Dominion Nuclear Connecticut, Inc.
Millstone Power Station
Rope Ferry Road
Waterford, CT 06385

Dominion

APR 30 2002

Docket No. 50-423
B18636

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Millstone Nuclear Power Station, Unit No. 3
2001 Annual Environmental Protection Plan Operating Report

In accordance with Section 5.4.1 of the Environmental Protection Plan (EPP), Dominion Nuclear Connecticut, Inc. hereby submits the Annual Environmental Protection Plan Operating Report, describing implementation of the EPP for the previous year. Enclosure 1 transmits information for the period January 1, 2001, to December 31, 2001.

There are no regulatory commitments contained within this submittal.

Should you have any questions, please call Mr. Paul Jacobson, Environmental Services, at (860) 447-1791, ext. 2335.

Very truly yours,

DOMINION NUCLEAR CONNECTICUT, INC.

J. Alan Price
Site Vice President - Millstone

Enclosure (1)

Attachment (1)

cc: H. J. Miller, Region I Administrator
V. Nerses, NRC Senior Project Manager, Millstone Unit No. 3
NRC Senior Resident Inspector, Millstone Unit No. 3

A. J. Rocque, Commissioner
State of Connecticut
Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

IE25

Docket No. 50-423
B18636

Enclosure 1

Millstone Nuclear Power Station, Unit No. 3

Annual Environmental Protection Plan Operating Report
January 1 - December 31, 2001

# Annual Environmental Protection Plan Operating Report
## January 1 - December 31, 2001

## Millstone Unit No. 3 Environmental Protection Plan

**Dominion Nuclear Connecticut, Inc.**
**Millstone Power Station**
**Rope Ferry Road**
**Waterford, Connecticut 06385**

**April 2002**

# Annual Environmental Protection Plan Operating Report
# January 1 - December 31, 2001

## Millstone Unit No. 3 Environmental Protection Plan


Prepared by: Jim Foertch

Reviewed by: Milan Keser

## Annual Environmental Protection Plan Operating Report - 2001

### 1. Introduction

This report covers the period January 1, 2001, through December 31, 2001. During 2001, Unit No. 3 completed a very successful seventh fuel cycle, with a capacity factor for cycle 7 of 98.1%. A refueling outage was conducted from February 3, 2001, to March 31, 2001, with the capacity factor for cycle 8 through the end of 2001 at 97.0%. The total capacity factor for all of 2001 was 80.8%.

Millstone Power Station was acquired by Dominion Nuclear Connecticut, Inc. (DNC) on March 31, 2001. The station's Operating License and National Pollutant Discharge Elimination System (NPDES) Permit were transferred to DNC, effective as of March 31, 2001.

As required by the Millstone Unit No. 3 Environmental Protection Plan (EPP), this Annual Environmental Protection Plan Operating Report (AEPPOR) includes:

- summaries and analyses of the results of environmental protection activities,
- a list of EPP noncompliances,
- a list of all changes in station design or operation which involved a potentially significant unreviewed environmental question, and
- a list of non-routine reports, describing events that could result in significant environmental impact.

### 2. Environmental Protection Activities

2.1 Annual National Pollutant Discharge Elimination System (NPDES) Report of Ecological Monitoring (EPP Section 4.2)

Paragraph 5 of the Station's NPDES permit requires continuation of biological studies of Millstone Power Station (MPS) supplying and receiving waters, entrainment studies, and intake impingement monitoring. These studies include analyses of intertidal and subtidal benthic communities, finfish communities, entrained plankton, lobster populations, and winter flounder populations. Paragraph 7 of the permit requires an annual report of these studies to the Commissioner of Environmental Protection. The report that fulfills these requirements for 2001, Monitoring the Marine Environment of Long Island Sound at Millstone Power Station, Waterford, Connecticut - Annual Report, 2001 (Annual Report), presents results from studies performed during construction and operation of MPS, emphasizing those of the latest sampling year. Changes to the biological communities noted in these studies are summarized in the Executive Summary section of the Annual Report (Attachment 1) and further discussed in the Annual Report itself.

## 2.2 Effluent Water Quality Monitoring

Paragraph 3 of the referenced NPDES permit requires monitoring and recording of many water quality parameters at MPS intakes and at multiple monitoring points within the plant, including outfalls of each unit to the effluent quarry, and outfall of the quarry to Long Island Sound. Paragraph 11 of the permit requires a monthly report of this monitoring to the Commissioner of the Connecticut Department of Environmental Protection (DEP). The report that fulfills these requirements, the Monthly Discharge Monitoring Report (DMR), includes data from all three (3) Millstone units. Consistent with prior annual AEPPOR submissions, water flow, pH, temperature and chlorine data pertaining to Unit No. 3 are summarized in Table 1.

Each monthly DMR identifies NPDES permit exceedances (i.e., events where a parameter value was beyond permitted limits) or exceptions (i.e., events where permit conditions were not met) for the month. Other events dealing with NPDES discharges, while not resulting in a permit exceedance or exception, are included in the DMRs to provide the DEP with additional information. Following are descriptions of events that occurred in 2001, relating to Unit No. 3 discharges, reported via the monthly DMRs.

- On February 4, 2001, a sprinkler head was accidentally dislodged, resulting in approximately 200 to 400 gallons of fire equipment water (domestic water) entering the Unit No. 3 Turbine Building Sump and discharged via DSN 006. Samples showed no detectable levels of chlorine at the sump.

- On February 8, 2001, less than five gallons of sulfuric acid leaked from a Unit No. 3 transfer pump onto the floor; a small amount entered the Makeup Waste Neutralization Sump (DSN 001C-4) through the floor drain. This tank is authorized to receive sulfuric acid additions for purposes of neutralization.

- On February 12, 2001, approximately 38 gallons of service water (sea water) entered the Unit No. 3 liquid high level waste drain tank (HLWDT) via a floor drain from the radiologically controlled area. Floor drains from the radiologically controlled area are an authorized input to the system. This is an authorized pathway for this wastewater. The water overflowed from a collection tote which was being used during a loss-of-power test. The drain contents were processed through the filters and demineralizers associated with DSN 001C-2. No effluent limits were exceeded upon discharge via DSN 001C-2.

- On February 16, 2001, an overflow of Unit No. 3 water purification makeup water occurred from a containment berm. Approximately 100 gallons entered a storm drain leading to DSN 006. The remaining water was tested and was determined to be below the permitted level of residual chlorine for DSN 006.

- On February 20, 2001, approximately 2 to 3 gallons of dilute hypochlorite solution was released into the Unit No. 3 circulating water bay from a break that occurred in an isolated hypochlorite line. Free available chlorine in the line was tested and determined to be less than the limit of detection (0.03 ppm).

- Between February 28, 2001, and March 1, 2001, approximately one (1) gallon of 10% hydrogen peroxide solution was used to clean and decontaminate a small section of the Unit No. 3 containment. It is expected that the peroxide was consumed during the decontamination process. However, any residual peroxide would have been collected in the containment sump, treated, and discharged via DSN 001C-2 or C-3.

- On May 9, 2001, approximately 10 to 25 gallons of a 93% sulfuric acid solution leaked from a bulk storage tank transfer pump into the surrounding secondary containment berm. The containment includes the Makeup Waste Neutralization Sump (DSN 001C-4). All of the sulfuric acid solution was contained either in the berm or in the sump. No sulfuric acid was discharged to Niantic Bay or Long Island Sound.

- On May 31, 2001, a small volume of rainwater mixed with residual sodium hypochlorite in the hypochlorite tank enclosure berm, and was released to a concrete pad adjacent to the Unit No. 3 Intake. The water on the pad was contained, neutralized, and cleaned up, and the remaining water in the berm, approximately 50 gallons, was pumped out and properly disposed. The source of the sodium hypochlorite was determined to be residue on the floor of the berm. The hypochlorite came from a previously identified pinhole leak in the "B" storage tank, which had been drained and was replaced.

- On July 18, 2001, the unit discovered that it failed to collect and analyze a weekly grab sample from DSN 001C-2 (Radiation Waste Test Tank Discharge) for specific conductivity. Instead, results for an in-line sample and a similar sample (that was not chilled to 4°C) were analyzed.

- On August 14, 2001, a leak in the Unit No. 3 "A" Reactor Plant Component Cooling (CCP) heat exchanger was discovered. It is estimated that the leak resulted in a release of approximately 700 gallons of CCP water containing hydrazine to service water over a period of five days. The service water system flow is approximately 30,000 gpm and discharges at DSN 001C-5. DSN 001C-5 is not an authorized discharge path for hydrazine. Upon discovery, the heat exchanger was removed from service and repaired.

- On August 23, 2001, approximately 1 to 2 gallons of sulfuric acid leaked from a bulk storage tank into a containment dike in the Unit No. 3 turbine building. It is possible that a small amount of the acid, along with water and sodium hydroxide used to clean up the spill, entered the Makeup Waste Neutralization Tank (MWNT) via DSN 001C-4, where it was held. DNC has determined that the acid tank vent path was not blocked. As a result, the process for receiving acid deliveries has been modified to decrease the allowable pressure used by the vendor when blowing residual acid out of the tank truck hose into the acid tank.

Over the past several years, Millstone Power Station had submitted several requests to the DEP for Emergency Authorizations (EAs) for various discharges. On October 13, 2000, the DEP consolidated these requests and issued EA0100176, authorizing certain discharges and containing various reporting requirements. Millstone Power Station submitted required reports for each quarter of 2001, and noted that all results reported for those quarters were within specified limits.

## 3. Environmental Protection Plan Noncompliances

During 2001, no EPP noncompliances were identified for Unit No. 3.

## 4. Environmentally Significant Changes to Station Design or Operation

During 2001, no Unit No. 3 Design Change Records (DCRs) or changes to System Operating Procedures met the acceptance criteria for inclusion in this report, i.e.,

a) were initiated during the report year, and

b) included a determination that an unreviewed environmental impact could occur.

## 5. Non-Routine Reports of Environmentally Significant Events

During 2001, no events occurred at Unit No. 3 that met the acceptance criteria for inclusion in this report, i.e., required submittal of a Licensee Event Report (LER) from Unit No. 3, and involved a situation that could result in a significant environmental impact. Of the 4 events that constituted reportable occurrences at Unit No. 3 in 2001, none were determined to cause a significant environmental impact.

Table 1. Millstone Unit No. 3 NPDES Data Summary, Jan. 1 - Dec. 31, 2001. Selected water quality parameters for Unit No. 3[1] (any exceptions or exceedances are in **bold** type, and further described in Section 2.2 of the report).

| | discharge flow range ($10^3$ gpm) | discharge pH range | discharge temp. range (°F) | discharge temp. (avg) (°F) | avg ΔT (°F) | max FAC (ppm) | max TRC (ppm) | max SWS FAC (ppm) |
|---|---|---|---|---|---|---|---|---|
| Jan. | 790-954 | 8.0 - 8.3 | 50.2 - 62.9 | 53.0 | 13.1 | 0.13 | < 0.03 | 0.20 |
| Feb. | 319-790 | 7.6 - 8.3 | 36.0 - 54.0 | 38.6 | 0.8 | 0.11 | < 0.03 | 0.20 |
| Mar. | 30-942 | 7.2 - 8.3 | 36.2 - 47.4 | 39.2 | 0.2 | 0.14 | < 0.03 | 0.18 |
| Apr. | 790-954 | 7.9 - 8.2 | 44.8 - 65.8 | 59.5 | 15.4 | 0.13 | 0.03 | 0.21 |
| May | 790-954 | 8.0 - 8.2 | 63.6 - 75.7 | 68.9 | 16.5 | 0.15 | 0.05 | 0.20 |
| June | 790-948 | 7.5 - 8.2 | 70.8 - 83.0 | 76.9 | 15.2 | 0.10 | < 0.03 | 0.17 |
| July | 790-948 | 7.8 - 8.2 | 72.2 - 86.7 | 82.2 | 15.0 | 0.09 | < 0.03 | 0.19 |
| Aug. | 790-954 | 7.0 - 8.1 | 82.5 - 91.7 | 85.7 | 15.3 | 0.11 | 0.03 | 0.22 |
| Sep. | 790-948 | 7.8 - 8.0 | 82.6 - 91.6 | 86.0 | 16.3 | 0.09 | 0.03 | 0.20 |
| Oct. | 790-948 | 7.8 - 8.0 | 72.5 - 87.0 | 79.2 | 16.4 | 0.10 | 0.03 | 0.20 |
| Nov. | 790-954 | 7.9 - 8.1 | 60.3 - 78.0 | 72.6 | 16.9 | 0.13 | 0.03 | 0.17 |
| Dec. | 790-954 | 7.9 - 8.2 | 60.3 - 76.4 | 68.3 | 17.7 | 0.13 | < 0.03 | 0.20 |

Notes:

(1) Parameters are measured at Unit No. 3 discharge (DSN 001C), except for TRC, which is measured at MPS discharge (quarry cuts; DSN 001) and SWS FAC (service water system; DSN 001C-5).

Abbreviations used:

Temp. = Water Temperature

ΔT = Delta-T (difference between discharge and intake water temperature)

FAC = Free Available Chlorine

TRC = Total Residual Chlorine

SWS = Service Water System

**Attachment 1 to the**

# Millstone Unit No. 3 Environmental Protection Plan
# Annual Environmental Protection Plan Operating Report

January 1 - December 31, 2001

Executive Summary Section of

"Monitoring the Marine Environment of Long Island Sound at Millstone Power Station, Waterford, Connecticut. Annual Report, 2001"

# Executive Summary

## Lobster Studies

The American lobster (*Homarus americanus*) is the single most valuable fisheries species in New England. In Connecticut, the regional economic value of the lobster fishery is between $12 and $15 million annually. Lobsters are also one of the largest mobile benthic invertebrates in the western North Atlantic and important inhabitants of coastal ecosystems. Several aspects of Millstone Power Station (MPS) operation could potentially impact the local population of American lobster. In early summer, after hatching from eggs, lobster larvae swim to the surface to begin the 6- to 8-week planktonic phase of their life cycle and are susceptible to entrainment through cooling water systems. Juvenile and adult lobsters can be impinged on intake travelling screens or be exposed to the heated effluent in the discharge area. Because of the economic and ecological importance of this species, lobsters have been monitored from May through October since 1978, using wire lobster traps set at three stations around MPS. Since 1984, entrainment studies have been conducted during the hatching season, to estimate the number of lobster larvae drawn through the cooling water system. The objective of the lobster monitoring program is to determine if operation of MPS has caused changes in local lobster abundance and population characteristics beyond those expected from changes in the fishery and natural variability.

Despite intense and increasing fishing effort on the species, landings made in the commercial fishery throughout New England have increased markedly over the last three decades. Commercial landings of lobsters in Connecticut waters of Long Island Sound (LIS) increased from 0.7 million pounds in 1979 to a record 5.6 million pounds in 1998. However, landings declined 70% between 1998 and 2000 to only 1.7 million pounds. Landings declined even further in 2001 when only 1.5 million pounds were harvested. The recent decline in lobster abundance has been attributed to a significant lobster mortality event in western LIS. Beginning in the fall of 1998 and throughout the summer of 1999, an unexplained highly virulent illness emerged in lobsters harvested from western LIS. Lobstermen reported that more than half of the lobsters caught in traps were dead or died before arriving at port. In some areas of western LIS landings have declined more than 90% over the past few years. Many researchers suspect that the die-off in western LIS was caused by multiple disease pathogens exacerbated by environmental stressors, such as increased seawater temperature, anoxia and contaminants. Concurrently with the lobster die-off in western LIS, a major outbreak of shell disease began in 1998 in eastern LIS and nearshore coastal areas of Rhode Island and Massachusetts. Naturally occurring bacteria and fungi have been implicated as causative agents of shell disease. These microorganisms consume the exoskeletons of crustaceans, resulting in a shell that is pitted and marred with necrotic lesions. The unsightly appearance of the shell greatly affects lobster marketability and although shell disease is not immediately fatal, death may ultimately occur.

In response to the die-off in western LIS and shell disease outbreak in eastern LIS, the U.S. Secretary of Commerce declared a failure of the LIS commercial lobster fishery in January, 2000. In 2001, the U.S. Congress allocated $13.9 million in federal disaster funds for the LIS lobster industry. Half of this Federal aid has been earmarked for research investigations on causes and economic impacts of the die-off and shell disease in LIS lobsters.

The most notable changes in the population characteristics of local lobsters during 2001 were observed in the proportion of egg-bearing females and their size structure, which may be related to changes in lobster growth and the size at which females become sexually mature. The benefits of earlier maturation may be significant to lobster population dynamics. Small size at maturity and subsequent egg production from sublegal-sized females may explain why LIS lobsters are so resilient in the face of intense exploitation. Currently, the smaller size at sexual maturity allows females to spawn once or twice before reaching the legal size and could maintain current population levels into the future. However, the long-term sustainability of the Connecticut fishery may now be threatened by the lobster die-off in western LIS and the widespread outbreak of shell disease in our area. During 2001, we found that egg-bearing female lobsters had the highest prevalence and severity of shell disease and although the effects of the disease on egg-development, hatching success and larval survival are unknown, the density of lobster larvae collected in samples of the MPS cooling water was the lowest observed in 18 years of lobster larvae entrainment studies. Alternatively, if larvae found in our area originate from the west, the lobster die-off in western LIS could be responsible for the low number of larvae found in our study area during 2001. The events of mass mortality in western LIS and the effects on recruitment and subsequent legal lobster abundance in our area due to the recent outbreak of shell disease could be significant, if egg-bearing females suffer higher mortality.

At present, the die-off and subsequent catastrophic decline in lobster abundance observed in western LIS has not been observed in our study area in eastern LIS. Although catch-per-unit-effort of 1.587 lobster/pot during 2001 continued to decline from the record high of 2.560 observed in 1999, the 2001 value was within the range of annual CPUEs observed since 1978. In addition, our results indicated a significant increasing trend in total lobster catch over the past 24 years. Furthermore, despite the fact that nearly all the legal-size lobsters are removed by fishing each year, no significant long-term trend in legal lobster abundance was observed in our area. These findings suggest that operation of the MPS cooling water system since the early 1970s has not caused a decrease in the local lobster population. Our monitoring studies indicate that the changes observed in lobster population characteristics and fluctuations in lobster abundance are related more to a combination of natural environmental processes (seawater temperature), episodic events (diseases), and overfishing, than to operations of MPS.

## Benthic Infauna

Studies of benthic infaunal communities inhabiting marine sedimentary environments in the vicinity of MPS have documented long-term and short-term trends in community and population-level parameters. Analysis of long-term data has provided evidence of acute and chronic impacts, some related to power plant construction and operation, and others, to presumably natural disturbances. Infaunal communities exhibiting evidence of MPS impacts were observed at the stations in the immediate vicinity of MPS (IN, EF and JC). Community changes at these sites were closely associated with changes in sediment composition related to power plant-induced disturbance. The infaunal community at GN reference site was unaffected by MPS and provided a baseline from which variability associated with natural environmental cycles and disturbances could be assessed.

The reference site (GN), well beyond any MPS influence has exhibited changes in sediments and community structure over the entire period. Sediment mean grain size was highly variable but silt/clay was relatively consistent, with no long-term trends in either parameter. Infaunal community composition at GN station has generally been dominated by three taxa (*Tharyx* spp., oligochaetes and *Aricidea catherinae*); however, some long-term trends in abundance of these taxa were noted. *A. catherinae*, common at GN in the early monitoring years, has declined in abundance, and *Tharyx* spp. abundance has increased over the 22-year study period. Some species at GN have exhibited relatively high year-to-year fluctuations that have proved useful in validating area-wide shifts in species abundance and community structure in response to natural causes and unrelated to MPS operation. For example, there was a pulse in abundance of the polychaete *Polydora socialis* at all stations in 2001 indicating a regional phenomenon. Similar population shifts occurred for the opportunistic polychaete *Mediomastus ambiseta*, at GN (and at stations near MPS) during 1983-88, 1994, and 1998-99. Other widespread population shifts in past study years included large increases in abundance of the amphipods *Leptocheirus pinguis* and *Ampelisca* spp., and of the polychaetes *Prionospio steenstrupi* and *Pygospio elegans*.

Infaunal community changes associated with MPS were first observed at IN and were caused by dredging and cofferdam removal during Unit 3 construction from 1983 to 1985. Since then, sediments (primarily silt/clay content levels) have stabilized and become more similar to sediments of pre-impact years. Evidence of some infaunal community stabilization and recovery was also apparent. In particular, numbers of individuals and species richness at IN have increased over the study period, as have abundances of organisms typically more common in early study years or at other sites, such as *A. catherinae* and *Tharyx* spp. These trends, along with concomitant decreases in abundance of *Nucula annulata* and other opportunistic species (e.g., the amphipods *L. pinguis* and *Ampelisca* spp.), indicate some degree of recovery at IN. Recovery at IN is not complete, however, as other organisms which have established post-impact community dominance, such as oligochaetes and *Protodorvillea gaspeensis*, maintained or increased their degree of dominance in recent years and may persist indefinitely.

Silt deposition at JC attributed to sediment scouring from MPS discharge area following Unit 3 start-up in 1986 resulted in increased sediment silt/clay content and abrupt changes in infaunal community structure. The altered community has exhibited changes in recent years, moving toward pre-impact community structure. For example, *A. catherinae* and *Tharyx* spp. abundances have approached levels observed prior to 1986. However, continued trends toward recovery noted in previous years (e.g., reduced silt/clay content during 1994 and 1995, and rebounding abundances of oligochaetes and *Polycirrus eximius* through 1993) turned out to be short-term community changes no longer evident in recent data. Additionally, the opportunistic mollusc *N. annulata* has maintained a population at JC through 2001 that is still well above pre-Unit 3 levels. This biological evidence of disturbance is consistent with trends in sediment characteristics; elevated silt/clay levels in sediments at JC were still evident in 2001.

The benthic infaunal site that experiences chronic MPS operational impact processes is the EF station. Current scour from the MPS discharge directly impacted both the sediments and the infaunal community 100 m from the discharge at EF, particularly after Unit 3 startup in 1986. Relatively coarse sediments with low silt/clay levels were characteristic of the 3-unit benthic habitat at EF. While sediment characteristics remain different from those observed prior to 1986, the altered sedimentary environment at EF, and the infaunal community it supports, stabilized under the new environmental conditions created by the 3-unit discharge. Discharge flow from Units 2 and 3 since 1998 has had little effect on this stabilization, which has allowed for rebounds of *Tharyx* spp. and *A. catherinae*, taxa common prior to 1986. In addition, oligochaete and *P. gaspeensis* abundances have generally decreased from high abundances during the early 3-unit period. Oligochaete abundances at EF during the last two years (2000 and 2001) were among the lowest observed during the study period, possibly related to the heavy mussel set observed in the discharge area in 2000.

## Eelgrass

Eelgrass is an ecologically important component of shallow water habitats. Eelgrass population monitoring has been part of marine environmental studies in the vicinity of MPS since 1985. Eelgrass populations at three locations were monitored during 2001: Jordan Cove (JC), White Point (WP) and Niantic River (NR). The JC and WP sites have been consistently sampled since 1985, while the NR station has been changed five times because of declines in the overall abundance of eelgrass in the Niantic River.

Eelgrass beds at the two monitoring sites nearest MPS (JC and WP) have exhibited slight, but statistically significant, long-term declines in most population parameters. However, compared to the Niantic River, they have generally supported healthy populations, based on parameters monitored throughout the 17-year study. These two populations are exposed to variability in water temperature more indicative of natural solar warming and hydrodynamic conditions in Jordan Cove than the MPS discharge. These natural factors are particularly influential at the JC sampling site, which is the most shallow of the study sites, and is immediately adjacent to extensive shallow sand flats vulnerable to solar warming. In addition to temperature, there does not appear to be any relationship between WP and JC population fluctuations and power plant discharge flow and heat output. With Unit 1 permanently retired, the likelihood of thermal plume incursion at JC and WP in the future is further reduced.

Eelgrass shoot density and standing stock biomass estimates have been most variable during the study period in the Niantic River, where reference stations have been monitored. A new sampling site was established in the Niantic River in 2000 within the only remaining viable eelgrass bed found in this estuary. Site relocation was necessitated by the 1999 die-off of the eelgrass bed where the previous site had been located. This was the fifth time since 1985 that we have documented loss of an eelgrass bed in the Niantic River. The condition of the present bed is in question, as standing stock and shoot density estimates were low at this site in 2000 and 2001. Because the Niantic River is located well away from any influence of the MPS thermal plume, declines at NR sites cannot be attributed to MPS operation. The spatial pattern of decline among study populations in the vicinity of MPS suggests a relationship to nutrient enrichment. Niantic River eelgrass beds may be more susceptible to nutrient loading from fertilizers and domestic septic systems due to restricted tidal exchange of the estuary and proximity to expanding housing developments when compared to the JC and WP sites in Jordan Cove. Eelgrass declines in coastal embayments similar to the Niantic River in Rhode Island and Massachusetts have been directly linked to increased housing development within their watersheds.

## Rocky Intertidal Studies

Several important operational events during more than 20 years of rocky intertidal monitoring have resulted in identifiable ecological changes to the shore community near the MPS discharge. While measurable, these changes are not widespread, but remain restricted to approximately 150 m of shoreline on the east side of the power plant discharge to LIS. Thermal impacts to the shore community at Fox Island were first observed in 1983, after the opening of the second quarry cut. Thermal addition to this site was modified when Unit 3 began commercial operation in 1986, and 3-unit operating conditions over the next 11 years allowed for long-term successional community development under a relatively consistent thermal regime. This community exhibited some changes during the extended shutdown of all three reactors from March 1996 through June 1998. Results of post-shutdown studies (1999-2001) showed that the thermally adapted community at FE was highly resilient because, as units returned to service, the characteristic components of this community quickly recovered.

Qualitative algal sampling had documented seasonal shifts in annual species at Fox Island-Exposed (FE) during 3-unit operation, and following Unit 3 restart in 1998. These shifts included abbreviated season for cold-water species (e.g., *Monostroma grevillei, Spongomorpha arcta* and *Dumontia contorta*) and extended season for warm-water species (*e.g., Grinnellia americana, Dasya baillouviana,* and *Bryopsis hypnoides*). Seasonality of these species at FE during the recent shutdown period was more typical of other sites. Initial establishment of perennial populations of *Graciliaria tikvahiae* and *Sargassum filipendula* at FE was also detected through qualitative studies during early 3-unit years. In addition, a new species not previously collected at any site (the red alga *Hypnea musciformis*) was identified at FE in 2001.

Dominant species abundance and distribution patterns at FE, established during 3-unit operation, were more resilient to the return of ambient conditions. Thermal impacts had been most notable in the low intertidal during 3-unit operation, due to tidal currents in the discharge area. The low intertidal *Chondrus* population and associated seasonal epiphytes at FE were replaced by a population of the opportunistic green alga *Codium fragile* supporting a perennial *Polysiphonia* spp. population and periodically heavy sets of the blue mussel *Mytilus edulis*. Winter declines in *Polysiphonia* abundance typical of other sites were observed at FE during the shutdown period, but otherwise, little change in low intertidal community composition was observed, relative to recent years when MPS was operating. Many characteristics of the impacted low intertidal community at FE (sparse, fluctuating populations of barnacles and *Chondrus,* heavy mussel sets) were probably related to the dominance of the *Codium* population, which persisted through the shutdown period, rather than direct thermal effects. This would explain the quick reversal of minor shutdown-related changes following unit restarts. However, the FE *Codium* population has declined after the shut-down period, and has been largely replaced by expanding populations of *Gelidium pusillum* and *Corallina officinalis*.

High *Ascophyllum nodosum* growth was observed at all sites in 2000-2001, compared to historical means, with highest growth at FN compared to other sites. This relationship among stations has been attributed to elevated temperatures from the MPS discharge. However, a similar relationship was observed during two recent growing seasons (1996-97 and 1997-98) while all three units were shutdown, but was not evident during the first year following Unit 3 (1998-99). Natural influences of other factors such as ambient temperature conditions, nutrients and light may play a more important role in determining *Ascophyllum* growing conditions at FN than does thermal plume incursion from the MPS discharge.

In addition to the localized changes noted for rocky intertidal communities in close proximity to the MPS discharge, the rocky intertidal monitoring program has documented patterns and modifications unrelated to MPS operation. These include introduction and spread of an exotic red alga, *Antithamnion pectinatum*, a long-term region-wide increase in abundance of the common brown rockweed, *Fucus vesiculosus*, and evidence of the regional nature of barnacle recruitment success from year to year.

## Fish Ecology Studies

The objective of the fish ecology monitoring program at MPS is to determine whether operation of the electrical generating units has adversely affected the occurrence, distribution, and abundance of local fishes. Potential MPS impacts include entrainment of fish eggs and larvae through the condenser cooling-water system; impingement of juvenile and adult fish on intake screens, which has been mitigated by the installation of fish return sluiceways; and changes in distribution or abundance attributable to the thermal discharge. Trawl, seine, and ichthyoplankton monitoring programs were established in 1976 to provide the basis for identifying taxa potentially affected, as well as information on long-term abundance trends used to measure changes in the local populations.

This report summarizes data collected in the monitoring programs from June 2000 through May 2001 (report year 2000-01). During the 2000-01 report period, MPS Units 2 and 3 were both operating most of the time and Unit 1 was shut down.

The potential effects of MPS were assessed by conducting detailed analyses on seven taxa most susceptible to MPS operational impact from entrainment or thermal effects. Analyses of these species generally focused on comparing temporal trends over the past 25 years. No significant long-term trends were detected for juvenile and adult silversides (*Menidia menidia* and *M. beryllina*) collected by seine in Jordan Cove (JC), all life stages of grubby (*Myoxocephalus aenaeus*), cunner (*Tautogolabrus adspersus*) eggs and larvae, and tautog (*Tautoga onitis*) and sand lance (*Ammodytes americanus*) larvae. Atlantic menhaden (*Brevoortia tyrannus*) larvae showed a significant increasing trend in abundance during the past 25 years. A significant negative trend was observed for silversides at the Intake (IN) trawl station. Since the mid-1980s, cunner have become less abundant at IN, exhibiting a significant negative trend, which may be related to the removal of the Unit 3 rock cofferdam, a preferred habitat for this species. Despite the negative trend in abundance for cunner at trawl station IN, their abundance at JC this year was at an historic high. While tautog eggs continued to exhibit a declining trend, juvenile and adult tautog abundance was at a 25-year high at station IN. The large numbers of tautog and cunner eggs entrained at MNPS did not appear to affect the spawning stocks of these two fishes because the proportion of juvenile recruits relative to adults has increased.

Densities of both bay anchovy (*Anchoa mitchilli*) eggs and larvae exhibited significant negative trends. This year the Δ-mean density for anchovy eggs was the lowest recorded. However, the Δ-mean density of larvae was within the range of abundance indices found during the past 5 years. Information from Rhode Island waters and Chesapeake Bay indicated that bay anchovy is experiencing a regional decline in abundance along the Atlantic coast. None of the long-term abundance trends determined for various life stages of selected species could be directly related to the operation of MPS.

## Winter Flounder Studies

The local Niantic River population of winter flounder (*Pseudopleuronectes americanus*) is potentially affected by the operation of MPS, particularly by entrainment of larvae through the cooling-water systems of the operating units. As a result, extensive studies of the life history and population dynamics of this important sport and commercial species have been undertaken since 1976. Each year, surveys of adult spawners are carried out in the Niantic River during late winter and early spring. Larval sampling is conducted at the plant discharges, in Niantic Bay, and at three stations in the Niantic River. Age-0 juveniles are collected at two sites in the river. Winter flounder are also commonly taken in the year-round trawl monitoring program (TMP).

During the 2001 adult winter flounder spawning season, Δ-mean trawl catch-per-unit-effort (CPUE) of fish larger than 15 cm in the Niantic River was 1.4, the lowest value found in 26 years, although not significantly different from a CPUE of 1.6 found in 1996. Abundance peaked in the early 1980s and decreased thereafter, most likely from stock and recruitment effects (i.e., decreased per-capita recruitment at high stock sizes), a generally warming winter trend, and increased rates of exploitation. Niantic River CPUE was significantly correlated with several other winter flounder abundance indices from throughout Southern New England and current abundance remains low.

The Jolly stochastic model was applied to mark and recapture data to estimate the absolute abundance of the Niantic River adult spawning population. The abundance estimate for 2000 was 9.3 thousand for all winter flounder larger than 20 cm. This was considerably less than estimated population sizes during 1984-91, which ranged between about 33 and 80 thousand, but was similar to estimates made since 1995, which were between 5.5 and 8.5 thousand. Annual female spawner abundance estimates since 1976 ranged from a low of 2 thousand in 2001 to 75 thousand in 1982, with corresponding total egg production estimates from about 1.7 to 43.7 billion for the same years. Since 1995, nearly all annual sex ratios of spawners have been highly skewed (>2) in favor of females, but most ratios were 1.7 or less from 1977 through 1994.

A post-spawning abundance survey was made in the river last year from mid-April through mid-May. Although less reliable because of non-random sampling, the CPUE of 11.8 for this survey was considerably higher than found during the regular spawning survey and indicated that more adult winter flounder were available for capture during late spring. It was not known whether or not most of these fish had been present during the spawning season in areas not sampled, or if they were from other stocks and entered the river after spawning elsewhere. These fish were marked with a unique brand and recapture rates in 2001 indicated that most of these fish were probably from the Niantic River stock and also that abundance was likely greater than indicated by the spawning survey CPUE.

Abundance of newly-hatched (Stage 1) winter flounder larvae was considerably below average in the Niantic River this year. However, despite recent low abundance of spawning females and egg production, newly hatched larvae were still more numerous than expected in 5 of the last 6 years. This was attributed to higher egg survival, which may have been as much as four times greater than in earlier years and represented a potentially important compensatory mechanism. Given their relative scarcity in the Niantic River during 2001, larval winter flounder abundance in Niantic Bay was much higher than expected. Abundances of Stage 2 and 3 larvae were among the lowest observed since 1984 in the river, but densities were at relatively high levels in the bay. This suggested potentially high rates of flushing and higher survival in the bay and LIS. Stage 4 larvae were also at record or near-record highs in the bay and at the larval station in the lower river, with the latter an indication of importation back into the river.

Rates of larval growth and development were positively correlated with water temperature, but other factors such as density and prey abundance probably also affected growth. Growth rate of larvae during 2001 in the river was about average, but in the bay growth rate was among the lowest of the 19-year period. Larval mortality rate in 2001 was also the lowest observed in 18 years, helping to account for the high abundance of older larvae. Density-dependence was examined by comparing mortality and egg production estimates (a measure of yolk-sac larval stage abundance) at various monthly and seasonal water temperatures. Results of this analysis suggested that larval mortality decreased with decreasing egg production (i.e., density-dependency) and increasing April water temperatures (i.e., faster development).

Following larval metamorphosis and settlement, demersal age-0 young were sampled by beam trawl at two sites in the Niantic River. Relatively high abundance of newly settled young was found in early summer, reflecting the large numbers of Stage 4 larvae. However, this year-class experienced record low growth and near-record low survival. Thus, the 2001 year-class, which had the potential to be among one of the strongest produced since 1983, exhibited good, although not exceptional abundance at the end of summer.

The 2000-01 Δ-mean CPUE calculated for young winter flounder taken during late fall and early winter at TMP stations did not reflect higher abundance of the 2000 year-class as indicated by beam trawl sampling during the summer of 2000. Nevertheless, these two age-0 abundance indices were significantly correlated and the relative magnitude of these indices suggested that the 1988, 1992, and 1994 year-classes of winter flounder were relatively strong, whereas the 1993 and 1997 year-classes were weak. Regardless of these values, however, fewer age-1 juveniles have been taken during each year of the Niantic River adult spawning population surveys since the early 1980s, with a CPUE for fish taken in the lower river navigational channel particularly low. This abundance decrease was much less when a CPUE was calculated for fish taken only in the upper portion of the river. The relative distribution of age-1 fish in Niantic River and Bay also may have changed over the years, which was attributed to environmental factors.

Young-of-the-year abundance indices were either not significantly correlated or were negatively correlated with the abundance of female adult spawners 3 to 5 years later. Conversely, positive correlations were found between age-1 abundance indices and these older fish. However, the forms of the significant relationships were unclear and none of the early life stages were considered to be a highly reliable predictor of potential future year-class strength. Unknown processes that occur after winter flounder become age-1 may be operating to produce fewer adult recruits from more abundant year-classes of juveniles. A stock and recruitment relationship was determined for the Niantic River winter flounder population using adult CPUE data. A February water temperature parameter significantly improved the model fit, but a depensatory parameter was non-significant.

The number of larvae entrained through the condenser cooling-water system at MPS is a measure of potential impact to winter flounder. Annual estimates of entrainment were related to both larval densities in Niantic Bay and plant operation. The 2000 and 2001 entrainment estimates of 331 and 376 million, respectively, were only exceeded by an estimate of 492 million in 1992. These totals reflected the high larval densities found in Niantic Bay during the past 2 years. As in previous years, Stage 3 larvae predominated (59%) in entrainment collections. All entrained larvae are presumed to die for impact assessment purposes, although a limited entrainment survival study showed that some (5%) older and larger larvae survived entrainment. The entrainment rate (annual abundance index divided by total flow) has varied since 1976 without trend, indicating that larval production and availability in Niantic Bay remained stable despite increased water use during the 1986-95 period of three-unit operation. Correlations between entrainment estimates and abundance indices of age-0 juveniles were positive, implying no entrainment effect and that the more larvae that were available for entrainment, the more that metamorphosed and settled in Niantic River and Bay. This was also illustrated by a comparison of annual entrainment and juvenile year-class strength, which indicated that entrainment estimates served as an index of emerging year-class strength rather than being the most important factor in setting abundance.

The impact of larval entrainment on the Niantic River stock depends upon the fraction of the annual winter flounder production entrained each year (determined as equivalent eggs). Empirical mass-balance calculations showed that a large number of entrained larvae likely come from a number of sources in LIS, including stocks associated with the Connecticut and Thames Rivers, as well as from the Niantic River. Estimates of the fraction of entrained larvae in 2001 from the Niantic River were similar for both the mass-balance model (21%) and an independently conducted analysis of genetic stock identification (22%). These remarkably similar estimates suggested that the mass-balance model provided accurate estimates of Niantic River larval stock entrainment. The Niantic River production loss estimate for 2001 was a relatively high 36.1% (18-year geometric mean = 11.5%), again likely reflecting a high flushing rate of larvae from the river. However, based on the apparent increase in egg survival noted in recent years, a factor which was not incorporated into the model, production loss estimates since 1995 may have been conservatively high.

A stochastic computer simulation model (SPDM) was used for long-term assessments of MPS impact. Annual female spawner biomass (lbs) was determined in simulations over a period extending from 1960, a decade before the operation of Unit 1, to 2060, 15 years after the projected shutdown of Unit 3 in 2045, which assumes that a 20-year operating license renewal will be attained by MPS. Conditional larval entrainment mortality rates (termed ENT) from the mass-balance model were applied in the model. The long-term geometric mean value was used in SPDM projections going forward, and to account for model uncertainties, both high and low rates calculated by scaling the mean value by a factor of 1.5 and 1/1.5, respectively, were also applied. Values of fishing mortality (F) provided by the CT DEP were used, with a recent mean rate of 0.74 applied going forward. Also, since the last application of the SPDM in an MPS Annual Report, the instantaneous natural mortality rate of age-1 winter flounder was re-estimated and the model re-calibrated to match current Niantic River female spawner biomass.

In the SPDM simulations, five stochastic time-series were generated, including a theoretical unfished stock, the size of which depended only upon the dynamics of winter flounder reproduction, natural rate of increase, and environmental variability; a baseline stock affected by rates of fishing in addition to the above; and three impacted stocks, which further added the effects of MPS (low, mean, and ENT rates going forward) to those of fishing and natural variation. Used initially in all simulations, an initial unfished stock size of 119,972 lbs represented the maximum spawning potential for the Niantic River stock and the critical stock size (25% of MSP) was determined as 29,993 lbs.

For the baseline projection, the exploited biomass was quickly reduced to about 30 thousand lbs by 1980 and declined further under high F to a low of 5,630 lbs in 1994, only 19% of the critical stock size. With some reduction in F beginning in 1999, the stock recovered somewhat, but remained between 12 and 13 thousand lbs through 2060. Under the mean ENT rate, the impacted stock also attained its lowest biomass of 4.3 thousand lbs in the mid-1990s. Absolute differences between the baseline and impacted stocks increased to about 6 thousand lbs in 2018. However, with the modeled retirements of Units 2 and 3, impacted stock sizes began to approach those of the baseline by 2060. The simulations under the high and low ENT rates generally paralleled those of the mean rate, only differing in magnitude. Of note, the F rate used in the SPDM is critical and actual spawner abundance could depart greatly in the simulations if this or other simulated conditions were not matched in reality. Fishing reduces stock biomass at a much greater rate than larval entrainment by removing individuals, particularly larger ones, from a year-class every year as long as any fish remain. In contrast, entrainment removes fish only once in the lifetime of a generation and then early in life before many compensatory processes have occurred.

To provide some perspective on Niantic River winter flounder stock size estimates, annual exploitation rates were determined and used with annual recreational and commercial landings data of winter flounder for LIS. The calculated exploitable biomass of Niantic River winter flounder probably represented only about 2% of the entire winter flounder resource in LIS during the past two decades.

To date, efforts of regulatory agencies to control fishing mortality have not resulted in large increases in abundance for winter flounder stocks across the region or in the Niantic River. Even so, the remaining small adult spawning stock in the river continues to produce relatively large numbers of larvae and young fish, which are a likely result of population compensatory mechanisms. The effective retirement of Unit 1 in late 1995 was followed by an immediate reduction of about one-quarter of the MPS cooling-water flow, which has permanently lessened plant impact, but has not resulted in stronger year-classes and subsequent enhanced recruitment to the spawning stock. Despite relatively good abundance of post-entrainment immature winter flounder, significant recruitment to the adult spawning population has not occurred in recent years, due to as yet unknown factors removing these fish from the population. Environmental effects, including changes to the Niantic River and interactions with other species, especially during early life history, also are important factors likely affecting the winter flounder recruitment process.