foot thermocline has been recorded.

A list of all fish species collected during the baseline study is presented in Table I. Collections were not made for a sufficient length of time to determine seasonal variations. The bay has a longstanding reputation as a major fish- and shellfish-producing area. In addition, a shallow area at the perimeter of the bay serves as a nursery ground for numerous commercially valuable fish species that are harvested outside of the bay proper.

PLANT DESCRIPTION

The plant utilizes two pressurized water reactors, each with a net electrical power output of 845 MWe, and employs once-through cooling.

INTAKE DESIGN AND OPERATION

Water from the bay flows into the shoreline intake structure via a dredged concrete channel that extends 4700 feet into the bay (Fig. 2). The depth to the bottom of this channel varies from 51 feet at the curtain wall near the intake to 40 feet at the offshore end. The total circulating- and service-water flow through the plant is at the rate of 2,640,000 gpm.

The curtain wall across the intake channel is parallel to the shoreline and extends 28 feet below the water surface. This permits drawing water from the presumably cooler limnological strata that occur at a greater depth. The total length of the wall is 560 feet. Beyond the curtain wall the channel width is reduced to 385 feet and its depth is reduced from 51 to 26 feet. The pumphouse contains 24 traveling screens serving 12 circulating-water pumps. The screens prevent passage of organisms greater than 0.25 inch in diameter. Water velocity under the curtain wall and at the traveling screens is 0.5 fps. The screens are cleaned by high-velocity water jets. Fish removed from the screens are washed into a trough and returned to Chesapeake Bay.

IMPINGEMENT SAMPLING

The AEC environmental technical specifications for the Calvert Cliffs Plant state that impingement sampling is to be carried out on five randomly selected days each week for one year.[2] Each collection should last one hour. In addition, on one of the five selected days three one-hour collections during three eight-hour periods should be made. The applicant has complied with these specifications.

DATA AVAILABILITY

Data for 1975 for the months of January through June and October have been obtained. A total sampling time of about 1.25 days/month is represented.

IMPINGEMENT DATA SUMMARY

Data for 1975 are summarized in Table II for the species with the highest total impingement and for all species.[3] Figures are extrapolated to monthly totals. The three most numerous species impinged were the bay anchovy, Atlantic croaker, and spot. Histograms are presented in Figures H1 and H2.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Slots have been constructed in the concrete walls separating the several intake forebays immediately in front of the traveling screens. These transverse slots supposedly provide locations of low current velocity and turbulence where fish can avoid the main current created by the water flow. The effectiveness of these slots in reducing impingement on the screens is not known. Fish survival after impingement is enhanced by their return, via a sluiceway, to the bay.

REFERENCES

1. "Final Environmental Statement, Calvert Cliffs Nuclear Power Plant Units 1 and 2." USAEC Directorate of Licensing. Docket Numbers 50-317 and 50-318. April 1973.

2. Operating License for Calvert Cliffs Unit 1, DPR-53, Appendix B, Section 4.1.2.1. July 1974.

3. C. J. Moore. "Impingement Study on the Chesapeake Bay at Calvert Cliffs, Maryland." Part of a Semiannual Operating Report for the Calvert Cliffs Station. Academy of Natural Sciences of Philadelphia. 1975.

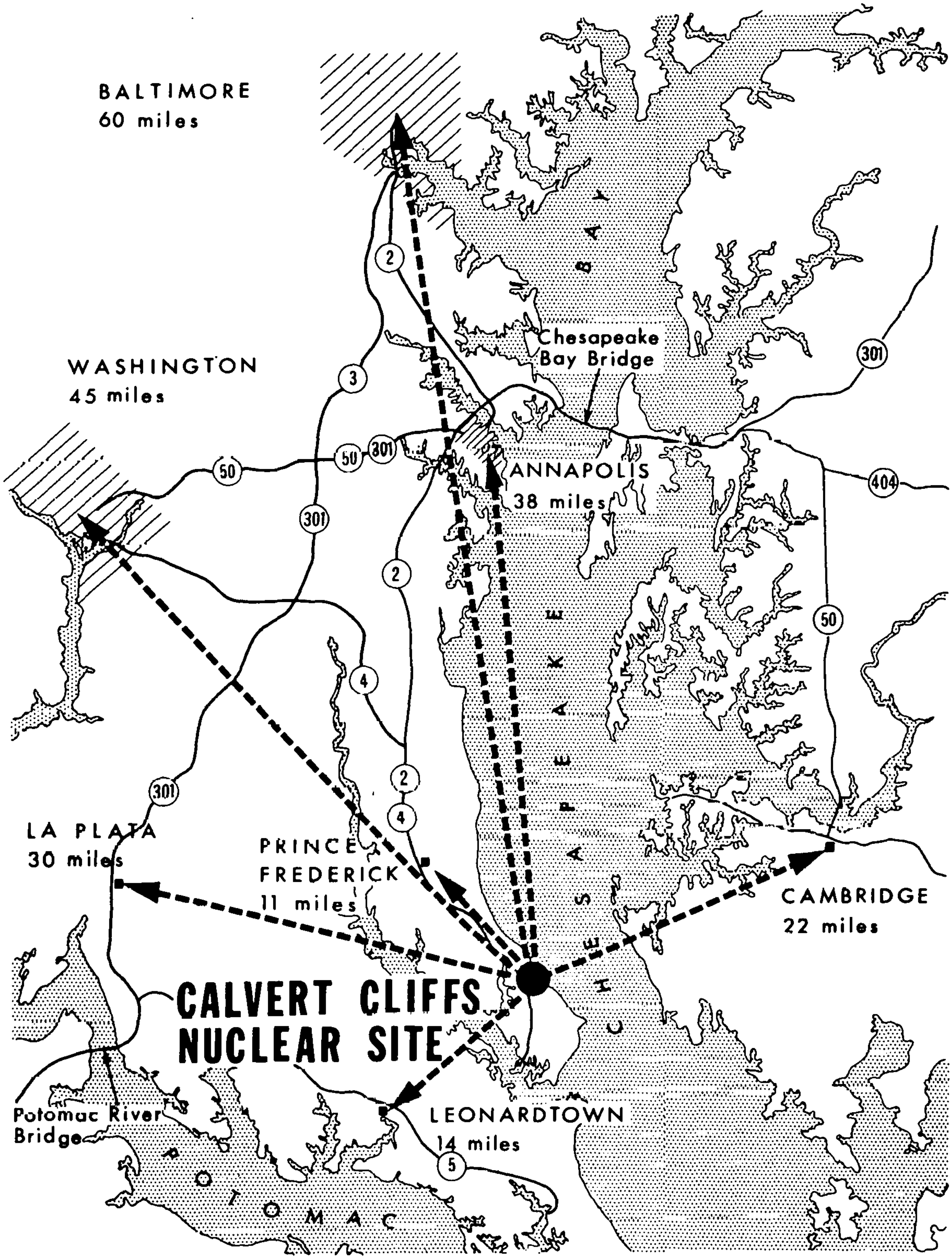


Fig. 1. Plant Location.

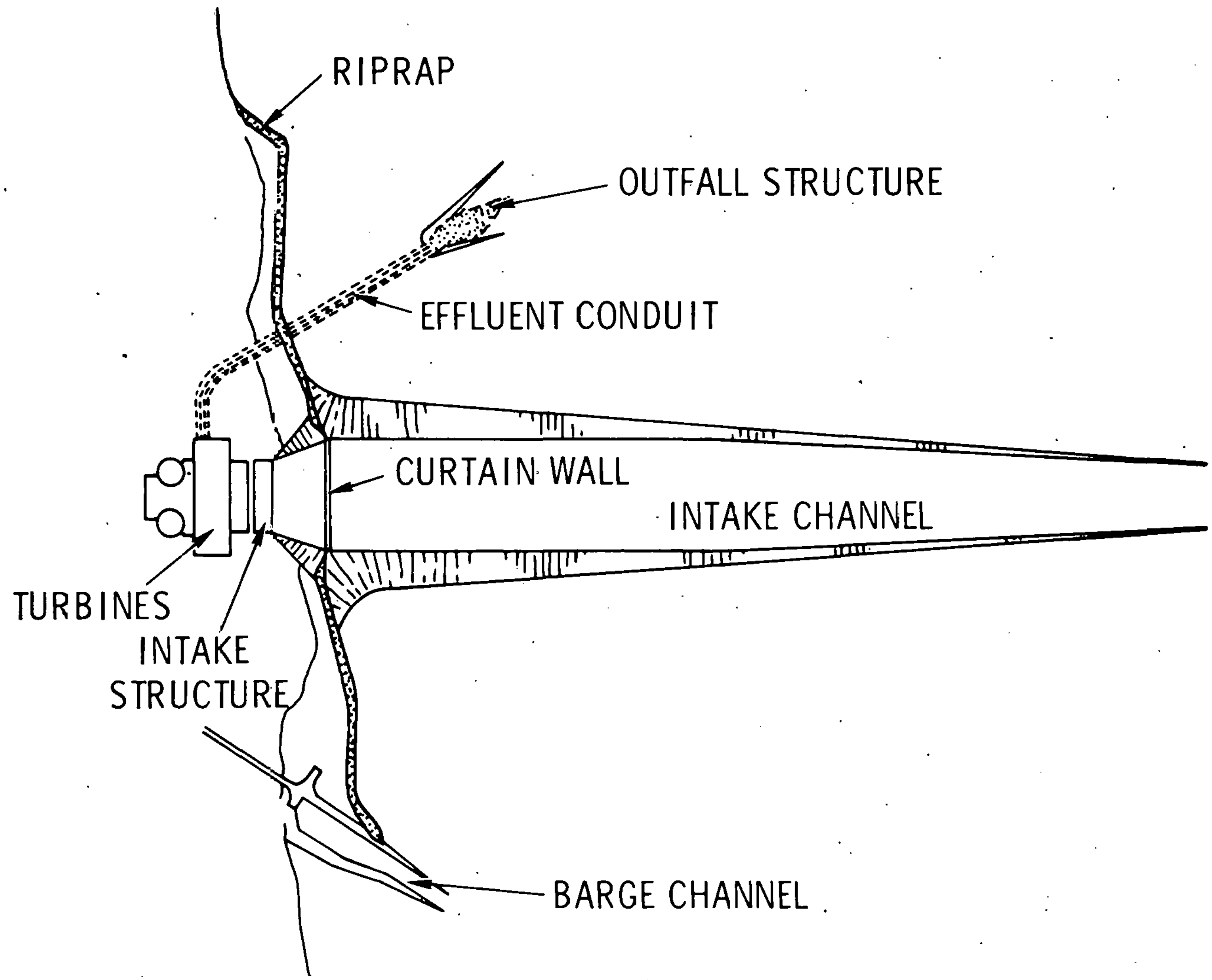


Fig. 2. Circulating-Water System.

Table I. Fishes Found at the Plant during Baseline Studies

Blueback herring	Threespine stickleback
Alewife	Northern pipefish
Atlantic menhaden	White perch
Gizzard shad	Striped bass
Striped anchovy	Pumpkinseed
Bay anchovy	Yellow perch
Eastern mudminnow	Bluefish
Golden shiner	Silver perch
Brown bullhead	Spotted seatrout
American eel	Weakfish
Rough silverside	Spot
Tidewater silverside	Black drum
Atlantic silverside	Naked goby
Atlantic needlefish	Northern searobin
Banded killifish	Striped blenny
Mummichog	Harvestfish
Striped killifish	Summer flounder
Sheepshead minnow	Winter flounder
Rainwater killifish	Hogchoker
Fourspine stickleback	Skilletfish
	Oyster toadfish
	Spotted hake
	Atlantic croaker

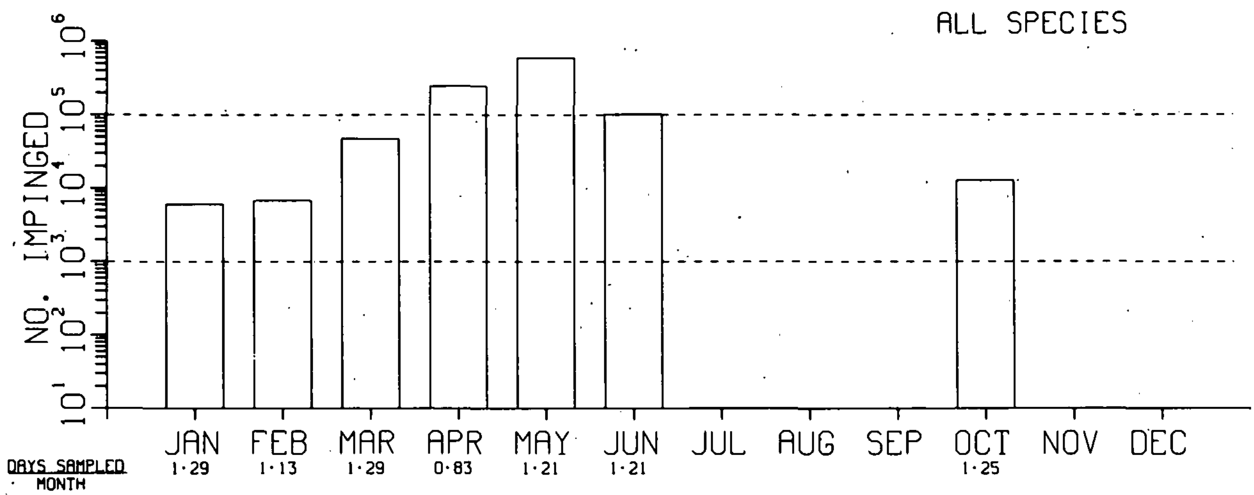
Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Bay Anchovy	Atlantic Croaker	Spot	Total
1975	7	763,514	130,500	63,510	1,018,317

CALVERT CLIFFS (N)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



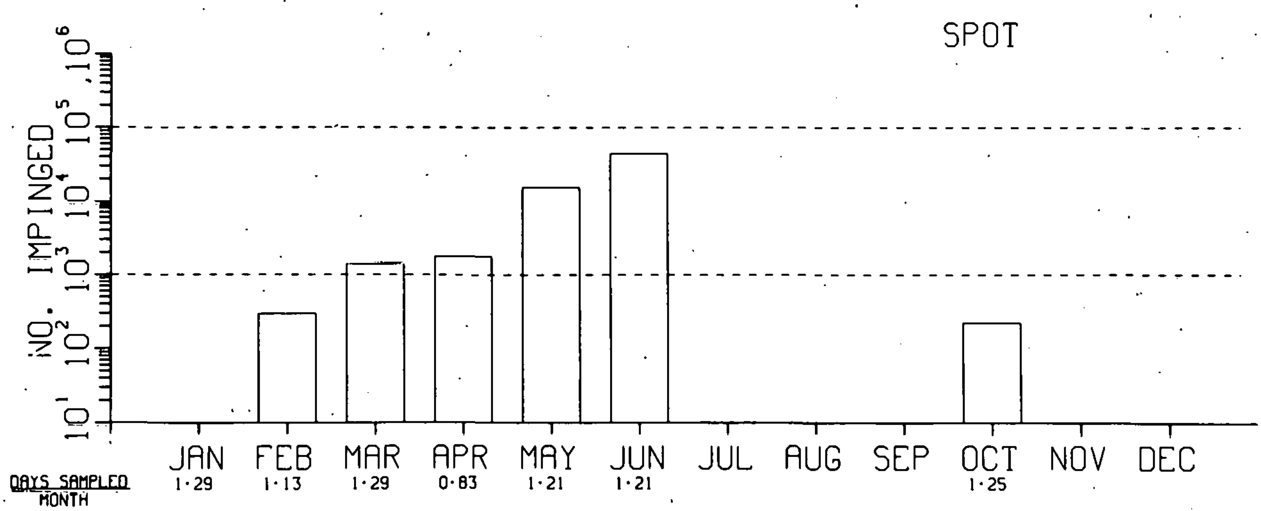


Fig. H1. Impingement Estimates.

CALVERT CLIFFS (N)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES

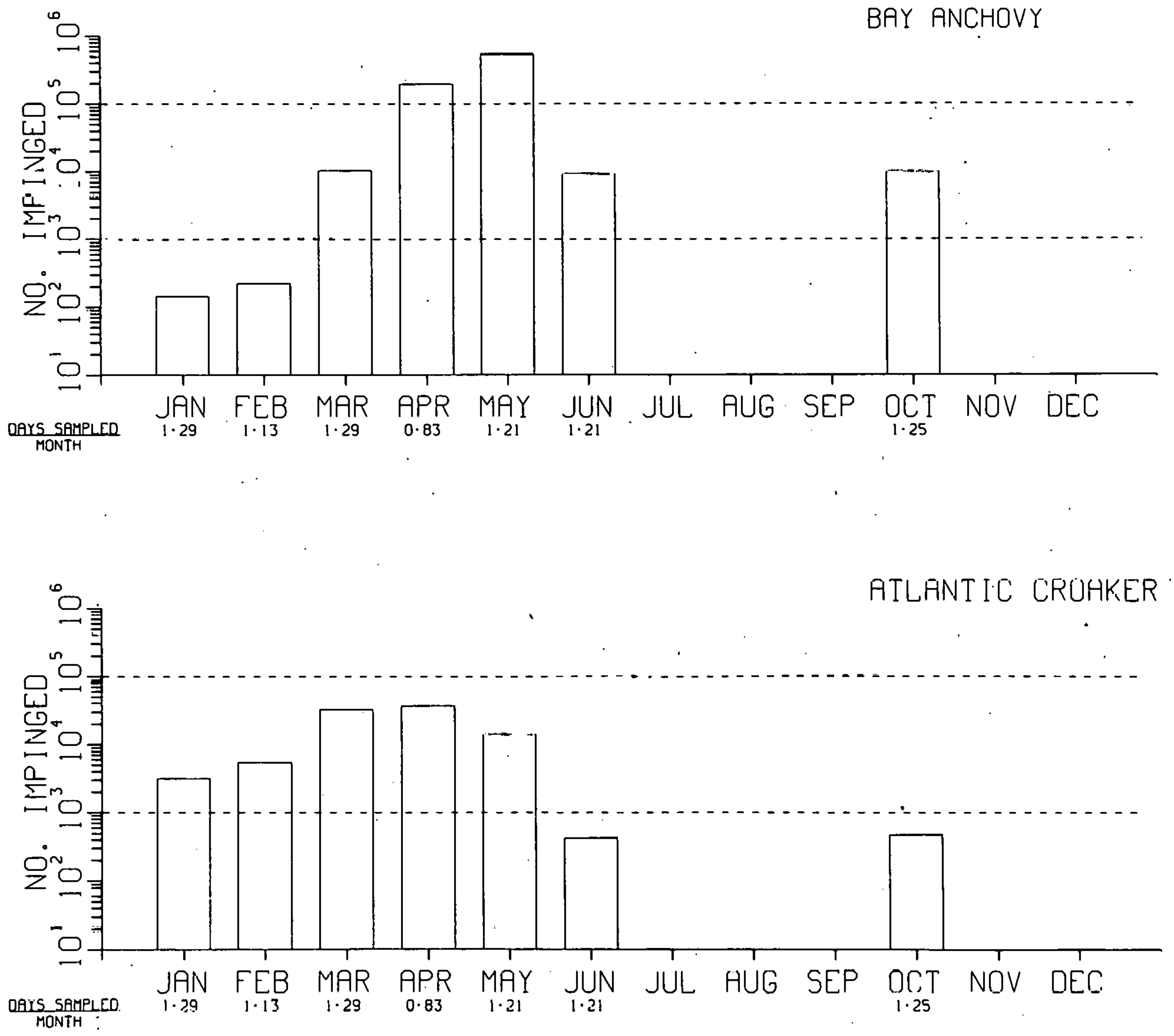


Fig. H2. Impingement Estimates.

SURRY POWER STATION UNITS 1 AND 2 (N)

SITE CHARACTERISTICS

The two units of Surry Station are located on a small peninsula in Surry County, Virginia, that protrudes into the James River 25 miles upstream from its junction with Chesapeake Bay.[1] The site consists of 840 acres of land at the tip of the Gravel Neck Peninsula (Fig. 1), which extends north into the southeasterly flowing river. The intake is located on the east side of the peninsula and the discharge is located on the west side. The site traverses the peninsula and forms the southern edge of the Hog Island Wildlife Refuge.

The James River flows as an inverted "V" around the peninsula, and is a typical tidal estuary. The shorelines are interspersed swamps and marshes. The river is dredged in the vicinity of the plant to a depth of 25 feet to accommodate barge traffic. The flow of the river has three components. In order of the volumes involved, these flows are (1) tidal flow, (2) saline wedge, and (3) freshwater runoff. The net result is that the ebb tide lasts longer than the flood tide. There are two tidal cycles per day and the mean tidal amplitude is 1.0 foot. The maximum rate of flow during the spring tides is 3.2 fps.

Summer ambient temperatures reach 80°F in the James River. It occasionally freezes over for short periods during the winter. Salinity upstream from the site is measured at 6.9 ppt. To maintain this level of salinity, salt-water intrusion on the flood tide should reach 101,400,000 gpm.

The James River at the site has a diverse fauna typical of an estuary. A list of fishes found in the area is given in Table I. There are six permanent residents in the estuary: brown bullhead, white catfish, white perch, hog-choker, striped killifish, and mummichog. Many other species are migratory. The area serves as an important nursery ground for the larvae and juveniles of such species as the spot, Atlantic croaker, white perch, striped bass, shad, and blueback herring. Sport fishing is important in the estuarine section of the river. Oysters and clams provide an important commercial enterprise.

PLANT DESCRIPTION

The Surry Power Station consists of two identical pressurized water reactors. Their net capacity is 788 MWe each. The station utilizes a once-through cooling system.

INTAKE DESIGN AND OPERATION

The utility has greatly modified the shoreline at the intake where a large pier with associated concrete structures and an intake canal were built (Fig. 2). In addition, an access channel is maintained from the center of the 25-foot river channel to the intake canal. The access channel is 150 feet wide and 5000 feet long. Water is pumped through it at a rate of 1,680,000 gpm into an eight-bay concrete intake structure equipped with an air-bubbler system to divert fishes from the forebay. Trash racks with 0.5-inch bars spaced on 3.5-inch centers remove large debris. Eight circulating-water pumps, each rated at 210,000 gpm, draw water at 1.03 fps over an embankment into a high-level intake canal that is 32 feet wide and 1.7 miles long. Its capacity is 45,000,000 gallons. Water flows by gravity to the plant condensers through trash racks and traveling screens constructed of 14-gauge wire mesh with 3/8-inch openings. Screens are rotated automatically by pressure differential and impinged fish are removed from the screens. Figure 3 shows a schematic of the basket-type screen that is used to prevent injury to fishes drawn into the intake structure on the eastern side of the peninsula.

IMPINGEMENT SAMPLING

The Environmental Technical Specifications for Surry Units 1 and 2 state that the fish killed on the traveling screens of the station shall be identified by species, size, and quantity. The actual sampling scheme at Surry varied from this. One report noted that estimates from high- and low-level screens were based on a series of five-minute replicates.[2] Four five-minute replicates per unit were taken five times per week during the day and three times per week during the night at the high-level screens. Low-level screens were sampled with only two five-minute replicates during the day. A second report states that it summarizes statistically derived totals of fish removed each week by the traveling screens.[3] In any case, it is assumed for the purpose of this survey that the totals given by the utility are the actual totals extrapolated to 24-hour continuous sampling.

DATA AVAILABILITY

Data are available for 1 January 1973 through 31 December 1975. Also on file is an abnormal-occurrence report for 4-5 December 1972. The plant was shut down during June 1974 and no data are available for that month. Impingement data from the high-level traveling screens are presented through May 1974. From July 1974 to December 1975 data were obtained from the low-level screens only and include survival percentages. These screens and survival rates are discussed below.

IMPINGEMENT DATA SUMMARY

The first recorded incidence of impingement for Surry Station is an abnormal-occurrence report for 4-5 December 1972, in which 134,670 blueback herring were reported killed on the intake screens. This was extrapolated to a potential loss of 500,000 to 600,000 fish per day (with all eight circulating-water pumps in operation) in a subsequent report by the AEC.[4] Continuous data are available thereafter from 1973 to 1975. Steps have been taken by the utility to solve the fish-impingement problem at Surry Station, and they are discussed below. Table II is a summary of the totals for five impinged species. They are the blueback herring, gizzard shad, Atlantic menhaden, Atlantic croaker, and threadfin shad. Histograms of monthly impingement estimates are shown in Figures H1 through H6. Both live and dead fish are included in the impingement totals that appear after July 1974 for the low-level intake screens.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

An air-bubble curtain was ineffective in keeping fish from the first set of pumps that move water into the elevated canal. A special set of intake screens was devised to remove fish. These are termed low-level traveling screens and are shown diagrammatically in Figure 3. Each screen section is equipped with a small trough for holding fish. A low-pressure wash and sluiceway system are used to return fish to the river. Since its inception, survival rates for all species have ranged from 80% to 95%, and a significant reduction in the rates of impingement on the high-level intake screens has resulted.[2] Yet, in terms of total numbers per year, Surry recorded more fish impinged in 1975 than ever before. Although survival rates have gone up dramatically, it is not yet certain whether the fish impingment problem has been thoroughly resolved at this station.

REFERENCES

1. Final Environmental Statements, Surry Units 1 & 2. USAEC Directorate of Licensing. Docket Numbers 50-280 and 50-281. May and June 1972.

2. Semiannual Operating Report, Surry Power Station Units 1 & 2. Virginia Electric and Power Company. Report Number SOR-4. 1 January through 30 June 1974.

3. Six-Month Operating Report, Surry Power Station Units 1 & 2. Virginia Electric and Power Company. 1 January through 30 June 1973.

4. T. D. Cain and C. W. Billups. "Preliminary Analysis and Evaluations of Reported Impingement Losses at Surry Power Plant." USAEC Environmental Specialists Branch. March 1973.

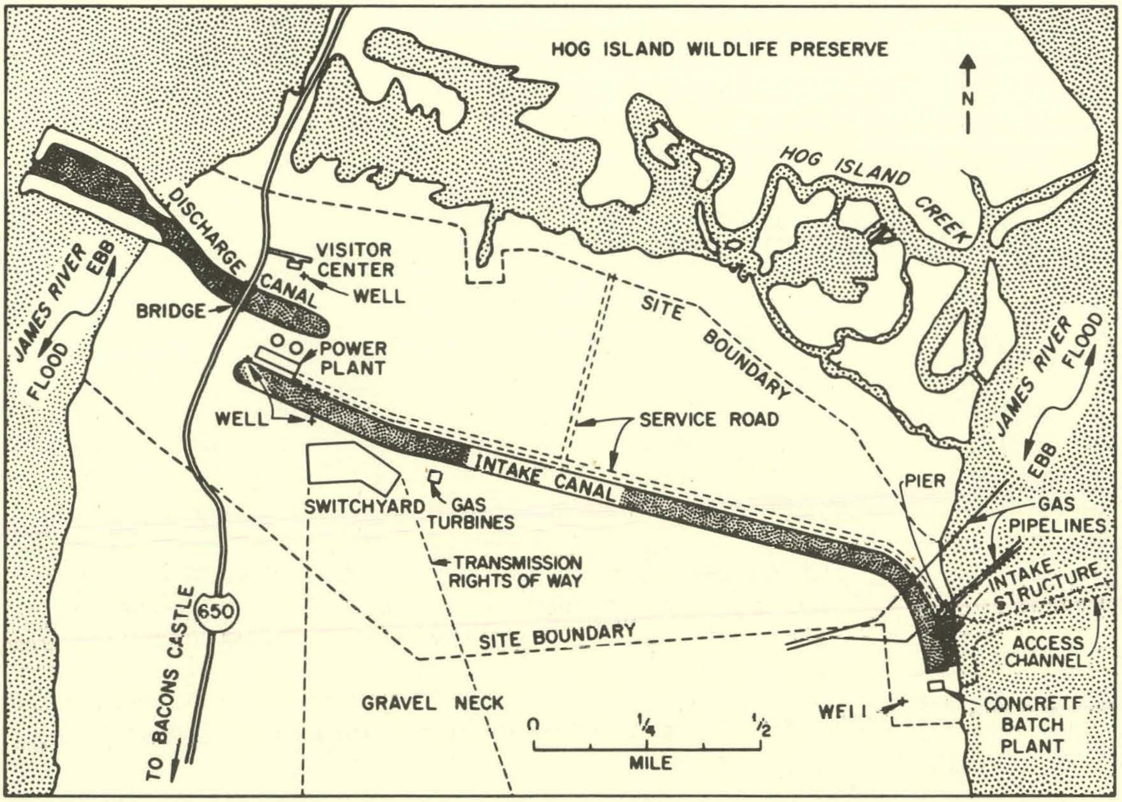


Fig. 1. Site Plan.

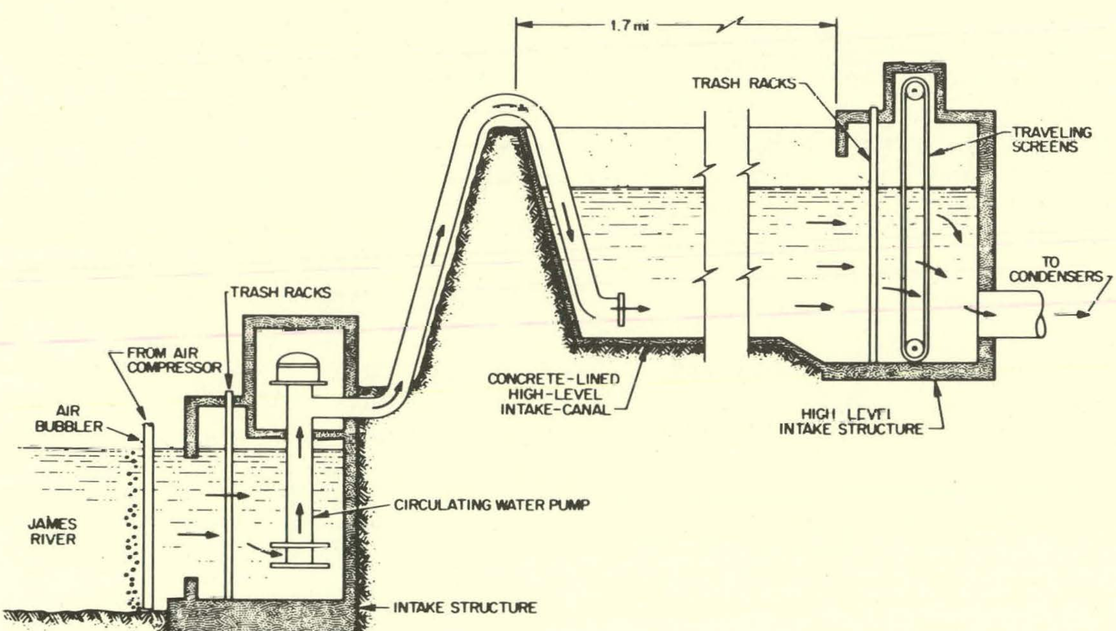


Fig. 2. Water-Intake System.

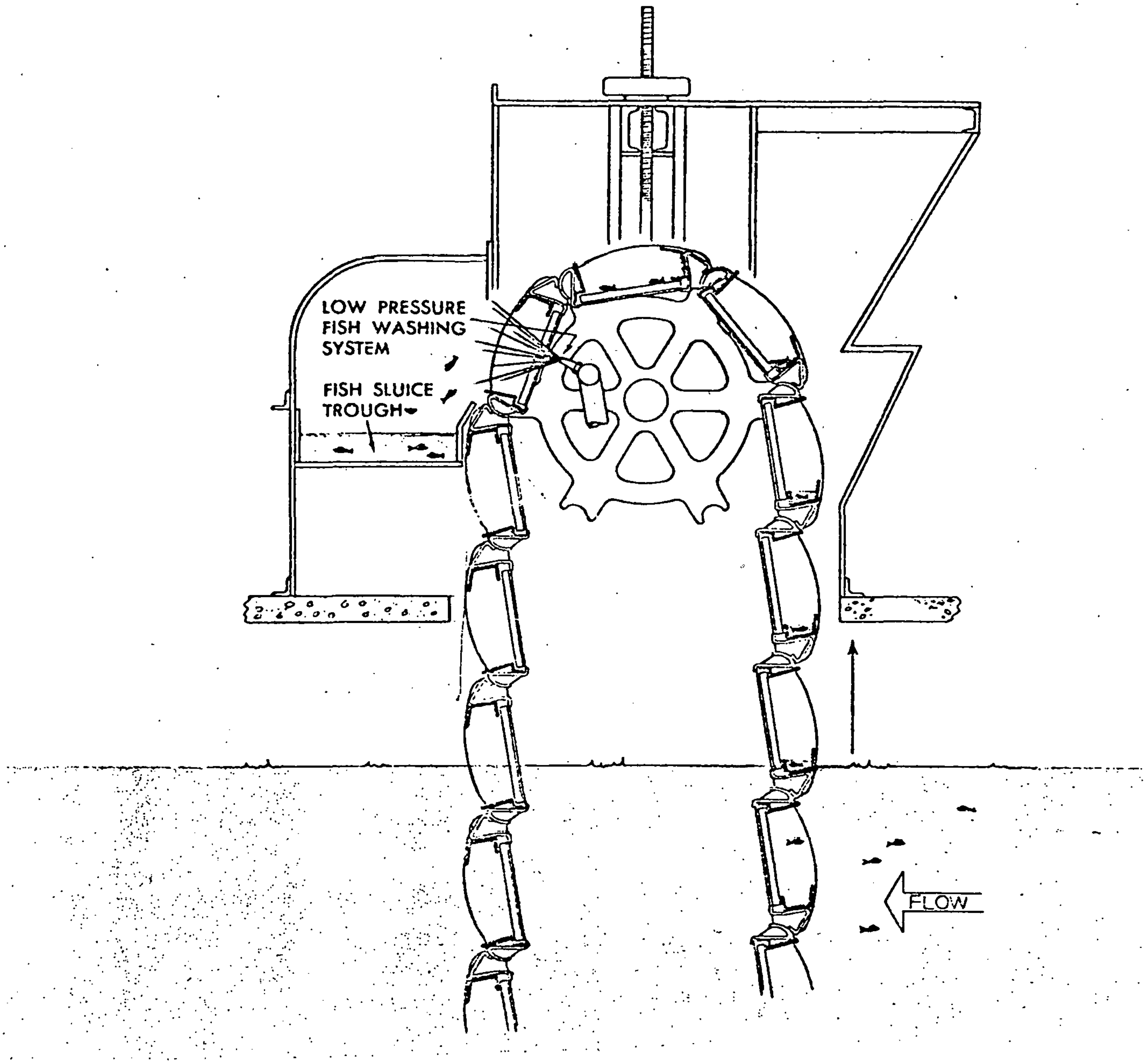


Fig. 3. Basket-Type Fish Screen.

Table I. Fishes Found at the Station

Atlantic sturgeon	Spottail shiner
American eel	Banded killifish
Tidewater silverside	Mummichog
Atlantic silverside	Striped killifish
Atlantic needlefish	Bay anchovy
Striped blenny	Naked goby
Crevalle jack	White catfish
Pumpkinseed	Brown bullhead
Sunfish	Channel catfish
Largemouth bass	Tessellated darter
Blueback herring	Yellow perch
Alewife	Summer flounder
Hickory shad	Bluefish
American shad	Mosquitofish
Atlantic menhaden	Silver perch
Gizzard shad	Weakfish
Threadfin shad	Spot
Carp	Atlantic croaker
Golden shiner	White perch
Bridle shiner	Striped bass
	Hogchoker
	Eastern mudminnow

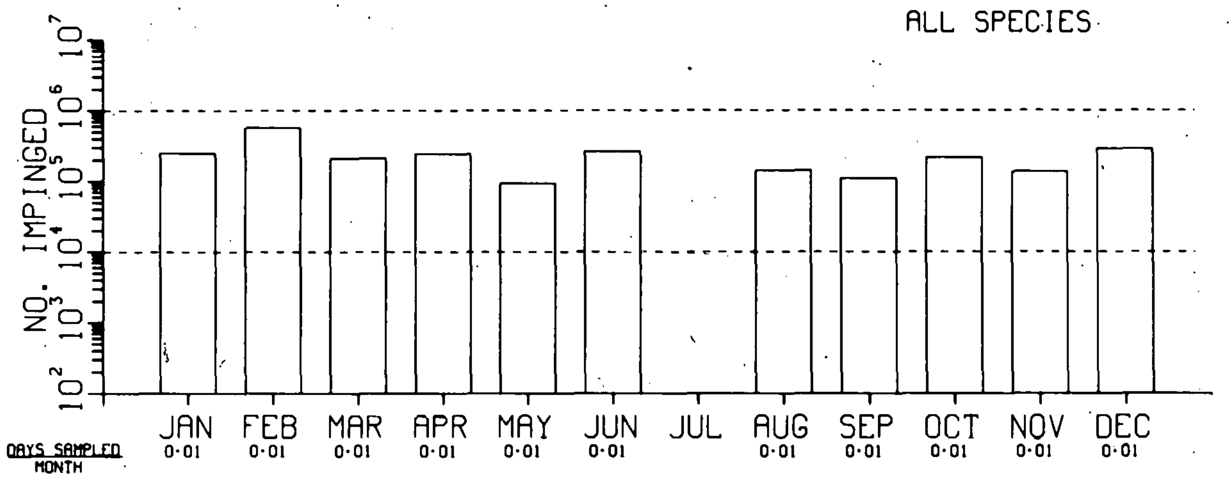
Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled					
		Blueback Herring	Gizzard Shad	Atlantic Menhaden	Atlantic Croaker	Threadfin Shad	Total
1973	11	849,912	302,792	266,419			2,532,288
1974	11	1,465,126	181,806		425,186		3,712,086
1975	12	564,936	1,658,088			184,564	6,092,355

SURRY UNITS 1 AND 2 (N)

FISH IMPINGEMENT DATA 1973

MONTHLY ESTIMATES



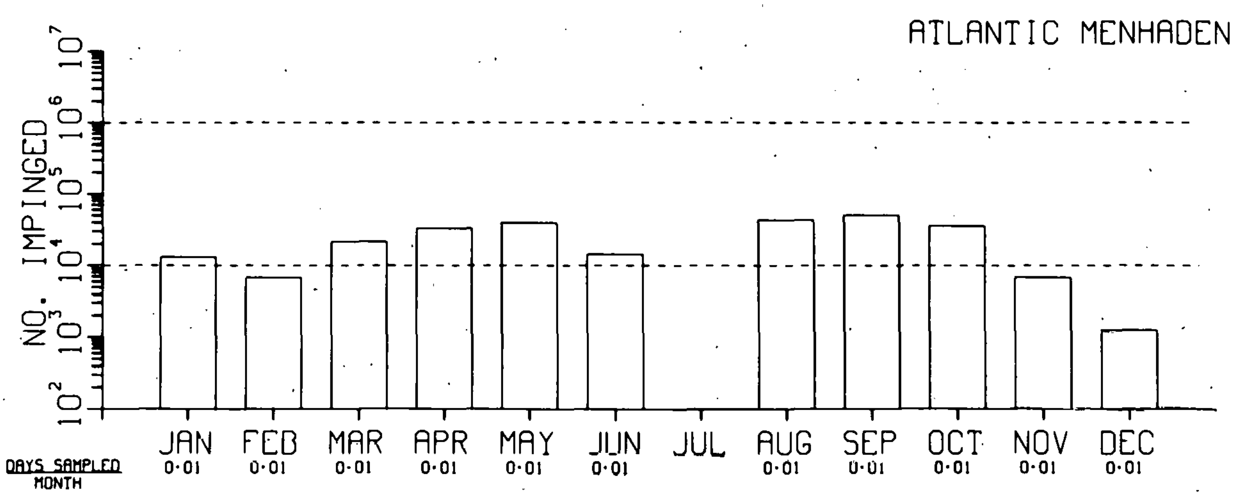


Fig. H1. Impingement Estimates.

SURRY UNITS 1 AND 2 (N)

FISH IMPINGEMENT DATA 1973

MONTHLY ESTIMATES

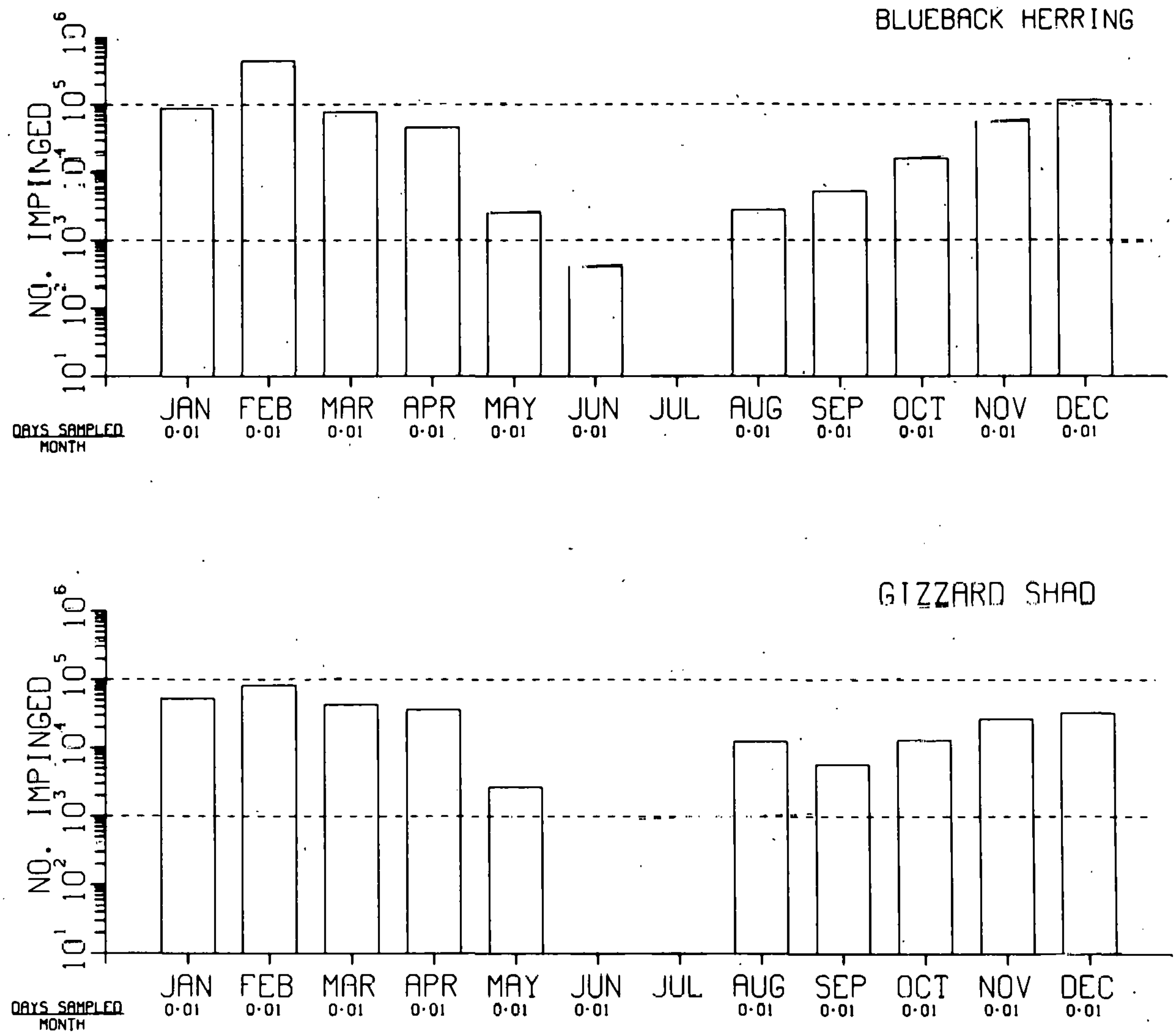


Fig. H2. Impingement Estimates.

SURRY UNITS 1 AND 2 (N)

FISH IMPINGEMENT DATA 1974

MONTHLY ESTIMATES

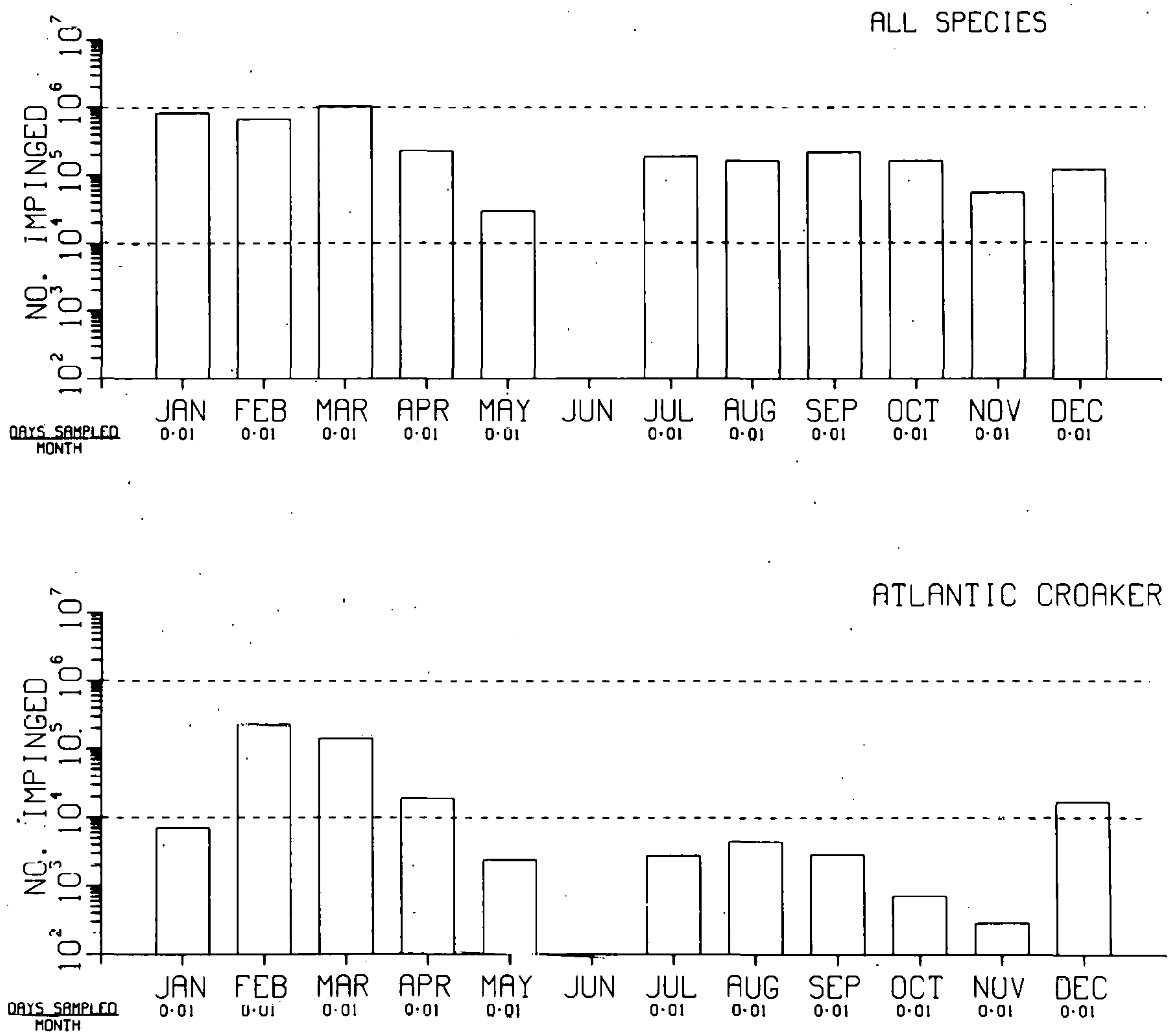


Fig. H3. Impingement Estimates.

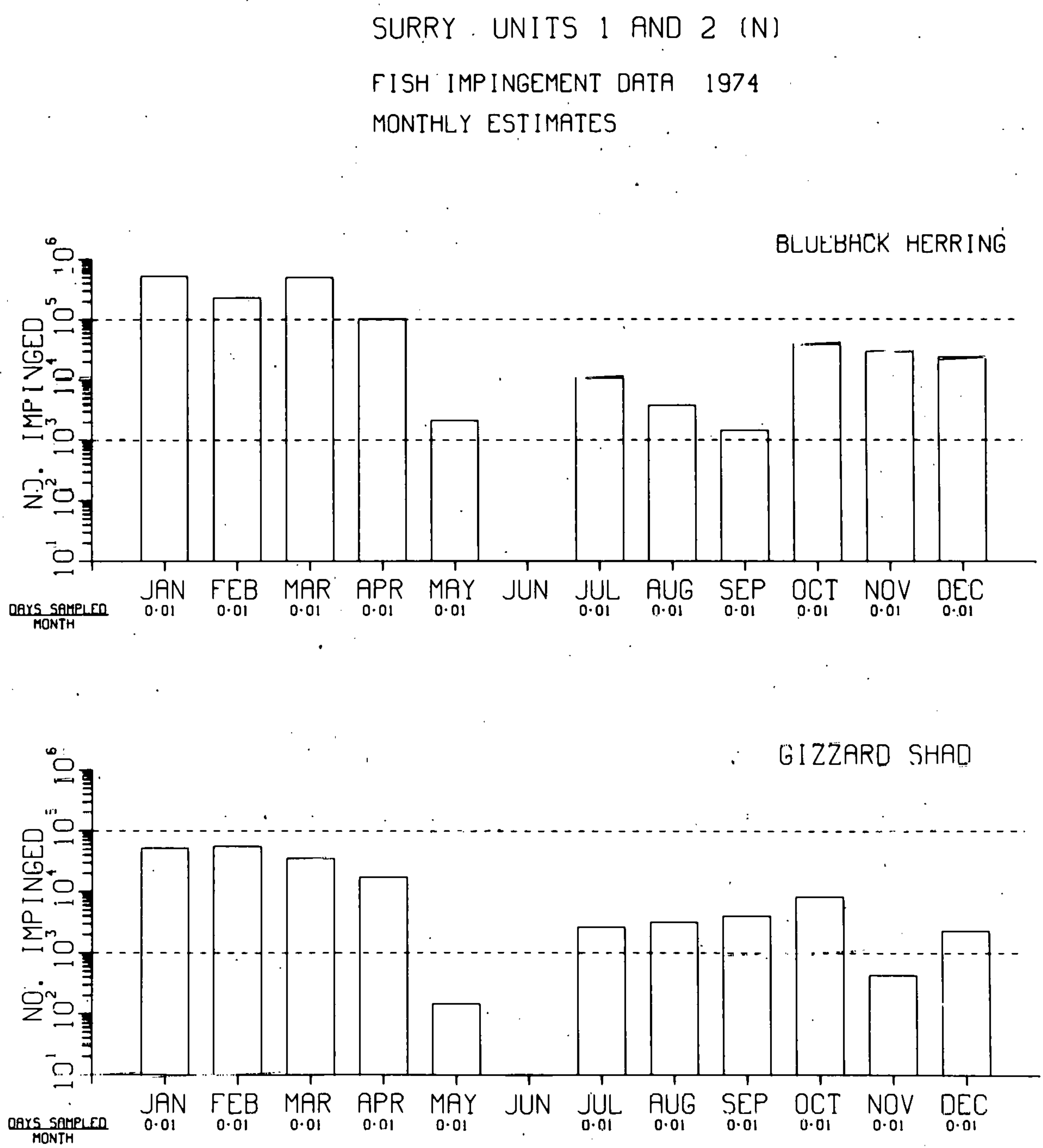


Fig. H4. Impingement Estimates.

SURRY UNITS 1 AND 2 (N)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES

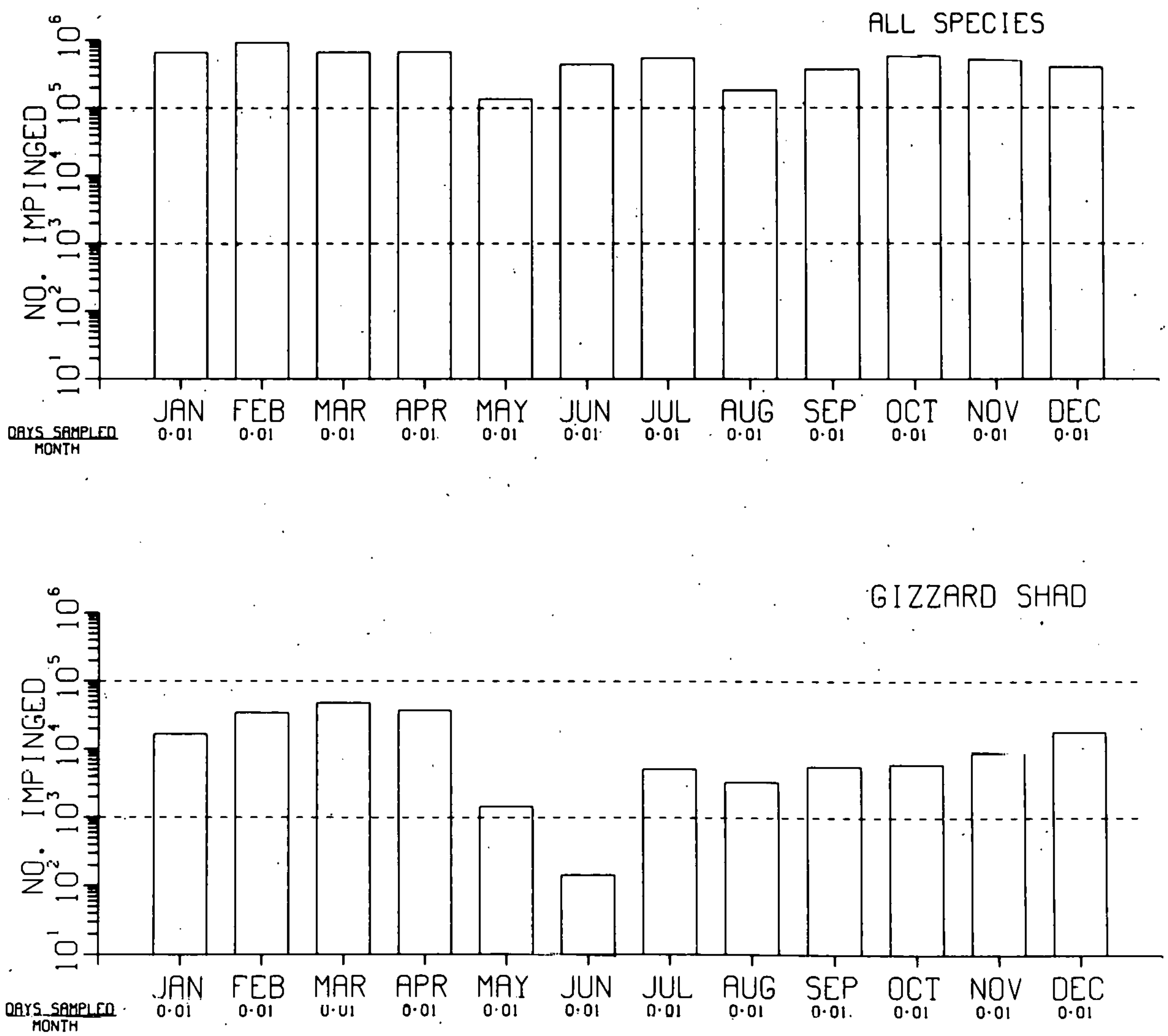
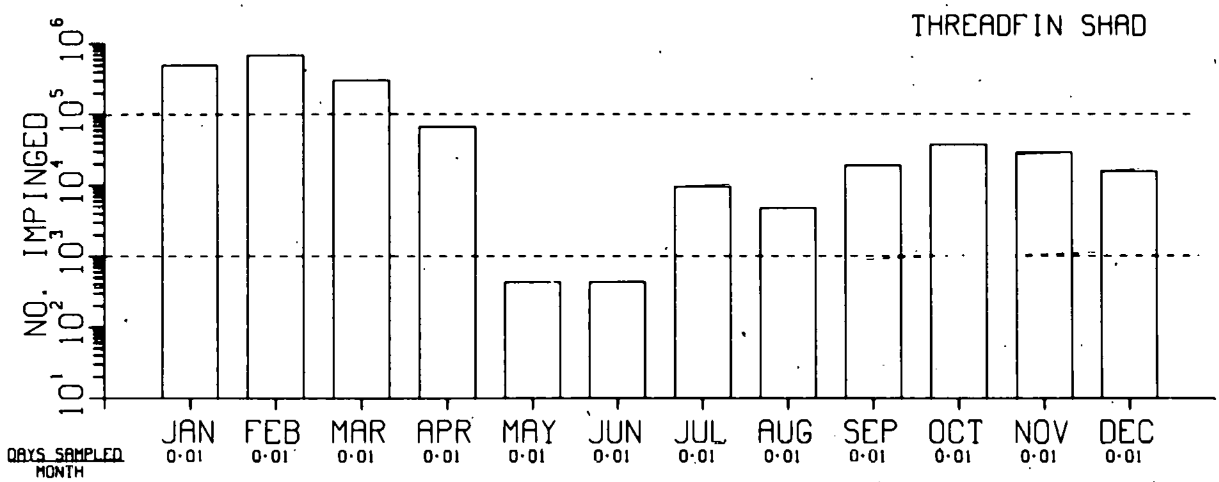


Fig. H5. Impingement Estimates.

SURRY UNITS 1 AND 2 (N)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



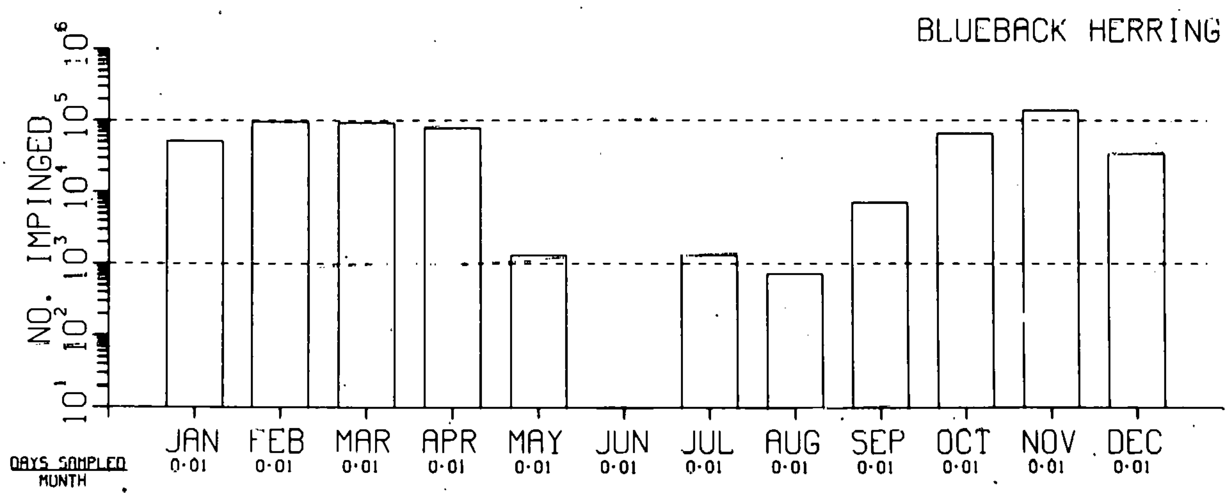


Fig. H6. Impingement Estimates.

BRUNSWICK STEAM ELECTRIC PLANT UNITS 1 AND 2 (N)

SITE CHARACTERISTICS

The plant is situated on the Atlantic Coastal Plain in a region of low relief, with elevations ranging from sea level to 30 feet MSL.[1] The site is located on a piece of land bounded on two sides by the Cape Fear Estuary. Cooling water is taken from and discharged into the estuary via artificial canals. Extensive marshes and swamps are characteristic of Brunswick County, North Carolina, where the site is located. Figure 1 shows the location of the plant, with nearby major landmarks.

Average flow at the mouth of the Cape Fear River is estimated at 3,900,000 to 4,800,000 gpm. The section of the river near the plant is characterized by strong semidiurnal tides with a range of about four feet. Salinity measured at the plant intake varies annually from 17.2 to 32.3 ppt. Only rarely does salinity at the site fall below half that of sea water.

During the spring, water temperature in the Cape Fear Estuary ranges from 64°F to 80°F, with a mean of 74°F. In summer, the temperature ranges from 75°F to 85°F, with a mean of 81°F. Autumn and winter mean water temperatures are 70°F and 62°F, respectively.

A list of fishes impinged on the intake screens at the Brunswick Steam Electric Plant is presented in Table I. Species variety in the estuary is large. In the baseline information, seasonal variations in the relative abundance of fishes were noted to be typical of other east-coast estuaries. Larval fish are present the year around. Clupeids migrate through the estuary annually on the way to their spawning grounds. The area is considered quite productive from the standpoint of aquatic life.

PLANT DESCRIPTION

The plant contains two boiling water reactors housed in dual containment structures. Each of the units has a design rating of 2436 MWt. Ultimate generating capacity is 1642 MWe for both reactors.

The plant employs once-through cooling and draws water through a three-mile, open, unlined canal from the Cape Fear River and discharges the heated effluent into the Atlantic Ocean about six miles from the plant site.

INTAKE DESIGN AND OPERATION

The intake canal serving the plant is 310 feet wide at the surface, 168 feet wide at the bottom, and 18 feet deep. It passes through 8500 feet of tidal marsh and 8500 feet of high ground. Water velocity through the canal is 0.41 to 0.95 fps.

The intake structure and its relation to the rest of the plant are shown in Figure 2. Bar racks are situated in front of the pumphouse and consist of 0.5-inch bars on 3.0-inch centers. Vertical traveling screens with 3/8-inch mesh prevent large marine life from entering the condensers. There are four circulating-water pumps delivering 1,300,000 gpm to the condensers. Velocities in front of the intake are listed at 0.5 to 1.4 fps, depending on the tide. Fish sluiced from the traveling screens are retained in a series of holding ponds that eventually return them to the estuary downstream from the intake-canal opening.

IMPINGEMENT SAMPLING

Sampling was conducted continuously at varying time intervals in order to determine the factors that influence the species abundance and the number of organisms collected. The day-vs.-night sampling was found to provide the widest data difference and, therefore, this was the method employed throughout the sampling period. A nekton-return program began on 28 June 1974 and additional samples were taken during the night to study the survival of impinged organisms.[2]

DATA AVAILABILITY

Data are available for all 12 months of 1974.

IMPINGMENT DATA SUMMARY

During the study period 2,465,000 organisms weighing 42,300 pounds were impinged. Of these, 15,600 pounds or 37% of the total weight of the catch were finfish. It should be noted that only two of the five circulating-water pumps were operating 78% of the time. All four pumps operated only 4.4% of the time. However, the impingement levels have been estimated as if the plant had operated at 100% of its capacity. The result may be an underestimate of the total number of fish the plant is capable of impinging at full operational capacity.

The three fishes most frequently impinged were the grey trout, Atlantic croaker, and Atlantic menhaden. A summary of their impingement data, as well as the total impingement, is presented in Table II. Figures H1 and H2 are histograms of the available data. Although the finfish represent only 37% by weight, they constitute 53% of the total catch in numbers for one year.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

Midway through the sampling the nekton-return program mentioned above was initiated to reduce mortality of marine organisms impinged at the plant. Fish survival was poor (only 2.6%).[2] No other methods to reduce impingement have been implemented.

REFERENCES

1. "Final Environmental Statement, Brunswick Steam Electric Plant Units 1 & 2." USAEC Directorate of Licensing. Docket Nos. 50-324 and 50-325. January 1974.

2. "Brunswick Steam Electric Plant Impingement Studies, January 19, 1974 to January 18, 1975." Carolina Power and Light Company. 30 pp. 1975.

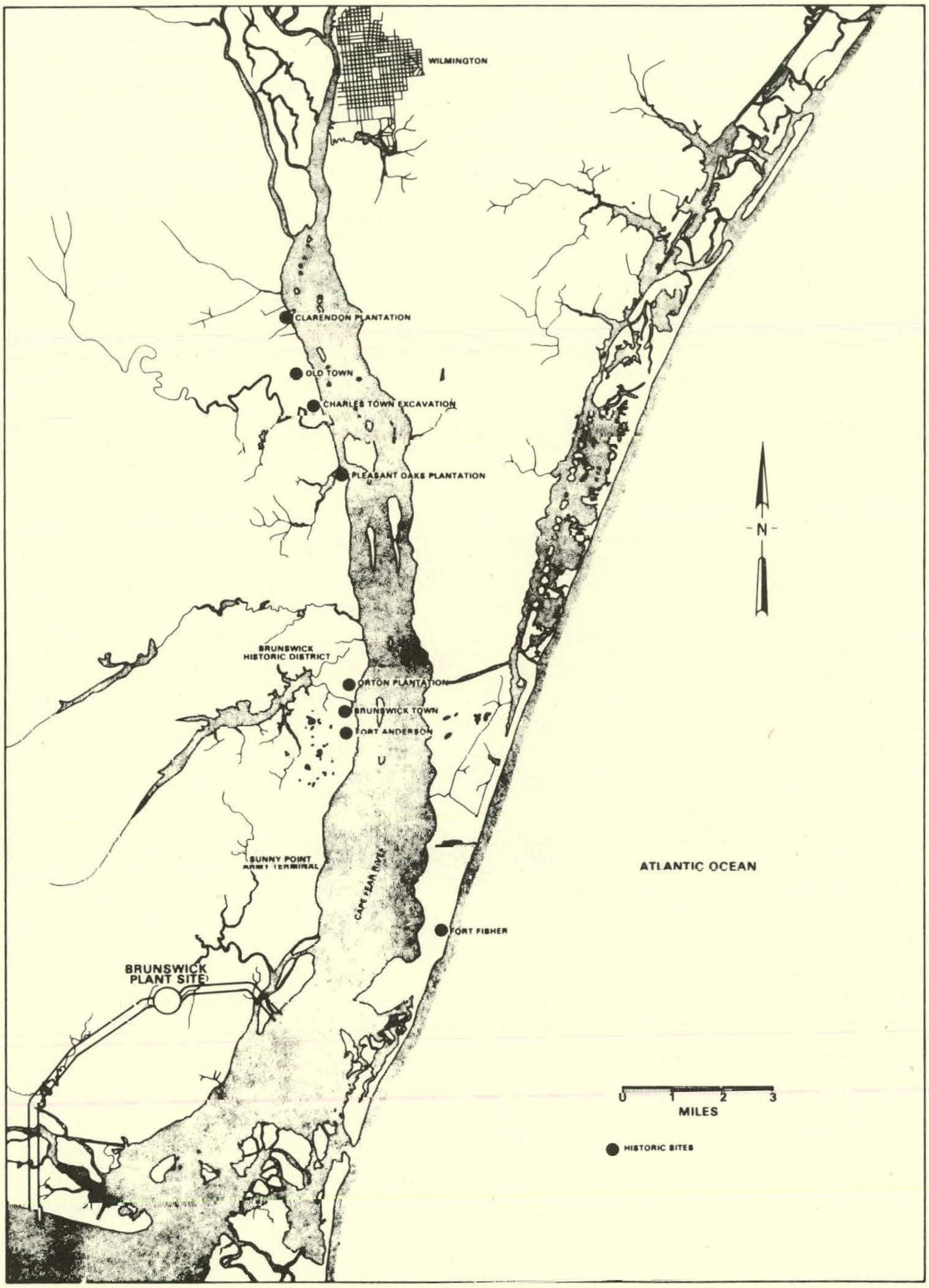


Fig. 1. Plant Location.

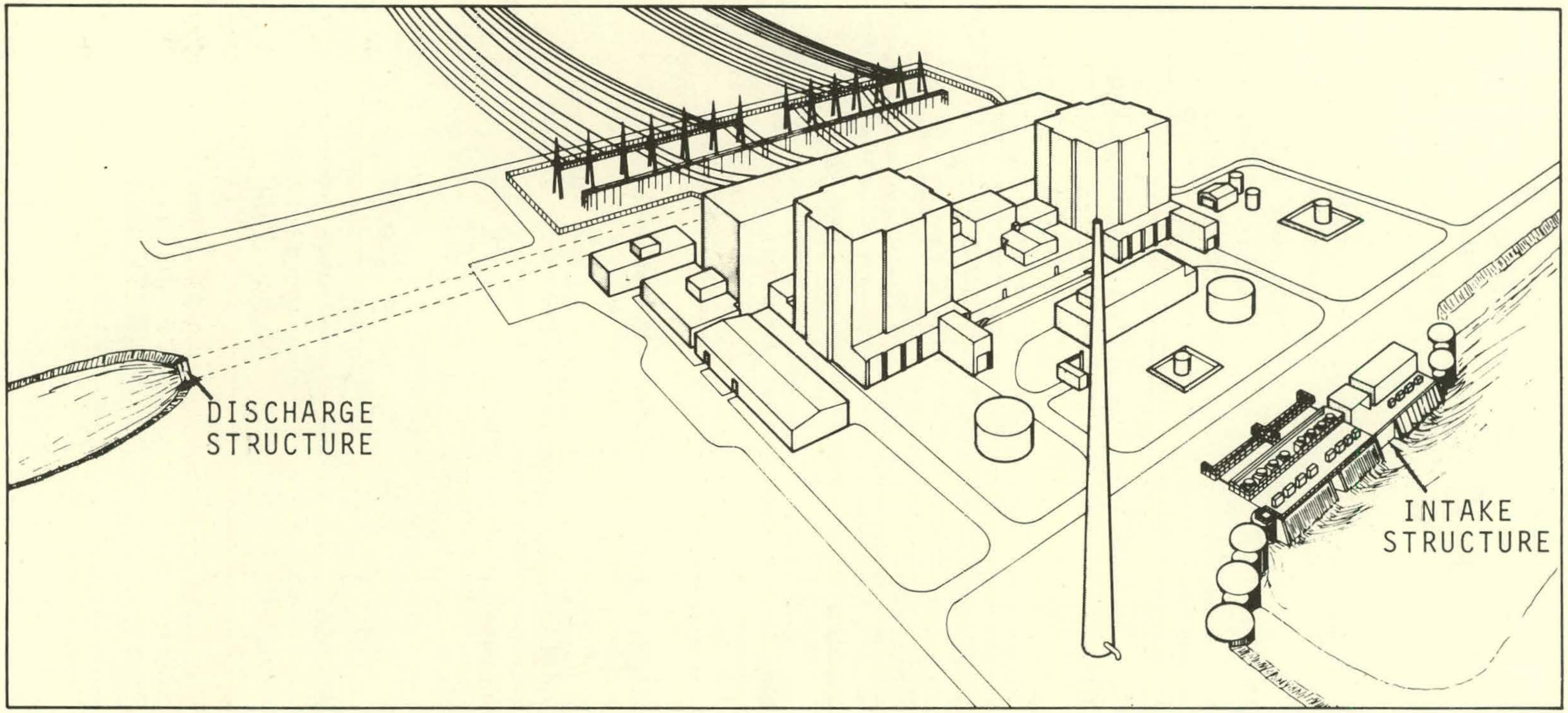


Fig. 2. The Plant Showing Intake and Discharge Structures.

Table I. Fishes Collected at the Plant

Cowfish	Longnose gar
Atlantic sturgeon	Pumpkinseed
Blueback herring	Warmouth
Hickory shad	Bluegill
Alewife	Gray snapper
American shad	Lane snapper
Orange filefish	Rough silverside
Bowfin	Tidewater silverside
Striped anchovy	Atlantic silverside
Bay anchovy	Southern kingfish
Ocellated flounder	Gulf kingfish
American eel	Northern kingfish
Ocellated frogfish	Atlantic croaker
Sheepshead	Largemouth bass
Sea catfish	Planehead filefish
Northern stargazer	Striped bass
Southern stargazer	Striped mullet
Gafftopsail catfish	White mullet
Silver perch	Smooth dogfish
Atlantic menhaden	Black grouper
Crevalle jack	Gag
Dusky shark	Speckled worm eel
Flier	Golden shiner
Snook	Batfish
Rock sea bass	Shrimp eel
Black sea bass	Blotched cusk-eel
Atlantic spadefish	Crested cusk-eel
Striped blenny	Atlantic thread herring
Spotted burrfish	Oyster toadfish
Atlantic bumper	Pigfish
Spotted whiff	Gulf flounder
Bay whiff	Summer flounder
Spotted seatrout	Southern flounder
Grey trout	Broad flounder
Sheepshead minnow	Harvestfish
Flyingfish	Butterfish
Southern stingray	Sea lamprey
Atlantic stingray	Sailfin molly
Bluntnose stingray	Black drum
Sand perch	Bluefish

Table I. Continued

Fat sleeper	Northern searobin
Gizzard shad	Striped searobin
Sharksucker	Blackwing searobin
Spinycheek sleeper	Leopard searobin
Ladyfish	Bighead searobin
Bluespotted sunfish	Cobia
Red grouper	Clearnose skate
Fringed flounder	Atlantic guitarfish
Silver jenny	Atlantic sharpnose shark
Bluespotted coronetfish	Red drum
Mummichog	King mackerel
Striped killifish	Spanish mackerel
Mosquitofish	Windowpane
Yellowfin mojarra	Lookdown
Darter goby	Atlantic moonfish
Sharptail goby	Northern puffer
Naked goby	Bandtail puffer
Seaboard goby	Northern sennet
Skilletfish	Guaguanche
Smooth butterfly ray	Star drum
Lined seahorse	Atlantic needlefish
Crested blenny	Blackcheek tonguefish
Halfbeak	Dusky pipefish
Feather blenny	Northern pipefish
Freckled blenny	Chain pipefish
White catfish	Inshore lizardfish
Smooth puffer	Tautog
Pinfish	Permit
Banded drum	Atlantic cutlassfish
Spot	Hogchoker
	Spotted hake

Table II. Summary of Fish Impingment Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Grey Trout	Atlantic Croaker	Atlantic Menhaden	Total
1974	12	161,843	54,254	96,138	1,303,829

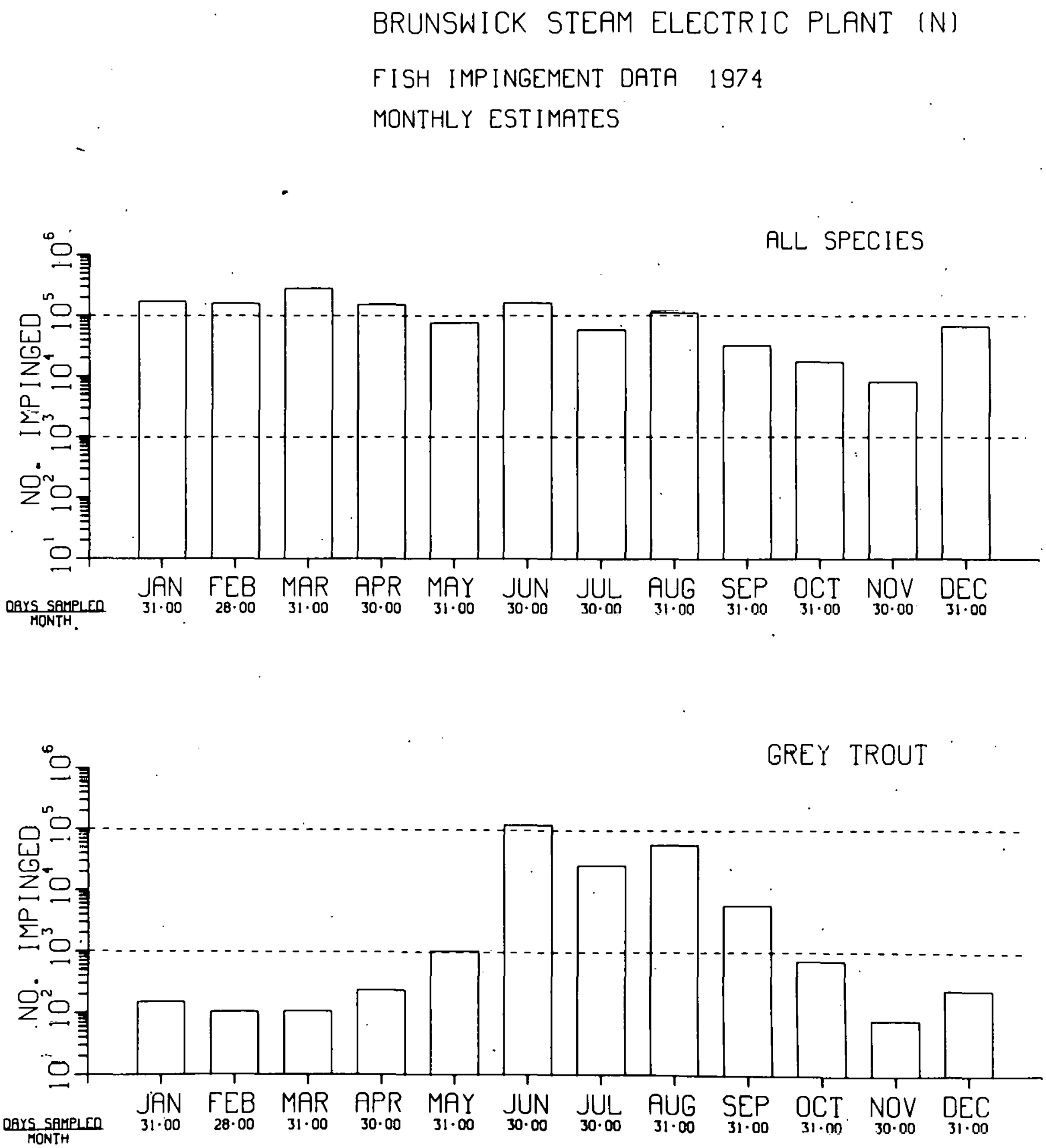


Fig. H1. Impingement Estimates.

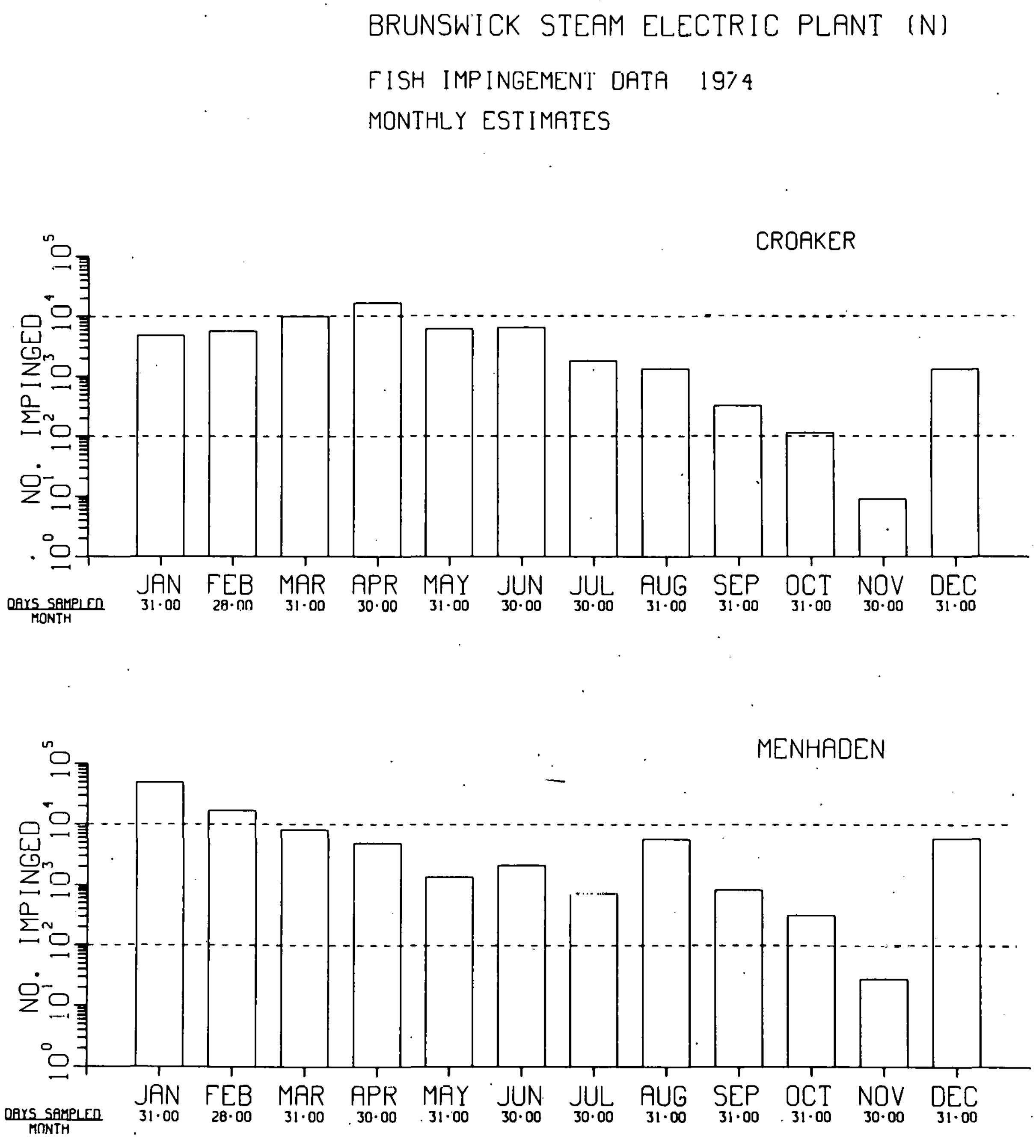


Fig. H2. Impingement Estimates.

A. M. WILLIAMS STATION UNIT 1 (F)

SITE CHARACTERISTICS

The A. M. Williams Station is located in Berkeley County, South Carolina, on a tidal portion of the Cooper River and at a point where the Back River forms a natural reservoir.[1] Figure 1 shows a plot plan of the station. The intake draws water from the Back River, which is 400 to 450 feet wide and fairly shallow at the station site. The discharge is into the main channel of the Cooper River, which is dredged regularly for barge traffic.

Thirty-one species of fish were impinged during the sample period (Table I). Most are freshwater species, but the presence of such individuals as the striped mullet shows the tidal influence in this estuarine area.

PLANT DESCRIPTION

The A. M. Williams Station has one 600-MWe oil-fired unit. It employs once-through cooling and is equipped with mechanical-draft cooling towers for additional cooling when high ambient water temperatures occur in summer.

INTAKE DESIGN AND OPERATION

Water is drawn from the Back River and flows through an intake canal that is is 1000 feet long and 50 feet wide. It then passes through bar racks to six vertical traveling screens with 3/8-inch mesh (Fig. 2). The maximum velocity of water through the screens is 1.14 to 1.89 fps. Three circulating-water pumps, each rated at 123,500 gpm, pump water to the condensers (Fig. 3). No special operational procedures for winter operation are required. Summer operation may include the use of mechanical-draft cooling towers and conversion to a closed-cycle mode of operation when ambient water temperature is high.

IMPINGEMENT SAMPLING

Impingement sampling is done by sluicing the impinged organisms and trash into a trough, which leads to a collection basket. All organisms impinged over a 24-hour period are included in a sample. Sampling is done for one 24-hour period every other week except during periods of high impingement, when the sampling is done once a week.

DATA AVAILABILITY

Data are available for 1975, except for the months of April and May when the station was shut down.[2]

IMPINGEMENT DATA SUMMARY

The three most numerous species impinged were the hogchoker, threadfin shad, and blueback herring. Table II lists the yearly numbers for each species and the total number of fish estimated to have been impinged over the 10-month sampling period in 1975. Monthly histograms for 1975 are presented in Figures H1 and H2.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. Personal communications with T. C. Nichols, Jr., of South Carolina Electric and Gas Company. 6-7 May 1976.

2. Personal communication with T. C. Nichols, Jr., of South Carolina Electric and Gas Company. 9 April 1976.

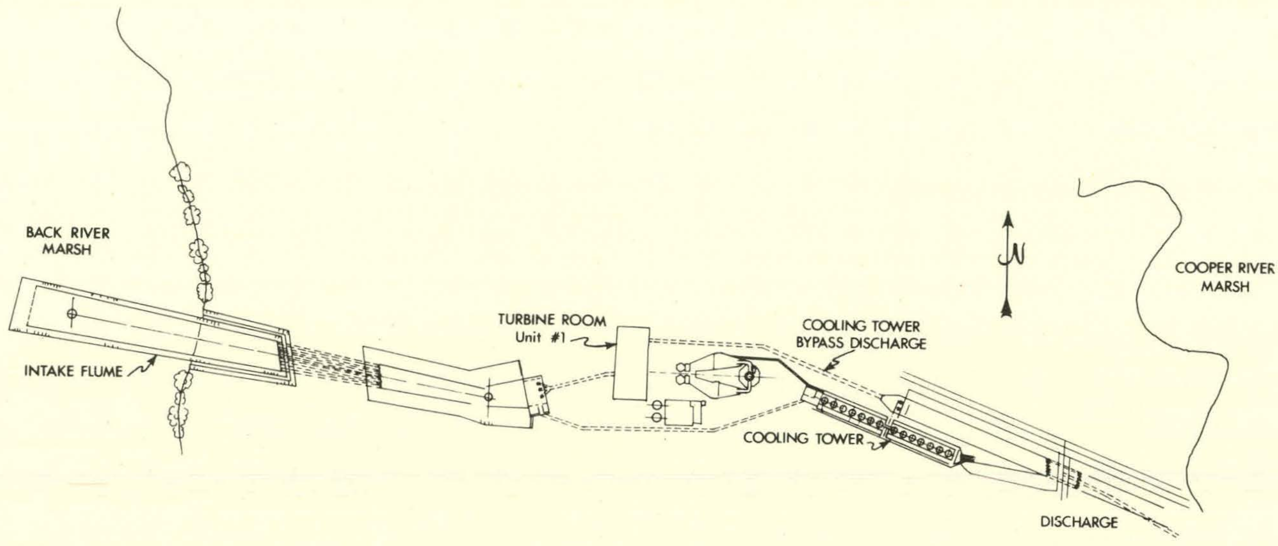


Fig. 1. Station Plot Plan.

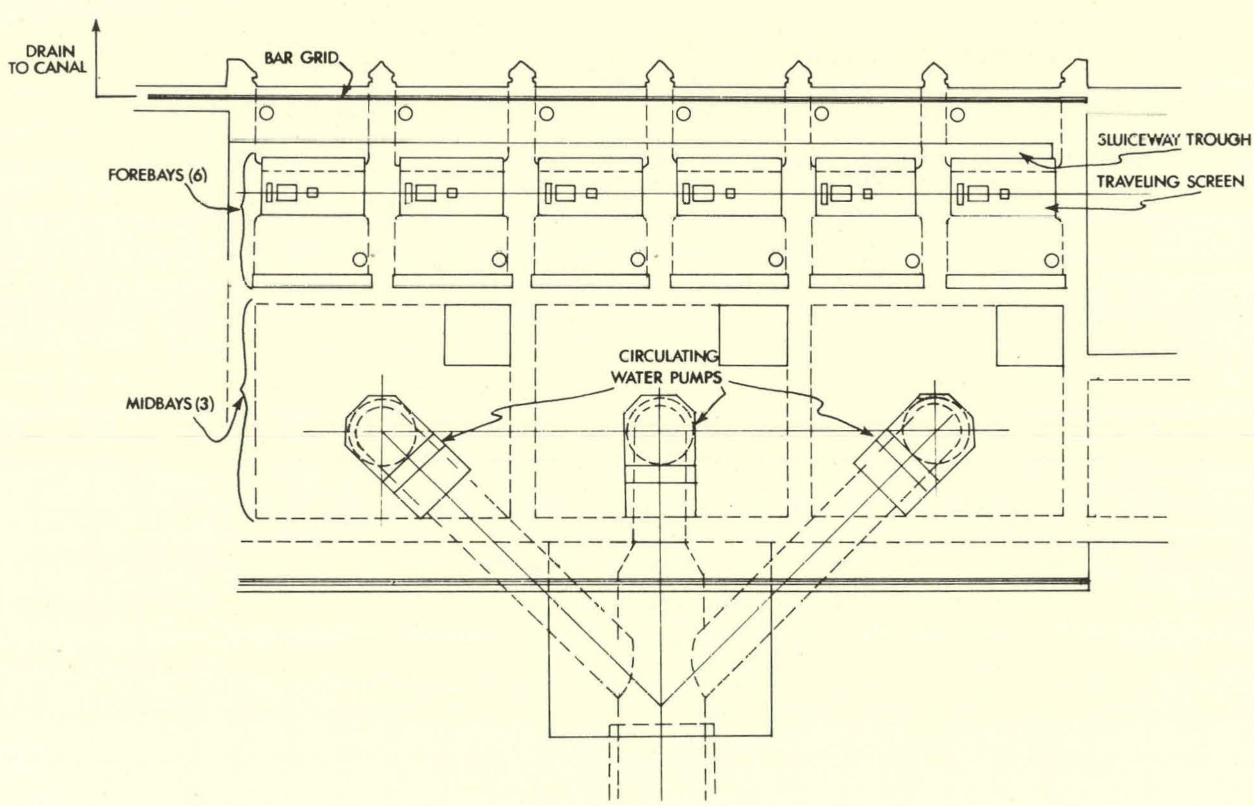


Fig. 2. Intake Screenwell Structure, Top View.

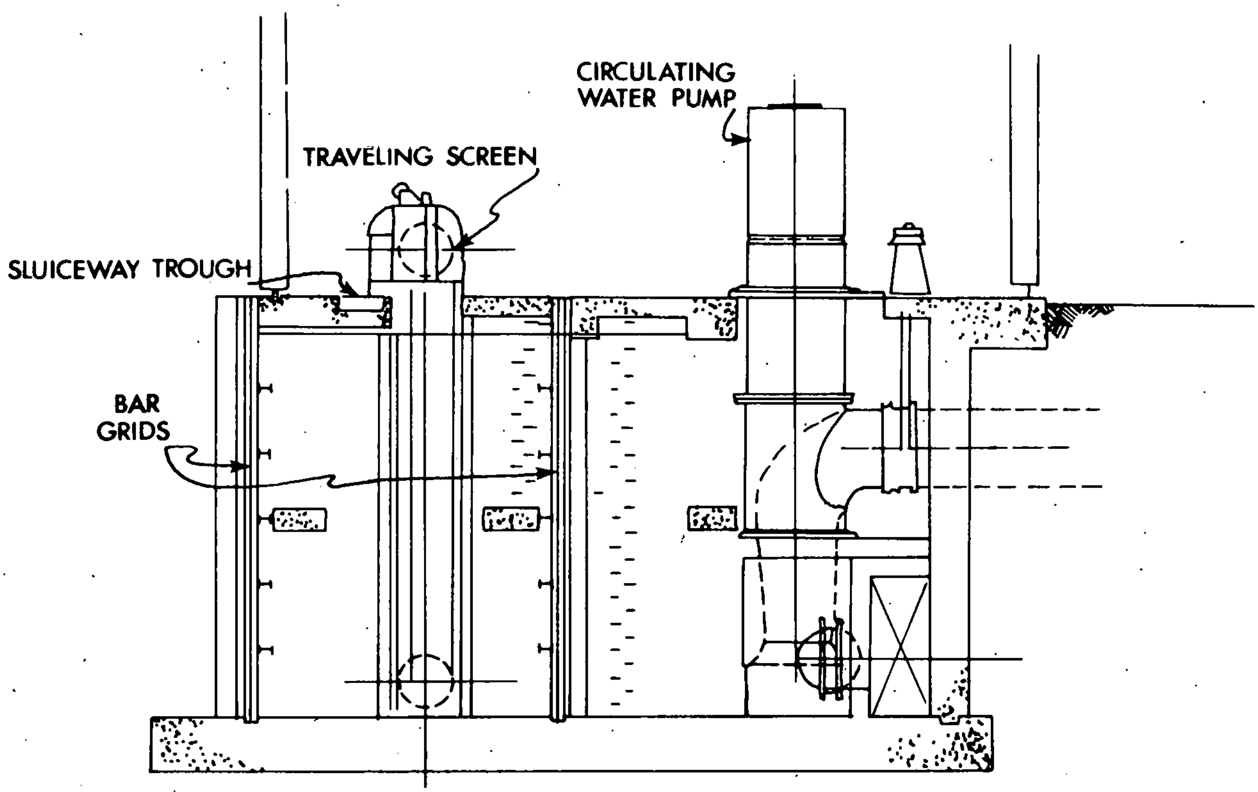


Fig. 3. Intake Screenwell Structure, Side View.

Table I. Fishes Impinged at the Station in 1975

Blueback herring	Channel catfish
Alewife	Spotted gar
Rock bass	Shortnose gar
Bowfin	Redbreast sunfish
Pirate perch	Warmouth
Flier	Bluegill
Carp	Redear sunfish
Gizzard shad	Striped bass
Threadfin shad	Striped mullet
Bluespotted sunfish	Southern flounder
Redfin pickerel	Yellow perch
Chain pickerel	White crappie
White catfish	Black crappie
Brown bullhead	Atlantic needlefish
Flat bullhead	Hogchoker
	Eastern mudminnow

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Hogchoker	Threadfin Shad	Blueback Herring	Total
1975	10	18,386	11,913	14,226	49,947

A. M. WILLIAMS STATION UNIT 1 (F)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES

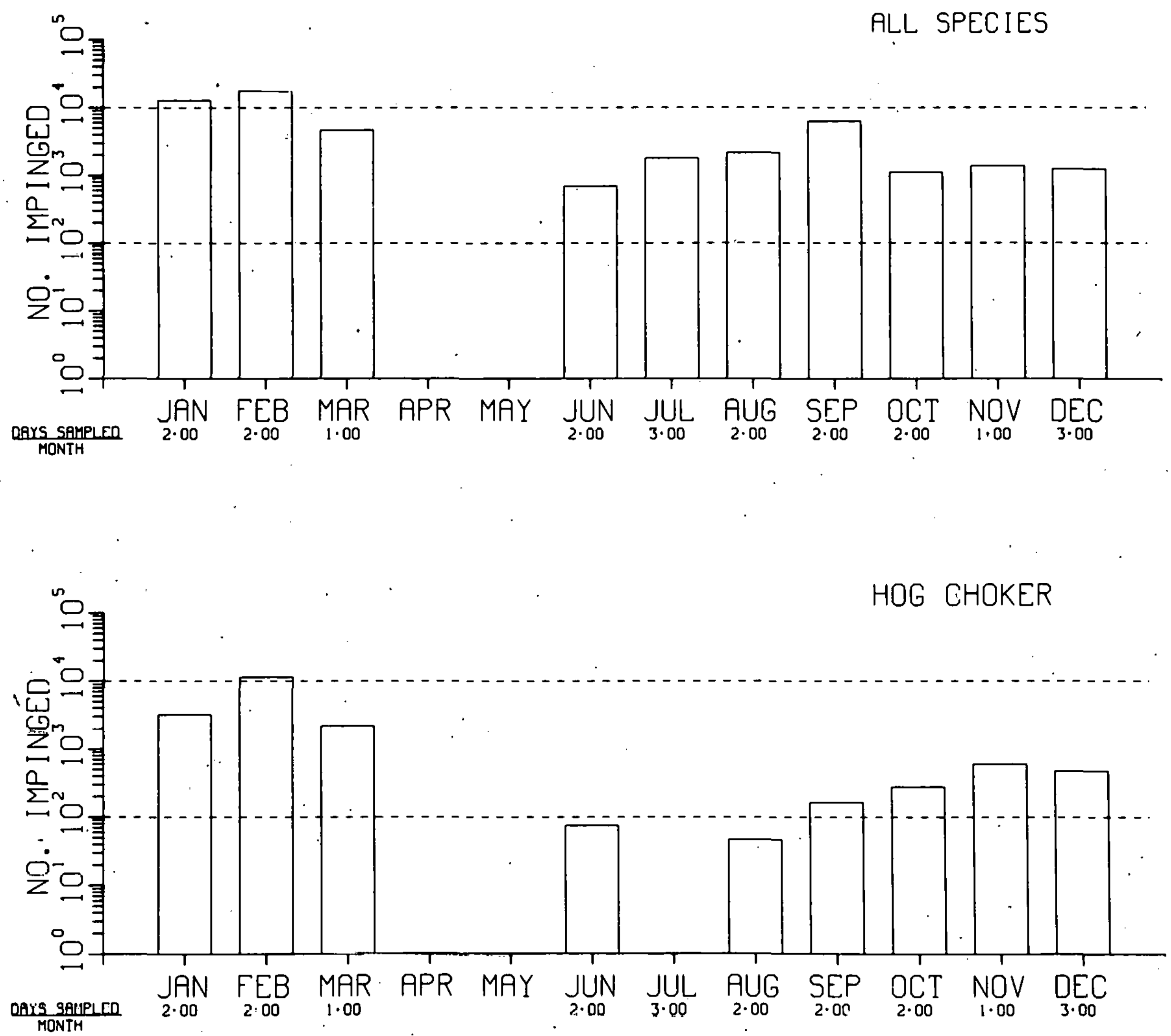
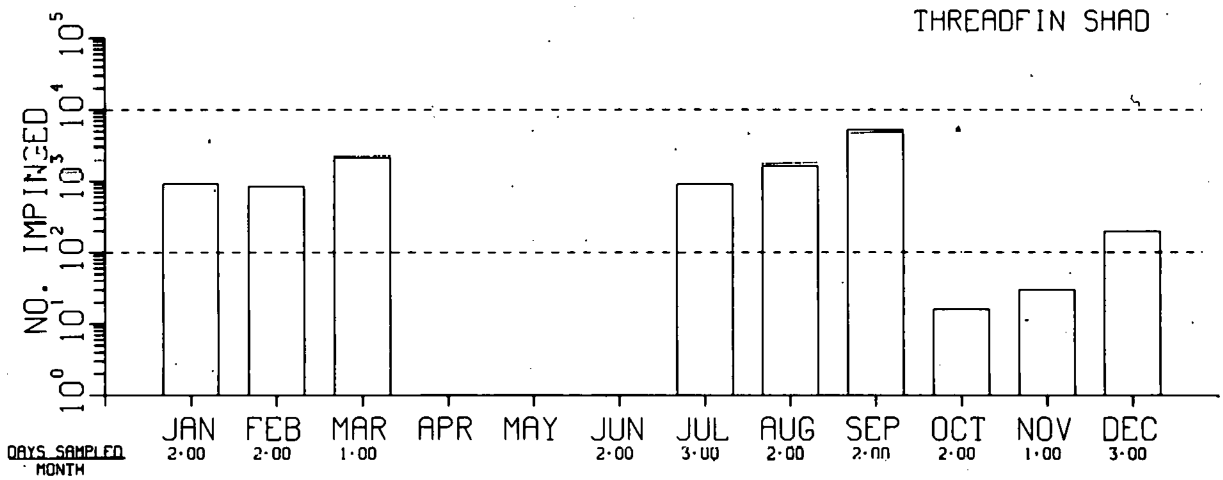


Fig. H1. Impingement Estimates.

A. M. WILLIAMS STATION UNIT 1 (F)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



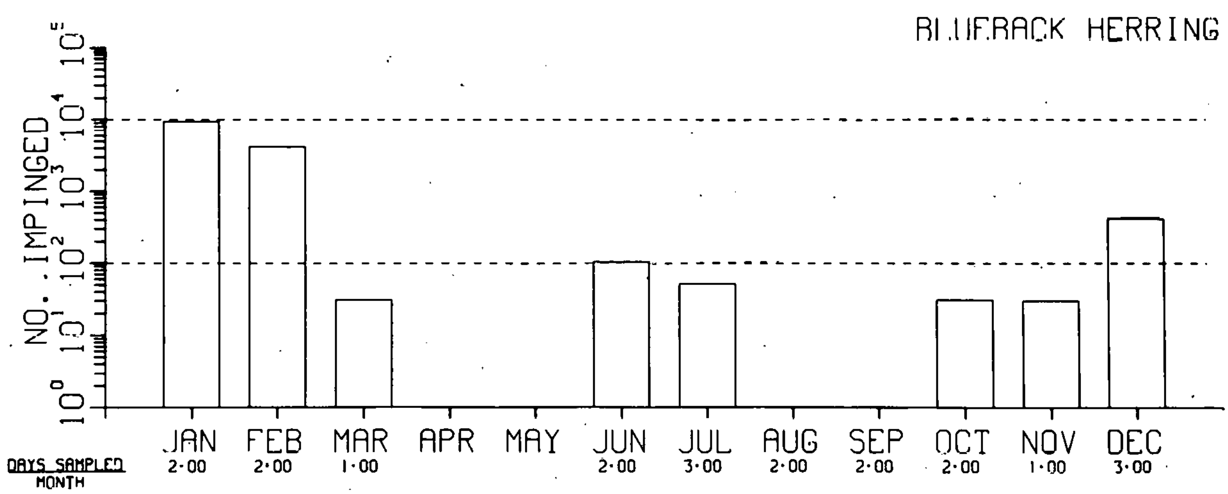


Fig. H2. Impingement Estimates.

TURKEY POINT PLANT UNITS 3 AND 4 (F-N)

SITE CHARACTERISTICS

The Turkey Point Plant is located on the western shore of Biscayne Bay about 25 miles south of Miami, Florida.[1] The site consists of the plant, which occupies 3300 acres, and the cooling-canal system, which occupies 7000 acres and has an ultimate water-surface area of 4000 acres (Fig. 1). Natural drainage of the area is east and south toward Biscayne Bay; however, no natural channels drain rainfall. The mean site elevation is one foot MSL, and inasmuch as average tidal variation is two feet, most of the site area remains under three to five inches of water much of the time. Biscayne Bay is very shallow, with a five-foot average and a 13-foot maximum at mean low water.

PLANT DESCRIPTION

The plant is comprised of four units, two fossil and two nuclear. The two nuclear units are identical pressurized water reactors designed to provide a total of 1520 MWe gross power. The fossil units provide a total of 801 MWe. The plant employs once-through cooling, drawing water from a system of canals.

INTAKE DESIGN AND OPERATION

The plant employs a closed system of canals in order to dissipate waste heat from all four units (Fig. 1). Makeup water is drawn from Card Sound (south of Biscayne Bay), and passes up through Card Sound Canal directly to the plant. The nuclear units have eight screenwells with one 156,000-gpm circulating-water pump each. The combined capacity of the pumps is 1,248,000 gpm. From the intake canal, water flows through trash racks and traveling screens into the eight screenwells. Cooling water that is discharged from the condensers of both the fossil and nuclear units is circulated through 4000 acres of canals before it is returned to the plant. All old channels to Biscayne Bay have been sealed off. The amount of makeup water needed is highly variable, depending on the rate of evaporation and degree of salinity in the canals.

IMPINGEMENT SAMPLING

No fish impingement data are available for this plant.[2]

DATA AVAILABILITY

No sampling was done [see 316(b) status in the introduction to this volume].

REFERENCES

1. "Final Environmental Statement, Turkey Point Plant," USAEC Directorate of Licensing. Docket Numbers 50-250 and 50-251. July 1972.

2. Personal communication with J. Ross Wilcox of the Florida Power and Light Company. 25 October 1975.

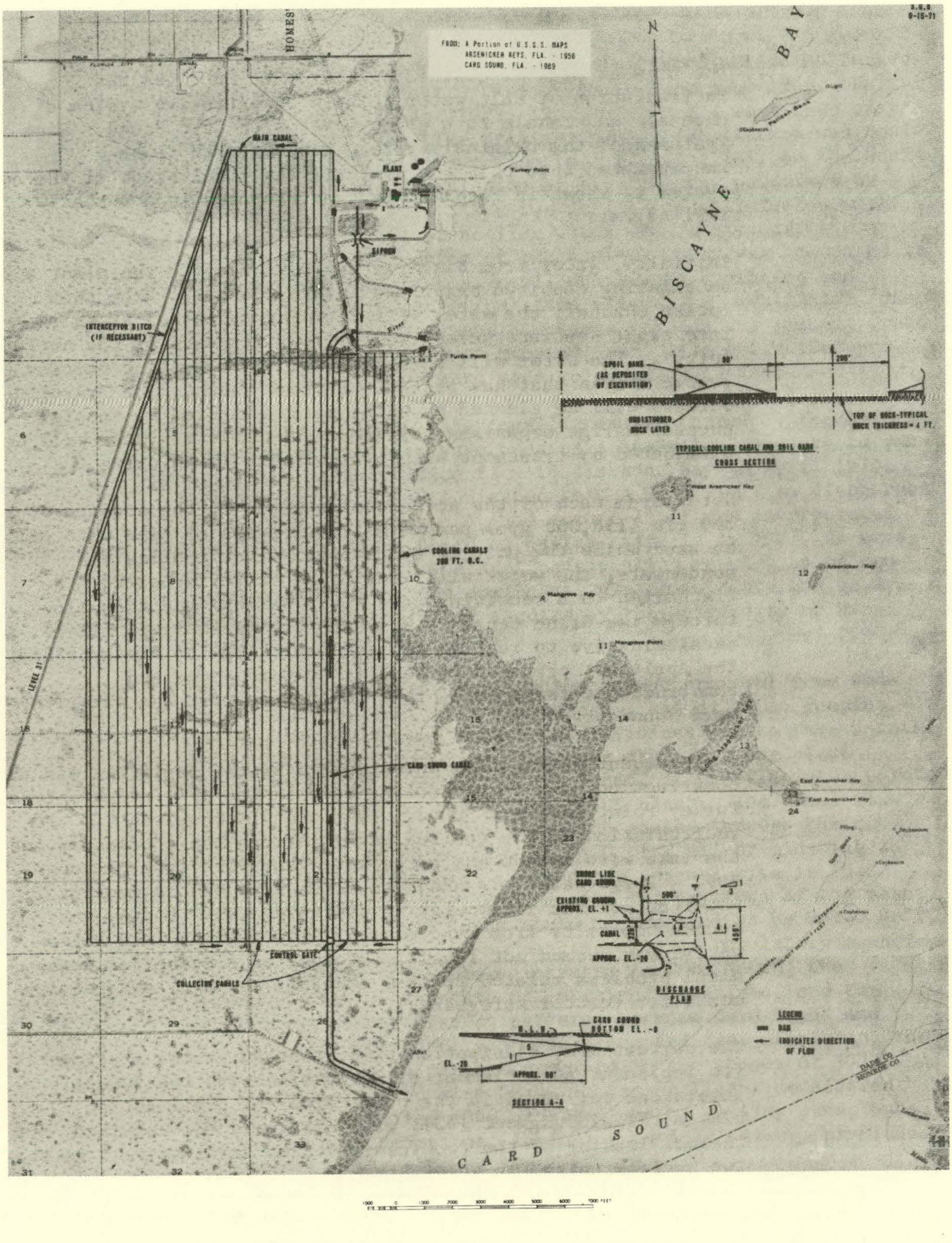


Fig. 1. Plant Location Showing Cooling-Canal System.

CRYSTAL RIVER PLANT (F-N)

SITE CHARACTERISTICS

The plant is located in Citrus County, Florida, facing the Gulf of Mexico, about midway between the mouths of Withlacoochee and Crystal Rivers as shown in Figure 1.[1] The region is characterized by gradually rising terrain and the entire area has very low relief (two to five feet MSL). The 4738-acre site is within the Terraced Coastal Lowlands of the coastal plain of Florida.

The marine area near the plant is a portion of the coastal estuarine zone that borders directly on the Gulf of Mexico. The shore at the site is marshy and receives almost no wave action. The Gulf is very shallow, with a mean depth of four to six feet at the discharge, and increasing 1.5 to 2.5 feet per nautical mile toward the west. A chain of spoil islands, extending eight miles into the Gulf, is located just north of the plant (Fig. 1) and affects water-circulation patterns over a large area.

Water temperature at the site varies from a mean maximum of 85.3°F in July to a mean minimum of 48.5°F in January. Salinity varies widely throughout the year, owing to the estuarine nature of the coastline. Inshore, at the discharge, the salinity ranges from 22 to 29 ppt, and increases to 35 ppt eight to ten miles offshore.

Fish variety and abundance around Crystal River is very high, with 115 species identified during impingement sampling.[2] A list of fishes identified at the Crystal River Plant is given in Table I.

PLANT DESCRIPTION

Crystal River Units 1 and 2 are oil-fired, with a combined generating capacity of 897 MWe. Unit 3 is nuclear, using a pressurized water reactor with a design rated capacity of 885 MWe. It is not in operation.[3] An overall site plan is illustrated in Figure 2. All three units are designed for once-through cooling.

INTAKE DESIGN AND OPERATION

A schematic of a typical intake structure for the plant is shown in Figure 3. Cooling water is withdrawn at the rate of 640,000 gpm for Units 1 and 2. Unit 3 will withdraw 700,000 gpm when it becomes operational. Intake water is delivered through a canal that is 150 feet wide and 15 feet deep at mean low water. The water velocity in the intake canal is 1.3 fps at ebb tide. A barrier net made of standard chain-link fencing sifts large debris and is manually cleaned. Water entering any of the three intakes first passes through vertical trash bars with four-inch spacing and then through traveling screens with 3/8-inch openings. Units 1 and 2 employ eight circulating-water pumps and Unit 3 will employ four circulating-water pumps. All are rated at 170,000 gpm each. There are no deicing or winter-operation procedures.

IMPINGEMENT SAMPLING

Twenty-four hour collections were made once per week in the noon-to-noon time period. Hourly samples were taken, and the impinged fish were sorted and preserved for identification. Collections were made for Units 1 and 2 only (the Unit 1 screens are referred to as the "east screens"). Total fish weight was recorded, and standard length was taken on subsamples.

DATA AVAILABILITY

The following data are available:

13 August 1972 to 4 August 1973 - Unit 2 ("west screens").
10 August to 25 August 1973 - Units 1 and 2.
8 February to 6 April 1974 - Units 1 and 2.

Because of the method used to report the data, only total numbers for all sampling dates, by month, are available. It is also not possible to determine, with complete accuracy, the three most numerous species impinged. An examination of the text provided three "representative" species with apparently high rates of impingement.[2]

IMPINGEMENT DATA SUMMARY

The three fish selected for their high rates of impingement were the polka-dot batfish, pinfish, and Atlantic threadfin. Figures for the total fish impinged were not prepared; however, a total of 55 days of sampling in 14 months yielded 792,698 fish belonging to 115 species. Extrapolation for continuous sampling at Unit 2 (inasmuch as 88% of the sampling was done at the west screens only) yields a total of 5,851,553 fish impinged at Unit 2 over the 14 months sampled. The projected figures for the Atlantic threadfin (Table II) suggest that this may actually be an underestimation of the total number of fish impinged. The absence of Atlantic threadfin in 1972 and 1974 may also suggest a large error in the sampling design that resulted in such an underestimation. Monthly estimates of impingement for the three species are presented in Figures H1 through H3.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None cited.

REFERENCES

1. "Final Environmental Statement, Crystal River Unit 3." USAEC Directorate of Licensing. Docket Number 50-302. May 1973.

2. "Crystal River Power Plant Environmental Considerations. Final Report to the Interagency Research Advisory Committee." Volumes II and III. Florida Power Corporation. October 1974.

3. Personal communication with D. Martin of Florida Power Corporation. 20 April 1976.

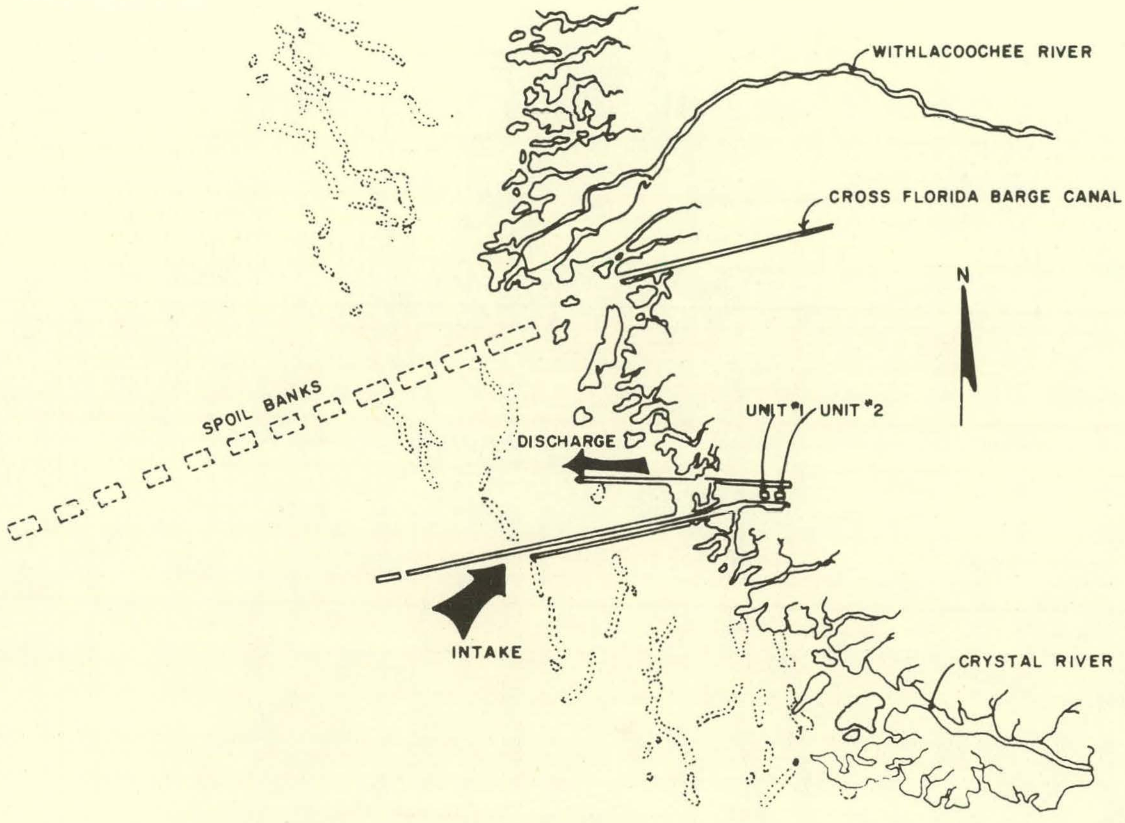


Fig. 1. Plant Location.

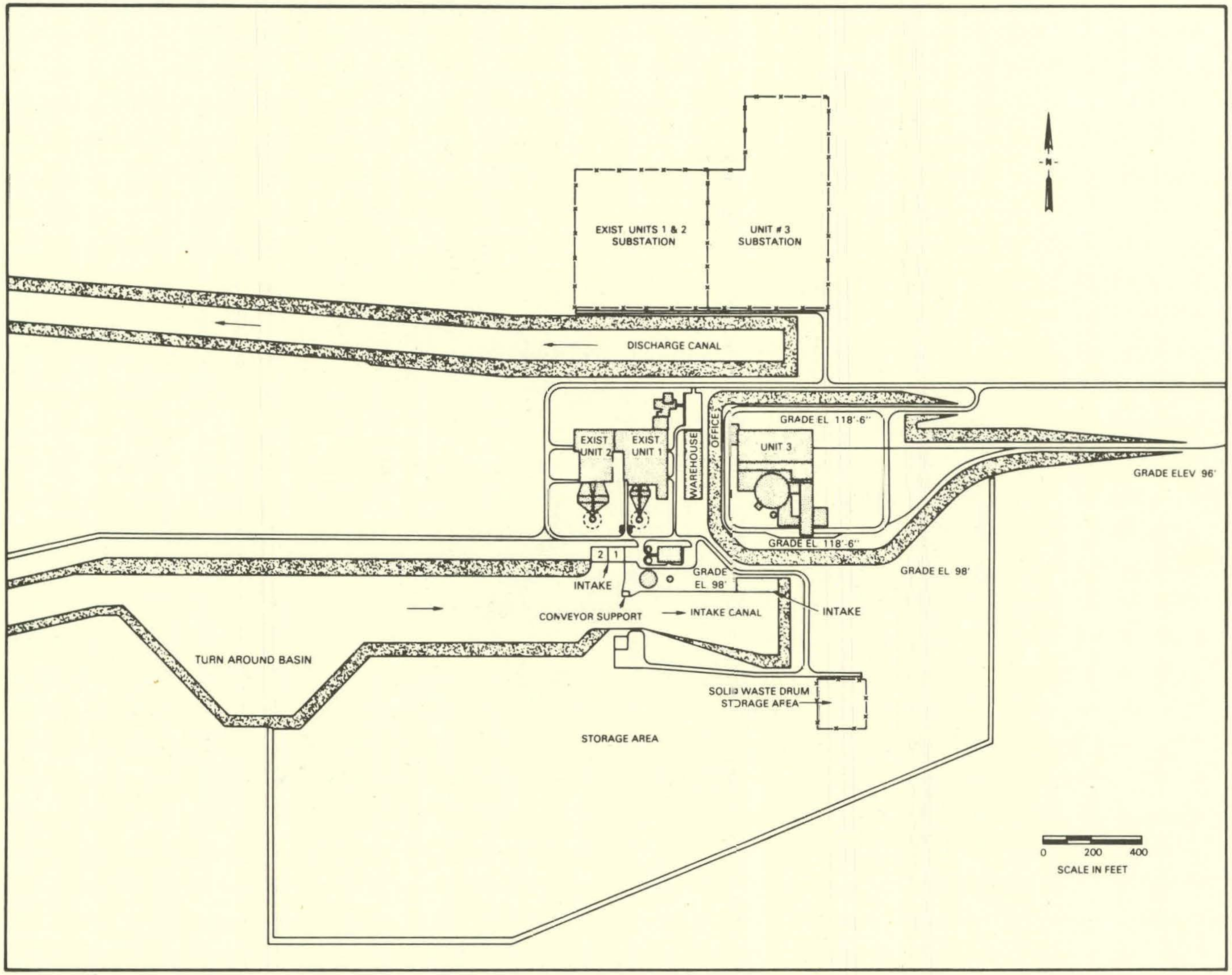


Fig. 2. Site Plan.

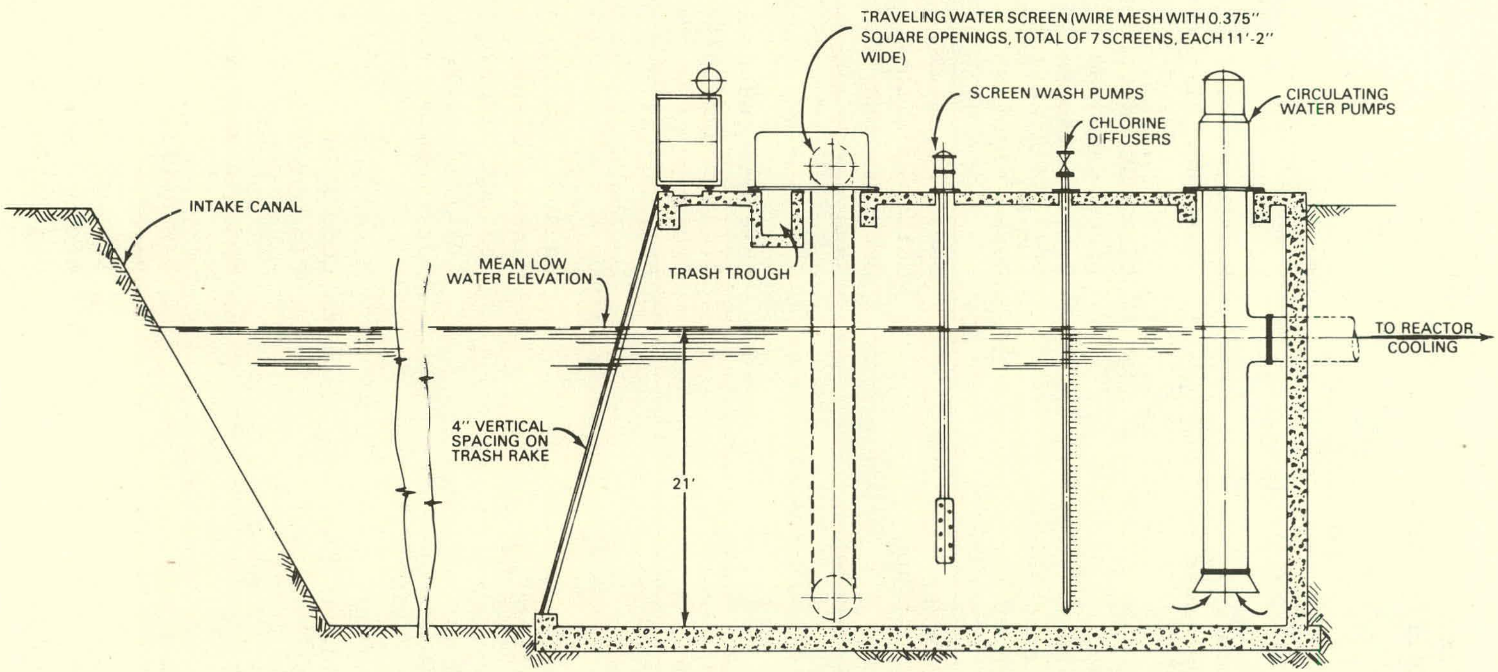


Fig. 3. Intake Structure.

Table I. Fishes Impinged on the Screens at Units 1 and 2

Blacktip shark	Halfbeak
Bonnethead	Atlantic needlefish
Atlantic stingray	Redfin needlefish
Smooth butterfly ray	Timucu
Ladyfish	Houndfish
Blackedge moray	Sheepshead minnow
Whip eel	Goldspotted killifish
Sailfin eel	Longnose killifish
Speckled worm eel	Rainwater killifish
Spotted spoon-nose eel	Tidewater silverside
Shrimp eel	Bluespotted cornetfish
Gulf menhaden	Lined seahorse
Scaled sardine	Dwarf seahorse
Atlantic thread herring	Fringed pipefish
Striped anchovy	Dusky pipefish
Bay anchovy	Chain pipefish
Inshore lizardfish	Gulf pipefish
Sea catfish	Southern sea bass
Gafftopsail catfish	Sand perch
Gulf toadfish	Gag
Midshipman	Whitespotted soapfish
Skilletfish	Bronze cardinalfish
Crevalle jack	Cobia
Atlantic bumper	Sharksucker
Leatherjacket	Southern stargazer
Lookdown	Banded blenny
Florida pompano	Florida blenny
Permit	Feather blenny
Red snapper	Frillfin goby
Gray snapper	Darter goby
Irish pompano	Naked goby
Spotfin mojarra	Code goby
Silver jenny	Clown goby
Mottled mojarra	Green goby
White grunt	Spanish mackerel
Bluestriped grunt	Harvestfish
Pigfish	Barbfish
Sheepshead	Leopard searobin
Grass porgy	Bighead searobin
Spottail pinfish	Ocellated flounder

Table I. Continued

Pinfish	Bay whiff
Silver perch	Fringed flounder
Sand seatrout	Gulf flounder
Spotted seatrout	Lined sole
Spot	Hogchoker
Southern kingfish	Blackcheek tonguefish
Atlantic croaker	Orange filefish
Red drum	Scrawled filefish
Atlantic spadefish	Fringed filefish
Slippery dick	Planehead filefish
Emerald parrotfish	Scrawled cowfish
Striped mullet	Southern puffer
White mullet	Bandtail puffer
Fantail mullet	Web burrfish
Northern sennet	Striped burrfish
Atlantic threadfin	
Polka-dot batfish	
Southern hake	
Bank cusk-eel	
Ballyhoo	

Table II. Summary of Fish Impingement Data at Units 1 and 2

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled: Polka-dot Batfish	Pinfish	Atlantic Threadfin
Unit 1				
1973	1	362	10	114
1974	3	4,621	346	0
Unit 2				
1972	5	17,218	100	0
1973	7	37,638	240	5,931,260
1974	2	9,476	1,190	0

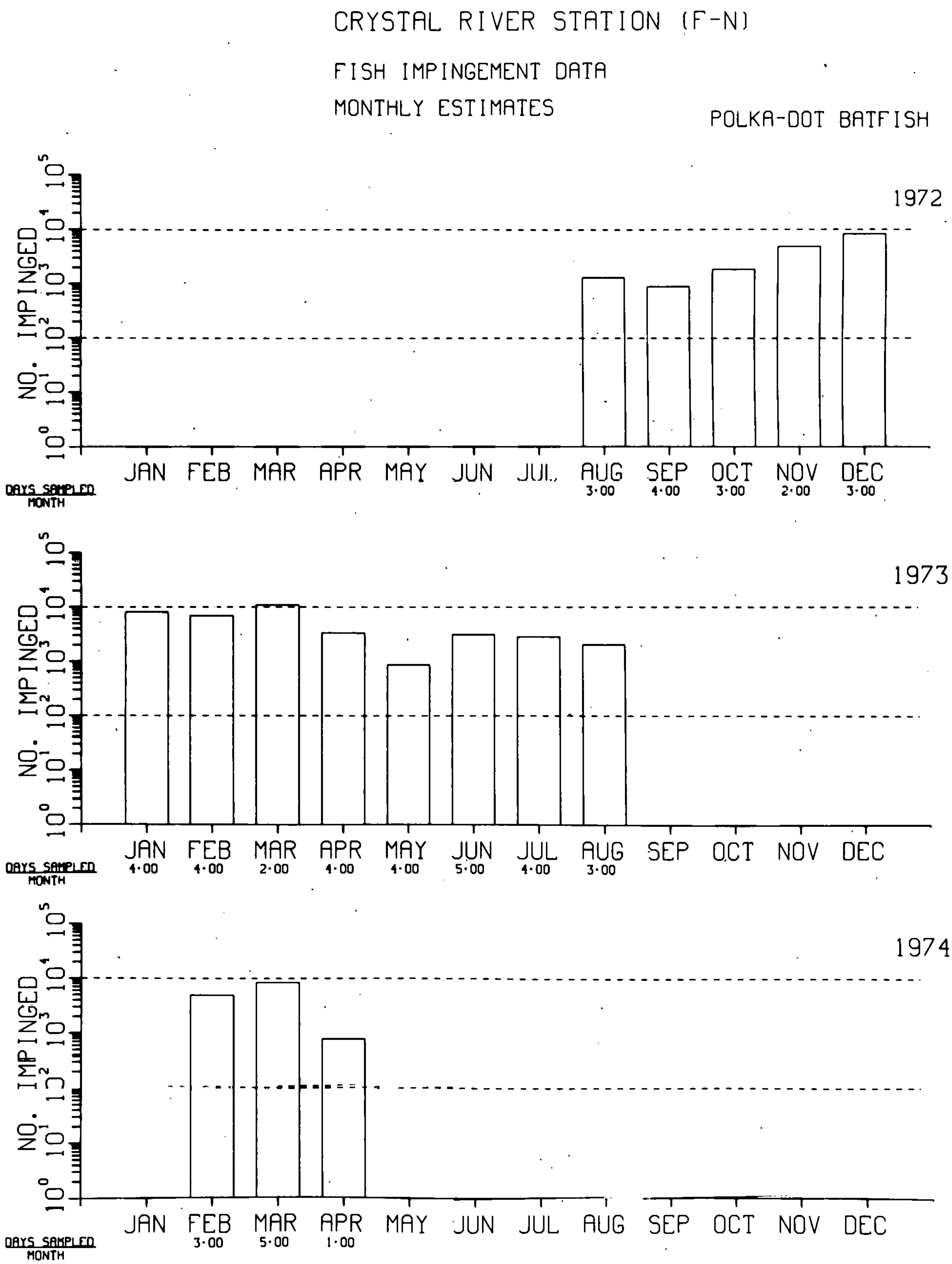


Fig. H1. Impingement Estimates.

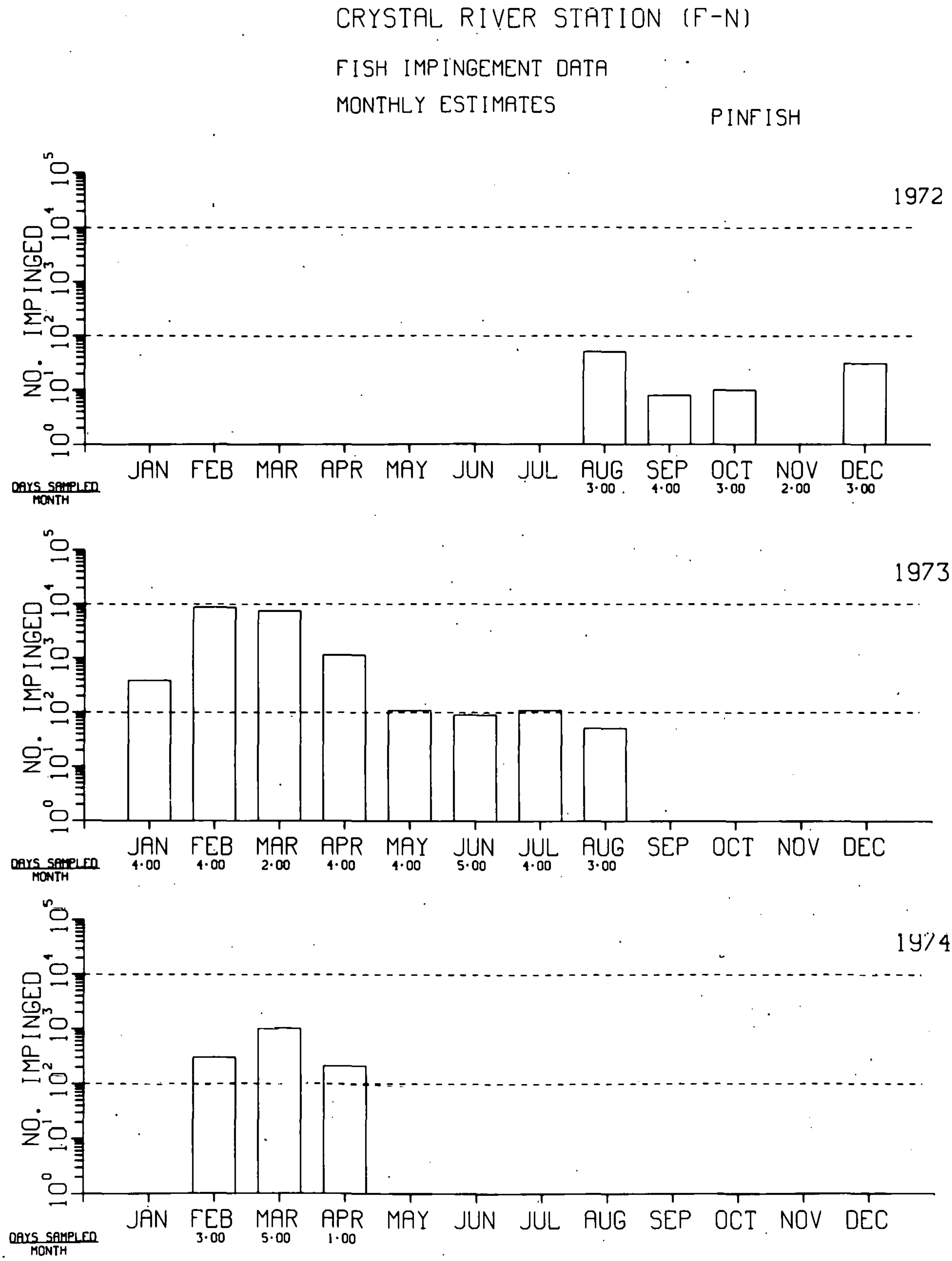


Fig. H2. Impingement Estimates.

CRYSTAL RIVER STATION (F-N)

FISH IMPINGEMENT DATA

MONTHLY ESTIMATES

ATLANTIC THREADFIN

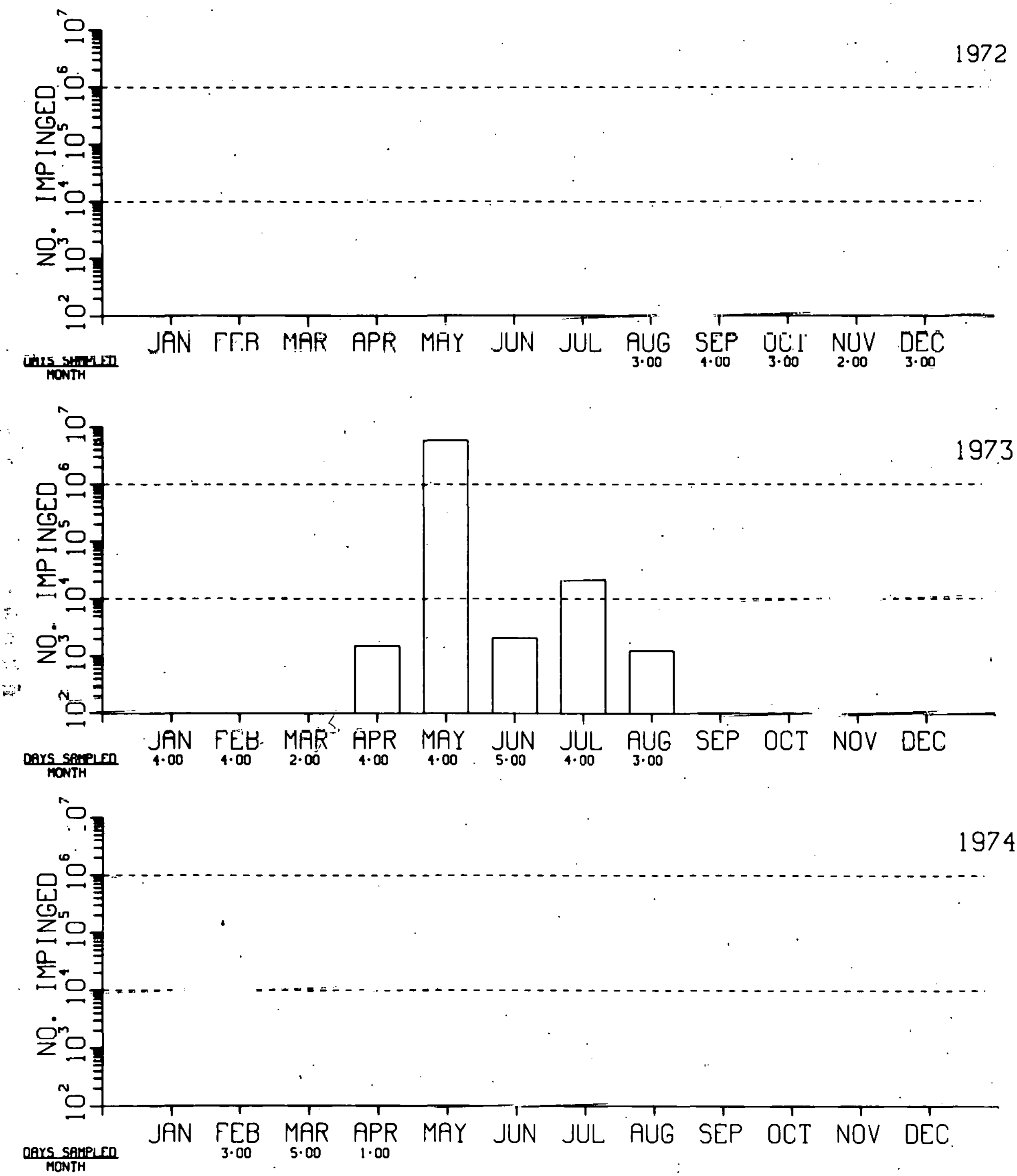


Fig. H3. Impingement Estimates.

WILLOW GLEN POWER STATION UNITS 1-5 (F)

SITE CHARACTERISTICS

The Willow Glen Station is located on the bank of the Mississippi River in St. Gabriel, Iberville County, Louisiana.[1] It draws water from and discharges water into the Mississippi River (Fig. 1). Twelve species of fish were found impinged on the intake screens during the year-long sampling period in 1975 (Table I). Only one marine species has been recorded at the site.

PLANT DESCRIPTION

Willow Glen is a five-unit gas-fired facility having a net generating capacity of 1586 MWe. The plant utilizes once-through cooling.

INTAKE DESIGN AND OPERATION

Units 1 and 2 have a common intake structure that consists of a steel frame with three-inch-square mesh. The water intake and trash rack are located in the river 532 feet from the levee. The intake structure is halfway between the mouth of the intake and the levee. Two nine-foot-diameter intake pipes supply four circulating-water pumps. There are two pumps per unit with traveling screens interposed. The screens are the link-belt type with 3/8-inch openings.

Unit 3 has a reinforced-concrete structure with coarse trash racks made up of 3/8-inch by 2-inch flat bars on 8-3/8-inch centers. A 12-foot-diameter pipe brings water to the structure, where there are four mixed-flow circulating-water pumps and four traveling screens similar to those for Units 1 and 2. Unit 4 is similar to Unit 3 except that there are only three pumps and the traveling screens are a different model.

Unit 5 is similar to Unit 4, with three pumps, bar racks with 8-3/8-inch spacing, and a 12-foot-diameter intake pipe. Two tunnels connect this intake to Unit 4, which is in turn connected to Units 1-3. In this way, if one or more intake structures fail because of bank erosion, the associated units can still remain in operation.

In all intakes, debris collected on the screens is washed from the baskets into the sluiceways by high-velocity sprays. The wash water and debris is returned to the river. Design rate of withdrawal at peak operating load is 811,200 gpm. No other information on intake operation or water velocities is available.

IMPINGEMENT SAMPLING

Sampling was begun in January 1975. Three five-minute samples of organisms were simultaneously washed off all the screens every three hours for a 24-hour period. This provided eight 15-minute samples over the period of one day. Species composition and weight were taken on all samples. Impinged organisms were placed in a holding tank and observed for 24 hours. Dual sets of tanks were maintained, and one set was filled with intake water and the other with discharge water. This design allowed assessment of mortality from all possible causes.

DATA AVAILABILITY

The sampling described above was carried out one day per month during 1975 with the following exceptions: there was no sampling in February, and the sampling was carried out two days per month during May, September, October, and November.

IMPINGEMENT DATA SUMMARY

Sampling took place for about 8% of one 24-hour period per month except during the four months mentioned above. The estimated numbers are derived by extrapolation to 24 hours and then to a month. The three most numerous species impinged were the freshwater drum, blue catfish, and gizzard shad. Table II presents a summary of the impingement totals for 1975. Monthly summaries are presented in Figures H1 and H2.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

None are reported being implemented, pending analysis of the sampling program.

REFERENCE

1. Personal communication with S. L. Adams of Gulf States Utilities Company. 26 March 1976.

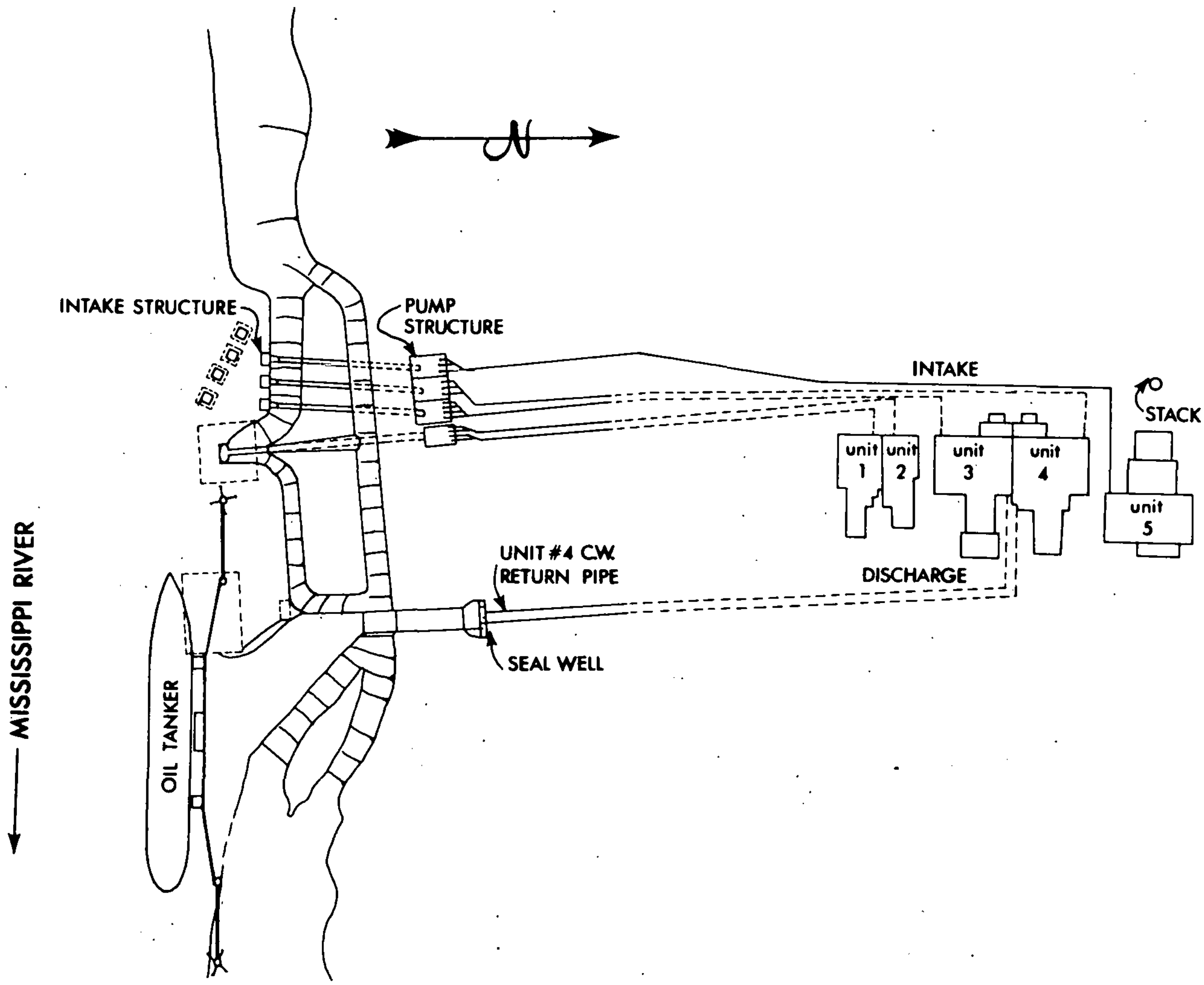


Fig. 1. Plot Plan.

Table I. Fishes Impinged on the Intake Screens at the Station

Skipjack herring	Blue catfish
Freshwater drum	Yellow bullhead
River carpsucker	Channel catfish
Gizzard shad	Bluegill
Threadfin shad	Yellow bass
	Paddlefish
	White crappie

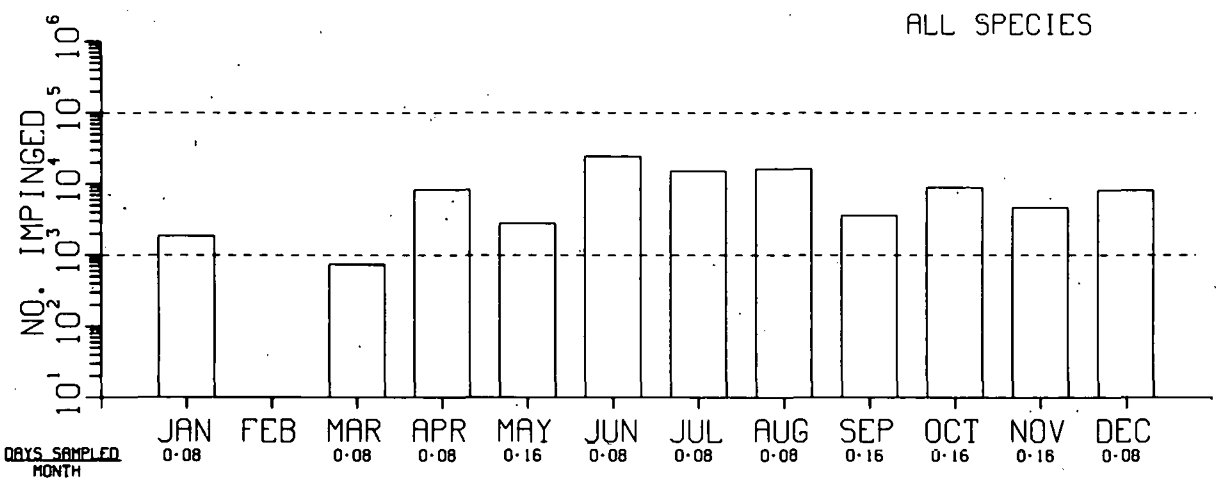
Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled: Gizzard Shad	Blue Catfish	Freshwater Drum	Total
1975	11	21,012	10,698	33,504	95,238

WILLOW GLEN STATION UNITS 1 - 5 (F)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



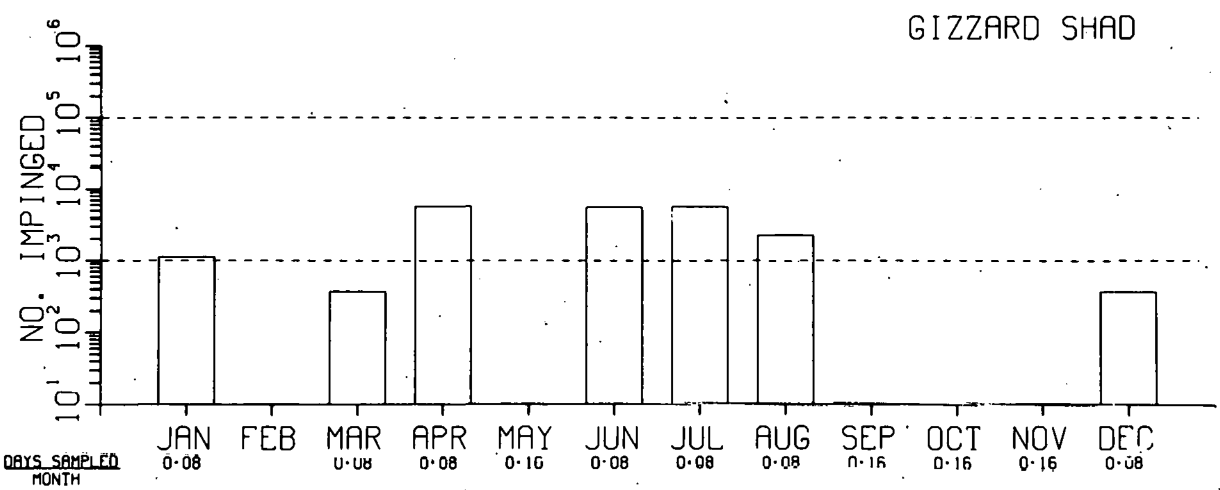
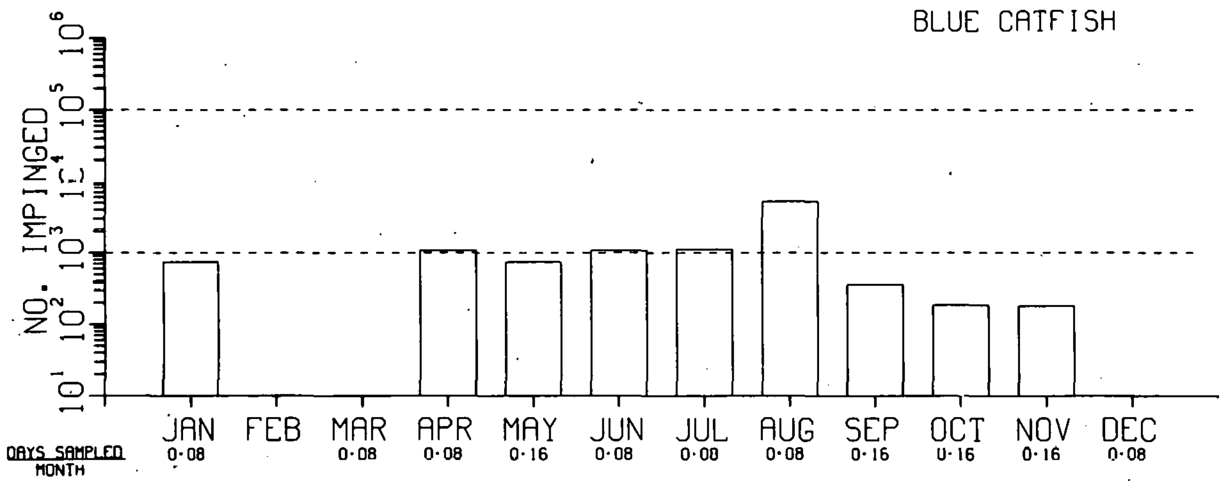


Fig. H1. Impingement Estimates.

WILLOW GLEN STATION UNITS 1 - 5 (F)

FISH IMPINGEMENT DATA 1975

MONTHLY ESTIMATES



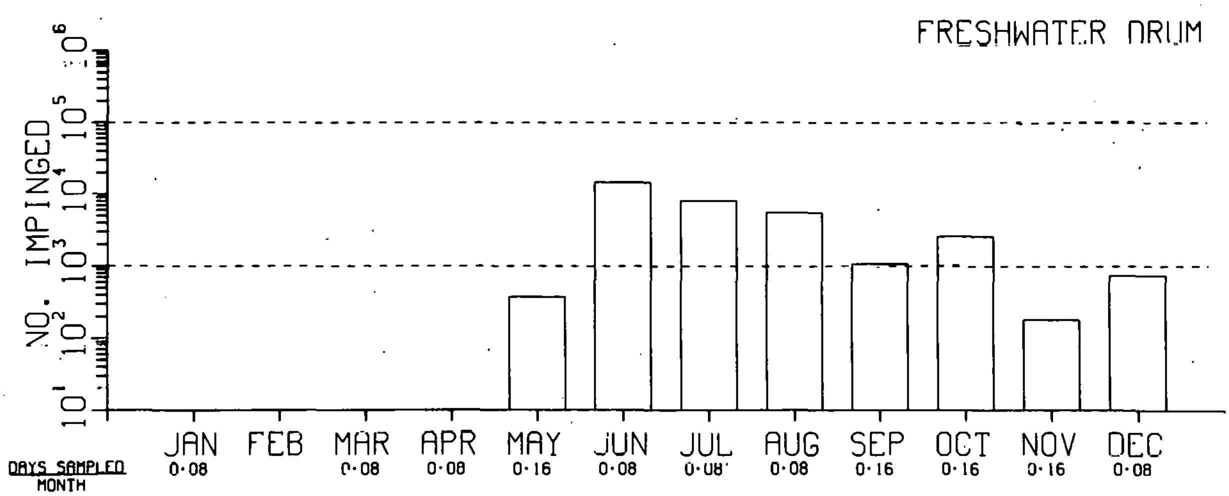


Fig. H2. Impingement Estimates.

CEDAR BAYOU GENERATING STATION UNITS 1-3 (F)

SITE CHARACTERISTICS

The Cedar Bayou Generating Station is located in Houston, Texas, and is operated by the Houston Lighting and Power Company.[1] The Cedar Bayou is a meandering tidal stream flowing into the northern end of Galveston Bay, Texas (Fig. 1). The original channel has been widened to 115 feet and dredged to a depth of 20 feet. The area immediately in front of the intake is somewhat deeper, measuring 25.5 feet after Unit 3 was installed. No water-quality parameters were included in the report.[1]

Ninety-five species were impinged on the intake screens of Units 1-3 (Table I). This diverse fauna is typical of the estuarine location of the plant site.

PLANT DESCRIPTION

Cedar Bayou Station is a natural-gas- and oil-fired facility with three units having a total net capacity of 2250 MWe. The station employs once-through cooling.

INTAKE DESIGN AND OPERATION

All intake structures are located inside a recessed bay and protected by a wooden boat barrier that extends about four feet under the water surface (Fig. 2). Units 1 and 2 have a common intake structure consisting of six identical forebays. The trash racks are set several feet back from the shoreline. Each forebay provides for a single circulating-water pump rated at 112,500 gpm, for a combined capacity of 675,000 gpm. The trash racks consist of slanted vertical bars on 4.0-inch centers. Four beams across the intake bay separate the trash racks from the vertical traveling screens (Fig. 3). Mesh openings are 0.375 inch. There are six screens for the two units.

Unit 3 intake also consists of six forebays, but there are major design differences (Fig. 4). The trash racks have been moved out into the channel so the traveling screens could be moved to within 4.5 feet of the shoreline. The endwalls between the bays are open. Each basket of the vertical traveling screen has an auxiliary lower retaining lip and a plain 6.25-inch center retaining lip (Fig. 5). A screen basket for the intake of Units 1 and 2 is shown in Figure 5 for comparison. Each pair of bays provides for a single circulating-water pump rated at 112,500 gpm, for a combined pumping capacity of 337,500 gpm. Therefore, the total station pumping capacity is 1,012,500 gpm.

Average water velocities at each of the three intake bays for Unit 1 are 0.78, 0.83, and 0.76 fps, and at those for Unit 2 are 0.73, 0.73, and 0.46 fps. Velocities at the Unit 3 structure are expected to be 50% less due to twice the intake area and half the pump capacity. Velocities at the traveling screens should be 20% greater than at the screens for Units 1 and 2, but not exceeding 1.5 fps, due to an equivalent reduction in area of the approach bay.

General operating procedures include rotating the screens once every eight hours for 15 minutes or whenever a four-inch differential develops. Screens are operated normally at low speed. When water temperatures are low (in winter), one circulating-water pump in each unit may be shut down.

IMPINGEMENT SAMPLING

Screen collections are made biweekly at eight-hour intervals for a 24-hour period. This results in a total of four samples in each collection. In addition, every three months, the intake screens are monitored at two-hour intervals for a 24-hour period. This procedure yields 13 samples per quarter. Before collection of samples, the screens are washed for 20 minutes. After stopping for 10 minutes to let organisms collect on the screens, they are again run for 20 minutes (this is considered a 30-minute sample for purposes of this survey) and samples are then collected and sorted. Subsampling of one-twelfth of the total catch was done when very large numbers of organisms were impinged.

DATA AVAILABILITY

Data are available from 11 April 1973 to 24 September 1975 for Units 1 and 2. Data for Unit 3 are available from 28 January to 24 September 1975.

IMPINGEMENT DATA SUMMARY

An impingement data summary for the Cedar Bayou Station is presented in Table II. The estimated magnitude of impingement was confirmed by the utility.[2] The three most numerous species were determined to be the gulf menhaden, Atlantic croaker, and spot. However, this may not be the case for all years and seasons. Survival after impingement varied widely, with soft fishes like the menhaden and anchovy suffering 80% to 90% mortality, and hardier fishes such as the croaker and spot having 80% survival. Intake velocities seldom exceed 1.0 fps at the intake, and the following explanation was offered by the utility to account for the high mortality: most of the impinged specimens are young, using the estuary as a nursery; periodic high rainfalls in the area cause large amounts of runoff and the narrow channel of the bayou cannot receive all of the fresh water without resulting in salinity shock to the young fish, especially gulf menhaden; the fish become disoriented and are impinged, and usually killed.[2]

Histograms of monthly impingement estimates are shown in Figures H1 through H6. Inasmuch as the sampling time never exceeded one day per month, extrapolation to monthly estimates is subject to a degree of error associated with interpretation of results using small sample sizes.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

All three units have low intake velocities, never exceeding 1.0 fps in the intake forebays and 1.5 fps at the screens. No special impingement-minimization features are present in the intake for Units 1 and 2, but the Unit 3 intake has major design changes that have resulted in a significant decrease in the rate of impingement for the first seven months of 1975. Trash racks have been moved forward into the channel and the screens moved to within 4.5 feet of the shoreline to allow a full tidal swing across their faces, walls between the bays have openings to allow for the free passage of fish, and each traveling-screen section has a modified trough to more gently lift impinged fish for washing into the sluiceway.

REFERENCES

1. "Cedar Bayou Intake Design and Impingement Study Data." Houston Lighting and Power Company. 24 February 1976.

2. Personal communication with Frank G. Schlicht of Houston Lighting and Power Company. 5 May 1976.

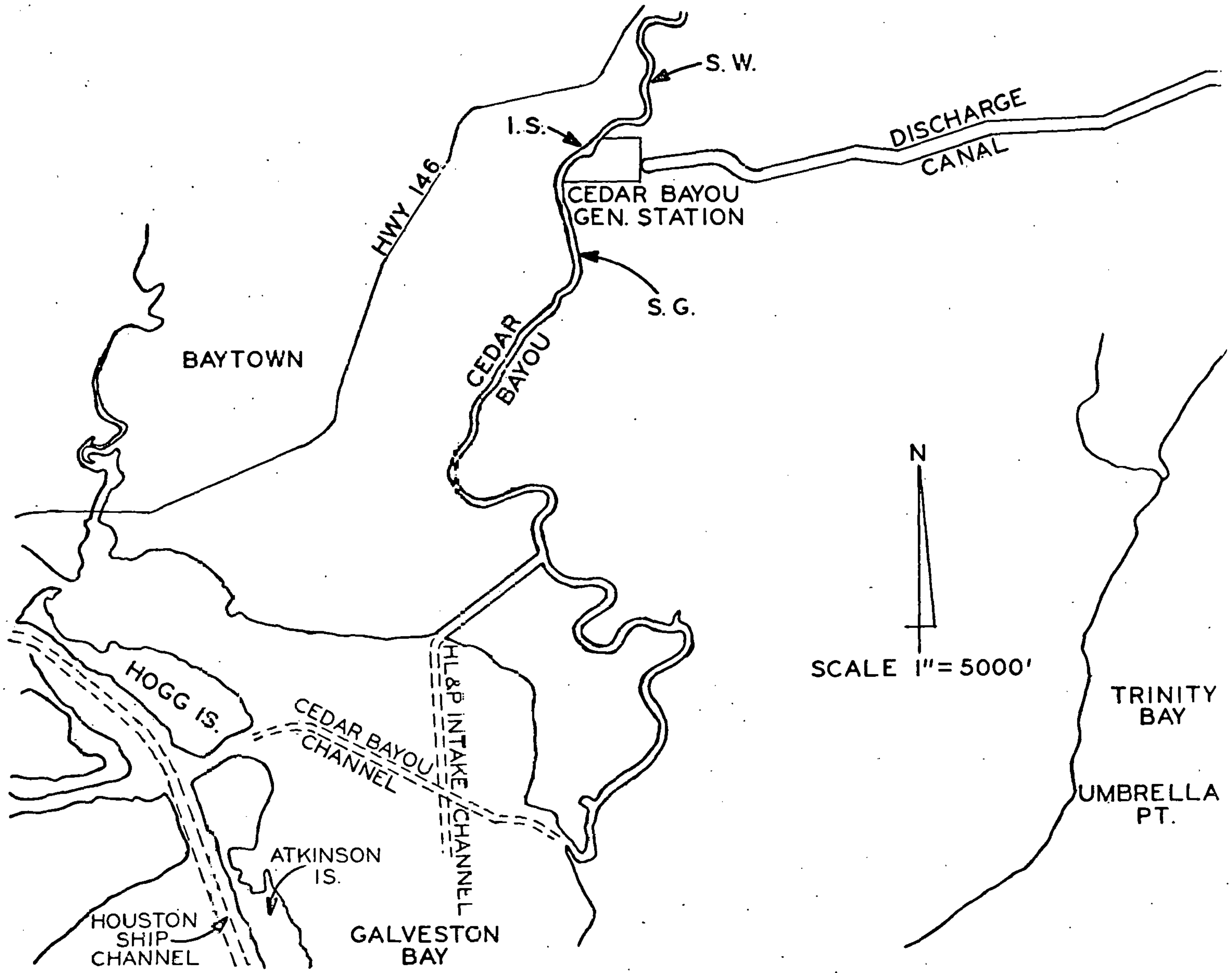


Fig. 1. Station Location.

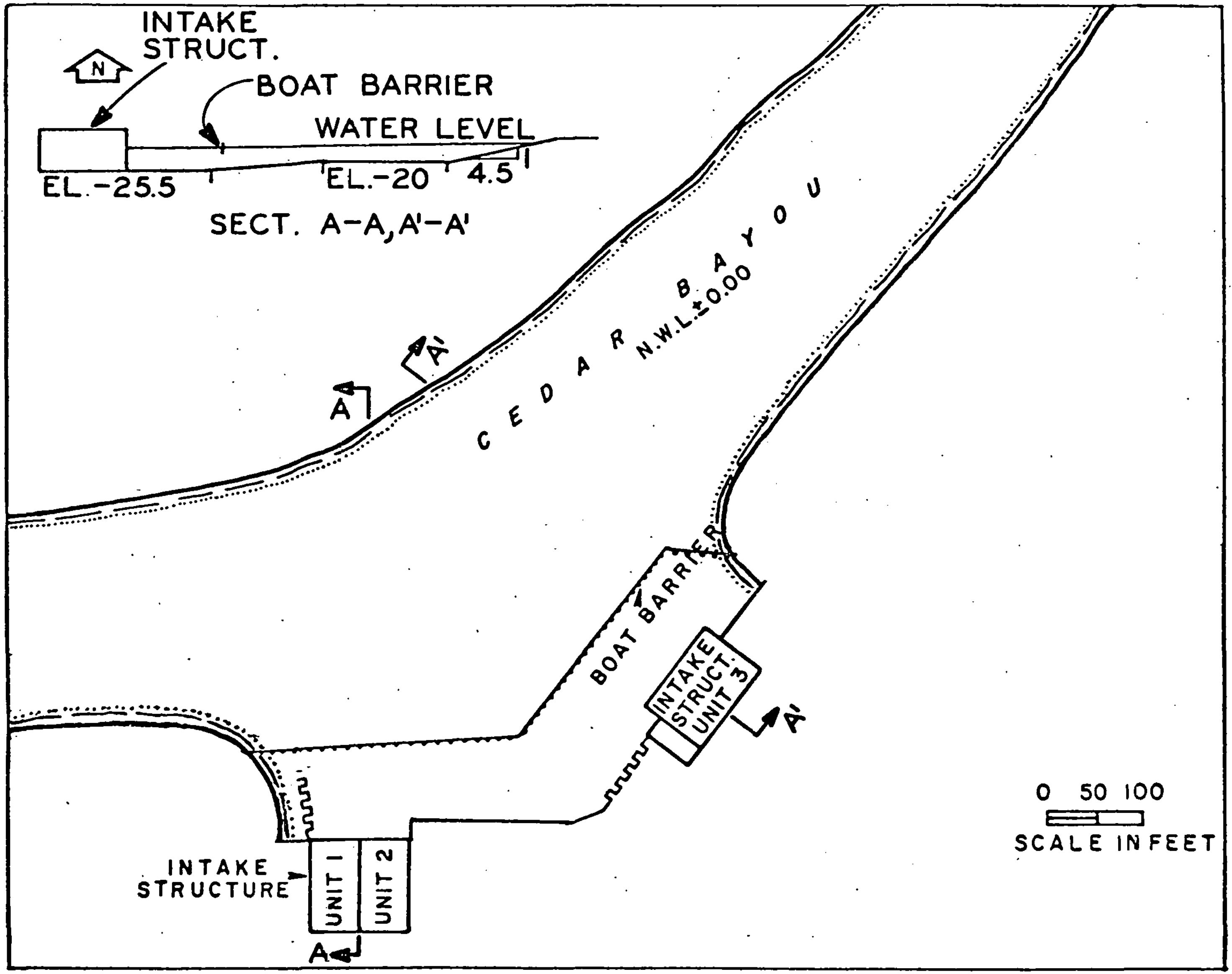


Fig. 2. Intake Locations

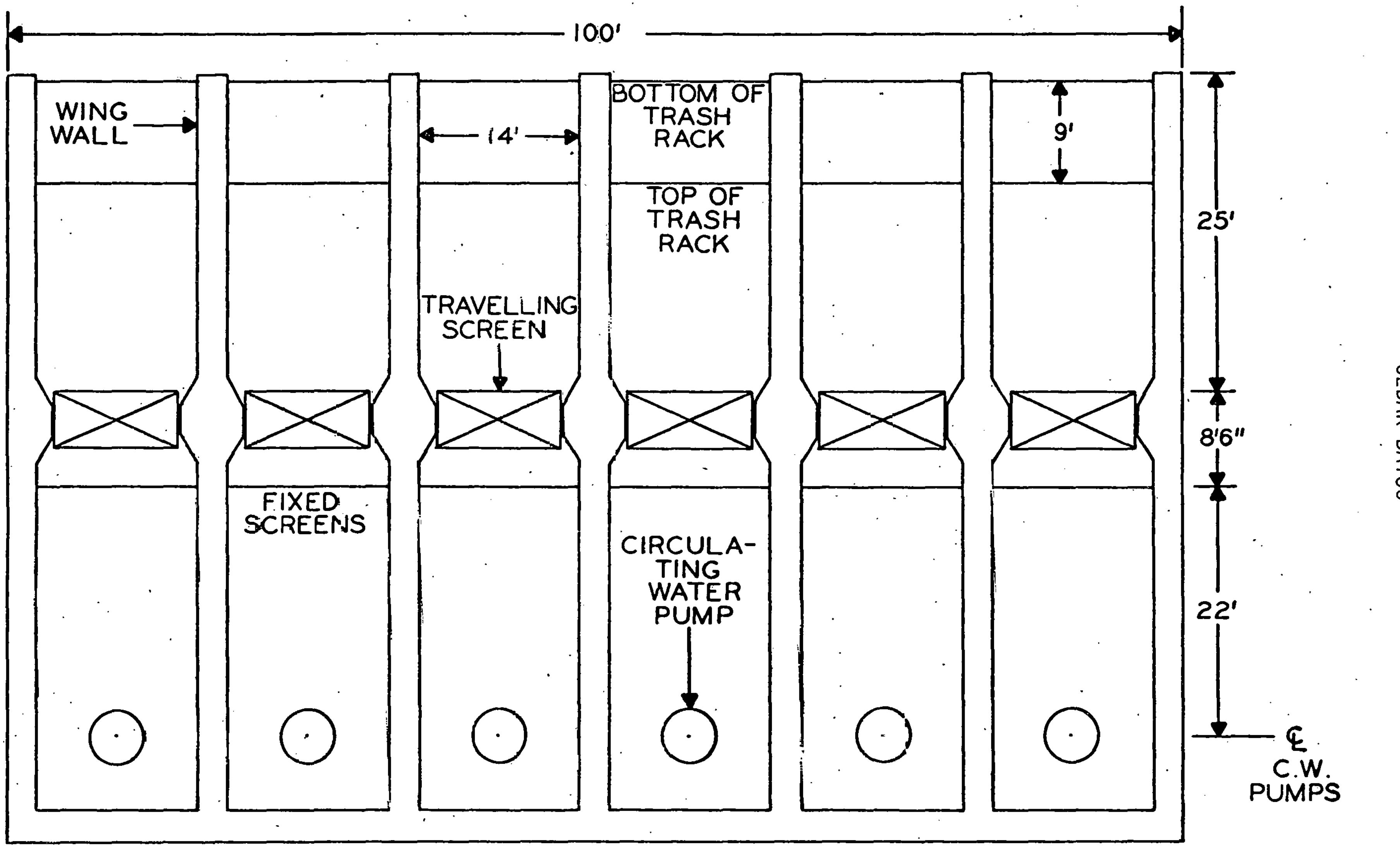


Fig. 3. Intake Structure for Units 1 and 2, Plan View.

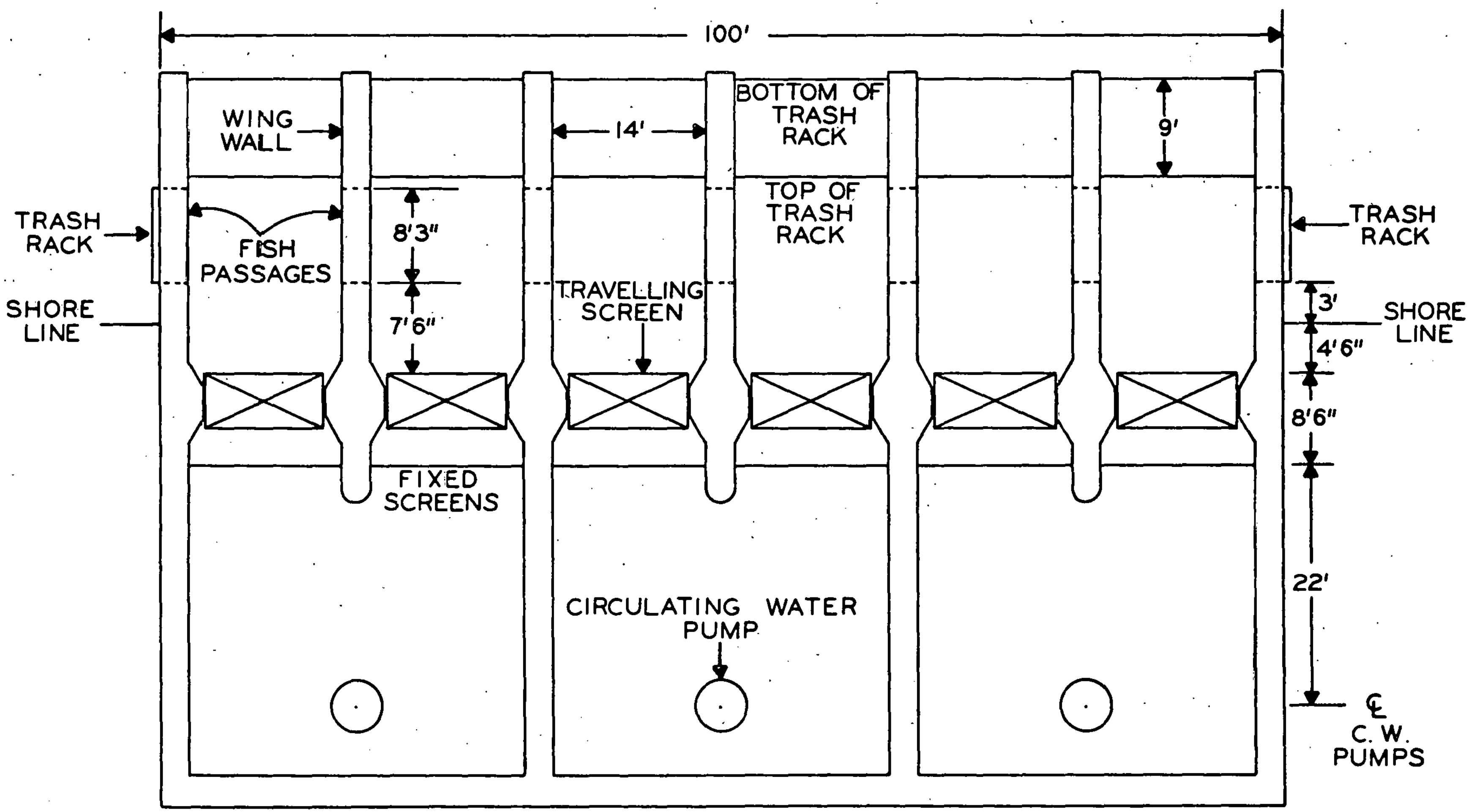


Fig. 4. Intake Structure for Unit 3, Plan View.

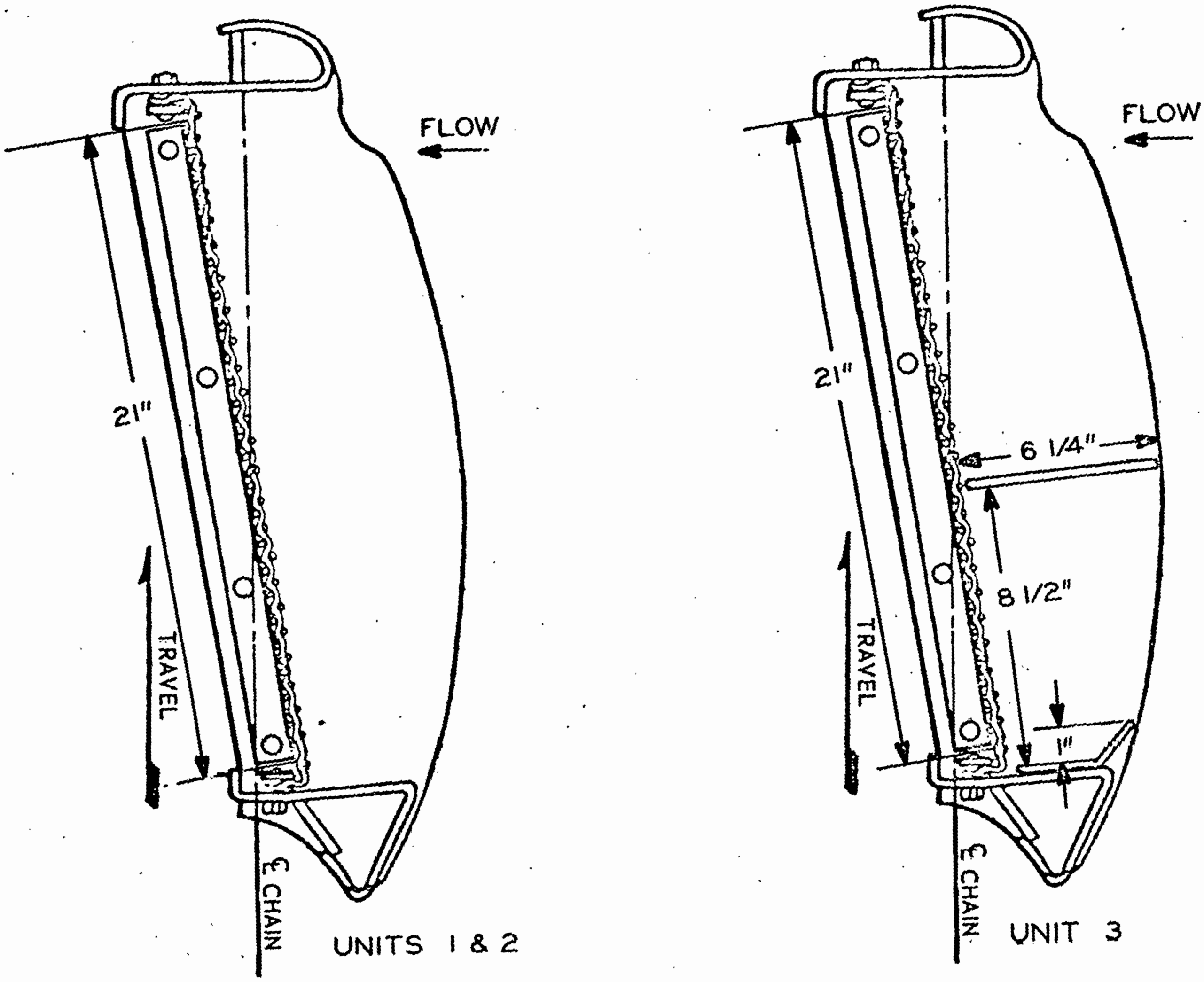


Fig. 5. Traveling-Screen Baskets.

Table I. Fishes Impinged at the Station

Lined sole	Bluegill
Striped anchovy	Spotted sunfish
Bay anchovy	Bantam sunfish
Pirate perch	Tripletail
Freshwater drum	Rough silverside
Sheepshead	Tidewater silverside
Sea catfish	Southern kingfish
Southern stargazer	Green goby
Gafftopsail catfish	Atlantic croaker
Silver perch	Largemouth bass
Gulf menhaden	White bass
Crevalle jack	Yellow bass
Horse-eye jack	Striped mullet
Atlantic spadefish	White mullet
Striped burrfish	Speckled worm eel
Atlantic bumper	Golden shiner
Bay whiff	Red shiner
Sand seatrout	Leatherjacket
Spotted seatrout	Shrimp eel
Silver seatrout	Southern flounder
Sheepshead minnow	Harvestfish
Carp	Gulf butterfish
Atlantic stingray	Sailfin molly
Fat sleeper	Black drum
Gizzard shad	Atlantic threadfin
Threadfin shad	Bluefish
Spinycheek sleeper	White crappie
Ladyfish	Black crappie
Fringed flounder	Atlantic midshipman
Spotfin mojarra	Bluespotted searobin
Mottled mojarra	Bighead searobin
Gulf killifish	Red drum
Bayou killifish	Spanish mackerel
Longnose killifish	Lookdown
Mosquitofish	Least puffer
Skilletfish	Star drum
Violet goby	Atlantic needlefish
Darter goby	Blackcheek tonguefish
Sharptail goby	Dusky pipefish
Naked goby	Chain pipefish

Table I. Continued

Bluntnose jack	Inshore lizardfish
Blue catfish	Atlantic cutlassfish
Black bullhead	Hogchoker
Yellow bullhead	Southern hake
Channel catfish	Atlantic moonfish
Pinfish	
Spot	
Shortnose gar	
Green sunfish	
Warmouth	

Table II. Summary of Fish Impingement Data

Year	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled: Gulf Menhaden	Atlantic Croaker	Spot	Total[a]
Units 1 & 2					
1973	9	88,032,217	9,459,770	1,866,668	91,791,599
1974	12	148,645,665	1,495,082	47,033	144,260,765
1975	7	30,524,721	3,356,563	955,442	38,567,189
Unit 3					
1975	7	6,617,251	2,329,538	47,801	11,982,743

[a] Fish totals are multiplied by a correction factor of 0.85 to eliminate the invertebrate portion of the sample. This is a liberal correction factor, and probably results in slightly lower total fish numbers than would otherwise be the case. As a result of this correction, the total of fish sampled in 1974 at Units 1 and 2 is lower than the number of gulf menhaden taken during that same year.

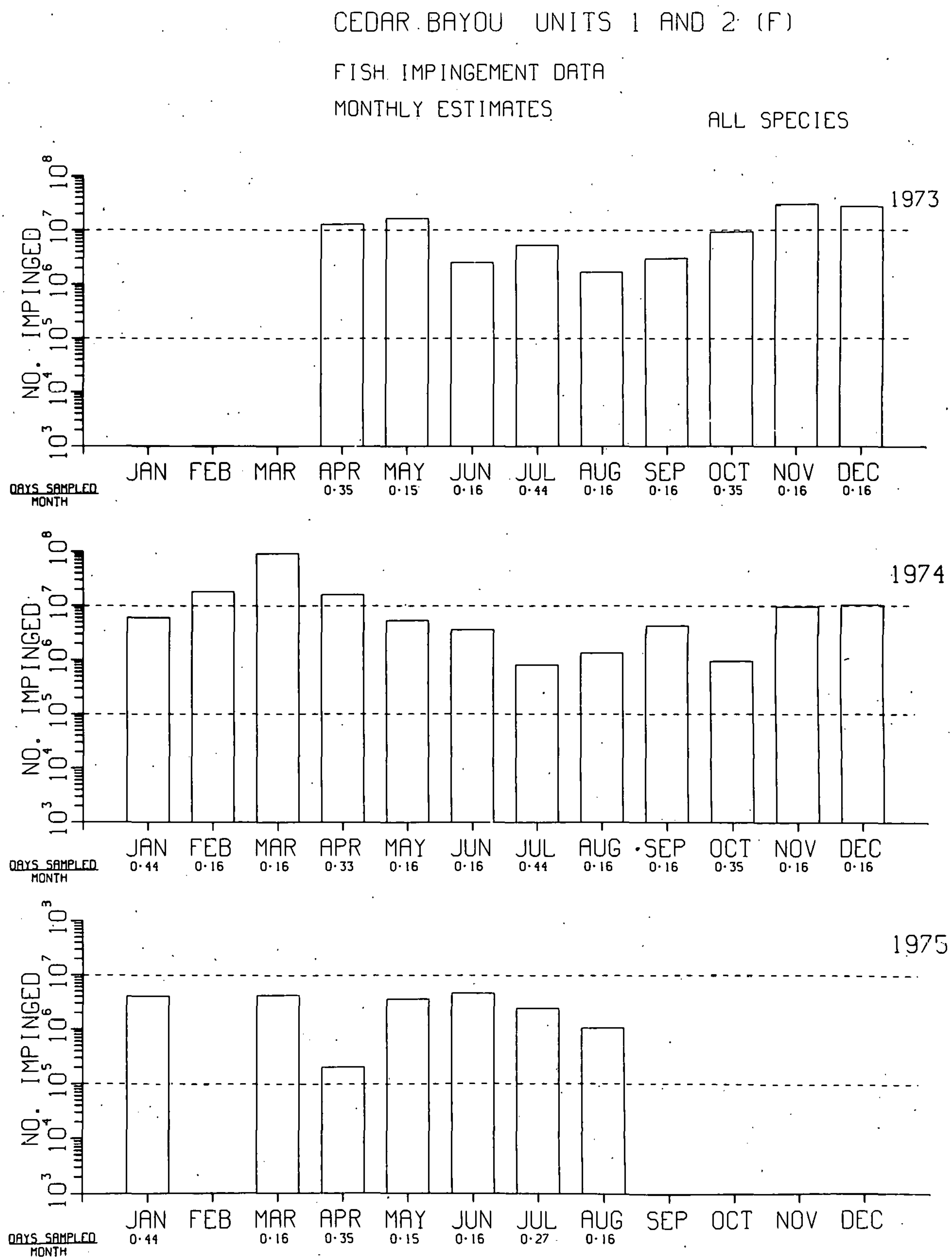


Fig. H1. Impingement Estimates.

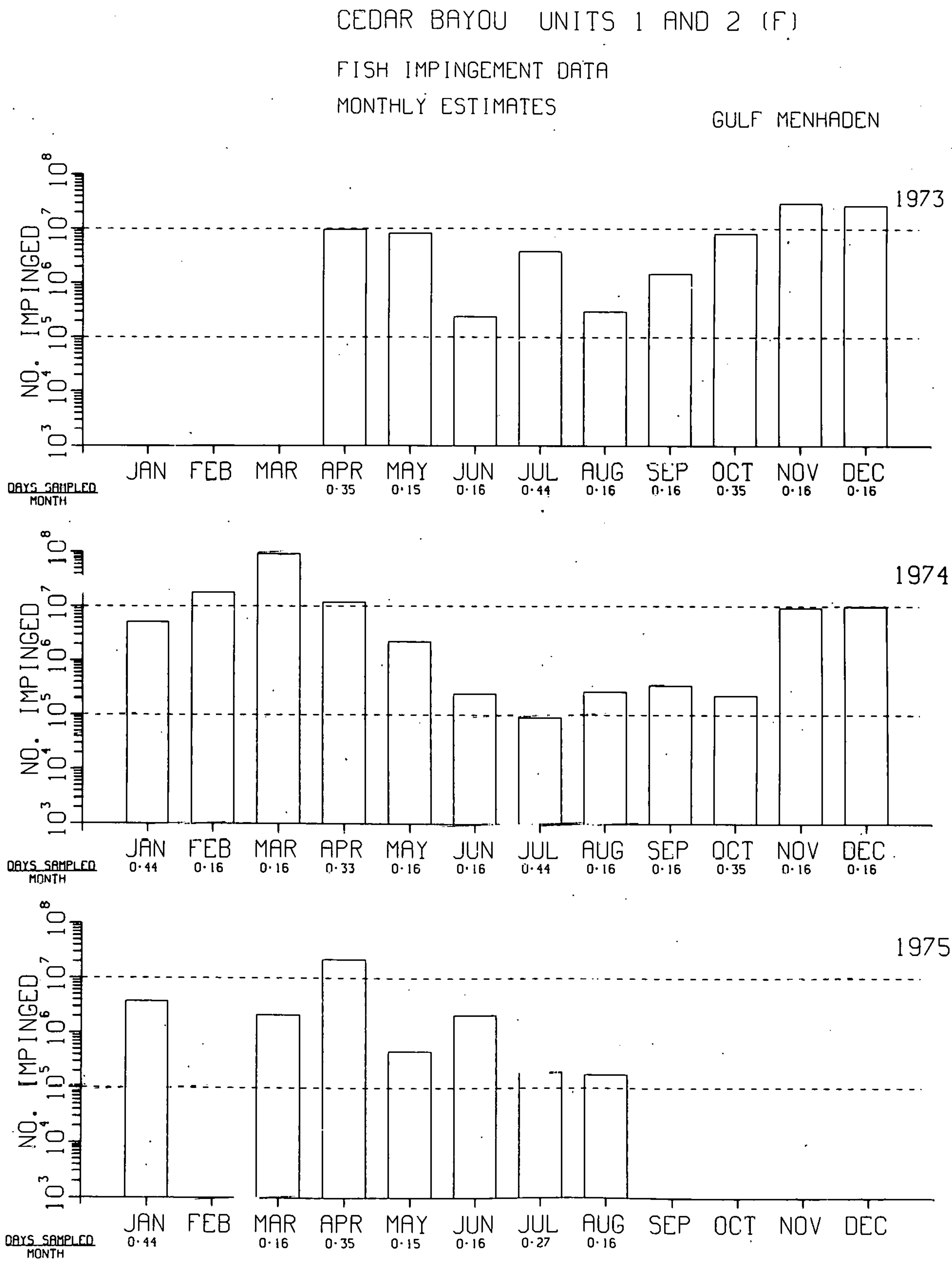


Fig. H2. Impingement Estimates.

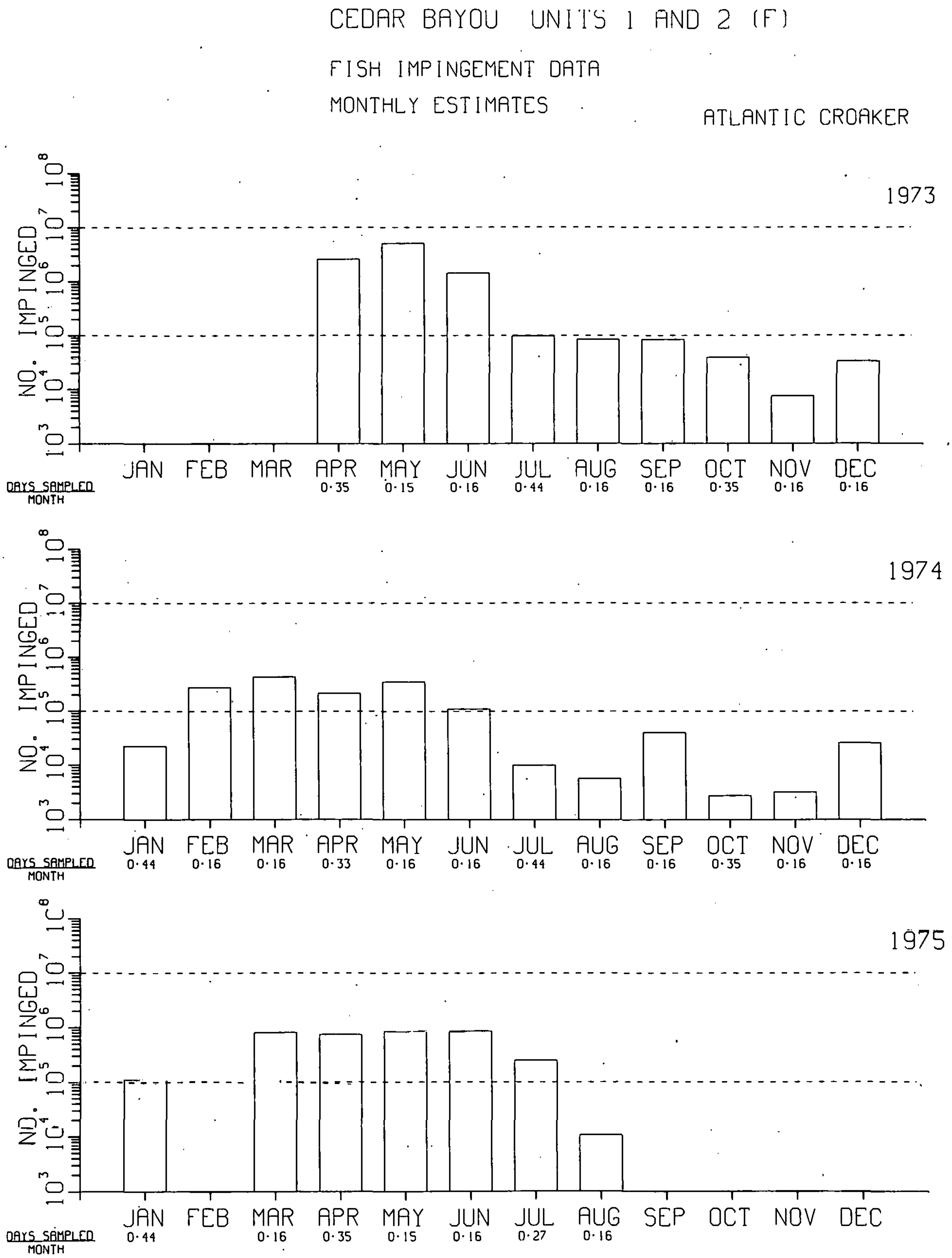


Fig. H3. Impingement Estimates.

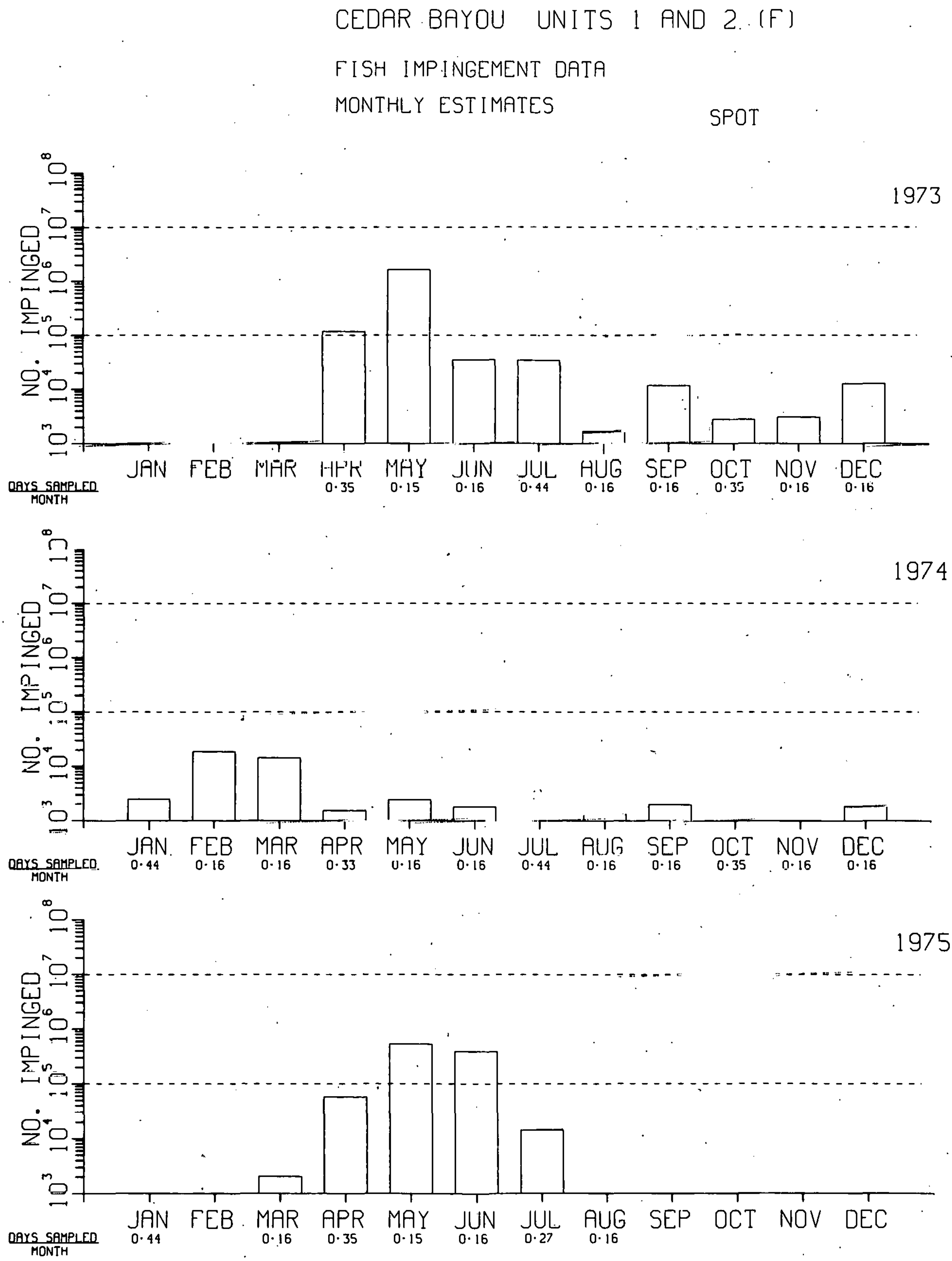


Fig. H4. Impingement Estimates.

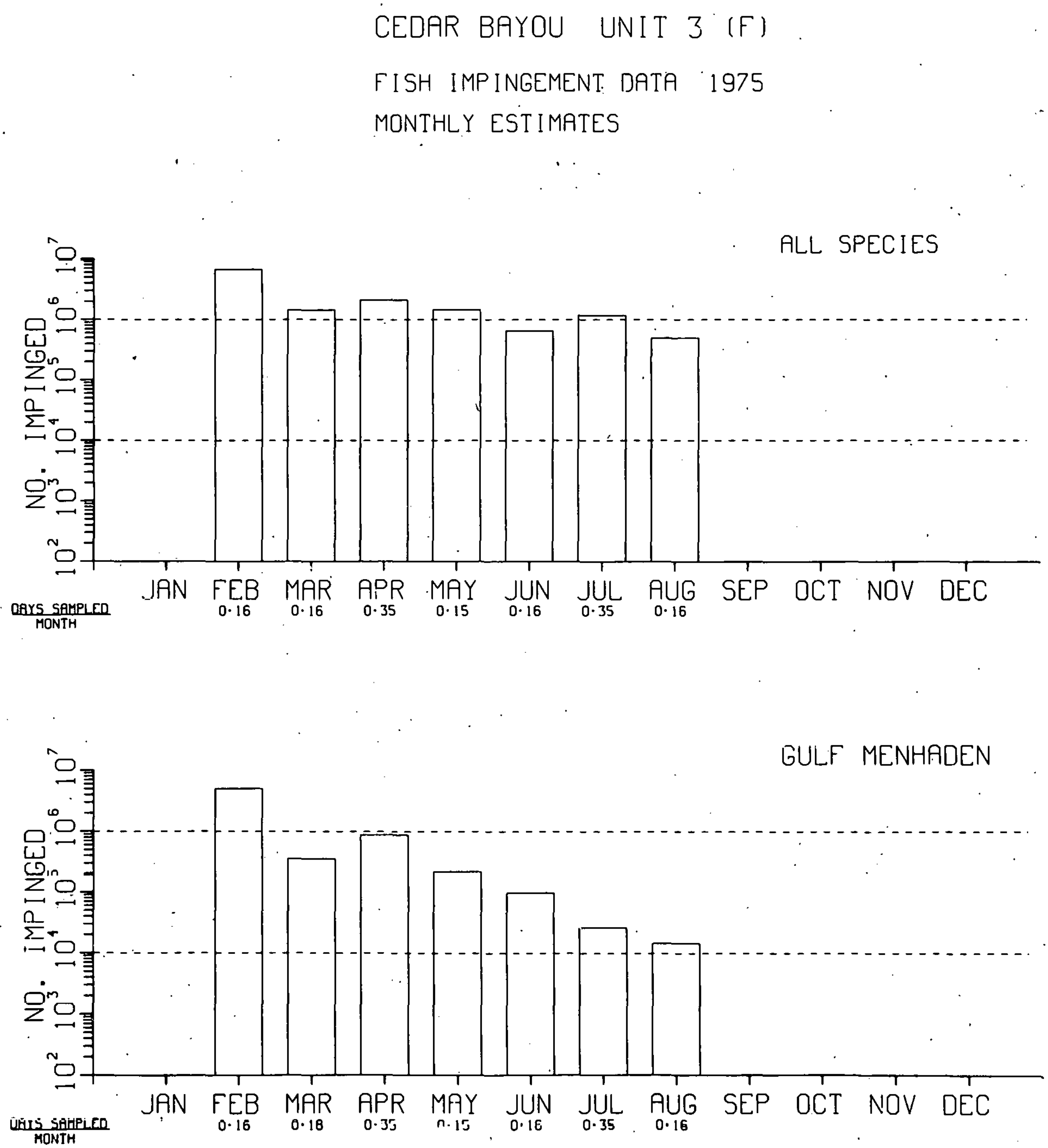


Fig. H5. Impingement Estimates.

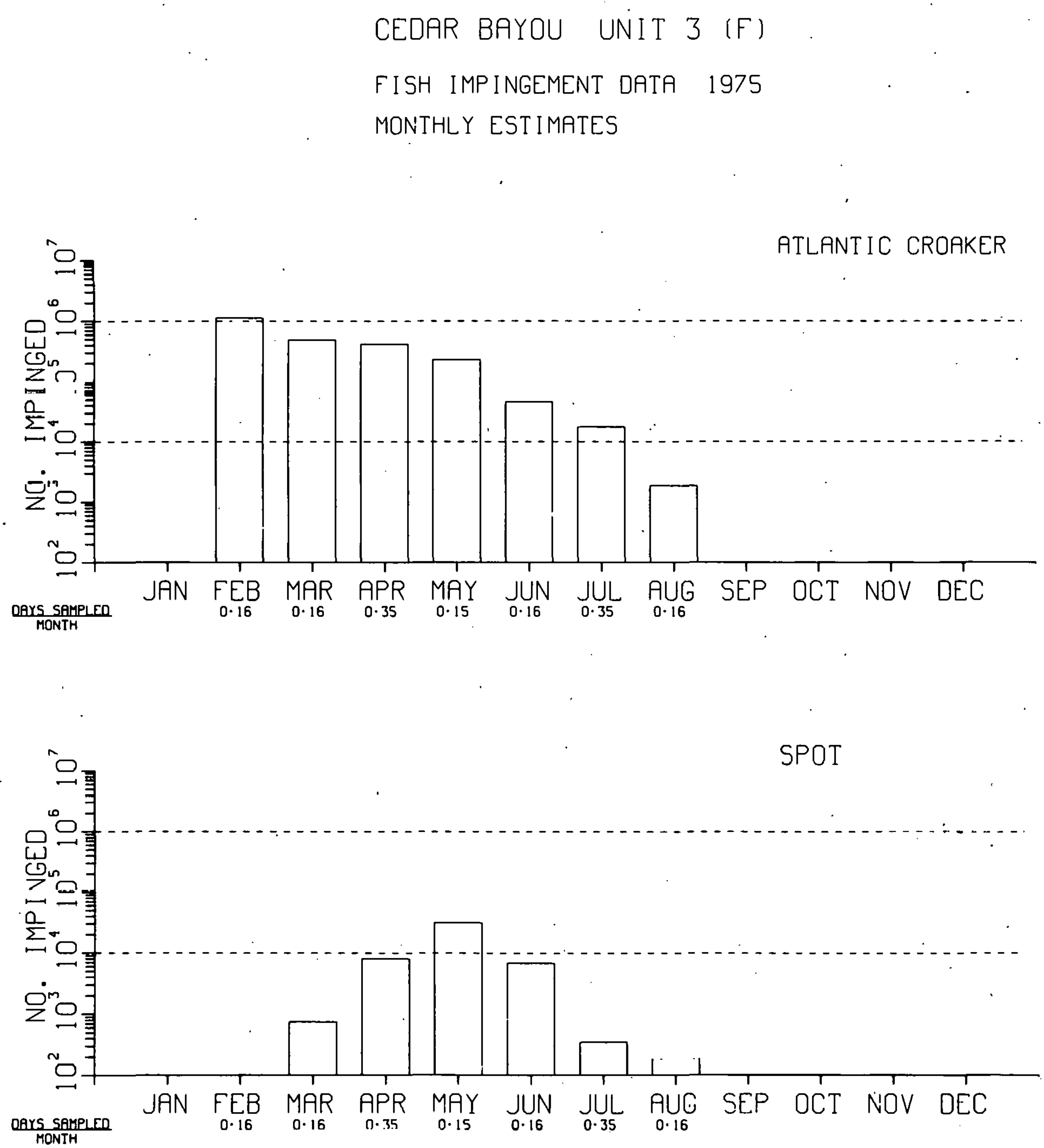


Fig. H6. Impingement Estimates.

BARNEY M. DAVIS POWER STATION (F)

SITE CHARACTERISTICS

The Barney M. Davis Power Station is owned and operated by the Central Power and Light Company and is located near Corpus Christi, Texas. It utilizes cooling water from the upper Laguna Madre, which is a mesohaline, hypersaline estuary.[1] This body of water is a coastal salt marsh, contiguous with the Texas intercoastal waterway. It is uniformly shallow with a depth averaging 4.0 feet. Salinity is high, typically ranging from 35 to 50 ppt, with extremes of 22 to 70 ppt occurring during heavy rains and drought. The area is covered by broad expanses of emergent sea grass. Water temperature reaches a high between 85°F and 88°F in the summer. In 13 months of sampling, 43 species of fish were collected on the screens (Table I).

PLANT DESCRIPTION

The station consists of two units that supply 650 MWe to the East Texas grid. Unit 1 is gas-fired with auxiliary oil-fired capacity. Unit 2 is an oil-fired facility. Both units employ once-through cooling. An aerial view of the station is shown in Figure 1.

INTAKE DESIGN AND OPERATION

Cooling water is drawn into the plant via a 3500-foot intake canal. A log boom at the mouth of the canal prevents floating debris from entering it. At the intake, 0.5-inch bar racks on 3.5-inch centers screen large debris from the inflowing water. Four Passavant traveling screens filter the incoming water (Fig. 2). This is the only installation in the United States that uses Passavant screens. In this system, water flows into the center of the rotating-band screen and is drawn "inside out" through the screen panels. The mesh in each panel is 0.5-mm polyester and nylon, and each rotating-band screen contains 53 such panels (Fig. 2). Each unit employs two circulating-water pumps rated at 80,000 gpm each.[2] The total flow, including service water, is 340,000 gpm for both units.[2] The screens and pumps are operated 24 hours a day at full capacity. Water velocities reach 0.75 fps at the outermost bar racks and 1.7 fps through the screens when they are completely clean. However, velocity at the screens increases to 3.1 fps when they are only partially clean. Because of consistent heavy loading of the screens by sea grasses, the high figure is perhaps more realistic.

IMPINGEMENT SAMPLING

Samples are usually taken twice a month, but may be taken four times during certain months. During a 24-hour sample period, two five-minute samples are taken six hours apart, yielding two daytime samples and two nighttime samples. Thus, total sampling time during each 24-hour period is 20 minutes. All fish collected from the screens are counted and identified to species.

DATA AVAILABILITY

Data are available for May 1975 to May 1976. However, totals are given only for the entire 13 months because estimates by month or sample period were not made available.

IMPINGEMENT DATA SUMMARY

Data obtained are extrapolated to continuous sampling over the entire 13 months of the study. The three most numerous species impinged were the gulf menhaden, bay anchovy, and tidewater silverside. These data are presented in Table II.

These figures may have a large margin of error due to the fact that sampling was carried out for only 7.33 hours during 13 months (9528 hours). Because of the large amounts of plant material clogging the screens, it is impossible to determine whether or not fish die due to impingement on the screens or due to suffocation in the matted plants.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The Passavant traveling screens employ an innovative design that is purported to minimize both impingement and subsequent mortality. A utility representative noted that this would be the case at this station but for the severe loading by sea grass and comb jellies (Ctenophora) that is experienced on nearly a year-round basis.[2] Various types of screen mesh, media, and prescreening devices are now in the design and testing stages and it is expected that they will eliminate the large amount of sea grasses that now clogs the screens.[2]

REFERENCES

1. Personal communication with M. L. Murray of Central Power and Light Company. 21 June 1976.

2. Personal communication with T. S. Jinnette of Central Power and Light Company. 6 July 1976.

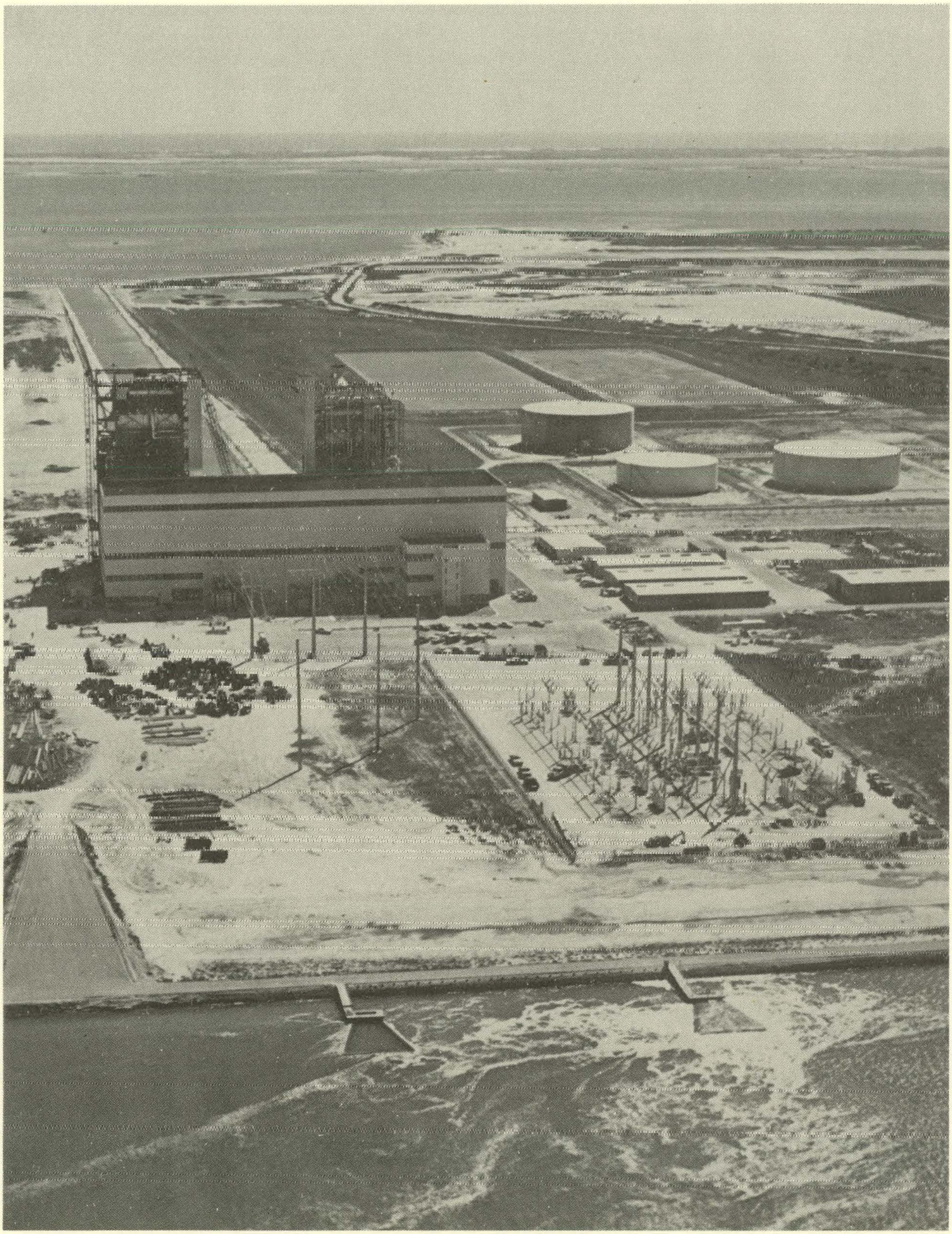


Fig. 1. Aerial View of the Station with Intake Canal in Background.

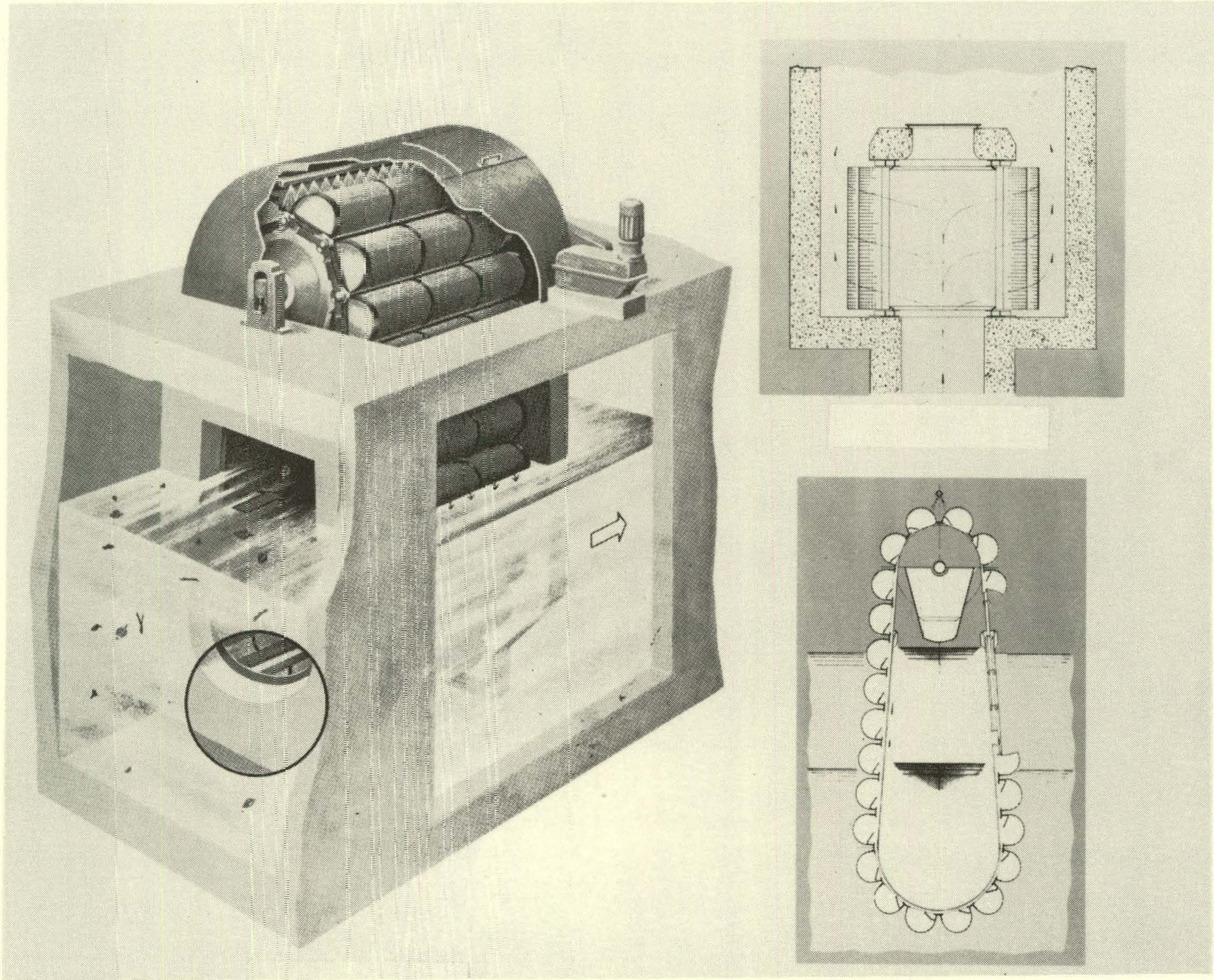


Fig. 2. Passavant Traveling Screen.

Table I. Fishes Impinged at the Station

Skipjack herring	Bluntnose jack
Striped anchovy	Pinfish
Dusky anchovy	Spot
Bay anchovy	Rainwater killifish
Sheepshead	Rough silverside
Sea catfish	Tidewater silverside
Silver perch	Atlantic croaker
Gulf menhaden	Striped mullet
Atlantic bumper	White mullet
Bay whiff	Leatherjacket
Weakfish	Gulf toadfish
Spotted seatrout	Shrimp eel
Sheepshead minnow	Gulf butterfish
Ladyfish	Butterfish
Silver jenny	Bluefish
Longnose killifish	Bighead searobin
Yellowfin mojarra	Red drum
Naked goby	Inshore lizardfish
Code goby	Least puffer
Skilletfish	Atantic needlefish
Gulf pipefish	
Permit	
Atlantic cutlassfish	

Table II. Summary of Fish Impingement Data

Years	No. of Months Sampled	Estimated No. of Fish Impinged during Months Sampled			
		Gulf Menhaden	Bay Anchovy	Tidewater Silverside	Total
1975-76	13	2,994,886	665,530	90,990	4,306,448

TROJAN NUCLEAR PLANT (N)

SITE CHARACTERISTICS

The plant site is located in Columbia County, Oregon, directly south of the town of Prescott.[1] Both the plant and the town are located on a rocky ridge running in a north-south direction adjacent to the Columbia River at Mile 72.5. The ridge and the site have an elevation of 75 feet MSL (Fig. 1).

The river channel at the site is 2400 feet wide, and the site area is well drained by streams and sloughs. The mean annual flow of the river is 100,000,000 gpm with peaks in May and June ranging from 200,000,000 to 310,000,000 gpm. Current velocity has an annual mean of 1.8 fps but may reach 3.0 fps during the high flows in May and June. Near-shore velocities are about 40% less than those in midchannel. The deeply cleft channel is 30 feet deep at the site. Maximum and minimum water temperatures at the site are 76°F and 40°F, respectively.

Although the Columbia River at the site is tidal, the saltwater wedge that travels upstream ends 20 miles downstream of the site. Flow reversal does take place and maximum rates of 57,900,000 gpm (1.3 fps) have been recorded; however, tidal variation at the site never exceeds 5.0 feet. Such flow reversal occurs about one-third of the time and is always accompanied by strong eddy turbulence.

A list of fishes taken on the lower Columbia River between River Miles 70 and 79 is given in Table I. There is a large number of commercially important anadromous species that frequents the river at the plant site. Figure 2 shows the timing of the upstream migrations of seven commercially important species inhabiting the Columbia River. The river represents a major North American breeding ground for all these species.

PLANT DESCRIPTION

The Trojan Nuclear Plant has one pressurized water reactor with a net electrical output of 1130 MWe. Heat is dissipated by closed-cycle cooling, employing a single 500-foot natural-draft cooling tower.

INTAKE DESIGN AND OPERATION

Water enters the intake structure through two adjacent bays located below a curtain wall. This wall is flush with the river bank. Each opening is 15.5 feet wide by 10.0 feet high and extends from -12 feet to -2 feet MSL. (The river-surface elevation is between two and six feet MSL for most of the low-water period of the year.) The curtain wall extends below the water surface to skim off floating debris and to prevent entry of surface-swimming fish. Trash racks, 36.3 feet high, extend from the riverbed to 23 feet MSL at a 15° angle. Openings are 2-5/8 inches wide, and the rack keeps large debris from reaching the traveling screens. The screens have number-5 mesh, 16-gauge wire screening (0.14-inch-square openings), and rotate at a speed of 10 feet per minute when operated. A differential switch automatically activates the screens when they are less than 85% clean. There are fish-escape openings located at the front of the traveling screens on both the upstream and downstream sides of the intake structure. Velocities at the trash racks, screen approaches, and traveling screens are given for normal and maximum operation in Table II. There are three service-water pumps rated at 20,000 gpm; however, under normal conditions, only one operates. During normal operation with the fish-rearing facilities in operation, there is a net removal of 29,000 gpm of makeup water from the river. A schematic of the entire circulating-water system is given in Figure 3.

IMPINGEMENT SAMPLING

Collections were made for 48 hours per month during the preoperational phase of plant startup, which lasted from July 1975 to January 1976. As of 16 February 1976 collections were made on a 24-hour basis, five days per week. The Environmental Technical Specifications call for daily samples during the first year of operation, with weekly samples during peak salmonid abundance.[2]

DATA AVAILABILITY

Preoperational data are available for July through December 1975. Operational data (at variable power levels) are available from January through 20 May 1976.

IMPINGEMENT DATA SUMMARY

Impingement numbers were small and limited to a few species. Raw numbers have been extrapolated to monthly totals. The data, both preoperational and operational, are summarized in Table III.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

No special features have been reported to be incorporated in the intake design for the purpose of minimizing impingement; however, the low intake velocities and water volumes associated with any plant using closed-cycle cooling tend to mitigate against large kills. In communications with the utility, it was noted that all the impinged eulachon were spent from spawning.[3]

REFERENCES

1. "Final Environmental Statement, Trojan Nuclear Plant." USAEC Directorate of Licensing. Docket Number 50-344. August 1973.

2. "Environmental Technical Specifications for the Trojan Nuclear Plant." Section 4.1.1.3. USAEC Directorate of Licensing.

3. Personal communications with George J. Eicher of Portland General Electric Company. 2 October 1975, 24 May 1976, and 10 June 1976.

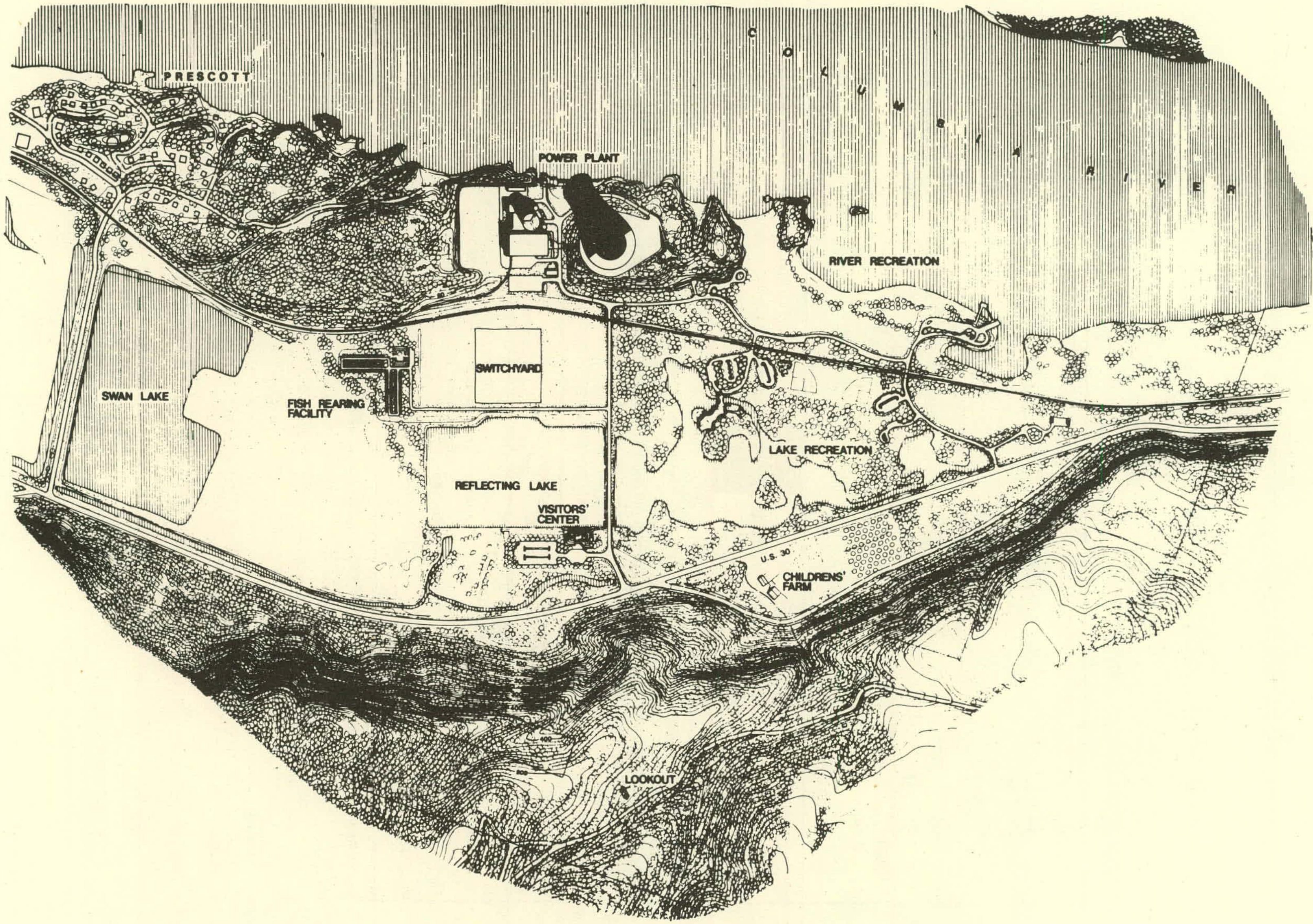


Fig. 1. Site Plan.

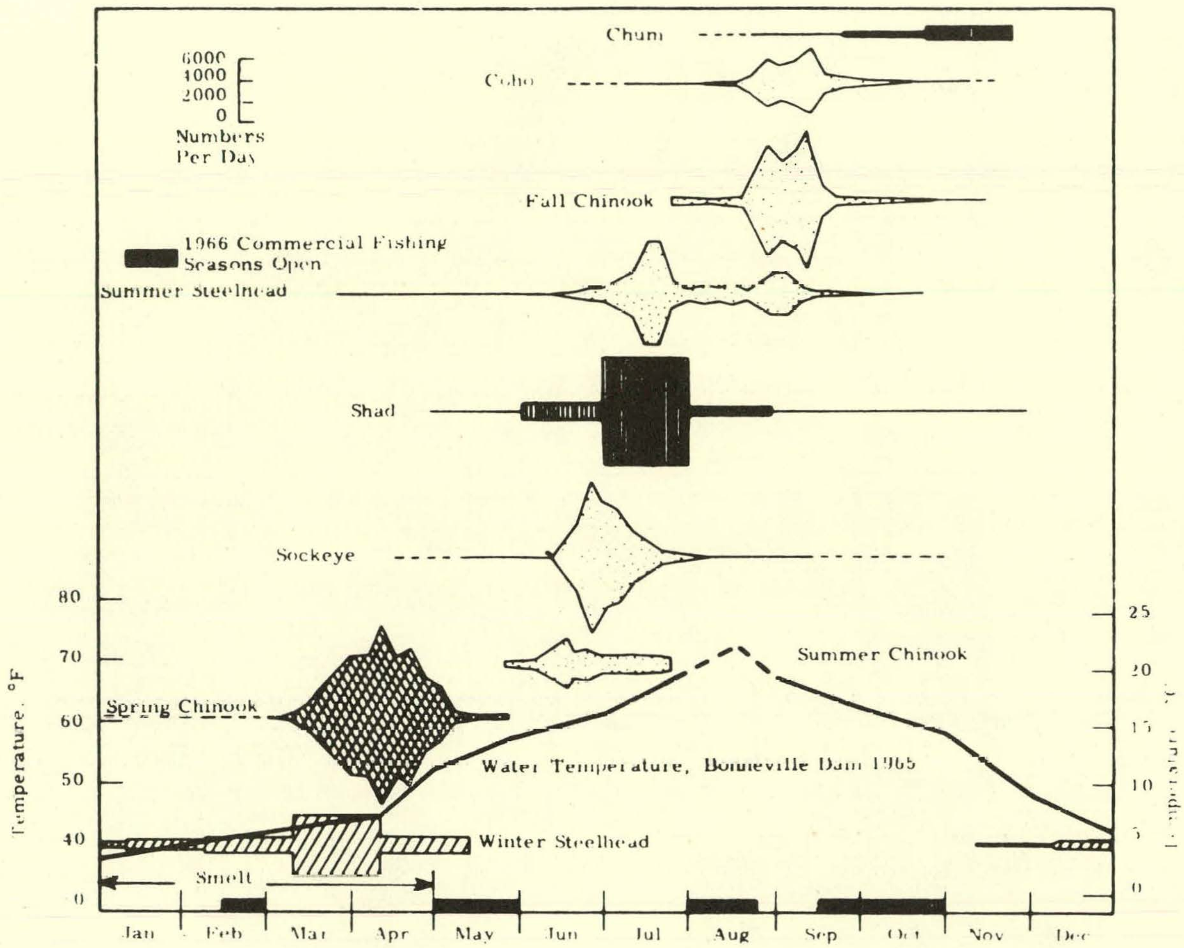


Fig. 2. Timing of Upstream Migrations.

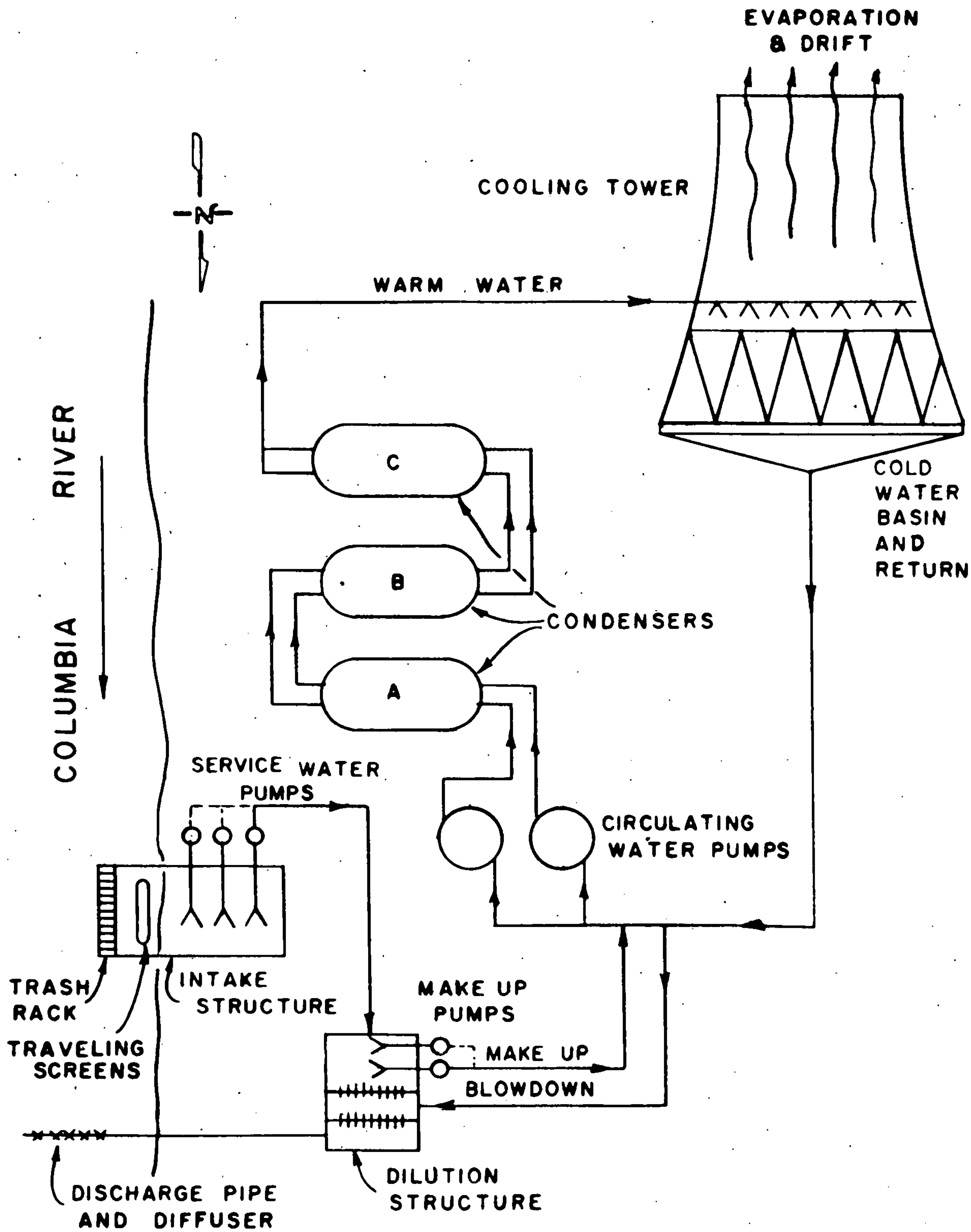


Fig. 3. Circulating-Water System.

Table I. Fish Captured in the Lower Columbia River between River Miles 70 and 79

Chinook salmon	Prickly sculpin
Threespine stickleback	Sockeye salmon
Coho salmon	Northern squawfish
American shad	Sand roller
Peamouth	White sturgeon
Yellow perch	Smallmouth bass
Steelhead	Eulachon
White crappie	Bluegill
Starry flounder	Pacific lamprey
Mountain whitefish	Redside shiner
Carp	Longfin smelt
Largemouth bass	Chum salmon
Largescale sucker	Chiselmouth
Brown bullhead	Black crappie
Cutthroat trout	

Table II. Flow Velocities in the Intake Structure

Flow[a] (gpm)	River Elevation (feet MSL)	Trash Racks Area (ft^2)	Trash Racks Velocity (fps)	Approach to Screens Area (ft^2)	Approach to Screens Velocity (fps)	Traveling Screens Area (85% clean) (ft^2)	Traveling Screens Velocity (fps)
Normal Operation (1 Service Pump, 2 Fish Pumps, 1 Screen-Wash Pump)							
29,600	-1.5[b]	131.4	0.50	161.4	0.41	35.1	1.88
30,200	1.0[c]	131.4	0.51	199.8	0.34	43.5	1.55
31,410	5.0[d]	131.4	0.53	261.3	0.27	44.7	1.24
32,370	10.5[e]	131.4	0.55	345.8	0.21	75.2	0.96
Maximum Operation (2 Service Pumps, 2 Fish Pumps, 2 Screen-Wash Pumps, 2 Fire Pumps)							
54,200	-1.5[b]	262.8	0.46	322.8	0.37	70.3	1.72
55,425	1.0[c]	262.8	0.47	399.6	0.31	87.0	1.42
57,740	5.0[d]	262.8	0.49	522.6	0.25	53.0	1.13
59,690	10.5[e]	262.8	0.51	691.6	0.19	149.4	0.88

[a] Nominal Flows:
One service-water pump - 20,000 gpm.
One fish-water pump - 4,500 gpm.
One screen-wash pump - 600 gpm.
One fire pump - 2,000 gpm.

[b] Design low-water elevation.

[c] Recorded low-water elevation.

[d] Mean water elevation.

[e] Mean high-water elevation.

Table III. Summary of Fish Impingement Data at the Plant for July 1975 to May 1976

Month	No. of Days Sampled	Estimated No. of Fish Impinged during Months Sampled									
		White Crappie	American Shad	Prickly Sculpin	Eulachon	Steel-head	Yellow Perch	Brown Bullhead	Threespine Stickleback	Black Crappie	Total
Jul	2	14									14
Aug	2										0
Sep	2										0
Oct	2										0
Nov	2	15	30								45
Dec	2			124							124
Jan	20			6							6
Feb	20			1							1
Mar	23			12	360						372
Apr	22			3	86	1	1	1	4		96
May	14									1	1
Total											659

PACIFIC GAS AND ELECTRIC COMPANY POWER PLANTS

SITE CHARACTERISTICS

Currently there are nine power plants in the Pacific Gas and Electric Company system (PG&E) that have 316(a) demonstration studies in progress. These consist of one nuclear, one combination nuclear-fossil, and seven fossil plants. For purposes of this survey, they have been divided into tidal-river or coastal-zone plants, depending on their location. Because the intake design in all cases is very similar and the status of fish-impingement studies is the same in all but one case (Diablo Canyon), all plants owned by this utility are discussed together in this one report.

Figure 1 shows the location of all plants in the PG&E system.[1] All are located in California; three (Contra Costa, Pittsburg, and Oleum) are tidal-river plants, whereas six (Diablo Canyon, Humboldt Bay, Morro Bay, Hunters Point, Potrero, and Moss Landing) are considered coastal-zone plants. These are artifical designations inasmuch as several plants are located on the interior shore of San Francisco Bay. Information was made available by the utility only for these nine plants; the status of the remainder is unknown.

PLANT DESCRIPTION

Humboldt Bay Power Plant (F-N)[2]

This three-unit facility is located near Buhne Point on Humboldt Bay, seven miles south of Eureka, California. The system employs once-through cooling for three generating units, one nuclear, the other two fossil. Intake water comes from Fisherman's Channel through a man-made canal and is discharged through a canal directly to Humboldt Bay. The net generating capacity of the station is 172 MWe. There are no technical specifications for fish impingement sampling at the nuclear unit.

Contra Costa Power Plant (F)[3]

The plant is located on the south bank of the San Joaquin River, 2.5 miles east of Antioch, California. The generating system uses fossil fuel and employs seven main and three house units to produce a net total of 1260 MWe. The facility employs once-through cooling, drawing water from and discharging it into the San Joaquin River.

Oleum Power Plant (F)[4]

The site is located near Davis Point on San Pablo Bay in Rodeo, California. It has two generating facilities rated at a total of 87 MWe.

This fossil-fueled facility uses once-through cooling and began operation in 1941. The site is on an enclosed bay-estuary.

Hunters Point Power Plant (F)[5]

The plant is located in India Basin on San Francisco Bay in San Francisco, California. Unit 1 was retired in 1972, with the remaining capacity of the main Units 2, 3, and 4, and two house units rated at a net total of 377 MWe. It is a fossil-fueled plant with adjoining intake and discharge. An earthen dike has been constructed to prevent recirculation of cooling water.

Potrero Power Plant (F)[6]

The plant is located at Potrero Point on San Francisco Bay in San Francisco, California. It is fossil fueled and employs once-through cooling for three units with a combined net generating capacity of 323 MWe.

Pittsburg Power Plant (F)[7]

The plant is located on Suisin Bay at Pittsburg, California. It is a fossil-fueled plant that employs seven generating units rated at a total capacity of 2002 MWe. Units 1-6 employ once-through cooling, drawing water from Suisin Bay and discharging it into the Sacramento River-Suisin Bay Estuary. Unit 7 (720 MWe) is cooled by an off-stream spray-canal system.

Moss Landing Power Plant (F)[8]

This facility is located 10 miles south of Watsonville, California, on Moss Landing Harbor and adjacent to Elkhorn Slough and Monterey Bay. It is a fossil-fueled plant with seven main and three house units supplying a total net capacity of 2060 MWe. All units use water from Moss Landing Harbor. Units 1-5 discharge into Elkhorn Slough and Units 6 and 7 discharge into Monterey Bay.

Morro Bay Power Plant (F)[9]

The plant is located on Morro Bay, 13 miles northwest of San Luis Obispo, California. This fossil-fueled plant has four generating units with a total net capacity of 1002 MWe. Once-through cooling is employed and water is drawn directly from Morro Bay and discharged into neighboring Estero Bay.

Diablo Canyon Power Plant (N)[10]

This nuclear facility is located on a 750-acre site in the extreme northern part of San Luis Obispo County on the Pacific Ocean, halfway between Los Angeles and San Francisco. Its two nuclear units employ once-through cooling, drawing water from Diablo Cove, where an artificial breakwater has been created, and discharging it into South Cove. This plant is not now operating because litigation is in progress, and no technical specifications have been issued in regard to fish impingement. The plant has a net electrical capacity of 2190 MWe. Water is being pumped at this time and studies are in progress to determine if there are any effects on the biota.[11]

INTAKE DESIGN AND OPERATION

The utility has long recognized the problem of fish impingment at cooling-water intakes. Studies carried out at the Contra Costa Power Plant[12] resulted in design modifications that reduced fish impingement significantly. Subsequently, the "Contra Costa Design" was employed to varying degrees throughout the PG&E system to reduce fish impingement. The salient features of this type of intake are outlined here, and these features exist, in whole or in part, in all of the plants mentioned above.

Contra Costa has two sets of intake structures of widely different designs. Units 1-5 are served by one intake structure (Figs. 2 and 3), which consists of a series of canals and gates through which water is diverted from a common intake channel to the condenser of each unit. Large numbers of fish build up in the area between the trash racks and traveling screens. With water velocities greater than predicted, this has resulted in very great fish mortalities, despite a fish-removal system incorporated in the original design. Various mitigative efforts were employed, including electric fish screens, sonic devices, circulating devices, lights, and velocity barriers to scare fish, but none proved successful over the wide range of fish sizes, salinities, and environmental conditions present at the plant. A new fish collector was finally adopted consisting of a lip with a full-length orifice extending a few inches in front of each traveling screen, connected to an eight-inch pipe with an open-impeller centrifugal pump. It was found that this system safely returned 98% of all fish up to 22 inches in length back to the San Joaquin River.

In units constructed thereafter, PG&E incorporated two new design modifications that alleviate the need for a complex scheme such as a fish-pump system. These two modifications are incorporated in the intake design at Contra Costa Units 6 and 7 (Fig. 4). The general design of the intake system is the same as that for Units 1-5: a curtain wall followed by trash racks and 3/8-inch-mesh traveling screens. However, the "Contra Costa Design" employs a "wide approach intake" that calls for (1) traveling screens built flush with the shoreline and (2) trash racks built out into the river to form a cage around the screens. This allows free passage of fish and permits full tidal-current swing across the face of the screens. In addition to these two modifications, the intake has been streamlined to eliminate areas of turbulence and abrupt velocity changes. Figure 5 depicts a cross section of the intake showing velocities through the traveling screens. Since the adoption of this design, PG&E has had a reduction of impingement to the extent that it "no longer considers it a major problem."[11] However, no data on fish impingement are available to support this contention.

IMPINGEMENT SAMPLING

No sampling is now being conducted under the directive of P.L. 92-500. Sampling may be underway at the Diablo Canyon Plant under environmental technical specifications imposed by the USNRC.

DATA AVAILABILITY

No impingement data are available for these plants.[13] No 316(b) studies have been initiated because no guidelines have been issued by the USEPA.[11,13]

REFERENCES

1. Personal communication with J. R. Adams of Pacific Gas and Electric Company. 23 September 1975.

2. "An Evaluation of the Effect of Cooling Water Discharges on the Beneficial Uses of Receiving Waters at Humboldt Bay Power Plant." Pacific Gas and Electric Company. July 1973.

3. "An Evaluation of the Effect of Cooling Water Discharges on the Beneficial Uses of Receiving Waters at Contra Costa Power Plant." Pacific Gas and Electric Company. July 1973.

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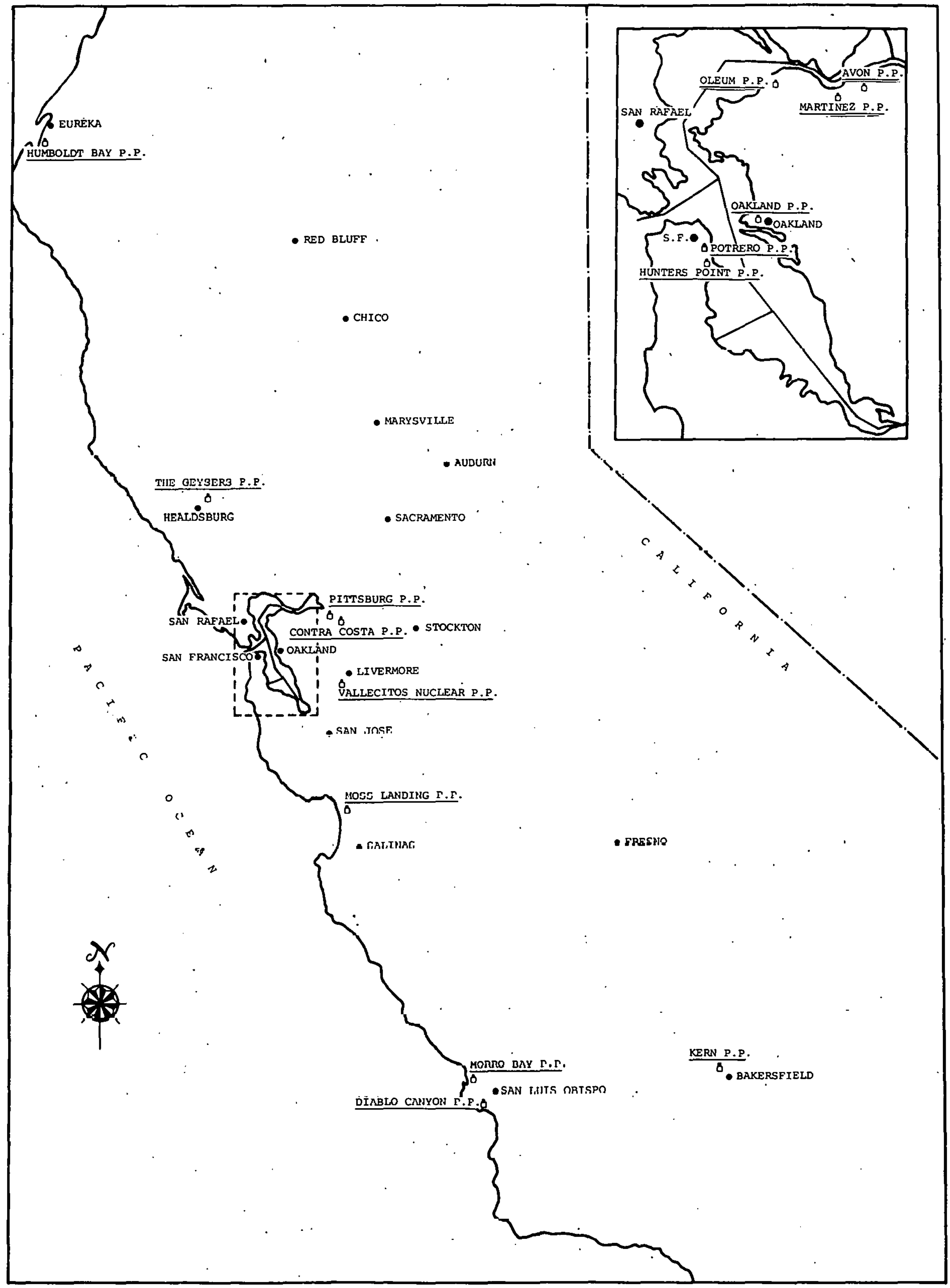

Fig. 1. Steam-Electric Power Plant Locations.

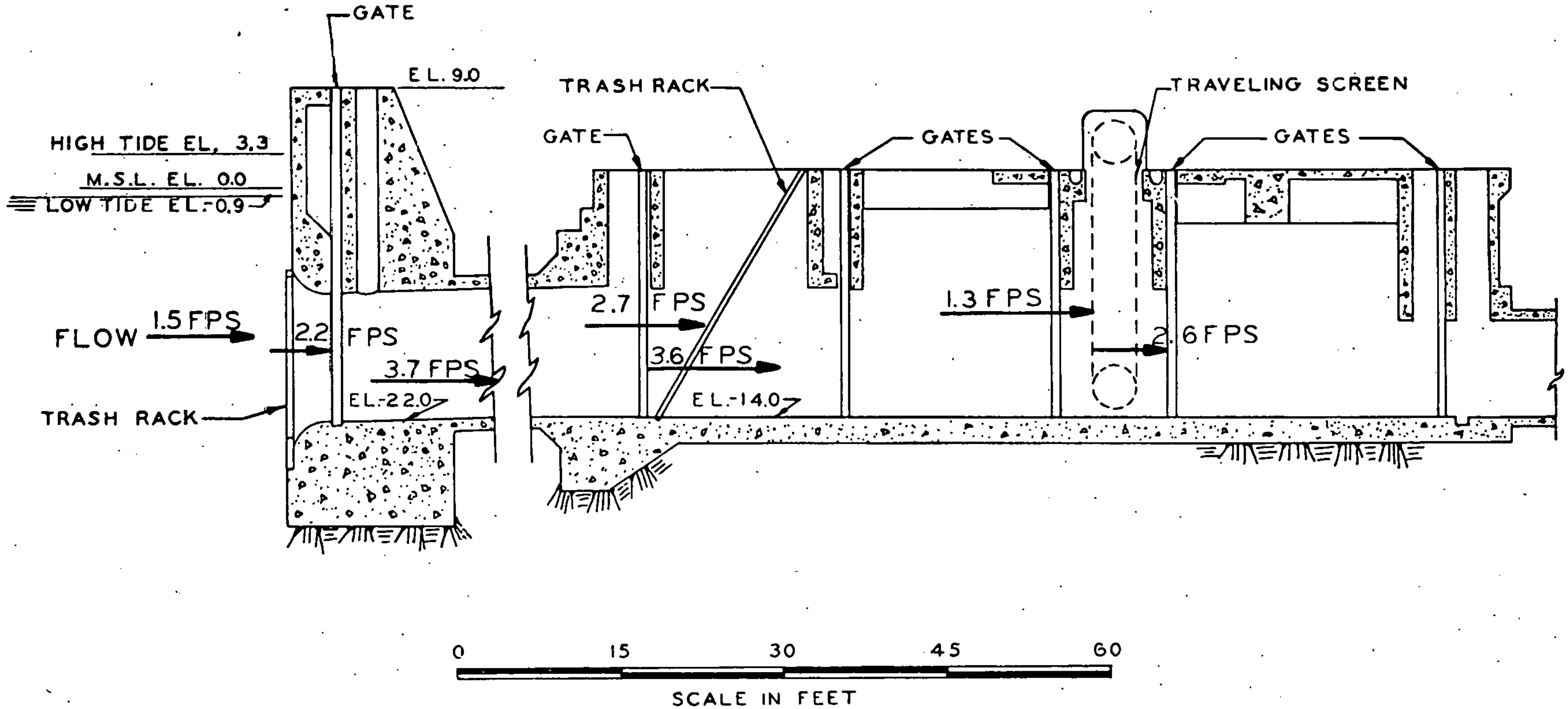

Fig. 2. Typical Section of the Cooling-Water Intake Structure at Contra Costa Units 1-5.

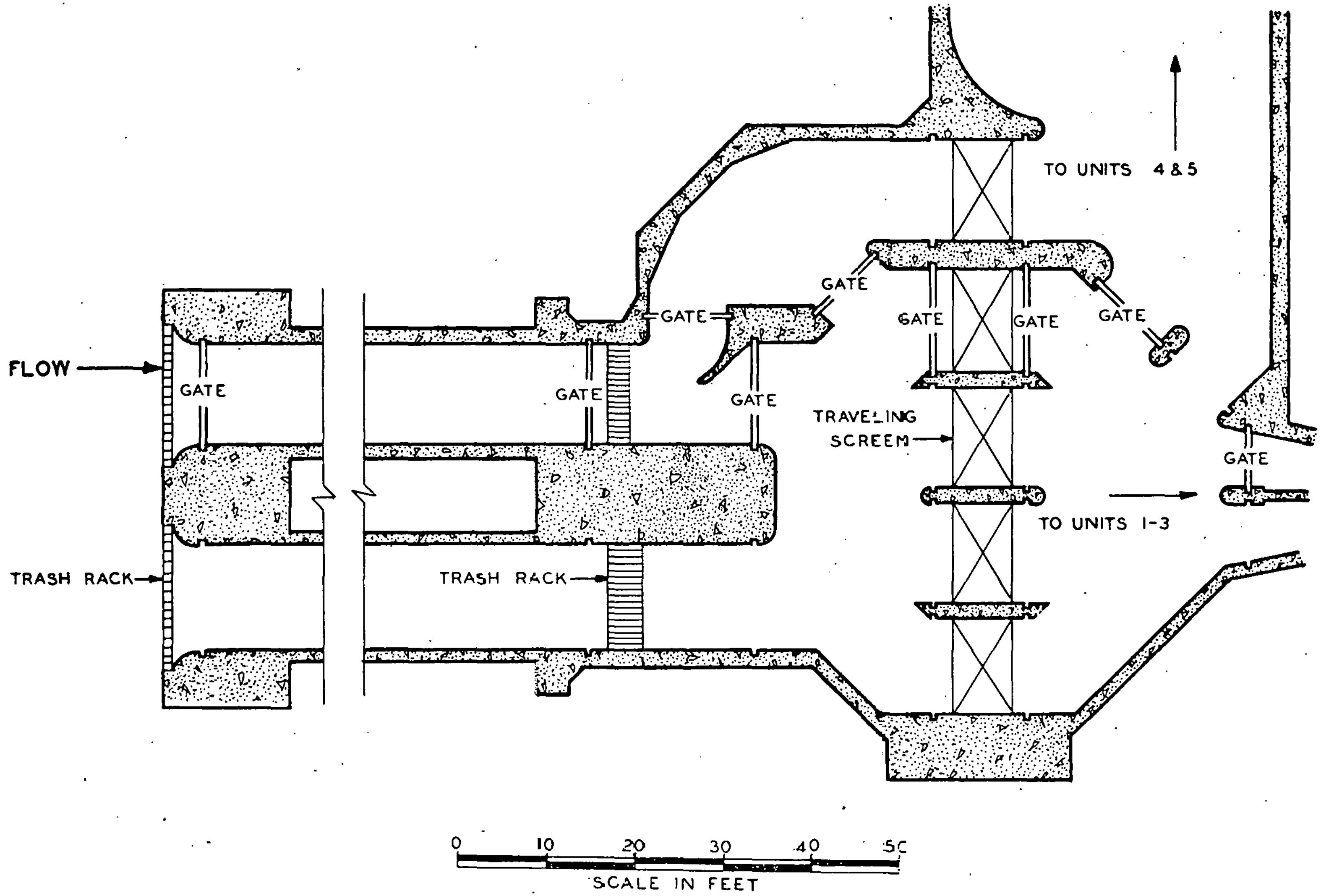

Fig. 3. Plan at -14 Feet MSL of the Cooling-Water Intake Structure at Contra Costa Units 1-5.

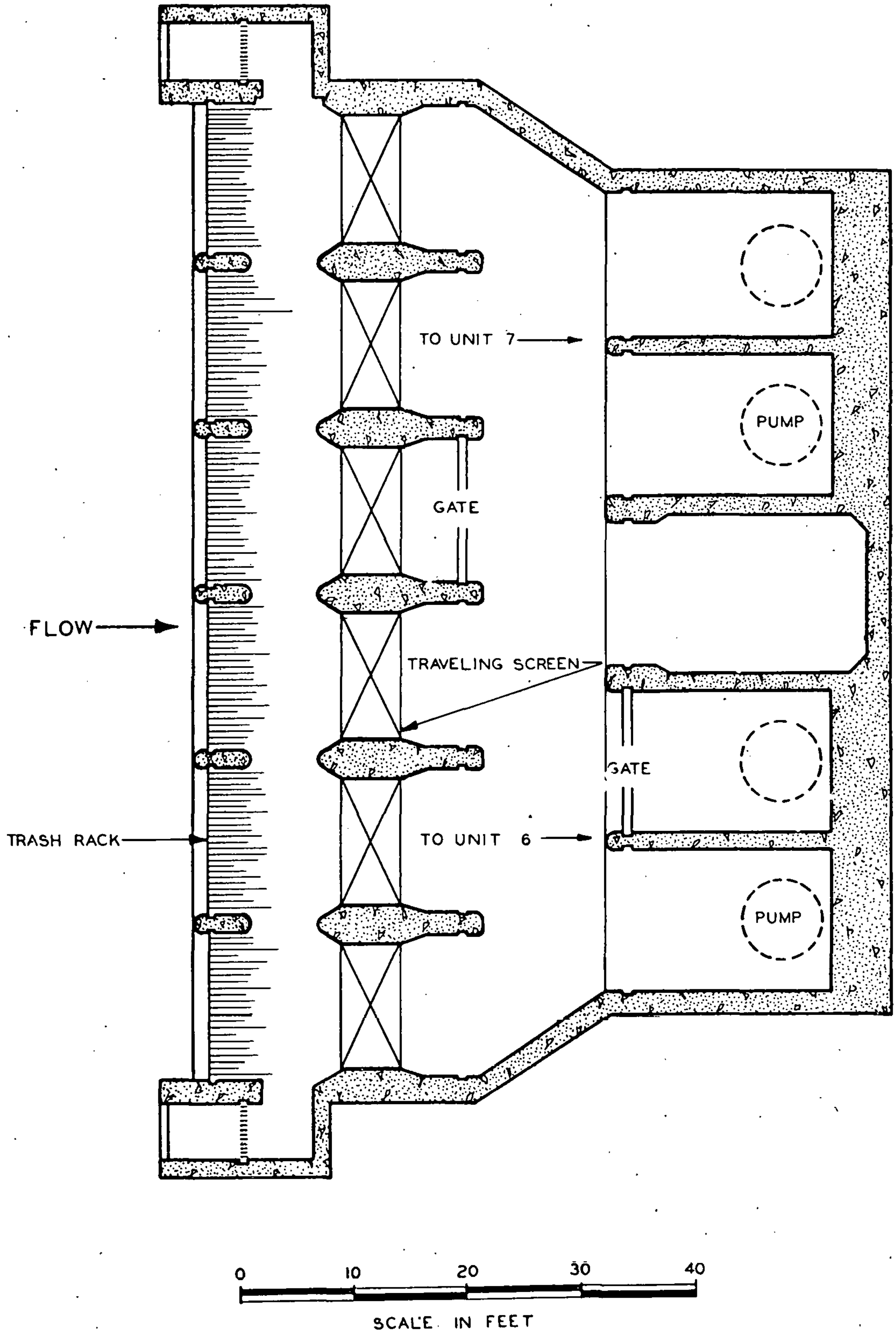

Fig. 4. Plan at -14 Feet MSL of the Cooling-Water Intake Structure at Contra Costa Units 6 and 7.

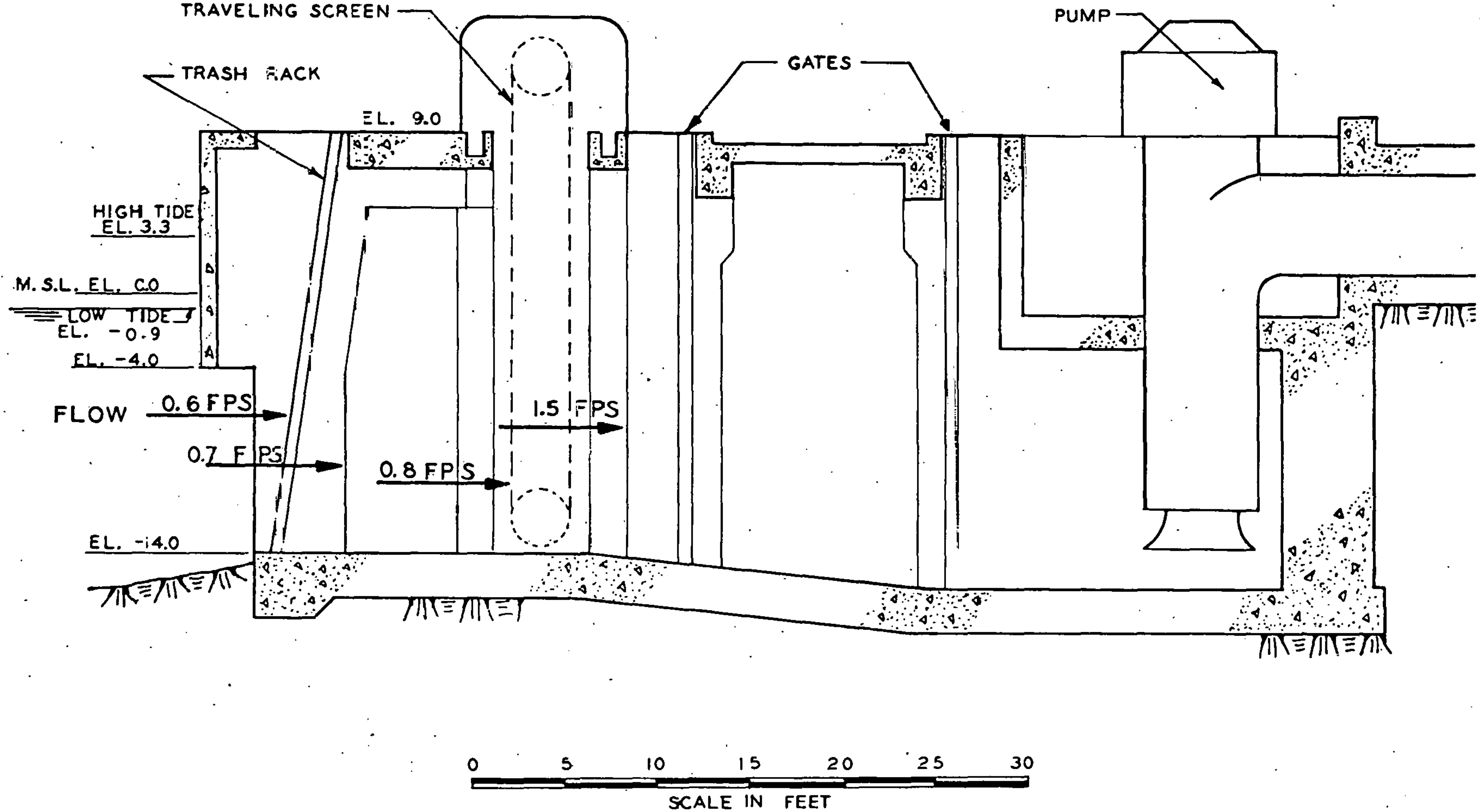

Fig. 5. Typical Section of the Cooling-Water Intake Structure at Contra Costa Units 6 and 7.

PG&E

SAN ONOFRE NUCLEAR GENERATING STATION UNITS 1-3 (N)

SITE CHARACTERISTICS

San Onofre Nuclear Generating Station is located on the Pacific Coast, 62 miles southeast of Los Angeles and 51 miles northwest of San Diego.[1] Unit 1 is situated on 16 acres within an 84-acre easement of the Joseph H. Pendleton Naval Reservation. Units 2 and 3 are located on the Naval reservation about 1000 feet to the south of Unit 1 on 52 acres of the original site. Figure 1 shows the location of all three units.

The station is located adjacent to shoreline bluffs on the northwest and southeast, and fronts a shore of coarse yellow sand. Inshore areas (shallower than 15 feet) have a coarse yellow-sand substrate; whereas farther offshore the bottom is grey sand or mud with patches of cobble rock. The ocean floor slopes gently seaward to a depth of 40 feet about 2500 yards offshore. Three current patterns are typically superimposed to produce a complex pattern. These are the tidal currents producing an inshore-offshore movement of 0.2 knots, a 0.3-knot current down the coast, and a 0.3-knot current up the coast, each of which occurs in succession. Tidal variations are mixed semi-diurnal in nature. The average high-tide and mean-tide levels are +4.5 and +2.7 feet mean lower low water, respectively. Water temperature varies from a mean high of 73°F in August to a mean low of 56°F in January.

A highly diverse fish fauna is present in the vicinity of the station. Table I presents a list of species taken within 50 miles of the site. The general location of the site is important for sport fishing and is adjacent to an important migration route for the California grey whale.

PLANT DESCRIPTION

Units 1-3 are pressurized water reactors. Unit 1 has a net electrical capacity of 429 MWe. Units 2 and 3 each have rated outputs of 1140 MWe, for a total station capacity of 2709 MWe. All units employ once-through cooling and draw water from the Pacific Ocean.

INTAKE DESIGN AND OPERATION

Each unit has a separate offshore intake structure of the "glory hole" design equipped with a velocity cap. Figure 2 shows the Unit 2 and Unit 3 design. The Unit 1 intake is located 3200 feet offshore and the intakes for Units 2 and 3 are 3400 feet offshore. The normal condenser flow is 350,000 gpm for Unit 1 and 795,000 gpm each for Units 2 and 3. All of the intakes are elevated 10.5 feet above the ocean floor at a depth of about 30 feet. The velocity caps induce horizonal flow, and water moves into the structure at 2.6 fps. The pipe between the intake structure and the screenwell for Unit 1 is 12 feet in diameter. Pipes are 18 feet in diameter for Units 2 and 3. Water velocity in the pipes is 7.3 fps and becomes 2.0 to 2.5 fps at the screens. Vertical trash bars protect the screens from damage by large debris. Units 2 and 3 have a fish-return system under construction. Unit 1 has two 175,000-gpm circulating-water pumps and a screenwell that is separate from those of Units 2 and 3. The screenwell design for Units 2 and 3 is shown in Figure 3.

IMPINGEMENT SAMPLING

Section 3.1.2.a of the Environmental Technical Specifications for the station states that an assessment of the impact on the fish population must be estimated by determining the number, size, and weight of fish and number of species impinged. The screens were sampled for thirty-eight 24-hour periods, and total figures for Unit 1 are available. No monthly totals were given nor could they be ascertained from the data presented.[2]

DATA AVAILABILITY

Data are available for seven months, for Unit 1 only, from 27 November 1974 to 25 June 1975.

IMPINGEMENT DATA SUMMARY

The data presented in Table II are figures derived from thirty-eight 24-hour sample periods that occurred during the dates mentioned above. No monthly impingement figures could be extrapolated from the figures given. The totals for the three most numerous species, queenfish, walleye surfperch, and white croaker, are extrapolated figures. No histograms for monthly totals were prepared because of the lack of appropriate data.

DESIGN AND OPERATIONAL FEATURES TO MINIMIZE FISH IMPINGEMENT

The main feature of the intake system common to all three units is the velocity cap that induces horizontal flow into the intake structure. However, these structures induce high intake velocities and may actually serve to enhance the entrainment of fish. Units 2 and 3 will have a fish-return system designed to minimize impingement at these two units. However, no data on its type or construction was made available. Unit 1 did not employ a fish-return system during the months when sampling was done.

REFERENCES

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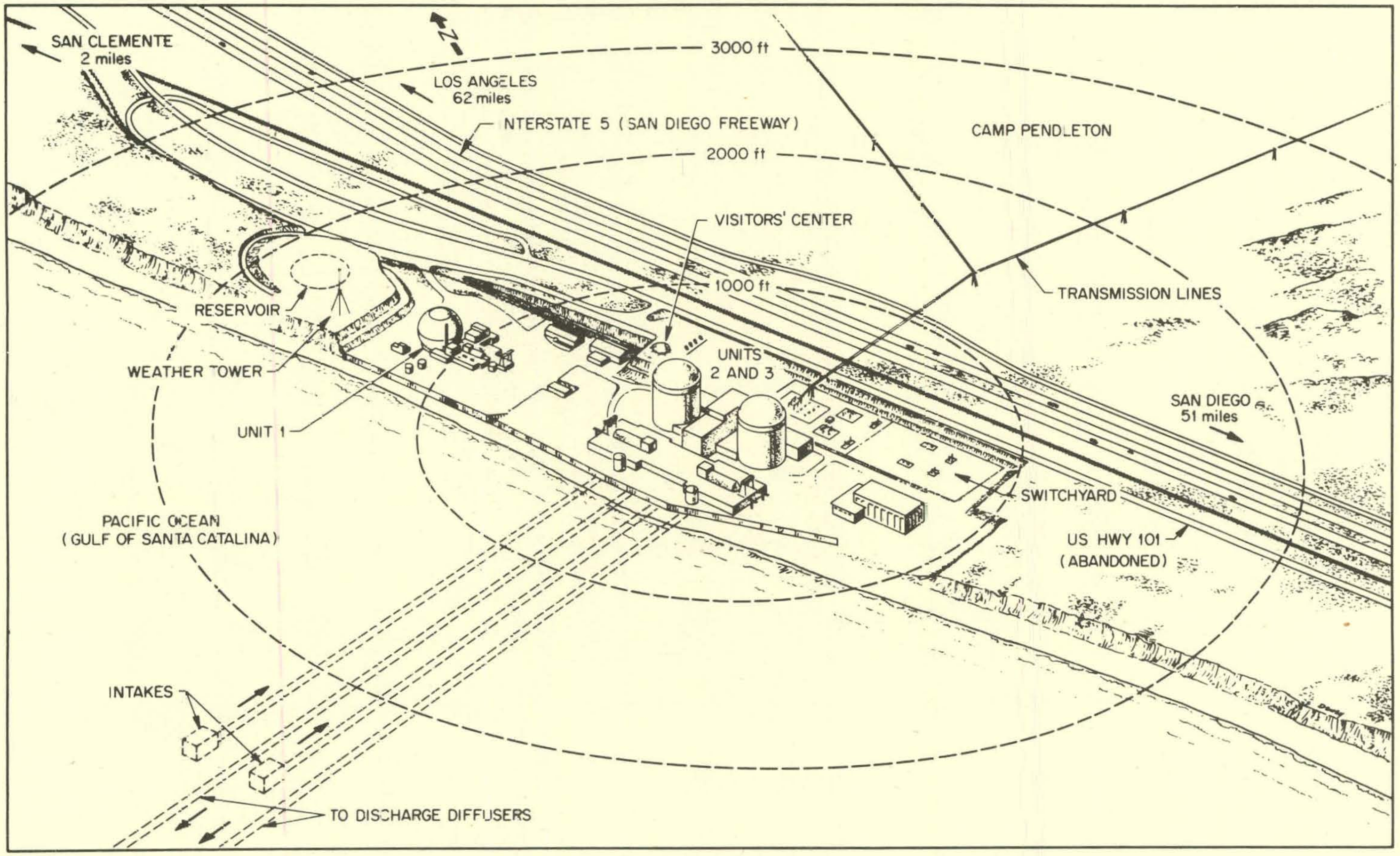

Fig. 1. Station Location.

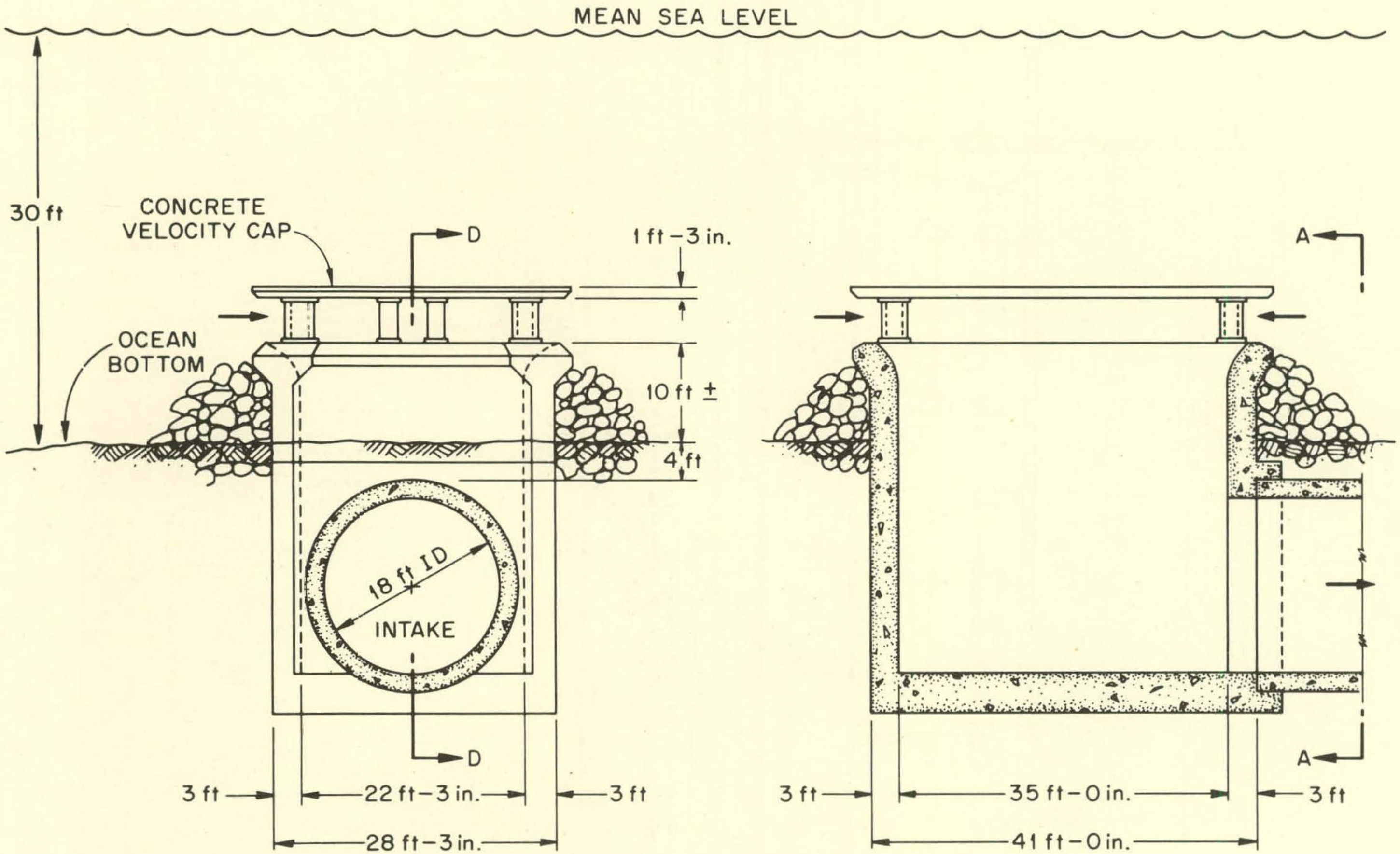

Fig. 2. Intake Structure Design for Units 2 and 3.

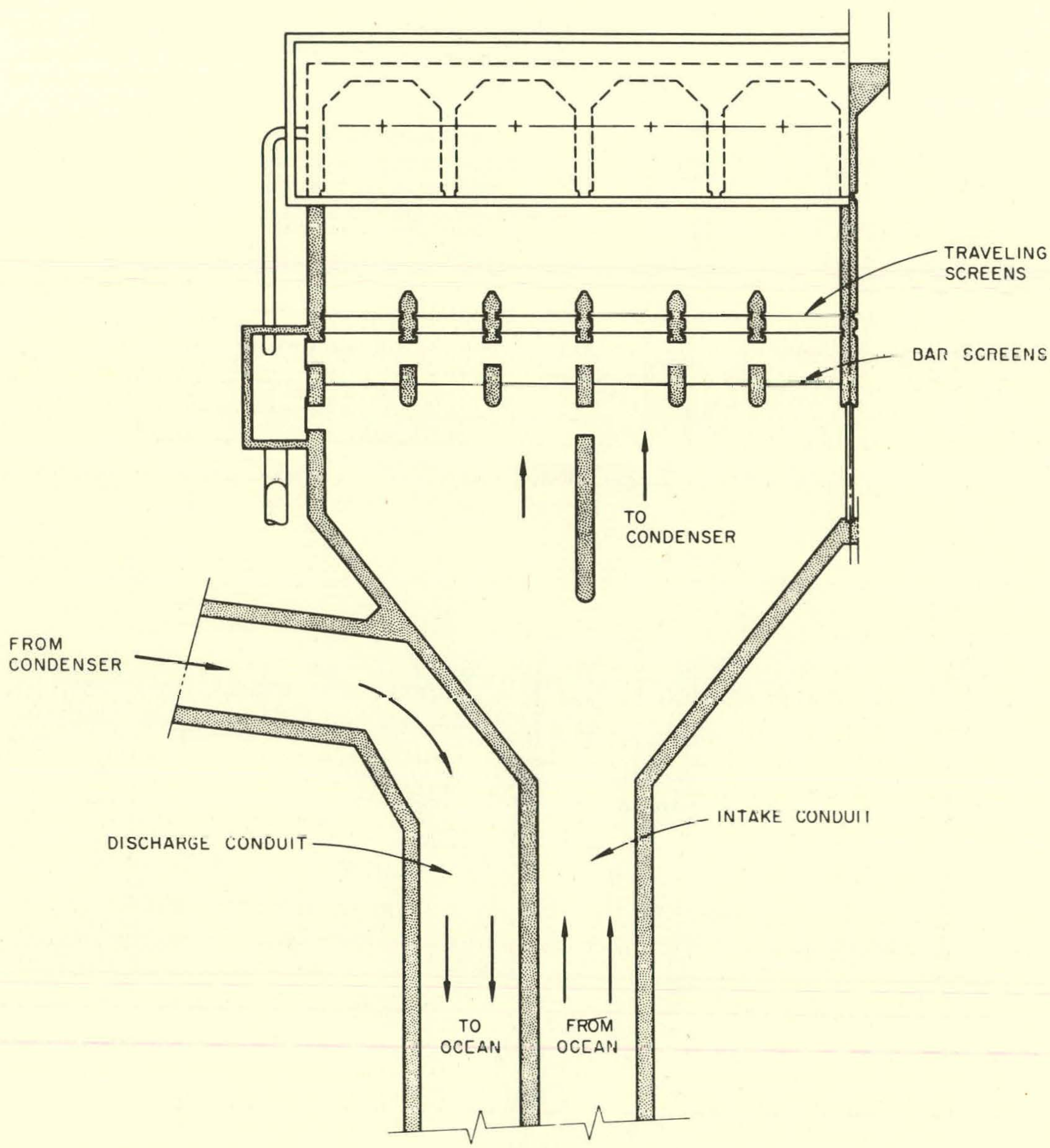

Fig. 3. Screenwell Design for Units 2 and 3.

Table I. Fish Fauna of Southern California in the Vicinity of the Station

Deepbody anchovy	Opaleye
Northern anchovy	Black perch
Slough anchovy	Dwarf perch
Pacific barracuda	Kelp perch
Kelp bass	Pile perch
Barred sand bass	Rubberlip seaperch
Spotted sand bass	Shiner perch
Striped bass	Bay pipefish
Blacksmith	Barred pipefish
Bay blenny	Kelp pipefish
Rockpool blenny	Southern spearnose poacher
Pacific bonito	Queenfish
Cabezon	Bat ray
California clingfish	California butterfly ray
Deepwater blenny	Pacific electric ray
California corbina	Calico rockfish
Black croaker	Kelp rockfish
Spotfin croaker	Olive rockfish
White croaker	Vermilion rockfish
Yellowfin croaker	Whitebelly rockfish
California moray	Northern ronquil
Yellowtail	Rough ronquil
Sarcastic fringehead	Smooth ronquil
Onespot fringehead	Salema
Yellowfin fringehead	Speckled sanddab
Garibaldi	Sargo
Arrow goby	California scorpionfish
Blackeye goby	Coralline sculpin
Cheekspot goby	Pacific staghorn sculpin
Shadow goby	Smoothhead sculpin
Painted greenling	Wooly sculpin
Shovelnose guitarfish	Giant sea bass
California halfbeak	White seabass
California halibut	White seaperch
Jacksmelt	Señorita
Giant kelpfish	Horn shark
Spotted kelpfish	Leopard shark
Striped kelpfish	Pacific angel shark
California killifish	Sheepshead
Jack mackerel	Brown smoothhound

Table I. Continued

Rock wrasse	Gray smoothhound
Specklefin midshipman	English sole
Longjaw mudsucker	Round stingray
Striped mullet	Walleye surfperch
California needlefish	California tonguefish
	Topsmelt
	Treefish
	C-O sole
	Diamond turbot

Table II. Summary of Fish Impingement Data

Years	No. of Months Sampled	No. of Days Sampled	Estimated No. of Fish Impinged during Months Sampled			
			Queenfish	Walleye Surfperch	White Croaker	Total
1974-75	7	38	159,338	21,922	11,105	212,521

SUMMARY

This volume covers 32 power plants located on estuaries and coastal waters. 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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