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APPENDIX B
REVIEW OF LOWER MISSISSIPPI RIVER FISHERIES

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EXECUTIVE SUMMARY

The Phase II rule developed under Section 316(b) requires consideration of the fishery of the cooling water source. The specific make up of a portion of the Comprehensive Demonstration Study (CDS), the Impingement Mortality and Entrainment Characterization Study (IMECS) is outlined by the rule. This Appendix will review these requirements within the context of the available literature for nine generating plants located on the Lower Mississippi River (LMR) and its associated tidal channels. The literature reviewed includes data collected at five of the stations as well as the more general literature and discussions with experts at universities and government agencies. This Appendix will evaluate whether these data are sufficient to support development of the IMECS and will also evaluate several important issues relative to the impingement and entrainment at the stations.

Two of the generating plants (i.e., Michoud and Paterson) are subject to performance goals for both impingement mortality and entrainment. The balance of the plants (i.e., Ritchie, Gerald Andrus, Baxter Wilson, Willow Glen, Waterford 1 & 2, Little Gypsy, and Ninemile) are subject to the impingement goal alone. In every case, US EPA has estimated, as part of the rule making process, that the likely capital and operation/maintenance cost of rule compliance at these stations will be negligible (i.e., $0). This cost estimate serves as the basis of the so-called Cost-cost test; the rule allows for a site-specific determination of Best Technology Available (BTA) if the costs of potential mitigation technologies are "significantly greater" than US EPA's assumed cost. This circumstance defines a standard for the data necessary for the IMECS intended to support this Compliance Alternative; the results of the Cost-cost test will be driven by the costs and feasibility of the various mitigation measures. The biological data are much less likely to influence the outcome of this test.

As shown below, Entergy has drawn the following conclusions based on the review of available literature:

- The historical studies at five of the plants represent sound efforts to estimate the annual rates of impingement including consideration of diel and seasonal variation. These studies were performed in the late 1970s and early 1980s.
- There is a strong consensus in the literature and among fisheries experts that the fishery of the LMR has not undergone significant changes since the collection of the impingement data. The dominant species as well as their population densities are unlikely to have changed significantly since the 1970s. This is consistent with informal observations by the plants' operators. Thus, the historically measured rates of impingement are likely to represent reasonable estimates of current rates of impingement.

- Entergy believes that available data support the rule's requirements of the IMECs. The available data provide a sound basis for characterizing the three general aspects of impingement mortality and entrainment required as part of the IMECS by 40 CFR 125.95(b)(3): (1) taxonomic identification of fish and shellfish within the zone of influence of the CWIS; (2) assessment of all life stages including temporal variation; and (3) estimation of current rates.

- The species impinged at the five plants change with movement toward the Gulf of Mexico in a logical fashion. As the salinity increases and with closer proximity to the Gulf, marine species increase in frequency.

- The distribution of plants with impingement data allows for inference of likely rates of impingement at nearby stations that have not rigorously quantified impingement.

- The most commonly impinged fish are also common in source water. Despite this, several important fish in the source water are under-represented among the impinged organisms. This is likely due to their strong swimming ability and/or their avoidance of the habitat near the cooling water intake structure (CWIS).

- The ten most commonly impinged fish constitute 90.7 to 98.7% of the total numbers of fish. Thus, the species of concern at each plant are clear.

- At the plants located on freshwater, the most commonly impinged species are generally forage fish or shellfish with little commercial or recreational value. The numbers of impinged fish are generally low compared to plants with similar flows located in other settings.

- Three young pallid sturgeon were impinged at two stations and several juvenile paddlefish were impinged at the plants. While the populations of these fish have generally declined in the LMR, there is a potential for their impingement. This suggests that efforts at restoration of these species may be a productive mitigation measure.

- Fish and shellfish impinged at the two estuarine stations are of higher commercial and recreational value. Despite this, the annual losses of these organisms are very modest.

- The masses and lengths of impinged fish are available in the studies and the vast majority of impinged finfish are juveniles.

- Data with which to evaluate temporal changes in impingement rates are available. Little change is apparent during the day and generally rates of impingement are stable throughout the year. The exceptions to this appear to be increases in impingement as young of the year return to the main channel following floods, observed at one station, and with migration of marine species into the estuaries observed at Michoud and Paterson.

- All of the plants have operating fish handling and return systems. Given the sensitivity of many of the impinged species at the fresh water plants, these systems may not contribute significantly to reductions in impingement mortality. The importance of shellfish among impinged organisms at the two estuarine plants, and these organisms' tolerance of handling, suggests that the return systems are likely to contribute to significant reductions in impingement mortality relative to the Calculation Baseline.

- Several of the plants located on the river's main stem (i.e., Baxter Wilson, Ritchie, Willow Glen, Waterford 1 & 2, Little Gypsy, and Ninemile) have CWIS that draw from deep, fast-moving water located several hundred feet offshore. There is a consensus that the population densities in these areas are far lower (95% lower) than in quieter, shallower water located along shore and in backwaters. This phenomenon contributes to each of these stations having greatly reduced rates of impingement relative to the Calculation Baseline (i.e., along shore) condition. In fact, these stations are very likely to be meeting the rule's performance goals for 80 to 95% reduction in impingement mortality.

- Few data are available on entrainment rates at Michoud and Paterson. Generally, the densities of ichthyoplankton at these stations should be low as most of the impinged species spawn well offshore in the Gulf. The importance of entrainment data is minimized by the fact that no technology intended to mitigate entrainment is either feasible or cost-effective. Data on the specific rates of entrainment is not likely to change the conclusions of the selected compliance alternative: the Cost-cost test.

1.0 INTRODUCTION

The Section 316(b) Phase II rule requires consideration of several biological issues during the evaluation of current and potential measures to mitigate impingement mortality and entrainment. Entergy owns and operates nine generating plants affected by the rule that are located along the Mississippi River in Arkansas, Mississippi, and Louisiana. This presents an opportunity to consider the biological resources within a common context. This will be part of Entergy's approach to rule compliance and this Appendix represents the first step in that process: a review of the fishery resources of the relevant stretch of river and its implications for rule compliance.

1.1 Goals

This Appendix was generated to support the submittal of the Proposal for Information Collection (PIC) for Entergy's nine Lower Mississippi River (LMR) Plants. Much of this information will be incorporated into the Impingement Mortality and/or Entrainment Characterization Study (IMECS), part of the Comprehensive Demonstration Study (CDS) required in the Phase II Section 316(b) rules. These documents will be prepared for each plant and will include an expanded discussion of the data as well as a more complete discussion of the data's implications at the plant. The goal

of this Appendix is to review fisheries-related data available for the LMR and the associated tidal channels. This review is intended to support the compliance options Entergy has elected to pursue in response to the regulations that pertain to the reduction of impingement mortality (IM) and entrainment (E) at electric power generating stations. In particular, this Appendix will address whether sufficient data are available to address the goals of the rule within the context of the compliance strategies outlined in the PIC. This Appendix evaluates ambient fish and shellfish populations and impingement data available on the LMR. The rates of impingement and entrainment will be considered within the context of our understanding of the biological resources of the Mississippi River in order to address several important questions relevant to the assessment of current and potential controls on IM and E. Potentially relevant questions are presented in Section II (below).

The aquatic biology of the Mississippi River is relatively well characterized by various agencies as well as private entities. In an effort to determine species that may be subject to impingement or entrainment at Entergy's facilities located on the LMR in Arkansas, Mississippi, and Louisiana, an extensive literature review was conducted. In addition, experts at museums, Universities, and regulatory agencies were contacted for additional information as well as their perspective on important ecological trends. State agencies were contacted as well as the United States Fish and Wildlife Service (USFWS), the U.S. Geological Survey (USGS), and the United States Army Corps of Engineers (USACE).

This Appendix reviews impingement data collected at the following Entergy plants: Baxter Wilson, Willow Glen Units 1 and 2, Willow Glen Unit 4, Waterford 1 and 2, Paterson, and Michoud. These data provide important perspective on the biological performance of the CWIS and, when coupled with other literature data, may provide a sufficient basis for the Impingement Mortality and Entrainment Characterization Study (IMECS) called for by the rule. The absolute rates of impingement will be considered relative to the location, design, and operation of the CWIS, and temporal trends will be discussed. The relative frequency of the species impinged will be discussed relative to population surveys of the LMR. Finally, a brief discussion of habitats of several commonly impinged species as well as potential rare, threatened, or endangered species will be presented.

Although many relevant data sources were obtained during the literature review, it should be noted that several sources contacted had limited biological data. These sources cited the lack of appropriate sampling equipment and under-sized boats as part of the reason for the lack of sampling effort on the Mississippi River. High water velocities are common on the Mississippi River and create safety concerns for routine sampling efforts. Such issues should be considered when planning any population survey that might be considered as part of the 316(b) compliance process.

Other agencies noted that relatively extensive data have been collected but has yet to be collated and evaluated. It may be appropriate to assess these data as part of the IMECS for the Entergy facilities.

1.2 Organization of Document

A review of the rule's goals is provided outlining the requirements for the IMECS. A general review of the LMR is then presented. Taxonomic identification of the most important species is provided and divided into freshwater and estuarine sections so the information can be more easily associated with a given plant[1]. A summary of the fisheries in the ambient water follows with species-specific discussions including habitat preference, spawning habits, food preference, swimming speeds, and handling survivability. Species with clear economic benefit and recreational importance are discussed as well as threatened and endangered (T&E) species.

A characterization of all life stages follows focusing on the life stages subject to impingement mortality (IM) and entrainment (E). Impingement data is summarized for the freshwater plants followed by the estuarine plants. The information was reviewed with a focus on potential temporal variations in IM and E. The importance of spatial differences in population densities is also discussed focusing on available literature and conversations with researchers.

Documentation of current IM and E at the plants follows focusing on actual measurements and anecdotal evidence. The representativeness of historical data is addressed considering potential fisheries trends in the LMR and whether the impingement data were collected under normal operating conditions. Available data were analyzed to determine their sufficiency to estimate the Calculation Baseline. The sufficiency of the data is also discussed as it pertains to supporting the other goals of the CDS.

Lastly, a discussion is presented that answers whether the available data is sufficient in supporting the IMECS. The most common species impinged and entrained are listed in this section. Implications for CWIS placement, design, and operation are discussed as well. All references cited are found at this end of this Appendix.

2.0 REVIEW OF THE RULE'S GOALS

The Phase II rule provides relatively specific requirements for the IMECS in amendments to 40 CFR 125.95(b)(3) (see excerpt, below). Entergy understands that these requirements are intended to support the assessment of the current CWIS as well as its alternatives within the

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1 The Paterson and Michoud plants use brackish water and are likely to affect estuarine species. The balance of the generating plants are located on the Mississippi River main stem and use water that is nearly always fresh.

context of the various Compliance Strategies. Among the specific questions that might be relevant are:

- What are the species potentially affected by the CWIS? Do they include species of potential concern such as those with high commercial or recreational value or those receiving special protections?

- Do the characteristics of the relevant species (e.g., temporal and spatial distributions, size of larvae and eggs, swimming speed) provide a basis for selection and design of mitigation technologies or measures?

- What are the actual rates of impingement and entrainment in order to calculate the monetized benefit of potential mitigation measures?

- How do the current rates of impingement and entrainment relate to those of the hypothetical Calculation Baseline? That is, what is the effect of any mitigation measures expressed as a percent reduction, relative to the Calculation Baseline, in impingement mortality and entrainment?

As noted in the PIC, the relative importance of these questions will vary significantly depending on the Compliance Strategy selected. For example, current data on the rates of impingement mortality and entrainment are much more likely to be important for supporting the Cost-benefit test than for the Cost-cost test. Similarly, it is likely to be much simpler to demonstrate consistency for some mitigation technologies than for others and the nature of the necessary data collection will vary accordingly. For example, there is a consensus that population densities in high velocity portions of the river are much lower than along the shore or in backwaters. Thus, demonstrating compliance with performance goals for CWIS located in the main flow of the river should be relatively simple. On the other hand, due to site- and species-specific variation, showing that a fish handling and return system results in sufficient impingement survival may require direct testing.

The following is the rule's requirements for the IMECS:

a) *125.95(b)(3)(i). Taxonomic identifications of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) that are in the vicinity of the cooling water intake structure(s) and are susceptible to impingement and entrainment.*

b) *125.95(b)(3)(ii). A characterization of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified pursuant to paragraph (b)(3)(i) of this section, including a description of*

the abundance and temporal and spatial characteristics in the vicinity of the cooling water intake structure(s), based on sufficient data to characterize annual, seasonal, and diel variations in impingement mortality and entrainment.

c) *125.95(b)(3)(iii). Documentation of the current impingement mortality and entrainment of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified pursuant to paragraph (b)(3)(i) of this section and an estimate of impingement mortality and entrainment to be used as the calculation baseline. Impingement mortality and entrainment samples to support the calculations required in Section 125.95(b)(4)(i)(C) and 125.95(b)(5)(iii) of the Rule must be collected during periods of representative operational flows for the cooling water intake structure and the flows associated with the samples must be documented.*

Within the context of the selected Compliance Strategies, these requirements will serve as the basis for assessing the sufficiency of the existing data to support the IMECS (see Section 4 of the PIC).

The following three sections of this Appendix will be organized consistent with the three separate provisions of the rule relative to the IMECS.

3.0 TAXONOMIC IDENTIFICATIONS [125.95(B)(3)(I)]

40 CFR 125.95(b)(3)(i) sets out the requirements of the IMECS relative to identification of fish and shellfish taxa potentially affected by impingement mortality and entrainment. The goals of this effort are to identify these species that are likely to dominate impingement mortality and entrainment with a special focus on those that have commercial or recreational importance. In addition, any species subject to special protections (e.g., state- or federally-listed threatened or endangered species) must be noted.

This section will review the available information in order to identify the relevant species and will provide a brief review of the nature of several important species. Separate discussions will be provided for the freshwater and estuarine systems. The discussions rely on station-specific data, industry-generated summaries of the ambient populations, the more general literature, and recent discussions with experts on the fishery of the LMR.

3.1 Mississippi River Species Composition

The fishery of the LMR changes with progression toward the Gulf of Mexico. The change is driven by the increase in salinity as well as physical proximity to the ocean. The first factor is especially important in the shipping channels near the Michoud and Paterson plants where the

typical salinity can approach one-third of that of seawater. On the river's main stem (e.g., at the Ninemile station), the salinity is far lower but estuarine species become more common. Thus, we expect that with movement from Entergy's Gerald Andrus, Ritchie, and Baxter Wilson plants to those stations located closer to New Orleans, more estuarine species will be encountered. In fact, this is borne out both in ambient sampling as well as the measured rates of impingement.

3.1.1 Freshwater

The boundary between the Upper Mississippi River (UMR) and LMR is typically considered to be near Alton, Illinois, a few kilometers above the confluence with the Missouri River. The LMR is approximately 1,834 km and flows un-dammed to the Gulf of Mexico (Schramm 2004). Levees have severed connection to the river from 90 percent of its historic 103,000 km^2 floodplain which historically extended almost 200 km from the riverbank (Schramm 2004).

The Mississippi River is a highly turbid waterbody with high current velocity. The productivity of the system is limited by light penetration and high suspended solids concentrations, as well as stability and habitability of the available substrate. As a result, the Mississippi River food chain is considered to be detrital-based, because phytoplankton occur in low densities and do not seem to be the major energy source. This is typical of larger southeastern and Midwestern rivers (LL&P 1974).

The flow regime of the LMR is considered to be an important determinant of the fish community. Flow records have been maintained on the LMR since 1900. The flow in the river varies substantially throughout the year and water levels fluctuate an average of 10 m (Schramm 2004). For example, at the Waterford Unit 3 facility (owned and operated by Entergy), located between Baton Rouge and New Orleans, average seasonal flows are estimated to be 580,000, 650,000, 280,000 and 240,000 cfs for winter, spring, summer, and fall, respectively. Average velocity in this portion of the river averages as high as 3.9 fps in April and as low as 1.1 fps (39-year avg.) in September (LP&L 1979). In the vicinity of Baxter Wilson flows as rapid as 8 knots (i.e., in excess of 10 fps) have been observed.

3.1.1.1 Summary of Literature

Fish species diversity typically increases from headwater to river mouth. Vertical distribution is patchy, with highest numbers at the river surface and at the bottom with the mid-depth virtually devoid of fish, probably due to very high currents located mid-depth (MP&L 1974). The most common freshwater species in the LMR include the gizzard shad, threadfin shad, goldeye, carp, river carpsucker, smallmouth buffalo, blue catfish, channel catfish, flathead catfish, river shiner, and freshwater drum. Bluegill, largemouth bass, and black and white crappie are also fairly common. In addition to the fish, two species of shrimp (*Macrobrachium ohione* and *Palaemonetes kadiakensis*) and a crayfish (Cambarinae) are abundant.

Large floodplain rivers like the Mississippi are dynamic and diverse ecosystems. These rivers are composed of several habitats including the main channel, side channel, floodplain, and backwater lakes that allow a diverse assemblage of organisms to persist. 195 species of freshwater fishes have been recorded to occur in the main-stem of the Mississippi and Atchafalaya rivers, representing almost one-third of the freshwater fish species in North America. Sixty-seven (67) species inhabit the headwaters, 132 species inhabit the Upper Mississippi River, and about 150 species inhabit the Lower Mississippi and Atchafalaya Rivers (Fremling *et al.* 1989). Baker *et al.* (1991) also estimated that 91 species of freshwater fishes inhabit the LMR, with 30 or more other species present intermittently.

Schramm (2004) identified three distinct habitat zones in the LMR: main channel, channel border, and backwater. The main channel is the portion of the river that contains the thalweg and the navigation channel. The channel border is the zone from the main channel to the riverbank and the backwater zone includes lentic habitats lateral to the channel border that are connected to the river at least some of the time in most years. These habitat zones are extremely relevant when considering species with the most potential for impingement and/or entrainment in the LMR habitat. This study, as well as additional habitat information is discussed further in this Appendix in sections *Review of Habitats* and *Differences in Fisheries Population Densities*.

The rule defines the Calculation Baseline condition as, among other factors, being located at the surface along the shoreline. This is considered to be the worst-case for both impingement mortality and entrainment. The discussion above supports the concept that a CWIS located along the shoreline or in a back-water will be much more likely to be in habitat with increased populations of fish relative to those in the main channel.

The LMR provides plentiful habitat for fishes that thrive in swiftly flowing water but few species can tolerate the high current velocities of the upper and middle water column of the channel (Baker *et al.* 1991). Most fishes likely inhabit areas near the banks (Pennington *et al.* 1983) and the channel bottom, where the current is slower (Baker et al. 1991). _Several fish species forage in the floodplain of the LMR when it is inundated by high water levels (Baker *et al.* 1991); these include gars, bowfin, common carp, buffalos, river carpsucker, channel catfish, blue catfish, white bass, crappies, and freshwater drum. Many fishes also use the inundated floodplain for spawning. Densities of larval fishes in the LMR are highest in backwaters, which are important nurseries for fishes, and which contain a larval fish assemblage differing from that of the main-stem river (Beckett and Pennington 1986).

Dr. Todd Slack with the Mississippi Museum of Natural Science was contacted to retrieve an updated list of species in the general area of each of Entergy's facilities located on the LMR. To date, lists have been provided for the vicinities of the Baxter Wilson facility near Vicksburg, Mississippi; the Gerald Andrus facility near Greenville, Mississippi; and the Ritchie facility near Helena, Mississippi. The results of the queries also contain upstream and downstream reaches, direct tributaries to the Mississippi River, and oxbow lakes. The list was compiled from the

Museum's current database and the Inland Fishes of Mississippi, authored by Dr. Stephen Ross (Ross 2001). Dr. Slack stated that the list is very extensive and should include all common fish in the area. This information was used primarily to determine potential occurrence of T&E species at these three plants, as well as to confirm the species identified in the Baxter Wilson impingement study.

Camp, Dresser & McKee, Inc. (CDM) and Limnetics (1976) conducted an ecological study of the LMR to determine the species composition, abundance, and biomass of the biological communities in the river. Six sites were selected for fish collections near Mississippi River ~~Mile~~ mile marker ~~(RM)~~ 786, 730, 665, 522, 301 and 175 AHP (Ahead of Pass) (with focus on the river near ~~RM~~ 522, ~~RM~~ 730 and 785 AHP). At each of the sites three habitats were sampled; (1) river channel; (2) clay-bank area; and (3) backwater area. A total of 65 species were collected during the study; 46 species at ~~RM~~ Mississippi River mile marker 785 AHP, 49 species at ~~RM~~ mile marker 730 AHP, and 57 at ~~RM~~ mile marker 522 AHP. The most commonly captured fish included the gizzard shad, threadfin shad, goldeye, carp, river carpsucker, smallmouth buffalo, blue catfish, channel catfish, flathead catfish, river shiner, and freshwater drum. In addition to the fish, two species of shrimp (*Macrobrachium ohione* and *Palaemonetes kadiakensis*) and a crayfish (Cambarinae) were collected.

Although many of the species observed in the plant impingement samples are similar in composition and relative abundance to the species found in the LMR itself, some species are noticeably absent or under-represented from the impingement samples. For example, of the most common fish in the LMR, shiners, smallmouth buffalo, and largemouth bass are rarely observed in the impingement samples. Skipjack herring, while common in the LMR, only account for a small percentage of the total number of fish impinged (generally less than 1%). This is confirmed by two surveys conducted on the LMR by Entergy at the Waterford 3 and Grand Gulf plants (see Table B-1). While quantitative comparisons are difficult, it is apparent that several species that dominate the ambient samples are poorly represented in impingement samples collected at near by stations. The differences in composition and frequency of fish known to be common in the LMR and those observed in the impingement samples is likely to due to habitat preferences and/or escape potential. The ambient river studies utilized different gear which has the potential to bias the results of the sampling event making inter-survey comparisons difficult.

3.1.1.2 Species-Specific Discussion

The following is a brief summary of the primary freshwater species expected to be impinged and/or entrained in power plant CWIS located in the LMR. A more in-depth biological profile will be included with the IMECS submittal. This list was compiled using data from LMR impingement studies and ambient river fisheries studies. Handling tolerance and swimming speeds are discussed as well as general biology, habitat and feeding preferences.

Handling Tolerance

Table B-2 presents data summarized by EPRI (2003) on the observed impingement survival of different fish species. This review does not include all species but does summarize an extensive set of studies for many important species. To support the assessment of potential survival upon fish handling and return, the species that are both common in the LMR and commonly impinged were assessed relative to the average and median rate of survival following removal from traveling screens.

EPRI (2003) indicated that the median extended survival for freshwater drum and gizzard shad is 20% (8 studies) and 7% (43 studies), respectively. Extended survival rates were not available for threadfin shad but the median initial survival was only 15% (5 studies). This suggests that any sort of fish handling and return system is not likely to achieve significant reductions in impingement mortality for the three finfish species that dominate impingement at the LMR freshwater plants. Of the two common invertebrate species impinged in CWIS, the initial survival for freshwater shrimp was 50% (1 study). Available data for other relevant taxa (including estuarine species) are also presented in Table B-2.

Swimming Speeds

US EPA states "intake velocity is one of the key factors that can affect the impingement of fish and other aquatic biota". In the immediate area of the intake structure, the velocity of water entering a CWIS exerts a direct physical force against which fish and other organisms must act to avoid impingement and entrainment" (Sempra 2002). In addition, technologies (wedgewire screens and velocity caps) may reduce CWIS velocities, and hence impingement and entrainment. In the LMR the typical high velocities assist in reducing impingement and entrainment by adding a force larger than the intake structure suction force at a 90° angle to the intake. This reduces the number of fish entering the CWIS. When the ambient water velocity is higher than the intake approach velocity, the major impetus is to pull the aquatic organisms downriver and not towards the CWIS intake pipes.

A species' swimming speed is important in determining its ability to avoid the suction force of CWIS intake pipes. Swimming speed information can be useful when considering the application of potential construction technologies, especially if the species in the vicinity of the CWIS are known. Thus, this information may be an important part of the IMECS. Available data for important species are presented in Table B-2.

Analysis of the impingement data showed moderate correlations between a species' swimming speed and its potential for impingement. River shrimp swim very slowly; adult males swim on average 7.6 mm/s. This species dominated impingement (as high as 57% of the total abundance) at the Willow Glen and Waterford 1 & 2 impingement studies. These high impingement rates were probably due, in part, to the shrimps' inability to break away from the suction created at the

intakes. Alternatively, gizzard shad and threadfin shad both have moderate swimming speeds when compared to other finfish (optimum of 23 cm/s for fish 25-50 mm) and were two of the most abundantly impinged fish in the impingement studies. Larger freshwater drum are able to swim relatively fast (optimum speed of 90 cm/s for 300 mm fish), however this species was the most abundantly impinged fish at Baxter Wilson, Willow Glen 1 & 2 and Willow Glen 4. Carp (optimum speed of 166 cm/s for 36-77 mm fish) and bluegill (critical speed of 101 cm/s for 64 mm fish) are able to swim relatively fast and were impinged in low numbers, likely due to their ability to swim faster than the approach velocity at the intakes.

Although a species' swimming speed likely a key element in determining its impingement potential, there are many factors that are important including individual size, behavioral cues, feeding habits, preferred location within the water column and relative to the CWIS location, and the tendency to school.

River shrimp

Ohio Shrimp (Macrobrachium ohione) may grow up to 4 inches long, live in fresh and brackish water along the eastern United States seaboard to the Gulf of Mexico, and are the only species of *Macrobrachium* found in the Mississippi River. Once common in the Mississippi River below St. Louis, they supported commercial fisheries that once existed near Chester and Cairo, Illinois, Ohio shrimp were thought to be extirpated (locally extinct) in the Mississippi River bordering Missouri and Illinois since 1962. In 1991, however they were rediscovered. The decline in the population of Ohio shrimp is thought to be related to the channelization of the river (Hrabik 1999).

In the LMR, however, this species is still quite abundant. M. *ohione* are the most common freshwater shrimp in Louisiana and can be found in the Atchafalaya and lower Mississippi Rivers, where almost all of the current production is used for bait.

Gizzard Shad

Gizzard shad occur primarily in freshwater and are most abundant in large rivers and reservoirs, avoiding high gradient streams. The species is most often found in large schools. Spawning generally takes place in late spring, usually in shallow protected water. Gizzard shad are planktivorous. The young feed on microscopic animals and plants, as well as small insect larvae, while adults feed by filtering small food items from the water using their long gill rakers. Gizzard shad generally grow to 14 inches and provide forage for most game species (Chilton 1997). Ross (2001) also noted that young gizzard shad tend to occur along shorelines in very shallow water, gradually moving offshore into deep water as they grow. Individuals older than age class 3 rarely occur in shallow water (Bodola 1966).

Schramm (2004) stated that this species is abundantly taken in the LMR. He also states that the gizzard shad is a backwater dependent species that may be found in all three main habitat zones;

the main channel, channel border and backwaters. Gizzard shad have little commercial or recreational importance although they likely serve as forage for game fish.

Threadfin Shad

Like gizzard shad, threadfin shad are most commonly found in large rivers and reservoirs. However, threadfin shad are most likely to be found in waters with a noticeable current and are usually found in the upper five feet of water. Spawning begins in the spring and continues through summer. Adults are considerably smaller than gizzard shad and rarely exceed 6 inches in length (Chilton 1997). The threadfin shad is a pelagic schooling species that primarily occupies the areas between the surface and the thermalcline with the greatest densities near the surface (Netsch *et al.* 1971). Schramm (2004) stated that this species is abundantly taken in all LMR surveys. He also states that the threadfin shad is a backwater dependent species that is most likely to be found in the channel border and backwaters. Again, threadfin shad serve as forage fish but have little other commercial or recreational importance.

Freshwater Drum

Freshwater drum occur in a wide variety of habitats, and is one of the most wide latitudinal-ranging fish in North America. They inhabit deep pools of medium to large rivers and large impoundments spending most of their time at or near the bottom. Young drum feed on small crustaceans and aquatic insect larvae, and adults feed on snails, small clams, crayfish, small fishes, and insect larvae (Swedberg 1968; Robison and Buchanan 1992). They are often found rooting around in the substrate or moving rocks to dislodge their prey (Chilton 1997). The freshwater drum is a pelagic spawner, usually spawning in the spring. The eggs are semi-buoyant and pelagic. In Wisconsin, schools of spawning fish have been observed milling at the surface with backs out of the water (Becker 1983; Chilton 1997). Schramm (2004) stated that this species is taken abundantly in all river surveys in the LMR. He also states that the freshwater drum is a riverine dependent species that is most likely to be found in the channel border and backwaters. Freshwater drum is taken on a commercial basis.

Blue catfish

The blue catfish is primarily a large-river fish, occurring in main channels, tributaries and impoundments of major river systems. _They are native to major rivers of the Ohio, Missouri, and Mississippi river basins. __They tend to move upstream in summer in search of cooler temperatures, and downstream in winter for warmer temperatures. _Blue catfish do not mature until reaching 24-inches. _They spawn in late spring or early summer when water temperatures reach 75° F. Males select nest sites which are normally dark secluded areas such as cavities in drift piles, logs, undercut banks, rocks, cans, etc. The blue catfish diet is quite varied but smaller fish tend to eat invertebrates, while larger fish eat fish and large invertebrates (Chilton 1997).

Common Carp

Common carp were first introduced in North America in 1877 and are now one of the most widely distributed fish in North America. They are primarily a warm-water species, and do very well in warm, muddy, highly productive (eutrophic) waters. Adults are primarily benthic and omnivorous, feeding on both plant and animal material. Common carp may grow as big as 75 pounds, but are generally considered a nuisance by North American anglers (Chilton 1997).

Ross (2001) states that carp occur in a variety of habitats but are more common in deep pools of streams or in reservoirs, especially in or near vegetated areas with mud or sand substrata. They are fairly tolerant of poor water quality and can survive low oxygen levels and high turbidity. Schramm (2004) stated that this species is commonly taken in most surveys in the LMR. He also states that the common carp is a backwater dependent species that is most likely to be found in the channel border and backwaters. _Schramm notes the importance of invasive species in the Mississippi River and stated the most important species presently established in the river include the common carp, grass carp, silver carp, bighead carp, and zebra mussel. Since the carp is a nuisance, any reduction in their numbers (i.e. impingement mortality) would be a benefit to the aquatic ecosystem as this would allow the proliferation of indigenous, non-invasive species.

3.1.2 Brackish Waters

The following is a summary of the species composition relative to Entergy's estuarine plants, i.e. Michoud and Paterson.

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3.1.2.1 Summary of Literature

The majority of the LMR is fresh_water; however, the water becomes brackish near the river mouth and during severe drought periods, the saltwater may rarely reach as far upstream as New Orleans, LA. The water is also brackish in the back channels and backwater lakes near the mouth of the river. Notably the shipping channels on which Paterson and Michoud are located are brackish in nature. As the water becomes more brackish, bay anchovy, striped mullet, blue crab, Atlantic croaker, seatrout, gulf menhaden, and penaeid shrimp may be found in the lower reaches of the LMR. These species typically utilize the Mississippi River for spawning, as nursery grounds, and for protection. These species are even more important in the shipping channels where the typical salinity is much higher.

Many of the species observed in the Michoud and Paterson plant impingement samples are similar in composition and relative abundance to the species found in the lower reaches of the LMR. However, species-specific properties such as habitat preference and escape potential, as well as intake placement can affect the composition of the impingement samples.

3.1.2.2 Species-Specific Discussion

Handling Tolerance

Initial and extended survival rates have also been determined for 15 estuarine species (Table B-2). The species with the highest initial and extended survival probabilities include brown shrimp, white shrimp, and blue crab which are common at the two brackish water plants, Michoud and Paterson. The species-weighted survival of these species at these two plants is discussed in Section 3 of the PICs for those plants. These species are also observed at lower frequencies among impinged organisms at Waterford 1 and 2 and are likely to be encountered at Ninemile, Waterford 3, and at Little Gypsy.

Swimming Speed

Spotted seatrout (cruising speed of 81 cm/s for 300 mm fish) swim at moderate speeds and were impinged in small numbers at the Michoud and Paterson plants. Bay anchovy (cruising speed of 21 cm/s for 90 mm fish) swim relatively slowly and were impinged in higher abundance at these same two plants (Table B-2). Although swimming speeds are not available for blue crab, white shrimp, and brown shrimp, these species are relatively slow swimmers and were impinged in moderate abundance (up to 20% total abundance) at Paterson and Michoud. These results suggest a connection between impingement rate and escape potential, with stronger swimming species capable of escaping the flow field of the intake and vice versa.

Atlantic croaker

The croakers are perhaps the most characteristic group of northern Gulf inshore fishes. In numbers of individuals, or biomass, they are among the top three (others being mullet and anchovies) in the Gulf. Most species spawn in the shallow Gulf, with the larvae entering the bays, where they spend their first summer in brackish water. Although most species are adapted to living on muddy bottoms, a few are found in more sandy habitats, and a few are adapted to rocky habitats.

The Atlantic croaker is one of the most common bottom-dwelling estuarine species with the young occurring in the deeper parts of the bays in the summer but departing in the fall. Only a few fish live past their first year but very large croaker are found at the mouth of the Mississippi River.

Sand seatrout (white seatrout)

The sand seatrout (croaker family) is a sport fish of some importance and is popular with most anglers. These fish spawn in deeper channels of the bays or in the shallow Gulf, the young staying over muddy bottoms. This species becomes almost entirely piscivorous at a relatively small size.

White Shrimp and Brown Shrimp

Bay systems serve as a nursery area for several commercially important species of penaeid shrimp, primarily white and brown shrimp. In the upper Gulf of Mexico brown shrimp are typically the dominant species from May through July, while white shrimp are dominant from August through April (Baxter *et al.* 1988). The natural diet of post larval penaeid shrimp includes copepods, amphipods, tanaids, and polychaetes, which account for 53% of their growth, with plankton accounting for the remainder (Minello *et al.* 1989).

Penaeid shrimp are most active at night, often swimming to the surface in shallow water. White shrimp seldom burrow as brown shrimp do, but they do usually rest on the bottom during the daylight hours. Mating and spawning for penaeid shrimp takes place offshore._ Brown shrimp breed year-round at depths of 50-120 meters; individuals in shallower water do not breed in the coldest months, i.e., January and February. White shrimp breed in shallower water (14 to 50 meters) and spawn mostly in the fall. _When conditions are suitable the females release between 0.5 and 1 million eggs. Twenty-four hours later the drifting eggs hatch as nauplii and begin a planktonic existence. After five molts the egg yolk is exhausted, and the nauplius transforms into a protozoea, a mysis, and finally a postlarva, which enters the bays to become a bottom dweller. They remain in the bays and estuaries until they are nearly mature then they migrate offshore to breed (Fotheringham 1980).

Bay anchovy

The anchovies are the most abundant of the schooling, pelagic fishes. The bay anchovy is an extremely common fish, restricted to the bays and close inshore areas. The species ranges from Maine to Florida and also occurs throughout the Gulf of Mexico. Adults usually attain a size of four inches (Hoese and Moore 1977). Bay anchovy are planktonic feeders. Although they are not important commercially, they do serve as a major forage species for many game fish. This species is able to exploit a wide variety of habitats and are also known to overpopulate, and can be used to indicate poor water quality (Monaco *et al.* 1989).

Blue crab

Both species of blue crab, *Callinectes sapidus*, and *Callinectes similis* are common along the northern Gulf of Mexico. Blue crabs are very tolerant and adapt much better to a variety of habitats compared to other species. A commercial blue crab fishery has existed in the Gulf of Mexico for several decades. The larger *C. sapidus* reaches a maximum carapace width of 21 cm compared to 12 cm for *C. similis*. Berried (egg mass) female *C. Sapidus* are found nearly year round with the peak of the breeding season being in June and July. After mating, the female migrates into deeper water where she attaches the fertilized eggs to her pleopods. The eggs hatch in two weeks releasing the young as zoeae which eventually molts into a megalops and then transforms into a diminutive adult form. The crabs mature in one year, begin breeding and

live perhaps two more years. Blue crabs are omnivores, feeding on fish, bottom invertebrates, vascular plants, and detritus (Fotheringham 1980).

3.2 Historical patterns

The riverine ecosystem of the Mississippi River has undergone many changes. Habitat loss and degradation, point and non-point pollution, toxic substances, commercial and recreational fishing and navigation, deterioration of water quality during drought periods, reduced availability of key plant and invertebrate food sources, and invasion of nonindigenous species are believed to have contributed to recent declines in the river's flora and fauna (McHenry *et al.* 1984; Bhowmik and Adams 1989). Although several key native organisms including submersed plants, native pearlymussels, fingernail clams, and certain fishes have decreased along substantial reaches of the river in recent years or decades, most species have changed little over time.

Consultation with several leading authorities from the universities and the agencies concerning historical patterns of fish populations in the LMR has been conducted. Dr. Rutherford and Dr. Kelso of Louisiana State University, Dr. Killgore of the USACE, and Hal Schramm with the USGS each indicated that the species characterization in the river has remained fairly consistent over the last 20 to 30 years and they would not anticipate a significant change in species for much of the river from well above the state of Mississippi down to Mississippi River ~~river~~ mile marker ~~(RM)~~ 90 AHP, just southeast of New Orleans, Furthermore, estimates of population densities (relative abundance) for the major species occurring in the river have remained relatively stable during the same time period.

Gizzard shad, threadfin shad, freshwater drum, and blue catfish were all described as species that were abundantly taken in river surveys both recently and historically. Carp, white crappie, skipjack herring, and bluegill were also commonly collected. Since these species were the most abundant collected in the 1970's studies, and are still collected in abundance in the present day, we can conclude there have been no significant changes in the LMR fisheries since the impingement studies in the 1970's. The most abundant freshwater invertebrates collected historically were river shrimp and crayfish, which dominated the impingement samples at many of the plants in the 1970s. Their abundance in the present day is unknown.

Based on the literature, the species currently present in the tidal portions of the LMR (e.g. white and brown shrimp, blue crab, Atlantic croaker, Gulf menhaden, bay anchovy, sand trout and hardhead catfish) are similar in composition and relative abundance to the species present historically (i.e., 1970 studies). These species are very typical of upper Gulf of Mexico estuaries and tidal river systems. Overall community structure does not appear to have changed the past several decades although saltwater commercial fishing harvest in Louisiana has declined somewhat. According to NMFS statistics, finfish landings have declined between 1984 and present day, however shellfish landings have remained relatively steady. The long-term decline in fin-fish harvest is primarily due to the corresponding decline in wetland habitat. .

3.3 Commercial and Recreational Species

The most commonly impinged species at Entergy's LMR plants have no significant recreational or commercial value, for example the commonly impinged shad species have no commercial or recreational significance._ This is true for the plants located on the freshwater portions of the river. At the two stations located on tidal channels, Paterson and Michoud, commercial species are more important. Despite this, adverse impacts to their populations or to the commercial harvest are not expected since the annual impingement rates associated with CWIS are typically low.

Commercial Fisheries

Freshwater

Commercial harvest in the UMR is dominated by four groups of fishes including the common carp, buffalos (bigmouth and smallmouth), catfishes (channel and flathead), and freshwater drum which together represent 95% of the total commercial catch in the UMR and 99% of the monetary value (Fremling *et al.* 1989). The common carp has ranked first among species in commercial catch for decades.

The same species harvested in the UMR also dominate the commercial fisheries for the freshwater portions of the LMR. Commercial harvest of fishes in the LMR is difficult to assess because of inconsistencies in methods of gathering and reporting data, however limited information indicates commercial harvest is increasing (Schramm 2004). _According to Schramm neither the commercial nor recreational fisheries appear to be over harvested, however fisheries for sturgeon and paddlefish should be carefully monitored. He also notes that future fisheries production may be threatened by loss of aquatic habitat, altered spatial and temporal aspects of floodplain inundation and nuisance invasions. _In addition, navigation traffic affects fish survival and recruitment via direct impacts and habitat alteration, and is expected to increase in the future (Schramm 2004).

Schmitt (2002) states that although water quality in most reaches has improved substantially from formerly severely degraded conditions, fish health remains impacted by various contaminants, in particular bioaccumulative organic compounds, throughout the river. _Meade (1995) also states that due to the extensive agriculture in the Mississippi floodplain and scattered urban areas, the river is an inland sink for fertilizers, pesticides and domestic and industrial wastes.

In the LMR, NMFS statistics for 1954-1977 show catches of 6-12 million kg and increasing over time (Risotto and Turner 1985). _Self-reported commercial harvests have been collected by the Tennessee Wildlife Resources Agency since 1990 and by the Kentucky Department of Fish and Wildlife resources since 1999. Annual catch for the Mississippi River bordering Tennessee during 1999-2000 varied from 36-125 tonnes. Landings of blue catfish and flathead catfish have increased substantially, while harvests of common carp, buffalo fishes, channel catfish and

freshwater drum have been highly variable. In Kentucky waters, catch ranged from 18-56 tonnes between 1999-2001, and buffalo and catfishes dominated the catch as well. Schramm (2004) notes that other states on the LMR either do not measure commercial catch or do so sporadically. In Louisiana commercial catch is measured but are not assigned to specific waters.

Brackish Water

In the brackish portions of the LMR the blue crab and penaeid shrimp (primarily white, brown and pink shrimp) are the two most important commercial groups. The blue crab commercial fishery in Louisiana is one of the largest crab fisheries in the U.S. in terms of biomass. A rapid growth in fishing effort occurred in the 1980's but by the mid-1990's the fishery exhibited declining catch rates. Although landings in Louisiana have decreased in recent years, landings averaged 42.9 million pounds during the 1990's which is 72.7% of the total Gulf of Mexico production. Marsh loss and habitat changes are two of the most important factors associated with the decreased production of blue crabs as well as excessive fishing effort, various environmental factors (reduced salinities), and illegal and incidental fishing mortality (LBCR 2005).

Commercial species represented 32% of the species (16 species of fish and 6 species of invertebrates) collected at the Paterson Plant during the 1977-79 impingement study. Commercial fish comprised 57% of the total impingement by number and commercial invertebrates represented 14% of the total impingement by number. At Michoud, 28% of the species (19 species of fish and 6 species of invertebrates) collected were commercially important species. Commercial fish comprised 31% and commercial invertebrates comprised 39% of the total impingement by number.

Blue crab represented 9.0% of the impinged organisms at Michoud (1977-79), 10.5% of the total at Paterson and 0.2% at Waterford 1 & 2 (1976-77). Based on estimated annual impingement rates (see Section IV), biomass measurements (from the Waterford 1 & 2 study), and high extended survivability rates, loss of blue crab from these facilities is insignificant, estimated to be much less than 0.1% of the total Louisiana landings. There should be no entrainment issues associated with blue crab also as they typically spawn in higher salinity waters.

Louisiana has the nation's most productive commercial shrimp fishery, landing about 100 million pounds a year at a dockside value of $150 million. The white shrimp and brown shrimp represent the vast majority of the landings. White shrimp represented 2.4% of the total abundance at Paterson and 20.0% of the total abundance at Michoud during the impingement studies in 1977-79. Using the estimated annual impingement rate for the Michoud Plant (see Section IV), extended survival probability of 50%, and 35 harvested shrimp per pound (LSU 2005), loss of white shrimp at these two plants is insignificant to the fisheries (<0.1%). Entrainment of white shrimp should also not pose a concern in the LMR as spawning typically occurs as far as 9 km from the shore in water depths of at least 9 meters (Whitaker 1983).

In 1977 and 1978 Gulf menhaden was the leading Louisiana species in volume and ranked third in value. In 1978 Gulf menhaden landings were a record 1,508 million pounds (Hollander 1981). In 2003 landings for all species harvested in Louisiana waters was 1.2 billion pounds. Mississippi landings were much less at 212 million pounds (NMFS 2005). Loss of organisms, due to impingement and/or entrainment at CWIS located in the LMR, are insignificant when compared to these figures.

Recreational Fisheries

The recreational fishery has not been rigorously defined in the LMR. Schramm (2004) states that fresh-water fishing catch rates are relatively high: but efforts are extremely low. Because of the large size, swift and dangerous currents, the presence of large commercial vessels and lack of public access, recreational fishing on these reaches has been largely discouraged. Providing access is difficult due to the large fluctuations in river levels and separation of many of the remaining floodplain lakes from the river during low water stages. Although recreational fishing has been somewhat limited historically on the main channel of the LMR, management agencies have initiated measures to improve access and increase public education regarding the fishing opportunities (Schramm 2004).

According to the literature, the recreational species targeted most often in the freshwater portions of the LMR include the bass, catfish, crappie, gar, and carp species. In the lower portions of the LMR increased salinity allows estuarine species to be targeted as well. Some species such as the spotted seatrout and southern flounder are usually not found in low salinity areas and would have minimal potential to be impinged and/or entrained at Entergy's lower plants. The sand seatrout (white seatrout) also a favorite of recreational fisherman, do inhabit areas within the tidal channels as demonstrated by the impingement data at the Patterson and Michoud (RM Mississippi River mile marker 92.6 AHP) plants where this species represented 12.6% and 4.2% of impingement, respectively. _Blue crabs are also targeted by recreational fishermen and have been documented at the Paterson and Michoud plants as well.

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3.4 Threatened and Endangered Species

The following threatened and endangered (T&E) species discussion focuses on federal and/or state listed species in Arkansas, Louisiana and Mississippi that have the potential to be impinged or entrained in the LMR. The federal T&E list (USFWS) and state lists (Louisiana and Mississippi) were reviewed and those species with any potential for impingement and/or entrainment are provided in Table B-3, located at the end of this Appendix. Literature was reviewed for the listed species, specifically for documented and expected occurrence in the LMR. The T&E lists can be queried per county/parish to determine the status of each species on a more regional level. Therefore the counties bordering the Mississippi River in Arkansas, Louisiana and Mississippi were the focus of the literature review. As a result of the literature review, very few species appear to have any potential to be impinged and/or entrained in the LMR.

T&E species suspected to inhabit, or that have been documented in the literature in the general vicinity of Entergy's LMR plants were retained for further consideration. A more in-depth analysis will be performed for the Comprehensive Demonstration Study (CDS). Most species were eliminated based on minimal potential to be found in the LMR, or due to their large size or non-aquatic nature (i.e., birds, whales, manatee, etc). The Cumberlandian combshell (a freshwater mussel), for example, has only been documented in Tishomingo County (northeast corner of Mississippi), therefore is not expected to inhabit the LMR. The Ozark cavefish listed in Arkansas, only inhabits underground caves, therefore should not be found in the LMR. Other species including the bayou darter was eliminated as a species of concern even though it has been documented in a county bordering the LMR. This species has been documented near the Mississippi River in both Claiborne and Lincoln counties, however it is apparently restricted to Bayou Pierre and the lower reaches of its tributaries: White Oak Creek, Foster Creek, and Turkey Creek in Mississippi (Ross 2001). Due to this species' apparent restriction to Pierre Bayou, and its habitat preference for shallow riffles and runs over coarse gravel or pebbles, it was not retained for further consideration since it has minimal potential for impingement and/or entrainment in the LMR. Other species eliminated from consideration were done so based on similar reasoning.

Bob Hoffman with the National Oceanic and Atmospheric Administration (NOAA) was contacted to determine the potential for sea turtles to inhabit the lower reaches of the LMR and tidal channels near the Michoud and Patterson Plant's (Hoffman 2005). Mr. Hoffman indicated that the loggerhead sea turtle is sometimes caught in commercial shrimp trawls in Lake ~~Ponachetrain~~Pontchartrain which is just north of these two plants. He stated the numbers in this area were fairly low. Two additional sea turtle species, the Kemp's Ridley and green, also inhabit the lower reaches of the LMR; however, Mr. Hoffman stated they would be rare this far up the river. He also stated that few sea turtles should be found above ~~RM~~ Mississippi River mile marker 90 AHP. According to Mr. Hoffman, the average size of most sea turtles in the area is between 1 and 2 feet in diameter (carapace size). Based on the use of intake racks, relatively low intake velocities, and the size of sea turtles in the area, he believes that potential impact to sea turtles associated with CWIS would be almost nonexistent. Based on this information, sea turtles were determined to have no impingement potential in the LMR.

Pallid Sturgeon (Endangered)

The pallid sturgeon is listed as endangered by the USFWS, Mississippi and Louisiana. This species can weigh up to 80 pounds and reach lengths of 6 feet, whereas the closely related shovelnose sturgeon rarely weighs more than 8 pounds.

Pallid sturgeons evolved and adapted to living close to the bottom of large, silty rivers with a natural hydrograph. Ross (2001) also states that this species is essentially restricted to the main channels of the Missouri and Mississippi Rivers. He states the principal habitat of the pallid sturgeon is the main channel of large, turbid rivers, although some have been captured from mainstem reservoirs on the Missouri River. Schramm (2004) stated that this species is considered

rare in the UMR and occasionally collected in the LMR. He also states that the pallid sturgeon is a riverine dependent species that is most likely to be found in the main channel or channel border.

Sexual maturity for males is estimated to be 7-9 years, with 2-3 year intervals between spawning. Females are not expected to not reach sexual maturity until 7-15 years, with up to 10-year intervals between spawning. _Pallid sturgeons are long lived, with individuals perhaps reaching 50 years of age (USFWS 1998). _According to Ross (2001) spawning coincides with spring runoff, and occurs between March and June throughout the species' range. Fishes in Louisiana and Mississippi begin spawning earlier than those in more northern areas.

Today, pallid sturgeons are scarce in the upper Missouri River above Ft. Peck Reservoir; scarce in the Missouri and lower Yellowstone Rivers between Ft. Peck Dam and Lake Sakakawea; very scarce in the other Missouri River reservoir reaches; scarce in the Missouri River downstream of Gavins Point Dam; scarce but slightly more common in the Mississippi and Atchafalaya Rivers; and absent from other tributaries (USFWS 1998).

All of the 3,350 miles of riverine habitat within the pallid sturgeons range have been adversely affected by man. _Approximately 28% has been impounded, which has created unsuitable lake-like habitat; 51% has been channelized into deep, uniform channels; the remaining 21% is downstream of dams which have altered the river's hydrograph, temperature, and turbidity. Commercial fishing and environmental contaminants may have also played a role in the pallid sturgeon's decline (USFWS 1998).

Jack Killgore with the USACE in Vicksburg was contacted for further information related to the pallid sturgeon (Killgore 2005, personal communication). He stated they have conducted species-specific sampling in the LMR and have not collected pallid sturgeon below ~~RM~~ Mississippi river mile marker 180 AHP. He stated the young of the year (YOY) fish <120 mm only swim 50 cm/sec., therefore would be of some concern at CWIS. Larger fish swim >3.0 fps and can out-swim typical intake velocities. Dr. Killgore stated that the pallid sturgeon almost always swims against the current and often employs a tactic called "hunkering" or substrate oppression. This is where the fish extends the pectoral fins and uses available substrate to hold on to. Doing this allows fish to alternately swim and rest when in strong currents.

Pallid sturgeon were impinged at the Waterford 1 & 2 plant in 1976 (2 juveniles) and at the Willow Glen plant (1 juvenile) in 1975. Based on the habitat and salinity at Michoud and Paterson, pallid sturgeon are not expected there.

Gulf sturgeon

The USFWS (2003) provides the following summary of the Gulf sturgeon, *Acipenser oxyrinchus*. This species is an anadromous fish (breeding in freshwater after migrating up rivers from marine

and estuarine environments), inhabiting coastal rivers from Louisiana to Florida during the warmer months and overwintering in estuaries, bays, and the Gulf of Mexico.

Historically, the Gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Its present range extends from Lake ~~Ponachetrain~~Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Sporadic occurrences have been recorded as far west as the Rio Grande River between Texas and Mexico, and as far east and south as Florida Bay. Due to its present range, the Paterson and Michoud plants are the only two plants of concern.

Gulf sturgeon feeding habits in freshwater vary depending on the fish's life history stage (i.e., young-of-the-year, juvenile, subadult, adult). Young-of-the-year Gulf sturgeon remain in freshwater feeding on aquatic invertebrates and detritus approximately 10 to 12 months after spawning occurs. Juveniles less than 5 kg (11 lbs) are believed to forage extensively and exploit scarce food resources throughout the river, including aquatic insects (e.g., mayflies and caddisflies), worms (oligochaetes), and bivalve molluscs. Subadult (age 6 to sexual maturity) and adult (sexually mature) Gulf sturgeon do not feed in freshwater.

Gulf sturgeon are long-lived, with some individuals reaching at least 42 years in age. Age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years. Gulf sturgeon eggs are demersal (they are heavy and sink to the bottom), adhesive, and vary in color from gray to brown to black. _Mature female Gulf sturgeon weighing between 29 and 51 kg (64 and 112 lb) produce an average of 400,000 eggs. _Habitat at egg collection sites consists of one or more of the following: limestone bluffs and outcroppings, cobble, limestone bedrock covered with gravel and small cobble, gravel, and sand (USFWS 2003).

The Gulf sturgeon has been documented in the LMR and Lake ~~Ponachetrain~~Pontchartrain; however, there is no record of Gulf sturgeon impingement at any of the Entergy plants.

Southern redbelly dace

The endangered southern redbelly dace is only listed by the state of Mississippi. It is a slender minnow, ranging from 1.6 to 2.8 inches in length, with extremely small scales and two narrow dusky stripes along its side. This species prefers permanent brooks of clear unpolluted water which flow between wooded banks and contain long pools of moving water (ODNR 2005). According to Ross (2001) this species occurs in upland streams of the Great Lakes and the Mississippi River Basins from Minnesota into the lower Tennessee River drainage of Tennessee, Alabama, and Mississippi. He also states the fish are typical of small, cool, clear streams with gravel, rubble, silt, and sand substrata. _Dace are quite habitat specific, so they are highly susceptible to localized environmental disturbance. _Sites where they have disappeared are characterized by erosion and loss of forest canopy cover, often associated with increased urban development.

The southern redbelly dace feeds in groups along the bottom on herbaceous material (ODNR 2005). Based on studies conducted in Minnesota and Kentucky, southern redbelly dace consume bottom sediments, including large quantities of sand, silt, and organic detritus and lesser amounts of aquatic insects (Ross 2001).

In Kentucky, southern redbelly dace spawn from late March to July. Total ova range from 5,708 to 18,887 in fish of 70-78 mm total length._ Southern redbelly dace are nest associates, spawning over nests or mounds of *Semotilus*, *Campostoma*, and *Nocomis*. As a consequence hybrids are common with other nest building fish. The total life span of the southern redbelly dace is approximately 3-4 years (Ross 2001).

According to Ross (2001) southern red-bellied dace is known in three drainages and four river systems in Mississippi: the lower Mississippi River South (Clark Creek, Hatcher Bayou), the Tennessee River (Clear Creek and unnamed tributary to Indian Creek), the Tallahatchie River (Murphy Branch), and the Yazoo River (Bliss Creek and Skillikalia Bayou and tributaries. Ross notes that recent attempts to collect the species in the vicinity of Vicksburg indicate that populations still remain in portions of Bliss Creek and Skillikalia Bayou in Warren County (Yazoo River system), and in Murphy Branch, Tallahatchie County (Tallahatchie River system). Compared to historical data, populations in Bliss Creek and Skillikalia Bayou have declined and Southern redbelly dace are apparently extirpated from Hatcher Bayou (lower Mississippi River South system) in Warren County.

In Arkansas southern redbelly dace have been documented primarily in the northwestern portion of the state. _A few individuals have been documented in the northeastern portion of the state inland from the Mississippi River (Robison and Buchanan 1992). Schramm (2004) stated that this species has been collected in the Mississippi River but there have been no records of collection since 1978. _The southern redbelly dace has been reported in backwaters but is most likely to be found at the channel border in the Mississippi River. This species has not been documented in any of the impingement studies reviewed. Finally, the habitat encountered at all of the CWIS is poorly suited to this species. Therefore, their potential impingement and/or entrainment appear very minimal.

<u>Crystal darter</u>

The endangered crystal darter is listed only by the state of Mississippi. The species prefers clean sand and gravel raceways of large rivers (Ross 2001). The crystal darter buries itself with only eyes protruding, as it lies in wait for passing prey. Spawning likely occurs in early spring in Mississippi, based on development of breeding tubercles in males (Collette 1965) and on the January-April spawning season documented for crystal darters in Arkansas. The presence of several size classes of oocytes suggests that this species produces multiple egg clutches. Mature or ripening eggs are 1.0 – 1.2 mm in diameter, and clutch sizes vary from 106 to 576 in fish of 62-87 mm standard length (SL). In Arkansas, mature male crystal darters averaged 76 mm SL and

mature females averaged 66 mm SL. Both sexes reach maturity after their first year. The life span of this species is between 2.5 and 4 years (George *et al.* 1996).

In Mississippi the crystal darter has been documented in several locations including Claiborne County, which borders the Mississippi River south of the Baxter Wilson Plant, however it appears limited to Bayou Pierre (Ross 2001). _In Arkansas, this species inhabits the lower reaches of moderately sized rivers, mainly below the Fall Line, where it is typically found in strong current over a sand or fine gravel substrate (Robison and Buchanan 1992). In Louisiana the crystal darter has only been documented from the Ouachita and Pearl River systems at locations inland from the Mississippi River (Douglas 1974).

Shramm (2004) considers the crystal darter rare in the LMR. He also states that this species is riverine dependent and is most likely to be found on the channel border or backwaters of the LMR. This species has some potential to be found in the LMR, therefore was retained as a T&E species of concern. Since this species is only listed by the State of Mississippi, impingement concerns are primarily focused on the Gerald Andrus and Baxter Wilson Plants._ This species has not been documented in any of the impingement studies reviewed in this Appendix therefore their potential for impingement and/or entrainment appears very minimal.

Pyramid pigtoe

The endangered pyramid pigtoe mussel is listed only by the state of Mississippi. It has been documented in several counties including two counties that border the Mississippi River; Washington and Warren counties. The Gerald Andrus and Baxter Wilson Plants are located in these two counties, respectively. This species has not been documented in any of the impingement studies reviewed therefore their potential for impingement and/or entrainment appears very minimal. _This species was retained as a species of concern due to their historical presence near the above mentioned two plants.

Fat pocketbook

The endangered fat pocketbook mussel is listed statewide for both Arkansas and Mississippi and by the USFWS. This species has not been documented in any of the impingement studies reviewed therefore their potential for impingement and/or entrainment appears very minimal. According to the USFWS (1997), today the fat pocketbook is found only in the lower Wabash and Ohio rivers, and in the lower Cumberland river._ Impoundments and dredging for navigation, irrigation and flood control have altered or destroyed much of this mussel's habitat, silting up its gravel and sand habitat and probably affecting the distribution of its fish hosts._ This species was retained for further consideration due to its wide historical range and state-wide listing.

This mussel prefers sand, mud, and fine gravel bottoms of large rivers. _It buries itself in these substrates in water ranging in depth from a few inches to eight feet, with only the edge of its shell and its feeding siphons exposed (USFWS 1997).

Reproduction requires a stable, undisturbed habitat and a sufficient population of fish hosts to complete the mussel's larval development. When the male discharges sperm into the current, the females downstream siphon in the sperm, in order to fertilize their eggs, which they store in their gill pouches until the larvae hatch. The females then expel the larvae. Those larvae that manage to find a host fish to clamp onto by means of tiny clasping valves, grow into juveniles with shells of their own. At that point they detach from the host fish and settle into the streambed, ready for a long (possibly up to 50 years) life as an adult mussel (USFWS 1997).

Paddlefish

Paddlefish, which were once prevalent in all of the tributaries of the Mississippi River, have been in decline due to habitat destruction and river modification, and were proposed for listing under the Endangered Species Act (ESA) in the 1990s. Although they were not listed under the ESA, trade in paddlefish became regulated under the CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora in 1992. Fish and Wildlife studies and state reviews caused several states to list and protect paddlefish, while adjacent states continued to maintain sport and commercial fisheries. This interstate problem was addressed in the 1991 founding of the Mississippi Interstate Cooperative Resource Association (MICRA) and its development of regional plans and research projects. MICRA continue to address the issues of inter-jurisdictional problems posed by the migratory paddlefish (Rasmussen and Graham 1998).

In Louisiana and Mississippi the paddlefish is given an S3 ranking (National Heritage Ranking System) which means it is rare and local throughout the state, or found locally (even abundantly at some of its locations) in a restricted region of the state, or because of other factors making it vulnerable to extirpation (21 to 100 known extant populations).

Populations still occur in 22 states._ Fourteen states allow sport fishing for paddlefish while only six states allow commercial harvesting. Ten states currently stock paddlefish to supplement natural populations or re-establish paddlefish in areas where they had formerly occurred (Graham 1997). _Schramm (2004) stated that this species is occasionally taken in the LMR. He also states that the paddlefish is a riverine dependent species that is most likely to be found in all three major habitat zones (river channel, channel bank, and backwaters).

Paddlefish spawn in the spring and usually require fast flowing water (floods which lasts several days), and clean sand or gravel bottoms for successful spawning. _During spawning paddlefish gather in schools. Young fish grow quickly, as much as six inches in several months. Fish generally become mature at 5-10 years and may live to be 20-30 years old. Paddlefish are

plankton feeders inhabiting open waters where they can filter large quantities of water (Chilton 1997).

Paddlefish have been documented in several of the LMR impingement studies reviewed in this Appendix. At Waterford 1 & 2 four paddlefish were impinged in June/July 1976; at Willow Glen (Unit 1 & 2) 5 individuals were impinged in June/July 1975; at Willow Glen (Unit 4) 2 individuals were impinged in July and December 1976; and at Baxter Wilson 104 individuals were impinged in 1973/1974 throughout the year. Although paddlefish numbers have declined the past several decades, impingement rates today are not expected to be at this same level. However, the data indicate paddlefish do utilize habitats near intake screens in the LMR; therefore, they are a species of concern.

4.0 CHARACTERIZATION OF ALL LIFE STAGES [125.95(B)(3)(II)]

The rule calls for the characterization of all stages that might be subject to impingement and, if appropriate, entrainment. This characterization is necessary to ensure the full scope of any potential impact is understood and that any implications for selection of mitigation measures are known. Entergy believes that the general literature supports understanding of the potential impacts to all life stages. As importantly, the impingement studies that are available were designed to facilitate understanding of diel and annual variations.

4.1 Life Stages Subject to IM and E

Life stages subject to entrainment are determined primarily by intake screen mesh size which is typically ⅜". Any life stage of fish or invertebrates less than the screen mesh size, is subject to entrainment including egg and post-larval individuals. Eggs are more susceptible as they lack any swimming capabilities. Post-larval organisms do have some swimming capabilities, although limited, and can at times escape the approach velocity associated with CWIS. As the organism grows larger than the mesh size of the CWIS screens, they become subject to impingement.

Most of the plants considered in this Appendix are only subject to performance goals for impingement mortality. The requirement to control entrainment is dispensed due to the low proportion of average annual river discharge used by the plant. US EPA concluded that, under this circumstance, any entrainment loses are likely to be minimal relative to the existing population.

Life stages subject to impingement include all stages greater than the intake screen mesh size. Impingement varies with species but young of the year (YOY) individuals dominated historical LMR impingement studies (based on length and weight data and observations). Exceptions were smaller species that typically do not exceed several inches in length even as adults. Current anecdotal observations also indicate that YOY currently dominate impingement at LMR CWIS.

Impingement data from other water_bodies (including Galveston Bay) also show a dominance of YOY on traveling water screens compared to adult organisms. Due to the placement of trash racks and debris screens on intake pipes, and due to their ability to out-swim intake approach velocities, larger organisms are not typically subject to impingement. Some exceptions include invertebrates (e.g., shrimp, crayfish, blue crab) which are generally smaller than fin-fish and have reduced swimming abilities. Adults of these species may become impinged in addition to juveniles.

Length data collected during the 1970's impingement studies demonstrate that YOY or juveniles typically dominate impingement. Average lengths for impinged individuals are as follows: gizzard shad (11.5 cm), threadfin shad (6.3 cm), freshwater drum (8.6 cm), blue catfish (8.7 cm), river shrimp (5.6 cm), channel catfish (7.2 cm), bluegill (4.6 cm), skipjack herring (11.9 cm) and common carp (39.9 cm) (Table B-2). Lengths for all of these species, except the common carp, are more typical of younger individuals than for adults.

4.1.1 Review of Impingement Data at the Freshwater Plants

Historic impingement data from Baxter Wilson, Waterford Units 1 and 2, Willow Glen Units 1 and 2 and Unit 4 are summarized in Table B-4. Impingement rates were calculated based on effort and flow. Impingement rates calculated based on effort resulted in an estimate of the number of organisms impinged per sampling event (typically 24 hours in duration) that was then extrapolated to an annual rate. The impingement rates calculated based on flow resulted in an estimate of the number of organisms impinged per volume of water sampled during the study, which was standardized to 10,000 cubic meters.

Baxter Wilson Impingement Study

Between March 12, 1973 and August 20, 1973, and between August 31, 1973 and March 1, 1974, an impingement study was conducted at Entergy's Baxter Wilson plant (Mississippi River mMile marker -433.2 AHP) (MP&L 1974). The study was conducted to verify estimates of fish impingement for the Grand Gulf Nuclear Station. The data for this study was compiled and submitted in two separate documents. Samples for the spring through summer 1973 were collected daily for the first two months and thereafter twice a week for either 24 or 48 hours and resulted in the collection of 36,326 fish and 1,186 invertebrates (37,512 total)._ Fifty-four fish species and twelve species of invertebrates were collected in the study. The samples for the August 1973 through March 1974 collection period consisted of a total of 18 sample days at Unit 1 and 14 sample days at Unit 2. _A total of twenty-five species of fish and eight invertebrate species were collected (2,517 total individuals). _With few exceptions, all of the fish were juveniles. The exceptions were the minnows, threadfin shad, bullheads and an occasional mature species of a larger fish such as gar or suckers. The majority of the river shrimp, however, were mature adults (MP&L 1974).

The shad species (gizzard, threadfin, and shad *spp.*) dominated impingement rates representing 56.3% of the total abundance followed by freshwater drum (31.7%), carp (2.7%), river shrimp (2.6%), white crappie (1.5%), sucker (1.3%), channel catfish (0.7%) and skipjack herring (0.4%). The estimated annual impingement rate is 160,730 individuals which equates to 1.96 individuals per 10,000 m^3 of water pumped through the plant.

Impingement rates were higher for Unit 2 by a ratio of 3.5 to 1 prior to July and 1.3 to 1 after July (March through July 1973). The differences observed in impingement rates between Unit 1 and Unit 2 were explained by two factors; (1) differences in design between the CWIS; and (2) differences in intake velocities (Unit 2 was higher) (MP&L 1974).

From March through June average daily impingement was relatively low (average of 25.6 organisms per day at the combined units). A sharp increase began in late June and peaked in mid-July reaching 3,916 organisms per day at Unit 1 and 4,952 organisms per day at Unit 2. By the end of August rates returned to pre-July values. The increased rate of impingement in mid-July was likely precipitated by two factors: (1) river stage decreased below flood stage, resulting in increased fish density in the river's main channel and (2) the importance of juveniles in the population. One of the effects of flooding is decreased fish density in the river proper, particularly during the reproductive period, as fish disperse into flooded backwaters. When the river returns within its banks, fish densities increase again. (MP&L 1974). Another factor contributing to the increased impingement in July is that larval fish, which previously were entrained in the spring, had grown significantly and were more prone to being impinged. In addition, these juvenile fish were more susceptible to impingement, due to their reduced swimming speed.

The decline in impingement after the mid-July peak was probably caused by the following two factors. YOY fish typically have an annually mortality rate of 95 to 99% and many of the fish died; and as the fish grow their swimming ability increases and they can avoid being impinged (MP&L 1974).

Waterford 1 and 2 Impingement Study

Espey, Huston and Associates, Inc. (1977) conducted a study between February 1976 and January 1977 at Entergy's Waterford Unit 1 and 2 CWIS. The purpose of the investigation was to evaluate the impact of the existing intake structures on the biota of the Mississippi River. The facility is located at Mississippi River Mmile marker 13029.9 on the west descending bank of the Mississippi River in Killona, Louisiana. Impingement sampling was conducted for 24 hours every two weeks for one year for a total of 24 samples. The report generated from this study includes individual lengths and weights for all species for each sampling event.

Results of this study show that many more fish were impinged compared to invertebrates. Total sample weight for each 24-hour sample ranged from 3,593 grams to 33,560 grams. Organisms varied in length from 25-30 mm to over 600 mm for some of the carp and American eels. River

shrimp dominated numerically and represented 49.7% of the total abundance followed by blue catfish (20.3%), threadfin shad (10.5%), bay anchovy (6.0%), freshwater drum (4.5%), gizzard shad (2.9%), skipjack herring (2.4%), channel catfish (2.1%), striped mullet (0.3%), and blue crab (0.2%). These ten species represented 98.7% of the total abundance. _Annual impingement rates were estimated to be 336,454 individuals which equates to 4.33 individuals per 10,000 m^3 of water pumped through the plant.

Willow Glen Plant

The Willow Glen Plant is located on the Mississippi River near ~~RM~~ mile marker 201.6 AHP. _Units 1 & 2 and Unit 4 were sampled individually. _The sluiceways were sampled for thirty-minutes four times per day, and four times per month (April-July) or two times per month (remainder of the year) between January 1975 and January 1976. The screens were rotated just prior to each sampling and, taken ~~together,~~ together; these samples represent a complete characterization of impingement over the relevant 24-hour period. Impingement rates based on flow were calculated individually for Units 1 & 2 and Unit 4 and then weighted to estimate the annual impingement when all five units were in operation. The annual weighted impingement was estimated to be 126,449 organisms per year, assuming maximum operation of all five units.

Unit 1 and 2

River shrimp represented 57.3% of the total abundance followed by freshwater drum (22.1%), gizzard shad (5.7%), threadfin shad (5.1%), crayfish, *procambarus spp.* (2.6%), blue catfish (2.4%), black crappie (0.7%), skipjack herring (0.6%), bluegill (0.6%), and white crappie (0.5%). These top ten species represented 97.4% of the total abundance. Using the figures from this study, annual impingement at Units 1 and 2 is estimated to be 26,210 organisms based on effort. Using the flow information recorded during the study, the impingement rate was 1.47 individuals per 10,000 m^3 of water pumped through the two units or 50,013 organisms per year.

Biomass and total abundance were analyzed for seasonal differences. Biomass varied somewhat throughout the year, however it was much higher in the spring and early summer (mid-March through early July) compared to the rest of the year. Total abundance showed similar trends with much higher rates in the summer (mid-June through early August). _The river shrimp contributed much of the observed seasonal difference observed.

Unit 4

River shrimp also dominated the collections at Unit 4 and represented 27.5% of the total abundance followed by crayfish (27.0%), freshwater drum (12.5%), gizzard shad (9.3%), threadfin shad (7.5%), blue catfish (5.8%), bluegill (1.4%), white crappie (1.4%), channel catfish (1,2%) and skipjack herring (0.9%). These ten species represented 95.4% of the total abundance. Based on effort the annual impingement at Unit 4 is estimated to be 5,037 organisms. Using the flow

information recorded during the study, the impingement rate was 0.13 individuals per 10,000 m^3 of water pumped through the Unit or 5,897organsims per year.

Total abundance showed similar trends observed at Unit 1 and 2 with higher rates in the summer (mid-June through early August). River shrimp and crayfish contributed much to this apparent peak in the warmer months of the year.

4.1.2 Review of Impingement Data at the Brackish Plants

A.B. Paterson Plant

The A.B. Paterson (Paterson) Plant is located in the New Orleans Parish on the Inner Harbor Navigational Canal (IHNC) just south of Lake PonachetrainPontchartrain. The IHNC splits from the Mississippi River near River Mile (RM)mile marker 92.6 AHP. A total of 523 samples (10-minute samples collected every 4-hours every other Thursday) were collected between August 1977 and December 1979 at the plant. Again, the samples can be grouped to represent a complete characterization or the impingement rate for a 24 hour period. A total of 68 species were collected from the sluiceway during the study. Atlantic croaker represented 32.3% of the impinged organisms followed by bay anchovy (17.1%), white (sand) seatrout (12.6%), blue crab (10.5%), Gulf menhaden (6.6%), sea catfish (4.5%), white shrimp (2.4%), spot croaker (1.9%), spotted seatrout (1.8%) and hogchoker (1.1%). These ten species represented 90.7% of the total abundance in the study.

Using the figures from this study, annual impingement is estimated to be 226,489 organisms which equates to 5.42 individuals per 10,000 m^3 of water pumped through the plant. _Weighted extended survival of the primary species impinged at the facility show that 37% of the organisms will survive impingement which significantly reduces any potential adverse impact created by the plant._ Results of this study showed that "during 1978-1979 estimated impingement impact for both stations (Patterson and Michoud) is less than the estimated impact of one local commercial fisherman operating half the time during the shrimping season". Estimated impingement impact of the Paterson Plant was 2.5% (1978) and 0.5% (1979) of 1 commercial fishing boat.

Since samples were collected every four hours, potential daily (diel) impingement fluctuations were analyzed. Minimum impingement rates were observed at 0400 and 2400 at Unit 1; 0400 and 1600 at Unit 3 and 0400 and 2000 at Unit 4. Maximum impingement rates were observed at 0800 at Unit 1; 2000 at Unit 2; 0800 and Unit 3; and 0800 at Unit 4. Although impingement rates were somewhat variable depending upon the unit, the very early hours of the day (0400) showed the lowest impingement rates, and the mid-morning hours (0800) had the highest impingement rates. _Potential seasonal variations were also analyzed at the plant and it was determined that the impingement rates were higher January through March in 1978 and in January in 1979.

Michoud Plant

The Michoud Plant is also located in the New Orleans Parish on the Intercoastal Waterway (ICWW) which splits from the Mississippi River near RM mile marker 92.6 AHP. A total of 666 samples were collected at this plant between August 1977 and December 1979 (10-minute samples collected every 4-hours every other Thursday). A total of 91 species were collected from the sluiceway during the study. Atlantic croaker represented 21.5% of the organisms collected followed by white shrimp (20.0%), bay anchovy (13.5%), brown shrimp (10.5%), blue crab (9.0%), sea catfish (7.8%), white seatrout (4.2%), gafftopsail catfish (1.8%), least puffer (1.6%) and blackcheek tonguefish (1.4%). These ten species represented 91.2% of the total abundance in the study.

Using the figures from this study, annual impingement is estimated to be 1,676,726 organisms which equates to 9.41 individuals per 10,000 m^3 of water pumped through the plant. Weighted extended survival of the primary species impinged at the facility show that 57% of the organisms will survive impingement which significantly reduces any potential adverse impact created by the plant. Results of this study were the same as the Patterson Plant study that showed "during 1978-1979 estimated impingement impact for both stations (Patterson and Michoud) is less than the estimated impact of one local commercial fisherman operating half the time during the shrimping season". Estimated impingement impact of the Michoud Plant was 12.7% (1978) and 2.2% (1979) of 1 commercial fishing boat.

Since samples were collected every four hours, potential daily (diel) impingement fluctuations were also analyzed at the Michoud plant. Minimum impingement rates were observed at 0400 and 1600 at Unit 1; 0400 and 1600 at Unit 2 and 1600 at Unit 3. Maximum impingement rates were observed at 0800 at Unit 1, 2, and 3. Although impingement rates were somewhat variable depending upon the unit, the very early hours of the day (0400) and mid-day (1600) showed the lowest impingement rates, and the mid-morning hours (0800) showed the highest impingement rates, consistent with the Paterson data.

Seasonal variations were also analyzed in this study and it was determined that impingement rates were highest in April, August and September in 1978, and in February and May in 1979.

4.2 Temporal variations in IM and E

Understanding of the temporal variations in impingement and entrainment is important for two potential reasons:

- In order to characterize accurately impacts of impingement mortality and entrainment. For example, if impingement events were more significantly common during the night, failure to sample during both day and night would bias the daily estimates of impingement.

Entergy believes that the existing data sets address this issue by inclusion of sampling throughout the year as well as both day and night conditions.

- In order to assess whether periodic flow reduction might serve as a mitigation measure. For example, if it can be demonstrated that impingement mortality occurs during a specific season and the plant can be idled or run with reduced cooling water flow during that period, this might present an effective mitigation strategy. At this point, Entergy is not able to commit to such operational measures.

4.2.1 Annual

Temporal variations in IM and E are the result of both biological factors (e.g., spawning season, migrations, etc.) and non-biological factors (e.g., river stage, plant operational status, etc.). Due to the multitude of factors that can potentially affect impingement mortality and entrainment at a given location, temporal variations are difficult to ascertain. Specific knowledge of the waterbody, plant CWIS, and the dominant species in the area can allow temporal variations to be estimated. Much of this information is available from the literature. One obvious factor that can affect impingement mortality and entrainment, and which takes precedent over biological factors is the operational status of a plant. Many plants operate on a "peaking reserve" status and only operate on a limited basis when energy production is needed. Typically power demand increases in summer, thus increasing impingement mortality and entrainment rates during the warmer months due to the increase in water withdrawal. As noted above, none of the Entergy plants can commit to such seasonal reductions in capacity. It should also be noted that the data available from the plants were collected during normal operating conditions and, therefore, do not reflect any bias associated with differential plant operation.

Spawning season is one of the most important biological factors affecting impingement mortality and entrainment rates. The primary period of reproduction and peak abundance of most LMR taxa is during the months of spring (typically March through May). The peak time of egg recruitment is during early spring, while larval recruitment is primarily late spring and early summer. Spring and summer therefore appear to be the most important seasons in the LMR in regards to entrainment as this is the time eggs and larval organisms are most abundant. Many of these organisms will be able to avoid entrainment later in the year as they grow larger, and increase their swimming ability.

It is interesting to note that the spawning period in the LMR correlates to the seasonal flooding/high water period. At the Waterford Unit 3 plant, for example, seasonal average flows have been calculated to be 580,000, 650,000, 280,000 and 240,000 cfs for winter, spring, summer, and fall, respectively. Elevated flows most likely push the eggs and larval fish past the CWIS more so than the rest of the year due to increased velocities.

In the Baxter Wilson impingement study previously discussed, it was observed that daily impingement was relatively low from March through June, with a sharp increase in late June peaking in mid-July. The increased rate of impingement in mid-July was likely precipitated by the reduction in river volume and the growth of juvenile fish. The reduction in impingement after mid-July was most likely caused by high natural mortality associated with most species, and an increase in swimming ability.

In the Waterford 1 & 2 study previously discussed, the most abundant species were also analyzed for seasonal variations in impingement rates. River shrimp were much more abundant from April through October with very few individuals impinged in the winter and early spring. The species with the most noticeable seasonal variation was bay anchovy which averaged well below 100 organisms per 24-hours except for the October 1976 sample where a marked increase occurred to 1100 individuals per 24-hours. Blue catfish impingement rates were variable throughout the year with no noticeable increase during any particular season, although winter rates were the highest observed. Freshwater drum showed an increase in impingement rates primarily during the summer (June through September). Threadfin shad impingement rates were relatively constant except for an increase in July and an increase in the winter months (December through January). *Gizzard shad impingement rates were constant throughout the year except for a slight* increase in the early winter from November through January. When all species were considered, there was no apparent seasonal difference in impingement rates, although temporal variations were observed with individual species.

Biomass and total abundance were analyzed for seasonal differences at the Willow Glen plant as well (Unit 1 & 2, and Unit 4). Biomass was variable, however higher values were observed in spring and early summer (mid-March through early July) compared to the rest of the year. Total abundance showed similar trends with higher rates in the summer (mid-June through early August). River shrimp and crayfish contributed much to this apparent peak in the warmer months of the year.

Potential temporal (seasonal) variations were also analyzed at the Paterson plant and it was determined that the impingement rates were higher January through March in 1978 and in January in 1979. Seasonal variations at the Michoud plant showed higher impingement rates in April, August and September in 1978, and in February and May in 1979.

4.2.2 Diel

As discussed previously, samples were collected at the Paterson Plant every four hours. Although impingement rates were somewhat variable depending upon the unit, the very early hours of the day (0400) showed the lowest impingement rates, and the mid-morning hours (0800) had the highest impingement rates.

Although impingement rates were variable at the Michoud Plant and were unit dependent, minimum impingement rates were typically observed in the very early hours of the day (0400) and mid-day (1600). The mid-morning hours (0800) showed the highest impingement rates consistent with the Paterson plant data.

Diel variations observed are most likely caused by species-specific daily patterns associated with rest and feeding periods. Organisms are much more active and mobile when feeding, and therefore have a higher chance of becoming impinged during these periods. In general most aquatic organisms are more active in the morning hours at daybreak which was demonstrated at the Paterson and Michoud Plants.

4.2.3 Importance of Temporal Variations

Power plants typically operate at consistent levels due to electricity demand and to reduce equipment stress and Operation & Maintenance (O&M) costs. For power plants that operate on an annual basis, temporal variations in impingement mortality and entrainment (both seasonal and diel) have no bearing on their operations. Since power plant production is driven by demand, which is typically higher in the warmer months, operational measures to specifically reduce impingement mortality and entrainment would be difficult to establish. Therefore, temporal variations have little bearing on the evaluation of potential mitigation measures. As noted above, Entergy believes that the available data were collected over the full range of diel and annual *variation allowing for a complete assessment.*

4.3 Spatial Differences in IM and E

Spatial differences in population densities are caused by many factors including habitat, water depth, and velocity. Most studies show higher fish densities at the channel bank and backwaters compared to the main channel. This is primarily due to increased habitat area, shallow water depths, and reduced river velocities. Beckett and Pennington (1986) stated that densities of larval fishes in the LMR are highest in backwaters, which are important nurseries for fishes, and which contain a larval fish assemblage differing from that of the main-stem river. Although the LMR provides plentiful habitat for fishes that thrive in swiftly flowing water, few species can tolerate the high current velocities of the upper and middle water column of channel areas for very long. Most fish prefer the channel bottom where current is slower (Baker *et al.* 1991). Most fishes likely inhabit areas near the banks, and most generally prefer the shallow, slower inside edge of a river as opposed to the deeper, faster current of the cut-bank edge (Pennington *et al.* 1983 and Sempra 2002). Since many fish exhibit specific preference for certain types of habitat, stream or river locations with diverse habitats may be expected to contain more fish species than locations with fewer habitat types (Schlosser 1982; Angermeier and Karr 1984; Reeves *et al.* 1993).

Since many fish species feed on invertebrates, their habitat preference is important as well. Rocky substrates associated with dike structures on the LMR support higher total densities of

aquatic invertebrates than abandoned channels, natural river banks, dike fields, temporary secondary channels, sandbars, revetted banks, main channel, and permanent secondary channels (habitats listed in order of decreasing invertebrate density) (Wright 1982). This apparent habitat preference for invertebrates further substantiates the fact that most fish will be associated with closer inshore (bank) habitats than deeper offshore habitats.

During the development of the Phase I 316(b) rules, the US EPA specifically notes that the selection of the location of the CWIS is one construction and design technology which can be used to minimize the impact of impingement mortality and entrainment (Sempra, 2002). The Phase II 316(b) rule also allows the highest density of organisms in the vicinity of the CWIS to be used as the Calculation Baseline. Using the reasoning for the Phase I rule and the Phase II Calculation Baseline, the location of *existing* intake structures (away from shoreline and in high velocity waters) could be used to "claim" credit for the reduction of impingement mortality and entrainment.

For Sempra's Phase I 316(b) Comprehensive Demonstration Study on the LMR near ~~RM~~ Mississippi River mile marker 132 AHP, they selected an offshore (between 150 and 675 feet depending on river stage) "middle" depth (between 16 and 30 feet depending on river stage) location for the CWIS for the sole purpose of minimizing the number and species of fish affected.

Most of Entergy's plants located on the river have their CWIS in a similar location.

4.3.1 Review of Habitats

Preferred habitat is defined as an area or habitat that an animal frequents most often, due to the unique characteristics of the habitat. Baker and his colleagues (Baker *et. al.* 1991) conducted an extensive study on aquatic habitats and fish communities in the LMR in which they identified all the potential habitat types found in the LMR and the species that prefer each habitat. The researchers found 13 distinct aquatic habitat types with six of these in the river main-stem (channel, natural step bank, revetted bank, lotic and lentic sandbars) and seven associated with the floodplain (e.g., seasonally inundated floodplain, oxbow lake, pond). Although individual sites within the river are frequently modified by many variables (erosion, deposition, etc.), the variety, distribution, and characteristics of the preferred habitats remain constant over time, unless the river undergoes a fundamental change in either flow or sediment load (Sempra 2002).

Habitat preference for adult fish is summarized for the dominant species impinged in the 1970's studies conducted at the Entergy plants along the LMR. Gizzard shad are considered abundant (A) or common (C) in all habitat zones except for the channel where they are considered uncommon (U). Threadfin shad are considered abundant or common in most habitats except lotic sandbars where they are considered uncommon. No ranking was given for threadfin shad in the channel. Freshwater drum are considered abundant or common in all habitats except floodplain ponds where they were not given a ranking. Freshwater drum are considered common in the

channel. Of the 133 species analyzed in the Sempra 316(b) CDS (Sempra 2002), 48 species (only 36% of the species) were assigned a ranking for the main channel. Twenty-three (23) species are considered probable (P) and likely to occur but records are lacking or inconclusive; 8 species are considered common; 8 species are considered uncommon; 5 species are considered abundant (shortnose gar, blue sucker, small mouth buffalo, blue catfish and flathead catfish); 3 species are considered rare; and 1 species (striped bass) is considered typical (T) in the channel where it occurs regularly but in low numbers.

4.3.2 Differences in Fisheries Population Densities

The following section discusses the differences in population densities of the different relevant habitats as they relate to the CWIS at the different Entergy plants.

4.3.2.1 USGS

No comprehensive ichthyofaunal surveys have been conducted on the LMR in at least the past 30 years (Schramm 2005, personal communication). The most difficult habitat to sample is the main channel, where current velocities and debris load are highest, and extensive commercial navigation occurs. Because researchers historically could not effectively sample the main channel, relatively little is known about the extent that fish use this habitat (Illinois Natural History Survey-INHS 1997). A current assessment of Mississippi River fishes was compiled from four different sources and reviewed by six ichthyologists familiar with Mississippi River fauna (Schramm 2004). Mr. Schramm notes the lack of *standardized* habitat classification for Mississippi River fishes. He therefore assigned one or more of three habitat zones to each species: main channel, channel border, and backwater. He defines the habitat zones as follows:

- Main channel - the portion of the river that contains the thalweg and the navigation channel where the water is relatively deep and the current, although varying temporally and spatially, is persistent and relatively strong;

- Channel border - the zone from the main channel to the riverbank. Current velocity and depth will vary, generally decreasing with distance from the main channel, but the channel border is a zone of slower current, more shallow water, and greater habitat heterogeneity. Channel border includes secondary channels and sloughs, islands and their associated sandbars, dikes and dike pools, and natural and reveted banks;

- Backwater zone - includes lentic habitats lateral to the channel border that are connected to the river at least some time in most years. This zone includes abandoned channels (including floodplain lakes) severed from the river at the upstream or both ends, lakes lateral to the channel border, ephemeral ponds, borrow pits created when levees were built, and the floodplain itself during overbank stages.

Fishes are considered backwater dependent if they require conditions such as little or no current, soft-sediment bottom, or aquatic or inundated terrestrial vegetation during at least some portion of their life cycle. Riverine-dependent fishes are those that require flowing water and sand, gravel, or rock substrate during at least some part of their life-cycle; these conditions may be found in the main channel or channel border zones. Schramm considered species peripheral (channel border) to the Mississippi River if available life history information indicated that the species inhabits tributary rivers or streams, prefers small rivers or streams, or avoids or is rare in large rivers.

Of the 137 resident species that Dr. Schramm researched, he was able to assign border habitat to 24 species and backwater habitat to 50 species. No species were expected to reside in main channel habitats throughout their life-cycle. The following fish species are noted by Schramm as 'backwater dependent' species: gizzard and threadfin shad, common carp, bluegill, largemouth bass, black and white crappie._ The following were noted to be 'riverine dependent' species: pallid sturgeon, shovelnose sturgeon, paddlefish, river carpsucker, and freshwater drum. The following species were also noted by the author as species that were abundantly taken in most surveys in the open river segments of the Mississippi River: gizzard and threadfin shad, emerald shiner, river carp sucker, smallmouth buffalo, blue catfish, flathead catfish and freshwater drum. Other species commonly taken in the open river include: longnose and shortnose gar, skipjack herring, red shiner, river shiner, common carp, silver carp, speckled chub, silver chub, bigmouth buffalo, channel catfish, brook silverside, warmouth, bluegill, and largemouth bass.

Fish production on the LMR has not been estimated and biomass estimates are highly variable but tend to range from 300-900 kg/ha^{-1}. Schramm (2004) stated that standing stocks in the LMR appear greater than the UMR. He reviewed biomass results from 5 studies that sampled, in a consistent and comparable fashion, 13 different habitats and noted the following:

- The lowest biomass estimate (21 kg/ha) was in the main channel (Dettmers *et al.* 2001) compared to the channel borders and backwaters that often exceeded 500-600 kg/ha. One backwater (abandoned channel not connected to river) habitat sampled resulted in a biomass estimate of 911 kg/ha (Lowery *et al.* 1987). The highest observed ratio of observed biomass densities between the river main stem and other habitats is 21 kg/ha/327 kg/ha or 6.4%, a 93% implied reduction with movement from the river side to the main flow. Other, higher biomass estimates would yield even larger estimates of reduction.

INHS scientists, in collaboration with the USGS and the USACE, sampled the fishes in the main channel of the Mississippi in 1996 with a specialized trawling vessel (INHS 1997). In the Mississippi River near Grafton, Illinois, 24 fish species were collected. Abundant species included freshwater drum, channel catfish, gizzard shad, smallmouth buffalo, and carp. _Other fishes caught less frequently in the main channel included the shovelnose sturgeon, lake sturgeon, and blue sucker. The researchers note that many of the fish use the main channel during the entire year such as gizzard shad, channel catfish, and smallmouth buffalo as they are suited for life in

fast-flowing river conditions. Many other fishes use the main channel only seasonally. The study's most diverse catches occurred in September and October when the river was at its lowest and temperatures were moderate. In these conditions, fish common to backwaters (e.g., bigmouth buffalo, shortnose gar, and black crappie) can be found in the main channel. Although this study focused on the fishes in the UMR main channel, the species are similar to those documented on the lower portions of the river (INHS 1997).

The river shrimp (Ohio shrimp), *Macrobrachium ohione,* was collected in high abundance during several of the 1970's impingement studies previously discussed. The Missouri Department of Conservation conducted a recent study of this species (Barko and Hrabik 2003) in the unimpounded Upper Mississippi River. In this study four physical habitats were sampled: main channel border, main channel border with wing dike, open side channel, and closed side channel. The objective of the study was to assess the association of river shrimp abundance with environmental factors and habitat types to understand the ecology of this species in a channelized river system. Ohio shrimp were most abundant in the open side channels. Inter-annual variability in catch per unit effort (CPUE) was observed with CPUE highest in 1996 and lowest in 2000. Approximately 8% of variation in Ohio shrimp abundance was explained by Secchi disk transparency (water turbidity). Current impingement rates for the Ohio shrimp in the LMR are most likely reduced at power plants with offshore CWIS compared to shoreline CWIS due to this species' apparent preference for side channel habitats compared to main channel border habitats.

4.3.2.2 Statements from Fisheries Researchers

After an extensive literature review two major conclusions can be made regarding fisheries in the LMR: (1) population density and diversity are higher at the channel bank and backwaters compared to the main channel; and (2) the overall fisheries in the LMR have not changed significantly since the 1970's. Several top fisheries researchers were contacted via telephone to verify these conclusions including Dr. Bob Kelso and Dr. Allen Rutherford with Louisiana State University Baton Rouge, LA; Dr. Jack Killgore with the U.S. Army Corps of Engineers (USACE) in Vicksburg, MS; Dr. Steve Gutreuter with the USGS in La Crosse, WI, and Hal Schramm with the USGS at the Mississippi Cooperative Fish and Wildlife Research Unit Mississippi State. A summary of the conversations is provided below.

<u>Dr. Jack Killgore</u>

Dr. Killgore stated that the fisheries in the Lower Mississippi River have remained relatively consistent since the 1970's, although the Upper Mississippi River (dammed portion) has undergone significant changes. In the LMR some species have declined including the pallid sturgeon and some of the sucker species; however, the overall community has changed very little. He stated he agreed that the most abundant species impinged in the 1970's studies (i.e., gizzard shad, threadfin shad, and freshwater drum) would be the same dominant species today. He

stated gizzard shad is probably the most numerically and biomass dominant species on the river and "nothing can reduce their numbers".

Dr. Killgore also agreed that the density (abundance) and diversity of organisms is higher along the bank and backwaters compared to the main channel. He also agreed that the extension of power plant intake pipes offshore and in deeper waters would reduce the amount of impingement and entrainment. He followed by stating that most larval fishes and juveniles do not utilize the deeper portions of the river (Killgore 2005, personal communication).

Dr. Bob Kelso and Dr. Allen Rutherford

Both professors agreed that the abundance and densities of fish in the river have remained consistent over the last 20 to 30 years. Species we have identified from the literature are consistent with what we would find in the river today. Dr. Rutherford also indicated that there shouldn't be a significant change in fish composition until you get to River Mile 90. This is the region of the river where significant mixing of salt water takes place. He did indicate that there would be influxes of estuarine species that are tolerant of freshwateras far upstream as Baton Rouge; however, these numbers are insignificant in comparison to the overall abundance in the river. As noted above, this is very consistent with the observed rates of impingement at the various Entergy plants located along the river.

Dr Kelso indicated that there would be a significant shift in abundance of fish and species diversity moving from the shoreline habitats out to the main channel of the river. Abundance numbers would drop by as much as 95%. Literature on the majority of the fish in the river should indicate that most of these fish are littoral in nature and require a significant level of structure which is not available in the main part of the channel. He further indicated that eggs and larvae associated with these species would also decrease proportionally. He stated most species spawn up near the shoreline habitats where there is structure, cover, and lower flow velocities.

Both indicated that species of fish occurring in the river are adapted to specific conditions occurring in the river. Most species, however, cannot sustain populations out in the main areas of the river due to the high velocities that occur there. Those few species that do occur in the main channel are usually fairly large in size, live close to the bottom, and have high swimming speeds, sufficient to avoid the intake structures (Kelso and Rutherford 2005, personal communication).

Dr. Steve Gutreuter

Dr. Gutreuter has been involved with several extensive projects involving sampling in of the Mississippi River main channel (see Detmers *et al.* 2001). He agreed that abundance and diversity was lower in the main channel compared to the side channel and backwaters. He did indicate that more recent studies show higher biomass than previously seen in the main channel primarily due to better gear and calibration. He stated much of this biomass is due to the typically

larger fish that inhabit the deeper waters of the main channel[2]. Dr. Gutreuter stated the more recent studies would not be published for at least one year, however he stated he was still comfortable with the– general conclusions of the 2001 study (i.e., that population densities decrease sharply with movement into high velocity portions of the river) (Gutreuter 2005, personal communication).

Hal Schramm - USGS

Mr. Schramm agreed that fish abundance and diversity is typically higher along the shoreline compared to the main channel. He also stated that several groups are currently conducting fisheries research in the main channel of the LMR and they have been getting interesting results. Specifically, several minnow species apparently utilize the main channel more so than was previously thought. Therefore, Mr. Schramm does have concerns for these smaller species due to their potential for impingement and/or entrainment. He stated additional research is needed to better understand these species as well as the other larger species that utilize the main channel. Mr. Schramm stated that due to the extensive area (habitat) the main channel encompasses, impingement is likely to have only a relatively small effect on the fish populations.

Mr. Schramm also stated that the precision of fish abundance values in the LMR is usually very poor primarily due to sampling techniques that are size, and/or species selective. Nevertheless, he agreed that abundance of the primary species observed in the LMR in the 1970's impingement studies (i.e., fresh water drum, gizzard shad, threadfin shad) would probably be the most abundant species impinged today as their numbers have probably changed little over time (Schramm 2005, personal communication).

4.3.2.3 Data Presented by SEMPRA

In the Sempra (2002) study conducted at ~~RM~~ Mississippi River mile marker 132.2 AHP, it was determined that although there are 13 distinct habitat types found in the LMR, only a few dominate the river's landscape in the lower reaches. The researchers used the habitats developed by Baker and his colleagues (Baker *et al.* 1991) to determine a species' abundance potential in the study area. They defined Baker's 13 habitat zones as Habitat Zone Distribution which is the correlation of a species to their preferred habitat throughout their life cycle. Preferred habitat also includes Habitat Range Distribution, which is the water column distribution most favored by the species throughout their life cycle. This is a key correlation component of the Habitat Zone Distribution for each species to identify a high probability habitat.

2 Such large fish are very likely to be able to resist impingement. A fact reflected in the very low frequency of impingement of large fish at Baxter Wilson, Waterford 1 & 2, and Willow Glen.

In the Sempra study, six habitats were reviewed specifically to determine the number of fish species and eggs associated with each type. Each habitat zone was determined to have a reduced number (from 133 potential species found in the LMR) of fish, egg and larval species associated with the habitat. This further validates the fact that the placement of a CWIS can reduce both impingement mortality and entrainment due to the reduction of species utilizing the habitat. Habitat at each of Entergy's LMR plants should be evaluated in the future to determine the number of species that potentially use the habitat associated with the CWIS placement.

5.0 DOCUMENTATION OF CURRENT IMPINGEMENT MORTALITY AND ENTRAINMENT [125.95(B)(3)(III)]

The rule requires the estimation of current rates of impingement mortality and, when appropriate, entrainment. These data may be necessary to support three potential activities:

- Estimation of the CWIS performance relative to the Calculation Baseline;
- Assessment of additional mitigation measures; and
- Estimation of the monetized benefit of potential mitigation measures under the Cost-benefit test.

The compliance approach proposed by Entergy does not rely on the Cost-benefit making this use of the data irrelevant. In fact, most of the plants under consideration will avail themselves, at least in part, of the Cost-cost test, the results of which are insensitive to the specific rates of impingement or entrainment. In addition, several of the plants differ significantly from the Calculation Baseline by a simple and tangible measure: placement of the CWIS in the high velocities of the main channel. Thus, Entergy believes that specific rates of impingement mortality and entrainment are not likely to have major impact on the outcome of this analysis.

Despite this, we believe that the data available on impingement at Baxter Wilson, Waterford 1 & 2, Willow Glen, Michoud, and Paterson are very likely to be representative of current conditions. In particular, the data were collected under the same plant operating conditions currently in effect and, as noted above, there is a consensus that the fishery of the LMR and the associated tidal channels has changed little since the data were collected.

5.1 Current Status of Fishery Population

The composition and relative abundance of the current fishery population is similar to population observed in the 1970s. This is consensus view from the literature as well as a group of experts

that Entergy has contacted recently (see above). Based on this, Entergy believes that the available data will be adequate to support the goals of the rule and the development of an IMECs.

5.2 Current Rates of IM and E

The following discussion focuses on likely current rates of impingement mortality and, where appropriate, entrainment.

5.2.1 Anecdotal Evidence

Plant operations personnel were interviewed at each of the plants to determine the current levels of organisms impinged, dominant species impinged, seasonal and diel variations of organism impinged. Information provided for each plant indicates that shad (threadfin and gizzard), freshwater drum, catfish (blue catfish and channel catfish), river shrimp, and crawfish are the most abundant species observed on the screens for the plants in the freshwater regions of the river (including the plant farthest downriver, Ninemile). Species most abundant on the screens in the tidally-influenced segments (i.e., Paterson and Michoud) consisted of croaker, shad (gizzard and menhaden), anchovy, white shrimp, brown shrimp and blue crab. Observed abundances (screens are operated on average twice per day for 10 to 15 minutes each shift) of organisms on the screens are reported to be low. Plant personnel indicate that there appears to be an increase in organisms on the screens as the river begins receding after floods. This is similar to the behavior document at Baxter Wilson.

Seasonal variations were identified as being relatively low. Shad and catfish species appear to have the greatest fluctuations in abundance with the greatest peaks occurring during the summer and fall months. Diel variations could not be determined due to the operation of the screens at the same time each day (once in the morning and once in the evening).

No threatened and endangered species have been observed by plant operations personnel on the screens.

5.2.2 Summary of IM and E Data

Based on the available evidence, we believe that the historically observed rates of impingement (as summarized in Table B-4) serve as reasonable estimates of current impingement behavior. Given the position of the various stations along the river, it is likely to be productive to consider them in the hierarchy demonstrated in Table B-5.

5.3 Sufficiency of Historical Patterns/Densities of Fish

Biological data used to address current impingement mortality and entrainment rates for the plants located on the Mississippi River are derived from a series of impingement mortality and

entrainment studies conducted at the identified power plants (Willow Glen, Baxter Wilson, Waterford 1 & 2, Waterford 3, A. B. Paterson, and Michoud) between the years 1973 and 1979. A total of six impingement mortality and entrainment studies were conducted in association with 9 plants located along the river. In general, these studies were conducted to evaluate and characterize the organisms impinged and entrained during the operation of each of these plants. Each of the studies was designed to quantify the number, species, rate, seasonality, and diel variations of impingement and entrainment occurring at each of the plants.

To date no other documented studies have been conducted at these plants by either the utility company nor by other state agencies and universities. The relevancy of the existing historical data can be shown to be representative of the species and relative abundances present in current conditions. The temporal data gap has been bridged by consulting with several leading authorities from the universities and the agencies concerning the relevance of the historical data. Dr. Rutherford and Dr. Kelso of Louisiana State University, Dr. Killgore of the USACE, and Hal Schramm with the USGS each indicated that the species characterization in the river has remained fairly consistent over the last 20 to 30 years and they would not anticipate a significant change in species for much of the river from well above the state of Mississippi down to river mile (RM) 90, just southeast of New Orleans, where saltwater mixes with the freshwater and the habitat associated with the river becomes more estuarine in nature. Furthermore, they indicated that estimates of population densities (relative abundance) for the major species occurring in the river have remained relatively stable during the same time period. In addition, each mentioned the lack of quantitative data to fully assess the fishery in the Mississippi River.

Our review of the literature suggests the lack of data is due to the feasibility of safely and effectively designing and coordinating a sample program to fully assess the fishery. It is therefore, our opinion and the opinion expressed by Dr. Kelso, Dr. Rutherford, Dr. Killgore, and Mr. Schramm that the existing data reviewed for the development of this document is the most current and applicable dataset available and the data presented in these studies is in fact relevant to current and existing conditions at each of the plants. Furthermore, it is our opinion that data from these plants can be used to support, supplement, and be used in lieu of data for other plants located on the river.

5.4 Representativeness of Historical Data

The riverine ecosystem of the Mississippi River has undergone many changes. Most of the natural changes have occurred gradually over hundreds of thousands of years, whereas human-induced changes have occurred rapidly and recently. Several factors have apparently contributed to the recent declines in the river's flora and fauna, including habitat loss and degradation, point and non-point pollution, toxic substances, commercial and recreational fishing and navigation, deterioration of water quality during drought periods, reduced availability of key plant and invertebrate food sources, and invasion of nonindigenous species (McHenry *et al.* 1984; Bhowmik and Adams 1989). Many of the biological changes observed in the Mississippi River have

occurred over the past century and not just the last several decades. Johnson (1987), for example noted that many fish species such as the river sucker and blue catfish have declined in the UMR due to dredging extending back 150 years, and dam construction during the 1930's, which both had a dramatic effect on the availability of fast-flowing water and rock-bottom habitats. Although several key native organisms including submersed plants, native pearlymussels, fingernail clams, and certain fishes have decreased along substantial reaches of the river in recent years or decades, most species have changed little over time.

At present, the Mississippi River's native fish assemblage appears intact (Fremling *et al.* 1989; Gutreuter 1997; Weiner at al. 1998). Shramm (2005) states that although some species are considered rare, with the exception of sturgeon, sport and commercial fisheries show no signs of over_fishing and may even support increased effort in harvest.

Schramm (2005) compiled four relatively current studies dated 1989, 1991, 1995, and 2000, and reported the abundance category of the fish species inhabiting the Lower Mississippi River. The most abundant fish species collected in the impingement studies discussed in this Appendix are as follows with their associated abundance category: gizzard shad, threadfin shad, freshwater drum, and blue catfish were all described as species that were abundantly taken in all river surveys. Carp, white crappie, skipjack herring, and bluegill were categorized as species that were commonly taken in most surveys. Since these species were the most abundant collected in the 1970's studies, and are still collected in abundance in the present day, we can conclude there have been no significant changes in the LMR fisheries since the impingement studies in the 1970's. The most abundant freshwater invertebrates collected were river shrimp and crayfish, which dominated the impingement samples at many of the plants. Their abundance in the present day is unknown.

Estuarine species and invertebrates were not analyzed in Schramm's study so abundance values could not be obtained for these species from his study. The most common estuarine species collected in the Michoud and Paterson impingement studies included white shrimp, Atlantic croaker, bay anchovy, sand seatrout, blue crab, Gulf menhaden, sea catfish, and striped mullet. A search of the literature shows that these species are the dominant species in the LMR in the present day as well.

5.5 Sufficiency of Data to Estimate Calculation Baseline

A complete and thorough review of current and historical data was performed to assess the quantitative value of existing data and to determine if the basis of the data were sufficient to support estimating calculation baselines for the plants identified in this review.

Current data available in the literature suggests that existing research may not provide an adequate quantitative assessment of the existing fisheries in the river. Most of the studies conducted were designed to sample specific regions of the river, such as backwater areas and

littoral zones, and to study specific species, such as the pallid sturgeon and paddle fish. Independently, these data may only provide a small subset of information on the overall fishery in the river. However, when looked at cumulatively, the extent of this data, combined with all the available data from the impingement and entrainment studies conducted at the plants, does provide a good qualitative assessment of the fish diversity and relative abundance in the river. Our findings have been corroborated by leading fishery biologists from LSU and the USACE.

Data collected in the previously discussed impingement and entrainment studies were initially evaluated based on operating condition at the time the study was conducted. These operating conditions are estimated to be at or near maximum operating capacity. Evaluating this data and applying it to current operating conditions requires several assumptions:

- Approach velocities and through screen velocities are assumed to be the same;
- Intake structures have not undergone any type of retrofit or substantial change in operation; and
- Densities of fish and shellfish and their diversity have not changed.

Based on the available information, we believe that each of these assumptions is valid. Therefore, the historical data can be deemed to be representative of current conditions.

Data reviewed in the literature and from existing impingement and entrainment studies provide a qualitative assessment of the fisheries in the Mississippi River and at the plants. These data provide an analysis of the fish assemblages, specifically juvenile and adult fish, occurring in different habitat zones associated with the river. The limits of this data include insufficient information pertaining to the egg and larval distribution associated with the identified adult species. However, this lack of data is not significant as entrainment rates are expected to be minor.

Since the spawning period for most LMR freshwater species occurs in spring and early summer, which is typically the time of the year for flood conditions, minimal entrainment rates are expected at the freshwater plants. This is primary due to the effects of dilution and swift currents which most likely will push the organisms past the CWIS. This concept is most likely to be observed at those CWIS located offshore and in swift waters. As discussed previously, velocities in the LMR often exceed 10 fps which is much greater than the CWIS approach velocities.

The lack of entrainment data at the estuarine plants (Michoud and Paterson) is also unlikely to have any relevance as minimal entrainment rates are expected at these plants as well. Minimal entrainment rates are expected based on the literature, and other estuarine entrainment studies in the upper Gulf of Mexico. The entrainment study (1974-75) conducted at Entergy's Sabine Plant located on Sabine Lake, Texas showed that copepods and barnacle nauplii dominated the

samples. These organisms are extremely numerous in most estuarine systems and any reduction in their numbers would most likely not have any impact on their local populations. Fish eggs and larvae were apparently not found in any of the Sabine entrainment samples although fish, blue crab, and shrimp dominated the impingement samples. This is not surprising given the location of this plant and the spawning behavior of most of the fish species found on the screens and in Sabine Lake during the impingement studies. Many of these species spawn in the near-shore Gulf (croakers, menhaden) with the larval or juvenile stages entering the bays and migrating to the marshes, where they continue their growth and development. These species tend to be impinged as opposed to entrained because they are largely absent from the upper estuaries as larvae and eggs.

Similar to the Sabine Lake estuarine community, most of the species impinged at the Michoud and Paterson Plants either spawn off-shore in the Gulf (penaeid shrimp, Atlantic croaker, menhaden, etc.), or carry their fertilized eggs under their abdomen until they hatch (blue crabs). Moreover, female blue crabs migrate to areas of higher salinity than that found in the area of the Michoud and Paterson Plants, for their eggs to hatch. Consequently, entrainment of the eggs and larvae of these species is expected to be minimal at the Michoud and Paterson Plants.

6.0 SUFFICIENCY OF DATA IN SUPPORTING THE IMECS

6.1 Most Common Species Impinged/Entrained

The most commonly impinged species are listed in Table B-4 and described in Section III.

6.2 Implications for CWIS Placement, Design, and Operation

Entergy believes that the data available on the fishery of the Mississippi River provides important perspective on the historically observed rates of impingement at Entergy's power plants. There are three sources of information that can support evaluation of impingement at Entergy's plants as well as understand the nature of the fishery of the Mississippi River:

- Site-specific data collected by Entergy during the 1970s. These data are very consistent with the goals of the rule. The potential for ecosystem changes to render them unrepresentative of current conditions should be considered, however a preliminary assessment has determined that minimal ecosystem changes have occurred since the data were collected.

- Data collected by other, nearby power stations on impingement rates. In some cases, these data sets are both more extensive and more current. The general patterns of impingement (e.g., relative frequency of species) are consistent with those observed from

impingement studies conducted at Entergy plants in the 1970s. As importantly, the literature has been relatively consistent over the last few decades suggesting that the impingement data are still representative of current conditions.

- The general literature on fisheries of the Mississippi River. This literature can provide important background regarding the behaviors of important species such as the timing and distribution of their eggs and larvae, their likely survival upon impingement, their habitat preferences, etc.

When this literature is considered as a whole, we believe that there are sufficient data currently available to complete an IMECS consistent with the goals of the rule (see Section 4.2). The following conclusions relative to impingement can be drawn:

- The assemblage of impinged organisms changes with movement toward the Gulf of Mexico. At Baxter Wilson, the impinged organisms are strictly freshwater species. At Willow Glen, located 230 miles closer to the Gulf, one estuarine species appears among the ten most commonly impinged species. Seventy miles further downstream, three estuarine species are noted among the most commonly impinged. At Michoud and Paterson, located in brackish, tidally-influenced channels adjacent to the river, few organisms occur that favor freshwater.

- The fish species that dominated impingement at the Entergy stations are also very important in the ambient surveys at similar locations. These include threadfin and gizzard shad, freshwater drum, and river shrimp which account for the vast majority of impinged organisms at the freshwater stations and Atlantic croaker, bay anchovy, and blue crab at the brackish water stations. Some species that are important in ambient surveys (notably catfish, carp) are under represented among impinged fish likely due to their strong swimming ability and/or their avoidance of the habitat near the CWIS.

- While water quality has improved since the 1970s surveys, other factors potentially affecting the fishery have been little changed. Most notably, management of the river for shipping and flood control has been consistent and invasive species have remained well established.

- The species makeup of the fishery of the LMR has been relatively constant over the last several decades. This suggests that improvements in water quality have not greatly changed the types of fish present in the river. This trend is evident in the literature and has been confirmed by direct communication with the relevant experts.

- The rates of impingement observed at Entergy stations during the 1970s appear to be reasonable estimates of ongoing rates. There has been little or no change in the operation of the CWIS (although the capacity factor has been significantly reduced at most plants) and changes to the river and its fishery appear to be relatively minor. Anecdotal

observations by the station operators confirm that the dominant impinged species are the same. Finally, the compliance strategies outlined at each of the stations are insensitive to modest changes in the rates of impingement or, when relevant, entrainment.

- The gizzard shad, threadfin shad, freshwater drum and bay anchovy do not tolerate handling well (as indicated by low rates of latent survival) and Atlantic croaker tolerates handling only moderately well. EPRI (2003) indicate that the median extended survival for freshwater drum and gizzard shad is 20% (8 studies) and 7% (43 studies), respectively. Extended survival rates were not available for threadfin shad but the median initial survival was only 15% (5 studies). The average extended survival for bay anchovy is 10% with an average initial survival of 30%. The median extended survival of Atlantic croaker, the most commonly impinged fish at the brackish water stations, was 36%. This suggests that any sort of fish handling and return system is not likely to achieve significant reductions in impingement, particularly for the three species that dominate impingement at the freshwater stations and bay anchovy, which is common at the brackish stations.

- Some other species, notably the crustaceans, survive handling much better. Data summarized by EPRI (2003) suggest that shrimp and crabs survive at rates of approximately 50% or better.

- The river's main channel harbors much lower densities of fish than the river's edges and backwaters. Data suggest that population densities in the main channel are less than 10% of what is observed in the backwaters. This trend appears to be a consensus view among fisheries biologists. The relatively low densities are driven by the high velocities and reduced preferred habitat, as well as significant suspended sediment load. This suggests that placement of the CWIS in the main channel is likely to significantly reduce the rates of impingement relative to placement along the shore or in a backwater.

- Annual variation in the rates of impingement may be significant. A significant change in impingement rate may be associated with the return of juvenile fish to the main channel following inundation of the flood plain. The annual cycle of the fish populations' age structure also may contribute in that juveniles are more susceptible to impingement. While this change was observed in one data set, it is notably absent from two others.

- The typical impinged fish is relatively small. The average fish impinged is on the order of 20 grams in mass (not including carp which average about 1500 g). This highlights the importance of juveniles in the impinged population, a group subject to high rates of natural mortality.

- State or federally listed species are not likely to be substantially impacted. Young paddlefish, a species of concern to several state agencies, were impinged in small numbers. Three pallid sturgeon were impinged at two stations. The effects, while small,

may present an opportunity for restoration to improve their stocks in the river. Impacts to other species are not anticipated either in the riverine or estuarine plants.

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Table B-1
Results of Ambient Fisheries Assessment at Grand Gulf and Waterford 3 Plants

Study Title	Location	River Mile	Period of Sampling	Sampling Frequency	Sampling Duration	Sampling Location		Six Most Common Species
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	June 1972 - August 1973	Monthly		Main River - Stations 1, 3, 5, 6, 8 & 10		**Total 69.7%** - Gizzard shad (37.4%) freshwater drum (10.3%), blue catfish (8.3%), flathead catfish (4.9%), river carpsucker (4.8%) smallmouth bufallo (4 0%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	June 1972 - August 1973	Monthly		Near Shore - Stations 1 & 8		**Total 91.8%** - Threadfin shad (30.8%) emeral shiner (25.5%), river shiner (14.1%), silvery minnow (11.6%), shiner spp. (6.9%), cypress minnow (2.9%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	August 1973	Once		Near Shore - No current - Station 1		**Total 97.1%** - Threadfin shad (36.2%), gizzard shad (31.5%), silvery minnow (23.6%), red shiner (2.6%), cypress minnow (2 3%), shiner spp. (0.9%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	August 1973	Once		Near Shore - Moderate current - Station 1		**Total 79.0%** - Channel catfish (22.8%), silver chub (20.8%), mooneye (15.0%), freshwater drum (8 8%), shiner spp (6.2%), silvery minnow (5.4%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	August & September 1973	5 trawl efforts conducted in August, 3 trawl efforts in September	15 minute tow (trawling)	Mississippi River Channel - Stations 3 & 6	Average Number of fish caught per hour. 37.07	**Total 91.7%** - Bluecatfish (29.2%), River shrimp (13.9%), shovelnose sturgeon (13 9%), Silver chub (12.5%), gizzard shad (5.6%), speckled chub (5.6%), grass shrimp (5.6%), channel catfish (5.6%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	September 1972 - August 1973	Dominant fish species in 3 macrohabitats		Backwater: Station 1		**Total 66.3%** - gizzard shad (30.2%), blue catfish (10.0%), river carpsucker (7.8%), freshwaler drum (6.5%), Shovelnose sturgeon (6.0%), White crappie (5.8%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	September 1972 - August 1973	Dominant fish species in 3 macrohabitats		River Bank: Stations 3,5, 6, 8		**Total 86.3%** - gizzard shad (52.3%), freshwater drum (15.5%), silver chub (5.6%), flathead catfish (5 2%), blue catfish (4.9%), river carpsucker (2.8%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	September 1972 - August 1973	Dominant fish species in 3 macrohabitats		Tributary: Station 10		**Total 68.3%** - gizzard shad (18.4%), shortnose gar (13.3%), blue catfish (12.4%), freshwater drum (11.0%), smallmouth buffalo (6.9%), Bowfin (6.3%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2		August 1973	Electrofishing	1.8 hours of effort	Hamilton & Gin Lakes	Average number of fish collected per hour: 275.3	**Total 94.3%** - bluegill (35.5%), threadfin shad (27.2%), gizzard shad (21.9%), sunfish sp. (3.8%), black crappie (3.1%), largemouth bass (3.1%)
Environmental Field Measurements Program - Larval fish	Grand Gulf Units 1 & 2	400 - 408	July 1973	Ichthyoplankton - Three replicate samples collected from surface using 0.505 mm mesh plankton net, twice per month	15 minute tow	Mississippi River Channel - Diurnal - Stations 3 & 6	Density of fish: 0.5415 per m3	**Total 92.4%** - Shad (42.0%), minnows (30.1%), drum (17.1%), crappie (2.6%), sunfish. (0.4%), sucker (0.2%)
Evaluation of the Waterford 3 Generating Station - Surveillance Program	Waterford 3	129.5	April 1973 - September 1976	Intermittently using a combination of gear types: surface trawls, otter trawls, gill nets and electronshockers		Vicinity of Waterford 3		**Total 90.1%** - Gizzard shad (38.0%), blue catfish (18.1%), threadfin shad (14.5%), striped mullet (10.4%), freshwater drum (6 9%), skipjack herring (2.2%)
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132	Average Number of fish caught per hour: 1.22	**Total 90.1%** - Gizzard shad (38.0%), blue catfish (18.1%), threadfin shad (14 5%), striped mullet (10.4%), freshwater drum (6.9%), skipjack herring (2.2%)
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132 - shallow stations	Average Number of fish caught per hour: 0.77	
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132 - deep stations	Average Number of fish caught per hour: 1.04	
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132	Minimum and Maximum Length of Fish (mm)	Gizzard shad (25 - 341), blue catfish (17 - 655), threadfin shad (17 - 190), striped mullet (68 - 397), freshwater drum (13 - 306), skipjack herring (20 - 325)

Table B-2
Length, Weight, Survival, and Swimming Speed Characteristics for Species Commonly Impinged at Entergy's Power Plants

		Length (mm)[1]		Weight (g)[2]		Initial Survival[3]		Extended Survival[4]		Swimming Speeds (cm/s)	
Common Name	**Scientific Name**	**Average**	**Median**	**Average**	**Median**	**Average**	**Median**	**Average**	**Median**	**Median/Mean**	**Critical/Optimum**
Freshwater Species											
Freshwater Drum	*Aplodinotus grunniens*	86.4	64.8	41.9	4.5	0.545	0 528	0.227	0.204	90 d	NA
Ohio river shrimp	*Macrobrachium ohione*	55.5	55.8	3.0	3.6	0 500	0.500	NA	NA	0.76 e	NA
Gizzard Shad	*Dorosoma cepedianum*	115 2	109.5	66.0	2.4	0.693	0.884	0.284	0.070	2 - 4 a	10 a
Threadfin Shad	*Dorosoma petenense*	63 3	53.5	4.7	1.5	0 325	0.153	NA	NA	2 - 4 a	10 a
Common carp	*Cyprinus carpio*	398.0	398.0	1545.3	1984.2	0.595	0.630	0.469	0.472	NA	166 h
Black crappie	*Pomoxis nigromaculatus*	NA	NA	NA	NA	0 524	0.507	0.119	0.014	NA	NA
Crappies	*Pomoxis* sp.	NA	NA	NA	NA	0.493	0 493	0.290	0.290	NA	NA
Channel Catfish	*Ictalurus punctatus*	71 8	62.8	18.6	2.6	0 843	0 800	0.697	0.588	50 f	55 2 g
Bluegill	*Lepomis macrochirus*	46.3	44.8	8.6	4.0	0.905	1.000	0.926	0.971	NA	101 - 130 j
Sucker family	Catostomidae	NA	NA	NA	NA	0.562	0.538	0.480	0.436	NA	169 - 259 k
Smallmouth buffalo	*Ictiobus bubalus*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bigmouth buffalo	*Ictiobus cyprinellus*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Skipjack herring	*Alosa chrysochloris*	119.4	112.0	42.8	8.1	NA	NA	NA	NA	NA	NA
Alosa species	*Alosa* sp.	NA	NA	NA	NA	0.736	0.839	0.206	0 061	NA	NA
Blue catfish	*Ictalurus furcatus*	86 8	83.8	22.4	12.1	NA	NA	NA	NA	30 b	NA
Brackish Species											
White shrimp	*Penaeus setiferus*	NA	NA	NA	NA	0.689	0.706	0.806	0.806	NA	NA
Brown shrimp	*Penaeus aztecus*	NA	NA	NA	NA	0.815	0.907	0.830	0.850	NA	NA
Bay anchovy	*Anchoa mitchilli*	NA	NA	NA	NA	0.295	0.178	0 100	0.000	21.1 l	NA
Gulf menhaden	*Brevoortia patronus*	NA	NA	NA	NA	0.249	0.251	0.136	0.136	NA	NA
Blue Crab	*Callinectes sapidus*	NA	NA	NA	NA	0.858	0.921	0.664	0.735	NA	NA
Hardhead sea catfish	*Arius felis*	NA	NA	NA	NA	0.434	0.277	0.710	0 703	NA	NA
Sand weakfish	*Cynoscion arenarius*	NA	NA	NA	NA	0.239	0.194	0.265	0.265	NA	NA
Spotted seatrout	*Cynoscion nebulosus*	NA	NA	NA	NA	0 544	0.400	0.000	0.000	81 l	NA
Sea trouts, Weakfishes	*Cynoscion* sp.	NA	NA	NA	NA	0.157	0.157	0.579	0.579	NA	NA
Striped mullet	*Mugil cephalus*	NA	NA	NA	NA	0 599	0 574	0.428	0.396	32 - 83 c	50 - 130 c
Atlantic croaker	*Micropogon undulatus*	NA	NA	NA	NA	0.669	0.827	0 416	0.357	NA	NA
Spot	*Leiostomus xanthurus*	NA	NA	NA	NA	0.622	0 718	0.410	0.332	NA	NA
American Shad	*Alosa sapidissima*	NA	NA	NA	NA	0.658	0.870	0 067	0.001	NA	NA
Least puffer	*Sphoeroides parvus*	NA	NA	NA	NA	0.738	0.729	0.610	0.610	NA	NA
Blackcheek tonguefish	*Symphurus plagiusa*	NA	NA	NA	NA	0.778	0.770	0.796	0 796	NA	NA

Notes:
NA - Data not available
1 Average and median length of impinged organisms from Waterford 1 & 2 and Willow Glen 4
2 Average and median weight of impinged organisms from Waterford 1 & 2, Willow Glen 1 & 2, and Willow Glen 4
3 Initial Survival. EPRI 2003.
4 Extended Survival (24 - 120 hours after impingement) EPRI 2003.
a Median and optimum swimming speeds. Barnes, J. 1977.
b Mean sustained speed. Venn Beecham et al., 2003.
c Median and optimum swimming speeds for fish 2.5-6.5 cm. Rulifson, R.A. 1977.
d Mean cruising speed for red drum. Wakeman and Wohlschlag 1982
e Mean speed for freshwater shrimp. Medland, et al., 2000
f Mean sustained speed. Venn Beecham et al. 2003.
g Critical speed. Sylvester 1992.
h Optimum speed Wolter and Arlinghaus. 2003
i Cruising speed for Northern anchovy. Huntley and Zhou. 2004
j Critical speed. Wolter and Arlinghaus. 2003.
k Critical speed for white sucker. Wolter and Arlinghaus. 2003
l Mean cruising speed. Huntley and Zhou. 2004.

Table B-3
Potential for Threatened and Endangered Species to Inhabit the Waters in Vicinity of Entergy's Power Plants Located on the Lower Mississippi River

Common Name	Taxonomic Name	State Status	Federal Status	Potential for Impingement or Entrainment (upstream → downstream)								
				Ritchie (AR)	Gerald Andrus (MS)	Baxter Wilson (MS)	Willow Glen (LA)	Little Gypsy (LA)	Waterford 1& 2 (LA)	Nine mile (LA)	Paterson (LA)	Michoud (LA)
Dace, southern redbelly	*Phoxinus erythrogaster*	MS (E)	Not Listed		Yes	Yes						
Darter, crystal	Ammocrypta aspella	MS (E)	Not Listed		Yes	Yes						
Pigtoe, pyramid	*Pleurobema perovalis*	MS (E)	Not Listed		Yes	Yes						
Pocketbook, fat	*Potamilus capax*	MS (E)	E	Yes	Yes	Yes						
Sturgeon, gulf	*Acipenser oxyinchus desotoi*	LA (T) MS (E)	T								Yes	Yes
Sturgeon, pallid	*Scaphirhynchus albus*	LA (E) MS (E)	E	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Paddlefish	*Polyodon spathula*	Not Listed S3 (MS, LA)	Not Listed	Yes	Yes	Yes	Yes	Yes	Yes	Yes		

Threatened (T), Endangered (E), Arkansas (AR), Louisiana (LA), Mississippi (MS), S3 – rare and local throughout the state (National Heritage Ranking System)

Table B-4

Summary of Historical Impingement Studies at Entergy's Power Plants

Location	Study Title	River Mile	Period of Sampling	Sampling Frequency	Sampling Duration	Sampling Location	Measured Annual Impingement Rate (organisms/yr)[a]	Plant Capacity (gpm)	Impingement per 10,000 m^3 [b]	Ten Most Common Species
Baxter Wilson	Baxter Wilson Impingement Study	433 2	March 12, 1973 - August 20, 1973	March 12 - May 11, 1973: Daily; May 12 - August 20, 1973 . Twice per week, August 31, 1973 - March 1, 1974: Once per week for 24 hours	24 hours	Screen wash trough	160,730	412,000	1 96c	**Total 97.1%** - Freshwater drum (31 7%), Gizzard shad (30.8%), Shad spp. (22.2%), Threadfin shad (3.3%), Carp (2.7%), River shrimp (2.6%),White crappie (1.5%), Sucker (1 3%), Channel catfish (0.7%), Skipjack herring (0 4%)
Willow Glen Units 1 & 2	Willow Glen 316(a) and 316(b) Demonstration	201.6	January 1975 - January 1976	April - July 4 times per month, 2 times per month *remainder of year* 30 minute samples collected 4 times over 24 hours	24 hours	Sluiceway	26,210	171,000	1.47d	**Total 97.4 %** - River shrimp (57.3%), Freshwater drum (22.1%), Gizzard shad (5.7%), *Threadfin shad* (5.1%), Crayfish (2 6%), Blue catfish (2 4%), Black crappie (0.7%), Skipjack herring (0 6%), Bluegill (0.6%), White crappie (9.5%)
Willow Glen Unit 4	Willow Glen 316(a) and 316(b) Demonstration	201.6	January 1975 - January 1976	April - July: 4 times per month; 2 times per month remainder of year 30 minute sampled collected 4 times per day	24 hours	Sluiceway	5,037	228,000	0 13d	**Total 94.5%** - River shrimp (27.5%), Crayfish (27 0%), Freshwater drum (12.5%), Gizzard shad (9 3%), Threadfin shad (7 5%), Blue catfish (5.8%), Bluegill (1.4%), White crappie (1.4%), Channel catfish (1.2%), Skipjack herring (0.9%)
	Willow Glen Plant						Weighted-average	902,400	0.70	
Waterford 1 & 2	Screen Impingement Studies	129 7	February 1976 - January 1977	24 samples; 4 times per month	24 hours	Screen wash trough	336,454	429,000	4.33d	**Total 98.7%** - River shrimp (49.7%), Blue catfish (20.3%), Threadfin shad (10.5%), Bay anchovy (6.0%), Freshwater drum (4.5%), Gizzard shad (2.9%), Skipjack herring (2.4%), Channel catfish (2 1%), Striped mullet (0.3%), Blue crab (0 2%)
Paterson	Impingement Impact of A B. Paterson & Michoud Stations	branches off at RM 92 6	August 1977 - December 1979	Every other Thursday 10-minute samples collected every 4 hours for 24 hours	24 hours	Sluiceway	226,489	149,581	5.42d	**Total 90.7%** - Atlantic croaker (32.2%), Bay anchovy (17 1%), White seatrout (12 6%), Blue crab (10.5%), Gulf menhaden (6.6%), Sea catfish (4.5%), White shrimp (2.4%), Spot croaker (1.9%), Spotted seatrout (1.8%), Hogchoker (1 1%)
Michoud	Impingement Impact of A.B Paterson & Michoud Stations	branches off at RM 92 6	August 1977 - December 1979	Every other Thursday. 10-minute samples collected every 4 hours for 24 hours	24 hours	Sluiceway	1,676,726	529,750	9 41d	**Total 91.2%** - Atlantic croaker (21 5%), White shrimp (20 0%), Bay anchovy (13.5%), Brown shrimp (10.5%), Blue crab (9 0%), Sea catfish (7 8%), White seatrout (4 2%), Gafftopsail catfish (1.8%), Least puffer (1 6%), Blackcheek tonguefish(1.4%)

a - Impingement rate estimated based on integration of sampling effort

b - Impingement rate estimated based on flow rate recorded during study

c - Flow rate used to calculate impingement rate were assumed to be at maximum plant capacity

d - Flow rates were recorded during impingement study and used to calculate impingement rate

Table B-5
Historically Observed Impingement as a Means of Representing Current Rates

Station(s)	Historical Data That is Representative of Current Conditions	Notes
Gerald Andrus	Baxter Wilson	Impingement Rates Likely Higher Due to Backwater Environment
Baxter Wilson, Ritchie	Baxter Wilson	
Willow Glen	Willow Glen	
Waterford 1&2, Little Gypsy, Ninemile	Waterford 1 & 2	Ninemile may have more estuarine species
Paterson	Paterson	
Michoud	Michoud	