

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



Febrary 5, 2003

D17404

Mr. James Grier
Supervising Sanitary Engineer
Permitting, Enforcement & Remediation Division, Water Management Bureau
Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

- References:
1. Email (C10844), J. Grier, DEP, to P.M. Jacobson, DNC, dated April 30, 2002 (10:07 AM).
 2. Letter D17333 and enclosures, G.D. Hicks to J.F. Grier, dated June 12, 2002.
 3. Email (C10875) with attachment and cover letter, J. Grier, DEP, to P.M. Jacobson, DNC, dated October 29, 2002 (1:48 PM).
 4. Letter D17306 and enclosures, G.W. Johnson to J.F. Grier, dated March 14, 2002.

**Millstone Power Station
Cooling-Water System Technology Study
Winter Flounder Mass-Balance Model - Review by ESSA Technologies Ltd.**

Dear Mr. Grier:

On April 20, 2002 Connecticut Department of Environmental Protection (DEP) requested certain information and materials from Dominion Nuclear Connecticut, Inc. (DNC) for use by its contractor, ESSA Technologies Ltd. (ESSA), for the purpose of performing a sensitivity analysis of the Millstone Power Station larval winter flounder mass-balance model (MBM) (Reference 1). Per DEP instructions, DNC forwarded these materials directly to ESSA with a copy sent to DEP (Reference 2). ESSA completed its analyses and submitted a report that was received by DEP on October 28, 2002. A copy of this report was forwarded electronically to DNC on the following day (Reference 3).

DNC performed a review of the report and analyses of the MBM completed by ESSA and hereby provides its comments as Enclosure 1 to this letter. In summary, although ESSA completed a thorough critical review of the MBM, DNC believes that some of ESSA's analyses, hypotheses, and interpretations were based on inappropriate or invalid conceptual models of larval winter

flounder distribution and movements in Niantic River and Bay. Further, if the DNC hypothesis regarding higher egg survival at low spawning stock abundance is accepted, then there is no discrepancy between the long-term declining trend of the Niantic River adult winter flounder spawning stock and recent higher MBM-derived estimates of Niantic River larvae entrained. Higher than average entrainment estimates during the past few years were also related to very low larval mortality rates during this period, which made additional larvae available in Niantic Bay for entrainment. In retrospect, the use of a constant egg survival rate applied to all years since 1984 for the estimation of production loss (i.e., conditional entrainment mortality rate) may have been an oversight. A lower egg mortality rate in recent years was suggested by higher than expected densities of Stage 1 larvae collected in the Niantic River. Using a higher egg survival rate resulted in production loss estimates that were consistent in magnitude with previous years. Finally, because the estimate of the fraction of Niantic River larvae entrained as determined directly by larval DNA analysis was so similar to the fraction determined by the indirect methodology of the MBM during two years of comparison, DNC believes that the MBM has been affirmed to provide a credible and realistic measure of Niantic River larval entrainment losses. Note that the 2001 larval DNA work, performed by Dr. Joseph Crivello of the University of Connecticut, was previously submitted to DEP on several occasions (References 2 and 4), although the work was not cited by ESSA in its report. Preliminary results for 2002 are provided in the attached response.

As there may be additional questions regarding this response, DNC personnel are available to meet with representatives of DEP and ESSA, if so desired. Please contact Mr. Paul Jacobson, Millstone Environmental Services at (860) 447-1791 ext. 2335 with any questions or to arrange such a meeting.

Very truly yours,

DOMINION NUCLEAR CONNECTICUT, INC.



Gerald D. Hicks

Director - Nuclear Safety and Licensing

Enclosure

cc: Mr. Ernest Beckwith
Connecticut Department of Environmental Protection
Marine Fisheries Office
P.O. Box 719
Old Lyme, CT 06371

Enclosure 1 to Letter No. D17404

COMMENTS ON THE OCTOBER 24, 2002 REPORT "ASSISTANCE WITH THE
EVALUATION OF A NATIONAL POLLUTANT DISCHARGE ELIMINATION
SYSTEM (NPDES) PERMIT APPLICATION FOR DOMINION NUCLEAR
CONNECTICUT'S MILLSTONE POWER STATION: REVIEW OF THE MASS-
BALANCE MODEL USED TO ESTIMATE THE NUMBER OF WINTER FLOUNDER
LARVAE ENTRAINED BY MILLSTONE POWER STATION (1984-2001)"
PREPARED BY ESSA TECHNOLOGIES LTD., TORONTO, ON AND VANCOUVER,
BC FOR THE BUREAU OF WATER MANAGEMENT, CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION, HARTFORD, CT.

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION
NPDES PERMIT No. CT0003263

PO Box 128
Waterford, Connecticut 06385-0128
January 2003

DNC Comments on the Review of the Millstone Power Station Larval Winter Flounder Mass-Balance Model Performed by Greig et al. (2002)

Summary

In the text following this summary, Dominion Nuclear Connecticut, Inc. (DNC) provides its comments on the larval winter flounder mass-balance model (MBM) review completed by Greig et al. (2002) of ESSA Technologies Ltd. for the Connecticut Department of Environmental Protection in regards to the application of Millstone Power Station (MPS) for a National Pollutant Discharge Elimination System permit. We respond in detail to specific analyses or statements made by Greig et al. (2002), addressing each in their order of occurrence by page and paragraph order.

In brief, although Greig et al. (2002) performed a thoughtful and comprehensive review of the MBM, we disagree with several of their key analyses, interpretations, and conclusions. First, regarding adult abundance, we note that in summarizing the decline, Greig et al. (2002) ignored the effects of high rates of fishing that occurred in the 1980s and early 1990s. These high rates of mortality profoundly affected adult abundance and should not be dismissed. We fundamentally disagree with the Executive Summary conclusion in Greig et al. (2002), which states that MPS has had a measurable adverse impact on Niantic River winter flounder. This overly generalized conclusion is neither supported by their analysis nor should have been properly an objective of the MBM review. In our reply we also note many instances whereby abundant larvae did not produce good year-classes of winter flounder due to high mortality rates during post-larval juvenile stages, which are not impacted by MPS or the fisheries. We believe that the considerable impact assessments performed by DNC (e.g., DNC 2001, 2002b) demonstrate that while MPS can have a measurable impact on winter flounder, MPS is not the primary reason for the present low abundance.

We believe that the declining trend in Niantic River adult winter flounder stock abundance does not preclude either an increasing number of newly hatched Stage 1 larvae found in the river or the possibility of increasing larval entrainment at MPS during recent years. We believe that both adult and larval abundance have been more than adequately measured by our sampling programs. The hypothesis of Greig et al. (2002) that a hyperstable larval distribution is present within the river and confounds larval density measurements is not supported by the data. In our opinion, based on the size of the river and the locations of the larval sampling stations therein, the geographic extent of our sampling is sufficient to note any spatial shift in either adult or larval distributions. With no evidence of spawning in Niantic Bay or even appreciable numbers of newly-hatched larvae in the bay, the Stage 1 larvae found within the river are most certainly produced there by Niantic River winter flounder spawners. The apparent paradox of higher than expected numbers of larvae at low adult stock size can be explained by the hypothesis of density-dependent survival of eggs. Based on the work of others, this could occur by decreased predation on eggs and increased egg viability from a relative increase in the age and size of female spawners found during the past few years. Further, we found very low larval mortality rates in 2000 and 2001, which made many more larvae available for entrainment in relation to other years. In retrospect, our use of a constant egg survival rate for the estimation of production loss led to high entrainment conditional mortality rates during the past few years. If we increase the egg

survival rate, as suggested by the higher than expected abundance of Stage 1 larvae, then production loss estimates for 1995-2000 fall within the range of values determined for 1984-94.

We also disagree with Greig et al. (2002) that mid-Niantic Bay monitoring station NB is not a good indicator of Niantic River larvae within the bay to determine the larval fraction entrained. We believe the hypothesized pathways of larval movements and MPS Zone of Influence model proposed by Greig et al. (2002) miss critical details with regards to physical and hydrographic features along the eastern shoreline of Niantic Bay, which we believe impedes direct movement of larvae along the shoreline to MPS. Instead, we believe water and larvae flow in and out of the Niantic River through the navigational channel, which has a northeast-southwest axis, directing discharge flow towards mid-Niantic Bay and monitoring station NB. Their analysis does, however, pose interesting questions regarding the data collected at NB. By our analysis, we conclude that this station "leads" (as used by Greig et al. 2002), rather than "trails" the entrainment monitoring station EN by about a week or so. In the future, we will investigate lagging the NB data by an appropriate time interval to examine its effect on MBM output. Varying other variables in the MBM has been done several times in previous sensitivity analyses (DNC 2001) and indicates that the model is quite robust regarding many assumptions and variations in parameter estimates.

We have no evidence after many years of sampling that larval winter flounder disintegrate during passage through the MPS condenser cooling-water system, leading to underestimates in entrainment as postulated by Greig et al. (2002). We acknowledge that some small Stage 1 winter flounder can be extruded through the 335- μ m mesh entrainment sampling net and therefore we apply a correction factor, which is based on their abundance in the lower Niantic River and the fraction of this water mass likely to be entrained at MPS. We believe that this factor more than adequately corrects for a potential underestimate of Stage 1 entrainment for impact assessment.

Finally, use of DNA microsatellite markers to identify and enumerate stocks of larval winter flounder entrained at MPS was accomplished in both 2001 and 2002. This work was completed by Dr. Joseph Crivello of the University of Connecticut and is a direct method of assigning larvae to a spawning population as opposed to the indirect methodology of the MBM. We were puzzled why Greig et al. (2002) did not comment on the very close estimates of entrainment attributed to the Niantic River in 2001 by the MBM (21%) and the DNA analysis (22%) as these results were submitted to both DEP and ESSA several times previously. A similar study was completed in 2002, and, although still preliminary, is presented and discussed in the following text. Results show a similar close correspondence of the fraction of entrained winter flounder larvae attributed to the Niantic River: 12% using the DNA analysis and 14% from the MBM results. We believe that this validates the MBM as a sound and credible quantitative method of differentiating larval stocks in the MPS entrainment totals and should alleviate concern over the validity of this approach to impact assessment.

DNC Comments on the Review of the Millstone Power Station Larval Winter Flounder Mass-Balance Model Performed by Greig et al. (2002)

Executive Summary:

Page i, Paragraph 3 - Millstone Power Station (MPS) Unit 3 went online in 1986, 5 not 4 years before 1991, a year in which Greig et al. (2002) note there was an abrupt change in abundance of winter flounder. In fact, the time-series of winter flounder abundance showed that in 1984, 2 years prior to Unit 3 start-up, adult spawner abundance had already decreased by about half from levels seen in 1976-83 (DNC 2002b: Table 4, p. 177). A similar level of decrease occurred rather abruptly from 1991 to 1992, with further decreases occurring into the late 1990s before leveling off. Note that fishing mortality rate (F) increased substantially in 1983 (only less reliable estimates were available before this year) and peaked in the early 1990s (DNC 2002b: Table 41, p. 263 and Fig. 48, p. 264). This information should also have been considered when discussing changes in adult spawner abundance due to the profound effects F can have on adult stock size. Because of lower size limits and other less restrictive regulations, a considerable percentage of winter flounder of even ages-2 and 3 were vulnerable to the fisheries prior to 1986 and age-4+ fish have remained as fully exploited since 1976 (DNC 2002b: Table 46, p. 264). Entrainment, on the other hand, occurs only once in early life history at an age where ample evidence exists for compensatory density-dependent rates of mortality. As will be discussed below, further large adjustments in year-class strength occur when winter flounder are in the post-larval first summer of life, a period during which they are least impacted by MPS, and also when they are older age-1 and 2 juveniles prior to adult recruitment. Finally, we do not understand how Greig et al. (2002) could have concluded only on the basis of their review of the larval winter flounder mass-balance model (MBM) that MPS has had a measurable adverse impact on the Niantic River winter flounder. Comments related to other points raised in the Executive Summary will be addressed below where introduced by Greig et al. (2002). 2

Part 2 - Context of Concern for MBM Estimation:

Section 2.1 - Page 3, Item (7) - DEP previously requested that DNC investigate the possibility of a depensatory stock-recruitment relationship (SRR) for NR winter flounder. This was done and reported in DNC (2002b: pp. 228-230). The depensatory parameter in the SRR was not significant. The discussion in DNC (2002b), based on current scientific literature, indicated that depensatory stock dynamics have been found to be very uncommon in fish populations and is most likely to occur in pelagic fishes. Larval sampling has been very consistent at MPS since 1984 and the apparent higher than expected abundance of Stage 1 (newly hatched) larvae when adult stocks were low and other findings (e.g., DNC 2002b: Fig. 23, p. 205) indicate that compensatory mechanisms are likely occurring in early life history. The low entrainment occurring during 1996-98 (also occurring in 1993, even though MPS intake volume reached a peak during the larval winter flounder season) would not necessarily result in larger year-classes because of other factors occurring in the larval and post-larval stage of the first year of life. In 1996, larval abundance was moderate, but larval mortality rate was higher than average and only a modest set of young occurred (DNC 2002b: Fig. 26, p. 207). With juvenile mortality about average, 1996 resulted in one of the poorer year-classes since 1984 (DNC 2002b: Fig 41, p. 240). In 1997, larval abundance was particularly high in the Niantic

River and Bay (DNC 2002b: Table 10, p. 193). However, the densities of juveniles settling in the Niantic River and surviving during the first half of summer were again relatively modest and with the third highest juvenile mortality rate observed since 1984 (DNC 2002b: Fig. 26, p. 207), the number of potential recruits was lower than would have been expected from larval abundance. With a below-average juvenile mortality rate in 1998, young winter flounder were more abundant at the end of summer this year despite higher entrainment. Adjustments in year-class strength during the post-larval demersal stage of development were even more apparent during 1999 through 2001, when entrainment increased as Units 2 and 3 went back online. In fact, the much higher than average juvenile mortality rate in summer of 2001 meant that the potentially largest year-class produced since the summer age-0 sampling began in 1984 was reduced to about average size (DNC 2002b: Fig 41, p. 240). This was an effect completely divorced from plant operation. Further discussion on entrainment and potential effects on winter flounder year-class size and on the formation of winter flounder year-class strength is found in DNC (2002b: pp. 245-246 and pp. 233-241, respectively). In addition, we believe that further adjustments in year-class strength are occurring at ages-1 and 2 prior to recruitment that have yet to be adequately understood, but which are also independent of MPS operation.

Section 2.2, Subsection 2.2.1 - Page 4, Paragraphs 1 through 3 - The trend in ENT (production loss or CMR, which is used by Greig et al. 2002) and the "puzzling" fact noted by Greig et al. (2002) that larval abundance has not declined in a fashion consistent with low adult spawner abundance can be explained if the compensatory decline in egg mortality hypothesis is real. The data leading to this conclusion are found in DNC (2002b: Table 39, pp. 255-256) and shown graphically by Greig et al. (2002: Fig. 1, p. 5), which shows a recent increase in annual estimates of CMR. Also, the estimated 82.2-89.6 million larvae assigned to the Niantic River by the MBM in the last 2 years (DNC 2002b: Table 39, pp. 255-256; corrected for Stage 1 entrainment) appeared to be at odds with the low adult population size and egg production estimates. These observations are consistent with density-dependent theory (e.g., Hilborn and Walters 1992) in that less egg deposition results in lower egg mortality, likely from predation, and thus, a higher hatching rate that results in more Stage 1 larvae. The relatively large number of larvae available for entrainment in 2000 and 2001 were also probably a result of the very low larval mortality rates in those years (DNC 2002b: Table 15, p. 204), leading to high densities in Niantic Bay (DNC 2002b: Table 15, p. 193). Low larval mortality, at least in 2001, likely was the reason for very high settling densities of demersal juveniles that year (DNC 2002b: Fig. 26, p. 207). As for the trend in ENT, the higher than average CMRs seen since 1995 coincide with the higher (except for 2000) than expected numbers of Stage 1 larvae observed in the Niantic River during the same years. Yet, in the calculation of production loss, unlike the calculated annual stage-specific larval mortality rates, the egg mortality rate ($M_{egg} = 1.61$, equivalent to a survival rate of 20%) has not been varied by year. This makes the calculation of Niantic River stage-specific abundance (the denominator in the production loss calculation) lower than it should be if egg mortality rates were reduced under low adult spawning stock sizes. As noted in DNC (2002b: p. 254), this would make the calculation of production loss conservatively high, perhaps by a factor of 4 or more. However, if the annual egg survival rate for the years 1995-2001 is increased somewhat arbitrarily from 20 to 50%, which is a reasonable assumption, then the CMR time-series resembles historical rates (Fig. 1), fluctuating around a revised geometric mean value of 9.6%.

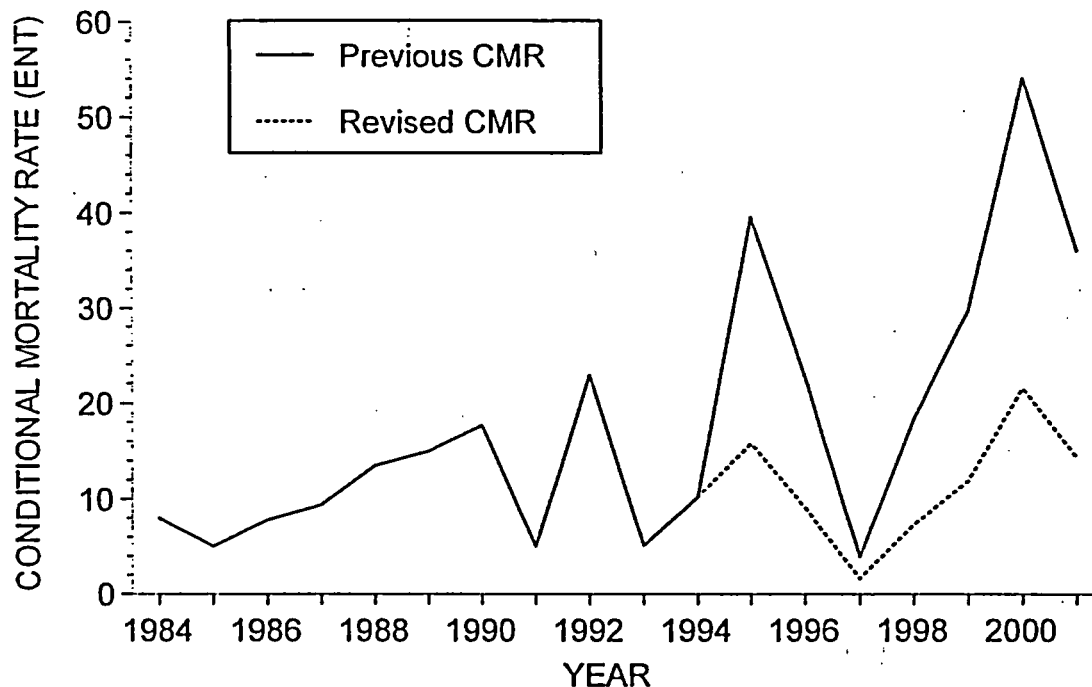


Fig. 1. Comparison of estimated CMR of Niantic River larval winter flounder from entrainment at MPS as given in DNC (2001b: Table 39, pp. 255-256) with a revised calculation based on increasing egg survival from 20% to 50% during the years 1995 through 2001.

Section 2.2, Subsection 2.2.2 - Page 5 - Another pattern of temporal change in the data series that should be considered is F, as shown in DNC (2002b: Fig. 48, p. 264).

Section 2.2, Subsection 2.2.2 - Page 7 - The argument that because the volume of cooling water used at MPS increased since Unit 3 came online in 1986 resulted in the decline of adult winter flounder some 4 years later was previously advanced by Gibson (1999). This premise was shown to be flawed in a review and critique of his paper submitted to DEP by Northeast Nuclear Energy Company (NNECO), the former owner and operator of MPS (NNECO 1999). Gibson's "enhanced" stock-recruitment model of Niantic River winter flounder, which incorporated a Unit 3 flow term in an attempt to demonstrate a plant effect, was shown to be not statistically different from the MPS stock-recruitment model and virtually identical to an "enhanced" model developed by NNECO that used fishing mortality rates in place of cooling-water flow. Both "enhanced" models were deemed inadequate on statistical grounds to separate and quantify the confounded effects of larval entrainment and fishing on Niantic River winter flounder recruitment.

Section 2.2, Subsection 2.2.3 - Page 8, Paragraph 1 - Although female spawner abundance and subsequent estimates of egg production (also dependent upon size-frequency) are used to provide the initial values in the denominator of ENT, it is important to note that annual stage-specific larval mortality rates, which can be quite variable, are used to determine stage-specific abundances. The use of a single egg mortality rate of 0.2 for all years was discussed above

and the effect of increasing egg survival, as suggested from field-collected data, was examined. Application of an egg mortality rate to estimates of egg production initiates the number of Stage 1 larvae. This was acknowledged by Greig et al. (2002) in Sections 3.3 and 3.4 (pp. 20-21) of their review. As noted in the discussion related to Subsection 2.2.1 above, larvae are further reduced by stage-specific mortality rates determined for each year. The questions of variable annual fecundity rates and egg viability remain open. For example, as discussed in DNC (2002b: pp. 233-234), larger female size and earlier time of spawning has been demonstrated to confer higher egg survival. Recent low abundance may have also resulted in better condition of female spawners because of less competition for food resources, which could also have resulted in higher fecundity. This is another way in which higher than expected numbers of Stage 1 larvae could have been found in recent years.

Part 3 - MBM and Estimation of Conditional Mortality Rate (ENT):

Section 3.1, Page 11 - Stage-specific larval mortality rates are determined from DNC sampling and not by DEP. This fact appeared to be correct as discussed further in Section 3.3 (p. 20) of Greig et al. (2002).

Section 3.2, Subsection 3.2.1, Pages 15-17 - The sensitivity of the MBM to changes in the *ToNR* and *FromNR* parameters is discussed below in the response to the material given by Greig et al. (2002) in Section 6.2, Pages 50-51, Point 2.

Section 3.2, Subsection 3.2.1, Page 15, Paragraph 2 - Greig et al. (2002) note that "while the Gompertz curves may provide a good fit to the cumulative density over the season, they do not accurately portray the pattern of variation in density within the larval season..." We took the first derivative of the Gompertz curve, using incremental weekly larval densities rather than cumulative densities, as suggested by Greig et al. (2002). It is beyond argument that the fitted curve sometimes overestimates and sometimes underestimates observed values. However, there is no consistent pattern. Therefore, we feel that the Gompertz fit smoothes out within-season variability and permits better calculation of MBM parameters.

Section 3.2, Subsection 3.2.2, Page 17, last Paragraph - Note that although the MBM might indicate that no entrainment is occurring early in the larval season, for the calculation of production loss (ENT or the CMR) a correction is made to account for the undersampling of Stage 1 larvae at EN during this period. A comparison of Stage 1 entrainment estimates for Niantic River larvae on Tables 37 (p. 252) and 39 (pp. 255-256) of DNC (2002b) shows that the correction can increase the total entrained considerably. For example, in 1984, the year used in the Greig et al. (2002) example, the initial calculation of 0.2 million Stage 1 larvae entrained was corrected to 9.8 million, an increase of 49 times. This corrects some of the potential error in underestimating Niantic River larval entrainment and may, in fact, even overestimate the number of Stage 1 larvae being entrained at MPS.

Section 3.4, Page 21 - Greig et al. (2002) provide a key insight into the MBM in that results are likely positively biased if no density-dependent effect is assumed in the denominator of the calculation of ENT, which has been

discussed several times previously in this response. Regarding the quality of the entrainment estimate, we believe that the present sampling plan of three day and three night collections during the larval winter flounder entrainment season results in accurate and precise estimates of larval winter flounder entrainment. Previous evaluations of entrainment that led to changes in sampling since the mid-1970s examined the number of times that entrainment samples were taken in a week, the number of replicates taken per sampling occasion, the gear used, location of sampling, and the methodology used in formulating the entrainment estimate (NUSCO 1983a, 1983b, 1991b, 1992). All evaluations showed that reductions in sampling frequency or replication did not result in substantive changes to the estimates. Further, the use of the Gompertz function in calculating entrainment estimates corrected a previous underestimate of entrainment resulting from the use of a seasonal median density in the calculation (NUSCO 1991b).

Section 3.5, Page 23 - Greig et al. (2002) offer possible explanations as to why there is not an obvious linear relationship between the abundance of Stage 1 larvae in the Niantic River and egg production estimates. The first is that a decline has not been observed because "larval sampling programs concentrate on preferred spawning areas or areas where larvae are concentrated by currents, so densities don't vary much while the true river-wide larval abundance declines as spawner abundance declines (a form of 'hyperstability, Hilborn and Walters 1992')." First, note that the example of hyperstability given in the Hilborn and Walters (1992) reference concerns large oceanic clupeoid fisheries and this phenomenon is related to the active search and handling of these species by a fishery. We believe that the argument of hyperstability is unreasonable, given the sampling locations in the Niantic River and the distance the bongo sampler is towed in relation to the relatively small size of the river (see DNC 2002b: Fig. 13, p. 190). Stations A, B, and C were located to provide density data in the northern arm, the mid-river basin, and the lower navigational channel of the Niantic River, respectively. The lengths of the tow paths for river stations shown on the figure are as accurate as possible, given the diagrammatic nature of the figure. Thus, the sampling station integrates larval densities over a relatively lengthy portion of typical habitat. We think it unlikely, given the hydrodynamics of the Niantic River as described by Kollmeyer (1972) and Dimou and Adams (1989), that larvae would be concentrated only at the stations sampled while they have declined elsewhere: the river is too well-mixed and the distance between the stations is about 1 km at most. We would be interested in receiving any information or citations that might be provided by ESSA or DEP pertaining to hyperstability as this phenomenon relates specifically to the sampling of ichthyoplankton.

The second explanation offered for the finding is that larval densities observed in the river are confounded by larvae originating from other spawning sites and transported into the Niantic River. Again, we believe that this hypothesis does not apply to Stage 1 larvae, which we believe are produced within the river with no evidence for spawning in the bay seen during the past 25 years of sampling. The statement by Greig et al. (2002) implies that significant spawning must be occurring very close to the Niantic River, such as in Niantic Bay, or in other areas close enough to transport considerable numbers of Stage 1 larvae into the river. This is simply not the case as densities of Stage 1 larvae are an order of magnitude lower in Niantic Bay than in the river (see DNC 2002b: Figs. 14 and 15, pp. 194-195). In fact, most of the Stage 1 larvae found in the bay probably originated in the river due to geographical scale

and the time it would take for larvae from other spawning grounds to be transported into Niantic Bay. Dates of peak abundance have not even been determined for Stage 1 larvae in Niantic Bay because “during several years this larval stage was rarely collected outside the Niantic River” (DNC 2002b: p. 197). Note that the same bongo sampler with 202- μ m mesh nets are used at all three river stations and at NB, so the low densities of Stage 1 larvae in Niantic Bay are not artifacts of collection.

Finally, Greig et al. (2002) note that a decline in adult spawning abundance has occurred because the adult sampling no longer captures the main spawning distribution, which they hypothesize “has been shifting further away each year since about 1990.” We do not accept the premise of this hypothesis and also note that the exact meaning of the statement in quotes is unclear. The measurement of adult spawning abundance is one area in which we have consciously tried to avoid a problem of hyperstability or bias. We have been careful to take trawl tows for adults throughout most of the river, even though adult spawners, because of low abundance in recent years, were concentrated in relatively few small areas. We do acknowledge that CPUE, which is a basic component in the egg production estimate, can be biased by sampling (e.g., DNC 2002b: pp. 178 and 180), leading to some error. However, annual CPUE is highly correlated with estimates of abundance using the Jolly model (DNC 2002b: Fig. 8, p. 184). Since the latter depends upon recaptures of marked fish made in subsequent years, it would seem that there would have to be a consistent fraction of the population exhibiting heterogeneous behavior with regards to the annual population surveys in avoiding capture over an extended period of years. With no evidence for this, we believe that the population is well-mixed and that we are sampling it randomly. We have also made efforts to examine the veracity of this final argument. By agreement with the East Lyme-Waterford Shellfish Commission, we previously avoided shallow flats formerly harboring bay scallops, but in 2001 we completed a few tows in shallow areas that had not been sampled by trawl for more than 15 years. No difference was found in the numbers of adults taken on the shallow mid-river flats and the other deeper areas routinely sampled for more than two decades (DNC 2002b: p. 180). We concede, however, that there could be some spawning in Smith Cove (see DNC 2002b: Fig. 2, p. 174), which cannot be sampled due to its shallowness, soft bottom, and considerable number of boat moorings. However, given the relatively small area of Smith Cove in relation to the other portions of Niantic River, we think it unlikely that a considerable number of spawners or their progeny are present there during the spawning season or afterwards.

Part 4 - MBM Representation of the Spatial Dynamics of Entrainment in Niantic Bay:

Section 4.1, Page 26, Paragraphs 1-3 - There is no “monitoring Station NR”, rather larvae are collected at three stations (A, B, and C) in the Niantic River. However, as noted throughout our reports and in Greig et al. (2002), station C in the lower river is of particular importance in the MBM calculations.

The conceptual pathway model postulated by Greig et al. (2002) here and noted in several places thereafter (e.g., pp. 26-28) refers to larvae that might “be swept along the *western* shore of the bay [emphasis ours]”, whereas we believe they most certainly meant the eastern shore (i.e., the proposed pathway 1 of Greig et al. 2002). Note that although dye studies showed that only about 20% of the water discharged from the Niantic River passed through MPS during

full three-unit operation (Dimou and Adams 1989), without proof to the contrary it could be possible that a greater proportion of larvae produced in the Niantic River are traveling along the eastern shoreline of Niantic Bay to become entrained at MPS. However, even the best hydrodynamic models of our study area lack small-scale detail and the ability to consider factors that retard movement of water and particles, such as shallows, rocky areas, and eelgrass beds. As shown on a nautical chart of Niantic Bay and vicinity (NOAA 1975), there is an extensive shallow (ca. 1.5 m or less in depth at mean low water) shelf extending about 500 m along the eastern shoreline of the bay from near the mouth of the Niantic River to about $\frac{3}{4}$ of the way south to Bay Point adjacent to the MPS site, where the shelf abruptly decreases in width to 100 m or less. This area, east of Waterford Island and its chain of rock outcrops and boulders extending to the north and south (also not depicted in the hydrodynamic models) has an extensive eelgrass bed present with additional scattered boulders and rocks. It is quite likely that water movement over this flat is considerably less than what is occurring in deeper waters of Niantic Bay. Most water flowing into and out of the Niantic River appears to move through the navigational channel leading into the river mouth, which has a southwest-northeast axis. Thus, most ebbing waters would flow towards mid-Niantic Bay (proposed pathway 2), the location of ichthyoplankton station NB. Note that the NB location is actually off the MPS intakes, about 200 m or so south of the location that is depicted in DNC (2002b: Fig. 13, p. 190; see Fig. 16, p. 27 of Greig et al. 2002 for a more accurate placement). The bongo sampler tow path maintained at station NB also integrates the densities of larvae over about one-fifth of the width of the bay (the length of the tow shown in Fig. 16 is also inaccurate: the distance should be the same as those shown for the river stations). The hypothesis that larvae could skirt the perimeter of the bay to either become entrained or flushed from the bay without passing through mid-Niantic Bay seems to be improbable. Further, it would not only appear to be a physical impossibility for larvae to "be carried through the bay directly to LIS without mixing", the second half of the proposed pathway 3 as written ("which would permit their assessment at Station NB") seems to be contradictory to the first half (i.e., this would seem to be pathway 2). A MPS computational fluid dynamics model that is presently under development (discussed below in the response to material presented in Section 4.3, Pages 29-32 of Greig et al. 2002) could possibly be used in the near future to address larval transport issues, including the effect of water flow retardation along the eastern bay shoreline.

Section 4.1, Page 26, Paragraph 4 - Observed differences between NB and EN to some extent are related to sampling. As noted previously in this response and as outlined in DNC (2002b), entrainment samples are taken at the MPS discharges (station EN; alternates weekly between unit discharges, depending upon their operation and if there are no equipment problems) throughout most of the larval winter flounder season on three dates each week (since 1993; formerly on four dates), during both the day (nearly always in mid-morning) and night (most samples taken at $\frac{1}{2}$ hour after sunset, but a few later in the evening up to about $\frac{1}{2}$ hour before sunrise). A net with 335- μ m mesh is used at EN. Sampling is conducted without regard to tidal stage (i.e., randomly), but this results in an approximately alternate weekly switch between flooding and ebbing tidal stages during day and night. Since 1993, sampling at field station NB during about the first half of the larval season (February and March) has been accomplished once a week using a bongo sampler with 202- μ m mesh net during daylight hours within 1 hour of slack

tide. From early April through the end of the larval season in June a 335- μ m mesh net is used at night during the second half of a flood tide. The sampling plan at NB has evolved from evaluations made of larval catches that considered gear efficiency and temporal and tidal factors that especially were related to the availability and catchability of larger and older Stage 3 and 4 larvae. A best estimate of abundance was desired that was least affected by behavioral changes most likely related to diurnal and tidal factors. During 1983-91, both day and night samples were taken twice a week at NB, but late season (April-June) day data are no longer used by DNC because of the probable undersampling bias. It appears that Greig et al. (2002) included the late season day data from 1983-91 in their analyses, which is understandable as we did not exclude these data or inform them otherwise. However, the use of these data appeared to have not affected their conclusions.

The inability to use a 202- μ m mesh net at EN requires a correction factor for Stage 1 entrainment, previously mentioned in this response. To illustrate possible differences in larval abundance between NB and EN, which could result from both location and sampling methods, a comparison was made between annual estimates of the Gompertz A parameter at NB and EN. The annual ratio of Stage 1 abundance at NB to that at EN ranged from 1.13 to 87.40 and had a geometric mean of 7.42. This demonstrates the greater catch of these smaller larvae by the 202- μ m mesh net of the bongo sampler in NB relative to the larger 335- μ m mesh entrainment net. The mean ratio for Stage 2 larvae was also positive (3.26; range of 1.41-9.42), but considerably lower than for Stage 1. At 1.31, the mean ratio for Stage 3 larval abundance was also positive (range 0.74-2.31), but the ratios in 8 of the 19 years were about 1.1 or less, indicating likely parity in the catches of Stage 3 larvae, which constitute about two-thirds of larval winter flounder entrainment. Stage 4 mean densities were slightly higher at EN (mean ratio of 0.82; range of 0.27-3.49), perhaps because of some avoidance of these larger larvae to the bongo sampler.

Section 4.1, Page 26, Paragraph 5 - An important consideration here is that if “consistently different larval densities along the west [*sic*] shore of the bay in the vicinity of MNPS relative to those at the NB monitoring station, averaging of the data from the two stations could give erroneous results.” Note that in the MBM program (p. 57, line 14 of Greig et al. 2002), the location variable ‘BAY’ combines data from station 5 (old designation for station NB) and the ‘D’ stations (designation for the various MPS unit discharges, station EN). Thus, the relative weight of NB in determining Niantic Bay larval densities is only 1/7, since as noted above this station for most years was only sampled once per week and EN was sampled six times. Bay density calculations are therefore driven by the abundance of larvae collected at the MPS intakes. This becomes important when considering the analyses examining the selection of station data performed in Section 5 of Greig et al. (2002).

Section 4.2, Page 28, Paragraph 2 and Page 29, Paragraph 2 - Greig et al. (2002) note that 20% of Niantic River water discharged at its mouth is entrained at MPS. Under present two-unit operation, this fraction has been reduced to 15% due to the shutdown of Unit 1 (DNC 2002b: p. 254).

Section 4.3, Pages 29-32 - This section on the MPS Zone of Entrainment (ZOE) proposed by Greig et al. (2002) is highly speculative. They note throughout their discussion various assumptions and caveats, which, depending upon the details, could change their results significantly. As noted in DNC (2002d), as part of a larger research project initiated by the Electric Power Research Institute (EPRI) of Palo Alto, CA, Alden Research Laboratory, Inc. developed a computational fluid dynamics model (termed the Hydraulic Zone of Influence or HZI) of water flow near MPS. At the time of the preparation of this response, the Alden work has been mostly completed and the future use of the HZI model will result in a more accurate estimate of the MPS ZOE.

Section 4.4, Page 32, Paragraphs 1 and 2 - An argument is made here that the NB location should be a trailing rather than a leading indicator of Niantic River larval entrainment, which relies on a diagrammatic representation of a hydrodynamic model that does not reflect the topography of the eastern shoreline and its effect on water flow (see the comment related to Section 4.1, Page 26, Paragraphs 1-3, above). Under former three-unit operation MPS withdrew only about 20% of the water discharged from the Niantic River and now entrains about 15% at most during full two-unit operation. The larvae in the remaining 80-85% of the water discharged from the Niantic River either re-enter the river on a subsequent flood tide, remain in Niantic Bay, or enter Long Island Sound. Station NB is not a point in space and sampling there integrates larval abundance over a linear distance of about 350-400 m. We do not see how larvae can move past NB without being sampled only to re-enter the bay to be sampled at another time. Greig et al. (2002) present data that seem to answer the trailing/leading question on Figure 22 - Panel B (p. 38). The bay Gompertz daily density plot when represented solely by catches at NB peaks approximately 10 days before that at EN in the example shown for 1984, although they note further (p. 37) that they determined that the difference averages only 1.7 days and has decreased in recent years.

An additional point should be made here: if Niantic Bay larval densities were to be solely represented by station NB, instead of averaging data from NB and EN (this is discussed in greater detail in the following section), as the former station has only been sampled once weekly since 1993, larvae "returning" to NB would have to do so not just on a subsequent flood tide, but still be there one week later.

Our analyses related to whether entrained larval densities trailed those in Niantic Bay used the dates of peak abundance, derived from the Gompertz t parameter estimate, which was apparently the same methodology used by Greig et al. (2002: e.g., Section 5.1.1). However, we could not determine how they found a 24-day lag between peak abundance at NB and EN in 1985 as our analysis showed a lag of only 4.25 days (Table 1). We also saw no "declining trend" in the magnitude of the difference in dates, beyond that resulting from the fact that prior to 1993, NB was sampled twice a week.

We also performed the analysis using NB data alone to represent "Bay" larval densities, as did Greig et al. (2002). Here, our results matched almost exactly, except that we found several years with lags between peak abundance at NB and EN of greater than the maximum of 11.5 days in 1984 reported by Greig et al. (2002). Our greatest

TABLE 1. Difference in the dates of peak abundance between larval winter flounder monitoring stations EN and Niantic Bay under two conditions: BAY = NB + EN and BAY = NB only.

Year	BAY = NB + EN			BAY = NB only		
	Date of peak abundance in Bay	Date of peak abundance at EN	Difference	Date of peak abundance in Bay	Date of peak abundance at EN	Difference
1984	April 21	April 25	-4.07	April 13	April 25	-11.54
1985	April 11	April 15	-4.25	April 6	April 15	-8.80
1986	April 22	April 23	-1.28	April 18	April 23	-5.39
1987	April 16	April 19	-2.73	April 6	April 19	-12.37
1988	April 17	April 20	-2.53	April 7	April 20	-12.19
1989	April 16	April 17	-0.36	April 10	April 17	-7.13
1990	April 16	April 19	-2.78	April 8	April 19	-10.39
1991	April 9	April 9	-0.70	April 4	April 9	-4.94
1992	April 26	April 28	-1.82	April 22	April 28	-5.40
1993	April 29	May 1	-2.17	June 17 ^a	May 1	+47.13
1994	April 28	April 29	-0.93	April 21	April 29	-8.37
1995	April 19	April 19	-0.64	April 9	April 19	-10.41
1996	April 20	April 19	+0.66	April 12	April 19	-7.28
1997	April 9	April 9	+0.03	April 3	April 9	-5.33
1998	April 24	April 25	-1.29	April 12	April 25	-12.56
1999	April 18	April 20	-1.99	April 10	April 20	-10.40
Mean difference (days)			-1.68	-8.83 ^a		

^a Poor fit to data in 1993, giving illogical result. Ignored the difference for 1993 in calculating the mean.

difference was 12.6 days (NB before EN) in 1998. We agree that the 1993 data from Niantic Bay are anomalous, owing to low larval abundance and atypical larval temporal distribution, leading to a poor Gompertz fit. Excluding 1993, peak abundances at NB occurred, on average, 8.83 days earlier than at EN. Thus, we feel that both our analyses as well as those of Greig et al. (2002) showed clearly that larval densities at EN trail those at NB.

Section 4.4, Page 33 - Of note, regarding the years chosen for examination by Greig et al. (2002), both 1992 and 1997 (despite none of the MPS units being in operation this year) had extremely high abundance of larvae in Niantic Bay as represented by the *A* parameter of the Gompertz function (DNC 2002b: Table 10, p. 193 and Table 32, p. 243). Overall densities of larvae in 1984 and 1999 were approximately 50-60% of those for 1992 and 1997 and were somewhat greater than the median value for the larval abundance time-series.

Larval production in 1997 was extraordinarily high given the relatively low abundance of spawners that year. Also, dates of peak abundance for Stage 2 and 3 larvae in Niantic Bay during 1997 were 10 to 23 days before those of the other 3 years considered with 1984 generally having the latest dates (DNC 2002b: Table 12, p. 198). This probably

factored into the differences observed in the timing and magnitude of the MBM parameter estimates. As an aside, note further that despite the high abundance of larvae in 1997, initial densities of metamorphosed young-of-the-year settling in the Niantic River were relatively low and, with higher than average mortality during summer, a relatively poor year-class resulted (NUSCO 1998). This further emphasizes the fact that larval production alone is not the final determinant of year-class strength and eventual adult recruitment, but events occurring post-entrainment (e.g., at settlement, during first summer of life) are of considerable importance in these processes, which take place without any MPS effects whatsoever.

There is no evidence that we have increased sampling efficiency at lower flow rates. Greig et al. (2002) seem to imply that lower cooling-water volume, perhaps synonymous with lower discharge velocity, could possibly affect sampling efficiency at the MPS discharges. In a comparative entrainment study made among the three units in 1988, no significant differences were found in larval winter flounder densities by unit, even though unit discharge velocities differed (NUSCO 1989). In 1997, most entrainment collections taken during the approximate mid-February through late June larval winter flounder season had recorded durations of 5 to 12 minutes, indicating lower velocity at the discharge (normally a 3-4 minute sampling time yields the required sample volume both Units 2 and 3). However, in 1997, the proportions of larvae taken at EN by stage (4% Stage 1, 14% Stage 2, 68% Stage 3, 14% Stage 4; NUSCO 1998) were similar to the long-term (1983-2000) average catch by stage (4% Stage 1, 19% Stage 2, 63% Stage 3, 14% Stage 4; DNC 2002b: p 241). Thus, there is no evidence of increased catches of smaller larvae because of any increased sampling efficiency related to discharge velocity or flow volume. In 1998, another low cooling-water volume usage year at MPS, the proportions of Stage 1 (2%) and 2 (8%) larvae (NUSCO 1999) were even lower than the long-term average.

Another explanation besides a compensatory response in egg survival for the higher than expected proportion of entrainment attributed to the Niantic River in 1997 and some other years is the inherent conservatism of the MBM, namely that all larvae are assigned to the Niantic River unless other factors in the MBM can account for them. Additional points raised by Greig et al. (2002) in the last paragraph of page 33 and on page 34 are speculative. The use of only the first portion of the season in these examples obscures the MBM results for the entire year. The 5-day groups 1-9 shown on Figure 19 (p. 34) include only February 15 through the end of March. Most larval winter flounder entrainment occurs from April through mid-May. Although Greig et al. (2002) endeavor to show an underestimate of early season entrainment, as noted previously, Stage 1 larval entrainment is corrected to account for any net extrusion early in the season prior to calculating ENT (i.e., CMR). With regards to Figure 21 (p. 35) of Greig et al. (2002), we must again note that larvae were present in higher densities early in the year in 1997 than in the other 3 years used for comparison, so it is not surprising that densities were higher at EN that year in comparison to the other years. The second earliest dates of peak abundance by stage occurred in 1999 and this was the other year having larvae entrained early in the season.

Part 5 - Observations Regarding Data Collection and Parameter Estimation:

Section 5.0, Page 37 - Greig et al. (2002) note that "... the approach of averaging the NB and EN monitoring station data to represent 'Bay' densities may be problematic." As the larval winter flounder sampling program developed over time, changes to methodology and to the analysis programs have also occurred. Since current practice is to sample NB only once per week, we felt that samples from ENT, taken six times per week (three day and three night), would better capture diurnal and tidally influenced variability, and better represent larval distribution in Niantic Bay. We still feel justified in using ENT as a surrogate Niantic Bay station, but it is apparent (cf. above discussion) that larval distributions at EN are not synoptic with NB. We can hardly argue that abundance patterns at EN lag behind those at NB by about a week, and at the same time, treat them all as replicate samples. It is apparent from our analyses (Table 1) and those of Greig et al. (2002: e.g., Fig. 25, p. 41) that there is little difference in, for example, proportion of Niantic River larvae entrained, whether $BAY = NB + ENT$ or $BAY = NB$ only. However, as they point out, it is important to remain consistent with our assumptions. We thus are planning to investigate whether we can improve our model by lagging the entrainment GROUP variable by an appropriate number of days.

Section 5.1, Page 37 - It was noted previously that larval densities at station NB effectively provide only 1/7 of the weighted average density for Niantic Bay (i.e., six samples are taken weekly at EN and averaged in with NB).

Subsection 5.1.1, Page 37, Paragraph 1 - We assume that Greig et al. (2002) meant to say "the average of NB and EN data" rather than "the average of EN and EN data" (emphasis ours).

Subsection 5.1.2, Page 39, Paragraph 1 - Although the Gompertz A parameter for all winter flounder larvae combined was higher for NB than EN, we noted previously that when viewed by developmental stage, this pattern was different, with Stages 1 and 2 having a higher A parameter estimates at NB, little apparent difference was seen for Stage 3 (the predominant stage entrained), and a higher value was found at EN than NB for Stage 4.

Subsection 5.1.2, Page 41 - There is no doubt that by using larval densities at station C in the Niantic River the MBM overestimates the number of larvae being flushed from the Niantic River early in the season. Higher larval densities at NB than at EN again indicate that NB is leading rather than trailing what is observed at the plant. The question of undersampling of larvae has been addressed several times in this response. As noted by Greig et al. (2002), the admitted undersampling of Stage 1 larvae at EN is corrected (or perhaps even overcorrected) before determining ENT (i.e., CMR).

Section 5.2, Pages 43-45 - Using station NB data to estimate both daily larval densities in Niantic Bay and to determine entrainment (Cases 2 and 3) is a logical progression by Greig et al. (2002), but may not be valid. The sampling methodology and collection of data at NB were described previously in the comments that addressed Section 4.1, Page 26, Paragraph 4. As noted in this particular comment, NB is sampled at a specific time of day and tidal stage, whereas entrainment sampling is randomized by tide and is completed during both day and night three

times a week. We believe that this sampling plan results in an accurate representation of larval winter flounder at NB, but that the increased sampling frequency and randomization by tidal stage during day and night at EN provides a better estimation of entrainment at MPS. Thus, we believe that Cases 2 and 3 (using only NB data to characterize entrainment) lack validity.

Part 6 - Synopsis and Recommendations:

Section 6.1, Page 49, Point 1 - We believe the fact that the number of entrained Niantic River larvae estimated by the MBM has not reflected the decreasing trend in egg production is a combination of compensatory mortality occurring in the egg stage not reflected in the calculation of ENT (CMR), higher larval survival in 2000 and 2001, and the inherent conservatism of the MBM, which attributes all larvae to the Niantic River unless there is an excess. By increasing egg survival from 20 to 50% during 1995-2001, the CMRs generated during these years are similar to those from 1984 through 1994 (see Fig. 1, above). Similarly, the apparently low natural mortality rates in 2000 and 2001 resulted in more larvae being available for entrainment at MPS in those years, despite low spawner abundance.

Section 6.1, Page 49, Point 2 - The finding of Greig et al. (2002) that combining data from NB and EN in the MBM results in an increase in Niantic River larvae entrained relative to the NB-only case is true. However, the differences in estimates (means differ by 3.6 million) appear to be inconsequential for the impact assessments. In any rate, this is another conservative aspect of the MBM and the estimation of MPS impact.

Section 6.1, Page 49, Point 3 - We are pleased that our correction for potential undersampling of Stage 1 larvae is in general agreement with results obtained by Greig et al. (2002) in their analysis. Note that the use of a 202- μ m mesh net with the bongo sampler at station NB enables us to determine when Stage 1 larvae are located in Niantic Bay and available for entrainment. At present full two-unit operation, only about 15% of the water discharged from the Niantic River is entrained at MPS.

Section 6.1, Page 50, Point 4 - We believe that our comments above regarding Section 4.4, Page 32, Paragraphs 1 and 2 demonstrate that NB should be a leading indicator of entrainment, rather than a trailing indicator. We further believe that the hydrodynamic models for water movement near MPS and the interpretations by Greig et al. (2002) overlook physical features that would retard movement of larvae along the eastern shoreline of Niantic Bay. Thus, it is unlikely that larvae could somehow move directly from the mouth of the Niantic River to either the MPS intakes or to Long Island Sound without being sampled at station NB in mid-Niantic Bay and accounted for in the MBM.

Section 6.1, Page 50, Point 5 - Based on discharge velocities of the MPS units and the abundant zooplankton present during late winter and spring, we believe the use of a smaller 202- μ m mesh net at EN would be impossible as the net would likely clog and fail (i.e., rupture). Based on our observations of thousands of samples processed since the mid-1970s, there is no evidence that a large number of larvae disintegrate while passing through the MPS cooling-

water system prior to their collection at EN. There is nothing in plant condenser cooling-water system design suggesting that this would happen frequently. When larvae are occasionally broken apart, we see fragments retained in the samples by their interaction with debris and zooplankton in the sample. We even have a data processing code for such larvae: TMID ("too mutilated to identify"). This code is not used frequently and when is it, is usually found in summer samples when a different suite of fish larvae are being entrained than winter flounder. Once again, a factor is used to adjust the entrainment estimate to account for the presumed extrusion of Stage 1 larvae.

Section 6.2, Page 50, Point 1 - We appreciate the insights to the MBM provided by Greig et al. (2002) and following their suggestion have calculated MBM results using daily densities interpolated from average weekly density data rather than by fitted Gompertz curves. To address this point we ran the last part of the MBM program using the actual weekly values instead of interpolated (from the Gompertz model) 5-day groups. This analysis indicated that in most cases (14 of 16 years), calculated values for annual total entrainment (TOTENTw) and Niantic River entrainment (TOTNRENTw) were higher (Table 2). However, under both methods the proportions of Niantic River larvae entrained to the total were very similar and ranged from 16.11 to 59.45 using weekly densities (NRPROPw) and ranged from 14.32 to 65.29 using 5-day groups from the Gompertz model (NRPROP). With the exception of the aberrant year of 1993, the ratios of NRPOPw to NRPROP were very similar during the 16 years, having a geometric mean of 1.013.

TABLE 2. Comparison between the MBM-calculated values for annual total larval winter flounder entrainment (in millions), Niantic River larval entrainment (in millions), and the proportion of total entrainment attributed to the Niantic River as determined from the Gompertz function fitted to 5-day groups (TOTENT, TOTENTNR, and NRPROP, respectively) and from actual weekly density values (TOTENTw, TOTENTNRw, and NRPROPw, respectively), with the ratio of NRPROPw to NRPROP.

Year	TOTENT	TOTENTNR	NRPROP (%)	TOTENTw	TOTENTNRw	NRPROPw (%)	NRPROPw: NRPROP
1984	83.848	37.317	44.51	113.468	51.660	45.53	1.022
1985	79.973	27.606	34.52	93.860	32.280	34.39	0.996
1986	120.956	24.708	20.43	150.027	33.099	22.06	1.080
1987	164.575	41.831	25.42	207.096	56.855	27.45	1.080
1988	183.443	43.558	23.74	233.721	85.959	36.78	1.549
1989	167.986	34.910	20.78	205.807	42.294	20.55	0.989
1990	132.463	43.283	32.68	183.166	65.210	35.60	1.089
1991	116.568	38.554	33.07	138.359	34.190	24.71	0.747
1992	491.723	84.976	17.28	611.019	98.464	16.11	0.932
1993	41.789	5.983	14.32	53.011	10.551	19.90	1.390
1994	173.533	57.734	33.27	208.065	68.143	32.75	0.984
1995	213.992	88.302	41.26	230.380	101.145	43.90	1.064
1996	48.672	31.776	65.29	53.708	31.931	59.45	0.911
1997	75.432	43.983	58.31	90.687	39.792	43.88	0.753
1998	83.838	29.819	35.57	92.441	33.144	35.85	1.008
1999	145.926	36.351	24.91	168.407	36.961	21.95	0.881
Geometric mean							1.013

Although this results in a somewhat higher larval entrainment from the Niantic River, the additional effects on production loss estimates (i.e., the CMR) and subsequent population modeling are not considerable. However, lacking the smoothing effect afforded by the Gompertz function, within-season variability was much higher for the MBM parameters *ENT*, *FromNR*, *ToNR*, and *Source or Sink*, when calculated using weekly densities. Further, the expected pattern of negative *Source or Sink* values early in the larval season, when more winter flounder larvae are flushed from the Niantic River than are imported from LIS, that switches to positive values later in the season as more larvae are imported, was not as clear (Table 3). Also, some weeks may lack sampling data as opposed to the fitted Gompertz distribution. In general, we feel that using weekly density data does not improve our ability to estimate annual larval distributions or the effect of MPS upon the local Niantic River population of winter flounder.

Section 6.2, Pages 50-51, Points 2 and 3 - The sensitivity of the MBM to changes in the *ToNR* and *FromNR* parameters was previously discussed in DNC (2001: Appendix B to Chapter 3 of Part II). In an earlier analysis presented in NUSCO (1991a) and summarized in DNC (2001), each of these parameter estimates was simply either doubled and halved to see what effect it had on MBM results for 1984-90 as the other parameters remained fixed and unchanged. Based on percent difference in entrainment from the original estimates, the MBM parameter *ToNR* was one of the least sensitive to change (see DNC 2001: Table B3-2, p. II-3B-13). The change in estimated entrainment ranged from -18.6 to -30.6% when *ToNR* was doubled and +10.3 to +23.1% when it was halved. Changing parameter *FromNR* in this way resulted in larger changes (+42.5-77.7% when doubled, -34.5-47.2% when halved), but this parameter is more precisely estimated than *ToNR* and errors in estimation were considered more likely for *ToNR* than *FromNR*.

A more comprehensive sensitivity analysis was presented in DNC (2001) using 16 years of data (1984-99). A full factorial design was employed to simulate errors involving all possible combinations of postulated error levels ($\pm 50\%$) and locations where densities were estimated (Stations C, NB, EN). Baseline outcomes were determined (i.e., actual annual estimates of percent larvae entrained that originated in the Niantic River and assuming no errors in the MBM). Bias ratios were determined based on the ratio of the outcome containing errors to the corresponding baseline. These biases were then randomly replicated to generate 5,000 bootstrap samples to describe and quantify the MBM sensitivity to errors in the three larval density estimates that are input to the model. A second set of simulations that was carried out consisted of a total of 32 outcomes of the percentages of entrained larvae attributed to the Niantic River when the annual estimates of larval mortality were either over- or underestimated by a factor of 2 (see DNC 2001: Table B3-4, p. II-3B-15). As before, the resulting biases were calculated as the ratio of outcomes with errors to the corresponding actual annual estimate, which was assumed to be correct. Also as before, the 32 biases were randomly replicated to generate 5,000 bootstrap samples to describe the mass-balance model sensitivity to errors in estimated larval mortality rate that is input to the model. The two independent sensitivity analyses are summarized by the empirical frequency distributions of the bootstrapped samples. As shown in DNC (2001: Figure B3-10, p. II-3B-26), a much wider range of biases, or greater sensitivity, for errors occurs with larval density estimates than for errors in larval mortality estimates. This result is in agreement with the more limited

TABLE 3. Comparison between the MBM-calculated parameter estimates (in millions^a) as determined from the Gompertz function fitted to 5-day groups as used in DNC (2002b) (top) and from actual weekly density values (bottom). Output for 1999 is shown as an example.

Group date start	5-day change	NumEnt	Mort	FromNR	ToNR	Source or Sink
<u>MBM estimates determined from Gompertz function:</u>						
15 Feb 99	0.0	0.0	0.0	11.6	0.0	-11.6
20 Feb 99	0.0	0.0	0.0	13.9	0.0	-13.9
25 Feb 99	0.0	0.0	0.0	15.9	0.0	-15.9
2 Mar 99	0.0	0.0	0.0	17.3	0.0	-17.2
7 Mar 99	0.2	0.0	0.0	18.1	6.8	-11.1
12 Mar 99	0.9	0.3	0.0	18.4	7.2	-9.8
17 Mar 99	2.7	1.1	0.2	18.1	8.9	-5.2
22 Mar 99	5.0	3.0	0.6	17.4	12.8	3.9
27 Mar 99	6.7	6.1	1.0	16.5	19.0	16.3
1 Apr 99	6.7	9.8	1.6	15.3	26.4	29.2
6 Apr 99	5.1	13.5	2.4	14.1	33.1	40.0
11 Apr 99	2.5	16.0	2.8	12.7	37.5	46.2
16 Apr 99	0.0	17.4	3.1	11.4	39.1	48.2
21 Apr 99	-1.9	16.7	3.2	10.2	38.2	46.0
26 Apr 99	-3.1	14.6	2.9	9.0	35.6	40.9
1 May 99	-3.6	8.8	2.5	7.9	31.9	31.7
6 May 99	-3.6	6.5	2.2	7.0	28.0	26.1
11 May 99	-3.3	6.7	1.7	6.1	24.2	23.2
16 May 99	-2.9	6.4	1.5	5.3	20.8	20.5
21 May 99	-2.4	5.3	1.2	4.7	17.9	17.3
26 May 99	-2.0	2.7	0.9	4.1	15.5	13.1
31 May 99	-1.6	2.2	0.7	3.5	13.6	11.3
5 Jun 99	-1.2	2.0	0.5	3.1	12.0	10.2
10 Jun 99	-1.0	2.0	0.4	2.7	10.8	9.5
15 Jun 99	-0.8	1.6	0.3	2.4	9.8	8.7
20 Jun 99	-0.6	1.6	0.3	2.1	9.1	8.3
25 Jun 99	-0.4	1.5	0.2	1.9	8.5	7.9
<u>MBM estimates determined from weekly density data:</u>						
18 Feb 99	0.0	0.0	0.0	3.2	10.2	6.9
25 Feb 99	0.0	0.1	0.1	5.3	10.6	5.5
4 Mar 99	0.0	0.2	0.1	92.2	10.9	-81.1
11 Mar 99	0.2	0.0	0.1	12.0	11.2	-0.6
18 Mar 99	0.3	0.9	0.2	25.1	12.2	-11.4
25 Mar 99	2.3	1.8	0.4	4.5	14.1	14.2
1 Apr 99	-1.3	8.6	1.2	14.5	24.8	18.8
8 Apr 99	4.2	8.6	1.9	11.4	30.8	34.1
15 Apr 99	1.0	36.3	6.8	31.2	83.4	96.4
22 Apr 99	-3.4	21.6	4.3	21.4	52.7	53.9
29 Apr 99	-2.5	31.0	6.8	8.6	77.0	103.6
6 May 99	-0.9	10.3	3.1	18.5	41.0	35.0
13 May 99	2.5	11.9	3.0	5.6	39.9	51.8
20 May 99	0.7	10.9	2.5	8.8	33.1	38.4
27 May 99	0.9	10.9	2.9	15.2	37.5	37.1
3 Jun 99	-5.5	12.1	4.0	8.6	47.8	49.8
10 Jun 99	-0.2	2.6	1.1	2.8	20.0	20.7
17 Jun 99	0.0	0.3	0.1	2.2	10.2	8.4
24 Jun 99	0.0	0.1	0.0	^b	9.5	^b

^a Due to rounding, any zero value represents less than 50,000 larvae.

^b No collection taken at station C in the Niantic River during this period, resulting in a missing value for both *FromNR* and *Source or Sink*.

findings of the sensitivity analysis conducted in 1991. In the DNC (2001) analysis, the frequency distribution of the bootstrapped samples permitted a computation of the quantiles associated with empirical probability confidence intervals that were useful to more realistically evaluate sensitivity of the mass-balance model. These quantiles showed that there was an approximate 90% probability that the biases resulting from the simulated errors in the larval density estimates range between overestimates of 69% and underestimates of 46% (DNC 2001: Table B3-5, p. II-3B-16). Similarly, approximate confidence interval for biases resulting from errors in mortality rate estimates would range between overestimates of 6% and underestimates of 9%.

Finally, an independent review of the MBM was performed by Dr. Eric Adams of the Massachusetts Institute of Technology (Adams 2001). He concluded from his analysis that for the years 1984-99, the fraction of entrained larvae originating from the Niantic River averaged about 30% (CV = 40%). The DNC MBM results for these years (DNC 2002b: Table 36, p. 250) had a mean fraction of larvae from the Niantic River of 27.5% (CV = 41%). Adams (2001) further concluded that the MBM calculations were conservative and his alternative models with different assumptions had a mean contribution of 18% (CV = 65%). As did Greig et al. (2002), Adams (2001) noted that the greatest uncertainty concerned measurements and model assumptions related to larval fluxes between Niantic River and Bay.

Section 6.2, Page 51, Text Paragraph 1 - The possibility of a supposed shift in in-river larval densities is unlikely and was previously addressed in our comment regarding Section 3.5, Page 23. Given the size of the Niantic River, we believe our three sampling stations adequately describe larval abundance and the possibility of a "hyper-stable ... larval abundance index..." postulated by Greig et al. (2002) is remote.

Section 6.2, Page 51, Text Paragraph 3 - Greig et al. (2002) note the possibility of using DNA or microelement typing to assess the relative contribution of larvae from different stocks of winter flounder at NB. We do not believe that this effort is warranted. The direct measure of larval stock identification at the MPS is preferable to measuring the components at NB to verify the indirect estimates of entrainment made using the MBM. We were puzzled why the DNA analysis of larvae entrained at MPS performed by Dr. Joseph Crivello of the University of Connecticut was not mentioned in Greig et al. (2002). This work provided a direct estimate of the fractions of larval winter flounder entrainment at MPS attributed to the Niantic River spawning stock and stocks located in the Thames River and just west of the Connecticut River. The report of Crivello (2002) was sent to DEP via DNC (2002a) and to both DEP and ESSA by DNC (2002c). The latter submission also included pages 251-254 of DNC (2002b), where the findings of the Crivello (2002) DNA analysis for 2001 samples (1,067 entrained larvae) were compared to MBM results. This comparison (DNC 2002b: Table 38, p. 253) showed that the fractions of larvae attributed to the Niantic River were virtually identical from DNA analysis (22%) and the MBM (21.4%). Certainly, there was some variation in timing of Niantic River larval entrainment between the two methodologies (see DNC 2002b: Fig. 45, p. 254), possibly related to the point samples taken for DNA analysis and the relatively smooth curve generated by the MBM. However, the highly similar end results lend much credibility to the MBM.

Because of the relevance of the larval winter flounder DNA analysis in relation to the MBM, we are including in this response the preliminary results from the 2002 work along with the 2002 MBM results, which are subject to further review prior to publication in the forthcoming Annual Report. As in 2001, Stage 1 and 2 larvae were collected from three source populations: the Niantic River, Thames River, and Westbrook. Based on their genetic characteristics, Dr. Crivello assigned 969 sampled entrained larvae to one of the source populations or as unknown. In 2002, 12.0% of the entrained larvae were assigned to the Niantic River, 7.8% to the Thames River, 59.1% to Westbrook, and 21.1% were unable to be classified (unknown). As in 2001, the entrained larval samples were collected based on a stratified random sampling model (i.e., weekly sample size proportional to long-term entrainment abundance distribution). The fraction of larvae assigned weekly to the Niantic River was applied to each corresponding total entrainment estimate from the MBM and the totals were then summed to obtain the DNA-based total for comparison to the MBM results of Niantic River larval entrainment. Because the MBM provides 5-day estimates of entrainment and the DNA samples were collected on a weekly basis, the time intervals did not precisely match and DNA fractions were interpolated whenever necessary to fill temporal gaps. Also, larvae entrained during the beginning and ending tails of the entrainment season were not sampled for DNA, necessitating the application of the initial and final DNA-based fractions to the summed entrainment totals for the tails. The 2002 MBM results showed that larvae were first entrained in early March and the season progressed until the end of June (Table 4). Total entrainment for 2002 was 167.7 million, about 45% of the 2001 estimate. Weekly estimates of entrained winter flounder larvae originating from the Niantic River were significantly correlated ($r = 0.59$; $p = 0.02$) with estimates from the MBM, with the trends in numbers appearing to be similar by both methods (Fig. 2). More Niantic River larvae were entrained earlier in the year than later. Total Niantic River entrainment and the fraction of total entrained were relatively similar for both methods: 19.5 million by the DNA analysis (11.6%) and 23.1 million by the MBM (13.8%) (Table 4). While these two methodologies provided relatively similar estimates, MBM-derived estimates of the proportion of Niantic River larvae were highest in the early part of the 2002 entrainment season, whereas the DNA analysis showed a consistently higher fraction later in the season (Fig. 3). Due to the conservative nature of the MBM (i.e., larvae are assigned to the Niantic River unless a surplus is shown), all entrained winter flounder larvae early in the season were attributed to the Niantic River by the MBM. Unfortunately, as a result of using a long-term average temporal distribution to guide DNA sampling, no genetic samples were taken early in the season to compare these results. Probably because 2002 had the highest winter (January-March) mean water temperature (5.67°C) observed at the MPS intakes since 1976, the larval season proceeded quicker than expected and larvae were more abundant and available to entrainment earlier in the season in 2002. Nevertheless, both methods showed that the numbers of Niantic River larvae peaked in late March and early April (Fig. 2). For the MBM, a likely conservative overestimate of Niantic River entrainment early in 2002 compensated for a possible underestimate later in the year, with the end result of relatively similar fractions and totals between the two methods. Since the MBM total for Niantic River larval entrainment was higher than the DNA-derived total, the model provided a conservative estimate of larval entrainment for the Niantic River winter flounder stock. Results for both years gave fractions and entrainment estimates similar in number and indicated that the MBM gives reasonable estimates of Niantic River larval entrainment for further impact assessment analyses.

TABLE 4. Five-day estimates of the total number of winter flounder larvae entrained at MPS, and the fraction and number of Niantic River winter flounder larvae entrained based on the genetic DNA analysis of Dr. Joseph Crivello of the University of Connecticut compared to the fraction and the number entrained based on MBM results.

5-day period	5-day entrainment estimate (10 ⁶)	DNA-based fraction ^a	Total (10 ⁶) attributed to the Niantic River from genetic study ^b	Mass-balance model fraction	Total (10 ⁶) attributed to the Niantic River from the mass-balance model
2 March	0.115			1.000	0.115
7 March	0.547			1.000	0.547
12 March	1.732			1.000	1.732
17 March	3.995			0.737	2.946
22 March	7.197			0.417	3.002
27 March	10.700			0.257	2.748
1 April	13.704	0.054	2.052*	0.173	2.368
6 April	15.637	0.074	1.157	0.126	1.966
11 April	16.317	0.078	1.273	0.098	1.595
16 April	15.888	0.082	1.303	0.080	1.276
21 April	14.665	0.153	2.244	0.069	1.012
26 April	12.990	0.134	1.741	0.062	0.800
1 May	11.145	0.115	1.282	0.057	0.634
6 May	9.330	0.291	1.054	0.054	0.504
11 May	7.664	0.110	0.843	0.052	0.402
16 May	6.204	0.104	0.645	0.052	0.323
21 May	4.966	0.097	0.482	0.052	0.261
26 May	3.941	0.250	0.985	0.054	0.211
31 May	3.106	0.125	0.388	0.055	0.172
5 June	2.436	0.000	0.000	0.057	0.139
10 June	1.902	0.533	2.417*	0.059	0.113
15 June	1.481			0.062	0.091
20 June	1.151			0.064	0.073
25 June	0.892			0.066	0.059
Mean fraction		0.120		0.138 ^c	
Total	167.7		19.526		23.089

^a Bolded values are actual fraction determined from DNA analysis (Crivello, pers. comm.), while non-bold values are interpolated.

^b * indicates values are products of the summed tails of the entrainment estimates and the DNA fraction.

^c Geometric mean.

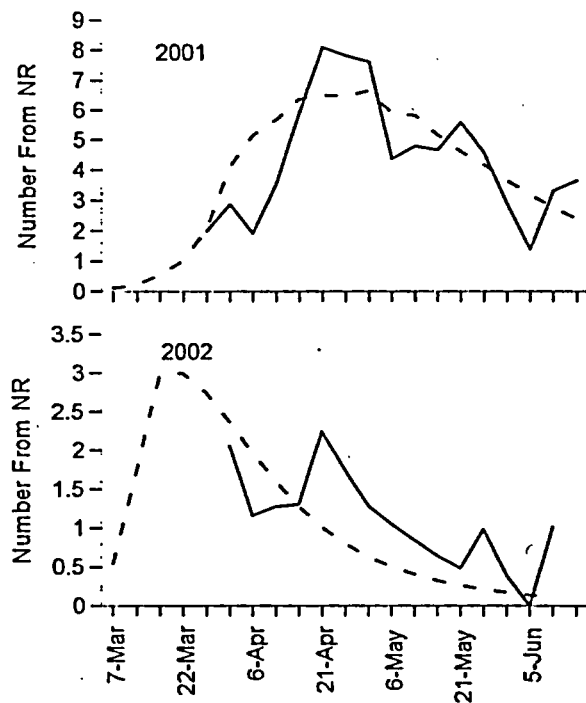


Fig. 2. Numbers of entrained winter flounder larvae attributed to the Niantic River as determined by DNA analysis (solid line) and the MBM (dashed line) in 2001 and 2002.

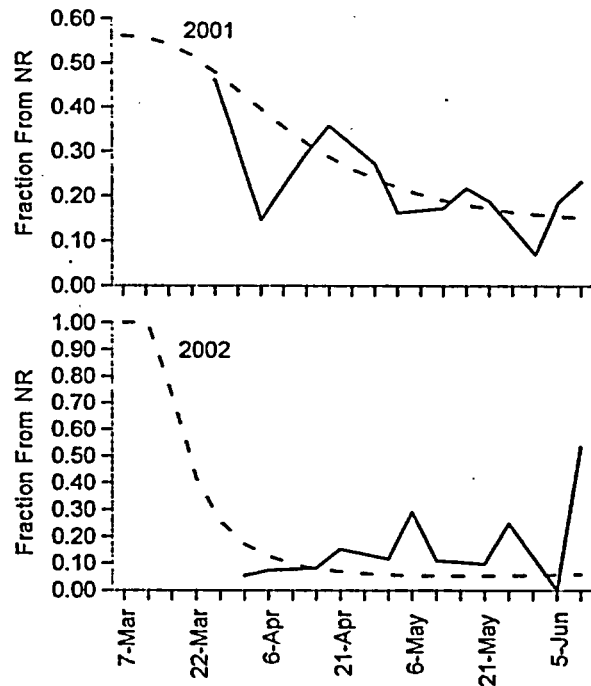


Fig. 3. Fraction of entrained winter flounder larvae attributed to the Niantic River as determined by DNA analysis (solid line) and the MBM (dashed line) in 2001 and 2002.

Mass balance Model flow description (prepared by ESSA for review purposes):

Page 63, Number 2 – In an aside, Greig et al (2002) noted that they did not know why the variable 'wdate' was adjusted by 3 in the SAS program. To clear up any confusion on this point in the MBM SAS coding, 'wdate' is adjusted by 3 simply to put this date into the middle of a week.

References Cited

- Adams, E.E. 2001. Appendix C to Chapter 3 of Part II. Larval mass balance studies at Millstone Power Station. *In* Millstone Power Station. An evaluation of cooling-water system alternatives. August 31, 2001. 17 pp.
- Crivello, J. 2002. Report to Millstone Environmental Laboratory, Ecological Advisory Committee. Analysis of winter flounder larvae. University of Connecticut, Storrs, CT. February 12, 2002.
- Dimou, N.K., and E.E. Adams. 1989. Application of a 2-D particle tracking model to simulate entrainment of winter flounder larvae at the Millstone Nuclear Power Station. Energy Laboratory Report No. MIT-EL 89-002. Massachusetts Institute of Technology, Cambridge, MA. 73 pp.
- DNC (Dominion Nuclear Connecticut, Inc.). 2001. Letter D17249 and Enclosure, W. Matthews, DNC, to M.J. Harder, CT DEP, dated August 31, 2001. Millstone Power Station. An evaluation of cooling-water system alternatives.
- DNC. 2002a. Letter D17306 and Enclosures, G.W. Johnson, DNC, to J.F. Grier, CT DEP, dated March 14, 2002. Winter flounder stock identification studies.
- DNC. 2002b. Winter flounder studies. Pages 167-287 *in* Annual report 2001. Monitoring the marine environment of Long Island Sound at Millstone Power Station Waterford, Connecticut. April 2002.
- DNC. 2002c. Letter D17333 and Enclosures, G.D. Hicks, DNC, to J.F. Grier, CT DEP, dated June 12, 2002 (with copy and additional materials to ESSA Technologies Ltd.). Request for information - winter flounder mass-balance model.
- DNC. 2002d. Enclosure 1 to Letter D17347, G.D. Hicks, DNC, to J. Grier, CT DEP, dated October 3, 2002. Responses to questions, comments and concerns regarding the August 31, 2001 report "Millstone Power Station. An evaluation of cooling-water system alternatives" as noted in the letter of May 9, 2002 from J. Grier, CT DEP, to Dominion Nuclear Connecticut, Inc.
- Gibson, M.R. 1999. Estimation of the reduction in recruitment of winter flounder in the Niantic River associated with operations at Millstone Nuclear Power Station. 15 pp. + 10 tab. + 27 fig. June 1999. Sent to Northeast Utilities Service Company, Millstone Power Station.
- Greig, L., I. Parnell, and J.D. Meisner. 2002. Assistance with the evaluation of a National Pollutant Discharge Elimination System (NPDES) Permit application for Dominion Nuclear Connecticut's Millstone Power Station: Review of the mass-balance model used to estimate the number of winter flounder larvae entrained by Millstone Power Station (1984-2001). Prepared by ESSA Technologies Ltd., Toronto, ON for Bureau of Water Management, CT DEP, Hartford, CT. 62 pp.
- Hilborn R., and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York. 570 pp.
- Kollmeyer, R.C. 1972. A study of the Niantic River estuary, Niantic, Connecticut. Final report phases I and II, physical aspects of the Niantic River estuary. Rep. No. RDCGA 18. U.S. Coast Guard Academy, New London, CT. 78 pp.

- NNECO (Northeast Nuclear Energy Company). 1999. Letter D14915 and enclosures, P. Jacobson, NNECO, to D. Cherico, CT DEP, dated September 15, 1999. A review and critique of the report entitled "Estimation of the reduction in recruitment of winter flounder in the Niantic River associated with operations at the Millstone Nuclear Power Station by Mark Gibson, June 1999."
- NOAA (National Oceanic and Atmospheric Administration). 1975. Nautical chart 13211, 9th ed. North shore of Long Island Sound, Niantic Bay and vicinity. U.S. Department of Commerce, National Ocean Service, Coast and Geodetic Survey. Rockville, MD.
- NUSCO (Northeast Utilities Service Company). 1983a. Winter flounder population dynamics. *In* Monitoring the marine environment of Long Island Sound at Millstone Nuclear Power Station, Waterford, CT. Annual report, 1982. 53 pp.
- NUSCO. 1983b. Plankton. *In* Monitoring the marine environment of Long Island Sound at Millstone Nuclear Power Station. Resumé, 1968-81. 37 pp.
- NUSCO. 1989. Fish Ecology Studies. Pages 159-206 *in* Monitoring the marine environment of Long Island Sound at Millstone Nuclear Power Station, Waterford, CT. Annual report 1988.
- NUSCO. 1991a. Winter flounder studies. Pages 9-86 *in* Monitoring the marine environment of Long Island Sound at Millstone Nuclear Power Station, Waterford, CT. Annual report 1990.
- NUSCO. 1991b. Ichthyoplankton Entrainment Estimation. Pages 261-270 *in* Monitoring the marine environment of Long Island Sound at Millstone Nuclear Power Station, Waterford, CT. Annual report 1990.
- NUSCO. 1992. Enclosure to letter D05660 dated July 29, 1992 from C.F. Sears, NUSCO, to T. Keeney, Commissioner, CT DEP. Ecological studies proposed for 1993 at Millstone Nuclear Power Station.
- NUSCO. 1998. Winter flounder studies. Pages 9-105 *in* Monitoring the marine environment of Long Island Sound at Millstone Nuclear Power Station, Waterford, CT. Annual report 1997.
- NUSCO. 1999. Winter flounder studies. Pages 161-274 *in* Monitoring the marine environment of Long Island Sound at Millstone Nuclear Power Station, Waterford, CT. Annual report 1998.