Enclosure C
Aquatic Ecology Documents

C1. Technical Review of the Aquatic Monitoring Program of WNP-2, Washington Public Power Supply System, Richland, Washington, September 1982 (ER Ref. WPPSS 1982)

C2. Operational Ecological Monitoring Program for Nuclear Plant 2 -1985 Annual Report, Washington Public Power Supply System, prepared April 1986 (ER Ref. WPPSS 1986)

C3. Operational Ecological Monitoring Program for Nuclear Plant 2 - 1986 Annual Report, Washington Public Power Supply System, prepared April 1987 (ER Ref. WPPSS 1987)

C4. Operational Ecological Monitoring Program for Nuclear Plant 2 -1995 Annual Report, Washington Public Power Supply System, prepared April 1996 (ER Ref. WPPSS 1996)

C5. Energy Northwest Columbia Generating Station Effluent Mixing Study, prepared June 2008 (ER Ref. EN 2008)

Note:

Operational Ecological Monitoring Program for Nuclear Plant 2 - 1987 Annual Report, Washington Public Power Supply System, prepared April 1988 (ER Ref. WPPSS 1988) is included in Enclosure B.

TECHNICAL REVIEW

OF THE

AQUATIC MONITORING

PROGRAM OF WNP-2

September 1982

Prepared by
Washington Public Power Supply System

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EXECUTIVE SUMMARY

In response to the Energy Facility Site Evaluation Council Resolution (EFSEC) No. 166 dated March 24, 1980, Washington Public Power Supply System has conducted an evaluation of the aquatic monitoring program in support of WNP-2. The review was quantitative in its assessment of historical pre-operational data and qualitative in its assessment of the value of future operational phase monitoring. This report summarizes the 1974-1980 data base for each monitoring program component (e.g. fish, benthos), identifies the adequacy of the data for baseline purposes, considers the potential for future operational phase impacts, and proposes a work scope for future operational phase monitoring.

Significant conclusions of this review are that:

1) An adequate preoperational baseline has been established.

2) Some phases of the preoperational program (e.g. periphyton) have a reasonable chance for detecting operational impacts, should they occur, whereas other components (e.g. phytoplankton and finfish) do not.

3) A continued but modified form of monitoring of periphyton, benthos, fish and water quality are necessary for operational impact assessment (Table 1.1).

As a result of the above conclusions the Supply System is recommending a) continuation of the periphyton, benthos, fish, and water quality monitoring programs, b) addition of thermal plume, toxicity and intake studies as required by the U.S. Army Corps. of Engineers, National Marine Fisheries Service (NMFS) and National Pollution Discharge Elimination System (NPDES) permits, and c) deletion of the phytoplankton and zooplankton monitoring programs.

The Supply System plans to initiate the proposed operational monitoring program prior to fuel load of WNP-2.

It is proposed that the results of the operational monitoring programs be presented annually to the regulatory agencies, and aspects of the program terminated at 1 to 3 years after operation if no significant impacts are detected.

1.0 INTRODUCTION

The passage of the National Environmental Policy Act of 1969 (NEPA) and of Public Law 92-500 in 1972 (FWPCA) provided regulatory agencies the authority to impose effluent limitations on facilities such as WNP-2. The environmental impacts associated with the construction and operation of WNP-2 were considered by EFSEC during the hearing process. Extensive preoperational studies were mandated by the Site Certification Agreement (SCA) and the NPDES permit.

The SCA recognized the need for flexibility in the design of the monitoring program and established conditions under which the program may be modified. In order to fully evaluate the design of existing environmental programs, it is necessary to have an in-depth understanding of the answers to the questions discussed below.

A) What are the creditable primary interactions* between the plant and the environment? Examples of creditable primary interactions include thermal enrichment of the receiving water and impingement of fish. Primary impacts at well designed power plants are few in number.

B) What are the creditable secondary and tertiary interactions between a plant and the environment? Most power plant impacts on an area's biology result from secondary or tertiary interactions. Two hypothetical examples of such interactions are:

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*Creditable interactions are those interactions which a reasonable and informed scientist/engineer believes exist or, alternatively, that the possibility of such an interaction is not totally unrealistic.

1) Chemicals in cooling tower drift change the soil chemistry (primary effect). This results in a change in the composition of the plant species present (secondary effect) which, in turn, causes a different group of vertebrates to dominate (tertiary effect). The area which may be so affected is clearly limited.

2) An increase in river temperature as a result of cooling tower blowdown causes the concentration of phytoplankton and organisms in all higher trophic levels to increase.

An example of a secondary interaction which is not creditable is the effect of a pH increase from 6.6 to 6.7 on a species which maintains healthy populations in a pH range of 6.0 to 7.5.

C) Are creditable interactions beneficial or harmful to the environment? A nearly universal assumption is that all power plant impacts are detrimental to the environment. This assumption is incorrect. Certainly the loss of ichthyoplankton is a negative effect which must be minimized. On the other hand, thermal enrichment may promote growth and survival of young fish during many months of the year.

The answer to this question may not be known. If it is not known, then a field and/or laboratory program must be considered.

D) What was the stated purpose of each program? As a result of experimental design or lack of analysis in reports, the answer to this is not always obvious.

E) What is the magnitude of hypothesized change which may be detected by the field program? Perhaps the weakest link in environmental programs is that statistical differences in some population parameters are not detectable through time even if there is a moderate to large alteration. One of the principal culprits is the inherent temporal and spatial inhomogeneity present in environmental data. It is not uncommon for programs to require an order of magnitude change in the real world in order to detect "statistically significant differences".

F) If indicator organisms are utilized in order to make "before and after" comparisons, do they possess any of the following undesirable characteristics?

1) Are they known to be or likely to be cyclic in abundance?

2) Are they known to be or likely to be insensitive to creditable plant induced environmental changes?

3) Is their biology so poorly understood that a competent biologist might reasonably be unable to segregate plant induced population changes from changes resulting from other causes?

In response to EFSEC Resolution No. 166, the Supply System has recently considered many of the above questions and conducted an extensive statistical review of the WNP-2 preoperational aquatic monitoring program. This report summarizes that review and provides recommendations for continued operational phase monitoring.

TABLE 1.1 WNP-2 OPERATIONAL MONITORING PROGRAM

SUB PROGRAM	LOCATIONS	SAMPLE AND COLLECTION FREQUENCY		TYPE OF ANALYSIS	PROGRAM DURATION [o]
I. PERIPHYTON					
PHASE I					
Core	1,7E,7M,7W,8 11E,11M,11W	Quarterly	4 replicates/sample	Total organic matter	At least 3 years
Gradient	1a,1b,7b-7f	2/ Quarter	4 replicates/sample	Total organic matter	At least 3 years
PHASE II					
Core	1,7E,7M,7W,8 11E,11M,11W	Quarterly	4 replicates/sample	Density and species composition	*
Gradient	1a,1b,7b-7f	2/ Quarter	4 replicates/sample	Density and species composition	*
II. BENTHIC MACROFAUNA	1,7E,7M,7W,8 11E,11M,11W	Quarterly	3 replicates/sample	Density, biomass and species composition	At least 3 years
III. FISH					
Drift[+]	Control, Plume	Twice, Spring 1984 Once, Summer-Fall 1984	200-300 fish per drift box	Record delayed mortality through 24 hours	One year
Entrainment[+]	WNP-2 Intake Basin	Weekly, April-June 1984	2 -12 hour samples per 24 hour period	Density and species composition	One year
Impingement[+] (NMFS-requirement)	WNP-2 Intakes	Monthly, March-November	one/time	Density and species composition	One year
Beach Seine[+]	Upstream of WNP-2 Intake	Weekly, April-June 1984	2 replicates/time	Density and species composition	One year

SUB PROGRAM	LOCATIONS	SAMPLE AND COLLECTION FREQUENCY		TYPE OF ANALYSIS	PROGRAM DURATION
IV. OTHER STUDIES					
Thermal Plume Monitoring, Aerial Overflights+	Discharge and Control Areas Upstream and Downstream	Twice, Summer-Fall 1984	One/time	Isotherms	One year
Ground Truthing+	Discharge and Control Areas Upstream and Downstream	Twice, Summer-Fall 1984	One/time	Isotherms	One year
Toxicity (NPDES Permit requirement)	Use Cooling Tower Water in Static Bioassay (EOF Lab)	Quarterly		96 hr. LC_{50}	One year
V. WATER QUALITY					
20 Different parameters (Site Certification Agreement Requirement)	-upstream of intake -discharge -300' downstream of discharge -∿ 1700' downstream of discharge	Monthly, except continuous for discharge flow, temperature, pH		Mean, standard deviation, range	At least two years

NMFS - National Marine Fisheries Service

NPDES - National Pollution Discharge Elimination System Permit

* - Depends upon results of Phase I program

o - Programs commence at fuel load(presently September 1983) unless otherwise specified

• - Fish provided by Department of Fisheries

+ - WNP-2 must be at ≥ 75% load

2.0 PHYTOPLANKTON

2.1 HISTORICAL SUMMARY

Phytoplankton samples were collected from the Columbia River near WNP-2 from September 1974 through March 1980 (1-6). Study objectives included: 1) determination of species composition, density, relative and seasonal abundance, primary productivity and pigment analysis; 2) collection of preoperational data for future assessment of potential operational impacts.

Phytoplankton samples were collected with either a 6 liter Van Dorn water bottle or a 10.4 liter plastic pail. Samples were collected from three depths (surface, mid, bottom) September 1974 through December 1976 and duplicate surface samples only January 1977 through March 1980. Frequency of sample collection was twice in 1974, six times in 1975, quarterly in 1976, and monthly January 1977 through March 1980. Station 1 was sampled from September 1974 through March 1980 (Figure 2.1). Stations 2 through 4 were sampled from September 1974 through December 1975. Additional sampling was performed at stations 8 and 11 from March through August 1978.

2.2 TECHNICAL SUMMARY

2.2.1 Relative Abundance and Density

Over 150 phytoplankton taxa were observed in samples collected from September 1974 through March 1980 (Table 2.1; 6, 7). Percent abundance is reported for station 1 because it was consistently sampled from 1974 through 1980. Diatoms (Chrysophyta; Bacillariophyceae) dominated the collections with respect to density and number of species. The dominant genera observed were Cyclotella, Stephanodiscus, Melosira, Asterionella, Fragilaria, and Synedra (Figure 2.2). Asterionella was the dominant genera during late winter and spring 1975 through 1978, while Stephanodiscus assumed this position in 1979 and 1980. Summer samples were co-dominated by Synedra, Melosira, Asterionella, Cyclotella, Fragilaria, or Stephanodiscus. Dominance of the fall samples varied, common genera included Cyclotella, Asterionella, Ankistrodesmus, and Stephanodiscus.

Phytoplankton densities at sample station 1 from September 1974 through March 1980 ranged from less than 0.1 x 10^6 units/liter in the winter to greater than 17.0 X 10^6 units/liter in the spring (Figure 2.3). A density increase in the fall was also observed from 1977-1979, when samples were collected monthly.

The null hypothesis of no year or season affects on density was tested with a two-way analysis of variance (ANOVA). Prior to analysis the data was log 10 transformed to help in meeting the assumptions for the ANOVA. The analysis was performed on the most complete and consistent data set - Station 1 from January 1977 through December 1979. Seasons were defined as: 1) December, January, February = Winter; 2) March, April, May = Spring; 3) June, July, August = Summer; 4) September, October, November = Fall.

The null hypothesis of no year or season effect on density was rejected at the 0.01 level (Table 2.2). Duncan's multiple range test (DMRT) was used to identify years or seasons which differed significantly. Duncan's test indicates that there were two year groups, 1977 and 1978, and 1979 (Table 2.3). Three seasonal groupings were identified by the DMRT: Winter-Fall, Fall-Summer, and Summer-Spring (Table 2.4). In 1974-1975, stations 1-4 were sampled at surface, mid and bottom depths. The null hypothesis of no station or depth affects on density was tested with a two-way ANOVA and not rejected (Table 2.5).

From March through August 1978, stations 1, 8 and 11 were sampled. In an effort to identify any station or date differences a two-way ANOVA was employed. The null hypothesis of no date affect on density was rejected at the 0.01 level, while the no station effect was not rejected (Table 2.6). Duncan's test indicates five date groups with only April and July densities being similar at the 0.05 level (Table 2.7).

2.2.2 Primary Productivity and Pigment Analysis

Primary productivity (i.e., mg/carbon 14/ℓ/hr) was measured on 12 dates from 1974 through 1976 (7, Figure 2.4). Peak productivity generally occurred in the summer or fall and minima occurred in the winter.

Productivity ranged from 0.042 to less than 0.001 mg $^{14}C/\ell/hr$ (Table 2.8). Generally, productivity was higher at the surface than at mid and bottom depths (Table 2.8). The difference in productivity observed with depth are probably attributable to light attenuation rather than phytoplankton stratification (1). ANOVA and DMRT were used to test differences in average productivity among stations. No significant differences ($p \leq 0.05$) were observed (1, Table 2.9). This indicates that for each sample date there was no statistically detectable cross- or downstream variation in phytoplankton productivity. Similar conclusions were reached following studies near the Hanford Generating Project (8).

Pigment analysis (i.e., chlorophyll a) was measured from September 1974 through March 1980. Chlorophyll a ranged from 0.4 mg/m^3 in March 1975 to 26.4 mg/m^3 in May 1979 (Figure 2.3). Generally, chlorophyll a concentrations peaked in late spring-early summer and were lowest in late fall-early winter. Peak chlorophyll and density values generally occurred at the same time, except in the Summer 1975 and 1978 and Spring 1979. On these three occasions the peaks varied by one month and this difference is probably attributable to the size of the dominant phytoplankton organism (i.e., single-celled diatoms produce less chlorophyll per unit biomass than the larger filamentous colonial forms : 6,7).

A two-factor ANOVA was used to test the hypothesis of no differences in chlorophyll a between years and seasons. The date set and seasons were defined as for density. Year and season effects were found to be significant ($\alpha = .01$: Table 2.10). Differences in chlorophyll a between years and seasons were examined using DMRT. Two year groups were identified (Table 2.11) and it appears that the chlorophyll a concentration in 1978-1979) was higher than in 1977. Two seasonal groupings were identified by the DMRT: Winter-Fall and Spring-Summer (Table 2.12).

In 1974-1975 and 1978, stations 1-4 and 1, 8 and 11, respectively, were sampled. A two-factor ANOVA was used to the hypotheses of no differences in chlorophyll a between stations and months. For both data sets (i.e., 1974-1975 and 1978) station effect was insignificant, whereas month effect was

significant at $\alpha = 0.1$ (Tables 2.13 and 2.14). Differences in chlorophyll a between months were examined using DMRT. In 1974 and 1975 all months were significantly different from each other, while in 1978 there were 3 monthly subsets (March; July and April; and April, August, June and May: Table 2.15). The results suggest that stations are not different for a particular sampling period, but that significant differences exist between sampling periods.

In 1974-1976, stations 1-4 were sampled at surface, mid and bottom depths. The null hypothesis of no station or depth effect on chlorophyll a was tested with a two-way ANOVA and not rejected (Table 2.16). The similarity in chlorophyll a concentration at various depths indicates the river near WNP-2 is vertically well mixed.

2.3 POTENTIAL ENVIRONMENTAL IMPACTS

Phytoplankton could potentially be impacted by WNP-2 via, 1) the withdrawal of river water at the intake and 2) the cooling tower discharge.

All phytoplankton which are drawn into the intake structure may be lost from the aquatic ecosystem. This loss will be small in comparison to the total population of these organisms in the Columbia River. It is estimated that the maximum intake water withdrawal (i.e., 55 cfs) will be less than 0.15% of the river volume at the lowest regulated river flow of 36,000 cfs.

Prolonged exposures to elevated temperatures and chemical concentrations have been reported to affect the growth rate survival and species composition of phytoplankton (9-11). However, the time interval in which phytoplankton will be in the WNP-2 discharge plume is too brief to cause significant change. During low river flow and a 13.9c delta temperature at the point of WNP-2 blowdown, the time intervals in which organisms would be exposed to temperatures of 2.8 and 1.4c above ambient would be approximately 5 and 35 seconds, respectively. These delta temperatures and exposure periods are below those reported to have measurable effects (9-16).

With the exception of residual chlorine, the resultant concentration of chemicals in the river after initial mixing will be at a level at which no measurable changes or detrimental effects have been reported (17, 18). The fresh water quality criteria for total residual chlorine (TRC) is 0.002 mg/ℓ (19). The TRC limitation imposed on WNP-2 is a daily maximum of 0.1 mg/ℓ. Discharges of residual chlorine from WNP-2 are expected to have no measurable impact on the plankton and aquatic invertebrates entrained in the river drift, in that maximum exposures to a concentration gradient of 0.1 to 0.002 ppm will be for an interval of approximately one minute, and then only when passage coincides with the centerline of the plume during periods of low flow (20).

3.4 PROPOSED OPERATIONAL MONITORING PROGRAM AND RATIONALE

A. Monitoring Program

No additional phytoplankton studies are recommended.

B. Rationale

There were no commercially important, rare, or endangered species of phytoplankton observed in samples collected near WNP-2 from 1974-1980.

Plants, primarily algae, are the primary form of autochthonous production in most aquatic ecosystems. Algae populations occur in rivers as phytoplankton and periphyton. In fast flowing streams or rivers like the Columbia near WNP-2, periphyton is the major form of autochthonous production (21). The food chain base in the Columbia River near WNP-2 probably consists of detritus and periphyton, not phytoplankton. Therefore, it can be concluded that phytoplankton probably do not constitute the food chain base supporting the indigenous populations of fish, and wildlife.

A diverse assemblage of algae, usually diatoms, dominates the autotrophic component of riverine systems. Attached algae usually dominate the microfloral populations in rivers, such as the Columbia. Where current velocities are strong, such as the Columbia River near WNP-2, phytoplankton productivity is probably insignificant (21). Comparisons of benthic and planktonic algae productivity indicates the benthic microflora may be more productive in the Columbia River (7).

No nuisance species were observed in significant numbers in the 1974-1980 samples. Heated water from up to nine plutonium production reactors has been added since 1944 to the Hanford Reach of the Columbia River at various times with accumulative volumes and Δt's much greater than those projected for WNP-2. No nuisance blooms of algae have been reported for this area of the river. The small incremental temperature increase in the river as a result of WNP-2 operation cannot reasonably be expected to cause a shift in the algal species composition. Thermally induced, species shifts of algae to nusiance populations normally occur at temperatures above that expected to occur downstream from WNP-2. For example, diatoms normally predominate at temperatures from 18 to 25^{o}C, green algae from 30 to 35^{o}C, and blue-green algae above 35^{o}C (22).

The average and maximum river flows entrained by the WNP-2 intake pumps are .05% and .15% respectively. Assuming homogeneous phytoplankton distribution in the river, .05-.15% of the phytoplankton population could potentially be affected by the WNP-2 intake structure. Assuming 100% phytoplankton loss, detection of such impacts is believed to be impractical.

Phytoplankton populations passively moving downstream may be entrained in the discharge plume. The relative portion of the Columbia River receiving heated water from WNP-2 operations is small. The width of the $\geq 0.6c\,\Delta T$ isotherm in the WNP-2 discharge plume is less than 2% of the cross sectional area of the Columbia River at low river flow (23). There is no mechanism operating at WNP-2 that would substantially alter the biomass or relative abundance of Columbia River phytoplankton. Given the rapid population cycling (short replacement time) of algae, any loss of cells or productivity can be expected to be naturally mitigated in a short time and the loss would not persist downstream.

Garton and Harkins (24) state that phytoplankton are essential in most aquatic systems, but due to the high variability in numbers and species composition, it is very difficult to arrive at valid conclusions using phytoplankton data unless samples are taken in greater numbers and with more frequency than will be usually practical.

Based upon the information presented above, the Columbia River near WNP-2 should be considered a low potential impact area for phytoplankton. The NRC (25) staff has stated that they are not concerned about the entrainment and/or impingement of plankton and benthic drift during operation of the WNP-2 intake. In addition, the NRC staff judges there will be no significant thermal plume impacts on aquatic biota (25).

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TABLE 2.1

Phytoplankton Taxa observed in samples collected near WNP-2, September 1974 through March 1980 (6, 7)

CHRYSOPHYTA (BACILLARIOPHYCEAE)

Asterionella formosa
Achnanthes lewisiana
A. lanceolata
A. minutissima
A. trinadis
A. exigua
A. linearis
A. cleveii
A. deflexa
A. lanceolata omissa
Amphora perpusilla
A. ovalis
Amphipleura sp.
Amphiprora sp.
A. pergalli
Amphipleura pellucida
Cymatopleura solea
Campylodiscus sp.
Caloneis sp.
Caloneis ventricosa v. (? subundulata)
C. amphisbaena
C. lewisii
C. hyalina
Cymbella tumida
C. naviculiformis
Cymbella sp.
C. turgid
C. sinuata
C. cistula
C. minuta
C. mexicana
F. crotonensis
F. construens
F. capucina
F. leprostauron
Frustulia sp.
F. rhomboides
F. vulgaris
Gomphonema sp.
G. parvulum
G. subclavatum
G. olivacedides
G. truncatum
G. ventricosum
G. olivaceum
G. olivaceum v. calcurea
C. geminatum
Gyrosigma sp.
Gyrosigma spencerii
Hannaea arcus
H. arcus v. amphioxys
Hantzschia amphioxys
Melosira spp.
M. ambigua
M. granulata
M. granulata v. angust
M. italica
M. varians
M. distans v. alpigena
M. americana
Meridion sp.
M. circulare
Navicula spp.
N. seminuloides
N. minima

CHRYSOPHYTA (BACILLARIOPHYCEAE)
(continued)

C. affinis
C. prostrata
C. muelleri
C. microcephala
Cymbellonitzschia diluviana
Cyclotella spp.
C. pseudostelligera
C. kutzingiana
C. meneghiniana
C. glomerata
C. comta
C. comensis
C. bodanica
C. satelligera
C. atomas
C. ocellata
Dinobryon divergens
Denticula sp
Diatoma sp.
D. vulgare
D. atenue v. tenue
D. hiemale v. (? mesodon)
Dipionmeis elliptica
D. puella
D. smithil v. dilatata
D. oculata
Epitahemia spp.
E. turgida
E. sorex
Eunotia sp.
E. pectinalis
Fragilaria leptostauron v. dubla
F. vaucheriue v. vaucheriae
F. leptostauron v. leptostauron
F. construens v. venter

N. tripunctata
N. cryptocephala
N. cryptocephala v. venota
N. mutica
N. arvensis
N. pupula
N. reinhardtii
N. pseudoreinhardtii
N. radiosa
N. viridula
N. peregrina
N. decussis
N. menisculus v. up.
N. capitata
N. cascadensis
N. bacillum
N. vitabunda
N. minuscula
N. infirmata
N. circumtexta
N. bacillum Ehr. v. bacillum
N. cincta
N. latens
N. mutica v. cohnii
N. mutica v. tropica
Nedium dubium
N. spp.
N. affine v. humerus
Nitzschia latens
N. paleacea
N. silica
N. palea
N. dissipata
N. innominata
N. perminuta
N. allansoni
N. frustulum

CHRYSOPHYTA (BACILLARIOPHYCEAE)
(continued)

N. osmophila
N. obsoleta
N. linearais
N. intermissa
N. acicularis
N. amphibia
N. oregona
N. fonticola
N. bacota f. lin.
N. recta
N. angustata
N. holsatica
N. gracilis
N. stagnorum
N. lauenbergiana
N. amphioxides
N. sigmoidea
N. subacicularis
N. accomodata
N. demota
N. hungarica
N. subpunctata
N. vermicularis
N. serpenticula
N. sigma v. diminuta
N. pexrtyi sp.
Opephora sp.
Pinnularia sp.
Pinnularia subcapitata v. paucisatriata
P. borealis
Rhoicosphenia curvata
Rhopalodia gibba
Rhizosolenia eriensis
Surirella spp.
S. linearis

CHRYSOPHYTA (BACILLARIOPHYCEAE)
(continued)

S. angustata
Synedra spp.
S. capitata
S. ulna
S. ulna v. chaseana
S. acus
S. delicatissima
S. rumpens
S. vaucheriae
S. parasitica
S. mazamaensis
S. cyclopum
S. pulchella
S. radians
S. socia
Stephanodiscus sp.
S. astraea
S. astrae v. min.
S. hantzschii
S. dubius
Stauroneis kriegeri
Tabellaria fenestrata
T. flocculosa

CHRYSOPHYTA (CHRYSOPHYCEAE)

Chrysococcus refescens
Cadosiga
Kephyrion spirale
K. asper
K. ovale
K. gracilis
Mallomonas alpina
Mallomonas tonsurata
Ochromonas-like
Rhizochrisis

CHLOROPHYTA

Ankistrodesmus falcatus
Actinastrum sp.
Asterococcus sp.
Botryococcus sp.
Crueicigenia quadrata
Cosmarium sp.
Cladophora sp.
Closterium acutum
C. sp.
C. gracile
Dictyosphaerium ehrenbergianum
Eudorina sp.
E. elegans
Golenkinia sp.
Kirchneriella obesa
Lagerheimia sp.
Mougeotia
Odcystis pusilla
O. lacustria
Pandorina morum
Pediastrum boryanum
P. tetras
P. duplex
Spirogyra sp.
Stigeoclonium spp.
Staurastram paradoxum
S. sp.
Scenedesmus quadicadua
S. abundans
S. acuminatus
S. longus
S. sp.
S. denticulatus
S. dimorphus
S. acutiformis
S. opoliensis
Schroederia judayi
S. setigera
Sphaerocystis schroeteri
Selanastrum minutum

CHLOROPHYTA
(continued)

S. sp.
Tetradesmus sp.
Tetraspora lacustris. lemm.
Treubaria triappendiculata
T. sp.
Ulothrix zonata
Zygnema sp.

CYANOPHYTA

Anacystis cyanea
A. montana
Anabaena sp.
Arthrosphira jenneri
A. brevis
Chroococcus sp.
Calothrix parietina
Dactylococcopsis sp.
Entophysalis rivularis
Lyngbya sp.
L. limnetica
Marssonniella sp.
Oscillatoria spp.
O. planctonica
O. limnetica
O. lutea
Oedogonium sp.
Spirulina sp.
Schizothrix calcicola
S. sp.
S fragilis
S. friesii
Plectonema sp.

RHODOPHYTA

Audouinello voilacea

PYROPHYTA

Ceratium hirundinella
Cryptomonas erosa
Glenodinium sp.
Rhodomonas minuta
R. lacustris

TWOWAY ANOVA: PHYTOPLANKTON DEN STATION1 1977-1979 BY YEAR SEAS 1

FILE (CREATION DATE = 07/29/02)
SUBFILE NONAME

TABLE 2.2

* * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * *
DEN
BY YEAR
SEASON
* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	30.449	5	6.090	11.309	0.000
YEAR	12.858	2	6.429	11.939	0.000
SEASON	17.592	3	5.864	10.889	0.000
2-WAY INTERACTIONS	9.847	6	1.641	3.048	0.023
YEAR SEASON	9.847	6	1.641	3.048	0.023
EXPLAINED	40.296	11	3.663	6.803	0.000
RESIDUAL	12.924	24	0.538		
TOTAL	53.220	35	1.521		

36 CASES WERE PROCESSED.
0 CASES (0.0 PCT) WERE MISSING.

ONEWAY ANOVA: PHYTOPLANKTON DEN STATION1 VS YEARS 1977-1979 14:00:38 07/29/82 P

FILE (CREATION DATE = 07/29/82)
SUBFILE NONAME

TABLE 2.3

- O N E W A Y -

VARIABLE DEN
BY VARIABLE YEAR

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE 0.050 LEVEL -

2.88 3.02

THE RANGES ABOVE ARE TABLE RANGES. THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
0.7820 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP77	GRP78
MEAN	7.0424	7.1284

SUBSET 2

GROUP	GRP79
MEAN	8.3510

FILE (CREATION DATE = 07/29/82)
SUBFILE NONAME

TABLE 2.4

- O N E W A Y -

VARIABLE DEN
BY VARIABLE SEASON

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE 0.050 LEVEL -

2.88 3.03 3.13

THE RANGES ABOVE ARE TABLE RANGES. THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
0.7461 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1	(Winter)	(Fall)
GROUP	GRP01	GRP04
MEAN	6.5015	7.2842

SUBSET 2	(Fall)	(Summer)
GROUP	GRP04	GRP03
MEAN	7.2842	7.8588

SUBSET 3	(Summer)	(Spring)
GROUP	GRP03	GRP02
MEAN	7.8588	8.3846

TWOWAY ANOVA: PHYTOPLANKTON DEN BY STATION DEPTH : STATIONS 1-4 ; 1974-1975 1

FILE (CREATION DATE = 06/16/82)
SUBFILE NONAME

* * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * *

DEN
BY STATION
DEPTH

TABLE 2.5

* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	872297.750	5	174459.531	0.095	0.993
STATION	869887.125	3	289962.375	0.158	0.924
DEPTH	2410.641	2	1205.320	0.001	0.999
2-WAY INTERACTIONS	199591.500	6	33265.250	0.018	1.000
STATION DEPTH	199591.469	6	33265.242	0.018	1.000
EXPLAINED	1071904.000	11	97445.813	0.053	1.000
RESIDUAL	153827968.000	84	1831285.250		
TOTAL	154899872.000	95	1630524.750		

96 CASES WERE PROCESSED.
0 CASES (0.0 PCT) WERE MISSING.

TWOWAY ANOVA: PHYTOPLANKTON DEN BY STATION DATE : STATIONS 1, 8, 11 ; 1978

FILE (CREATION DATE = 06/17/82)
SUBFILE NONAME

TABLE 2.6

* * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * *

DEN
BY STATION
DATE

* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	14045142.000	7	2006448.750	43.937	0.000
STATION	129614.063	2	64807.031	1.419	0.268
DATE	13915528.000	5	2783105.500	60.943	0.000
2-WAY INTERACTIONS	397772.000	10	39777.195	0.871	0.574
STATION DATE	397772.313	10	39777.227	0.871	0.574
EXPLAINED	14442914.000	17	849583.125	18.604	0.000
RESIDUAL	822006.000	18	45667.000		
TOTAL	15264920.000	35	436140.563		

36 CASES WERE PROCESSED.
0 CASES (0.0 PCT) WERE MISSING.

FILE (CREATION DATE = 06/17/82)
SUBFILE NONAME

TABLE 2.7

- O N E W A Y -

VARIABLE DEN
BY VARIABLE DATE

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE 0.050 LEVEL -

2.89 3.03 3.13 3.20 3.25

THE RANGES ABOVE ARE TABLE RANGES. THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
0.0968 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP GRP01 (MARCH)
MEAN 6.5954
- - - - - - - - - - -

SUBSET 2

GROUP GRP06 (AUGUST)
MEAN 7.2047
- - - - - - - - - - -

SUBSET 3

GROUP GRP05 (JULY) GRP02 (APRIL)
MEAN 7.3743 7.3946
- - - - - - - - - - - - - - - - - - -

SUBSET 4

GROUP GRP04 (JUNE)
MEAN 7.6718
- - - - - - - - - - -

SUBSET 5

GROUP GRP03 (MAY)
MEAN 7.9082

TABLE 2.8

Analysis of Variance Among Depths for Each Date and Station for Columbia River Primary Productivity Rates (mg C/ℓ/hr) for Each Station near WNP-1, 2 and 4 (1-3).

Date	Depth	Station 1	2	3	4
September 25, 1974	S	.0258	.0184	.0305*	.0135
	M	.0248	.0191	.0198*	.0172
	B	.0013*	.0015*	.0015*	.0016
December 4, 1974	S	.0041*	.0042*	.0052*	.0040*
	M	.0019	.0020	.0013	.0007
	B	.0008	.0011*	.0011*	.0009
March 11, 1975	S	.0020	.0037	.0026*	.0008*
	M	.0048	.0052	.0056*	.0041*
	B	.0024	.0031	.0014*	.0027*
June 17, 1975	S	.0244*	.0220*	.0192*	.0234*
	M	.0039	.0067	.0042*	.0055*
	B	.0016	.0023*	.0028	.0030*
July 15, 1975	S	.0254*	.0304*	.0319*	.0300*
	M	.0020	.0042	.0056	.0050
	B	.0026	.0005	.0044	.0016
August 21, 1975	S	.0238*	.0254*	.0264*	.0277*
	M	.0040	.0045	.0060	.0067
	B	.0017	.0023	.0015	.0037
September 16, 1975	S	.0292*	.0256*	.0272*	.0283*
	M	.0046	.0062	.0030	.0046
	B	.0019	.0046	.0051	.0024
December 16, 1975	S	.0020	.0032	.0019*	.0032*
	M	.0003	.0004	.0009	.0006
	B	.0011	.0008	.0020	.0005
March 29, 1976	S	.0265	--	--	--
	M	.0285	--	--	--
	B	.0040	--	--	--
June 14, 1976	S	.0337	--	--	--
	M	.0157	--	--	--
	B	.0149	--	--	--
September 21, 1976	S	.0420*	--	--	--
	M	.0186*	--	--	--
	B	.0012*	--	--	--
December 7, 1976	S	.0018	--	--	--
	M	.0017	--	--	--
	B	.0021	--	--	--

*Significantly different at the 0.05 level of probability from means of samples from other depths at this station on this date.

-- Not Sampled
S - Surface
M - Mid
B - Bottom

TABLE 2.9

Duncan's Multiple Range Test Among Stations (Values are Averages of 3 Depths) of Carbon-14 Primary Productivity Rates (mg C/ℓ/hr) for Columbia River Phytoplankton Samples Taken near WNP-1 2 and 4 (1).

	Station				
Date	1	2	3	4	Duncan's Multiple Range Test for Comparison of Means*
September 25, 1974	.0173	.0130	.0172	.0108	1 3 2 4
December 4, 1974	.0023	.0024	.0025	.0019	3 2 1 4
March 11, 1975	.0030	.0040	.0032	.0025	2 3 1 4
June 17, 1975	.0100	.0103	.0087	.0106	4 2 1 3
July 15, 1975	.0100	.0117	.0140	.0122	3 4 2 1
August 21, 1976	.0098	.0107	.0113	.0127	4 3 2 1
September 16, 1975	.0119	.0121	.0117	.0118	2 1 3 4

*Similarity of means of indicated by underlining. Differences are significant at 0.05 level of probability.

FILE (CREATION DATE = 07/29/82)
SUBFILE NONAME

TABLE 2.10

* * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * *

REP
BY YEAR
SEASON

* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	62.687	5	12.537	33.194	0.000
YEAR	15.969	2	7.985	21.140	0.000
SEASON	46.718	3	15.573	41.230	0.000
2-WAY INTERACTIONS	7.293	6	1.216	3.218	0.008
YEAR SEASON	7.293	6	1.216	3.218	0.008
EXPLAINED	69.980	11	6.362	16.844	0.000
RESIDUAL	22.662	60	0.378		
TOTAL	92.642	71	1.305		

72 CASES WERE PROCESSED.
0 CASES (0.0 PCT) WERE MISSING.

ONEWAY ANOVA:PHYTOCHLORO A STATION 1 YEARS 1977-1979   12:51:03 07/29/82 P.

FILE   (CREATION DATE = 07/29/82)

SUBFILE NONAME

TABLE 2.11

- O N E W A Y - - - - - - - - - - - - - - - - - - -

VARIABLE REP
BY VARIABLE YEAR

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE 0.050 LEVEL -

2.82 2.97

THE RANGES ABOVE ARE TABLE RANGES. THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
0.7454 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP77
MEAN	1.1291

SUBSET 2

GROUP	GRP78	GRP79
MEAN	2.0863	2.1654

ONEWAY ANOVA PHYTOCHLORO A STATION 1 SEASONS 1977-1979 13:02:41 07/29/82 P

FILE (CREATION DATE = 07/29/82)
SUBFILE NONAME

TABLE 2.12

- O N E W A Y -

VARIABLE REP
BY VARIABLE SEASON

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE 0.050 LEVEL -

2.82 2.97 3.07

THE RANGES ABOVE ARE TABLE RANGES. THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
0.5811 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN
SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1	(Winter)	(Fall)
GROUP	GRP01	GRP04
MEAN	0.8[illegible]	1.1950

SUBSET 2	(Summer)	(Spring)
GROUP	GRP03	GRP02
MEAN	2.[illegible]095	2.8266

2WAY ANOVA:STATION AND SMONTH COMPARISONS

FILE (CREATION DATE = 05/25/82)
SUBFILE NONAME

* * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * * *

CHLOR
BY STATION
SMONTH

TABLE 2.13

* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	53.730	10	5.373	1229.860	0.000
STATION	0.020	3	0.007	[redacted]	[redacted]
SMONTH	53.698	7	7.671	[redacted]	[redacted]
2-WAY INTERACTIONS	0.116	21	0.006	1.264	0.207
STATION SMONTH	0.116	21	0.006	[redacted]	[redacted]
EXPLAINED	53.846	31	1.737	[redacted]	0.000
RESIDUAL	0.690	158	0.004		
TOTAL	54.536	189	0.289		

384 CASES WERE PROCESSED.
194 CASES (50.5 PCT) WERE MISSING

2WAY ANOVA:STATION AND SMONTH COMPARISONS : 1978 1

FILE (CREATION DATE = 05/25/82)
SUBFILE NONAME

* * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * *

[redacted]

TABLE 2.14

* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	0.758	7	0.108	41.861	0.000
STATION	0.018	2	0.009	[redacted]	[redacted]
SMONTH	0.754	5	0.151	[redacted]	[redacted]
2-WAY INTERACTIONS	0.261	10	0.026	[redacted]	[redacted]
STATION SMONTH	0.261	10	0.026	[redacted]	[redacted]
EXPLAINED	1.019	17	0.060	[redacted]	0.000
RESIDUAL	0.028	11	0.003		
TOTAL	1.047	28	0.037		

72 CASES WERE PROCESSED.
43 CASES (59.7 PCT) WERE MISSING.

FILE (CREATION DATE = 05/25/82)

TABLE 2.15

SUBFILE NONAME

ONE WAY

VARIABLE CHLOR
BY VARIABLE SMONTH

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE 0.050 LEVEL -

2.92 3.07 3.17 3.23 3.28

THE RANGES ABOVE ARE TABLE RANGES. THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
0.0817 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

	(MARCH)
GROUP	GRP51
MEAN	0.7443

SUBSET 2

	(JULY)	(APRIL)
GROUP	GRP55	GRP52
MEAN	0.9201	1.0517

SUBSET 3

	(APRIL)	(AUGUST)	(JUNE)	(MAY)
GROUP	GRP52	GRP56	GRP54	GRP53
MEAN	1.0519	1.0751	1.2017	1.2093

TWO WAY ANOVA:PHYTO CHLORO A BY DEPTH AND STATION

TABLE 2.16

FILE (CREATION DATE = 07/12/82)
SUBFILE NONAME

* * * * * * * * * * A N A L Y S I S   O F   V A R I A N C E * * * * * * * * * *

REP
BY DEPTH
STATION

* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	6.435	5	1.287	0.740	0.594
DEPTH	0.712	2	0.356	0.205	0.815
STATION	5.722	3	1.907	1.097	0.351
2-WAY INTERACTIONS	0.342	6	0.057	0.033	1.000
DEPTH STATION	0.342	6	0.057	0.033	1.000
EXPLAINED	6.777	11	0.616	0.354	0.971
RESIDUAL	354.660	204	1.739		
TOTAL	361.437	215	1.681		

216 CASES WERE PROCESSED.
0 CASES (0.0 PCT) WERE MISSING.

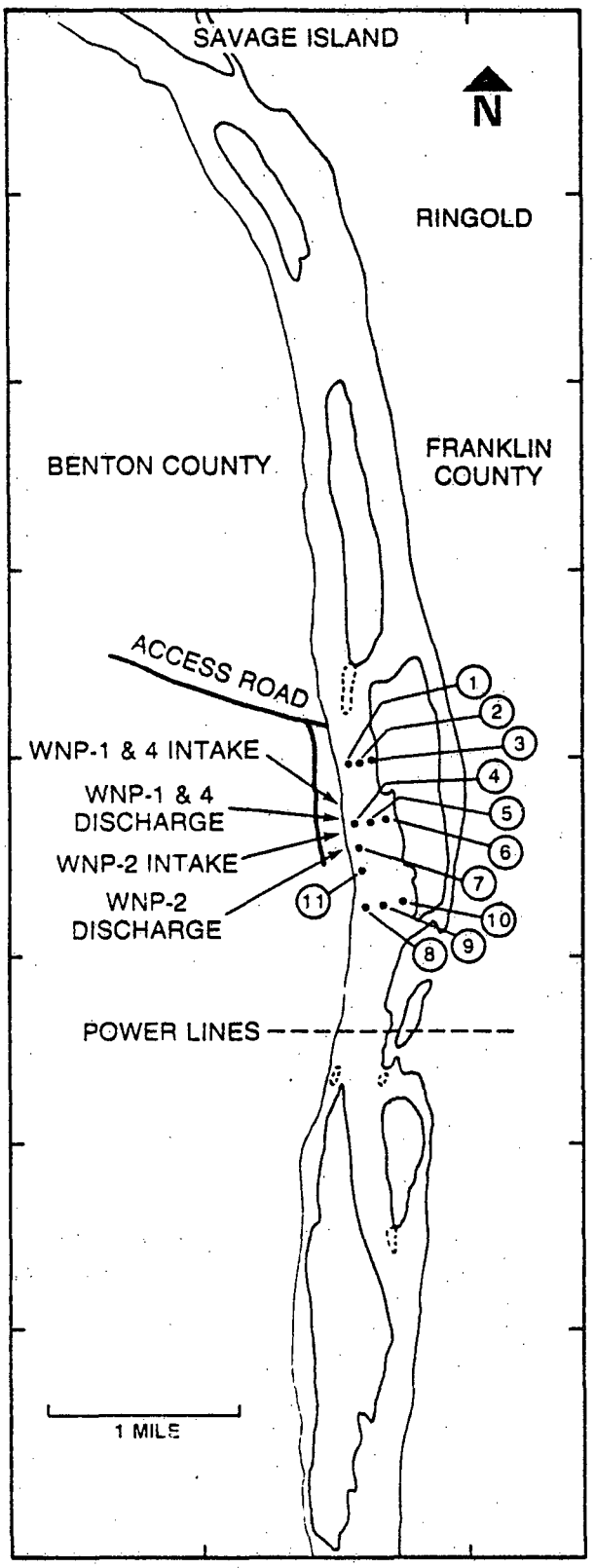
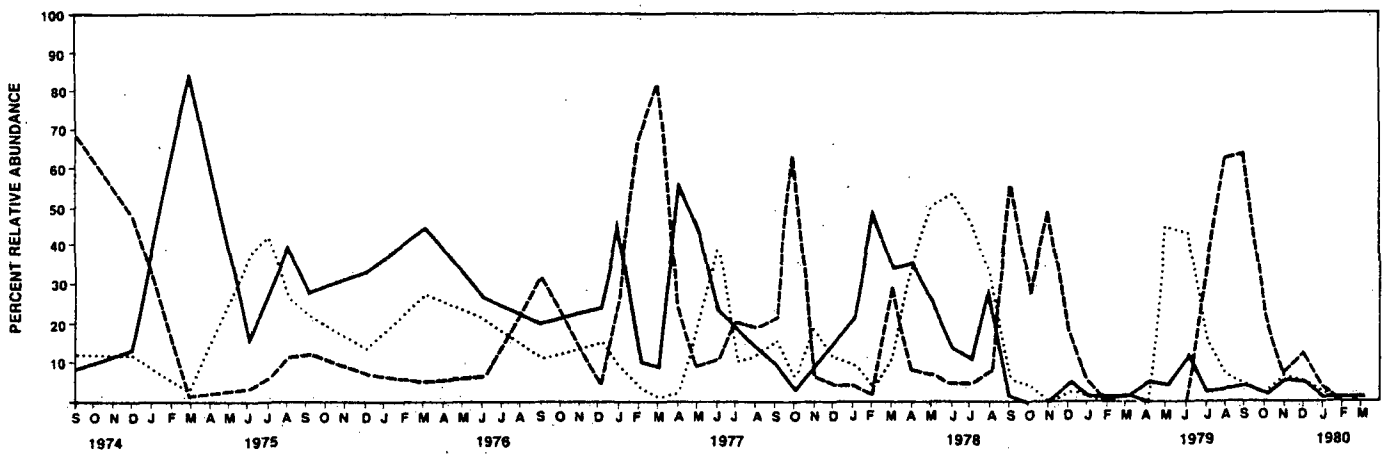


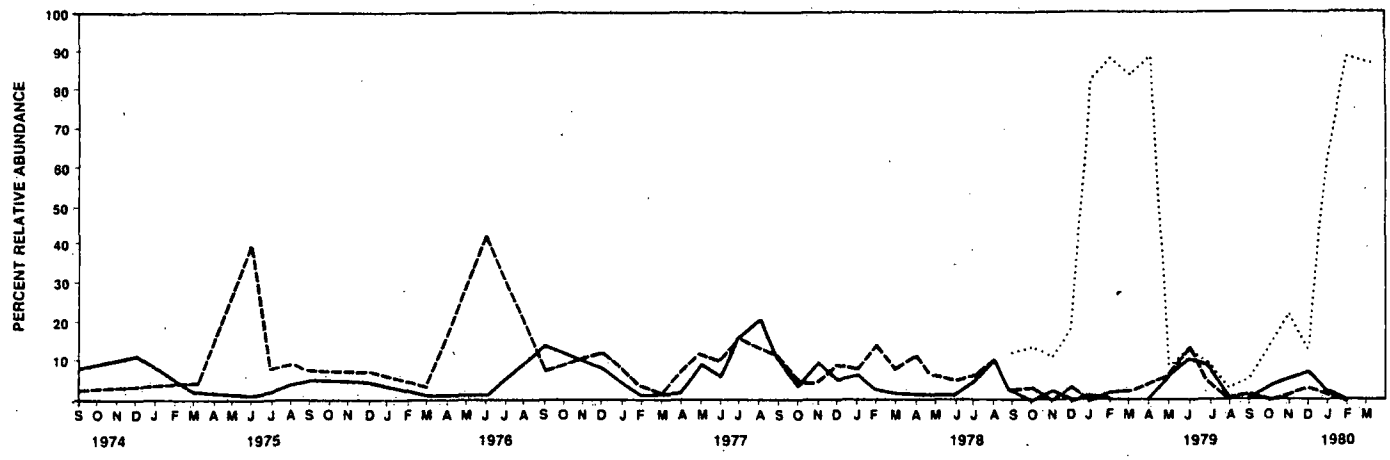
FIGURE 2.1

Columbia River near WNP 1, 2 and 4 Site (RM 352). Numbers indicate sampling stations. The river flow is from north to south.

821325



KEY
- CYCLOTELLA SP.
- MELOSIRA SP.
- ASTERIONELLA SP.



KEY
- FRAGILARIA SP.
- SYNEDRA SP.
- STEPHANODISCUS SP.

FIGURE 2.2 RELATIVE ABUNDANCE OF DOMINANT PHYTOPLANKTON ORGANISMS COLLECTED NEAR WNP-2

821444-1A

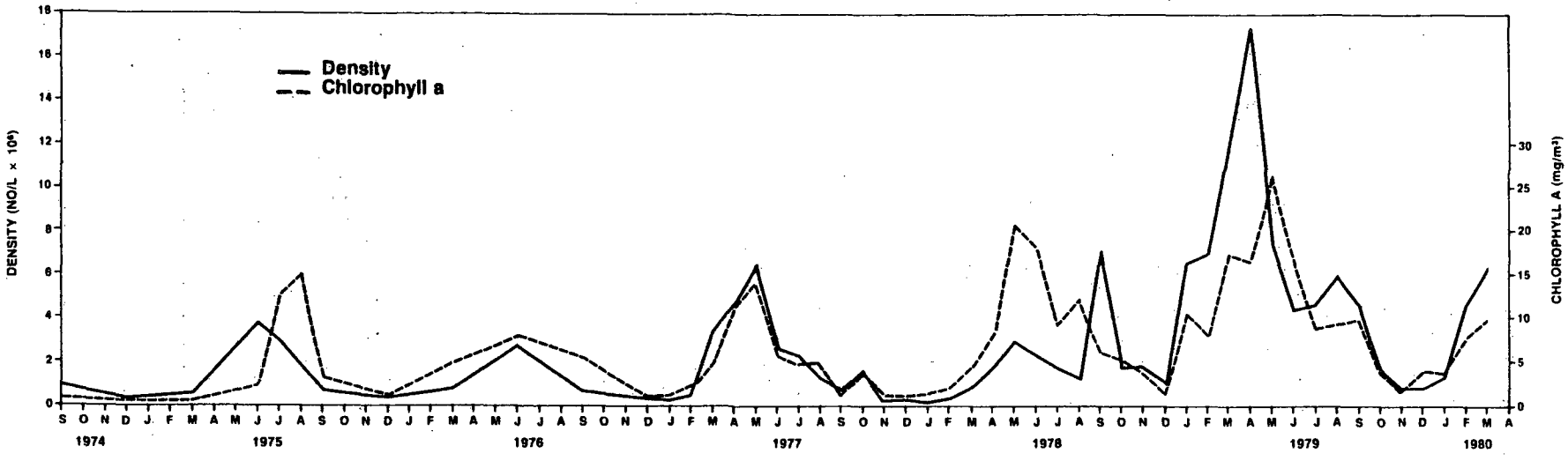


FIGURE 2.3 PHYTOPLANKTON DENSITY AND CHLOROPHYLL A NEAR WNP-2: STATION 1 September 1974 - March 1980

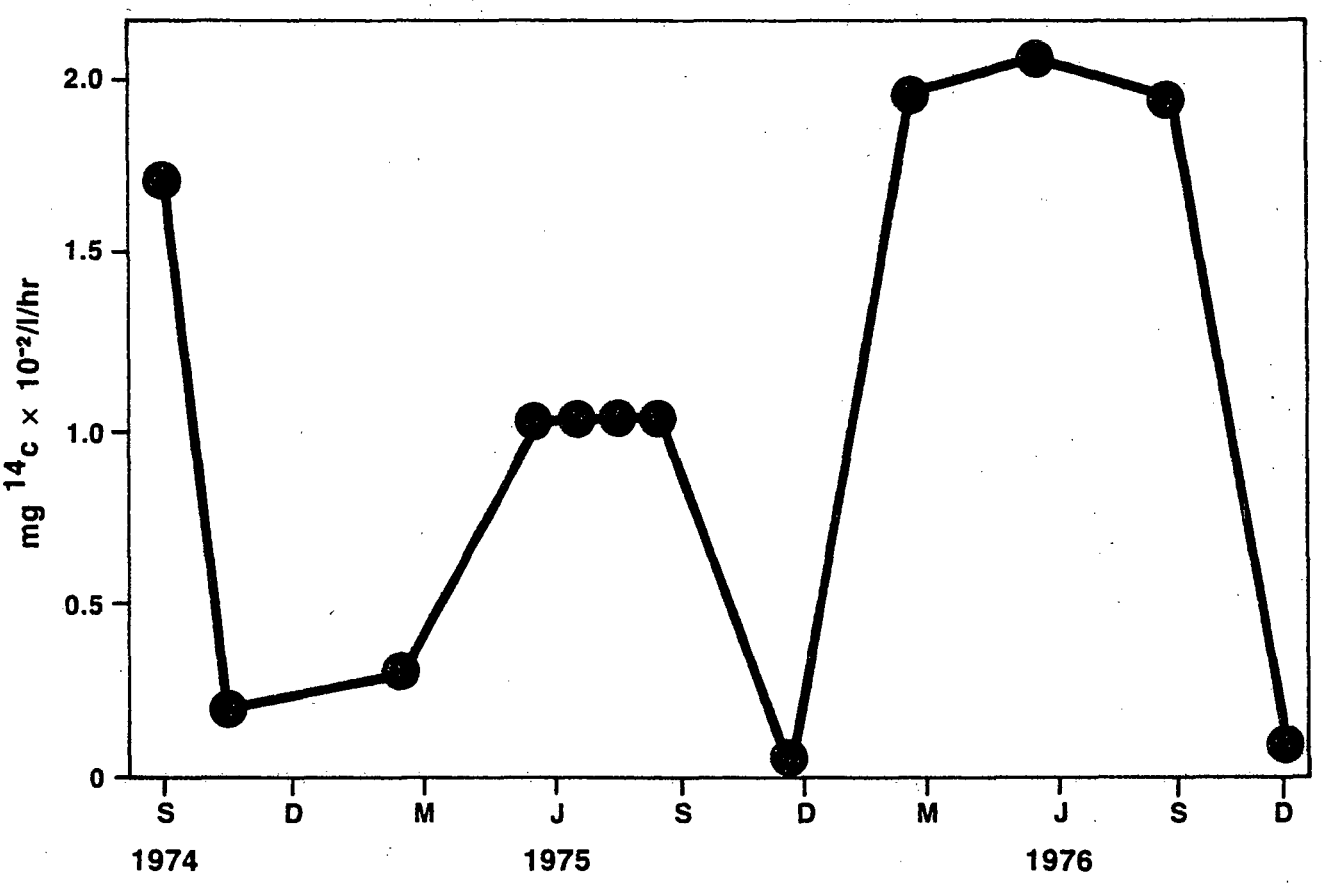


FIGURE 2.4 Primary Productivity Rates (mg ^{14}C/l/hr) for Columbia River Phytoplankton Collected at Station 1 near WNP 1, 2 and 4

821520

3.0 ZOOPLANKTON

3.1 HISTORICAL SUMMARY

Zooplankton samples were collected from the Columbia River near WNP-2 from December 1974 through March 1980[1-6]. Study objectives included: 1) determination of species composition, density, and relative and seasonal abundance; and 2) collect preoperational data for future assessments of potential operational impacts.

A 153 micron mesh net with a 0.3 meter diameter mouth and a 5:1 length to diameter ratio was used to take duplicate stepped oblique zooplankton tows. Samples were taken once in 1974, six times in 1975, quarterly in 1976 and once each month from January 1977 through March 1980[7]. Tows were taken at Stations 1, 2, 3, 5 and 6 from December 1974 through December 1975 (Figure 3.1). Station 1 was sampled from March 1976 through March 1980. Tows were also made at Stations 8 and 11 from March through August 1978.

3.2 TECHNICAL SUMMARY

Fifty-eight zooplankton taxa were observed in samples collected from December 1974 through March 1980 (Table 3.1: 6, 7). Seasonal relative abundance was dominated by Bosmina, Cyclops and Diaptomus (Figure 3.2: 6, 7). Bosmina dominated the July through September samples except in 1976 and percent relative abundance ranged from 41.8 to 78.5. Generally, Cyclops dominated the spring and early summer samples. Percent relative abundance ranged from 0.6 to 79.6. Diaptomus generally predominated in the winter and early spring, and percent relative abundance during this time ranged from 4.1 to 57.3. Rotifera dominated the late winter and early spring 1977 samples.

Average numbers of zooplankton per cubic meter (no/m^3) ranged from less than 10 in December 1974 to 4702 in August 1977. Zooplankton densities generally followed a trend of winter minimums and late spring and early summer maximums (Figure 3.3). In 1977 and 1979 maximum values occurred in August. The dramatic density increase found in the summer of 1977 was probably influenced by extremely low river discharges that year. The 1977 mean river flow (cfs) at Priest Rapids was 84,530 compared to a range from 113,200 to 145,900 in the years 1974-1978 (8-12). Reduced flows can result in higher plankton densities by increasing residence time of the water, permitting more production, and decreasing the export of plankton (13).

The null hypothesis of no year or season effects was tested with a two-way ANOVA. The analysis was performed on the largest available consistent data set - station 1 from 1977 through 1979. Seasons were defined as: 1) December, January, February = Winter; 2) March, April, May = Spring; 3) June, July, August = Summer; 4) September, October, November = Fall. Duncans multiple range test was used to identify years or seasons which differed significantly.

The null hypothesis of no year effect was rejected at the 0.05 level while that for seasons was rejected at the 0.01 level (Table 3.2). Duncan's test indicates that there are two seasonal groupings: Fall-winter and spring-summer (Table 3.3). Duncans test was not sufficiently sensitive to identify which years were statistically different from the others.

In 1974, 1975 and 1978 Stations 1-3, 1-3 and 5-6, and 1, 8 and 11 respectively were sampled. In an effort to identify any station differences a one way ANOVA test was performed. Tables 3.4 through 3.6 show that the stations were not significantly different at the five percent level. The results suggest that the sample stations are quite similar in regard to zooplankton density.

3.3 POTENTIAL ENVIRONMENTAL IMPACTS

Zooplankton could potentially be impacted by WNP-2 via, 1) the withdrawal of river water at the intake and 2) the thermal component of the cooling tower discharge.

All zooplankton which are drawn into the intake structure may be lost from the aquatic ecosystem. This loss will be small in comparison to the total population of these organisms in the Columbia River. It is estimated that the maximum intake water withdrawal (i.e. 55 cfs) will be less than 0.15% of the river volume at the lowest regulated river flow of 36,000 cfs.

Prolonged exposures to elevated temperatures have been reported to affect the growth rate survival and species composition of zooplankton in the area of thermal discharges (14-18), however, the time interval in which zooplankton will be in the WNP-2 thermal plume is too brief to cause significant change. During low river flow and a 13.9c delta temperature at the point of WNP-2 blowdown, the time intervals in which organisms would be exposed to temperatures of 2.8 and 1.4c above ambient would be approximately 5 and 35 seconds, respectively. These delta temperatures and exposure periods are below those reported to have measurable effects (19-21).

3.4 PROPOSED OPERATIONAL MONITORING PROGRAM AND RATIONALE

A. Monitoring Program

No additional zooplankton studies are recommended.

B. Rationale

There are no commercially important, rare, or endangered species of zooplankton observed in samples collected near WNP-2 from 1974-1980.

The most common fish species near WNP 2 are opportunistic feeders and utilize zooplankton only on occassion. Macroscopic and microscopic analysis of gut contents from fish collected near WNP-2 from 1974 through 1977 indicate zooplankton are a minor component of the diet for the more common fish in the Columbia River (3-5).

The average and maximum river flows entrained by the WNP-2 intake pumps are .05% and .15% respectively. Assuming homogeneous zooplankton distribution in the river, .05-.15% of the zooplankton population could potentially be affected by the WNP-2 intake structure. Assuming 100% zooplankton loss, detection of such impacts is believed to be impractical.

Zooplankton populations passively moving downstream may be entrained in the discharge plume. The relative portion of the Columbia River receiving heated water from WNP-2 operations is small. The width of the 0.6c isotherm in the WNP-2 discharge plume is less than 2% of the cross sectional area of the Columbia River at low river flow (22).

Garton and Harkins (23) state that zooplankton are essential in most aquatic systems, but due to the high variability in numbers and species composition, it is very difficult to arrive at valid conclusions using zooplankton data unless samples are taken in greater numbers and with more frequency than will be usually practical. In addition, they state that in a body of flowing water, the zooplankton at any spot are largely the product of upstream conditions and not of conditions at the point of sampling. They conclude that zooplankton data at potential sites of heat discharges into flowing waters are of dubious worth.

Based upon the information presented above the Columbia River near WNP-2 should be considered a low potential impact area for zooplankton. The NRC (24) staff has stated that they are not concerned about the entrainment and/or impingement of plankton and benthic drift during operation of the WNP-2 intake. In addition, the NRC staff judges there will be no significant thermal plume impacts on aquatic biota (24).

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Table 3.1 Taxanomic categories of Columbia River zooplankton collected near WNP-2 from December 1974 through March 1980 (6, 7).

Coelenterata
- Hydra spp.

Bryozoa
- Ectoprocta
  - Paludicellidae
    - Paludicella articulata

Annelida
- Oligochaeta
- Hirudinea

Aschelminthes
- Nematoda
- Rotifera
  - Brachionidae
    - Kellicottia longispina
    - Kellicottia spp.
    - Keratella cochlearis
    - Keratella spp.
    - K. quadrata spp.
    - Brachionus spp.
    - Euchlanis spp.
  - Lecanidae
    - Lecane spp.
  - Synchaetidae
    - Synchaeta spp.
    - Polyarthra sp.
  - Testudinellidae
    - Testudinella spp.

Arthropoda
- Tardigrada
- Crustacea
  - Cladocera
    - Leptodoridae
      - Leptodora kindtii
    - Sididae
      - Sida crystallina
      - Latona spp.
      - Diaphanosoma spp.
    - Daphnidae
      - Daphnia spp.
      - Ceriodaphnia spp.
    - Bosminidae
      - Bosmina spp.
      - Bosmina longirostris
    - Macrothricidae
      - Macrothrix spp.
      - Ilyocryptus spp.
    - Chydoridae
      - Pleuroxus spp.
      - Alona spp.
      - Chydorus spp.
    - Eurycercinae
  - Ostracoda
  - Copepoda
    - Cycolpoid copepodid
    - Copepoda nauplii
    - Calanoida
    - Temoridae
      - Epischura spp.
      - Temoridae copepodid
    - Diaptomidae
      - Diaptomus spp.
      - D. ashlandi
    - Cyclopoida
      - Cyclopidae
        - Cyclops spp.
        - Bicuspidatus thomasi
    - Harpacticoida
    - Amphipoda
  - Acari
  - Insecta
    - Plecoptera
    - Collembola
    - Ephemeroptera
    - Trichoptera
      - Rhyacophilidae
      - Hydropsychidae
    - Diptera
      - Chironomidae
      - Simuliidae
        - Simulium sp.

Platyhelminthes
- Turbellaria
  - Dugesia sp.

Protozoa
- Vorticella sp.

Arachnida
- Hydracarina

2WAYANOVA: ZOOPLANTON DEN BY YEAR, SEASON

FILE (CREATION DATE = 06/02/82)
SUBFILE NONAME

TABLE 3.2

* * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * *

DEN
BY YEAR
SEASON

* *

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	54.370	5	10.874	13.280	0.000
YEAR	6.256	2	3.128	3.820	0.028
SEASON	48.114	3	16.038	19.587	0.000
2-WAY INTERACTIONS	23.279	6	3.880	4.738	0.001
YEAR SEASON	23.279	6	3.880	4.738	0.001
EXPLAINED	77.649	11	7.059	8.621	0.000
RESIDUAL	44.216	54	0.819		
TOTAL	121.865	65	1.875		

72 CASES WERE PROCESSED.
6 CASES (8.3 PCT) WERE MISSING.

ONEWAY ANOVA: DEN VS SEASON 09:31:52 06/02/82 PAGE

FILE (CREATION DATE = 06/02/82)
SUBFILE NONAME

TABLE 3.3

- O N E W A Y -

VARIABLE DEN
BY VARIABLE SEASON

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE 0.050 LEVEL -

2.83 2.97 3.07

3-11 THE RANGES ABOVE ARE TABLE RANGES. THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
0.7712 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

	(Winter)	(Fall)
GROUP	GRP01	GRP04
MEAN	4.5131	4.7649

SUBSET 2

	(Spring)	(Summer)
GROUP	GRP02	GRP03
MEAN	6.0546	6.5166

ONEWAY ANOVA: DEN VS STATION: 1974

TABLE 3.4

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FILE (CREATION DATE = 06/02/82)
SUBFILE NONAME

- O N E W A Y -

VARIABLE DEN
BY VARIABLE STATION

ANALYSIS OF VARIANCE

SOURCE	D. F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	2	0.1173	0.0586	1.288	0.3947
WITHIN GROUPS	3	0.1366	0.0455		
TOTAL	5	0.2538			

ONEWAY ANOVA: DEN VS STATION: 1975

TABLE 3.5

13:31:03 06/02/82 PAGE

FILE (CREATION DATE = 06/02/82)
SUBFILE NONAME

ONEWAY

VARIABLE DEN
BY VARIABLE STATION

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	4.9880	1.2470	1.096	0.3760
WITHIN GROUPS	31	35.2816	1.1381		
TOTAL	35	40.2696			

ONEWAY ANOVA: DEN VS STATION: 1978 TABLE 3.6 14:23:55 06/02/82 PAG

FILE (CREATION DATE = 06/02/82)
SUBFILE NONAME

- O N E W A Y -

VARIABLE DEN
BY VARIABLE STATION

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	2	0.1695	0.0848	0.230	0.7957
WITHIN GROUPS	33	12.1534	0.3683		
TOTAL	35	12.3229			

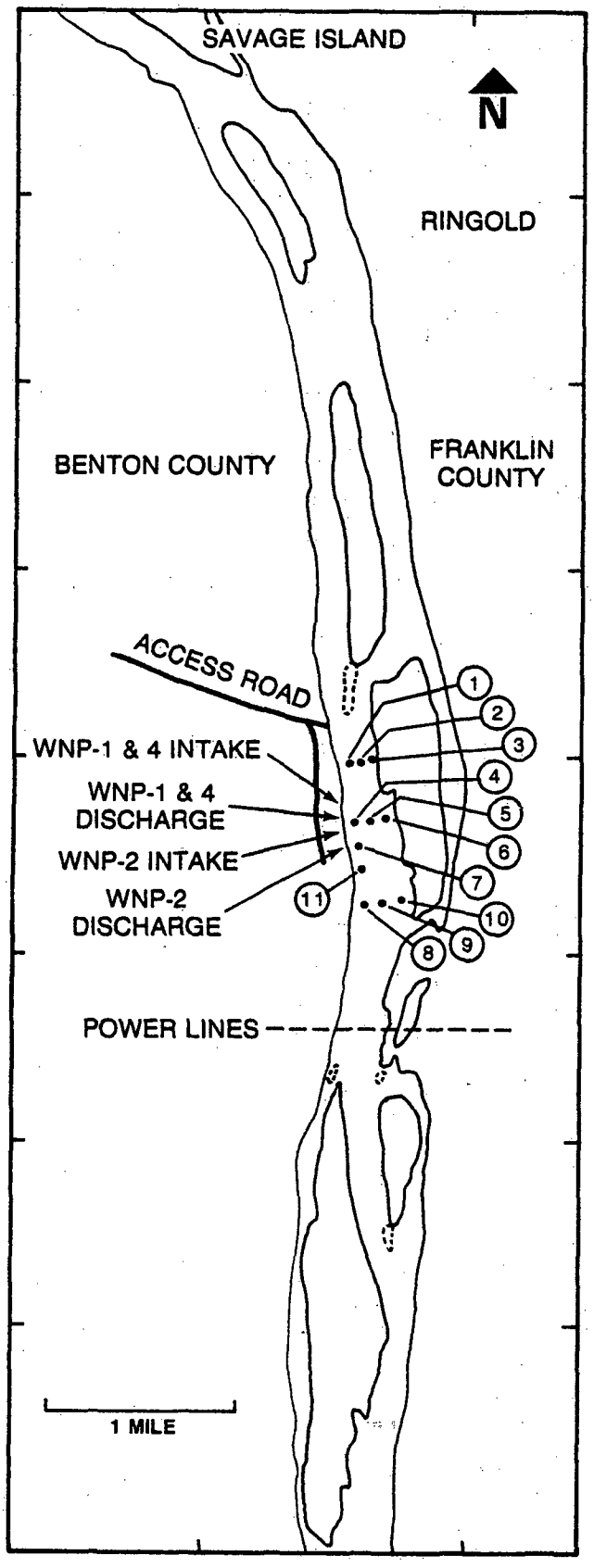


FIGURE 3.1

Columbia River near WNP 1, 2 and 4 Site (RM 352). Numbers indicate sampling stations. The river flow is from north to south.

821325

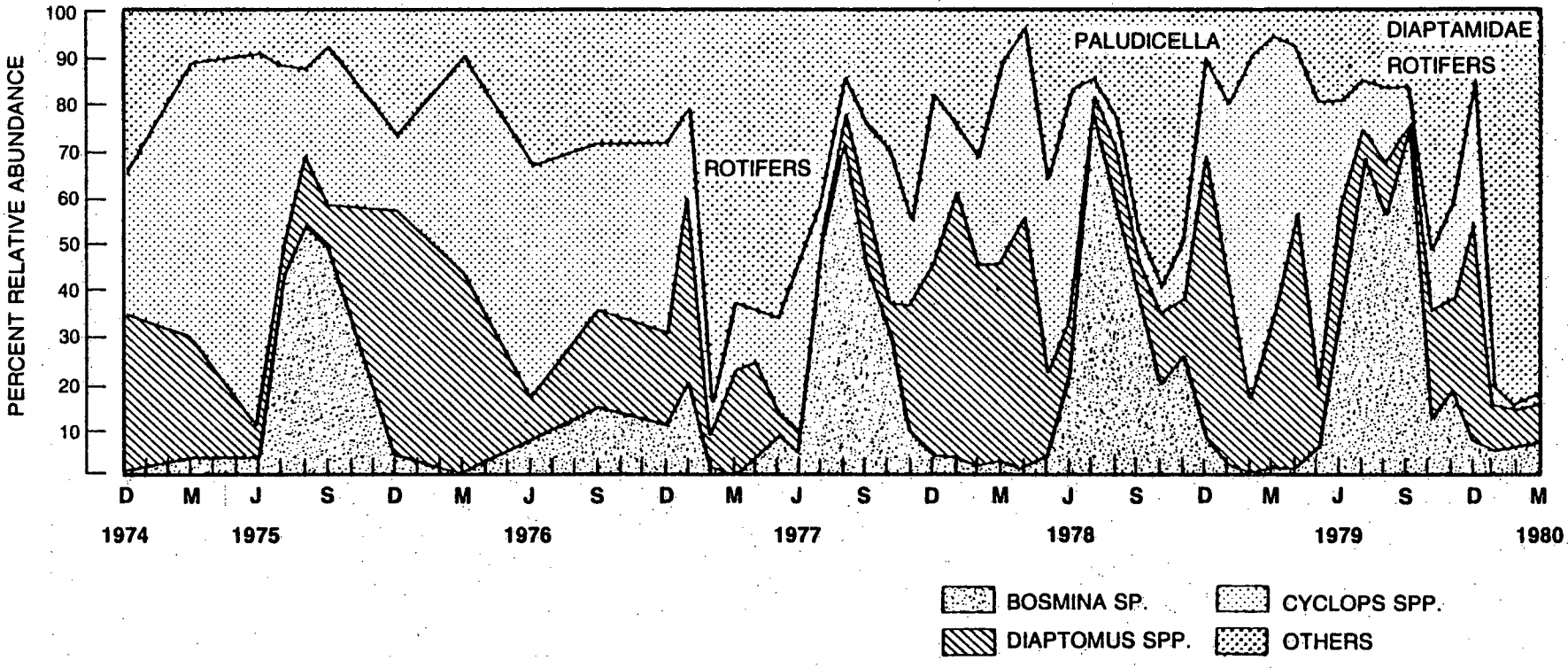
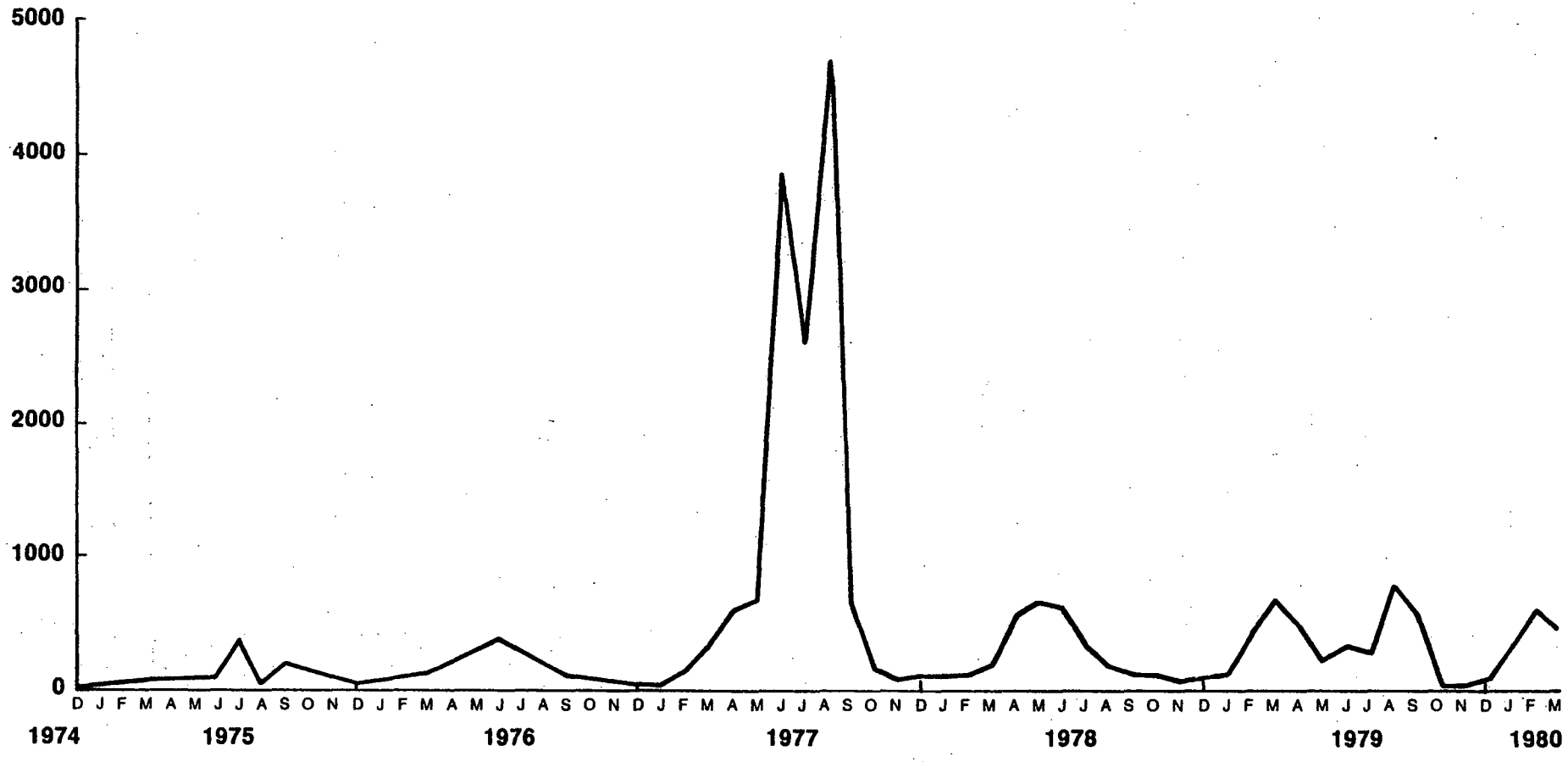


FIGURE 3.2 RELATIVE ABUNDANCE OF DOMINANT ZOOPLANKTON ORGANISMS COLLECTED FROM STATION 1 NEAR WNP-2 (MODIFIED FROM REFERENCES 6.7).

FIGURE 3.3

ZOOPLANKTON DENSITY FOR STATION 1, NEAR WNP-2



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4.0 PERIPHYTON

4.1 HISTORICAL SUMMARY

Periphyton samples were collected from the Columbia River in the vicinity of WNP-2 from March 1977 through March 1980 (1-6). Study objectives included: 1) determination of species composition, density, and relative abundance; and 2) collection of preoperational data for future assessments of potential operational impacts.

Eight stations were sampled on a quarterly basis over the study period (Figure 4.1). Most stations were sampled regularly, but only station eight was sampled on all collection dates.

Stations were situated such that one was 200m upstream of the WNP-2 cooling system intake, six others were spaced over the length and breadth of the expected area of the discharge plume, and another was 310m downstream of the discharge beyond the plume.

Samples were collected using glass slide diatometers emplaced and retrieved by scuba divers (1). Four variables were measured from these samples: 1) density (taxonomic abundance), 2) dry weight, 3) total organic matter (TOM), and 4) chlorophyll *a* (1).

4.2 TECHNICAL SUMMARY

4.2.1 Species Composition and Abundance

The periphyton community composition was determined from density data. Unfortunately different powers of magnification were used for microscopic identification before and after August 1978, rendering these two periods not directly comparable (6).

From March 1977 through June 1978, 39 genera and 3 groups identifiable only to a higher taxon were encountered on diatometers (Table 4.1). In terms of relative abundance diatoms predominated, and small pennate diatoms were the most abundant single group, comprising from 21 to 67 percent of the total density on four of six collection dates. Other common forms during this time period were Melosira spp., Gomphonema sps., Cyclotella spp., Cymbella spp., and Cocconeis spp. (Table 4.1).

From August 1978 through March 1980 at least 162 taxa, including 155 identifiable to species were encountered (Table 4.2). Once again diatoms were dominant in most cases, with the blue-green algae Schizothrix sp. and Plectonema sp. being the only other occasionally numerous forms. On June of 1979 Schizothrix sp. was numerically dominant.

Dominant species for each of the samples taken from August 1978 through March 1980 were as follows: the centric diatom Cyclotella glomerata (August 1978); the diatoms Achnanthes sinutissima and Cocconeis placentula (December 1978); the diatom Gomphonema olivaceum (March 1979); the filamentous blue-green Schizothrix #2 (June 1979); Cocconeis placentula (September 1979); the diatom Achnanthes deflexa (December 1979); and the diatoms Gomphonema olivaceoides, Nitzchia frustulum and Stephanodiscus hantzschii (March 1980).

Typical planktonic forms were observed together with the benthic microflora (attached algae or periphyton) and often at high density. This occurred especially in June 1979 and March 1980 when the planktonic centric diatoms Stephanodiscus hantzschii and Melosira italica and the planktonic colonial diatoms Asterionella formosa and Fragilaria crotonesis were dominant or very abundant. The planktonic centric diatom Cyclotella glomerata was dominant in August 1978. During their periods of greatest abundance these planktonic forms sedimented out of solution onto the bottom and constituted a larger proportion of the microflora on the slides than at other times of the year when phytoplankton densities were low.

Average total densities of periphyton ranged from 648 cells/cm^2 (Station 11M, June 1978) to 1,796,817 cells/cm^2 (station 8, March 1979). Values were typically between 100,000 and 1,500,000 cells/cm^2.

The general seasonal trend was a summer low with a spring or winter peak in abundance (Figure 4.2). This pattern persisted for all seasons at station eight, the only location sampled on every collection date, but was less consistent for other stations. Stations 8 and 11W were depicted because they were frequently sampled and followed patterns representative of all stations.

A three factor ANOVA was used to test the hypotheses that there were no differences in density between years, seasons, and stations. Seasons were defined as: December, January, February = winter; March, April, May = spring; June, July, August = summer; September, October, November = fall. Three collection dates, March and June 1977, and December 1979 were excluded from the analysis because of insufficient sampling. The data were log transformed ($\log_{10}$ (x)) to better meet the assumptions of the ANOVA.

All three main effects were found to be significant. Year and season effects were significant at the 1 percent level of α, and the station effect was significant at the 5 percent level (Table 4.3). Differences between stations on individual sampling dates were evaluated via DMRT. These comparisons show significant differences between stations (α=.05) on several occasions (Table 4.4). Some relationships occurred repeatedly: for instance, the mean density at station 11E was lowest or next to lowest of all stations six of the eleven times it was sampled; and the mean density at station eight was the highest of all stations on six of thirteen collection dates. However, changes in relative station ranks followed no discernible pattern and reasons for the observed differences are unclear. The lack of statistically significant differences in most comparisons reflects that variability within stations often exceeded variability between stations.

4.2.2 Periphyton Biomass

Periphyton biomass was measured in terms of total organic matter (TOM, g/m^2) and chlorophyll *a* (mg/m^2). Dry weight was used only to calculate TOM.

Values of TOM ranged from 0.13 g/m^2 (station 11M, June 1978) to 26.7 g/m^2 (station 11W, September 1977). The general seasonal pattern was a summer low with peak values occurring during fall and winter (Figure 4.3). Unlike density, spring values of TOM also tended to be low.

A three factor ANOVA was used to test the hypotheses that there were no differences in TOM between years, seasons, and stations. Seasons were defined as for density, and once again, March 1977, June 1977, and December 1979 were excluded due to insufficient sampling.

Year and season effects were found to be significant (α=.01), but station was not (Table 4.5). A two factor ANOVA grouping stations by sampling date allowed a more powerful test of station differences, however, and when this analysis was performed this effect was also significant (=.05) (Table 4.5).

Seasonal patterns for chlorophyll *a* were not consistent over the duration of the study period (Figure 4.4): prior to August 1978 levels were relatively high and stable, ranging from 68 mg/m^2 (station 8, March 1977) to 129 mg/m^2 (station 8, June 1978); but from August 1978 through March 1980 chlorophyll *a* levels fluctuated seasonally, ranging from 1.7 mg/m^2 (station 7M, June 1979) to 120 mg/m^2 (station 7M, March 1980). Seasonal fluctuations over the latter period closely paralleled those of density, i.e. rising from a summer low to a spring high.

A three factor ANOVA was used to test the hypotheses that there were no differences in chlorophyll *a* between years, seasons, and stations. The season definitions and the sampling dates were the same as those used for the periphyton density and TOM analysis.

Year and season effects were significant (α=.01) for chlorophyll a, but station was not (Table 4.6). As for TOM, the station effect was shown to be significant (α=.05) when tested via two way ANOVA, with stations grouped by sampling dates (Table 4.6).

Differences in TOM and chlorophyll a between individual stations were examined using DMRT. On several dates significant differences were detected between stations for both measures of biomass (Table 4.7), and as with density station eight frequently ranked high for TOM and chlorophyll a. Most differences were not significant though, and changes in relative rank followed no discernible pattern.

The concordance of fluctuations in periphyton density, TOM, and chlorophyll a was examined via correlation analysis. The 5 percent level of significance was applied unless otherwise stated. Over all samples (all stations and dates) there were low but significant correlations between density and chlorophyll a (r=.291), and TOM and chlorophyll a (r=.226), but the correlation between density and TOM was not significant (r=.081).

Because chlorophyll a seasonal patterns differed markedly before and after August 1978, correlations were also performed with these periods as separate data sets. When treated as such, the correlation between density and chlorophyll "a" was not significant for the earlier period (r=.04), but was highly significant (α=.01) for the latter (r=.771). Between TOM and chlorophyll a the correlation was significant and negative before August 1978 (r=.366), but not significant after (r=.155). Correlations between density and TOM were not significant in either case (r=.128, r=.280, respectively).

The variability of the TOM and chlorophyll a sampling methods was compared by way of coefficients of variation (CV=S/x) calculated from replicate measurements. The coefficients of variation were similar for

both methods, with mean values being .23 and .21 for TOM and chlorophyll a, respectively. A Mann-Whitney U test showed that these values were not significantly different (α=.05).

4.3 POTENTIAL ENVIRONMENTAL IMPACTS

Periphyton could potentially be impacted by the thermal and chemical components of the cooling tower discharge. During preoperational sampling, diatoms have dominated the benthic microflora in the area of the WNP-2 discharge due to favorable environmental conditions, including water temperatures less than 30°C(7).

Elevated water temperatures may result in increased biomass, reduced species diversity, or changed species composition (7-10), but changes, if any, are expected to be small. A study of the thermal tolerance of Columbia River periphyton found that an increase of as much as 10°C above ambient river temperatures significantly changed (increased) biomass only during a short period in winter, with the domination of diatoms persisting (9). Due to the rapid dilution of discharge water in the mixing zone, thermal conditions that could measurably affect the natural periphyton community will be experienced only in the immediate vicinity of the outfall within the 1.4°C isotherm. Even under extreme conditions (river flow 36,000 cfs, blowdown = 4000 gpm) this zone is expected to extend less than 20 feet downstream of the discharge (11).

With the exception of residual chlorine, the resultant concentration of chemicals in the river after initial mixing will be at a level at which no measurable changes or detrimental effects have been reported (13, 14).

Intermittent discharges of residual chlorine will have rapid dilution and be reduced further by the chlorine demand of the water. During periods of low flow, an effluent concentration of 0.1 ppm would be diluted to 0.01 ppm approximately 15 feet downstream from the point of discharge; while levels of approximately 0.01 ppm would occur in an area represented by the 1.4°C isotherm and less than 0.002 ppm in an area outside of the 0.28°C isotherm (12).

The tolerance of aquatic organisms to chlorine is species specific, with the effective concentration causing mortality or detrimental effects somewhat dependent on the chemical forms, and markedly affected by the duration of the exposure.

Intermittent residual chlorine concentrations of 0.1 ppm may have an algistatic effect on periphyton (15, 16) in the immediate vicinity of the outfall, i.e., within an area 15 feet below the discharge, with the actual area affected depending upon the persistence of residual chlorine in the blowdown.

4.4 PROPOSED OPERATIONAL MONITORING PROGRAM AND RATIONALE

Periphyton will continue to be studied as an indicator of environmental quality near WNP-2 for several reasons. It forms a vital link in the aquatic food chain and is sensitive to thermal and chemical discharges. Because periphyton is attached to the substrate, any impact that occurs tends to be largest at its source, making its cause more easily identifiable. Also, the variability of periphyton samples taken during the preoperational phase at WNP-2 is low enough to indicate that it will be a suitable environmental indicator.

It is extremely important to the success of an environmental monitoring program to maintain consistent methods and to have data over an equal time span for preoperational and operational periods (17-19). Therefore, the basic periphyton monitoring program (core program) will be continued with sampling schedules, locations, and methods mostly the same as in

the past (Table 4.8). The only changes in this program will be to discontinue measuring periphyton chlorophyll a; and to initially analyze periphyton samples only for biomass (TOM). There are several reasons for discontinuing chlorophyll a: biomass will already be measured as TOM; chlorophyll a levels are affected by many variables that are not easily measured or controlled; and, inconsistencies in past chlorophyll a data make its interpretation difficult. If a significant impact is suspected, further analysis for densities and species composition can be performed on preserved samples. Neither of these changes will impair the ability of the program to detect significant impacts.

Periphyton studies will begin at fuel load and will be conducted for three years during the operation of WNP-2. This will allow enough time to account for yearly variability in the biota and physical conditions, and will provide a data set that is balanced in terms of time for preoperational and operational periods. If no significant impact has been detected within three years, the study will be terminated.

Because the impact of WNP-2 on the aquatic environment is expected to be small, the core periphyton program is not likely to delimit its extent very precisely. To accomplish this, a supplemental study will be conducted close to the cooling tower discharge where any detectable impact is most likely to occur. A string of periphyton stations will be established at 6.1m intervals along the center-line of the discharge plume, extending downstream 30.5m from the discharge port (Figure 4.5). These stations will be exposed to a gradient of thermal and chemical conditions resulting from the spreading and mixing of the discharge plume. Two control stations, also 6.1m apart, will be established at location 1, upstream of the discharge. Sampling and analysis methods will be the same as for the rest of the periphyton program, but samples will be collected every 6 weeks to provide a larger sample size and more thorough seasonal coverage (Table 4.8).

Sampling will begin at fuel load and continue for three years during the plant operational phase: if no significant impact has been detected in that time, the study will be terminated.

4.5 REFERENCES

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TABLE 4.1

Columbia Rever Benthic Microflora from Glass Slides Collected near WNP-1, 2, and 4 (RM 352) in 1977 and 1978.

Chrysophyta

Amphipleura sp.
*Amphora sp.
Asterionella sp.
Caloneis sp.
Cocconeis sp.
Cyclotella spp.
Cymatopleura sp.
Cymbella spp.
Diatoma sp.
Dinobryon sp.
Diploneis sp.
Epithemia spp.
Fragilaria spp.
Frustulia sp.
Gomphonema spp.
Gyrosigma sp.
Hannaea sp.
Melosira spp.
Navicula spp.
Nitzschia spp.
Rhizosolenia sp.
*Rhoicosphenia sp.
Rhopalodia sp.
**Hantzschia spp.
Small pennate diatoms
Stephanodiscus spp.
Synedra spp.
Surirella sp.
Tabellaria sp

Chlorophyta

Ankistrodesmus sp.
Closterium sp.
Cosmarium sp.
Pediastrum spp.
Scenedesmus spp.
Staurastrum sp.
Stigeoclonium sp.
Treubaria sp.

Cyanophyta

Anabaena sp.
Plectonema sp.
Unknown bluegreen

*Not observed in 1977 phytoplankton collections (Tables 2.3).
**Observed in 1978 periphyton collection only.

TABLE 4.2

Columbia River benthic microflora collected in the vicinity of WNP-1, 2, and 4, August 1978 to March 1980.*

ALGAL DIVISION/SPECIES

CHRYSOPHYTA (BACILLARIOPHYCEAE)

Melosira ambiqua
Melosira granulata
Melosira granulata v. angust.
Melosira italica
Melosira varians
Melosira distans v. alpigena
Stephanodiscus astraea
Stephanodiscus astraea v. min.
Stephanodiscus hantzschii
Stephanodiscus dubius
Cyclotella stelligera
Cyclotella pseudostelligera
Cyclotella kutzingiana
Cyclotella meneghiniana
Cyclotella glomerata
Cyclotella comta
Cyclotella comensis
Tabellaria fenestrata
Diatoma tenue
Diatoma vulgare
Asterionella formosa
Opephora martyi
Fragilaria crotonensis
Fragilaria construens
Fragilaria capucina
Fragilaria leptostauron
Fragilaria vaucheriae
Hannaea arcus
Hannaea arcus v. amphioxys
Synedra ulna
Synedra ulna v. chaseana
Synedra acus
Synedra delicatissima
Synedra rumpens
Synedra vaucheriae
Synedra parasitica
Synedra mazamaensis
Synedra cyclopum
Synedra pulchella
Synedra radians
Cocconeis placentula
Achnanthes lewisiana
Achnanthes lanceolata
Achnanthes minutissima
Achnanthes exigua
Achnanthes linearis
Achnanthes flexella
Achnanthes cleveii
Achnanthes deflexa
Achnanthes pergalli
Rhoicosphenia curvata
Funotia pectinalis
Diploneis smithii v. dilatata
Diploneis oculata
Navicula seminuloides
Navicula minima
Navicula tripunctata
Navicula cryptocephala

CHRYSOPHYTA (BACILLARIOPHYCEAE)
(cond't)

Navicula cryptocephala v. veneta
Navicula mutica
Navicula arvensis
Navicula pupula
Navicula reinhardtii
Navicula pseudoreinhardtii
Navicula radiosa
Navicula viridula
Navicula peregrina
Navicula decussis
Navicula menisculus v. up.
Navicula capitata
Navicula cascadensis
Navicula bacillum
Navicula vitabunda
Navicula minuscula
Navicula infirmata
Caloneis hyalina
Pinnularia borealis
Amphipleura pellucida
Gomphonema parvulum
Gomphonema subclavatum
Gomphonema olivaceoides
Gomphonema truncatum
Gomphonema ventricosum
Gomphonema olivaceum
Gomphonema olivaceum v. calcarea
Cymbella turguidula
Cymbella sinuata
Cymbella cistula
Cymbella minuta
Cymbella mexicana
Cymbella affinis
Cymbella prostrata
Cymbella muelleri
Cymbella microcephala
Amphora perpusilla
Amphora ovalis
Epithemia sorex
Epithemia turgida
Rhopalodia gibba
Hantzschia amphioxys
Cymbellonitzschia diluviana
Nitzschia latens
Nitzschia paleacea
Nitzschia silica
Nitzschia palea
Nitzschia dissipata
Nitzschia innominata
Nitzschia perminuta
Nitzschia allansoni
Nitzschia frustulum
Nitzschia stagnorum
Nitzschia osmophila
Nitzschia obsoleta
Nitzschia linearis
Nitzschia lauenbergiana
Nitzschia amphioxides
Nitzschia sigmoidea
Nitzschia acicularis
Nitzschia subacicularis
Nitzschia amphibia
Nitzschia oregona
Nitzschia accomodata
Nitzschia fonticola
Nitzschia demota
Nitzschia bacata f. lin.
Nitzschia recta
Nitzschia R1

CHRYSOPHYTA (BACILLARIOPHYCEAE) (cond't)

Nitzschia hungarica
Nitzschia angustata
Nitzschia subpunctata
Nitzschia vermicularis
Nitzschia serpenticula
Nitzschia sigma v. diminuta
Nitzschia holsatica
Nitzschia gracilis
Cymatopleura solea
Surirella linearis
Surirella angustata
Chrysophyte statospore #11
Chrysophyte statospore #1

CHLOROPHYTA:

Ankistrodesmus falcatus
Scenedesmus quadricauda
Scenedesmus abundans
Scenedesmus acuminatus
Scenedesmus longus
Schroederia judayi
Chlorella
Ulothrix zonata
Stigeoclonium R1

CYANOPHYTA:

Anacystis cyanea
Anacystis montana
Entophysalis rivularis
Oscillatoria lutea
Lyngbya limnetica
Oscillatoria limnetica
Arthrospira jenneri
Arthrospira brevis
Schizothrix calcicola
Schizothrix #2
Schizothrix fragilis
Schizothrix friesii
Calothrix parietina

RHODOPHYTA:

Audouinella violacea

PYRROPHYTA:

Rhodomonas minuta

* Numbered genera indicate particular species which were identified to genera, but which could not be identified to species. These species have been measured, drawn and photographed for future identification. Chrysophyte statospores were given numbers to differentiate the forms observed.

TABLE 4.3

Three way ANOVA on periphyton density data. The data was log ten transformed prior to analysis.

Analysis of Variance

DENSITY
BY STATION
YEAR
SEASON

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	40.610	13	3.124	23.094	0.000
Station	2.208	7	0.315	2.332	0.028
Year	7.008	3	2.336	17.269	0.000
Season	31.182	3	10.394	76.841	0.000
EXPLAINED	40.610	13	3.124	23.094	0.000
RESIDUAL	17.449	129	0.135		
TOTAL	58.059	142	0.409		

TABLE 4.4

Periphyton density: Homogeneous subsets of stations as determined by Duncans Multiple Range Test (DMRT). Connecting lines indicate no significant difference between means ($\alpha = .05$).

Mo/Yr	Station
3/77	8 7M
6/77	8 1
9/77	11M 7M 11E 8 7W 1 11W
12/77	7W 1 7M 7E 11M 11E 11W 8
3/78	11E 7W 11W 7M 11M 8 7E 1
6/78	11M 7E 7W 8 11E 11W
8/78	1 7M 7E 11M 11E 11W 8
3/79	11E 11M 7M 7E 11W 8
6/79	11E 11M 11W 7E 7W 1 7M 8
9/79	7M 11E 11W 1 11M 7E 8 7W
12/79	11E 7E 11M 8 1 11W 7M 7W
3/80	7W 11E 11M 11W 7E 1 7M 8

TABLE 4.5A-B

Two and three way ANOVA on periphyton TOM data.

Three Way
Analysis of Variance

ASH
BY STATION
YEAR
SEASON

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	5487.557	13	422.120	32.433	0.000
Station	122.455	7	17.494	1.344	0.233
Year	2873.648	3	957.883	17.269	0.000
Season	1101.534	3	367.178	73.598	0.000
EXPLAINED	5487.557	13	422.120	32.433	0.000
RESIDUAL	1952.254	150	13.015		
TOTAL	7439.811	163	45.643		

Two Way
Analysis of Variance

ASH
BY STATION
SPERIOD

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	1143.684	10	114.368	207.005	0.000
Station	4.020	1	4.020	7.277	0.013
Speriod	956.541	9	106.282	192.370	0.000
2-Way Interactions	12.293	6	2.049	3.708	0.011
Station Speriod	12.193	6	2.049	3.708	0.011
EXPLAINED	1155.977	16	72.249	130.769	0.000
RESIDUAL	12.155	22	0.552		
TOTAL	1168.132	38	30.740		

TABLE 4.6A-B

Two and three way ANOVA on periphyton Chlorophyll "A" data.

Three Way
Analysis of Variance

CHLORO
BY STATION
YEAR
SEASON

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	119938.938	13	9226.070	15.023	0.000
Station	4584.588	7	654.941	1.066	0.389
Year	72504.016	3	24168.004	39.353	0.000
Season	43051.555	3	14350.518	23.367	0.000
EXPLAINED	119938.938	13	9226.070	15.023	0.000
RESIDUAL	77995.938	127	614.141		
TOTAL	197934.875	140	1413.820		

Two Way
Analysis of Variance

CHLORO
BY STATION
SPERIOD

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	152519.250	16	9532.453	39.841	0.000
Station	6280.200	7	897.171	3.750	0.002
Speriod	146259.000	9	16251.000	67.921	0.000
2-Way Interactions	29384.906	57	515.525	2.155	0.001
Station Speriod	29384.914	57	515.525	2.155	0.001
EXPLAINED	181904.156	73	2491.837	10.415	0.000
RESIDUAL	16030.719	67	239.264		
TOTAL	197934.875	140	1413.820		

TABLE 4.7

Homogeneous subsets of stations as determined by Duncans Multiple Range Test. Underlined groups are not significantly different (α=.05). Means are ordered from left to right, smallest to largest.

DATE	TOM	CHLOROPHYLL A
3/77	7M 8	8 7M
9/77	8 1	8 1
12/77	7W 8 7M 1 11M 11E 11W	7W 11W 11M 7W 8 11E 1
3/78	11M 1 7E 8 7W 7M 11E 11W	7M 7E 11M 11W 8 11E 7W 1
6/78	7W 11E 7E 11M 11W 1 7M 8	8 7M 11W 7E 11M 7W 1 11E
8/78	11M 7M 7E 11W 8	11E 11M 7W 11W 7E 8
12/78	7M 11E 7E 11M 1 11W 8	7M 11E 11M 7E 11W 1 8
3/79	7E 11E 11M 7M 11W 8	7E 11E 7M 11M 11W 8
6/79	11M 1 7M 7E 11W 7W 11E 8	7M 7E 7W 8 11M 1 11E 11W
9/79	7M 7E 11E 8 11W 1 7W 11M	11E 7M 11M 1 8 7E 7W 11W
12/79	1 7E 7W 7M 8 11M 11W 11E	11E 11M 8 7E 11W 1 7W 7M
3/80	11M 7E 7W 11E 1 11W 7M 8	7W 7E 11M 11E 11W 1 8 7M

TABLE 4.8

Description of sampling effort for the core and gradient studies. TOM is total organic matter.

			Variables to be Measured		
Study	Stations	Sampling Frequency	Phase 1	Phase 2*	Replicates/ Sample
Core	1	Quarterly	TOM	Density & Species Composition	4
	7E	"	"	"	"
	7M	"	"	"	"
	7W	"	"	"	"
	11E	"	"	"	"
	11M	"	"	"	"
	11W	"	"	"	"
	8	"	"	"	"
Gradient	1a	2/quarter	"	"	"
	1b	"	"	"	"
	7a	"	"	"	"
	7b	"	"	"	"
	7c	"	"	"	"
	7d	"	"	"	"
	7e	"	"	"	"
	7f	"	"	"	"

* Phase 2 may be conducted if a significant impact is suggested by Phase 1.

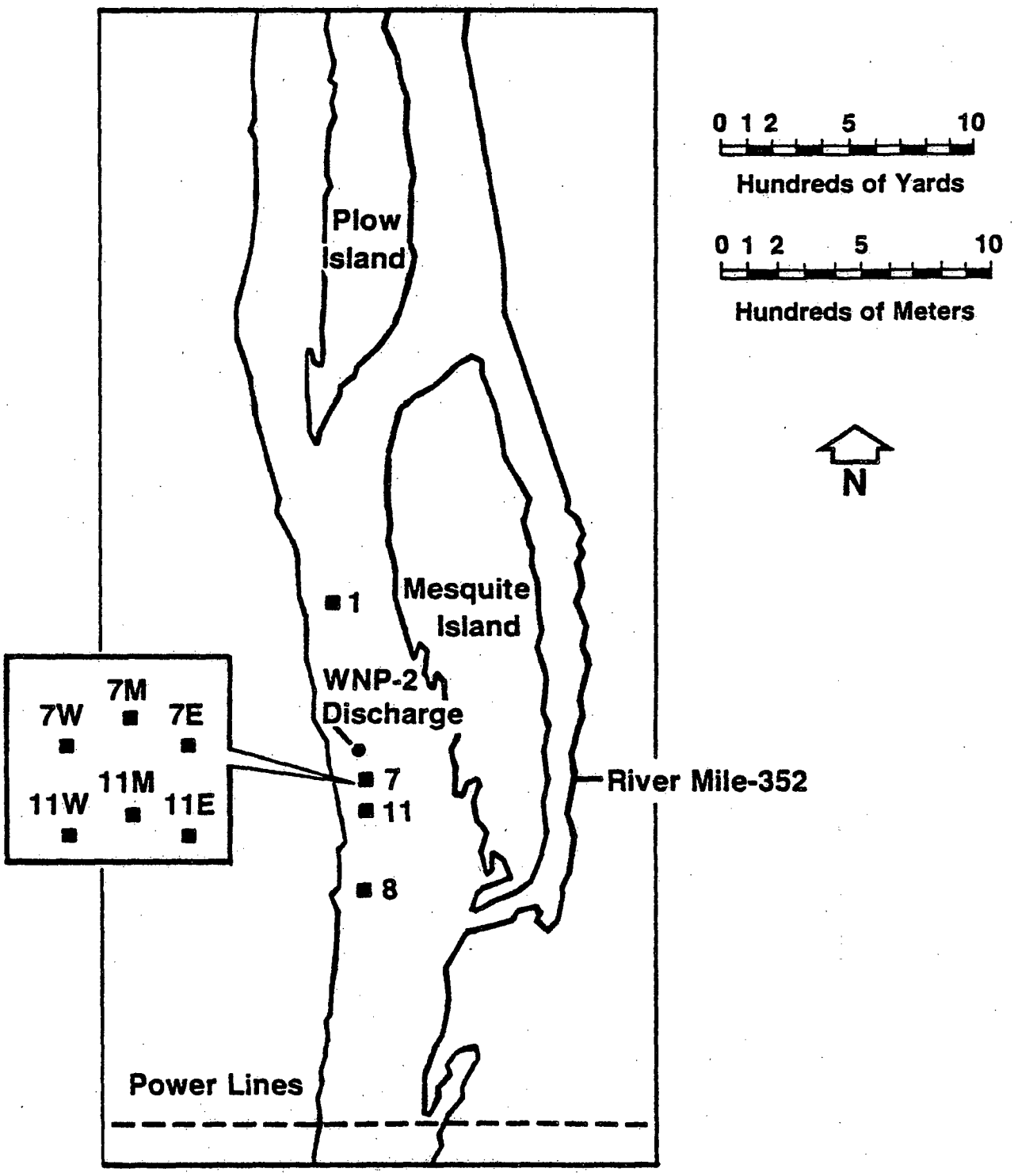

Figure 4.1 Location of sampling stations in the Columbia River.

821602

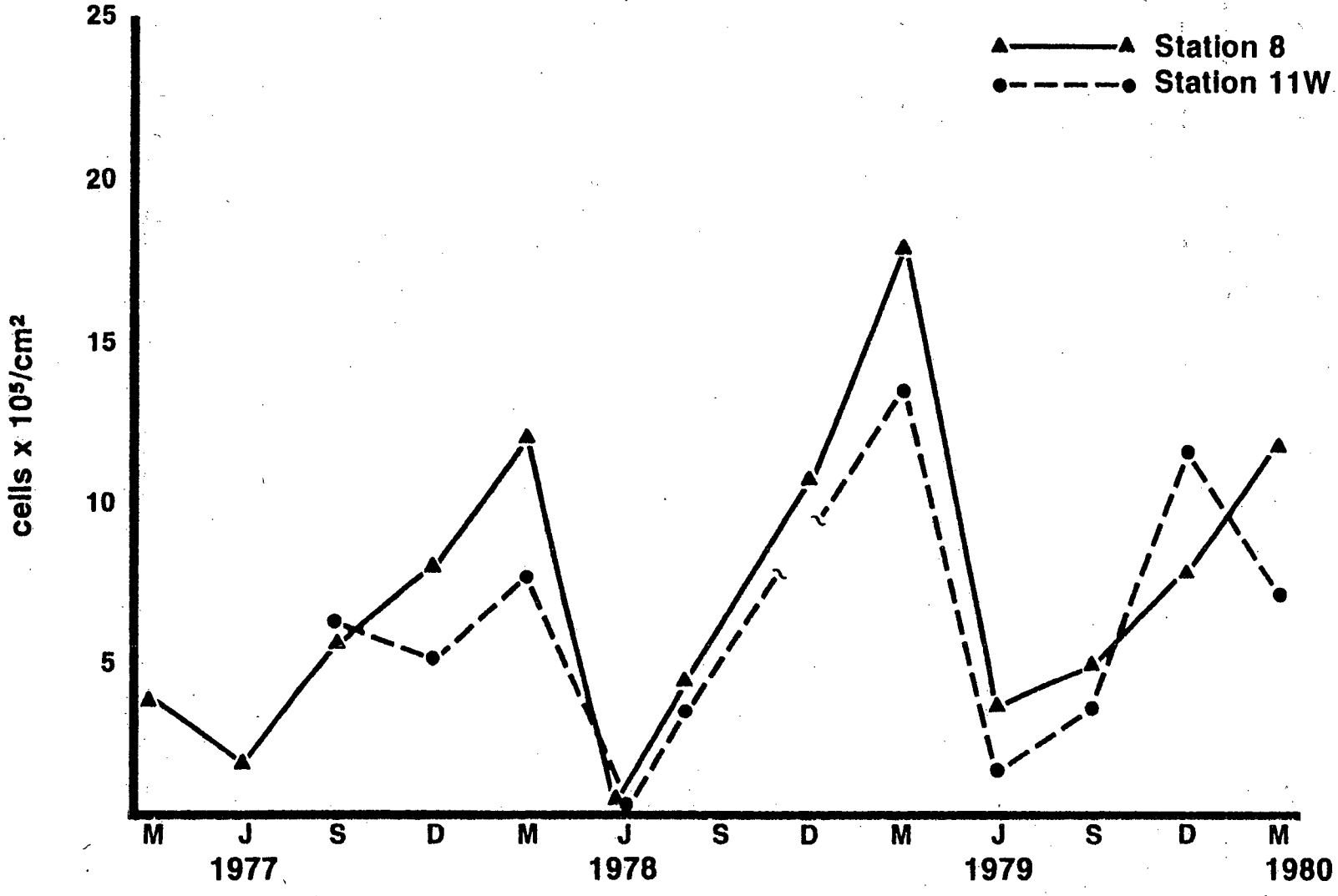

Figure 4.2 Periphyton density at Stations 8 and 11W from March 1977 through March 1980. Samples were not collected at Station 11W in March or June 1977, or December 1978.

821602

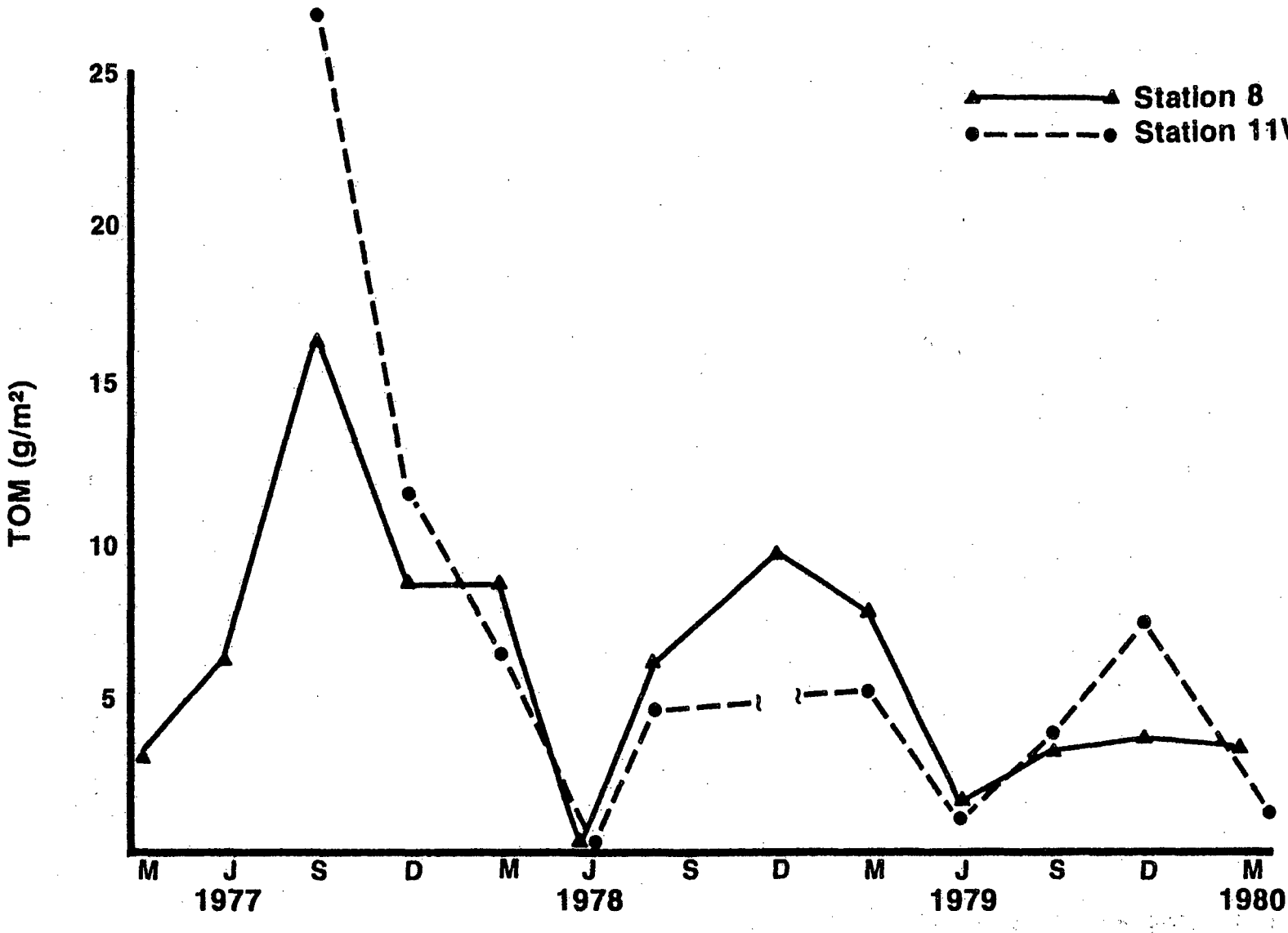

Figure 4.3 Periphyton total organic matter (TOM) at Stations 8 and 11W from March 1977 through March 1980. Samples were not collected at Station 11W on March or June 1977, or December 1978.

821602

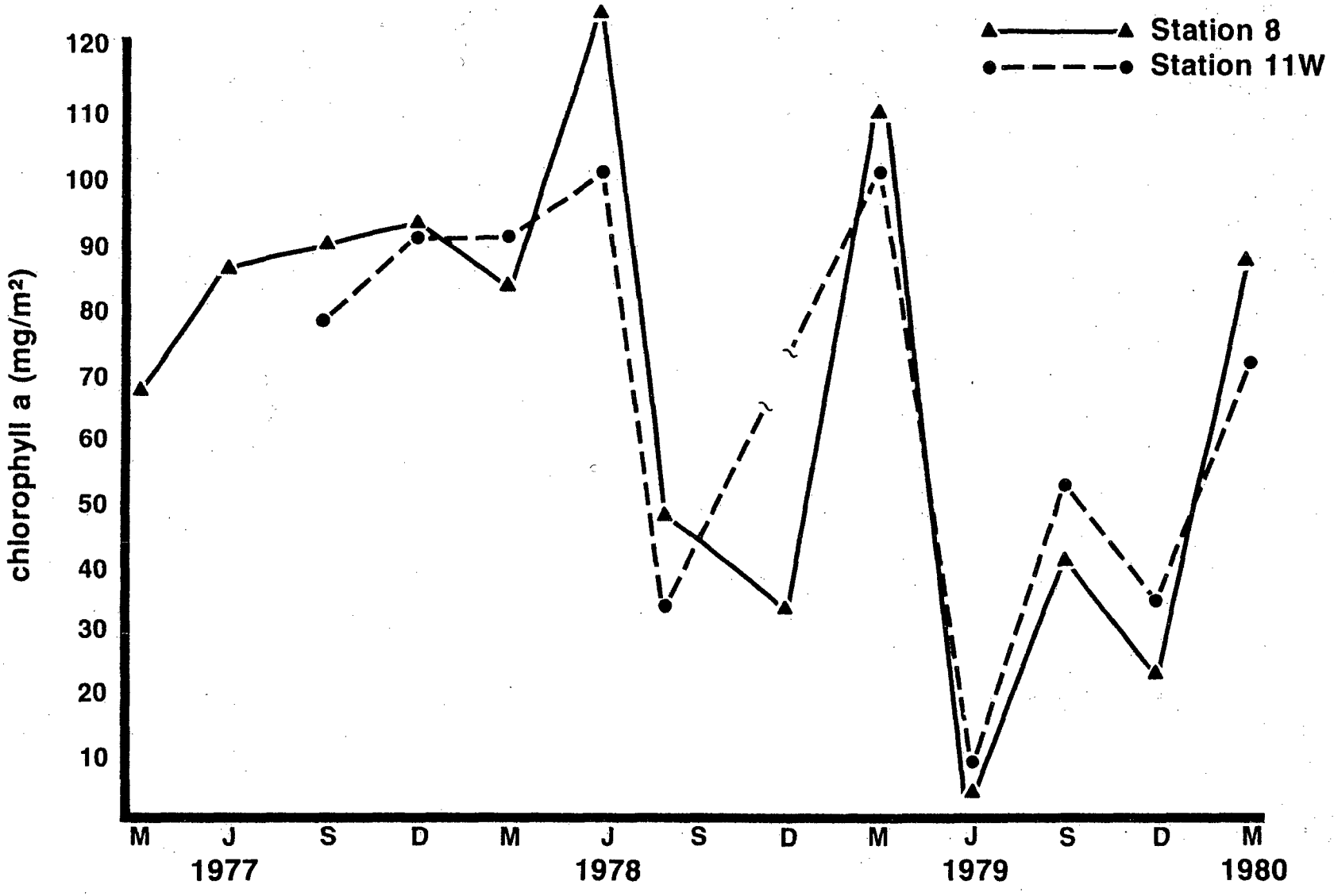

Figure 4.4 Chlorophyll a at Stations 8 and 11W from March 1977 through March 1980. Samples were not collected at Station 11W in March or June 1977, or December 1978.

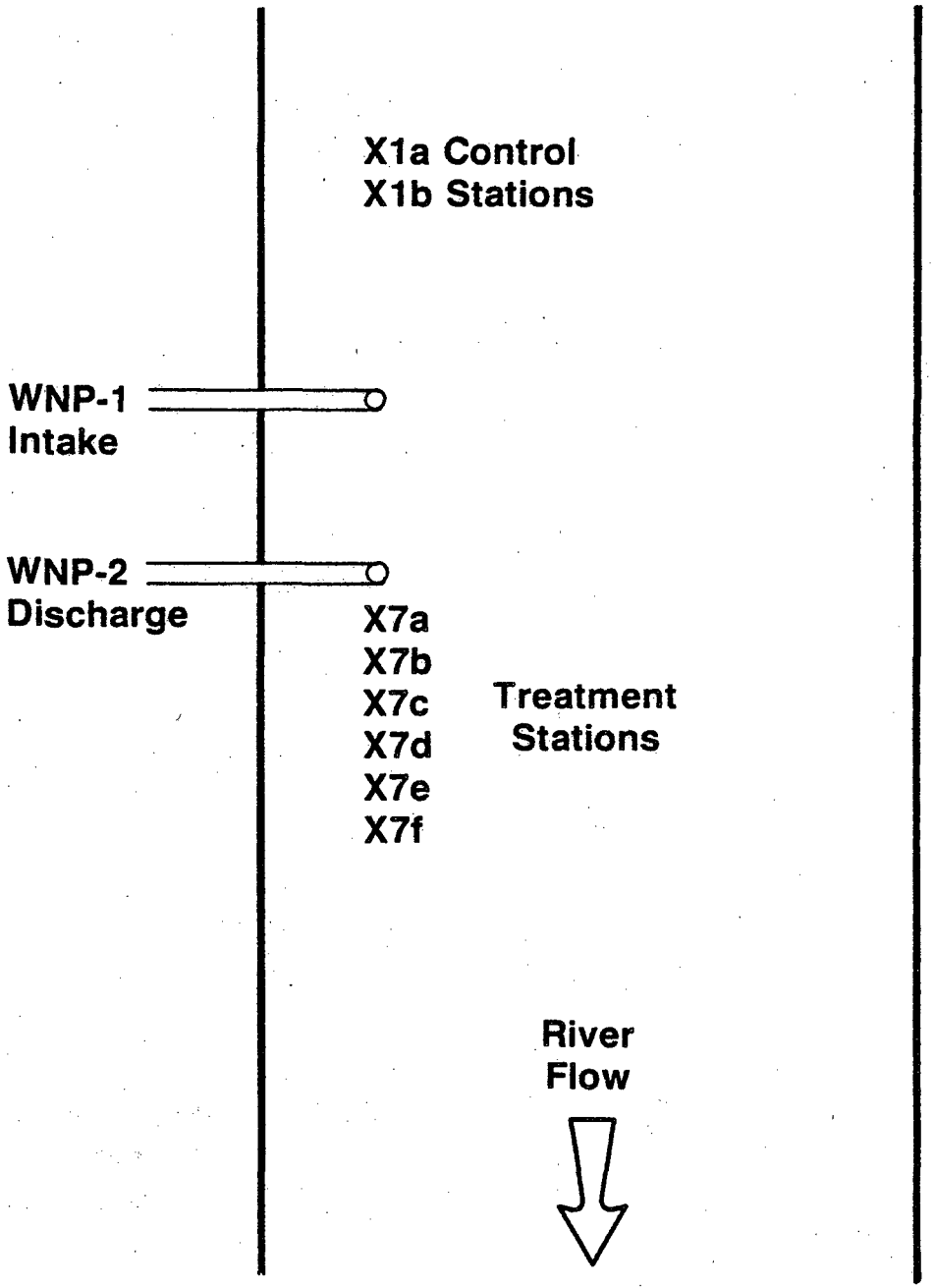

Figure 4.5 Diagramatic representation of the station arrangement for the supplemental periphyton study (not drawn to scale).

821602

5.0 BENTHIC MACROFAUNA

5.1 HISTORICAL SUMMARY

Benthic macrofauna were sampled in the vicinity of WNP-2 from September 1974 through March 1980 (1-6). Study objectives included: 1) determination of species composition, density, and relative abundance; and 2) collection of preoperational data for future assessment of potential operational impacts.

A number of stations were sampled through the years, but only eight were sampled consistently: stations 1, 7M and 8 from September 1974 through June 1977, and these stations as well as stations 7E, 7W, 11E, 11M, and 11W, thereafter (Figure 4.1).

Samples were collected in October and December of 1974, March, June, July, September and October of 1975, and quarterly for the duration of the study.

From September 1974 through March 1975 the benthic macrofauna were sampled via "grabs" of substrate gravel and ringold material collected by scuba divers. From June through December 1975 grab sampling was continued and supplemented by rock filled basket samplers emplaced and retrieved by scuba divers (1). The grab sampling was discontinued in April 1976 and baskets only were used from that date on.

Two variables were measured from benthic macrofauna samples: 1) density (taxonomic abundance); and 2) dry weight (biomass). Density data was collected during all years of the preoperational program (1974-1980), whereas biomass was measured from August 1978 through March 1980.

5.2 TECHNICAL SUMMARY

Because of infrequent and irregular sampling at other stations the following analysis will be limited to stations 1, 7E, 7M, 7W, 8, 11E, 11M, and 11W. It will also be limited to the basket samples for similar reasons. This approach is considered to be valid because populations of

benthic organisms from baskets are similar to those from natural substrates in the Columbia River near WNP-2, and baskets provide a standard basis for the quantification of operational impacts (6).

5.2.1 Species Composition

The benthic macrofauna community composition was determined from density and biomass data. Unfortunately, identification was carried to different levels before and after August 1978, rendering these two periods not directly comparable.

From September 1975 through June 1978, 18 taxonomic groups were encountered (Table 5.1). Trichoptera and Chironomidae (Diptera) larvae were dominant during this period, comprising from 1 to 99% and 1 to 96% of total numbers, respectively. Combined percentages for these groups ranged from 62% to 99% of the total, except in June 1975 when Simulids (Diptera) were especially abundant.

Trichoptera (Hydropsychidae) and Chironomidae also dominated the period from September 1978 through March 1980 when a total of 32 taxa were identified (Table 5.2). Other major taxa which occassionally accounted for more than 10% of total density included Simulidae and Lythoglyphus sp. (Gastropoda).

In terms of biomass, the fauna was generally dominated by Hydropsychidae, with other major contributors being Lythoglyphus, Limnaea, Chironomidae, and Simulidae.

5.2.2 Density

Seasonal patterns for total density are shown in Figure 5.1. Density values were generally low in the spring and summer, and high in the fall and winter, ranging from 699 organisms/m^2 (station 8, July 1975) to 120,432 organisms/m^2 (station 8,

September 1976). Stations 1, 7M, and 8 are depicted because they were sampled consistently and were representative of all stations.

A three factor ANOVA on log (X + 1) transformed data was used to test the hypotheses that there were no differences in density between years, seasons, or stations. The seasons were the same as for other analyses in this report. The year and season effects were highly significant ($\alpha = .01$), but the station effect was not (Table 5.3). A two factor ANOVA grouping stations by sampling date allowed a more powerful test of station differences, however, and when this analysis was performed this effect was also highly significant (Table 5.3). The significant interaction of stations, and seasons is reflective of frequent changes in the relative ranks of stations.

Between station differences were analyzed using DMRT on log (X + 1) transformed data. From June 1975 to June 1977 when only stations 1, 7M, and 8 were sampled, station 8 consistently ranked the highest (Table 5.4). Differences between stations were frequently not statistically significant, however. From September 1977 through March 1980 when all 8 regular stations were sampled stations 11W and 7W frequently ranked high, and stations 1 and 8 were usually among the mid-ranks. Station 7M still often ranked low. Once again, differences between stations were frequently not significant and not consistent through time, indicating that variability between stations is often no greater than the variability within stations.

5.2.3 BIOMASS

Mean total biomass ranged from 3.67 g/m^2 (Station 7M, March 1979) to 236.67 g/m^2 (Station 11E, September 1979). Biomass levels followed a seasonal pattern similar to density: low during spring, and higher in the fall and winter (Figure 5.2).

Biomass was also relatively high during June (summer) 1979, and relatively low during August (fall) 1979, but because of the few years of sampling it is not know whether these occurrences fit the usual pattern.

A three factor ANOVA on log (X + 1) transformed data was used to test for differences in biomass between years, seasons, and stations (seasons were defined as for density). All three main effects were found to be highly significant ($p < .01$; Table 5.5).

Differences between seasons (all years and stations grouped together) and stations (on individual sampling dates) were examined via DMRT on log (X + 1) transformed data. All seasons were significantly different and the order of ranking was winter, fall, summer, spring, from highest to lowest. Results of the comparisons between stations were not as simple. Stations 1 and 8 were frequently low, but comparisons between stations were frequently not significant and relative rankings were not consistent over time (Table 5.6). This indicates that for biomass as for density, between station variability was often no greater than within station variability.

5.3 POTENTIAL ENVIRONMENTAL IMPACTS

Benthic macrofauna could potentially be impacted by WNP-2 from: 1) the withdrawal of river water at the intake; and 2) the thermal and chemical components of the cooling tower discharge.

All benthic drift which enters the intake structure is likely to be lost from the ecosystem, but this loss will be small in comparison to the total benthic invertebrate population in the Columbia River. It is estimated that the maximum intake water withdrawal will be less than 0.15% of the river volume even at the lowest regulated river flow of 36,000 cfs. Assuming a homogeneous distribution of organisms, at most

0.15% of the benthic drift will be drawn into the intake structure. At average flows and withdrawl rates, the proportion of drifting organisims removed would be approximately .05%.

The effects of the cooling tower discharge on the benthic macrofauna are also expected to be negligible. The upper temperature limits of the majority of benthic invertebrates occuring in the Columbia River near WNP-2 appear to range from 29°C to 33°C with tolerance somewhat dependent on species, stage of development, and acclimation temperature (7). Coutant (8) found that for most Columbia River benthic invertebrates, temperature increases less than the lethal limit resulted in increased rates of growth and development. Under normal conditions discharge temperatures will be well below the above mentioned lethal limits. Even under the most extreme conditions effluent temperatures are not expected to exceed 28°C at the point of discharge, and dilution of the discharge water in the mixing zone will rapidly lower its temperature to ambient levels (9).

With the exception of residual chlorine, the resultant concentration of chemicals in the river after initial mixing will be at a level at which no detrimental effects in benthic communities have been reported (10, 11). Intermittent discharges of residual chlorine will have rapid dilution and be reduced further by the chlorine demand of the water. During periods of low flow, an effluent concentration of 0.1 ppm would be diluted to 0.02 ppm approximately 15 feet downstream from the point of discharge, while levels would be approximately 0.01 ppm in an area represented by the 1.4°C isotherm and less than 0.002 ppm in an area outside of the 0.28°C isotherm (9).

The tolerance of aquatic organisms to chlorine is species specific, with the effective concentration causing mortality or detrimental effects somewhat dependent on the chemical form, and markedly affected by the duration of the exposure. Discharges of residual chlorine from WNP-2 are expected to have no measurable impact on the aquatic invertebrates entrained in the stream drift, in that maximum exposures to a

concentration gradient of 0.1 to 0.002 ppm will be for an interval of approximately one minute, and then only when passage coincides with the centerline of the plume during periods of low flow. Intermittent residual chlorine concentrations of 0.1 ppm may have a lethal effect on sensitive sessile benthic organisms in the immediate vicinity of the outfall, i.e., within an area 15 feet below the discharge (9). The actual area affected will depend upon the persistence of residual chlorine in the blowdown. Such losses would be expected to have a negligible impact on the river population, and cause no measurable change in the composition or abundance of food organisms for fish. The abundance of benthic organisms is known to naturally fluctuate widely, and is limited in areas of the main channel due to turbulent flow.

5.4 PROPOSED OPERATIONAL MONITORING PROGRAM AND RATIONALE

Benthic macrofauna studies will be continued during the operational phase of WNP-2. Benthic invertebrates form an important part of the food chain supporting juvenile salmonids and other fish, and many are relatively immobile and thus could be exposed to plant discharges for extended periods of time. No major impact to the benthic macrofauna from plant operations is expected, but because of their importance to the aquatic ecosystem as a whole, this group of organisms should continue to be monitored.

To maintain consistence with the preoperational program, sampling methods, schedules, and locations will be kept the same during the operational phase. That is, basket samples will be collected quarterly at eight stations (1, 7E, 7M, 7W, 8, 11E, 11M, 11W) to provide data on benthic macrofauna density, species composition, and biomass. Studies will commence prior to WNP-2 fuel load and continue for three years during the operation of WNP-2.

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TABLE 5.1

Taxonomic groups encountered in the benthic macrofauna from September 1975 through June 1978.
(from basket samples taken at stations 1, 7E, 7M, 7W, 8, 11E, 11M, and 11W).

GAMMARUS
PACIFASTICUS
ARACHNIDA
HYDRA
DUGESIA
NEMATODA
OLIGOCHAETA
EPHEMEROPTERA LARVAE
TRICHOPTERA
TRICHOPTERA PUPAE
TRICHOPTERA LARVAE
CHIRONOMIDAE PUPAE
CHIRONOMIDAE LARVAE
SIMULIDAE PUPAE
SIMULIDAE LARVAE
ODONATA LARVAE
HEMIPTERA LARVAE
LEPIDOPTERA
PYRALIDAE LARVAE
PHYSA
FISHEROLA NUTTALI
SPONGILLA LACUSTRIS

TABLE 5.2

Taxonomic groups encountered in the benthic macrofauna from September 1978 through March 1980.
(from basket samples taken at stations 1, 7E, 7M, 7W, 8 11E, 11M, and 11W).

DAPHNIA
HYDRACARINA
HYGROBATIDAE
HYDRACHNIDAE
TURBELLARIA
DUGESIA
CURA
NEMATODA
OLIGOCHAETA
HIRUDINEA
BAETIDAE NYMPH
TRICHOPTERA ADULT
TRICHOPTERA PUPAE
TRICHOPTERA LARVAE
HYDROPSYCHIDAE PUPAE
HYDROPSYCHIDAE LARVA
LEPTOCERIDAE PUPAE
LEPTOCERIDAE LARVAE
RHYACOPHYLIDAE LARVAE
HYDROPTILIDAE PUPAE
HYDROPTILIDAE LARVAE
PSYCHOMYIIDAE LARVAE
PSYCHOMYIIDAE PUPAE
GLOSSOSOMATIDAE LARVAE
GLOSSOSOMATIDAE PUPAE
DIPTERA ADULT
CHIRONOMIDAE PUPAE
CHIRONOMIDAE ADULT
CHIRONOMIDAE LARVAE
SIMULIDAE PUPAE
SIMULIDAE LARVAE
SIMULIDAE ADULT
COLEOPTERA ADULT
ELMIDAE ADULT
ELMIDAE LARVAE
HEMIPTERA ADULT
CORIXIDAE NYMPH
PYRALIDAE LARVAE
MOLLUSCA
PHYSA
LIMNAEA
FISHEROLA SP.
PARAPHOLYX
FLUMINCOLA

TABLE 5.3

Two and three way ANOVA on benthic macrofauna density data.
The data was log (X + 1) transformed prior to analysis.

THREE WAY

DENSITY
BY STATION
YEAR
SEASON

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	59.727	13	4.594	66.484	0.000
Station	0.969	7	0.138	2.002	0.056
Year	3.449	3	1.150	16.638	0.000
Season	40.408	3	13.469	194.911	0.000
EXPLAINED	59.727	13	4.594	66.484	0.000
RESIDUAL	15.065	218	0.069		
TOTAL	74.792	231	0.324		

TWO WAY

DENSITY
BY STATION
SPERIOD

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	66.517	17	3.913	139.847	0.000
Station	1.026	7	0.147	5.237	0.000
Speriod	65.540	10	6.554	234.246	0.000
2-WAY INTERACTIONS	4.190	68	0.062	2.202	0.000
Station Speriod	4.190	68	0.062	2.202	0.000
EXPLAINED	70.707	85	0.832	29.731	0.000
RESIDUAL	4.085	146	0.028		
TOTAL	74.792	231	0.324		

TABLE 5.4

Homogeneous Subsets of Stations as Determined By DMRT on Log (X + 1) Transformed Benthic Macrofauna Density Data
Connecting lines indicate no significant difference ($\alpha = .05$). The order is from low to high, left to right.

Month/Year								
6/75	7M	8						
7/75	1	7M	8					
9/75	7M	1	8					
10/75	1	7M	8					
12/75	7M	1	8					
4/76	1	8						
6/76	7M	1	8					
9/76	7M	1	8					
12/76	1	7M	8					
3/77	1	7M	8					
6/77	7M	8	1					
9/77	8	11E	7E	7M	11M	1	7W	11W
12/77	7W	7E	8	1	7M	11M	11W	11E
3/78	11E	11M	11W	7E	1	8	7W	7M
6/78	7M	8	1	11W	7E	7W		
8/78	1	11M	7M	11E	7E	8	7W	11W
12/78	7E	7M	7W	8	11E	1	11M	11W
3/79	7M	11E	1	7E	11M	7W	11W	8
6/79	7M	11M	1	7E	8	11E	7W	11W
9/79	7W	7E	11W	8	11E	1	7M	11M
12/79	7E	1	11M	7W	7M	11E	8	11W
3/80	11M	7M	7W	1	11E	7E	8	11W

TABLE 5.5

Three way ANOVA on benthic macrofauna biomass data.
The data was log (X + 1) transformed prior to analysis.

THREE WAY

BIOMASS
BY STATION
YEAR
SEASON

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
Main Effects	46.747	12	3.896	52.498	0.000
Station	2.660	7	0.380	5.120	0.000
Year	1.028	2	0.514	6.925	0.001
Season	25.532	3	8.511	114.694	0.000
EXPLAINED	46.747	12	3.896	52.498	0.000
RESIDUAL	11.428	154	0.074		
TOTAL	58.174	166	0.350		

TABLE 5.6

Homogeneous Subsets of Stations from DMRT on Log (X + 1) Transformed Benthic Macrofauna Biomass Data
Connecting lines indicate groups that are not significantly different ($\alpha = .05$). Order is low to high rank, left to right

Month/Year	Homogeneous Subsets							
8/78	1	8	11M	7M	7E	11E	7W	11W
12/78	8	1	7W	7E	11E	7M	11W	11M
3/79	7M	1	11E	7E	7W	11M	8	11W
6/79	7M	11M	1	8	11E	7E	7W	11W
9/79	8	1	7E	11W	7W	7M	11M	11E
12/79	8	11M	7E	1	7M	11W	7W	11E
3/80	11M	8	7M	1	11E	11W	7E	7W

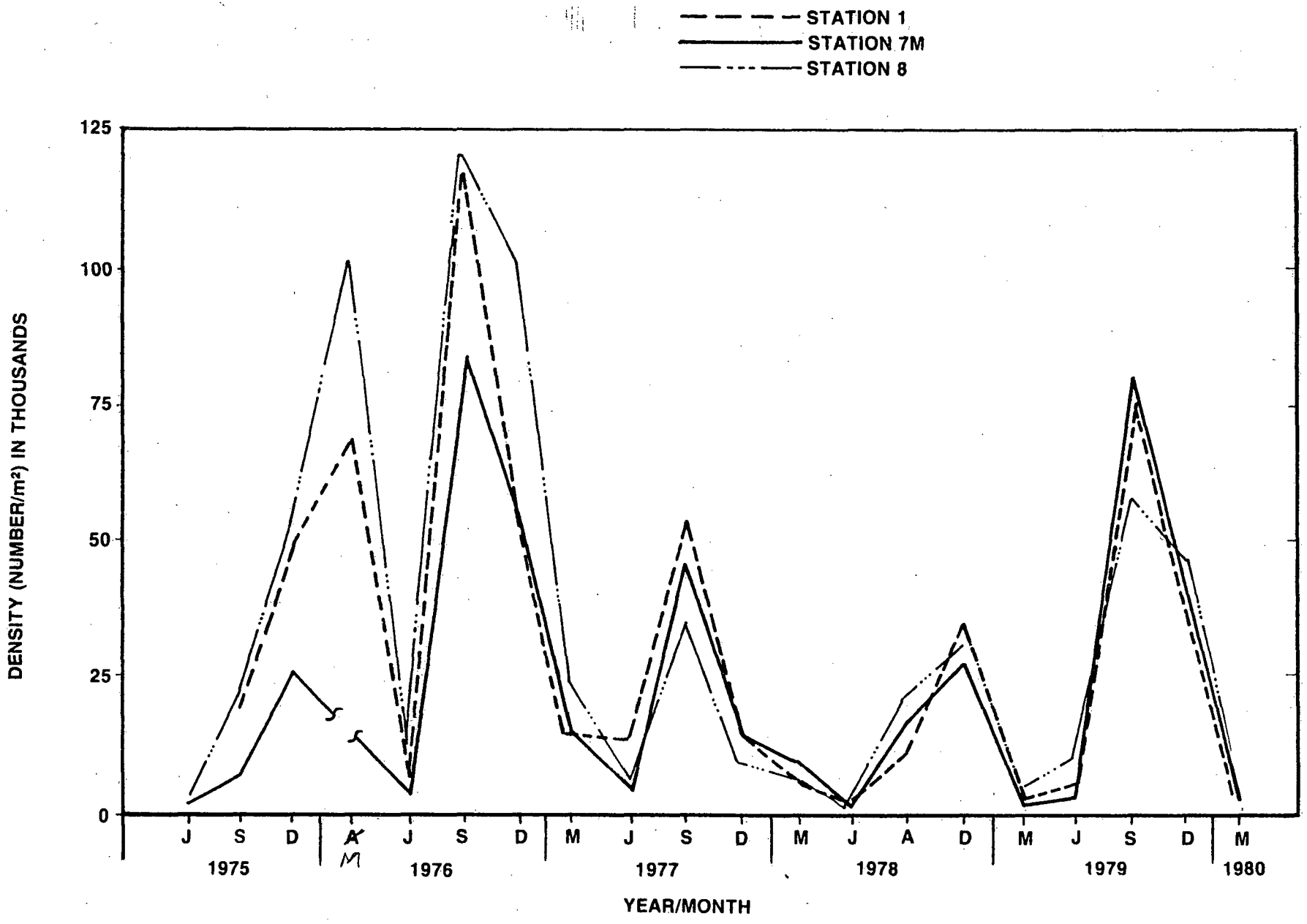

FIGURE 5.1 BENTHIC MACROFAUNA DENSITY (NUMBER/m²) AT STATIONS 1, 7M, AND 8 JUNE 1975 THROUGH MARCH 1980

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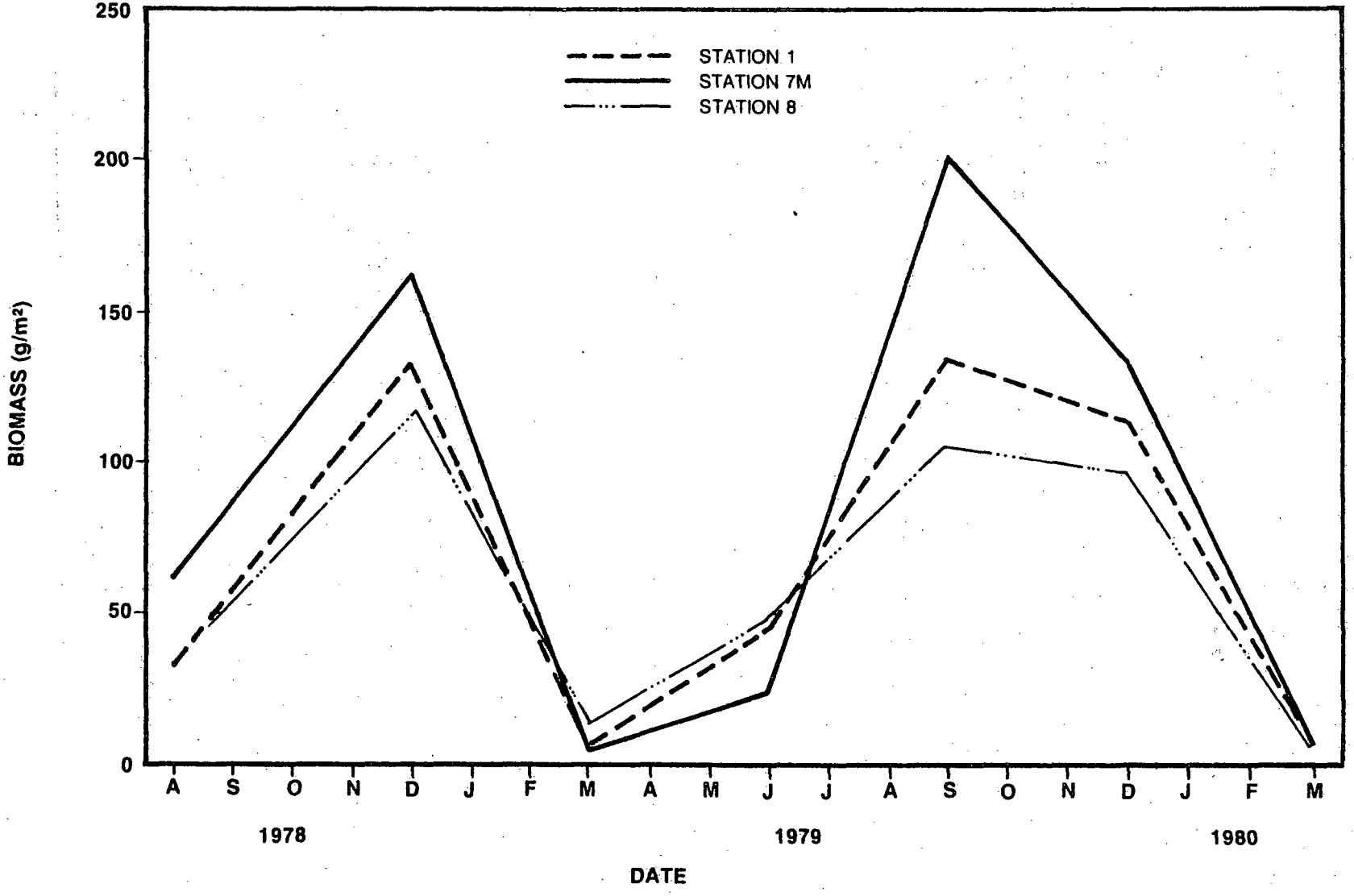

FIGURE 5.2 BENTHIC MACROFAUNA BIOMASS (g/m²) AT STATIONS 1, 7M AND 8, AUGUST 1978 THROUGH MARCH 1980.

6.0 FISH

6.1 HISTORICAL SUMMARY

Fishes, primarily salmonids, represent the most important aquatic organisms in the Columbia River in terms of their commercial and recreational value. Fish communities in the Columbia River near WNP-2 were studied during the period September 1974-March 1980 (1-6).

The objectives of these fish studies were:

a) Collect preoperational data for future assessments of potential operational impacts (e.g. cooling tower blowdown),

b) Determine the species composition, seasonal abundance and distribution in the study area,

c) Determine community characteristics, which include food habits, age-growth patterns, species length-weight relationships, and incidence of external parasites.

Sample techniques used consistently included beach seining, hoop netting, gill netting, and electroshocking. Numerous sample gear, sample locations and frequencies were employed 1974-1976, whereas, from 1977-1980, sample locations (Figure 6.1) techniques and sample frequencies (Table 6.1) were more consistent. Fish captured were identified, enumerated, measured, weighed and sexed. Scale and stomach samples were collected from selected species. Additional data on length-weight relationships, spawning condition and parasites was obtained for some species at the site.

6.2 TECHNICAL SUMMARY

General

A total of 37 species representing 12 families were collected from September 1974 through March 1980 at the site (Table 6.2). Chinook salmon

(Oncorhynchus tshawytscha) numerically comprised approximately 44% of all fish caught by all collecting methods during this study (Table 6.3). Other common species were redside shiner (Richardsonius balteatus) 11.3%, largescale sucker (Catostomus macrocheilus) 8.8%, northern squawfish (Ptychocheilus oregonensis) 6.9%, peamouth chub (Mylocheilus caurinus) 6.7%, and other sucker species (Catostomus spp. and Catostomus columbianus) 6.7%. All other species individually comprised less than 5% of the total catch.

As expected, each of the gear types employed during the study was selective for different fish species and size groups. Beach-seine catches generally consisted of small, shore-oriented fishes such as chinook salmon, mountain whitefish, redside shiner, northern squawfish, peamouth chub, minnows, and suckers (Table 6.4). Twenty-four different species were captured in beach seines.

The boat electrofishing catch was represented by 16 species and composed primarily of larger-sized fishes. Mountain whitefish, largescale sucker and bridgelip sucker were particularly prominent in the catch (Table 6.4). The collection of larger fish was probably attributable to sample stations being located offshore.

Twenty-seven species were captured in gill nets. The catch was dominated by chiselmouth, northern squawfish, peamouth chub, largescale sucker, bridgelip sucker, and redside shiner (Table 6.4). The net mesh-sizes favored capture of large individuals, although smaller members of several species were collected in the small-meshed end panels.

A total of 24 species were collected in hoop nets, with the catch composed principally of northern squawfish, redside shiner, bluegill, smallmouth bass, and yellow perch (Table 6.4). Numbers captured were generally very low compared to the other gear types and considering the overnight sampling duration.

Beach seine catch data for the commonly collected species, chinook salmon, redside shiner and northern squawfish are presented in Figures 6.2 through 6.4. Movement of chinook salmon fry through the Hanford Reach occurred from late April to early July, with the peak movement occurring in late May 1977-1979 (Figure 6.2). Length frequency histograms support that the fish are fry (Figure 6.5).

The 1977 through 1979 data set was most consistent in regard to sample location and frequency and thus was used for the beach seine, hoop net and gill net analyses. In order to stablize variances, the observations were transformed prior to analysis using the logarithmic (x+1) transformation.

Beach Seine

The null hypothesis of no year, station, or month effects on the beach seine catch per unit effort (CPUE:) was tested with a three way ANOVA individually for chinook salmon, redside shiner and northern squawfish. For chinook salmon, the null hypothesis of no station or month effect was rejected at the 0.01 level while that for year was not (α = 0.05) (Table 6.5) Duncans Multiple Range Test (DMRT) indicates that there are four month groups and not unexpectedly mean CPUE was highest in May (Table 6.6). The DMRT was not sufficiently sensitive to identify which stations were statistically different from the others. The three way ANOVA for redside shiner showed no station or year differences, while the month effect was significant at the 0.01 level (Table 6.5). The DMRT showed the mean CPUE for redside shiner to be highest in September and August (Table 6.6). For northern squawfish the null hypothesis of no station or month effect on CPUE was rejected at the 0.01 level while that for year was not rejected (α = 0.05: Table 6.5). The DMRT showed the mean monthly CPUE to be highest in August (Table 6.6). This corresponds well with the expected timing of juvenile recruitment, since the peak in spawning occurs in early July in Washington (7). In addition, the DMRT showed the highest catch at station 1 and all other stations to be similar (Table 6.6).

Hoop Net

The null hypothesis of no station, year or month effects on the hoop net CPUE was tested with a three way ANOVA individually for northern squawfish, redside shiner and bluegill. For northern squawfish and bluegill the null hypothesis of no station, year or month effect was rejected at the 0.01 level, whereas it was not rejected for redside shiner (Table 6.5). The DMRT results for northern squawfish indicate that the 1977 CPUE was higher than 1979, similarly the August monthly values appear higher than the other months, however neither of these results are significant at the 0.05 level (Table 6.6). CPUE at station 4 was significantly higher than at either of the other three sample locations. Bluegill DMRT results (Table 6.6) reflect that the CPUE in 1979 was higher than other years and that station 4 CPUE was higher than the other stations. Neither of the aforementioned results were significant at the 0.05 level, but it is obvious that September catches were significantly different from the other months (Table 6.6). The results of these analyses are not surprising considering the generally low CPUE found with hoop nets during the preoperational studies.

Gill Net

The effect of station, year and month on gill net CPUE was tested with a three way ANOVA individually for largescale sucker, peamouth chub, northern squawfish, bridgelip sucker, chiselmouth and redside shiner. At the 0.01 level, year effect on gill net CPUE was not significant except for redside shiner and chiselmouth (Table 6.5). The DMRT showed that redside shiner and chiselmouth CPUE was highest in 1978, and 1977 respectively (Table 6.6). Month effect on gill net CPUE was significant at the 0.01 level only for redside shiner and northern squawfish (Table 6.5). Station effect on gill net CPUE was significantly different for all species except redside shiner (Table 6.5). For all species except redside shiner the DMRT showed that station 4 CPUE was highest (Table 6.6). Station 4 is located downriver and cross-river from the intake and discharge structures.

In summary the ANOVA and DMRT results indicate that for all species, except for redside shiner collected by beach seine and gill net, the CPUE between stations was different. Beach seine station 1 and gill net and hoop net station 4 all located downstream of the discharge had the highest mean CPUEs. All other sampling stations for a particular gear type had similar CPUE values.

Age and growth information was determined for species that met the following criteria: 1) frequently collected and sample size was adequate, 2) adequate distribution of length and age classes, and 3) reliability of aging by scale annulus count. Mountain whitefish, chiselmouth, northern squawfish, redside shiner and peamouth chub age and growth information is presented in Figure 6.6. Age-growth data for these species were generally similar to those reported in other studies (8-11).

In addition, representative seasonal length-weight relationships were derived for sample populations of several species in the study area (Table 6.7). In all cases, ordinate intercepts were near the origin. Values for the regression line slopes ranged between 2.12 and 4.03, approximating isometric growth conditions (slope = 3). Correlations (r values) were also uniformly high, being below 0.9 in only two instances.

Food items identified from stomach analysis included larval and pupal aquatic insects (mainly caddisflies and midges), molluscs, zooplankton, small fishes, algae, and detritus. The kinds and abundance of macroinvertebrates in diets were generally reflective of the community composition identified in benthic macrofauna sampling. Seasonal food habit information for common species is discussed in detail in the Annual Report (1-6).

Most species of fish had few external parasites. Chinook salmon, mountain whitefish, bridgelip sucker, carp, redside shiner, and peamouth chub each had less than 10 percent infestation. The mean number of parasites per fish for these species ranged from 0.001 to 0.163.

Further information on selected species (e.g. chinook salmon, rainbow trout) is presented in the Annual Reports (1-6). Specific data include life history information, temporal and spatial distribution, age-growth relationships, food habits, migration/movement patterns, and population estimates.

6.3 POTENTIAL ENVIRONMENTAL IMPACTS

Fish could potentially be impacted by WNP-2 via, 1) the withdrawal of river water at the intake and 2) the cooling tower discharge.

The effects of the intake structure upon aquatic biotic populations are expected to be insignificant. Because the velocity of water across the face of the intake is several times faster than the intake velocity, impingement has never been detected and is not considered possible. Essentially all of the drifting fish fry or larvae which are drawn into the intake structure will be killed. This loss, however, will be so slight in comparison to the total populations of these organisms in the river water passing the site that the loss will not significantly affect the ecosystem. It is estimated that the maximum river water withdrawal will be less than 0.15% of the river volume, at the lowest regulated flow of 36,000 cfs.

Sport and commercial fish species which may be affected are the whitefish (Prosopium williamsoni), steelhead trout (Salmo gairdneri, American shad (Alosa sapidissima) and salmon (Oncorhynchus sp.). The whitefish deposit adhesive eggs, thus only the drifting larvae may encounter the intake structure. Juvenile salmonids (e.g., chinook fry) emerging from the gravel upstream from the intake structure may also be vulnerable to impingement or entrainment; again, however, the fact that such a small volume is withdrawn renders the total impact minimal. The fact that most young salmon pass through the area of the intake structure during the spring runoff when flows are high and the velocity greater than 3 fps further decreases their relative susceptibility to impingement or entrainment. In addition, most downstream migrant 0-age chinook salmon are found near shore (12) and thus not susceptible to impact at the offshore intake structure.

The WNP-2 intake structure was inspected for fish impingement in December 1978 and May - December, 1979 by consultants and by Supply System divers in the summers 1980-1982. During the inspections no impinged fish were observed on the intake screens.(6)

Fish entrainment sampling and collection efficiency testing at WNP-2 was performed May 1979 through May 1980. Analysis of 69 entrainment samples revealed no fish eggs or fish larvae.(6) During these tests the makeup water pumps were operated in a manner that approximated plant operating conditions. Further discussion of potential impingement/entrainment impacts is presented in Section 7.2 of this report.

As a result of cooling-tower blowdown, heated water will be discharged into the Columbia River with the temperature differential at the point of discharge approximately 9.5^{o} to $14^{o}C$ during the months of January to June and approximately 4.5^{o} to $6.7^{o}C$ during the months of July through December. The maximum blowdown rate will be 14.5 cfs and the maximum temperature of the effluent $28^{o}C$.

The effluent will be rapidly diluted in the initial mixing zone, with the thermal increment decreased by a factor of 5 within 15 feet, and by a factor of 10 within approximately 100 feet downstream of the outfall. Full vertical mixing will occur within 200 to 300 feet of the outfall during periods of minimum licensed flow, with the temperature differential reduced by a factor of approximately 50. During the most extreme conditions (i.e., a blowdown of 14.5 cfs and the maximum temperature differential of $14^{o}C$ at the point of discharge during minimum licensed flow) the thermal increment in the river will be less than $0.11^{o}C$ above the receiving water temperature 750 feet downstream and less than $0.006^{o}C$ above ambient after complete mixing in the river. The initial mixing zone will be located in the main channel approximately 280 feet from the west shoreline, during periods of low flow. Temperature differentials greater than 1.4^{o} and $0.28^{o}C$ will occupy approximately 4 and 7%, respectively, of the cross-sectional area of the main channel during periods of minimum licensed flow and a discharge thermal increment of $14^{o}C$.

Temperature, through both direct and indirect action, is one of the important parameters influencing the fishery resources in the Columbia River. The anadromous fish, particularly the salmonids, are the most economically important species. A review on the tolerance and thermal requirements of fish[13] indicates that in the Hanford reach of the river salmonids are the species most sensitive to and directly affected by thermal discharges.

The Hanford reach of the Columbia River is used extensively as a spawning and rearing area by chinook salmon and steelhead trout, as well as a major migration route for other adult and juvenile salmonids. The thermal plume from the discharge of cooling tower blowdown does not intersect with any reported spawning areas.[14]

The nearest chinook and steelhead spawning areas are approximately 3/4 mile downstream and the thermal increment ($0.03^{o}C$) in the river at this point is expected to have no measurable effect on spawning or on the growth and development of egg and larval stages.

During movement in the main channel, juvenile salmonids could be involuntarily carried through the effluent plume, with their downstream velocity assumed to be essentially that of the riverflow, e.g., 2.9 to approximately 6.0 fps, during minimum and average flow rates.

During May through September the temperature of the receiving water will be above the salmonids upper incipient lethal temperature ($21.1^{o}C$) at the point of discharge. However, these temperature differentials would be reduced by 80% within 15 ft of the outfall, and at minimum flow the temperature of the receiving water would be within the zone of thermal tolerance for juvenile salmonids after a time interval of 5 sec from the point of discharge. During worst-case conditions (periods of low flow and an ambient river temperature of $20.2^{o}C$) and a maximum effluent temperature of $28^{o}C$, temperatures above the ultimate incipient lethal temperature or greater than $21.8^{o}C$ in the receiving water would persist for an interval of approximately 5 sec downstream of the outfall. Temperatures also would be less than that reported as the upper incipient lethal temperature after an interval of approximately 35 sec.

Although juvenile salmonids could encounter potentially lethal temperatures if their route of passage coincided with the area of initial mixing, it seems unlikely that the thermal discharges as a result of the operation of the WNP-2 Plant will have any measurable impact. This is because the temperatures and duration of exposure are less than those reported to have any direct lethal or sublethal effects. As previously noted, most juvenile chinook salmon migrate close to shore which further reduces the possibility of impact.

During periods of migration, adult anadromous fish would be expected to avoid the thermal plume and the potentially lethal temperatures associated with the areas of initial mixing. Ambient water temperatures which exceed 21.3°C are reported to impede or block adult salmonid migration.[15] The thermal increment is expected to be approximately 1.4°C above maximum ambient temperatures (20.2 to 21.3°C), 15 ft downstream of the outfall. During the periods of peak adult salmonid migration, the maximum cross-sectional area of the river which would be expected to evoke an avoidance response is less than 7% of the main channel during worst-case conditions, and assures free passage of adult migrants. Temperatures between 10.1 and 21.3°C were reported to cause no avoidance or blockage of migration near the confluence of the Snake and Columbia Rivers, whereas when the ambient temperatures exceed 21.3°C migration preference was in the lowest temperature zone.[15, 16] In a study on the Hanford reach of the river, adult salmonid demonstrated a general preference for migration along the eastern shoreline (across the river from WNP-2 outfall) from Priest Rapids Dam downstream to Richland.[17] The study also indicated that the thermal discharges from the early Hanford reactors had no significant effects on migration.

"Cold shock" is an additional concern at some nuclear power stations utilizing natural bodies of water as cooling sources. Cold shock problems stem from the sudden cessation of thermal discharge upon plant shutdown, since the thermal plume issuing from power plant acts as an attractant to aquatic organisms, particularly fishes. These organisms reside in the artifically heated waters for long periods, becoming acclimated to the elevated temperatures and, in fact, dependent on them for survival. Fish

mortalities have occurred at a few plants following shutdowns and much effort has recently gone into devising ways to eliminate these fish kills. Cold shock is never expected to occur at WNP-2 because of its location on a swiftly flowing reach of the Columbia River. For fish to become acclimated to the warmer temperatures of the plume they would have to occupy these waters for several days, which is not expected to happen in the strong river currents. Fish populations downsteam from the mixing zone, i.e., where the river has become thermally homogeneous, will experience temperatures that are essentially natural.

6.4 PROPOSED OPERATIONAL MONITORING PROGRAM AND RATIONALE

A. Monitoring Program

It is recommended that the fisheries program consist of drift studies through the thermal plume, concurrent beach seine and entrainment studies, and the bioassays required in the NPDES permit. (See Section 7.2 for further information on the later two programs.) Both the drift and beach seine-entrainment studies would be performed during one spring outmigration period after the plant reached at least 75% load. In addition, drift studies would be performed in summer/fall time period. Follow-on (e.g., distribution) studies would be considered if the results warranted.

Entrainment studies would consist of weekly 24 hour samples during the months of April, May and June. In addition, outmigrating salmonid fry would be collected weekly at one location near the intake structures by beach seine.

During the spring and summer/fall time periods, juvenile salmonids collected by beach seine or provided by the Department of Fisheries would be placed in live boxes and drifted through either the plume or alongside the plume to provide for a control. All fish would then be held for 24 hours to assess delayed mortality - if any. The drift tests would be performed three times.

B. Rationale

The WNP-2 preoperational fishery program was typical of those performed over the last decade by the electric utility industry. During that decade, much was learned about the nature of thermal power plant impacts on fishery resources. In general, these studies have not proven useful in quantitatively assessing impacts. For example, one of the most exhaustive fishery studies conducted was on striped bass in the Hudson River. After more than 10 years, studying up to 100 miles of river at an annual cost ≥ $1,000,000 there were no conclusive results in spite of high entrainment and impingement numbers.

The creditable impacts associated with WNP-2 are entrainment and thermal and chemical stress. Each of these potential impacts is addressed by a phase of the proposed program. Together, they will provide information on whether or not there is any added mortality component to outmigrating salmonids.

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TABLE 6.1

Fish sampling frequency by gear from January 1977 through March 1980 in the Columbia River near the WNP-1, 2 and 4 intake and discharge sites. (D = day, N = night, O = overnight, NS = not scheduled.)

MONTH	BEACH SEINING	HOOP-NETTING	GILL NETTING	BOAT ELECTROFISHING
January 1977	NS	+	+	NS
February	D	+	+	NS
March	D	+	+	D
April	D,D	+	+	D
May	D,D	O,O	+	D
June	D,D	O,O	+	D
July	D	O	O	D
August	D	O	O	D
September	D	O	O	D,D,N
October	D	O	O	NS
November	D	NS	O	NS
December	NS	NS	O	NS
January 1978	NS	NS	O	NS
February	D	NS	O	D[(a)]
March	D,D	NS	O	D,D[(a)]
April	D,D	NS	O,O	D,D[(a)]
May	D,D	O,O	O,O	D,D[(a)]
June	D,D	O,O	O	D,D[(a)]
July	D,D	O	O	D,D[(a)]
August	D	O	O	D[(a)]
September	D	O	O	D,N,D,N
October	D	O	O	D,N,D,N
November	NS	NS	O	NS
December	NS	NS	O	NS

TABLE 6.1
(continued)

MONTH	BEACH SEINING	HOOP-NETTING	GILL NETTING	BOAT ELECTROFISHING
January 1979	NS	NS	0	NS
February	D	NS	0	NS
March	D	NS	0	D,N,D,N
April	D,D	NS	0,0	D,*,D,N
May	D,D	0,0	0,0	D,N,*,*
June	D,D	0,0	0,0	D,N,D,N
July	D	0	0	D,N,D,N
August	D	0	0	D,N,D,N
September	D	0	0	D,N,D,N
October	D	0	NS(b)	D,N,D,N
November	NS	NS	NS	NS
December	NS	NS	NS	NS
January 1980	NS	NS	NS	NS
February	D	NS	NS	NS
March	D	NS	NS	D,N,D,N,

*Boat engine failure prevented sampling.
+Locations not sampled consistently
(a)Back pack electrofishing
(b)Sampling discontinued per EFSEC Resolution No. 157 (Reference 18)

TABLE 6.2

COMPOSITE LIST OF FISH SPECIES BY FAMILY COLLECTED NEAR WNP 2
FROM SEPTEMBER 1974 THROUGH MARCH 1980

Family	Scientific Name	Common Name	Sample Method and Time Period*						
			(a) GN	(b) TN	(c) BS	(d) HN	(e) TL	(h) MT	(i) ES
Acipenseridae-Sturgeons	Acipenser transmontanus (Richardson)	White sturgeon	1,2,3,4	1,3,4			2		6
Catostomidae-Suckers	Catostomus columbianus (Eigenmann & Eigenmann)	Bridgelip sucker	1,2,3,4, 5,6	1,2,3,4	1,2, 4,5	1,2,3,			4,5,6
	C. Macrocheilus (Girard)	Largescale sucker	1,2,3,4, 5,6	1,2,3,4 4,5	1,2,3 4,5	1,2,3	1,2		4,5,6
	C. platyrhynchus (Cope)	Mountain sucker	1						
Centrarchidae-Bass and Sunfish	Lepomis gibbosus (Linnaeus)	Pumpkinseed	2		4	1,2,3, 4,6			
	L. macrochirus (Rafinesque)	Bluegill	2		1,2, 4,6	1,2,4, 5,6			4
	Micropterus dolomieui (Lacepede)	Smallmouth bass	1,2,4, 5,6	1,3,4	1,3, 4,5	2,3,4, 5,6			5
	M. salmoides (Lacepede)	Largemouth bass	2,5,6		1,4,5	5,6			4,5
	Pomoxis nigromaculatus (Leseur)	Black crappie	1,2,4, 5,6	1,3,4	1(f), 4,2(f)	1,2,4 5,6			4
Clupeidae-Herrings	Alosa sapidissima (Wilson)	American shad	6	1,4					4,6

TABLE 6.2
(continued)

Family	Scientific Name	Common Name	Sample Method and Time Period*						
			(a) GN	(b) TN	(c) BS	(d) HN	(e) TL	(h) MT	(i) ES
Cottidae-Sculpins	Cottus asper (Richardson)	Prickly scuplin	5,6	1,3,4	1,3,4, 5,6	1,3,4, 5,6	1		4,5
	C. belidingii (Eigenmann & Eigenmann)	Piute scuplin					1		4,5
	C. rhotheus (Smith)	Torrent scuplin			1,3,4, 5	5	1,2		4,5
	C. bairdi (Girard)	Mottled scuplin		5,6					5
Cyprinidae-Minnows and Carp	Acrocheilus alutaceus (Agassiz & Pickering)	Chiselmouth	1,2,3,4, 5,6	1,2,3,4	1,2,4	1,2,3, 4,5,6			4,5,6
	Cyprinus carpio (Linnaeus)	Carp	1,2,3,4, 5,6	1,2,3,4	3,4	1,3,4	1		4,5,6
	Mylocheilus caurinus (Richardson)	Peamouth chub	1,2,3,4 5,6	1,2,3,4	1,2,3 4,5,6	1,4,5	1		4,5,6
	Ptychocheilus oregonesis (Richardson)	Northern squawfish	1,2,3,4 5,6	1,2,3,4	1,2,3 4,5,6	1,2,3 4,5,6	1,2		4,5,6
	Rhinichthys cataractae (Valenciennes)	Longnose dace				1,2,3, 5			4,5
	R. osculus (Girard)	Speckled dace				2,3			4

TABLE 6.2
(continued)

Family	Scientific Name	Common Name	Sample Method and Time Period*						
			(a) GN	(b) TN	(c) BS	(d) HN	(e) TL	(h) MT	(i) ES
Cyprinidae-Minnows and Carp (cond't)	Richardsonius balteatus (Richardson)	Redside shiner	1,2,3,4 5,6	1,2,3,4	1,2,3 4,5,6	1,2,3 4,5,6			4,5,6
Gasterosteidae Sticklebacks	Gasterosteus aculeatus microcephalus (Girard)	Three-spined stickleback			3,4,5, 6	3			4,5
Ictaluridae-Freshwater catfishes	Ictalurus melas (Rafinesque)	Black bullhead		1		1,6			
	I. natalis (Leseur)	Yellow bullhead		1,2,4		1,3,6			
	I. punctatus (Rafinesque)	Channel catfish	1,2,3,4 6	1,2,3,4		1			
	I. nebulosus	Brown bullhead				5			
Percidae-Perches	Perca flavescens (Mitchill)	Yellow perch	1,2,3,4 5,6	1,2,4	1,2,3 4,5,6	1,2,3 4,5,6	1		4,5,6
	Stizostedion vitreum vitreum (Mitchill)	Walleye	1,6						
Percopsidae-Trout-perches	Percopsis transmontana (Eigenmann & Eignemann)	Sand roller	1,2,4,6		3	1,2,3 4,5,6			4
Petromyzontidae-Lampreys (g)							2		
	Entosphenus tridentatus	Pacific lamprey							6
Salmonidae-Salmon, Trout, Whitefish	Oncorhynchus kisutch (Walbaum)	Coho salmon	1,2,3,5, 6	2,3	3,4,6				4

TABLE 6.2
(continued)

Family	Scientific Name	Common Name	Sample Method and Time Period* (a) GN	(b) TN	(c) BS	(d) HN	(e) TL	(h) MT	(i) ES
Salmonidae-Salmon, Troup, Whitefish (contd.)	O. nerka (Walbaum)	Sockeye salmon	1,3,4,6	1,3	3				4
	O. tshawytscha (Walbaum)	Chinook salmon	1,2,3,4 5,6	1,2,3,4	1,2,3 4,5,6	1,3			4,5,6
	Prosopium williamsoni (Girard)	Mountain whitefish	1,2,3,4 5,6	1,2,3,4	1,3,4 5,6		1,2		4,6
	Salmo gairdneri (Richardson)	Rainbow (Steelhead) trout	1,2,3,4 5,6	1,2,3,4	1,3,6	1,3,4	1		4,5,6
	Salvelinus malma	Dolly varden	1,3						
	Coregonus culpeaformis (Mitchill)	Lake whitefish	5						

(a) GN = Gill Net
(b) TN = Trammel Net
(c) BS = Beach Seine
(d) HN = Hoop Net
(e) TL = Trotline
(f) 100 ft. net
(g) Observed but not collected
(h) MT = Minnow Trap
(i) ES = electroshocker

Time Period

*1 = September 1974 through September 1975
2 = October 1975 through February 1976
3 = March 1976 through December 1976
4 = January 1977 through December 1977
5 = January 1978 through August 1978
6 = August 1978 through March 1980

TABLE 6.3

NUMERICAL ABUNDANCE OF FISH SPECIES COLLECTED BY ALL SAMPLING METHODS NEAR WNP 2 FROM SEPTEMBER 1974 THROUGH MARCH 1980

	Number Caught Per Time Period*							
Species	1	2	3	4	5	6	Total	Percent Relative Abundance
Oncorhynchus tshawytscha	2626	70	4277	3600	3370	1908	15851	44.1
Mylocheilus caurinus	723	156	505	882	55	97	2418	6.7
Catostomus marcocheilus	653	147	299	1383	78	590	3150	8.8
Ptychocheilus oregonensis	410	90	862	639	247	226	2474	6.9
Prosopium williamsoni	346	18	244	287	51	383	1329	3.7
Catostomus columbianus	261	50	153	368	38	329	1199	3.3
Acrocheilus alutaceus	263	122	129	256	92	381	1243	3.5
Richardsonius balteatus	246	105	2363	793	219	335	4061	11.3
Cyprinus carpio	72	6	25	50	20	40	213	0.6
Salmo gairdneri	58	15	35	93	10	16	227	0.6
Perca flavescens	51	52	17	108	20	21	269	0.7
Cyprinid fry	50	0	30	13	22	0	115	0.3
Acipenser transmontanus	44	3	12	0	0	1	60	0.2
Rhinichthys cataractae	36	0	37	24	0	0	97	0.3
Catostomus spp.	23	0	634	453	104	0	1214	3.4
Pomoxis nigromaculatus	19	16	0	25	0	14	74	0.2
Ictalurus punctatus	20	15	0	0	0	2	37	0.1
Cottus asper	18	0	13	24	116	14	185	0.5
Rhinichthys spp. fry	11	0	0	0	0	0	11	0.1
Percopsis transmontana	10	8	11	15	0	3	47	0.1

TABLE 6.3
(continued)

Species	1	2	3	4	5	6	Total	Percent Relative Abundance
Oncorhynchus kisutch	0	10	0	0	20	19	49	0.1
Lepomis macrochirus	0	8	0	27	0	24	59	0.2
Micropterus dolomieui	0	3	11	20	0	23	57	0.2
Lepomis gibbosus	0	3	0	0	0	5	8	< 0.1
Rhinichthys osculsus	0	0	14	0	0	0	14	< 0.1
Cottus sp.	0	0	0	127	172	12	311	0.9
Cottus beldingii	0	0	0	18	0	0	18	0.1
Cottus rhotheus	0	0	0	15	38	0	53	0.1
Micropterus salmoides	0	0	0	13	0	2	15	< 0.1
Oncorhynchus nerka	0	0	0	11	0	7	18	0.1
Gasterosteus aculeatus	0	0	0	0	12	9	21	0.1
Entosphenus tridentatus	0	0	0	0	0	1	1	< 0.1
Alosa sapidissima	0	0	0	0	0	21	21	0.1
Ictalurus melas	0	0	0	0	0	2	2	< 0.1
Ictalurus natalis	0	0	0	0	0	7	7	< 0.1
Stizostedion vitreum vitreum	0	0	0	0	0	2	2	< 0.1
Cottus bairdi	0	0	0	0	0	1	1	< 0.1
Cyprinid and Catostomid fry	0	0	0	0	0	1008	1008	2.8
	5940	897	9671	9244	4684	5503	35939	100.0

	Time Period		
*1 = September	1974	through September	1975
2 = October	1975	through February	1976
3 = March	1976	through December	1976
4 = January	1977	through December	1977
5 = January	1978	through August	1978
6 = September	1978	through March	1980

TABLE 6.4

Order of Numerical Abundance of Fish Taxa Collected near WNP 2 from January 1977 through December 1979 by Gear Type

Species	1977				1978				1979			
	BS	GN	HN	BES	BS	GN	HN	BES[a]	BS	GN	HN	BES[a]
Oncorhynchus tshawytscha	3150	19	0	10	3178	14	0	7	1872	11	0	2
Catostomus macrocheilus	369	106	4	776	2	74	2	99	0	115	0	349
Mylocheilus caurinus	771	52	1	1	22	25	5	1	1(233)[b]	84	0	7
Richardsonius balteatus	555	62	40	0	307	136	17	2	39(175)[b]	46	1	0
Ptychocheilus oregonensis	388	104	45	16	104	81	26	0	74(1374)[b]	109	0	4
Catostomus spp.	399	0	0	1	96	0	0	0	0	0	0	0
Catostomus columbianus	17	67	4	228	0	36	3	40	0	57	0	225
Prosopium williamsoni	216	1	0	60	44	7	0	44	7	9	0	280
Acrocheilus alutaceus	1	237	3	8	0	137	6	6	0	302	2	19
Cottus sp.	3	0	0	0	43	0	0	6	6	0	0	0
Perca flavescens	70	24	3	0	5	7	3	2	4	1	11	0
Salmo gairdneri	0	60	1	20	0	11	0	0	1	7	0	6
Cyprinus carpio	1	12	0	27	0	17	0	3	0	37	0	0
Lepomis macrochirus	17	0	8	0	1	0	2	0	1	0	21	0
Pomoxis nigromaculatus	20	2	1	0	0	3	8	0	0	2	1	0
Cottus asper	4	0	9	0	5	1	7	0	2	2	10	0
Rhinichthys cataractae	0	0	0	2	0	0	0	0	0	0	0	0
Micropterus dolomieui	0	3	9	4	0	1	2	0	0	7	13	0
Cottus beldingii	0	0	0	0	0	0	0	0	0	0	0	0
Percopsis transmontana	0	2	11	0	0	2	0	0	0	0	1	0

TABLE 6.4
(continued)

Species	1977				1978				1979			
	BS	GN	HN	BES	BS	GN	HN	BES(a)	BS	GN	HN	BES(a)
Cottus rhotheus	1	0	0	0	7	0	0	0	0	0	0	0
Micropterus salmoides	10	0	0	0	0	1	0	0	0	0	1	0
Cyprinid fry	13	0	0	0	19	0	0	0	0	0	0	0
Oncorhynchus nerka	0	4	0	7	0	0	0	0	0	7	0	0
Oncorhynchus kisutch	0	0	0	0	0	30	0	0	1	8	0	0
Gasterosteus aculeatus	0	0	0	0	8	0	0	0	8	0	0	0
Ictalurus punctatus	0	0	0	0	0	1	0	0	0	1	0	0
Ictalurus natalis	0	0	0	0	0	0	1	0	0	0	6	0
Lepomis gibbosus	0	0	0	0	0	0	2	0	0	0	2	0
Cottus bairdi	0	0	0	0	0	0	0	0	1	0	0	0
Stizostedium vitreum vitreum	0	0	0	0	0	0	0	0	0	2	0	0
Ictalurus melas	0	0	0	0	0	0	0	0	0	0	2	0
Alosa sapidissima	0	0	0	0	0	0	0	0	0	4	0	17
Acipenser transmontanus	0	0	0	0	0	0	0	0	0	0	0	1
Entosphenus tridentatus	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	6005	755	139	1160	3841	584	84	210	2017	811	71	911

(a) No boat electroshocking January through August 1978

(b) Numbers in parenthesis are additional fish collected in nonstandard catch.

KEY: BS - Beach Seine HN - Hoop Net GN - Gill Net BES - Boat Electroshocker

TABLE 6.5

Three Factor ANOVA Results for Ln(X+1) Transformed Columbia River Catch Per Unit Effort Data, (1977 to 1979).

Species	Sampling Method	Significance of F		
		Stations	Years	Months
Chinook salmon	beach seine	.012	.333	.000
Largescale sucker	gill net	.000	.786	.030
Bridgelip sucker	gill net	.000	.365	.045
Peamouth chub	gill net	.000	.036	.126
Redside shiner	beach seine	.288	.160	.000
	hoop net	.026	.024	.039
	gill net	.414	.012	.006
Northern squawfish	beach seine	.000	.425	.005
	hoop net	.000	.003	.000
	gill net	.000	.210	.001
Bluegill	hoop net	.000	.000	.000
Chiselmouth	gill net	.000	.090	.027

TABLE 6.6

Duncan's Multiple Range Results for Ln(X-1) transformed Columbia River Catch Per Unit Effort Data, 1977 to 1979.

Species	Sampling Method	Duncan's Multiple Range Test[a] Years	Months	Stations
Chinook	beach	---	Feb. Aug. Oct. Nov. Jul. Mar.	3 6 5 4 2 1
salmon	seine		Nov. Jul. Mar. Apr.	
			Apr. June	
			May	
Largescale sucker	gill net	---	---	3 1 2 4
Bridgelip sucker	gill net	---	---	1 3 2 4
Peamouth chub	gill net	---	---	1 2 3 4
Redside	beach	---	Feb. Mar. Oct. Apr. Jun. May Jul.	---
shiner	seine		Sep. Aug.	
	hoop net	---	---	---
	gill net	79 77	Jan. Mar. Apr. Dec. Nov. Feb. Oct. Aug. Jun. Sep. Jul.	
		77 78	Nov. Feb. Oct. Aug. Jun. Sep. Jul. May	---

TABLE 6.6

(continued)

Species	Sampling Method	Duncans Multiple Range Test[a] Years	Months	Stations
Northern squawfish	beach seine	---	Nov. Mar. Feb. Apr. May Jun. Jul. Oct. Sep. Sep. Aug.	3 5 2 6 4 1
	hoop net	79 78 77	Oct. Jul. May Jun. Sep. Aug.	2 1 3 4
	gill net	---	Jan. Feb. Dec. Mar. Nov. Oct. Apr. May Aug. Sep. Nov. Oct. Apr. May Aug. Sep. Jun. Jul.	1 2 3 4
Bluegill	hoop net	78 77 79	May Jul. Jun. Oct. Aug. Sep.	1 2 3 4
Chiselmouth	gill net	78 79 77	---	3 2 1 4

(a) - No value indicates lack of significance ($\alpha \leq 0.01$) with three-factor ANOVA; where underlining occurs values without the same underline were significantly different at the 5 percent level; arranged in increasing order from left to right.

TABLE 6.7

Parameters of length-weight relationships based on regression analysis for several common fish species collected near WNP-1, 2 and 4 by season.

Year	Season[1]	Species	Upstream/ Downstream[2]	Sample Size	Intercept ($\times 10^{-5}$)	Slope	r
1978	Fall	Chiselmouth	Downstream	18	1.83	2.95	.975
		Northern squawfish	Downstream	13	2.48	2.86	.998
		Redside shiner	Downstream	7	3.72	2.81	.990
		Redside shiner	Upstream	13	5.03	2.75	.971
		Chinook salmon	Upstream	8	1.07	3.03	.998
		Mountain whitefish	Upstream	10	1.12	2.99	.999
		Largescale sucker	Upstream	9	1.38	2.95	.985
1978	Winter	Coho salmon	Downstream	11	0.23	2.78	.990
1979	Spring	Coho salmon	Downstream	11	0.23	3.23	.990
		Mountain whitefish	Upstream	28	0.24	2.85	.966
		Largescale sucker	Downstream	7	36.74	2.42	.945
		Largescale sucker	Upstream	18	90.45	2.27	.805
		Bridgelip sucker	Downstream	14	0.57	3.14	.981
		Chiselmouth	Downstream	16	55.35	2.36	.797
		Chiselmouth	Upstream	10	2.06	2.92	.995
		Northern squawfish	Downstream	24	1.70	2.94	.962
		Peamouth chub	Upstream	14	1.71	2.93	.991

TABLE 6.7
(continued)

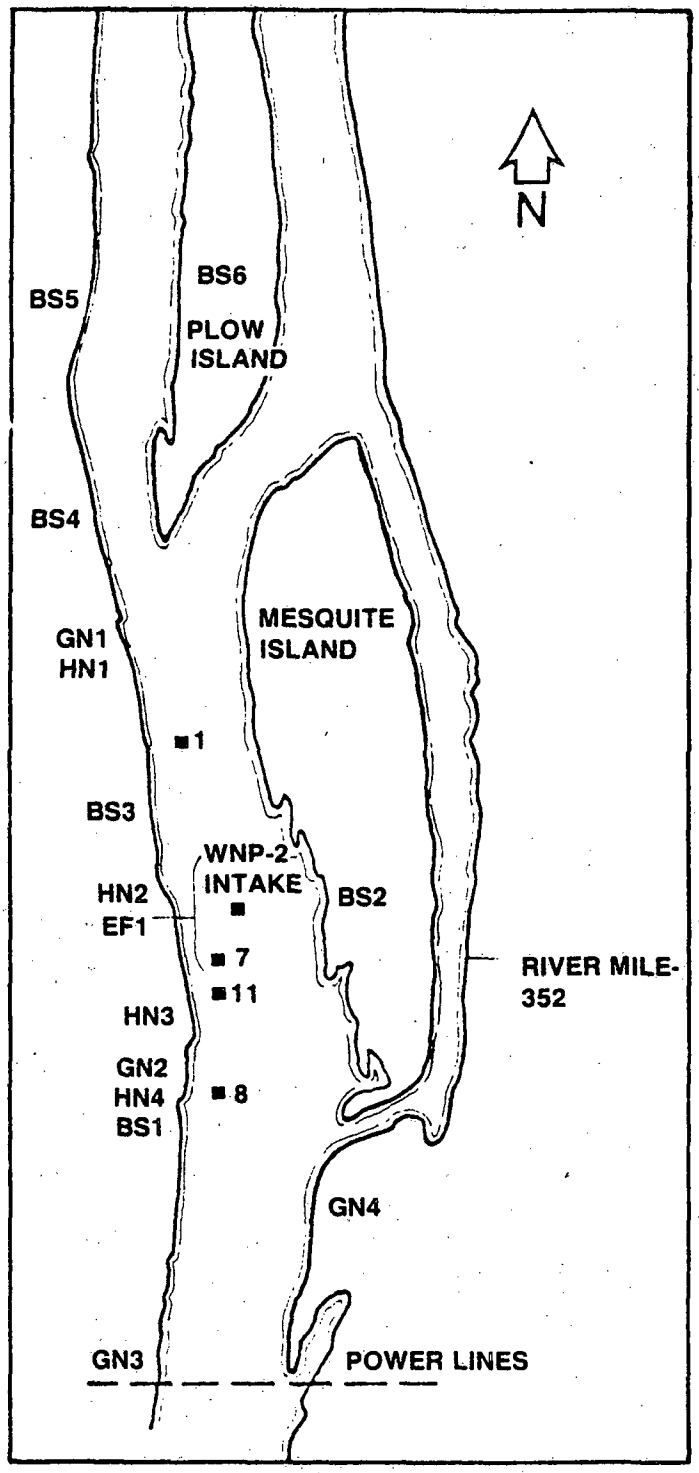
Year	Season[1]	Species	Upstream/ Downstream[2]	Sample Size	Intercept ($x10^{-5}$)	Slope	r
1979	Summer	Chinook salmon	Downstream	5	3.86	2.82	.999
		Chinook salmon	Upstream	10	4.87	2.80	.958
		Sockeye salmon	Downstream	6	2.16	2.89	.999
		Largescale sucker	Downstream	5	0.16	3.32	.983
		Largescale sucker	Upstream	19	0.35	3.18	.977
		Bridgelip sucker	Downstream	10	1.27	2.97	.968
		Bridgelip sucker	Upstream	16	1.07	3.00	.968
		Chiselmouth	Downstream	22	1.68	2.97	.992
		Chiselmouth	Upstream	7	2.75	2.48	.973
		Northern squawfish	Downstream	33	73.15	2.28	.995
		Redside shiner	Upstream	18	3.42	2.40	.997
		Redside shiner	Downstream	9	123.68	2.16	.999
		Peamouth chub	Downstream	32	18.90	2.49	.996
		Peamouth chub	Upstream	6	25.08	2.45	.968
		Yellow perch	Downstream	9	8.80	2.62	.989
		Mountain whitefish	Upstream	32	17.26	2.52	.996

TABLE 6.7
(continued)

Year	Season[1]	Species	Upstream/ Downstream[2]	Sample Size	Intercept ($\times 10^{-5}$)	Slope	r
1979	Fall	Mountain whitefish	Upstream	32	2.04	2.90	.983
		Largescale sucker	Upstream	16	3.24	2.82	.986
		Bridgelip sucker	Upstream	16	59.84	2.35	.949
		Chiselmouth	Upstream	9	1.14	3.04	.992
		Northern squawfish	Downstream	15	50.33	2.36	.999
		Northern squawfish	Upstream	9	24.37	2.47	.997
		Peamouth chub	Downstream	6	92.51	2.22	.954
		Bluegill	Downstream	5	171.55	2.12	.934
		Bluegill	Upstream	5	0.08	3.72	.987
		Smallmouth bass	Downstream	8	1.29	3.06	.997
		Smallmouth bass	Upstream	6	0.06	3.70	.972
		American shad	Upstream	15	0.01	4.03	.981
1980	Winter	Mountain whitefish	Upstream	8	100.55	2.20	.936
		Bridgelip sucker	Upstream	5	5.17	2.76	.984
		Largescale sucker	Upstream	8	1.38	2.96	.987

[1]Fall: September, October, November
Winter: December, January, February
Spring: March, April, May
Summper: June, July, August

[2]Captured upstream or downstream relative to the WNP-2 intake structures.



BS: BEACH SEINE
HN: HOOP NET
GN: GILL NET
EF: ELECTROSHOCK

FIGURE 6.1

Location of fish sampling stations in the Columbia River near WNP-2.

FIGURE 6.2
CATCH PER UNIT EFFORT FOR CHINOOK SALMON COLLECTED IN BEACH SEINES NEAR WNP-2, JANUARY 1977-MARCH 1980.

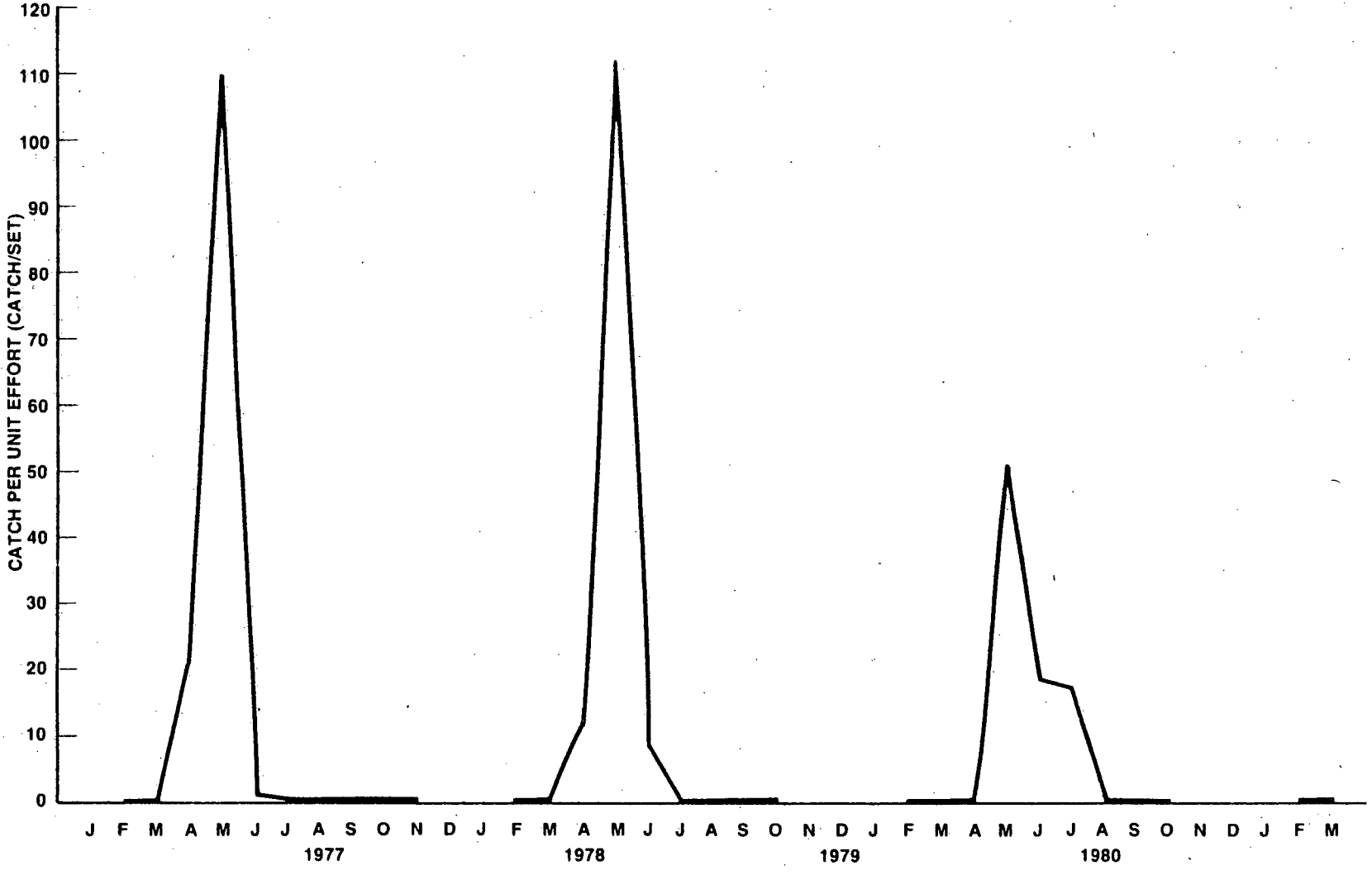


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FIGURE 6.3
CATCH PER UNIT EFFORT FOR REDSIDE SHINER COLLECTED IN BEACH SEINES NEAR WNP-2, JANUARY 1977-MARCH 1980.

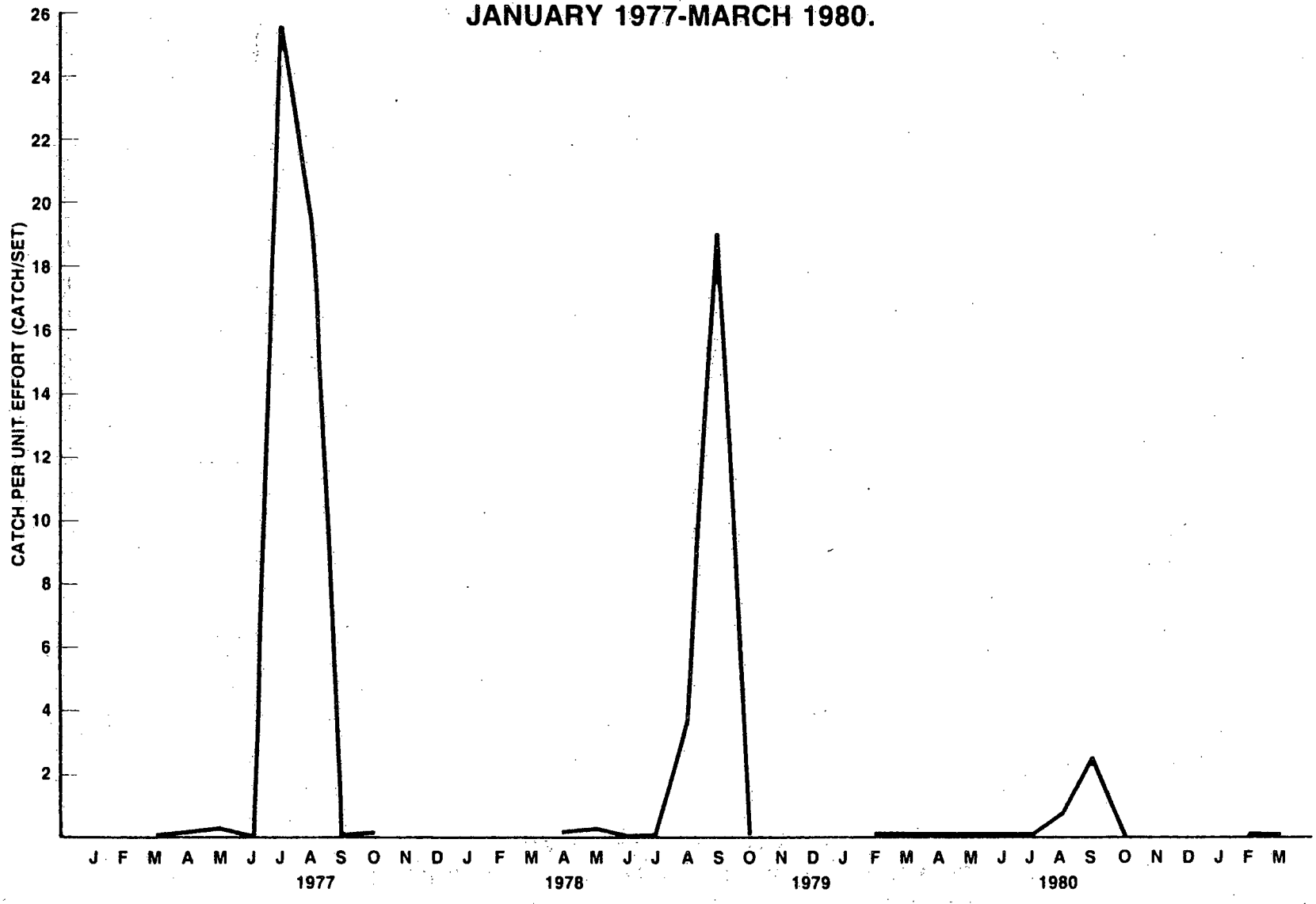

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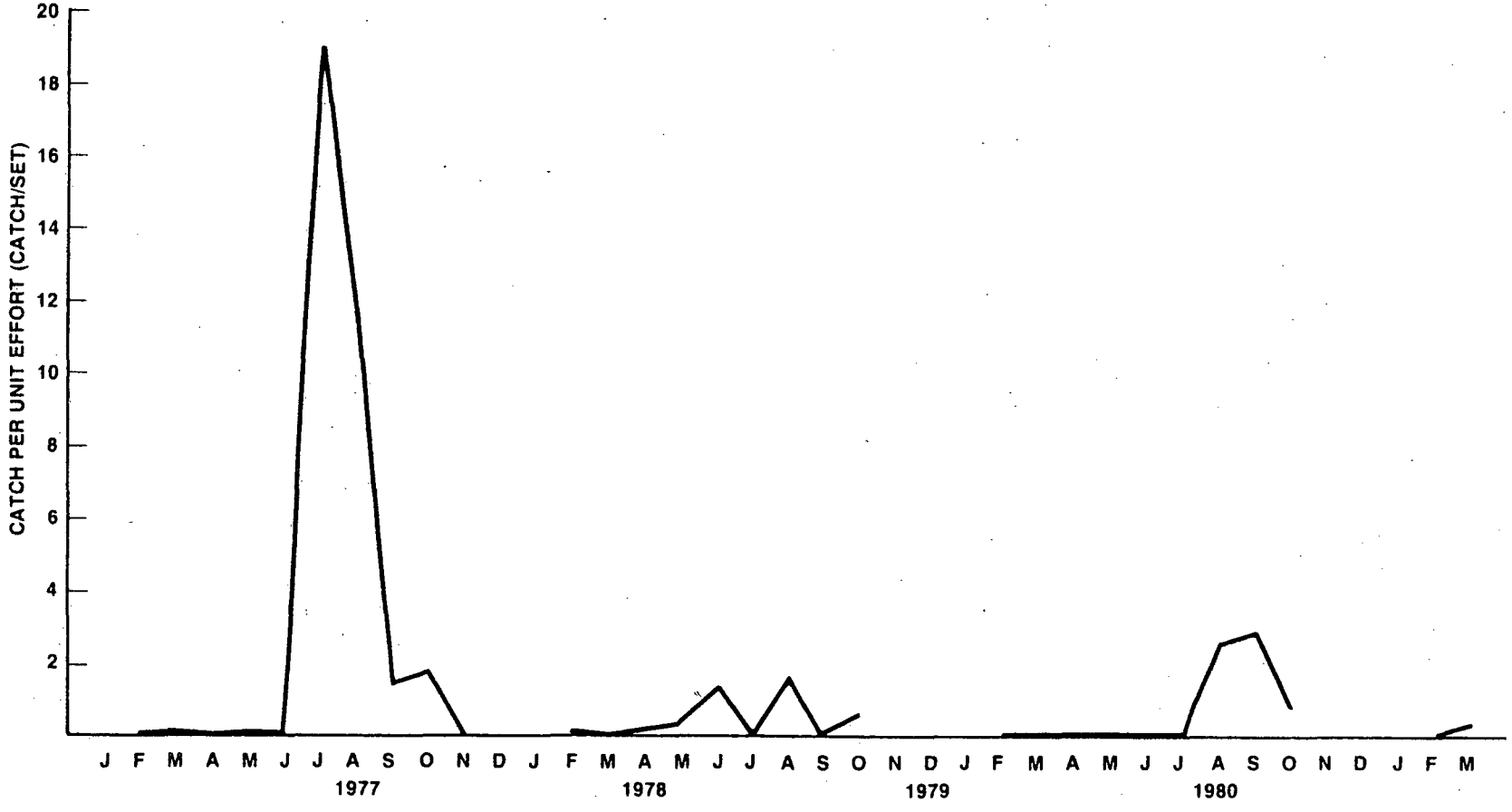
FIGURE 6.4
CATCH PER UNIT EFFORT FOR NORTHERN SQUAWFISH COLLECTED IN BEACH SEINES NEAR WNP-2, JANUARY 1977-MARCH 1980.



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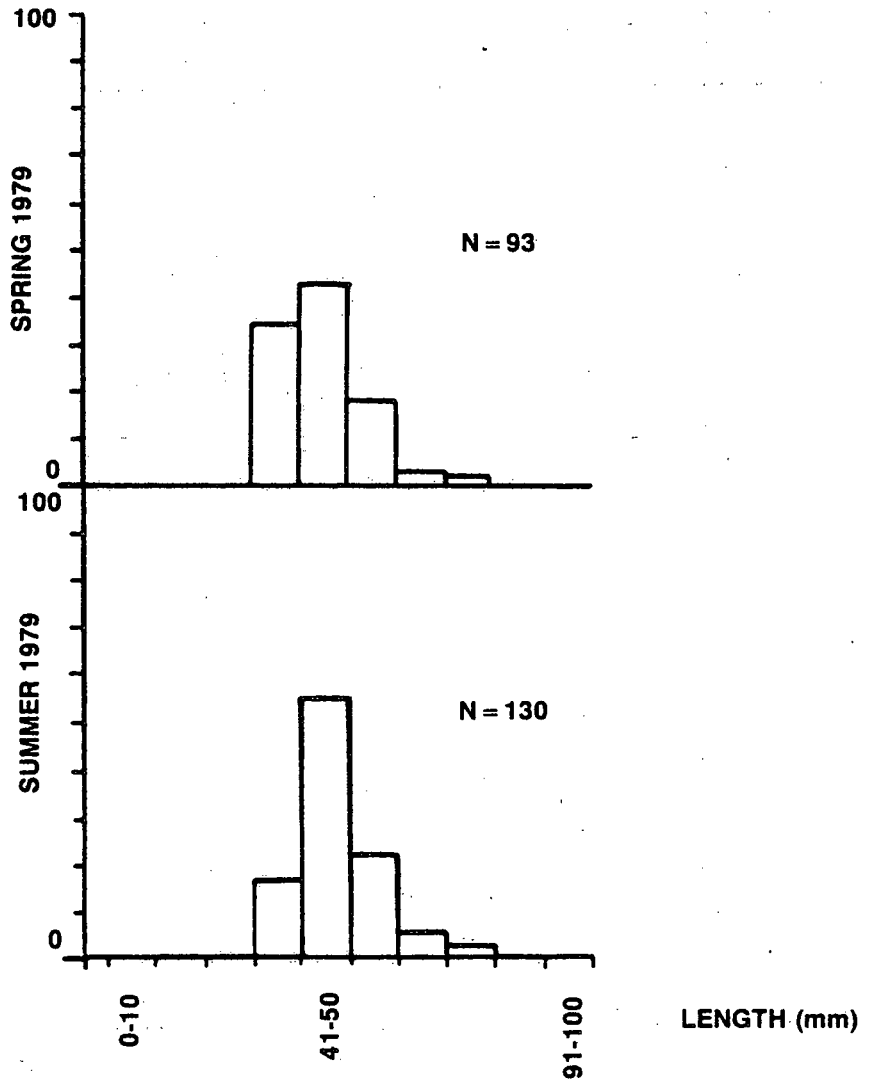

FIGURE 6.5
LENGTH-FREQUENCY OF CHINOOK SALMON FRY (*ONCORHYNCHUS TSHAWYTCHA*) COLLECTED IN BEACH SEINES NEAR WNP-2.

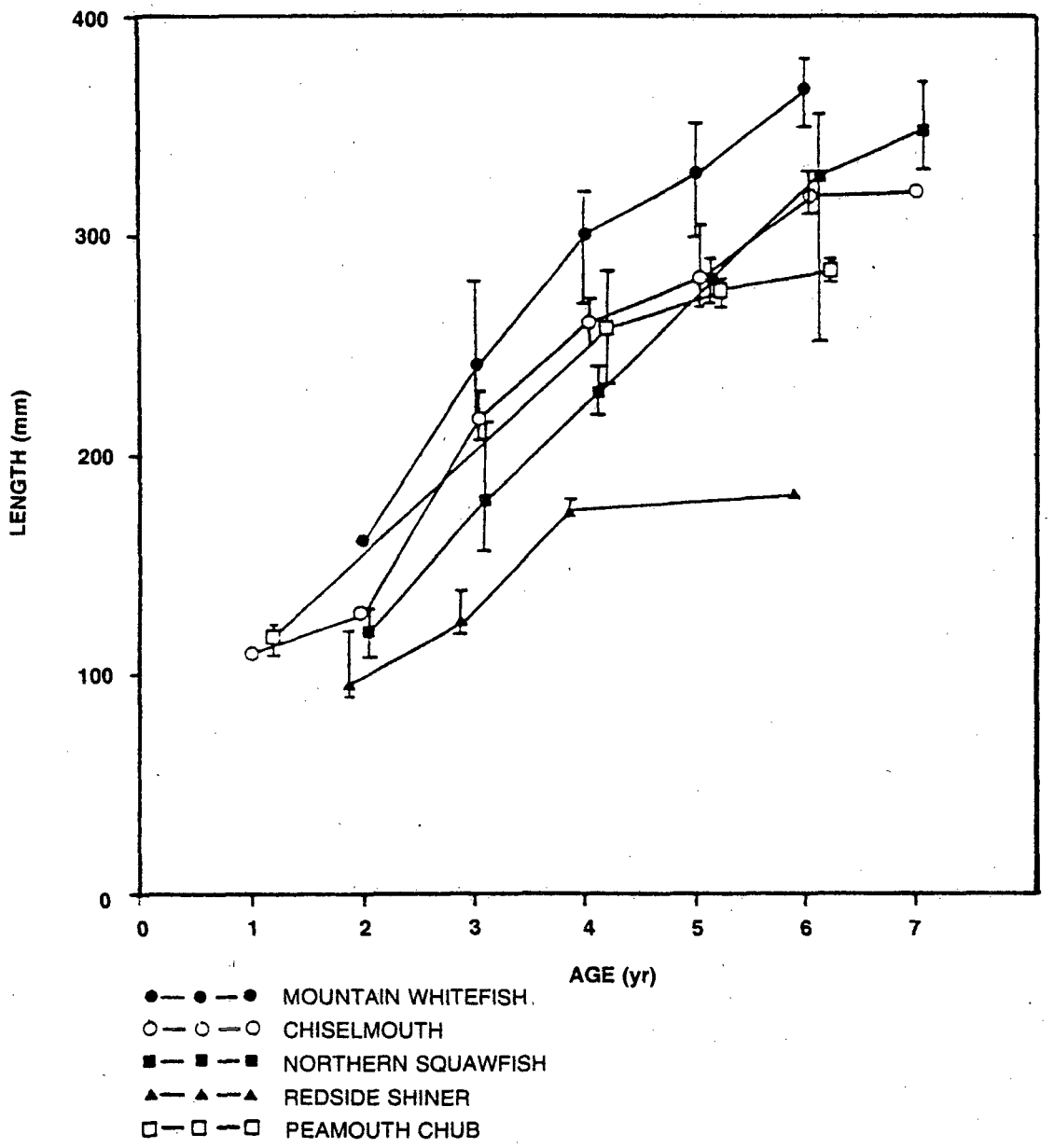

FIGURE 6.6. MEAN FORK LENGTHS (mm) AND RANGES AT AGE (years) FOR FIVE COMMON SPECIES COLLECTED NEAR WNP-2.

7.0 OTHER AQUATIC PROGRAMS

7.1 HISTORICAL AND TECHNICAL SUMMARY

EFSEC Resolution No. 132 dated January 23, 1978, revised the WNP-2 monitoring program[1]. Page 9, Section IV.D of the revised program required other aquatic programs, specifically:

> "A study of the effects of operating the intake and discharge systems will be undertaken to meet the requirements of the Corps of Engineers permit[2]. This study will be coordinated with the National Marine Fisheries Service and other fisheries agencies."

The discharge monitoring program required by Special Condition bb of the Army Corp permit will be performed during operation and is presented in Section 7.2.

The intake monitoring program required by Special Conditions w and x of the Army Corps permit was performed May 1979 through May 1980. Prior to performance of the intake study, the goals and monitoring program design were submitted for review and comment to the National Marine Fisheries Service (NMFS), Washington Department of Fisheries (WDF), Washington Game Department (WGD) and U.S. Fish and Wildlife Service. Concurrence on program goals and design was reached in the winter of 1979 and tests initiated in May 1979.

The conclusion of these tests were:

1. Intake Flow Field

   Velocity and direction measurements and patterns were similar over the different flow rates and pumping conditions tested. Decreased velocities, less than 0.6 m/sec, near the intakes represented only a small proportion, 28-38 m^3, of the volume of water flowing past this portion of the river.

2. Intake Structure Inspections

Inspections of intake structures by scuba observation revealed no incidents of fish impingement, damage or other irregularities. Minor accumulations of debris, some algal periphyton and sponges were noted on and around the structures.

3. Intake Entrainment

Entrainment sampling during a period when chinook salmon fry were abundant in the river failed to produce any evidence of entrainment. Sampling efficiency data indicated approximately 80 percent of entrained fish can be expected to be retained in the entrainment sampling cages during a 12-hour sampling period. The efficiency test data indicate entrainment is not likely to be a problem at WNP-2 with the present intake design and placement, and that a 12-hour sampling interval using the existing sampling devices is adequate to measure entrainment.

Detailed information on methodology and results are presented in references 3 and 4.

Special condition G.26 of the National Pollution Discharge Elimination System (NPDES) permit for WNP-2 requires performance of 96 hour toxicity tests of discharge water using salmonids as the test organisms(5). Test protocol and schedule will be established with EFSEC prior to WNP-2 operation. Emphasis will be placed on addressing the impacts of chlorination during these tests. The results of the tests will be used in establishing long-term chlorination procedures for WNP-2.

7.2 PROPOSED OPERATIONAL MONITORING PROGRAM AND RATIONALE

A. Monitoring Program

It is recommended that weekly, 24 hour entrainment samples be collected during the months of April, May and June.

The entrainment studies would be performed during one spring out-migration after the plant has reached at least 75% load. If the results of these studies warrant, further studies will be proposed. In addition, the intake screens will be examined monthly March through November during the first year of plant operation.

The discharge structure and river sampling locations both up and downstream will be monitored for the chemical and physical parameters in the water quality monitoring program, Section 8.2.

A two-phase thermal plume mapping program is proposed. One phase would map the surface temperatures using aerial infra-red photographic techniques. The other phase of the program will use direct measurement techniques to measure surface and subsurface temperatures. Efforts will be made to have the two study phases coincide and test performance at a time when plant thermal load is maximum, and ambient river temperature is high and river flow is low. During these studies river and discharge flow and river velocity will be measured.

B. Rationale

The thermal plume mapping and toxicity tests will provide information needed for operational impact assessment of the WNP-2 discharge. In addition, these programs will meet regulatory requirements imposed by EFSEC and NMFS.

The intake structures will be examined monthly (weather and river conditions permitting) , March through November, during the first year of operation to insure that debris is not accumulating on the screens and that fish impingement is not occurring.

The entrainment monitoring addresses one of the creditable impacts associated with WNP-2. However, the following is still very relevant to impingement and entrainment impact for WNP-2:

1) Under normal WNP-2 operation water intake withdrawal will be 35 cfs and the maximum water withdrawal possible is 55 cfs. Under worse case conditions the lowest regulated river flow passing the WNP-2 intake will be 36,000 cfs. Thus under these worse case conditions the WNP-2 intake will entrain from .05 to .15% of the passing river flow. Assuming homogeneous juvenile fish distribution in the river, .05-.15% of this population could potentially be effected by the WNP-2 intake structure.

2) Because the current vector down the screens (ambient river flow) will always be more than 10 times as great as the current vector going into the screens, it is not considered possible to impinge fish or debris on the screen surface.

3) The NRC staff (6) made the following statements in regard to WNP-2 impingement and entrainment monitoring:

"Impingement

The applicant has calculated that under maximum operating conditions, water velocity at the intake system/river interface will be 0.15 m/s (0.5 fps) at the 1-cm (3/8-in) holes in the pipes and about 0.03 m/s (0.1 fps) at a distance of 2.5 cm (1 in) from the pipes (ER-OL, Sec. 5.1.2.2). The staff finds these values to be within the representative range for such intake systems.

Larger fish, including large juveniles, can swim at speeds greater than the approach velocities discussed above. For example, young sockeye and coho salmon may swim at speeds of from five to seven body lengths per second (Refs. 17, 18); thus, a 4-cm (1.5-in) fish is capable of swimming at least 0.2 m/s (0.7 ft/s). Juvenile chinook, coho, and sockeye salmon spawned above Priest Rapids Dam will arrive at the intake site as large juveniles, and the hatchery-reared salmon and steelhead trout released to the river by the state will also be large juveniles. Thus, these juveniles should be able to escape impingement.

Out-migration of Hanford-area chinook juveniles occurs during periods of moderate to high river discharge during late spring and early summer when both flow rate past the intake and river volume available for migration will be greater than during periods of lower flow. Therefore, the probability of fish impingement will be lower during periods of out-migration compared to other times. For this reason, the staff believes that impingement impacts will not be serious during out-migration periods.

The staff also expects that large juvenile and adult fishes will not be vulnerable to impingement on the WNP-2 intake structures. This conclusion is based on a consideration of fish swimming speeds discussed above and is supported by results of intake inspection studies conducted by the applicant in December 1978 and May through December 1979 (Ref. 19), which showed that no fish were impinged during the inspection periods. During this test, the velocities at the intakes were maintained at near operational levels.

Entrainment

Naturally spawned salmon juveniles, newly emergent from their gravel spawning redds (nests), may be vulnerable to entrainment through the 1-cm (3/8-in) intake pores. The potential for newly emerged juveniles to become entrained by the WNP-2 intakes will depend upon the distribution and habitat preference of the salmon juveniles, discharge rates of the Columbia River, and makeup water withdrawal rates. Although movement in the WNP-2 area of chinook juveniles spawned in the Hanford area is not well known, the fish are thought to be more common in nearshore areas than in midstream (Ref. 20). If this is the case, and because the intake structure is located in midstream, entrainment impacts would be reduced.

Under maximum operating conditions, about 0.8 m^3/s (12,500 gpm) of water would be withdrawn from the river at each intake; this would be twice the volume withdrawn under normal operating conditions, but still less than 0.2% of the lowest regulated river discharge of 1020 m^3/s (36,000 cfs). If it is assumed that all emergent salmonids would be at their smallest size and evenly distributed throughout the river upstream of the intakes, then the proportion of the young fish population that would be entrained would be equal to the proportion of the river discharge that was withdrawn. Thus, under such conditions, about 0.2% of the young salmonids, a negligible fraction, would be entrained. From 1961 to 1975, the number of redds between Priest Rapids Dam and the site ranged from 728 to 4508 per year for fall chinook (ER-OL, Table 2.2-2). (The number of redds is proportional to the number of adult spawning salmon.) If, in a hypothetical situation, the number of redds was decreased by WNP-2 intake operation by 0.2% (representing a loss of returning year classes), the number of redds lost would range from about one (in a year when 728 redds were present) to nine (when 4508 redds were present). From 1961 to 1975, an average of 2391 redds was observed per year, with a standard deviation of $\pm$ 1249 redds. Thus, the maximum postulated effects of WNP-2 presented here are two to three orders of magnitude less than variations in salmon numbers caused by other factors.

The staff is not concerned about the entrainment and/or impingement of plankton and benthic drift during operation of the WNP-2 intake (emphasis added). Even if all of such organisms in the makeup water perished, the impacts would be short-lived because of the rapid reproductive rate of many plankton, the suspension of benthic algae, and the recruitment of upstream benthic drift.

Based on the above, the staff concludes that entrainment effects will be so small as to be immeasurable except by direct monitoring of the WNP-2 intake water. This conclusion is supported by data

from an entrainment study conducted by the applicant. From May 1979 through May 1980, when pumps were operated nearly at plant operation levels, no fish eggs or larvae were found in 69 samples of makeup water (Ref. 19)."

7.3 REFERENCES

1. Letter, W.L. Fitch to R. Woodruff, Subject: WNP-2 Environmental Monitoring Program Revisions: Resolution No. 132, dated January 23, 1978.

2. U.S. Army Corps Permit, No. 071-OYC-1-000221-75-9.

3. Preoperational Environmental Monitoring Studies near WNP-1, 2 and 4, August 1978 through March 1980, WPPSS Columbia River Ecology Studies, Vol. 7, Beak Consultants, Inc., Portland, Oregon, June 1980.

4. Mudge, J.E., G.S. Jeane, K.P. Campbell, B.R. Eddy and L.E. Foster, Evaluation of a perforated pipe intake structure for fish protection, 1981. In: Dorn, P.B. and J.T. Johnson (ed), Proceedings of the Workshop of Advanced Intake Technology.

5. State of Washington Energy Facility Site Evaluation Council, National Pollution Discharge Elimination System Waste Discharge Permit No. WA-002515-1 for WNP-2. Expiration date September 8, 1985.

6. Final Environmental Statement Related to the Operation of WPPSS Nuclear Project No. 2, Docket No. 50-397. U.S. Nuclear Regulatory Commission, Washington D.C., December 1981.

8.0 WATER QUALITY

8.1 HISTORICAL AND TECHNICAL SUMMARY

The Site Certification Agreement for WNP-2, Attachment 1, Section V, page 9 requires no preoperational water quality monitoring program (1). The basis for no further work was that numerous studies have been conducted for approximately 37 years in connection with the Hanford Site activities concerning the physical and chemical characteristics of the Columbia River in the vicinity of WNP-2. These studies included both general observations and detailed analyses of the effects on the river of effluents from the plutonium production reactors. These reports which were reviewed, evaluated, and summarized by Becker and Waddel (2), and Neitzel (3) provide an accurate and comprehensive historical picture of the river.

In an effort to update site specific data, water quality studies were performed from July 1980 through June 1981. Water chemistry samples were collected upstream of the WNP-2 intake and analyzed weekly for alkalinity, cadmium, chromium, copper, hardness, iron, lead, mercury, nickel, dissolved oxygen, pH and zinc. In addition samples were measured monthly for ammonia-nitrogen, barium, boron, calcium, chloride, cobalt, color, floride, magnesium, manganese, nitrate-nitrogen, total organic nitrogen, oil and grease, total phosphorus, orthophosphorus, potassium, settleable matter, sodium, total dissolved solids, total suspended solids, specific conductance, sulfate and turbidity. In most cases the methods of analysis were in accord with Environmental Protection Agency Procedures (4).

Table 8.1 summarizes the results of the 1980-1981 water quality study performed upstream of WNP-2. The results of this study are in good agreement with earlier studies.

8.2 PROPOSED OPERATIONAL MONITORING PROGRAM

Table 8.2 presents the recommended operational program, which includes sample parameters, locations and frequencies.

8.3 REFERENCES

1. Letter, W. L. Fitch to R. Woodruff, Subject, WNP-2 Environmental Monitoring Program Revisions, dated January 25, 1978.

2. Becker, C. D. and W. W. Waddel, A Summary of Environmental Effects Studies on the Columbia River, Battelle, Pacific Northwest Laboratories, Richland, WA, November 1972.

3. Neitzel, D. A., A Summary of Environmental Effects Studies on the Columbia River 1972 through 1978. Battelle Pacific Northwest Laboratories, Richland, WA, August, 1979.

4. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1979.

TABLE 8.1

COLUMBIA RIVER WATER QUALITY
UPSTREAM OF WNP-2 INTAKE STRUCTURE: 1980-1981

Parameter	No. Of Data Points	Average	Range
Alkalinity, mg/l as $CaCO_3$	52	59.2	53-64
Aluminum, mg/l	1	0.15	-
Ammonia, ug/l as N	12	10.1	5-28
Antimony, mg/l	1	0.15	-
Arsenic, ug/l	1	1	-
Barium, mg/l	12	0.1	-
Beryllium, ug/l	1	3.0	-
Boron, mg/l	12	0.01	-
Bromide, mg/l	1	0.14	-
Cadmium, Total, ug/l	52	0.53	0.1-8.4
Cadmium, Dissolved, ug/l	39	0.42	0.1-6.8
Calcium, mg/l	12	18.5	16.2-20.4
Carbon, Total Organic, mg/l	1	2	-
Chemical Oxygen Demand, mg/l	1	5	-
Chloride, mg/l	12	1.0	1.0-1.8
Chromium, Total, ug/l	52	0.78	0.5-2.6
Chromium, Dissolved, ug/l	37	0.5	0.5-1.6
Cobalt, ug/l	12	1.5	1-11
Color, PCU	12	12.5	5-25
Copper, Total, ug/l	52	3.5	1-16
Copper, Dissolved, ug/l	44	2.0	1-7
Cyanide, ug/l	1	2.0	-
Fluoride, mg/l	12	0.17	0.13-0.29
Hardness, mg/l as $CaCO_3$	52	68.6	56-80
Iron, Total, ug/l	52	55.7	27-140
Iron, Dissolved, ug/l	47	18.1	1-50
Lead, Total, ug/l	52	1.8	1-24

TABLE 8.1 (Contd.)

Parameter	No. Of Data Points	Average	Range
Lead, Dissolved ug/l	50	1	1-2
Magnesium, mg/l	12	4.0	3.2-4.9
Manganese, ug/l	12	9.9	6-15
Mercury, Total, ug/l	52	0.52	0.2-4.1
Mercury, Dissolved, ug/l	50	0.2	0.2-1.0
Molybdenum, ug/l	1	2.0	-
Nickel, Total, ug/l	52	1.8	1-10
Nickel, Dissolved, ug/l	39	1.1	1-3.4
Nitrate, ug/l as N	12	129.0	10-290
Nitrogen, Total Organic, mg/l	12	0.5	<0.5-0.5
Oil & Grease, mg	12	1.5	1-6
Oxygen, Dissolved, mg/l	51	10.9	8.7-13
pH	50	7.85	7.4-8.4
Phenol, ug/l	1	8.4	-
Phosphorus, Total, ug/l	12	27.5	14-44
Phosphorus, Ortho, ug/l	12	17.9	6-38
Potassium, mg/l	12	0.77	0.52-0.91
Selenium, ug/l	1	2.0	-
Silica, mg/l as SiO_2	10	4.46	1.9-6.2
Silver, ug/l	1	0.3	-
Sodium, mg/l	12	2.0	1.2-2.4
Solids, Total Dissolved, mg/l	12	93.2	54-131
Solids, Total Suspended, mg/l	12	4.0	1-10
Specific Conductance, mho/cm	12	140.0	122-169
Sulfate, mg/l	12	12.4	8.9-16.7
Sulfide, mg/l	1	0.10	-
Thallium, ug/l	1	1.	-
Tin, ug/l	1	30.	-
Titanium, ug/l	1	6.	-

TABLE 8.1 (Contd.)

Parameter	No. Of Data Points	Average	Range
Turbidity, JTU	12	2.5	0.46-12
Zinc, Total, ug/l	52	19.0	5-47
Zinc, Dissolved, ug/l	47	13.7	5-39

Note: For averaging purposes, data reported as less than some value was assumed to be that value divided by two. In a few instances, the dissolved metals data exceeded the corresponding total metals values. These data were judged to be in error and were not included in determination of the range and average figures above.

TABLE 8.2

OPERATIONAL WATER QUALITY MONITORING PROGRAM

Measured Items	Station 1*	WNP-2 Discharge	Station 11*	Station 8*	Wells in Vicinity of Plant Site +
Quantity (flow)	-	C	-	-	-
Temperature	M	C	M	M	-
Dissolved Oxygen	M	-	M	M	-
pH	M	C	M	M	Q
Turbidity	M	-	M	M	-
Total Alkalinity	M	M	M	M	Q
Filterable Residue (Total Dissolved Solid)	M	M	M	M	-
Nonfilterable Residue (Suspended Solids)	M	M	M	M	-
Conductivity	M	M	M	M	-
Iron (Total)	M	M	M	M	-
Copper (Total)	M	M	M	M	-
Nickel (Total)	M	M	M	M	-
Zinc (Total)	M	M	M	M	-
Sulfate	M	M	M	M	-
NH_4+ Nitrogen	M	M	M	M	-
NO_3- Nitrogen	M	M	M	M	Q
Ortho Phosphorus	M	M	M	M	Q
Total Phosphorus	M	M	M	M	Q
Oil and Grease	M	M	M	M	-
Chlorine, Total Residual	-	D	M	M	-
Hardness	M	M	M	M	-

Symbols Key

C = Continuous
M = Monthly
Q = Quarterly
D = Daily, when chlorine is added

*Refer to Figure 2.1 for station location

+ Samples will be collected if wells are being used for drinking water