C. Response to Comments Concerning In-Stream Thermal Limits

Comment C1: Agencies have not made any claim or showing that water temperatures in the Charles River, to the extent that they have been or would be affected by Kendall Station's discharge, have had or would have any of the general effects described in those statements. It is not enough for the Agencies to "have concerns" because water temperatures matter. Rather, the Agencies must make a determination whether the particular water temperatures in these particular water bodies caused by the particular discharges from Kendall Station in fact would interfere with the protection and propagation of a BIP. The permitting documents conspicuously fail to address that central and determinative issue. Instead the Agencies have identified what they consider to be a "reasonable potential" for the discharge to cause or contribute to water quality impairments and then proposed limits so extremely low that they believe they cannot fail to eliminate that potential, as opposed to limits designed to assure the protection and propagation of a BIP.

Response to C1: It appears that EPA's analysis of the company's variance application as presented in the Determination Document (DD) and Mirant's current argument in support of its variance have passed by each other. Contrary to Mirant's implication, however, this mismatch did not occur because EPA intends to shirk any responsibility to make a determination concerning "appreciable harm." Rather, the basis for Mirant's demonstration under section 316(a) has been a long, involved and evolving affair. It appears to EPA that the grounds on which Mirant wishes to argue for its variance have shifted, and EPA will recast its analysis accordingly.

Ultimately, it is important to remember that it is the permittee's responsibility to present information that clearly demonstrates to the satisfaction of EPA and MassDEP that specific temperatures, while above water quality standards, are still protective of the BIP. As described at length in the DD, the permit applicant carries the burden of proof when seeking a variance under section 316(a). The process Mirant, EPA, MassDEP, and the resource Agencies undertook to assess Mirant's 316(a) variance application was long, and Mirant's arguments for a variance may have migrated over time. But under every scenario provided for in section 316(a) and EPA's regulations implementing that provision, Mirant has failed to meet its burden of proof for the variance it appears to want.

When EPA assembled the DD, the approach to the section 316(a) analysis was based primarily on the clear representations in the company's original application that the company expected the operating scenario for Kendall Station to change significantly, from a peaking station to a base-load operation with a more continuous output and discharge (Kendall Application 2001, Section 4). The application was originally filed at a time when natural gas was relatively inexpensive and the newly deregulated energy supply market promised to be lucrative. Therefore, EPA did not focus the analysis on the provision in the 316(a) variance regulations that allows an applicant to demonstrate that "the normal component of the [existing] discharge" would result in "no appreciable harm." It appeared at that time that Mirant's discharge going forward would not reflect the "normal component" of the facility's historic operations.

With these comments on the draft permit, however, Mirant is arguing there is no appreciable harm from the normal component of its existing discharge, and therefore, its existing permit conditions suffice to protect the BIP pursuant to 40 CFR 125.73(c)(1)(i). It appears that the company has implicitly adapted its arguments and variance application to the new economic reality of higher gas prices and stiff competition within the electricity generation market. But even under this scenario, it is the applicant that continues to carry the burden of proof concerning "no appreciable harm." EPA's regulations provide that the applicant must submit a "demonstration" to "show . . . [t]hat no appreciable harm has resulted from the normal component of the discharge . . ." Id.

Mirant arguably is correct that EPA's DD did not explicitly make a formal determination as to appreciable harm. But the approach was taken largely because EPA did not understand that Mirant was relying on this element of the 316(a) regulations to make its demonstration. Nevertheless, there are elements of the findings in the DD which look at Mirant's existing operations and attempt to assess trends revealed by Mirant's recent operations (DD at Section 5.3). Although the DD presents these data as one way to predict the potential impact of the Station when operated as a base-load facility, it is also clear that they represent the beginnings of an assessment of the Station's existing operations. Now that Mirant has chosen to focus on the "no appreciable harm" basis for a 316(a) variance, EPA will assess the data available to determine whether Mirant has demonstrated to EPA's satisfaction that there is "no appreciable harm" resulting from its existing discharge. This assessment is presented at some length in Response to Comment C3 below, which contains a determination whether there is evidence of historical and/or recent appreciable harm to the BIP in the lower Basin.

EPA is unclear regarding the source of Mirant's comment that EPA relied on a "reasonable potential" standard to assess the impacts of Mirant's discharge. In discussing the impacts from the Station's thermal discharge, EPA did not use this standard in the support document entitled "Clean Water Act NPDES Permitting Determinations for Thermal Discharge and Cooling Water Intake." It is possible that Mirant inferred from EPA's extensive discussion of the potential impacts of the new operating scenario Mirant presented in its application that EPA was using a reasonable potential standard. And it might have behooved EPA to be more clear about the standard applied under the regulations, although in fairness, the original application and the shifting arguments put before EPA during the long consultation leading up to the draft permit made it difficult for EPA to focus its analysis with precision. EPA essentially treated Mirant's application as an effort to make a demonstration under section 125.73(a) of the regulations, because the provisions under section 125.73(c)(1) appeared to be irrelevant given the prospect of a dramatic change in the Station's discharge when compared to the historic "normal component of the discharge." Under that scenario, the DD clearly determined that Mirant had not met its burden of proof that existing permit conditions would protect the BIP, and EPA undertook an effort to develop alternative temperature limits that would.

There is no comprehensive historical data set of ambient river temperatures for appropriate locations and depths to correlate with Kendall Station discharge temperatures at various river flows in order to identify under what operational conditions the facility would greatly influence lower Basin temperatures. There was also no biological monitoring program in place before 1999 to determine if the indigenous population of aquatic organisms was affected by Kendall Station discharge. Limited biological data collected in 1999 and 2000 submitted by the permittee failed to convince EPA and MassDEP that the BIP would be unharmed from proposed future operation. No acceptable thermal model was submitted by the permittee to address the issue of thermal discharge impact in lieu of a comprehensive historical data base. Therefore, the initial submission by the permittee failed to meet the burden of predicting thermal impacts to the receiving water resulting from Station discharge temperatures. Because the thermal conditions in the river were not identified along with information that would support a conclusion that no resultant appreciable harm to the BIP was expected, EPA and MassDEP were forced to identify protective temperature limits in a different manner. EPA and MassDEP relied on site-specific biological and water quality data, in addition to the scientific literature, to select biologically based temperature limits that must not be exceeded in any 50% cross-section area of the Charles River in order for the BIP to be protected.

Now that the company has altered its approach and is focusing on a demonstration under section 125.73(c)(1)(i), EPA will undertake a more specific consideration of appreciable harm. As will become apparent below, Mirant has also failed to meet its burden to demonstrate "no appreciable harm."

Mirant also complains that EPA set these alternative temperature limits "extremely low," and elsewhere contends that they are lower than necessary to protect the BIP. EPA vigorously disputes the contention that these limits are unnecessarily low. But with that said, it is also true that there is considerable scientific uncertainty about precisely what temperatures would protect the BIP while giving Mirant as much operational flexibility as possible to heat the river. In the face of such uncertainty, and in light of the applicant's burden to show "no appreciable harm," it is reasonable for EPA and MassDEP, when relying on incomplete, unclear or conflicting biological or water quality data, to establish permit limits that tend to be more conservative and protective of the BIP.

Comment C2: Among Mirant Kendall's submissions that the Agencies admittedly failed to consider, one stands out above all others. By a letter dated November 13, 2003, and follow-up submissions, Mirant Kendall submitted the results of river monitoring for the summer and early fall of 2003. By then, Mirant Kendall had completed the upgrade to Kendall Station, which operated consistently with its proposed and future operations. The upgraded facility discharged during July 2003 at an average of 394 mmBTU/per hour.

The Agencies should have great interest in the results of the river monitoring from those months that the fully upgraded plant was operating. Instead, even though the submissions of 2003 data are in the Administrative Record, the Agencies admit that they have not fully considered those data. Yet these are the most pertinent data from the Charles River because they are real-world data from the actual discharge operating after the plant was upgraded and operating as it is likely to operate in the future. It was irresponsible for the Agencies to disregard these data while instead relying on unrealistic assumptions and laboratory studies that are largely unrepresentative of Charles River conditions. The Agencies should reconsider the proposed temperature limits after considering the most pertinent data, along the lines suggested by the further comments below, and re-issue a revised draft permit for public review and comment.

Response to C2: These data have now been considered as part of this response to comments document. All data submitted by the permittee which was collected from 1999 through 2005 have been reviewed to determine if appreciable harm to any populations of resident or anadromous species is evident. EPA and MassDEP have used this data set to investigate whether historical or current appreciable harm to the BIP of the lower Charles River Basin can be identified. This discussion is included in Response C3. The considerable amount of fisheries data collected by Mirant was also used to support permit requirements.

In addition, EPA and MassDEP have carefully considered the site-specific data Mirant has submitted in designing the permit limits, and the Permitting Agencies reject the implication that the permit limits are based solely on unrealistic laboratory studies. There are several elements of the permit design that specifically account for the site-specific data the applicant submitted:

1. during the springtime period, the permit allows the temperature limits to be exceeded 6 times to reflect the wide temperature variations that Mirant documented in the lower Basin in the spring;

2. the averaging time to measure the delta T temperature limit has been changed to 24 hours to reflect the potential time it takes for water to travel from the background monitoring station to the monitoring stations in the ZPH, as supported by Mirant's continuous temperature data collection;

3. with the exception of certain monitors on the edge of the ZPH during the summer period, the in-stream temperature regime includes a 2 degree F margin of compliance to reflect a combination of the diel fluctuations and changes with depth in the lower Basin's temperature profile (documented by Mirant) and the recognition that Kendall Station must operate conservatively to maintain compliance with the in-stream temperature limits; and finally

4. while the Permitting Agencies looked to the scientific literature to understand the tolerance of the indicator species to heat exposure, the permit does not pluck the most conservative, "no effects" numbers from those studies and impose them as permit limits; EPA and MassDEP were careful to determine values from those studies that were necessary, though not necessarily ideal, to protect the ZPH for the BIP.

Therefore, it is not accurate to assert that the Permitting Agencies "disregarded" the data Mirant submitted.

Comment C3: Mirant Kendall continued its voluntary program of temperature and biological monitoring of the Charles River during 2004. The Agencies should consider these results as well as the earlier biological monitoring results, as they continue to show that upgraded operations of Kendall Station have not caused any apparent or appreciable harm to the BIP in the Charles

River.

Response to C3: EPA and MassDEP have decided to respond in some detail to Mirant Kendall's claim that there has been no appreciable harm from Mirant Kendall's thermal discharge. EPA and MassDEP consulted extensively in the preparation of Response C3. MassDEP conducted a scientific analysis and generated a draft response. EPA reviewed this draft de novo and concurred in it, and the two agencies collaborated extensively in its production. The final response is the joint product of both agencies, although, for purpose of simplicity, the response refers primarily to EPA. (One further note: MassDEP developed a large number of figures and charts for analyzing Mirant's field data, all of which have been placed into the administrative record. EPA and MassDEP analyzed and based their decision on the totality of these analyses and charts. Those cited in the Response C3 have been relabeled for conformity with the figure numbering scheme for these responses to comments.)

EPA and MassDEP have determined that Mirant has not overcome the evidence that its recent thermal discharge has caused appreciable harm to the BIP. Briefly, the alewife and blueback populations sampled decrease across space as one approaches Mirant Kendall's discharge. Supporting data suggests that the cause of this phenomenon is that the discharge results in temperatures that the majority of alewife individuals, and even a large percentage of blueback individuals, will avoid. Because of Mirant Kendall's discharge, the bulk of the alewife population, and very substantial numbers of the blueback population, are excluded, for long periods of time, from unacceptably large areas of the lower Basin. This habitat exclusion constitutes appreciable harm.

I. Background

A. Temperature sensitivity of alewife and blueback

Alewife (*Alosa pseudoharengus*) has been identified as the most temperature sensitive anadromous species documented to inhabit the lower Basin in any notable number. American shad is more temperature sensitive, but does not appear to be present in the lower Basin during most surveys. Blueback herring are present in substantially higher numbers than alewives, allowing for more statistically significant conclusions, but are less temperature sensitive. Both alewives and bluebacks are of heightened concern to Massachusetts resource agencies (Due to a major downturn in adult stocks throughout the state, the Massachusetts Division of Marine Fisheries (MA DMF) has issued a moratorium on the take of adult fish of these species. See Response C6). Alewife was selected as the representative anadromous species to reflect the health of the BIP and evaluate whether the entire indigenous fish population was in balance.

As a general principle of biology, a population of organisms exposed to a stress (such as heat) will exhibit a range of response to that stress. Specifically, alewives – like any other fish – exhibit a range of thermal tolerances, with some individuals being particularly temperature-tolerant, others particularly temperature-sensitive, and most in between.

Consequently, one would expect a priori, and in fact research in controlled studies generally confirms, that some individuals will be captured in the water at temperatures which the majority of individuals cannot tolerate. In other words, the fact that <u>some</u> fish have been captured at a relatively high temperature does not mean that the BIP has not experienced appreciable harm, but rather simply that the temperature is not quite high enough to exclude the most temperature tolerant individuals in the population. Accordingly, the appreciable harm determination must be made with regard to the bulk of the population and, as noted above, in the context of the cumulative impact of all significant impacts on the species affected.

Moreover, the ecology of fish populations is complex and a number of confounding factors can sometimes render the data difficult to analyze. This is certainly true for the Charles River alewife data, where a variety of influences besides Mirant Kendall's thermal discharge – including variations in river flow, reductions of discharge of untreated sewage, natural cycles in the strengths of particular year classes, improvements to the fishways at the Cordingly Dam in October 2004 and the Watertown Dam in April 2005, and so on – can affect the health of the BIP. Furthermore, as is generally true with quantitative observational data from the wild, individual data points sometimes yield anomalous results; data sets collected by slightly different measurement techniques sometimes suggest conflicting conclusions; and low numbers can yield unrepresentative or statistically inconclusive results. Given these limitations, EPA and MassDEP have used the best science available to ascertain whether the BIP in the lower Charles Basin has experienced appreciable harm.

Based on the timing of the permit renewal submission (the permittee's latest application was submitted in February of 2001), the timing of the upgrade to Kendall Station, and the time period bracketing the collection of a sufficient amount of water quality, biological and Station operational data, the analysis for both appreciable harm (discussed in this response) and the thermal discharge profile of Kendall Station (see Response B1) was divided into two time periods. The period from 1988 through 2000 is referred to here and in Response B1 as representing historical or past conditions. The time period from 2001 through 2005, i.e. the recent past, is referred to for purposes of convenience as "current conditions".

Because of the absence of a sufficient body of useful site-specific data for Charles River indigenous fish populations during historical or past conditions (1988 through 2000), a determination of appreciable harm was not possible for this time period. A limited amount of biological data, collected in 1999 and 2000 from the Charles River in the vicinity of Kendall Station, was submitted along with Mirant's permit renewal application in February of 2001. EPA determined, however, that this information was not sufficient to demonstrate that no appreciable harm was being caused by the Station's discharge.

EPA and MassDEP have examined the more complete biological data set submitted more recently by the permittee. This included site-specific Charles River water quality and biological data collected in 2002-05**.** This data set, referred to here and in Response B1 as representing "current conditions" was sufficient for the Permitting Agencies to determine that the thermal discharge from Kendall Station has caused appreciable harm to the alewife and blueback populations in 2004-2005.

B. Ecological importance of lower Charles River Basin habitat

The lower Basin of the Charles, downstream of the B.U. Bridge, is important habitat to all life stages of alewives. Data for the juvenile life stage are most prominent and indicate that this area is especially important as a nursery area for juveniles and deserves protection. The wide section of the lower Charles River Basin, downstream of the Watertown Dam, is important spawning and/or nursery habitat for alewives and bluebacks. The nursery season for these fish extends through the late spring, summer and early fall, and indeed juvenile alewives and bluebacks have been found in the lower Basin, downstream of the B.U. Bridge from mid-June through the fall.

Adult river herring that find their way into the Charles and are able to move past the thermal plume and are not kept from breeding due to the attractive nature of MKS's effluent plume encounter yet another obstacle that inhibits upstream movement, the Watertown Dam. MADMF made extensive repairs to the fish ladder at this site in early April, 2005, which should enhance upstream movement. Because the Watertown Dam restricts upstream movement, the habitat downstream of the dam is especially important to anadromous fish. According to the scientific literature, bluebacks spawn primarily in fast moving water, while alewives prefer slow-moving shoreline areas. Thus, the area downstream of the B.U. Bridge would be the most likely spawning habitat for alewives in river segments downstream of the Watertown Dam. MADMF has observed spawning of river herring at the MIT boathouse. The fish spawning at this site were thought to be alewives due to the low water velocities at this site. Mirant's ichthyoplankton analyses in 1999 and 2000 indicate that the area is likely spawning habitat. River herring larval densities of 1-10 larvae per cubic meter were found at sites near the intake in May and June during those years. These are very high densities and indicate that extensive spawning was probably occurring downstream of the Watertown Dam those same years.

C. Appreciable harm demonstration

Once again, it is not EPA's burden to demonstrate that there has been prior appreciable harm; it is Mirant Kendall's burden to demonstrate that there has not been prior appreciable harm. See 40 C.F.R. § 125.73 (c)(1)(i). Exclusion from unacceptably large areas of spawning or nursery habitat constitutes appreciable harm. See Draft Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Section of Nuclear Facilities Environmental Impact Statements, § 3.3.5.1, at 28-29 (EPA, May 1, 1977) ("1977 Technical Guidance Manual").

Another important point bears emphasis. EPA cannot conduct its Section 316(a) analysis – i.e., whether the BIP would be protected by temperature limits less stringent than the water quality standards would otherwise require – in a vacuum. The discharger's Section 316(a) demonstration "must show that the alternative effluent limitation desired by the discharger, considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected, will assure the protection and propagation of a [BIP]." 40 C.F.R. §§ 125.73(a) (emphasis added), 125.73(c)(1)(i) ("taking into account the interaction of such thermal component with other pollutants and the additive effect of other thermal sources"); see also 33 U.S.C. § 1326(a) ("taking into account the interaction of such thermal component with other pollutants"). The lower Charles River is impaired by, among other criteria, organic enrichment/low DO, noxious aquatic plants, contaminated sediments, harmful bacteria, and increased turbidity. Although EPA does not rely on specific impacts of these impairments to temperature sensitive species, this "cumulative impact" requirement is important to keep in the background when assessing the impacts of excessively warm water to the BIP. See Section 5.4 of the Determination Document.

A discharge may be determined to be in a low potential impact area for fish if the following conditions are satisfied:

1. The occurrence of sport and commercial species of fish is marginal;
2. The discharge site is not a spawning or nursery area;
3. The thermal plume will not occupy a large portion of the zone of passage which would block or hinder fish migration under the most conservative environmental conditions (based on 7-day, 10-year low flow or water level and maximum water temperature); and
4. The plume configuration will not cause fish to become vulnerable to cold shock or have an adverse impact on threatened or endangered species.

See 1977 Technical Guidance Manual, § 3.3.5.2, at 29. The receiving area for the Mirant Kendall discharge (i.e., the lower Charles River Basin) does not meet these criteria and hence is not a "low potential impact area." The discharge site has been documented to be a nursery area through Mirant's push-net surveys, shoreline seine surveys and impingement/entrainment evaluations. MADMF has also determined that the discharge area is a spawning area. Consequently, the lower Basin is an area of potential impact for fish.

Accordingly, Mirant's burden in a § 316(a) variance application is to prove that fish communities will not suffer appreciable harm from any of the following:

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

See id. § 3.3.5.1, at 28-29.

With that background, EPA has determined that Mirant has not overcome the evidence that its recent thermal discharge has caused appreciable harm to the BIP. Briefly, the alewife and blueback populations sampled decreases across space as one approaches Mirant Kendall's discharge. Supporting data suggests that the cause of this phenomenon is that the discharge results in temperatures that the majority of alewife individuals, and even a large percentage of blueback individuals, will avoid. EPA finds that, because of MKS's discharge, the bulk of the alewife population, and a very substantial portion of the blueback population, are excluded, for long periods of time, from unacceptably large areas of the lower Basin. This habitat exclusion constitutes appreciable harm.

II. Analysis

All data discussed in this review were collected in the lower Charles River Basin, i.e., from the Watertown Dam to the new Charles River Dam at the terminus of the Charles. All data were collected downstream of the BU Bridge where the river greatly widens and deepens.
EPA and MassDEP reviewed several distinct sources of data in assessing the influence of Kendall Station's discharge on alewife abundance. Each source of data has its own advantages and limitations. Day-time and night-time shoreline seine data are available from as far back as 1999 and 2002 respectively, and in some years include data points for a broad range of temperatures. On the other hand, shoreline seining is subject to confounding factors that may be present at specific shore locations (e.g., food supply or cover). Push-net sampling, which is conducted in open water away from the shoreline, minimizes these confounding variables and in theory should produce the most reliable results. On the other hand, push-net sampling began only in 2003, and for these years, the total number of alewives captured is low, which can make it difficult to draw statistically significant conclusions. To some extent that problem can be addressed by examining blueback push-net data, since bluebacks were captured in much higher numbers and therefore exhibit trends with greater statistical significance. On the other hand, as noted above, bluebacks can tolerate higher temperatures than alewives.

Acknowledging these inescapable limitations in the data, EPA and MassDEP have examined these data sets closely. While the results are not always completely consistent, the weight of the evidence indicates that Mirant Kendall's thermal discharge has caused extensive habitat exclusion, and thus appreciable harm to the BIP, in the lower Basin.

A. Push-net data vs. distance from Mirant Kendall discharge

1. Alewife

As noted above, push-net sampling is, as a general matter, a more reliable method of assessing the abundance of river herring. At a number of other sites in the eastern U.S., juvenile river herring have been found to rise to the surface to feed at dusk. Juveniles are caught in open-water areas during low-light periods and are also caught near the surface in the daytime in turbid waters. Because push-net samples are collected in open water, at the surface and away from the shoreline, the effect of temperature avoidance can be directly addressed without the potentially-confounding habitat variables of shoreline food and/or cover.

In 2003, Mirant Kendall initiated push-net sampling to assess abundance of juvenile river herring downstream of the B.U. Bridge. Mirant Kendall followed techniques used in Virginia and conducted push-net sampling in the wide section of the lower Charles River Basin at dusk and at night with a large net mounted on the front of the collection boat. Juvenile river herring were captured near the surface at stations across the lower Basin from the B.U. Bridge down to the Old Locks at the Science Museum (i.e., both upstream and downstream of the discharge). Since each push-net survey lasted 5 minutes, catch per survey is used here to represent catch per unit effort (CPUE).

Although push-net sampling was conducted from 2003-05, the quality and representativeness of the alewife dataset for each year varies. The alewife data from 2004 and 2005 are the most extensive of the three datasets. In 2003, push-net sampling was initiated in late July. Over the July-September period of sampling in 2003, only 2 alewives were captured, which is not enough data to analyze. By contrast, 125 juvenile alewives were captured in July-September in 2004 and 183 were caught over this same time period in 2005. Finally, while push-net sampling took place in the day as well as at night, in both 2004 and 2005, nearly all alewives caught by push-net were caught at night. (This is not surprising because alewife juveniles feed at the surface in dim light.) Consequently, only night-time data are evaluated here.

Total alewife population has been very low in the Charles in recent years. For example, in 2004, which had the most extensive sampling program, a total of 125 juvenile alewife were captured in push-nets; in 2005, the total was 183. These absolute numbers are extremely low in comparison to the number of bluebacks captured in the same surveys, which is demonstrated by the relative catch rates per survey. The overall number of juvenile bluebacks caught per survey (July-September sampling period, total catch all surveys/total number of surveys at all stations) over the years of 2003-2005 ranged from 30 to 148 fish per survey. By comparison, the range in juvenile alewife catch over those same surveys and years ranged from 0.01 to 1.33 fish per survey. Nevertheless, even though there were very low numbers of juvenile alewives (often none) caught on any particular push-net event, the large number of events allows an investigation of patterns in catch rate from station to station.

The push-net data allow an evaluation of whether proximity to Mirant Kendall's discharge played a role in juvenile alewife abundance in the lower Basin. The Agencies examined spatial trends in catch per push-net survey. Typically, when there is substantial variability in the data – which is certainly the case with the catch per push-net survey – the median provides a more accurate metric of central tendency than the mean. However, the catch at stations near the discharge was so low, and so often zero, that the median catch per push-net survey would be zero fish per event for stations near the discharge. Consequently, EPA has used the <u>mean</u> catch per push-net survey for this analysis.

Table C3-1 below lists, for each push-net station, the approximate distance of the station from the Mirant Kendall discharge; the total number of juvenile alewives in all surveys in the months specified (July-September for both 2004 and 2005); the number of sampling events during those months; and the mean number of juvenile alewives per sampling event. It illustrates a general trend of declining alewife abundance as one approaches Mirant Kendall's discharge.

Table C3-1: Juvenile Alewife Densities at Push Net Stations, by Distance to Mirant Kendall Discharge (2004-05)

		Total# alewives		**# sampling events**		**Mean alewives/event**	
Station	**Distance**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**

		Total# alewives		# sampling events		Mean alewives/event	
Hyatt	1.4[1]	52	84	24	22	2.17	3.8
MIT	0.8[1]	26	5	24	14	1.08	0.36
Lagoon	0.6[1]	32	--	26	0	1.23	--
Old Locks	0.5[2]	6	52	24	24	0.25	2.17
A. Fiedler	0.4[1]	4	--	25	0	0.16	--
Boston	0.2[3]	3	19	24	26	0.13	0.73
Mid-Channel	0.1[2]	0	10	26	26	0.00	0.38
Sh. Diffuser	0.05[2]	2	13	26	26	0.08	0.5
Totals		**125**	**183**	**199**	**138**	**0.62**	**1.33**

Key:
1: upstream of discharge
2: downstream of discharge
3: directly across river from discharge
Table C3-1A contains the exact same data as Table C3-1, but instead of being sorted by decreasing distance to the Mirant Kendall discharge, is sorted from upstream to downstream.

Table C3-1A: Juvenile Alewife Densities at Push Net Stations, by upstream to downstream location (2004-2005)

		Total # alewives		#sampling events		Mean alewives/event	
Station	**Distance**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
Hyatt	1.4[1]	52	84	24	22	2.17	3.8
MIT	0.8[1]	26	5	24	14	1.08	0.36
Lagoon	0.6[1]	32	--	26	--	1.23	--
A. Fiedler	0.4[1]	4	--	25	--	0.16	--
Boston	0.2[3]	3	19	24	26	0.13	0.73
Sh. Diffuser	0.05[2]	2	13	26	26	0.08	0.5

Mid-Channel	0.1[2]	0	10	26	26	0.00	0.38
Old Locks	0.5[2]	6	52	24	24	0.25	2.17
Totals		**125**	**183**	**199**	**138**	**0.62**	**1.33**

Key:
1: upstream of discharge
2: downstream of discharge
3: directly across river from discharge

Tables C3-1 and C3-1A illustrate the decline in alewife abundance compared to the distance from each push-net station to the discharge. In 2005 CPUE declines by half or more from the Hyatt station to the MIT station. From MIT downstream to the Boston station, the 2004 data show a continued sharp decrease. In 2004, the mean CPUE is at its lowest for the three stations closest to Mirant Kendall's discharge, and then rebounds somewhat at the Old Locks station, half a mile downstream of the discharge.

In general, the 2005 dataset is similar to that of the 2004 dataset: CPUE is highest at the Hyatt reference station and decreases at stations closer to the discharge. These data are presented graphically in Figures C3-1 and C3-2. The axis denoting distance on these and other graphics in this section depicts the distance from the discharge to each station. The thermal plume from Mirant travels both upstream and downstream and has the potential to affect habitat in either direction. Push-net stations were also located both upstream and downstream of the thermal discharge. As a result of this arrangement of stations in the graphics, the greatest distance in miles from the Kendall discharge denoted in the graphics is 1.4 miles (the distance from the discharge to the most upstream station), whereas the total distance between the farthest upstream and farthest downstream stations (one downstream station was located 0.5 miles distant from the discharge) was 1.9 miles. Station distances were arranged in this manner, rather than in linear distance downstream from a certain point, so that regressions based on station distance from the discharge could be generated. 2004 data demonstrate that there is a statistically significant ($p = 0.0005$) decline in mean alewife abundance as station proximity to the discharge increases. That is, at stations closer to the discharge, alewife densities decline. A similar trend also exists in 2005; however, the pattern is not statistically significant at the 0.05 level ($p = 0.10$ for the 2005 alewife dataset).

The trend that is visible, but not statistically significant, in the 2005 data, is confirmed by a more detailed analysis. The 2005 dataset is influenced by a sampling anomaly. One station (MIT) was surveyed about 36-46% less frequently than the other five stations (14 events at this station vs. 22-26 at other stations over the July-September 2005 time period). MIT station also has the poorest fit to the regression line. Because the entire alewife dataset is sparse, with many events yielding no fish, a major difference in the number of sampling events at a particular station could have a large effect on the metric for that station. That is, the probability that an accurate characterization of alewife densities over time has been produced at the MIT station is reduced compared to other stations. Under the assumption that this station has been inadequately sampled in comparison to the others, the data may be re-analyzed without the data from MIT station. The remaining dataset -- i.e., July-September 2005 juvenile alewife push-net data for all stations except MIT station -- yields a statistically significant ($p = 0.0038$) drop in density of alewives that is highly correlated ($R^2 = 0.957$) with proximity to the discharge. See Fig. C3-3. Thus, in both 2004 and 2005 juvenile alewife densities decreased with nearness to the discharge and the pattern exists both upstream and downstream of the discharge across a linear distance of about 1.9 miles of the lower Basin, downstream of the B.U. Bridge.

These regressions support the hypothesis that proximity to the discharge has negatively affected juvenile alewives' use of the upper water column in the terminal segment of the Charles.

2. Bluebacks

As noted above, bluebacks are both more temperature-tolerant, and more numerous in the lower Basin, than alewives. Notwithstanding this greater temperature tolerance, even bluebacks were adversely affected by Mirant's discharge. Because bluebacks were present in much higher numbers than were alewives, the temperature/distance/abundance analysis for bluebacks is much more robust.

In general, blueback push-net data follow the same spatial pattern as the alewife push-net data. See Figures C3-4 and C3-5. The densities of juvenile bluebacks in push-nets far exceeded those of alewives: in 2004, 8,894 bluebacks were captured in the same surveys that captured only 125 alewives, and in 2005, 12,177 bluebacks were captured compared to only 183 alewives. (Although the bluebacks' greater temperature tolerance is certainly a reasonable hypothesis for their significantly greater total numbers, EPA does not have sufficient data to confirm this hypothesis and does not rely upon it.) Because of these greater numbers, EPA was able to use the median (as opposed to mean) number of fish captured across all sampling events at each station mentioned above for our analysis.

The correlation between median blueback densities at each station and station distance to the Kendall discharge is quite strong in 2004 (see Fig. C3-4; R^2 value = 0.8059) and even stronger in 2005 (see Fig. C3-5; R^2value = 0.9299). Both regressions are statistically significant ($p = 0.0024$ for 2004 and $p = 0.0019$ for 2005) and their slopes are substantial, especially that for the 2005 dataset. Median densities in 2005 were greatly affected: the density at the Boston station (median no. bluebacks/event = 49.5), which is located on the Boston side of the Charles and directly across the river from the Kendall discharge, was only 25% that at the Hyatt reference station (median no. bluebacks/event = 195.5). Densities at the two stations nearest the discharge were even lower (median no. bluebacks/event = 36 and 24 at the mid-channel and shallow-diffuser stations respectively), about 12 to 18% of the median density found at the Hyatt reference station.

In summary, for both 2004 and 2005, as push-net stations got closer to the discharge, juvenile alewife and blueback densities declined. In addition, for both years, the inverse relationship of juvenile density at each station vs. station distance from the discharge was statistically significantly ($p < 0.05$). Furthermore, this pattern existed throughout the wide section of the lower Charles, from slightly downstream of the B.U. Bridge to a point past the old boat locks adjacent to the Museum of Science, a distance of about 1.9 linear miles.

3. <u>Temperature vs. distance from Mirant Kendall's discharge</u>

EPA examined the relationship between proximity to the discharge and water temperature. Not surprisingly, the temperature increases as one approaches the discharge.

EPA performed regressions on the mean surface water temperature at each station over the time periods in question (July-September 2004 and July-September 2005) vs. station distance from Mirant Kendall's discharge. These regressions, presented in Figures C3-6 and C3-7 for 2004 and 2005 respectively, show a strong positive correlation between temperature and proximity to the Kendall discharge. Indeed, the relationship between distance and temperature for 2005 is essentially linear ($R^2 = 0.9809$). Both regressions are statistically significant (for 2004, $p = 0.0016$; for 2005, $p = 0.000138$. This strongly suggests that the cause of the temperature distribution over the lower Basin is, in fact, Mirant Kendall's discharge.

It is, of course, theoretically possible that the alewives' avoidance of Mirant Kendall's discharge is actually not caused by the discharge, but rather by some other, as yet unknown factor that geographically happens to correlate rather well with the discharge. However, EPA has not identified (and Mirant Kendall has not suggested) a credible alternative explanation for this spatial pattern, and, most likely, Occam's razor points directly to the source.

4. <u>Water temperature vs. juvenile densities</u>

The regressions presented above (Figures C3-1through C3-5) strongly suggest that juvenile alewife and blueback densities in push-nets declined with increasing temperatures caused by Mirant Kendall's thermal discharge. EPA investigated the statistical significance of this potential relationship for both alewives and bluebacks using the 2004 and 2005 datasets (see Figures C3-14 through C3-18). As was done for the 2005 analysis of alewives vs. distance (graphics C3-2 and C3-2), regressions both for alewife density with and without the MIT station information were presented. Note that in regressions for the 2004 and 2005 datasets the following characteristics are apparent for both alewives (when the information for that species at the MIT station is removed for 2005) and bluebacks: a) juvenile densities at each station decline as the mean water temperature measured at each station at time of sampling increases; and that b) the correlations between juvenile densities and water temperatures are statistically significant ($p < 0.05$) in each case.

The spatial analysis of the push-net sampling for juvenile alewives and bluebacks in both 2004 and 2005 indicates that both species' densities declined with proximity to the discharge and that this decline may be attributed to the increased temperature caused by Mirant Kendall's thermal effluent. This pattern existed throughout the widest section of the lower Charles River, from slightly downstream of the B.U. bridge to a point past the old boat locks adjacent to the Museum of Science – a distance of about two miles This information supports the hypothesis that MKS's thermal discharge negatively affects juvenile alewives' and bluebacks' usage of the upper water column in the terminal segment of the Charles.

B. Juvenile alewife catch in Push-nets vs. temperature

Juvenile alewife presence in push-nets for the 2004 and 2005 sampling seasons (July-September) are presented in Figures C3-8 and C3-9 respectively. These figures present the average number of juvenile alewives captured per survey in each of several temperature ranges along with the number of surveys conducted in that temperature range. Temperature data reported here are the surface water temperature measurements taken at a spot along the sampling transect at the time of push-net sampling.

Figure C3-8 illustrates how the number of juvenile alewives per survey (Catch Per Unit Effort - CPUE) declines with temperature. Most strikingly, even though more than thirty surveys were conducted in 2004 at temperatures at or above 80º F, not one alewife was captured at these temperatures.

Figure C3-9 (the 2005 dataset) does not present as stark a picture, and in fact the CPUEs are, overall, higher in 2005 than in 2004. Moreover, the 2005 data does include a small number of individuals appearing in nets when surface water temperatures at time of catch were as high as 84º F. However, the 2005 data is still consistent with the general trend discernible from the 2004 data: alewives flourish primarily at temperatures below 80 °F, and decline thereafter. The 2005 data reveal a sharp decline in CPUE above 73 °F, and a further decline, to zero, above 84 °F. While the trend is not perfect, the following observations from the 2005 dataset are worth noting:

- The CPUE at 65-66 °F (23 alewives/event) dwarfed that of all higher temperatures; the next closest value is 6.5 alewives/event at 72-73º F, and no temperature above 73 °F yielded even 2 alewives/event.

- While the CPUE at 82-83 °F was 1.75 alewives/event, the CPUE at 83-84 °F was a only 0.5 alewives/event after 10 surveys, and no fish at all were captured in the 28 surveys above 84 °F.

- The low numbers of fish reported at warmer temperatures are not simply due to fewer surveys. More push-net surveys were conducted at 81-82º F than any other temperature range, and yet an average of only 0.78 juvenile alewives were captured per survey in this range.

- The majority of surveys were conducted above 75 °F, and yet fish densities were very low at all temperatures in this range; CPUE exceeded 1.75 alewives/event only in the cooler (< 75 °F) temperatures, which represented a small minority of surveys.

While the 2005 push-net data is probably an inadequate basis from which to draw independent conclusions, it is generally consistent with, and confirms, the inference from the more extensive 2004 data (and the scientific literature reviewed in the Determination Document) that temperatures above approximately 81º F did not provide suitable habitat for juvenile alewives in the lower Basin. These findings also parallel field data from streams in the Chesapeake drainage where almost all juvenile alewives were captured at temperatures below 80ºF. See section 5.7.3i of the Determination Document.

C. Night-time shoreline seine data vs. location

As noted above, shoreline seine sampling is potentially subject to confounding influences and is thus not as reliable as push-net sampling. Nevertheless, it can be a useful source of data in conjunction with push-net sampling. In this case, the shoreline seine data is generally consistent with the conclusions drawn from the push-net data.

. Mirant reported shoreline seine catch data from sampling events in which two different-length nets were used. In order to estimate the relative densities of juvenile herring captured by shoreline-seine, the catch must be based on the area sampled. Thus, shoreline-seine data presented below are standardized (normalized) to 1000 square feet of littoral zone sampled.

Mirant Kendall conducted shoreline-seining in the lower Basin beginning in 1999. From 1999 to 2000, only daytime sampling was conducted. The permittee sampled two shoreline stations upstream of the facility at night beginning in 2002 and extending through 2005. These are the Hyatt and Lagoon stations. In addition, the Boston station was sampled at night in 2005 but not in previous years. Both the Hyatt and Lagoon stations are upstream of the discharge. The Hyatt station is considered a "reference" station because it is located about 1.4 miles upstream of Mirant's discharge, near the B.U. Bridge. The Lagoon station was located much closer to the discharge, on the Boston side of the Basin, about 0.6 miles upstream from the Kendall discharge. Although this station is well upstream of the facility, based on temperature data provided by Mirant, it was thermally affected by the discharge. Thus, the Lagoon station is considered here to be a “test” station. The Boston station, also a test station, is located across from the Kendall discharge, on the Boston shoreline about 0.3 miles distant from the discharge, and is expected to be more frequently affected by the thermal discharge than the Lagoon station.

The alewife density in the daytime shoreline seine was extremely low. For example, in 2002, after sampling 119,723 ft^2 in the daytime shoreline seine, the average juvenile alewife density was 0.01 alewives/1000 ft^2. In 2003, after sampling 76,391 ft^2, the average density was 0.00. These numbers are so low as to preclude analysis. Since alewife juveniles feed at the surface in dim light, the company initiated nighttime shoreline-seine sampling in 2002 in an attempt to “find” the alewives that were not appearing in the daytime shoreline seine sampling.

As anticipated, the night-time seining found substantially larger numbers of alewives, enabling more reliable analyses. Because only nighttime seining produced juvenile alewives in any considerable numbers, the following analysis focuses on night-time shoreline seine data. Table C3-2 lists the nighttime catch per unit effort of sampling of juvenile alewives at these shoreline beach-seine stations.

Table C3-2. Night-time catch of juvenile alewives at Hyatt, Lagoon and Boston stations, as number of juveniles per 1000 ft^2 of area sampled (Catch Per Unit Effort, CPUE). Periods for which data were collated: 2002: late August through September; 2003: July through September; 2004: July through September; 2005: August through September. These were the only periods each year for which data were available during the July-September period (period of warmest water temperatures in the lower Charles).

Year	CPUE Hyatt Station	CPUE Lagoon Station	CPUE Boston Station
2002	31.2	1.9	n/a
2003	20.8	0.4	n/a
2004	32.4	4.6	n/a
2005	87.5	14.8	9.4

The data from the Hyatt and Lagoon stations are graphically presented in Figure C3-10. Mean temperatures at the Lagoon station were consistently higher than those at the Hyatt station over these periods, and in 2005, the mean temperature at the Boston station was the highest of the three stations listed. The data indicate that the nighttime juvenile alewife CPUE at the Lagoon station is much lower than that at the "reference" Hyatt station, and the CPUE at the Boston station is lower still. This station-to-station drop in catch rates is correlated with proximity to the discharge. Consequently, while the river's overall alewife population appears to have increased somewhat in 2005 (see Other Considerations section below for potential reasons), the night-time shoreline seine data suggest that juvenile alewives displayed a strong preference for the upstream, cooler Hyatt station, or, put differently, a strong preference to avoid the area influenced by MKS's thermal discharge. Of course, as noted above, shoreline seine data may be subject to confounding influences, and if this were the only data available, it might be inconclusive. But viewed in the context of the push-net data, the night-time shoreline seine data supports the general inference that juvenile alewives avoid higher temperatures in the lower Basin.

D. Nighttime shoreline seine data vs. temperature

EPA attempted to analyze the influence of temperature on nighttime shoreline seine data by comparing the CPUE to the surface water temperatures collected at each station when seining took place. The 2003-04 data suggest a fairly straightforward temperature-alewife density relationship, although the 2005 data are inconclusive.

In 2003, only three surveys were conducted at temperatures higher than 80º F; no alewives were found in these high-temperature surveys. See Figure C3-11. In 2004, the data indicates a declining CPUE trend as temperature increases between 71° F and 80º F, although no surveys were conducted at temperatures above 80º F. See Figure C3-12.

In 2005, no clear pattern emerges from the data points. See Figure C3-13. For example, at 79-80 °F, the average density was only 4.8 juvenile alewives/1000 ft^2 were caught; just one degree warmer, in the 80-81º F range, the density was 47 times greater (224 alewives/1000 ft^2). At the hot end of the spectrum, 1,389 ft^2 were sampled at 85-86º F and not one juvenile alewife was found, but between 86-87º F, four fish were found in just 280 ft^2 of sampling. The 2005 data appear to illustrate the influence of confounding variables, and thus no firm conclusions can be drawn. However, it is worth noting that, as a simple visual inspection of Figure C3-13 illustrates, the average densities for temperatures above 81º F were generally lower (in most cases substantially lower) than densities for temperatures below 81ºF and the four temperature categories with the highest CPUE were all found at or below a temperature of 81ºF.

Overall, EPA finds that the night-time shoreline seine data is roughly consistent with the inferences drawn from the push-net data. However, because of the limitations of the data set, no firm conclusions can be drawn from the night-time shoreline seine.

III. <u>Summary</u>

1. Very few alewives are present in the lower Basin.

   A. In 2003, juvenile alewives were essentially absent from the open-water areas sampled by push-nets downstream of the B.U. Bridge in 2003; only 5 juvenile alewives were captured in 237 separate push-net surveys. (By contrast, 6,036 blueback juveniles were captured in the same surveys.)

   B. In 2004, the total number of alewives caught in push-nets increased from 2003 levels, but only to 125 fish. The number of surveys also increased by about 50% from 2003. (By contrast, 8,894 blueback juveniles were caught in the same surveys.)

   C. In 2005, the total number of alewives caught in push-nets increased to 183 fish. (By contrast, 19,926 blueback juveniles were caught in the same surveys.)

2. In 2004 and 2005, the density of both species of juvenile river herring declined with approach to the discharge

   A. Push-net catch of juvenile alewives declined with proximity to the discharge. In both 2004 and 2005, juvenile alewife densities decreased with nearness to the discharge, and the pattern exists both upstream and downstream of the discharge across a linear distance of about 1.9 miles of the lower Basin, downstream of the B.U. Bridge. In 2004, juvenile alewife capture rates at stations within 0.5 miles of the station were less than 13% of the value at the Hyatt reference station; in 2005, capture rates for juveniles alewives at stations within 0.2 miles of the discharge were $\leq$ 20% of the value at the Hyatt reference station.

   B. Push-net catch of juvenile bluebacks also declined with proximity to the discharge. Although bluebacks are more temperature-tolerant than alewives, bluebacks are far more numerous in the lower Basin, allowing for more robust statistical analysis. The bluebacks exhibited a spatial distribution similar to the alewives, suggesting that even these more temperature-tolerant fish avoid the Mirant Kendall thermal plume.

C. Night-time catch of juvenile alewives in shoreline seines declined with proximity to the discharge. At the Hyatt Station, located about 1.6 miles upstream of the discharge, the night-time catch of juvenile alewives remained fairly constant (20-32 fish/1000 ft^2) for the four years of study (2002-05). However, night-time catch at the Lagoon Station, located only 0.6 miles away from the Kendall Station discharge, was consistently and substantially lower (0.3-14.4 fish/1000 ft^2).

3. Very few juvenile alewives are found above 80º F.

A. 2004 push-net juvenile alewife catch rates of in push-nets declined with increasing temperatures even though fishing intensity increased greatly as temperature approached 80º F. Although more than 30 surveys were conducted at temperatures in excess of 80º F, no juvenile alewives were captured in those surveys.

B. The 2005 push-net data is not as uniform as the 2004 data, but is generally consistent with it. While a small number of juvenile alewives (between 0.5 and 1.75 fish/event) were captured at temperatures above 80 ºF (and indeed as high as 84 ºF), the overall pattern indicates a sharp decline in fish density above 73 ºF, and a decline to zero above 84 ºF. Although 28 surveys were conducted at temperatures in excess of 84 ºF, no juvenile alewives were captured in those surveys.

C. The night-time shoreline seine sampling data are arguably inconclusive, but are not inconsistent with the inference drawn above. The 2003 data indicate a precipitous drop above 80 ºF, with no fish caught above that temperature. However, only 833 ft^2were sampled above 80 ºF, so this may be a data artifact. Similarly, the 2004 data indicate a more gradual decline in CPUE from a peak at 71-72 ºF, but no surveys were conducted above 80 ºF. Finally, the 2005 data indicate generally higher CPUE below 81 ºF, but the data do not display a clear overall trend. Because shoreline seine sampling is subject to confounding factors specific to the particular sections of shoreline sampled, these anomalies are not surprising.

The Charles River data cited above, combined with the scientific literature summarized in the Determination Document, support the inference that the thermal discharge from Kendall Station at levels documented in 2002-05 resulted in alewives and bluebacks avoiding, or being excluded from, large portions of the Basin. Moreover, the areas from which these fish are excluded are, in EPA's technical judgment, unacceptably large. First, alewives and bluebacks are species of heightened concern, so their nursery and/or spawning grounds merit particular attention. Second, the area from which alewives (and, to a lesser degree, bluebacks) are excluded is substantial: about 1.3 linear miles, . Because this exclusion area is located within the widest section of the lower Basin, it occupies a considerable proportion of the surface area of the Basin. Consequently, the above data lead EPA to conclude that both alewives and bluebacks have suffered appreciable harm attributable to MKS's thermal discharge (along with other cumulative stresses).

EPA judged that the push-net information submitted by the permittee was essential in evaluating appreciable harm that was due to the facility's heated discharge. As such, the continuation of push-net sampling has been included in the biological monitoring section of the final NPDES permit (see Part I.A.14.d.1).

IV. Other Considerations

In 2005, the total alewife population in the lower Basin enjoyed a modest resurgence, after years of decline. (A similar increase was observed in bluebacks.) At the same time, Mirant Kendall's thermal discharge was highest in 2005, which, judging from the data, raised water temperatures well above ambient levels. Additionally, ambient temperatures at the Hyatt station were higher than those in other years, partly due to reduced river flows, but perhaps also due to the Mirant Kendall discharge. Mirant Kendall has suggested that – despite consistent evidence from scientific literature showing thermal avoidance at temperatures like those seen in the Basin -- fish densities increased in 2005 because of the high water temperatures. This "thermal enhancement" argument is erroneous for the following reasons. Cf. Response to C23.

First, as one would predict from the literature, the push-net data (and, to a lesser extent, the shoreline seine data) indicate that alewives display a strong aversion to high temperatures. One would expect the opposite (i.e., that fish would be drawn to high temperatures) if an attraction to high temperatures resulted in increased feeding opportunities, increased vigor, a reduction in predation, or some other variable that increased their ability to survive and produce viable offspring. To the contrary, the density of fish found at push-net stations decreased with proximity to the Mirant Kendall discharge, and decreased with rising temperatures. In other words, while the total number of alewives in the Basin increased in 2005, those fish tended to avoid the area near Mirant Kendall's discharge and, by inference, its thermal plume.

Second, as a general rule, the total population of a given "year class" of anadromous fish can vary for reasons unrelated to river conditions in the particular year in which the class is measured. These can include other environmental stressors, whether natural or man-made; predator-prey cycles; and, for some stocks, fishing. One stressor may decrease as another is increasing, partially or totally masking the effect of the latter. Moreover, the size of an anadromous fish population can be affected by conditions in different places (i.e., the ocean, where the class's parents spent their adulthoods) or in different times (i.e., the same river several years before, when the class's parents were juveniles). All these factors make it hazardous to draw conclusions from one or two years of increasing (or decreasing) total population, particularly when the actual totals are quite low. In this analysis, EPA has not focused primarily on year-to-year changes in the total numbers of alewives. Rather, EPA's appreciable harm determination has focused on the fact that Mirant Kendall's thermal plume appears to exclude juvenile alewives from large portions of the lower Basin – an important nursery ground – for extended periods of time during which those fish need to build strength for the punishing journeys ahead.

Third, moving from the general to the specific, there are explanations for the apparent rise in juvenile alewife stocks in 2005 that are more plausible than Mirant Kendall's hypothesis of an attraction to warmer temperatures. A number of structural improvements to fishways occurred within the Charles River prior to the summer of 2005 which were expected to, and probably did, greatly improve the ability of adults to move upstream to spawn. These include:

- The replacement of the baffles in the fishway at the Watertown Dam in April of 2005, during the period of upstream migration of both alewives and bluebacks. The Watertown Dam is the first obstruction upstream of the New Charles River Dam that fish must pass in order to move to upstream spawning sites. In previous years, fishway baffles had deteriorated at this site. Fishways are engineered to provide a particular range of flows and turbulence that are attractive to anadromous fish. Replacement of the Watertown Dam baffles increased the "attractive flow" of this fishway. In addition, poaching of river herring had become a problem at the Watertown Dam fishway, although the extent of the damage to the populations of river herring was unknown. Steel structures were installed to prevent poachers from accessing the fishway in April of 2005. These actions should have increased the number of fish passing though the fishway.

- Improvements at the Cordingly Dam, located farther upstream from the Watertown Dam. The fishway at Cordingly received new baffles in October of 2004, which was projected to improved fish movement past Cordingly Dam.

- New procedures for locking fish into the Charles, beginning in 2004. The new procedures for allowing fish to enter the system could reasonably be expected to result in a greater number of fish actually moving into the Charles.

One other important fact to consider is that much of the production of juvenile fish within the Charles is expected to take place upstream of the Mirant Kendall facility. High numbers of fish found within the lower Basin in the summer of 2005 would have resulted from increased numbers of adults attempting to enter the Charles <u>before</u> the summer of 2005.

With respect to Mirant Kendall's suggestion that there appears to be a correlation between years of low river flows and years of high production, see Response to C23.

V. Conclusion

EPA has concluded, based on Mirant's field data, that a majority of alewives and bluebacks are excluded from unacceptably large areas of important habitat in the lower Basin, and that this exclusion can be tied to both the location of Mirant Kendall's discharge and the higher river temperatures associated with it. While not every single data point in every single survey points unambiguously in this direction, the weight of the evidence points to large-scale habitat exclusion. Consequently, in EPA's professional judgment, Mirant Kendall's thermal discharge has caused (and continues to cause) appreciable harm to the BIP.

Comment related to C3 from Mark Jaquith: In 2003 the herring run was very healthy. Where are they now? This year (2004) there were very few fish. I do not have the resources to answer that question, but I do believe that it calls Mirant's claim into suspicion.

Response to Comment related to C3 from Mark Jaquith: There are a number of ways to measure the strength of an anadromous fish run in a river. One common way is to count the number of adult fish as they enter the river to spawn. The only measurement of the strength of the adult alewife and blueback herring run in-migration in the lower Basin was conducted as a pilot study by the permittee in 2002. The pilot study estimated that approximately 45,000 river herring entered the Charles River. This permittee listed many problems with the technique used to arrive at this value. EPA agreed that any future study would need refinement before any estimate would be considered reliable. Also, it has been noted at other anadromous fish runs with multi-year adult anadromous fish counts that year to year runs can vary greatly. There is no way to place the 45,000 adult river herring value within this context, even if the number was considered reliable.

EPA and MassDEP do not have sufficient information to document that the herring run in 2003 was "very healthy." According to collection data for blueback herring juvenile and adults, submitted by the permittee and listed in Response to Comment C23, blueback herring catch rates were generally stable and similar in 2002, 2003 and 2004. While alewife catch rates did not follow this pattern, there is sufficient collection information to contradict the assertion that there were very few river herring seen as a whole in 2004.

Comment related to C2 and C3 from CLF: CLF states that (1) fish populations are not thriving and the river is currently impaired, (2) there is a severe conflict of interest that undermines the credibility of any data provided by Mirant Kendall, and most of Mirant Kendall's recent studies lack scientific rigor, (3) observations of an individual fish at some particular high temperature in the Basin provides virtually no insight into the natural biology of the species in question and should not be used, and (4) setting protective limits based only on estimates of lethal temperatures, or avoidance temperatures, is not consistent with promoting the propagation of the indigenous species in question.

Response to Comment related to C2 and C3 from CLF: While EPA and MassDEP have evaluated information that would suggest that the Charles River is below its expected carrying capacity for anadromous fish runs, this information is being treated as a preliminary indicator of the health of the anadromous fish populations. Estimates of resident fish populations in the lower Basin have not been attempted. It is difficult to quantify what measurements would define a "thriving population." It must be pointed out that EPA's regulatory responsibility is to ensure that a balanced indigenous population is maintained.

As noted in the Determination Document (DD), the Charles River is currently listed by MassDEP as impaired for organic enrichment/low DO, noxious aquatic plants, and taste, odor and color problems, along with, contaminated sediments, harmful bacteria, and increased turbidity (Breault *et al.*, 2002; Fiorentino, *et al.*, 2000; MA EOEA, September 2003). The thermal discharge from Kendall Station is not specifically listed as an impairment to the lower

Basin at this time.

Regarding the conflict of interest concern, from the inception of the NPDES program, it has been the responsibility of the permittee (or applicant) to collect and present data used by regulatory Agencies to establish or revise permit requirements and evaluate 316(a) variance requests and 316(b) determinations. It is in the best interest of the permittee to provide clear, correct, and complete data sets for agency evaluation, or risk having a permit application or renewal be denied.

Environmental data collected by NPDES permit applicants are not routinely given rigorous peer review and are not generally submitted for publication. This information is routinely collected using standard operating procedures and submitted along with supporting quality assurance documents such as calibration logs. This data is of value in determining the impact of a facility's discharge on the receiving water. A discussion of the range of temperatures where fish were observed provided site-specific context for the temperature limit discussions in the Determination Document. There is no instance in the formulation of thermal limits for Kendall Station where a small number of fish observed at a high temperature was used as the sole justification for a higher temperature as a permit limit.

Indeed, it was pointed out in several parts of the DD that "Setting temperature limits based only on individuals that may naturally be able to tolerate warmer temperatures is not thought to be an approach that is sufficiently protective of the population as a whole." (Section 5.6.3k of the DD) EPA's assessment of the data submitted by the applicant in the DD and in this response to comments document demonstrates that EPA has reviewed those data and corresponding arguments presented by the permittee with both care and an appropriate regard for the obvious self-interest of the permittee. EPA has diligently scrutinized the materials submitted by the permittee and has not accepted outright the permittee's analysis of the appropriate temperatures necessary to protect the BIP.

Comment related to C3 from CRWA: CRWA states that it is dangerous to extrapolate from avoidance and lethal temperatures to establish thermal conditions under which fish will thrive and successfully reproduce in the long-term. CRWA suggests that a healthy river of the size of the Charles has an estimated carrying capacity of roughly 300,000 river herring, yet recent estimates put the adult population near 45,000 (i.e. only 15% of capacity). Finally, CRWA notes that MADMF has recently committed about $300,000 for renewed efforts to bring back healthy populations of migratory fishes to the Charles, which may be thwarted if Mirant Kendall is allowed to operate under the draft permit proposed by EPA.

Response Comment related to C3 from CRWA: The lower Charles River Basin, prior to the influence of Kendall Station, is among the warmest rivers in Massachusetts. EPA and MassDEP recognize that if the scientific literature was exclusively consulted to set protective temperature limits, these limits would consistently be exceeded by ambient conditions in the lower Charles River Basin. See Response to CLF Comments related to C45 for a detailed illustration of this point. It would be unreasonable to expect the Kendall Station to effectively cool the Basin in order to meet its permit conditions. EPA has used its best scientific judgment to balance the low temperatures suggested in the literature to avoid long-term chronic impacts with the actual conditions occurring in the Basin.

Estimates of carrying capacity and adult in-migrating populations of anadromous fish in the lower Basin are not believed to be sufficiently refined at this time to be the basis for the major determinations included in the permit. See Article #1 in the Appendix accompanying Response C23 for details of MA DMF's Charles River carrying capacity estimates.

EPA and MassDEP are aware of the new efforts underway to reestablish anadromous fish runs in the lower Basin, particularly for American shad (see Response to C51). Protective temperature limits for American shad have not been established at this time. However, if this restocking effort re-establishes American shad in the lower Basin, the next permit, or a permit modification, may establish temperature limits that are appropriate to protect American Shad.

Comment C4: At several points in the DD, the Agencies refer to the potential past or future effect of the withdrawal and discharge of cooling water to serve the Blackstone Station, which is located in Cambridge upstream from the B.U. Bridge and the Kendall Station. As the Agencies recognize, the Blackstone Station has not operated to withdraw or discharge material amounts of cooling water other than sporadically in recent years. Blackstone Station is owned by Harvard University, which currently operates it to generate on-campus steam but not to generate electricity. The use for on-campus steam does not require the withdrawal or discharge of significant quantities of cooling water (rather, immaterial amounts of river water are now used for cooling of miscellaneous equipment). Further, Blackstone's steam turbine generator is no longer operable and is incapable of generating electricity. Harvard has publicly announced that it does not intend to resume electric generation using a repaired or replaced condensing steam generator system. Further, the Blackstone NPDES permit is in its renewal process, providing a mechanism and process for consideration of its future operating scenarios within that context, rather than in a speculative manner in Kendall Station's permit process. Accordingly, in determining what permit conditions are appropriate for Kendall Station, the Agencies should not assume there will be any additional effects from an upstream power plant.

Response to C4: EPA and MassDEP are in contact with the Blackstone Station's permittee and are aware of their intent to fundamentally change the way Blackstone Station is operated. The permit applicant for Blackstone Station has proposed to eliminate its thermal discharge to the Charles River. However, until a renewed permit for Blackstone Station is finalized, EPA and MassDEP will not predict future Station operation or potential impacts to the river in absolute terms. To avoid speculating about the Blackstone Station, EPA and MassDEP are not assuming any additional effects from the Station in setting permit conditions for Kendall Station that control the biologically based temperatures required to be maintained to protect the BIP. The possible heated discharge from Blackstone was a consideration in deciding on a location for background monitoring. EPA and MassDEP do not expect the Blackstone Station to impact the background monitor measurably. It must be noted, however, that Mirant is required by the permit to collect periodic temperature data in addition to the data collected by the fixed Monitoring Stations (See Part I.A.14.c.1 of the Final Permit). The additional temperature data will be used to generate contour maps of temperature throughout the Basin. This information will be reviewed to directly assess the appropriate location of all fixed Monitoring Stations, including background Station 1.

Comment C5: Mirant Kendall believes that the Agencies' proposed temperature limits as specified on Attachment A to the Draft Permit are without adequate justification. The permit writers have sought to establish those temperatures mostly by reliance on literature values of highly uncertain applicability to the complex and particular circumstances of the Charles River. By this comment, Mirant Kendall suggests an alternative approach that relies on the ambient temperatures in the Charles River itself and is thereby inherently consistent with the biology of the river.

Mirant Kendall believes this approach will best allow the Agencies to meet their stated goal of determining the "appropriate deviation from ambient or natural temperature conditions without adverse effects to the biota and to the balanced indigenous population." The core of this suggested alternative is to determine the range of temperatures that have supported the BIP of yellow perch and alewives in the Charles River at the times of year corresponding to the in-stream limits in the permit. Although Mirant disagrees with the biological validity of some of the calendar periods designated by the Agencies in the Draft Permit, for purposes of moving forward it bases this alternative approach on those same calendar periods. For all fall, winter and spring periods (through mid June), Mirant agrees with EPA's conclusion in Section 5.9 of the DD that the continuous record of Kendall Station intake temperatures is a reasonable representation of ambient conditions. For each such time period, the historical record of intake temperatures would be analyzed statistically to determine the average temperatures for the time period and also the range of variation from the average (standard deviation, 90% upper confidence bound, and 95% upper confidence bound).

Where there is no finding or evidence that the range of recent ambient temperatures have caused appreciable harm to the BIP, temperature limits derived from that statistical analysis would, by definition and by design, fall within the normal range of the temperatures that the Charles River has experienced without unacceptable harm to the BIP. Discharges consistent with maintaining such temperature limits would accordingly be sufficiently limited to protect and propagate the BIP. The approach of using statistical analysis and standard deviations to determine the range of temperature to consider acceptable is consistent with EPA New England's own approach to considering whether to expect ecological damage from a range of in-stream temperatures. See MK Comment Ex. No. C5, a memo produced in response to Mirant Kendall's public records requests to DEP, in which a member of EPA New England's ecological risk assessment staff indicates that a temperature within 2 standard deviations of the mean should not be considered harmful.

The suggested statistical approach also is consistent with the approach Massachusetts has taken to determining whether a water body segment is in attainment with the Massachusetts WQS for temperature. Under the Massachusetts approach, a water body is in attainment as long as no more than 10% of the temperature readings (24-hour averages) are in excess of the WQS. That approach appropriately recognizes that a range of temperatures around and above the target temperature is consistent with attainment of the standard without causing limitations on the ability of the water body to support aquatic life.

The suggested use of a statistical analysis of the historical temperatures is not a full compliance system all by itself. The full compliance system also involves determining appropriate targets for the summer, when the intake temperatures are not as representative of ambient conditions, determining just where to measure the determinative temperatures, determining what averaging time to use, and determining the consequences for the plant's operations as a target temperature is approached or exceeded.

To illustrate this approach, Mirant Kendall has analyzed the record of continuous temperature monitoring from 1998 to 2004 at its intake on the Broad Canal. The Agencies acknowledge that these intake temperatures are a reliable indicator of ambient conditions during the fall, winter and spring, provided normal seasonal river flow conditions are present. Mirant Kendall believes the intake temperatures also are useful for illustrating the magnitude of historic variation during the summer months, but can exceed "ambient" by up to 2 ºF or 3 ºF if the plant is operating at high thermal loads during low flow conditions in the summertime

The statistical analysis from 1998 through 2004 – which comprise a full range of cooler and warmer years – shows the following for 24-hour average temperatures at the Broad Canal intake, as compared to the Agencies' proposed temperature limits in Appendix A to the Draft Permit.

Frequency Distribution of 24-hour Average Temperatures (°F) at Kendall Intake, Compared to Agencies' Proposed 4-hour Block Average Temperature Limits in ZPH.

Time of Year	Mean at Intake	Standard Deviation	90% Confidence Upper Bound	95% Confidence Upper Bound	Draft Permit in ZPH
April 2-14	49.38	4.76	57.23	58.90	61
April 15-30	55.37	3.94	61.88	63.26	65
May 1-10	61.21	4.02	67.84	69.24	66.4
May 11-22	63.70	3.57	69.09	70.34	68
May 23-31	64.76	3.44	70.44	71.64	70
June 1-7	67.81	3.74	73.98	75.29	72
June 8-11	68.76	3.85	75.11	76.46	75
June 12-August 31	77.07	4.12	83.88	85.32	83

Those results indicate that for 1998 to 2004, the means of the 24-hour average temperatures at the intake were well below the Agencies' proposed 4-hour average temperature limits in the ZPH. At the 90% confidence upper bound, which is more than one but less than two standard deviations from the mean, the 24-hour average intake temperature were lower or very similar to the Agencies' proposed limits excepting for early June.[1] At this 95% confidence upper bound, which is two standard deviations above the norm, the 24-hour average intake temperatures again ranged from below the Agencies' proposed limits for some time periods to warmer in others. Mirant Kendall also analyzed the same temperature record using the daily maximum 4-hour block averages instead of 24-hour averages. The following table again compares the results to the Agencies' proposed temperature limits in Appendix A to the Draft Permit.

Frequency Distribution of Maximum 4-hour Block Average Temperatures (°F) at Kendall Intake, Compared to Agencies' Proposed 4-hour Block Average Temperature Limits in ZPH.

Time of Year	Mean at Intake	Standard Deviation	90% Confidence Upper Bound	95% Confidence Upper Bound*	Draft Permit in ZPH
April 2-14	50.03	4.84	58.02	59.72	61
April 15-30	56.14	4.06	62.84	64.26	65
May 1-10	62.15	4.36	69.34	70.86	66.4
May 11-22	64.16	3.59	70.09	71.35	68
May 23-31	65.61	3.53	71.43	72.66	70
June 1-7	68.76	3.78	74.99	76.32	72
June 8-11	69.66	3.89	76.08	77.44	75
June 12-August 31	77.97	4.18	84.87	86.33	83

***2 standard deviations above the mean**

These results indicate that for 1998 to 2004, the means of the daily maximum 4-hour block average temperatures at the Broad Canal intake also were well below the Agencies' proposed temperature limits in the ZPH, but that on some occasions the daily maximum 4-hour block average temperature exceeded the proposed limits. That is unsurprising because contrary to nature, the Agencies' proposed limits apply at all times and do not vary according to the river's daily temperature cycle.

Response to C5: EPA has considered this alternate approach and has decided not to apply it because it does not appear to be a sound means of setting temperature limits protective of the BIP.

Within Comment C5, Mirant refers to a record of an oral communication with a member of EPA's ecological risk assessment staff regarding the use of temperature standard deviations in assessing potential impacts. This communication was a set of notes prepared by Gerald Szal of MassDEP based on a phone interview conducted by Gerald Szal with David McDonald of the EPA Region 1 Laboratory in Chelmsford, MA. The note was prepared for a meeting with

[1] As explained in other comments, Mirant Kendall believes the Agencies' proposed temperature limits for early May and early June are fundamentally mistaken.

Mirant. The statement referenced by Mirant is two sentences long and reads as follows: "Dave McDonald, ecological risk assessment, Region I: use 2 standard deviations from the mean as an upper maximum limit or population will not be protected. This amounts to the 95%-ile figure."

Mirant has taken the interview between Mr. Szal and David McDonald out of context. Properly understood, this approach concerned development of an upper temperature for alewife movement into the lower Charles Basin using field-data from: a) temperatures at which alewives were observed entering freshwater systems; and b) numbers of alewives known to run at those temperatures. Mr. McDonald's suggestion was to use the 95%-ile figure from the frequency distribution of alewife entry and associated temperatures to arrive at an upper maximum temperature. To arrive at that figure, the resource Agencies used the frequency distribution of run strength as it applied to temperatures at which fish were known to run. Mr. McDonald's suggestions did not state that daily average temperature values or daily maximum temperature values would be appropriate to use. The intent was to include (when possible) only temperature data from the hours that fish were documented moving into the freshwater system. Data from three separate rivers were analyzed (see Table 5.7.3c-3 and accompanying text in the DD). Each had an anadromous alewife run. Data from Richkus (1974) were also used. Here, run strength was sharply diminished at temperatures above 64.4 ºF. The exercise resulted in an upper 95%-ile value of slightly higher than 65 ºF. Therefore, the result of the data review showed that about 95% of the alewives entering the freshwater in these systems did so at temperatures lower than about 65 ºF. In fact, most of them entered when water temperatures in the freshwater system were well below this value.

Mirant has used the two sentences from Mr. Szal's note in an inappropriate context. Mr McDonald's idea in the phone conversation was to use the run strength and temperature information when fish were entering the system from a successful run to arrive at an upper maximum temperature. By contrast, Mirant proposes to use temperatures from the system itself, without knowing whether or not fish were moving into the freshwater system during the hours (or days) included in the "statistically-based" frequency distribution of water temperatures. This approach is inappropriate because temperatures will be included when it is not known whether fish are entering the system. Using this method, there will be no correlation of run strength with temperature.

Further, the temperatures identified by Mirant during other times of the year were also left uncorrelated with biological data. Mirant identified a certain high ambient temperature that could be expected in the lower Basin for a short period of time, but provided no supporting information that this temperature resulted in no stress to the resident and anadromous fish in the lower Basin. EPA and MassDEP can not accept this approach and can not justify a protective temperature limit based solely on the fact that the temperature is expected to occur in a water body under ambient conditions. During certain times (heat waves, droughts, etc.) water temperatures in any water body, although considered ambient temperatures, would never the less place stress upon the BIP. Mirant's statistical approach does not take this into account.

Even if this issue could be addressed by Mirant in this particular case, another flaw in this approach is evident. If a maximum temperature limit were to be established using this approach, EPA and MassDEP would be allowing an infrequent, high temperature to be attained as a result of a man-made thermal discharge for a much longer time period than noted by the statistical assessment. This can not be justified as a protective approach for the BIP. Not only has Mirant misused the guidance proposed by EPA, it has misused its own stated form of the guidance in developing alternate temperature limits:

1) With regard to temperatures appropriate for the alewife run: One of EPA and MassDEPs' primary concerns during the spring is that temperatures at the mouth of the Charles should not run so high that alewives are discouraged from entering the system. Mirant should have used the temperatures from the Charles collected during those times when alewives were known to be entering the system. Only these temperatures should be used to develop a frequency distribution and the Maximum 95%-ile figure for alewife entry into the Charles. This method was clearly not followed in Mirant's tables for Comment C5.

2) With regard to summer ambient temperatures, the data do not support Mirant's contention that the intake temperatures are only 2-3 ºF higher than upstream ambient. Information presented in the DD shows that the intake temperature can be more than 5 ºF higher than ambient upstream temperatures. Although Mirant presents temperatures for June through August that range up to 85.3º F, intake temperatures during these times do not reflect ambient and may be many degrees higher than ambient. Thus, the tables Mirant presents in comment C5 do not reflect ambient river temperatures.

3) With regard to the table presenting 4-hour block average temperatures in Mirant's Comment C5, it appears Mirant has selectively used the temperature data, which has skewed the temperature profile higher. To develop a frequency distribution, and further, to select a particular percentile (e.g., 95th) from that dataset, the researcher must use the entire dataset. Based on the title of this table ("Frequency Distribution of <u>Maximum</u> 4-hr Block Average Temperatures" (emphasis added)), it appears Mirant produced a depiction of temperature information skimmed from the highest 4-hr block temperatures from the 7-year dataset (1998-2004). To accomplish this, Mirant selected the highest 4-hr block temperature from each day in each of the seven years and calculated the mean temperature from this maximum temperature data set. This equates to using only one sixth (approximately 17%) of the available ambient river temperature data rather than the full dataset to arrive at the 90th and 95th percentile figures.

In order to develop a percentile of the type suggested by Mirant in Comment C5, the entire dataset must be used. If it is not, the "95%-ile" estimate is not representative of the data and is of little value.

Based on the assessment above, EPA and MassDEP do not agree with Mirant's suggested alternative approach to developing permit limits for temperature.

Comment C6: The DD cites to several studies of river herring performed by William Richkus, Ph.D., in Rhode Island waters in the 1970s. Since then, Dr. Richkus has gone on to serve as the Program Manager for the Power Plant Research Program (PPRP) in Maryland. Mirant Kendall retained Dr. Richkus to undertake an independent review of the draft NPDES permit and the permitting documents. In his report, Dr. Richkus makes comments on the bases for EPA and DEPs selection of protective temperatures in the zone of passage and habitat, and also, on alleged errors and over-conservatism of the Agencies' general approach.

Response to C6: EPA and MassDEP note preliminarily that Dr. Richkus did not have available to him the entire administrative record which the Permitting Agencies had assembled as of the date he formulated his comments. And obviously, he could not have considered the material that has come to the permitting Agencies following the date of his comments. Therefore, his analysis is necessarily limited to a subset of the materials EPA and MassDEP considered in developing both the draft and the final permit.

Just as obviously, Dr. Richkus was not involved in the years-long process that EPA and MassDEP undertook to develop this permit and respond to the varying proposals the permit applicant put forward. While his comments bring a fresh perspective to the deliberation, unencumbered by the history behind this permit's development, they also fail to appreciate the extent to which the permit is a product of EPA and MassDEP's efforts to address the applicant's expressed needs for operational flexibility and desire to avoid relying on a model to develop protective discharge limits.

As a general matter, Dr. Richkus finds the draft permit too strict and too complex, complaining of the 230 page long explanation EPA and MassDEP assembled to support the limits in the draft permit. EPA and MassDEP generally find his assessment difficult to reconcile with both his own proposed template for responsible thermal limits and the needs of the applicant. As discussed below, the formula he recommends on which Maryland relies to address thermal discharges would appear to be considerably more restrictive than the limits in this permit. Therefore, it is hard to understand how he concludes that the draft permit is too strict. Moreover, his description of EPA's basis for developing protective in stream temperatures suggests he may not have grasped the entirety of the analysis the permitting agencies presented in those 230 pages. On page 3 of his comments, Dr. Richkus asserts that EPA and MassDEP derived the instream temperatures "[b]ased on literature data." EPA and MassDEP did start with literature data, but then tempered those values considerably based on the ambient characteristics of the lower Basin. Dr. Richkus did not make note of this step in the analysis.

EPA and MassDEP have no quarrel with Dr. Richkus's general observation that this is a complex permit. What Dr. Rickkus is not in the best position to appreciate, however, is that the complexity of this permit is almost entirely the product of the applicant's expressed need to discharge more heat than would be allowed by a simple set of end-of-pipe limits modeled to assure protective in-stream temperatures. In brief, Mirant's desire to use the actual, real-time assimilative capacity of the river, which a model by necessity must underestimate, makes this permit more complex than permits typically issued by EPA New England and MassDEP. If the applicant were prepared to offer a set of simple end-of-pipe discharge limits that were genuinely protective of the BIP, EPA and MassDEP would gladly consider them in an effort to reduce the monitoring burden on Mirant and the enforcement burden on the Permitting Agencies. But it appears that such limits would further restrict the Kendall Station's operational flexibility.

EPA and MassDEP have selected the most important statements in Dr. Richkus' review and present an assessment of these statements below:

Dr. Richkus: Pg. 3, Par. 4: "One statement made in the Fact Sheet□.'The Facility's operation is believed to have a significant impact on the water quality and aquatic populations that exist in the Charles river from the mouth of the river upstream to where the river passes Watertown□' does suggest that some prejudgment on the facility's effects may exist since this specific statement does not appear to be substantiated by the detailed material presented in the determination document."

EPA and MassDEP disagree that pre-judgment took place. First, there is clear evidence that Kendall's discharge has a significant effect on the physical water quality of the basin. The DD substantiates these effects with frequent examples of water temperature impacts. Mirant's data show conclusively, for example, that ambient temperatures found well-upstream of the facility are lower than those downstream of the facility, especially in the summertime during periods of low-flow. Modeling by the permittee, which was not accepted by the agencies but has been used as a general guide, has shown that the facility has a great potential to heat the lower Basin and field data have verified that river temperatures have been pushed well beyond the 83 ºF standard for warm water streams due to releases of heat from the discharge. Numerous field measurements conducted by EPA, USGS, Mirant and a variety of state resource agencies have confirmed that the facility's thermal releases cause water temperatures to be warmer than ambient temperatures. Thus, Dr. Richkus' statement that the agencies have not substantiated the fact that the facility has a significant impact on water quality is not consistent with the data record.

In any case, the Permitting Agencies disagree with Dr. Richkus characterization of the information presented in the DD regarding Mirant's effects on the aquatic community in the Charles and any alleged "prejudgment." Judgments regarding effects were based on data collected and analyzed both by Mirant and the resource agencies. Further, merely because this statement was made early in the Fact Sheet does not mean that it represents a conclusion drawn prior to this analysis. Rather, the statement provided a short overview of the conclusions the permitting agencies had reached after assessing the available data.

Dr. Richkus: Pg. 4, para. 2. Dr. Richkus states that the "context for my general opinion of this draft permit is the thirty years of experience I have had in assessing impacts of power plants in Maryland and making recommendations to Maryland's permitting agency on thermal discharges from those plants." Dr. Richkus goes on to state what the requirements are in Maryland regarding thermal discharges. They are summarized here:

a) the maximum allowable discharge temperature in Maryland is 32 C (89.6 ºF);
b) mixing zones may not exceed 2 ºC (3.6 ºF) above ambient as a 24-hr temperature over more than 50% of the river;

c) the 24-hr. average temperature may not exceed 2 ºC (3.6 ºF) over ambient over more than 5% of the bottom passed by 6 hrs. of streamflow; and

d) the 24-hr average temperature may not exceed 2 ºC (3.6 ºF) above ambient over more than the distance traveled by stream flow in 6 hrs.

Dr. Richkus also states that, based on his experience in dealing with facilities that meet these criteria, his agency found no evidence that fish movements were blocked by thermal plumes in the plant's receiving waters.

These statements bear further examination. Based on the information below, it is fairly clear that permit limits for Maryland thermal discharges are much more restrictive than are those proposed for Kendall in the draft permit:

Variable	Maryland	Mirant Kendall Draft Permit
Max. Discharge Temperature	89.6 °F	105 °F
Delta Temperature in Mixing Zone	3.6 °F (24-hr avg)	No limit- may be 20° F over ambient due to T of discharge
Cross-Section Allowed to Exceed Bottom area	50%; 3.6 °F > ambient; Over 5% of bottom passed in 6 hrs of stream flow	50%, but at much higher T; No limit in Zone of Dilution; By comparison, 5% of the bottom passed in 6 hrs would be a very small section of the bottom in the summertime

Dr. Richkus states that facilities not meeting the Maryland criteria were required to evaluate the effects of their discharge on the "balanced indigenous population" (actually, the community of organisms) in the receiving waterbody. All the facilities mentioned in Richkus' preamble to his comments had only small, localized effects. Dr. Richkus states that "all studies conducted at Maryland facilities over a period of 30 years have confirmed that the simple thermal mixing zone criteria specified in Maryland's regulations are protective of the biotic communities in the vicinity of the plant discharges."

EPA and MassDEP have demonstrated above that the Maryland mixing zone criteria are substantially more restrictive than those developed for the Kendall draft permit. Therefore, Dr. Richkus' preamble does not appear to support the argument presented in his more detailed comments that follow. This preamble presents the unsurprising observation that when more restrictive permit limits are required, no wide-scale effects were found. EPA and MassDEP agree that more restrictive permit limits would result in less impact. This preamble could be interpreted to signal Mirant's intent to substitute more restrictive thermal criteria along the lines of the Maryland criteria as outlined in Dr. Richkus' review for those in the Kendall draft permit. However, this more conservative thermal approach does not appear to be included in any other comments or alternative approaches submitted by Mirant.

Dr. Richkus: Page 5, paragraph 2: Dr. Richkus states that the conclusions drawn in Maryland are based primarily, but not exclusively, on results of field studies assessing the status of fish population and communities present in receiving waters.

In response to this comment, see Response C23.

Dr. Richkus: Page 5, paragraph 3: Dr. Richkus states that the draft permit is unnecessarily complex. His example of this complexity is "the specification of four-hour average temperatures as the basis for assessing compliance with temperature limits."
The comment incorrectly implies that four-hour averages are exclusively used throughout the permit to assess compliance. This is not the case. In the permit there are two basic types of temperature requirements. First, there is the delta temperature limit. This is not a 4-hour average limit. It is a 24-hour average value. The second type of limit is the maximum temperature limit for each of a number of different temporal periods. These are calculated as 4-hour averages.

EPA and MassDEP might agree with Dr. Richkus that 4-hour temperatures "at a <u>single</u> horizontal and vertical point with a water body, have little biological meaning for mobile organisms such as fish." EPA and MassDEP disagree vigorously, however, that this is a fair characterization of how the permitting agencies are using the 4-hour temperature limits to protect the BIP. With the possible exception of the monitor on the surface at the Boston side of the lower Basin designed to protect access to the surface for the BIP, no single monitor or 4-hour time period is assigned individual biological significance in the draft permit. The permit is designed to protect a temperature profile across a cross-section of the lower Basin so that the collection of all the temperatures across the grid of monitoring points assures a reasonable zone of habitat and passage for the BIP. The permit becomes complex precisely because it gives the permittee the flexibility, during most of the year, to heat up the Basin in almost any configuration of 50% of the grid points depending on the flow conditions of the river. A single responsibly located monitoring point might well have simplified the permit writer's task, but it would have further curtailed Mirant's ability to add heat to the Basin. The rationale for 4-hour sampling specifically is provided in Section 5.10.3b of the DD and further described in Response D3.

Dr. Richkus also states that in his (1974a) statistical analysis of factors influencing migration patterns over the course of the annual spawning run, 24-hr. average temperatures were used. While this statement is true, were it not for the fact that Richkus also tracked hourly temperatures, he would not have found that there was a substantial drop in movement of adult alewives into freshwater at temperatures higher than 18 C (64.4 F). The following is taken from his 1974 paper, with annotations in brackets provided:

In the Annaquatucket river, very little movement through the fishway was recorded when

> water temperatures were below 8 C [Hourly measurements were presented in the bulk of the Richkus figures]. As a result, fish movement during early portions of the run was recorded only in late afternoon. At the end of both spawning runs, fish movement tended to be low when water temperature exceeded 18 C [Again, hourly temperatures were presented]. Daily peaks of movement then occurred in the morning, at daily temperature minima. These data indicate that temperature acts as a gating factor, determining whether fish present at the entrance to the stream or estuary will enter and move upstream.

Thus, while some of Dr. Richkus' statistical analyses involved 24-hr average temperatures, he used hourly temperature data to find the temperature maximum at which there was a sharp drop in run strength over a daily cycle of temperatures. Information of this sort is vital to development of site-specific temperature limits.

In Richkus' studies, and in many others, alewives were found to move up into freshwater during daylight hours. Because temperatures typically rise during daylight hours and fall at night, the use of a 24-hour average temperature of, for example, 65 F, might only allow a few hours for fish to enter the Charles if most fish avoid moving into water that is higher than 64.4 F. This is because most of the cooler temperatures would occur at night when fish do not typically enter freshwater. Because the locks at the New Charles Dam are only opened on occasion during the day, further reduction in time allotted for the run will occur. As a result, the 4-hr. temperature average seemed appropriate in this particular setting. Different criteria might be more appropriate in other settings, such as those referenced by Richkus in Maryland.

A detailed explanation of the use of 4-hr. averages is provided in EPA and MassDEPs' Response D3.

Dr. Richkus: Page 5, para. 5: Dr. Richkus states that the Agencies have, for the most part, dismissed or discredited certain empirical data submitted by Mirant.

EPA and MassDEP have examined all data presented by Mirant. After consideration, in some cases, valid concerns were raised regarding data presented by the permittee. The rationales associated with the concerns were included. Examples are the tables discussed in EPA and MassDEPs' Response C5. Reasons for these actions are discussed in the DD and elsewhere in these responses to Mirant comments. Dr. Richkus did not specify a particular data set that he felt was unjustifiably dismissed or discounted. Without specific identification of this data, EPA is unable to address this comment effectively.

Moreover, Dr. Richkus's comment seems to ignore completely the extent to which EPA and MassDEP did temper a literal application of temperature values taken from the scientific literature with adjustments designed to reflect empirical observations and data taken from the lower Basin.

Dr. Richkus: On Page 6, Section 5.0 Comments Relating to Citations of Richkus (1974a), Dr. Richkus takes issue with the fact that the DD uses information from his 1974 paper to conclude that many fish appeared to avoid temperatures in excess of 64.4 ºF. Rather, Dr. Richkus concludes that the sharp decline of fish movement into the freshwater system at temperatures above 64.4 ºF is "simply the beginning of the end of the run," and that he interprets this as "being the temperature that corresponds to the natural end of the seasonal migration period, not an avoidance temperature."

While EPA and MassDEP are cognizant of the consideration the permitting agencies should give Dr. Richkus's current views in citing conclusions from reports of his own research, it is nevertheless reasonable for the permitting agencies to look at the data that he collected to examine the post hoc interpretations he now presents about the meaning of his research. As a result, EPA and MassDEP disagree with Dr. Richkus' current interpretation of his 1974 research for several reasons.

First, if the 64.4 ºF temperature were not an avoidance temperature, there should be no difference in hourly patterns of fish entry in the freshwater system at temperatures higher than 64.4. But there was a difference in hourly patterns, which was pointed out by Richkus in the 1974 paper. As water temperatures rose above 64.4 ºF temperature over the course of each day towards the end of the 1971 and 1972 runs, fish movement into the freshwater system sharply declined.

Second, the patterns of fish movement into three other systems in Massachusetts and New Hampshire were similar to that in the Annaquatucket studied by Richkus (see DD, Table 5.7.Cc-3). In the 19 separate runs (three separate systems) the vast majority (typically 95-99%) of fish moved into these systems at temperatures below 66 F. Fish movement into these systems dropped sharply at temperatures higher than this temperature value. The record further shows that almost all of the 19 runs followed the same thermal pattern seen by Richkus in his two-year study. His statement that "this pattern of arrival is coincidental with a particular temperature regime" could be interpreted as a weak correlation between fish arrival and water temperature. In fact, all the runs for which there is data show the same approximate upper limit. To the permitting agencies, it appears that the strong coincidental nature of this upper thermal limit across so many runs fully supports the reasoning that the upper thermal limit is an avoidance temperature. Dr. Richkus appears to imply that there was a steady climb in temperatures throughout the anadromous fish runs evaluated by the state, and that, serendipitously, fish stocks were essentially depleted on the day that instream temperatures finally climbed to 65 F. This was not the case, however. Temperatures in the streams evaluated by the Agencies did not simply rise over time. Water temperatures rose and fell well above and below the mid-60s over the duration of the run. During those times when temperatures were below this level, many more fish entered the freshwater systems than did when temperatures were above this level. The same phenomenon occurred in the Richkus studies. This is evidence that most fish were avoiding entering the system when temperatures were high.

As described in the discussion included in Response C3 of this document, different individual fish are expected to have slightly different avoidance temperatures. The fact that some fish, though relatively few, entered the system at temperatures higher than 64.4 ºF is evidence of this. More importantly, entry at temperatures above 64.4 ºF in the Richkus studies was sharply curtailed. Runs in Massachusetts and New Hampshire followed the same pattern.

Third, laboratory work conducted by Graham (1956) showed that 50% of adult alewives acclimated to a temperature of 50 ºF died when transferred to a temperature of 68 ºF. Because of this, avoidance temperatures of fish acclimated to about 50 ºF are expected to be much less than the 68 ºF. This laboratory information complements the field data sets from Massachusetts, Rhode Island and New Hampshire in those streams where there is temperature and run-strength data for fish entering the freshwater systems.

Dr. Richkus: Page 7, 2nd paragraph: Dr. Richkus states that there were several examples of "unsupported speculation" in the DD. EPA and MassDEP address this allegation of speculation as follows, starting with a reference to each of the assertions, in Dr. Richkus's words, that he asserts are unsupported:

1. DD at [page] 92: "a small subset of the total population "[of alewives] "is likely to run at temperatures higher than the 64.4ºF value, but it is assumed that a much larger proportion will refuse entry to the lower Charles at temperatures above this value."
   EPA and MassDEP have explained the reasons for this observation in the response to Dr. Richkus' comments directly preceding this entry, and disagree that the permitting agencies are speculating.

DD at [page] 45: "a statement that fish aggregated at dams experience increased predation and harvest."

The concentration of migrating fish downstream of an obstruction is commonly observed to experience intense predation from birds, predator fish, and man's activities. These predators take advantage of the large numbers of fish "piled up" in one location. In the site-specific example of the lower Charles River Basin, observation of fish aggregated at the mouth of the Charles River have coincided with elevated angling pressure and the activity of predator fish, most notably striped bass (*Morone saxatilis*), feeding on the schools of river herring waiting to enter the river from the locks (J.H. Nagle, personal observation, April, 2002).

Fish aggregated at the base of the Watertown Dam have been observed being removed by a number of fishermen using nets to capture large numbers of river herring to use as bait fish (D. Webster, pers. comm., April, 2002). Indeed, as part of their November 14, 2005, Marine Fisheries Advisory, MADMF has instituted a three year moratorium on the harvest, possession, and sale (322 CMR 6.17) of river herring in response to recent drastic declines of many river herring spawning runs. This applies to river herring in the Commonwealth or in the waters under the jurisdiction of the Commonwealth and these actions are prohibited through 2008. This includes the Charles River.

DD at [page] 46: "fish exposed to stressor of a constricted, man made fish passage may be less able to cope with stress of elevated water temperature."

It is a generally accepted biological principal that stress from one source will likely lower an animal's ability to cope with other stressor. That is one reason why laboratory testing exposes the target organism to varying levels of one environmental stressor while all other environmental conditions are maintained within an optimal range. When multiple stressors are tested on an organism at the same time, the threshold response to the level of the stress has been documented to be more sensitive than when only one stressor was tested. There are many examples of this type of response in the scientific literature. One example has been included here: Synergistic effects of acidity and aluminum on fish (golden shiners) in Louisiana, Robinson, J.W.and Deano, P.M., January 1985, Journal of Environmental Science and Health, Part A:Vol/Issue A20:2).

DD at [page] 47: "shading from bridges represents stress on fish."

Photoperiodism and sensitivity to light have been documented to be important cues in anadromous fish behavior. One factor that is thought to influence the spawning movement of anadromous fish is the position and duration of sunlight. Shading in a river has been observed to possibly contribute to avoidance behavior in anadromous species. Shading from bridges may interfere with this response to light. Section 5.10.4a of the DD, which referenced Dixon (1996) and Loesch *et al*. (1982), fully support this position.

Dr. Richkus: In paragraphs 4 and 5, page 7, Dr. Richkus takes issue with statements in the DD that fish waiting to move upstream will experience large changes in temperature when moving from Boston Harbor into the Charles. He states that temperature data provided to him by Mirant for the spring months of 2000 indicated that delta temperatures (above and below the Charles Dam) differed by only 2-5 ºF, and data show that there is a shallow lens of warmer, less saline water present near the surface below the dam. He later compares temperature differences seen in 2000 with those that he has seen in Narragansett Bay where fish successfully moved upstream.

EPA and MassDEP considered several interactive factors in evaluating the delta temperature information. First, alewife adults typically enter freshwater systems during the daytime. Second, during daylight hours, alewife adults are expected to be located well below the surface, out of the well-lit area where their predators would be able to track them by sight. Therefore, bottom or mid-water column water temperatures in Boston Harbor are more likely to be determining acclimation than are surface water temperatures.

Delta temperature differences between the river and the surface temperature in Boston Harbor seen in 2000, when the facility was not operating at full power, are not those requested by the facility, nor are they the point of contention.

The question that was addressed by EPA and MassDEP is: what is the upper limit of a delta temperature that should be allowed? In evaluating this question the permitting agencies compared the site-specific temperature limits set for the Charles (i.e., draft permit limits) with temperatures in Boston Harbor during immigration of alewives. Boston Harbor temperatures in April and early May are in the mid-to-high 40s (º F) as outlined in the DD (see Table 5.7.3c-4). The draft permit sets a permit limit of 65 ºF at Station 8 (near the New Charles River Dam Locks) for April 15-May15. This would allow nearly a 20 ºF rise in temperature between the harbor and the Charles, not the 2-5 ºC (3.6-8 ºF) rise supposed by Dr. Richkus. Thus, Dr. Richkus' comments are inconsistent with the maximum allowable temperatures being evaluated.

Dr. Richkus: On page 8, paragraphs 2 and 3, Dr. Richkus appears to take issue with setting an upper maximum temperature for the Charles River during the springtime anadromous fish run. He states that "migration occurs over widely varying temperatures and... it is not possible to predict what a 'suitable' temperature for fish movement is at any given time."

EPA and MassDEP strongly disagree with Dr. Richkus' apparent contention that it is inappropriate to set an upper temperature maximum in the spring. Setting upper thermal maxima for incoming alewives is important to ensuring the maintenance of the balanced indigenous population of this fish species in the lower Charles because of Kendall Station's documented ability to raise water temperatures. Reasons for this concern include: a) the fact that massive adult alewife kills in the Great Lakes have been linked to sudden temperature rises (Graham, 1956 and Otto et al., 1976); b) the laboratory work by Graham (1956) that establishes an LC50 of 68 ºF for alewife adults acclimated to 50 ºF; c) the close correspondence between the 64.4 ºF temperature in the Richkus studies, above which alewife run strength drops substantially (even over a 24 hour time series), and end-of-run temperatures seen in 19 alewife runs in Massachusetts and New Hampshire.

Due to the factors discussed in this response, EPA and MassDEP take the position that setting upper thermal maxima in this system is a reasonable approach to protect the BIP. In addition to the reasons stated above, the lower Charles has been shown to be an impaired waterbody and the Kendall discharge has the potential to increase water temperatures to the level where areas of exclusion and/or toxic effects (to eggs and larvae) would result if no limits were in place. The permittee has failed to present sufficient, compelling information to address this concern. EPA and MassDEP fully understand that it is a difficult task to set appropriate thermal limits, and that there is a complex array of data from which judgments must be made. However, this does not change the contention that limits must be set to protect the BIP in the lower Charles River Basin.

Dr. Richkus: On page 8, paragraphs 4 and 5 through page 9, paragraph 1, Dr. Richkus questions the reasoning presented in the DD pertaining to outward migration of juvenile alewives in the late summer and fall. The DD states that there is a concern that warm water from the discharge has the potential to delay outward migration, and further, that this delay could result in increased predation to juveniles. Dr. Richkus states that outward migration is not triggered by a particular low temperature, but rather, by large downward fluctuations in temperature, such as those that take place during rain events. In addition, Dr. Richkus speculates that predation of juveniles in estuaries would be higher than that seen in the freshwater system. The logical extension of this position, in the view of the Permitting Agencies, is that even if the facility's discharge were to hold back outward migration, survivability might be improved rather than decreased.

EPA and MassDEP maintain that outward migration typically occurs from September through mid-November, and in at least one system, well into December (see Response to C27). Due to low river flows, during much of this time the Kendall Station discharge will have a sizable influence on water temperatures in the lower Basin. Although Dr. Richkus provided information on downward migration occurring in waves being triggered by an abrupt decline in temperature, abrupt declines at sites upstream of the Kendall discharge will be ameliorated by the discharge. Thus, fish exposed to an abrupt decline at upstream sites will encounter a zone of much warmer temperatures. Delta temperatures between upstream and down will run up to about 5 ºF in the

ZPH, but will run much higher on the Cambridge side in the Zone of Dilution. Dr. Richkus' information did not address a situation such as that presented by the Kendall discharge and the Permitting Agencies still have a concern regarding slowed or protracted out-migration.

Regarding survival if outward migration is slowed: Cooper (1961) found extremely high mortality in alewives within the freshwater system prior to seaward migration. He stated that:

> The success of spawning, in terms of numbers of juveniles migrating to the sea, was exceptionally low during the 1959 season. Less than one juvenile entered the sea for every adult that reached the spawning grounds.

Thus, it appears that the potential for high mortality to larvae and juveniles within the freshwater system does exist.

It can not be declared for certain whether a protracted or deferred out-migration has a negative impact on the alewife population. Information from another alosid species, the American shad, does support the assumption that deferred out-migration would lower the survival of juveniles. The following is taken from Klauda, et al. (1991):

> Estimates of juvenile American shad mortality rates in the nursery areas [of the Connecticut River, studies of Crecco, et al. 1983] range from 1.8-2% per day. Thus, if the juveniles remain in the nursery areas for three months before emigrating seaward, their survival rate would be about 30%. Conversely, 70% of the juveniles would perish before reaching the ocean [based on Richkus and DiNardo, 1984] assuming constant mortality rates during the larval and juvenile stages. Longer residence times in freshwater and brackish areas would further reduce first year survival of American shad cohorts.

In contrast, higher temperatures are expected to increase growth rates. This may result in fish becoming larger sooner and possibly leaving the system earlier. On the other hand, if out-migration is primarily stimulated by large temperature fluctuations, and the facility plays a role in ameliorating these fluctuations, juveniles would be expected to remain in the system longer.
Dr. Richkus: In paragraph 2, page 9, Dr. Richkus takes issue with the fact that the DD states that "...Richkus noted that alewives spawn at temperatures much higher than those at which they first enter"

EPA and MassDEP agree that the reference to Richkus (1974) was incorrect. However, it is not agreed that the temperature information is incorrect for two reasons. First, Mullen et al., (1986) states that Cianci (1969) found that the minimum water temperature that spawning begins in alewives is 10.5 ºC (50.9 ºF). Richkus (1974) states that alewives were observed entering the freshwater system at much lower temperatures: 7.5 ºC (45.5 º F) in 1971 and 6 ºC (42.8 ºF) in 1972. In addition, Edsall (1970) states that alewives stop spawning at 27 ºC (80.6 ºF). Since alewives were seen entering the system at temperatures well below those at which they are known to spawn, and have been seen spawning at temperatures well above those at which they have been known to enter freshwater systems, we assumed that it was appropriate to state that "alewives spawn at temperatures much higher than those at which they first enter".

The second reason for this statement, which was not fully explained, applies to systems like the Merrimack. Alewives are known to move over 26 miles upstream to spawn. Because springtime water temperatures continue to rise during the period in which movement upstream occurs (which may take over a month), it appears appropriate to assume that spawning temperatures for any particular fish are typically higher than temperatures at which entry to the system occurs. EPA and MassDEP agree with Dr. Richkus that there may be exceptions to this expected occurrence, especially for alewives that enter during the middle of the run and spawn in a location close to the point of entry.

Comment C7 (Part I): Section 5.4 of the DD lays out several environmental and man-made stressors that are present in the lower Charles River Basin. The EPA then proceeds, without any foundation in the record, to speculate that these stressors adversely impact the ability of the River's population to cope with the additional stress of elevated temperatures. Based upon this speculation, the EPA justifies the development of thermal limits which "incorporate safety factors to account for multiple environmental stressors," resulting in maximum thermal limits that are below limits specified in relevant literature. This approach is unsubstantiated by any record evidence and directly leads to overly stringent thermal limits. EPA should eliminate such safety factors in setting its thermal limits or should identify its specific evidentiary basis for each instance in the permit where a hypothetical basis for historic thermal stress is alleged.

Response to C7 (Part I): In the DD, EPA does not state with certainty that the environmental stressors present in the Charles River adversely impact the ability of the River's population to cope with the additional stress of elevated temperatures. Instead, EPA maintains that "The cumulative effect of these stressors may reduce an organism's ability to cope with any one stress (Leggett and O'Boyle, 1976)." Regulations require EPA to consider all stressors that may affect the indigenous fish populations in a water body when setting thermal limits for a facility's discharge. It would have been useful if the permittee had performed a qualitative and quantitative evaluation of these stressors as part of their 316(a) variance request, but this important issue was not addressed comprehensively in Mirant's permit application. The potential negative impacts of stratification in the lower Basin were identified by the permittee, but only in relation to speculation regarding future benefits of a proposed deep water diffuser. Therefore, a general discussion and listing of likely stressors to the indigenous fish populations was considered appropriate as the draft permit was assembled.

EPA and MassDEP are not sure what the basis is for Mirant's assertion that the discussion of stressors in section 5.4 is "without any foundation in the record." Each of the characteristics EPA describes is documented by reference to either personal field observations or studies of the area. Admittedly, some of the characteristics were not the subject of extensive analytical study; however, it does not require a thorough engineering survey to appreciate that the shoreline of the lower Basin on the Cambridge side of the river near Kendall station has been considerably altered by man-made structures. And in virtually all cases EPA refers to studies in the scientific literature that document why a given characteristic may stress the BIP.

EPA's development of the record concerning these stressors was appropriate given the relatively slight weight they were accorded in our overall analysis of temperatures required to protect the

BIP. These potential stressors combine with several other general factors to lead EPA and MassDEP to err on the side of protecting the BIP in the face of uncertainty about the science. Most notable among these other general factors are 1) the burden of proof Mirant carries and failed to meet to affirmatively demonstrate that its proposed discharge is consistent with protecting the BIP and 2) the significant value EPA and MassDEP place on protecting the lower Basin. Therefore, it is inaccurate to point to this general survey of stressors as the sole or even primary reason EPA and MassDEP chose any particular temperature limit in the permit.
In addition, EPA and MassDEP examined site-specific biological and water quality data and scientific literature to establish the protective temperatures for the permit. These limits did not incorporate a full 100% habitat suitability index as a way to provide a safety factor for the indigenous fish populations. In most cases, the suitability index temperature was in the range of 50% suitability or less. The safety factors considered for the final permit are not "overly stringent thermal limits." The comment made by Tidwell in Comment C8 (below) further supports the contention that one type of stress on a fish may influence the way they cope with temperature sensitivity.

Comment C7 (Part II): Upon reviewing the Draft Permit, Mirant Kendall has investigated whether fish from the Charles River exhibit any generally acknowledged symptoms of overall stress. Specifically, MRI examined the length/weight relationships of the fish compared to the data from other systems for which data were available. For YOY alewives, data from the Charles River were compared to data from North Carolina coastal waters and from Seneca Lake, New York. As documented in MK Comment Ex. No. C7, the Charles River fish compared favorably to both populations. While Mirant Kendall does not suggest these results to be determinative, they provide a good first indication that the Agencies' speculation about multiple stresses is likely exaggerated

Response to C7 (Part II): EPA and MassDEP acknowledge that definitive stress to individual fish has not been clearly documented under the metric of length/weight relationship for fish in the lower Basin. Mirant references an analysis of data conducted by their consultants on early life stage information in which the consultant found that early life stages of alewives in the lower Charles grew at an accelerated rate when compared with other populations. This finding is not necessarily consistent with the idea that the fish in the lower Charles are not stressed. Mirant's findings led EPA and MassDEP to compare this information with data from Kellogg (1982). That researcher found the growth rate of early life stage alewives that survived high temperature exposures increased substantially as the exposure temperature increased. However, the mortality rate of the fish used in the experiment greatly increased with rising exposure temperatures (see Response C44). EPA and MassDEP note that very few juvenile and adult alewives have been captured by Mirant in comparison with bluebacks, a more heat-tolerant, sympatric congener. The potential relationships among a) high growth rates, b) reduced presence of alewives in the lower Basin compared to bluebacks, c) differential heat-tolerance of these congeners, and d) high temperatures in the lower Basin, have not been explored.

In addition to the above, measurements other than length/weight relationships, are also used to evaluate stress on individual fish (e.g., organ weight and color, parasites, stomach contents, lesions and malformed organs and appendages). None of these additional metrics have been sufficiently explored to more fully evaluate physically manifestations of stress on the lower

Basin fish populations. It is clear that potential stressors are present in the lower Charles River Basin. It remains to be shown how the majority of fish respond to these stressors. In the absence of this information, and in light of the other general factors militating toward a conservative approach, it is reasonable for the Permitting Agencies to take a conservative approach in establishing protective temperature limits.

Comment related to C7 from CLF: The proposed conditions for the Lower Basin will add temperature shock to the list of stressors affecting migratory fishes as they are forced to make the abrupt transition from the Basin to the sea at the locks. It is common knowledge that sudden changes in water conditions such as temperature, salinity and pH, stress fishes, often killing them. Due to the absence of well designed fish-ways through the dams in the lower Charles, the fishes that migrate in and out of the river are forced to experience highly unnatural shifts in water conditions. For example, they are not able to move gradually from salt water to freshwater as they did throughout their evolutionary history, but rather are plunged from one environment to the other through the lock system. Under the proposed permit, those that survive the locks will be subjected to massive temperature changes in addition to pH and salinity changes, as well as to a habitat that has been polluted by many sources and is abnormally stratified. Though these cumulative impacts to the migrating fish have not been properly analyzed by EPA, it does not require a lot of new science to recognize that this is a serious problem that undermines efforts to re-establish healthy runs of indigenous fishes in the Charles. Sadly, migrating herring have been observed to swim into the discharge pipe and attempt to spawn. Migratory fishes have a strong, and usually adaptive, behavior that leads them up-stream (rheotaxis). In this circumstance, where the flow of water through the plant is so large compared to the flow of the river, the fishes' natural behavior short circuits its efforts to reproduce in the Charles. This effect of the discharge should be addressed.

Response to Comment related to C7 from CLF: Using the data available, MassDEP performed a considerable analysis of the likely impacts to fish related to the change in water temperature across the New Charles River Dam and Locks during in-migration and out-migration (DD Section 5.4.2 and 5.8.2). Real time continuous collection of water temperatures on both sides of the dam, along with other monitoring efforts required as part of the monitoring program of the permit will better quantify this issue. In addition, information on pH, and salinity are also required to be collected, as a way to further understand the cumulative impacts to fish migrating across the dam. While river herring have been documented swimming into the Kendall Station discharge pipe, it is not known if it is a widespread, continuous occurrence that impacts the health of the entire fish population. Part I A.14.e.8 of the Final Permit has been amended to include regular surveillance of the discharge area to quantify this behavior.

Comment C8: In Section 5.4 of the DD, the Agencies hypothesize that stresses in the wild will be greater than those in the various laboratory studies they consulted. This is speculation contrary to both (a) the generally accepted observation that fish in field studies usually show greater tolerance to stresses than in lab studies for reasons including but not limited to the opportunities for adaptation and avoidance of stress in the field, and (b) the added stress of confinement in lab studies. See, for example, the Tidwell reference at the end of Section 5**,** which states that the lab confinement was believed by the authors to lead to an unrealistically greater sensitivity to water temperature.

Response to C8: As a threshold matter, EPA and MassDEP are not prepared to adopt the approach implied in the comment Mirant makes in clause “(a),” above. The suggestion appears to be that EPA should discount the impact that temperatures studied in the lab might have in the wild, because wild fish can avoid those temperatures in the field. But “avoidance” is precisely the behavior EPA and MassDEP are trying to minimize in the Zone of Passage and Habitat. The Permitting Agencies have already given to the permittee the potential to heat roughly half the width of the lower Basin in the area of the discharge to levels that EPA and MassDEP expect will certainly cause avoidance behavior, and may cause lethality. The Zone of Passage and Habitat is meant to be the portion of the lower Basin to which the fish can retreat to avoid the potentially much higher temperatures in the Zone of Dilution. If EPA and MassDEP were to apply temperatures from lab studies in the Zone of Passage and Habitat using the assumption that an account should be made for the ability of the fish to avoid those temperatures, the assumption would essentially be made that the fish should be avoiding the entirety of the lower Basin in the area of the discharge. This approach would completely defeat the intended design of the temperature regime in the permit.

Another way of making the Permitting Agencies’ point is to observe that the permittee’s comment “(a)” does not follow the objective of the experiment. Avoidance of stress, in this case elevated temperature, would nullify the objective of the lab experiments. The objective is to determine the physiological responses of fish that are unable to escape the carefully controlled elevated temperature. The experiments are used by the Agencies to provide guidance as to what temperatures, if occurring throughout the habitat, would result in chronic and acute stress, including mortality, when so much of the habitat is affected that avoidance is not possible.
EPA and MassDEP acknowledge that when fish are confined in an experimental tank, it is a potential source of stress. EPA and MassDEP still maintain that the assemblage of physical conditions in the lower Basin result in a greater set of stressors upon indigenous fish populations than would be encountered in a more typical free flowing stream or in the reference tank of a controlled experiment. In order to test the response of the fish to a single stressor, peer reviewed toxicity tests generally remove other stressors the fish are exposed to in their natural environment, such as pursuit by predators, poor water quality, sparse food availability, etc.
In addition, the remark cited by Tidwell supports the EPA and MassDEP position that one type of stress (lab confinement) that fish are exposed to can lead to greater sensitivity to water temperatures. If one type of stress is believed by researchers to diminish a fish’s ability to tolerate higher water temperatures, this should also hold true for stressors in the wild.

Comment C9: In DD Section 5.4.1, the Agencies hypothesize that exposure to water quality in the Harbor may make anadromous fish less able to cope with elevated temperatures once they enter the river. Mirant Kendall encourages the Agencies to revisit this speculation by comparing the specific water quality conditions in Boston Harbor to those in the Charles River. Mirant Kendall believes that the Agencies will find that due to stratification in the river, the parameters they cite (especially low dissolved oxygen and contaminated sediments) in the river will likely be worse (in the absence of the proposed new outfall and diffuser) than the fish will find prevalent in the Harbor. In fact, in Section 5.4.4, the Agency seems to agree.

Response to C9: EPA and MassDEP can find no evidence that naturally occurring thermal stratification and low dissolved oxygen levels have been routinely documented to be present in the lower Basin "...once they [anadromous fish] enter the river" in the spring. Rather, when migrating fish enter the river in the late winter and spring from Boston Harbor, the lower Basin has been documented to contain sufficient oxygen from surface to bottom, with no pronounced thermal stratification for the majority of the time period (Kendall Hydrographic Data for 2004, Mirant Kendall, October 2004). This evaluation does not take into account the thermal plume from Kendall Station, which may cause certain areas of the basin to contain a warmer layer of water at or near the surface.

Based on its evaluation, EPA and MassDEP do not agree that when anadromous fish are expected to migrate into the Charles River, the water quality of the river will be worse due to stratification, than water quality in Boston Harbor. EPA and MassDEP continue to support the judgments stated in the DD concerning other stressors that anadromous fish must face when moving from Boston Harbor to the lower Charles River Basin.

Comment C9 (continued): In Section 5.4.2 of the DD, the Agencies speculate that "[i]f an anadromous fish successfully passes through the [new Charles River dam and] locks, it is immediately faced with a markedly different group of water quality characteristics. No acclimation period under intermediate mixed water quality conditions is possible." This is clearly contradicted by the vertical profile data Mirant has already supplied the Agencies for 2000, 2002, 2003, and the data submitted herein for 2004, which consistently show that during the spring anadromous runs, the surface waters of the Harbor just below the Dam and the bottom waters just above the Dam provide intermediate, mixed water quality conditions for the entering fish.

Response C9 (continued): EPA and MassDEP do not dispute vertical profile data that show some mixing of river and harbor waters just below and above the dam. The area where these waters mix is a small fraction of the intermediate mixing zone normally seen in an estuary, where incoming and outgoing tides and downstream river flows mix large volumes of water from bank to bank, setting up a gradual gradient of salinity and temperature along a large area that often stretches for miles. Add to this the observation that at certain times every day, under high tide conditions in the harbor, this small mixing zone on the downstream side of the dam (in the harbor) is shut off, as the lock is closed to prevent movement of water from the harbor to the river, and it is doubtful this mixing area provides much of a benefit for anadromous fish attempting to acclimate to water quality conditions in the river.

In addition to this observation, anadromous fish entering the river will likely be found throughout the water column and have been observed occupying a staging area below the dam that is not confined to the area immediately downstream of the open lock which transfers water from the river to the harbor. Not all in-migrating fish will be able to take advantage of this limited surface water mixing zone. Also, to avoid predation from birds and to seek desired light levels during the day, it is unlikely large numbers of fish will remain at the surface of the harbor and therefore would further be restricted from any meaningful benefit from this limited mixing area.

Comment C10: Section 5.4.3 of the DD speculates that inability to pass the Watertown Dam may make fish less able to cope with the elevated temperatures in the Lower Basin. Mirant Kendall finds this speculation implausible because the Dam is about 6 miles upstream of Kendall Station, and, therefore, fish unable to pass it are nowhere near the thermal influence of the plant. However, Mirant Kendall agrees that the inability of anadromous fish to get upstream of this dam and the subsequent dams is a major impediment to the reproductive potential of the anadromous species in the Charles River, and one that could be mitigated by the Agencies' implementation of plans for passage improvements that have existed but not been acted upon since at least the late 1980s.

Response to C10: Although the Watertown Dam is approximately 6 miles upstream from the thermal influence of the Station, any anadromous fish attempting to move past the Watertown Dam to spawn must first have encountered the thermal influence of the Station on its way upstream and must also navigate past the Station's thermal plume on the way downstream when out-migrating to Boston Harbor. The premise of the discussion at Section 5.4.3 of the DD was that the man-made constriction to passage at the Watertown Dam results in additional stress to anadromous fish. These stressed fish must then move downstream and encounter the elevated temperatures of the thermal plume from the Station as they move to the harbor. The Agencies maintain that fish that were stressed because they were blocked from upstream migration and subjected to increased predation effort may be more sensitive to elevated temperatures once they encounter them further downstream. See Response C3 for a discussion of improvements at the Watertown Dam that may be providing some relief from these stressors.

Comment C10 (continued): In Section 5.4.6, the Agencies also expressed concern that shading from bridges may cause spawning anadromous fish populations to be less able to cope with elevated water temperatures in the Lower Basin. Mirant Kendall's tagging and tracking studies of spawning anadromous fish (alewives and blueback herring) in 2002 and 2003, which were provided to the Agencies in November, 2003 (see Comment C2), lend no support to this speculation. To the contrary, they indicate that both species move easily through the area of elevated water temperature.

Response C10 (continued): EPA and MassDEP recognize the dedicated effort made by Mirant Kendall to attempt to characterize river herring migration patterns through fish tracking studies. EPA and MassDEP reviewed the fish tracking data submitted by the permittee in November, 2003. While the data shed light on the upstream movement of the anadromous fish that were tagged, this data do not fully support the statement that "both species move easily through the area of elevated water temperature." While 42 percent of the tagged alewife made the initial journey between the locks and Harvard Bridge in less than a week, only 20 percent of the tagged blueback herring had the same outcome. The blueback herring study showed that, of the 10 fish successfully tracked, 6 fish took six days or longer to travel initially from the locks to Harvard Bridge and 2 fish never traveled past the Longfellow Bridge. The most recent alewife and blueback studies were conducted to demonstrate the effect of the facility upgrades (see Comment C2) on the anadromous fish. However, with only 19 fish tagged, the N size is judged to be too small to draw definitive conclusions.

Comment C11: Section 5.4.11 of the DD states that "[t]he attraction to the faster moving water of the Kendall Station discharge may delay or completely inhibit the migration of river herring. The percentage of the population that is confused and fails to migrate in time is an unknown." This speculation is contrary to the results of Mirant Kendall's river herring tagging and tracking studies in 2002 and 2003. These studies showed that few, if any herring lingered at all (less than 10 percent of those tagged), and that all passed upriver in less than a week during the four-to-eight week spawning period.

Response to C11: As stated in Response C10, EPA and MassDEP cannot conclude from this data that the Kendall Station discharge does not delay or inhibit to some degree the migration of river herring.

Comment related to C11 from Roger Frymire: Once we got the herring runs back in the late 1990's, the one place where the herring seem to be the thickest is at the outfall pipe into the Charles River and actually trying to swim up the outfall pipe. I don't know if the plant was running at that point, so I don't know if the water was super hot at that point. It doesn't seem to affect the herring the one time I've seen them.

Response to Comment related to C11 from Roger Frymire: EPA and MassDEP are aware of the observation (at least one incident documented with video tape) of river herring attempting to swim into the discharge pipe at Kendall Station to spawn. Since the scope of this potential disruption in anadromous fish spawning has not been quantified, EPA and MassDEP have included a surveillance program in the final monitoring plan to determine the extent of this activity. Part I A.14.e.8 of the final permit has been amended to include regular surveillance of the discharge area to quantify this behavior. See Response Related to C7 from CLF.

Comment C12: Sections 5.4.4 and 5.4.5 of the DD address concerns regarding water quality conditions, including eutrophication in the Charles River, which are believed to adversely impact both fish and zooplankton populations. These are water quality conditions that could be directly benefitted by operation of the new outfall and diffuser, which the draft permit fails to approve. Additional concerns identified in Sections 5.4.10, notably, low dissolved oxygen, could also be mitigated by incorporation of the proposed diffuser.

Response to C12: As previously stated in the permit and supporting documents, EPA and MassDEP believe that there are potential benefits and drawbacks to an outfall diffuser. The diffuser has not been allowed at this time because sufficient data has not been presented to indicate whether the potential negative water quality impacts will predominate over the water quality benefits with the diffuser discharge. See generally the Response to Comments in Section E.

Comment C13: In Section 5.5.2 of the DD, the Agencies note that site–specific data from 2002 and 2003 and amended proposals were "evaluated as time permitted," with the intent to consider fully that information prior to issuance of a final permit. Mirant Kendall believes the choice to defer consideration of this recent, Charles River specific data, and to base the proposed temperature and time limits on non-site specific data and literature sources, makes the Draft Permit so flawed as to require a second draft. The following are a few examples of how failure to consider the more recent information would leave the Agencies without an understanding of (a) how the plant did not cause appreciable harm when operating at levels representative of those proposed for the future, and (b) in situations where river temperatures exceeded, without appreciable harm, proposed limits now evident to have been set too low by the Agencies in the Draft Permit.

Response to C13 (a): A full discussion of appreciable harm is included in Response C3, including an assessment of the affects of Kendall Station's operations since the spring of 2003. EPA and MassDEP dispute Mirant's position that Kendall Station's operation in past years is representative of future operation. Response B1 provided evidence to support EPA and MassDEP's position.

Response to C13 (b): While evidence of appreciable harm is presented in Response C3, EPA and MassDEP acknowledge that it is possible that ambient water temperatures in the lower Basin could exceed the thermal limits in the permit for brief periods without causing measurable harm to the indigenous population of fish. This acknowledgment is clearly demonstrated in the section of the permit that allows the Station to add waste heat to the receiving water under certain conditions when ambient spring time temperatures exceed the temperature limit in effect at the time. The intent of the temperature limits and maximum delta T allowance are to ensure that protective temperatures are not exceeded for unnatural, extended periods of time.

Comment C13 (c): The Station upgrade was completed in late summer 2002 and new market rules for electrical dispatch went into effect in spring 2003. Only thereafter do the plant operations and river monitoring data reflect the higher utilization rates representative of proposed future operations (e.g. 83% of permitted maximum capacity in July 2003, more than 50% overall for the summer of 2003, and about 70% in April 2004). See MK Comment Ex. No. B1.

Response to C13 (c): Station operation and yearly summer heatload values are examined in Response B1.

Comment C13 (d): - Beginning in 2002, continuing in 2003 and 2004, Mirant conducted continuous monitoring of river temperatures upstream and in the proposed ZPH, so that the biological results can be definitively correlated with local temperature histories and demonstrate with confidence whether the organisms likely experienced particular temperatures, and for how long. For example, these data establish with relative certainty that all larval and Young-of-the-Year ("YOY") river herring experienced river-wide exceedances of the Agencies' proposed limits for more than a week in the summer of 2002, and in mid May 2004.

Response to C13 (d): The permit is designed to prevent temperature exceedances from lasting for several weeks as a result of a man-made thermal discharge. EPA and MassDEP agree that some number of Young-of-the-Year ("YOY") river herring were likely exposed to temperatures higher than the permit's proposed limits for more than a week in the summer of 2002, and in mid May 2004. First, it is not clear how this elevated temperature exposure affected the short and long term health of the blueback herring and alewife that came in contact with these elevated temperatures. Second, EPA and MassDEP do not agree that there is relative certainty that <u>all</u> larval and Young-of-the-Year ("YOY") river herring experienced <u>river-wide</u> exceedances during these time periods that would have constituted violations of the permitted limits. The continuous monitors deployed by the permittee did not measure temperatures in all the representative locations and depths specified in the draft permit. It is possible that even under the conditions identified in the summer of 2002, a sufficient number of monitoring points at the cross sectional area of the lower Basin at proposed Monitoring Stations 3, 4, 5 and 6, and at other required monitoring locations, may have met the four hour average temperature limits at sufficient depths to remain in compliance. In this way, a sufficient volume of the lower Basin may have maintained protective temperatures. EPA and MassDEP make this point as a reminder that water temperatures at or above the proposed limits can been observed in parts of the lower Basin without the ZPH being compromised. The Permitting Agencies disagree that mid-May 2004 temperatures affected juvenile river herring, as YOY do not appear until approximately mid-June.

Comment C13 (e): Age composition studies of returning adult river herring in 2002 and 2003 provide definitive evidence that all life stages of the 1999-year class appear to have suffered no appreciable harm from the river conditions in 1999, which included extreme low flows and exceedances of the proposed Draft Permit limits. A. R. Nos. 489 and 470.

Response to C13 (e): Once again, the permittee used a small amount of river temperature data collected in 1999 at selected locations, along with continuous facility intake data collected from a 12-foot thick mixed water column in the Broad Canal to predict whether the permit compliance limits in the ZPH would be exceeded. EPA and MassDEP do not agree this prediction is valid. The permittee is reminded that continuous monitoring points positioned at representative locations and depths within the lower Basin, collecting temperature data, using a four hour average temperature calculation, would have to be exceeded at a sufficient number of points to constitute a permit violation in the ZPH. The 1999 temperature data used by Mirant simply can not make this prediction with confidence.

Also, EPA and MassDEP do not agree that the low number of alewife observed in the lower Basin in 2002 and 2003 constitute definitive evidence that all life stages of the 1999-year class appear to have suffered no appreciable harm. A more extensive analysis of river herring sampling data is discussed in Response C3.

Comment C13 (f): The Agencies have failed to explain how the thermal conditions in 1999 could plausibly be associated with "appreciable harm" when, as detailed in the July 28, 2003 and November 13, 2003 submittals A.R. Nos. 489 and 470, abundance of every life stage from larvae through returning adults was so high compared to the results from the cooler year 2000. For example, the Draft Permit sets a 72 °F 4-hour average block limit to protect alewife reproduction during the first week in June, yet despite 100% exceedance of that threshold in 1999, *Alosa* larval densities in the ZPH of more than 1500 per 100 cubic meters were measured on June 8, followed by greater abundance of juvenile alewives in July 1999 than in any other sampling year. Mirant Kendall does not believe it is appropriate to make the argument that "it might have been better" in the absence of specific supporting data.

Response to C13 (f): The permit requires compliance with specific protective temperatures at specific points in the lower Basin. The only long term continuous temperature data available in 1999 was measured at the intake of the Station, not at the specific points required in the permit. Although it was acknowledged that temperature data from the Station intake could serve as a general approximation of ambient conditions in the river, this data cannot be used with certainty for a retrospective prediction of whether an exceedance of the 50% ZPH compliance limit actually took place downstream of the facility's discharge. See Response C13 (d) and (e) for a further discussion of the problems associated with predicting permit exceedances with limited temperature data.

Comment C13 (g): Refined sampling techniques for quantifying the relative abundance of

YOY river herring at specific temperatures were implemented by Mirant in 2002 and 2003. These include night beach seining and use of push nets, which provide definitive evidence of relative abundance of river herring in portions of the ZPH and near shore habitats at temperatures both above and below absolute and Delta T limits in the Draft Permit. See November 13, 2003 data letter (A.R. No. 470 and MK Comment Ex. No. C3). These data also document the relative absence of alewives from shallow depths in the ZPH where the Draft Permit sets protective temperature limits, presuming they would be present.

Response to C13 (g): An analysis of alewife data from 2003 through 2005 is discussed in Response C3. In short, Mirant seems to suggest that the relative absence of alewives from the ZPH in the vicinity of the discharge indicates that this area is not valuable habitat to support the BIP, or at least that it does not merit protection using the permit's in-stream temperature regime. It is at least equally plausible to conclude that the absence of alewives suggests that heat from the discharge is deterring the species from using valuable habitat. Indeed, EPA and MassDEP have a substantial body of information that argues against Mirant's perspective on the juvenile datasets. Mirant's *daytime* shoreline seining documented catch of juvenile alewives in 1999, but very low levels afterwards. Mirant initiated nighttime seining in late summer, 2002 and began catching alewives along the shoreline at night, but none or almost none during the daytime. A number of factors may have caused this apparent diurnal change in behavior. In addition, two of the shoreline seining stations that were sampled at night (Lagoon and Boston) were closer to the discharge and had much higher temperatures than did the third station (Hyatt) which was located farther upstream. Thus, there is cause to believe that the lowered catch at the Boston and Lagoon stations was due to Mirant Kendall's thermal discharge. Push-net data from 2004 and 2005 show a similar pattern (see Response to C3) of declining juvenile alewife (and blueback) abundance with increasing proximity of sampling stations to the discharge.

Comment C13 (h): Beginning in 2002 and continuing in 2003 and 2004, depth of capture information was recorded for gill-net sampling. This information demonstrates the relative absence of resident species in the upper water column at all times of day and night, the use of the fully oxygenated water column by river herring, and the voluntary distribution of river herring and yellow perch across vertical temperature gradients more than twice those proposed as limits in the Draft Permit.

Response to C13 (h): EPA and MassDEP were concerned that due to boat traffic and other logistic concerns, the first few feet of the water column were not efficiently sampled as part of the gillnet sampling program. Not withstanding this concern, the observation that resident species were not collected in the upper water column was fully considered. That is why the compliance point at a depth of 2 feet at Monitoring Station 4 (near middle of river, closer to the Boston side) was not required to be met at all times as part of the ZPH.

EPA and MassDEP recognize that river herring use the entire oxygenated water column in the lower Basin when temperatures are low enough to allow that use. That is why provisions were made for protection of the entire water column in at least part of the river.

As discussed in the DD, EPA and MassDEP understand that during gill-net sampling, different fish of the same species were taken from depths with different temperature regimes. Finding individuals of the species caught at different temperatures is consistent with the observation that, within a range, individuals of a species have different levels of tolerance for temperatures. It does not necessarily mean that individuals of the species move freely between large temperature gradients.

Comment C13 (i): The Agencies' failure to fully consider actual data in the record specific to current conditions in the Charles River, with the upgraded facility operating as planned, puts into serious doubt the validity of the temperature and time limits set in the Draft Permit, as well as the definition of the ZPH. The Agencies should conduct a comprehensive assessment of the data previously submitted by Mirant, as well as the supplemental 2004 data provided with these comments prior to finalizing the permit. Further, in the event that the Agencies continue to utilize literature or data from other sources in preference to actual data collected in the Charles River, the Agencies should substantiate the superiority and relevance of such sources.

Response to C13 (i): EPA and MassDEP fully evaluated the data submitted as part of this Response To Comments document. The permit includes provisions supported by both scientific literature from a variety of sources as well as, where appropriate, site-specific data submitted by the permittee. Please see Response to CLF Comment related to C45 for a full discussion of temperature limits that would be considered if the limits were based strictly on scientific literature values.

Comment C13 (j): Based on its review of the Administrative Record and related documents, Mirant Kendall is also concerned that the Agencies did not fairly evaluate some of the information it provided. For example, in A.R. No. 481, Agencies' personnel represented that the researchers at the Virginia Institute of Marine Sciences (VIMS) did not agree with the manner in which Mirant Kendall used VIMS data on water temperatures and abundance of juvenile alewives. However, upon review of the actual correspondence from John Olney of VIMS, (MK Comment Ex. No. C13), one finds that his opinion was "Overall, I see nothing wrong with this approach. Company general temperature trends (as numbers of days in each temperature require during each season) to an integrated index of juvenile production may also be reasonable."

Response to C13 (j): Mirant is concerned that EPA and MassDEP did not fairly evaluate some of the information provided to them. Specifically, Mirant notes that EPA and MassDEP did not agree with the manner in which Mirant used VIMS data on water temperatures and abundance of juvenile alewife information. Mirant states that a memorandum from John Olney of the Virginia Institute of Marine Science (VIMS) stated that "Overall, I see nothing wrong with this [Mirant's] approach."

While the overall approach Mirant used was not of concern to Dr. Olney, there were specific demonstrations made by the permittee that were not judged to be appropriate. Specifically, Mirant took the VIMS dataset and used it to "demonstrate" that alewives did not avoid temperatures when water temperatures were in the mid-80s (F). Dr. Olney was sent the information that Mirant provided to the state. He reviewed it and wrote a memorandum to G. Szal of MassDEP explaining how the data in the VIMS survey were collected. VIMS collected juvenile alewives and river herring along river segments, some of which were about 30 miles long. These trips were initiated near dusk when water temperatures typically are in decline. At the very beginning of each of these fairly lengthy boat trips, a surface water temperature was taken. A "push-net" mounted at the front of the collection boat was used to collect fish down to about a meter. Mirant used the catch information collected during these trips and the temperature information taken at the beginning of the trip to assert that fish were sometimes caught in great abundance when water temperatures were in the mid-80's. However, unless temperatures were recorded at the time of catch, and at the catch location and representative depth, it is impossible to determine the temperature at which fish were captured. Dr. Olney's response to this particular aspect of Mirant's assertion was:

> The VIMS and Chesapeake Bay monitoring data used in this analysis do not offer sufficient spatial or temporal resolution to answer questions about thermal preferences in alosine fishes. For example, the 2002 cruise-specific catch data provided by my staff to TRC are mean rates from 8-10 stations occupied on each date. Temperature at each station is not provided and temperature/catch rate variability along the 30-mile stretch of river sampled is lost in the averaging. A more robust data set, with temperature-catch rate pairs from this sampling over a number of years, should be a bit more helpful in generally describing temperature preferences. However, these data may not be easily accessed or available from VIMS sampling.

It is evident from Dr. Olney's response that no clear relationship can be identified from the VIMS temperature data vs. juvenile alewife catch. The goal of the Permitting Agencies was to provide temperature limits that did not prohibit use of specific habitats in the Charles River through avoidance of particular temperatures. The permittee's analysis of the VIMS data was not appropriate to address this issue.

Comment related to C13 from CLF: EPA calls into question the value of strong scientific studies on perch (and other species) because they were not conducted in the lower Basin of the Charles, and thus perhaps not applicable to this location. For example, studies on temperature and the developmental biology of yellow perch, carried out in Minnesota, are among the best scientific studies available. EPA suggests that since the summer air temperatures in Minnesota are cooler than those in Massachusetts, the water temperature limits for yellow perch should be correspondingly increased when extrapolating this study to the Charles yellow perch population, yet EPA provides no scientific justification for this. Indeed, the best scientific evidence would lead to the conclusion that the same species of fish in a warmer locale will shift its reproductive biology earlier in the season, maintaining species-typical water temperature for eggs, larvae and young. For example, yellow perch spawn from late January to early March in North Carolina, depending on water temperatures, or roughly 2 months earlier than in the New England region. For a given species, there is much more variation in calendar dates for spawning among localities that in optimal temperature ranges.

Response to Comment related to C13 from CLF: EPA did not intend to call into question the scientific studies on perch and other species, but rather, to evaluate the studies within the context of the wide variety of information used to establish protective temperature limits.

EPA understands that within a population of fish, when an environmental condition is changed, the majority of the population will likely respond more or less in the same way. However, within limits, the change will produce a variety of responses across the population. The biological responses will generally cover the entire range, from a decrease in survival for some individuals, to avoidance behavior in other individuals, through a no-effects response from some individuals. The rises in resistance of organisms to herbicides, insecticides, or antibiotics are all examples of this natural selection. This general response has been documented in salmon raised in hatcheries (Fleming and Petersson, 2001). In the case of the lower Charles River Basin, elevated water temperatures make up the environmental condition in question. A majority of the fish population will respond in a certain way to elevated temperatures (avoidance behavior, for example), while some smaller percentage of the population will likely have a more severe, detrimental response to the increased temperatures. Another, small percentage of the population at the other end of the spectrum will show fewer ill effects. This assumes that the elevation in temperature is not so severe as to induce mortality to the majority of the population.

CLF concedes that "the same species of fish in a warmer locale will shift its reproductive biology earlier in the season". This response is certainly one example of the overall process EPA attempted to characterize when evaluating scientific literature results from a different region of the country. The Commonwealth of Massachusetts has characterized the lower Charles River Basin as among the warmest rivers in Massachusetts (G. Szal, MassDEP, personal communication, June, 2005). The warm water characterization of the river, the majority of which is outside the influence of the Kendall Station discharge, is likely due to urban development of the watershed and the damming of the mouth of the river, among other influences. EPA assumed the overall warmer characteristics of the lower Basin have probably persisted since the installation of the first dam at the mouth of the river, at the turn of the twentieth century. Over the many generations of fish that inhabited the lower Basin since that time, it seemed likely that those segments of the population more tolerant to the warmer conditions were selected for in succeeding generations. This natural selection process was not a dramatic occurrence that produced fish that would withstand or thrive in water temperatures greatly in excess of the temperature range described for the species in the literature. Further, this ongoing natural selection process was not used by EPA to justify excessive temperature limits. Rather, it was introduced into the DD discussion as a way to further evaluate the site-specific conditions of the lower Basin, better gauge where in the range of published temperatures the maximum temperature limits would be appropriate, and assess the somewhat unique characteristics of the populations of fish that reside in the lower Basin

CLF further supports EPA's approach when they state "For a given species, there is much more variation in calendar dates for spawning among localities that in optimal temperature ranges." This statement acknowledges that there is expected variation in optimal temperature ranges among localities. That is EPA's understanding as well.

EPA does not want to give the impression that an increase in the overall temperature of the Basin has resulted in a simple overall increase in the heat-tolerance of sensitive species such as alewives. Based on recent information (2003-2005) it is evident to the Permitting Agencies that high water temperatures have negatively affected the population of alewives in the Charles (see Response C3). Moreover, the temperature above which there is greatly reduced catch of juvenile alewives in the lower Basin (i.e., 81ºF) matches the temperature that EPA and MassDEP had determined to be the maximum protective temperature for this species and life stage based on a *previous* review of the scientific literature (see DD section on alewives). It would be expected that if there were a phenotypic drift in the Charles River population to tolerate higher temperatures, the avoidance temperature derived from field data for that population would be higher than that developed from the literature from other populations that were not exposed to high temperatures. However, there was a match between the literature-derived value and the field data which argues against any upward phenotypic drift in temperature tolerance in the Charles River population.

In addition, there are reasons why an upward drift in temperature tolerance might not occur. The driving force behind any shift in a frequency distribution of genotype and resulting phenotypic manifestations is an increase in reproductive success of those individuals with the different phenotype. For the frequency distribution of temperature preference and/or temperature tolerance of a given population to undergo a shift over time, there would have to be an advantage that relates to an increase in reproduction potential of the individuals that are more tolerant of the stressor. In the Charles River, increased fitness may accrue to individuals that actively *avoid* high temperatures if the population size is small enough and the stated behavior results in exposure to a higher abundance or quality of food, or decreases exposure to predation. Of course all the above arguments are hypothetical. At present, there is no evidence of a phenotypic shift in either direction.

Based on juvenile and adult catch information and the one-time adult estimate of stock size conducted by Mirant in 2002, the alewife population in the Charles River appears to be small. This is of concern to EPA and MassDEP. Encroachments on alewife habitat brought about by increases in water temperatures may not simply cause the population to become more heat tolerant. Such encroachments have a potential to result in reductions in stock biomass or in a decreased ability of the population to expand to its potential. This concern of the Permitting Agencies over habitat loss extends to other thermally-sensitive species as well.

Comment C14: Section 5.6 of the DD lays out the Agencies' rationale for the selection of the thermal limits and time periods for resident fish species in the lower Charles River Basin. In Section 5.6.3.a, the Agencies identify the yellow perch as the resident species most sensitive to elevated temperatures. Subsequent sections set out the rationale for the determinations of the temperature and time limits for each stage of the life cycle of the yellow perch, to be applied in the ZPH. As an initial matter, Mirant Kendall has significant concerns regarding the definition of the ZPH for this species for the spawning segment of the life cycle. These concerns are discussed in Section D below.

Mirant also has specific concerns regarding the appropriateness of the specific temperature and time limits established for this species, as detailed in the following comments. Mirant again asserts that the EPA must base the Draft Permit's temperature and time limits on the results of a comprehensive assessment of the actual Charles River data presented to date and supplemented herein.

Response to C14: EPA and MassDEP do not agree that protective temperature limits can be derived by considering only the results of the assessment of the actual Charles River environmental data. While this site-specific information is important, it must be considered along with scientific literature and associated relevant information collected both in New England and from other parts of the country to gain an overall understanding of the response of fish populations to elevated temperatures. Writing the permit to simply ensure that the lower Basin gets no hotter than it has been in recent history assumes that Mirant's discharge has had no appreciable harm on the BIP to date, a showing on which Mirant has not carried its burden of proof. Moreover, as detailed in response to comment C3, EPA and MassDEP have shown evidence of appreciable harm. Therefore, the permitting agencies need to look to data beyond the actual conditions in the lower Basin in an attempt to assess the conditions necessary to protect the BIP.

Regarding Mirant's concern for considering the needs of yellow perch in defining a ZPH, see Response C15 below.

Comment C15: Sections 5.6.3b and c of the DD address the protective temperature and time period for the egg stage of the yellow perch. The Agencies state that, based on the likely location of yellow perch eggs, a maximum ZPH temperature of 66.4 F would maintain a protective temperature of 64.4 F. As noted above, Mirant has significant concerns with the definition of the ZPH for this species. As described in more detail in section D, Mirant believes EPA should re-focus on a compliance location at or close to the most proximate suitable habitat for yellow perch eggs, above the Longfellow Bridge. The upstream edge of the ZD (see Attachment B to the Draft Permit) is above the Longfellow Bridge and closer to the discharge than any viable perch spawning areas, as described above. Based on the extensive available thermal data on the Kendall Station's thermal plume, Mirant Kendall asserts that maintenance of a sequence of 24-hour average temperatures not-to-exceed the 90-95% confidence values in Table C-5 at a 6-foot depth, at the upstream edge of the ZD from March 20 to May 10 would be adequately protective of the BIP of yellow perch in the Lower Charles.

Response to C15: EPA and MassDEP take the position that all areas along the Boston shore of the lower Basin are suitable habitat for yellow perch eggs. This includes areas downstream of the Longfellow Bridge. EPA and MassDEP are unaware of any site-specific assessment submitted by the permittee as part of the re-licensing process that evaluated the near shore habitat of the lower Basin relating to suitability for yellow perch eggs. In addition, the presence or absence of yellow perch eggs has not been documented in specific locations of the Basin by the permittee. In the absence of any site-specific information, the Permitting Agencies take the conservative position that all near shore habitat in the lower Basin is suitable for yellow perch eggs. Juvenile yellow perch were caught at the Boston Station in 2005, though in low numbers, indicating that the area is used as nursery habitat. It must be further noted that areas of near shore habitat on the Cambridge side of the lower Basin may also be suitable habitat for yellow perch eggs if thermal conditions were suitable. This part of the river has been allocated as part of the Zone of Dilution, however, and is not being considered as suitable yellow perch habitat due to the water temperatures expected to occur in this area of the river as a result of Kendall Station's thermal discharge.

It must also be noted that in its comments, the permittee has criticized the monitoring and compliance plan as being too complicated and extensive. However, the permittee requests a new compliance location at the upstream edge of the ZD from March 20th to May 10th as part of its comments here, further adding to the complexity of the monitoring and compliance plan. The permittee's comments regarding maintenance of a sequence of 24-hour average temperatures not-to-exceed the 90-95% confidence values in Table C-5 at a 6-foot depth are fully addressed in Response C5.

Comment related to C15 from CLF: In the development of the draft permit and temperature limits based on yellow perch, EPA departs from the data provided in reputable scientific sources to shift its recommendations higher based on limited observation made in the river, without adequately acknowledging that the river is impaired and is not currently supporting a BIP. EPA utilizes water temperatures measured by MKS in the intake pipe to set limits for the protective maximum temperatures above where the science would indicate they should be. Temperature data from the intake pipe are not reliable since the temperature at the intake is elevated due to the nearby discharge point. Spawning temperature limits (Protective Maximum Temperatures ("PMT")) are set over a range from 54 to 63 ºF, extending well outside the ranges considered favorable for normal perch spawning in the published literature. EPA acknowledges that the best available science indicates that their upper limit of 63 ºF corresponds to habitat suitability for spawning in this species of only 20% (i.e. unsuitable habitat; HSI = 0.2). EPA then adds 2 ºF to the range of PMTs in order to arrive at proposed temperature limits for the ZPH. It is argued that by using these higher temperature limits for the ZPH, they will ensure that the PMTs are not exceeded in the locations and time periods used by perch during spawning. This is not well justified and will not adequately protect a balanced indigenous population. There is little justification for setting the temperature limits 2 ºF higher than the already excessive temperatures selected as PMTs, and then guessing that the actual temperature where the fish are spawning will be cooler (e.g. in deeper water). The final permit should rest squarely on the thermal conditions derived from published science for yellow perch, and measurements in the ZPH should ensure that these temperatures are not exceeded due to excess thermal loading by MKS or any other user of this public resource. Since yellow perch has been selected by EPA as a critical indicator species, the temperature monitoring plan should be designed to provide direct measurements of water temperatures in the habitat areas used by this species for all life stages. Temperature monitoring is apparently not being done in locations that are representative of the habitat used by yellow perch. The monitoring plan is thus not adequate and should be modified.

Response to Comment related to C15 from CLF: The lower Charles River Basin is subject to a variety of conditions that EPA and MassDEP expect place stress on the BIP. However, this stretch of the river is not currently listed as impaired for fisheries or fish habitat, in contrast to CLF's inference. Further, EPA and MassDEP did not use intake temperatures recorded at Kendall Station to select protective temperature limits. Instead, EPA and MassDEP used the multi-year continuous ambient temperature database measured at the Station's intake in certain cases to compare protective temperature values from the literature with site-specific values recorded at the intake. EPA and MassDEP clearly pointed out in the DD the shortfalls with the intake temperature data set, including the time period when intake temperatures did not reflect ambient conditions (June 15 - August 31).

EPA and MassDEP do not agree that "There is little justification for setting the temperature limits 2 ºF higher than the already excessive temperatures selected as PMTs, and then guessing that the actual temperature where the fish are spawning will be cooler (e.g. in deeper water)." In the DD, Figures 5.10.5c-1 through 5.10.5c-5 clearly document a daily temperature fluctuation of at least 2 ºF specifically in the lower Basin. This data was reasonable justification for EPA and MassDEP's reasoning regarding the 2 ºF allowance in the temperature limits. Also, extensive vertical profile data submitted by the permittee and listed in the DD documented cooler water temperatures with depth at various locations in the lower Basin. This site-specific supporting evidence refutes any claim that guess work was involved in the formation of protective temperature limits. The 2 ºF temperature limit allowance is discussed in further detail in the Response to Comment related to C44 from MA CZM and CLF.

While EPA and MassDEP were confident that the 2 ºF higher compliance temperature was protective of the BIP during all times it was incorporated into the draft permit, Charles River "Hydro Data" submitted by the permittee for the summer of 2005 prompted a review of the 2 ºF compliance temperature allowance for the summer time period. A full discussion of this review and subsequent action is also included in Response to Comment related to C44 from MA CZM and CLF.

EPA and MassDEP concede that all relevant habitats are not being specifically monitored as part of the monitoring and compliance plan. However, the monitoring plan is comprehensive and will provide a great deal of valuable temperature data to ensure thermal compliance. Additional continuous monitoring locations are not necessary. Periodic thermal monitoring of the entire Basin will be a valuable supplement to the fixed monitoring stations. This complementary information will provide sufficient detail to fully characterize the thermal profile of all important fish habitats in the Basin. The monitoring plan has been judged to fully meet the objectives of the permit. The Permitting Agencies have maintained this position, taking into consideration comments from the permittee that the monitoring and compliance program is excessive.

Regarding the comment that "The final permit should rest squarely on the thermal conditions derived from published science for yellow perch..." EPA and MassDEP disagree with this approach. There is no doubt that referring exclusively to scientific literature to determine protective temperature limits is one way to arrive at a protective approach to protecting the BIP. However, scientific literature and reference material at best identify a temperature tolerance range and a general time period when a species life stage is expected in a region. Without taking site-specific information into consideration to establish representative acclimation temperatures and spawning timing, for example, the permit limits would be overly conservative. Refer to "Response Related to C45 from CLF" for a full discussion of temperatures based strictly on scientific literature values compared with ambient temperatures. In their comments on the draft permit, the MADFW stated that the protective temperatures established for yellow perch in the permit are acceptable.

Regarding the protective temperature of 63 ºF selected for yellow perch spawning, this temperature was established only for the tail end of the yellow perch spawning period (April 15th through April 30th). Lower temperatures were selected for the beginning (54 ºF) and middle (59 ºF) of the expected yellow perch spawning period. As discussed fully in the DD, the time period at the end of April was characterized by markedly increased ambient temperatures, as documented in 1994, 1996, 2001 and 2002. The "stair-step" approach of increasing maximum protective temperatures as the spawning season progresses recognized the need for rising temperatures to ensure successful yellow perch spawning.

Comment C16: The Sections 5.6.3d and e of the DD detail the rationale for the protective temperature and time period for the larval stage of the yellow perch. These sections describe EPA's rationale leading to the determination that the WQS of 83 ºF from April 1 through July 15 is adequate to protect larval yellow perch. The target is 80.6 ^{o}F where the fish actually are present. Although Mirant asserts that the supporting studies upon which the target temperature is based are overly conservative (e.g., the Tidwell study indicated that effects were exaggerated by tank confinement), Mirant believes that maintenance of 24-hour average temperatures not-to-exceed 80.6 ^{o}F in 50% of the cross-sectional area of the river running perpendicular to the banks opposite Station 2, from April 1 to July 15, would be adequately protective of the BIP of spawning yellow perch in the Lower Charles.

Response to C16: EPA and MassDEP do not agree that a 24-hour average temperature is appropriate when setting maximum protective temperature limits in the lower Charles River Basin. The permitting agencies are concerned that Kendall Station has the potential to substantially increase the water temperature of the lower Basin under certain conditions within any 24 hour period.

One difficulty the permitting agencies have in analyzing the ability of Kendall Station to change water temperature in the lower Basin is that there is no acceptable thermodynamic model available to assess the potential temperature impacts of this discharge. Typically, EPA and MassDEP would have an applicant do several modeling runs designed to compare the expected impact of the facility over a short term period with the impacts over longer term periods. If there were no significant differences in the thermal profile of the lower Basin when subjected to short term changes in temperature compared with longer term variations, then it would be reasonable for EPA and MassDEP to use a longer averaging period to protect the BIP, because it would be as effective as the more data intensive short term averages in maintaining protective temperatures. In this case, however, that tool is not available.

Therefore, EPA and MassDEP are left to decide how to protect the BIP from potential spikes in temperature that could result from allowing compliance to be averaged over a 24 hour period. For example, the volume of once-through cooling water allowed to be used by the Station (80 MGD) combined with the allowed increase in temperature across the condensers (20 ^{o}F rise in temperature) under certain conditions in the lower Basin, could markedly raise the temperature of the Basin, conceivably above the protective temperature limit for some period. If the Station then lowered the temperature change across the condensers or reduced the volume of once-through cooling water (i.e. curtailed generation), the remaining hours in the 24 hour period would more closely mirror ambient river conditions, especially if the river is maintaining a downstream flow into Boston Harbor. Under these conditions, the calculated 24 hour temperature limit at a compliance point in the river may meet the 81 $^{\circ}$F limit, while in reality, actual conditions in the river were much warmer than the biologically based limits for part of the day. These unprotective higher temperatures would be "hidden" within the calculation of an average temperature over 24 hours.

The Permitting Agencies concede that a suitable thermal model of the lower Basin is necessary to analyze fully how different averaging times might affect temperatures. Until such a model is available, however, EPA and MassDEP are compelled to take a conservative approach when setting protective thermal limits for the lower Basin. Therefore, a 24-hour average was not considered a protective approach to calculate compliance limits in this case.

Another factor that causes the permitting agencies to be conservative about the averaging time is that this permit is designed to enforce actual in-stream temperatures, not modeled in-stream results. Typically, EPA and MassDEP control discharges at the end of the pipe based on modeled predictions of how those temperatures will affect the receiving water. In modeling the discharge, it is common to use so-called reasonable "worst case" episodes when running the model to ensure that the discharge limits would protect water quality even when, for example, the flow in the river is lowest or a heat wave is occurring. This "worst case" design in most modeling has an inherently protective effect on the resulting discharge limits, since most of the time the receiving water will not reflect the "worst case" modeled.

With this permit, however, the real-time continuous nature of the compliance program allows the permittee to take advantage of the actual assimilative capacity of the lower Basin at any given time to absorb heat, and the permit does not include the inherent "buffer" or constraint on heat discharges that end-of-pipe limits derived from worst-case modeling would provide. Kendall Station has the ability to raise temperatures in the lower Basin at any time right up to levels that are necessary to protect the BIP. Therefore, there is the prospect that the BIP could face exposure to temperatures on a continuing basis that are designed to be adequately protective, but, as noted in comments from CLF and others, are not optimal. Whereas a modeled end-of-pipe limit would tend to ensure protection with a margin of safety during normal conditions and expose the BIP to marginal but protective temperatures only during the actual occurrence of worst-case conditions, this permit risks exposing the BIP to more persistent and frequent temperatures that are very close to the levels that cause harm. EPA and MassDEP do not believe it would be advisable to add on top of this scenario a 24 hour average, which gives the facility the ability to maximize generation and raise temperatures several degrees above the protective levels during the afternoon and early evening, only to balance them out against reduced generation and resulting lower temperatures at night and in the morning.

Although Mirant has focused this comment on yellow perch, EPA and MassDEP are obligated to assess the implications of the temperature averaging time for all the most sensitive species that must be protected as part of the BIP. For example, allowing for short term temperature spikes during the day risks interrupting a migratory pulse of anadromous fish attempting to enter the lower Basin or pass the thermal influence of the Station.

Comment related to C16 from CRWA: Yellow Perch Larvae- Permit limitations would allow temperatures to rise to 75 ºF between June 8-11 and 83 ºF between June 12 and October 31. These temperatures approach or are at those that cause between 45 and 100% daily mortality of the larvae. These temperatures are not protective of the larvae nor is there a margin of safety associated with these limits. Additionally, the "no effect" temperature should be used to set temperature limits outside of the Mixing Zone. EPA and MassDEP must state what this temperature is and how it will be used to set protective limits in the ZPH.

Response to Comment related to C16 from CRWA: As stated and supported in the DD, the temperature limits selected in the permit ensure that habitat for yellow perch will likely be cooler in the habitat where the larvae reside. The margin of safety takes into account that the continuous, fixed temperature Monitoring Stations 3, 4, 5 and 6 were established in locations deemed to measure the greatest magnitude of Kendall Station's thermal plume at the highest relative temperatures. This placement ensured that all other areas of the ZPH will be cooler than the measurements taken at these monitoring and compliance points. See also response related to C15 from CLF which notes the supportive comments received from MA DF&W regarding temperature limits to protect yellow perch.

Comment related to C16 from CLF: EPA concludes that the maximum protective temperature for Yellow Perch larvae should be 80.6 ºF. Nevertheless, a precautionary, science-based approach to protecting the propagation of these indigenous fish would dictate halting thermal pollution from MKS at temperatures that are much less than the 80.6 ºF. Even though some of the eggs might be cooled by being close the bottom, spawning and the mobile larvae would still be compromised by the proposed temperature limits. A lower temperature limit is also supported by *Krieger et. al.*, where suitable temperatures (suitability > 90%) for spawning and embryo development were in the 46 to 57 ºF range, and for later stages of development from about 64 to 75 ºF.

EPA apparently adjusted its assessment of the suitable maximum protective temperature upward to 80.6 ºF for larvae on the basis of just two samples taken in the Basin during July 2002, when larval perch were collected at 82.4 ºF and 79.0ºF near the B.U. Bridge. There are several serious problems with the logic used here for larvae and later for setting limits for juvenile perch. There is no scientific justification for using a few observations of larvae at high temperatures as evidence that the larval (or juvenile) perch found were thriving at these temperatures. For example, no data were provided on the condition of the larvae compared with larvae growing at other temperatures and no studies indicating that survival to adulthood was normal compared to other sites where temperatures are lower. Additionally, it appears that there has not been any quantitative assessment of the population of yellow perch in the Basin so it is not even known how abundance of adults compares to an expected carrying capacity for this species.
As pointed out in the Determination Document, 80.6 ºF corresponds to a habitat suitability index of only about 40%. EPA's obligation in permitting is to maintain suitable habitat for indigenous fishes, particularly the selected indicator species. Habitat suitability should be as close to 100% as possible (HSI = 1.0). The available scientific work indicates that 80.6 °F is too high to be protective of larval perch. No explanation is provided for choosing the very low suitability criterion of 40%, and the corresponding marginal conditions for these animals.
Additionally, experimental data show that larval mortality begins to increase rapidly when water warms to about 70 ºF. There is no justification for using a few observations of larval fish living under marginal conditions as a basis for departing from what the best available science tells us. A protective maximum near 75 ºF may be justified for larvae, juveniles and adults, but is still too high for spawning and egg development. EPA's development of a rational for higher limits for juvenile yellow perch (80.6 ºF) is weak for the same reasons presented above.

Response to Comment related to C16 from CLF: EPA and MassDEP did not "...adjust[] its assessment of the suitable maximum protective temperature upward to 80.6 ºF for larvae on the basis of just two samples taken in the Basin during July 2002, when larval perch were collected at 82.4 and 79.0 ºF near the B.U. bridge." Rather, the DD discussed a statement in the literature by Kreiger, which reported that yellow perch larvae tolerated temperatures up to 28 ºC (82.4 ºF; Krieger *et al.,* 1983). The DD further stated that "While 28 ºC (82.4 ºF) was also recorded as the ambient temperature associated with yellow perch larval collection in early July of 2002, it should not be considered a protective temperature based on that fact alone." Further discussion of the literature and site-specific water quality data were used to justify the protective temperature selected for yellow perch larvae.

A graph showing protective temperatures based solely on literature values compared with ambient temperatures in the Charles River clarifies the problematic nature of relying solely on conservative literature values. This figure (Figure C45 CLF-1) is fully discussed in "Response Related to C45 from CLF"

CRWA and CLF both suggest that EPA and MassDEP should design the permit so that temperatures in the ZPH have no effects on the resident and anadromous species: CRWA uses the term "no effects", while CLF refers to the goal of having 100% "habitat suitability." EPA and MassDEP disagree that the permit should be enforcing temperatures designed to ensure "no effects" on the resident species in the ZPH. While a "no effects" regime in the ZPH would be a highly conservative approach to protecting resident and anadromous fish species in the lower Basin, the Permitting Agencies have concluded that it would be more conservative than necessary to protect the BIP. The goal of the permit, as specified in the CWA 316(a) regulations, is to maintain temperatures in the ZPH at a level that protects the BIP in the lower Basin as a whole. EPA and MassDEP have concluded that the BIP can tolerate some temperature effects in the ZPH, in light of the fact that those effects will diminish with distance from the discharge plume. The goal of the permit is to ensure that the BIP is not completely excluded from the lower Basin in the vicinity of the discharge and that the ZPH is sufficiently hospitable to maintain and protect the BIP in the entirety of the lower Basin. To achieve this goal, it is not necessary to keep the ZPH at levels that ensure "no effects," but rather at levels that avoid such effects large enough to significantly impair the ability of the BIP to occupy the lower Basin.

Comment C17: Protective Temperature and Time Periods for Yellow Perch Juvenile Stage Overly Stringent. Sections 5.6.3f and g of the DD detail the rationale for the protective temperature and time period for the juvenile stage of the yellow perch. The sections describe Agencies' rationale leading to the determination that the WQS of 83 ºF throughout the ZPH is adequate to protect juvenile yellow perch. The target is 80.6 °F where the fish actually are present. This life stage is fully mobile, choosing habitats it prefers and avoiding conditions of stress. Therefore, the field data on capture locations at different temperatures collected and submitted by Mirant Kendall should be given greater weight than laboratory studies upon which the Agencies have relied, both in terms of defining thresholds as well as establishing the appropriate compliance locations. Specific examples are as follows:

- There is no support for an avoidance threshold below 83 °F for this life stage, certainly none in the neighborhood of the 80.6 °F chosen by default by EPA as the protective threshold from the generic "Habitat Suitability Index" (See also comments in MK Comment Ex. No. C6 on the questionable value of the Index as applied here.)

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- The Agencies correctly state "yellow perch were collected on many separate occasions above 26.1^{o}C (79.0^{o} F)," but far understates the extent of those collections. Contrary to the implication of "the mere presence of a small number of individual fish" the data demonstrate the consistent regular presence of juvenile and adult yellow perch in the great majority of the 2002 and 2003 beach seine collections at temperatures above 80 °F (up to 86.4 °F) in the preferred shallow vegetated habitats, i.e., upstream of the ZPH. These included the largest catch at the Lagoon station in 2003 (11 individuals at 81.7 °F); three of the larger 2002 catches at the Magazine Beach Station (30 at 81.5 °F, 12 at 81.8 °F, and 14 at 80.2 °F); catches on all three dates over 80 ºF at the Hyatt station in 2002; and additional catches in 2003 at 84.8 °F at the Fiedler Station, and 83.6 °F at the Greenough Station.

The Agencies should revise the target temperatures in the Draft Permit in recognition of the above site-specific data, in preference to reliance on the Habitat Suitability Index to establish default avoidance temperatures (which that index does not provide).

Also, the Agencies should target its compliance points for this life stage to the locations actually occupied by the fish. The data from extensive collections and tagging studies show that these fish are only significantly present in shallow water in the areas upstream of the ZPH. In the ZPH, when they are present, they are less abundant and are in deep water. Extensive gill net and push net results from the ZPH (Boston station and Below Broad Canal) show that this life stage of yellow perch is essentially absent from depths shallower than 12 feet at all times of day and night in the spring and summer. The species is regularly present deeper than 12 feet at these locations, but only when there is salinity less than about 16 ppt at these preferred depths. Mirant asserts that maintenance of 24-hour average temperatures not-to-exceed 83 °F in 50% of the cross-sectional area of the ZPH defined by Stations 3, 4, 5 and 6 in the summer would be adequately protective of the BIP of juvenile and adult yellow perch in the Lower Charles.

Response to C17: EPA and MassDEP weighed both the juvenile yellow perch collection field data as well as the scientific literature information when setting protective temperature limits. The field data collection was part of the justification for selection of a temperature limit, that according to the Habitat Suitability Index for Yellow Perch Juveniles (Krieger, 1983) identified only a relatively low habitat suitability of 40% at 27ºC (80.6 °F).

Evidence that yellow perch (YP) were present in greater numbers upstream of the influence of the Station's discharge and were found primarily in deeper, cooler water in the ZPH can be viewed in several ways. One reason for this observed pattern of distribution could be that the habitat identified by the permittee downstream of the discharge is less suitable for YP for reasons not associated with higher water temperatures. However, no scientific assessment of the quality of yellow perch habit in the lower Charles was submitted by the permittee to support this position. It is at least as equally plausible that the YP pattern of distribution documented by extensive collections and tagging studies was directly caused by avoidance of otherwise suitable downstream habitat due to the thermal influence from Kendall Station. Temperature data from the lower Basin and literature values for YP habitat suitability for temperature do support this position. The objective of the protective temperature limits is to preserve habitat that will not cause avoidance behavior.

One concern noted in the field data was that a single, surface-water temperature value was presented along with each beach seine collection. A near surface and a near bottom temperature reading at the greatest depth sampled would have confirmed whether near bottom temperatures were cooler in the areas sampled. For example, a beach seine collection site with the deepest point of approximately one meter could reasonably possess a near surface temperature of 81.8 °F, but a near bottom temperature a degree or more cooler (°F). A further confounding factor that must be considered is the overall area sampled in a beach seine collection site. If the field temperature collected along with the fish sampling is going to be proposed for consideration as a permit limit, near surface and near bottom temperatures at several representative locations within the seined area would add additional support to the argument that a proposed temperature coincided with the habitat being used by the yellow perch.

EPA and MassDEP do not view a 24-hour average maximum temperature limit as appropriately protective in the specific case of the lower Charles River Basin for the reasons presented in Response C16.

Comment C18: Protective Temperature and Time Periods for Yellow Perch Adult Reproductive Condition Overly Stringent; Incompatible with Other Species of Concern. Section 5.6.3h of the DD details the selection of the protective temperature and duration for the adult reproductive condition of the yellow perch. This section presents the rationale for the 149-day "chill period" of ZPH temperatures below 50 °F assumed by the Agencies to be required for protection of gonadal maturation in yellow perch. This approach is fundamentally flawed because the threshold was selected based on the assignment of exaggerated importance to one parameter (gonadal maturation), which results in a threshold too low to support other important requirements for that species and another species (alewife). The rationale for this requirement is based on lab experiments controlled to determine optimal temperatures for gonadal maturation for yellow perch from a significantly colder location (Duluth, Minnesota). This approach has several flaws:

- The authors of that study acknowledged that different perch populations in other areas (extending as far south as Alabama) each experienced different chill periods, therefore the 150 days specified in the study for the Minnesota setting is arbitrary and unproven for the warmer Charles River. (EPA acknowledges this likelihood in Section 5.6.3h).

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- It is also questionable whether optimization of gonadal maturation is a beneficial objective. The Krieger study indicates chill temperatures cold enough to optimize gonadal maturation occurs as a tradeoff with reduced overall growth. The Agencies have failed to thoroughly assess the chill period tradeoffs. For example, growth is strongly correlated with ability to avoid predation (e.g., in this system, by largemouth bass). Mirant questions whether yellow perch are more limited in this setting by ripening of their gonads or by lack of suitable, preferred low-salinity, well-oxygenated habitat warm enough for survival over winter.

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- Maintaining temperatures below 50 °F in the ZPH (which is poorly suited for yellow perch overwintering and spawning as described elsewhere in these comments) in the second week in April foreshadows potential conflict with the need for slightly higher temperatures (in the low 50s ºF) to initiate and sustain with vigor the alewife run, something of acknowledged importance in the ZPH. Mirant Kendall's gill net collections show that the run intensified at temperatures in the low 50s in each of the last three years after remaining negligible while temperatures remained in the 40s.

Comment related to C18 from CLF: Yellow perch breed during the spring, as early as February but typically during the period from April through May. Thus, this is a period during which water conditions should be supportive of the development of eggs, larva, and juveniles. Normally, water temperatures for breeding yellow perch are within the 44 to 56 ºF range. In the first half of April, the draft permit indicates a temperature limit of 61 ºF, increasing to 65 ºF in the second half. This period corresponds to the early portion of the spawning period for yellow perch, when temperatures normally would be in approximately 44-50 ºF range. The proposed limits are too high for normal reproduction in yellow perch and need to be adjusted downward in the revised permit.

The proposed chill period temperature limit of 50 ºF is apparently set to be at the upper limit of temperatures that are sufficient for normal ovary development in yellow perch. Use of the absolute upper limit is not precautionary for yellow perch. A winter temperature of 39.2 ºF has been shown to be optimal of ovary development in yellow perch, with females producing eggs at over 75% viability. Viability at the winter temperature proposed by EPA (50º F) was very low (< 25%). The argument put forth by EPA that the Charles Basin does not currently achieve extended periods with water temperatures near 40º F is not compelling. The river was impaired during the time period examined by MKS, with thermal pollution from a number of sources including MKS. This is no justification for setting the limits higher than dictated by the biology. Further, the use of 50º F as an upper temperature limit for winter temperature in a New England river is highly unnatural, and will not support the natural community of an aquatic organism that has evolved to pass through a winter period with water temperatures near freezing. The permit should not allow MKS to elevate water temperatures in the ZPH above 39º F during the chill period. In order to promote the propagation of yellow perch, and other species, EPA must set more protective limits. During the period when perch eggs or larvae would normally be present (i.e. mid March through mid June), the discharge of any heated water should be limited such that water in the shallows of the Basin does not exceed 55 ºF. Even though temperatures may naturally rise above 55º F during this time period and decrease habitat suitability, there is no justification for allowing MKS to stress the perch population further with discharge of heated water. During the fall and winter, the Basin must be allowed to cool at least to the high 30's.

Response to C18 and related comment: The permittee implies that it is in the best interest of the yellow perch population to raise temperatures in the lower Basin to levels higher than 50º F in the wintertime, in part, because the study cited by the Permitting Agencies for this temperature was conducted in Duluth, MN (Hokanson, 1977), where temperatures are typically colder than they are in MA. Thus, the 149-day "chill" period specified in the draft permit (i.e., the requirement that Mirant not raise the water temperature outside the ZD beyond 50º F or release heated water if the temperature at the border of the ZD is 50º F or above) is an invalid requirement. Conversely, CLF asserts that the 50º F chill temperature is not low enough to support spawning, and should be lowered to 39º F.

The following is taken from Hokanson (1977):

> "Maturation requirements - a winter minimum temperature of 10º C (50.0º F) is near the upper limit for maturation of gonads in yellow perch and walleye. Jones et al. (1977) reared adult yellow perch from Minnesota in the laboratory under a natural day-length cycle and 16 thermal regimes from October through June. The maximum percentage of females spawning declined as the winter minimum temperature at which they had been held increased (Fig. 1). Optimal conditions for maturation that terminated in spawning occurred when fish were exposed to 6º C (42.8º F) or lower for 185 days from October 30, whereas no viable spawning occurred when the fish were maintained at a minimum temperature of 12º C (53.6º F) or higher."

It is important to note that at least two items from the quote above:

a) The 50 ºF temperature used in the Draft Permit was not the preferred temperature in the study; i.e., it was not the temperature with the highest success rate in producing spawning. The preferred temperature was about 43 ºF.

b) At a temperature of 50 ºF and a chill-duration of 160 days (temperatures did not exceed 50 ºF), no spawning took place. At the 50 ºF temperature, spawning only took place when the chill period exceeded 160 days (compare this to the 149 days required in the Mirant Kendall draft permit). When the chill period for this 50 ºF experimental chamber was increased beyond 160 days, spawning increased in a fairly linear fashion until the 200-day mark. Still, at this temperature (50 ºF), spawning took place in only 50% of the females. In those experimental chambers where chill temperatures were lower (8, 6 and 4 ºC), spawning percentage rose to a much higher percentage and spawning took place after shorter chill periods.

In summary, Hokanson found that at least 160 days of temperatures at 50 ºF or less were needed to induce spawning in any of the yellow perch studied. Thus, the permit limit of 50 ºF appeared to the Permitting Agencies to be the absolute maximum temperature that would allow any spawning to take place given the short number of days for this chill period (149 days).

Consistent with the approach to enforcing a temperature regime elsewhere in this permit, the

Permitting Agencies have used the scientific literature to set temperatures in the ZPH that do not ensure an ideal habitat for the species, but attempt to ensure that the ZPH is sufficiently hospitable that the BIP will be maintained in the lower Basin taken as a whole. Both variables for the chill period in the permit (temperature and number of days) are less conservative than those in the referenced paper. As CLF observes, these temperatures are well above those naturally found in Massachusetts rivers that typically freeze-over during the winter, such as the lower Basin of the Charles (except, of course, for that area influenced by Mirant's discharge). Therefore, EPA and MassDEP disagree that the permit completely ignores the trade-offs Mirant presents in its arguments that the chill period temperature is set too low. These tradeoffs include the need for low early spring temperatures for sufficient gonadal development in yellow perch and increasing spring temperatures to accommodate alewife migration. In capturing this potential trade off in permit conditions, EPA and MassDEP believes there is sufficient time in the spring, after the YP chill period, to allow for alewife migration.

In conclusion, EPA and MassDEP expect that the chill period temperatures the permit will enforce in the ZPH will yield temperatures in the lower Basin as a whole that should support subsequent spawning for the YP, and it is not necessary for the permit to enforce temperatures in the ZPH that perfectly mimic background temperatures free of any influence from Kendall Station's discharge.

Comment C19: Protective Temperature and Time Periods for Yellow Perch Adult Spawning Stage Overly Stringent, Not Applied in Correct Location. Section 5.6.3i and j of the DD detail the selection of the protective temperature and time period for the adult spawning stage of the yellow perch. Mirant Kendall asserts that the ZPH is not appropriate habitat for yellow perch spawning. Therefore, any limits to protect perch spawning should be re-focused on those upstream areas suitable for that purpose. Further, there are no data in the referenced studies to support the selection of a 4-hour averaging period as applicable or appropriate for perch spawning.
Based on the site-specific data in the record, Mirant Kendall asserts that, from March 20 to April 30, maintenance of 24-hour average temperatures not-to-exceed the 90-95% confidence upper bounds of ambient temperatures (Comment C5) in 50% of the cross-sectional area of the river running perpendicular to the banks opposite the upstream edge of the ZD would be adequately protective of the BIP of spawning yellow perch in the lower Charles.

Comment related to C19 from CRWA: According to Page 68 of the DD, the literature identified yellow perch adults as the resident adult fish stage most sensitive to elevated water temperatures. EPA selected a Habitat Suitability Index of 0.5, which corresponds with an upper temperature limit of 59 F. There is no justification for adopting this HSI and the higher limit. The temperature range for adult breeding extends only to 54 ºF. EPA presents no evidence to show that yellow perch adults can spawn at higher temperatures. With other adjustments, the maximum temperature is set at 65 F, which is 11 degrees higher than the yellow perch's maximum breeding temperature. High temperature limits and a HSI of 0.5 fly in the face of EPA's ten year effort toward a swimmable and fishable Charles River by Earth Day 2005.

Comment related to C19 from CLF: Clearly, the success of the permit in setting temperature limits that promote a BIP is heavily dependent upon using appropriate seasonal dates for the species evaluated, particularly with respect to critical natural history phases such as migration and spawning. The spawning period indicated for yellow perch is limited to just 5 weeks (20 March through 30 April) and this is not justified by the best available science. Yellow perch begin to spawn when the water has warmed enough and continue to spawn at least into May so long as the water does not get warmer than about 55 ºF. Based on the scientific literature, under improved conditions in the Charles, one would expect these fish to continue to spawn in May, June and possibly into early July. This means that a protective permit would set temperature limits so as to be supportive of spawning, egg and larval development, and the growth and maturation of young through the spring and early summer.

Response to C19 and related comments: The permittee asserts that the ZPH is not appropriate habitat for yellow perch spawning (discussed in section D of the Mirant Comments); that the 4-hr. average is not appropriate for perch spawning and that the 90-95% confidence upper bounds of ambient temperatures should be used as is outlined in Comment C5. EPA and MassDEP address the YP habitat issue in Response C17 and D11. With regard to the 90-95% confidence upper bounds: this question was addressed in the Response to Comment C5 with respect to alewives. The same argument applies for yellow perch.

In response to CRWA and CLF's concerns, EPA and MassDEP agree that the temperatures enforced in the ZPH are not ideally suited to support yellow perch spawning according to the available literature. Again, the goal of the ZPH is to enforce temperatures that are sufficiently hospitable to maintain the BIP in the lower Basin as a whole, not to make the ZPH itself an optimal habitat for the BIP.

The overall concerns EPA and MassDEP have with a 24 hour averaging period for compliance with a protective temperature limit rather than a 4 hour averaging period is discussed in Response C16. Yellow perch, like other species, are characterized as spawning under a relatively narrow range of water temperatures. Taking into account the documented influence Kendall Station has to manipulate temperatures in the lower Basin, allowing a spawning temperature limit to be averaged over a 24 hour period would conceivable allow the facility to raise temperatures beyond expected spawning temperatures for YP for short periods within a day, while still meeting a calculated protective limit over the 24 hour period. It is not considered protective to design a permit where a protective spawning temperature could be consistently exceeded within each 24 hour period and still maintain that the temperature limits is achieving the goal of protecting the BIP. A four hour averaging period is a better mechanism to ensure that protective temperature limits are not consistently exceeded within the averaging period.

Comment C20: Protective Temperature and Time Periods for Yellow Perch Adult Stage Overly Stringent. Sections 5.6.3k and l of the DD detail the selection of the protective temperature and time period for the adult stage for yellow perch. These sections describe the rationale behind selection of the WQS of 83 °F throughout the ZPH as adequate to protect adult yellow perch. The target is 80.6 °F where the fish actually are present.

The Agencies assert there is an absence of site-specific avoidance temperatures for adult yellow perch in the Charles River. Mirant Kendall believes that considerable information exists in the site-specific data it collected and which the Agencies admit they have not fully considered.

Mirant Kendall encourages the Agencies to review the site-specific data it has submitted, with particular attention to the fact that most of the fish captured were in mixed schools comprised of adults and juveniles.

Mirant Kendall asserts that maintenance of 24-hour average temperatures not-to-exceed 83 °F more than three days per month and the 95% confidence upper bound on any day in 50% of the cross-sectional area of the ZPH defined by Stations 3, 4, 5 and 6 in the summer would be adequately protective of the BIP of juvenile and adult yellow perch in the Lower Charles.

Response to C20: As stated in Response C17, evidence that yellow perch (YP) were present in greater numbers upstream of the influence of the Station's discharge and were found primarily in deeper, cooler water in the ZPH can be viewed in several ways. One reason for this observed pattern of distribution could be that the habitat identified by the permittee downstream of the discharge is less suitable for YP for reasons not associated with higher water temperatures. However, no scientific assessment of the quality of yellow perch habit in the lower Charles was submitted by the permittee to support this position. It is at least as equally plausible that the YP pattern of distribution documented by extensive collections and tagging studies was directly caused by avoidance of otherwise suitable downstream habitat due to the thermal influence from Kendall Station. Temperature data from the lower Basin and literature values for YP habitat suitability for temperature do support this position. The objective of the protective temperature limits is to preserve habitat that will not cause avoidance behavior in fish downstream of the discharge.

One concern noted in the field data was that a single water temperature value was presented along with each beach seine collection. A near surface and a near bottom temperature reading at the greatest depth sampled in a few representative locations in the sample area would have provided a better assessment of the actual water temperatures that coincided with the presence of YP. This concern is fully discussed in Response C17. With regard to the 95% confidence upper bounds: this question was addressed in Response C5, Section 2 for alewives. The same argument applies for yellow perch.

It is not clear what justification the permittee relied on to support its proposed permit requirement that a temperature limit, no matter how it is derived or what averaging period is used, can be exceeded up to three days in a month and still be considered protective. EPA and MassDEP will not consider this approach when no reasonable justification is presented to ensure the requirement is protective of the BIP.

EPA and MassDEP did not view a 24-hour average maximum temperature limit as appropriately protective in the specific case of the lower Charles River Basin for the reason presented in Response C16.

Comment C21: Temperature Limits More Stringent than Expected Range of Ambient Conditions. In setting their proposed temperature limits and associated time periods, the Agencies stated that the goal as "to determine the appropriate deviation from ambient or natural temperature conditions without adverse effects to the biota and to the balanced indigenous population." (DD Section 5.1). Further, the Agencies stated that "Kendall Station intake temperatures seemed to be a reasonable approximation of ambient river conditions in the spring." (DD Section 5.6.3i). The proposed temperature and time limits, however, are less than two standard deviations above the mean temperatures experienced by the resident species for the same calendar periods over the spring and summers of the last six years, and in one case (June 1-7), less than a single standard deviation above the mean. Thus in fact, the Agencies' proposed thermal limits do not fall within the naturally occurring range (2 standard deviations) of ambient temperatures in the river.

Based on more than six years (1998-2004) of essentially continuous monitoring at the Broad Canal intake, the Agencies' proposed 4-hour block average limits compare as follows to the means, Standard Deviations and 90% and 95% upper bounds of ambient temperatures for the respective periods:

Frequency Distribution of Maximum 4-hour Block Average Temperatures (°F) at Kendall Intake, Compared to Agencies' Proposed 4-hour Block Average Temperature Limits in ZPH

Time of Year	Mean at Intake	Standard Deviation	90% Confidence Upper Bound	95% Confidence Upper Bound*	Draft Permit in ZPH
April 2-14	50.03	4.84	58.02	59.72	61
April 15-30	56.14	4.06	62.84	64.26	65
May 1-10	62.15	4.36	69.34	70.86	66.4
May 11-22	64.16	3.59	70.09	71.35	68
May 23-31	65.61	3.53	71.43	72.66	70
June 1-7	68.76	3.78	74.99	76.32	72
June 8-11	69.66	3.89	76.08	77.44	75
June 12-August 31	77.97	4.18	84.87	86.33	83

***2 standard deviations above the mean**

MK Comment Ex. Nos. C.21-1 and C.21-2 graphically illustrate how the upper end of the normal ambient temperature range for some of the periods is higher than the Agencies have set their proposed limits. For both the May 1-10 and June 1-7 periods, the Agencies' proposed limits are about 3 °F below the 90th percentile values for those same periods.

Even assuming that based on monitoring data from upstream areas the Agencies might view "ambient" as up to 2 °F lower than the intake temperature in low flow periods, the Draft Permit limits provide either no deviation at all from the background range (June 8-11), or up 2 °F lower than the background range (June 1-7).

Looking beyond the intake data, the temperatures in the proposed ZPH have frequently exceeded the proposed limits. MK Comment Ex. Nos. C21-3 and C21-4 show the numbers of days and percentage of each period that exceeded the proposed limits from 1999 to 2004 based on continuous measurements at the intake (Table C21-3) and, more recently, at thermistors throughout the basin (Table C21-4). Those thermistors included one representative of “ambient” at the Harvard Bridge and ones in the ZPH near station 3 on the Boston side (“Boston”) and just above the Charlestown Dam. The proposed limits were exceeded for at least a few days in each of the last six years both at “ambient” and ZPH locations. For example, in summer 2002, there were 9 days of exceedances at the Harvard thermistor and more than 30 days with exceedances in the Boston ZPH between June 12 and August 31. However, as discussed extensively in Mirant Kendall’s submittals and throughout this section of the comments, the Agencies have set limits below these historic temperatures despite the absence of any evidence from the ongoing river studies that those actual temperatures have caused biological harm.

Response to C21: This comment is similar to other comments by Mirant which urge EPA and MassDEP to peg the maximum temperatures allowed in the permit to the upper end of temperatures as they might have fluctuated historically in the lower Basin. In short, EPA and MassDEP do not believe it would protect the BIP to authorize Kendall Station to heat the lower Basin to levels that represent the upper bound of ambient temperatures. Just because individuals of the BIP have survived occasional temperature spikes does not support the conclusion that the BIP would be protected under a regime where the lower Basin could see those temperatures maintained artificially high on a continuing basis.

As detailed in the DD, EPA and MassDEP reviewed scientific literature and site specific biological data submitted by the permittee to establish protective temperature limits. Only then did EPA and MassDEP compare these limits with approximate ambient water temperatures in the Charles River to obtain an overall picture of how the limits compared with natural conditions in the river.

The permittee provides a frequency distribution of Maximum 4-hr Block Average Temperatures at the Kendall intake and compares these with the draft permit limits. By doing this, the company fails to follow its own advice in presenting the 90 or 95th percentile data. This was discussed in Response C5 (3). Mirant does not develop a 90th or a 95%-ile figure for the available data. To do so, it would have to provide all the 4-hr block averages for the time period in question. Instead, based on the title for the table on page 32 of the Mirant comments, the company has taken the maximum 4-hr block averages from each day and has developed upper bounds of the confidence limits for these. This is not seen as an appropriate use of the dataset which results in temperature values that are much higher than the true 90th or 95th percentile temperatures.

Mirant states that the Agencies "might view 'ambient' as up to 2 ºF lower than the intake temperature" in the table on the same page during low-flow periods. Based on information presented in the DD, ambient temperatures at the B.U. Bridge have been documented more than 5 ºF lower than those at the intake. Thus, Mirant's temperature values for the June - August time period may be flawed.

Mirant also compares thermistor records from the Kendall intake to "ambient" data at the Harvard Bridge. The Harvard Bridge is not the ambient station established in the permit. The "ambient" station is much farther upstream, near the B.U. Bridge. During months of low-flow (e.g., June through September) temperatures at the Harvard Bridge may be substantially increased by the thermal plume from the Kendall discharge. Thermal influence of the plume has been projected by the permittee to range as far upstream as the B.U. Bridge, (near the permit's "ambient station"), which is well upstream of the Harvard Bridge.

Comment C22: Suggested Revisions to Temperature and Time Periods Based on Site-Specific Field Data from Lower Basin. Mirant asserts that the in-stream limits proposed in the Draft Permit are overly stringent and not supported by site-specific data in the record. Section 5.6.3m of the DD notes that as "more site-specific field data is collected from the lower basin, these temperature limits and time periods may be modified." Mirant further asserts that the data presented in the record to date, supplemented by the additional 2004 data provided concurrent with these comments, is sufficient to support a revision of these temperature and time limits.

Further, the proposed absolute water temperature limits are all based on simultaneous 4-hour averaging at an upstream location of much smaller water volume, which therefore cools much more rapidly than the ZPH when temperatures are at the in-stream limit.

This requirement would arbitrarily force Kendall Station to remain shut down unnecessarily, for example after cool nights when the 4AM to 8AM B.U. Bridge temperature has cooled by about one degree overnight while the larger volume in the ZPH has only allowed the temperature to cool by about half a degree. Finally, as discussed in more detail in Comment D2, Mirant asserts that use of 4-hour block averaging is unreasonable and arbitrary for each of the limits proposed for the protection of resident species.

Response to C22: EPA and MassDEP reviewed all submitted data in assembling responses to the comments and issuing the final permit for Kendall Station, including the 2004 and 2005 data. EPA and MassDEP do not agree that the additional site-specific data submitted with the permittee's comments warrant a less stringent temperature limit approach that relies more extensively on ambient temperatures. To the contrary, based on Comment Response C3, the newly submitted data support EPA and MassDEP's decision to start the design of the ZPH with a survey of the scientific literature for protective temperatures. Having found evidence of appreciable harm from the existing discharge, EPA and MassDEP are not prepared to simply adopt that status quo to protect the BIP. Nevertheless, the permitting Agencies note again that the permit tempers a strict application of the literature values to account for the conditions in the lower Basin, as CLF and CRWA are quick to point out.

EPA and MassDEP agree that the ambient temperature station (Station 1) is located in a smaller water volume than the area of the lower Basin adjacent to Kendall Station. As stated in the DD, it was necessary to place this station at least that far upstream in order to prevent the ambient temperature monitors from coming in contact with the thermal plume from the Station. The Station's thermal plume has been documented to influence water temperatures as far upstream as the B.U. Bridge.

It appears, however, that the permittee has misinterpreted the compliance mechanism that involves the ambient temperature monitor at Station 1. This monitor is primarily used to determine compliance with the maximum delta T of 5 °F between Station 1 and all other monitoring stations. Based on data submitted by the permittee that documented a "lag" in temperatures from the ambient station to the downstream stations, EPA established a 24-hour average value when delta T compliance is calculated.

It is unclear what unfair penalty the Station is subjected to when the ambient monitor (Station 1) and the downstream monitors are all at the proposed limit (e.g. 70 °F on May 25th) and the Station 1 location cools faster. According to the permit, the maximum four-hour temperatures in the ZPH must not exceed the limit in effect (70 °F in this example) regardless of what the ambient conditions might be. In fact, the ambient temperature monitor at Station 1 will likely always record a cooler temperature when the Station is in operation or has recently operated. The fact that the lower Basin adjacent to the Station has a greater volume of water and takes longer to cool also means that this same larger volume of water takes longer to heat. This capacity to absorb heat is used to great advantage by the Station as it discharges its waste heat. Therefore, EPA and MassDEP believe any effect created by the different rates of cooling and heating for the ambient monitor and the ZPH monitors cuts in both directions and likely cancels itself out over time.

The response to comment that the 4-hour block averaging is unreasonable and arbitrary for each of the limits proposed for the protection of resident species is fully discussed in Response D2.

Comment C23: Temperature Limits and Time Periods for the Most Sensitive Anadromous Species are Overly Stringent, Unsupported by Charles River Experience and Should be Revised.

Section 5.7 of the DD lays out the rationale for the selection of the thermal and time limits for anadromous fish species in the lower Charles River Basin. In Section 5.7.2, the Agencies define the alewife as being the resident species most sensitive to elevated temperatures. Subsequent subsections set out the rationale for the determinations of the temperature and time limits for each stage of the life cycle of the alewife, to be applied in the ZPH.

As an initial matter, Mirant has significant concerns regarding the definition of the ZPH for this species. These concerns are discussed in Section D below. With respect to the temperature and time limits established for this species, Mirant has concerns regarding the appropriateness of the specific temperature limits and time periods established based on the data sources used to set them. These concerns are summarized below, followed by specific examples of errors incorporated in the draft permit.

In general:

- For the targeted anadromous species, river herring (alewife), Mirant Kendall asserts that best available information clearly demonstrates that the BIP in the Charles River is limited by hydrologic modifications, which confine the population to the lower portions of the river, and make the population extremely vulnerable to "washout" of eggs and larvae any time there are flow episodes >~ 400 cfs between mid-May and mid-June.

- Mirant Kendall's sampling program found that larvae and YOY alewives were significantly more abundant and larger in May through August after the two low-flow springs (1999 and 2004) without high flow episodes between mid-May and mid-June as compared to the three other years sampled with such episodes (2000, 2002 and 2003). See MK Comment Ex. No. C23-1.

- Mirant Kendall notes that these data also demonstrate that periodic exceedances of the Agencies' proposed thermal limits for mid May and early June (about 10 days each in 1999 and 2004) were experienced without any evidence of appreciable harm. To the contrary, the results indicate that in the years of lesser relative abundance of alewives and no larval growth until mid-June (2000, 2002 and 2003), there were far fewer thermal exceedances: zero (2002, 2003) to three days (2000) in the mid-May to mid-June timeframe. MK Comment Ex. No. C21-4.

- Mirant Kendall's site-specific monitoring program demonstrates the greater importance of river flows in mid-May to mid-June compared to exceedances of the proposed temperature limits. This demonstration is reinforced by the observation of greater relative numbers of returning adult alewives from the 1999 and 2001-year classes, compared to returns from the 1998 and 2000-year classes. 1999 and 2001 were lower-flow years with frequent exceedances of the Agencies' proposed thermal limits in spring and summer, while 1998 and 2000 were cooler years with very few exceedances of thermal limits, but significant flow events in the critical mid-May to mid-June timeframe for egg and larval retention and growth. MK Comment Ex. Nos. C21-3 and C23-2.

Further, the extensive site-specific data collected by Mirant, yet not fully considered by the Agencies, strongly suggest the absence of harm to the BIP as the upgraded Station operated under its existing permit. For example:

- The data collected by Mirant Kendall on the abundance of alewives in the river demonstrate that despite periodic exceedances of the Agencies' proposed thermal limits for mid-May and early June (about 10 days each in 1999 and 2004), there was actually observed greater abundance and more rapid growth of alewives as opposed to appreciable harm. By contrast, as discussed above, the years of lesser relative abundance of alewives and virtually no larval growth until mid-June (2000, 2002 and 2003), experienced very few thermal exceedances, zero (2002, 2003) to three days (2000) in the mid-May to mid-June timeframe. MK Comment Ex. Nos. C21-3, C21-4, C23-3.

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- YOY alewives were more abundant in the later summer and fall of the three years (1999, 2002 and 2003) that had frequent exceedances of the Agencies' proposed 83 °F limit for mid-June to October, as compared to 2000, which did not experience exceedances. During one of these years, 2003, Kendall Station operated at heat loads of more than 50% of permitted capacity throughout the summer, including about 83% in July. This heat load profile is typical of that envisioned by Mirant Kendall for future commercial operation of the facility.

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- In the spring of 2003, tagged adult alewives from the spawning run moved effectively upstream past the plant and across horizontal Delta T's greater than the 5 °F proposed limit in the Draft Permit.

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- In the Spring of 2004, mid-May densities and lengths of Alosa larvae, and early to mid-summer occurrence of alewife YOY in beach seine samples MK Comment Ex. No. 23-1, were all significantly greater than in any year since 1999, following more than 70% of permitted heat load discharge by Kendall Station during the spawning run in April, 50-60% of permitted heat load in July/August, and 11 days of exceedance of the Agencies' proposed thermal limits for alewife protection in mid-May.

Response to C23: Mirant asserts, through a number of statements, that the draft permit limits for temperature and time periods are overly-stringent and that they are unsupported by both newly-reported data and formerly-presented site-specific data from the Charles River. In response to comment C44, EPA and MassDEP further discuss refinements to the temperature regime which the permitting Agencies concluded are necessary to protect the BIP. In this comment C23, Mirant basically makes two broad assertions:

1. "Washout" of eggs and larvae during high flow years have a bigger effect on the abundance of river herring than temperature variations; and

2. The presence of alewives during periods of higher temperatures strongly suggests the absence of harm to the BIP from the upgraded Station's operation.

In addition, Mirant makes two more specific points:

3. Tagged alewives moved effectively across horizontal changes in temperature (delta T's) greater than 5 F; and

4. Alosa larvae densities and lengths in the Spring of 2004 appear to be greater during a period of elevated heat output from the Station.

As background to the responses to these points, EPA and MassDEP have extensively reviewed the data Mirant has submitted, including the 2004 and 2005 data. Many of the conclusions that are pertinent to responding to this comment C23 are explained and presented in more detail in Response C3, concerning a finding of appreciable harm from Kendall Station's discharge. Therefore, this response will sometimes refer back to the analysis and conclusions presented in Response C3.

1. Washout

One key component of Mirant's contention is that "For the targeted anadromous species, river herring (alewife), Mirant Kendall asserts that best available information clearly demonstrates that the BIP in the Charles River is limited by hydrologic modifications, which confine the population to the lower portions of the river and make the population extremely vulnerable to ’washout’ of eggs and larvae any time there are flow episodes >~400 cfs between mid-May and mid June."

As a threshold matter, it may not remain true that the anadromous species remain largely confined to the lower Basin. None of the sampling to date has fully assessed the degree of adult river herring movement past the Watertown Dam. Improvements were made in the fish ladder at that Dam in 2005, but unless a reliable method of counting river herring that move into the lower Charles, and that move past the Watertown Dam, is developed and implemented, EPA and MassDEP will have no basis for the degree of confinement of the adult population below the Watertown Dam. Prior to 2005, the permitting agencies expect that Mirant’s statement that the bulk of the population was confined below the Watertown Dam was a reasonable assessment, based on the fact that the Watertown Dam fish ladder was not functioning properly in past years.

If the hypothesis is true that the population of river herring in the lower Basin is greatly influenced by washout during high-flow years (although the night-time beach-seine data do not support this view), it stands to reason that these may be the years of highest mortality to eggs and larvae. Washout during high-flow years would result in a substantial drop in the production of adults. Since washout rates in the lower Basin are primarily influenced by the amount of rainfall, this environmental variable in the river is beyond the control of the permittee and the regulators. Therefore, EPA and MassDEP must treat such washout as a “significant impact” in the assessment under 40 CFR 125.73(a) of “the cumulative impact of [the] thermal discharge <u>together with all other significant impacts</u> on the species affected” (emphasis added).

Consistent with Mirant's hypothesis, the low flow years would be important to rebuilding populations of alewives, bluebacks and, potentially, American shad in the Charles. It would follow then that EPA and MassDEP must be especially careful to assure that the permit allows alewife to maintain a balanced indigenous population and allow other anadromous stocks to be protected during low-flow years. During the years of high flows, Kendall Station would likely have less operational difficulty in meeting the thermal limits required by the permit, due to the higher level of dilution available in the lower Basin. Ironically, even though it should be easier to meet the permit’s thermal limits in high flow years, if Mirant is correct, the generally cooler ZPH will be supporting a smaller population of river herring because of washout.

Following the logic of this premise, it is during the low flow years that preserving the lower Basin as suitable habitat for the BIP emerges as especially important to generate a stronger year class of the species compared with the overall lower recruitment that took place under “washout” conditions in wetter years. Also, it is true that Kendall Station’s discharge of heat will have its greatest impact on the lower Basin during times of low flow, because of the lower dilution levels available to absorb the heat. Therefore, it is precisely during the low flow years that the permit’s heat limits become especially important to maintain temperatures in the ZPH that will protect the lower Basin as habitat for the BIP. Contrary to Mirant’s suggestion that washout somehow minimizes the importance of temperature for protecting the BIP, washout becomes a factor in the cumulative impact analysis that supports the contention that temperature limits are even more critical in the low flow years, with the potential to support even greater reproductive productivity.

If the bulk of the population of alewives that enters the lower Charles was confined to the segment of river downstream of the Watertown Dam, then the potential cumulative impacts of Mirant's operations resulting in added heat, entrainment and impingement in the lower Basin would be substantial in low-flow years. Habitat for adult alewife spawning is apparently best below the B.U. Bridge in the wide section of the river (see Response to C3 and personal communications to G. Szal). In addition, limited sampling for juveniles by Mirant in segments of the river upstream of the B.U. bridge produced few or no juvenile alewives, while sampling downstream of the B.U. bridge was relatively productive in certain years, depending on how close this sampling was to the Mirant discharge (See Response C3). In addition, river herring larval densities in 1999 and 2000 were quite high in the area downstream of the B.U. Bridge, indicating that spawning took place in the wide section of the river. If it is indeed true, that the alewife population was primarily confined downstream of the B.U. Bridge, then Mirant's negative impacts to the alewife population would be quite substantial.

A review of each of the categories of potential loss due to Mirant's operations is a necessary component of this response to comments, and has resulted in requirements by MassDEP in the State Water Quality Certification (WQC) for modeling and monitoring to determine the extent of impact from each of these categories. By Mirant's own projections (see the Determination Document, Table 8.1.2-2 in Section 8.1.2i) entrainment losses to river herring larvae occurred in 1999 and 2000 amounting to 14% and 23%, respectively, of the total herring larvae population that was produced in the lower Basin. If the entire population of river herring was confined to the lower Basin due to the spawning constraints at the Watertown Dam during those years, these percentage losses of larvae due to entrainment would translate to the same percentage loss of equivalent adults. That is, if there were a loss of 23% of the larval population due to the facility in year 2000, and all other forms of mortality to that population were to remain unchanged, the number of adults projected to have resulted from the year 2000 larval population is expected to be about 23% lower than it would have had entrainment not occurred. The State WQC includes monitoring programs to evaluate population size of anadromous species of interest and the degree of their movement past the Watertown Dam.

In addition to entrainment impacts, Mirant's operations have also been shown to have large-scale negative effects on the nursery habitat of river herring. EPA and MassDEP have shown (see Response C3) that Mirant's discharge, in 2004 and 2005, deterred juvenile alewives (and bluebacks) from utilizing much of the lower Basin as nursery habitat. Impingement losses are of concern as are potential effects of the discharge pipe. Mirant has provided video documentation that the discharge pipe attracted river herring, and some of these fish attempted to breed in the discharge pipe. An assessment of the loss of breeding potential for river herring due to this attraction to the discharge pipe will be possible based on monitoring included in the final permit (See Response Related to C7 from CLF).

If alewives are primarily confined to the lower Basin, the effects of Mirant's operations may be quite severe in low flow years. The permitting Agencies are prepared to agree with Mirant's hypothesis that years of low river flow may be quite important to the rebuilding of river herring stocks downstream of the Watertown Dam due to low rates of larval washout during these years. Because of Mirant's ability to directly affect all life stages of river herring and certain life stages of other fish of concern in the lower Basin, as well as their habitat, especially in years of low river flow, Mirant's impacts to these populations during these years may be quite severe. Section 316(a) charges EPA and MassDEP to ensure that the permit protects the BIP from those cumulative impacts.

In order to more fully understand the effects of Mirant's operation on the populations of species of concern, MassDEP, through its Water Quality Certification process, has determined that there needs to be a quantification of the potential effects of various components of the plant's operation on these species. If future monitoring leads EPA and MassDEP to find that the facility is continuing to negatively impact the BIP, the modeling and monitoring program will assist the Permitting Agencies in directing attention to the operational components that are of greatest harm to these populations.

2. Temperature and Alewife Presence

In Response C3, EPA and MassDEP present an extended analysis of the data that Mirant uses to assert that the BIP tolerates, or, according to Mirant, arguably enjoys, temperatures that are higher than the limits in the draft permit. The Permitting Agencies here present a brief overview of those conclusions.

The alewife population appears to be much reduced in comparison with the potential of the lower Basin to support the species. While EPA and MassDEP acknowledge that the dams have an obvious impact on the "carrying capacity" of the lower Basin, the permit must protect the BIP in the context of all the stresses that population faces. Therefore, EPA and MassDEP need to be especially careful to protect habitat for the BIP in the lower Basin from the impact of excessive heat, given the fragility of its hold in the area.

It does appear that heat has a negative impact on the species. When EPA and MassDEP disaggregate the data Mirant summarizes in this comment, some patterns become clear which demonstrate that heat from the Kendall Station's discharge has the effect of excluding alewives from habitat in the lower Basin. Samples taken closer to the outfall and closer to the heat of the discharge had fewer alewives than samples taken further away. Also, the catch rate per unit effort of sampling at temperatures above 81ºF was either zero or was generally much lower than that at temperatures lower than 81ºF. Therefore, the sampling provides support for the concern EPA and MassDEP have that elevated temperatures from the plant's discharge can exclude alewives from habitat in the lower Basin.

Finally, as discussed in more detail in Response C3, EPA and MassDEP have concluded that this habitat exclusion is an appreciable harm for this BIP. The permitting agencies confirm this conclusion even in the face of Mirant's argument that the total population of certain species appears to have been higher in some years when the temperatures were higher. Arguably, to some extent, this dynamic may be explained by lower rates of "washout" during the hotter dry summers. Indeed, there are any number a variables that may affect overall potential biomass of an anadromous year class in any given year, temperature being only one variable, and not necessarily the controlling variable. But two conclusions seem reasonably well supported in the data presented on this record: the alewife population is low in the Charles River Basin,[1] and alewives appear to avoid the higher temperatures from which the permit is designed to protect them. If Mirant is correct that the population increases slightly during low-flow years, it is quite plausible that this rebound would be even more robust if the species had better access to more habitat.

In Comment C13, Mirant dismisses this line of analysis as an "it might have been better" argument. Mirant's point appears to be that the permitting agencies need affirmative proof that heat is the sole or primary factor affecting the survival of the BIP in the lower Basin. Mirant asserts that it is not enough for EPA and MassDEP to conclude that heat is a contributing factor, among many, to depressed BIP populations. But in studies of ecology in the real world, as with empirical but non-laboratory sciences generally, the best science available often involves attempting to discern how a wild population was affected by a stressor without the knowledge of precisely how the population would have fared absent the stressor. In short, the lower Basin does not readily permit EPA and MassDEP to conduct a controlled field experiment isolating the effect of heat on the BIP. To the extent practicable, EPA and MassDEP are able to separate out the impact of temperature from the very complicated multi-variable system naturally operating in the lower Basin to affect the health of the BIP, there is a statistically significant relationship between increased heat and reduced presence of alewife. Therefore, heat does appear to exclude alewives from habitat. If the low river flows and correspondingly low rates of washout during hot years have an ameliorating effect that is greater than the negative effect of the heat in those

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[1] Only one estimate of the adult alewife population size currently exists for the Charles. This estimate was provided by Mirant and was based on sonar recordings of river herring (i.e., blueback herring and alewives combined) at the entry to the lower Basin in the spring of 2002. Mirant estimated that about 45,000 river herring entered the lower Basin that year. Mirant also conducted gill-netting near the New Charles River Dam near the point of alewife entry to the lower Basin. Based on the relative proportions of alewives to total river herring in these nets, in combination with the total river herring estimate, Mirant estimated that about 8,000 adult alewives entered the lower Basin in 2002.

These fish numbers have been referenced by many interested parties and regulatory agencies to assist in the evaluation of the anadromous fish run in the Charles River, including EPA and MassDEP in this document. It must be clearly understood, however, that these numbers were derived from a pilot study conducted by the permittee in 2002. A list of assumptions, potential sources of error and suggested refinements were documented for future field efforts to better estimate herring runs at that location. Any use of the fish entry estimates from 2002 must take the preliminary nature of these numbers into account.

It is important to note that the permittee's preliminary estimate of 45,000 adult river herring is well below the estimated carrying capacity for the Charles. MADMF provided two estimates of the herring carrying capacity of the Charles. These two estimates were 250,000 and 500,000 fish. Neither estimate considers any issues with respect to herring passage at the New Charles River Dam or at the Watertown Dam; both dams may affect the ability of alewives to move upstream and populate the upper Basin.

The permittee's estimate of the adult run strength as projected by the 2002 pilot study, (i.e., 45,000 fish), although preliminary in nature, is still about 1/6th to 1/11th the MADMF estimates of the system's capacity. Because the 2002 alewife estimate (8,000 fish) of population size was so small, there is potential concern that any downward trend in alewife population size could result in a loss of this population from lower Charles.

years, this observation does not mean that heat is not an appreciable harm to the species. And it certainly does not mean that Mirant should have authority to add even more heat in a hot, low flow year when ambient river conditions alone are likely stressing the BIP.

Mirant is especially poorly positioned in this proceeding to discredit EPA and MassDEP's use of the argument that the company might characterize as "it might have been better." Mirant here carries the burden of proof to show that heat levels it advocates for its discharge will protect the BIP, and is correspondingly required to demonstrate no appreciable harm from its existing discharge, if that is the analysis on which it wishes to rely. EPA and MassDEP have concluded that the effect of habitat exclusion, which heat has caused, would be an appreciable harm to alewives in a hot, low flow year. The permitting agencies are simply saying that this interpretation of the data is at least equally as plausible as Mirant's assertion that the marginally higher number of alewives in hot years must mean that heat does not harm the BIP. Hypothetically, in the unlikely event that the two theories were indeed equally plausible, Mirant's hypothesis does not prevail because the company carries the burden of proof. But EPA and MassDEP conclude that the case is not nearly so close, because the permitting agencies' hypothesis aligns reasonably well not only with the data collected in the lower Basin, but also with the directional indications of laboratory experiments where the effects of heat on the alewife could be isolated and studied in a controlled environment.

3. Tagged alewives and delta T's

As explained in more detail in Response to C33, EPA and MassDEP find that Mirant's tagging study was inconclusive as to the effect of the discharge on migration patterns of alewives. The permitting agencies also address parallel comments about the delta T limits in the permit in Response C6.

4. Alosa larvae densities and lengths in the Spring of 2004

The permittee stated that larvae (both bluebacks and alewives combined) and YOY alewives were larger in May through August after the two low-flow springs (1999 and 2004) than in other years. Mirant also contended that the data indicate that in the years of low flow (1999 and 2004) there were high larval growth rates although there were many alleged exceedances of the draft permit limits for temperatures during those years.

As a threshold matter, EPA and MassDEP do not necessarily concede that the data demonstrate that 1999 and 2004 saw the level of exceedances of the draft permit limits which Mirant asserts. The temperature readings taken in 1999 and 2004 were not collected according to the design of the temperature compliance regime in the draft or final permit. So there is no clear correspondence between this historic data and the limits included in the permit. Response C13 (d) contains a discussion of this issue.

But even if EPA and MassDEP accept Mirant's premise for the purposes of analysis, the permitting agencies do not accept the company's conclusion. EPA and MassDEP understand that it has been shown that the growth rate of alewife larvae is accelerated by warmer temperatures. However, the researcher Kellogg (1982), who did much of the work on temperature effects to growth rates, demonstrated that larval survival greatly decreases with warmer temperatures. Thus, as temperature increased in these experiments, survival decreased. In Kellogg's experiments, the test chambers with the highest temperatures to which alewives were exposed had the fewest survivors. This is discussed at length in Response C44 and is an important issue to understand for those involved in the Kendall Station permitting process. Mirant's demonstration that the growth rates of early life stage juveniles were greatly increased over that of several other populations may not be indicative of high-quality conditions for the alewives of the Charles. To the contrary, based on Kellogg's research, "super-sized" YOY would be typical of a temperature-stressed population with a low survival rate.

While it is true that river herring larvae were found in high densities on several dates in June of 1999, it is impossible to tell whether these were bluebacks or alewives. The high larval densities in 1999 may have translated into high alewife juvenile densities in that year. Certainly, juvenile alewives were found in comparative abundance in 1999 in day-time beach seines and the rate of capture in 2004 was higher than in 2002 and 2003. The density rise in 2004 must be taken in the overall context of the multi-year sampling data. The daytime capture rate in 2003 was zero; the capture rates in 2000 and 2002 were essentially zero. The alewife juvenile catch rate in 2004 increased from zero, but still, it was only one-tenth of the 1999 catch rate.

Comment C24: The Record Contains Adequate Charles River - Specific Evidence Regarding Impacts to Alewives. Section 5.1 of the DD notes “It can take many years of study for population effects to become apparent.” Mirant Kendall disagrees with the Agencies’ assertion in this regard. Rather, Mirant Kendall believes that if the Agencies had considered the site-specific data on the record, it should conclude that the required periods of time have indeed passed to make a well-informed judgment for the population of the anadromous species of most concern here, alewives. This species completes a reproductive cycle (largely in its river of birth) each year, so that one can readily compare reproductive success in warmer and cooler years based on information in the record.

For example, the Draft Permit specifies that a 72 °F 4-hour block limit is needed to protect alewife reproduction for the first week in June, yet despite 100% exceedance of that threshold in 1999, *Alosa* larval densities in the ZPH of more than 1,500 per 100 cubic meters were observed on June 8, followed by an abundance of juvenile alewives in July 1999 that was greater than in any other sampling year.

Response to C24: The permittee disagrees with Section 5.1 of the DD which states that "it can take many years of study for population effects to become apparent." The permittee states, for example, that Alosa larval densities (i.e., river herring densities) in 1999 were high despite 100% of the 72 ºF threshold in that year. In addition, alewife juvenile densities were high that year.

EPA and MassDEP continue to support the statements made in the DD that it can take many years of study for population effects to become apparent. Please see Response C23 above. In brief, Mirant may be correct that low flow years help support an especially strong class of river herring, while wash-out in high flow years depresses their densities. EPA and MassDEP conclude that it will continue to be critical to assess the health of the BIP across the years as their numbers wax and wane in response to several variables, some of which are beyond reasonable regulatory control, such as river flow, and some of which are required to be regulated consistent with protecting the BIP, such as Kendall Station's thermal discharge.

Regarding the statement that there was 100% exceedance of the threshold temperature in 1999, it must be pointed out that the temperature information provided by Mirant to predict that permit exceedances took place in the past were based on the intake temperatures at the Station. It has been shown that the intake temperatures, especially during periods of low flow (e.g., early summer, 1999), are greatly influenced by re-entrainment of the discharge. Thus, it is expected that much of the "threshold exceedance" was likely not a permit exceedance in the ZPH (although there is no way to substantiate this either way, since no temperature measurements were recorded in the ZPH), but was simply an elevated temperature period at the intake due to re-entrainment of the discharge. That is, intake temperatures, while used as a surrogate for ambient temperatures until June 15th in the DD analysis, could not be reliably used to predict an exceedance in a Zone of Passage and Habitat. Based on the permit limits, an exceedance would have occurred only if the temperature limits were not being met at a minimum of 50 % of the temperature monitoring points positioned at various depths and locations along the bank-to-bank transect downstream of the discharge (Monitoring Stations 3, 4, 5 and 6) as well as at other Monitoring Points in the Basin. Response C13 (d) also deals with this subject.

Contrary to Mirant's assertion that there is no problem with the alewife population in this Basin, based on the available data, it appears that the alewife population in the Charles has diminished over the past few years and only exists at very low levels and that appreciable harm to the juvenile population has occurred due to Kendall Station's discharge. Please refer to: a) the discussion of the adult gillnet data presented in Response C43 which shows a steady decline in catch per unit effort of both blueback herring and alewives since 2002; b) the discussion of the push-net datasets relative to the finding of appreciable harm in Response C3; c) the discussion of either zero catch or much reduced catch of juvenile alewives at temperatures higher than 81ºF in Response C3; and d) the discussion of daytime vs. nighttime shoreline seine data for both blueback herring and alewives in Response C48.

In addition to the data examination listed above, daytime shoreline seine information for alewives is presented below in Table C24-1.

Table C24-1: daytime alewife catch in beach seines for all years sampled since 1999. Data are collated from all seining stations sampled each year and results are presented as the number of alewives caught per 1000 square feet of area sampled.

Year	Total number of alewives caught	Total number of square feet sampled	Juvenile alewives per 1000 square feet
1999	441	38,888	11.3
2000	2	75,600	0.03
2002	1	119,723	0.008
2003	0	76,391	0.0
2004	67	55,835	1.2

2005	45	77,779	0.58

Juvenile presence showed a modest increase in 2004 compared to the two previous years, but was still only about 10% of the number collected in 1999 based on the daytime beach-seine capture. In 2005 when Mirant's intake volumes were at their highest levels of all years studied, and their discharge caused high temperatures in the lower Basin downstream of the Harvard Bridge, the daytime alewife catch rate dropped to about half the 2004 level.

Although juvenile lengths may have been greater in 1999 and 2004 than in other years, it is possible this was a response to elevated temperatures in the Basin. The increased growth rate in 2004 mentioned by Mirant coincides with high water temperatures. As discussed in Response C44, Kellogg's (1982) research demonstrated that although high temperatures were associated with high growth rates of the juvenile alewives surviving the tests, high temperatures were associated with greatly increased overall mortality of the juveniles used in these tests.

If it is true that low-flow years are important to the rebuilding of alewife stocks, it is imperative that permitted temperature limits protect against habitat loss due to high water temperatures throughout the water column, where D.O. is at least 5 mg/l, during periods of lower river flows in the lower Basin.

Comment C25: Charles River-Specific Record Evidence is Sufficient to Establish Impacts of Plant Discharge on Anadromous River Herring. In Section 5.1 of the DD, the Agencies assert that mortality of anadromous river herring after leaving the system complicates the process of assessing the plant impact. Contrary to the Agencies' assertion, mortality after leaving the system is irrelevant to determining the effects of the discharge. Even in theory, the discharge can only affect the following parameters, all of which take place and have been monitored along with corresponding data on temperatures and river flows by Mirant Kendall wholly within the system:

- Spawning migration of adults, monitored by gillnet and tagging studies in 1999, 2002, 2003 and 2004
- Reproductive success, monitored by ichthyoplankton collections in 1999, 2002, 2003 and 2004
- Distribution and development of YOY fish, monitored by beach seine in 1999, 2002, 2003 and 2004, and gill net and push net in 2003 and 2004
- Exit of YOY from the system, monitored by beach seine in 1999, 2002, 2003 and 2004, and gill net and push net in 2003 and 2004

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The DD fails to explain how the Agencies considered and weighed the results of the above site-specific monitoring efforts with the various literature studies to derive the proposed thermal limits for alewife protection. Mirant Kendall strongly believes that the those studies suggest that thermal conditions in 1999, summer 2002, summer 2003, and spring 2004 show no evidence of appreciable harm to the BIP despite frequent exceedances of the proposed thermal limits in the Draft Permit, when compared to 2000, when the proposed limits were not exceeded.

Comment related to C25 from CLF: EPA should use the best available science on the indicator species to set guidelines that will promote a balanced indigenous population. We do not agree with EPA's assertion that studies of indicator species under current conditions in the Charles River add crucial new data upon which permitting limits should be based.

Response to C25 and related comment: The permittee asserts that the site-specific record is sufficient to establish impacts of Station discharge on anadromous fish. Conversely, CLF comments that studies of the BIP under current conditions in the Charles are not scientifically useful.

EPA and MassDEP disagree that mortality to fish after leaving the system is irrelevant to determining effects of the discharge. Because the facility has the ability to warm the system, it can greatly affect the change in temperatures encountered by out-migrating adults and juveniles that move from the Charles River to Boston Harbor. This is one reason why a delta T limit in the receiving water is necessary. The likely changes in temperature encountered by out migrating river herring was fully discussed in the DD in Section 5.7.3c. There is also a discussion of this issue in Response C6. The short and long-term effects of this delta temperature on the out-migrating fish of both life stages are unknown. Also, the thermal component of the Station's discharge may modify the timing of when anadromous species enter the Charles River, as well as when they leave. Thus, mortality associated with leaving the system complicates the process of assessing Station impact because the facility's heat affects the Delta Temperature between the Charles River and Boston Harbor and related in-migration and out migration timing. These factors influence survival.

Beyond the question of increased mortality as the fish leave the system, the permittee maintains that mortality to fish <u>after</u> leaving the system is irrelevant to determining effects of the discharge. Mortality to anadromous fish that occurs beyond the influence of the Station's discharge must be taken into consideration in the same manner that the hypothesis of increased mortality from river herring egg and larval "washout" from the lower Basin is considered. Even though this environmental variable is beyond the control of the permittee and the regulators, EPA and MassDEP can not dismiss its impacts. The expected mortality of anadromous fish in the marine environment is viewed as a "significant impact" in the assessment under 40 CFR 125.73(a) of "the cumulative impact of [the] thermal discharge <u>together with all other significant impacts</u> on the species affected" (emphasis added).

Mirant states that the DD fails to explain how the EPA and MassDEP considered the results of site-specific monitoring, such as spawning migration of adults monitored by gill-net and tagging studies; reproductive success monitored by ichthyoplankton studies; distribution and development of YOY fish monitored by beach-seine, gill-net and push-net; and exit of YOY from the system monitored by beach-seine, gill-net and push-net.

Most of Mirant's questions are addressed in the Responses C3, C23 and C44 of this document. Exit of YOY from the system is not directly addressed, although there has been a noticeable depletion in adult alewife presence in the Basin based on adult catch rates in gillnets since 2002. The juvenile information is more variable and does not show a clear trend regarding either a rise or fall in densities over the years of specific surveys, although most of the surveys show a decrease in numbers. The push-net catch rate for juvenile alewives in daytime is essentially zero. The nighttime catch rate of alewives in push-nets has been very low since sampling began in 2003. This is discussed more fully in Response C3. The daytime catch rate of juvenile alewives in the shoreline seine has dropped substantially since 1999 (see Response C24 above) and rates seen in 2005 are about 1/20th those seen in 1999. The nighttime shoreline seine catch rate for juvenile alewives was variable from 2002-2005 and has consistently been much lower at the station closer to the discharge than at the reference station (see discussion of shoreline seine results in Response C3). However, there was a rise in the overall numbers caught at both the test and reference station in 2005 compared to numbers seen from 2002-2004.

EPA and MassDEP have noted this overall rise in nighttime shoreline seine catch rates for juvenile alewife. There have been some substantial changes in the Basin which may have allowed a Basin-wide increase in juveniles in 2005. Substantial changes were made to improve fish passage past the Watertown Dam. By allowing increased fish passage past this obstruction in 2005, the Massachusetts Division of Marine Fisheries greatly increased the potential for alewife breeding upstream of the Watertown Dam that year. Eggs that were deposited at upstream sites, and the resulting larvae, would have encountered more favorable nursery habitat, especially with regard to the thermal component, than that found downstream of the B.U. Bridge. EPA and MassDEP contend, that, due to Kendall Station's discharge and the notably higher temperatures resulting from that discharge over a wide expanse of the lower Basin in 2005, the population of alewives present in the lower Basin in that year was subjected to large-scale habitat exclusion.

Comment C26: The Agencies' "Margin of Safety" Produces Temperature Limits Too Low to Enhance or Support BIP. Section 5.1 of the DD asserts that the temperature limits EPA has selected strive to achieve a margin of safety to ensure a balanced indigenous population." Lowering temperature limits to create an assumed margin of safety, in this case, ignores consideration of the likelihood that temperatures can be too low to enhance or even support the BIP. Specifically, for river herring, including alewives, there is abundant evidence that lower temperatures delay and/or interrupt the spawning run.

Also, a study in the Connecticut by Savoy & Crecco suggest that growth of alosid larvae is delayed by cooler temperatures. The Draft Permit fails to describe fully and account for the potential consequences of enforcing stricter than necessary thermal limits.

Response to C26: Mirant is concerned that the permit limits, if set too low, would in this case delay or interrupt the river herring spawning run in the lower Basin. First, EPA and MassDEP do not agree that an unreasonable margin of safety has resulted in temperature limits that are too low. Second, EPA and MassDEP are unsure as to the foundation of Mirant's argument. For the sake of discussion only, if a temperature limit were set too low, this limit would not prevent the ambient conditions of the river to rise above the limit and allow the natural seasonal temperature cycle to take place. Kendall Station is not in violation of its permit if natural river temperatures exceed the permit limits. On the other hand, if a temperature limit in the permit is set too low in the view of Mirant and the river does not naturally reach this limit, Mirant seems to be saying that anadromous fish spawning runs would be delayed or interrupted in the lower Basin without the added heat contributed by Kendall Station. EPA and MassDEP do not support the position that completely removing the Station's thermal discharge from the lower Charles River Basin would negatively impact the natural spawning runs of anadromous fish.

There is abundant evidence that larval and juvenile habitat in the warmer months may be limited by high temperatures, that zooplankton communities in the lower Basin may be negatively impacted by warming of the Basin in the summertime, and that adult, larval and juvenile yellow perch and juvenile alewife habitat may be limited due to excessive warming by the facility (see the review of site-specific data in Response C3). Although it has been shown that the growth rate of alewife larvae is accelerated by warmer temperatures, Kellogg (1982) demonstrated that larval mortality greatly increases with warmer temperatures (see Response C44 below). In addition, the frequency of nuisance species may increase (e.g., blue-green algal blooms) with warmer temperature and/or large-scale community alterations may occur (e.g., with zooplankton; see Moore, et al., 1996).

Even if it were true that introducing heat into the system at one time of the year enhanced conditions for a particular life stage of one particular organism, it does not mean that this action would be beneficial for the entire system. The problem with "enhancing" conditions for one organism by addition of a pollutant is that it can have the opposite effect on other organisms in the system. EPA and MassDEP maintain that the more the lower Basin reflects natural conditions, the greater the possibility that the entire community of organisms that has successfully competed in the system will be restored and maintained in a balanced state. Mirant's own push-net and shoreline seine data (see Response C3) from 2003 - 2005 indicated that high temperature (in excess of 81 ºF) are problematic for juvenile alewives. "Enhancing" the thermal regime beyond this value is not seen as protective for this species.

Comment related to C26 from CLF: Animal life indigenous to the Charles will be seriously jeopardized if the permit goes into effect. The planned conditions within the ZPH will not be appropriate to support the indigenous species. Even though the permit includes an intricate system of date-specific temperature limits, and limits based on assessed temperature differential, this permit does not achieve an acceptable margin of safety.

Response to Comment related to C26 from CLF: EPA and MassDEP relied on scientific literature and site specific field collection information to derive protective temperature limits. While an area in the vicinity of the Station discharge will have elevated temperatures expected to cause acute or chronic negative effects on aquatic organisms, this relatively small volume of excessively heated water will not destabilize the BIP.

EPA acknowledges that this permit involves a sensitive balance between two competing demands: first, Mirant's concern that, consistent with the structure of 316(a), the variance for temperature discharges be no more stringent than necessary to assure protection of the BIP; and second, CLF and others' concern that the limits must indeed "assure the protection and propagation" of the BIP. Accordingly, EPA and MassDEP have designed this permit to balance these interests, while acknowledging that in the face of scientific and technical uncertainty, the permitting agencies have generally erred on the side of protecting the BIP.

Though EPA and MassDEP agree that there are elements of this permit design that do not create an optimal environment for the BIP, the permitting agencies vigorously disagree that no acceptable margin of safety has been incorporated into the protective temperature limits. The permit limits and overall compliance approach have been designed to incorporate a reasonable margin of safety in the following ways:

First, the life stages of the resident and anadromous species most sensitive to elevated temperature (yellow perch and alewife) were selected as the representative species used to determine protective temperature limits. Identifying these species, and then choosing the most sensitive subset of life stage and species deemed to be most sensitive to elevated temperature for a particular time period, ensured that all other species and life stages in the BIP are further protected from threshold temperatures that produce negative effects. See Responses C3 and C44. This approach provided a clear margin of safety for the majority of species in the BIP.

Second, the averaging time period used in the permit for temperature limit compliance is 4 hours. While this averaging period was selected for another reason (see Responses C16 and D3), this time period is less than the acute and chronic time intervals cited in the majority of scientific literature referenced in the permitting documents. This provides another layer of safety for the BIP.

Third, the location of the cross section continuous monitoring stations downstream of the discharge (Stations 3 - 6) will capture the worst case thermal impacts from the discharge. See Response Related to D2 from Riverways. Permit compliance is based on meeting protective temperatures in this critical area. All other upstream and downstream regions of the ZPH will be at least as large as the compliance cross section area. Most areas will be much greater in area and likely cooler with increased distance from the discharge point. The resulting margin of safety that ensures that a Zone of Passage and Habitat will be greater than 50% of any given cross sectional area in the majority of locations in the lower Basin will be periodically verified by required water quality monitoring.

Fourth, the real-time, continuous, in-situ design of the compliance regime that the permittee must meet provides a margin of safety that does not allow the facility to raise temperatures to a level that might cause thermal blockage.

Comment C27: Mischaracterization of time period for basin function as alewife nursery. Section 5.7.1 of the DD includes a statement that the basin serves as a developmental nursery "from the spring to the winter." There is no evidence from Mirant Kendall's sampling programs to indicate that the basin is a nursery for sensitive anadromous species beyond the early fall. The Agencies should provide the evidentiary basis for the assertion that the basin supports that function "to the winter."

Response to C27: EPA and MassDEP based this wording on the fact that juvenile river herring in other systems in Massachusetts have been known to out-migrate as late as early December (pers. comm. Phillips Brady, MADMF to G. Szal, DEP). If the number of juvenile alewives found in the system were to begin to climb higher, it is expected that the period of out-migration will be extended beyond what the permittee has documented to date. The nursery "season" should not be limited to that currently seen with the alewife population at its current small size.

Comment C28: Mistaken Speculation that Higher Water Temperatures will Halt Alewife Spawning Run. Section 5.7.1a (Adult Spawning Migration) states: "If the river temperature range passing through the lock is higher than the range a particular anadromous species has evolved to seek as part of the trigger to begin the spawning run, fish may not attempt to navigate the man-made structure. Highly reduced or completely halted spawning runs resulting from an 'attractant flow' temperature that is above the range suitable for an anadromous species to initiate a spawning run has the potential to make the propagation of a balanced population impossible".

Richkus (1974), notes that, especially at the beginning of the spawning run and continuing throughout most of the run, movement upstream was stimulated by increased temperatures. The same phenomenon would be expected to occur on the Charles River. Thus, fish would respond positively to increased temperatures at the beginning of the run, not be deterred from moving upstream.

Response to C28: Much of the response to this question has already been outlined in the Response C6 and Response C26 of this document. In part, EPA and MassDEP agree with the permittee. At the beginning and middle portions of the adult alewife run, adults have been documented to respond positively to increases in temperature. However, this is only true as long as the increases in temperature are not so great that they fall outside the temperature "envelope" of the adults acclimated to certain temperatures in Boston Harbor.

There is ample evidence in the literature, for a wide range of poikilothermic (i.e., "cold-blooded") fish species, that an "envelope" of suitable temperatures exists for each life stage. As acclimation temperature increases, so does the maximum temperature of avoidance, up to a point. The same situation exists for toxicity endpoints (see DD, Figure 5.7.3c-2). The use of temperature envelopes in predicting avoidance and/or toxicity endpoints is common in the evaluation of thermal discharges (see Brayton Point, 2002; and Armour, 1991). The agency statement simply refers to temperatures that are outside of the "acceptance envelope" for the particular acclimation temperature of the in-migrating fish.

Although Mirant references the 1974 Richkus study, the permittee failed to also reference the work of Graham (1956), in which fish acclimated at different temperatures were transferred to water of higher temperatures. These data were used in combination with the Richkus dataset to set an upper limit for avoidance temperature of fish acclimated to the mid-40's or low 50's (ºF). The difference between Richkus' study and the situation in the lower Charles is that EPA and MassDEP are allowing the temperature of the lower Charles to be artificially manipulated. It should be remembered that the Charles River is one of the warmest river basins in the state. This is primarily due to anthropogenic alterations (see Response C42) in the Basin. The concern is that the water temperature in the lower Charles, which is already high, when pushed even higher during low-flow springs and additional heat from Kendall Station, could rise to a level beyond that which induces avoidance in the incoming populations of anadromous fish. Mirant's comment could be interpreted to imply that there is no reason to provide any upper temperature limit for the period during which alewife adults are in-migrating. This position is contrary to the accepted approach that some level of increased temperature would induce avoidance. The temperature that EPA and MassDEP used for setting the avoidance level was based on the work of Graham (1956), Richkus (1974) as well as temperature and run strength information from alewife runs in Massachusetts and New Hampshire (see Table 5.7.3c-3 in the DD)

Comment C29: Mistaken Speculation that Elevated Temperatures will Lead to Earlier Alewife Spawning. In Section 5.7.1 of the DD, the Agencies further state “It must also be noted that elevated water temperatures may cause fish to enter earlier in the year than they naturally would. In this case, spawning may be induced to take place at an earlier date than the species naturally evolved to spawn. This could result in fish eggs hatching to the larval stage at a time before the larvae’s food source becomes abundant”

While elevated temperatures may stimulate upstream migration of alewife and other anadromous fish, the overall temperature regime in their spawning area is what determines if they will spawn, not the temperature that may trigger the upstream migration. The migration trigger could not, in turn, induce spawning or the hatching and development of eggs and larvae if the temperature in the spawning area is not suitable. To the extent that elevated temperatures might stimulate egg and larval development, such temperatures would also stimulate the productivity of the planktonic elements of the aquatic ecosystem that serve as the food base for the larvae. Both larvae and food base would respond in a similar fashion to the temperature regime in which they exist. Thus, elevated temperatures could not decouple this relationship, as suggested in this speculative statement.

Comment related to C29 from Riverways: Adult herring begin their run based on several factors including water temperatures and they are keyed on to flows in their upward migration. Have fisheries biologists determined if the constant flow from the facility might disrupt the timing of the alewife and blue back runs leading to reduced success? Might the large discharge in an impoundment also have disruptive consequences to the herring’s up-river migration? Consideration should be given to studying these two issues to ensure the already compromised anadromous and other fish populations are not further stressed.

Response to C29 and related comment: Mirant raises a legitimate concern with regard to this assumption. In a natural system, where solar heating causes temperature to rise in a system, it is more likely that large portions of the water body rise in temperature. Thus, where these temperature increases are substantial, one would expect to find a gradual change in zooplankton community structure as one moves from upstream to downstream reaches of the system. Although the downstream reaches may be warmer, there is typically not an abrupt change in temperature.

When a large thermal discharge is introduced to the system, especially one that exists at the extreme downstream reach of the system, there is no evidence that the community of drifting organisms will undergo a fairly natural change in composition over as great an area as might occur if that system were warmed only by solar heating. There is also no evidence that the springtime community of organisms drifting into water that is 5-10 ºF warmer would undergo an abrupt change to mimic the community that would be seen under the same temperature regime in a natural system. Some travel time would be involved, and the extent of change and area of change would be flow-dependant. Thus, new larvae hatching in areas warmed by the discharge would not be expected to have access to a community of zooplankton that had matured and undergone changes in a temperature regime that was similar to that at the point where these fish were deposited as eggs.

The areal extent of zooplankton community change would be flow dependant. It might be expected that there would be no change in the spring due to higher river velocities, but that wide-spread changes might occur in the summer as river velocity approached extremely low values in areas downstream of the B.U. Bridge. At 7Q10 flows, Mirant has projected that it would take more than 200 days for a particle of water to move from the discharge to the new Charles River Dam.

Spawning periods upstream and downstream of the discharge will probably differ. The measurable heatload from the Station's discharge is expected to bring fish into the basin earlier than usual; the extent to which this would happen depends upon river flows and thermal discharge. The amount of spawning habitat and degree of spawning actually accomplished by river herring downstream of the discharge has not been quantified, but the presence of eggs in ichthyoplankton samples from the lower Basin indicate that some spawning may take place downstream of the discharge; thus, some spawning may take place 1-3 weeks earlier than it would without the discharge in this area if there is a 5-10 ºF change in temperature due to the Station's discharge. Modeling projections submitted by Mirant as well as temperature profile data from the lower Charles River Basin support the observation that the facility's discharge can raise Basin temperatures 5-10 ºF. See Response F4 for a more detailed discussion of this subject.

The permittee, EPA and MassDEP have all been made aware, through photographic evidence, that river herring breeding has been documented to occur in the discharge pipe. The extent to which this activity takes place is not known. If, as Mirant suggests, there is little spawning habitat downstream of the discharge, fish having entered the lower Basin in the early spring may have to wait for temperatures to warm up farther upstream in order to spawn there. The apparent attraction of the discharge has been shown to be great enough to induce spawning, overcoming the normal aversion that fish have to high temperatures (as much as a 20 ºF delta T from the intake), even though the eggs from this spawning event are not expected to survive. Harmful attraction to heated discharges has also been seen in other species (e.g., striped bass and menhaden) at other facilities in Massachusetts. By prematurely bringing fish into the lower Charles with high discharge temperatures and allowing fish access to the discharge pipe, during certain years the Kendall discharge has the potential to repeat its documented attraction of river herring, possibly resulting in additional, unproductive spawning efforts in the discharge pipe. The number of fish "lost" to the breeding population is unknown. The monitoring program has been amended to include regular surveillance of the discharge area to quantify this behavior. This requirement may be found in Part I.14.e.8 of the Final Permit.

Comment related to C29 from CLF: Migrating herring have been observed to swim into the discharge pipe and attempt to spawn. This effect of the discharge should be addressed.

Response to Comment related to C29 from CLF: While this fish behavior has been documented at the Station discharge, it is not known if it is a widespread, continuous occurrence. The monitoring program has been amended to include regular surveillance of the discharge area to quantify this behavior. This requirement may be found in Part I.14.d.8 of the final permit.

Comment C30: Mistaken Speculation that Early Alewife Spawning Could Make Early Life Stages Unable to Cope with Early Season Temperatures. Section 5.7.1 of the DD continues to state "The early life stages may also be unable to cope with the early season, cooler than expected, water temperatures."

The development time of both eggs and larvae is a well-defined function of water temperature. At lower temperatures, eggs take longer to hatch, and larvae grow at a slower rate. These stages do not "expect" a particular water temperature; their physiology responds to the naturally varying temperature regimes. Sudden drops in temperature have been demonstrated to result in substantial mortality of early life stages of many anadromous species. No such phenomena have ever been demonstrated to occur with respect to sudden increases in temperature, and, in fact, elevated temperatures enhance survival. As an example, American shad larval survival is favored at water temperatures greater than 20^{o}C.

Response to C30: Eggs and larvae that drift with the currents of the Charles River have the potential to mix with the elevated temperatures of the Station's thermal plume and then move out of its influence. This short duration exposure to higher temperatures and subsequent return to more ambient water temperatures by no means represents "naturally varying temperature regimes." In a low flow year, when retention times are long in the lower Basin, the potential rise and fall of water temperatures experienced by these drifting life stages could happen more than once. Leaving the influence of the Station's thermal plume would expose eggs and larvae to sudden drops in temperature, possibly triggering the substantial mortality of early life stages of many anadromous species documented in the scientific literature.

As noted in Response to C44, elevated temperatures have been shown to increase growth rates of larvae, which could be inferred to enhance survival. It cannot be ignored, however, that elevated temperatures also correspond to increased mortality of larval fish.

Comment C31: Misunderstanding of the Characteristics of the Thermal Plume During Alewife Spawning Periods. Section 5.7.1b of the DD states: "If water temperatures are high enough to cause fish to avoid the thermal plume, fish may be blocked from traveling to the upstream area." Plume-related temperature differentials during the high flows inherent during the spawning run are too small to have this effect. For example, running at about 90% load in early to mid-April 2004, temperature differentials between upstream (Harvard thermistor) and the Boston ZPH thermistor were 1 to 2^o F, too small to cause such a blockage. Mirant Kendall's tagging and tracking studies of both alewives and bluebacks revealed no evidence of such blockage in 2002 or 2003.

Response to C31: It must be noted that the permitted limits will be in effect for five years. EPA and MassDEP agree that it is reasonable to expect that high river flows will coincide with alewife spawning periods. However, unusually warm, dry periods do occur, and it is possible this combination of warm weather and low flows could take place during the alewife spawning period on a given year. At this time, the permit limit will ensure that the already stressful conditions being experienced by in-migrating and spawning alewife will not be made worse by the addition of waste heat from Kendall Station to the level that temperatures are no longer protective.

Several aspects of the 2002 sonic tracking studies with alewives raise concerns with EPA and MassDEP with respect to the issue of thermal blockage. There are several ways that thermal blockage could be manifested in the tracking studies if thermal blockage was actually taking place. One way that it might be manifested is if the permittee found that certain fish did not proceed upstream past the facility.

Of 28 fish captured and used in the 2002 tracking studies, there were five that were only detected by the monitors downstream of the facility 0-3 times. Afterwards the fish disappeared and did not trigger a detection in the monitors. EPA and MassDEP expect that these fish moved back out into the Harbor, regurgitated their tags, died, or stayed out of range of the mobile or fixed recorders. While their exact fate is open to debate, it appears from this report that these fish did not travel upstream past the old locks adjacent to the Museum of Science or they would have been detected by the Boston or Cambridge recorders. Additional evidence should be explored to determine whether blockage occurred.

Second, three additional fish never moved upstream of the Museum of Science. These fish may have died, regurgitated their tags or moved back out into the harbor. It is not currently known whether thermal blockage or avoidance behavior played a part with any of these fish, but the potential for blockage can not be ruled out. These eight fish account for about 29% of the total fish in the study. The fact that almost a third of the fish tagged never traveled upstream of the facility should be considered problematic. One potential explanation, which was not fully considered by Mirant, is that a thermal blockage occurred.

Third, many of the tagged fish appear to have spent a large amount of time near the Longfellow Bridge station, which is adjacent to the Kendall Station discharge pipe. This is evidenced by the timing and number of recorded detections by recorders near and downstream of the discharge. Because river herring have been filmed spawning in the discharge pipe, there is a concern that the reason that alewives spent so much time in the vicinity of the Kendall discharge was because they were breeding in and adjacent to the discharge pipe. This breeding behavior is not expected to result in viable offspring (see Response C29 and C30) and may also result in negative physiological effects to the adults.

As was stated in Response C29, the monitoring program has been amended to include regular surveillance of the discharge area to quantify this behavior. This requirement may be found in Part I.14.d.8 of the final permit.

Comment C32: Mischaracterization of Impacts of Thermal Plume on Alewife Out-Migration. Section 5.7.1c of the DD indicates that the adults will be weakened by spawning and exposed to stress as they swim past Kendall Station's plume to the marine environment. Mirant Kendall's tagging studies tracked numerous river herring making this return journey past the plume and showed no evidence of adverse effects, such as a pattern of signal loss between the Longfellow and downstream hydrophones.

Returning adult alewives from the 1999-year class dominated both the 2002 and 2003 spawning runs, and the 2002 run included a period in April when water temperatures exceeded 65^{o} F. Mirant Kendall questions whether this would be likely to occur if the adults were experiencing appreciable harm on their return journey past the plant.

Section 5.7.1c further hypothesizes that the plume may warm the river enough to delay the out-migration of YOY anadromous fish, and that those fish will be subject to greater predation in the basin than in the coastal environment. The plant's discharge changes water temperatures locally by about the same amount as the daily background diurnal variation (5^{o} F), whereas the out-migration of YOY occurs throughout the summer and early fall as temperatures drop over a much larger range of 25 to 35^{o} F. Mirant Kendall's beach seine and push-net sampling of YOY river herring above, in and below the plume throughout the late summer and fall of 1999, 2000, 2002 and 2003 have shown no evidence of such a delaying effect.

Further, the Determination Document fails to explain why the Agencies believe YOY river herring are subject to greater threat of predation in the basin (which has a relative paucity of pelagic predators) than in the coastal environment, which is dominated at this time of year by large schools of aggressive pelagic predators, including, for example, bluefish and striped bass.

Response to C32: The permittee failed to note that there was a substantial decline in the juvenile population of alewives in the Charles in the years 2000, 2002 and 2003 as well as a substantial decline in the relative proportion of adult river herring that were alewives after 2002 These are substantial issues. This data is discussed in detail in Response C3.

As a general response to the permittee, EPA and MassDEP must use the credible information available to predict what water temperatures will be problematic to all aspects of anadromous fish migration into and out of the lower Charles.

With regard to the tagging studies, because the permittee observed certain fish to pass the facility going upstream and downstream does not mean that these fish would have done so at or above permitted limits. Kendall Station's thermal discharge during these years was well below the maximum the Station was capable of discharging. EPA and MassDEP have designed a permit to protect the BIP even during periods of peak Station thermal output and ambient temperatures, including periods with diminished river flows.

Water temperatures exceeded 65 ºF at the intake structure of the Station for a period in April of 2002. As pointed out before, this temperature was not confirmed at precise points in the ZPH or at the entrance to the basin, as specified in the permit. Mirant has presented no accompanying data showing that fish moved into the basin during this atypical time of elevated water temperature. No investigation was presented to see what percentage of the fish refused entry at this temperature. It is reasonable to assume that a natural interruption in anadromous fish movement into a river, if brief, may not have a measurable impact on the overall success of migration and spawning for that year. Even taking this lack of focused analysis into account, the overall issue of periodic ambient temperature increases in the spring was fully discussed and addressed by EPA and MassDEP in the Determination Document. This resulted in allowing up to six temperature-limit exceedances in the spring as part of the permit compliance program.

Issues related to a delay of juvenile herring out-migration possibly attributed to the thermal discharge of the Station and the resulting negative effects on river herring populations are addressed in Response C6 of this document.

EPA and MassDEP acknowledge that during river herring out-migration the coastal environment is expected to contain pelagic predators, including bluefish and striped bass. Striped bass have also been collected in the lower Basin. There are several reasons to support the position that YOY river herring are subject to greater threat of predation in the Basin. First, there is the general observation that the fish in the lower Basin are confined to a relatively small area compared with the coastal area. Predatory fish and birds would likely be more successful when feeding in the confined lower Basin at that time.

In addition, Cooper (1961) found extremely high mortality in alewives within the freshwater system prior to seaward migration. He stated that:

> The success of spawning, in terms of numbers of juveniles migrating to the sea, was exceptionally low during the 1959 season. Less than one juvenile entered the sea for every adult that reached the spawning grounds.

Thus, it appears that the potential for high mortality to larvae and juveniles within the freshwater system does exist.

While it can not be stated for certain whether a protracted or deferred out-migration has a negative impact on the alewife population, information from another alosid species, the American shad, does support the assumption that deferred out-migration would lower the survival of juveniles. The following is taken from Klauda, et al. (1991):

> Estimates of juvenile American shad mortality rates in the nursery areas [of the Connecticut River, studies of Crecco, et al. 1983] range from 1.8-2% per day. Thus, if the juveniles remain in the nursery areas for three months before emigrating seaward, their survival rate would be about 30%. Conversely, 70% of the juveniles would perish before reaching the ocean [based on Richkus and DiNardo, 1984] assuming constant mortality

rates during the larval and juvenile stages. Longer residence times in freshwater and brackish areas would further reduce first year survival of American shad cohorts.

This information serves to explain why EPA and MassDEP believe YOY river herring are subject to greater threat of predation in the lower Basin than in the coastal environment

Comment C33: Adequate Site-Specific Data is in the Record to Establish Temperature Limits and Time Periods of Alewife Adult Spawning In-Migration in Charles River.

The Section 5.7.3c of the DD states "many years of spawning data at a specific river system would be needed to properly characterize the spawning habits of a site-specific spawning school." There is nothing in the literature on anadromous alosine species (e.g., American shad, river herring) to suggest, however, that a "site-specific spawning school" would exhibit responses to primary environmental variables such as temperature in a manner uniquely different from responses exhibited by the same species in other portions of their range, particularly within major geographical regions such as New England. Extensive literature exists, especially for American Shad, that shows that they respond similarly to temperature over much of their range.

Mirant Kendall's data on the age distribution of returning adult alewives in 2002, 2003 and 2004 indicates that the adults from various year classes enter the river and move upriver together over the course of about a month.

Section 5.7.3c states "There have been no long-term, site-specific investigations performed to pin point the temperature range associated with anadromous species spawning in the lower Charles River Basin." To the contrary, Mirant believes that the considerable data it collected provide important information on this topic, which was not fully considered by the Agencies. The site-specific gill net data for adults, and the YOY length distribution data collected in 2002 and 2003 and summarized and submitted to the Agencies in July 2003 (A.R. No. 489) showed that the run of alewives in the lower Charles near Kendall Station began in April, when water temperatures reached the 50s, and that fish captured after the third week in May were "spent," i.e. had completed spawning. In between, the runs continued without interruption across a range of water temperatures in the 50s and 60s, including several days in the third week of April 2002, when water temperatures exceeded 65^{o} F. Essentially all the YOY fish captured were too large to have been born in June.

The same pattern was observed in 2004. This included a 9-day period in mid May when river-wide temperatures remained between 68 and 72^{o} F. Kendall Station's heat load to the river overall averaged about 70% of the permitted maximum in April 2004, including three periods of at least four consecutive days each during the run, in mid and late-April, at about 90% of the permitted maximum. Mirant Kendall believes these levels of operation are representative of how the Station will operate for some periods in the future.

As in 2002 and 2003, length distribution of the YOY alewives in 2004, MK Comment Ex. No. C3, indicates that essentially all were born in April and May. Mirant Kendall believes the

Agencies should carefully considered this data before issuing the Final Permit. Mirant Kendall requests that the Agencies explain why the temperatures experienced without interruption of these runs (i.e., up to 72° F) are not adequate thresholds to protect future alewife runs in lieu of the lower thresholds they have proposed in the Draft Permit.

Section 5.7.3c discusses dates of first appearance of river herring at the Watertown Dam fishway. While dates are specified in these paragraphs, water temperatures are not. Yet, in the next paragraph, the discussion turns to the lack of knowledge of temperatures at the dam when fish first passed into the Basin. Also, the statement is made that the time it takes fish to move from the dam to the Watertown fishway is unknown. However, the Mirant radio tracking study data, discussed on the next page, provides such information. The alewife tracking studies conducted in spring 2003 and submitted to the Agencies in November 2003 (A.R. No. 470) contain definitive site-specific information that the fish released in the ZPH below the Museum of Science moved past Kendall Station through the ZPH to the area above the Longfellow Bridge in one to two days. This would appear to contradict the assertions in section 5.7.3c and elsewhere of the DD that they are significantly distracted by the plant discharge. Seven of the nine tagged alewives released on three dates passed through the ZPH in a day or less, and the other two in less than two days. Mirant Kendall asserts that while some fish may be attracted to the plant discharge, the tagging and tracking studies demonstrate that it is not a significant distraction. The Agencies should fully consider these studies and adjust their findings accordingly prior to issuing the final permit.

Section 5.7.3c discusses at length the 1999 and 2000 sampling results relative to the timing and temperatures associated with the alewife run. Mirant notes that these data are consistent with, but far less definitive than, the data from the 2002, 2003 and 2004 seasons discussed above. Section 5.7.3c discusses the results of the impingement sampling, speculating that the thermal discharge may reduce swim speed and increase impingement mortality. Mirant Kendall asserts that this speculation is counter to observations of river herring behavior in the Broad Canal, and to the fact that the highest intake velocities are just over 1 foot per second, well below the relevant swim speed of the herring. Mirant Kendall suggests that the Agencies consider the alternative explanation that river herring weakened by spawning (many of which die under baseline conditions anywhere) are likely more vulnerable to impingement. This is consistent with the observation that the great majority of impingement occurs in June of each year, when spawning has been underway for one to two months, rather than in April or May, during the early periods of upstream runs. Note also that a major high flow episode raised the river to flood stage during June in the one year of significantly greater impingement (2000).

Section 5.7.3c describes data on runs and corresponding temperatures in other rivers, noting that temperatures of 74 ºF in the Merrimack in 1991 was higher than in other years. The discussion fails to note, however, that 1991 was, by far, the year of the largest river herring run (both alewives and bluebacks) in the Merrimack River during the 1988 to 2000 period under discussion, as well as the largest in the more than 20-year history of the monitoring program. There were sustained counts of about 4,800 to more than 6,200 fish per day at the monitoring point throughout the 10 days of 70-74 ºF temperatures in 1991, more fish than the totals counted over the entire run in some other years. The Determination Document fails to explain how this largest recorded run could reasonably have been sustained in this manner if the 70-74 ºF temperatures were sufficient to cause avoidance.

Section 5.7.3c states that "[i]t is not advisable to use periodic extreme natural temperature occurrences as the basis to formulate year in and year out temperature limits." The presentation of temperatures that have been recorded as coinciding with river herring spawning runs in a number of New England rivers documents concurrence but not cause and effect. As indicated in prior comments, the beginning and end of spawning runs do not unilaterally coincide with certain temperatures, but rather are functions of when the first and last fish arrive at their spawning stream.

Further, Mirant Kendall asserts that it is precisely from the study of extreme natural temperature occurrences that one can gather the information needed to document absence or occurrence of adverse effects. Hence, the importance of observations of sustained alewife runs in the Merrimack River during 1991 at temperatures of 70-74^{o} F, and likewise in the Charles River this year at temperatures from May 3 to 18 rising from 65 to 70^{o} F, with most of the period above 68 °F.

Response to C33: The permittee's assertions cover a number of topics. Each is discussed below.

Mirant states that the DD makes a statement about data needs for a "site-specific spawning school" which infers that data are needed for fish that particularly return to the Charles. Mirant asserts that there is nothing in the literature on anadromous alosine species to suggest that a site-specific school would exhibit responses to primary environmental variables such as temperature differently from those exhibited by the same species in other portions of their range. Dr. Olney's (Professor of Biology, Virginia Institute of Marine Sciences) memorandum to G. Szal, MA DEP (11/17/2002) states the following:

"As to your other questions, we know that there is latitudinal variation in life history traits of alosine fishes and I would guess this to include variation in temperature preferences and the effects of temperature on vital rates."

This is one of the reasons that EPA and MassDEP were concerned about using information from alosine fishes that are found at very different latitudes. Because of this, and other literature that shows latitudinal differences in temperature tolerances in fish, EPA and MassDEP maintain that if there was specific information on the Charles River alewives, this information would be more appropriate than that from other rivers.

Mirant (pg 39, 3rd and 4th paragraphs) takes issue with the DD which states that there have been no long-term site-specific investigations in the lower Charles which pin-point the temperature range associated with anadromous species spawning. Mirant states that the runs of alewives in 2002 and 2003 began in April and that fish captured after the third week in May had completed spawning. Furthermore, temperatures during this period in both years ranged from the 50s to the 60s (ºF) and included several days in the third week of April 2002 when water temperatures exceeded 65 ºF.

In order to provide temperature limits that will allow river herring to spawn in the Charles, EPA and MassDEP must not only assure that water temperatures are appropriate for spawning but must also assure that water temperatures in the lower segment of the Charles allow entry of these fish.

Mirant's comments suggest that the permittee feels that it has an exhaustive knowledge of alewife migration in the Charles and that it has information demonstrating that alewives are running through areas with temperatures higher than 65 ºF. EPA and MassDEP maintain that the permittee failed to support its position that temperatures higher than 65º F would protect the alewife run.

First, there is only one preliminary pilot study that estimates the in-migrating adult population: 8,000 fish from a 2002 survey conducted by the permittee. Very few alewives were actually collected in 2002, and the 8,000-fish estimate was made from a combination of the proportion of alewives/total river herring caught in combination with sonar counts of the entire river herring population (about 45,000 fish). A population size of 8,000 is by no means a large population. Estimates of the size of the adult herring run in the Taunton River are upwards of a million or more. In addition, MA DMF estimates of the river herring carrying capacity of the Charles falls in the range of 250,000 to 500,000 adults. With a lack of data to the contrary, EPA and MassDEP must assume that the population of alewives in the Charles does not approach the river’s estimated carrying capacity. In addition, the relative run strength of alewives, bluebacks and total river herrings (alewife and blueback herring combined) appears to have dropped substantially since 2002, judging from the gill-net information provided by Mirant in its 2006 data submittal (see discussion of gill-net data in Response C43). A reduction in adult alewife run strength from a preliminary estimate of only 8,000 fish in 2002 to lower levels does not bode well for the alewife population in the lower Charles. Reductions in blueback run strength are also of concern. Although Mirant may be correct that there were alewives running in the Charles at temperatures that were occasionally higher than 65 ºF, it appears these runs were not robust. Therefore, it would not be appropriate to assume that such higher temperatures were actually protective of the BIP. Also, it must be pointed out that temperatures above 65 ºF could be measured in part of the lower Basin without prompting a permit violation.

Second, Mirant has provided temporal information on alewife catches made during some of the spawning runs. Mirant suggests that the run extends for only a month because this is how long it has taken the bulk of the population to move into the Charles over the past few years. Because the population of alewives is currently small, EPA and MassDEP expect that, if the population can increase in size, the temporal duration of the run will expand. Also, the level of sampling effort conducted likely missed the first anadromous fish entrants into the river, if they were in small numbers, as well as the tail end of the spawning run. EPA and MassDEP disagree with the approach of limiting the expected duration of spawning in the Charles River to what was bracketed only by the sampling result under present conditions in the river. This approach would have the effect of assuming that the current population represents a healthy, protected BIP. Mirant has not demonstrated that the BIP is sustainable at these population levels.

Third, Mirant's sampling of adult alewife populations was not exhaustive and sample sizes were quite small. Because EPA and MassDEP expect that much of the past sampling was destructive due to loss of the mucus layer and other trauma to fish that accompanies gill-netting, the Permitting Agencies are not suggesting that this type of sampling be increased. Other data gathering methods to gain information on the fish population size, such as estimates using hydro acoustics, have been suggested. However, with the population size so small, a small catch may simply mean that the fish were not in the sample at the time the sampling took place. Some fish may have migrated prior to or after the time nets were set; since their numbers are so low they may not have appeared in the permittees' subsamples of the river herring (2 species) migrating stock. This is a common problem with subsampling. The subsample, by definition, only comprises a subset of the entire sample. As such, it does not define the actual bounds of the population; in this case, the bounds of the run duration. Mirant discusses its data as if the subsample of the population entering the Basin was not a subsample at all, but that the data collected, in fact, denote the entire temporal duration of the run. This contention is simply not true.

Based on Mirant's data, the fact that these data are a subset of all potential run characteristics, and other information discussed above, EPA and MassDEP expect that the actual temporal duration of the run may include periods not mentioned by the permittee. Thus, as long as water temperatures are appropriate for entry, it is expected that fish may still be attempting to enter the system through the first week of June.

With regard to the upper temperature limit of in-migrating alewives, Mirant states that runs took place while temperatures reached above the 65 ºF limit: "the runs continued without interruption across a range of water temperatures in the 50s and 60s (ºF), including several days in the third week of April 2002, when water temperatures exceeded 65 ºF." First, it is important to remember that Mirant's contention that temperatures exceeded 65 ºF does not mean the permit limit of 65 ºF within the ZPH would have been violated. The reasons EPA and MassDEP do not automatically assume this would be a permit violation relates to the type of temperature data Mirant used compared with the way temperature compliance would be measured and calculated under the permit requirements. This is fully discussed in Response C13 (d). Setting this point aside for the sake of this discussion, the permittee has not submitted adult alewife capture records in waters that were in excess of 65 ºF directly upstream of the dam, nor have they submitted records of alewife capture at the dam that are coincident with water temperatures in excess of 65 ºF at the dam. Thus it cannot be said that the runs continued "without interruption" when water temperatures exceeded 65 ºF. When temperatures exceeded 65 ºF, runs very well may have been interrupted. In addition, records submitted by Mirant show many days when areas were sampled but no alewives were caught. Mirant has not documented that the runs continued in the face of temperatures higher than 65 F.

On Page 39, Mirant states that in 2002 and 2003 the length distribution of juveniles is such that, based on modeling of growth "essentially all" (most?) "were born in April and May." Mirant goes on to ask that the Permitting Agencies explain why "temperatures experienced without interruption" by the adult run (temperatures up to 72 ºF) are not adequate to protect future runs.

The maximum temperature seen during the April-May period must not be the maximum limit allowed for the whole period. EPA and MassDEP recognize that temperatures suitable for entry and/or spawning may not always occur during the April-May period. Sometimes, temperatures may rise above this level, but these occurrences do not establish that persistently high temperatures would protect the BIP.

As explained above, the permittee has not provided information demonstrating that temperatures as high as 72 ºF will not cause avoidance behavior to in-migrants. Although temperatures in the Broad Canal at Kendall Station's intake may have risen to 72 ºF, this does not mean that upstream, ambient temperatures or temperatures at the dam were at this level when fish were migrating through these areas. Nor does it mean that the 72 ºF value should be used as a permit limit. EPA and MassDEP have been unable to find, and the permittee has failed to present, data from any run in the northeastern U.S. that shows that a substantial proportion of a run will enter the freshwater breeding stream when temperatures are as high as 72 ºF. In addition, the permit allows for six separate events where temperatures in the ZPH may exceed ambient temperatures by more than the site-specific limits. Although temperatures within the ZPH may have been as high as Mirant contends during this period, this is not a reason to use the temperature maximum as the allowable temperature for the entire period. This issue is discussed further in Section 5.7.3c of the DD.

On Page 39 in the last paragraph, Mirant takes issue with statements in the DD that deal with alewife movement through the lower Basin of the Charles. The permittee asserts that, contrary to EPA and MassDEP's assertions, there is much site-specific information pertaining to adult alewife movement through the lower Basin. Mirant states that alewife tracking studies of 2003 demonstrated that 7 of 9 alewives tagged on three dates passed through the ZPH in a day or less and the other two in less than two days and states further that the discharge plume is "not a significant distraction." The permittee asserts that EPA and MassDEP should "fully consider these studies and adjust their findings accordingly prior to issuing the final permit."

The extent to which the heated discharge plume is a distraction to the alewife population is currently unknown. No studies have been presented to EPA or DEP which document the extent to which wasteful spawning within the discharge pipe takes place. The Division of Marine Fisheries is conducting a re-stocking program for American shad in the Charles and potential loss of spawning stock to the discharge pipe is a concern to EPA and MassDEP. Another concern is that out-migrating fish may also be attracted to the plume. See Response C29 and C31 for additional information regarding this issue.

With regard to Mirant's references to the 2003 alewife sonar tracking, it appears that Mirant may not have discussed all the information available from these studies. In actuality, 28 adult alewives were ""tagged" (implanted) with sonic transmitters. Five of these had no or very few (0-3) "hits" (receiver actuations) from mobile and fixed receivers scattered throughout the lower Basin. Potential reasons for the lack of hits include a) death; b) regurgitation of the transmitter; and c) movement back into Boston Harbor. Three other tagged alewives did not move upstream of the Museum of Science but were found around the Charlestown Dam (i.e., the New Charles

River Dam). These may also have died, regurgitated their tags or moved back into Boston Harbor. These eight fish account for about 29% of the fish in the survey.

Many of the remaining 20 fish appear to have spent much of their time in the lower Basin near the Kendall discharge. It is not currently known whether they attempted spawning in the discharge, whether they attempted to spawn in the Zone of Dilution or whether they attempted to spawn upstream of the facility. Based on the above, it is difficult to tell the significance of any impacts that the Kendall discharge and temperatures in the Zone of Dilution may have on alewife spawning. The knowledge of specific points in the Basin where alewives currently spawn is poor. EPA and MassDEP conclude that Mirant's tracking study was inconclusive, and therefore does not dispel the Permitting Agencies' concerns about the Station's discharge, which are based on scientific literature and site specific Charles River environmental data.

In paragraph 3 of page 40, Mirant rebuts the Permitting Agencies' assumption in the DD that the thermal discharge may reduce swim speed and increase impingement mortality. It suggests that the Agencies consider the fact that river herring, weakened by spawning are likely more vulnerable to impingement. The impingement sampling conducted by Mirant did not include the reproductive condition of the river herring impinged. Aside from the timing of impingement, there is no direct evidence which Mirant can use to support their argument. As noted above, some of the river herring in-migration behavior documented in the fish tracking study conducted by Mirant described fish that remained in the lower Basin and did not quickly move upstream. This could be a result of contact with the thermal discharge from Kendall Station. However, even if weakened post spawning (spent reproductive condition) adult river herring were primarily impinged, this does not diminish the burden of the permittee to minimize impacts from impingement.

On page 40, Mirant points to the fact that river herring in the Merrimack (both alewives and bluebacks) were found in the river at the "monitoring point" when temperatures ranged up to 74 ºF, and states that the DD fails to explain how this run could have been sustained if the 70-74 ºF temperatures were sufficient to cause avoidance.

Much of the section in the DD that deals with in-migration of alewives documents temperatures recorded at points of in-migration. Because Kendall is located very close to the new Charles River Dam, heated water from its discharge can affect water column temperatures all the way from the facility to the dam. Thus, the focus of much of the literature and field data review was on entry temperatures for alewife adults, i.e., temperatures recorded at points of entry to freshwater systems.

EPA and MassDEP fully expect that the range of spawning temperatures may be higher than the range of entry temperatures. This is due to the following: a) alewives often have to travel many miles upstream to find a spawning site; b) it may take many days or weeks to travel from the point of entry to a stream to the spawning site; and c) in general, water column temperatures continue to rise in the spring when the spawning run takes place. Thus, the temperatures over which river herring spawn may extend to higher temperatures than does the temperature range experienced by in-migrants at the point of entry.

The Merrimack River "monitoring point" referred to by Mirant in this section is the Lawrence dam, located approximately 26 miles upstream of the mouth of the river. This is a considerable distance upstream from the point of entry to the Merrimack. Judging from the data presented by the company on herring movement in the Charles, it could have taken weeks for the fish to move from the mouth of the river up to the Lawrence dam. In addition, at times, fish are "held up" at the dam for several days or more, prior to being lifted and counted, because of problems in operating the fish lift at this location. Finally, there is no information regarding the spawning success of the fish that were counted in 1991 when the high temperatures were seen. It is not known from the data available whether these particular fish were able to successfully spawn, or if successful spawners were only limited to fish that entered earlier that year.

Due to the large difference between the Kendall Station and the Lawrence Dam in proximity to the mouth of their respective rivers (Charles and Merrimack Rivers), EPA and MassDEP did not use data from the Lawrence Dam to establish entry temperatures for alewives in the Charles. All other data (information near points of entry from 19 separate runs from three different rivers) supported the contention that very few fish entered these systems when temperatures were above 65 ºF.

Mirant also states that "it is precisely from the study of extreme natural temperature occurrences that one can gather the information needed to document absences or occurrence of adverse effects." The permittee proceeded to explain the importance of the Merrimack River data, collected 26 miles upstream of the mouth of the river, showing that river herring were at this location when temperatures reached up to the mid 70s (ºF). The company does not, however, allude to any of the other 19 site-specific studies referenced in the DD where runs were essentially over when temperatures reached above 65 ºF. Nor does the facility attempt to discuss the difference between temperatures at point of entry vs. temperatures at migratory way-points or final spawning sites in the Merrimack.

It must also be pointed out that once permitted temperature limits are finalized, these maximum temperatures may be legally reached consistently for prolonged periods over many years by the permitted facility. EPA and MassDEP do not support setting these temperature limits using extreme natural temperature occurrences as the basis. Even natural extreme temperature occurrences may stress aquatic life. The BIP can tolerate such extremes because they are by definition infrequent in duration and are unlikely to take place every year. EPA and MassDEP conclude that allowing this type of temperature to be maintained for extended periods, year after year, is not protective of the BIP.

Comment related to C33 from MA DMF: The Charles River remains listed under Section 303(d) of the CWA as impaired for nutrients and nuisance algae. But effects of the facility thermal discharge should not be ignored. During summer conditions the lower basin exceeds the state water quality standard of 83^{o} F. With the river herring population substantially below the river capacity and our ongoing efforts to enhance their abundance and distribution, we believe temperature limits should provide greater protection for the bulk of the spring run as opposed to the end of the run. To protect the in-migrating river herring, we request the permit include the upper thermal limit from April 15-30 of 60F and 65 °F from May 1 - May 15. We request the permit include a thermal limit of 80^{o} F within the ZPH in summer for the protection of juvenile American Shad.

Comment related to C33 from NOAA: We recommend that a thermal limit of 80 degrees F in the ZPH from June 15 to October 31 be included in the permit to protect juvenile American Shad.

Response to Comments related to C33 from MADMF and NOAA: Although EPA and MassDEP are aware of the recent American shad stocking program, the permitting agencies did not receive sufficient documentation to establish that American shad were present in the lower Basin in sufficient numbers to qualify as part of the BIP. Indeed, no life stages of American shad were collected during the six years of biological monitoring conducted by the permittee. While the resource agencies did provide evidence that American shad were present in the Charles in colonial times, there is no evidence that American shad have been present in the lower Basin in appreciable numbers since the damming of the lower Charles. Therefore, EPA and MassDEP are not setting limits in the permit designed to protect American shad at this time. Ongoing biological monitoring required by the permit, along with close communication with the resource agencies, will allow EPA and MassDEP to monitor the efforts underway to establish American shad in the Charles. Future protective temperatures will be justified accordingly. Regarding MADMF's request for lower spring temperature limits to protect in-migrating river herring, see Response to Comment related to C37 from CZM.

Comment C34: Inappropriate Generalized Model in Lieu of More Appropriate Literature and Site-Specific Data to Set Temperature Limits for Alewife Adult Spawning Stage and Presumed Avoidance Thresholds.

Section 5.7.3c of the DD states that the EPA utilized a generalized model of temperature effects to fish to aid in the development of site-specific temperature limits for the lower Charles River, notably the USFWS temperature effects model in Armor (1991). Mirant Kendall has extensive comments regarding the use of the model as well as the specific inputs used in the model and its application.

First, notably, the introduction to that publication states:

> "Recommendations derived from these options may be applied to streams that are or will be affected by channel modifications, diversions, reservoir releases, or adjoining land-use practices such as vegetation removal, all of which may alter temperature regimes."

Note that the model is intended to be applied in circumstances where habitat changes alter the overall temperature regime (e.g., where dredging of a river causes alteration of the natural temperature regime), and it was developed for application to free flowing streams (in this specific case, it was applied to chinook salmon). There is nothing in the publication that suggests that the method is applicable to, or appropriate for, assessment of consequences of a point-source thermal discharge that dissipates in a receiving water body, except to the extent that such a discharge alters the overall temperature regime of the receiving water body (which would be determined by modeling). It does not appear to be applicable to the assessment of biological consequences of spatially specific temperature deviations. It also is presented from the perspective of effect on a fish population, and not on the fate of individual fish that encounter specific temperatures. This is acknowledged in the DD on page 85 ("the temperature causing a specific effect to the population is lower than"), the Agencies have not applied in that way.

The Agencies' application of the model appears to be fraught with errors and misconceptions, but most importantly, is unnecessary and inappropriate to accomplish the stated purpose (para 18) "to predict avoidance temperatures of adult alewives in the Lower Charles River Basin." Mirant Kendall suggests that the Agencies instead consider the work of Lindenberg of the Massachusetts Division of Fish and Wildlife, who studied the distribution of a reportedly balanced population of adult and juvenile alewives for several years in a stratified impoundment with benthic oxygen depletion in central Massachusetts. Lindenberg's publication of that work is included as a reference at the end of Chapter 5, but it is not cited by the Agencies in the discussion. He found that at night more than 200 alewives (85% adults, 15% YOY) were collected in the surface waters while the temperature was 32.2 ºC (89.96 ºF). He explained the consistent night-time presence of the alewives near the surface at temperatures above 25.5 ºC (77.9 ºF) as an adaptation to the lack of suitable deep habitat because of oxygen depletion, and contrasted it to the earlier findings from the Midwest used instead here by the Agencies for their model. Mirant Kendall notes that the Lower Charles is a stratified semi-impounded system of the same depth as studied by Lindenberg, with similar benthic oxygen depletion. It does not resemble the Lake Ontario setting, from which the Agencies attempt to extrapolate Graham's data from 1956. The Determination Document fails to explain why the Agencies expect avoidance at even lower temperatures when it was observed not to occur at higher temperatures by Lindenberg.

Response to C34: It is true that the USFWS model was developed to be applied to streams whose temperature regimes were altered. Nonetheless, the model has seen wide application. In its most simple form, such as that used by the EPA and MassDEP, the model simply pulls together information on the effects of acclimation temperatures on upper toxicity and/or avoidance temperature endpoints. The result is a temperature "envelope." The envelope is bounded by lines described from toxicity and/or avoidance information from the literature. The inside of the envelope describes the range of temperatures, mediated by acclimation temperature, that cause no detrimental effect or behavior for the life stage for which the temperature envelope was developed. Lawler, Matusky and Skelly (LM&S) Engineers, who did much of the modeling for thermal discharges in the Hudson River, recently used temperature envelopes of this same type and applied them to the marine and anadromous species of interest for the Brayton Point 316(a) and (b) evaluation. Although some of the endpoints used in the model were contested by the EPA and MassDEP, the simplified "temperature envelope" describing the effects of acclimation on temperature endpoints was not contested. EPA and MassDEP maintain that this is one of the approaches that is well-accepted among fisheries scientists familiar with thermal evaluations, as illustrated by the contributors to the Brayton Point permit development.

The permittee stated that the model appears to be "fraught with errors and misconceptions, but more importantly, it is unnecessary and inappropriate". The permittee suggested that, instead of using this model, EPA and MassDEP should use the work of Lindenberg (1976) who collected more than 200 alewives (85% adults, 15% YOY) in a Massachusetts lake when the temperature was 32.2 ºC (89.96 ºF). Mirant stated that Lindenberg took these measurements at a stratified impoundment in Massachusetts suffering from oxygen depletion and further stated that the lower Charles is a similar waterbody to the one studied by Lindenberg. Therefore, the permittee maintained that the work of Lindenberg should be considered rather than the model of Armour.

The model of Armour was employed by EPA and MassDEP to evaluate the potential effect of very low acclimation temperatures in Boston Harbor in the springtime on avoidance and toxicity to alewives entering the lower Charles. The "model" temperature envelope described is based on a compilation of data from several literature sources. The permittee's suggestion to use a one-time high temperature summertime observation to set the range of allowable springtime temperatures for alewives (from the Lindenberg study) is completely inappropriate.

The permittee selected a single, high value from the literature to promote the use of high site-specific limits in the Charles. It is true that the Lindenberg paper states that alewives were caught near the surface at night on one occasion when temperatures were in the high 80s (ºF). However, this is the only datapoint in the Lindenberg lake studies where temperatures exceeded 80.1 ºF when fish were captured. Based on Lindenberg's descriptions, it appears that these fish were at the surface to avoid low dissolved oxygen in deeper water. No follow-up evaluation was reported by Lindenberg to determine the effect of this high-temperature event on the alewives in the study area. Lindenberg did not indicate whether this single high temperature data point could be sustained by alewives for long periods of time. Using a single high temperature event to set a permitted temperature limit that is in effect for an extended period is not consistent with EPA or MassDEP's permitting approach. Refer to the Response C33 for additional information.

High-temperature events in other systems have been found to induce stress or be lethal to exposed fish. The Lindenberg observation does not demonstrate that high temperatures are suitable for constant habitation by alewives. Based on the description of the impoundment and the water quality characteristics, alewife likely had no choice to seek a habitat with lower temperatures. Other literature as well as site-specific data from the Charles, shows that, when given other, cooler water for habitation, alewives will avoid temperatures in the low 80s (ºF) (see the EPA/DEP review of Charles River site-specific data for the push-net surveys in Response C3). In addition, sustained high-temperatures have been shown to be toxic to alewives (Otto, et al, 1976).

Issues of alewife toxicity and/or avoidance are not the only concern of regulators with regard to high temperatures. Long-term, basin-wide heating above the 77 ºF mark has been shown to be detrimental to zooplankton, one of the primary food groups of alewives. This information is further detailed in the DD. More than a one-time observation on alewives is necessary to develop a comprehensive temperature regime for the protection and propagation of the different life stages of alewives living in the Charles.

Comment C35: Erroneous Assumptions and Justifications in Applying the U.S. Fish and Wildlife Model to the Lower Charles; Alewife Temperature Response.

In Section 5.7.3c of the DD, the alewife temperature response is based on Graham (1956) for Great Lakes alewives. At issue here is whether the temperature responses of landlocked alewives are the same as those of anadromous alewives. Mirant Kendall is unaware of any literature that supports or refutes that conclusion. However, because of the extreme environmental changes experienced by migrating anadromous alewives, in both temperature as well as salinity, physiologically they would be more adapted to wider temperature variation than landlocked alewives.

Also, anadromous alewives are larger, which also affects their response to short-duration temperature changes. Mirant Kendall further questions the Agencies' logic, presented on p. 87, for dismissing the EA data on thermal tolerance of anadromous river herring (that the population is more southern); the Determination Document fails to establish the basis for this conclusion. The speculation here and elsewhere in the document that "southern populations" may be less temperature sensitive than New England populations is unsupportable and contrary to basic natural science. The temperature ranges at the geographic extremes of a species range reflect the limits of its sensitivity. In New England, anadromous alewives (and, for that matter, resident yellow perch) are in the geographic middles of their ranges, where they have adapted to the widest spectrum of temperature swings. Canadian populations, at the northern extremes of the range, could be less well adapted to the warmer temperatures regularly seen by Massachusetts fish.

Another factor that places the utility of these literature findings in question is that laboratory studies establish an acclimation temperature by keeping fish at that temperature for an extended period of time. In the natural environment, fish move through waters with substantial differences in temperature, and their acclimation temperature cannot be predicted without knowledge of these movement patterns. Thus, application of the laboratory mortality study results to a free-ranging fish is questionable.

Further, in their application of the model, the Agencies assume abrupt transitions from low Boston Harbor temperatures to temperatures more than 10 ºF warmer in the Lower Charles. This is not a valid assumption. As verified by Mirant Kendall's monitoring above and below the dam in 2000, 2002, 2003 and 2004, the near-bottom temperatures where fish enter immediately above the dam and the surface temperatures in the Harbor immediately below it are very similar – within 1-2^{o} F. The Agencies' use of data from an MWRA station further out in the Harbor, beyond this immediate transition area, is misleading and inappropriate.

Response to C35: In Comment C34, the permittee recommended using data (Lindenberg, 1976) from a landlocked population of alewives to support a high-temperature limit in the Charles. In this comment, the permittee questioned the logic in using data from a landlocked alewife population.

EPA and MassDEP reviewed the available data from the northeastern U.S. as well as other data.

Mirant's reference to data from the "northern extremes of the range" refers to data that the EPA and MassDEP used from the Great Lakes. The dataset used is actually from the same approximate latitude as northern Massachusetts, not from the northern extremes of the range for alewives. Certain types of data, especially that relating to delta temperatures, were not available from the anadromous population in the northeast, but were only available from landlocked populations. EPA and MassDEP are aware that landlocked populations of fish may have somewhat different characteristics than migrating fish, but decided to use data from landlocked populations when data from anadromous populations in the northeast were not available.

On page 42, Mirant questions the permitting Agencies' logic in dismissing the EA (Environmental Analysts) dataset because the information was drawn from a more southern population. Mirant criticizes EPA and MassDEP's logic in speculating that southern populations might be less sensitive to warm temperatures than are more northern populations.

A wide variety of different species, including certain fish, have been shown to have temperature tolerances that vary with the latitude at which segments (i.e., species populations) of that species can be found. Please refer to the Response C33 and Dr. Olney's statement regarding latitudinal variation. While Dr. Olney's statement certainly does not verify any such variability in alosids, his statement, along with other literature sources cited in the DD, prompted EPA and MassDEP to use caution in using thermal-tolerance data from species-populations in the mid-Atlantic states when other data were available from latitudes more similar to the Charles River. When latitudinal differences exist, typically the more southern populations are more tolerant of heat than those found farther north.

On Page 42, Mirant questions the utility of using data from laboratory studies that acclimate fish for long periods of time at a certain temperature to develop field-based temperature limits. The permittee maintains that in the field, fish often move through different water temperatures throughout the day.

EPA and MassDEP agree that this is certainly a shortcoming of using only laboratory data on alewives to set permit limits. Because of this, EPA and MassDEP did not rely solely on laboratory data to develop the permit limits. Information utilized included published literature from field studies at a suite of anadromous fish runs in New England, site-specific catch-rates and temperature data from the lower Charles, thermal tolerance data from alewives taken from the Great Lakes at similar latitudes to Massachusetts, and thermal tolerance data from elsewhere (including field and laboratory data from other important species) to establish temperature criteria for the lower Charles. All this information, and methods used to evaluate these data are described in the DD.

On Page 42, Mirant states the concern that in evaluating the potential Delta Temperatures encountered by anadromous fish entering the lower Charles, EPA and MassDEP used Boston Harbor temperatures rather than surface-water temperatures directly below the dam. In comparing Charles River water temperatures with surface-water temperatures directly below the dam, the permittee found that the two temperatures are fairly similar; very little delta temperature change was seen. By contrast, Mirant asserts that the Agencies speculated that temperature differences encountered by incoming fish would be quite great.

EPA and MassDEP compared Boston Harbor temperatures from a Boston Harbor station nearby, but not directly below the dam. Surface water temperatures directly below the dam were not considered appropriate for three reasons: 1) alewives have been observed to be at lower depths in the water column during the daytime to seek suitable light intensity and avoid being targeted for predation; 2) alewives in other systems are known to migrate only during daylight hours. Dixon (1996), and others cited by Dixon, noted that alosid fishes move up and down in the water column in a particular "isolume", i.e., a particular range of light intensity, supposedly in order to balance the need to avoid vision-based predators, but still be able to see other alosids in order to maintain a school. 3) River water from the Charles is both warmer and much less saline than Boston Harbor water. Both attributes cause this river water to be much more buoyant (less dense) than the water in Boston Harbor. As a result, EPA and MassDEP expect that the Charles River water will not immediately mix with the Boston Harbor water. Thus, surface water temperatures taken from below the dam are expected to be considerably warmer than bottom temperatures near the dam.

Because of the fact that alewives prefer to be in low-light when migrating, it is logical to assume that alewife movement into the locks is from a deeper location in the harbor, rather than from the surface. Thus, they are expected to encounter larger delta temperatures than if they were migrating from the surface.

EPA and MassDEP are open to reviewing studies that might be able to document the actual delta temperature changes encountered by alewives throughout the in-migration and out-migration seasons. Temperature Monitoring Stations 8 and 9, required by the permit, will provide important, site specific information on this subject.

Comment related to C35 from CLF: This suggestion that species widely distributed throughout Eastern North America (e.g. yellow perch) have evolved adaptations to the very recent (i.e. within 50 years) conditions in the Charles River, is not supported in any way by EPA (i.e. no references to scientific sources provided). Indeed, EPA goes on to explain that this kind of local evolution within a water body is not likely, using an example of how thermal conditions in the Great Lakes (i.e. lake Ontario) cause well known die-offs of alewives, a species that has only recently be introduced to the lakes, and is not adapted to natural temperature extremes. All indications are that the fishes indigenous to the Charles have not undergone major adaptation to current conditions. Had they adapted, they would be flourishing under prevailing conditions, yet their numbers are much lower than expected for a healthy river of this kind (see discussion of carrying capacity for herring below). The species examined (e.g. river herring, yellow perch) are found in many widely distributed bodies of water, do not appear to be isolated populations, but rather appear to enjoy the low rate of gene flow that is required to prevent substantial genetic divergence. Within a species, fundamental aspects of fish biology such as reproductive behavior and egg development are well known to follow regional variation in water temperature, with timing such that the these events usually occur at similar temperatures, but different dates, in various locales. Thus EPA's suggestion that what we have learned about temperature in other parts of a fishes' geographic range may not apply to the Charles is ill founded.

Response to Comment related to C35 from CLF: This issue is addressed in Response Related to C13 from CLF.

Comment C36: Erroneous Assumptions and Justifications in Applying the U.S. Fish and Wildlife Model to the Lower Charles; Unsupported Assumptions Regarding Avoidance. The avoidance line on Figure 5.7.3c-1 in the DD is based on a misuse of data from Richkus (1974), and on unsupported assumptions about how avoidance is related to other temperature response data. This figure has no valid scientific basis. Further, speculation that "Adult and egg mortality or chronic effect in this location is considered likely" is unjustified and unsupported. For example, how could chronic effects occur at this location when the fish do not remain there?

Response to C36: EPA and MassDEP disagree with the statement that the assumptions used regarding how avoidance is related to other temperature-response data are un-supported. The DD provides literature sources that support the observation that avoidance temperatures are usually lower than temperatures inducing toxicity. It provides LC50 toxicity data from Graham and couples this with information from Coutant to predict a NOAEL. In developing the application, EPA and MassDEP assumed that the slope of the NOAEL parallels the slope of the LC50 data-line. In the absence of specific information on NOAELs for alewives at the range of acclimation temperatures presented in the graphic, assuming parallel slopes is a reasonable approach, or is at least the best the Permitting Agencies can do absent more specific data. A similar approach was used by Lawler, Matusky and Skelly (LM&S) Engineers in the Brayton Point 316(a) and (b) analysis. When there are no alternative datapoints, typically a straight line is drawn to attach data and a linear relationship is assumed between datapoints. The toxicity information was coupled with field information from Richkus; the endpoint taken from the Richkus study is generally supported by 19 other field studies in Massachusetts and New Hampshire.

With regard to the comment on toxicity at the discharge pipe, EPA and MassDEP disagree with Mirant that toxicity to eggs deposited at this location is unjustified and unlikely. It is true that no field studies were submitted by the permittee to gain information on eggs deposited at this site by river herring. However, the Permitting Agencies fully expect that eggs deposited by river herring in the discharge pipe at temperatures that are 15-20ºF above ambient would have a low chance of survival due to both heat and chlorine effects. In addition, if these eggs settled to the bottom during some years, they could possibly encounter deep, isolated pockets of denser water, with higher salinity and lower oxygen levels, especially in the late spring and early summer. Although the highest densities of river herring larvae were captured in the lower Basin by Mirant in May and June, herring larvae were also captured in the lower Basin through mid-August in 2000 (data from Mirant, Vol. 1, NPDES Application, Feb. 2001). The typical duration of the larvae stage in river herring is 2-3 weeks. These data lead the Permitting Agencies to conclude that at least one of the species of river herring (probably bluebacks) is still spawning in June and July, when low oxygen levels begin to become a problem in the lower Basin. Therefore, herring spawning in the discharge pipe can lead to the loss of eggs due to anoxia, depending on when those eggs are deposited.

Mirant questions the idea that short-term effects to eggs and larvae can cause long-term (i.e., chronic) effects. Short-term exposures to certain toxicants have been known to cause negative effects to physiology and/or behavior of fish. Many of these effects occur at some time distant from the exposure. With regard to heat and chronic toxicity to fish, Williams and Coutant (2003) found that modifications of schooling behavior in an atherinid fish (Atherina mochon) resulted when egg and larval stages of that fish were subjected to short-term exposures to sublethal increases in water temperature. Exposures in these experiments were administered to eggs only, larvae only, and both eggs and larvae. Analysis of the behavior of larvae at 10-35 days posthatch revealed that locomotor ability and ability to maintain presence in a school were greatly diminished in heat-exposed fish. Diminished ability to maintain a school is a chronic, negative effect because a decrease in schooling behavior is expected to diminish, or even prevent successful maturation and spawning. With regard to adults, the chronic and/or acute effect to adult alosids that are attracted to the plume is unknown. Based on studies by Graham, however, a 20 ºF rise in temperature due to the discharge could induce death in alewives if the duration of exposure was long enough. Currently, the duration of exposure of those fish attracted to the plume is unknown.

If adult alewife avoid Kendall Station's thermal plume, they are, in effect, being excluded from habitat. This shrinking of habitat, in a healthy population, could result in increased competition among fish in the remaining habitat for food, desirable spawning locations, and less available space for predator avoidance. These stressors could contribute to chronic conditions of low weight, unsuccessful spawning and overall reduced survival. In a depauperate population, with only a small area within which to breed, habitat exclusions may have a greater impact on the survival of the population.

Comment C37: Erroneous Assumptions and Justifications in Applying the U.S. Fish and Wildlife Model to the Lower Charles; Incorrect Assumptions Regarding Temperature Impact on Alewife In-Migration.

In Section 5.7.3c, the DD states that "[d]ata from studies which evaluate temperatures at entry to the run are the most valuable in developing avoidance temperatures." This statement is incorrect. As discussed in prior comments, higher temperatures enhance upstream migration at the beginning of the run (i.e., fish avoid low temperatures), and at the end of the run, the cessation of the run is most probably related to the absence of additional fish rather than to their avoidance of the temperature at that time. Also, the statement that "temperature on the spawning beds [note the misuse of the term 'spawning beds'; river herring are broadcast spawners and do not employ spawning beds] will have risen to levels higher than those at the mouth of the stream." The discussion presented in this part of the document ignores the very wide diurnal as well as multi-day temperature fluctuations that occur in natural systems, around the long-term seasonal trend that does occur. The speculation about avoidance of "high entry temperatures" being genetically selected against has no scientific basis.

Comment related to C37 from MA CZM: CZM recommends replacing the ambient temperature limits in the permit, which are 61º F from April 2 to April 14 and 65º F with 60º F for the entire month of April. Further, CZM suggests EPA and MassDEP allow the applicant to evaluate the ability of this temperature limit to protect in-migrating alewife and document the beginning, duration and end of the migration through a study designed in cooperation with EPA, MassDEP, DMF and CZM.

Comment related to C37 from CLF: EPA has determined that the alewife is the most appropriate indicator species to use for its evaluation of river conditions for anadromous fishes because it is judged to be the most sensitive to elevated temperatures at all life stages. One can think of water temperature as a being part of a biological calendar for aquatic species. Exposure to abnormally warm temperatures in a crucial location, such as near the mouth of a river, can result in a misreading of the calendar, and a potentially devastating de-synchronization of reproductive behavior with the availability of suitable habitat and food. As the water temperature increases, the fish that have aggregated near the river mouth are triggered to begin their spring spawning run. If the water is heated by thermal discharge, this natural behavior will be disrupted. If outflow temperatures are too high when migrating fishes arrive, the migration can be blocked. Migration can also be triggered too early leading to spawning under sub-optimal conditions, including the production of eggs and larvae under conditions that are not favorable to their survival.

Alewives typically begin spawning runs when water temperatures are in the 45 to 55 ºF range during April. When spring temperatures reach about 64 ºF, alewives generally will no longer migrate into rivers. However, the ZPH temperature limits proposed by EPA for the April-May spawning run period for Massachusetts will exceed 64 ºF at the beginning of the typical spawning period in mid April. According to a careful analysis of New England spawning runs presented by EPA, runs are essentially finished (i.e. 95% of fish have migrated) by the time water reaches 65 ºF, typically in May. By the end of May, EPA proposes allowing temperature in the ZPH to climb as much as 6 ºF above the behavioral threshold for inward migration (i.e. to 70 ºF). The water in the ZD will be even warmer and it is these thermally loaded waters that migrating alewives will encounter as they reach the mouth of the river. The schedule of proposed limits is not consistent with the available science on alewife behavior and is not supportive of these indigenous migratory fish that have been selected as indicators of habitat suitability. Indeed, the limits proposed by EPA are inexcusable because they will so obviously interfere with the migrations of alewife, and probably other migratory species.

In the section of the Determination Document dealing with protective temperatures for migrating adult river herring, EPA writes that ". . . many years of spawning data at a specific river system would be needed to properly characterize the spawning habits of a site-specific spawning school," suggesting that detailed knowledge of herring behavior in the Charles river is required to best understand the habitat requirements of this species and thus set permit limits. As explained above, we do not agree with this reasoning for herring, or for any other species that currently struggles to maintain its toe-hold in the Charles. EPA provides no support for the notion that temperature, or any of the other cues, regulating behavior of river herring might vary substantially from one river to the next. Indeed, the bulk of the published literature on Alosids would indicate otherwise, with the dates of spawning runs varying with latitude, but being relatively stable with respect to water temperature. As noted in the comments above on Yellow Perch, there is little support for the contention that the sub-populations of herring, or any other fishes, in the Charles have diverged substantially from members of their species studied in other rivers. The lack of site-specific data on these species, particularly data taken in an impaired waterway such as the Charles, does not represent a pronounced obstacle to our scientific understanding of the biology of these species, and should not be put forth as a justification for departing from the conclusion supported by the published literature for each of the species considered.

Response to C37 and related comments: These issues have been addressed in responses to previous comments in this document (see especially Response C6, Response C33 and Response C34). In addition, Mirant alleges that the analysis in this section ignores “very wide diurnal as well as multi-day temperature fluctuations,” whereas CLF asserts that EPA and MassDEP have selected temperatures beyond the upper end of the tolerance of the BIP. At the end of Section 5.7.3c of the DD, however, EPA and MassDEP specifically accounted for the diurnal fluctuations in the lower Basin. The permitting agencies noted that these fluctuations should help ensure that the permit temperature limits actually achieve protective in-stream temperature levels for the BIP, because if Mirant is to maintain compliance with the permit limits, it is reasonable to expect the in-stream temperatures to fluctuate below those maximum allowed temperatures. While Mirant was implicitly arguing that the fluctuations are a basis for setting higher temperatures, EPA and MassDEP decided that the fluctuations should serve as a margin of safety within the river system to help maintain temperatures to protect the BIP.

Regarding the MA CZM recommendation to replace the ambient temperature limits included in the permit (16.1 °C (61 °F) from April 2 to April 14 (in place to protect yellow perch juvenile development) and 18.3 °C (65 °F)) with 15.6 °C (60 °F) for the entire month of April, EPA and MassDEP present the following information. While EPA and MassDEP acknowledge that temperatures below 18.3 °C (65 °F) would also be protective of the onset of alewife in-migration, the limit of 18.3 °C (65 °F) is fully justified by the record. There is evidence that temperatures above 18.3 °C (65 °F) halted the in-migration of alewife. There is no evidence in the record that a temperature just above 15.6 °C (60 °F) resulted in a negative impact to alewife in-migration. The permit limits are not designed to identify optimal temperatures, but rather maximum temperatures above which harm to the BIP would be expected, based on the scientific literature and site-specific data.

Another protective measure in the permit plays a central role in the month of April. The delta T limit of 5 °F above ambient will limit the temperature in the lower Basin in April long before the maximum temperature limit becomes part of the compliance protocol. Figure C37-1 shows hourly temperatures from Kendall Station's Intake, recorded for the month of April from 1994 through 2002. During this time of year, these temperatures are thought to generally represent ambient conditions in the Charles River. The highest hourly temperature from among those 9 years was assembled for the maximum temperature line (green). The average of all 9 hourly temperatures was assembled for the "average" line (gray). The lowest hourly temperature from among those 9 years was assembled for the minimum temperature line (blue).

Based on this information, even when examining the maximum temperatures, the delta T of 5 °F requirement would hold temperatures in the ZPH at or below 60 °F for at least the first two weeks of April. When the average temperature is examined, Kendall Station heatload would not generally increase ZPH temperatures above 60 °F for approximately the first two thirds of April (until April 22). After that, temperatures would still remain several degrees F below the 65 °F limit due to the maximum delta T of 5 °F. When this information is added to the fact that higher flows usually occur in the Charles River during the month of April, it is reasonable to expect that the ZPH will be well below the maximum limit of 65 °F for the entire month of April in most years. During a hot, dry April, the maximum temperature limit of 65 °F will ensure that the BIP is protected.

Comment C38: Erroneous Assumptions and Justifications in Applying the U.S. Fish and Wildlife Model to the Lower Charles; Unsupported Assumptions Regarding Alewife Out-Migrations.

Section 5.7.3c of the DD asserts that "out-migrations continue to occur long after in-migrations have ceased." This observation is not support for a temperature difference between entry and spawning temperatures. There may be a lag between in-migration and spawning at the very beginning of a run if upstream migration is triggered by a brief high temperature excursion followed by a drop in temperature. In such an instance, fish may move upstream, but not actively spawn until temperatures rise to appropriate levels. However, during the major portion of any spawning run, temperatures are sufficient for fish to spawn throughout the entire period. Thus, fish entering will spawn when they are present in appropriate spawning locations and do so continuously throughout the run, not at some specific temperature. The fact that out-migrations continue long after in-migrations have ceased is simply a result of spawned-out fish remaining long after completion of spawning. Richkus (1974b) documented spawned out adults moving downstream throughout the summer. While Mirant Kendall offers no specific explanation for the delay in out-migration of these fish, nothing in the literature would suggest a link between that behavior and water temperatures.

Response to C38: EPA and MassDEP agree with the permittee that keeping the lower in-migration temperature limits in place for a longer period, rather than replacing them with the higher spawning temperature limits (as is currently reflected in the permit), would be more protective of the alewife in-migration. However, maintaining the in-migration temperature for a longer period of time is inconsistent with the steady rise in the ambient temperature of the river documented in the majority of years where data is available.

Mirant's comment that there is nothing in the literature to suggest a link between out-migration behavior and temperature suggests that the permit need not include temperature limits to protect out-migration. While EPA and MassDEP do not believe that the highest temperature limit in the permit needs to be lowered to protect out-migration, as explained immediately below, the delta T limit of 5º F in the permit does have the effect of reducing the maximum allowable temperature for the facility in parallel with any natural cooling of the river at the end of the summer.

Comment related to C38 from RiverWays: The need for out migration passages deserves as much attention as adult spawning migration. If the larval fish are unable to traverse the Basin safely in the late summer/early fall, all efforts to protect spawning populations will be wasted.

Larval fish are less tolerant of unfavorable conditions than adult populations.

Response to Comment related to C38 from RiverWays: EPA and MassDEP recognize that temperature limits that will protect a successful out-migration are as important as other temperature limits established in the permit. The maximum temperature limit in the ZPH in the late summer and early fall is 81ºF at certain Monitoring Points at Monitoring Stations 2, 3 and 7. However, during the late summer and early fall, as ambient temperatures in the Charles begin to fall, the delta T limit of 5 ºF in the ZPH will play a more central in ensuring that out-migration temperatures are suitable. When ambient temperatures drop to 73 ºF, for example, the maximum temperature in the ZPH will only be allowed to be 5 ºF above that, or 78 ºF, even though the maximum limit at certain Monitoring Points at Monitoring Stations 2, 3 and 7.is 81 ºF. This delta T limit will serve to maintain protective out-migration temperatures in the ZPH.

Comment C39: Erroneous Assumptions and Justifications in Applying the U.S. Fish and Wildlife Model to the Lower Charles; Site-Specific Data Excluded, Leads to Incorrect Conclusions Regarding Alewife In-Migration.

Section 5.7.3c of the DD presents selected data on temperatures reached by the end of herring runs. It is misleading and inappropriate to exclude certain relevant data from this material. See for example the discussion of the 70-74^{o} F temperatures in the 1991 Merrimack River run in Comment C33, and the site-specific experience from this year's run in the Charles River.

This year's data from Mirant Kendall's sampling in the Charles River also contradicts the Agencies' assumption that "a much larger proportion will refuse entry to the Lower Charles at temperatures above this value (64.4 ^{o}F)." In this year's run, 75% of the alewives caught below Longfellow Bridge through the third week in May (last date of "ripe" females) were caught when temperatures had been above 64.4 ^{o}F, and as high as more than 69 ^{o}F MK Comment Ex. No. C33-3.

Response C39: Based on the thermographs provided by the permittee, at times, alewives entered the lower Basin after water temperatures above the permit limits were recorded. As described fully in Responses C13 (d) and (e) and C24, there are a number of problems associated with predicting what would have been "permit exceedances" using temperature data that does not approximate the station locations, depths and calculations used to determine temperature compliance in the permit. Based on this, EPA and MassDEP can not determine with certainty if the permit limit would have been violated in the ZPH during the time periods identified by the permittee. The permittee states that alewife continued to enter after these events took place. It must be noted that the permittee does not state that adult entry to the system occurred when temperatures were at or above 65 ºF and the Permitting Agencies have seen no information to support the idea that alewives entered the Basin at times when the water temperatures at the point of entry were equal to or greater than 65 ºF .

Based on the adult gill-net information (see Response C43), the percentage of the adult river herring population comprised of alewives is at low levels. While it is true that adult alewives moved into the system after some high temperature events, neither EPA, MassDEP, nor Mirant have managed to provide an answer as to why such a dramatic decline has taken place in the abundance of alewives. This is of concern to EPA and MassDEP and lends further support to overall temperature limit approach established in the permit. Results from the monitoring program will provide further information regarding the appropriate, protective temperature limits needed to protect the BIP.

Please see Response C33, where the following issues are discussed: a) the use of the Merrimack data to develop permit limits for entry temperatures in the Charles; b) reasons for not using the highest temperatures reached during the run as the maximum allowable temperature for the run; and c) the use of six days of temperature limit excursions allowed in the draft permit to address occasionally dramatic natural springtime temperature fluctuations.

Comment C40: Erroneous Assumptions and Justifications in Applying the U.S. Fish and Wildlife Model to the Lower Charles: Site Specific Data Excluded, Leads to Incorrect Conclusions Regarding Alewife In-Migration.

Section 5.7.3c of the DD states"[a]t the early part of the run avoidance temperatures will be lower than those for the latter part of the run." This statement is refuted by results in Richkus (1974) and in Collins (1952). Both laboratory and field studies show fish are attracted/stimulated by high temperatures over a wide temperature range. Richkus (1974) showed that during the early portion and most of the entire spawning run, only declines in temperature appeared to inhibit upstream migration. Very high short-term temperature excursions resulted in high upstream migration rates, which is not indicative of avoidance. For this reason, establishing a maximum April temperature of 15.6 ^{o}C does not appear to be necessary to ensure entry of alewives into the Charles River.

Section 5.7.3c of the DD assumes "that in-migration has not been inhibited to threaten the protection of the BIP for alewife in the Charles from 1995 to 2002." This is a crucial point, with which Mirant Kendall agrees. Mirant Kendall further believes the results of its gill-net sampling indicates that the same can be said about the in-migrations in 2003 and 2004. Mirant Kendall strongly suggests that the Agencies also consider the corresponding data on later season temperatures associated with year class success in the same manner, notably the data from 1999, where relative abundance of larvae and alewives as young-of-the-year and as returning adults (in 2002 and 2003) all point to an absence of appreciable harm to the BIP despite frequent exceedances of the temperature limits proposed in the Draft Permit.

Mirant Kendall suggests that a rigorous statistical analysis to identify the means and standard deviations of the corresponding temperatures in each two-week averaging period be applied to inform the Agencies' "Stair Step" approach and to derive appropriate springtime limits corresponding to the historical range of background temperatures. Mirant presented such a statistical analysis in Comment C5 above.

Response to C40: The statement that avoidance temperature will be lower in the beginning of the run than at the end was based on the observation that there is a positive relationship between acclimation temperature and avoidance temperature. Mathur, et al. (1983) found a positive relationship between acclimation and avoidance temperature in bluntnose minnow, channel catfish, smallmouth bass, spotfin shiner, bluegill, green sunfish, yellow perch and other centrachids and cyprinids. The fact that a positive relationship typically exists between these two factors as well as between acclimation and temperature-based toxicity endpoints is well established in the literature.

Much of the literature supplied to EPA and MassDEP from the permittee supports the fact that a positive relationship exists between toxicity endpoints and acclimation temperature. In many of the toxicity-based evaluations reviewed by EPA and MassDEP, toxicity endpoints from excessive temperature exposure are positively related to acclimation temperature among different fishes. It has also been established in studies of many species of fish in geographical zones outside of the tropics (i.e., outside those areas where temperatures are nearly constant) that avoidance occurs at temperatures lower than those known to induce toxicity. It follows logically, therefore, that avoidance temperatures are also positively related to acclimation temperatures.
EPA and MassDEP assumed that this relationship, established for other species, also existed for alewives. Thus, when the alewife run begins in April in the Charles and acclimation temperatures in Boston Harbor are in the low-to-mid-40s (ºF), EPA and MassDEP assumed that the avoidance temperature would be lower than avoidance temperatures at the end of the run (1st week in June) when acclimation temperatures were much higher (see Table 5.7.3c-4 in the DD). The model assumes that avoidance temperatures follow the same slope that is followed by the toxicity endpoints. The assumption that a positive relationship exists between acclimation temperature and avoidance was employed throughout the Brayton Point Power Plant 316(a) demonstration in sections pertaining to development of temperature envelopes for different fish species.

In the second paragraph of Comment C40, Mirant quotes the DD: "in-migration has not been inhibited to threaten the protection of the BIP for alewife in the Charles from 1995 to 2002", and states that this is a crucial point with which Mirant agrees. The company also believes that "the results of its gill-net sampling indicates (sic) that the same can be said about the in-migrations in 2003 and 2004", i.e., that the runs have not been inhibited.

It was not until Mirant provided EPA and MassDEP with the 2004 data (submitted on August 30, 2005, AR#557) and 2005 data (submitted in April, 2006, AR#560) that the analysis contained in Response C3 was able to be performed. Thus, prior to these comments, EPA and MassDEP had an incomplete picture of the effects of the facility on capture rates of juvenile alewives; nor were EPA and MassDEP fully aware of the decline in the relative abundance (and, it appears, the relative year-to-year run strength) of adult alewives, bluebacks and total river herring (alewife and blueback herring combined) that has taken place since 2002 (see the Permitting Agencies' Response C43 regarding relative year-to-year run strength).

The permittee suggests that a statistical analysis of intake temperatures be used to derive appropriate springtime limits such as that proposed in Comment C5 above. Mirant's proposal in Comment C5 is based on a misinterpretation of EPA's suggestion to use a 95%-ile figure in assessing toxicity data. In addition, Mirant did not follow its own guidance in developing the information presented in the Tables in Comment C5. Please see Response C5 for a full discussion.

Comment C41: Mischaracterization of Timing of Alewife Adult Spawning Stage. Section 5.7.3d of the DD states "the number of spawning fish entering the lower Charles River Basin will increase, but the duration of the run may also increase." This statement contradicts the concept that temperatures control the run. If fish avoid temperatures above certain levels that establish when the run will occur, the duration of a run could not change in response to the number of fish comprising the spawning run.

This section suggests that there is not sufficient site-specific data to determine the probable expected beginning and end of the alewife in-migration. Mirant's collection data from 1999 to the present indicates that the alewife run begins as early as the first week in April (generally when water temperatures reach the 50s) and continues through the third week in May, at varying water temperatures up to the low 70s.

Response to C41: Based on the preliminary estimate of in-migration from 2002, the current adult alewife spawning run appears to be far below the estimated carrying capacity of the river. EPA and MassDEP assumed that if the run is relatively small, that run would not reach its potential duration. As the number of fish entering the system increases, it is expected that a greater proportion of the appropriate temperature range would be utilized, i.e., that the tails of the frequency distribution of run strength would become more apparent in the sampling.

Based on the permittee's gill net sampling analysis near the dam, the alewife run extends from early April through early June (not the third week in May as stated). So few alewives were captured in each of these years that it is important to recognize all the data when assessing the start and end of in-migration. EPA and MassDEP agree, however, that under current conditions, most of the alewife run has occurred in the period stated by the permittee.

Comment C42: Proposed Temperature Limits for Alewife Adult Spawning Below Historic Ambient. Section 5.7.3d of the DD lists the proposed in-stream limits from April 15 through June 7. As discussed in Comment C5 above, the proposed temperatures are in line with historic background in April, but 2-5 ºF below the range of historic background that has prevailed during successful spawning runs in May and June.

Response to C42: There are several components to EPA and MassDEPs' response to this comment. First, an important qualifier in the permittee's statement is the word "range." It may be true that, at times, temperatures recorded at the Kendall Station intake exceeded the permit limits in May and June during alewife runs. This does not mean that the average temperatures or even the 70th or 90th percentile ambient temperatures are above the temperature limits in the permit. Nor does this mean that alewives were moving into the system when these temperatures were exceeded. This is addressed in the Response C5. Much of the reason for the limits in the springtime is to provide access to the Charles for alewives moving into the system. The other reason for the springtime limits is to allow these fish to continue movement past the narrow constriction near the Science Museum and past the Station.

Second, other water quality variables, such as dissolved oxygen (D.O.), may at times, even in fairly pristine systems, fail to meet state standards, with negligible effects. However, the State D.O. standard has not been set at the lowest values experienced by the system. This is due to the fact that, although downward spikes may be withstood if they are not frequent, sustained low D.O. cannot be withstood by many of the organisms in the system. In addition, if a lower D.O. standard were allowed, localized, downward D.O. spikes would not be the only problem for the resource. Dischargers of substances that lower dissolved oxygen could increase the duration of low D.O. events, the areal extent of these events, the magnitude of any natural declination in D.O. and/or the frequency of such events, all of which will increase the probability that the population of concern will be negatively affected. The same situation exists with temperature.

EPA and MassDEP are confident that there is a substantial dataset based on field and laboratory evaluations to justify springtime temperature limits. Some parties (see Comment related to C42 from CLF) argue that the permit limits are too high to allow continued access of alewives into the Charles during the spring.

Third, six exceedances of the springtime limits have been allowed because EPA and MassDEP recognize that, at times, the ambient water temperature has exceeded the permit site-specific limits. These exceedances were included to provide additional operational flexibility for the Station during changing river temperatures, regularly documented in the spring.

Fourth, the lower Basin of the Charles is already stressed with regard to temperature. According to a statewide analysis of stream temperatures conducted by DEP personnel in concert with USGS, water temperatures in the lower Charles are among the highest in the state. This is probably due to a number of factors, including natural tannins in the water which color the water and increase its potential to absorb infra-red radiation. The river is also greatly expanded and river velocities decreased due to the New Charles River Dam, allowing more surface area and longer retention times to absorb solar heat. There are also large inputs of street runoff, CSOs and other discharges, all of which may at times be much warmer than ambient water temperatures in the Charles.

Fifth, the state of alewife stocks in the Charles appears to be far from robust. As mentioned in response to comments above, the adult alewife stock has been directly estimated only once, in 2002, at 8,000 fish. Since this was a preliminary estimate based on a pilot study, it can not be regarded for certain whether this was a successful run. However, the combined alewife/blueback herring run that year (45,000 fish) was well below the MADMF estimate of carrying capacity for that system (250,000 - 500,000 fish). In addition, EPA and MassDEP have provided an analysis of Mirant's gill-net, daytime beach-seine, night-time beach seine and push-net data, all of which supports the position that the juvenile alewife population descended to very low numbers in 2000, that adults followed in 2003 and that both life stages remain at low levels.

Comment related to C42 from CLF: Indeed, the limits proposed by EPA are inexcusable because they will so obviously interfere with the migrations of alewife, and probably other migratory species.

Response to Comment related to C42 from CLF: According to information submitted by the permittee, as well as some historical data, the profile of the past heated discharge from Kendall Station has not completely blocked the migration of anadromous fish species into or out of the Charles River.

If by interference, the commentor means that migrating fish may avoid a portion of the river near the Kendall Station thermal discharge point, then EPA and MassDEP concedes this to be a probable response. EPA does not feel this response in and of itself will lead to a destabilization of the BIP. Anadromous fish passage, although far lower than estimated carrying capacity of the river, has been documented in the lower Basin under past thermal discharge loads.

Comment C43: Temperatures and Time Periods for Alewife Egg Stage Based on Incorrect Assumptions. Section 5.7.3e of the DD discusses various measured temperatures and laboratory toxicity studies of alewife hatch success rates measured over several days of exposure to different temperatures. Mirant Kendall asserts that these data are not currently applicable to the conditions in the ZPH for two related reasons. First, the spring river flows during alewife spawning (generally well in excess of 400 cfs, and always above about 100 cfs) do not allow alewife eggs in the upper water column to remain within the ZPH long enough to hatch and develop before washing out into the Harbor. Second, if the eggs sink into the lower water column, they will be subject to cooler temperatures, but will likely perish in the anoxic conditions there. This situation could be mitigated for at least some eggs in the lower water column if the proposed new outfall and diffuser are implemented, as discussed in Section E of these comments.

Section 5.7.3f of the DD indicates adult alewives are expected to end their spawning run by June 7, therefore adding four days for incubation and placing last egg hatching around June 11. Site-specific gill net data documenting ripe adults and the site-specific length data for young-of-the-year alewives collected by Mirant Kendall since 1999 indicate that the last alewife eggs would be expected in late May, not the first two weeks in June. The Agencies should review these data and revise accordingly.

Response to C43: There are several interactive components to this issue: placement of eggs, duration of the adhesive stage, duration of the pelagic stage, current velocities and their potential effects on egg and larval wash-out, and anoxic conditions in the water column.

Both blueback and alewife eggs are demersal (on the bottom) in still water and adhesive in lotic waters until they are "water hardened," which typically takes less than 24 hrs (from Mullen, 1986). After that time, eggs of both species lose their adhesive properties and may drift in the water column. Depending on water temperature, alewife eggs may remain in the egg stage for up to two weeks. Depending on where they are spawned, and on water velocities at the spawning site, certainly, eggs may be displaced downstream. If they are placed along the shoreline in weedy areas where velocities are negligible, there may be little displacement downstream. Anoxic conditions typically begin in very deep areas in the summer (after egg deposition for alewives) and progress upstream and higher into the water column as the summer progresses.

Alewife spawning sites that are in shallow to mid-depths should not be affected in the spring by anoxic conditions (see also Response C36 regarding river herring spawning in the discharge pipe).

Most spawning should take place near or on the bottom. The spawning sites in the lower Basin are not likely to be profoundly anoxic in the spring due to high flows, with the exception of some years, where very deep pockets may contain dense harbor water, elevated in saline, and lower in D.O. (according to information presented by EPA and USGS). Adults are not expected to venture to lower D.O. areas to deposit their eggs. The shoreline areas downstream of the B.U. Bridge have the slowest water velocities, and thus, the highest potential for retaining eggs. Because the shallow areas are along the shoreline in the area downstream of the B.U. Bridge, it is important that water near the surface be maintained at temperatures appropriate for egg and larval survival to offer these life stages adequate habitat.

The development of alewife eggs to the larval stage is more rapid with increasing temperature. Because eggs deposited toward the end of the spawning run will hatch the fastest due to the gradual increase in water temperatures as spring progresses, those deposited at the end of the run should have the greatest potential for survival if wash-out rates are a concern because they will be exposed to potential wash-out for the shortest duration of time. In addition, river velocities typically diminish in the late spring and early summer, further lessening the potential for wash-out. Thus, it is important to ensure that temperatures are adequate for survival for those eggs deposited at the end of the run.

As the season progresses, boat traffic through the locks increases thus allowing salt water to flow into the lower Basin. River flows typically decrease as spring nears a close and due to the increase in saltwater and a decrease in the removal of water from the Basin, the anoxic layer lengthens and rises, but only up to a point. EPA and MassDEP are unaware of any data showing that shoreline areas (less than 6' in depth) experience anoxia at any time of the year. Thus the shoreline areas should provide the best habitat for both spawning and egg and larval development for alewives.

Mirant contends that alewife and blueback eggs that are deposited in the lower Basin during high-flow years experience the highest wash-out rates. As a point of operational concern, during years with high springtime flows, the permittee is not expected to need to reduce or curtail generation in order to meet the thermal limits, due to ample dilution. Rather, the permittee contends that years with low springtime flow rates will be most important to re-building alosid populations. The periodic occurrence of low flow years are thought to allow alewife eggs in the upper water column to remain within the ZPH long enough to hatch and develop before washing out into the Harbor. This occurrence is in contrast to the permittee's statement in this comment. Thus, during these low-flow years the shorelines, as well as the water column in the ZPH, must have water temperatures that are amenable to the successful growth of alewife eggs and larvae. From an operational standpoint, these low flow years will likely provide the greatest challenges to Kendall Station regarding temperature limitation.

Concerning the timing of the egg stage, Mirant states that, based on the adult presence during the spring run, eggs cannot be present through June 11th, the last date at which limits to protect eggs are found in the draft permit. Mirant also states that the adult alewife run only extends through the third week in April. Mirant bases this argument on gill-net data.

The Permitting Agencies reviewed the adult gill-net information to evaluate the temporal duration of the springtime run. A summary of the gill-net and dip-net data is provided below. Data for 1999 and 2000 are not included because sampling was limited to the Broad Canal in those years:

Table C43-1: Relative population size of adult blueback herring and alewives judging from gill-net and dip-net sampling.

Dates of sampling span from the first date of river herring adult capture in the spring to the end of June when blueback catch decreases to near-zero catch. Gill net data were collected in 1984 by MADMF. All other data are transcribed from the April, 2006 data submission from Mirant Kendall. Mirant's gill-net data reported below are only for years when gill-netting was conducted outside the Broad Canal.

Year	Dates of Sampling	Total alewives	Total bluebacks	Total # river herring	% alewives
1984	5/9 - 6/21	49	94	143	34.3
2002	4/4 - 6/28	153	683	836	18.3
2003	4/17- 6/26	65	381	446	14.6
2004	4/21- 6/30	27	346	373	7.2
2005	4/29- 6/30	62	421	483	12.8

* Dates of sampling for 1984 are from MA DMF. Dates of sampling from other years span from the first date in the spring when either bluebacks and/or alewives were capture in gillnets to the last sampling date in June. By the end of June, river herring presence in gill nets tapers off and typically includes only small numbers of bluebacks.

Table C43-2: Year-to-year variability in catch per unit effort of river herring species. Dates of sampling and other information as in Table C43-1 above. The three columns on the right of this table depict "catch per unit effort" as the total number of fish caught over the dates of sampling at all gill-net stations divided by the total hours of gill netting over those dates.

Year	Dates of Sampling*	Total alewives	Total bluebacks	Total hours gill netting	Alewives per hour	Bluebacks per hour	Herring per hour
1984	5/9 - 6/21	49	94	n. a.	n. a.	n. a.	n. a.
2002	4/4 - 6/28	153	683	201.1	0.76	3.4	4.2
2003	4/17- 6/26	65	381	207.3	0.31	1.8	2.2
2004	4/21- 6/30	27	346	274	0.1	1.3	1.4
2005	4/29 – 6/30	62	421	349.4	0.18	1.2	1.4

Several pieces of information are important to the discussion on alewives. First, contrary to what Mirant states in their comments, adult alewives have been caught in gill-nets through the first week in June in 2002 through 2005 (see Mirant's April 2006 data submittal to the Permitting Agencies).

Second, Table C43-1 illustrates that the percent of the total catch of river herring that is comprised of alewives has dropped consistently from 1984 through 2005. The relative percent alewives increased slightly in 2005, but did not reach that seen in 2002 or earlier.

Third, the relative year-to-year run strengths of bluebacks, alewives and total river herring all decrease after 2002 (see Table C43-2). Data in Table C43-2 were compiled as the catch per unit effort (in this case, as catch per hour of gill netting). This allows comparisons of run strength to be made among all years. Because the 1984 data were collected using a different method, data from that year cannot be compared to data from other years using this method.

These data indicate a decline in adult run strength since 2002. Mirant used sonar in the spring of 2002 to estimate the total river herring population entering the Charles River and gill-net sampling to estimate the proportion of these herring that were alewives (although issues have been raised concerning the accuracy of the results). Using this approach, the adult population entering the Charles was estimated at only 8,000 fish in 2002. Further reductions to such a small population are of substantial concern to regulators and underscore the need to curb any additional erosion of this population.

Not shown above is a week-by-week breakdown of sample data. Based on the available data, it appears that the highest adult alewife densities occur from early April through the third week of May as the permittee maintains. However, in all four of the years that gill-netting was conducted outside of the Broad Canal, adult alewives were caught into June, albeit, only seven in 2002, one in 2003, three in 2004 and five in 2005. Because such a small total number of alewives were caught in gill nets over these years, a single adult fish in each year can account for a fairly high percentage of fish. For example, in 2003, a single adult alewife accounts for about 2% of the 2003 adult alewife catch, and about 4% of the 2004 catch.

Mirant has proposed an estimate of the alewife run duration. However, their estimates on run duration are based on a very small dataset. EPA and MassDEP are concerned that because the alewife run appears to be small, the sampling, though fairly rigorous, produces very few adults. This means either that the sampling is inefficient or the adult alewife population size is small.

Making a determination of run duration with only a small subsample of the adult population will lead to wide confidence intervals in the actual run duration (see Response C33).. Mirant provided no confidence intervals for run duration. Because the Charles River alewife run appears to be small, EPA and MassDEP are concerned that if only the bulge in the run is protected, an important portion of the run could be excluded by selecting inappropriate temperature limits. Late migrants may be very important to the success of the run due to the diminution of wash-out rates in the late spring. As Mirant has intimated in a number of comments, the low-flow years may be those most important to rebuilding alosid stocks in the

Charles.

Based on the adult dataset in the tables above, and information from the literature that it takes about 11 days for alewife eggs to hatch to larvae at 70 ºF (and longer for cooler water), EPA and MassDEP assert that they are justified in establishing the permit date of June 11 for the end of the alewife egg stage.

Comment C44: The discussion of mortality rates of eggs and larvae at various temperatures in section 5.7.3g ignores the fact that developmental time and growth rates are also related to temperature, and all these factors combined contribute to the ultimate cumulative larval survival that establishes the year class strength. Kellogg (1982) found that maximum larval growth occurred at 29.1 ^{o}C (84.4ºF). The fact that maximum growth occurred at such a temperature argues against a high level of thermal stress occurring under those conditions. The Agencies discount Mirant Kendall's site-specific data as "informative as a guide," apparently giving more weight to laboratory studies. The Agencies' assertion that temperature data from Mirant Kendall's ichthyoplankton sampling are unrepresentative is misleading and incorrect. A complete, representative, river-wide temperature profile is available from the time series (including continuous readings) made at various locations. These not only include the temperatures measured on the boat at the time of collection, but more importantly, indicate the temperature history to which the collected larvae have been exposed. For example, larvae collected between July 7 and July 10 in 1999, 2002 and 2003 are known to have experienced and survived river-wide temperatures in the upper 80s during the first week in July.

The Agencies incorrectly indicate that the viability of larvae was not evaluated in Mirant Kendall's sampling. While no "condition factor" was (nor could readily be) determined, larvae were measured. The resulting length distributions, along with subsequent measurements of juvenile abundance, together provide an indication of whether conditions (including temperature, flow, etc.) were sufficiently protective for the larvae to develop to the young-of- the-year stage, when their identity as alewives or bluebacks was confirmed. In none of the sampling years of 1999 through 2004 was there any evidence that basin temperatures had curtailed growth or development. Relative abundance of young alewives and length distribution of larvae correlated well with river flow conditions during May and June, but did not correlate with temperature differences between warm and cool years.

Finally, the Agencies state that "[u]sing the presence of river herring larvae (made up of both alewife and blueback larvae) to formulate upper temperature limits may result in a maximum temperature limit that exceeds the temperature limit best suited for alewife larvae alone." Does this comment indicate that it is the Agencies' intent to optimize the temperature for alewife larvae alone or to protect the BIP of both alewives and bluebacks? Mirant Kendall believes it is likely that the optimum temperatures for blueback larvae may be slightly higher than those for alewife larvae, but still low enough to protect alewife larvae. The Agencies should clarify their objectives. It is Mirant Kendall's understanding that the CWA requires protection of the BIP rather than optimization for a single species. The Agencies discuss 24-hour laboratory studies of mortality at different acclimation temperatures. Mirant Kendall notes that in those studies, conditional mortality only occurred at Delta Ts of about 14 ^{o}F. Mirant Kendall further notes that whatever acclimation temperature is chosen, drifting yolk-sac larvae will not experience a Delta T of more than 6 °F passing through the ZPH in 24 hours. Section 5.7.3h (time for larval stage) concludes that the period extends to July 7. Based on the sizes of YOY alewives collected in Mirant's sampling, this estimate appears to be about two weeks too late.

Response to C44: It is important to understand the Kellogg dataset because the study results clearly demonstrate the effect of high temperatures to alewife larvae. The results of this published scientific literature contradict the permittee's contentions regarding heat effects.

Kellogg's experiment was a fairly straightforward evaluation of the effect of different temperatures on survival and growth of alewife larvae. He transferred alewife larvae to 7 different test vessels; water in each test vessel was kept at a different temperature for a 12-day test. Tests were begun with 500 larvae in each test vessel. Eight separate water temperatures were evaluated (see table below) ranging from 12.9 ºC (55.2 ºF) to 29.1 ºC (84.4 ºF). Kellogg evaluated toxicity at two different salinities: a) water with a slight degree of salinity (1-1.3 parts per thousand [seawater is about 32 parts per thousand]); and b) freshwater with no added salts. At the end of each test he counted and weighed the surviving fish. His results are transcribed below.

Transcribed from Table 2 in Kellogg (1982)

	Salinity 1.0 - 1.3 ppt				Fresh Water	
	Replicate 1		Replicate 2			
Mean Temp. F[1] + SD[2]	No. Fish surviving	Dry weight per fish (mg)	No. Fish surviving	Dry weight per fish (mg)	No. Fish surviving	Dry weight per fish (mg)
55.2 + 1.1	124	0.06	108	0.05	113	0.05
59.4 + 0.4	71	0.09	64	0.1	11	0.09
64.8 + 0.5	133	0.14	38	0.22	120	0.14
69.4 + 0.7	71	0.26	61	0.24	27	0.28
74.7 + 0.5	44	0.34	16	0.4	14	0.53
79.5 + 0.5	31	0.86	24	0.85	19	0.56
84.4 + 0.2	14	1.12	11	0.95	0	0.00

1: degrees Fahrenheit
2: standard deviation of temperatures during toxicity tests

Note that as temperature increases, survival decreases in each of the tests, but the mean dry weight of the survivors (which were sacrificed at the end of the test and weighed) increases with temperature. Although the body weight of the fish that survived the 12-day exposure increased dramatically with temperature, the percent survival plummeted at temperatures above 64.8 ºF in all three experiments (i.e., the two replicate experiments conducted in low-salinity water and the one experiment conducted with freshwater only). The permittee, in their review of the paper, did not include this second aspect of the experiment, i.e., that as temperature increases, survival of the test organisms drops dramatically.

The data from the 84.4 ºF test exposures, in which a high rate of growth in the few surviving fish occurred, was purported by Mirant to "argue against a high level of thermal stress." Mirant refers to the increased growth rate but neglects to mention the survival levels at this temperature: 2.8% and 2.2% in the low-salinity experiments and zero in the experiment with freshwater only. In the freshwater tests, no larvae survived the 84.4 ºF test exposure; survival at this temperature only occurred in the group that was tested in slightly saline water. In fact, survival of the 12-day exposure in freshwater tests was only seen at 79.5 ºF or below. Even at this temperature (79.5 ºF), larval survival in the freshwater experiments was only 3.8%.

The permittee's discussion of the Kellogg temperature/growth information did not incorporate the results that survival was either at or near zero in the high-temperature (84.4 ºF) tests. Clearly EPA and MassDEP are unable to allow temperatures to persist that would promote 98-100% mortality in alewife larvae, even though the few larvae surviving these temperatures would have extremely high growth rates.

Mirant (paragraphs 1-3 under Comment C44) also asserts that EPA and MassDEP did not consider the Charles River site-specific temperature vs. larval river herring data in setting temperature limits. Mirant's statement is true. It is important to know the justification EPA and MassDEP used to support the decision not to use the river herring larval catch data to set temperature limits for alewife larvae.

First, EPA, MassDEP and the permittee have no information as to whether the larvae collected were alive, stressed or dead. The manner of collection prevented the permittee from determining this. Larvae were collected in a plankton net and the contents of the net were immediately transferred to formalin prior to being examined in the laboratory. Secondly, the researchers collecting the larvae were unable to determine whether or not the larvae collected were alewives or blueback herring. Extreme measures would have had to be taken to separate the two species at this life stage. Because there are substantial differences in temperature tolerance between these two species, larvae collected at the higher temperatures may all have been bluebacks. In addition, juvenile and adult blueback herring dramatically dominated river herring collections. As a result, it is likely that most of the larvae collected were probably blueback herring rather than alewives. By using temperature-larvae count data, EPA and MassDEP would be biasing temperature information in favor of the species that was more heat-tolerant. Because of these issues, EPA and MassDEP were unable to compare in a meaningful way the alewife larval catch numbers with water temperature at time of catch.

Mirant (third paragraph under Comment C44) stated that information in blueback larvae should be used to formulate "upper temperature limits." The company questions whether EPA and MassDEP are attempting to "optimize the temperature for alewife larvae alone" rather than protecting the BIP which would include bluebacks.

EPA and MassDEP agree that the BIP includes bluebacks, but it also includes alewives. EPA and MassDEP clearly articulated in Section 5.7.2 of the DD that alewives were used as the anadromous indicator species. Prior to finalization of the re-stocking program for American shad, the alewife are the most temperature-sensitive of the anadromous fish species present in the Charles River. It is a species of considerable concern to the resource agencies, because there has been a decrease in the number of streams along the coast that support alewife runs. In addition, based on the juvenile catch statistics, and the small adult population size estimate in 2002 (the only year that an adult estimate of population size, based on adult catch, is available), the Charles River alewife population appears to be small. The resource agencies that commented on the framework of the permit agreed that by protecting the species most sensitive to high temperatures, the other species in the community will also receive protection. As a result both bluebacks and alewives are protected as part of the BIP.

Mirant asserted that EPA and MassDEP discuss 24-hr acute toxicity studies conducted in the laboratory in which exposed larvae experience mortality at a Delta T of about 14 ºF. Fish drifting into the ZPH would only be expected to experience a Delta T of about 5 ºF. Mirant also stated that the larval period extends to July 7. Based on the sizes of YOY alewives collected in Mirant's sampling, the company alleges that this estimate appears to be about 2 weeks too late.

EPA and MassDEP reviewed the laboratory studies of both Environmental Analysts (EA) as well as that of Kellogg (1982). The EA studies cited in the DD were 24-hr studies in which fish were transferred from one temperature (the acclimation temperature) to another. These resulted in a 24-hr TL05 (5% kill) at 82.2 ºF. As we noted above, in the Kellogg laboratory tests in freshwater, the highest temperature at which any larvae survived in a 12-day exposure, when kept in freshwater, was 79.5 ºF and maximum survival was at 64.8 ºF. Not all the Kellogg data were discussed in the DD. However, the Kellogg data were based on continuous exposures and appear to be the more pertinent for this discussion. EPA and MassDEP have established a permit to ensure the overall survival of the alewife larval population. EPA and MassDEP realize that temperatures in the lower Basin naturally exceed this level for brief, infrequent periods, but assert that additional and more continuous increases well beyond this level must be minimized.

Mirant also uses the alewife YOY size information to back-calculate the period that is likely that of alewife larval presence in the basin. There appear to be problems with this approach. First, the permittee has shown that alewife YOY are much larger than are alewife larvae from farther south in the U.S. and are also larger than a landlocked population in the mid-west. Because the YOY in the Charles are larger than expected, they would "appear" to be older than they actually are, based on growth simulations that use data from other populations as a model. Thus, based on YOY growth lines that are developed from other populations, Mirant would have back-calculated the fish to have left the larval stage in approximately the third week of June, when it is equally plausible that they might not have left this stage until the second week in July.

Second, the fact that YOY fish have been shown to be much larger than the same age fish in other populations may point to the fact that they grew in water that was at a higher temperature than the fish from other sites. In Kellogg's work (see the chart at the beginning of the Response C44) as growth rate increased, survival of the test population decreased noticeably. Often, a high growth rate is associated with an abundance of food. However, it can also be due to increased metabolic rate, which as Kellogg has shown, may result in greatly decreased survival of the population at large.

It is unclear whether or not the "super-sized" Charles River YOY are representative of a thermally-stressed population, with relatively few, large YOY, or whether they are representative of a healthy population that grows larger more quickly than its southern counterparts. Judging from the daytime catch of alewife juveniles, the stock has declined markedly since 1999 (see Comment C3). Based on the EPA and MassDEP review of the 2004 push-net data, there appears to be an extremely large area of reduced alewife abundance in the vicinity of the Station discharge. Alewife catch rate in push-nets increased greatly at increasing distance from the discharge; mean temperature over the period of push-net operation (July-September) decreased at increasing distance from the discharge. Thus, catch rate decreased both with nearness to the discharge and decreased with increasing temperatures. In addition, the catch rate of juvenile alewives was generally reduced or zero at temperatures > 81 ºF. All this information provides support for the contention that the surviving juveniles caught well-downstream of the B.U. Bridge in the last three years were thermally-stressed.

Many of the juveniles that were used by Mirant to assess the relative size of juveniles from different rivers were taken from this "thermally-enhanced" area of the Charles. Based on the preceeding discussion, it is possible that the small juvenile alewife population, made up of juveniles that exhibit very high growth rates, may fit the Kellogg model of a thermally-stressed population. Other considerations, such as food availability and survival rates, would have to be considered to fully evaluate this relationship.

Comment related to C44 from MA CZM: In light of the site-specific information and published data from the literature, CZM recommends using 27.2º C (81º F) as the ambient limit in that it is protective of alewife larvae. CZM disagrees with EPA that the documented summertime daily temperature change of 1.1º C (2º F) in the Charles River is a valid reason to set the permitted ambient temperature limit 1.1º C (2º F) above the temperature that EPA has judged to be protective of alewife larvae.

Comment related to C44 from CLF: There is little justification for setting the temperature limits 2 ºF higher than the already excessive temperatures selected as PMTs, and then guessing that the actual temperature where the fish are spawning will be cooler (e.g. in deeper water).

Response to Comments related to C44 from MA CZM and CLF: EPA agrees with MA CZM that establishing 27.2 ºC (81 ºF) as the ambient limit would be protective of alewife larvae. However, based on the site-specific continuous temperature data from the lower Basin, the likely habitat that will be used by larval alewife, and the operational realities of Kendall Station, allowing the compliance limit to remain 1.1 ºC (2 ºF) above the temperature that EPA has judged to be protective of alewife larvae would still generally be protective of the species. EPA and MassDEP expect that under most conditions, enforcing 83 ºF at the required monitoring points which establish the ZPH will likely achieve sufficient areas with 81 ºF to protect the BIP. This is based on analysis of the following Charles River temperature data available at the time the Draft Permit was issued. First, the temperature in the river naturally varies by about 2 ºF during a typical day. Second, vertical profile data revealed a general decrease in temperature with depth. Added to this is the reality that if the facility is to reliably comply with its permit limits in a natural system like the lower Basin, with multiple temperature variables over which the permittee exercises no control (for example, unexpected rain events or sudden clearing of clouds), it will have to operate with a conservative margin of compliance below the designated compliance limit of 83 ºF. Therefore, it is reasonable to predict that the actual temperature in most of the ZPH will be below 83 ºF during the periods when that is the maximum allowable temperature.

Regarding CLF's comment, EPA and MassDEP do not agree that "There is little justification for setting the temperature limits 2 ºF higher than the already excessive temperatures selected as PMTs, and then guessing that the actual temperature where the fish are spawning will be cooler (e.g. in deeper water)." In the DD, Figures 5.10.5c-1 through 5.10.5c-5 clearly document a daily temperature fluctuation of at least 2 ºF specifically in the lower Basin. This data was reasonable justification for EPA and MassDEP's reasoning regarding the 2º F allowance in the temperature limits. Also, extensive vertical profile data submitted by the permittee and listed in the DD documented cooler water temperatures with depth at various locations in the lower Basin. This site-specific supporting evidence refutes any claim that guess work was involved in the formation of protective temperature limits.

Moreover, the permit requires real-time, continuous, in-situ temperature data from the lower Basin, along with additional temperature profiles to construct thermal contour maps of the lower Basin. EPA and MassDEP will evaluate the 1.1 ºC (2 ºF) allowance over the protective temperature once this comprehensive temperature database has been analyzed to confirm whether past environmental data reasonably predicted the expectation that enforcing 83 ºF will yield sufficient habitat at 81 ºF.

As stated previously, EPA and MassDEP continue to believe that the 2 ºF compliance margin on which the temperature regime relies outside the summer season is fully supported by the water quality datasets examined. But after EPA and MassDEP received and fully reviewed temperature data for the summer of 2005, the Permitting Agencies concluded that it was necessary to include a safeguard set of compliance points required to meet the 81º F limit during the summer to ensure that protective temperatures for the BIP are not exceeded in the ZPH.

The Draft Permit established 83 ºF as the compliance temperature within the ZPH based on evidence that the hydrodynamics of the river and the operating practices at the facility would ensure that the protective temperature of 81 ºF would be maintained most of the time in the majority of the ZPH, providing an adequate thermal refuge for alewife. While that assessment may remain valid in most circumstances, the results of the analysis of the 2005 hydrologic data (Hydro Data) submitted by the permittee, as discussed in detail below, raised concerns that under certain lower-flow, thermal water quality conditions and during high levels of output from Kendall Station, there would be insufficient healthful refuge absent a requirement that a maximum temperature of 81 ºF be maintained for certain ZPH stations.

EPA and MassDEP acknowledge that, during the times in question in 2005, temperature readings at a number of these stations were not continuous. Therefore it is possible that temperatures lower than 81 ºF may have occurred at these stations between readings and that, because temperature readings were not obtained throughout the ZPH, temperatures lower than 81 ºF may have occurred at these times elsewhere in the ZPH. However, based on the 2005 temperature and oxygen profile dataset, either temperatures exceeded 81ºF and/or dissolved oxygen values were below 5.0 mg/L (the Massachusetts Water Quality Standard for Class B waters) at all depths at which these variables were measured at many of the temperature monitoring stations downstream of the Longfellow Bridge in 2005. Judging from the Hydro Data for 2005, this condition frequently existed at monitoring stations in the summer of 2005:

After reviewing recent datasets from Mirant, and from EPA, the Permitting Agencies have determined that a limit of 27.2 ºC (81ºF), at certain ZPH Monitoring Stations, is needed to provide habitat for juvenile alewives during the warmest months of the year. Presented below is the Permitting Agencies' reasoning for increased protection at ZPH Stations 2, 3 and 7.

A review of the available scientific literature was conducted by the Permitting Agencies and results were published in the Determination Document for this permit. In that document, the Permitting Agencies had stated that to provide habitat for juvenile alewives, a maximum temperature of 81ºF would be needed. Due to ordinary temperature fluctuations known to occur in the lower Basin, the Permitting Agencies had stated that a limit of 83ºF at ZPH Stations from June 12 through October 31 would result in water temperatures of 81ºF or below throughout the majority of the ZPH Stations most of the time during the warmer months of the year. EPA and MassDEP expected that the 83ºF limit would provide adequate habitat within the ZPH for both juvenile alewives as well as for the most sensitive inland species, the yellow perch.

The importance of the 81 ºF temperature to alewives was underscored through the Permitting Agencies' review of Mirant's field studies. An analysis of the 2003-2005 datasets on shoreline seining and push-net sampling for juvenile alosids (see Response C3) demonstrated that, based on the 1977 Federal Guidance, Mirant's thermal discharge had caused "appreciable harm" to juvenile alewives and bluebacks. Upon a more-detailed review of those data, the Permitting Agencies found that the juvenile alewife catch per unit effort of sampling in the lower Basin either greatly diminished or was zero at water temperatures in excess of 81ºF. This analysis of the local, juvenile alewife population and the response of that population to heat, reinforced the Permitting Agencies original findings from the scientific literature that 81ºF was a critical temperature for this species and life stage.

As stated above, the summer time compliance temperature of 83ºF set in the Draft Permit was based on the assumption this limit would yield viable thermal habitat of 81ºF for juvenile alewives throughout most of that area much of the time. The Permitting Agencies have now concluded after analyzing Mirant's 2005 "Hydro" dataset and other relevant information, that it would not be sufficiently protective of the BIP to rely solely on the assumption that a compliance temperature of 83ºF in the ZPH would result in a protective temperature of 81ºF being achieved in a large portion of the ZPH for a majority of the time. Two of the key components of the Permitting Agencies' goals in setting warm-weather permit limits for this facility are to: a) maintain habitat for anadromous and resident fish species within the ZPH; and b) maintain a passageway of viable habitat along the Boston shoreline and through the old boat locks that lie adjacent to the Museum of Science so that fish passage throughout the lower Charles is not blocked by Kendall Station's thermal plume. Mirant's 2005 dataset, in combination with the other findings reviewed above, demonstrated to the Permitting Agencies that a temperature limit of 81ºF at key ZPH stations, was necessary to meet these goals. A review of some of the findings from the Permitting Agencies' analysis of the 2005 Hydro dataset follows.

Temperatures greater than 84.2ºF were seen at the following stations, all of which are beyond the ZD (information taken from Mirant's 2005 Hydro dataset): **a)** at the **Above Locks** Station on July 21 at depths of 6 ft and above; **b)** at the **Museum** Station on that same date at depths of 9 feet and above; and at the same station on August 9 at depths of 3 feet and above; **c)** at the **Old Locks** Station at all depths monitored (i.e., surface to 9 ft.) on July 21; at that same station on August 9 for depths of 12 feet and above (i.e., 12 ft., 9 ft., 6 ft., 3 ft., 2 ft. and surface) and on August 11 at that same station at depths of 6 ft. and above; **d)** at the **Old Channel** Station on July 21 at monitored depths of 6 ft and above; at that same station on August 9 at monitored depths of 12 ft. and above**;** on August 15 at that same station at monitored depths of 6 ft. and above; **e)** at the **Boston** Station, July 19, at depths of 3 ft and above; at that same station on July 20 at monitored depths of 9 ft and above; on August 9 at that station at the 2 ft. depth, the only depth monitored that date; on August 11 at that station at all monitoring depths from the surface down to 9 ft.

At issue here are two items. First, temperatures higher than the NOAEL temperature for juvenile alewives of 84.2 ºF were measured at stations within the ZPH. Second, on certain occasions, there appeared to be no refuge for juvenile alewives from potentially toxic temperatures and/or low oxygen concentrations (i.e., oxygen concentrations below the Massachusetts Water Quality Standard for warm waters of 5.0 mg/L for oxygen) at certain stations. On these occasions, temperatures exceeded the 84.2 ºF value at each depth for which monitoring occurred (monitored depths were typically distributed at the surface and at depths below the surface of 2 ft., 3 ft., and at three foot intervals below this level as well as a near-bottom depth) and/or oxygen concentrations at monitored depths fell below 5.0 mg/l.

This apparent loss of any refuge for juvenile alewives may have occurred frequently at stations within the ZD, but also appears to have occurred within the ZPH. For example, on about 44% of the monitored dates between June 30 and August 29, conditions at the Shallow Diffuser Station (a station within the ZD) fell into this category, although at this particular station, monitoring was only conducted at depths down to six or nine feet. The apparent loss of any refuge also occurred at the Museum and Old Channel Stations, both of which are located within the ZPH. In stark contrast to this are the data from two stations located far upstream from the discharge, the B.U. Station and the Hyatt Station. Water temperature measurements taken at these stations never reached the 84.2ºF level, providing evidence that temperatures causing acute or chronic impacts within the lower Basin were a result of the Kendall Station thermal discharge and not due to ambient conditions in the lower Basin. There should be no argument that the high temperatures described above, which were primarily found downstream of the Longfellow Bridge and which were not found upstream, were caused by Kendall Station's release of very warm water into the Basin.

Beyond raising toxicity concerns for stations outside the ZD, Mirant's 2005 Hydro dataset also leads the Permitting Agencies to believe that there was little viable habitat for juvenile alewives at critical ZPH stations throughout the warmest months. Over much of the July-August 2005 period at the stations monitored, no refuge to juvenile alewives appeared to be available from: a) temperatures above 81ºF; and b) oxygen concentrations below 5.0 mg/L, at any of the monitored depths. A list of stations and dates during which there appeared to be no refuge from these conditions is provided below:

Table C44_CZM_CLF-1 sets out the locations at which temperature and dissolved oxygen readings were taken by Mirant in 2005. The "A" stations are located within the area delineated within the permit as the Zone of Dilution (ZD). The "B" stations are located within or on the border of the area delineated as the Zone of Passage and Habitat (ZPH). The "C" stations are substantially upstream of the facility's cooling water discharge. Water temperatures in the lower Basin in 2005 were so high that they exceeded the juvenile alewife NOAEL temperature (84.2ºF; see discussion of the Otto, *et al*., research in Section 5.7.3c of the DD) at stations within the ZD (temperatures above 100ºF were measured by EPA in 2005 and 2006; see Table F4.P2.CLF-1 and -2 in "Response to F4 (part 2) and Related Comment"), but also at stations in the ZPH. Although the permit grants a variance from the state water quality regulations that allows Mirant to raise temperatures inside the ZD to levels known to induce toxicity, the data documents that during 2005 Mirant's operations regularly pushed temperatures to toxic and avoidance levels in the ZPH.

Table C44_CZM_CLF-1. List of monitoring stations, number of monitoring dates and percentage of those dates in the July-August sampling period for which, at each monitoring depth, the following condition existed: a) temperature exceeded 81ºF; and/or b) dissolved oxygen concentration (D.O) was below 5.0 mg/L. Data were taken from the "Hydro 2005" dataset sent to regulators by Mirant in April, 2006.

Monitoring Station	# dates with all depths monitored > 81ºF and/or D.O. <5 mg/l	# of dates with monitoring during July-Aug.	% of events with >81ºF &/or < 5mg/L D.O at all depths
A. (Stations Expected Within The Zone of Dilution)			
Shallow Diffuser	12	15	80%
Deep Diffuser	3	9	33%
Mid-Channel	2	5	40%
Station C	5	9	56%
B. (Stations Expected Within or On The Edge of The Zone of Passage and Habitat)			
Above Locks	2	9	22%
Museum	3	9	33%
Old Locks	6	13	46%
Old Channel	6	9	66%

Boston	9	15	60%
C. (Stations Substantially Upstream of Kendall Station's Discharge)			
MIT	1	13	8%
Hyatt	0	14	0%

At two stations, the Boston and Old Channel Stations, refuge from high temperatures and low oxygen did not appear to exist on 60% or more of the occasions when monitoring was conducted. By contrast, levels of these two important habitat variables at the MIT Station, located about 0.8 miles upstream of the discharge (but still influenced by the thermal plume, judging from the Hydro dataset) were poor on only one of the thirteen dates when monitoring was conducted. Note also that the Hyatt Station, the "ambient" reference station farthest removed from the discharge, had no dates in which temperature and dissolved oxygen conditions would have been considered unacceptable at all depths. Temperatures at the Hyatt Station exceeded 81ºF on only one of the monitored dates and this occurred only at one of the monitored depths (the surface) when the water temperature there rose to 81.1ºF. Similarly, temperatures reported for the B.U. Station only surpassed the 81ºF point on one of the monitoring dates when temperatures rose to 82.2ºF and 82.3ºF at the surface and at the 2 ft. depth, respectively, in 2005. On these occasions when high temperatures were measured in the upper water column at the Hyatt and B.U. Stations, a refuge with adequate dissolved oxygen concentrations was available at both stations at depths below those with the high temperatures. These data demonstrate that thermal habitat conditions improved as station distance from the thermal discharge increased during the summer of 2005.

The Permitting Agencies contend that temperatures in excess of 81ºF and/or low oxygen conditions (i.e., below the State Standard of 5.0 mg/l for warm waters) would have been stressful to the bulk of the juvenile alewife population. This condition would have been especially problematic for juvenile alewives that were in the early portion of this life stage and were small in size due to their relative inability to swim long distances in a short time and thus escape widespread conditions of poor habitat. The Permitting Agencies also contend that these conditions would have limited the free movement of juvenile alewives from areas downstream of the Old Boat Locks to areas upstream of the Longfellow Bridge. Conditions such as those seen at many of the ZPH stations over the summer of 2005 are also expected to have eliminated the thermal refuge for yellow perch, the resident, most thermally-sensitive fish species, in areas downstream of the Longfellow Bridge and are expected to have blocked their movement to areas at upstream sites.

Conditions outlined in the Final Permit for Stations 2, 3 and 7 address several of the physical and behavioral realities regarding juvenile alosids, American shad and yellow perch. Alosids, American shad and yellow perch all feed well below the surface in the daytime. These fish need a thermal refuge below the surface that has dissolved oxygen levels that are adequate for growth and survival. At night, juvenile alosids and American shad rise to the surface to feed. (See the DD, Section 5.7.3i,). In order to do so, they need temperatures at the surface that will not induce avoidance. Due to their relatively small size (about 1 inch in length) when they are in the early portion of the life stage, juvenile alosids are not able to travel great distances to feed in one section of the lower Basin in the daytime and a different section at night. Thus, adequate habitat must be available at each of the ZPH stations throughout the day and night to allow these fish to move up and down in the water column throughout the summer season.

Water quality conditions should also allow fish passage upstream and downstream past the Kendall discharge. The only route that will allow this passage, without mandating movement across Kendall Station's thermal plume, is through the old boat locks adjacent to the Museum of Science and along the Boston shoreline. Juvenile alewives (and/or fish of other thermally-sensitive species) that find themselves downstream of the old boat locks adjacent to the Museum of Science should not be prevented from moving upstream because they are repulsed by Mirant's buoyant thermal plume and the low dissolved oxygen concentrations found below it. The 81ºF temperature limit at Monitoring Stations 3 and 7 will ensure a thermal passageway throughout the warmest months of the year. By establishing an 81 ˚F temperature compliance limit at either the six or twelve- foot depth during all of the four-hour daytime periods, the Permitting Agencies will ensure that a thermal refuge is available during those periods at depths normally inhabited by juvenile alosids during the daytime. The 81ºF nighttime limit at the 2 ft. depth during at least one of the two four hour night time blocks will ensure that juvenile alewives are able to access the surface to feed throughout the ZPH during at least half the night. In addition, by requiring the permittee to meet the 81˚ F temperature for one of the four-hour night time periods, EPA and MassDEP expect that a thermal refuge from temperatures in excess of 81˚ F will be provided at lower depths during the other night time period at the identified monitoring stations.

Therefore, EPA and MassDEP have added the 81 ºF compliance points to ensure that the permit achieves the in-stream temperatures which the biology indicates are necessary to protect the BIP. The new hydrological data raised enough of a concern about how the lower Basin might respond to extended periods of Kendall Station operating at high capacities, that the Permitting Agencies concluded these refined compliance values are advisable to ensure that the BIP has a reliable refuge from inhospitable conditions. As explained at the beginning of this response, EPA and MassDEP expect that this new set of targeted temperature requirements will largely track what would happen as a result of enforcing 83 ºF across the ZPH. If the compliance points in the ZPH closer to the discharge plume are at 83 ºF or below, the compliance points along the outer margin of the ZPH will likely meet the 81 ºF temperatures now provided for in the permit. So EPA and MassDEP do not expect these new compliance temperatures to make a substantial change in the effect of enforcing the 83 ºF temperature on which the draft permit exclusively relied during the summer to achieve 81 ºF. But these new limits will ensure that some refuge is available if an unusual combination of events arise that confounds the assumptions EPA and MassDEP made in assuming that enforcing 83 ºF would consistently protect the BIP.

Comment C45: Temperature Limits for Alewife Juvenile Stage Based on Incorrect Data. Section 5.7.3i and j of the DD suggests that a protective temperature would be expected to be below 84.7^{o} F., based on 24-hour exposure tests in the lab. This is inconsistent with the results of the Lindenberg study referenced at the end of Section 5, which found a thriving alewife population in central Massachusetts where juveniles voluntarily occupied waters up to 32.2 °C (89.9 °F). Given these data, the Determination Document fails to justify why both a lower threshold and a 4-hour averaging period are necessary to protect the BIP.

Response to C45: The 84.7 ºF value is a toxicity endpoint derived from a 24-hr. test exposure conducted by Ecological Analysists (EA, 1978). EA derived estimated that about 5% mortality would occur to young-of-the-year alewives at that temperature. The Permitting Agencies state in the DD that this temperature is too high for the ZPH because it was shown to induce toxicity. In addition, the DD states that this temperature was expected to induce avoidance in juveniles and, as a result, is too high for the ZPH.

The Lindenberg (1972) work is discussed in Response C34. Briefly, no-follow-up information was collected by Lindenberg to evaluate the result of the one-time, high-temperature event on the population. Nor did Lindenberg suggest that temperatures in the high-80s (ºF) could be sustained by the alewife population. Use of the phrase "voluntarily occupied" is misleading, because dissolved oxygen below those areas occupied was very low; the fish may have been responding to a habitat squeeze and had no choice. The title of this paper is "Seasonal depth distribution of landlocked alewives, Alosa pseudoharengus (Wilson), in a shallow, eutrophic lake." The key term here is "eutrophic". The author states that dissolved oxygen levels in the cool, hypolimnetic waters were at or near zero in the summertime. The author had only one capture event at a temperature above 80.7 ºF, but concludes that "The fact that Congamond alewives could be caught consistently in surface waters of 25 to 32 ºF (Table 1) indicates that they have been forced to adapt by lack of oxygen at cooler levels during the summer."

Another interpretation of the Lindenberg one-time observation is that the lack of oxygen forced these fish into extremely warm water, which was stressful, and may have resulted in acute or chronic toxicity. Only once was there a recorded incident at a temperature in excess of 26.7 ºC (80.1 ºF) in the Lindenberg field observations. No follow-up information was collected regarding the physiological or behavioral effects of this one-time high exposure.

Comment related to C45 from MA CZM: In light of the site-specific information and published recommendations in the literature, CZM recommends using 27.2º C (81º F) as the temperature limit within the ZPH that will be protective of the normal development and biological needs of juvenile alewife. This temperature limit should be met at all points in the ZPH that are to be considered viable habitat for juvenile alewife.

Response to Comment related to C45 from MA CZM: See Response Related to C44 from MA CZM and CLF for details concerning the 2 ºF compliance buffer and how that is being applied in the Final Permit. As discussed in C44, EPA and MassDEP are adding compliance requirements to enforce 81 ºF at key points and times to assure refuge for the BIP along the Boston side of the Basin.

Comment related to C45 from CLF: Peer reviewed habitat suitability models have been developed by scientists with the US Fish and Wildlife Service for juvenile river herring and American Shad. During the summer and fall, optimal temperatures for juvenile alewife were determined to be in range of 59 to 68 ºF, and for shad 50-77 ºF. Blueback herring were found to be more temperature tolerant, with optimal temperatures between 68 and 86 ºF. The temperatures proposed in the draft permit are not suitable based upon these careful determinations of habitat suitability. The temperature limit of 83 ºF, from June 12 through October coincides with the period during which juvenile river herring and shad should be feeding and growing as they make their way to the sea. Juvenile alewives normally exhibit a pattern of behavior in which the surface waters are used near dawn and dusk. However, under the permit the surface water in the Basin could be at least 15 ºF above the optimal range in the ZPH (83 ºF , 4 hour average) and even higher in the ZD. Thus, juvenile alewife will clearly be subjected to marginal habitat conditions if they enter the surface waters of the lower Basin; temperatures of 77 ºF and above are also known to result in avoidance behavior in alewives.

Response to Comment related to C45 from CLF: EPA disagrees with this approach. There is no doubt that relying exclusively on scientific literature to determine protective temperature limits is one way to arrive at a protective approach to protecting the BIP. However, scientific literature and reference material at best identify a range of temperature tolerance limits and a general time period when a species life stage is expected in a region. Without taking site-specific information into consideration to establish representative acclimation temperatures and spawning timing, for example, the permit limits could be overly conservative or not sufficiently protective.

In order to fully respond to CLF's comments and evaluate the range of protective water temperatures and time periods proposed by CLF, EPA graphically represented the limits and time periods from their comments alongside the limits and time periods from the draft permit. Figure C45_CLF-1 shows a year long maximum temperature of 75 ºF for yellow perch larvae and adults, as opposed to the 83 ºF limit in the draft permit. Adult spawning and egg development temperatures, as well as adult reproductive temperatures, were at times 10 ºF lower than the permit limits.

Figure C45_CLF-2 also shows that limits proposed by CLF were from 4 to 17 ºF lower than those included in the draft permit.

When the lowest temperature limit from CLF for either the resident species or the anadromous species was assembled into one year figure, these CLF limits were consistently below the draft permit values (Figure C45_CLF-3).

In order to compare the CLF limits to approximate ambient conditions in the lower Basin, the CLF temperature limits were next graphed alongside the maximum, average, and minimum hourly average intake temperatures from Kendall Station from 1994 through 2002 (Figure C45_CLF-4). As fully discussed in the DD (Section 5.9.2), these temperature values were the only available proxy for a general approximation of ambient temperature conditions in the Basin, with the exception of the time period from June 15 through August 31. The Permitting Agencies wish to note that during this summertime period (June 15 through August 31) there may be substantial re-entrainment of the thermal plume into the Broad Canal. During this time intake temperatures have been documented to be above ambient river temperatures recorded upstream (see Response C5).

A visual inspection of the graph shows that with the exception of a two week time period in January, a three week time period in February and the majority of the month of October, the limits proposed by CLF were always below the highest hourly average ambient Basin temperatures seen from 1994 through 2002. When looking at average hourly ambient temperatures from 1994 through 2002, the CLF limits are below average ambient conditions from approximately mid-March through mid-June, with the exception of a brief time period in mid-April. Late June through mid-September also showed limits below ambient conditions, as well as all of November and the first half of December. Even when the lowest recorded ambient temperature among any of the years from 1994 through 2002 is examined, there are still considerable periods of time (May through the middle of June, late August through mid-September and the majority of November) where the CLF proposed temperature limits are lower than minimum ambient temperatures (Figure C45_CLF-4).

During time periods when the limits are below documented ambient water temperature conditions, under the current compliance regime, Kendall Station would be unable to add any waste heat to the ZPH. In many other circumstances, the CLF temperature limits are similar enough to the ambient conditions to require Kendall Station to maintain Δ T levels well below the 5 ºF limit.

There is no question that the temperature limits proposed by CLF, if enforced, would be protective of the BIP. The question EPA must evaluate is whether such low temperatures are “necessary” to protect the BIP. If the higher temperatures EPA and MassDEP have analyzed would still be protective of the BIP, Mirant has the right to a variance under section 316(a) of the CWA at those temperatures. EPA and MassDEP are satisfied that the temperature limits established in the Final Permit are fully protective of the BIP.

Comment C46: Summary of Temperature Limits and Time Periods for Anadromous Species Protection. Section 5.7.3k of the DD summarized the temperature and time limits proposed for protection of the selected anadromous species. As described in the detailed comments above, these temperature and time limits are based on inappropriate data or analyses, overly stringent and inconsistent with ambient data and should be revisited.

Response to C46: The detailed responses to Mirant's general Comment C46 are provided in previous sections of this document.

Comment C47: Proposed Maximum Temperature and Time Limits, Combined with Refusal to Authorize Proposed Diffuser Fail to Ensure Desired Goal of Protection and Propagation of BIP. Section 5.5.2 of the DD states “[t]he establishment of maximum water temperatures in the permit for the receiving water meets the desired goal of protection and propagation of the balanced indigenous fish populations.” The Determination Document fails to explain how the proposed temperature and time limits meet this desired goal in the absence of approval of the proposed new outfall and diffuser. For example the permit does not ensure:

- Maintenance in the winter of sufficiently warm, well–oxygenated deep water with salinity below 14 ppt to support a balanced indigenous population of yellow perch;
- Maintenance of the Permit-mandated 50 ºF chill period for yellow perch gonadal maturation through mid-April without jeopardizing the timely start and build-up of the temperatures in the 50s that appear associated in this system with vigorous progression of the alewife run;
- Maintenance of early June temperatures in the mid to upper 70s that were associated in 1999 with high-end larval densities and growth, YOY abundance, and returning adult year class strength of alewives; and
- Maintenance of adequate overall algal biomass to support the food base for the river herring BIP.

In each of these instances, EPA should analyze whether the temperature limits in the Draft Permit, combined with the refusal to authorize the proposed new outfall and diffuser, would make it more difficult to achieve the objective of maintenance of the targeted BIP.

Response to C47: The permittee takes the position that the diffuser is needed to allow for specific temporal habitats to occur with regard to salinity and dissolved oxygen. EPA and MassDEP do not embrace a fundamental assumption implicit in this comment. Mirant appears to believe that the heat discharge from the Kendall Station can be used to orchestrate a man-made temperature regime to enhance conditions for the BIP. Not surprisingly, all of Mirant's "enhancements" involve adding heat to the lower Basin. But EPA and MassDEP believe that the goal of this permit is to try to protect as much of the natural temperature regime of the lower Basin as possible, consistent with the best science available to determine how much additional heat the Station can add while still protecting the BIP.

The first man-made habitat Mirant recommends is the "maintenance in the winter of sufficiently warm, well-oxygenated deep water with salinity below 14 ppt to support a balanced indigenous population of yellow perch." Please see Response C18. Yellow perch do not need warm water in the wintertime. They need water below 50 ºF. Although the diffuser would purportedly assist in lowering the salinity and increasing oxygen, EPA and MassDEP have other concerns with the diffuser that are addressed elsewhere in Section E of this document.

Mirant asks how the <50 ºF chill period is to be maintained without jeopardizing the timely start and build-up of temperatures in the 50s that appear associated with vigorous progression of the alewife run. Mirant's comment seems to suggest that it is necessary to heat the lower Basin in the spring to jump-start the herring migration with warmer temperatures than the river would reach without anthropogenic influence. EPA and MassDEP support actions which allow natural ambient conditions to influence the aquatic habitat as much as possible, rather than attempt to artificially warm or cool the lower Basin.

The permittee questions how the maintenance of early June temperatures in the mid-to-upper 70's (ºF) will be achieved. These temperatures were associated in 1999 with high-end larval densities and growth, YOY abundance, and returning adult year class strength of alewives. A discussion of larval densities and temperature has been presented in the DD and in Response

C44. EPA and MassDEP plan neither to heat or cool the Basin, but to allow temperatures to fluctuate in as natural a manner as possible.

The permittee questions how an adequate overall algal biomass will be maintained to support the food base for the river herring BIP. There is a concern by EPA and MassDEP that warm temperatures combined with high phosphorus in the lower Basin have been associated with cyanobacteria (blue-green algae) blooms. This occurrence can negatively affect zooplankton populations (see discussion of zooplankton in Section 5.8.2l of the DD). Zooplankton are one of the primary foods of river herring and American shad larvae and juveniles. The concern of EPA and MassDEP is not how to maintain an adequate biomass, but how to limit excess algal growth in the lower Basin to protect the food supply for the BIP. The lower Charles Basin is already considered an impaired waterbody by DEP and EPA and has been listed as such for organic enrichment, noxious aquatic plants, low dissolved oxygen and other constituents (see Section 2.5 of the DD).

Comment related to C47 from CRWA: With respect to a BIP, CRWA does not agree that these temperatures are protective. CRWA is very concerned that the high temperature limits proposed in this permit will result in death or disruption/prevention of breeding of these organisms. EPA and MassDEP should explain how the areal extent and temperatures of the mixing zone/zone of dilution are protective of aquatic life. A population dynamics model should be constructed to evaluate Mixing Zone impacts in combination with intake effect and habitat loss due to the high temperatures.

Nor do we feel that the aquatic life in the lower Charles is “balanced”. There is virtually no benthic community, there are blue-green algal blooms and the system is highly eutrophic. The Massachusetts DMF estimates the carrying capacity of the Charles River for river herring to be 400,000 fish per year, much higher than the 45,000 (including 8,000 alewife) counted in 2002 by the permittee. Comment C47, Comment C26 (CRWA)

Response to Comment related to C47 from CRWA: For all the reasons explained in response to previous comments, EPA and MassDEP maintain that based on the full body of information available, the temperature limits included in the Final Permit are protective of the BIP going forward. A comprehensive monitoring program will document the extent to which the Station influences the habitat of the lower Basin.

Comment C48: EPA Misapplication of Scientific Literature in Characterizing Biological Effects Associated with Temperature Changes in Lower Basin. In several instances in the Determination Document, the EPA appears to have misapplied data in the literature cited in characterizing biological effects associated with temperature changes in the lower Basin. Several examples follow.

Section 5.8.2e of the DD discusses laboratory studies and field observations of landlocked populations of Great Lakes alewives. As noted elsewhere in these comments, anadromous alewives, such as those of the Charles River, would have adapted to wider ranges of Delta T than landlocked populations in the Great Lakes. The attempted extrapolation of the Great Lakes results is inappropriate and misleading.

Section 5.8.2i of the DD speculates that during low flows out-migrating fish may experience cold shock. This is unlikely to be significant, if it occurs at all, for several reasons. First, under low flows the fish can only out-migrate voluntarily. This occurs when the dam operators allow mixing in the sluices between the river and the harbor. This only occurs for brief periods each day when flows are low. When flows are higher (lessening the Delta Ts), the sluices are opened for longer periods and more mixing of the waters and out-migration take place. In addition, out-migration occurs over a wide range of temperatures (about 25°F) spanning the period from mid-summer to mid-fall.

The Agencies should evaluate how the successful runs of alewives are sustained in the Monument River when those out-migrating fish upon exiting the river to the Cape Cod Canal may encounter not only a Delta T leaving the river, but a second up-to-20°F Delta T when the tide stage is such that they encounter the abrupt front of Cape Cod Bay water that is up to 20°F colder than the Buzzards Bay water it replaces.

Section 5.8.2k of the DD states that there is a lack of data ("little or no evaluation") regarding impacts of Kendall Station's discharge on adult and young alosids in the Charles River. Mirant disagrees. While there is little "pre-operational" data before Kendall Station commenced operating in the 1950s, there is an abundance of recent data, which directly address the impacts in question by comparing abundance and distribution of the fish at different temperatures and under different flow conditions. Specific opportunities for comparison, some of which have been highlighted by Mirant Kendall in past correspondence on this record include:

- Spawning migration of adults, monitored by gill net and tagging studies in warm springs 1999, 2002, and 2004 compared to cool springs 2000 and 2003.

- Reproductive success, monitored by ichthyoplankton collections in 1999, 2002, 2003 and 2004.

- Distribution and development of YOY fish, monitored by beach seine in 1999, 2002, 2003 and 2004, plus gill net and push net in 2003 and 2004.

- Exit of YOY from the system, monitored by beach seine in 1999, 2002, 2003 and 2004, gill net and push net in 2003 (ongoing in 2004).

- Evidence of year class success based on age distribution of returning adults, including fish from the 1998, 1999, 2000, and now 2001 year classes.

Based on these studies, Mirant would assert:

1. Despite numerous temperature exceedances throughout 1999, Mirant Kendall's sampling demonstrated an abundance of every life stage from larvae through returning adults relative to any other year after river-wide exposure to temperatures in the mid- to-upper 70s throughout early June and about 15-20% exceedances of 83 ^{o}F (up to 85 ^{o}F) in the ZPH between June 12 and August 31.

2. The Draft Permit specifies that a 72 ºF 4-hour block thermal limit is needed to protect alewife reproduction for the first week in June. The Determination Document fails to explain how 100% exceedance of that threshold in 1999 could plausibly be associated with *Alosa* larval densities in the ZPH of more than 1,500 per 100 cubic meters on June 8, followed by greater abundance of juvenile alewives in July 1999 than in any other sampling year.

3. Age analysis of 2004's returning adult alewives shows much greater percentage abundance of three-year-old fish from the 2001-year class than of 4-year-old fish from the 2000 year class. MK Comment Ex. No. C23-2. The Determination Document fails to explain how the 2001-year class could so predominate over the 2000-year class, given the number of thermal exceedances that would have occurred in 2001 compared to the much cooler 2000. Thermal conditions during the usual peak timeframe of the alewife run in 2001 included 11 days in early May with temperatures between 68 ^{o}F and 72 ^{o}F at the Broad Canal intake; only 3 days were that warm in 2000. Between June 12 and August 31 in 2001, there were about 10% exceedances of 83^{o} F at the Kendall intake (up to 86 ^{o}F). There were no such exceedances in 2000.

Like 1999, the other relatively abundant year class, the alewives born in 2001 had a prolonged period (in this case 6 weeks from end of April to mid June) to remain in the basin and grow without a major flushing event of sustained flows greater than 400 cfs. The 2000 year class experienced a major flushing event at what was likely the worst time, early to mid June, when alewife spawning was likely complete but the fish were too young to resist advection. As shown in the Table below, larval densities in the Harbor increased by tenfold, from about 5% to more than 50% relative to those in the lower river before and after this June episode. The increase would be even greater after accounting for the dilution in the Harbor due to the Tidal water exchange.

Alosa Larval Densities in the Lower Charles and Boston Harbor Before and After June 2000 High Flow Event

Time Period	Avg. Waltham Flow For period (cfs)	Mean Alosa density at Museum at end date (#/100m3)	Mean alosa density at Harbor at end date (#/100m3)

May 16 - 23	431	91.4	4.8
May 24 - 31	429	106.7	0.7
June 2 - 7	391	167.7	18.7
June 8 - 20	597	43.9	27.5

– The thermal conditions (including Kendall Station heat loads over 50% in 2003) between June 12 and August 31 in 2002 and 2003 exceeded the proposed thermal limits in the Draft Permit on a number of days, yet abundance of alosid larvae and YOY alewives compared favorably to that of the much cooler similar flow year, 2000. As stated above, the year 2000 had no exceedances of 83^{o} F at the plant intake the entire summer, between June 12 and August 31. The year 2002 had exceedances of 83^{o} F on 37% of the days in the proposed ZPH (up to 88^{o} F) and 11% (river-wide) of the days between June 12 and August 31. The year 2003 had exceedances of 83^{o} F on 20% of the days in the ZPH (up to 86^{o} F) between June 12 and August 31.

– The densities and lengths of larval alosids at specific points in the season (early June 1999 and mid-to-late May, 2004) were greater than in all the other sampling years (2000, 2002, 2003) in contrast to the Draft Permit thermal limits' implication that the heat loads (e.g., 90% in mid April 2004) and/or temperatures immediately prior to those collections were high enough in early June 1999 and mid-May 2004 to cause appreciable harm.

– The frequency of occurrence of YOY alewives in early summer beach seine collections (July early August) were much greater in 1999 and 2004 than in any of the other sampling years (2000, 2002, 2003), despite the Draft Permit thermal limits' implication that the heat loads in April 2004 and temperatures prior to those collections in early June 1999 and mid-May 2004 were high enough to cause appreciable harm.

Response to C48: The permittee asserts that in a number of places in the DD, EPA appears to have misapplied data from the literature in characterizing biological effects associated with temperature changes. The first of these is that anadromous alewives would have adapted to wider ranges of delta temperatures than those in the Great Lakes. Thus, it is inappropriate to use data from the Great Lakes populations to evaluate delta temperatures. This is unsupported conjecture on the part of the permittee. Reasons for using the Great Lakes toxicity data are outlined in Section 5.8.2e of the DD. Notably, EPA and MassDEP are concerned that, while migrating herring may appear to be more robust than their land-locked counterparts in the Great Lakes, it is equally possible that the combined stress of going through both the abrupt temperature change and abrupt salinity change measured on either side of the New Charles River Dam and Locks would stress the migrating population as much or more than a land-locked population experiencing a possibly less severe temperature change without any accompanying salinity change.

Mirant states that in Section 5.8.2i on Cold Shock to out-migrating fish, there is speculation that during low flows, out-migrating fish may experience cold shock. However, Mirant asserts this is likely to be insignificant because fish can only out-migrate voluntarily. Mirant contends that during high flows, there will be much mixing in Boston Harbor, mitigating the abrupt change in temperature. Mirant instructs EPA and MassDEP to evaluate how the alewives in the Monument River adjust to large temperature changes from Buzzards Bay and Cape Cod Bay.

EPA and MassDEPs' concern is that out-migration occurs throughout the late summer and fall. If there is a great difference between Boston Harbor temperatures and those to which juveniles are acclimated in the lower Charles, as water and fish are discharged to the Harbor, the warm water will rise. River water from the Charles is both warmer and much less saline than Boston Harbor water. Both attributes cause this river water to be much more buoyant (less dense) than the water in Boston Harbor. As a result, EPA and MassDEP expect that the Charles River water will not immediately mix to a great extent with the Boston Harbor water. However, both juvenile and adult alewives seek a relatively dark "isolume" (range of light concentrations). They are thought to do so to avoid visual predators. This behavior brings them well away from the warm surface waters into the much cooler depths of Boston Harbor. Thus, the concern for cold shock from too great a temperature difference is a real concern to EPA and MassDEP. Although it might be said that the fish out-migrate voluntarily, these fish have no estuary in which to gradually become acclimated to cooler temperatures. They simply move through the dam structure into the waters of Boston Harbor. The minimal amount of mixing of river water and Boston Harbor water which has been observed immediately downstream of the dam in no way replicates the wide expanse of mixing that takes place in a healthy estuary. The permittee did not present a tracking study accompanied by a chronic toxicity evaluation on alewife juveniles existing in the Monument River, and the Permitting Agencies have found none in the literature. Therefore, EPA and MassDEP have no basis for evaluating alewives in the Monument River.

Mirant disagrees with the statement (in Section 5.8.2k of the DD) that there is a lack of data regarding impacts of Kendall Station's discharge on adult and young alosids in the River. Mirant states that, despite numerous exceedances throughout 1999, there was a greater "abundance of every life stage from larvae through returning adults relative to any other year." The company states that the determination document fails to explain how large exceedances of the 72 ºF threshold in June could be associated with high alosa larval densities followed by greater abundance of juvenile alewives in July 1999 than in any other year. Mirant continues with other documentation that exceedances of certain permit limits occurred, yet there appears to be no problem with alewife populations in the lower Basin. Mirant uses the term "relatively abundant year class" to refer to alewives born in 1999, 2001 and also states that the frequency of occurrence of YOY alewives in "early summer" beach seine collections were greater in certain years when a number of temperature exceedances occurred. A number of other field data are referenced.

Year-class success is not simply a function of one variable. Models used by the U.S. Fish and Wildlife Service to assess habitat require evaluation of many variables. A decrease in a particular variable during one of the life stages may be accompanied by an increase in that same variable during the same year. Mirant attempts to show that although there were exceedances of temperature limits during a particular period in June or August, the success of a particular age-group was affected differently than expected.

In order to evaluate temperature effects on the population of alewives in the lower Basin it is best to begin with an overview of population trends over time as measured in the field monitoring program conducted by Mirant.

Larval data: The permittee failed to present information on alewife larval stage densities to EPA and MassDEP. Although Mirant discusses Alosa densities, which includes bluebacks and alewives in the lower Basin, without information specifically on alewife densities, it becomes difficult to tease-out any temperature relationships. This is especially a problem because alewives appear to be present in much-reduced numbers compared to blueback herring. Thus, although the Alosa densities may be correlated with different flow regimes or temperature regimes, the densities of alewife larvae may not, because bluebacks are so much more numerically dominant. Mirant was unable to distinguish between the larvae of alewives and bluebacks. It is true that there were relatively high densities of river herring larvae in 1999, but Mirant was unable to discern whether these were bluebacks or alewives. Thus, it cannot be said that there was an abundance of larval alewife larvae during any particular year.

It must also be pointed out that the 100% exceedance referred to by Mirant is based on the Station intake data. Mirant did not specify in the comment if additional temperature data were used in its assessment. EPA and MassDEP do not agree that there is enough evidence to support the statement that the 72 ºF, 4-hour block thermal limit was actually exceeded 100% of the time for the first week in June, 1999. The intake temperature data used by the permittee to reach this judgment could not accurately reflect the temperatures in all the representative locations and depths specified at the Monitoring Stations in the Final Permit. It is possible that even under the conditions identified in 1999, a sufficient number of Monitoring Points at the cross sectional area of the lower Basin at proposed Monitoring Stations 3, 4, 5 and 6, and at other required monitoring locations, may have met the four hour average temperature limits at sufficient depths to result in Kendall Station remaining in compliance. In this way, a sufficient volume of the lower Basin may have maintained protective temperatures. EPA and MassDEP make this point as a reminder that water temperatures at or above the maximum temperature limits can been observed in parts of the lower Basin without the ZPH being compromised. This issue is also discussed in Response C24 of this document. In addition, as discussed in Section 5.9.2 of the DD, up to a 9 ºF rise in temperature has been noted between intake temperatures and temperatures at the Watertown Dam, and up to a 5 ºF rise in temperature has been seen between stations near the B.U. Bridge and the intake. During low-flow years, intake temperatures are greatly influenced by re-circulation of the discharge plume. Thus, the 100% exceedance figure given by Mirant is also not fully credible until an analysis of the thermal plume re-circulation effects on intake temperature has been presented to EPA and MassDEP. Because 1999 was a low-flow year, EPA and MassDEP expect that there was much re-introduction of discharge water into the intake which may have greatly raised temperatures over the true ambient, upstream temperatures in the Charles.

Mirant suggests that the Permitting Agencies have not given adequate consideration to specific datasets that deal with adult, larval and juvenile river herring. EPA and MassDEP respond that they have thoroughly analyzed each of the datasets available that deal with these life stages, but have come to a much different conclusion than Mirant has regarding the interpretation of these data. Although many of the datasets that Mirant points to in Comment C48 have been discussed elsewhere in the response to Mirant's comments, the Permitting Agencies review and expand on some of those responses below.

Adult data: Based on the gillnet catch over the years 2002 through 2005 (see Tables C43-1 and C43-2 in Response to C43), it appears that the overall entry of bluebacks and alewives into the Charles has declined substantially since Mirant conducted a sonar estimate of stock size in 2002. Mirant estimated in 2002 that approximately 45,000 river herring entered the lower Basin. This was a preliminary assessment by Mirant, and there were a number of questions regarding methods that have not yet been resolved (see Response to C51 Related to American shad from MA DMF and Footnote 1 in Response C23). If the gillnet catch rate is an index of the population size in the lower Basin, which seems a logical assumption, and Mirant's sonar estimate is even a very general approximation of the 2002 river herring stock, then the river herring population has declined from about 45,000 fish in 2002 to about 15,000 in 2005. Both figures are *extremely* low for river herring entry to a major river system. Even taking into consideration that Mirant's stock estimate for 2002 is in error, the gillnet information still indicates substantial declines since 2002.

The river herring population decline roughly follows Mirant's operational increases in heatload to the lower Basin documented each summer from 2002 through 2005 (see Figure B1-3 in Response B1). The Permitting Agencies feel that this interpretation of the adult gill net information is at least as appropriate as that which Mirant has suggested (i.e., that between-year differences in abundance are influenced by warm and cool springs).

Juvenile data: Juvenile river herring can be identified to the level of species, i.e., juvenile alewives can be distinguished from juvenile bluebacks. Response C3 includes a discussion of the alewife juvenile life-stage field data. Based on the analysis of juvenile datasets, the Permitting Agencies determined that both alewives and bluebacks have been subjected to appreciable harm attributable to MKS's thermal discharge.

Over the years that the beach seine sampling program was conducted, alewives essentially disappeared from the daytime samples after about 1999. Nighttime beach seining began in 2002, but only at two stations (Hyatt and Lagoon), and alewives were present in the nighttime samples collected at these stations. A third station (Boston) was added to the nighttime beach seine program in 2005. The alewife catch from these stations is presented in Response to C3 (see Table C3-2 and Figure C3-10).

It is discussed in Response to C3 that nighttime catch per unit effort (CPUE) of alewives at the Lagoon Station, located about 0.6 miles from the discharge, was always much lower than that at the Hyatt reference station, located much farther upstream (about 1.6 miles upstream from the discharge). In addition, when the Boston Station was added in 2005, the CPUE at that station was even lower than that at the Lagoon Station. The Boston station, at only 0.3 miles distant from the discharge, was nearer to the discharge than the Lagoon Station. Thus, in 2005, when water temperatures in the vicinity of the discharge were at their highest, the CPUE of alewives in shoreline seines decreased substantially with station proximity to the discharge across all three beach seine stations. This pattern mimics that seen in the 2004 and 2005 push-net datasets (also presented in Response to C3), where the density of juveniles for both river herring species declined with station proximity to the discharge.

Juvenile blueback herring collected in the shoreline beach seine samples were typically found in greater numbers during the daytime than at night, which is the opposite diurnal pattern to that seen for juvenile alewives. Therefore, only the daytime shoreline seine data for bluebacks are discussed here. In addition, unlike the clear pattern seen in the push-net data, juvenile bluebacks captured in shoreline beach seine samples showed no particular pattern of increase or decrease in numbers with nearness to the discharge, with the exception of the 2005 beach seine samples. Juvenile bluebacks are more tolerant of high temperatures than are alewives, and mean shoreline seine temperatures measured at times of sampling over the warmest months (July-September) were not exceptionally high (all less than 78ºF) in years prior to 2005.

In 2005, the summertime thermal regime in the lower Basin, in the vicinity of Kendall's discharge, changed substantially. Mean water temperatures over the July-September period at all shoreline seine stations, except for the Hyatt reference station, exceeded 80 ºF. The range in mean temperatures over the time period mentioned at stations downstream of Hyatt was 80.1 ºF to 83.3 ºF. Short-term excursions in temperature at stations near the discharge far exceeded these values. By comparison, the mean temperature at the Hyatt Station was only 78.7 ºF over the July-September period in 2005 and the highest temperature measured at the Hyatt Station over the entire 2005 summer was only 81.1 ºF.

In 2005 the juvenile blueback density pattern from the shoreline seine dataset also changed. Although there was no distinct distance vs. density relationship as that seen in the push-net data, the highest mean density of juveniles (40.2 fish per 1000 square feet of area sampled) over the July-September 2005 sampling period was found at the Hyatt Station, the station farthest from the discharge. In addition, the station closest to the discharge (Boston Station, only 0.3 miles distant from the discharge) had the lowest mean density of juvenile bluebacks (8 fish per 1000 square feet of area sampled) over the time period specified. The patterns of blueback and alewife densities in 2005 suggest to the Permitting Agencies that herring presence was adversely affected by high water temperature.

The Permitting Agencies mention in Response to C3, that the pattern of declines in density seen in the shoreline seine surveys could have been due to differences in shoreline habitat variable such as abundance and quality of food and/or cover. However, the alewife pattern seen in the 2004 dataset and similar patterns in 2005 for both species led the Permitting Agencies to take a closer look at the push-net catch dataset. Push-net data was judged to provide a better signal of thermal influence than the shoreline seine data because the push-net stations were located in deeper water and were thus much less apt to be influenced by inter-station differences in shoreline habitat.

An extensive review of the push-net dataset is presented in the Response to C3. Briefly, the Permitting Agencies have demonstrated that when the data are collated over the months of highest water temperature (July-September), densities of juvenile bluebacks and alewives decline with proximity to the discharge. In addition, the regression analyses conducted on the data were statistically significant and show that the declines in densities were significantly correlated with increases in water temperature. Based on these analyses, EPA and MassDEP assert that the facility caused appreciable harm to the alewives and bluebacks in the lower Charles over the years 2004 and 2005.

The Permitting Agencies also note in Response to C3 that the total catch of alewives at push-net and beach seine stations was highest in 2005. The Permitting Agencies discuss potential reasons for this. These include the fact that in the early spring of 2005, repairs were made to the fish ladder at the Watertown Dam, and this increased the potential movement of alewives past this barrier, increasing the spawning potential of the population in 2005. The Permitting Agencies contend that, because of Mirant's discharge in 2005, large-scale habitat exclusion occurred and the overall push-net catch could have been much higher in 2005 were it not for the habitat impacts from the Kendall Station discharge. Please refer to Response to C3 for a more detailed discussion of both operational changes at the MDC Dam with regard to fish passage in 2005 and structural changes made at upstream sites in 2004 and 2005.

Although there are some anomalies in the complete juvenile dataset, the weight of evidence leads EPA and MassDEP to conclude that Kendall Station's discharge was responsible for large-scale habitat exclusion to river herring in 2004. Based on these data, Mirant's discussions of differing thermal exceedances during different years appear somewhat moot. Additional analysis by the Permitting Agencies has resulted in field support for the independent finding in the DD that a temperature of 81 ºF is the maximum protective temperature for juvenile alewives. Based on a review of all the field data for juvenile alewives, it is evident that catch rates of juvenile alewives are either greatly reduced or zero at water temperatures greater than 81 ºF.

Based on the discussion above, EPA and MassDEP assert that, contrary to Mirant's contentions, the Permitting Agencies have conducted a thorough analysis of the available juvenile data.

With this background information in place, specific components of Comment C48 by Mirant can be more easily addressed. Mirant provides a list of "recent data" which "directly addresses the impacts in question", i.e., impacts of Kendall Station's discharge on adult and young alosids in the Charles, "by comparing abundance and distribution of the fish at different temperatures and under different flow conditions. Each of these is addressed in turn below:

Mirant: "Spawning migration of adults, monitored by gill net and tagging studies in warm springs 1999, 2002 and 2004 compared to cool springs 2000 and 2003.

Response: Spawning migration, as evidenced by the adult gill-net data, declined sharply in 2003 and remained low in 2004 and 2005.

Mirant: "Reproductive success, monitored by ichthyoplankton collections in 1999, 2002, 2003 and 2004"

Response: As stated in other comments, ichthyoplankton data cannot be used to address impacts to alewives, the target anadromous species, because a) the permittee did not differentiate between blueback and alewife larvae; b) blueback larvae are expected to be more tolerant of heat than are alewife larvae; c) the ratio of alewife juveniles to blueback juveniles caught in daytime beach seines and push-net surveys was so low that at times it was well below 0.1%. Thus, any trends seen in temperature and larvae counts most probably only applies to bluebacks, the more abundant and heat-tolerant of the two species.

Mirant: Distribution and development of YOY fish, monitored by beach seine in 1999, 2000, 2003 and 2004, plus gill net and push net in 2003 and 2004.

Response: Please see discussion above and that in Responses to C3 for the analysis of juvenile river herring distributions in the lower Basin and Response to C44 for a response to Mirant's analysis of juvenile development data.

As explained in Response C3, EPA and MassDEP have found the diminution of habitat as evidenced by the push net datasets for 2004 and 2005 to be an appreciable harm to the juvenile alewife and blueback populations.

Mirant: Exit of YOY from the system, monitored by beach seine in 1999, 2002, 2003 and 2004, gill net and push-net in 2003 (ongoing in 2004).

Response: Alewife catch in push-nets has been extremely low over all years that the sampling program has been conducted. In approximately 237 push- net events in 2003, only five juvenile alewives were captured. These events occurred at stations throughout the lower Basin, from the B.U. Bridge down along both sides of the river, as well as below the discharge and into the Old Locks. By contrast, 6,036 bluebacks were captured. A station-by-station breakdown of push-net data in 2004 and 2005 is presented in Response to C3 (see Table C3-1). Over the July-September period for those two years, the catch rates of juvenile alewives increased slightly, but were still extremely low. Juvenile alewife catch in 2004 was 125 fish over 199 surveys; by comparison, 8,894 juvenile bluebacks were caught in the same surveys. In 2005, the total alewife catch over the 138 surveys conducted in July-September was 183 fish compared to 12,177 bluebacks. Catch rates in the beach seine is discussed above.

Contrary to Mirant's contentions, it appears to the Permitting Agencies that there is reason for *great* concern regarding the alewife population in the Charles and the impacts of Kendall Station operation. The extremely low juvenile alewife catch rate in push-nets over the years that the program has been conducted is troubling to the Permitting Agencies and generally mimics the low catch rates of adults in gillnets. Habitat losses due to Kendall Station's discharge exacerbate an already difficult situation. The Permitting Agencies are hopeful that the structural repairs to dams and fishways in 2004 and 2005 (discussed in Response to C3), the operational changes implemented by the MDC Dam operators, combined with intake and discharge limitation at Kendall Station will all help the alewife stocks in the Charles to increase.

Mirant: Evidence of year class success based on age distribution of returning adults, including fish from the 1998, 1999, 2000 and now 2001 year classes.

Response: This has been discussed above. Briefly, based on the gillnet catch rate information, the Permitting Agencies contend that both the alewife and blueback populations have declined substantially since 2002. If the catch rate is compared in gillnets during the months of April-June over the 2002-2005 period to the one-time preliminary estimate of adult river herring entry to the Charles (about 45,000 fish in 2002), the results are of concern. The overall catch rate has declined from about 4.2 fish/hour in 2002 to 1.4 fish/hour in 2005. If the gill net catch rate is an index of the population size in the lower Basin, which seems a logical assumption, then the river herring population has declined from approximately 45,000 fish in 2002 to about 15,000 in 2005. Both figures are *extremely* low for river herring entry to a major river system. The decline roughly follows Kendall Station's operational increases in heatload, as reflected by summer heatload values from 2002 through 2005.

Mirant: Based on the studies outlined above, Mirant asserts that they have demonstrated an "abundance of every life stage from larvae through returning adults…after river-wide exposure to temperatures in the mid-to-upper 70s throughout early June and about 15-20% exceedances of 83 ºF (up to 85 ºF) in the ZPH between June 12 and August 31."

Response: EPA and MassDEP have judged that the data do not support Mirant's characterization that "an abundance" of juvenile or adult bluebacks or alewives has been found in the lower Charles at any time since 1999. With regard to the temperature dataset, as described above (see Response to C3), the permittee collected only surface temperature data during these collection events. Stomach content analyses of these fish showed that they were feeding on the bottom along the shoreline. Because the surveys were conducted at depths up to 4 feet, and water temperatures in the summertime often drop with depth (as documented in vertical profiles of water temperature in the lower Basin), it is probable that the actual water temperatures at the depths where alewife juveniles were captured was some value lower than that recorded at the surface. This would lend support to the findings of the push-net surveys, that temperatures above 81 ºF were generally avoided by alewives. No juvenile alewives were captured in any of the 31 push-net sampling events that occurred at temperatures > 80 ºF in the 2004 surveys and catch rates of juvenile alewives in 2005 were greatly diminished at temperatures greater than 81ºF. The permittee is directed to a more in-depth discussion of the shoreline seine and push-net surveys in Responses to C3 and C44. Mirant uses the term "river-wide exposure" and couples this with temperatures in excess of 83ºF (to 85ºF). However, the fish density information coupled with instantaneous temperature measurements show a consistent pattern: the bulk of juvenile alewives avoided temperatures in excess of 81ºF. Please refer to Responses to C3 and C44 for a more extensive discussion of this information.

Mirant: The DD "fails to explain how 100% exceedance of the 72 ºF threshold" in 1999 could plausibly be associated with Alosa larval densities in the ZPH or more than 1,500 per 100 cubic meters on June 8, followed by greater abundance of juvenile alewives in July 1999 than in any other sampling year".

Response: See Response to C24 and the discussion in this response regarding the potential difficulty in determining with certainty whether the prediction of a "retroactive" temperature exceedance of the ZPH is meaningful in the absence of temperature data collected from relevant Monitoring Points and time averaging utilized (exceedances at more than 50% of the river transect Monitoring Points of Monitoring Stations 3 – 6 or at other Monitoring Stations using a four hour average).

The issues that Mirant goes on to discuss in paragraphs numbered 2-5 in Comment C48 are essentially variations on the arguments Mirant included in the paragraph numbered 1, that Mirant found herring at temperatures which would allegedly violate the permit. EPA and MassDEP believe that the analysis above responding to paragraph 1 adequately refutes the conclusions Mirant presents in paragraphs 2-5.

Comment C49: Speculation Regarding Impacts on Zooplankton is Contradicted by Field Data. In Section 5.8.2l of the DD, the Agencies extrapolate from research by Moore in other northeast region lakes and apply it to the Charles River as support for asserting that zooplankton populations may be adversely affected by the thermal discharge and thereby less of a viable food source for the YOY river herring. This speculation is contradicted by the site-specific data collected by Mirant, and is incorrect for the following reasons:

- The lower Charles River Basin cannot be assumed comparable to the other northeast lakes because it is periodically estuarine, and it is stratified with higher salinity and lower DO as one proceeds to greater depths in the water column.

- Zooplankton densities in Mirant Kendall's collections in the Charles River in the plume area near Kendall Station and at background locations are similar (about 200 organisms per liter); and that number is similar to the densities documented to support the river herring BIPs in other east coast estuaries, including the James, the Hudson, and the Potomac.

- Zooplankton species favored by YOY alewives and bluebacks (based on analysis of stomach contents), i.e., rotifers, cladocerans, copepods, were similarly present in both collections within the influence of and collections not influenced by, the heated discharge. However, only shallow upstream locations contained larvae of benthic insects and clams, which are preempted from the ZPH by the absence of sufficient dissolved oxygen to support a viable benthic community.

- Feeding YOY bluebacks were consistently captured in comparable densities, whether far from or close to the discharge, at the several push-net stations located between the Harvard Bridge and the Museum of Science at temperatures up to 85^{o} F. This indicates that neither the temperature nor the zooplankton densities at these locations were sufficiently influenced by the discharge to affect the feeding distribution of the fish.

- There was no evidence from cell counts that the numbers of Cyanobacteria (blue-greens) was correlated with heat from the discharge, nor sufficient at any time to adversely affect food availability for the herring.

- Blue-greens were among the stomach contents of the herring. Given these data, and that the temperatures were below the $30\text{-}35^{o}$ C range the Agencies indicate to favor blue greens, the Determination Document fails to explain how the data from the field does or does not support the Agencies' speculation about impact.

Response to C49: Mirant asserts that the EPA and MassDEP discussion on Zooplankton (Section 5.8.21 in the DD) is speculative and contradicts site-specific data collected by Mirant and is incorrect for a number of reasons. EPA and MassDEP cite studies by Moore et al. (1996) that review temperature effects to Zooplankton communities in northeastern U.S. lakes. Mirant outlines six reasons why it feels that EPA and MassDEPs' conclusions regarding temperature effects are invalid for the lower Charles.

1. The first reason is that temperature effects from the Moore et al., studies cannot be extrapolated to the lower Charles because the lower Charles is periodically estuarine as it is stratified and has higher salinity and lower D.O. (at depth).

Response: Fresh water continually moves over the lower Basin even when the system is stratified by salinity and temperature. Within this upper layer, zooplankton and other drifting organisms continue to persist, as evidenced by the plankton sampling conducted by the permittee. Thus, although the lower layer of the Basin has been shown to increase in salinity during most years as the summer progresses, the upper portion remains as freshwater. It is this upper layer that is most important to alosid juveniles, as evidenced by both shoreline seine-sampling and push-net surveys. Moreover, the lower Basin is not "estuarine" in the sense that it behaves like most esturaries. There is no gradual shift of salinity and temperatures in a progression from a marine to a riverine environment. The lower Basin sometimes behaves much more like a lake into which salt water intrudes.

2. Mirant asserts that zooplankton densities in Mirant's collections in the plume area and at background stations are similar (about 200 organisms per liter) and that number is similar to densities documented to support river herring BIPs in other east coast estuaries including the James, Hudson and the Potomac.

Response: EPA and MassDEP's concern regarding the zooplankton communities was not the quantity of the zooplankton as a food source but the quality. Moore et al.'s research found that zooplankton communities that were characterized by large zooplankters, when subjected to temperatures in excess of 77 ºF for 7-10 consecutive days, experienced a substantive change in community structure. Large forms, preferred by alosids for food, were replaced by smaller forms. Thus, the food base of alosids is expected to deteriorate when subjected to temperatures in excess of 77 ºF for 1-1.5 weeks. During the summer, when the lower Basin is a nursery for alosids larvae and juveniles, low river flows become common. It is during these times that the Kendall Station thermal plume can exert the greatest effect on the zooplankton community. The areal extent, duration, magnitude and frequency of high-temperature events in the lower Basin in the vicinity of the discharge may all be increased due to the thermal load released into the Charles River from Kendall Station. Thus, the potential for negative effects to the food base of alosids will also increase.

3. Mirant states that zooplankton species favored by YOY alewives and bluebacks, based on stomach contents, were similarly present in both collections within the influence of and out of the influence of the plume. However, shallow areas preempted from the ZPH by the absence of sufficient oxygen contained benthic insects and (fingernail) clams which are also important to alosids.

Response: It should be remembered that, at the time these studies were conducted, Kendall Station's summertime BTU output was far-below the permitted level (see the graphic depiction of summertime BTU output in Response to B1). Thus, the full thermal impact of the Station at maximum generation was not being discharged to the lower Basin when these studies were conducted. In addition, zooplankton are expected to slowly respond to high temperatures. Effects of the thermal plume on the zooplankton community are expected to vary with both temperature and duration of exposure.

With regard to dissolved oxygen effects, low dissolved oxygen (less than 5.0 mg/L) sometimes occurs in the upper water column in the lower Charles River Basin. This does not mean, however, that oxygen levels below 5.0 should be used as the new water quality standard for the lower Basin. The Basin can be characterized as stressed, based on a fairly wide number of water quality variables, and benthic communities have been severely affected by the poor water quality in the Basin (USGS 2000).

Mirant's field work has established that the shoreline areas are important in providing food for alosid juveniles. Although the benthic community has been shown to be severely impacted in the deeper sections of the Basin with low dissolved oxygen levels and contaminated sediment, benthic communities in the shallow shoreline areas have not been as greatly affected. In certain areas, directly upstream and across from the facility, fingernail clams and other benthic organisms persist. Mirant has reported that alosid juveniles captured in beach-seines along these shorelines have had benthic insects and fingernail clams in their guts.

4. Mirant states that YOY bluebacks that were feeding were consistently captured in

comparable densities whether far from or close to the discharge, and at push-net stations at temperatures up to 85 ºF. Mirant feels that this indicates that neither temperature nor zooplankton densities were sufficiently influenced by the discharge to affect the feeding distribution of the fish.

Response: Blueback juveniles are known to tolerate much higher temperatures than alewives. The latter were chosen as the anadromous species most sensitive to temperature. Permit limits from June 12-October 31 were set to protect juvenile alewives.

In the Response to C3, the Permitting Agencies have shown that Mirant's contention regarding "comparable densities" of juvenile bluebacks at stations both near and far from the discharge was not supported by the data for the 2004 and 2005 sampling seasons. Mirant's comments imply that fish were captured at approximately equal rates at high and low temperatures up to 85 ºF. The Permitting Agencies demonstrate in the Response to C3 that the push-net catch rates for both juvenile alewives and juvenile bluebacks declined significantly with proximity to the discharge in 2004 and 2005. In addition, these declining densities were associated with increasing temperatures.

Whether or not the size distribution of zooplankton was affected by periods of time when temperatures were above 77 ºF is unknown. However, fish densities are often associated with food quantity and quality. The push-net surveys were designed to capture alewife and blueback herring away from the shoreline. It would be expected that river herring densities in different areas of the Basin would correspond to the quantity/quality of food present and/or other aspects of habitat quality (e.g., temperature). Due to the relative paucity of the benthos and emerging insects in areas away from the shoreline in the lower Basin, fish captured in push-nets would be expected to be feeding primarily on zooplankton. This expectation has not been fully evaluated, however. Whether the statistically-significant drop in capture rates of juvenile bluebacks and alewives was a direct effect of temperature or was also an effect of decreasing zooplankton food quality has not been assessed, although, based on the discussion above (item 2), the latter is also an expected effect of temperature increases.

5. Mirant states that the numbers of Cyanobacteria did not appear to be correlated with heat from the discharge, nor were they sufficient to adversely affect food availability for the herring.

EPA and MassDEP do not agree that no correlation exists between the number of Cyanobacteria in the Basin and the heat from the Station's discharge. Response E19 discusses this issue in detail and provides support for the permitting agencies' position.

In addition, EPA and MassDEP never intended to infer that blue-green algae do not occur when temperatures are below the 30-35 ^{o}C range. What is clear is that as river temperatures rise above 30 ^{o}C, blue-greens display an increased growth rate. See Figure 5.1-1 of the DD for an illustration of this occurrence.

Comment related to C49 from CLF: The habitat in the Basin will be further degraded because elevated temperatures are likely to reduce the availability of crucial invertebrate prey. It is well known that the precise timing of reproduction in fishes with respect to peaks in plankton availability is a critical determinant of the survival of juvenile fishes of many species, or year class strength. Zooplankton are essential as food for juvenile fishes, including perch and herring, and are also a dominant part of the diet for adult herring. Research on herring indicates that reproduction has evolved to produce synchrony with zooplankton population cycles. With increasing temperatures, the timing and composition of the available zooplankton will change in the Charles. Under the proposed permit, water temperature will approach the thermal tolerances some of the temperate zooplankton species and the algae that these invertebrates require for their food will decrease in availability. The warmer waters will favor blue-green algae which can be toxic to zooplankton and fishes. When waters are warmed to 77 ºF or higher for a protracted period of time, the species makeup of the zooplankton assemblage shifts to smaller species, and the species that form the principal food sources for Alosid fishes are lost. The combined effects of elevated temperatures changing the timing of migrations both in and out of the river, the thermal stress caused by high temperatures in the Basin, the effects on invertebrate prey populations could be devastating for the indigenous species EPA is responsible for protecting. These stresses will interact in a complex fashion with the already marginal conditions in the Basin to produce habitat that will not promote the successful passage of young fish into the sea.

Response to Comment related to C49 from CLF: EPA and MassDEP share the concern that elevated water temperatures may have an impact on the availability and make-up of crucial invertebrate prey residing in the Basin. The Permitting Agencies have lowered the temperature limits at key ZPH Monitoring Stations for the warmest months and have concluded that the temperature regime in the permit should provide for a mix of zooplankton adequate to support the BIP. A discussion of zooplankton in the lower Basin is contained in Response C49. See Section E (particularly Response E19) of the Response to Comments for information regarding phytoplankton in the lower Basin.

Data from the lower Basin phytoplankton summer community sampling program was also examined. Table E19-2 in Section E of the Response to Comments showed the relative percent of blue-green algae in the lower Basin summer community, based on a limited dataset. EPA and MassDEP are concerned about the potential impact of the thermal discharge on the blue-green populations because of the relationship between growth rates for blue greens and increasing temperature. See Figure 5.1-1 of the DD for an illustration of this occurrence. As a result, the final permit has retained the monitoring first proposed in the draft permit requiring algal monitoring during the growing season in order provide a more complete data set.

Comment C50: Agencies' Proposed Allowances are Impractical Because they Fail to Reflect River Temperature Patterns. The Draft Permit proposes to allow up to six 24-hour periods between April 15 to June 7 each year when temperatures may exceed the otherwise applicable in-stream limits by 2°F, but those periods must be non-consecutive and only three could be used over any consecutive four weeks. The Agencies explain those allowances as appropriate recognition of the insignificance of some short term rises in temperatures during the spring, which due to quite variable flow and weather conditions naturally exhibits great and unpredictable variability in water temperatures for any particular date.

The proposal does not adequately reflect the circumstances and, as a result, does not actually provide any practical allowances for the operations of the Kendall Station. First, prohibiting use of consecutive allowance days ignores that during typical springtime warm spells (e.g., June 1-7, 1999 and May 11-22, 2004), temperatures rise naturally above the proposed limits for several consecutive days at a time.

Second, the thresholds at which these proposed allowances are capped are too low. Allowing 2° F above 72° F from June 1-7 (i.e., a limit of 74° F) still would have shut the plant in 1999 when the temperatures were consistently above 74° F, yet the strongest year class of alewives in Mirant Kendall's monitoring was developing during that time. Third, a restriction to no more than three allowance days in 4 weeks is arbitrary and inconsistent with river temperature patterns in a year like 2004, where exceedances in the May 1-14 period were followed by exceedances in the May 15-22 period, a time period when Mirant Kendall's monitoring program shows that the second best (over the 5 years of monitoring) standing crop of YOY alewives was developing.

Mirant Kendall believes the concept of allowing slightly higher temperatures for brief periods is very important, and suggests the Agencies carefully consider incorporating an approach as described in Comment C5 above. This approach would limit higher temperature periods to 3 days per month, but would tie the thresholds more formally to the historic range of temperatures in the river by establishing the allowance range as the range between the 90^{th} and 95^{th} percentiles of the historic river temperatures.

Response to C50: As stated in the DD, the temperature allowances in excess of springtime protective temperature limits were an appropriate recognition of the insignificance of some short term rises in temperatures during the spring, which due to quite variable flow and weather conditions, naturally exhibits great and unpredictable variability in water temperatures for any particular date. These brief spikes in temperature were documented for the majority of years examined. However, when ambient temperatures rise for extended periods to values not normally seen, (only in 1999 and 2004 in the two examples cited by the permittee) it places stress on the fish that is likely harder to deal with than a brief spike in temperature. That is why these temperature allowances were not permitted to be grouped together. EPA and MassDEP concluded that allowing consecutive days of exceedances would add further stress, in the form of even higher temperature levels, to fish coping with an unusual period of elevated water temperatures.

Thermal limits were not designed to maximize Station operation. The protection of the BIP was the objective of the permitting process. Any allowances developed as part of the spring temperature limits were not based on the warmest spring years recorded, but took into account all years where temperature data was available. EPA and MassDEP do not support basing thermal limits on extreme conditions only. This was never part of the permitting design.

EPA and MassDEP explored in detail the approach contained in Comment C5 in Response C5.

Comment C51 related to American Shad (from MA DMF): We maintain an anadromous fish program to improve the abundance and distribution of river herring and American Shad in the Charles River. Much of our stocking effort has been relocating blueback herring up river to improve fish passage. The alewife population is too scarce to support any removal from the (Charles) river system. The permittee's estimates of 45,622 river herring (of which an estimated 8000 are alewife) from sonic tracking confirm the population level for both species is extremely low. The permittee's figure of 203,000 adult river herring used for an equivalent adult entrainment loss estimate may also underestimate the carrying capacity for the river. Beginning in 2005, Marine Fisheries will begin a three year program of stocking fingerling American Shad in the Charles River. We believe the draft permit should provide control measures and effluent limitations that serve to protect these resources.

Response to C51: As described in Response C3, the 2002 estimate of adult alewife has been referenced by many interested parties and regulatory agencies to assist in the evaluation of the anadromous fish run in the Charles River. It must be clearly understood, however, that these numbers were derived from a pilot study conducted by the permittee in 2002. A list of assumptions, potential sources of error and suggested refinements were documented for future field efforts to better estimate herring runs at that location. Any use of the fish entry estimates from 2002 must take the preliminary nature of these numbers into account.

The Permitting Agencies are fully aware of MA DMF's concerns regarding American shad and note that a cooperative re-stocking effort between MA DMF and the U.S. Fish and Wildlife Service began in the Charles in 2006. Adult fish are expected to return to the Basin in 2011. EPA and MassDEP discussed protective temperature values for American shad, in the event restoration efforts for this species were to re-establish this species in the lower Basin. This is documented in Section 5.7.4 and Figure 5.8.1-1 of the DD. Based on a description of the detailed restoration effort included in a February 16, 2006 letter from MA DMF to EPA (AR# 561), potential temperature limits to protect American shad have been again considered. The objective of ensuring protective temperatures of 78 ºF (American shad larval stage protective temperature) from June 12 through June 30, and 80 ºF (American shad juvenile stage protective temperature) from July 1 through October 30 would be incorporated into the temperature compliance profile of the permit. At this point, EPA and MassDEP have been unable to obtain evidence that American shad are sufficiently present in the lower Basin to constitute an element of the BIP that requires specific protection under the permit. The Permitting Agencies believe that the temperature compliance regime in the Final Permit will certainly help maintain the Basin at lower temperatures than are currently allowed in Kendall Station's permit, and the this Final Permit is directionally consistent with the American shad restoration project. Moreover, with the combination of the 83 ºF temperature limits during the summer and the new targeted limits to protect certain areas at 81 ºF along the Boston shore, EPA and MassDEP expect that the natural variability and compliance margin with which Mirant must operate the facility will likely result in temperatures in the ZPH much of the time which will not exceed the levels necessary to protect American shad.

Comment C52 related to American Shad (from CLF): Alteration of natural temperature cycles will interfere with migrations in and out of the river, and elevated winter temperatures will compromise natural strategies for surviving this period of the year for fishes and other aquatic animals.

The timing of spawning runs of American shad are similar to the river herring, typically taking place from late April through June, when spring water temperatures reach about 50 ºF. Migration comes to an end when the water reaches about 68 ºF. Again, the temperature limits proposed by EPA are too high and would curtail shad spawning runs by early May, when the ZPH would be allowed to reach the 68 ºF behavioral threshold for upstream migration. This species has been documented in the Charles River system in the past. MA DMF attempted to reintroduce this species into the system in greater numbers in the 1980's and into the early 1990's. The population has not rebounded and fisheries biologists have been unable to determine the reason(s). Fish sampling by the permittee did not collect adult American shad in 1999, 2000 or 2002." The temperature limits put forth in EPA's draft permit are not consistent with supporting a shad population in the Charles River, and will undermine ongoing efforts by MA DMF to re-establish this species. A renewed DMF shad stocking program is scheduled to begin this year, but will fail if this permit is not revised so as to hold temperatures in the natural range for these migratory fishes.

Juvenile shad remain in the natal river through the summer on into fall. Seaward migrations are triggered when falling water temperatures reach about 66 ºF during September through early November. Blueback herring exhibit a similar behavioral pattern, with the young fish beginning their seaward journey when fall temperatures reach 69 ºF. If this draft permit goes into effect as written, these young fish will begin the migration out of the upper reaches of the river in cool water, and then will encounter much higher temperatures in the ZPH of the Basin, and even higher if they venture into the ZD. With a maximum protective limit of 83 ºF during this period, water could reach this very high temperature if the system of measuring ambient temperature failed due to local thermal loading near the BU bridge. The unnatural spatial temperature regime is likely to interrupt the temperature-triggered migration to the sea and thus will result in higher mortality among the young of the year.

Discussion of warmest temperatures permitted for the ZPH.
Although the specific time periods and temperature limits are laid out in the draft permit, the discussion in the Determinations Document is at times confusing as to which limits will actually be enforced (e.g. Fig 5.6-1). Multiple references are made to 83 ºF, apparently because this is a water quality standard for a Class B body of water. However, as written, it is at times difficult to know whether EPA is proposing to use 83 ºF as some kind of overall limit for the ZPH for all seasons, or only during the 12 June through 31 October period. For example, on page 61, EPA writes "Based on the discussion above, the temperature limit of 28.3ºC (83ºF) must be in place in the ZPH from April 1 through July 15 to protect yellow perch larvae, unless replaced by a lower temperature limit to protect a more sensitive life stage or species occurring in the Basin at the

same time." However, the draft permit clearly indicates that a standard substantially lower than 83 ºF is being proposed during all but the last portion of this period. Fig. 5.6-1 shows the stair-step series of limits developed in the Determinations Document, and presented in Attachment A, but also includes a limit line at 83 ºF that extends to through the entire year. The intent of this graph, and the text, needs to be made clear.

Response to C52: Revised, protective temperature limits for the protection of American shad have not been included in the permit at this time. See Response C51 Related to American shad from MADMF. A discussion of temperature limits taken exclusively from the literature, proposed by CLF.