316 DEMONSTRATION

VERMONT YANKEE NUCLEAR POWER STATION

CONNECTICUT RIVER
VERNON, VERMONT

BIOLOGICAL, HYDROLOGICAL & ENGINEERING INFORMATION

aquatec INC.

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AND

ENVIRONMENTAL IMPACT ASSESSMENT

(For the period 16 May to 14 October)

VERMONT YANKEE
NUCLEAR POWER CORPORATION

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SUMMARY

This report presents biological, engineering, and hydrological information in support of Vermont Yankee Nuclear Power Corporation's request, pursuant to Sections 316a and 316b of the Federal Pollution Control Act Amendments of 1972, for alternate temperature standards for its electric generating station located along the Connecticut River in Vernon, Vermont, during 16 May to 14 October. The alternate temperature standards requested in this 316 Demonstration are for increases in mixed river temperatures of 2 to 5°F based upon upstream ambient temperatures:

Ambient Water Temperature (°F)	Temperature Increase Standard (°F)
Above 63	2
>59, ≤63	3
>55, ≤59	4
Below 55	5

This 316 Demonstration is the culmination of a nearly ten year effort referred to as Project **SAVE** (Save Available Vermont Energy). Biological data obtained as part of Project SAVE and studies conducted during the past 20 years to fulfill monitoring requirements form the basis of the bioassessment of the aquatic community. The bioassessment focused on potential effects of Vermont Yankee's open or hybrid cycle operation during 16 May to 14 October.

Changes in the phytoplankton, zooplankton, and macroinvertebrate communities as a result of Project SAVE operation were not detected during the ten year study. Fish impingement of resident fish was low during Vermont Yankee operation with negligible effect on the fish community. Resident fish, smallmouth bass, white perch, yellow perch, walleye and spottail shiner, were not excluded from any habitats in the river due to plant operation nor was growth of these species adversely affected by open or hybrid operation during Project SAVE. There was no blockage of upstream migration of adult anadromous fish, Atlantic salmon and American shad. Downstream migrating Atlantic salmon smolts moved into and through Vermont Yankee's thermal plume without any observed delay.

The results of these studies have documented that Vermont Yankee Project SAVE operation, 16 May through 14 October, has not altered the distribution, abundance or diversity of aquatic biota of the Connecticut River near Vernon. The conclusion of this study is that continued Vermont Yankee operation under the sliding scale temperature standards, presented above, will occur in such a manner that the protection and propagation of a balanced, indigenous community of shellfish, fish, and wildlife in and on the Connecticut River in the Vernon area will be assured.

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1.0 INTRODUCTION

1.1 Historical Overview

Vermont Yankee Nuclear Power Station is located on the west shore of the Connecticut River in Vernon, Vermont. Vernon Dam and Vernon Station, a hydroelectric generating facility, are located approximately one-half mile downstream of Vermont Yankee (Figure 1.1).

The rated reactor core thermal power level of Vermont Yankee is 1593 Megawatts (MW) providing a gross electrical output of 537 MW. The remaining 1056 MW are removed as waste heat by the circulating cooling water as it passes through the condenser.

Vermont Yankee was originally designed in 1967 with a once through condenser cooling water system. This system would have utilized Connecticut River water pumped once through the condenser and the heat would have been transferred directly to the river. During public hearings ending in 1972, which preceded the licensing and operation of Vermont Yankee, concerns were expressed of possible environmental impact of a once through mode of condenser cooling. In response to these concerns two mechanical draft cooling towers were installed. These towers were designed to dissipate directly to the atmosphere all, or part of, the heat added to the circulating water from cooling the condenser. Any use of the cooling towers, however, results in a reduction in plant generation due to losses in the plant's thermodynamic efficiency and to the energy needed to operate the cooling tower fans and pumps.

Under the conditions of the U.S. Atomic Energy Commission's full power operating license, issued early in 1973, Vermont Yankee was required to use closed cycle condenser cooling until determinations could be made concerning the possible environmental impact from the discharge of heat to the river. For the first two years of plant operation (1972-1973), only the closed cycle mode of condenser cooling was utilized. In 1974, to obtain empirical data to make a determination of environmental impact, Vermont Yankee was permitted to discharge heat in compliance with existing State of Vermont temperature standards, concurrent with an intensive biological and hydrological testing program. This program was developed with the aid of the Technical Advisory Committee (informally organized around 1968 or 1969) that consisted of fisheries and water quality experts from the States of Vermont, New Hampshire, and Massachusetts.

These studies, referred to as the "Phase Studies," were conducted during 1974-1978. As a result of these Phase Studies and the pre-operational studies, a 316 Demonstration was made for alternate temperature standards (Binkerd et al. 1978). Subsequently in 1978, Vermont Yankee was granted an amended NPDES Permit to discharge condenser cooling water to the river from 15 October to 15 May according to the following criteria:

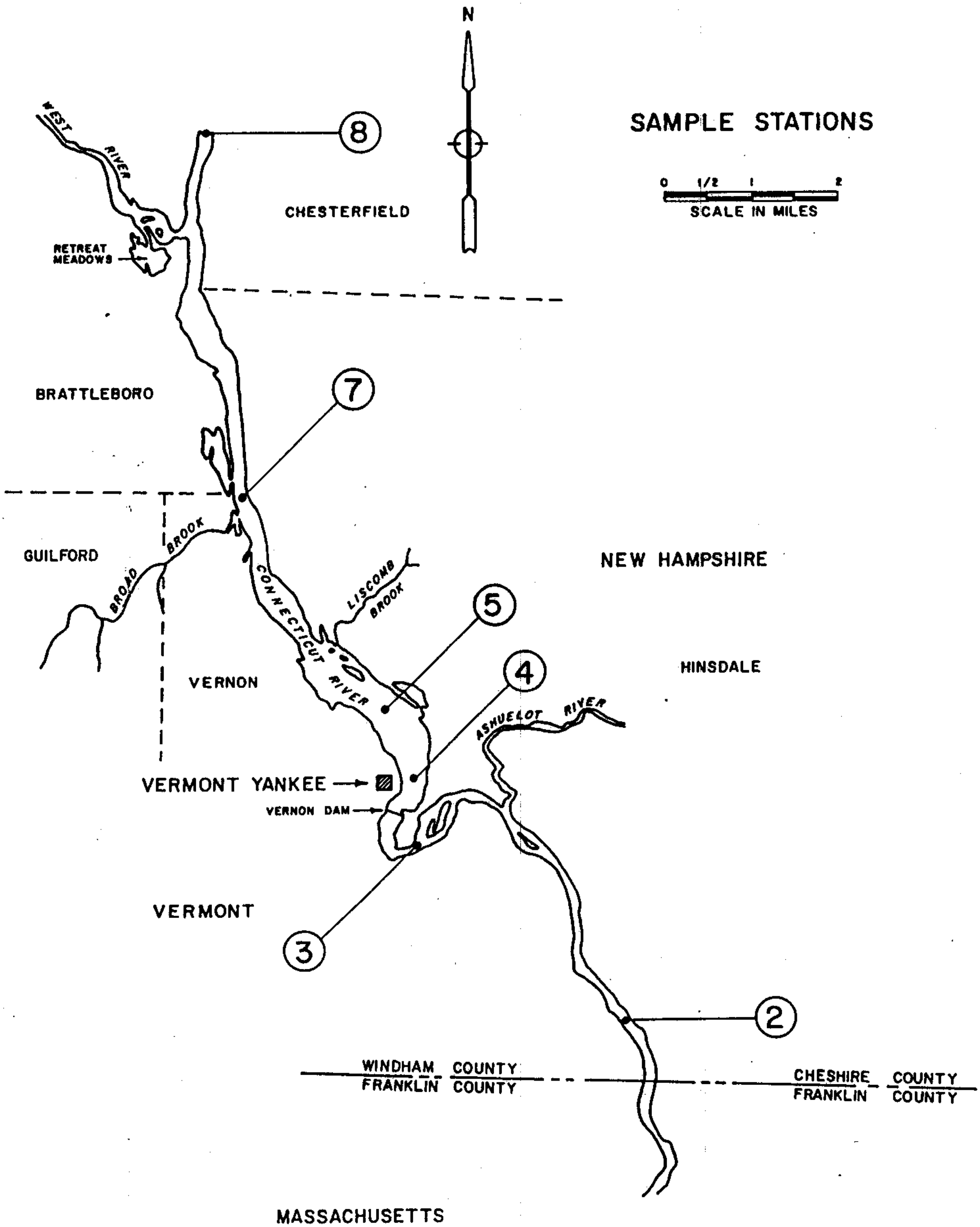


Figure 1.1 Location of Vermont Yankee and biological monitoring stations.

1. The temperature at Station 3 during open cycle operation shall not exceed 65°F;

2. The rate of temperature change at Station 3 shall not exceed 5°F per hour; and

3. The increase in temperature above ambient at Station 3 shall not exceed 13.4°F.

During the remainder of the year the plant operated in the closed cycle mode.

In 1981, Vermont Yankee proposed a program and a study plan to the State of Vermont's Department of Water Resources for evaluating alternate operational condenser cooling modes from 16 May to 14 October. The study plan was for evaluation of the thermal discharge and impingement/entrainment effects on the Connecticut River and its aquatic biota. The goal of this program, referred to as Project **SAVE** (**S**ave **A**vailable **V**ermont **E**nergy), was to maximize Vermont Yankee's energy production without objectionable environmental impact.

1.2 Operational History of Project SAVE

The groundwork for Project SAVE was formulated in 1981 at meetings between Vermont Yankee representatives and the Technical Advisory Committee. To begin Project SAVE, State of Vermont temperature standards were assumed to define a level of thermal impact which was not objectionable. Test programs were discussed at these meetings and experimental studies were applied for under Section A1.6.(1) of Vermont Yankee's NPDES Permit No. VT0000264. These studies focused on intensive biological investigations, particularly fisheries, and the optimization of plant operation within temperature standards. The temperature standards in effect for this area of the Connecticut River in 1982, were the warm water fish habitat standards which allowed 1 to 5°F in mixed river temperature increase, depending upon upstream ambient water temperatures.

Although "background" biological studies and intensive planning occurred in 1981, Project SAVE investigations began in earnest in 1982 with a major riverine ichthyoplankton sampling program. Approximately 830 ichthyoplankton samples were obtained during May through August at stations upstream, adjacent to, and downstream of Vermont Yankee's discharge. Monthly fishing efforts for resident fish were increased and included monthly summer trapnetting at 16 locations and the employment of an additional method for collecting fish, electrofishing, at these same locations. Riverine sampling of fish using these two methods was supplemented by gill nets and seines.

As part of these intensified studies, tagging of adult fish began in 1982. Three species of fish, smallmouth bass (Micropterus dolomieui), walleye (Stizostedion vitreum vitreum), and white perch (Morone

americana) were part of this initial effort. Due to a high mortality rate of tagged white perch and low tag returns of walleye, this program was modified to concentrate on smallmouth bass during subsequent years of Project SAVE.

During 1982-1985, impingement of fish at the intake structure was monitored in accordance with Vermont Yankee's NPDES Permit. This Permit required sampling of the plants circulating cooling water traveling screens and service water traveling screens during summer closed cycle operation.

In 1984, the success of the American shad (*Alosa sapidissima*) reproducing in upper Turners Falls pool, an area within one mile downstream of Vermont Yankee, was documented. Electrofishing efforts targeted the young-of-the-year shad to investigate growth and outmigration of shad in a region receiving heated water from Vermont Yankee.

During the early years of Project SAVE, the plant was operated in either open or hybrid mode for various time periods from 16 May to 14 October (Table 1.1). Due to the increased frequency of movement of the recirculation gate demanded by Project SAVE, operational difficulties with the gate were encountered and the reliability of the gate was reduced which placed constraints on planned thermal discharges during Project SAVE; however, an increased energy production of 5,000 to 18,000 MW hours (MWh) per year was realized during 1982-1985.

Table 1.1 Operational history of Vermont Yankee during Project SAVE and the corresponding additional energy production.

Year	Operational Dates Project SAVE	Five Month Additional Energy Production (MWh)
1982	16 May to 31 May; and 15 September to 13 October	11,000
1983	24 June to 6 July	5,000
1984	16 May to 15 June	18,000
1985	16 May to 29 May	6,000
1986	Not Operated	0
1987	16 May to 7 August	13,877
1988	16 May to 19 July	10,120
1989	16 May to 14 October	68,315
	Total	132,312

In 1985, the goals of Project SAVE were reassessed since the current NPDES Permit would expire in January 1986 and would be reissued for another five year period. Also, during 1985, revised Vermont Water Quality Standards were being implemented by the Vermont Water Resources Board. As part of these new standards, the habitat designation of the Connecticut River near Vernon was changed from warmwater to coldwater fish habitat. This change meant that the coldwater fish habitat temperature standards, 1°F above ambient for thermal discharges, were now to be applied to the Connecticut River near Vernon. Presumably, this change in habitat designation was not in response to the resident fishery, but to the restoration goals for anadromous fish, Atlantic salmon (<u>Salmo salar</u>) and American shad, to the Connecticut River.

In the 1986 NPDES Permit, temperature standards for 15 October to 15 May remained the same as in the previous NPDES Permit; however, a 1°F temperature standard for the period of 16 May to 14 October was now permitted. Biological monitoring program requirements of the Permit were drafted in two sections. Part I, Task Oriented Monitoring, defined specific plankton, fish, and invertebrate sampling requirements. Part II, Goal Oriented Monitoring, broadly defined five goals which were to be addressed during the five year duration of the 1986 NPDES Permit. Vermont Yankee was required to design and present study proposals annually which addressed one or more of these goals. The study plans were developed in close conjunction with the Vermont Yankee Environmental Advisory Committee (VYEAC), now, a formal advisory body whose function was defined in the 1986 NPDES Permit. Also, a five year experimental program was permitted instead of the year-to-year authorization required prior to 1986.

Many of the goal oriented studies have focused on the anadromous fish being established in the Connecticut River. Juvenile American shad have been monitored annually for relative year class strength, growth, and distribution in the upper Turners Falls pool. Age and sex composition of the returning adult American shad population have been studied at the Vernon Dam fishway during 1989-1990. Beginning in the spring of each year, 1988-1990, the downstream migratory behavior of Atlantic salmon smolts was investigated by radiotelemetry. Other studies have included habitat documentation of juvenile American shad, plankton, and macroinvertebrates. Monitoring of fish and other biota, as required by Part I of the 1986 NPDES Permit, was similar in scope and methodology to previous monitoring.

In 1986, Vermont Yankee underwent an extended maintenance and refueling outage to replace pipes in the containment building. In early 1987, the recirculation gate and one intake gate were upgraded with hydraulic operators to withstand repeated cycling. Open or hybrid operation for Project SAVE continued in 1987. Energy production resulting from Project SAVE peaked in 1989 with 68,315 MWh produced.

2.0 316 DEMONSTRATION

2.1 Alternate Temperature Standards

This 316 Demonstration is the culmination of the nearly ten year effort of Project SAVE and the previous effort extended for the 316 Demonstration submitted in 1978. The data collected as part of these two studies, and the analysis of additional data obtained as part of the NPDES Permit requirements, provided the basis for this Demonstration.

This petition for alternative temperature standards is consistent with Section 316 in the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500, and with Vermont Water Quality Standards, 27 April 1990, Section 3-01,d. Both Federal and State statutes allow for alternative temperature standards provided that the present standards can be shown to be more stringent than necessary to assure the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife in and on the Connecticut River near Vernon, Vermont.

The alternate temperature standards applied for in this 316 Demonstration are for increases in mixed river temperatures of 2 to 5°F based upon upstream ambient temperatures (Table 2.1).

Table 2.1 Alternate temperature standards applied for in this 316 Demonstration.

Ambient Water Temperature (°F)	Temperature Increase Standard (°F)
Above 63	2
>59, $\le$63	3
>55, $\le$59	4
Below 55	5

These alternate temperature standards would apply during 16 May to 14 October and at river temperatures noted above. Temperature standards for the period of 15 October to 15 May have been addressed in the 1978-316 Demonstration.

This is MOST current

2.2 Demonstration Approach

The effects of both Vermont Yankee's thermal discharge and cooling water intake were considered in this report with regard to requirements in Sections 316(a) and 316(b), respectively. The draft 316 Technical Guidance Manuals developed by the U.S. Environmental Protection Agency (EPA) (EPA 1977a, 1977b) have been utilized to format this Demonstration. In these draft Technical Guidance Manuals, the EPA has outlined three predictive approaches for 316 a and b Demonstrations:

1. Type 1: Lack of Prior Appreciable Harm;
2. Type 2: Protection of Representative Important Species (RIS); and
3. Type 3: Low Potential Impact.

By definition, and in concurrence with members of VYEAC in 1986, the potential impacts for the phytoplankton, zooplankton, and macroinvertebrate communities were deemed low (Type 3) in accordance with the Technical Guidance Manual decision criteria. However, additional studies have been conducted on these three communities. Interpretation of these data was presented following the Type 1 format, Lack of Prior Appreciable Harm.

The Type 2 format, Representative Important Species, was used for the fish community Demonstration. With the approval of the VYEAC, seven species of fish were selected as the RIS: Atlantic salmon, American shad, smallmouth bass, walleye, yellow perch, white perch, and spottail shiner.

2.3 Bioassessment Summary

The bioassessment of the aquatic community focused on the potential effects of Vermont Yankee's open or hybrid cycle operation from 16 May to 14 October. The proposed alternate temperature standards, a sliding scale of 2 to 5°F increase in mixed river temperatures, are discussed in Section 4, Engineering and Hydrological Information. Based upon measured temperatures and river discharges during the past 20 years, the likelihood of possible temperature increases for each day (and hour) that could be expected from Vermont Yankee operation are presented. The bioassessment of these proposed temperature standards, 2 to 5°F, was viewed in light of the fluctuating ambient temperatures. The increase in mixed river temperature due to Vermont Yankee operation was relatively low compared with these natural variabilities in ambient temperatures.

A Type 1 Demonstration narrative was conducted for the phytoplankton, zooplankton, and macroinvertebrates. With the concurrence of the VYEAC and the 316 Technical Guidance Manual's definition of low potential impact for these three communities, the impact of Vermont Yankee's operation was deemed as low. However, routine sampling and analyses of these communities have been conducted throughout Project SAVE. This sampling did not detect any changes in these communities, either in shifts towards undesirable species or loss of species as a result of plant operation.

A Type 2 Demonstration, Representative Important Species, was conducted for the fish community near Vernon. During the 18 year Vermont Yankee monitoring history of the Connecticut River while Vermont Yankee was operational, fish mortality due to cold and/or heat shock has never been observed. The fish community composition near Vernon has changed since 1981. New species of fish, American shad, Gizzard

shad, sea lamprey, Atlantic salmon, and blueback herring have been captured in the region. The presence of these fish was a result of the operation of the Turners Falls Dam and Vernon Dam fishways which began in 1980 and 1981, respectively. Resident fish community composition was similar to historical conditions, although natural long-term population cycles were noted.

Fish impingement of resident fish was low during Project SAVE, which was consistent with historical analyses of previous Vermont Yankee impingement rates. The average impingement rate of fish was 26 fish per day, averaging 320 grams. Fifty-nine juvenile Atlantic salmon were impinged during the 1981-1989 impingement studies. Four of these salmon were impinged during the period of this 316 Demonstration, 16 May to 14 October. Only one American shad was impinged during all of Project SAVE. Impingement limits for these two species of anadromous fish are currently regulated in Vermont Yankee's 1986 NPDES Permit. These limits were not approached, nor exceeded, during Project SAVE.

Ichthyoplankton entrainment has also been investigated since 1982. Ichthyoplankton samples at all locations were routinely dominated by minnows and white perch larvae. Densities in front of and in the intake structure were low, typically less than one fish per cubic meter of water, which was much less than densities observed in upstream littoral areas sampled by ichthyoplankton seine. Larval walleye were a sparse component of the ichthyoplankton near the intake. Walleye larvae were present for about two weeks in May. During the eight years of Project SAVE operation and ichthyoplankton entrainment, there were no detectable changes in the fish community near Vernon as a result of ichthyoplankton entrainment and plant operation.

Migration of anadromous fish was evaluated during Project SAVE. The analysis of American shad upstream passage at Vernon Dam did not detect any correlation between plant operation and the size of the shad run at Vernon. Major upstream migrations of American shad through the Vernon Dam fishway were documented while Vermont Yankee was operating in open or hybrid cycle modes. Juvenile American shad have inhabited upper Turners Falls pool annually since 1984. American shad were not excluded from any large areas as a result of Vermont Yankee operation.

Adult Atlantic salmon have also migrated upstream and through Vernon Dam fishway while Vermont Yankee was operating in open or hybrid cycle modes as part of Project SAVE with no blockage of migration observed. The Vernon Dam fishway passed 75 percent of the Atlantic salmon that were passed through Turners Falls fishway. Radiotelemetry studies of the Atlantic salmon smolts demonstrated rapid downstream movement of these fish into and through Vermont Yankee's thermal plume without any observed delays.

Growth of resident fish, smallmouth bass, white perch, yellow perch, and walleye, was comparable among locations and over time. Decreases in growth rate due to plant operation were not observed.

Growth rates for these species were rated as average to above average when compared with growth rates reported for the same species in other North American drainages. The resident RIS fish species were found in areas within and outside of the thermal plume with no documented exclusion of habitat due to plant operation. There was no blockage of movement of resident fish due to the thermal plume.

3.0 BIOLOGICAL INFORMATION

3.1 Phytoplankton

3.1.1 316 Demonstration Criteria

In accordance with the EPA draft Technical Guidance Manual, the decision criteria for the 316 Demonstration will be successful if it can be shown that the site is a low potential impact area for phytoplankton. The EPA defined open systems in which phytoplankton are not the major food chain base as low potential impact areas. Accordingly, most rivers, including the Connecticut River, are in this category. By definition, the area of the Connecticut River near Vermont Yankee is an area of low potential impact. This Demonstration was made with a narrative which summarized the phytoplankton analyses conducted as part of the Vermont Yankee monitoring program.

3.1.2 Phytoplankton Bioassessment

Twenty years of studies have been conducted on the phytoplankton community. Binkerd et al. (1978) summarized the 1968-1977 analyses conducted on entrainment and thermal effects on the phytoplankton community due to Vermont Yankee operation. The conclusion of this study was that the "operation of Vermont Yankee in hybrid or open cycle condenser cooling modes had not effected a demonstrable change in the phytoplankton community of the river." In addition, that study found that entrainment does not usually result in a complete loss of viability of phytoplankters.

Sampling of phytoplankton during 1981-1985 was conducted monthly at Stations 7 and 3 and at the Vermont Yankee intake and discharge structures (Aquatec et. seqq. 1982). Phytoplankton sampling was required monthly, April through November, at the intake and discharge structures as part of the 1986 NPDES Permit. Two other studies conducted on phytoplankton in the Turners Falls and Vernon pools documented riverine phytoplankton composition (Shambaugh 1987, Shambaugh and Downey 1990).

Observations on phytoplankton composition in the Connecticut River near Vernon during 1981-1989 revealed a continued diversity in the number of species present (Table 3.1). Seasonal succession of the algal community and physical effects, such as river discharge, were noticeable as in previous studies. During Project SAVE, there was no shift observed in the community composition towards nuisance algae as a result of Vermont Yankee operation.

3.2 Zooplankton

3.2.1 316 Demonstration Criteria

The criteria for a Demonstration of low potential impact for zooplankton listed by the 316 draft Technical Guidance Manual are:

Table 3.1 Checklist of phytoplankton collected in the Connecticut River near Vernon, Vermont.

CYANOCHLORONTA
- Cyanophyceae
  - Chroococcales
    - Chroococcaceae
      - *Aphanocapsa* sp.
      - *Aphanocapsa elachista*
      - *Aphanothece* sp.
      - *Chroococcus* sp.
      - *Gomphosphaeria* sp.
      - *Gomphosphaeria aponina*
      - *Gomphosphaeria lacustris*
      - *Gomphosphaeria naegeliana*
      - *Merismopedia* sp.
      - *Microcystis* sp.
      - *Microcystis aeruginosa*
  - Nostocales
    - Nostocaceae
      - *Anabaena* sp.
      - *Anabaena planctonica*
      - *Anabaena spiroides*
      - *Anabaena wisconsinense*
      - *Aphanizomenon* sp.
      - *Aphanizomenon flos-aquae*
      - *Raphidiopsis* sp.
    - Oscillatoriaceae
      - *Lyngbya* sp.
      - *Oscillatoria* sp.
      - *Oscillatoria limnetica*
      - *Oscillatoria limosa*
      - *Oscillatoria rubescens*
      - *Oscillatoria splendida*
      - *Phormidium* sp.
    - Rivulariaceae
      - *Calothrix* sp.

CHLOROPHYCOPHYTA
- Chlorophyceae
  - Volvocales
    - Chlamydomonaceae
      - *Carteria* sp.
      - *Chlamydomonas* sp.
    - Volvocaceae
      - *Eudorina* sp.
      - *Gonium* sp.
      - *Pandorina* sp.
      - *Pandorina morum*
      - *Volvox* sp.
      - *Volvox aureus*
  - Chlorococcales
    - Chlorococcaceae
      - *Characium* sp.
      - *Schroederia* sp.
      - *Tetraedron*
      - *Tetraedron caudatum*
      - *Tetraedron caudatum* var. longispinum
      - *Tetraedron minimum*
      - *Tetraedron trigonum*
    - Palmellaceae
      - *Gloeocystis* sp.
      - *Gloeocystis gigas*
      - *Sphaerocystis* sp.
      - *Sphaerocystis Schroeteri*
    - Oocystaceae
      - *Ankistrodesmus* sp.
      - *Ankistrodesmus convolutus*
      - *Ankistrodesmus falcatus*
      - *Ankistrodesmus falcatus* var. acicularis
      - *Ankistrodesmus spiralis*
      - *Closteriopsis* sp.
      - *Kirchneriella* sp.
      - *Kirchneriella obesa*
      - *Kirchneriella obesa* var. major
      - *Kirchneriella subsolitaria*
      - *Lagerheimia* sp.
      - *Lagerheimia ciliata*
      - *Lagerheimia quadriseta*
      - *Nephrocytium* sp.
      - *Oocystis* sp.
      - *Quadrigula* sp.
      - *Quadrigula closteroides*
      - *Quadrigula lacustris*
      - *Selenastrum* sp.
      - *Selenastrum minutum*
      - *Selenastrum Westii*
      - *Treubaria* sp.
      - *Treubaria triappendicularia*
      - *Westella* sp.
      - *Westella linearis*
    - Micractinaceae
      - *Golenkinia* sp.
      - *Micractinium pusillum*
    - Dictyosphaeriaceae
      - *Dictyosphaerium* sp.
      - *Dictyosphaerium pulchellum*

Table 3.1 (continued).

Scenedesmaceae
- Actinastrum sp.
- Actinastrum Hantzschii
- Actinastrum Hantzschii var. fluviatile
- Coelastrum sp.
- Crucigenia sp.
- Crucigenia crucifera
- Crucigenia fenestrata
- Crucigenia quadrata
- Crucigenia rectangularis
- Crucigenia tetrapedia
- Scenedesmus sp.
- Scenedesmus acuminatus
- Scenedesmus arcuatus
- Scenedesmus arcuatus var. platydisca
- Scenedesmus bijuga
- Scenedesmus dimorphus
- Scenedesmus falcatus
- Scenedesmus obliquus
- Scenedesmus quadricauda
- Scenedesmus quadricauda var. westii
- Tetradesmus sp.
- Tetrastrum sp.
- Tetrastrum heteracanthum

Hydrodictyaceae
- Pediastrum sp.
- Pediastrum biradiatum
- Pediastrum Boryanum
- Pediastrum duplex
- Pediastrum duplex var. coharens
- Pediastrum duplex var. gracilimum
- Pediastrum duplex var. rotundatum
- Pediastrum obtusum
- Pediastrum simplex
- Pediastrum simplex var. duodenarium
- Pediastrum tetras
- Sorastrum sp.

Coccomyxaceae
- Elakatothrix sp.
- Elakatothrix gelatinosa
- Elakatothrix viridis

Zygnematales

Zygnemataceae
- Mougeotia sp.
- Spirogyra sp.
- Zygnema sp.
- Zygnemopsis sp.

Desmidiaceae
- Anthrodesmus sp.
- Closterium sp.
- Cosmarium sp.
- Desmidium sp.
- Micrasterias sp.
- Spondylosium sp.
- Staurastrum sp.

Oedogoniales

Oedogoniaceae
- Bulbochaeta sp.
- Oedogonium sp.

Ulotrichales

Ulotricaceae
- Ulothrix sp.

Chaetophorales

Chaetophoraceae
- Stigeoclonium sp.

Cladophorales

Cladophoraceae
- Cladophora sp.
- Rhizoclonium sp.

Tetrasporales

Tetrasporaceae
- Schizochlamys compacta
- Tetraspora sp.
- Tetraspora lacustris
- Tetraspora lamellosa

Microsporales

Microsporaceae
- Microspora sp.

EUGLENOPHYCOPHYTA

Euglenophyceae

Euglenales

Euglenaceae
- Euglena sp.
- Phacus sp.
- Trachelomonas sp.

CHRYSOPHYCOPHYTA

Chrysophyceae

Ochromonadales

Ochromonadaceae
- Uroglena sp.

Dinobryaceae
- Dinobryon sp.
- Dinobryon bavaricum

Table 3.1 (continued).

Dinobryon cylindricum
Dinobryon divergens
Dinobryon sertularia
Dinobryon Vanhoeffenii
Synuraceae
Mallomonas sp.
Mallomonas akrokomos
Mallomonas pseudocoronata
Mallomonas urniformis
Synura sp.
Synura uvella
Chromulinales
Hydruraceae
Hydrurus foetidus
Rhizochrysidales
Rhizochrysidaceae
Chrysamoebae sp.
Diceras sp.
Chrysocapsales
Chrysocapsaceae
Chrysocapsa planktonica
Prymnesiophyceae
Isochrysidales
Derepyxidaceae
Cladomonas fruticulosa
Xanthophyceae
Heterochlondales
Stipitococeaceae
Stipitococcus sp.
Heterococcales
Chlorotheciaceae
Centritractus sp.
Ophiocytium sp.
BACILLARIOPHYCOPHYTA
Bacillariophyceae
Fragilariales
Fragilariaceae
Asterionella sp.
Asterionella formosa
Centronella reichelti
Diatoma sp.
Diatoma vulgare
Fragilaria sp.
Fragilaria capucina
Fragilaria crotonensis
Hannaea sp.
Hannaea arcus
Meridion sp.
Meridion circulare
Synedra sp.
Synedra acus
Synedra ulna
Tabellaria sp.
Tabellaria fenestrata
Tabellaria flocculosa
Achnanthales
Achnanthaceae
Achnanthes sp.
Cocconeis sp.
Naviculales
Naviculaceae
Frustulia sp.
Gyrosigma sp.
Navicula sp.
Gomphonemaceae
Gomphonema sp.
Cymbellaceae
Cymbella sp.
Surirellales
Surirellaceae
Campylodiscus hibernicus
Surirella sp.
Surirella ovalis
Nitzschiales
Nitzschiaceae
Nitzschia sp.
Coscinodiscales
Coscinodiscaceae
Melosira sp.
Melosira granulata
Melosira italica
Melosira varians
Rhizosoleniales
Rhizosoleniaceae
Rhizosolenia sp.
Rhizosolenia eriensis
Biddulphiales
Chaetoceraceae
Attheya sp.
PYRROPHYCOPHYTA
Dinophyceae
Peridiniales

Table 3.1 (continued).

Peridinaceae
Peridinium sp.
Peridinium inconspicuum
Ceratiaceae
Ceratium sp.
Ceratium hirundinella
Glenodinaceae
Glenodinium sp.
CRYPTOPHYCOPHYTA
Cryptophyceae
Cryptomonadales
Cryptomonadaceae
Cryptomonads
Cryptomonads sm.
Cryptomonads lg.
Chroomonas sp.
Cryptomonas sp.
Cryptomonas ovata
INDETERMINATE
Indeterminate cells
Indeterminate colonies
Indeterminate filaments
Indeterminate flagellates
RHODOPHYCOPHYTA
Rhodophyceae
Nemalionales
Batrachospermaceae
Batrachospermum sp.

Table 3.2 (continued).

Monogononta
  Flosculariacea
    Conochilidae
      Conochiloides sp.
      Conochilus sp.
      Conochilus hippocrepis
      Conochilus unicornis
    Hexarthridae
      Hexarthra sp.
    Testudinellidae
      Filinia sp.
      Filinia longiseta
      Filinia terminalis
      Pompholyx sulcata
      Testudinella sp.
      Testudinella patina
  Collothecacea
    Collothecidae
      Collotheca sp.
      Collotheca mutabilis
      Collotheca pelagica
  Ploima
    Notommatidae
      Cephalodella gibba
      Notommata sp.
    Synchaetidae
      Polyarthra sp.
      Polyarthra dolichoptera
      Polyarthra euryptera
      Polyarthra major
      Polyarthra remata
      Polyarthra vulgaris
      Synchaeta sp.
    Ploesomatidae
      Ploesoma sp.
      Ploesoma hudsoni
      Ploesoma lenticulare
      Ploesoma truncatum
    Gastropodidae
      Ascomorpha sp.
      Gastropus sp.
      Gastropus stylifer
    Trichocercidae
      Trichocerca sp.
      Trichocerca cylindrica
      Trichocerca longiseta
      Trichocerca multicrinis
      Trichocerca rattus
      Trichocerca rousseleti
    Asplanchnidae
      Asplanchna sp.
      Asplanchna priodonta
    Brachionidae
      Brachionus sp.
      Brachionus angularis
      Brachionus budapestinensis
      Brachionus calyciflorus
      Brachionus pterodinoides
      Brachionus quadridentata
      Brachionus rubens
      Brachionus variabilis
      Euchlanis sp.
      Euchlanis alata
      Euchlanis meneta
      Euchlanis parva
      Euchlanis pellucida
      Kellicottia sp.
      Kellicottia bostoniensis
      Kellicottia longispina
      Keratella sp.
      Keratella cochlearis
      Keratella hiemalis
      Keratella quadrata
      Keratella serrulata
      Keratella taurocephala
      Lecane sp.
      Lecane flexilis
      Lecane leontina
      Lecane luna
      Lecane mira
      Lecane ohioensis
      Lepadella sp.
      Lepadella ovalis
      Lepadella patella
      Macrochaetus sp.
      Monostyla sp.
      Monostyla bulla
      Monostyla copeis
      Monostyla crenata
      Monostyla lunaris
      Monostyla quadridentata
      Monostyla stenroosi

Table 3.2 (continued).

- *Mytilina* sp.
- *Mytilina ventralis*
- *Mytilina ventralis* var. brevispina
- *Notholca* sp.
- *Notholca acuminata*
- *Platyias* sp.
- *Platyias patulus*
- *Trichotria* sp.
- *Trichotria pocillum*
- *Trichotria tetractis*

TARDIGRADA
ANNELIDA
  Oligochaeta
ARTHROPODA
  Crustacea
    Cladocera
      Leptodoridae
        Leptodora sp.
        Leptodora kindtii
      Sididae
        Diaphanosoma brachyurum
        Sida sp.
        Sida crystallina
      Daphnidae
        Ceriodaphnia sp.
        Ceriodaphnia lacustris
        Ceriodaphnia reticulata
        Daphnia sp.
        Daphnia galeata mendotae
        Daphnia retrocurva
        Scapholeberis sp.
        Scapholeberis kingi
      Bosminidae
        Bosmina sp.
        Bosmina longirostris
        Eubosmina coregoni
      Macrothricidae
        Ilyocryptus sp.
        Ilyocryptus spinifer
        Macrothrix laticornis
        Streblocercus serricaudatus
      Chydoridae
        Acroperus harpae
        Alona sp.
        Alona affinis
        Alona costata
        Alona guttata
        Alona quadrangularis
        Alonella sp.
        Alonella excisa
        Alonella exigua
        Alonella nana
        Camptocercus sp.
        Camptocercus rectirostris
        Chydorus sp.
        Chydorus gibbus
        Chydorus sphaericus
        Graptoleberis testudinaria
        Leydiga acanthocercoides
        Leydiga quadrangularis
        Monospilus dispar
        Pleuroxus sp.
        Pleuroxus denticulatus
        Pleuroxus hamulatus
        Pleuroxus hastatus
        Pleuroxus procurvus
        Pleuroxus striatus
      Polyphemidae
        Polyphemus sp.
        Polyphemus pediculus
    Ostracoda
    Eucopepoda
      Copepoda
        Copepoda nauplii
        Copepoda adult
      Calanoida
      Cyclopoida
  Insecta
    Ephemeroptera
GASTROTRICHA
  Chaetonotoidea
    Chaetonotida
      Chaetonotidae
        Chaetonotus sp.
INDETERMINATE

November. In the 1986 NPDES Permit, macroinvertebrate sampling effort at the same four stations was required three times per year, June, August, and October. A study of spatial and temporal distribution of macroinvertebrates downstream of Vernon Dam was conducted in 1986 (Wood 1988).

Over two hundred taxa, representing nine phyla, were obtained during Project SAVE's macroinvertebrate sampling (Table 3.3). No commercial, endangered, or threatened species were identified.

The discharge of heat during the 16 May to 14 October period resulted in buoyant plumes which remain near the surface in lower Vernon pool (Binkerd et al. 1978, Binkerd et al. 1990b). The potential impact of this discharge on benthos in Vernon pool is low during this time period, being limited to the area at the discharge and some near-shore areas in shallower water downstream from the discharge along the Vermont shore of Station 4. The macroinvertebrate community at Station 4 was diverse with dipterans and oligochaetes being predominant (Aquatec, <u>et</u>. <u>seqq</u>. 1978). Burrowing mayflies, caddisflies, and other mayflies were consistently collected at these stations throughout the NPDES monitoring program.

Downstream of Vernon Dam, the macroinvertebrate community was also represented by a diversity of organisms. Densities of macroinvertebrates at five locations have varied seasonally ranging from 10 to 3,000 organisms per square meter (Wood 1988, Aquatec <u>et</u>. <u>seqq</u>. 1982). Dipterans (Chironomids) and oligochaetes were the predominate organisms at the downstream stations. Caddisflies, particularly Hydropsychidae, were a significant component at Station 3. Other caddisflies and mayflies were represented routinely in macroinvertebrate collections at these stations. Freshwater clams were consistently a part of the macroinvertebrate community downstream during the late summer (Wood 1988).

Macroinvertebrate diurnal drift was investigated during 1986 (Wood 1988). During the daytime, chironomids were the predominate drift organisms captured. At night, the hydropsychid densities increased and these organisms were the most abundant organisms captured.

A diverse community of macroinvertebrates was present at all stations during Project SAVE. The operation of Vermont Yankee did not result in changes in the benthic community downstream which were outside the natural seasonal fluctuations. The absence of commercial and endangered species from this region and the lack of measurable harm to the community indicated that appreciable harm to the macroinvertebrate community by Project SAVE operation did not occur.

Table 3.3 Checklist of macroinvertebrates collected in the Connecticut River near Vernon, Vermont.

PROTOZOA
PORIFERA
  Demospongea
    Haplosclerina
      Spongillidae
COELENTERATA
  Hydrozoa
    Hydroida
      Hydridae
          Hydra sp.
PLATYHELMINTHES
  Turbellaria
    Tricladida
      Planariidae
          Dugesia sp.
          Dugesia tigrina
NEMATODA
BRYOZOA
  Gymnolaemata
    Ctenostomata
      Paludicellidae
          Paludicella sp.
          Paludicella articulata
  Phylactolaemata
      Cristatellidae
          Cristatella mucedo
      Fredericellidae
          Fredericella sultana
      Plumatellidae
          Hyalinella sp.
          Plumatella sp.
          Plumatella repens
      Lophopodidae
          Lophopodella carteri
      Pectinatellidae
          Pectinatella magnifica
ANNELIDA
  Oligochaeta
    Haplotaxida
      Aeolosomatidae
          Aeolosoma sp.
      Enchytraeidae
      Naididae
          Allonais sp.
          Chaetogaster sp.
          Dero sp.
          Nais sp.
          Ophidonais serpentina
          Paranais sp.
          Pristina sp.
          Slavina appendiculata
          Stylaria sp.
          Stylaria lacustris
      Tubificidae
          Branchiura sowerbyi
    Lumbriculida
      Lumbriculidae
          Lumbriculus sp.
  Hirudinea
    Rhynchobdellida
      Glossiphonidae
          Actinobdella sp.
          Helobdella sp.
          Helobdella elongata
          Helobdella stagnalis
          Placobdella sp.
      Piscicolidae
          Piscicola sp.
  Polychaeta
      Sabellidae
          Manayunkia speciosa
ARTHROPODA
  Arachnoidea
    Acariformes
      Hydrachnidae
      Arrenuridae
          Arrenurus sp.
    Araneae
    Hydracarina
  Crustacea
    Cladocera
      Chydoridae
      Daphnidae
      Leptodoridae
          Leptodora kindti
      Sididae
          Sida crystallina
      Polyphemidae
    Isopoda
      Asellidae
          Asellus sp.

Table 3.3 (continued).

Asellus racovitzai
Caecidotea sp.
Trichoniscidae
Trichoniscus demivirge
Amphipoda
Gammaridae
Crangonyx sp.
Gammarus sp.
Synurella sp.
Talitridae
Hyalella sp.
Hyalella azteca
Decapoda
Cambaridae
Cambarinae
Orconectes sp.
Orconectes limosus
Orconectes obscurus
Ostracoda
Eucopepoda
Insecta
Collembola
Entomobryidae
Tomocerus sp.
Isotomidae
Isotomurus tricolor
Plecoptera
Taeniopterygidae
Taenionema sp.
Taeniopteryx sp.
Leuctridae
Perlidae
Acroneuria sp.
Neoperla sp.
Perlesta sp.
Phasganophora sp.
Perlodidae
Chloroperlidae
Hastaperla sp.
Ephemeroptera
Baetiscidae
Baetisca sp.
Baetidae
Acentrella sp.
Acerpenna sp.
Baetis sp.
Baetis intercalaris
Baetis levitans
Centroptilum sp.
Cloeon sp.
Pseudocloeon sp.
Caenidae
Brachycercus sp.
Caenis sp.
Ephemerellidae
Attenella sp.
Ephemerella sp.
Ephemerella attenuata
Ephemerella needhami
Eurylophella sp.
Eurylophella bicolor
Ephemeridae
Ephemera sp.
Hexagenia sp.
Hexagenia bilineata
Hexagenia limbata
Hexagenia munda
Hexagenia recurvata
Hexagenia rigida
Litobrancha recurvata
Heptageniidae
Epeorus sp.
Heptagenia sp.
Heptagenia flavescens
Leucrocuta sp.
Nixe sp.
Serratella sp.
Stenacron sp.
Stenonema sp.
Stenonema ares
Stenonema bipunctatum
Stenonema femoratum
Stenonema fuscum
Stenonema ithaca
Stenonema luteum
Stenonema tripunctatum
Leptophlebiidae
Polymitarcidae
Ephoron sp.
Siphlonuridae
Ameletus sp.
Isonychia sp.

Table 3.3 (continued).

- Tricorythidae
  - *Tricorythodes* sp.
- Odonata
  - Aeschnidae
    - *Basiaeschna* sp.
    - *Boyeria* sp.
  - Coenagrionidae
    - *Anomalagrion* sp.
    - *Anomalagrion hastatum*
    - *Argia* sp.
    - *Chromagrion* sp.
    - *Enallagma* sp.
    - *Ischnura* sp.
  - Corduliidae
    - *Epicordulia* sp.
    - *Neurocordulia* sp.
    - *Somatochlora* sp.
    - *Tetragoneuria* sp.
  - Gomphidae
    - *Dromogomphus* sp.
    - *Gomphus* sp.
    - *Gomphus confraternus*
    - *Ophiogomphus* sp.
    - *Stylurus* sp.
  - Libellulidae
    - *Pantala* sp.
  - Macromiidae
    - *Didymops* sp.
    - *Macromia* sp.
- Megaloptera
  - Corydalidae
  - Sialidae
    - *Sialis* sp.
- Neuroptera
  - Sisyridae
    - *Climacia* sp.
    - *Sisyra* sp.
- Trichoptera
  - Brachycentridae
    - *Brachycentrus* sp.
  - Glossosomatidae
    - *Glossosoma* sp.
  - Hydropsychidae
    - *Cheumatopsyche* sp.
    - *Hydropsyche* sp.
    - *Hydropsyche phalerata*
    - *Macronema* sp.
  - Hydroptilidae
    - Hydroptilinae
      - *Agraylea* sp.
      - *Hydroptila* sp.
      - *Ochrotrichia* sp.
      - *Oxyethira* sp.
    - Orthotrichiinae
      - *Orthotrichia* sp.
  - Lepidostomatidae
    - *Lepidostoma* sp.
  - Leptoceridae
    - *Ceraclea* sp.
    - *Mystacides* sp.
    - *Nectopsyche* sp.
    - *Oecetis* sp.
    - *Triaenodes* sp.
  - Limnephilidae
    - *Hydatophylax* sp.
    - *Neophylax* sp.
    - *Pycnopsyche* sp.
  - Molannidae
    - *Molanna* sp.
  - Philopotamidae
    - *Chimarra* sp.
  - Phryganeidae
    - *Phryganea* sp.
  - Polycentropodidae
    - *Cernotina* sp.
    - *Cyrnellus* sp.
    - *Neureclipsis* sp.
    - *Phylocentropus* sp.
    - *Polycentropus* sp.
  - Psychomyiidae
    - *Psychomyia* sp.
- Lepidoptera
  - Pyralidae
    - *Acentria* sp.
- Hymenoptera
- Coleoptera
  - Carabidae
    - *Brachinus* sp.
  - Cerambycidae
  - Chrysomelidae
    - *Galerucella* sp.
  - Dytiscidae

Table 3.3 (continued).

Deronectes sp.
Elmidae
Ancyronyx sp.
Dubiraphia sp.
Gonielmis sp.
Macronychus sp.
Neoelmis sp.
Optioservus sp.
Stenelmis sp.
Gyrinidae
Dineutes sp.
Gyrinus sp.
Haliplidae
Haliplus sp.
Hydrophilidae
Berosus sp.
Helophorus sp.
Melyridae
Psephenidae
Psephenus sp.
Staphylinidae
Corrodentia
Liposcelidae
Diptera
Anthomyiidae
Limnophora sp.
Ceratopogonidae
Chaoboridae
Chaoborus sp.
Chironomidae
Tanypodinae
Ablabesmyia sp.
Ablabesmyia annulata
Ablabesmyia mallochi
Ablabesmyia parajanta
Alotanypus sp.
Clinotanypus sp.
Coelotanypus sp.
Djalmabatista sp.
Labrundinia sp.
Paramerina sp.
Procladius sublettei
Procladius sp.
Thienemannimyia sp.
Diamesinae
Pagastia sp.
Potthastia sp.
Potthastia longimanus
Pseudodiamesa pertinax
Prodiamesinae
Monodiamesa sp.
Orthocladiinae
Acricotopus sp.
Corynoneura sp.
Corynoneura taris
Cricotopus sp.
Cricotopus bicinctus
Cricotopus intersectus
Cricotopus sylvestris
Cricotopus tremulus
Diplocladius sp.
Eukiefferiella sp.
Eukiefferiella potthastia
Heterotrissocladius marcidus
Hydrobaenus sp.
Nanocladius sp.
Nanocladius distinctus
Orthocladius sp.
Parametriocnemus lundbecki
Psectrocladius sp.
Psectrocladius psilopterus
Rheocricotopus sp.
Symposiocladius sp.
Synorthocladius sp.
Thienemanniella sp.
Tvetenia sp.
Tvetenia bavarica
Tvetenia discoloripes
Chironominae
Axarus sp.
Chironomus sp.
Chironomus decorus
Cladopelma sp.
Cladotanytarsus sp.
Cryptochironomus sp.
Cryptochironomus fulvus
Cryptotendipes sp.
Demicryptochironomus sp.
Dicrotendipes sp.
Dicrotendipes neomodestus
Dicrotendipes nervosus
Einfeldia sp.

Table 3.3 (continued).

Endochironomus sp.
Endochironomus nigricans
Endochironomus subtendens
Glyptotendipes sp.
Glyptotendipes lobiferus
Harnischia sp.
Harnischia curtilamellata
Lauterborniella sp.
Lenziella sp.
Micropsectra sp.
Microtendipes sp.
Microtendipes caelum
Nilothauma sp.
Nilothauma babiyi
Pagastiella sp.
Parachironomus sp.
Parachironomus abortivus
Parachironomus carinatus
Parachironomus frequens
Paracladopelma sp.
Paracladopelma longanae
Paralauterborniella sp.
Paratanytarsus sp.
Paratendipes sp.
Phaenopsectra sp.
Phaenopsectra dyari
Phaenopsectra flavipes
Polypedilum sp.
Polypedilum convictum
Polypedilum fallax
Polypedilum illinoense
Polypedilum nr. scalaenum
Pseudochironomus sp.
Rheotanytarsus sp.
Rheotanytarsus distinctissimus
Rheotanytarsus exiguus
Robackia sp.
Robackia demeigerei
Stempellina sp.
Stempellinella sp.
Stenochironomus sp.
Stictochironomus sp.
Tanytarsus sp.
Tanytarsus glabrescens
Tanytarsus guerlus
Tribelos sp.
Tribelos jucundus
Xenochironomus sp.
Zavrelia sp.
Dolichopodidae
Empididae
Chelifera sp.
Chelifera precatoria
Hemerodromia sp.
Ephydridae
Heleidae
Heleinae
Bezzia glabra
Culicoides sp.
Palpomyia sp.
Palpomyia tibialis
Probezzia sp.
Stilobezzia sp.
Psychodidae
Psychoda sp.
Simuliidae
Simulium sp.
Tabanidae
Chrysops sp.
Tipulidae
Antocha sp.
Hemiptera
Corixidae
Gerridae
Metrobates sp.
Hydrometridae
Hydrometra sp.
Nepidae
Ranatra sp.
Homoptera
Aphididae
Chermidae
Membracidae
MOLLUSCA
Gastropoda
Basommatophora
Ancylidae
Ferrissia sp.
Lymnaeidae
Lymnaea sp.
Physidae
Physa sp.

Table 3.3 (continued).

Planorbidae
Gyraulus sp.
Gyraulus parvus
Helisoma sp.
Helisoma anceps
Mesogastropoda
Hydrobiidae
Amnicola sp.
Amnicola limosa
Birgella subglobosa
Valvatidae
Valvata piscinalis
Valvata tricarinata
Stylommatophora
Pelecypoda
Prionodesmacea
Sphaeriidae
Musculium sp.
Pisidium sp.
Pisidium henslowanum
Sphaerium sp.
Unionidae
Alasmidonta undulata
Elliptio sp.
Elliptio complanata
Lampsilis sp.
Ligumia sp.
ROTATORIA
Monogononta
Flosculariacea
Conochilidae
Conochilus sp.

3.4 Fish

3.4.1 316 Demonstration Criteria

According to the EPA's 316 draft Technical Guidance Manual, the fish section of the 316(a) Demonstration is judged successful if the applicant can show that fish communities will not suffer appreciable harm from:

1. Direct or indirect mortality from cold shocks;
2. Direct or indirect mortality from excess heat;
3. Reduced reproductive success or growth as a result of plant discharges;
4. Exclusion from unacceptably large areas; and
5. Blockage of migration.

The first two criteria, mortality resulting from thermal shock, are addressed in Section 3.4.2.1, Community Composition, for all species of fish. The remaining three criteria, growth, habitat exclusion, and blockage of migration, are addressed where appropriate in Section 3.4.2.4, Representative Important Species. All Demonstration criteria are not always appropriate for each RIS. For example, the growth of Atlantic salmon near Vernon cannot be applied to the two migratory lifestages present, either smolt or adult, since these fish were transient. Blockage of both upstream and downstream migration is an important topic for this species and was fully addressed.

Entrainment of ichthyoplankton and impingement of fish are discussed in Sections 3.4.2.2 and 3.4.2.3. The Demonstration focused on documenting low impingement rates at the intake structure, and on changes in the fish community near Vernon in relation to Vermont Yankee Project SAVE operation.

3.4.2 Fish Bioassessment

3.4.2.1 Community Composition

The fish community of the Connecticut River near Vermont Yankee has been studied extensively as part of this 316 Demonstration and the previous 1978-316 Demonstration. Approximately 3,500 riverine fish collections, exclusive of ichthyoplankton samples, have been made since 1968 (Table 3.4). About 60 percent of this effort involved the use of trapnets, which have been used routinely throughout the 22 year period. Seines and gillnets have been used during 1968 through the early 1980's, but in recent monitoring, these methods have not been used systematically. Electrofishing was first used extensively in 1982 and subsequently became a routine methodology. Over 83,000 fish have been captured during the 22 years of monitoring.

The riverine fishing effort was part of the larger monitoring program conducted by Vermont Yankee in which over 13,000 biological samples have been collected. Biologists conducting studies as part of

Table 3.4 Historical fishing effort for juvenile and adult fish, 1968-1989. (CPE = number of fish caught per hour).

Year	Trap Net Coll's	Trap Net Hours	Trap Net Fish	Trap Net CPE	Gill Net* Coll's	Gill Net* Hours	Gill Net* Fish	Gill Net* CPE	Seine** Coll's	Seine** Fish	Electro-fishing Coll's	Electro-fishing Fish	Other Coll's	Other Fish
1968	-	-	-	-	-	-	-	-	1	3			2	43
1969	24	719	199	0.28	27	641	177	0.28	12	3,330	1	288	159	2,740
1970	162	6,101	2,242	0.37	109	2,602	638	0.25	6	1,241			13	12
1971	29	612	142	0.23	3	57	14	0.25						
1972	46	1,061	400	0.38	24	532	42	0.08					1	
1973	61	1,405	694	0.49	29	667	142	0.21	6	839			91	82
1974	86	2,220	1,454	0.65	63	1,775	36	0.02	17	511			8	8
1975	151	3,919	2,109	0.54	58	1,360	319	0.23	63	2,858			9	11
1976	85	2,279	1,620	0.71	35	922	80	0.09	10	1,366				
1977	55	1,414	958	0.68	27	654	94	0.14	5	1,163			1	30
1978	57	1,445	1,035	0.72	32	781	199	0.25	16	536				
1979	38	884	473	0.54	19	449	203	0.45	9	1,785				
1980	68	1,553	1,170	0.75	27	607	284	0.47	3	148				
1981	100	2,440	2,144	0.88	42	1,008	326	0.32	6	889				
1982	307	7,084	6,162	0.87	13	305	27	0.08	6	344	24	1,987		
1983	195	4,164	3,381	0.81	4	88	0	0.00	23	3,336	60	3,994	5	756
1984	189	3,780	2,709	0.72					13	1,877	62	1,825	2	
1985	115	2,408	2,274	0.94					18	4,055	98	2,132		
1986	112	2,287	1,546	0.68							44	2,300		
1987	112	2,342	1,814	0.78							44	1,630		
1988	112	2,378	1,913	0.81							44	2,081		
1989	112	2,427	1,803	0.74							44	2,076		
Total	2,216				512				214		421		291	

* Method not used after 1983.
** Method not used after 1985.

the NPDES monitoring requirements were on the Connecticut River sampling approximately 60 to 120 days annually, from May through October. During this 18 year sampling history, there has been no mortality of fish observed, either due to heat and/or cold shock, resulting from Vermont Yankee's operation.

Fish capture rates have varied from year-to-year, partly as a function of the different levels of effort and methodologies employed. The most consistent methodology employed has been trapnetting. Capture rates for trapnets, expressed as catch per unit effort (CPE), did not display any reduction in catch rates during the years. There has been a slight but discernible increase in fish capture rates during 1981-1989 as compared to previous years. not necessarily better

Plume attraction studies conducted as part of the earlier "Phase Studies" were summarized in the 1978-316 Demonstration. There was no apparent attraction of resident fish to the warmer waters along the Vermont shore downstream of Vermont Yankee's discharge. These studies and other more recent data indicate that the potential for attracting fish to the thermal plume areas and subsequent mortality resulting from thermal shock from increasing or decreasing temperature were negligible.

An annotated checklist of selected Connecticut River fish was presented in Binkerd et al. (1978). Biological data collected on all fish have been computerized (Park 1990). The 83,000 fish captured during 1968-1989 were represented by 39 species of fish (Table 3.5). During the Project SAVE experimental studies, 1981-1989, thirty-six species of fish were collected. Three species of fish not observed during Project SAVE were represented by very few individuals in previous years and their presence in the Connecticut River near Vernon was most likely due to incidental displacement from upstream tributaries. There were seven new species of fish recorded during 1981-1989 (Table 3.6).

Table 3.6 Fish species which were not observed or were first observed during 1981-1989.

Species Not Observed	**Common Name**
Catostomus catostomus	longnose sucker
Semotilus atromaculatus	creek chub
Couesius plumbeus	lake chub
Species First Observed	
Notropis volucellus	mimic shiner
Petromyzon marinus	sea lamprey
Alosa sapidissima	American shad
Alosa aestivalis	blueback herring
Dorosoma cepedianum	gizzard shad
Rhinichthys atratulus	blacknose dace
Notropis atherinoides	emerald shiner

Table 3.5 Checklist of fish collected in the Connecicut River near Vernon, 1968-1989. Taxonomy is in accordance with Robins et al. 1980.

Scientific Name	Common Name
Petromyzontidae	Lampreys
Petromyzon marinus Linnaeus	Sea lamprey
Anguillidae	Freshwater eels
Anguilla rostrata (Lesueur)	American eel
Clupeidae	Herrings
Alosa aestivalis (Mitchill)	Blueback herring
Alosa sapidissima (Wilson)	American shad
Dorosoma cepedianum (Lesueur)	Gizzard shad
Salmonidae	Trouts
Salmo gairdneri Richardson	Rainbow trout
Salmo salar Linnaeus	Atlantic salmon
Salmo trutta Linnaeus	Brown trout
Salvelinus fontinalis (Mitchill)	Brook trout
Osmeridae	Smelts
Osmerus mordax (Mitchill)	Rainbow smelt
Esocidae	Pikes
Esox lucius Linnaeus	Northern pike
Esox niger (Lesueur)	Chain pickerel
Cyprinidae	Carps and minnows
Couesius plumbeus (Agassiz)	Lake chub
Cyprinus carpio Linnaeus	Common carp
Hybognathus regius Girard	Eastern silvery minnow
Notemigonus crysoleucas (Mitchill)	Golden shiner
Notropis atherinoides Rafinesque	Emerald shiner
Notropis cornutus (Mitchill)	Common shiner
Notropis hudsonius (Clinton)	Spottail shiner
Notropis volucellus (Cope)	Mimic shiner
Rhinichthys atratulus (Hermann)	Blacknose dace
Semotilus corporalis (Mitchill)	Fallfish
Semotilus atromaculatus (Mitchill)	Creek chub
Catostomidae	Suckers
Catostomus commersoni (Lacepede)	White sucker
Catostomus catostomus (Forster)	Longnose sucker
Ictaluridae	Bullhead catfishes
Ictalurus natalis (Lesueur)	Yellow bullhead
Ictalurus nebulosus (Lesueur)	Brown bullhead
Cyprinodontidae	Killifishes
Fundulus diaphanus (Lesueur)	Banded killifish
Percichthyidae	Temperate basses
Morone americana (Gmelin)	White perch
Centrarchidae	Sunfishes
Ambloplites rupestris (Rafinesque)	Rock bass
Lepomis gibbosus (Linnaeus)	Pumpkinseed
Lepomis macrochirus Rafinesque	Bluegill
Micropterus dolomieui Lacepede	Smallmouth bass
Micropterus salmoides (Lacepede)	Largemouth bass
Pomoxis nigromaculatus (Lesueur)	Black crappie
Percidae	Perches
Etheostoma olmstedi Storer	Tessellated darter
Perca flavescens (Mitchill)	Yellow perch
Stizostedion vitreum vitreum (Mitchill)	Walleye
Cottidae	Sculpins
Cottus cognatus Heckel	Slimy sculpin

Four of these species, sea lamprey, American shad, blueback herring, and the gizzard shad, have appeared as a direct result of the installation and operation of fishways required for the Connecticut River Anadromous Fish Restoration Program. Fishways at Turners Falls and Vernon Dams had direct bearing on the passage of resident and anadromous fish into regions near Vernon. Fishway operation began in 1980 and 1981 at Turners Falls and Vernon, respectively, which coincided with the initiation of Project SAVE in 1981.

The American shad and, to a lesser extent, the blueback herring have become an established population in the upper Turners Falls pool with young-of-the-year fish being present from July through early-October. Ammocoetes (larval sea lamprey) have been collected in bottom sediments from the Connecticut River near Vernon. Gizzard shad were first recorded in the Connecticut River near Vernon in 1989. Gizzard shad spawning success in Vernon pool was documented in 1989 with the capture of about 120 young gizzard shad (Briggs and Downey 1990).

taxonomy may have accounted on.

The mimic shiner was first identified upstream of Vernon Dam in the West River near Brattleboro, Vermont in 1983. This species was observed in 1984 near Vernon and has since become a common minnow in fish collections.

Only one specimen of the emerald shiner was obtained in an impingement sample during Project SAVE. Two blacknose dace were collected at Station 5, upstream of Vermont Yankee, in seine samples obtained on two successive days in 1985. The presence of these two species probably was a result of incidental displacement from upstream drainages.

Although sampling methodologies have varied during the 22 years of studies, the overall relative composition can be inferred from data collected with the various gears used for juvenile/adult fish collection. The fish community near Vernon was characterized as a coolwater fish community (Tables 3.7 and 3.8) (Downey 1990e). Sunfishes, including the basses, have historically represented about 30 percent of the total fish sampled. Yellow perch, white suckers, white perch, and minnows were all numerically important components of the fish community. Overall, the population has generally stayed consistent with some minor annual variations observed. American shad in the river near Vernon, a direct result of fisheries management goals, have become an important community downstream of Vernon Dam. Mimic shiners, a recently identified species from the area, were an important component of the minnow community.

Long-term cycles in resident populations were also noticeable. A strong recruitment of white perch was quite apparent in 1982 and 1983. This species, which had represented five to ten percent of the fish community in the 1970's, accounted for nearly 20 percent of the community during 1982 and 1983. Relative numbers of yellow perch in the community have increased in recent years, also reflecting improved

Table 3.7 Number and weight of fish collected upstream of Vernon Dam, 1968-1989. Impingement and ichthyoplankton samples are not included.

	1968-1980				1981-1989			
	Total Number		Total Weight		Total Number		Total Weight	
	(No.)	(%)	(g)	(%)	(No.)	(%)	(g)	(%)
Sea Lamprey					1	<0.1		
American eel	20	0.1	15,310	0.5	123	0.3	58,176	1.0
Alosa sp.					253	0.7	1,225	<0.1
Blueback herring					270	0.7	1,065	<0.1
American shad					46	0.1	6,133	0.1
Atlantic salmon	1	<0.1	77	<0.1	1	<0.1	195	<0.1
Rainbow trout	1	<0.1	108	<0.1				
Brown trout					11	<0.1	3,616	0.1
Brook trout	1	<0.1	135	<0.1				
Northern pike					10	<0.1	9,121	0.1
Chain pickerel	11	0.1	3,619	0.1	21	0.1	8,399	0.1
Cyprinidae	158	1.0	87	<0.1	1,605	4.1	7,505	0.1
Cyprinus sp.					81	0.2	382	<0.1
Common carp	309	1.9	1,229,677	44.1	311	0.8	1,171,820	19.4
Eastern silvery minnow	168	1.0	1,070	<0.1	159	0.4	1,289	<0.1
Golden shiner	1,072	6.5	35,305	1.3	992	2.6	52,159	0.9
Notropis sp.					3	<0.1	2	<0.1
Comon shiner					69	0.2	813	<0.1
Spottail shiner	1,216	7.4	9,840	0.4	4,441	11.4	18,511	0.3
Mimic shiner					1,086	2.8	286	<0.1
Blacknose dace					2	<0.1	1	<0.1
Fallfish	3	<0.1	91	<0.1	2	<0.1	28	<0.1
Catostomidae					1,037	2.7		
Longnose sucker	2	<0.1	352	<0.1				
White sucker	1,386	8.4	478,597	17.2	3,638	9.4	1,580,832	26.2
Yellow bullhead	5	<0.1	170	<0.1	9	<0.1	1,222	<0.1
Brown bullhead	52	0.3	3,588	0.1	93	0.2	24,454	0.4
Banded killifish	752	4.6	1,501	0.1	115	0.3	297	<0.1
White perch	2,828	17.1	386,484	13.8	5,077	13.1	981,298	16.2
Centrarchidae					12	<0.1		
Rock bass	466	2.8	43,989	1.6	1,570	4.0	146,860	2.4
Lepomis sp.	2,067	12.5	1,524	0.1	494	1.3	1,356	<0.1
Pumpkinseed	1,765	10.7	21,632	0.8	3,372	8.7	233,561	3.9
Bluegill	375	2.3	11,242	0.4	1,298	3.3	84,849	1.4
Micropterus sp.					6	<0.1	304	<0.1
Smallmouth bass	583	3.5	119,821	4.3	2,229	5.7	440,864	7.3
Largemouth bass	271	1.6	11,308	0.4	846	2.2	273,048	4.5
Percidae					29	<0.1		
Tesselated darter	57	0.3	64	<0.1	134	0.3	99	<0.1
Yellow perch	2,665	16.1	277,509	9.9	9,027	23.2	659,399	10.9
Walleye	280	1.7	137,485	4.9	385	1.0	270,246	4.5
Indeterminate					3	<0.1	654	<0.1
Total	16,514		2,790,585		38,861		6,040,069	

Table 3.8 Number and weight of fish collected downstream of Vernon Dam, 1968-1989. Ichthyoplankton samples are not included.

	1968-1980				1981-1989			
	Total Number		Total Weight		Total Number		Total Weight	
	(No.)	(%)	(g)	(%)	(No.)	(%)	(g)	(%)
Sea lamprey					13	0.1	4,441	0.2
American eel	34	0.3	15,084	1.1	146	1.0	42,014	1.6
Clupeidae					5	<0.1	50	<0.1
Alosa spp.					2	<0.1	1,194	<0.1
Blueback herring					82	0.5	4,486	0.2
American shad					1,428	9.5	81,140	3.0
Atlantic salmon					1	<0.1	162	<0.1
Brook trout					1	<0.1	129	<0.1
Rainbow trout	11	0.1	1,092	0.3				
Northern pike	1	<0.1	400	<0.1	14	0.1	22,881	0.9
Chain pickerel	29	0.2	12,389	0.9	15	0.1	5,729	0.2
Cyprinidae	3,400	25.8	2,790	0.2	431	2.9	446	<0.1
Common carp	46	0.3	228,490	16.7	47	0.3	232,973	8.7
Eastern silvery minnow	1	<0.1	16	<0.1	30	0.2	41	<0.1
Golden shiner	320	2.4	5,956	0.4	98	0.7	4,822	0.2
Lake Chub	2	<0.1	12	<0.1				
Spottail shiner	2,112	16.1	1,586	0.1	843	5.6	4,954	0.2
Mimic shiner					769	5.1	1,163	<0.1
Fallfish	9	0.1	4,046	0.3	181	1.2	12,873	0.5
Catostomidae					201	1.3		
Longnose sucker	9	0.1	3,473	0.3				
White sucker	1,769	13.4	359,722	26.3	3,241	21.5	1,204,344	44.8
Yellow bullhead	3	<0.1	77	<0.1	1	<0.1	492	<0.1
Brown bullhead	133	1.0	25,316	1.9	91	0.1	34,560	1.3
Banded killifish	299	2.3	724	0.1	93	0.6	138	<0.1
White perch	832	6.3	162,917	11.9	252	1.7	65,945	2.5
Centrarchidae					10	<0.1		
Rock bass	922	7.0	125,626	9.2	2,139	14.2	292,832	10.9
Lepomis sp.	254	1.9	164	<0.1	404	2.7	731	<0.1
Pumpkinseed	375	2.9	25,273	1.8	492	3.3	29,847	1.1
Bluegill	467	3.6	63,349	4.6	686	4.6	96,353	3.6
Micropterus sp.					20	0.1	1,949	0.1
Smallmouth bass	782	5.9	132,757	9.7	1,783	11.8	347,387	12.9
Largemouth bass	68	0.5	6,840	0.5	142	0.9	18,149	0.7
Black crappie	48	0.4	6,732	0.5	1	<0.1	15	<0.1
Tesselated darter	31	0.2	29	<0.1	6	<0.1	26	<0.1
Yellow Perch	1,082	8.2	144,007	10.5	1,260	8.4	108,144	4.0
Walleye	114	0.9	37,274	2.7	116	0.8	64,629	2.4
Indeterminate					4	<0.1	38	<0.1
Total	13,153		1,366,141		15,048		2,685,079	

recruitment success of previous years. These changes were most likely natural cycles. There has not been any significant changes in the fish community species composition during Project SAVE, which were attributable to Vermont Yankee operation.

3.4.2.2 Fish Impingement

Approximately 40,000 fish have been collected in 1,560 impingement samples (Table 3.9) (Downey and Haro 1985, Briggs and Downey 1990).. Seventy-five service water intake traveling screen samples obtained during 1981-1983, yielded a total of 20 fish; less than one fish per three days of sampling (Downey and Haro 1985). Due to this very low impingement rate, service water traveling screen monitoring was not required in the 1986 NPDES Permit.

Fish impingement on the circulating water traveling screens averaged about 26 fish and 320 grams per day (Briggs and Downey 1990). More than 80 percent of these fish were small sunfishes, rock bass, minnows, and yellow perch which were typically less than 100 millimeters in total length.

Fifty-nine Atlantic salmon juveniles have been collected from the circulating water traveling screen samples since 1981 (Table 3.10). Nearly all (about 95 percent) of these smolts were caught between 20 April and 15 May; a time period outside of this 316 Demonstration.

Table 3.10 Collection dates for Atlantic salmon smolts impinged on Vermont Yankee's circulating water traveling screens, 1981-1989.

Collection	Number of Atlantic Salmon Smolts Impinged								
Date	1981	1982	1983	1984	1985	1986	1987	1988	1989
20 April							1		
25 April								1	
27 April							1		
1 May								18	
2 May				1					
4 May				1					
5 May									4
7 May									13
8 May									1
9 May								2	5
10 May								4	
11 May								2	
15 May									1
20 May							2		
22 May		1							
31 May				1					
Annual Total	0	1	0	3	0	0	4	27	24

Table 3.[illegible] Numbers, weights, and corresponding percentages of fish from circulating water traveling screen impingement collections, 1974-1989. Weights have been rounded to the nearest gram.

	1974-1984				1985-1989				1974-1989			
	Total Number		Total Weight		Total Number		Total Weight		Total Number		Total Weight	
	(No.)	(%)	(g)	(%)	(No.)	(%)	(g)	(%)	(No.)	(%)	(g)	(%)
Sea lamprey					2	<0.1	8	<0.1	2	<0.1	8	<0.1
American eel	5	<0.1	599	0.2	3	<0.1	630	1.6	8	<0.1	1,229	0.3
Blueback herring	11	<0.1	48	<0.1					11	<0.1	48	<0.1
American shad	1	<0.1	16	<0.1					1	<0.1	16	<0.1
Gizzard shad					1	<0.1	2	<0.1	1	<0.1	2	<0.1
Rainbow trout	2	<0.1	13	<0.1					2	<0.1	13	<0.1
Atlantic salmon	4	<0.1	198	0.1	55	1.6	2,724	7.0	59	0.1	2,922	0.8
Brown trout	4	<0.1	289	0.1					4	<0.1	289	<0.1
Brook trout	2	<0.1	144	<0.1	2	<0.1	169	0.4	4	<0.1	313	<0.1
Rainbow smelt	67	0.2	790	0.2	11	0.3	55	0.1	78	0.2	845	0.2
Common carp	40	0.1	9,619	3.0	2	<0.1	277	0.7	42	0.1	9,896	2.8
Eastern silvery minnow	519	1.4	3,227	1.0	37	1.1	243	0.6	556	1.4	3,470	1.0
Emerald shiner					1	<0.1	4	<0.1	1	<0.1	4	<0.1
Golden shiner	543	1.5	6,604	2.1	19	0.6	258	0.7	562	1.4	6,862	1.9
Common shiner	9	<0.1	49	<0.1	4	0.1	26	<0.1	13	<0.1	75	<0.1
Spottail shiner	12,936	35.5	56,150	17.6	240	6.9	1,000	2.6	13,176	33.0	57,150	16.0
Mimic shiner	17	<0.1	25	<0.1	14	0.4	16	<0.1	31	<0.1	41	<0.1
Fallfish	2	<0.1	733	0.2					2	<0.1	733	0.2
Creek chub	3	<0.1	7	<0.1					3	<0.1	7	<0.1
Unidentified cyprinids	226	0.6	1,659	0.5	6	0.2	2	<0.1	232	0.6	1,661	0.5
White sucker	291	0.8	13,289	4.2	22	0.6	2,469	6.3	313	0.8	15,758	4.4
Longnose sucker	2	<0.1	61	<0.1					2	<0.1	61	<0.1
Yellow bullhead	26	0.1	294	0.1	12	0.3	65	0.2	38	0.1	359	0.1
Brown bullhead	673	1.8	8,767	2.7	467	13.5	3,040	7.8	1,140	2.9	11,807	3.3
Banded killifish	381	1.0	1,134	0.4	4	0.1	12	<0.1	385	1.0	1,146	0.3
White perch	2,182	6.0	51,658	16.2	73	2.1	3,336	8.6	2,255	5.6	54,994	15.4
Rock bass	2,615	7.2	21,368	6.7	776	22.4	4,281	11.0	3,391	8.5	25,649	7.2
Pumpkinseed	3,559	9.8	16,040	5.0	179	5.2	2,442	6.3	3,738	9.4	18,482	5.2
Bluegill	1,152	3.2	8,347	2.6	443	12.8	7,022	18.0	1,595	4.0	15,369	4.3
Unidentified *Lepomis* spp.	6,681	18.3	15,719	4.9	589	17.0	1,292	3.3	7,270	18.2	17,011	4.8
Smallmouth bass	781	2.1	25,898	8.1	61	1.8	2,169	5.6	842	2.1	28,067	7.8
Largemouth bass	181	0.5	3,740	1.2	33	1.0	258	0.7	214	0.5	3,998	1.1
Tessellated darter	151	0.4	414	0.1	25	0.7	61	0.2	176	0.4	475	0.1
Yellow perch	3,361	9.2	66,634	20.9	377	10.9	7,100	18.2	3,738	9.4	73,734	20.6
Walleye	21	0.1	3,784	1.2					21	<0.1	3,784	1.1
Slimy sculpin	3	<0.1	11	<0.1	1	<0.1	5	<0.1	4	<0.1	16	<0.1
Unidentified	33	0.1	1,622	0.5					33	<0.1	1,622	0.5
Total	36,484		318,950		3,459		38,966		39,943		357,916	

Vermont Yankee has anadromous fish impingement limits placed upon their operational mode by the 1986 and previous NPDES Permits. If Atlantic salmon impingement rates exceeded 0.1 percent of the estimated smolt equivalents migrating past Vermont Yankee, the plant would have reverted to a completely closed cycle mode until 15 June. American shad impingement rate was limited to one impinged shad for each adult shad passed at the Vernon Dam fishway and/or transported by State/Federal fisheries personnel upstream of Vernon Dam. Impingement of these two anadromous species never approached nor exceeded any of these impingement limits during the nine years of Project SAVE.

Analyses of 16 years of impingement data indicated that impingement of resident and anadromous fish by Vermont Yankee had little effect on the resident fish community and the anadromous fish, Atlantic salmon and American shad.

3.4.2.3 Fish Entrainment

Ichthyoplankton enumeration began in 1977 as part of the evaluation of the Vermont Yankee's phase studies. Sampling in 1977 focused on ichthyoplankton sampling at various depths in the intake structure forebay. Larval fish collected were enumerated and ichthyoplankton densities reported by Binkerd et al. (1978) were generally less than one fish per cubic meter.

In 1982, an intensive investigation of ichthyoplankton was undertaken at the intake structure and at various locations in the river, both upstream and downstream of Vernon Dam (Binkerd et al. 1983). Ichthyoplankton were collected at various depths during 1982-1985 at the intake structure and at selected locations as part of Project SAVE. Ichthyoplankton sampling in front of the intake structure was required weekly, 1 May to 15 July, as part of the 1986 NPDES Permit. During the eight years, 1982-1989, over 1,800 samples have been collected with a 0.5 meter net, while 63 seine samples using a 500 micron mesh have been obtained (Table 3.11).

Nearly 37,000 ichthyoplankton were collected representing 14 different fish taxa (Table 3.12). Differences in the total number of ichthyoplankton captured in Vernon and Turners Falls pools were primarily the result of the significantly higher sampling effort in Vernon pool. Minnows and white perch were the most abundant ichthyoplankton, representing about 95 percent of the larvae collected. Sunfishes (Lepomis spp.), suckers, yellow perch, and walleye were collected consistently, but usually in low densities. Other fish, particularly smallmouth bass, were captured infrequently. The relatively low abundance of bass captured using a towed 0.5 meter net in the main portion of the river was not surprising and was most likely the result of the shallow water nesting behavior of this species.

Table 3.11 Ichthyoplankton sampling effort, number of 0.5 meter net samples, 1982-1989.

	Depth (m)	1982	1983	1984	1985	1986	1987	1988	1989
Station 2									
	<5		8	27	5				
	5-10								
	>10								
Stebbin Island									
	<5				10	6	2	3	
	5-10								
	>10								
Station 3									
	<5	45	28	54	10	7	3	3	
	5-10	18						2	
	>10	9						2	
Station 4									
	<5	98	29	18	10	21	11	2	
	5-10	40	12	18	10	16	6	2	
	>10						2		
VY Boat Launch									
	<5						6		
	5-10						6		
	>10						6		
VY Intake									
	<5	2			1	10	44	12	11
	5-10	37		17	7	10	21	11	11
	>10	127		32	12	3		10	11
Station 5									
	<5	176	64	84	45	33	12	3	
	5-10	123	36	46	43	33	12	3	
	>10	96							
Other Locations									
	-	58					15		
Annual Total		829	177	296	153	139	146	53	33

Table 3.12 Relative abundance of ichthyoplankton collected near Vernon, 1982-1989. Vernon fish were obtained from 1,584 samples while Turners Falls fish represented 242 samples.

	Vernon Pool		Turners Falls Pool	
	(No.)	(%)	(No.)	(%)
Clupeidae	2	<0.1	1	<0.1
American shad	15	<0.1	2	0.1
Blueback herring	7	<0.1		
Cyprinidae	4,018	12.1	288	8.5
Common carp	41	0.1	25	0.7
Golden shiner	20	<0.1	3	0.1
Notropis spp.	15,020	45.2	1,828	53.8
Catostomidae	87	0.3	7	0.2
White sucker	541	1.6	23	0.7
White perch	12,348	37.2	1,057	31.1
Centrarchidae	7	<0.1	1	<0.1
Rock bass	1	<0.1		
Lepomis spp.	434	1.3	120	3.5
Smallmouth bass	2	<0.1		
Percidae	11	<0.1		
Tessellated darter	13	<0.1	1	<0.1
Yellow perch	339	1.0	28	0.8
Walleye	225	0.7	9	0.3
Indeterminate	95	0.3	5	0.1
Total	33,226		3,398	

A distinct pattern of seasonal succession of ichthyoplankton was apparent during these studies. The yellow perch were usually the first larvae to be encountered in early to mid-May (Table 3.13). Walleye larvae were consistently captured during mid-May, 15 May to 28 May, while white perch were collected during mid-May to early-July. Minnows, usually collected beginning in early-June, were the principal component of ichthyoplankton during late-June and July.

Table 3.13 Earliest and latest dates of capture of ichthyoplankton for four game fish species, 1982-1989.

	Date of Capture							
	Smallmouth Bass		White Perch		Walleye		Yellow Perch	
Year	Earliest	Latest	Earliest	Latest	Earliest	Latest	Earliest	Latest
1982	26 Jun	30 Jun	17 May	21 Jul	17 May	09 Jun	11 May	10 Jun
1983	22 Jun	23 Jun	20 May	06 Jul	16 May	23 May	12 May	02 Jun
1984			18 May	11 Jul	14 May	08 Jun	07 May	08 Jun
1985			16 May	11 Jul	14 May	21 May	03 May	21 May
1986			14 May	08 Jul	14 May	20 May	14 May	29 May
1987			14 May	09 Jun			04 May	26 May
1988			16 May	13 Jul			10 May	23 Jun
1989			23 May	14 Jul			12 May	19 May

Yellow perch and walleye larvae were only collected during a three week interval, indicating that spawning occurred during a relatively narrow time frame. White perch ichthyoplankton, on the other hand, appeared in samples from mid-May through July, with peak densities observed in late-May. These observations indicated that the white perch did not spawn all at once, but continued to spawn throughout the spring and early-summer.

Ichthyoplankton densities were typically less than one fish per cubic meter, although densities of minnows during late-June and July of three to five fish per cubic meter were occasionally observed. Near the shore in shallower regions of Vernon pool, densities of ichthyoplankton, specifically minnows collected by seining, have been estimated as high as 3,000 fish per cubic meter (Downey 1990d).

Overall, density of ichthyoplankton were found not to be dependent upon sampling depth, but a marked depth preference among the different species was observed. Minnows were generally more abundant in surface (less than 5 feet) samples, while white perch were most numerous in deeper (greater than 5 feet) samples (Downey 1990d).

Densities of the two most abundant fish taxa, minnows and white perch, near the Vermont Yankee intake structure were comparable to other sampling locations. Walleye were also collected at low densities in and near the intake. Walleye densities were very low and more than 90 percent of the larval walleye were captured annually during 15 May to 28 May (Downey 1990d). Densities of walleye appear to be highest in the mid-depth strata while surface and near-bottom samples contained a lower abundance of larval walleye.

The operation of Vermont Yankee did result in fish being entrained in the circulating water cooling system. Densities of the abundant taxa were relatively low in intake water and were comparable to densities observed in river samples. Shallow shoreline areas were more productive and contained much higher densities of the abundant taxa. Because of the low densities in the intake samples observed during the eight year sampling program, the effect of entrainment on walleye and other game species, such as smallmouth bass, was minimal. If ichthyoplankton entrainment resulted in an adverse effect on the fish community, these effects would have been noticeable as either major changes in the fish community and/or decreases in the relative abundance of the Representative Important Species. As is demonstrated in Section 3.4.2.1, Community Composition, and Section 3.4.2.4, Representative Important Species, no changes in the fisheries in the Connecticut River near Vernon were documented as a result of Project SAVE operation. The evaluation of ichthyoplankton near Vernon indicates that the entrainment of ichthyoplankton through Vermont Yankee's circulating water cooling system did not result in appreciable harm to the fish community during Project SAVE.

3.4.2.4 <u>Representative Important Species</u>

Based on a consensus of the VYEAC, seven species of fish were selected to be Representative Important Species: Atlantic salmon, American shad, smallmouth bass, white perch, walleye, yellow perch, and spottail shiner. The objective of this section is to discuss, when applicable, the distribution of the species in the river near Vernon, migration of the species relative to the thermal plume areas, and growth.

ATLANTIC SALMON

Atlantic salmon, an anadromous fish, are presently undergoing extensive restoration efforts in the Connecticut River. The Atlantic salmon were historically residents of the Connecticut River and its tributaries, but with the construction of Turners Falls Dam in 1798 and dams at Vernon, Vermont and Holyoke, Massachusetts, the salmon were extirpated. The recent construction of fishways at dams on the Connecticut River and the hatchery stocking program have resulted in Atlantic salmon returning to the Connecticut River drainage.

Atlantic salmon spawn in the gravely reaches of tributaries and smaller streams in the fall. There the eggs overwinter and hatch into young salmon, termed parr. These young salmon remain in the freshwater for one to two years before they undergo smoltification; a physiological change preparing the fish for life in salt water. Once smoltification begins in April and May, the salmon migrate into the main stem of the Connecticut River and then move downstream into the Atlantic Ocean. The salmon will usually spend two winters at sea before returning as adults to the same stream in the spring, May through July, to spawn. Unlike the Pacific salmon, Atlantic salmon do not necessarily die after spawning, and can spawn again in following years.

Since this species is presently being restored, the production of parr and smolts is totally dependent upon hatchery operations. Most of the fry and smolts are stocked in the West and White Rivers in Vermont and in the Ammoonusic River in New Hampshire. Generally, several hundred thousand parr and smolts are released upstream of Vermont Yankee in these three rivers. When a wild population of salmon becomes established in the Connecticut River, spawning will most likely occur in these tributaries, and others, which contain suitable habitat for spawning and parr survival. Spawning in the main stem of the Connecticut River is unlikely due to lack of available habitat and their spawning behavior. The interaction between Vermont Yankee operation and Atlantic salmon will occur during the times of migration through the Vernon region, i.e., upstream migration of adults and downstream migration of smolts.

During Project SAVE, the returns of adult Atlantic salmon to the Connecticut River have been low, with a maximum annual return of 529 salmon in 1981 (Rideout and McLaughlin 1985). Many of these returning

adult Atlantic salmon are trapped at Holyoke Dam and retained for brood stock in the federal hatchery system. Since 1985, about ten percent of the adult Atlantic salmon have passed through Holyoke Dam fishway. A total of 59 Atlantic salmon adults have been passed through the Turners Falls Dam fishway gatehouse between 1981-1990. Forty-four of these salmon were passed through Vernon Dam fishway (Table 3.14), resulting in a 75 percent passage efficiency.

Table 3.14 Annual upstream passage of smallmouth bass, Atlantic salmon, American shad and walleye at the Vernon Dam fishway. These data were obtained from Cox (1990) and unpublished data (K. Cox, Vermont Fish and Wildlife; personal communication).

	Number of Fish			
Year	Smallmouth Bass	American Shad	Atlantic Salmon	Walleye
1981	2,529	97	8	498
1982	1,542	9	0	363
1983	467	2,597	0	211
1984	262	335	0	56
1985	181	833	4	83
1986	703	982	4	71
1987	660	3,459	13	96
1988	281	1,370	5	72
1989	466	2,953	0	20
1990	440	10,868	10	89

Behavioral delays of these salmon were not observed during Vermont Yankee Project SAVE operation (Table 3.15). During many of the documented Atlantic salmon passages at Vernon Dam fishway, Vermont Yankee was operating in a hybrid or open cycle mode as part of Project SAVE (Figures 3.1, 3.2, and 3.3).

The behavior of outmigrating smolts in the vicinity of Vermont Yankee's thermal plume was investigated in 1980 and 1981 (McAvoy 1980, 1981) and again in 1988 and 1989 (Downey et al. 1990b). These studies used radiotelemetry to monitor juvenile Atlantic salmon movement through and past regions affected by Vermont Yankee's thermal plume. With temperature modulated transmitters used in the latter study, the movement of smolts into the thermal plume and downstream to Vernon Dam without delay was documented. The conclusion by Downey et al. (1990b) was that fully smoltified Atlantic salmon move through and downstream of Vermont Yankee's thermal plume without any appreciable avoidance behavior. These observations of adult and Atlantic salmon smolt migration patterns relative to Vermont Yankee operation indicate that blockage of Atlantic salmon migration by the thermal plume did not occur.

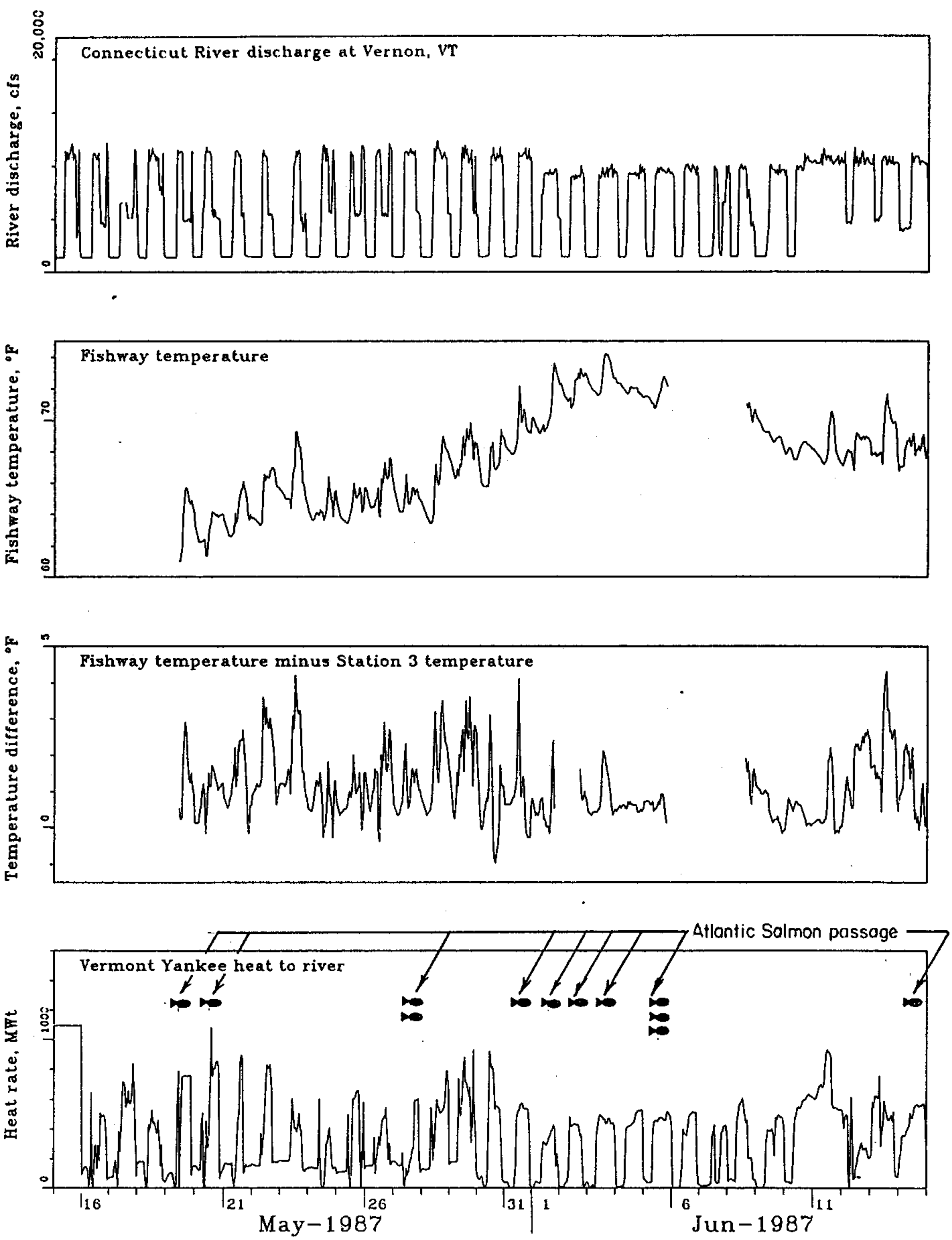


Figure 3.1 River discharge, fishway temperature, and Vermont Yankee operation during passage of adult Atlantic Salmon in the Vernon Dam fishway, 1987.

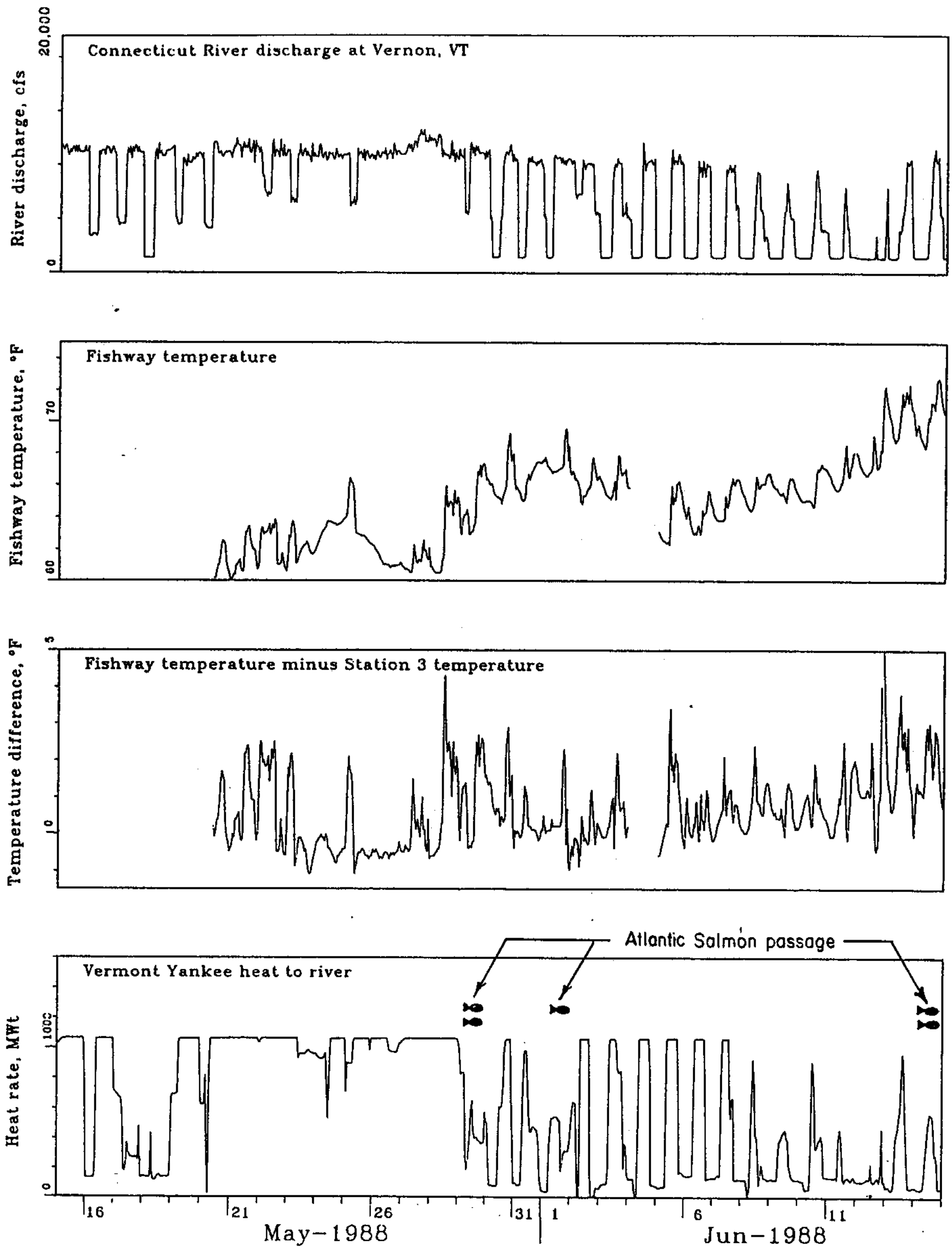


Figure 3.2 River discharge, fishway temperature, and Vermont Yankee operation during passage of adult Atlantic Salmon in the Vernon Dam fishway, 1988.

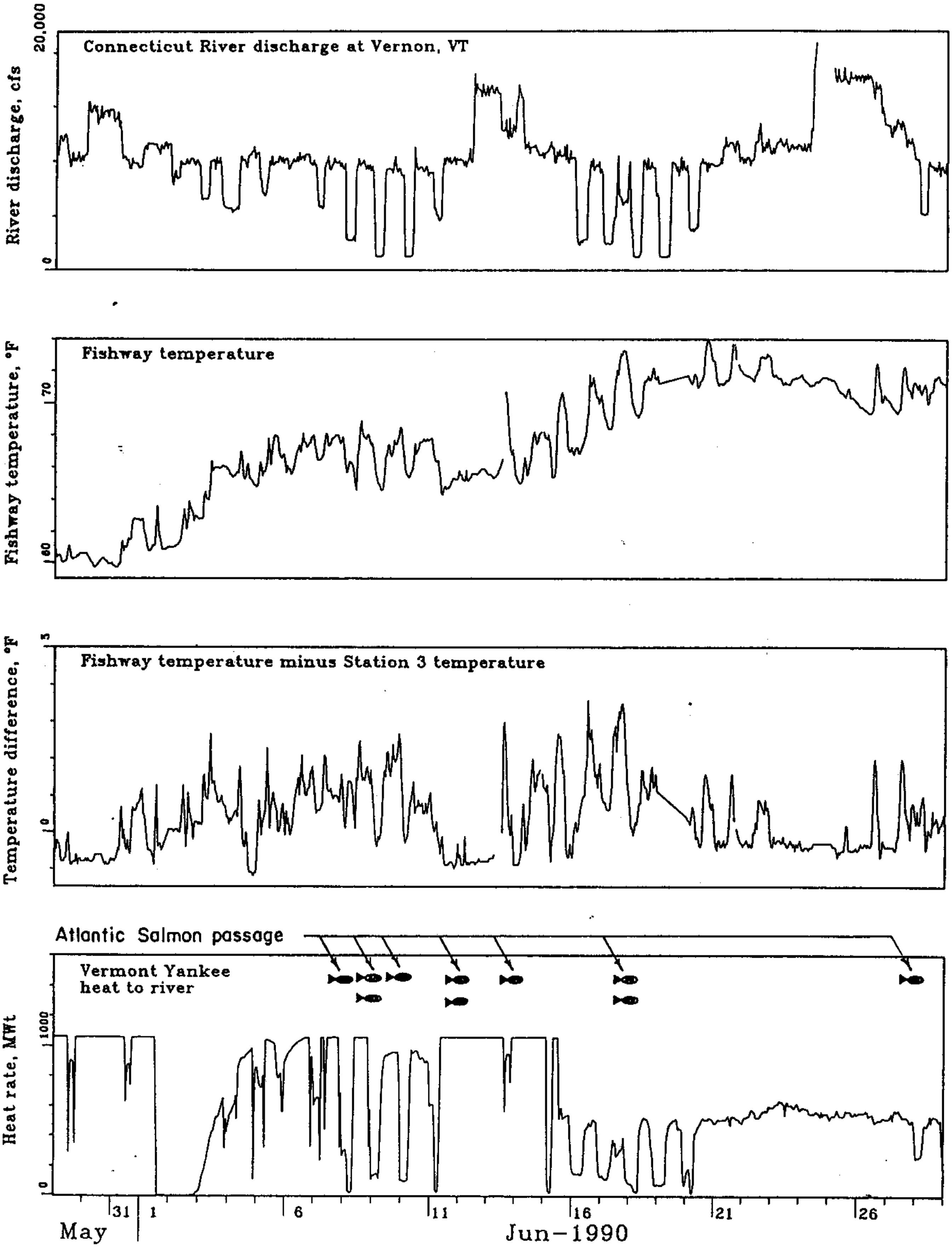


Figure 3.3 River discharge, fishway temperature, and Vermont Yankee operation during passage of adult Atlantic Salmon in the Vernon Dam fishway, 1990.

Table 3.15 Adult Atlantic salmon observed at the Vernon Dam fishway and Vermont Yankee operation, 1985-1989. Atlantic salmon passage times and dates were obtained from Cox (1990) and unpublished data (K. Cox; Department of Fish and Wildlife, personal communication).

Time of First Observation	VY Operation (% of open cycle)	Time of First Observation	VY Operation (% of open cycle)
1985		1988	
1230h 27 May	75	1045h 29 May	40
1115h 29 May	<5	0820h 01 Jun	46
		0825h 01 Jun	47
1986		0750h 14 Jun	5
1810h 20 May	Not Operating	1750h 14 Jun	29
1308h 22 May	Not Operating		
1345h 23 May	Not Operating	1990	
1025h 01 Jul	Not Operating	0900h 08 Jun	42
		0900h 09 Jun	78
1987		1000h 09 Jun	86
1705h 19 May	72	0800h 10 Jun	79
1208h 20 May	32	1400h 12 Jun	100
0740h 27 May	20	1600h 12 Jun	100
1306h 27 May	11	0900h 14 Jun	100
0800h 31 May	<5	0700h 18 Jun	<5
1700h 01 Jun	37	0700h 18 Jun	<5
0845h 02 Jun	38	1900h 18 Jun	50
0725h 03 Jun	14		
0950h 05 Jun	43		
1030h 05 Jun	43		
1945h 05 Jun	48		
0800h 14 Jun	38		

AMERICAN SHAD

American shad, an anadromous fish, are also part of the Anadromous Fish Restoration Program. Management efforts to restore these fish to their native Connecticut River range began in the late 1950's and the shad passage at the Holyoke Dam fishway in the 1980's have ranged from 275,000 to 530,000 per year.

The American shad begin ascending the Connecticut River in April and continue through early-July. Males usually enter the river first. Spawning takes place near the water's surface with eggs and sperm released in open water. The fertilized eggs, which are slightly heavier than water, then settle to the bottom.

Larval shad emerge from the egg at about nine to ten millimeters (mm) and spend the summer in freshwater. During the late-summer and fall, the juveniles migrate downstream. American shad will spend

three to four years in the ocean before returning to their native river to spawn. From 1955-1986, between 10 and 65 percent of the Connecticut River adult American shad returned as repeat spawners (Crecco and Savoy 1987).

Connecticut River shad migration, the number of fish passed at fishways, declines steadily as the run progressed upstream. Passage at the Turners Falls fishway was only about one to seven percent of Holyoke Dam fishway passage (Table 3.16). Passage at Vernon Dam fishway ranged from about 8 to 40 percent of Turners Falls fishway passage between 1983-1990. The percent passage efficiencies of Vernon Dam in 1981 and 1982 were even higher, but low numbers of American shad were passed at Turners Falls Dam. The reduction in fish progressing upstream was, in part, the result of American shad maturing and spawning in the river between fishways.

Table 3.16 Adult American shad passage at three Connecticut River fishways, 1980-1990. Percent efficiency (% Eff) relative to the immediate downstream facility passage is also expressed. Data were obtained from Kynard and O'Leary (1989a, 1989b), Cox (1990), Meyers (1990) unpublished data (Cox, Vermont Department of Fish and Wildlife personal communication), and S. Amaral, Massachusetts Cooperative Fishery Research Unit).

Year	Holyoke Fishway (No.)	Turners Falls Fishway (No.)	Turners Falls Fishway (% Eff)	Vernon Dam Fishway (No.)	Vernon Dam Fishway (% Eff)
1980	380,000	298	<0.1	Not Constructed	
1981	380,000	200	<0.1	97	48.5
1982	290,000	11	<0.1	9	81.8
1983	530,000	12,705	2.4	2,597	20.4
1984	500,000	4,333	0.9	335	7.7
1985	480,000	3,855	0.8	833	21.6
1986	350,000	17,858	5.1	982	5.5
1987	280,000	18,959	6.8	3,459	18.2
1988	290,000	15,787	5.4	1,370	8.7
1989	354,000	9,511	2.7	2,953	31.0
1990	363,788	27,908	7.7	10,868	38.9

The passage at the upstream fishways, Turners Falls and Vernon, began in mid- to late-May when the fishways are first operated. The runs at these two fishways typically peaked between 25 May and 10 June, but low numbers of shad continue to pass up to the closing of the fishways in early-July (Downey 1990f).

The passage efficiency of the Vernon Dam fishway was compared with the increased energy production by Vermont Yankee during Project SAVE, 1981-1990. The American shad passage efficiency at Vernon Dam

fishway was high during years of high thermal discharge (1989 and 1990) and during 1986 when Vermont Yankee was not operating. No correlation between Vernon Dam fishway shad passage efficiency and Vermont Yankee Project SAVE operation was observed. during this study.

Sex ratios of the adult American shad population was heavily skewed in favor of males at the Vernon Dam (Staats 1990). The male component of the Vernon Dam fishway population was estimated at 82 percent which was comparable to the sex ratio of the American shad population sampled in the river below Vernon Dam. Males also represented about 71 percent of Turners Falls fishway population (Amaral 1990). Predominance of males at upstream locations was typical of many American shad populations in other rivers of North America (Table 3.17). The hypotheses for these sex ratio differences in migration include the higher energetic cost to the female in upstream migration, behavioral differences, and/or size (sex) selectivity of the fishways.

The young-of-the-year American shad abundance and growth in the upper Turners Falls pool have been monitored since 1984 (Downey 1985a, 1985e, 1987, 1988a, 1990a, and 1990b). The growth rates observed during these studies range from 0.4mm per day to 1mm per day which were comparable with the growth rates of young-of-the-year American shad in the lower Connecticut River (Crecco et al. 1981). Changes in growth rates of young American shad were not observed as a result of Project SAVE.

Reproductive success of the American shad in the Vernon pool was documented in 1982 and 1983 by the capture of young-of-the-year American shad (Downey 1990f). These two years of juvenile shad recruitment coincided with the trucking of adult American shad by State and Federal personnel from the Holyoke Dam fishway to a release point in the Vernon pool, several miles upstream of Vermont Yankee. The reasons for the lack of documented spawning success by adult American shad in Vernon pool in subsequent years are not known. The low proportion of female to male American shad and their sexual maturity when passed into the Vernon pool may be factors. The lower Vernon pool region, between Vermont Yankee's discharge and the dam, does not contain appreciable spawning habitat for American shad. Since significant recruitment of juvenile shad occurs each year immediately downstream of Vernon Dam, it is unlikely that Vermont Yankee operation was a significant factor for the lack of spawning success in Vernon pool.

SMALLMOUTH BASS

Smallmouth bass are an important game fish in the Connecticut River. Although the smallmouth bass are not native to the Connecticut River (Scarola 1973), these fish are now common near Vernon. The smallmouth bass represented about four percent of the fish captured upstream of Vernon Dam and about 11 percent downstream.

This species typically inhabits the same area during its life. In recapture investigations of smallmouth bass in other drainages, individuals were usually recaptured within one-half to three miles of

Table 3.17 Sex composition of adult American shad populations from three drainages. Data were obtained from Chittenden (1969), RMC (1988, 1989, 1990), Moffitt (1979), Sherer (1975), Henry and Kaska (1984), Henry and Krska (1984), Amaral (1990), Cox (1990) and Staats (1990).

	Year	Sample Size	Composition (%)	
			Male	Female
Delaware River				
	1961	198	86	14
	1962	220	99	1
	1963	302	62	38
	1964	199	38	62
	1965	23	52	48
Susquahanna River, Conowingo Dam	1987	5,304	76	24
	1988	3,375	74	26
	1989	4,077	77	23
Farmington River, Rainbow Dam	1976	916	73	27
	1977	297	78	22
Connecticut River, Holyoke Dam	1970	1,611	75	25
	1971	672	66	34
	1972	3,808	40	60
	1973	3,652	20	80
	1982	837	63	37
	1986	-	50	50
	1988	-	69	31
	1989	680	46	54
Connecticut River, Turners Falls Dam	1983	-	91	9
	1986	75	60	40
	1988	51	78	22
	1989	46	71	29
Connecticut River, Vernon Dam	1988	43	98	2
	1989	176	82	18

their original location (Scott and Crossman 1973). Tag and recapture studies conducted on this species near Vernon confirmed this behavior (Binkerd et al. 1990a). Movement upstream and downstream through the Vernon Dam fishway has been documented (Table 3.14).

The distribution of smallmouth bass appeared to be unaffected by the presence of the thermal plume. These fish were routinely collected at Station 4 along the Vermont shore, an area where the thermal plume was located. Although this species resides at Station 4, studies by Binkerd et al. (1978) have demonstrated that the thermal plume did not attract these fish.

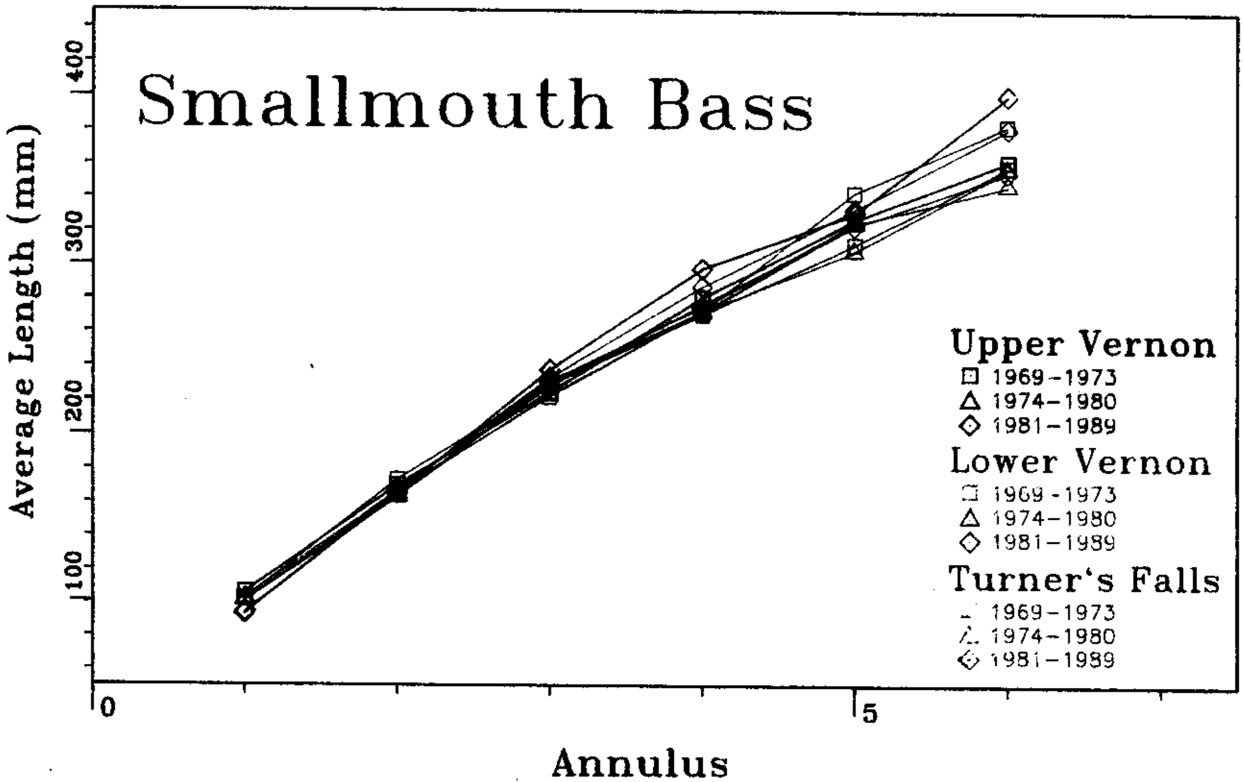
Downstream of Vernon Dam, smallmouth bass were an important component of the fish community. This upper Turners Falls pool region, which was less than one mile downstream of Vermont Yankee, receives thermal effluent when Vermont Yankee was operating. The presence of a viable smallmouth bass population in the thermal plume region, and downstream, indicated that smallmouth bass are not excluded from any area as a result of Vermont Yankee's thermal discharge.

The general health, parasitic burden, and overall condition of the smallmouth bass near Vernon were comparable to smallmouth bass collected in Bellows Falls pool (Downey 1984a).

Growth of juvenile and adult smallmouth bass have been monitored for 22 years (Downey 1985b, 1990c). Smallmouth bass near Vernon grew to a size of about 90 to 100mm the first year (Downey 1990c). Back-calculated lengths at each scale annulus were computed and grouped according to location of capture, and three time periods (Figure 3.4). Annual growth, defined as the mean length at annulus formation, was similar for all time periods and locations, with one exception. The calculated size of smallmouth bass at age one, for bass captured in the two locations affected by Vermont Yankee's thermal discharge, and at the one location upstream of Vermont Yankee, was statistically smaller for 1981-1989 when compared with corresponding estimates for the 1968-1973 and 1974-1980 periods. The mean difference was six to eight millimeters. Comparison of mean length at age one of bass captured in the two locations receiving thermal discharge and the upstream location not affected by thermal discharge were essentially the same for the 1981-1989 age one calculations. This observation suggests that the apparent smaller size at age one was not directly related to thermal discharges. Lengths at age one for Connecticut River smallmouth bass were above the average of other back-calculated lengths at age one for smallmouth bass populations from other drainages in North America (Downey 1990c).

WHITE PERCH

White perch are found along the Atlantic coast in North America from the St. Lawrence River to South Carolina. These fish are usually found in brackish water but can survive as freshwater landlocked populations. White perch thrive in a variety of habitats but seem to be more successful in warmer waters that reach 75°F or more in the summer (Scott and Crossman 1973).



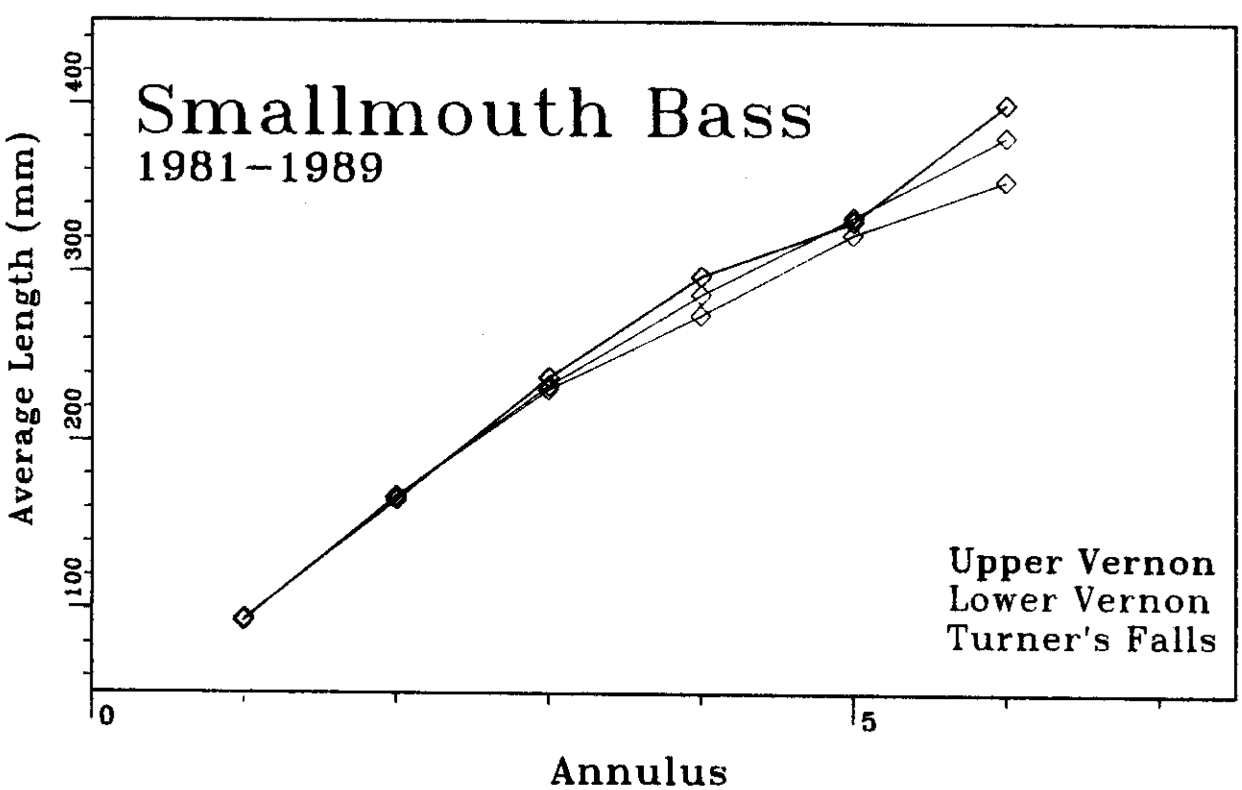


Figure 3.4 Mean back calulated total length in millimeters for Smallmouth Bass, 1969-1989.

The white perch population in the Connecticut River near Vernon is not native. Fish surveys conducted in 1939 did not collect any of these fish, but in 1968 this species was a component of the fish community (Aquatec et segg. 1972).

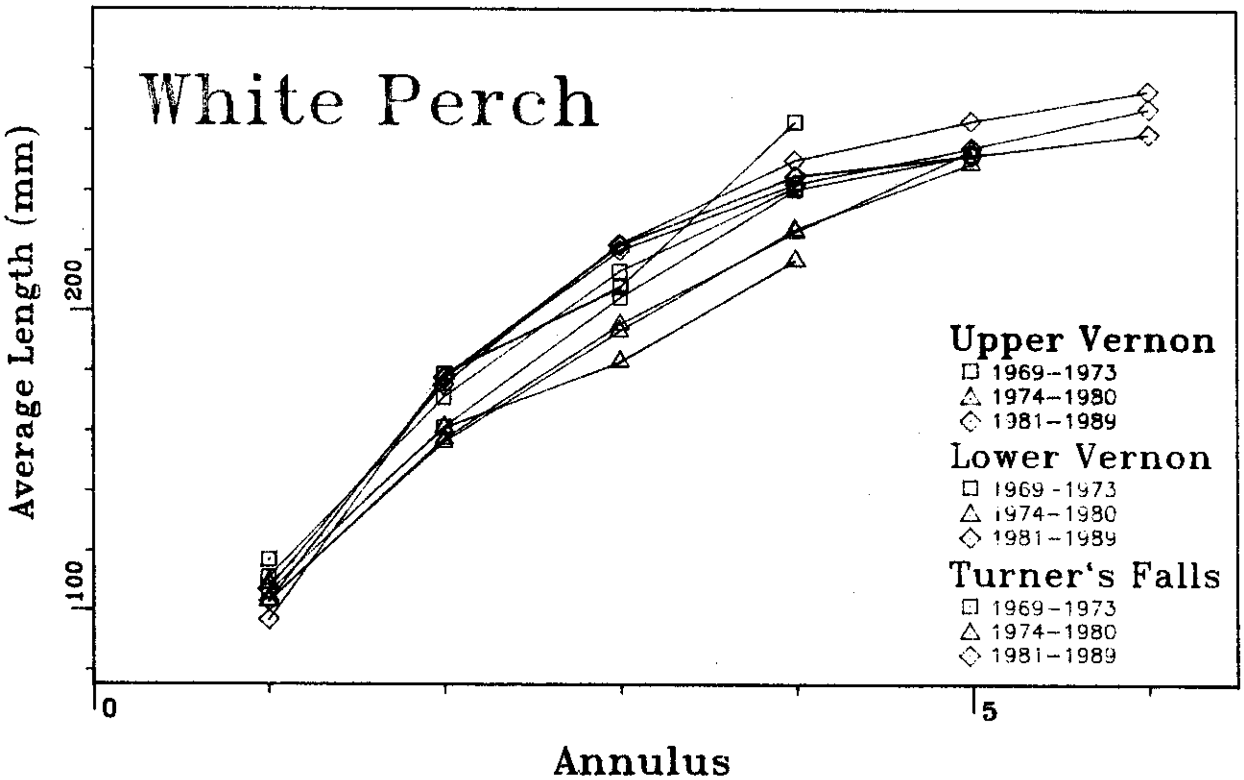
Sexually mature adults have been captured in late-May through June near Vernon. White perch larvae have been collected in ichthyoplankton samples from 14 May to 21 July, although the peak densities of white perch collected in the river occur during the end of May through early-June (Binkerd et al. 1983). This pattern of extended larval recruitment, presumably indicative of recent spawning, indicated that the Connecticut River white perch population spawned over a six to eight week period. This protracted spawning period has been observed in other white perch populations. Mansueti (1961) noted that only a portion of the total number of eggs are released at one time and eggs ripen progressively over time being released in two or three separate spawning acts.

In ichthyoplankton samples collected near Vernon, white perch accounted for half of the larval fish captured (Downey 1990d). White perch larvae were rarely caught in surface water samples but represent a major component of ichthyoplankton captured at a depth of five feet or more. White perch have been collected at all stations sampled in the Turners Falls and Vernon pools, including at the Vermont Yankee intake. White perch densities typically average less than one fish per cubic meter.

White perch are a large component of the fish community in the Connecticut River near Vernon, particularly in the lower Vernon pool. In this pool, white perch represented about 5 to 25 percent of the fish captured annually (Downey 1990e). The white perch represented about five to eight percent of the population during 1968-1980 in the Vernon pool. Several strong year classes resulted in the white perch becoming a dominant component in the early 1980's, peaking at over 25 percent of the fish captured in 1982-1983. The white perch component of the fish community declined over subsequent years resulting in the relative composition of the white perch returning to previous levels. Long-term population fluctuations in white perch are not uncommon and have been reported in other populations.

In the upper Turners Falls pool, white perch were numerically less dominant. The relative composition of white perch in this pool ranged from five percent during 1968-1980 to about two percent in 1981-1989.

The growth of white perch has been consistent throughout the three regions studied (Figure 3.5). Differences of growth during Project SAVE, 1981-1989, were not evident in any region when compared to time periods of 1965-1973, and 1974-1980. The mean size at annulus of white perch from the three Connecticut River regions was comparable to other white perch populations in North America (Downey 1985c, 1990c).



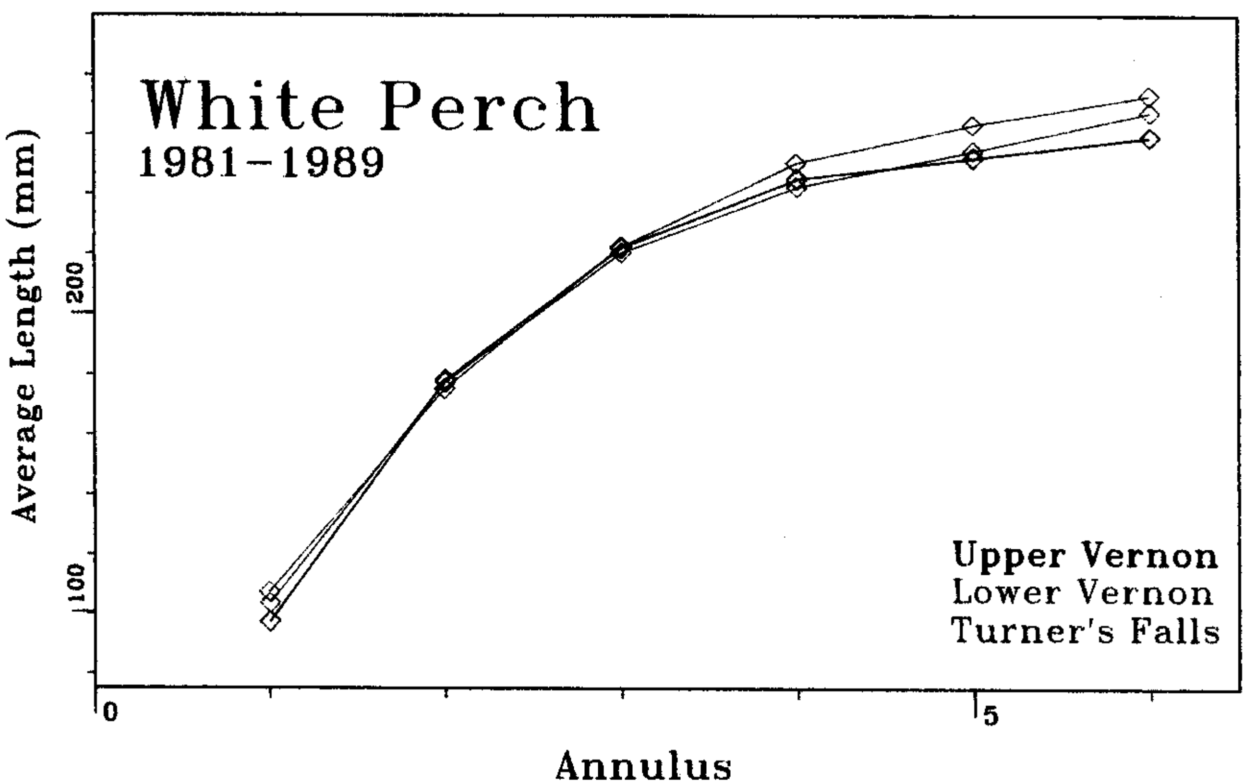


Figure 3.5 Mean back calulated total length in millimeters for White Perch, 1969–1989.

These evaluations of white perch distribution and growth demonstrate that exclusion of habitat, or changes in growth, did not occur during Project SAVE operation.

WALLEYE

The walleye are an important game fish in the Connecticut River near Vernon. This species is not indigenous to the Connecticut River, but was presumably introduced from Lake Champlain (Bailey 1938). The walleye represented about one-half to two percent of the fish captured in the Turners Falls and Vernon pools. Walleye have been captured consistently at Station 4 near the Vermont shore. Individuals of this species were collected throughout the summer and early fall at Station 4 during closed cycle operation and at times when Vermont Yankee was operating in an open or hybrid cycle during Project SAVE (Binkerd et al. 1983). Walleye have been documented moving through the Vernon Dam fishway in the spring while heat was being discharged to Vernon pool (Table 3.14).

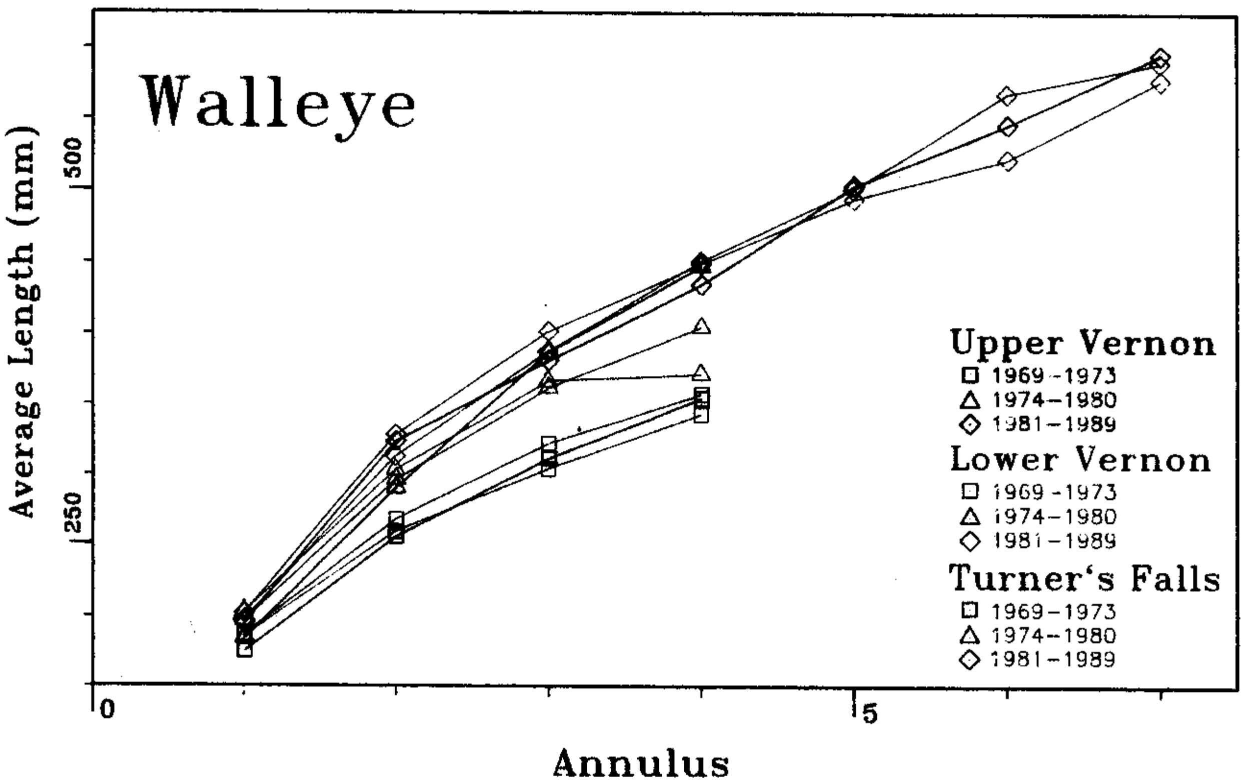
Walleye spawning in the Connecticut River support what has been reported for other populations (Scott and Crossman 1973). In the ichthyoplankton samples collected between 1982-1989, walleye larvae were only obtained in a relatively short time period; primarily from 14 May to 23 May. If a 10 to 15 day egg maturation and larval hatching process is assumed, this would indicate that most of the walleye spawning near Vernon takes place in late-April to the first week of May.

Although walleye larvae have been collected throughout the Vernon and Turners Falls pools, walleye spawning areas have not been documented. Station 4, being composed of predominately silty substrates, contains little, if any, suitable habitat for walleye spawning.

Growth of walleye in the various regions of the Connecticut River near Vernon have shown a statistically non-significant but noticeable trend of increased growth in regions affected by thermal discharge during the 22 years of these studies (Figure 3.6) (Downey 1984b, Downey 1990c). The comparison of mean size at annulus among the three regions of capture during the same time intervals did not reveal any trends. Overall, mean size at annulus was above the average reported for other walleye populations in the northeast (Downey 1990c). The analyses of walleye distribution and growth during 1981-1989 indicate that Project SAVE operation did not result in an adverse effect on this species.

YELLOW PERCH

Yellow perch have a circumpolar distribution in fresh water in the northern hemisphere. This species is very adaptable and can utilize a wide variety of warm to cooler habitats. They are most abundant in open water lakes with moderate vegetation and softer sand/mud bottoms.



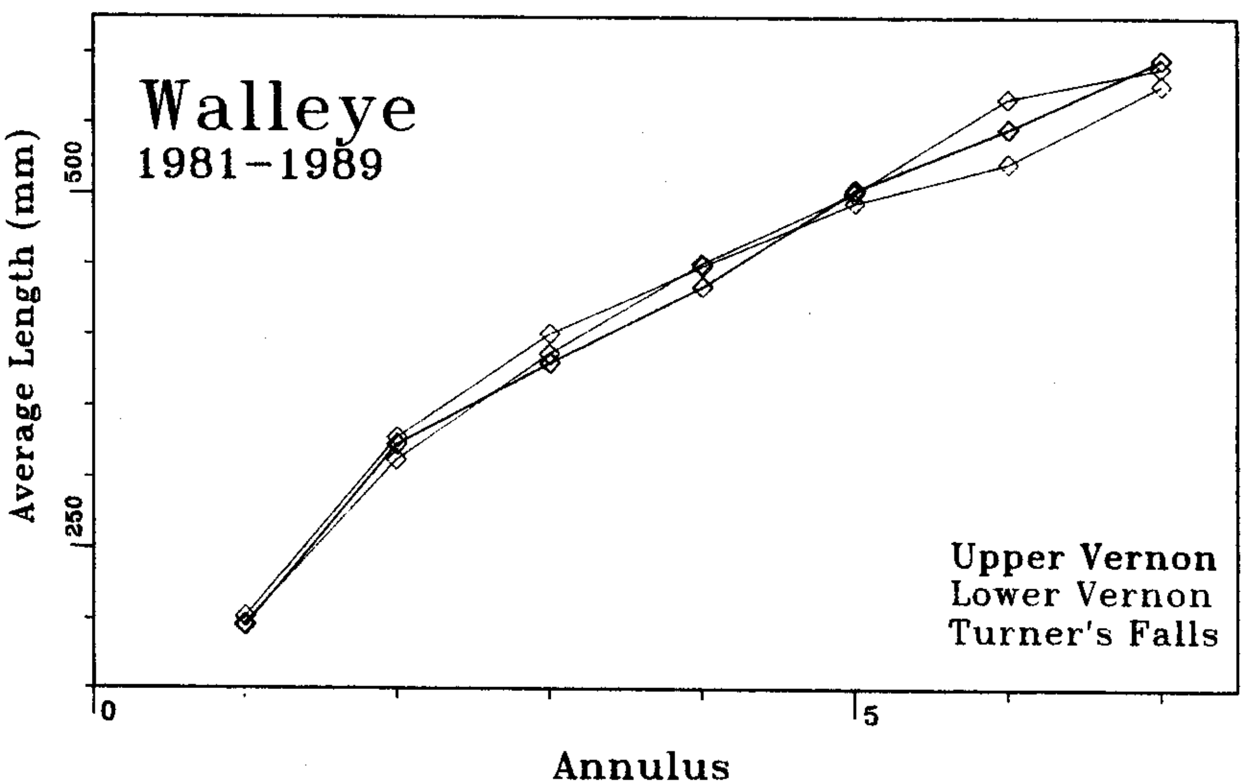


Figure 3.6 Mean back calulated total length in millimeters for Walleye, 1969-1989.

In the Vernon pool, yellow perch were a major component of the fish community. Yellow perch represented about 16 percent of the community during 1968-1980 and about 23 percent of the community during 1981-1989. These fish were found throughout the lower Vernon pool including those locations affected by thermal effluent. In the upper Turners Falls pool, the relative abundance of yellow perch has remained relatively constant, about eight percent, for the two time periods.

Spawning of yellow perch typically occurs mid-April through early-May. In ichthyoplankton samples, yellow perch larvae were most often obtained between 3 May and 26 May, with larvae/small juveniles captured as late as 10 June. The yellow perch ichthyoplankton represented less than one percent of the ichthyoplankton collected annually.

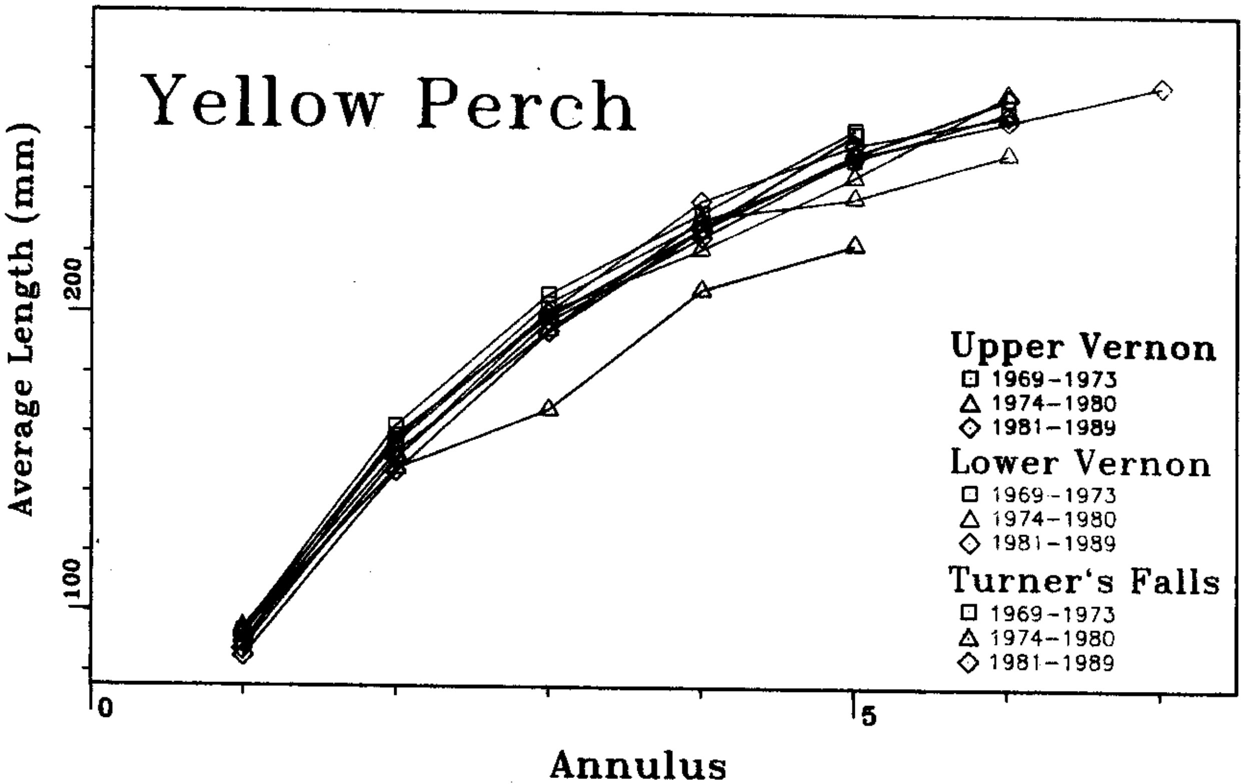
Parasitic burdens of yellow perch collected near Vernon included digenetic trematodes, monogenetic trematodes, fish leeches, and nematodes encysted in the visceral mesenteries which were comparable to infestations observed in yellow perch located in Bellows Falls pool (Downey 1984a). One striking difference observed was the heavy infestation of yellow grub (Clinostomum marginatum) in the yellow perch captured in the Bellows Falls pool, a 100 percent incidence, whereas the yellow grub was not isolated in yellow perch captured near Vernon. Since that study (Downey 1984a), yellow perch captured near Vernon were routinely examined and only a few fish have been recorded with light yellow grub infestation.

Yellow perch growth has been generally comparable among fish captured in three locations during 1969-1989 (Figure 3.7). Statistically significant lower growth rates of 1974-1980 cohorts were observed for yellow perch captured in upper Vernon pool; an area outside the influence of the thermal plume (Downey 1985d, 1990c). Significant differences in the growth of fish captured among the three locations were not observed during Project SAVE, 1981-1989. The analysis of the growth and distribution of yellow perch near Vernon did not reveal any significant effect of Project SAVE operation on this species.

SPOTTAIL SHINER

The spottail shiner occurs in parts of Canada south into the United States to Georgia in the east and Iowa and Missouri in the west (Scott and Crossman 1973). This species is generally regarded as a fish of relatively large lakes and rivers.

Spottail shiners were reported to be the most abundant fish in the Connecticut River near Vernon (Binkerd et al. 1978). This species continued to be abundant in the Connecticut River near Vernon. In Vernon pool, the spottail shiner accounted for eight percent of the fish captured during 1968-1980 and 11 percent of the fish captured (exclusive of 500 micrometer seine samples) during 1981-1989. In upper Turners Falls pool, about 16 percent of the fish captured during 1968-1980 were spottails while they represented about five percent of the fish captured during 1981-1989.



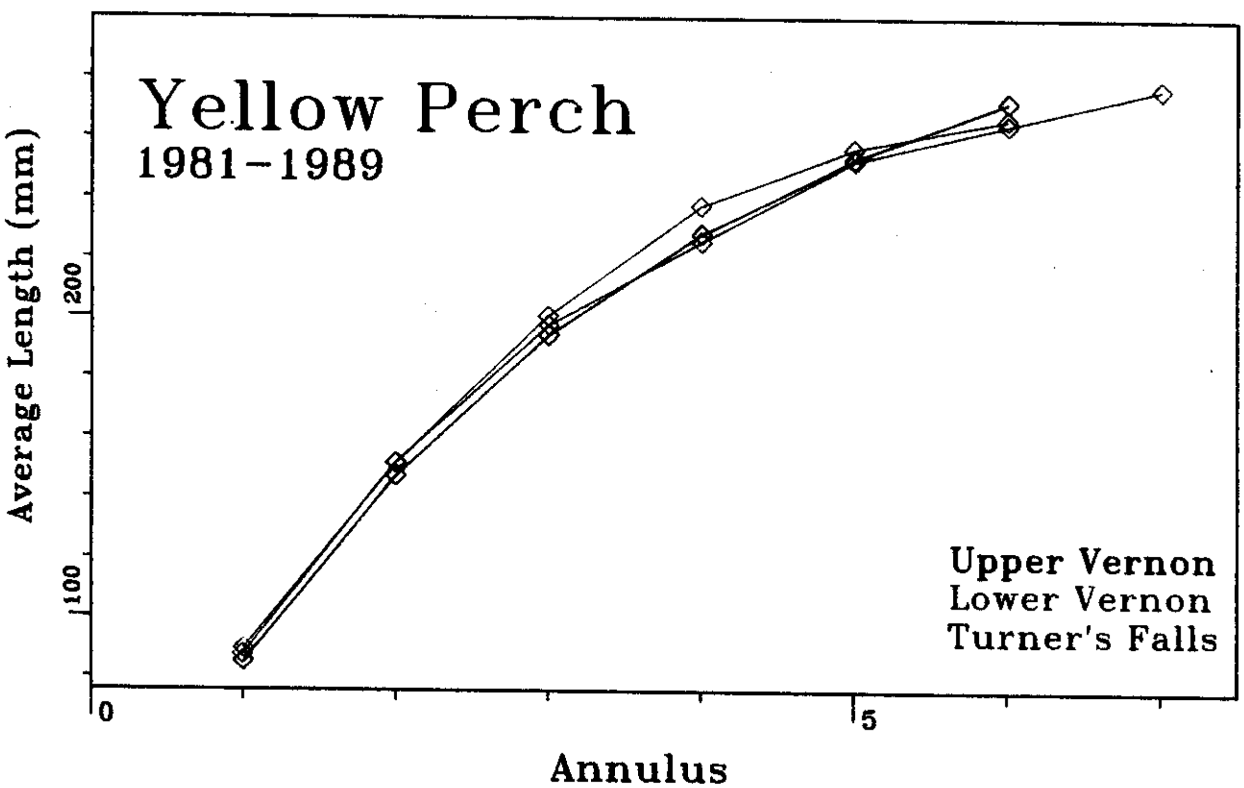


Figure 3.7 Mean back calulated total length in millimeters for Yellow Perch, 1969-1989.

Minnow larvae first appeared in late-May and were the dominant ichthyoplankton during June through August. The minnow larvae (*Notropis* spp., *Hybognathus regius*, and *Notemigonus crysoleucas*) were not known well enough for positive differentiation. These ichthyoplankton were found in the largest densities in surface samples, less than five feet deep.

At least three age groups of spottail shiners were collected in the Vernon and Turners Falls pools during 1968-1989. Observed sizes were consistent with reported size at annulus formation for spottail shiners (Scott and Crossman 1978).

The presence and abundance of spottail shiners in Vernon and Turners Falls pools demonstrate that no significant reduction in growth and distribution of spottail shiner have resulted from Project SAVE operation.

4.0 ENGINEERING AND HYDROLOGICAL INFORMATION

4.1 Introduction

This section describes the thermal effects on the Connecticut River due to the discharge of heat from Vermont Yankee during the period 16 May to 14 October. The thermal effects on the Connecticut River are described in two regions: in Vernon Pool where thermal plumes were observed, and downstream of Vernon Dam where the heated water was well mixed with ambient river water.

4.2 Vermont Yankee Facilities and Operation

Vermont Yankee facilities are essentially unchanged since 1978. The location of gates are the same as previously described by Binkerd et al. (1978); however, gear-driven gate operators on four gates, one intake gate, two cooling tower bypass gates, and the recirculation gate, have been replaced with hydraulic gate operators to withstand frequent cycling. A temperature data acquisition system was installed in 1984 as a replacement to a system first installed in 1976 (King 1985). The system was modified and now includes pH recording and monitoring of Vernon Dam fishway temperatures (King 1990).

Heat has been discharged from Vermont Yankee to the Connecticut River since 1982 between 16 May and 14 October without exceeding temperature standards permitted for Project SAVE. Plant operation within the test temperature standards has been achieved in part due to a computer simulation (Binkerd et al. 1983). In 1981 and early in 1982, the computer simulation of plant operation was developed based on plant design information independent of actual operational data.

The simulator was verified through extensive physical experiments in the spring and summer of 1982. The following year, the computerized version of the simulator was used to develop a manual for plant operators (Johnston and Binkerd 1984). Several revisions to this manual have been written and provided to the Vermont Yankee operators. Revision 4, dated May 1990, is currently being used for the control of heat discharged to the river.

4.3 Vernon Dam Facilities and Operation

The Vernon Dam and Vernon Station were described in Binkerd et al. (1978). Many changes have been made by the New England Power Company to the dam and hydroelectric station since 1978. A fishway was constructed and first operated in 1981. Also, the wooden flashboards along the crest of the dam were increased from six feet high to eight feet high in 1984. Most of these wooden flashboards were replaced in 1987 with hydraulically operated gates. Presently, there are nine gates along the crest of the dam and only two sections of wooden flashboards remain.

Since the installation of these gates, the typical pool elevation has increased by about two feet; pool elevations of over 219.5 feet

above mean sea level (msl) are now common. The hydraulically operated gates have also reduced the frequency with which the pool water elevation is reduced to dam crest elevation (about 212 feet msl). Hydraulically operated gates allow more control on the location of spillage over the dam's crest, which affects the shape of the thermal plume in Vernon Pool.

4.4 Effect of Discharged Heat on Connecticut River Temperatures

The heat discharged by Vermont Yankee results in thermal plumes in Vernon pool and increased mixed river temperatures downstream. A summary of temperature increases at Station 3 was produced for the years 1968-1983 (Johnston 1984). An update of Johnston (1984) by Luxenberg (1990a) summarized temperature increases at Station 3 for 1984-1989.

Temperature gradients were quite apparent in Vernon pool, typically between the discharge structure and Vernon Dam. At low river discharges, thermal plumes extended upstream of the discharge structure. Thermal plumes measured from May to October, 1989, were displayed in Binkerd et al. (1990b). Some differences were observed in these plumes compared with the plumes measured by Binkerd et al. (1978) during the late fall, winter, and early spring. In general, thermal plumes observed in the summer had smaller areas of higher excess temperatures, and larger areas of lower excess temperatures; but the shape and characteristics of the 1989 summer plumes were similar to previously measured thermal plumes in Vernon pool. These differences were most likely due to increased pool elevation, selective hydraulic gate operation, and higher ambient river temperatures.

Temperature patterns near the Vernon Dam fishway during high river discharge indicated that exit fishway temperatures were often equal to or less than Station 3 temperatures during high river discharge (Binkerd 1985a). During lower river discharge, however, exit fishway temperatures were often 1 to 2°F higher than Station 3 temperatures and differences as much as 3 to 4°F have occurred.

The heated water became well mixed with ambient water by Station 3 as a result of Vernon Dam and Station operation. As this heated water was transported downstream to Long Island Sound, temperature increases were reduced due to longitudinal mixing and transfer of excess heat to the atmosphere. The temperature increase near Holyoke Dam (58 miles downstream) could have been 0.1 to 1.5°F for initial increases of up to 5°F at Station 3 during the period 16 May to 14 October (Luxenberg 1985).

4.5 Thermal Impact Assessment

Temperature increases resulting from Vermont Yankee operation under the proposed alternate temperature standards are limited by the river discharge (discharged based) or the temperature standard (criteria based). Criteria based temperature increases were

determined by hourly upstream Station 7 temperatures (Figure 4.1) and proposed alternate temperature standards. Discharged based temperature increases were determined by available river discharge records from 1973-1989 (Figure 4.2) and the assumption that Vermont Yankee discharged all of its excess heat. The minimum of these two values, either criteria based or discharged based temperature increases, formed a data set of temperature increases that would have occurred had Vermont Yankee operated using the proposed alternate temperature standards. Hourly probabilities of creating a river temperature increase were calculated using this data set. An example of these calculations is illustrated in Table 4.1. Interpolated probability values for the occurrence of 0.5, 1.5, 2, 3, 4, and 5°F temperature increases are plotted in Figure 4.3.

According to this analysis, in May when river discharge is high, the maximum proposed temperature standard (5°F) will not be reached. Also, there is less than a five percent chance of achieving a 4°F increase during the mid-May period. During the summer (July-August) there is a 60 to 80 percent chance that a 2°F increase will occur. In this mid-summer period, the proposed temperature based standard of 2°F increase will dominate. In October, 5°F increases will occur about ten percent of the time.

The mean hourly temperature at Station 7 was subtracted from the 20 year maximum measured temperature and plotted in Figure 4.4 along with the standard deviation of temperature calculated from Station 7 data. The simulated maximum temperature increase and the simulated increase not exceeded 68.3 percent of the time are also plotted in Figure 4.4 for comparison.

The historical mean and maximum temperatures are plotted along with temperatures measured at Stations 3 and 7 in 1989 (Figure 4.5). During 1989, the plant was discharging heat to the river the entire time under Project SAVE. Station 3 temperatures were usually warmer than Station 7 temperatures during 1989. Both Stations 3 and 7 temperatures fluctuated frequently about the mean sometimes by 5°F or greater. The historical daily minimum temperature occurred in mid-June, 1989, followed by historical daily maximum temperature in late-June, indicating the wide fluctuations in ambient temperatures that can occur in a very short time period.

This analysis illustrates that expected temperature increases will be typically less than the historical standard deviation from mid-May to late-September. During late-September to mid-October, expected temperature increases will exceed the historical standard deviation of the mean ambient temperature. It is anticipated that river temperature increases will not always be at the level of proposed temperature standards, but, in many instances, will be much lower due to expected high river discharges.

Table 4.1 Example of data on 18 May, 0800 hours, statistics, and calculations for thermal impact assessment.

Year	18 May at 0800 hours: Station 7 Temperature °F	18 May at 0800 hours: Connecticut River Discharge cfs	Temperature Increases, °F: 1[#] Criteria Based	Temperature Increases, °F: 2[@] Discharge Based	Temperature Increases, °F: 3 Minimum of Columns 1 & 2	4[$] Rank of Column 3	5[C,*] Percent Probability of Temperature Increase in Column 3
1970	54.0						
1971	51.2						
1972	51.5						
1973	52.5	17,920	5.0	0.9	0.9	12	67
1974	55.2	23,260	4.0	0.7	0.7	16	89
1975	59.0	11,690	3.0	1.4	1.4	9	50
1976	57.2	16,240	4.0	1.0	1.0	10	56
1977	59.0	7,860	3.0	2.0	2.0	4	22
1978	50.2	24,310	5.0	0.7	0.7	17	94
1979	62.1	9,430	3.0	1.7	1.7	6	33
1980	55.4	1,380	4.0	11.6	4.0	1	6
1981	55.6	17,030	4.0	0.9	0.9	11	61
1982	57.6	10,030	4.0	1.6	1.6	7	39
1983	50.0	20,420	5.0	0.8	0.8	15	83
1984	47.9	20,340	5.0	0.8	0.8	14	78
1985	59.3	1,490	3.0	10.8	3.0	2	11
1986	60.9	1,370	3.0	11.7	3.0	3	17
1987	60.0	8,150	3.0	2.0	2.0	5	28
1988	60.2	11,180	3.0	1.4	1.4	8	44
1989	55.9	19,720	4.0	0.8	0.8	13	72
Maximum	62.1[A,D,E]	24,310[B]			4.0[D]		
Mean	55.7[A,D,E]	13,048[B]					
Minimum	47.9[A]	1,370[B]					
Standard Deviation	4.1[A,D]				1.8[D,!]		

A Statistics used in Figure 4.1
B Statistics used in Figure 4.2
C Statistics used in Figure 4.3 (Interpolate to get probabilities at specific temperature increases)
D Statistics used in Figure 4.4 (Interpolate to get temperature increases at specific probability)
E Statistics used in Figure 4.5

Use 2-5 °F criteria
@ Use 16040/discharge
$ Highest increase has rank = 1, Lowest increase has rank =17
* = 100 x rank/18
! Temperature increase with 68.3 percent probability of being equal to or less than actual increase

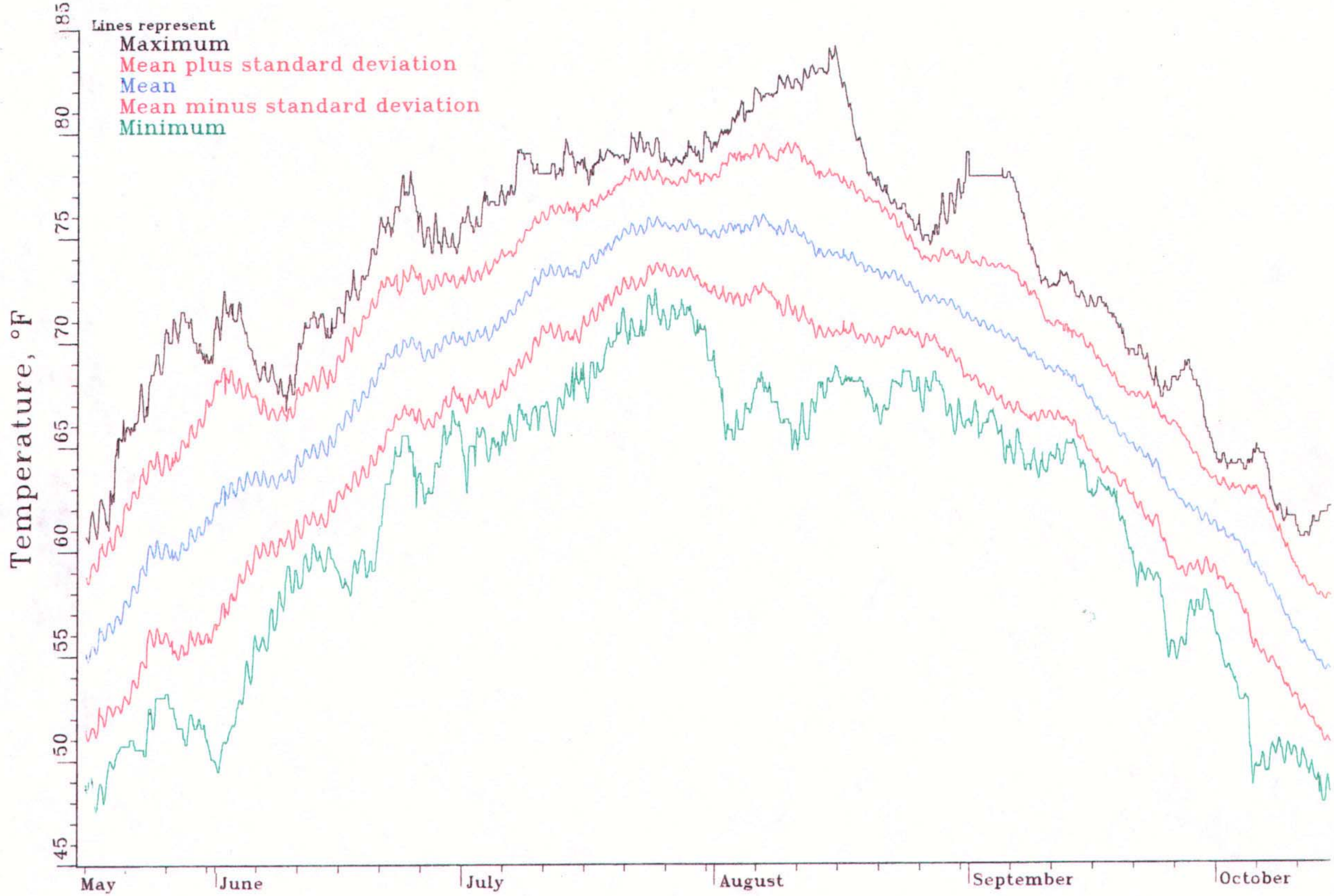


Figure 4.1 Range of Station 7 temperatures, 1970–1989.

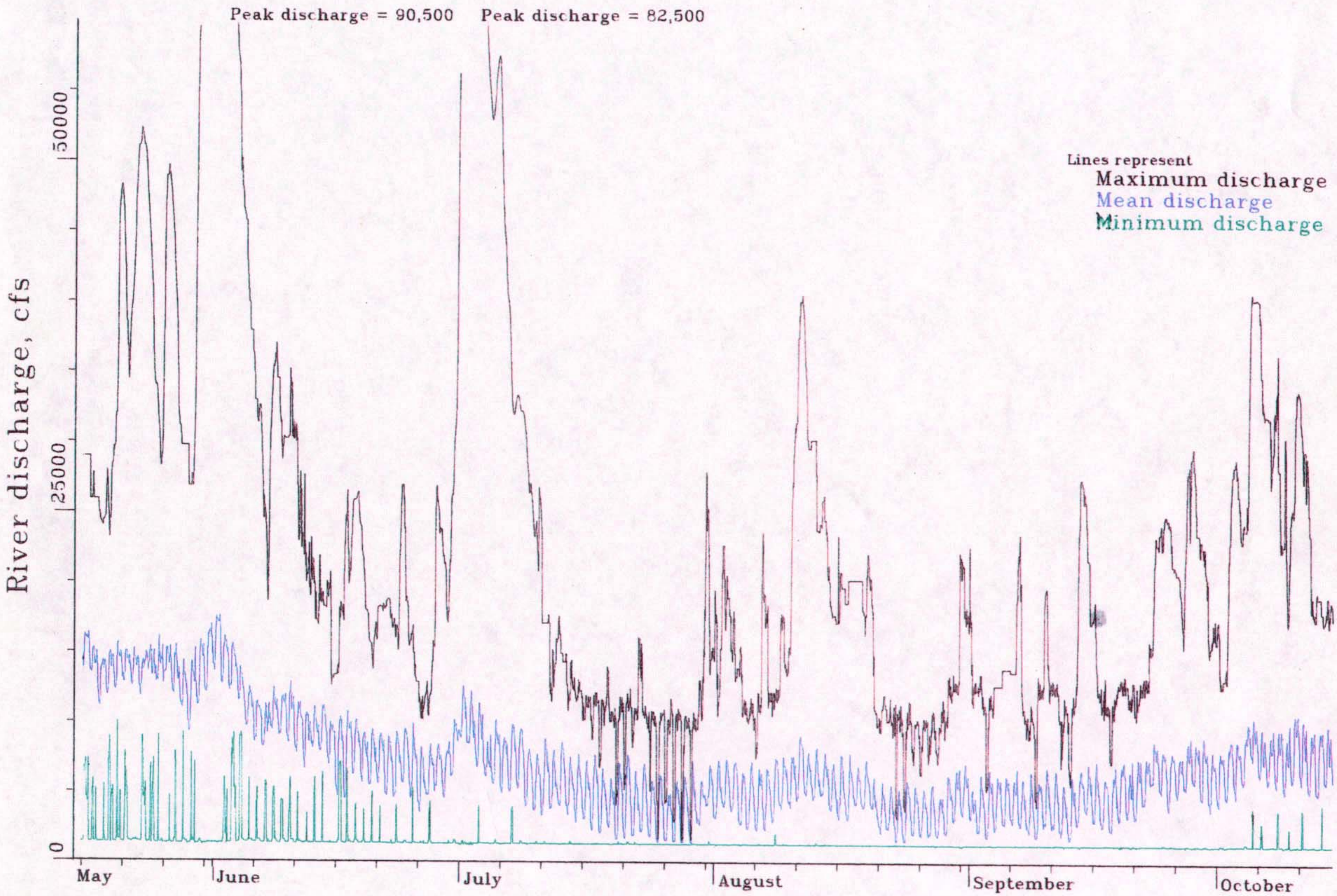


Figure 4.2 Range of Connecticut River discharge at Vernon, Vermont, 1973–1989.

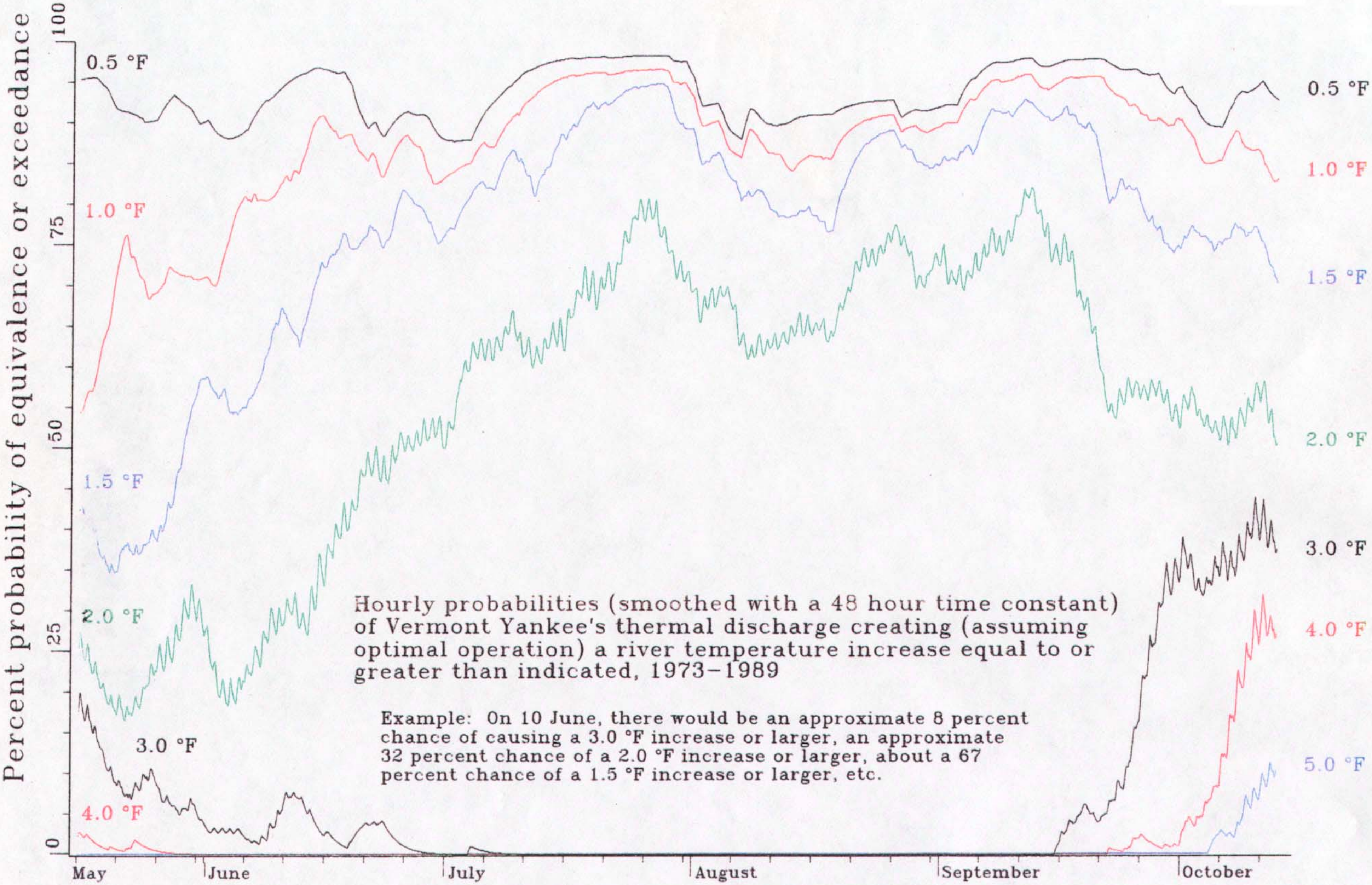


Figure 4.3 Distribution of simulated temperature increase using 2 to 5 °F temperature standard.

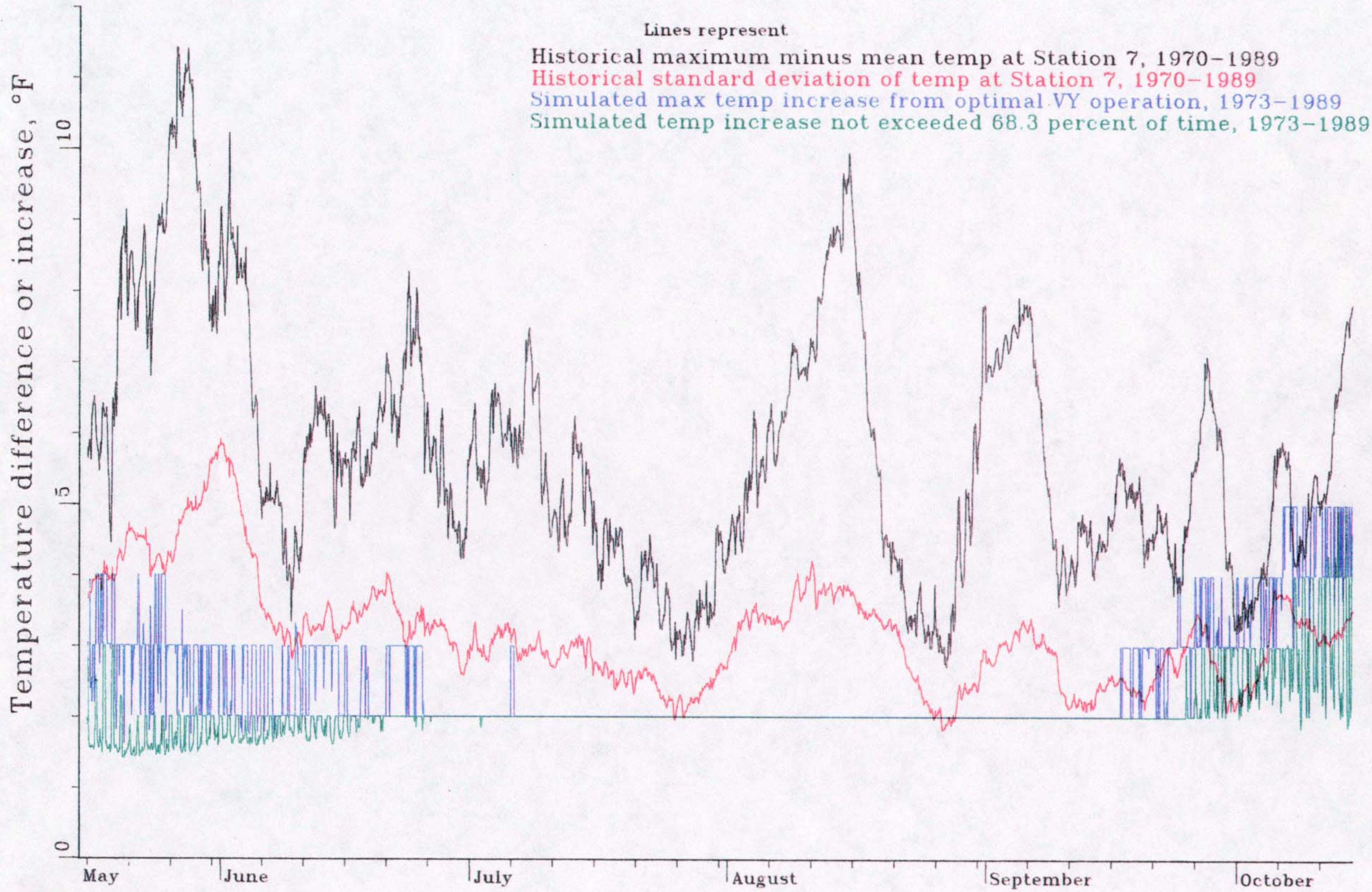


Figure 4.4 Comparison of temperature differences with simulated increases.

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