Tampa Bay Estuary Program
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EFFECTS of CHANGES in FRESHWATER INFLOWS on BIOLOGICAL RESOURCES of TAMPA BAY TRIBUTARIES

FINAL REPORT

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Effects of Changes in Freshwater Inflow on Biological Resources of Tampa Bay Tributaries

Prepared for:

Gulf of Mexico Program
Stennis Space Center, MS

and

Tampa Bay Estuary Program
St. Petersburg, Florida

Prepared by:
Janicki Environmental, Inc.
1155 Eden Isle Dr. N.E.
St. Petersburg, Florida 33704

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Project scientific guidance was provided by the following group:

Holly Greening	Tampa Bay Estuary Program, St. Petersburg, FL
Robert McConnell	Tampa Bay Water, Clearwater, FL
Michael Flannery	Southwest FL Water Management District, Brooksville, FL
Ernst Peebles	University of South Florida, St. Petersburg, FL

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EXECUTIVE SUMMARY

The specific objectives of this project were to:

- Identify and compile existing data and produce general characterization assessments (status and trends) for freshwater inflow, fish species, benthic species and communities, and vegetation for Tampa Bay and tidal tributaries and streams,

- Assess potential relationships between freshwater inflow and biological effects in Tampa Bay tributaries, and

- Develop a quantitative model to be used as a potential management tool to determine potential biological impacts of freshwater inflow on Tampa Bay tributaries.

The diverse set of data available to examine relationships between freshwater inflow and biological resource responses in the Alafia River were compiled, integrated, and documented by this project. This comprehensive database represents a very important resource for ongoing work on the Alafia River, and the data will be capable of being readily expanded in the future as additional data are reported.

In the pilot study portion of the project, Artificial Neural Networks were demonstrated to provide a powerful tool for studying relationships between biotic and abiotic factors in ecological modeling. This analysis has established a foundation for further research into the application of feed forward neural network models as a tool to describe complex ecological relationships observed in Tampa Bay's Alafia River.

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GLOSSARY

Activation function-A mathematical function which takes the weighted activation values coming into a unit ,sums them, and translates the result to a position along a given scale.

Anadromous=migrating from the sea to freshwater (rivers and streams) to spawn

Artificial Neural Network=a computer software based in the architecture of the biological neural network of the brain

Back-Propagation=a type of neural network model that generally has one input layer , one output layer and one or more hidden layers; to train the model the weights are propagated forward and back creating recursive feedback training.

Connection weights=determines connection strength between neurons; weights are adjusted to store experiential knowledge and make it available for later use in prediction and classification.

Cross Validation= Testing a network during training on a data set which is not used to change the weights. Used to control a network's generalization ability.

Decision Tree= A classification algorithm used to predict outcomes based conditional probability and minimization of an error function.

Euryhaline=able to tolerate a wide range of salinity

Feed-Forward= A type of neural network model where information is passed in a unidirectional manner from input to hidden to output layers and no feedback mechanisms exist.

Layer=a group of artificial neurons; a neural layer is analogous to the groups in which neurons in the brain work in

Input Layer=first layer of the neural network

Output Layer=final layer of the neural network; its value is highly dependent on the structure of the neural network model

Hidden layer=intermediate layer(s) of neural network models generally consisting of the input layer modified by the activation function and multiplied by the input layer weights

Neurons=a.k.a processing entities, cells, nodes

Principal Components Analysis= A statistical variable reduction technique which projects a multidimensional set of data onto a new coordinate system in which the principal axis accounts for the majority of the data variation and orthogonal axis account for resulting variation not explained by the first principal axis.

1.0 INTRODUCTION

The natural processes and management of freshwater inflow and the influences of freshwater inflow on ecological resources is a subject of significant concern in the Tampa Bay region. Freshwater represents both an important limited ecological resource and an important limited potable water supply resource. The watershed surrounding Tampa Bay is comprised of nine major sub-basins and 76 minor subbasins. Major surface tributaries to Tampa Bay include the Hillsborough, Alafia, Little Manatee River, Manatee River, an (at times) the Palm River/Tampa Bypass Canal. Many minor tributaries including numerous creeks, drainage ditches, and coastal streams also contribute to incoming freshwater in Tampa Bay. Freshwater inflow to Tampa Bay results from stormwater, runoff, overland flow, point source contributions from both domestic and industrial waste, springs, rainfall, and groundwater. Prior to urbanization in the Tampa Bay region, freshwater flows were determined by natural parameters such as rainfall, topography, soil types and vegetative cover within the system (Zarbock 1999). Of these variables, the single most important variable responsible for significant changes in flow regimes was rainfall (Flannery 1989, Zarbock 1999). Tampa Bay exhibits seasonal rainfall patterns, with more than half of all rainfall entering the watershed from June through September (Flannery 1989).

1.1 Freshwater and Tampa Bay

Significant flow alterations to Tampa Bay were evident in the early 1900's. Drainage patterns were changed by ditching, canal construction, canalization of streams and rivers and by the construction of surface impoundments such as the Hillsborough River reservoir (Zarbock 1999). Agricultural land use increased, causing changes in freshwater runoff from land clearing and increased groundwater pumping. During this same period, phosphate mining also resulted in changes in land use (Zarbock 1999).

Today land use changes in the watershed of Tampa Bay are still occurring. Changes in land use are occurring and coinciding with increases in urban development, agriculture and industrial water uses. Other large hydrologic alterations include the Tampa Bypass Canal and, the Lake Tarpon outfall.

Land use changes and anthropogenic influences do not represent the complete set of causes for stream flow changes. Decadal scale changes in rainfall and tropical disturbances have been identified as a contributor to decreases in stream flow. Stream flow in west-central Florida abruptly declined starting in the 1970's. There has been a 36% decrease in annual average flow in the post-1970 period as compared to the pre-1970 period (SDI Environmental Services Inc. 1998). Decreases in tropical disturbances and resulting decreases in rainfall in addition to non-climatic influences explain the reduction. Rainfall and flow data from the region report significantly lower rainfall and flow in the tributaries of Tampa Bay. A study comparing average annual rainfall from post-1970 and pre-1970 showed an average annual difference of 5.3 inches at the Tampa International Airport. Of the seven rainfall stations analyzed six exhibited a decline in average annual rainfall (SDI Environmental Services Inc. 1996). Stream flow in the major tributaries to Tampa Bay also showed a significant decrease in the same time period. For example the number of days with stream flow exceeding 1000 cfs in the Alafia River was over 800 between 1940-1969 during 1970-1999 the number dropped to just over 400 (SDI Environmental Services Inc. 1998). The Hillsborough, Manatee and Withlacoochee exhibited similar trends with the Withlacoochee dropping from over to 1200 to 500 days during the same time periods (SDI Environmental Services Inc. 1998).

The changes in rainfall may be closely linked with the Atlantic Multidecadal Oscillation (AMO), a naturally occurring variation in North Atlantic Ocean temperatures that occurs every 20 to 50 years. Higher than normal sea surface temperatures during the AMO period lead to increased wet season rainfall while cooler temperatures lead to lower summer season rainfall (Enfield et al. 2001). It is important to recognize that regional changes in land use and population affect freshwater inflows as well as global changes in climate change.

Tampa Bay currently has one of the highest population densities per square mile within the Gulf of Mexico watershed (Klein et al. 1996). Population densities are expected to increase by 35% or more during the next two decades (Klein et al. 1996). Increases in population levels have led to increased use of ground and surface water. In addition, land use changes caused by urbanization, agricultural and industrial development have led to significant changes to the hydrology of watershed, ultimately affecting Tampa Bay and the surrounding tributaries.

In the 1990's there was a call to action among managers, scientists and the public in the Tampa Bay Watershed. Lack of rainfall and continued water consumption from agricultural, industrial and public water use in the northwestern region of the Tampa Bay watershed, are believed to have contributed to lowered water levels in many lakes and wetlands. It became evident that if the rate of consumption of groundwater continued along with population increases, water availability would not keep pace with consumption. In order to keep up with future supply and demand southwest Florida would need to rely on surface water withdrawals in addition to groundwater withdrawals to meet water needs.

In May of 1998, the Southwest Florida Water Management District (SWFWMD), Tampa Bay Water and its Member Governments (consisting of Pasco, Hillsborough, and Pinellas Counties, the cities of St. Petersburg, Tampa and, New Port Richey) approved new water supply and ground water withdrawal reduction agreements. These agreements outline the time frame, plan of action and requirements for meeting reductions in groundwater withdrawals as well as obtaining environmentally sustainable sources of water supplies. The water plan specifically stated that groundwater production must be reduced at the eleven long producing well fields from a current permitted level of 158 mgd (million gallons per day) to 90 mgd by the end of 2007 (SWFMD 2001). Additionally, by December 2002, 38 mgd of new water must be supplied (increasing to 85 mgd by 2007) for distribution to the Tampa Bay member governments (SWFMD 2001). Currently, Tampa Bay Water meets the goal by reducing groundwater pumping from a permitted average of 158 mgd to 121 mgd in 2003 and will further lower pumping to 90 mgd by 2008 to allow the regional well field areas to recover.

Surface water withdrawals are also underway in the region to supplement the reduced ground water pumping. The Alafia River is being used for public supply in Tampa Bay Water's service area located within the Northern Tampa, Eastern Tampa Bay and the Southern Water Use Caution Areas. A surface water withdrawal intake structure is located on the south side of the Alafia River at the intersection of Bell Shoals Road and the river. The withdrawal rate is based on Alafia River Flow at Bell Shoals Road, with the following parameters; no withdrawal for flow rates less than 80 mgd, 10% withdrawal for flow rates between 80 and 517 mgd (or 8 to 51.7 mgd), and a maximum withdrawal capped at 51.7 mgd. In addition to surface water withdrawals, a desalination plant has also been built and is currently operational. When in full operation the plant will produce 25 mgd with the expansion potential to 35 mgd. This will provide the Tampa Bay region with 25% of its drinking water.

Estuaries are very dynamic ecosystems, and the regions where the estuarine environment meets the downstream riverine systems may be potentially affected by freshwater inflow management actions. These areas are generally extremely high in productivity as the allochthonous particle filled nutrient rich fresh water mixes with the more saline waters of the estuary. As the demand for water rises, groundwater sources are expected to be increasingly unable to provide the supply required. As a result it will be necessary to use additional surface water sources, which include desalination and surface water. It will be important to determine the ecological risks in systems undergoing water withdrawals. In addition, it will be important to evaluate any potential risks which may incur downstream of these rivers in estuaries dependant upon receiving freshwater flow. Upstream of estuaries, freshwater delivery is effected by dams, diversions and withdrawals. Water removal can have a significant effect on a riverine system such as the Alafia River, where water is removed. It may also potentially impact areas within Hillsborough Bay and Tampa Bay.

1.2 Conceptual Model of Freshwater Flow Effects to the Tampa Bay Estuary

This project was focused on Hillsborough Bay and the associated tributaries, particularly the Alafia River. A conceptual model was developed to show how relationships between freshwater flow and fish species are examined by this project (Figure 1-1). Understanding freshwater inflows and subsequent biological responses will contribute to the development of quantitative relationships for the composition, abundance, and distribution of fish species in the Alafia River. Using multiple predictor and response variables, this project works towards quantifying the potential relationships between freshwater inflow and fish by developing a simple conceptual model linking the two. The relationship investigates changes in physical, physiological and trophic variables.

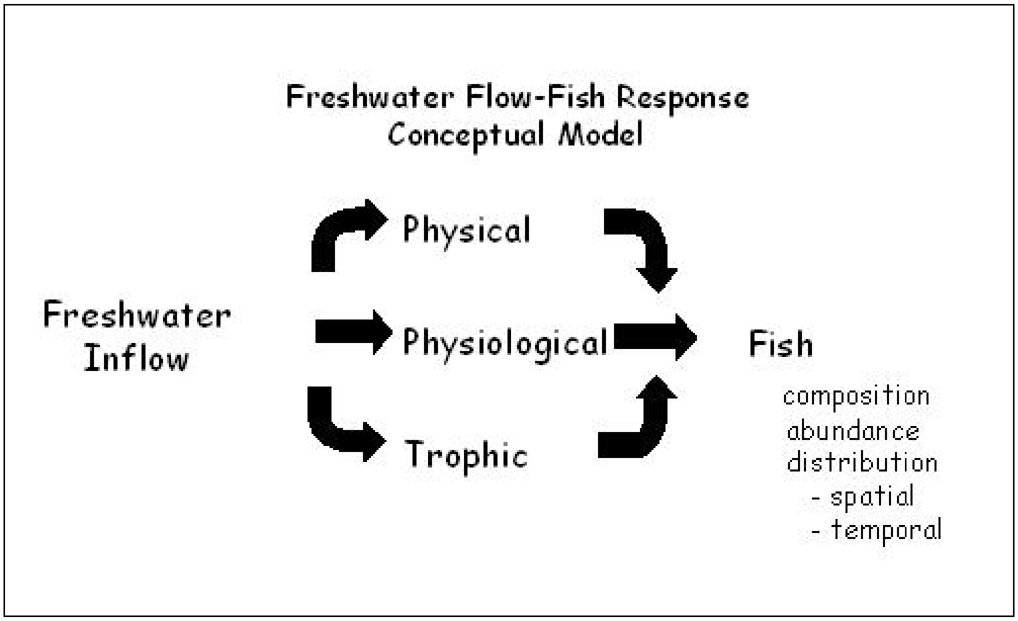

Figure 1-1. Conceptual model showing potential links between freshwater flow and fish.

Physical

Flow can affect a number of important water quality constituents, which then act to effect fish abundance and composition. Flow can change salinity regimes and act to affect the timing and location of the chlorophyll maximum in the downstream estuary that in turn determine fish species and composition within any given system.

Salinity plays a very important role in sustaining the biological health of an estuary. Salinity has both direct physical effects on the physiology of living resources and it is also a conservative indicator of other direct physical flow/residence time related effects on the living resources. Tampa Bay exhibits typical estuarine circulation patterns with less dense freshwater at the surface and more dense saline water at the bottom creating a salt wedge affect from the downstream region to the upstream region of the estuary. Tidal changes, which vary temporally and spatially, also affect salinity by increasing salinities on flood tide and decreasing salinities on ebb tide. Salinity may very seasonally distributed, with lower salinity during the wet summer months and higher salinities during the dry winter months. Studies completed for the Tampa Bay watershed and surrounding region report that isohalines respond to freshwater flow in a linear pattern in the five spring dominated rivers north of Tampa Bay but in a curvilinear manner in seven rivers dominated by surface runoff located to the south (Janicki Environmental 2001). Small reductions in freshwater flow in rivers exhibiting a curvilinear system result in dramatic upstream movements of isohalines especially during the dry season (Flannery et al. 2002). Shifts in isohalines can indicators of major changes in community structure (Jassby et al. 1995). Shifts can also eliminate suitable living habitat by placing favorable salinities outside of their shoreline or benthic habitat that may not be located where the new isohaline occurs. Additionally, there is a strong positive relationship between the extent of vertical stratification and the frequency and aerial extent of bottom water hypoxia resulting in fish kills and declines in benthic communities (Buzzelli et al. 2002).

In the Alafia River, the effects of flow on chlorophyll *a* are particularly important and are a primary factor in determining community composition and total production in the system. Flow may affect chlorophyll *a* in several ways, by increasing chlorophyll abundance, changing the location of peak chlorophyll *a* abundance, or decreasing chlorophyll *a* abundance and residence time. Higher than normal flows are associated with increased nutrient loading. This is normal in most estuaries and is critical to the ecosystem because increased nutrient loads are followed by increased chlorophyll *a* abundance. Higher chlorophyll a resulting from algae blooms provides more food for zooplankton that in turn provides more food for young fish. Decreases in flow can change the timing and size of algal blooms and consequently provide less fish to higher trophic species. During extremely high flow conditions, flushing is more rapid and residence time in the river is reduced (Flannery et al. 2002; Peterson and Festa, 1984; Jassby et al. 1995). Very high flows may not result in higher chlorophyll abundance, due to the relationship between the residence time of water within the system, and uptake and growth rates of the phytoplankton community. The net effect of high flows, under certain conditions, may be no increase or a decrease in chlorophyll *a* abundance, compared to what might be expected. An example of this type of net effect has been recently reported in the Caloosahatchee River (Janicki Environmental 2003). Analysis of flow and chlorophyll a values showed that when flows in the river reached an excess of 150 m^3/s or higher in the preceding months, physical factors such as residence time override biological factors such as nutrient uptake and algal growth in determining mean monthly chlorophyll-a concentrations. During times of low freshwater inflow, chlorophyll *a* is typically located further upstream than during times of high flow. Low flow also allows a longer residence time for chlorophyll *a* and other nutrients.

Physiological

Physiologically salinity is an important factor for biota in tidal rivers, and is largely influenced by the amount of freshwater inflow entering the system. Salinity may affect the distribution and abundance of individual species, and the overall composition of the fish community. Flow is inversely related with salinity in tidal rivers. During high flow periods, salinity at particular location will be lower with the opposite effect during low flow periods. Salinity gradients move up and down the river based on changes in flow conditions.

Salinity also acts to affect species distribution of the fish by limiting their range of tolerance. Osmotic limitations restrict the ability of many freshwater species from using habitat in downstream portions that are tidally influenced. Marine species also face osmotic problems that restrict access to upstream freshwater habitats. However, numerous euryhaline species have adaptations that allow them to live in a wide range of salinity conditions. Eggs and larvae of some estuarine fishes cannot tolerate high salinity of the marine environment that may result from reduced freshwater flows. The quantity and seasonal timing of freshwater inputs are particularly critical to these sensitive stages.

Numerous species of fish and shellfish are dependent on estuarine habitat at some point in their life cycle. A majority (78%) of marine fish species live in a narrow band of water less than 200m deep along the margins of land masses in and near estuaries (Moyle and Cech 1996). The dynamic physical regime determined by freshwater flow is essential for the spawning of numerous species. Tampa Bay and its tributaries are home to marine fish that complete their life cycles there, marine species that spend only part of their life cycles there because of low-salinity limits, anadromous species transiting from salt to freshwater and freshwater fish. Because estuaries are environments that host extreme ranges in salinities, physical properties rather than biological ones usually determine species composition. As a result estuarine species are lower in number as compared to marine and freshwater species. Most importantly estuaries act as nursery grounds for many fish and invertebrates. Over 23 species use Tampa Bay as a nursery area, including blue crabs, menhaden, Spanish mackerel, mullet, spotted sea trout and red drum (Coastal Environmental 1995).

Dissolved oxygen in rivers and estuaries is usually high enough to sustain fish and other biota, except when high loading of nitrogen and phosphorus result in excessive primary production. Fish are heterotrophs that rely on primary production, either directly from phytoplankton biomass or indirectly by preying on herbivorous fish that consume phytoplankton. Generally, higher biomass of primary producers results in a greater abundance of primary and secondary consumers that typically concentrates fish in the portion of the river or estuary at the chlorophyll maximum (Cole 1994). However, under certain conditions, excessive phytoplankton biomass in the water column can degrade water quality. The accumulation of organic matter (phytoplankton) is followed by decomposition that is achieved by bacterial respiration. Bacterial respiration consumes oxygen from the water column. If increases in organic matter and the resultant increase in bacterial respiration and oxygen consumption exceed the rate of oxygen production or invasion from the atmosphere, reductions in dissolved oxygen may occur. Marked reductions in dissolved oxygen levels have negative affects on other organisms in the water column. Therefore it is very important to adjust flows in river such that flow is high enough to deliver the necessary nutrients for the chlorophyll maximum to be reached in optimal fish habitats and not to allow flows to decrease to such a level that production associated anoxia or hypoxia occurs.

Trophic

Changes in flow can alter the species composition of the phytoplankton community. Extremely high flows can reduce the phytoplankton community by causing excessive flushing and insufficient residence time. Too little flow can act to increase residence time such that excess productivity becomes a problem. In extreme cases, shifts in species dominance may occur, resulting in blooms of harmful (toxic) algal species. Noxious, toxic, large or otherwise inedible algae lead to inefficient zooplankton grazing. This can lead to decreased trophic efficiency decreases in secondary and tertiary production.

Changes in community structure, food web interactions, rates of primary and secondary production and material cycling will ultimately change the biotic integrity of the ecosystem. River-derived inputs mostly nutrients and particulate organic matter, act as the main catalyst for phytoplankton production. Primary animal associations of shallow Gulf of Mexico estuaries such as Tampa Bay include infaunal macroinvertebrates, epifaunal macroinvertebrates, and fish (Livingston 1997). Although it is very hard to quantify the long-term relationships of freshwater input and estuarine primary productivity, there is a direct connection between the primary production of an estuary and the secondary food webs. Studies from one Gulf of Mexico estuary, Apalachicola Bay, suggested that prior to the onset of a drought there were relatively small changes in the various trophic levels of the system (Livingston et al. 1997). In response to a drought there was an initial increase in herbivore biomass, followed by a distinct reduction probably resulting from nutrient limitation. During the drought there were extreme changes in secondary production as evidenced by shifts in trophic organization. Additionally there was a 1-2 yr response time for the entire food web shift as a result of decreases in freshwater flow. Similar conditions were found in San Francisco Bay resulting from a drought. The system exhibited initial high chlorophyll a concentrations associated with increased water clarity and higher salinity but then a subsequent drop during the later part of the drought concurrent with peak densities of suspension-feeding bivalves, polycheates and amphipods (Livingston et al. 1997). This changes in primary and secondary production resulted in long- term changes in food web dynamics consistent with those found in Apalachicola Bay.

Fish Responses to Freshwater Inflow

The species that make up estuarine fish communities exist in a continual state of change, but the basic structure of the community is fairly constant, and predictable. The stability of fish species are the result of four main factors: the regular distribution of species along gradients of salinity, temperature, and other variables; the predictable seasonal movements of fishes in and out of the estuary; the dominance of estuaries by a relatively few but interchangeable species; and the robust food webs (Moyle and Cech 1996). The fishes of Gulf Coast estuaries are associated with distinct temperature and salinity ranges at capture. These ranges are usually expansive making the alignment of species along any given environmental gradient difficult to determine (Moyle and Cech 1996). Although species alignment is difficult to determine at small spatial scales there is distinct differences between fish communities at the upper ends of estuaries and those of more saline and less thermally changing lower ends. The most numerous species at the upper ends are usually small planktivores, such as the bay anchovy (*Anchoa mitchilli*) and juvenile gulf menhaden. Juvenile croaker are often abundant along with the "true" estuarine species the hogchoker (*Trinectes maculatus*). Freshwater and anadromous species are usually present but in low numbers. Moving downstream to more saline water, marine fish dominate with true estuarine fish and estuarine-dependent fish.

Species Distribution

Many floral and faunal species are limited in range by the physiological challenges and stresses associated with variable salinity environments. Osmotic limitations restrict the ability of many freshwater species from using habitat in downstream portions that are tidally influenced. Marine species also face osmotic problems that restrict access to upstream freshwater habitats that are low in salinity. However, numerous euryhaline species have adaptations that allow them to live within a wide range of salinity conditions

Species Abundance

The physiological stresses caused by salinity may affect the success of individual fish within a species, consequently affecting the overall abundance of that species. While the distribution of a given species is determined by salinity, species able to tolerate saline conditions may still be affected by salinity-related stressors. Species typically have an optimal salinity that is somewhere within the range of salinity that they may be able to inhabit. The salinity in which the eggs, larval, or juvenile forms of certain species develop, may impact their growth and survival rates. It will also affect the availability of prey and where adults of the species congregate and forage

Species Composition

The composition of the fish community in a tidal system is likely to change based on the salinity regime. Responses in the fish community are expected to be the composite result of the affects of salinity on all the individual species within the community, as described previously.

Another way of assessing changes in fish composition is to classify fish into groups based on their ecological affinity. Ecological affinity is an important concept when examining fish community composition and habitat usage along gradients of environmental conditions. For the purpose of this project each species was classified into one of the three groups defined as:

> *Freshwater group* - species are typically residents of freshwater origin, which may have an extended range that includes low salinity areas.

Estuarine group - estuarine resident species that spend their entire lifecycles, including spawning, in estuaries OR species of marine origin which are frequently found in estuaries but may travel back and forth between the Gulf of Mexico and Tampa Bay.

Estuarine-Dependent group - marine species that spend at least one important phase of their lifecycles in estuaries. They often utilize the marsh and estuary for its nursery value

1.3 Objectives

The specific objectives of this project were to:

- Identify and compile existing data and produce general characterization assessments (status and trends) for freshwater inflow, fish species, benthic species and communities, and vegetation for Tampa Bay and tidal tributaries and streams,

- Assess potential relationships between freshwater inflow and biological effects in Tampa Bay tributaries, and

- Develop a quantitative model to be used as a potential management tool to determine potential biological impacts of freshwater inflow on Tampa Bay tributaries.

2.0 DESCRIPTION OF THE ALAFIA RIVER

The Alafia River is one of several tributaries to Tampa Bay that is becoming increasingly important as a current and future potable water supply resource. An increase in the regional demand for potable water, combined with concern about groundwater over-pumping, has generated a focus on surface water resources as one of several new sources (e.g., reverse osmosis of sweater, new surface reservoirs, aquifer storage and recovery and others) for potential withdrawals. Due to current and future water withdrawal activities, it is important to understand these systems and the ecological relationships most likely to be affected by, and indicative of, alterations to flow.

2.1 Physical Characteristics

Location

The Alafia River spans two counties, with headwaters originating in western Polk County, and converging to form the river in Hillsborough County (Figure 2-1). The two main tributaries to the Alafia River are the North Prong of the Alafia River and the South Prong of the Alafia River. Smaller perennial and intermittent tributaries also contribute to the Alafia River flow. The river flows westerly for approximately 24 miles, from Polk County, through Hillsborough County and to the Hillsborough Bay segment of Tampa Bay (SWFWMD 2001a). The Alafia River and watershed are bounded to the north by the Hillsborough River watershed, to the east by the Peace River watershed, to the south by the Little Manatee River watershed and finally, to the east, by Tampa Bay (SWFWMD 2001a). A number of second and third magnitude springs contribute to the flow in the Alafia River (SWFWMD 2001b).

Morphology

Morphology in the Alafia River gradually changes from the headwaters to the river mouth. The tributary streams of the Alafia River are relatively narrow, with deep-cut banks, few large swamps, and as a result are fairly swift-flowing compared to most streams in Florida. The substrate is predominantly bedrock and hardwood tree canopy covers most of the channel.

The river drops sharply near Bell Shoals Road, where four shoals comprise the Bell Shoals complex (located between river kilometers 16-18). During times of low flow and low tides, these shoals impound some of the river flow, maintaining water levels upstream. The limestone sills also limit tidal influence to the lower 15 river kilometers (Bell Shoals represents the approximate upstream extent of tidal influence) (Peebles, 2002). From Bell Shoals Road to U.S. 301, the river meanders in a narrow, deeply incised channel. Along this section, the river channel ranges from 14 to 140 miles wide and 1.2 to 4 meters deep.

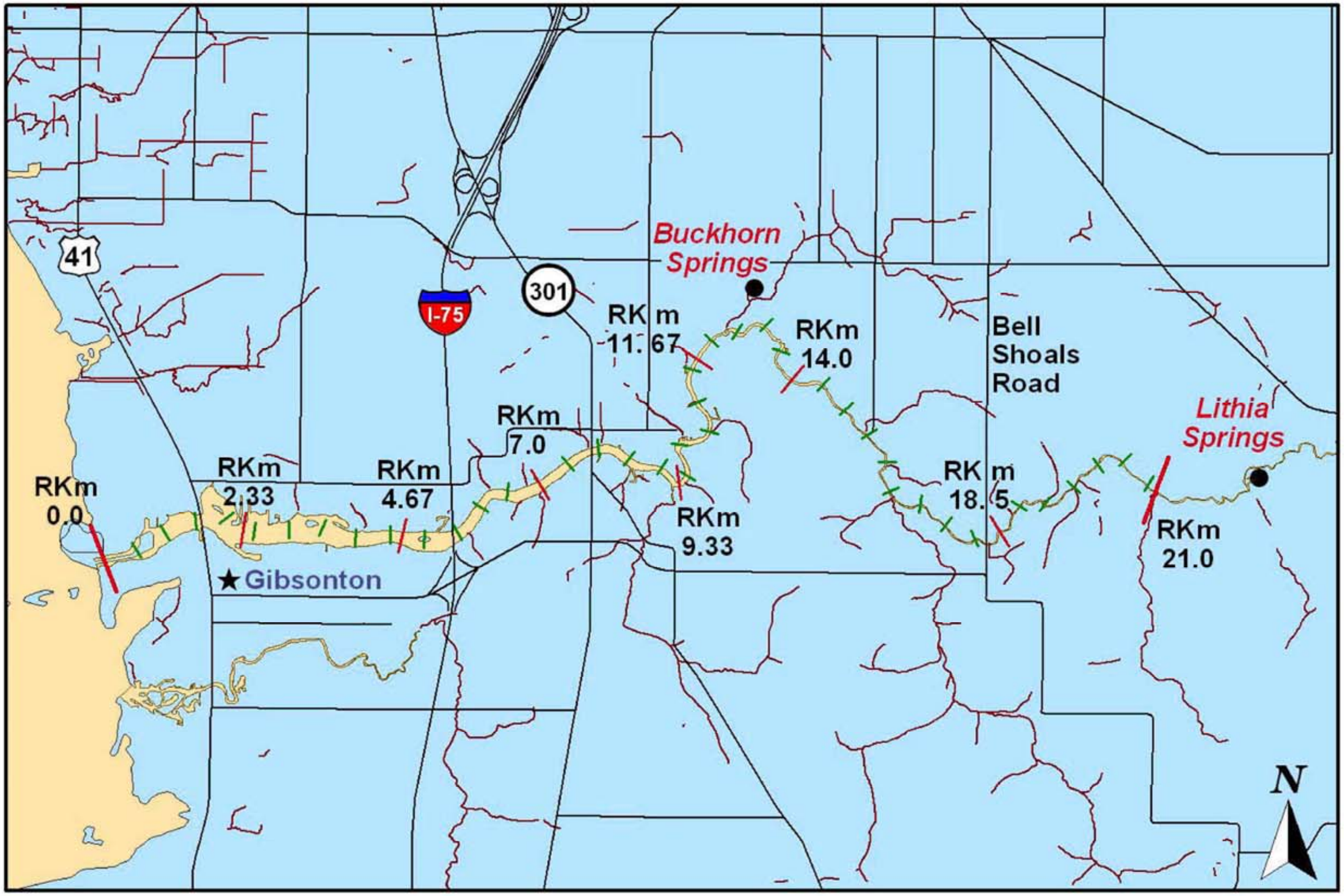

Figure 2-1. Map of the lower Alafia River, showing river kilometer (Rkm) and spring locations.

Further downstream, from U. S. 301 to U. S. 41, the channel widens from 105 to 460 meters, with relatively little changes in depth (Giovannelli, 1981). The Alafia River mouth has been extensively modified by dredge/fill activities which occurred prior to 1930 (Fehring, 1985). The channel was dredged to provide a main ship channel to Tampa Bay for the phosphate processing plant. The channel is located west of U.S. Highway 41 and passed the rivers natural mouth to its north. The former river mouth was then partially filled changing the rivers mouth permanently. Through the years dredge spoil has accumulated over the historic mouth reducing it to a small tidal creek with little connection to the river (Stoker, 1996; Parsons Engineering Science, 2002).

2.2 Watershed and Land Use

The Alafia River watershed includes approximately 270,000 acres or 460 square miles (SWFWMD 2001a). Land use within the watershed consists primarily of agriculture, residential development, and phosphate mining (SWFWMD 2001a). Predominant land use is agricultural, consisting of crop and pasture land. Land use in the lower portion of the watershed consists mainly of residential development. The eastern most portion of the watershed, including the headwaters, particularly the south side of North Prong and South Prong, are affected by phosphate mining. Additionally, residents within the watershed predominantly use septic tanks, and several privately owned sites use a combination of pumped sewage and land application.

Additionally, no natural lakes occur within the Alafia River Watershed. However, several lakes in the upper regions of the watershed, have been produced as a result of phosphate mining activities, which include borrow pits, slime ponds, reservoirs for recycling process waters (Wolfe and Drew, 1990). The Edward Medard Reservoir is one such lake that cuts across the Little Alafia River and includes strip-mine pits and tailing ponds (USGS, 1983). In addition, Tampa Bay Water is currently constructing a large regional reservoir for potable water supply.

2.3 Hydrology/Flow

Annual flow for the Alafia River at Bell Shoals Road ranges from under 50 cfs to approximately 2500 cfs (Figure 2-2). The most recent extended period of low flow began in the second half of 1999 and extended into 2001. Mean annual flow for Bell Shoals Road is 332.8 cfs and percentiles of flow are as follows (PBS&J 2003):

- 95% = 975 cfs
- 90% = 683 cfs
- 75% = 376 cfs
- 50% = 201 cfs
- 25% = 123 cfs

- 10% = 79 cfs
- 5% = 58 cfs

Monthly variations in flow are presented in Figure 2-3. Seasonal high flows occur in mid to late summer and extend through early fall. The lowest flows occur during April and May, which corresponds to the end of the dry season, just prior to the onset of the wet season.

Two second magnitude springs, Lithia and Buckhorn, are fed from the Floridian aquifer and contribute approximately 35-50 cfs of flow to the lower portion of the river (Kurz et al., 2002, SWFWMD 2001a, SWFWMDb). Lithia Springs alone accounts for up to 27% of total river flow during the dry season and up to 10% during the wet season (EES 1977b). Buckhorn and Lithia Springs are located approximately 12 and 22 river kilometers from the river mouth, respectively. In addition to Lithia and Buckhorn Springs, a number of smaller (third magnitude) springs contribute to the total spring flow to the river, including Bell Creek Spring (also referred to as Boyette Spring) (SWFWMDb). The springs discharge into separate runs, and water from both Lithia and Buckhorn Springs is pumped/diverted for industrial use (SWFWMD 2001b). Spring discharge varies seasonally, closely following season changes in precipitation. The seasonal pattern in discharge, along with chloride concentrations of <30 mg/L, indicates the springs are readily recharged by rainfall occurring in close proximity to the springs and that open circulation of groundwater in the aquifer is occurring (SWFWMD 2001b) .

2.4 Water Quality

Water quality concerns in the Alafia River are hypothesized to be related to nutrients (nitrogen and phosphorus) and coliform bacteria, with low oxygen being reported in some locations. Anthropogenic influences associated with impacted water quality are numerous along the extent of the river. These influences include phosphate mining, processing and transportation, residential development, citrus production, and animal feeding operations. Phosphate mining and the production of fertilizers have occurred in the Alafia watershed, with extensive activity in the North Prong sub-basin. Advances in gypsum stacks and on-site stormwater storage treatment ponds are being developed with the intention of alleviating the potential for degradation of water quality and habitat.

While it is unknown what water quality conditions were in pre-development and pre-mining days, water quality in the watershed has been reported to have been impacted by the phosphate mining that began in the Alafia River basin over a century ago and continues on today (Stoker, 1996). In the mid-1970's the greatest source of ambient orthophosphate in west- central Florida was from waste produced during mining operations, and the highest phosphorous concentrations and loads in Florida were observed in the Alafia River (Kaufman, 1975). It is unknown what water quality conditions were like in the Alafia before mining began. While concentrations of orthophosphorous in the Alafia River have been reported to be decreasing since the mid-1960's, periodic spills from mining operations have occurred, resulting in large increases in total phosphorous concentration and load in the river (Stoker, 1996).

Several stream segments in the Alafia (Lower Alafia, Buckhorn Creek, Bell Creek, Fishhawk Creek, Turkey Creek, English Creek, North Prong, South Prong) are listed in the Florida 1998 Section 303(d) Report. The parameters of concern among these segments include dissolved oxygen, coliform bacteria, nutrients, metals, and turbidity.

Nitrogen and Spring Loading

Lithia and Buckhorn Springs have accounted for significant loading of nitrate rich water to the Alafia River with estimates of 157 tons of N annually (Parsons Engineering Science, 2001). Lithia and Buckhorn Springs discharged approximately 22% of the nitrate that enters Tampa Bay through the Alafia River.

Dissolved Oxygen

Long-term dissolved oxygen (DO) concentrations have been monitored by the Environmental Protection Commission of Hillsborough County (EPCHC) at two stations located at kilometer 1.7 and from 18.1. Dissolved oxygen (DO) concentrations in the Alafia River were observed to show typical seasonal trends with higher DO in the cooler months and lower DO in the warmer summer months. High ambient dissolved oxygen levels have been found in dense phytoplankton blooms, which occasionally occur, in the mid and lower reaches of the Alafia River from 0-14 km. (Tampa Bay Water HBMP, (HBMP)). Surface dissolved oxygen concentrations in the lower and middle river segments have been observed to fall below 4.0 mg/L. Dissolved oxygen in the bottom waters are typically lower than surface water values with strong vertical salinity stratification observed in the middle and lower Alafia that can seasonally result in hypoxic (< 2.0 mg/L) and anoxic (<0.2 mg/L) (HBMP). Stronger flows and lack of a salinity caused stratification and phytoplankton blooms in the upper reaches of the river result in a relatively constant dissolved oxygen concentrations throughout the water column (HBMP). Box and whisker plots for dissolved oxygen values within a year, for years 2000-2003, are provided by HBMP strata in Appendix A.

Chlorophyll a

Long-term chlorophyll-a concentrations have been monitored by the EPCHC at two stations located at kilometer 1.7 and from 18.1. Over the most recent three year period, the Southwest Florida Water Management District and Tampa Bay Water HBMP Alafia River monitoring programs have investigated spatial and temporal patterns in the chlorophyll-a in the lower Alafia River. In the middle and lower river segments, chlorophyll-a concentrations exhibit very wide ranges of variability due to the periodic occurrences of very high phytoplankton densities. Box and whisker plots for observed chlorophyll a values within a year, for years 2000-2003, are provided by HBMP strata in Appendix A.

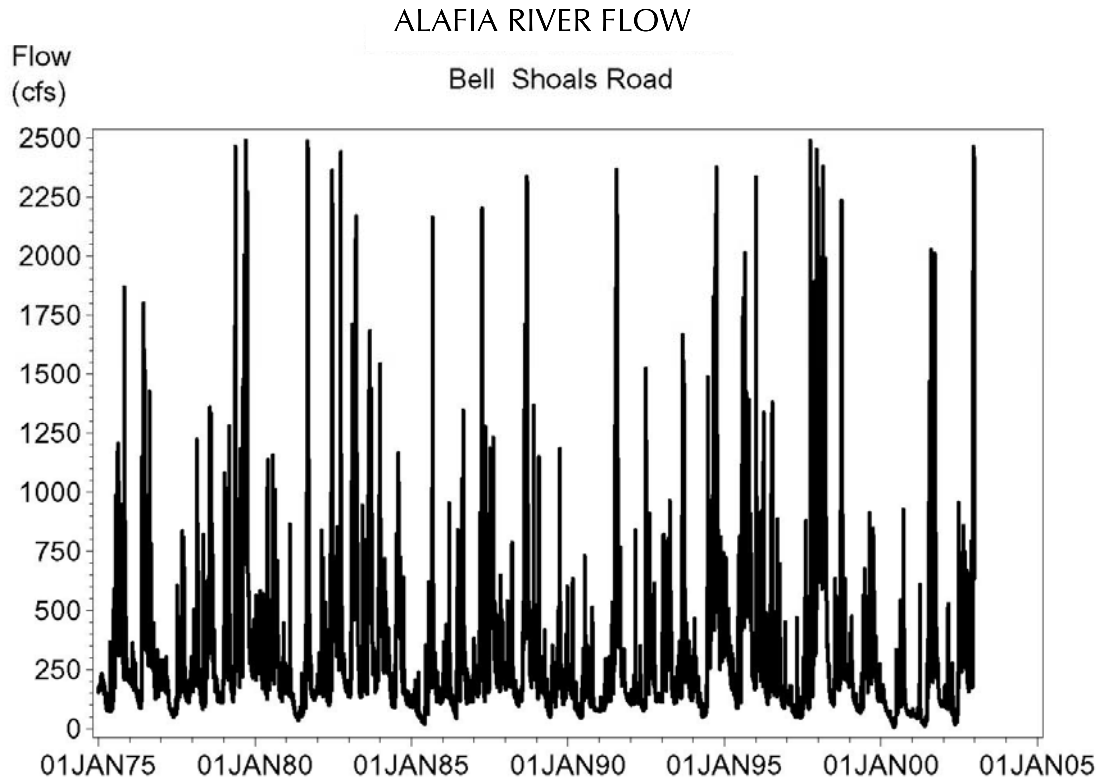

Figure 2-2. Flow data estimated at Bell Shoals Road for 1975-2003.

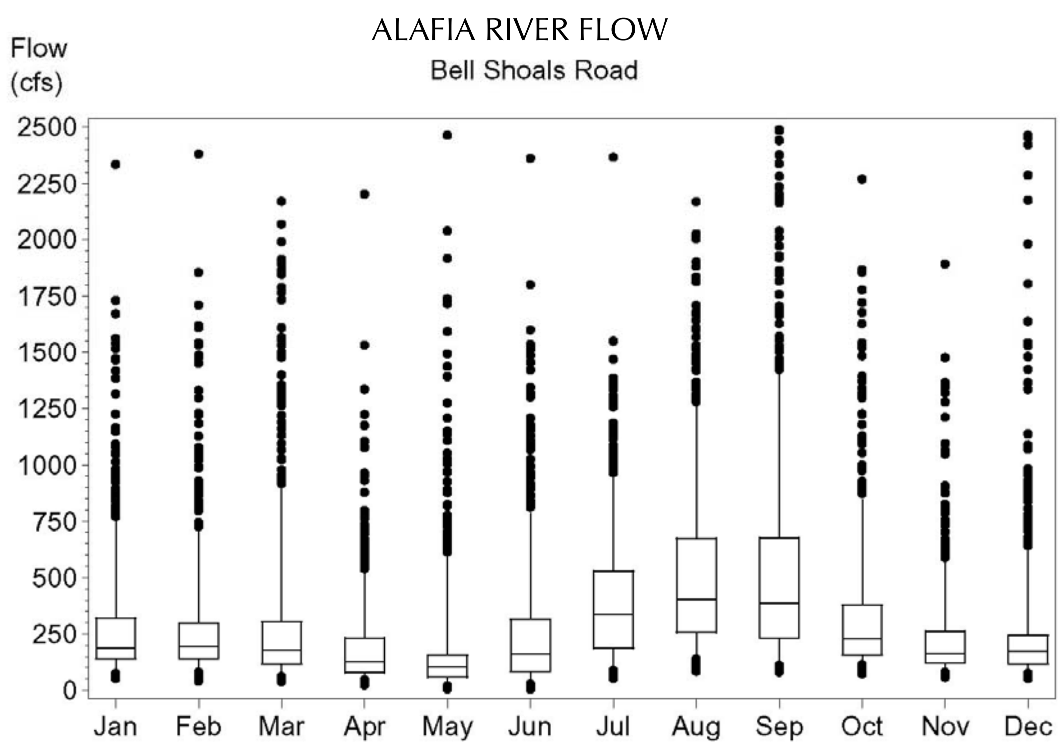

Figure 2-3. Box and whisker plots of monthly flow data estimated at Bell Shoals Road for 1975-2003.

Salinity

The Alafia River is characterized by a gradient of increasing salinity, starting from the upper most tidally influenced region, to downstream at the river mouth. The river is characterized by freshwater conditions upstream of river kilometer 17. Between Rkm 7 and Rkm 0 (at the mouth), salinities between 20-25 ppt are common. The largest observed variations in surface salinity, both within and between years, occurs in the normally higher salinity portions of the lower river, during times of seasonally high freshwater inflows. In the tidally influences portion of the river, flow has dropped substantially, becoming slow and sluggish. During times of high flow and high tide, the occurrence of a salt wedge is evident as surface salinity can be as low as 1 ppt while bottom salinity is observed as >20 ppt (Wolfe and Drew, 1990). Example salinity distributions for an above normal rainfall year and a below normal rainfall year are presented in Figure 2-4.

Similar patterns in distribution are seen in bottom salinities, with several exceptions. During times of intermediate flows, near bottom salinities are notably higher than surface salinities for corresponding areas between the river mouth and Rkm 13. The lower reaches of the Alafia River are characterized by salinity stratification due to the differences in corresponding surface and bottom salinities. However, exceptions to the normal salinity stratification do occur during extensive periods of extremely low freshwater flows and periods of extremely high freshwater flows. During prolonged extremely low flows, higher salinities in bottom water have been observed extending as far upstream as Rkm 17, which is typically a freshwater reach of the river. During prolonged periods of very high flows, freshwater conditions have been observed in surface and bottom waters extending as far downstream as the river mouth (Rkm 0).

Box and whisker plots for observed salinity values within a year, for years 2000-2003, are provided by HBMP strata in Appendix A.

2.5 Sediments

Box and whisker plots for percent fines and percent organics, for years 2000-2003, are provided by HBMP strata in Appendix B.

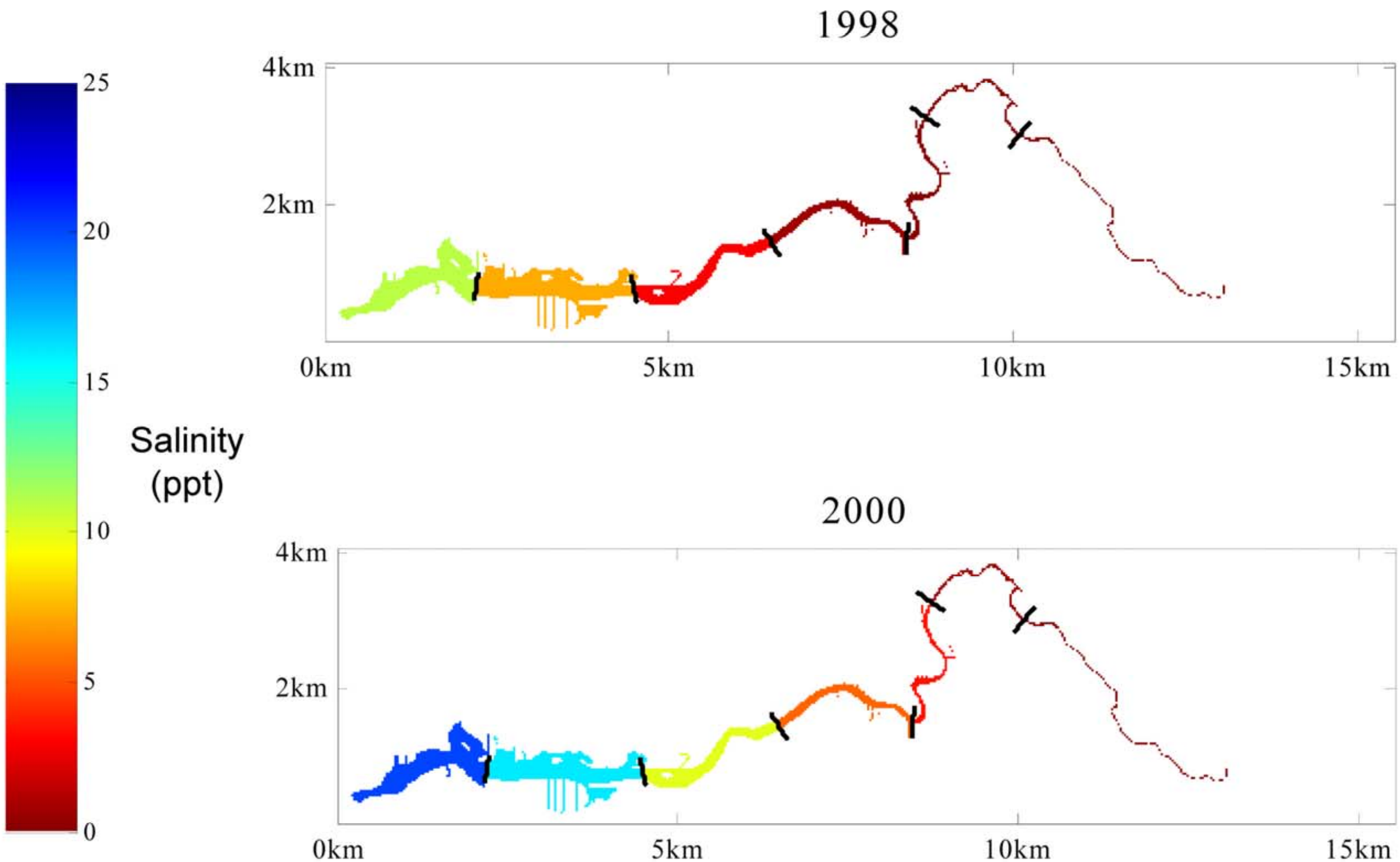

Figure 2-4. Median salinity distribution for the lower Alafia River during an above average rainfall year (1998) and a below average rainfall year (2000).

2.6 Biology

Vegetation

The Alafia River contains a range of vegetative habitats extending from Bell Shoals downstream to the river mouth. Although much of the habitat is limited in extent and fragmented from anthropogenic modifications, a range of habitats exist which support ecologically important species, in terms of recreational fishing and federally protected and endangered species.

The most abundant types of emergent vegetation are (PBS&J, 2003):

- Needlerush marsh (47% of emergent veg., 18.86 hectares (ha)),
- Mangrove swamp (38% , 15.10 ha).
- Mixed herbaceous wetland (5%, 1.98 ha),
- Brazillian pepper (4%, 1.55 ha) and
- Wetland hardwood forest (4%, 1.55 ha).

In terms of aerial extent, the lower 10 Rkm's contain 97% of all emergent vegetation (PBS&J, 2003). Approximately 89% (or 35.77 ha) of all emergent vegetated area occurs at or below Rkm 7, with the majority occurring at or below Rkm 5 (PBS& J, 2003).

Riparian vegetation on undeveloped shoreline, upwards of river kilometer 5 consists of hardwood trees. Much of the developed areas in the lowermost portion of the river consist of fill and hardened shoreline, which replaced former salt marsh habitat (Kurz et al, 2002). Within the lower 5 river kilometers (near the mouth), shoreline habitats include areas of leather fern (*Acrostichum danaeifolium*), mangroves, intertidal marshes and oyster reefs. Black mangroves (*Avicennia germinans*) and red mangroves (*Rhizophora mangle*) are present, but limited to the southern shore. Black needlerush (*Juncus roemarianus*) marshes vegetate small intertidal areas (Peebles, 2002).

Benthos

Benthic invertebrates comprise an important component of the Alafia River ecosystem. Benthic invertebrates serve important ecological roles including forming the food base for other invertebrate and vertebrate species. Additionally, benthos are often monitored and incorporated into water quality assessments. Since benthos are relatively immobile compared to other organisms, such as fish, the benthic community tends to reflect local conditions integrated over time. Diversity and specific taxa are known to decrease in response to environmental disturbance or declines in water quality.

The most frequently occurring species, all of which were present in at least 10% of all benthic samples taken within the Alafia River in recent years are as follows (PBS&J, 2003):

- *Grandidierella bonnieroides*, amphipod, Class Malacostraca
- *Laeonereis culveri*, annelid, Class Polychaeta
- *Streblospio benedicti*, annelid, Class Polychaeta
- *Nemertea sp.*, nemertea, class not identified
- *Chironomus sp.*, chironomid, Class Insecta
- *Mytilopsis leucophaeta*, bivalve, Class Bivalve
- *Tubificidae sp.*, oligochaete, Class Oligochaete
- *Ampelisca cf.* abdita, amphipod, Class Malacostraca
- *Steninonereis martini*, annelid, Class Polychaete
- *Cyathura polita*, isopod, Class Malacostraca

Box and whisker plots for invertebrate abundance, species richness and diversity are provided for each of the HBMP strata in Appendix C.

Fish

While many factors and processes outside the Alafia River watershed influence the distribution and abundance of fish species within the river, the suitability of available habitat in the river, in terms of foraging and nursery grounds, also influences fish recruitment and production. Within watershed factors that influence fish populations and communities are the hydrologic and salinity regime, pollution levels/contamination concentrations, available substrate and vegetation, and local fishing activities.

Species dominant as adults in the lower Alafia River include (Janicki Environmental, Inc. 2004):

- bay anchovy *(Anchoa mitchilli)*
- silversides *(Menidia spp.)*
- spot *(Leiostomus xanthurus)*
- mojarras (*Eucinostomus spp.)*
- pinfish *(Lagondon rhomboids)*
- rainwater killifish *(Lucania parva)*
- striped mullet *(Mugil cephalus)*
- hogchoker *(Trinectes maculates)*
- tidewater mojarra *(Eucinostomus harengulus)*
- red drum *(Sciaenops ocellatus)*
- striped killifish *(Fundulus majalis)*

Species abundant at larval and juvenile stages in the lower Alafia River include (Peebles, 2002):

- menhaden (*Brevoortia spp.*)
- sand seatrout (*Cynoscion arenarius*)

- hogchoker (*T. maculates*)
- silversides (*Menidia spp*.)
- skilletfish (*Gobiesox strumosus*)
- gobies (*Gobiosomus spp., Microgobius spp*.)

Planktonic eggs of the following species were found in the lower Alafia River, indicating these species use of the river as a spawning area (Peebles, 2002):

- bay anchovy (*A. mitchilli*)
- striped anchovy (*Anchoa hepsetus*)
- unidentified sciaenid fish (likely to include silver perch (*Bardiella chrysoura*), spotted seatrout (*C. nebulosus*), and sand seatrout (*C. arenarius*)

Species with non-planktonic eggs (includes estuarine resident species) that are likely to use the Alafia River as spawning habitat include (Peebles, 2002):

- Silversides (*Menidia spp*.)
- Gobies (multiple species)
- Blennies (multiple species)
- Skilletfish (*G. strumosus*)
- Killifish (*Fundulus spp*.)
- Mosquitofish (*Gambusia holbrooki*)
- Sailfin molly (*Poecilia latipinna*)
- Pipefish (*Syngnathus spp*.)

Box and whisker plots for fish abundance, species richness and diversity are provided for each of the HBMP strata in Appendix D, and box and whisker plots for ichthyoplankton abundance, species richness and diversity are provided for each of the HBMP strata in Appendix E.

2.7 Water Use

Major water uses in the Alafia River Watershed include agricultural and mining, as well as public supply. Water withdrawals in 1998 were distributed as follows (SWFWMD, 2001):

- 30% (29.8 MGD) Agricultural
- 28% (27.9 MGD) Mining/Dewatering
- 25% (24.9 MGD) Public Supply
- 15% (15.5 MGD) Commercial/Industrial
- 2% (1.5 MGD) Recreation

Currently, several public supply wellfields pump groundwater from the Floridian and Intermediate Aquifers within the watershed. Total groundwater withdrawals for 1998 totaled approximately 99.6 MGD.

Tampa Bay Water's Water Use Permit

Tributaries to Tampa Bay are becoming increasingly important as one of many water supply sources. An increase in demand for potable water, combined with a resource management need to reduce groundwater pumping, has led to an increasing focus on surface water resources as a part of the total supply alternatives. In Tampa Bay Water's Master Water Plan, a need for developing new water supply resources for the region was identified. Feasibility studies conducted in 1998 assessed the use of excess surface water flows from the Alafia River, the Tampa Bypass Canal, and high flow from the Hillsborough River, to supplement potable water supply for the region.

In July 1999 the Southwest Florida Water Management District (SWFWMD) issued a Water Use Permit to Tampa Bay Water for the development of the Alafia River Project as a regional public water supply (WUP No. 2011794.00). Pumping and conveyance facilities were constructed and surface water withdrawals began on February 7, 2003. Withdrawals from the Alafia River occur at a single pump station, located upstream of Bell Shoals Road. A flow based withdrawal schedule has been determined based on estimated river discharge at Bell Shoals Road. In March of 1999, SWFWMD issued a final Water Use Permit for the diversion of high water from the Hillsborough River via the Tampa Bypass Canal (WUP No. 2011796.00). Withdrawals from the Tampa Bypass Canal are also managed and permitted on a flow-based schedule (Tampa Bay Water, 2000). To address the question of how reductions in freshwater flow potentially affect the Alafia River, Hillsborough River and Tampa Bypass Canal, Tampa Bay Water has, as required by its Water Use Permit, established a Hydrobiological Monitoring Program (HBMP) (see Appendix M: Data sources).

The Alafia River Project, a component of Tampa Bay Water's Master Water Plan, is the only major surface withdrawal from the river. The project includes an intake structure and pumping facility on the Alafia River at Bell Shoals. The Water Use Permit issued for this project allows a range of 8-52 MGD of withdrawals during flow regimes above the minimum flow of 124 cfs (Tampa Bay Water, 2000). Water withdrawn from the river will be directly routed to the new Tampa Bay Regional Surface Water Treatment Plant. River withdrawals in excess of daily treatment capacity will be routed to the Tampa Bay Regional Reservoir, which will cover approximately 1100 acres and hold a volume of 15 billion gallons (Tampa Bay Water, 2000) .

While the Alafia River Project constitutes the only major surface withdrawals made directly from the river, two other permitted withdrawals for industrial use occur at Lithia and Buckhorn Springs, located above and below Bell Shoals, respectively. Withdrawals from Lithia Springs ranged from 4.1-4.6 MGD for 2000. Withdrawals from Buckhorn Springs are less and ranged from 0.27-0.4 MGD for 2000. These withdrawals are pumped to Cargill, Inc., a fertilizer processing plant located at U.S. 41 adjacent to the river (Tampa Bay Water, 2000).

To address the question of how reductions in freshwater flow affect the Alafia River, Hillsborough River and Tampa Bypass Canal, Tampa Bay Water has, as required by its Water Use Permit, established a Hydrobiological Monitoring Program (HBMP). A HBMP focus group was organized to solicit technical input from a team of consultants, academic experts, and federal, state and local agencies. The goal of HBMP is to insure that water bodies affected by the permitted water withdrawals do not deviate from the normal rate and range of fluctuation such that water quality, vegetation and animal populations are not adversely impacted in streams and estuaries. Additionally, it was desired that significant salinity regimes are not altered and recreational and aesthetic values are maintained.

The HBMP was designed as a comprehensive environmental monitoring program that establishes integrated sampling of critical indicators. Sampling occurs throughout specified reporting units, which were selected to account for the unique characteristics of different natural resources. The HBMP identified three monitoring program elements: hydrology/water quality, biota and habitat/vegetation. For each program element, a list of critical indicators has been specified. Critical indicators for the hydrology/water quality element include flow, water level, salinity, conductivity, dissolved oxygen, temperature, Secchi disk depth, light transmission, chlorophyll-a, color, total and dissolved organic carbon, and total suspended solids. Critical biotic indicators include: benthic macroinvertebrate infauna and epifauna, ichthyoplankton, zooplankton, juvenile and adult fish, and water-dependent birds. Critical habitat/vegetation indicators include: emergent and submerged aquatic vegetation, sediment grain size and sediment total organic matter.

The Tampa Bay Water HBMP employs a probabilistic sampling design, which in the Alafia River consists of seven strata: 6 estuarine and 1 freshwater. Estuarine strata extend from Rkm 0 to Rkm 14. The freshwater stratum covers Rkm 14-18.

3.0 STATUS AND TRENDS OF THE ALAFIA RIVER

In addition to the detailed description and status characterization presented based on analysis of observed data to date (Section 2 and appendices), statistical status and trend analyses are presented in this section for chemical and biological variables in the Alafia River.

3.1 Trend Methodology

Trend analyses for this report were completed using a seasonal Kendall Tau approach. The core statistical testing procedures were provided by EPA seasonal Kendall Tau Fortran programs available from the EPA Laboratory in Corvallis, Oregon. The authors developed statistical software to drive these core programs, and produce the automated outputs.

The procedure applied to the trend testing produces a page of graphical output in the detailed statistical appendices for each step in the analysis.

Note: The determination of seasonality step (Step 4) was completed for trend analyses using monthly data, and it was not completed for trend analyses using annual data (i.e., the annual flow trend tests).

Step 1-Time Series Plot

In the first step of each trend analysis a time series plot of the raw data was prepared for the period of record. Figure 3-1 provides a sample page of the actual output. This figure provides a valuable overall view of the trends and status of the parameter of interest.

Step 2-Univariate Statistics

In the second step of the trend analysis, the time series data were averaged to monthly values, and a complete set of univariate statistics was calculated to present the seasonality of the data on a monthly intra-annual basis (Figure 3-2). This provides a valuable overall view of the seasonality of the data.

Step 3-Correlation Analysis

In the third step of the analysis, a correlation analysis was performed for each monthly value, the previous month's value, two months prior etc., until correlation statistics were calculated for all previous months up to 15 months prior. A table of these values is provided in the output.

Step 4-Determination of Seasonality

In the fourth step of the analysis, an objective determination was made as to whether seasonality existed in the time series of data. An operationally defined and objective test to identify the presence of seasonality was applied. A correlelogram was provided as part of the output (example in Figure 3-3). If a correlation value on this plot was statistically significant then it would lie beyond the confidence limits shown. If the data presented by the plot had seasonality, then one would expect the 6-month lag values to be negatively correlated and the 12-month lag values to be positively correlated. The objective test measured the proportional distance between the zero line and the lower 95% confidence limit for the 6-month lag correlation (label 9), and the proportional distance between the zero reference line and the upper 95% confidence limit for the 12-month lag correlation (label 10). If the sum of distance 9 and 10 was greater than 1, or if distance 10 was greater than 1 then seasonality was determined to exist.

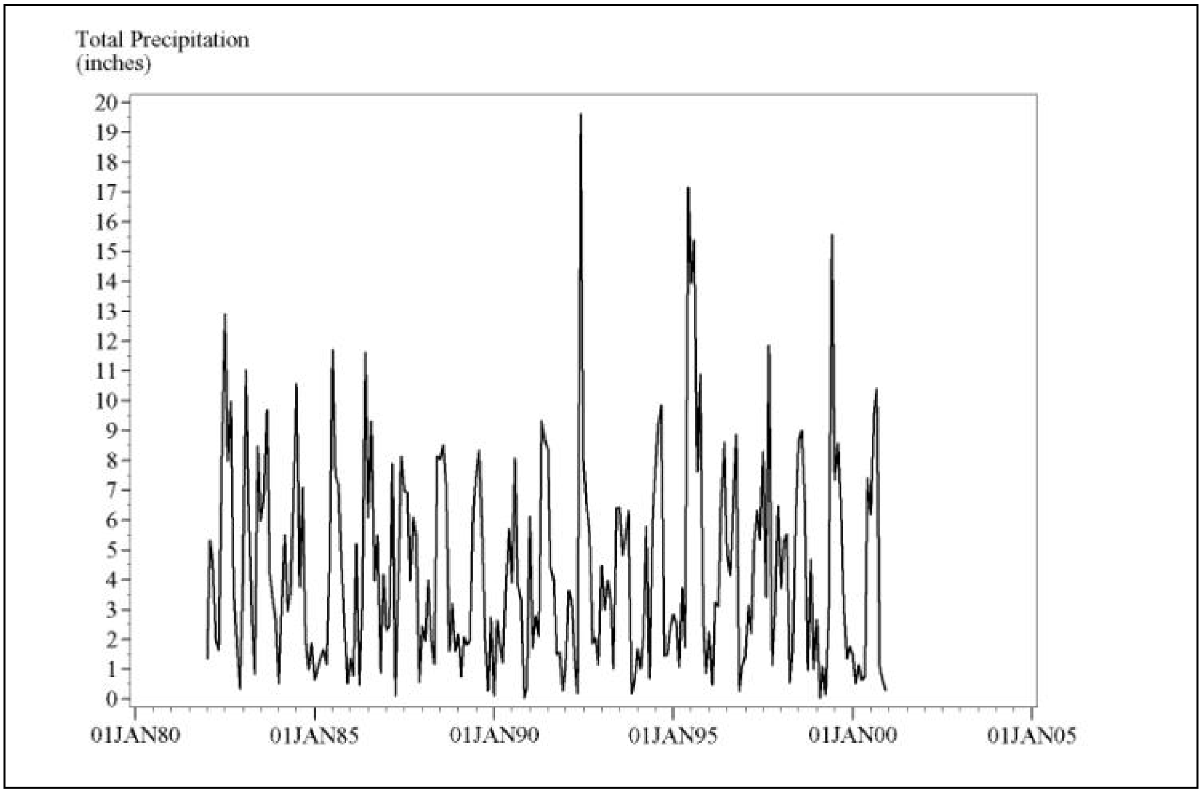

Figure 3-1 Sample time series plot of raw data for step 1 of trend analysis.

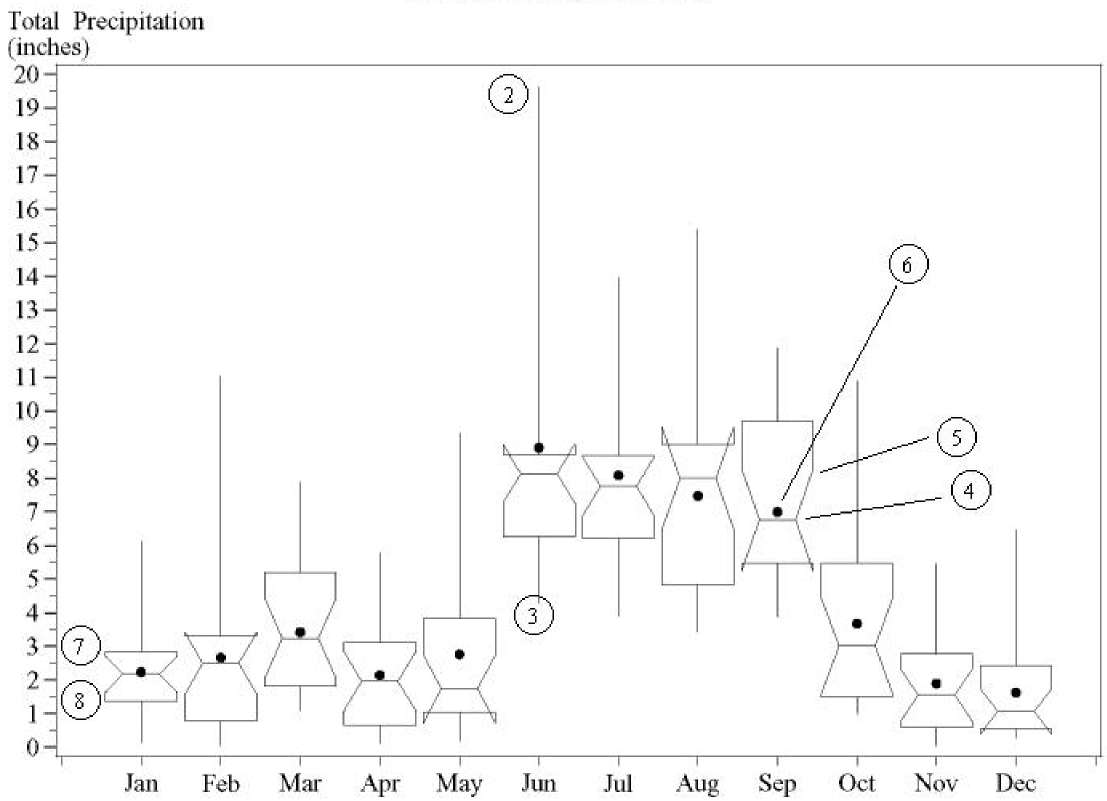

Figure 3-2 Sample seasonal univariate results output for step 2 of trend analysis. If the confidence limits around the medians for any pair of months did not overlap, then the medians were considered to significantly different at an alpha level of 0.05.

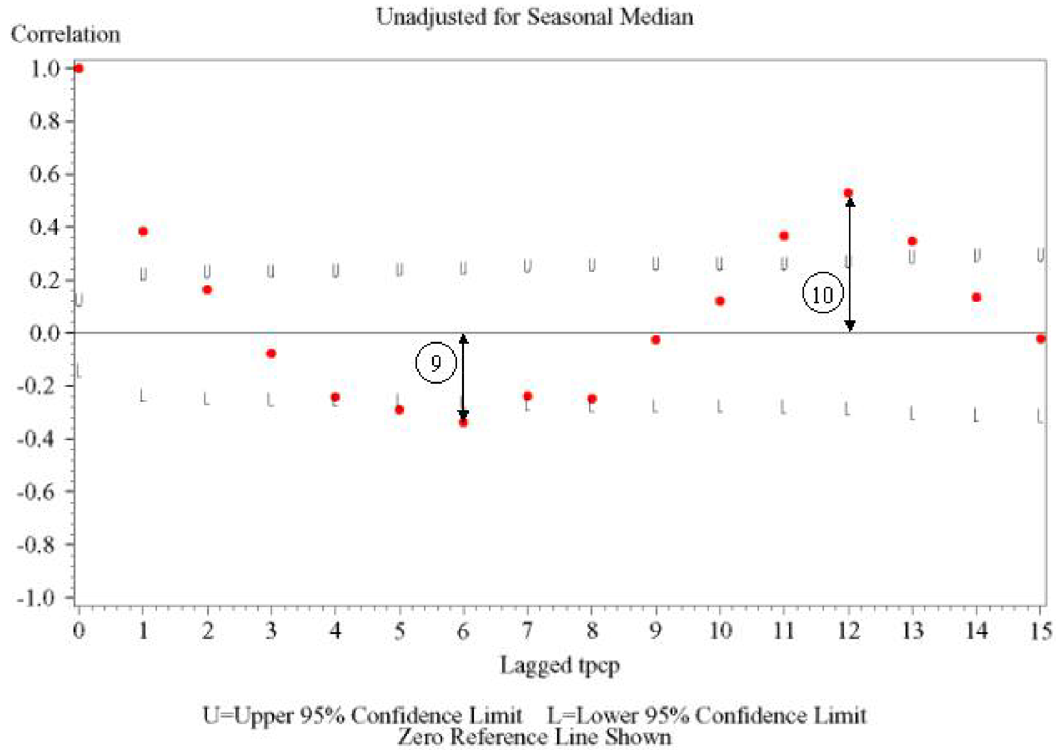

Figure 3-3 Sample seasonality test information output for step 4 of trend analysis.

If the data were determined to be seasonal, then the data are adjusted for season by subtracting the median monthly value from each data point. The season-adjusted data were then applied to a Kendall Tau. The Kendall Tau test determined the slope of the time series of data, and p-values for various data conditions. Tables of these values are provided in the results. However, in all cases summary trend tables are provided in the appendices showing the appropriate p values, slopes, and significance results for each trend.

Step 5-Testing for Autocorrelation

The next step was to test the data for autocorrelation in a similar fashion to that completed to identify seasonality. In the first phase of this analysis, the season-adjusted data were de-trended by removing the effects of the slope identified. A diagnostic figure was then provided of these data (Figure 3-4).

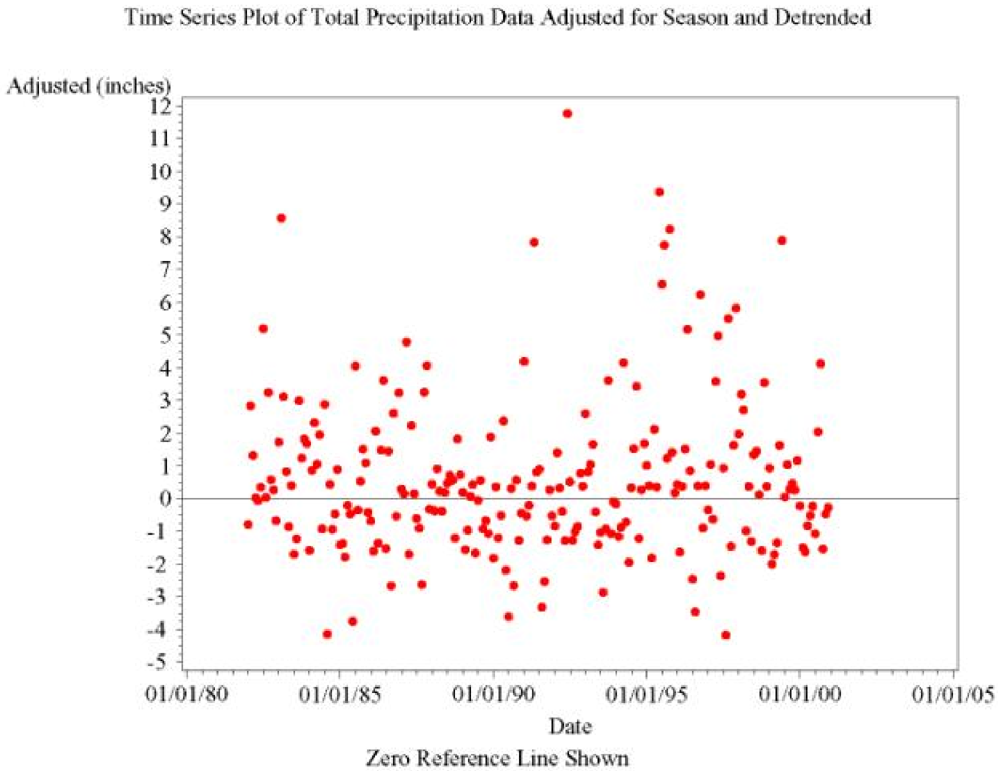

Figure 3-4 An example of the season adjusted and de-trended data for step 5 of trend analysis.

Then the season adjusted and de-trended data were prepared in the form of a correlelogram to test for the presence of autocorrelation in the time series. Figure 3-5 presents an example of this page of the detailed output. If both the 1-month lag (label 11) and the 2-month lag (label 12) are significantly correlated with the present values, then the data were identified as autocorrelated.

In the final step of each trend analysis the appropriate p-value, significance assessment, slope, autocorrelation assessment (present/absent), and seasonality assessment (present/absent) of the trend analysis were compiled from the pages of output and tabulated in a summary table of trend test results. For the surface water quality trend tests, these tabulated summaries were indexed to the detailed pages of outputs through the display numbers.

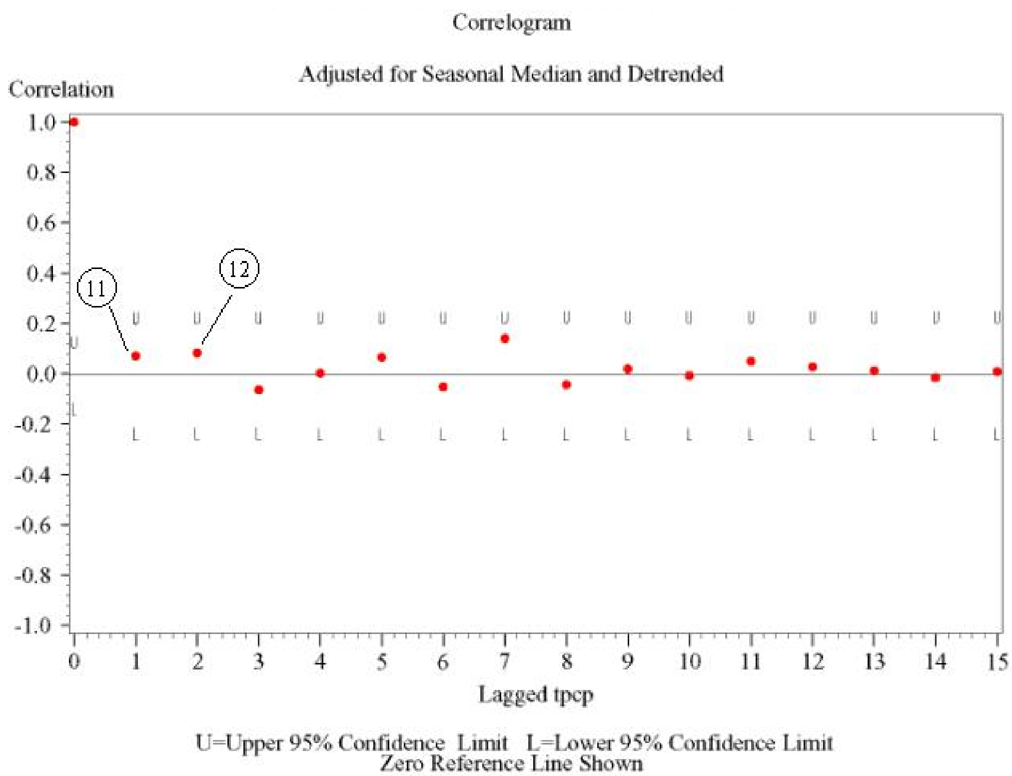

Figure 3-5. Sample autocorrelation test figure for step 5 of trend analysis.

Step 6-Calculate Seasonal Kendall Tau Statistic

Finally, a seasonal Kendall Tau statistic was calculated to quantify the rate of change for each statistically significant trend.

3.2 Alafia River Trend Results

Flow

Trends in flow data were tested for low flows (15^{th} percentile for each year of the time series), normal flows (50^{th} percentile for each year of the time series), peak flows (75^{th} percentile for each year of the time series), and overall flows (daily flow values for the entire time series. Detailed statistical results and time series figures are presented in Appendix F, and the summary of the trend results is presented in Table 3-1.

The determination of seasonality step described above (Step 4) was completed for the flow trend analyses using monthly means of the daily flow data, and it was not completed for trend analyses using annual data (i.e., the annual low flow, normal flow, high flow tests.

Yearly flows (at the 15th, 50th and 85th percentiles) showed no significant trends for the years 1975-2003 (Table 3-1). Daily flow (aggregated to monthly means for the trend analysis) also exhibited no significant trend for the same time period. Seasonality was detected in the monthly flow record.

Nutrients

Trends in nutrients were tested using monthly data values. Detailed statistical results and time series figures are presented in Appendix G, and a summary of the trend results is presented in Table 3-1.

Total nitrogen at EPCHC station 114 (Alafia at Bell Shoals Road) and station 74 (Alafia at U.S. 41) showed significant decreasing trends from 1975 to 2002 and from 1980 to 2002 respectively, with a rate of change equal to -1.0 percent of the mean per year for both stations (Table 3-2). No trend was detected for the station 153 (Alafia at U. S. 301), which is located in between station 114 and 74 for the short period from mid-1999 to 2003.

Total phosphate was observed to have a decreasing trend at stations 114 (1975-2002) and 74 (1980-2002) by -2.5 and -3.6 percent of the mean per year, respectively. An increasing trend was observed at station 153 by 8.0 percent for th short period from mid-1999 to 2003.

Dissolved Oxygen

Trends in dissolved oxygen were tested using monthly data values. Detailed statistical results and time series figures are presented in Appendix H, and a summary of the trend results is presented in Table 3-3.

A significant decreasing trend was observed for surface and mid-water column dissolved oxygen at station 74 from 1975 to 2002, furthest downstream (Table 3-3). A significant increasing trend in bottom do was observed at station 153 from mid-1999 to 2002. All other station and sample level combinations showed no statistically significant trends.

Chlorophyll

Trends in chlorophyll were tested using monthly data values. Detailed statistical results and time series figures are presented in Appendix I, and a summary of the trend results is presented in Table 3-4.

Chlorophyll trends were either not statistically significant or decreasing (Table 3-4). Decreasing trends were detected for chlorophyll a and total chlorophyll at station 153 for mid-1999 to 2003 and at station 74 from 1975 to 2002. Decreasing trends for chlorophyll b and c were detected at stations 114 and 74 from 1975 to 2002.

Salinity

Trends in salinity were tested using monthly data values. Detailed statistical results and time series figures are presented in Appendix J, and a summary of the trend results is presented in Table 3-5. Station 114 at Bell Shoals Road was not tested for salinity trends because it is a typically freshwater station.

Salinity was observed to have either no significant trend or a decreasing trend, based on sample level and station (Table 3-5). Station 153 was reported to have very large declining trends in salinity for the period tested. However, it was only tested for data reported from mid-1999 (the date the station was initiated) to 2002. This short time period started with an unusual drought period and ended with an unusually wet period. Please see detailed time series plots presented in Appendix J.

Table 3-1. Summary trend results for yearly flow (15th, 50th and 85th percentiles) and monthly flow for the Alafia River at Bell Shoals Road.

Station	Location	Parameter	Seasonal	Auto-correlated	P-value	Slope (cfs/yr)	Trend Direction	Rate of Change (% of mean/yr)	Trend Period
114	Alafia at Bell Shoals	yearly flow (15th)	n/a	no	0.129	-1.579	no trend		1975-2003
114	Alafia at Bell Shoals	yearly flow(50th)	n/a	no	0.442	-1.426	no trend		1975-2003
114	Alafia at Bell Shoals	yearly flow (85th)	n/a	no	0.639	2.91	no trend		1975-2003
114	Alafia at Bell Shoals	monthly flow	n/a	yes	0.668	-0.763	no trend		1975-2003

Table 3-2. Summary trend results for total nitrogen and total phosphate at three stations along the Alafia River.

Station	Location	Parameter	Sample level	Seasonal	Auto-correlated	P-value	Slope (cfs/yr)	Trend Direction	Rate of Change (% of mean/yr)
114	Alafia at Bell Shoals	total nitrogen	Middle	yes	yes	0.043	-0.020	decreasing	-1.0
153	Alafia at US 301	total nitrogen	Middle	No	no	0.790	0.030	no trend	
74	Alafia at US 41	total nitrogen	Middle	No	no	0.000	-0.015	decreasing	-1.1
114	Alafia at Bell Shoals	total phosphate	Middle	yes	yes	0.000	-0.076	decreasing	-2.5
153	Alafia at US 301	total phosphate	Middle	yes	no	0.002	0.090	increasing	8.0
74	Alafia at US 41	total phosphate	Middle	yes	yes	0.000	-0.043	decreasing	-3.6

Table 3-3. Summary trend results for dissolved oxyg
en (surface, middle and bottom) at three stations along the Alafia River.

Station	Location	Parameter	Sample level	Seasonal	Auto-correlated	P-value	Slope (cfs/yr)	Trend Direction	Rate of Change (% of mean/yr)
114	Alafia at Bell Shoals	dissolved oxygen	Surface	Yes	no	0.453	0.000	no trend	
114	Alafia at Bell Shoals	dissolved oxygen	Middle	Yes	yes	0.136	-0.011	no trend	
114	Alafia at Bell Shoals	dissolved oxygen	Bottom	Yes	no	0.367	0.000	no trend	
153	Alafia at US 301	dissolved oxygen	Surface	No	no	0.437	-0.061	no trend	
153	Alafia at US 301	dissolved oxygen	Middle	No	no	0.516	0.100	no trend	
153	Alafia at US 301	dissolved oxygen	Bottom	Yes	no	0.014	0.355	increasing	10.5
74	Alafia at US 41	dissolved oxygen	Surface	Yes	no	0.008	-0.031	decreasing	-0.5
74	Alafia at US 41	dissolved oxygen	Middle	Yes	no	0.017	-0.024	decreasing	-0.5
74	Alafia at US 41	dissolved oxygen	Bottom	Yes	no	0.507	-0.006	no trend	

Table 3-4. Summary trend results for chlorophyll (a, b, c and total) for three stations along the Alafia River.

Station	Location	Parameter	Sample level	Seasonal	Auto-correlated	P-value	Slope (cfs/yr)	Trend Direction	Rate of Change (% of mean/yr)
114	Alafia at Bell Shoals	Chlorophyll a	Middle	No	No	0.538	0.022	no trend	
114	Alafia at Bell Shoals	Chlorophyll b	Middle	Yes	Yes	0.014	-0.015	decreasing	-1.7
114	Alafia at Bell Shoals	Chlorophyll c	Middle	Yes	yes	0.014	-0.073	decreasing	-3.1
114	Alafia at Bell Shoals	Chlorophyll Total	Middle	Yes	No	0.242	-0.105	no trend	
153	Alafia at US 301	Chlorophyll a	Middle	Yes	no	0.015	-5.215	decreasing	-13.6
153	Alafia at US 301	Chlorophyll b	Middle	No	no	0.229	0.030	no trend	
153	Alafia at US 301	Chlorophyll c	Middle	Yes	no	0.263	-0.860	no trend	
153	Alafia at US 301	Chlorophyll Total	Middle	Yes	no	0.025	-7.033	decreasing	-14.8
74	Alafia at US 41	Chlorophyll a	Middle	No	no	0.000	-0.310	decreasing	-1.6
74	Alafia at US 41	Chlorophyll b	Middle	Yes	no	0.000	-0.058	decreasing	-4.7
74	Alafia at US 41	Chlorophyll c	Middle	Yes	no	0.000	-0.396	decreasing	-5.1
74	Alafia at US 41	Chlorophyll Total	Middle	No	no	0.000	-0.775	decreasing	-2.8

Table 3-5. Summary trend results for salinity (surface, middle and bottom) at US 41 gauge on the Alafia River.

Station	Location	Parameter	Sample level	Seasonal	Auto-correlated	P-value	Slope (cfs/yr)	Trend Direction	Rate of Change (% of mean/yr)
153	Alafia at US 301	salinity	Surface	yes	No	0.004		decreasing	-39.1 *
153	Alafia at US 301	salinity	Middle	no	no	0.055		no trend	
153	Alafia at US 301	salinity	Bottom	no	no	0.047		decreasing	-19.2 *
74	Alafia at US 41	salinity	Surface	yes	no	0.000	-0.262	decreasing	-1.7
74	Alafia at US 41	salinity	Middle	yes	yes	0.682	0.027	no trend	
74	Alafia at US 41	salinity	Bottom	no	yes	0.781	0.020	no trend	

* Note: Station 153 was only tested for data reported from mid-1999 (the date the station was initiated) to 2002. This short time period started with an unusual drought period and ended with an unusually wet period. Please see detailed time series plots presented in Appendix J.

4.0 Analytical Approach to Examining Effects of Freshwater Inflow on Biological Resources

Approaches to understanding relationships between biological organisms and their environment include comparative field studies with concomitant sampling of species and environmental parameters and model development to predict the distribution and abundance of organisms across environmental gradients (Olden and Jackson 2002). Increasingly ecologists are tasked with evaluating the effects of human disturbances on ecological processes and identifying environmental thresholds for ecological risk assessment (Qian et al. 2003). These thresholds often depend on complex interactions among organisms which tend to exhibit nonlinear relationships with environmental gradients. Many traditional modeling approaches are inappropriate for describing these relationships.

Traditional statistical techniques used for modeling ecological relationships include linear and multivariate regression and linear discriminant analysis techniques which rely on parametric assumptions including statistical distributions of variables, distribution of errors, independence and model linearity (Manel et al. 1999; Olden and Jackson 2002). Tampa Bay Water has recently applied these types of regression approaches to the Alafia River HBMP data to examine relationships between freshwater inflow and living resources (Janicki Environmental, 2004), and the Southwest Florida Water Management District is conducting similar efforts using ichthyoplankton and other fish population data (Peebles, 2002).

Recently, many ecologists have turned to more recently developed and novel techniques for predicting species distributions including classification trees and artificial neural networks (ANN) which do not rely on distributional assumptions of the data.

Artificial neural networks have gained acceptance for a broad spectrum of applications and have been found to satisfactorily model complex ecological relationships even when the causal factors may be poorly understood (Scardi et al. 2000). Examples of successful uses of ANN in ecology include modeling dissolved oxygen (Rounds 2002; Soyupak et al. 2003), nutrients (Clair and Ehrman1996; Suen and Eheart 2003), Phytoplankton abundance (Gurbuz et al. 2003; Olden 2000; Karul et al. 2000; Karul et al 1999; Wilson and Recknagel 2001), macroinvertebrate and fish distributions (Zanden et al 2004; Dedecker et al 2004; Mastrorillo et al 1997; Scardi et al. 2000; Olden and Jackson 2002) and river birds (Manel et al 1999). Common to these studies is the use of the feed forward neural network model and backpropagation algorithm to estimate connection weights. Many of these studies showed that ANN models were adequate for modeling empirical data and attained predictive capacities equivalent to or superseding traditional analysis techniques.

Neural networks, as the name implies, are mathematical architectures based on a simplified conceptualization of the structure and function of the human brain. Neurons and axons makeup the framework for the ANN models. Neurons store and process information and axons transmit signals to other neurons in the network. Generally neural networks contain an input layer, hidden layer and output layer, each of which contain and process information (Figure 1). Each neuron from one layer is connected to all neurons of the next layer in the information pathway. In feed forward neural networks, Neuron signals are transferred by the axon in a unidirectional path from the input layer through the hidden layer to the output layer (Olden and Jackson 2002). These are by far the most common types of ANN models used in ecological studies.

Statistically, whereas procedures such as multiple regression are pre-programmed, neural network models are trained though presentation of examples (Garson 1998). Neural networks that use backpropagation algorithms process information through iterative techniques designed to minimize the difference in the predicted and observed response values. This process is referred to as supervised learning. Weights are assigned to the axon connections and an activation function or transfer function is calculated as the sum of all connection weights fed to a neuron times the neuron outputs. These connection weights are initialized and through a learning process called backpropagation are optimized for a set of data to minimize the differences between predicted and observed values in the output layer. Ideally, applications of neural networks will involve a training phase where a portion of a given dataset is used for model development and a validation phase where independent data are presented to the model to examine its robustness in predicting new information.

Neural network modeling offers the opportunity to describe data collected from ecological studies in a flexible and iterative way that may maximize the predictive capacity for complex nonlinear relationships. Our goal with this project was to develop a feed forward neural network model to predict patterns of abundance and distribution of riverine dependent fish species in the Alafia River as responses to hydrologic flow characteristics.

4.1 Objectives and Rationale

The objectives of this pilot study were to examine the relationship between patterns of abundance and distribution of phytoplankton, zooplankton, juvenile and adult fishes and fish community structure and hydrologic flow characteristics in the Alafia River using a feed-forward Neural Network (NN). Specifically, the following three questions were proposed:

1) Are there biotic indicators measured routinely in the Alafia River that exhibit a demonstrable relationship with hydrologic flow characteristics?

2) Which biotic indicators appear most sensitive to changes in flow characteristics?

3) Which hydrologic flow characteristics appear to be most important in determining biotic indicator abundance?

4.2 Data Used For Analysis

The data used for this study were taken from an ongoing field intensive hydrobiological monitoring plan conducted by Tampa Bay Water for Upper Tampa Bay known as the HBMP. The HBMP integrates water quality, vegetation, zooplankton and fish sampling components into a program designed to ensure that, following the implementation of permitted surface water withdrawals, flows in the Upper Tampa Bay tributaries do not deviate from normal rate and range of fluctuation to the extent that: water quality, vegetation and animal populations are adversely impacted in streams and estuaries. The HBMP design further is intended to ensure that salinity distributions in tidal portions are significantly altered as a result of withdrawals or; recreational use or aesthetic qualities of the resource are adversely impacted.

The HBMP design has stratified the Alafia River based on the number of kilometers from the river mouth. Each stratum is a 2.33 Km section of the river labeled AR1-AR8 beginning at the river mouth and increasing numeric sequence to Lithia springs. For the purpose of this report, the Alafia River was post stratified into three river "Regions" (Lower, Middle and Upper) by combining strata AR1 and AR2 forming the Lower region, strata AR3 and AR4 forming the Middle region and all other strata forming the Upper region (Figure 4-1). Little sampling was performed above stratum AR6 due to logistical problems associated with biotic sampling in these regions. This post stratification was based on empirical evidence from previous studies in the Alafia River that suggested salinity regimes and patterns of biotic species abundances corresponded adequately with these designations.

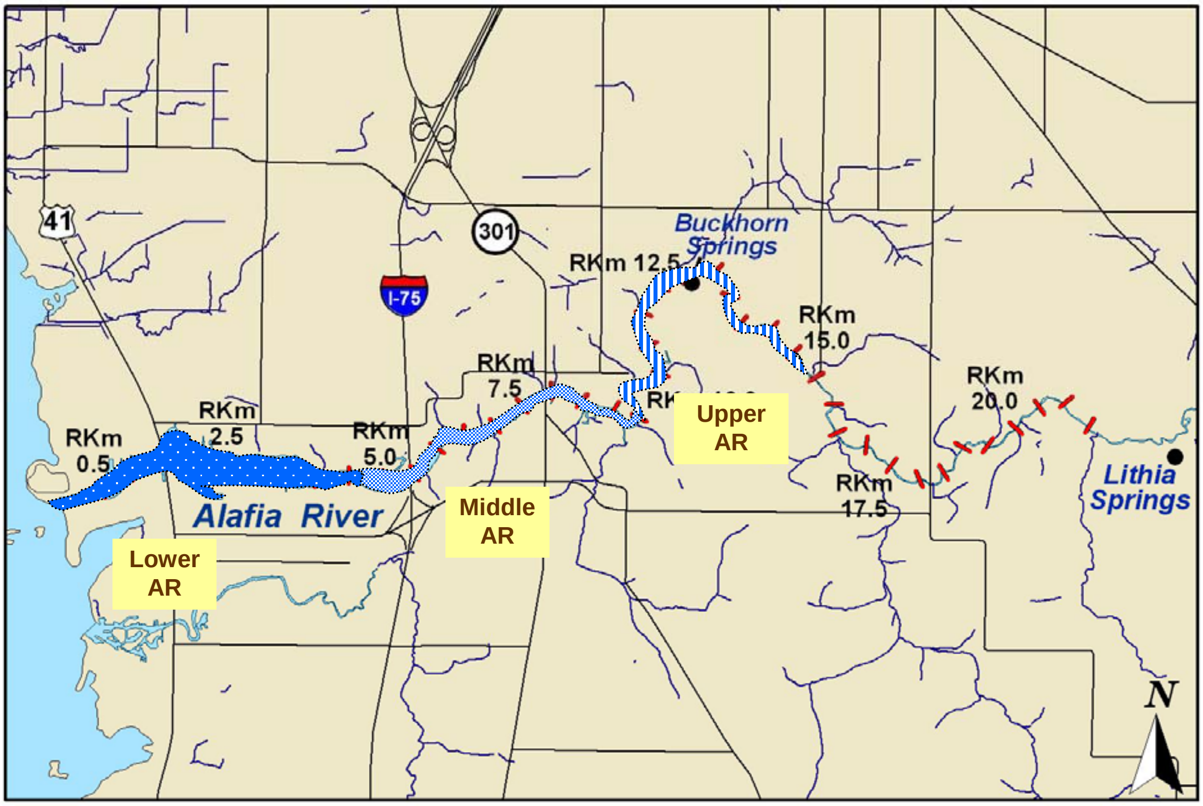

Figure 4-1. Alafia River with post stratified regions. Strata are based on Alafia River HBMP Strata increasing in number from the mouth.

Site selection for the water quality and fish components was based on a stratified probabilistic design such that each stratum received equal sampling effort each month. Plankton sampling and flow measurements were taken at fixed stations within the river. Plankton samples were conducted monthly, at night, beginning at a fixed station located within each river stratum. Though not a probabilistic design, the sampling design maximized the potential for encountering plankton species and ensured an equal number of samples were taken within each river stratum, each month.

Several species collected by the HMBP program were designated as potential indicator species for ecosystem health. These species, along with other frequently encountered species, were used for the neural network analysis. Regional averages for each species were calculated based on catch per unit effort (CPUE). For plankton sampling these averages were based on the collection date each month. Weekly regional CPUE averages were calculated for fish samples since sampling could take place over multiple days within a given randomly selected week each month. Further, similarly collected fish data from the Fisheries Independent Monitoring (FIM) program were used to increase the available sample size and supplement a gap in the data between (December-April 2000).

The Alafia River has a daily continuous flow record that extends back until approximately 1940; however, 1975 is considered a demarcation of changes in land use for the river basin that represent relatively current conditions. Therefore, the historic flow data from 1975 through December of 2003 were used to calculate long term Julian date average flows for Bellshoals Road. The Bellshoals Road flow is derived from measures at Lithia springs and includes a factor for the ungauged portion between Lithia Springs and Bellshoals Rd. The Bellshoals Road flow is calculated based on the following equation.

$$\text{BellShoals\_flow} = \text{Lithia Springs flow} * ((335 + 39.2)/335) + \text{Lithia Springs flow}$$

Once standardized, the flow data were averaged over consecutive previous days (7, 15, 30, 60 and 90 days) to obtain several measures of flow characteristics in the days prior to biological sampling. Further, the coefficient of variation (CV) and range of these lag averages were calculated to characterize the variability in flow over the days prior to sampling. These variables were then considered as inputs into the feed forward NN models.

4.3 Data Standardization

Since many of the biological organisms studied exhibit seasonal patterns of peak abundance which may be confounded with the seasonality of the flow regime, the analytic approach we used was to remove seasonality from the data and focus on the relationship between changes from the expected (average) flow condition based on long term historical averages (1975-2003) in relation to changes in the response variable abundance compared to its average for that month over the sampling period (1998-2003). Mathematically, the data transformation can be expressed as:

$$Ys = \frac{y - \overline{y}}{std(\overline{y})}$$

where:

$\boldsymbol{Ys}$ = Standardized value of Y

y = Observed value

$\overline{y}$ = Monthly mean value across years

4.4 Feed Forward Network Model

The MATLAB software package (version 6.5.1) was used to implement and train a feed forward neural network model containing a single hidden layer using the Levenberg-Marquardt training algorithm (MATLAB Neural Network Toolbox Users Guide, 2001). The model architecture was restricted by the number of available sampling pairs to minimize the potential for over-fitting. Initial models were constructed using the five input flow variables, 8 hidden nodes and an output variable corresponding to each river region (Figure 4-1) .

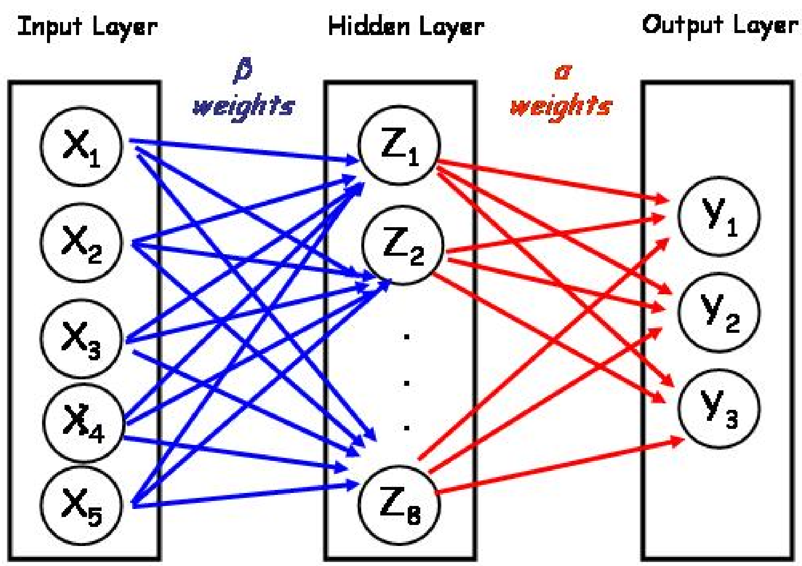

Figure 4-1. Diagram of the neural network architecture used for modeling the HBMP plankton and fish data.

The relative importance of each input variable's weight to the total output weight for each output was evaluated using a method described by Garson (1998). Input variables were sequentially removed from the model based on their contribution to the total weight similar to the backward selection procedure commonly used in multiple regression analysis. The final neural network models contained only the two most influential flow variables. Performance of the trained models were assessed using the coefficient of determination (R^2) a measure of the percentage of variation in the response variable explained by the model. Models with the highest R^2 were retained for further analysis.

5.0 Chlorophyll and Plankton Results

A set of neural network models were developed that could be successfully applied to a range of problems involving the prediction of abundance patterns in biological organisms given a set of flow variable inputs. We started with a simple model predicting Chlorophyll a concentrations. Results suggest that the 7 day average flow conditions (sample date and 6 days prior to sampling) contributed most to the predictive weight of the models. The models were able to successfully predict chlorophyll a concentrations in three river regions using a model with a single input (the 7 day average flow), 4 hidden nodes and 3 outputs (Figure 5-1).

It is clear that the models were able to approximate a function describing the distribution of chlorophyll in the river. The highest peaks in chlorophyll a were associated with periods of low flow condition in all three river regions and the model appeared to adequately fit the observed patterns in the chlorophyll data. Following the identification of neural network model that could be used to recognize dynamics of chlorophyll a concentrations in the Alafia River, additional models were developed for the zooplankton and fish datasets where more data points were available to build more complex feed forward NN models and test the utility of these models to predict abundance based on flow conditions.

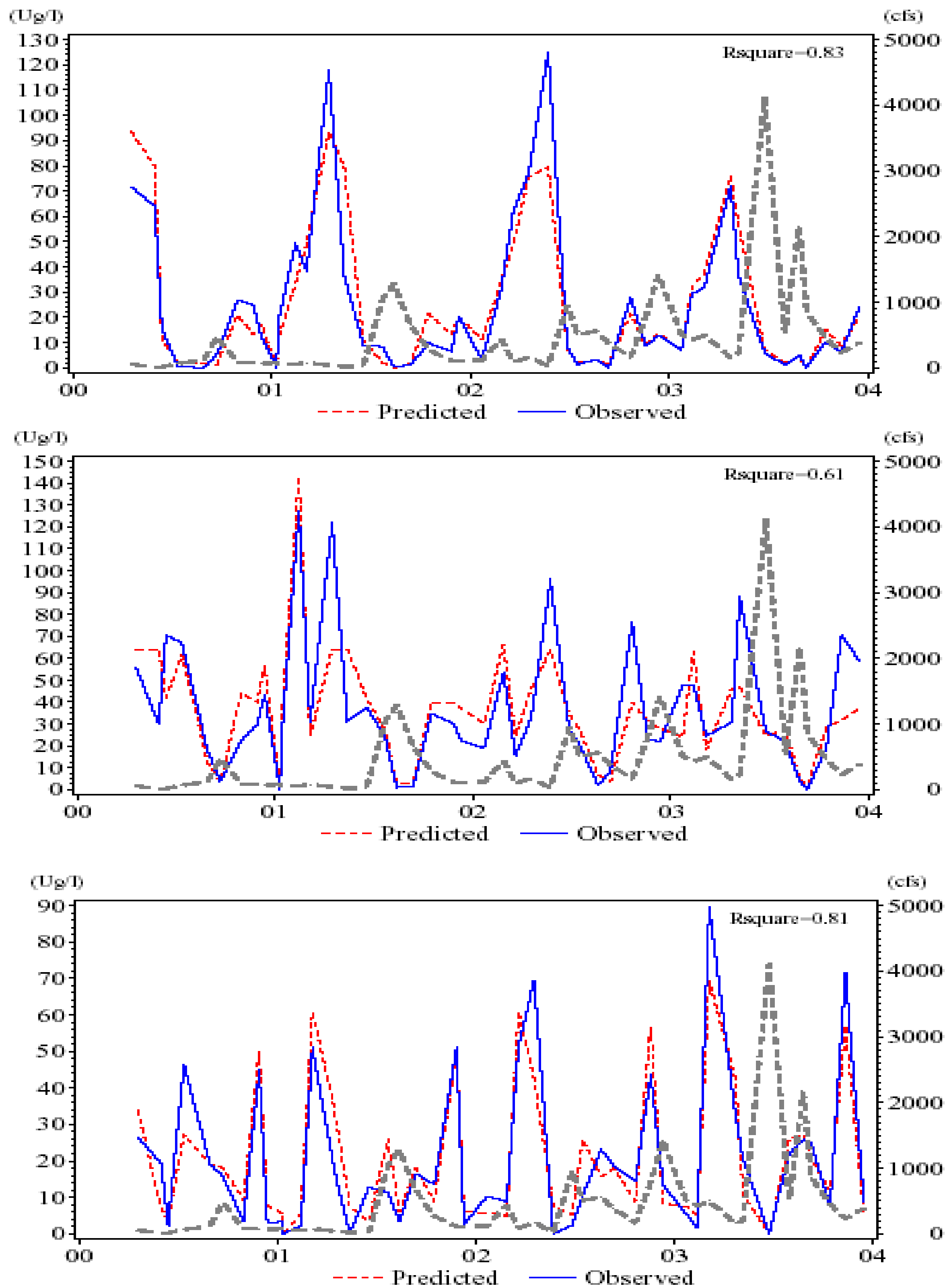

Figure 5-1. Predicted and observed plots of Chlorophyll a abundance using a feed forward neural network model. Plots are arranged from top to bottom for Upper, Middle and Lower Alafia River.

5.1 HBMP Plankton Data

A total of 743 plankton samples were collected between June, 1998 and December, 2003 (Table 5-1). Sampling over this time period was consistent except for a 5 month gap in the data between November, 1999 and April, 2000. Results of post stratification reduced the effective sample size to 62 sampling events per river region for a total of 186 input (Flow) and target (CPUE) data pairs for neural network analysis.

Table 5-1 Number of plankton samples taken in the Alafia River between 1998 and 2003 by Month and Year

	Month												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**All**
Year													
1998	.	.	.	.	.	12	12	12	12	12	12	12	84
1999	12	12	12	12	12	11	12	12	12	12	.	.	119
2000	.	.	.	12	12	12	12	12	12	12	12	12	108
2001	12	12	12	12	12	12	12	12	12	12	12	12	144
2002	12	12	12	12	12	12	12	12	12	12	12	12	144
2003	12	12	12	12	12	12	12	12	12	12	12	12	144
Total	48	48	48	60	60	71	72	72	72	72	60	60	743

Species chosen for neural network analysis from plankton collections are listed in Table 5-2 with the months in which they were most prevalent in the plankton collections. These species were chosen either because they were listed as indicator species by the HBMP program or due to their overall dominance in the plankton samples.

Table 5-2. List of species collected in plankton samples and used in neural network analysis with months with expected capture.

		Months of Abundance											
Scientific Name	**Common Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Americamysis almyra	Opossum Shrimp			**X**	**X**	**X**	**X**				**X**	**X**	**X**
Anchoa mitchilli (Eggs)	Bay Anchovy			**X**	**X**					**X**			
Anchoa mitchilli (Juveniles)	Bay Anchovy	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Brevoortia smithi (Juveniles)	Yellowfin Menhaden				**X**	**X**	**X**	**X**					
Cynoscion arenarius (Juveniles)	Sand Seatrout				**X**	**X**	**X**	**X**	**X**	**X**			
Decapod zoeae	Crustacean Larvae				**X**	**X**	**X**	**X**			**X**	**X**	
Mnemiopsis mccradyi	Ctenophore			**X**	**X**	**X**	**X**				**X**	**X**	
Palaeomonetes pugio	Grass Shrimp						**X**	**X**	**X**	**X**	**X**		

The backward selection procedure identified the input flow variables that contributed most to the predictive ability of the NN models (Table 5-3). Fifteen and 30 day average flow conditions were consistently among the variables retained for the final model runs based on this procedure except for with the Ctenophore and juvenile Menhaden models. The 7 and 15 day averages drove the models for Bay Anchovy eggs and juveniles while models for Opossum shrimp and Sand Seatrout were driven mostly by 15 and 30 day flow averages.

Table 5-3. Input variables used for final neural network models in plankton analysis. The capital X denoted the variable contributing the most weight to model predictions.

Species	7 day Average	15 day Average	30 day Average	60 day Average	90 day Average
Bay Anchovy (eggs)	x	x			
Bay anchovy (Juv.)	x	x			
Ctenophores	x			x	
Decapod zoeae		x		x	
Grass Shrimp		x			x
Menhaden (Juv.)				x	x
Opossum Shrimp		x	x		
Sand Seatrout (Juv.)		x	x		

The amount of variation explained by the models varied considerably by species and river region (Table 5-4). In general, the neural network models adequately predicted species abundances in the region of the Alafia River where they were most prevalent in the plankton samples. For example, predictions were relatively consistent for the grass shrimp, juvenile Menhaden, and juvenile Bay Anchovy which displayed consistent temporal trends among river regions (Figure 5-3.). While the Sand Seatrout and Bay Anchovy eggs were poorly predicted in the upper river due to their paucity of occurrence in that region. An exception was the Opossum Shrimp which was poorly modeled in the upper river region despite apparently consistent spatial and temporal distributions in that region.

Table 5-4. Performance of neural network models for predicting species abundance from Alafia River flow characteristics based on standardized input and target vectors.

Species	**R^2**		
	Upper	**Middle**	**Lower**
Opossum Shrimp	0.18	0.42	0.62
Bay Anchovy eggs	0.00	.34	.44
Bay Anchovy Juv.	0.34	0.51	0.42
Yellowfin Menhaden Juv.	0.62	0.69	0.57
Sand Seatrout Juv.	0.06	0.56	0.41
Decapod Zoeae	0.29	0.48	0.39
Ctenophore	0.32	0.62	0.64
Grass Shrimp	0.45	0.50	0.56

The best model predictions of the observed plankton abundance as determined by the R^2 statistic occurred for Grass Shrimp and juvenile Menhaden (Figures 5--4 and 5-5).

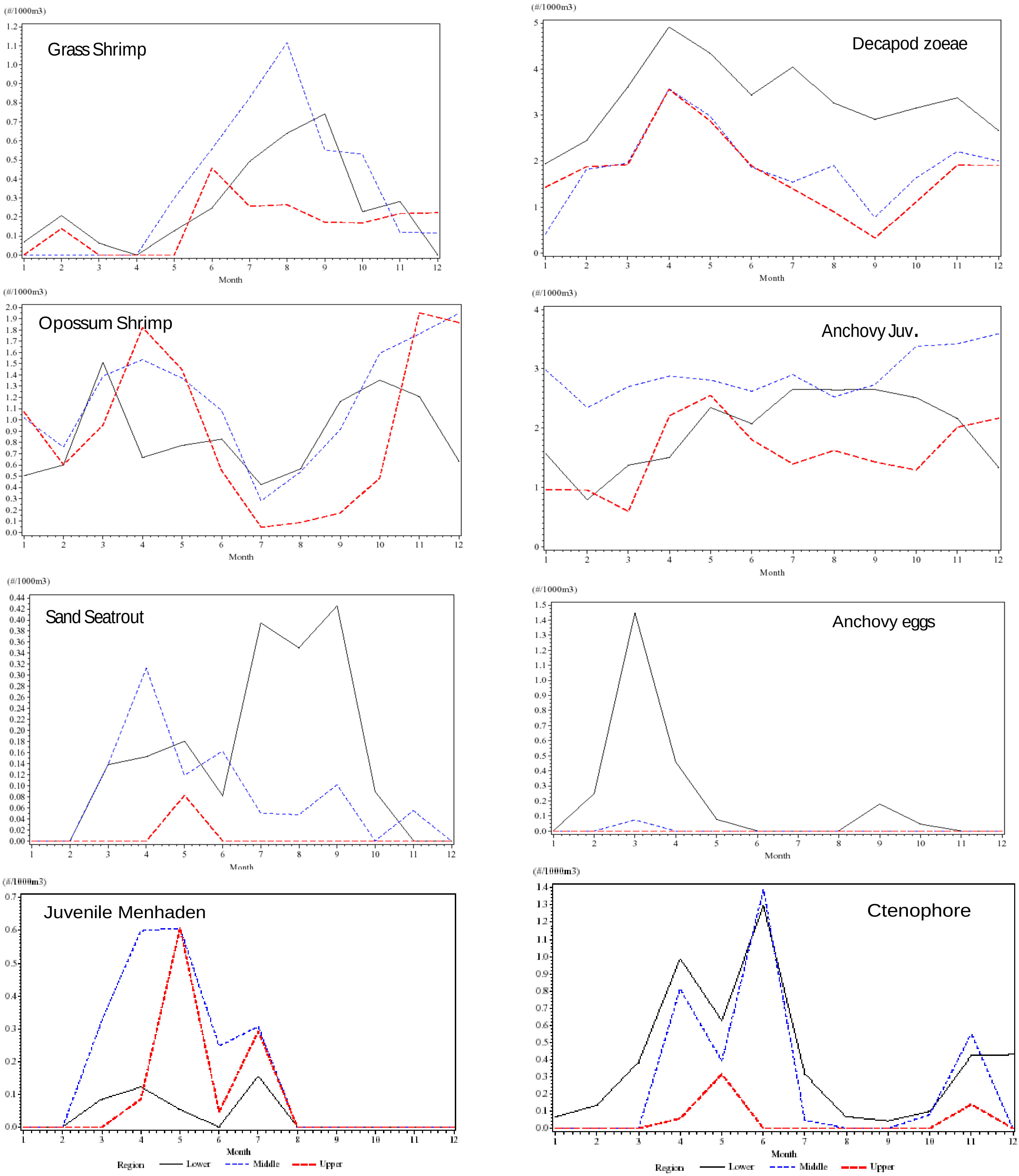

Figure 5-3. Monthly abundance (log (#/1000m3)) across years by Alafia River Region for dominant indicator species collected from HBMP Alafia River plankton sampling June, 1998- December, 2003

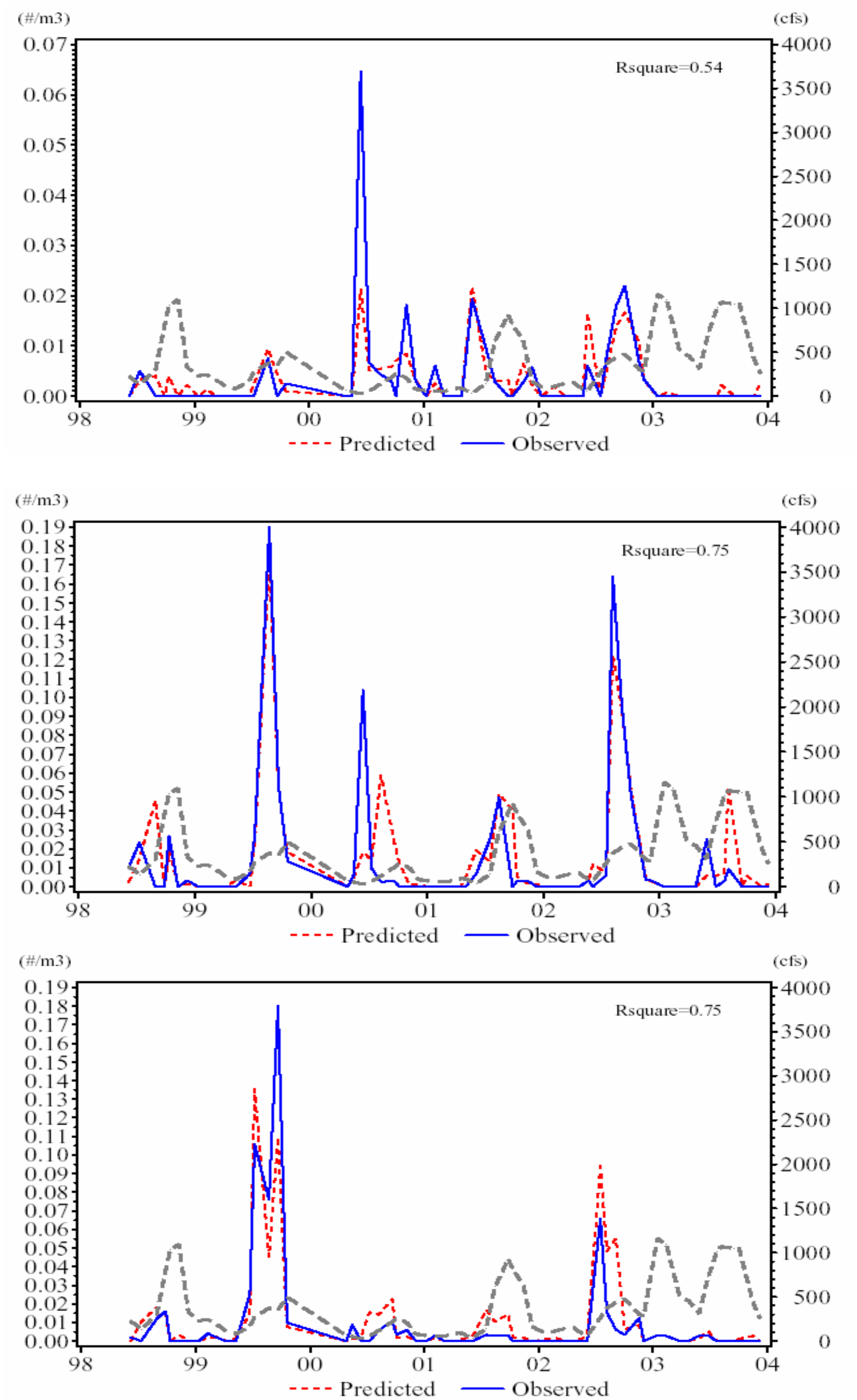

Figure 5-4. Predicted and observed juvenile Grass Shrimp abundance from feed forward neural network model. Plots are from top to bottom; Upper, Middle and Lower Alafia River Regions. The broken Grey line represents the 60 day lag average flow at Bellshoals Rd.

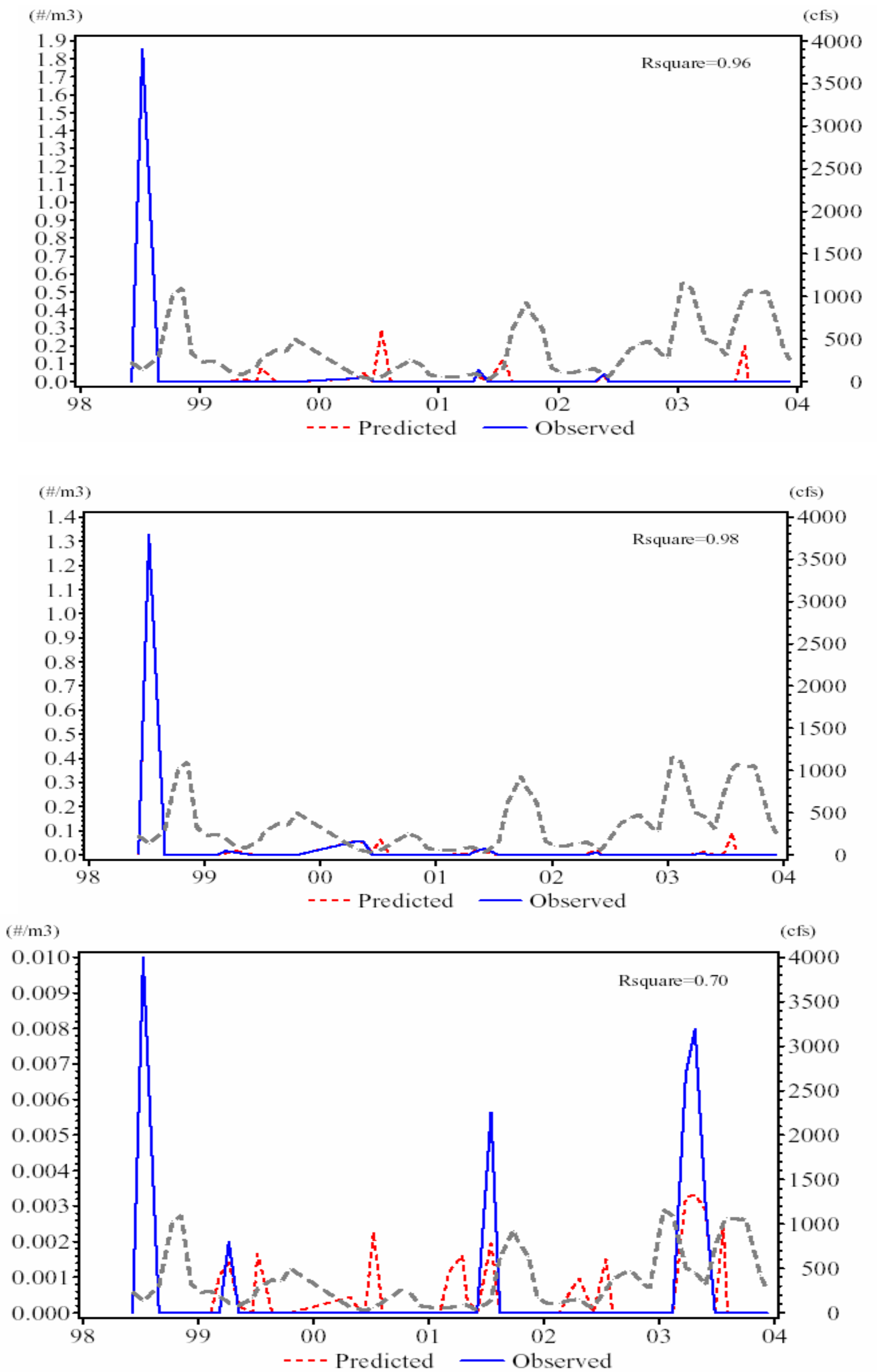

Figure 5-5. Predicted and observed juvenile Menhaden abundance from feed forward neural network model. Plots are from top to bottom; Upper, Middle and Lower Alafia River Regions. The broken grey line represents the 60 day lag average flow at Bellshoals Rd.

The multivariate approach allowed us to examine the data for possible spatial-environmental interactions and identify regions of the river where we might focus our attention for further research into the relationships between flow and species abundance patterns. For instance, Grass shrimp abundance was generally higher in the lower and middle river regions, but decreased flow conditions associated with the winter of 2000-2001 were associated with an apparent upstream shift in abundance into the upper river region. Conversely, Bay Anchovy eggs were continually absent from collections in the upper Alafia River in this dataset and therefore contributed nothing to the predictive ability for the NN model. This would be a circumstance where reducing the model to predict only in a specific region or time period is warranted. Predicting multivariate outcomes (river regions) simultaneously serves as an efficient means of data exploration and model development; however, the models may result in increased prediction error relative to a more spatial restricted model.

Plankton Model Validation

The grass shrimp data were then used to validate the utility of the NN model to predict new information based on a trained network. For this exercise, the Grass Shrimp dataset was randomly divided with approximately 65% of the data sequestered for training the network and the remaining data used as a validation dataset. The network was training on the training dataset and then inputs and targets from the validation dataset were presented to the model to test its utility in predicting new information. The trained grass shrimp model was able to adequately predict grass shrimp abundance in the lower and middle regions of the Alafia River once the seasonality component was reintroduced into the data; however, predictions of grass shrimp abundance in the upper regions of the Alafia were poor (Figure 5-6). The upper region validation results indicated that additional data would be required to train a suitable model for the upper regions while avoiding overparameterization of the model.

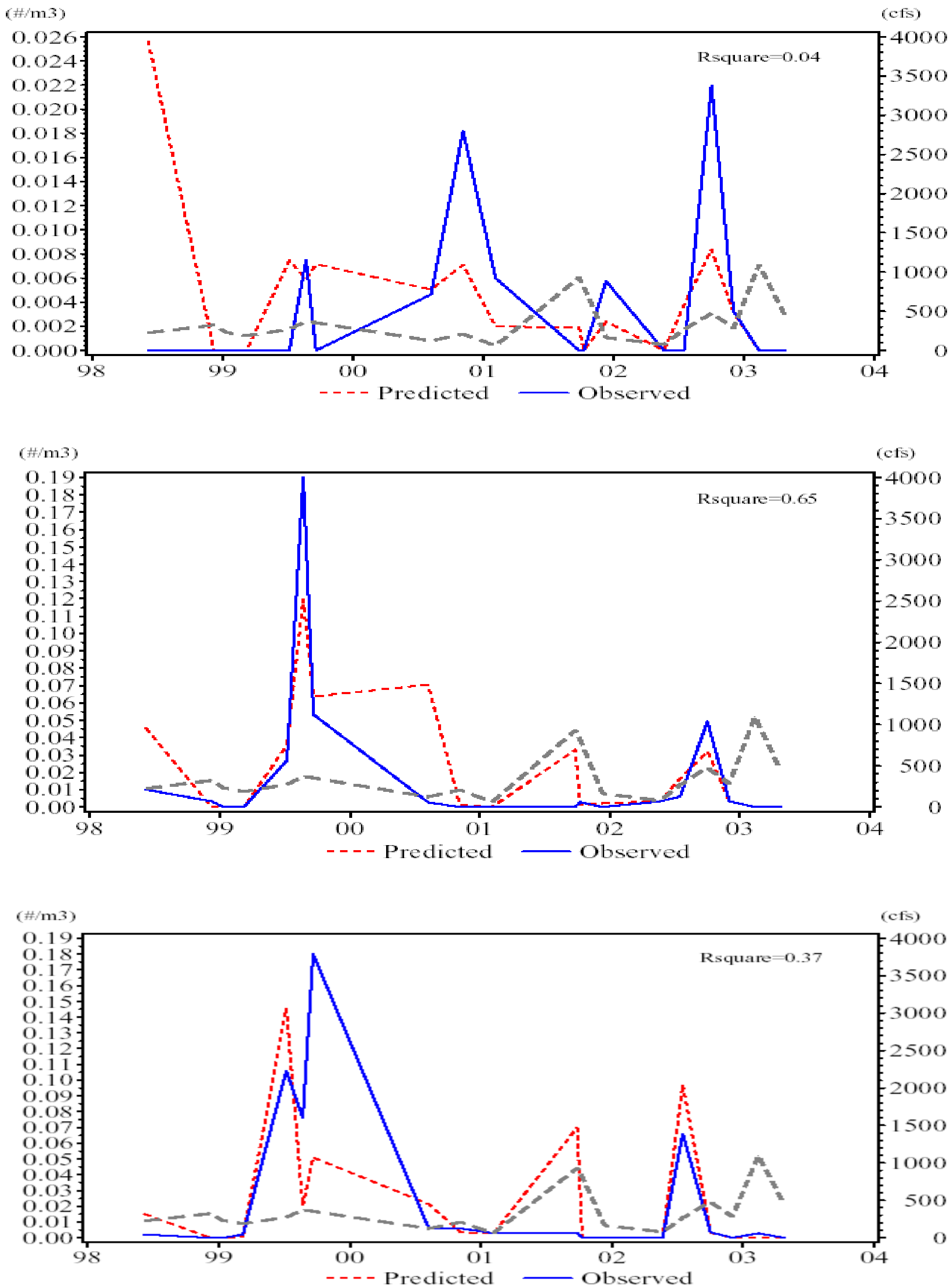

Figure 5-6 Predicted vs. observed plots for Grass shrimp validation efforts from HBMP plankton collections 1998-2004. Plots are arranged from top to bottom from Upper, Middle and Lower Alafia River.

6.0 HBMP Fish Data Results

For further application of the pilot study, additional models were developed for juvenile and adult fish populations collected using 21m boat set seines in the Alafia River.

Dominant fish species chosen for neural network analysis are listed in Table 6-1 along with scientific names and times of expected occurrence in the Alafia River. These species were selected based on their identification as indicator species (HBMP year 3 report), dominance in the catch and because they represent a variety of traits by which fish species utilize the Alafia River. Several species including Bay Anchovy, Silversides, Grass Shrimp, and Hogchoker were collected throughout the year while others including Menhaden, Striped Mullet, Silver Perch and Spot had temporal patterns of recruitment into the Alafia River. However, two species, the Silversides and Mojarras, were only identified to the genus level due to hybridization and difficulty of identifying to species level below 30mm in standard length, respectively, and Grass Shrimp abundance was apparently not recorded prior to 2000.

Table 6-1. List of species collected in seines and used in neural network analysis with months with expected capture.

			Months of Abundance											
Scientific Name	**Common Name**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Anchoa mitchilli	Bay Anchovy	Upper Region	x	x	x	x	x	x	x	x	x	x	x	x
		Middle Region	x	x	x	x	x	x	x	x	x	x	x	x
		Lower Region	x	x	x	x	x	x	x	x	x	x	x	x
Menidia spp.	Silversides	Upper Region	x	x	x	x	x	x	x	x	x	x	x	x
		Middle Region	x	x	x	x	x	x	x	x	x	x	x	x
		Lower Region	x	x	x	x	x	x	x	x	x	x	x	x
Paleomonetes pugio	Grass Shrimp	Upper Region	x	x	x		x		x			x	x	x
		Middle Region	x	x	x	x	x	x	x	x	x	x	x	x
		Lower Region	x	x	x		x			x	x	x	x	x
Leiostomus xanthurus	Spot	Upper Region		x	x		x	x						
		Middle Region		x	x	x	x	x	x	x				x
		Lower Region	x	x	x	x	x	x	x	x	x			
Eucinostomus spp.	Mojarras	Upper Region	x		x			x	x	x		x	x	x
		Middle Region	x	x	x	x	x	x	x	x	x	x	x	x
		Lower Region	x	x	x	x	x	x	x	x	x	x	x	x
Lagodon Rhomboides	Pinfish	Upper Region		x	x	x	x	x	x	x	x			
		Middle Region		x	x	x	x	x		x	x	x		x
		Lower Region	x	x	x	x	x	x	x	x	x			
Brevoortia spp.	Menhaden	Upper Region					x	x				x		
		Middle Region			x	x	x						x	
		Lower Region		x		x	x	x	x					
Trinectes maculates	Hogchoker	Upper Region	x	x	x	x	x	x	x	x	x	x	x	x
		Middle Region	x	x	x	x	x	x	x	x	x	x	x	x
		Lower Region	x	x	x	x	x	x	x	x	x	x	x	x
Mugil cephalus	Striped Mullet	Upper Region						x						
		Middle Region	x	x	x	x	x	x	x				x	
		Lower Region	x	x	x	x	x	x	x		x			x
Bairdiella chrysoura	Silver Perch	Upper Region												
		Middle Region					x	x	x	x				
		Lower Region					x	x	x	x	x	x		

6.1 Neural Network Modeling

The same methodology was used for modeling fish species as was used for the plankton models. Backward selection methods were used to select the two most influential flow variable inputs on fish abundance in all three river regions. Generally, the 30, 60 and 90 day flows were most influential in predicting species abundance in the Alafia River (Table 6-2). Bay Anchovy and Silverside models were driven by the 30 and 60 day flows while Spot, Hogchoker and Striped Mullet were driven by the 60 and 90 day flows.

Table 6-2. Input variables used for final neural network models in fish analysis.

Species	7 day Average	15 day Average	30 day Average	60 day Average	90 day Average
Bay Anchovy			x	x	
Silversides			x	x	
Grass Shrimp			x		X
Spot				x	X
Mojarras		x	x		
Pinfish		x	x		
Menhaden	x				X
Hogchoker				x	x
Striped Mullet				x	x
Silver Perch	x			x	

Plots comparing the predicted and observed values for each species and region are displayed in Appendix K. The time series of predicted and observed responses for each species can be found in Appendix L. The neural network models fit the fish data well though some models displayed considerable regional variation (Table 6-3). The Striped Mullet, Spot and Mojarras achieved the best fit as judged by the R^2 statistic. Common to these species was the occurrence of a single consistent annual peak in abundance followed by periods of low abundance (Appendix L). Species such as Bay Anchovy, Hogchoker and Silversides which were present in samples year round, obtained somewhat lower R^2 values but predictions appeared to be less influenced by extreme catches in a particular month. These species also displayed considerable variation in the predictive ability among river regions indicating potential spatial and environmental interactions.

Table 6-3. Performance of neural network models for predicting species abundance from Alafia River flow characteristics based on standardized input and target vectors.				
Species	**R^2**			
	Upper Region	**Middle Region**	**Lower Region**	**All Regions**
Bay Anchovy	0.88	0.45	0.54	0.56
Silversides	0.71	0.55	0.59	0.62
Grass Shrimp	0.72	0.53	0.95	0.87
Spot	0.84	0.80	0.85	0.83
Mojarras	0.68	0.40	0.82	0.79
Pinfish	0.64	0.65	0.69	0.66
Menhaden	0.52	0.84	0.88	0.84
Hogchoker	0.49	0.71	0.88	0.60
Striped Mullet	0.85	0.80	0.72	0.73
Silver Perch	0.28	0.57	0.65	0.65

6.2 Sensitivity Analysis:

To determine which species were most sensitive to fluctuations in the Alafia River flow regime, the Bellshoals Road flow was artificially adjusted by 20% in both an increasing and decreasing direction of change, and the network responses for each species were simulated based on the trained network. The mean percent changes in response to the flow adjustments are presented in Table 6-4 in the order of the most responsive fish with respect to mean response over the time series and river regions. Within specific seasons and regions, the results are expected to vary.

Table 6-4 Sensitivity analysis results for juvenile and adult fish.

Species	Predicted Response To Flow Increase (%)	Predicted Response to Flow Decrease (%)	Mean Change in Response (%)
Pinfish	30	230	130
Bay Anchovy	80	120	100
Striped Mullet	140	40	90
Grass Shrimp	80	80	80
Hogchoker	20	130	80
Silver Perch	50	40	50
Menhaden	30	40	40
Mojarras	20	10	20
Silversides	20	10	20
Spot	0	20	10

6.3 Fish Validation

To test the utility of the neural network models to predict new information based on a trained network, a cross validation study was conducted by randomly dividing the data on Silversides with approximately 60% of the data sequestered for training the network and the remaining data used as a validation dataset. The network was training on the training dataset and then inputs and targets from the validation dataset were presented to the model to test its utility in predicting new information (Figure 6-2).

The fish validation results indicated that additional data would be required to train suitable models while avoiding overparameterization of the model. The R^2 value for the silversides model fit dropped from 0.62 (Table 6-3) to 0.56 (Figure 6-2), and the validation data set predictions presented considerably more scatter than the predictions in the calibrated models (Appendix K). In particular, our validation results indicated that occasional high peak abundance values were difficult to predict well if they were not included in the original model development dataset. This observation is reflected in Figure 6-2 by the five underestimated predictions of observed silversides abundance where the observed abundance was greater than 400 per square meter.

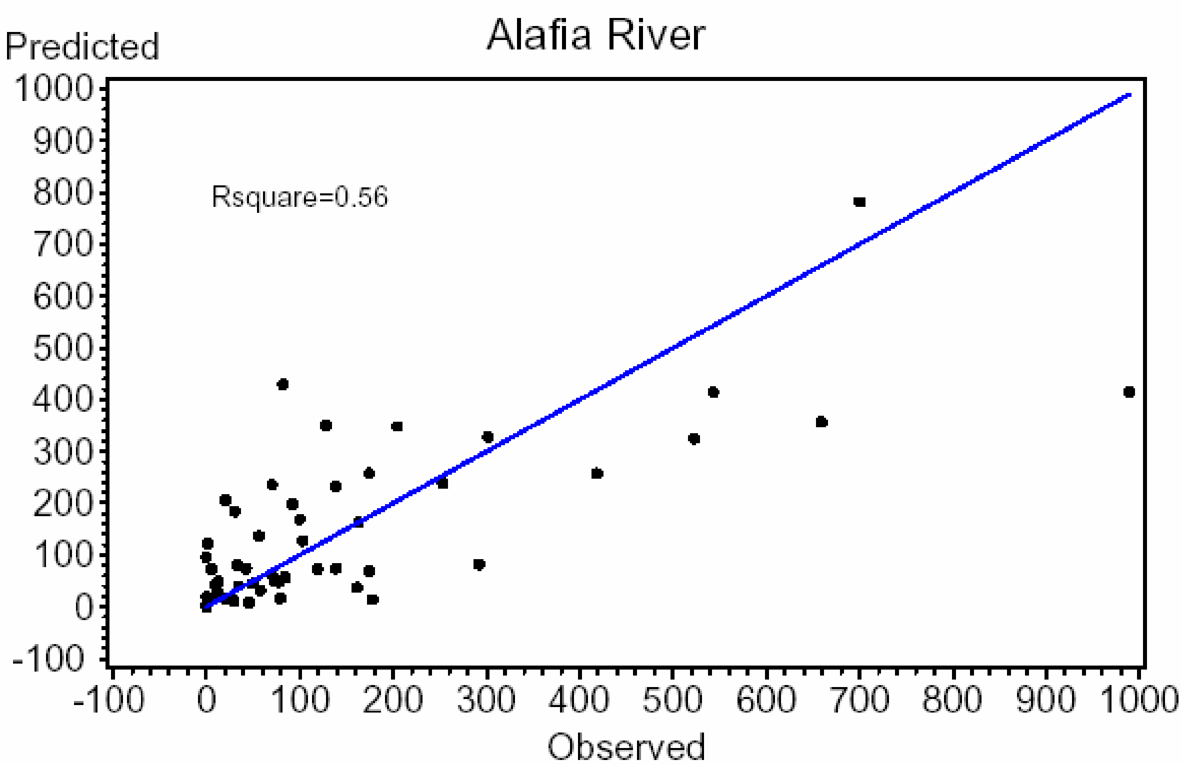

Figure 6-2 Predicted vs. Observed Plots for Silversides (#/100m2)
All Regions of the Alafia River

7.0 Discussion:

The diverse set of data available to examine relationships between freshwater inflow and biological resource responses in the Alafia River were compiled, integrated, and documented by this project. This comprehensive database represents a very important resource for ongoing work on the Alafia River, and the data will be capable of being readily expanded in the future as additional data are reported.

In the pilot study portion of the project, Artificial Neural Networks were demonstrated to provide a powerful tool for studying relationships between biotic and abiotic factors in ecological modeling (Olden 2000). This analysis has established a foundation for further research into the application of feed forward neural network models as a tool to describe complex ecological relationships observed in Tampa Bay's Alafia River.

Neural networks have an important advantage over approaches such as regression analysis in that they can accommodate interactions among variables without any *apriori* specification (Quin et al. 2003). Through this pilot study investigation, it was found that neural network models were applicable to modeling interactions between the Alafia River flow regime and various aspects of the associated biotic ecosystem. Using a dataset intended to characterize baseline measures of aquatic health in the Alafia River, we successfully applied neural network models to Chlorophyll a concentrations, zooplankton abundance, fish abundance and measures of community structure. Not only could the models be trained to predict abundance patterns in the existing data, but through examples of cross validation, it was demonstrated that presenting the trained models with new information yielded adequate predictions even though the available datasets were small relative to those commonly used in neural network analysis.

Although the models developed for this pilot study are parameterized to the point of summarizing the relationships expressed in the observed data, they should not be applied directly to freshwater inflow resource management problems in their current state. As demonstrated by the validation results, the models are likely to be over-parameterized and would require refinements for application. In order to apply these models, one would identify biological resources of interest that are important, present in suitable abundance during a particular period of impact (e.g., a time period expected to be impacted by water withdrawal schedules), and provide a early warning indicator of flow changes. One would then reduce the number of parameters in the models until the prediction skill of the model was balanced with the validated robustness to prediction error.

Predicting abundance simultaneously in all river regions served as a generalistic approach to modeling individual species abundance that allowed us to explore the effects of the flow regime on species abundance and also the interactions among river regions. In some cases where the underlying function describing abundance is significantly different between river regions, the model may have trouble finding a solution that minimizes the error for all three regions individually. The multivariate approach allowed us to discern where such cases may exist so that we could refine analysis to a specific region where the relationships between abundance and flow could be examined on a finer spatial scale**.**

Model validation was performed on both the river wide estimates and the region specific models. The results indicated that the region specific models were easier to validate and required a more simplistic model; however, in several cases the region wide models also appeared to be robust in predicting new information. These two approaches represent different strategies that may correspond to different management approaches related to the scale on which potential inference is to be based.

Dimension reduction is common practice in quantitative ecology (Qain et al 2003). Besides the analysis presented above, we examined relationships between the flow regime and metrics of community structure including the number of species per sample, Abundance (CPUE), Shannon Weiner Diversity (H′) and factor scores from principal components analysis. We found that species richness and abundance metrics were not well modeled with the fish datasets but Shannon Weiner Diversity was adequately modeled once the seasonality was reintroduced to the data (Figure 6-1).

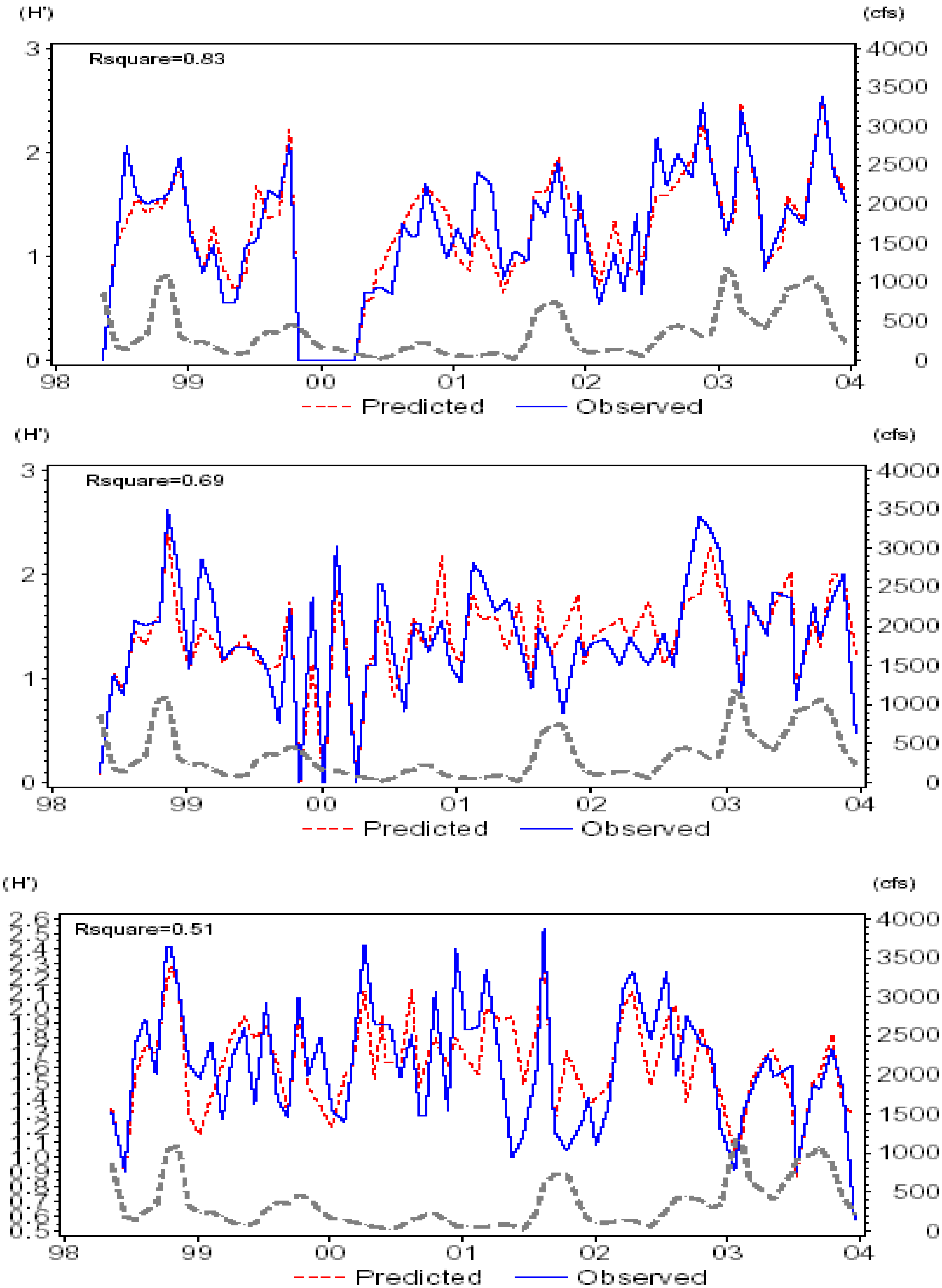

Figure 6-1. Predicted vs observed plots for Shannon Weiner Diversity index from feed forward neural network model. Plots are from top to bottom; Upper, Middle and Lower Alafia River Regions. The broken Grey line represents the 60 day lag average flow at Bellshoals Rd.

The poor modeling of cpue and species richness is not surprising given dynamic utilization of the estuary, and it may be due to extreme values in the data even after standardization as neural network models are somewhat sensitive to the range of input and target variables presented. This artifact may mean that outlying observations have increased leverage on model predictions, an area of further research. Bootstrap aggregation techniques may yield more stable estimates after being iteratively trained with varying subsets of data and predictions averaged across trials however more data are generally required for such techniques.

A criticism of neural networks has been that they provide little insight into the underlying causal factors driving the hypothesized relationships. Techniques for evaluating connection weights as a means of identifying important predictor variables driving responses in empirical data have been developed that refute these historical assertions (Olden and Jackson 2002, Garson 1998). The authors of this paper used a connection weight partitioning method developed by Garson to interpret connection weights in relation to their importance in model adequacy and generalized the equation to accompany more than one output variable. While this procedure does not make the models deterministic, it serves as a reliable means of reducing variables from the input layer that do not contribute significant information to the model predictions in line with the principal of parsimony.

While neural networks are a flexible alternative to regression modeling for ecological data they are not without constraints and limitations. Generally, it is advisable to have large datasets to work with to ensure that the training data cover all possible scenarios that might be experienced in future predictions. While the data used were somewhat limited by regional averaging to avoid the increased variability associated with pseudo-replication, they included both very wet (2003) and dry (2000-2001) years such that variations outside the range of flow conditions in the dataset would be improbable. Our models were simplistic in that only flow variables were used as model inputs. With more data, more complex models could be established that address the trophic relationships between flows, nutrient inputs, primary production, and higher order species interactions. Ideally, to address these situations, data would be collected simultaneously or in close interval scales to minimize the confounding effects of pooled data across time.

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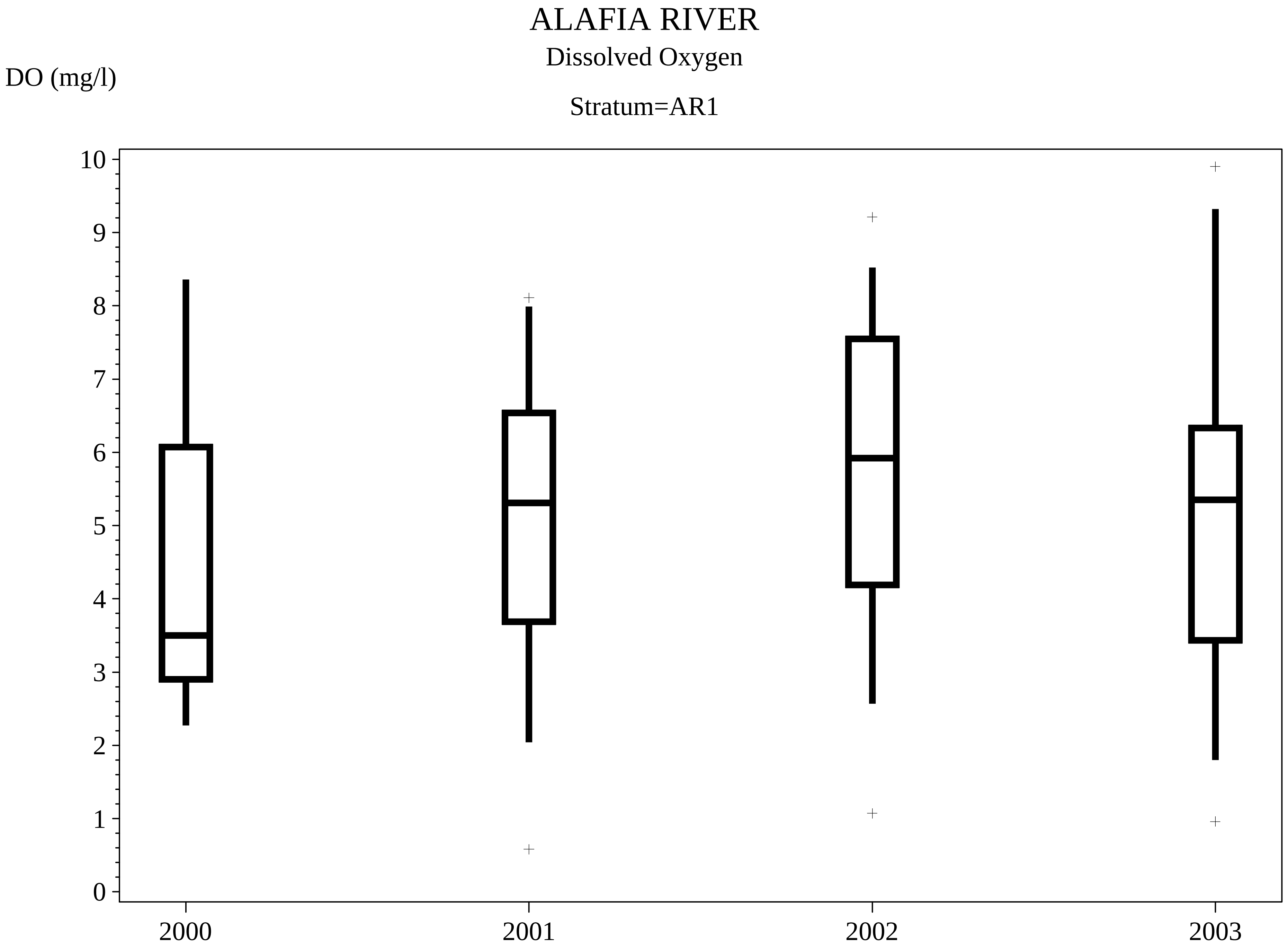
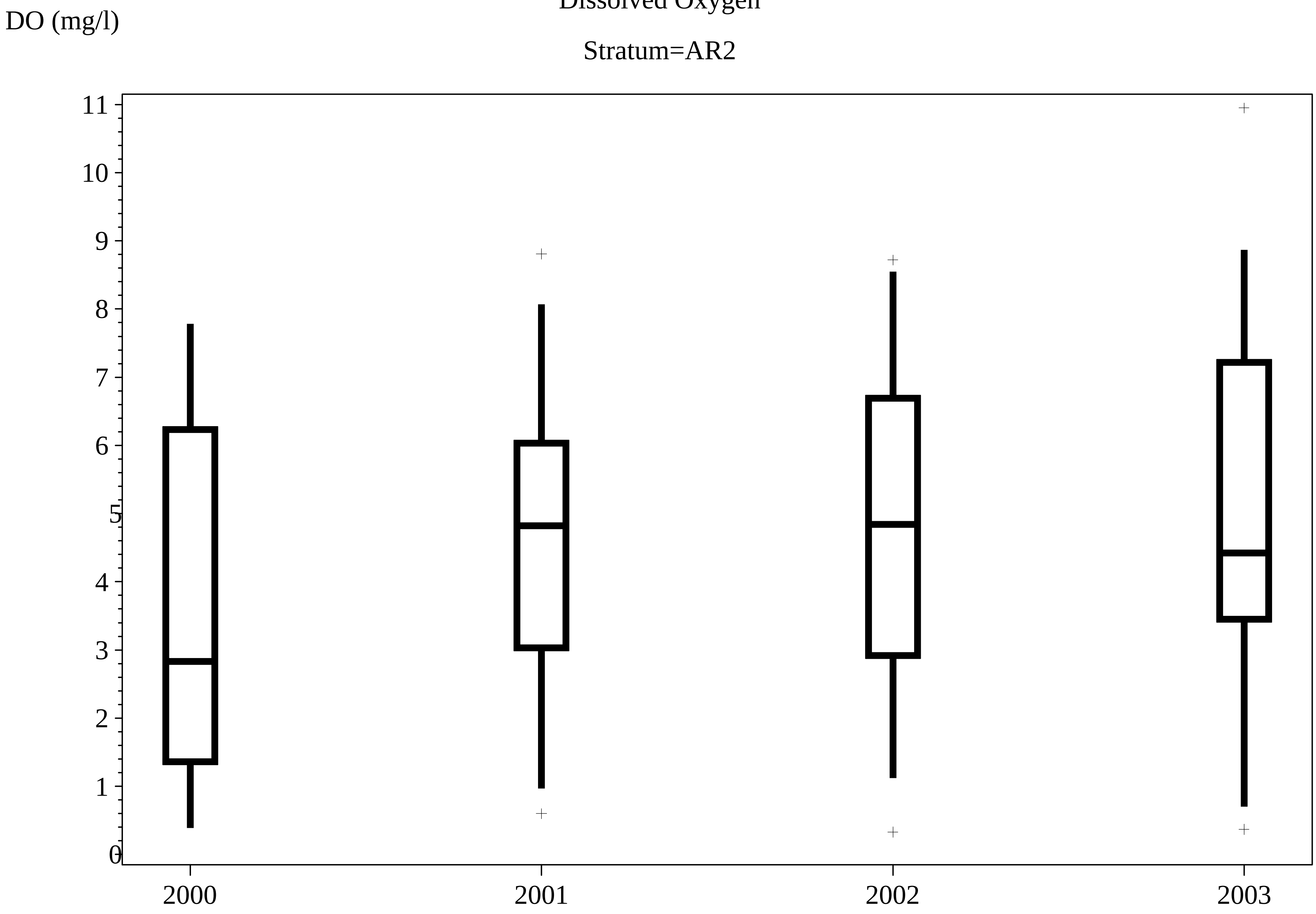
APPENDIX A:
WATER QUALITY BOXPLOTS

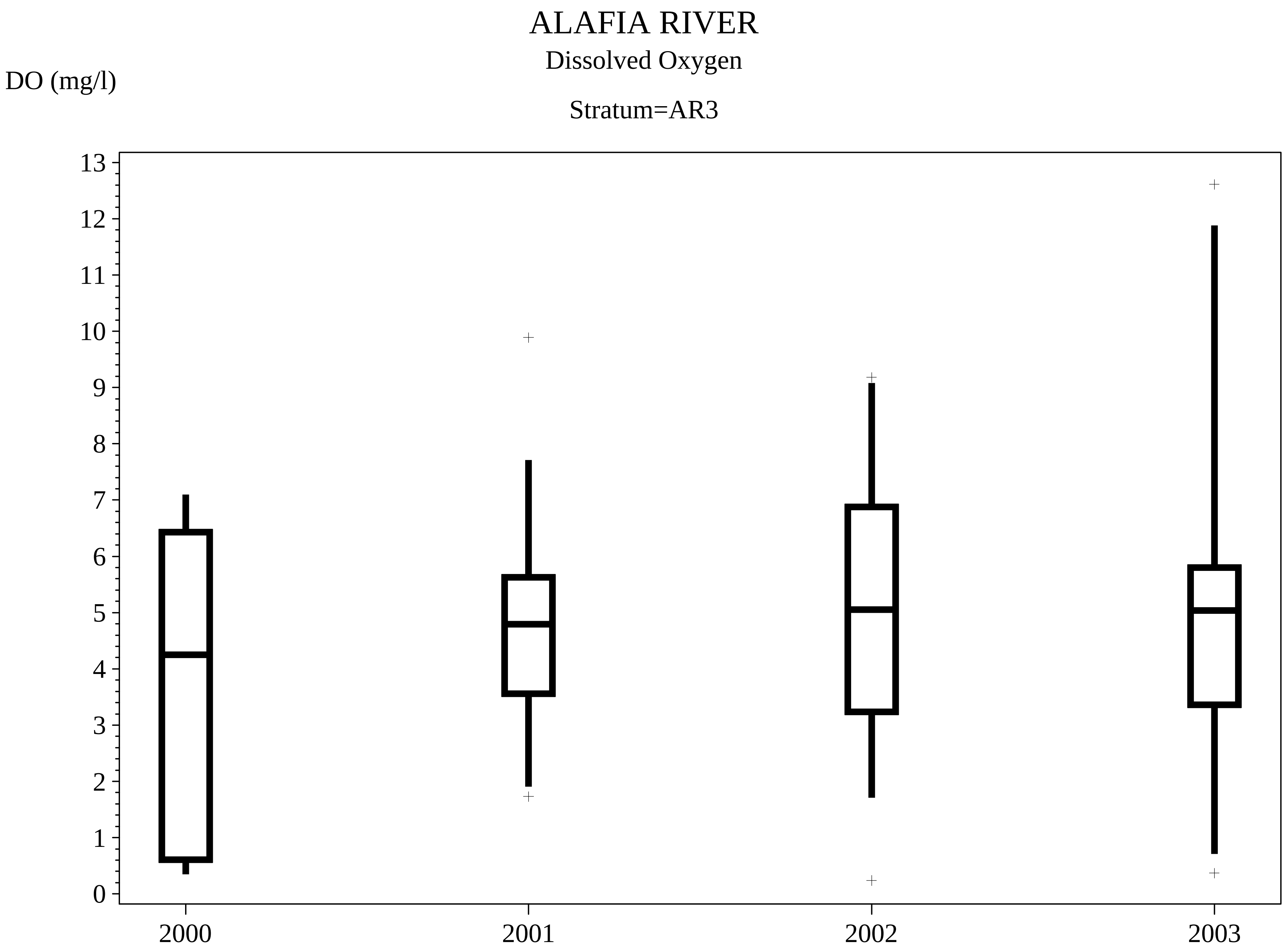

ALAFIA RIVER
Dissolved Oxygen
DO (mg/l)
Stratum=AR1
10
9
8
7
6
5
4
3
2
1
0
2000
2001
2002
2003

ALAFIA RIVER

Dissolved Oxygen

Stratum=AR2




ALAFIA RIVER
Dissolved Oxygen
DO (mg/l)
Stratum=AR3
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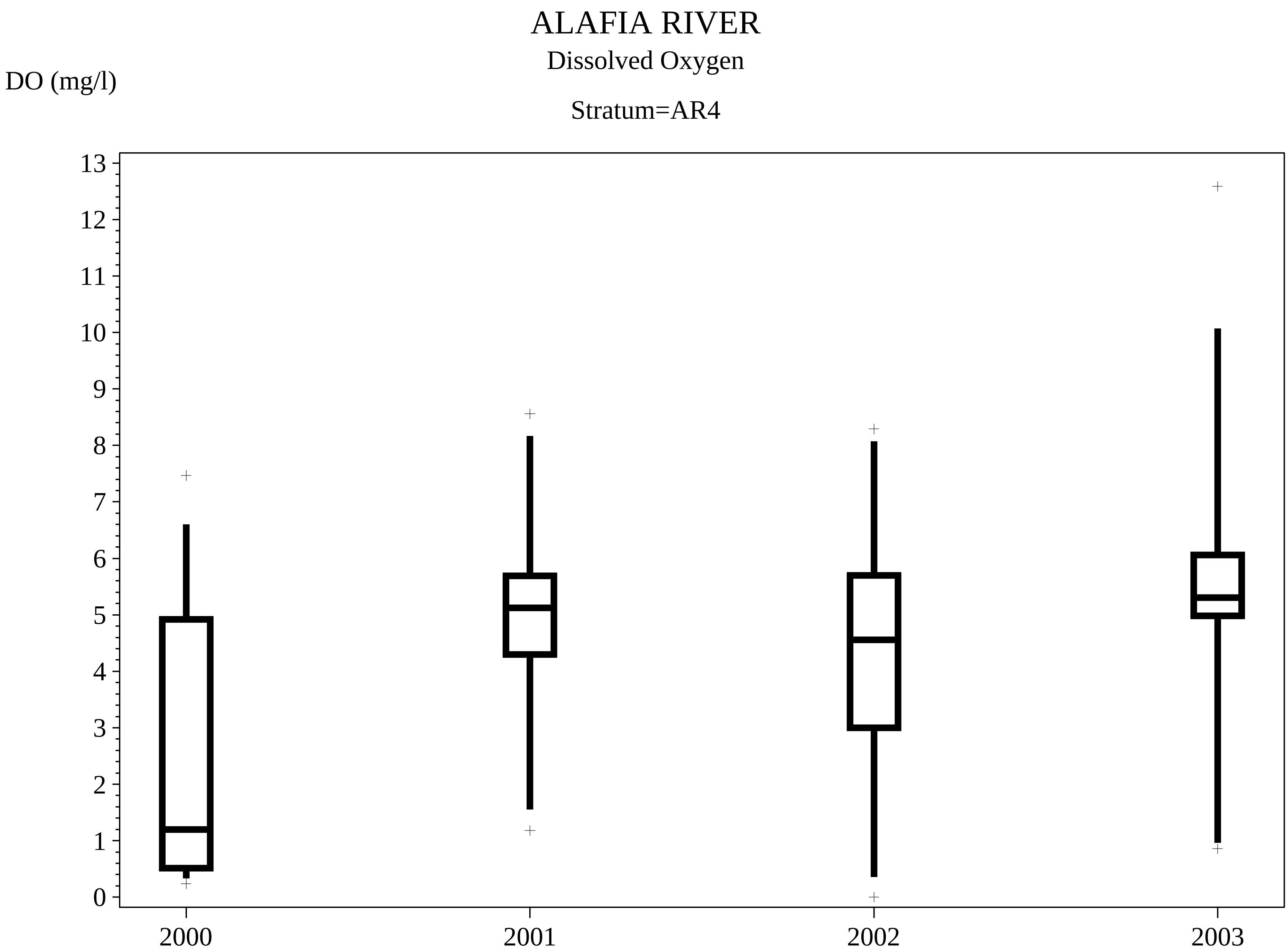
12
11
10
9
8
7
6
5
4
3
2
1
0
2000
2001
2002
2003

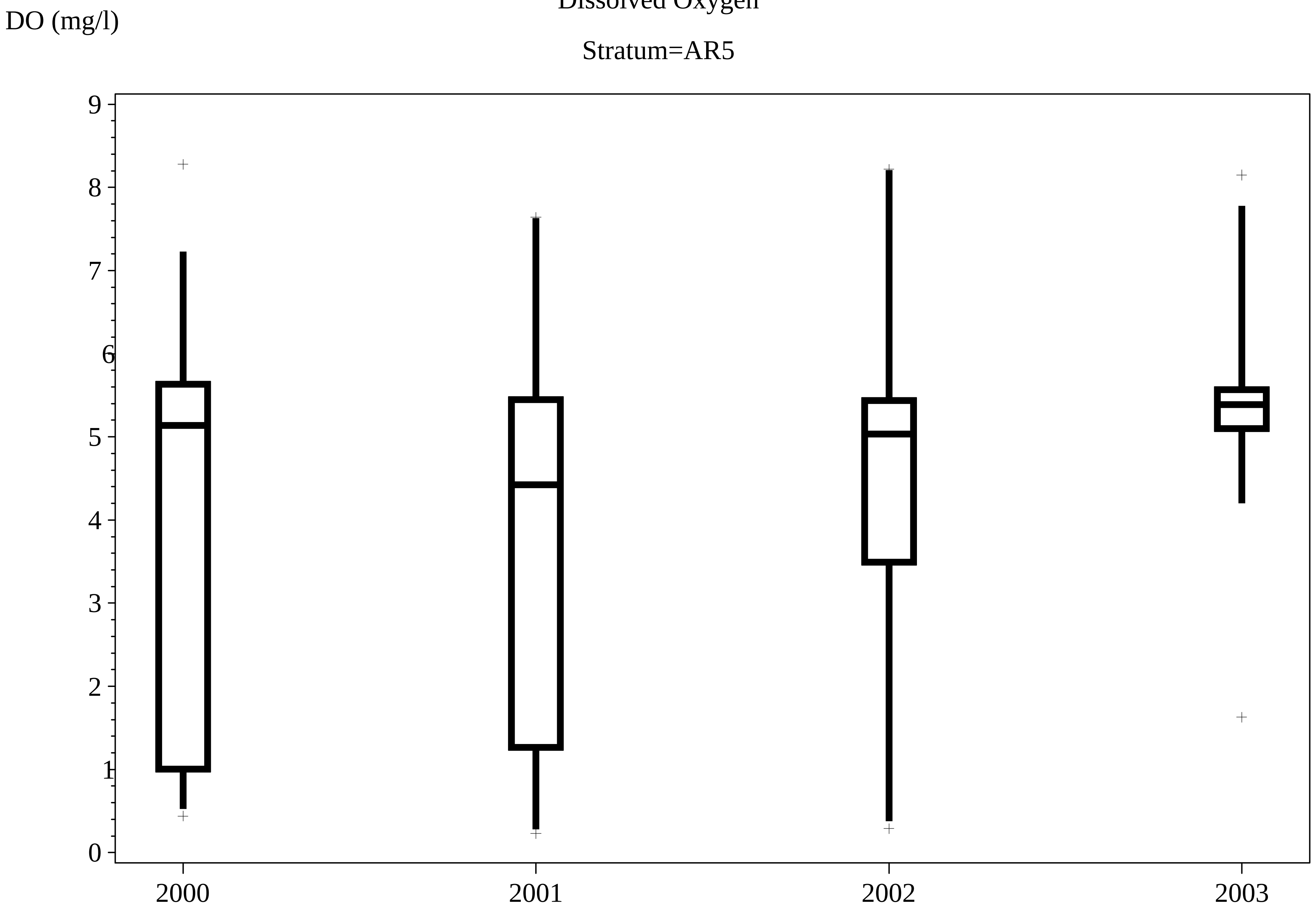


ALAFIA RIVER
Dissolved Oxygen
DO (mg/l)
Stratum=AR4
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2000
2001
2002
2003

ALAFIA RIVER

Dissolved Oxygen

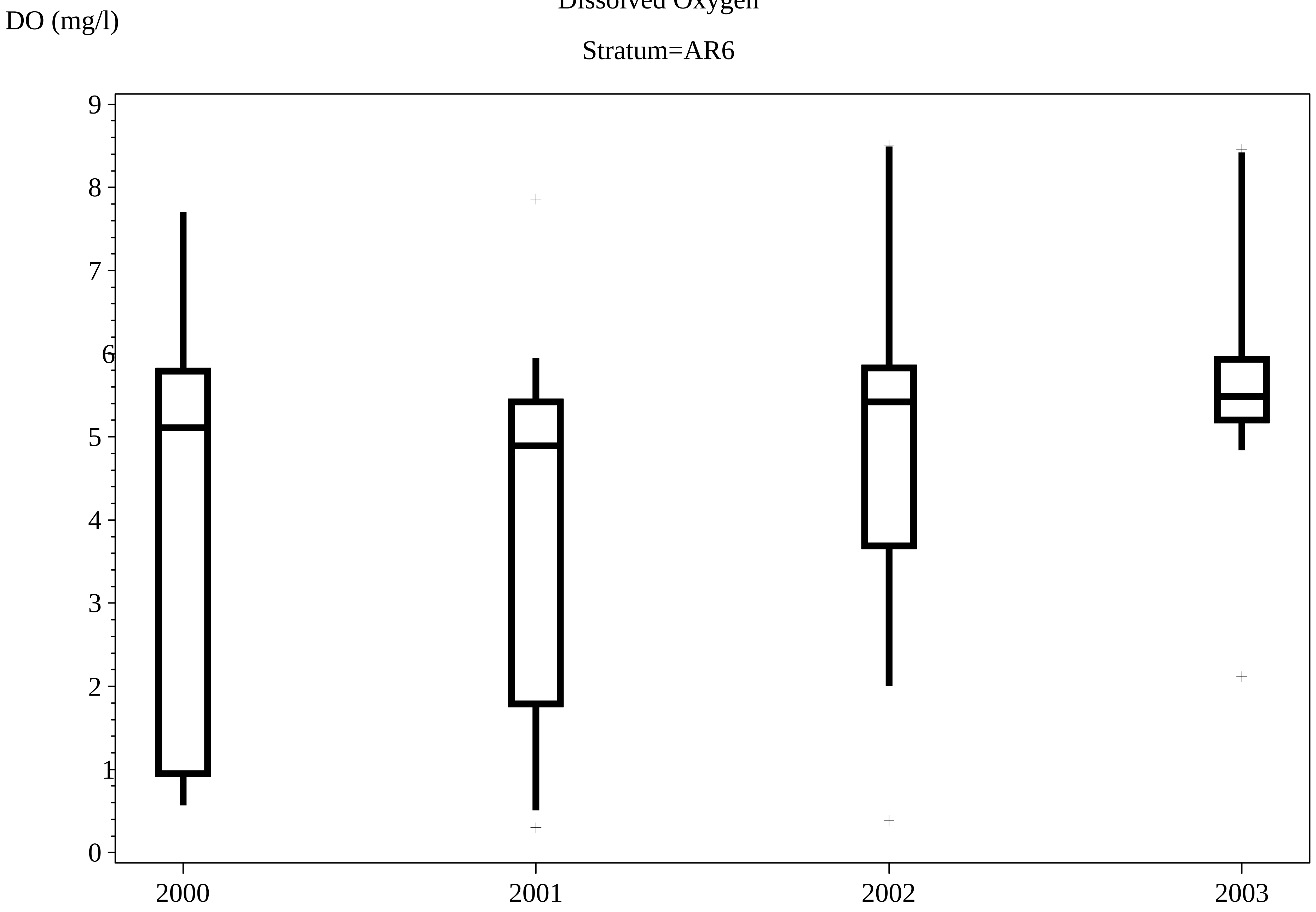
Stratum=AR5



ALAFIA RIVER

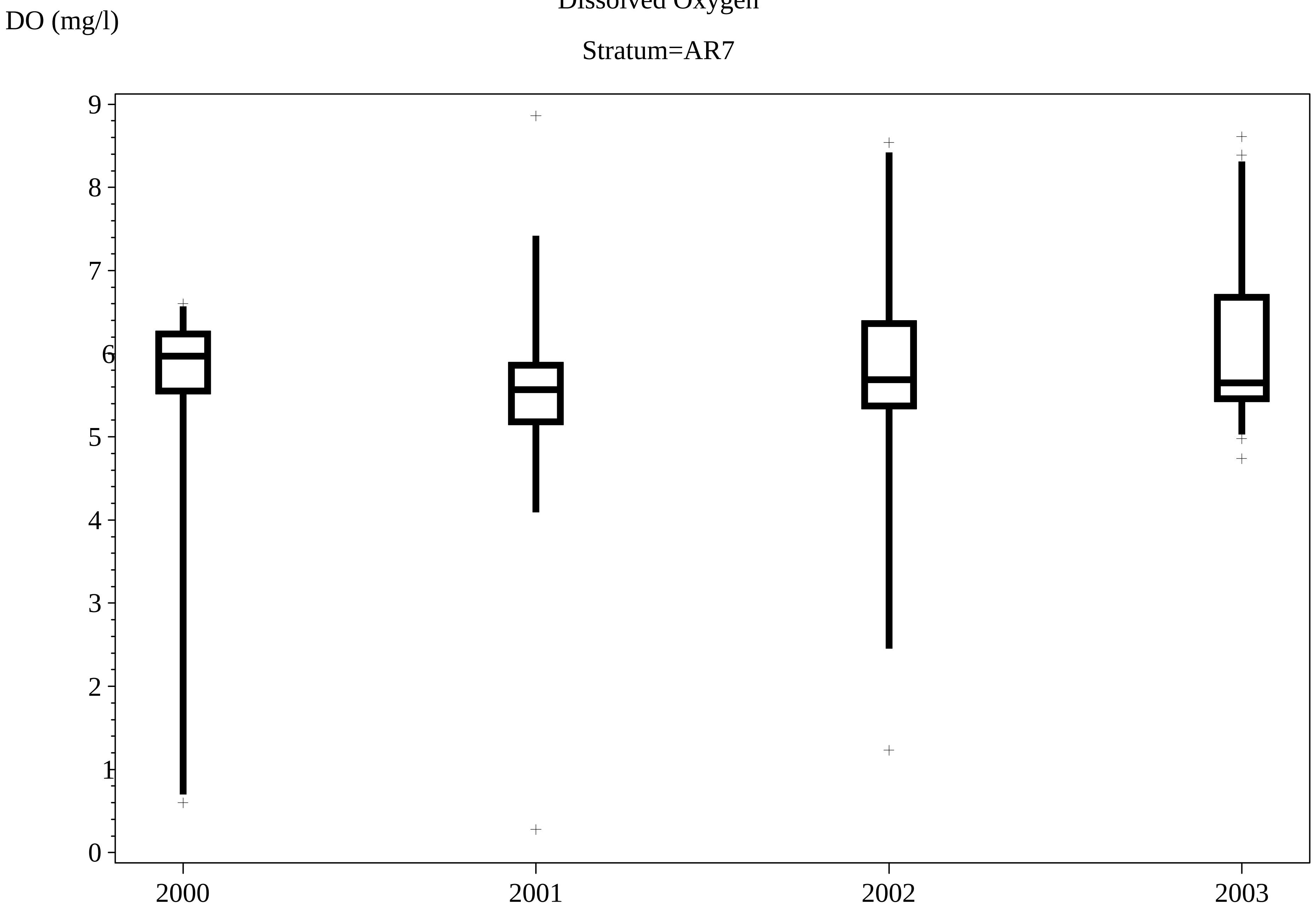
Dissolved Oxygen

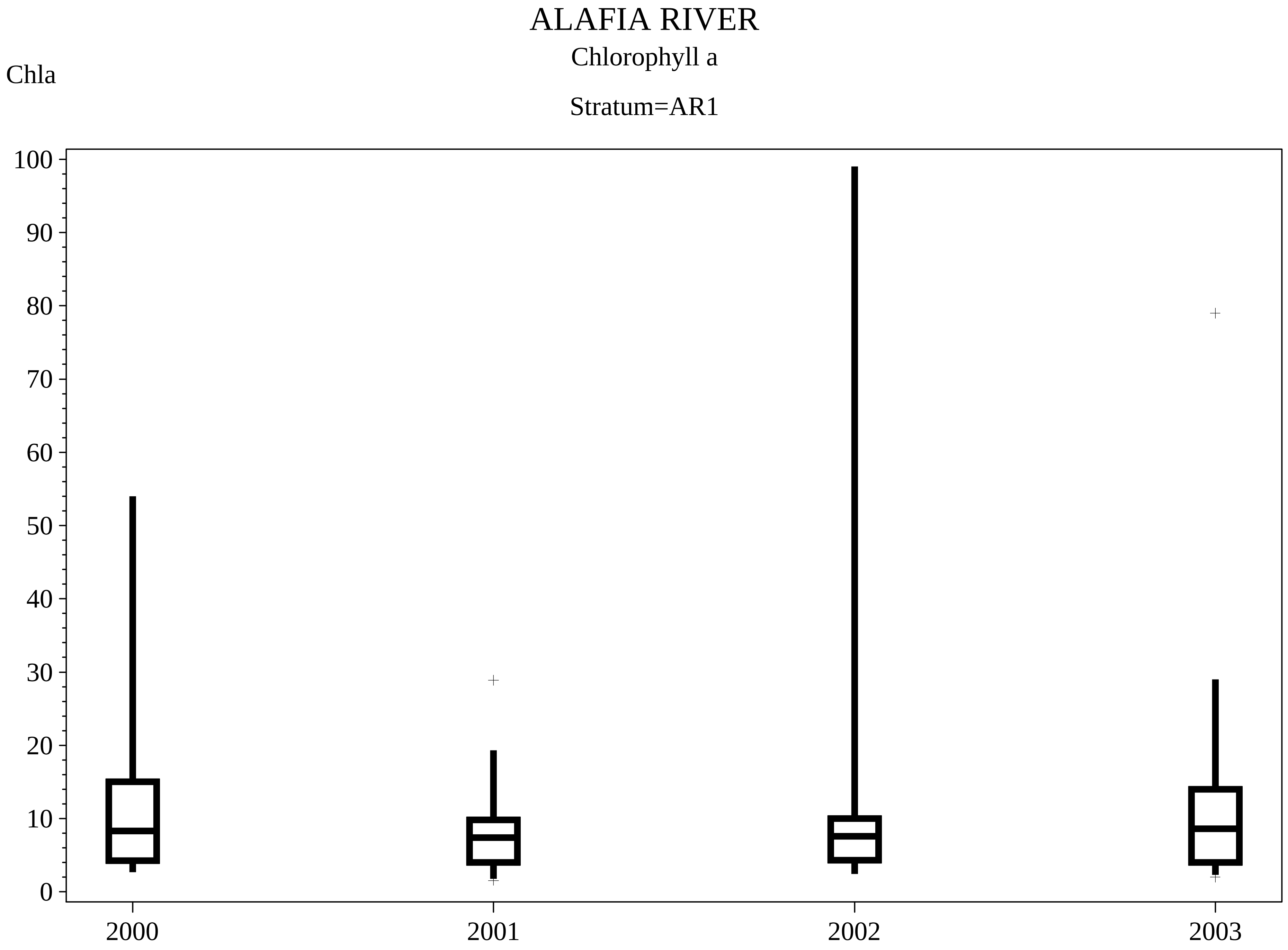
Stratum=AR6



ALAFIA RIVER

Dissolved Oxygen



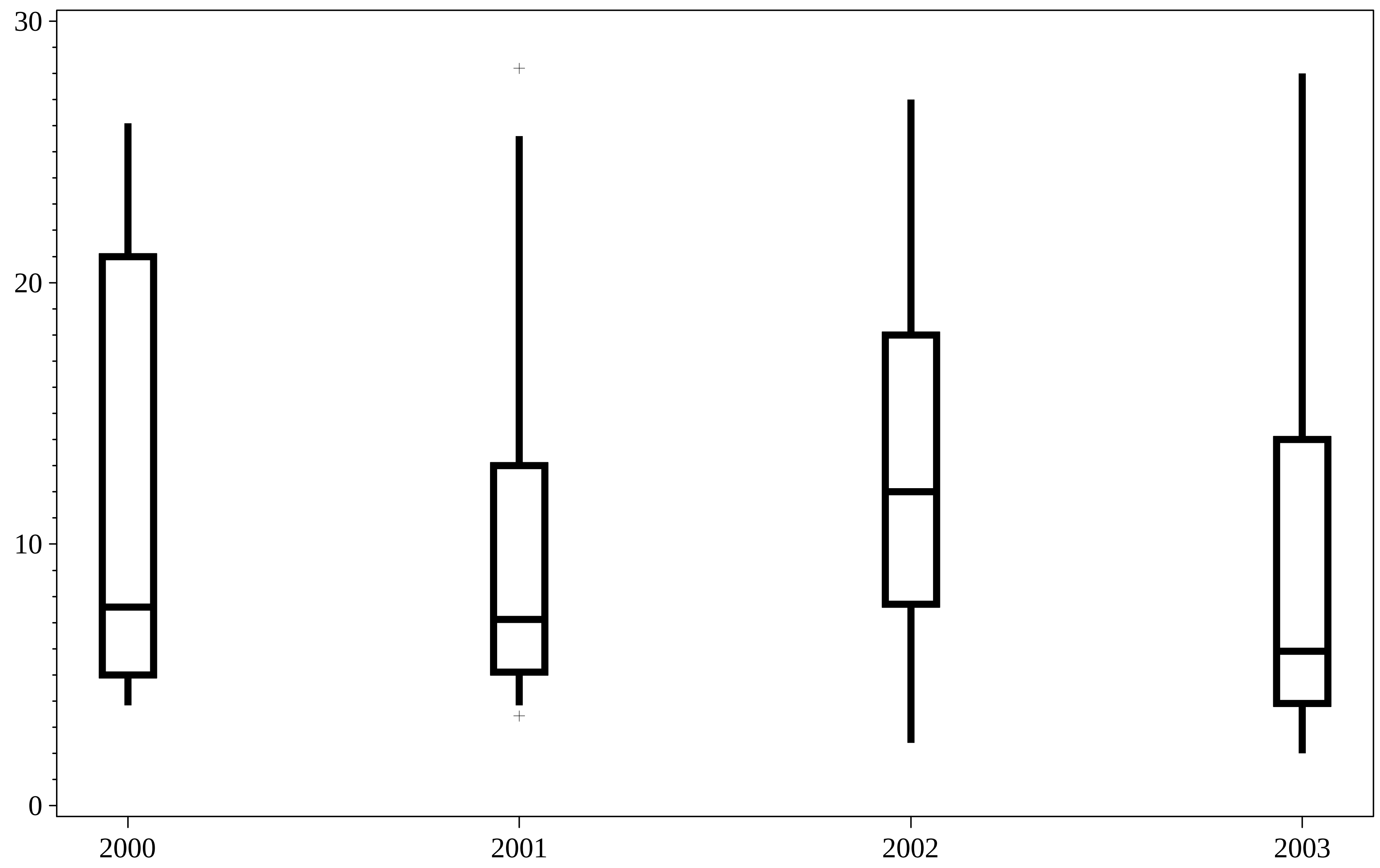


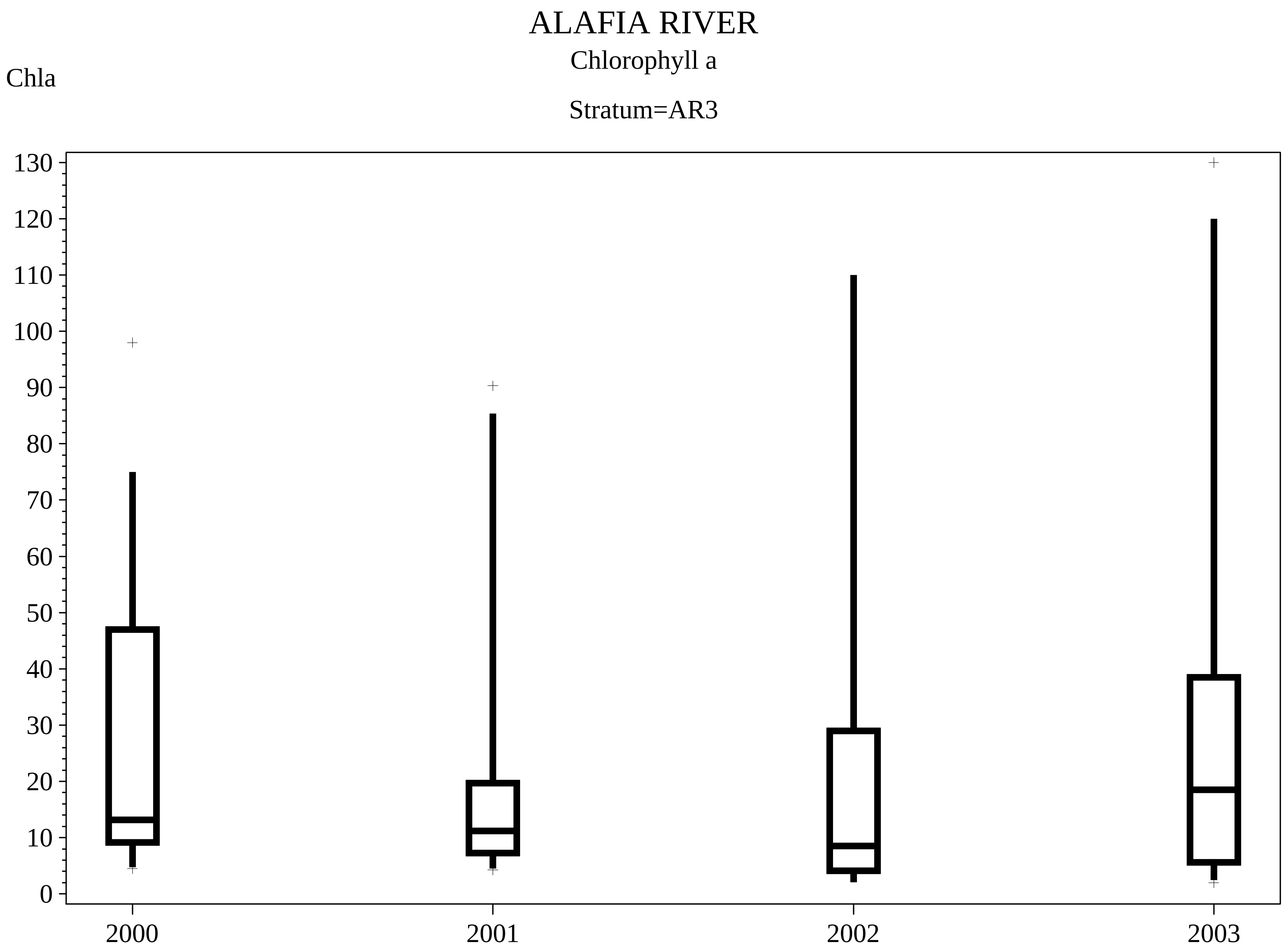
ALAFIA RIVER
Chlorophyll a
Chla
Stratum=AR1
100
90
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003

ALAFIA RIVER

Chlorophyll a

Stratum=AR2

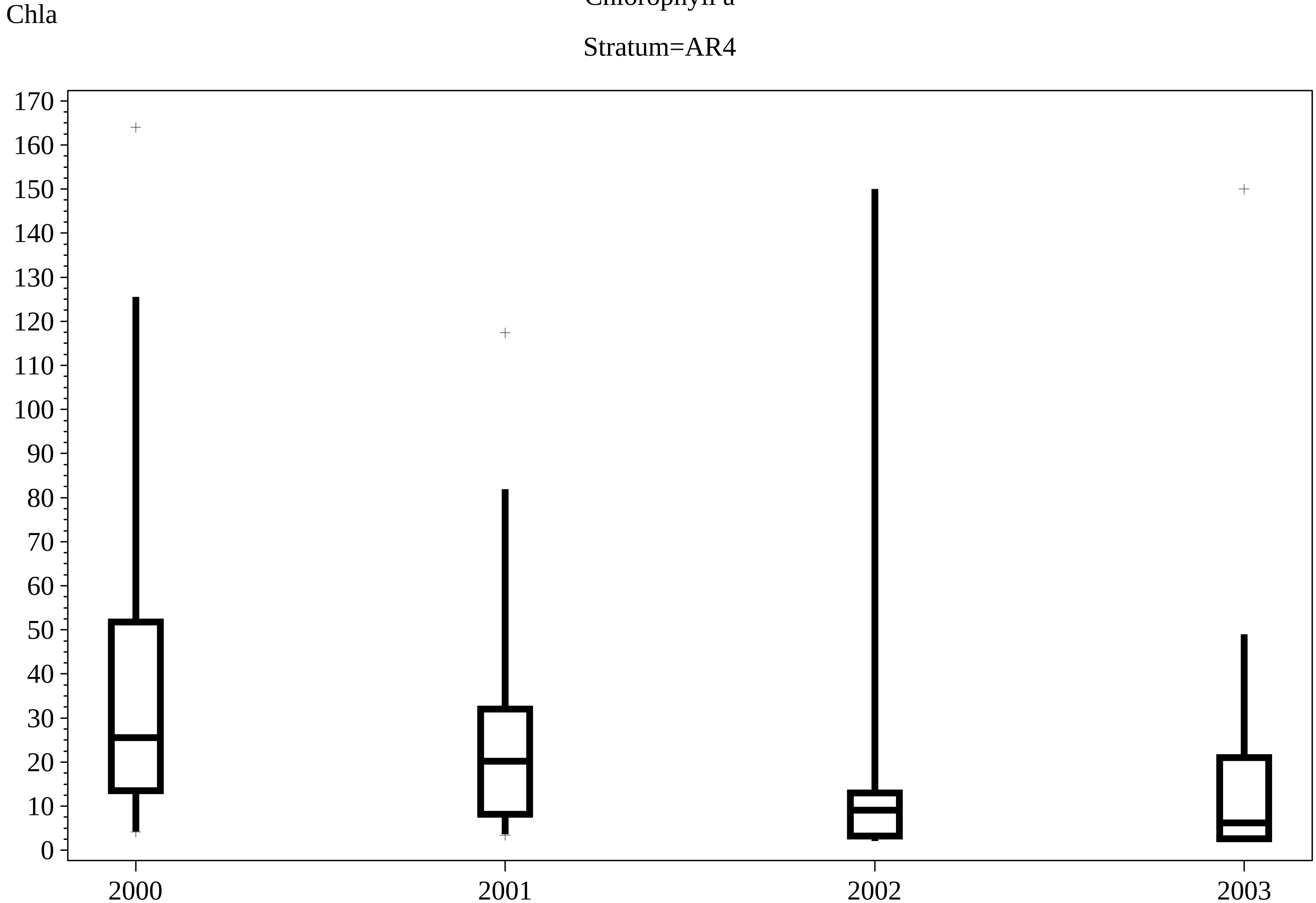



ALAFIA RIVER
Chlorophyll a
Stratum=AR3
Chla
0
10
20
30
40
50
60
70
80
90
100
110
120
130
2000
2001
2002
2003

ALAFIA RIVER

Chlorophyll a

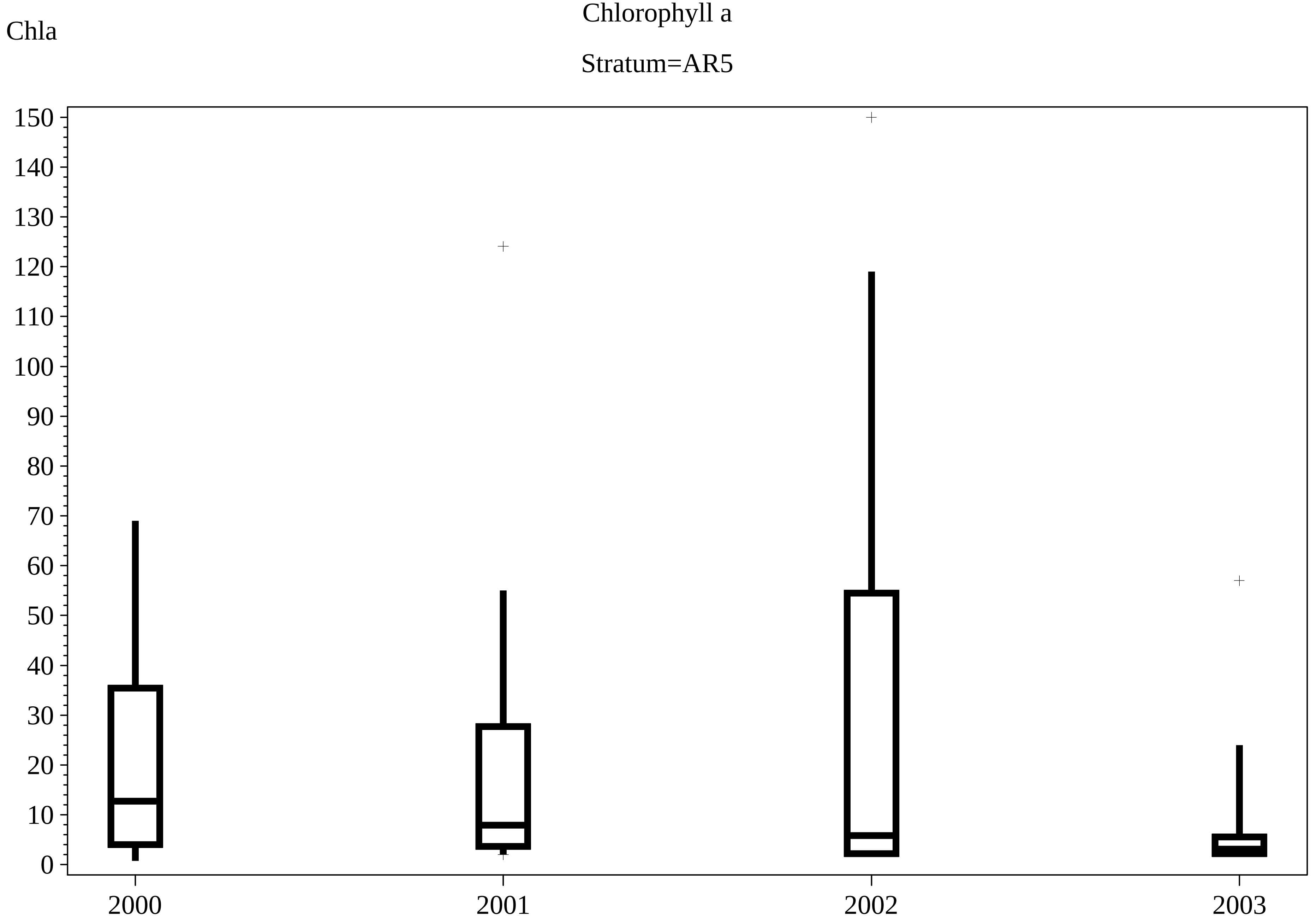
Stratum=AR4



ALAFIA RIVER

Chlorophyll a

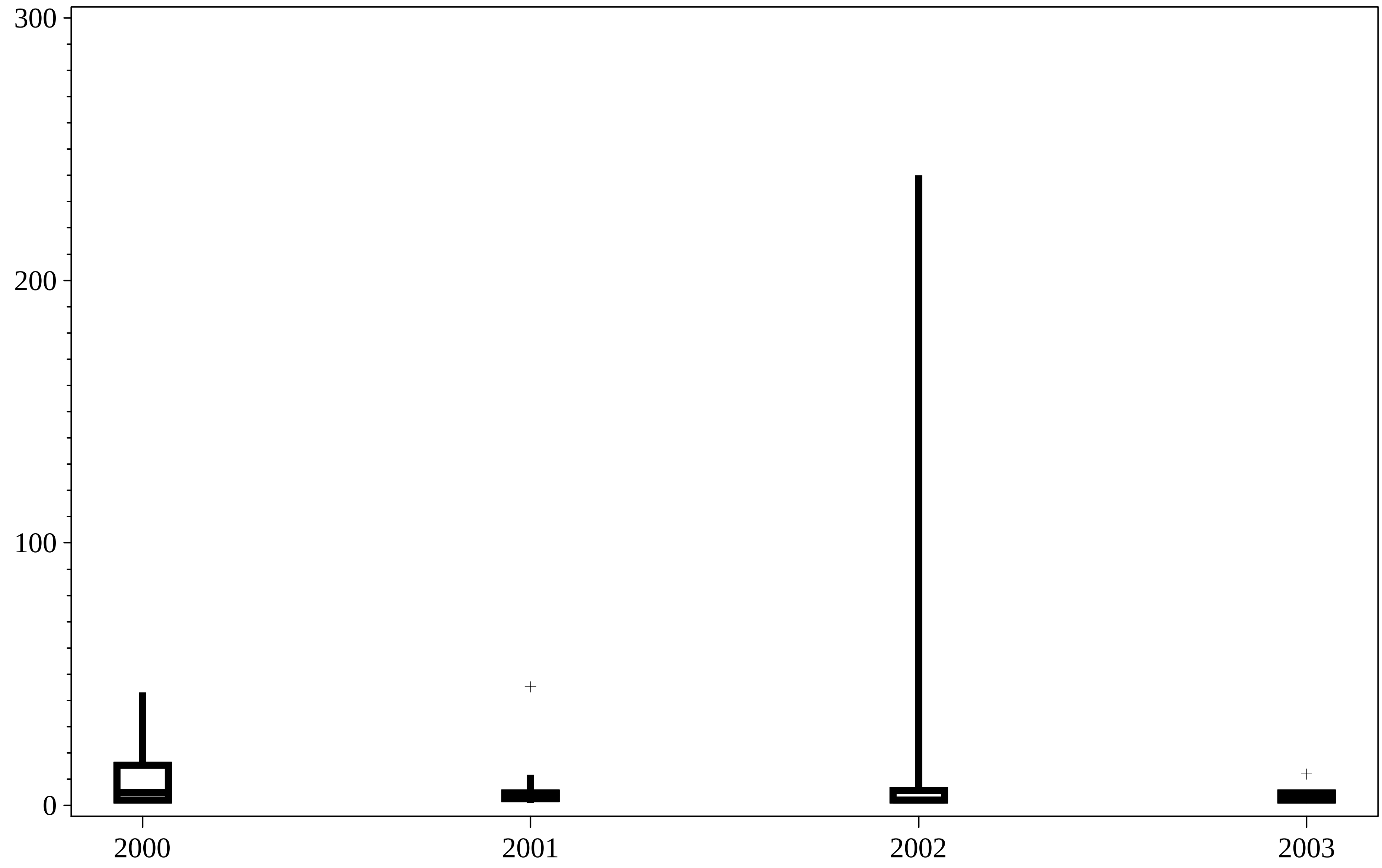
Stratum=AR5

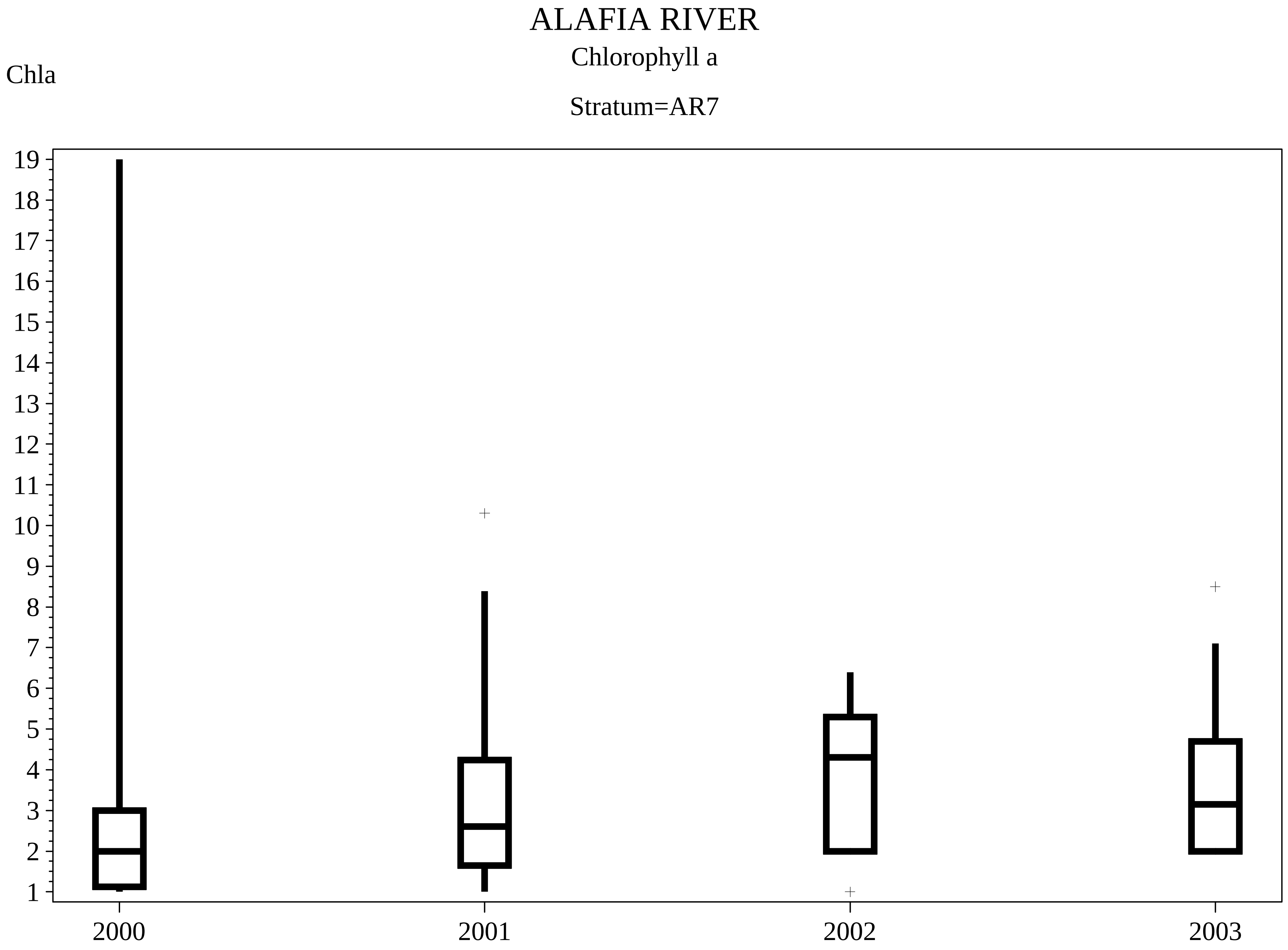


ALAFIA RIVER

Chlorophyll a

Stratum=AR6



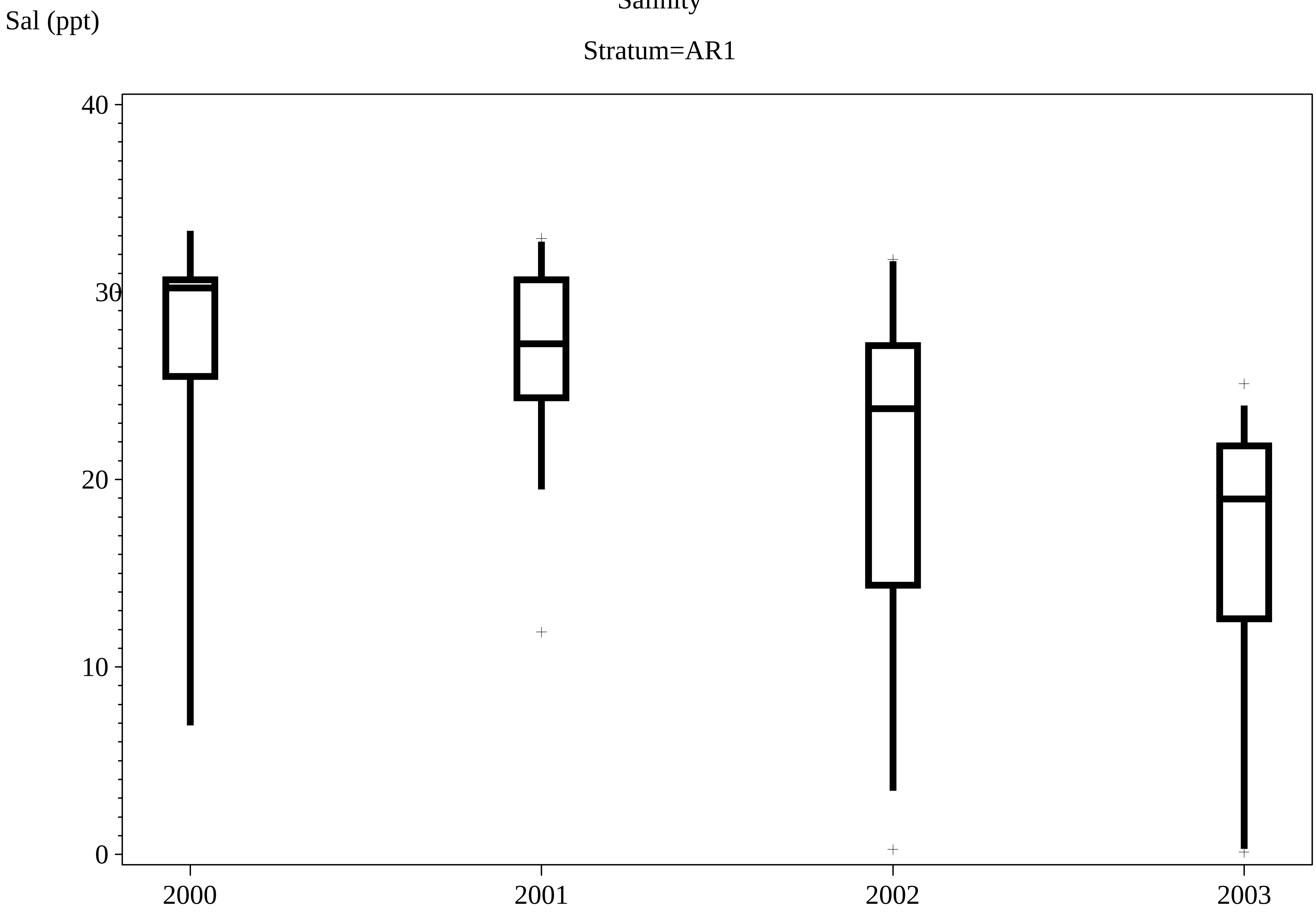


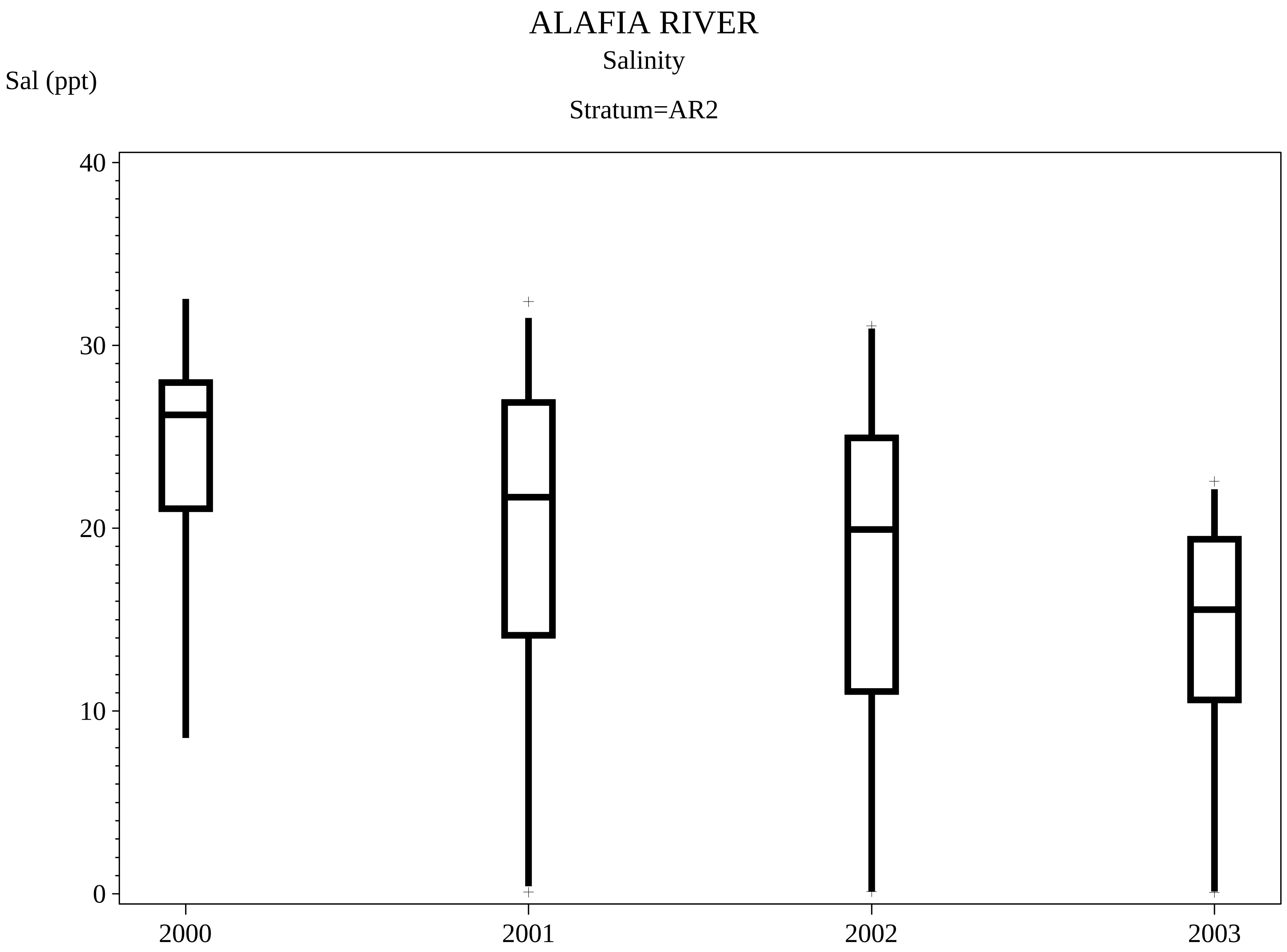
ALAFIA RIVER
Chlorophyll a
Chla
Stratum=AR7
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
2000
2001
2002
2003

ALAFIA RIVER

Salinity

Stratum=AR1

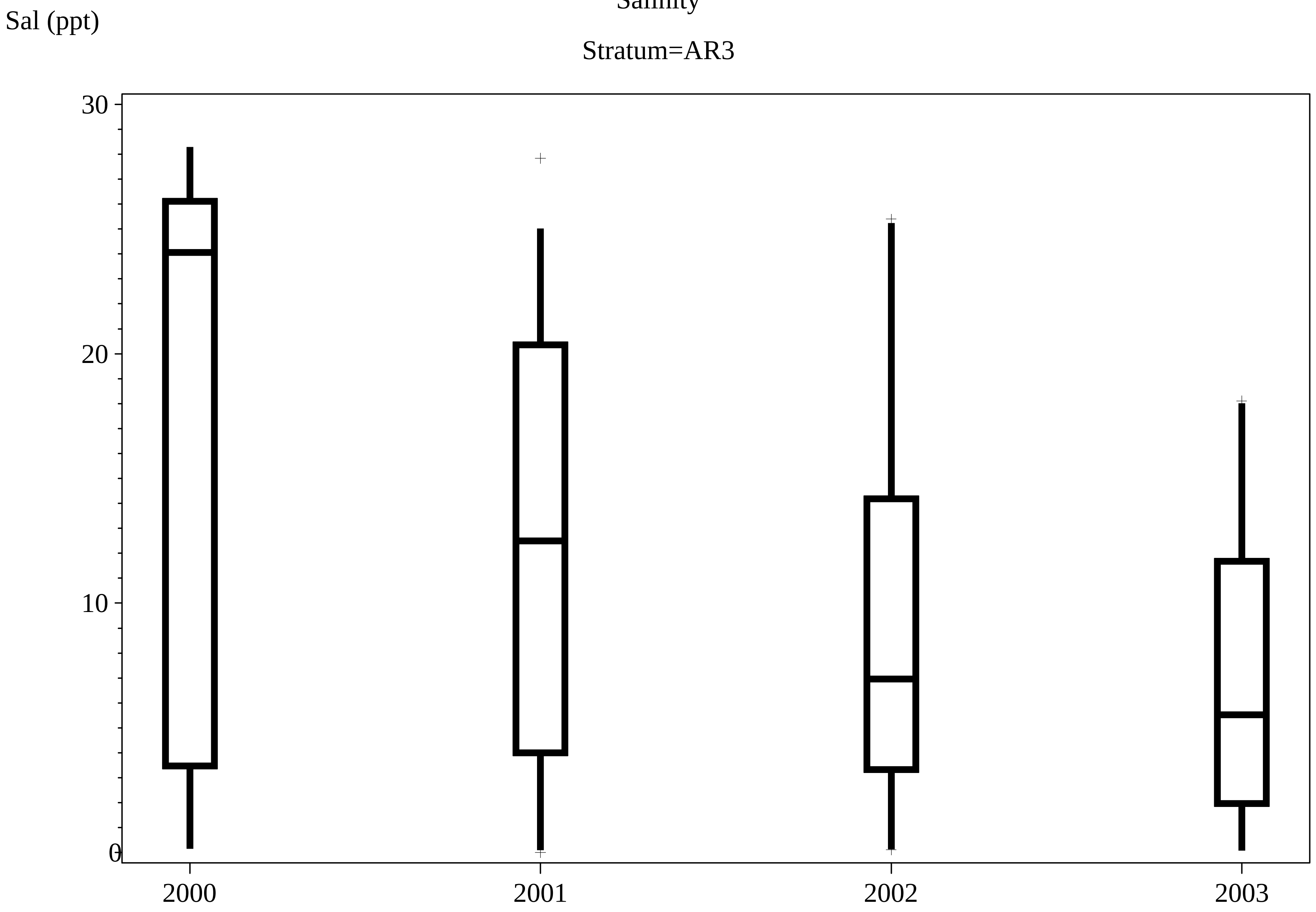


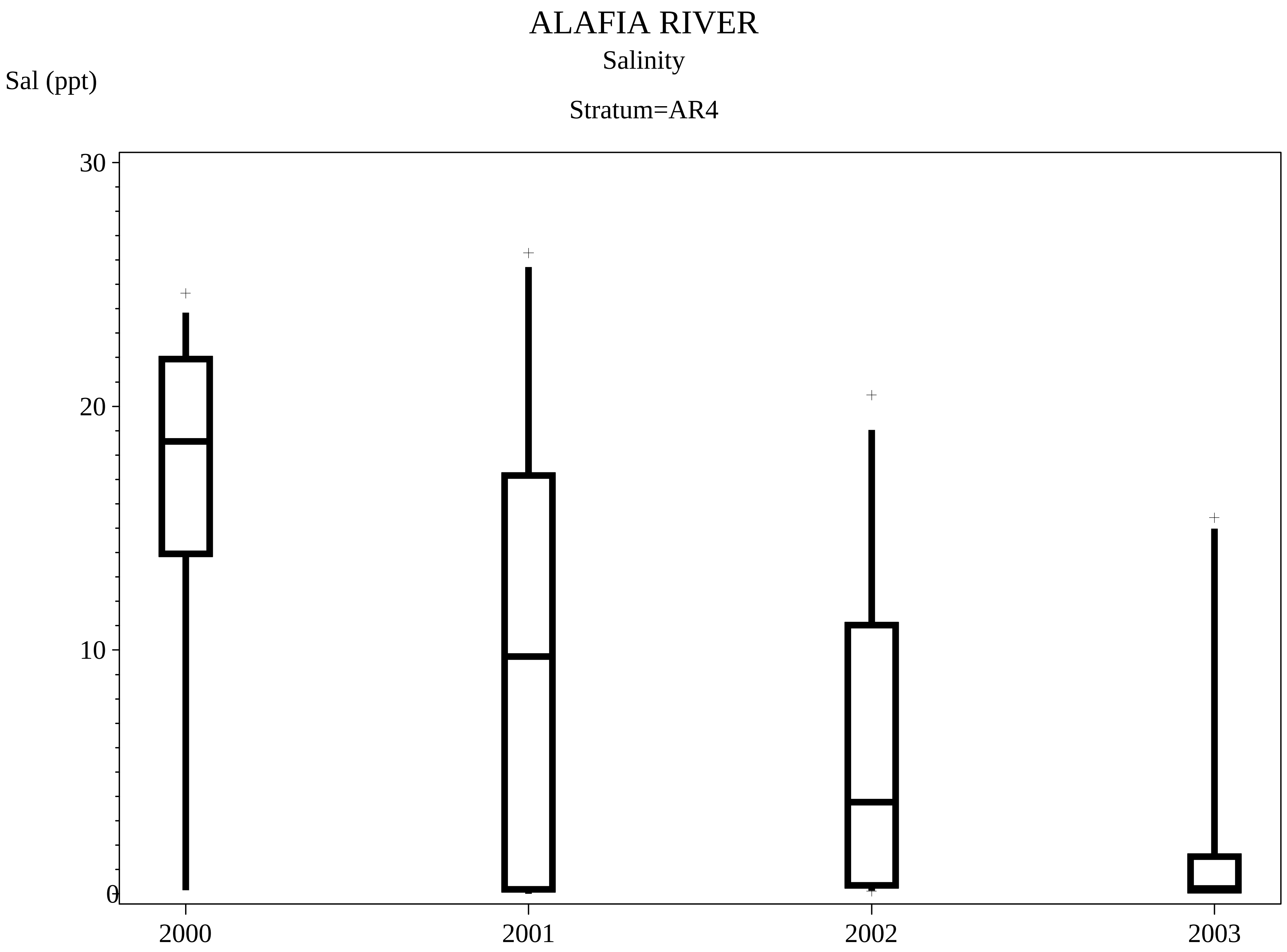

ALAFIA RIVER
Salinity
Sal (ppt)
Stratum=AR2
40
30
20
10
0
2000
2001
2002
2003

ALAFIA RIVER

Salinity

Stratum=AR3

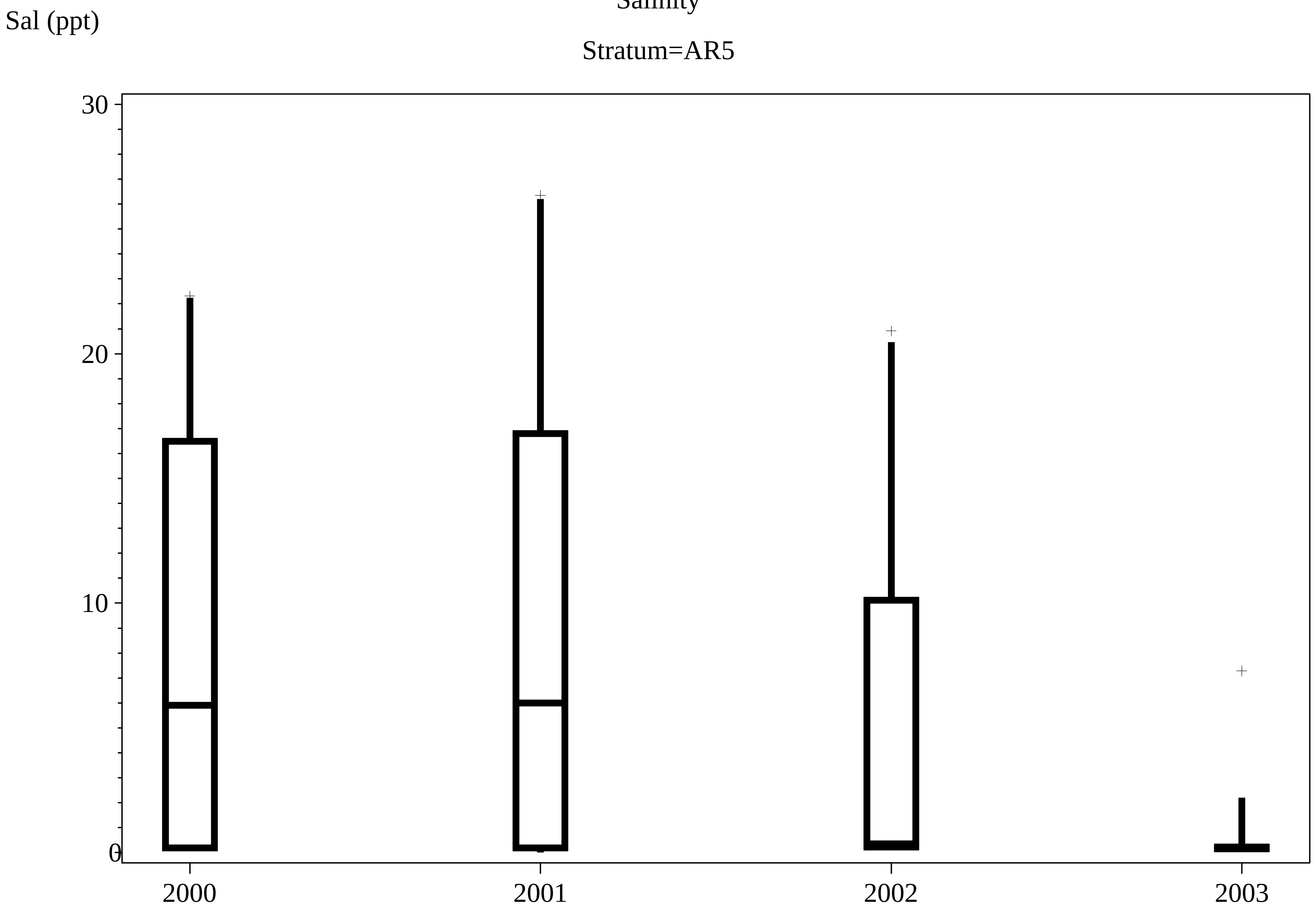



ALAFIA RIVER
Salinity
Sal (ppt)
Stratum=AR4
30
20
10
0
2000
2001
2002
2003

ALAFIA RIVER

Salinity

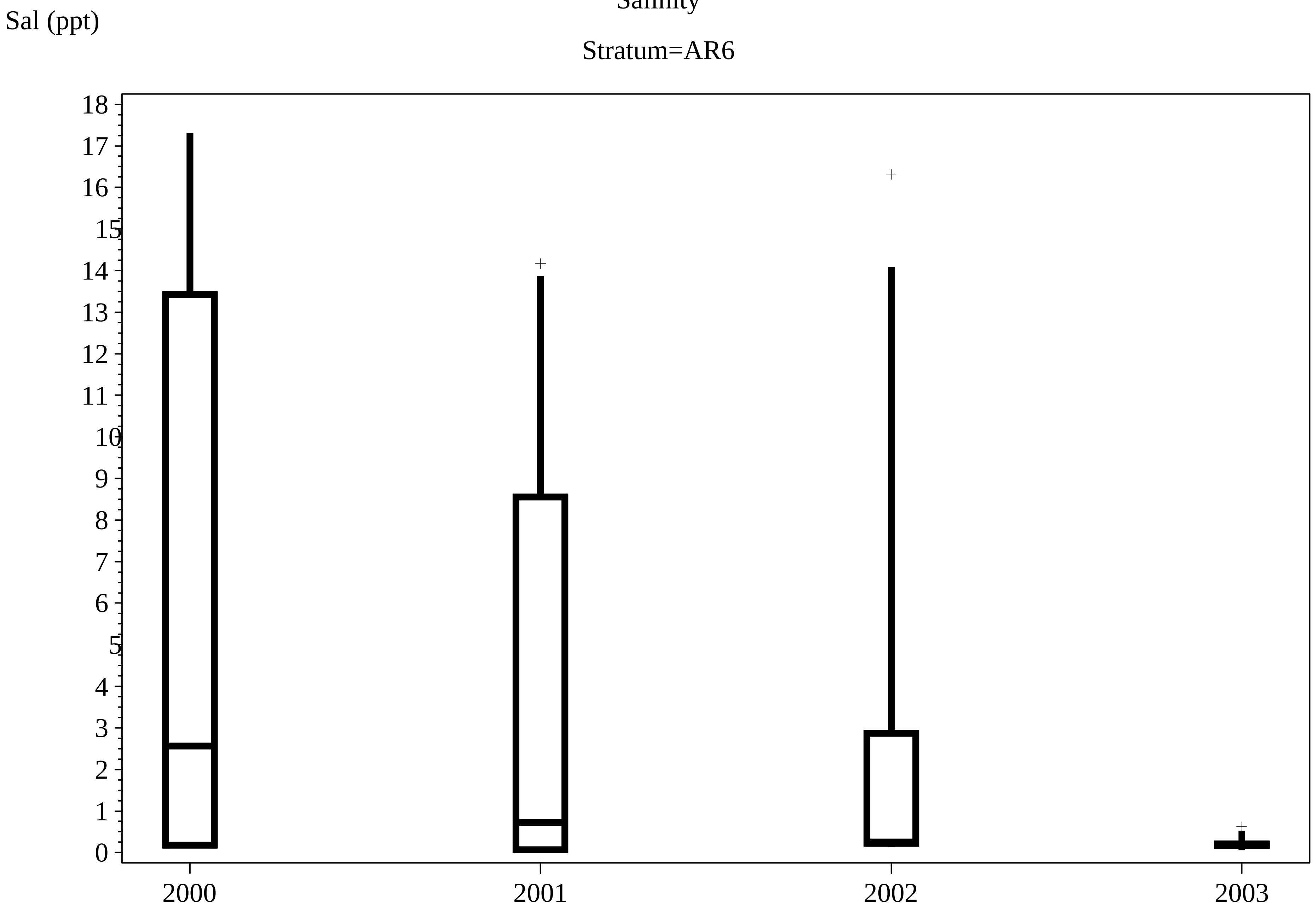
Stratum=AR5

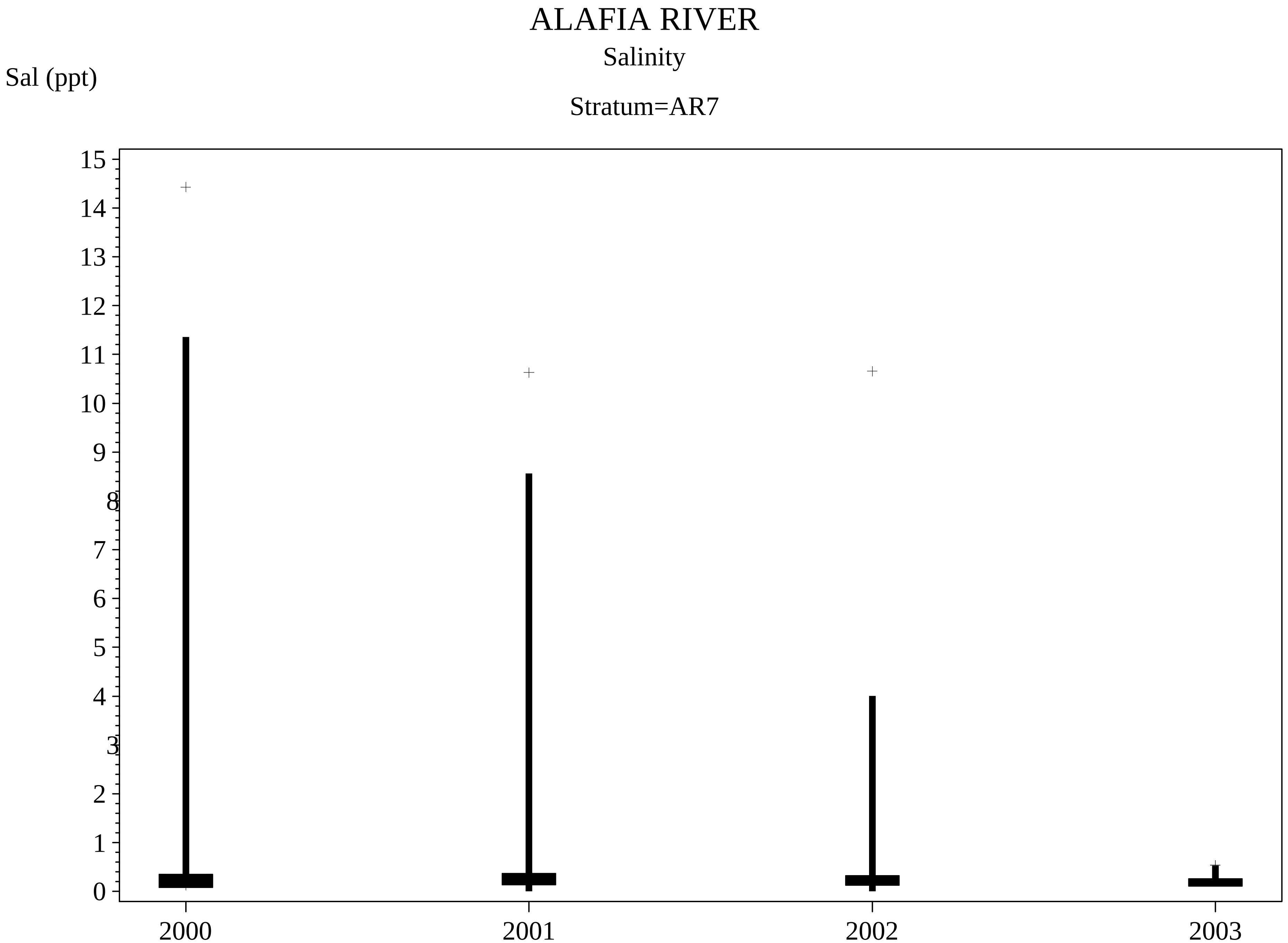


ALAFIA RIVER

Salinity

Stratum=AR6



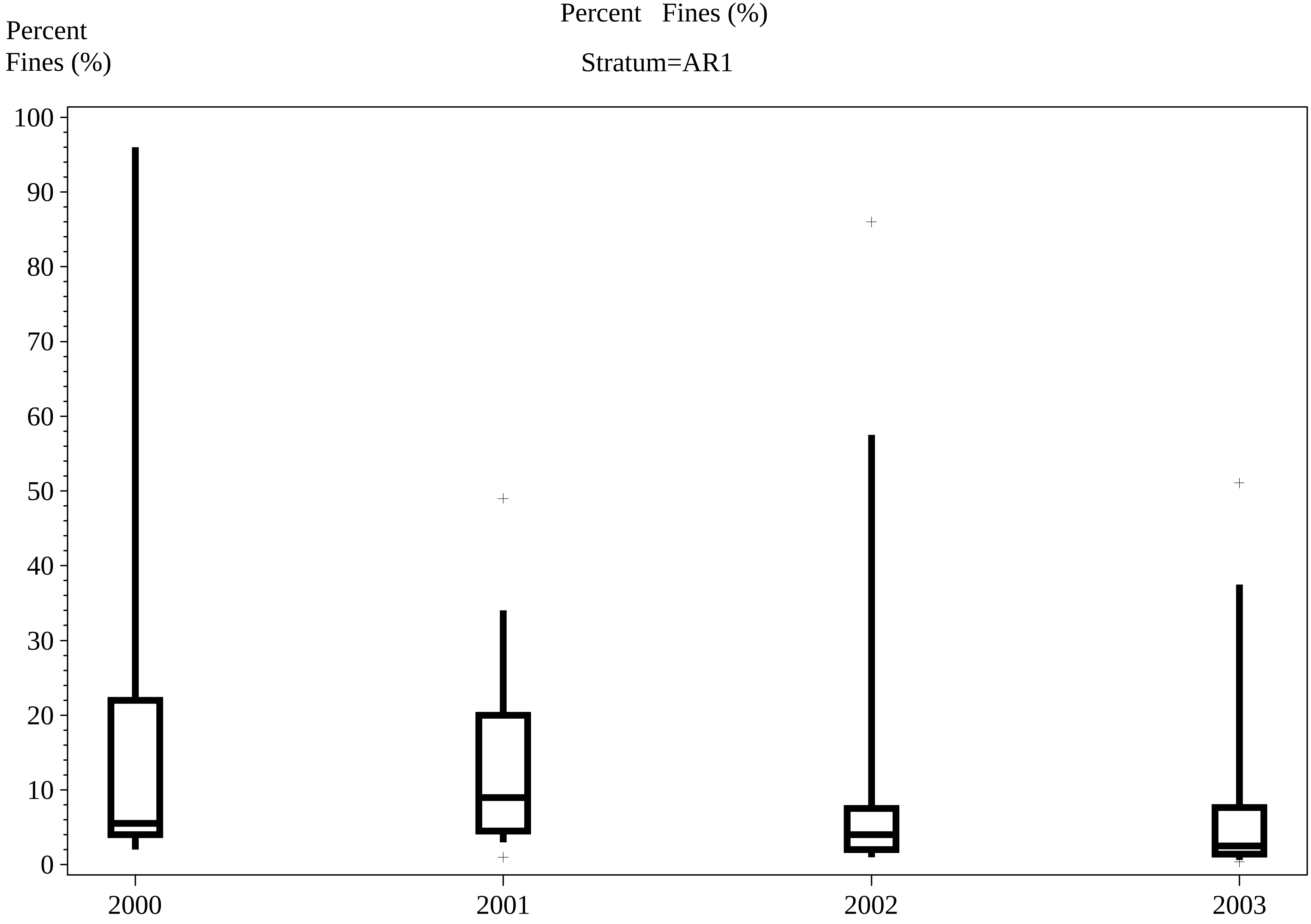

ALAFIA RIVER
Salinity
Sal (ppt)
Stratum=AR7
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2000
2001
2002
2003

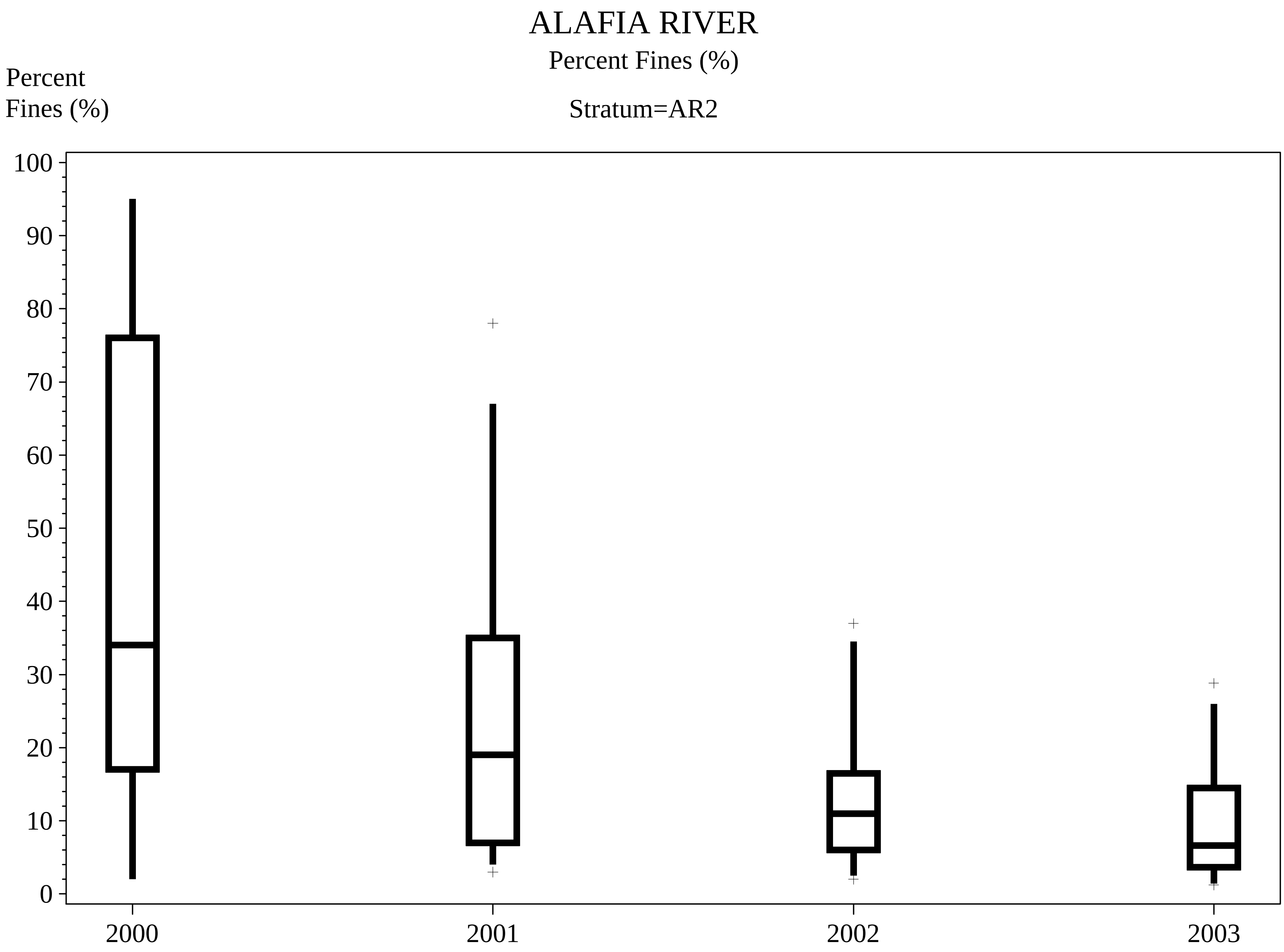
APPENDIX B:
SEDIMENT BOXPLOTS

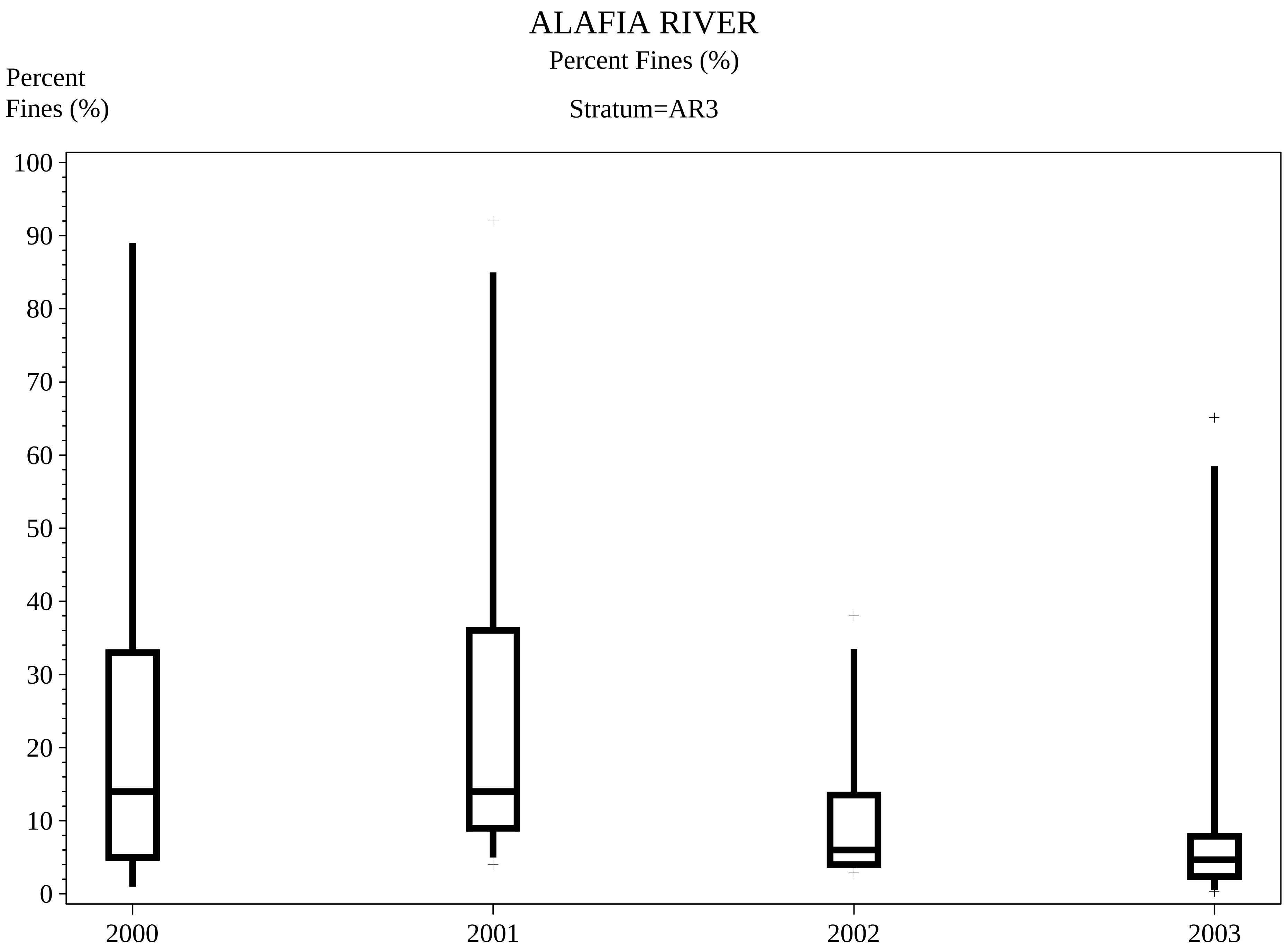
ALAFIA RIVER

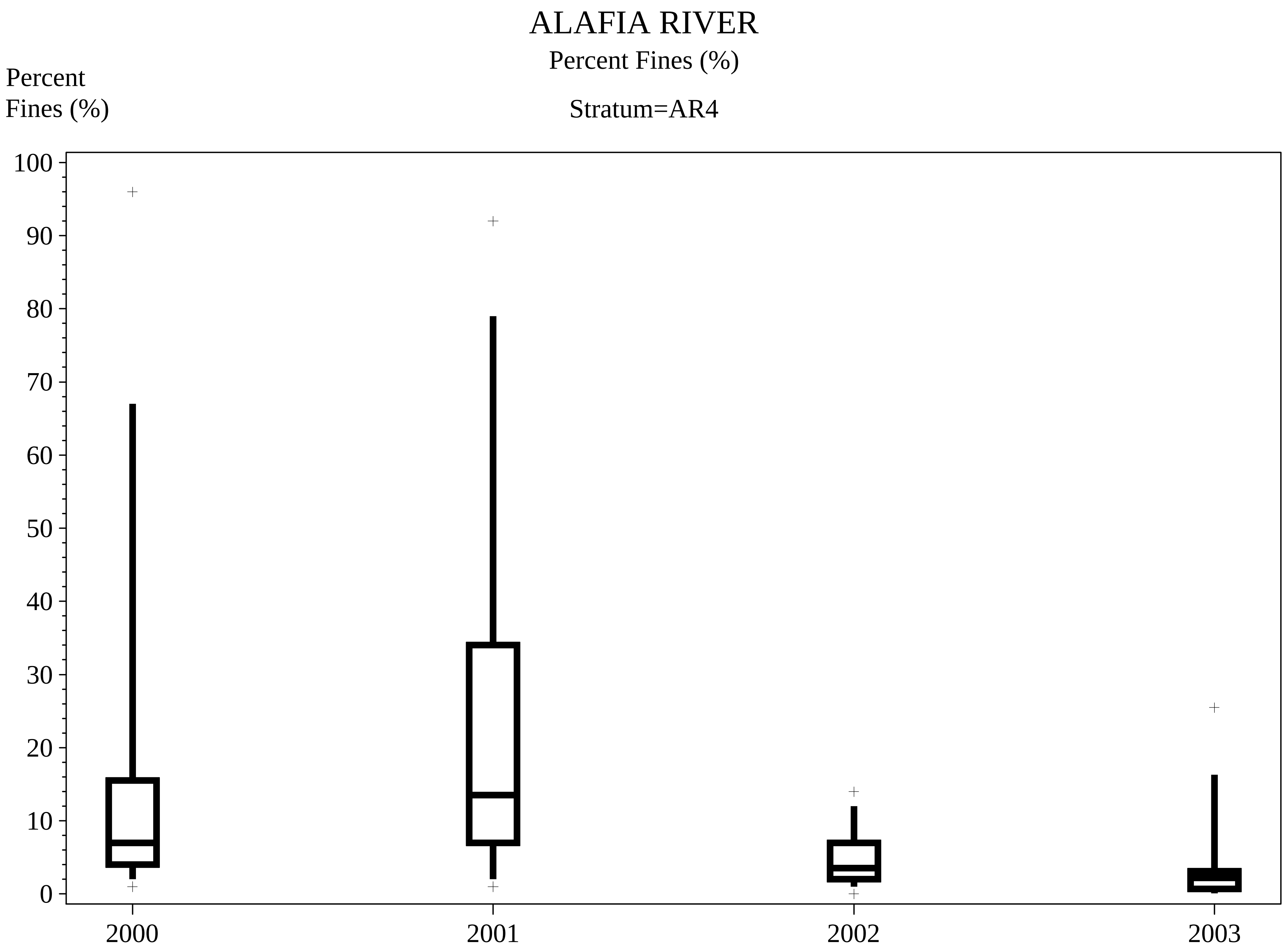
Percent Fines (%)

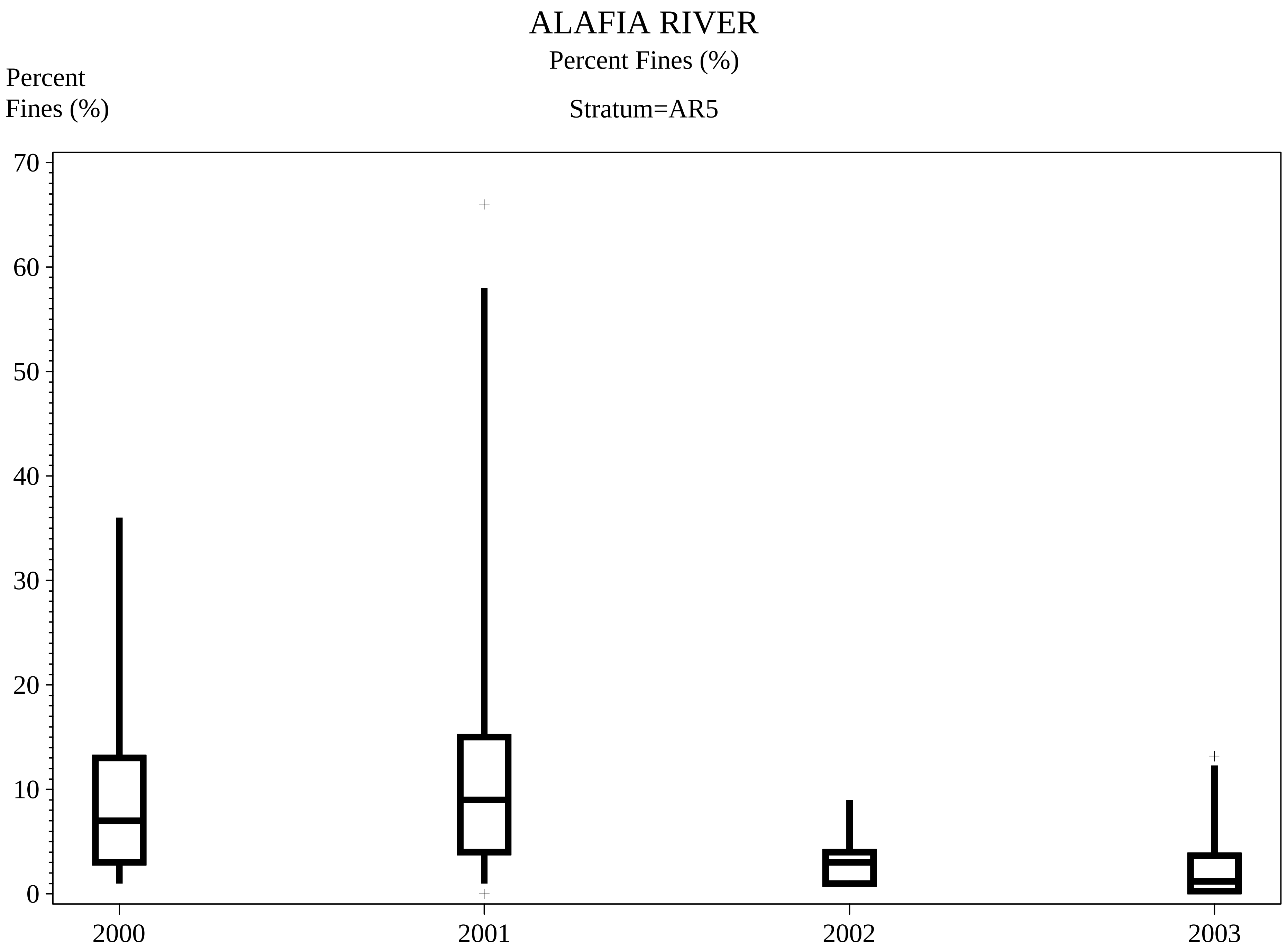
Stratum=AR1




ALAFIA RIVER
Percent Fines (%)
Stratum=AR2
Percent
Fines (%)
100
90
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003


ALAFIA RIVER
Percent Fines (%)
Stratum=AR3
Percent
Fines (%)
100
90
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003

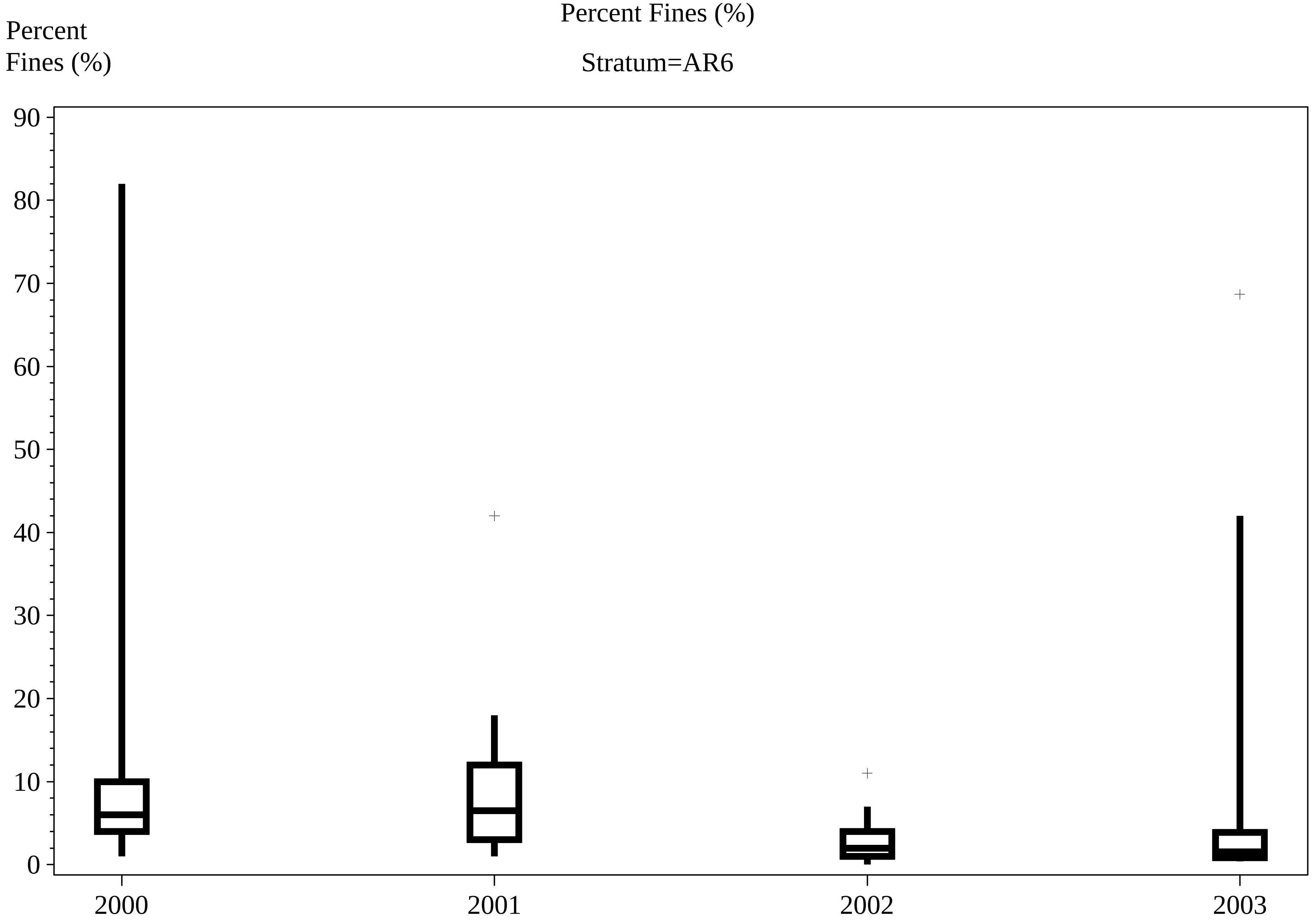

ALAFIA RIVER
Percent Fines (%)
Stratum=AR4
Percent
Fines (%)
100
90
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003


ALAFIA RIVER
Percent Fines (%)
Stratum=AR5
Percent
Fines (%)
70
60
50
40
30
20
10
0
2000
2001
2002
2003

ALAFIA RIVER

Percent Fines (%)

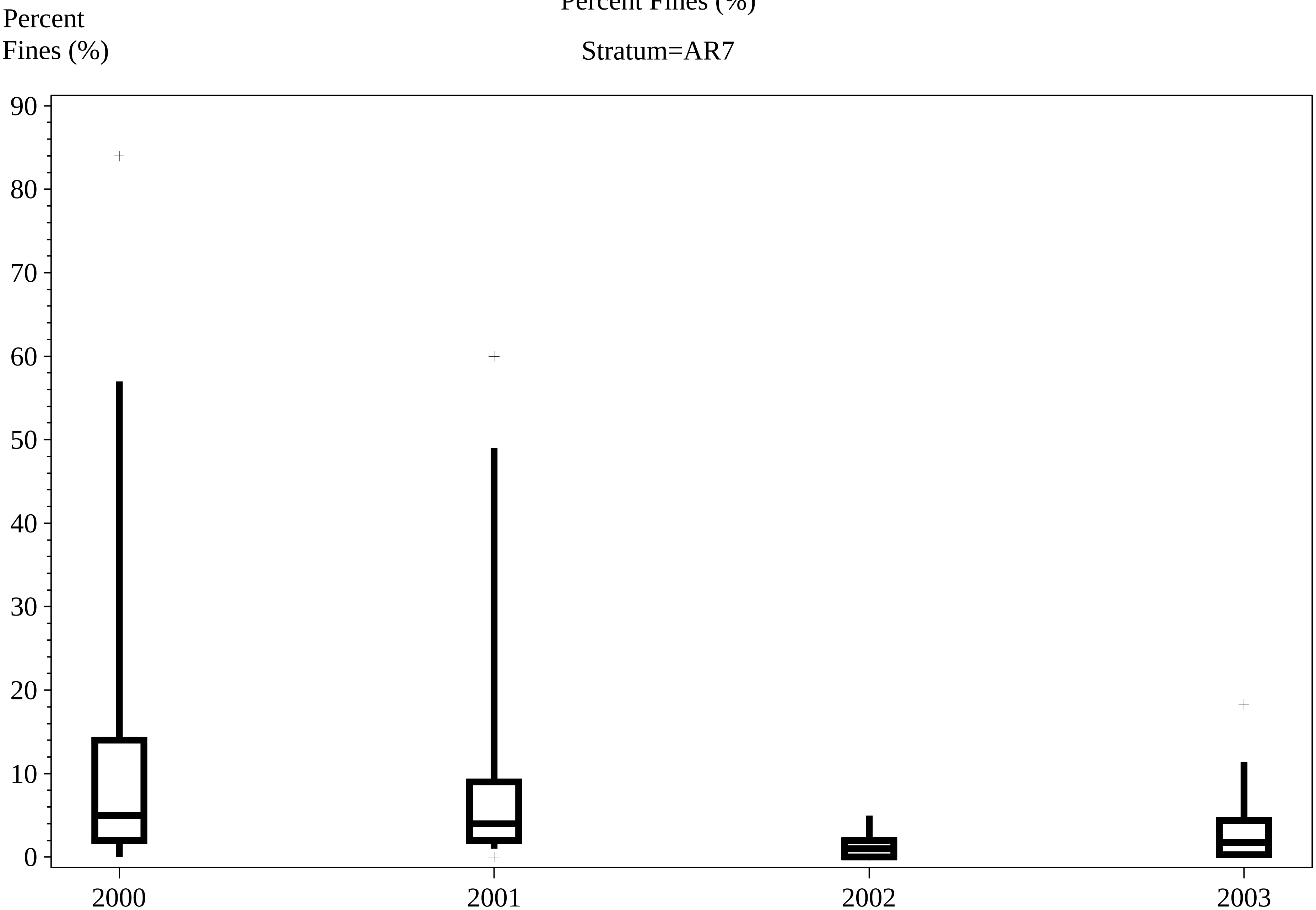
Stratum=AR6

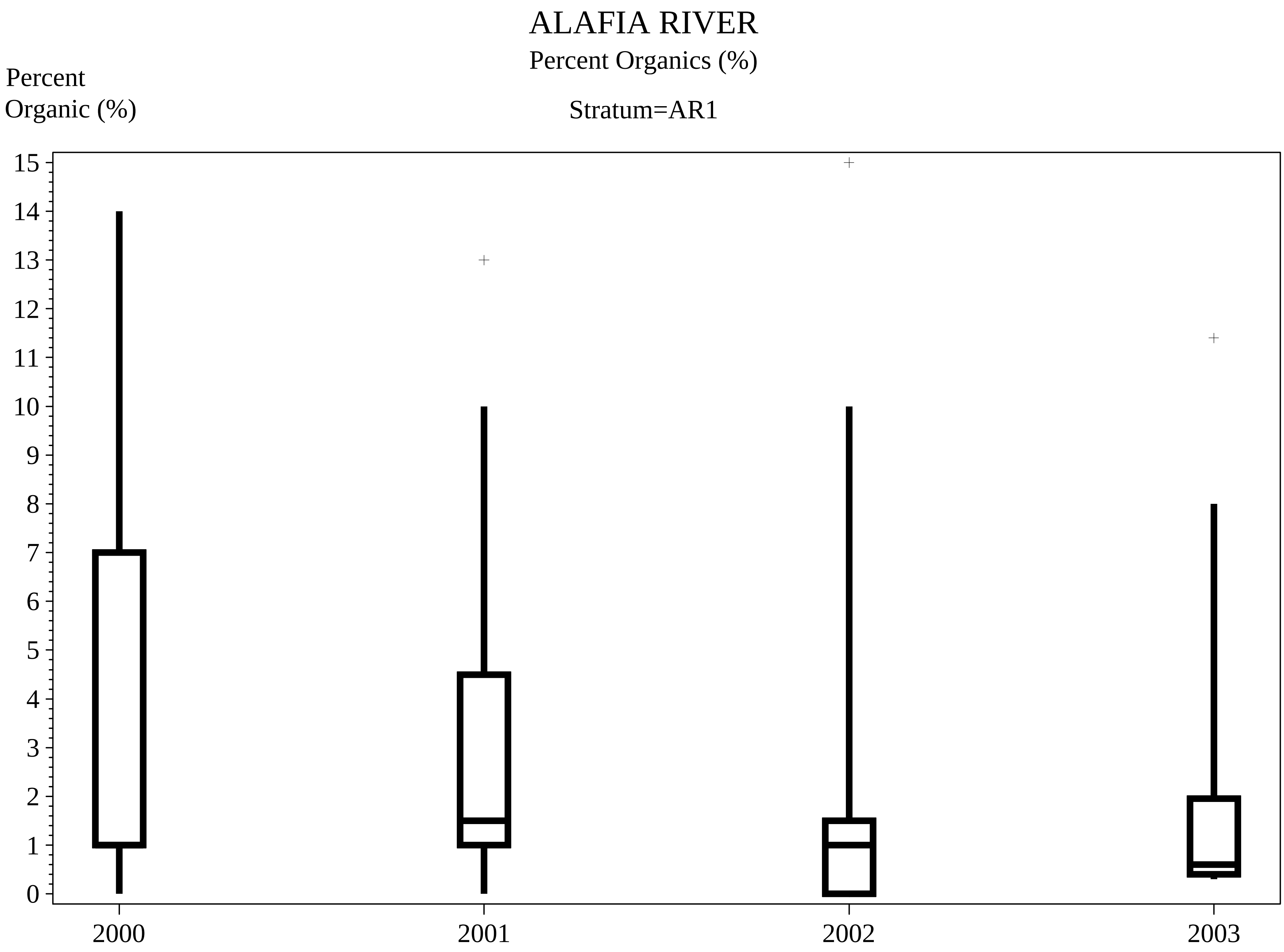


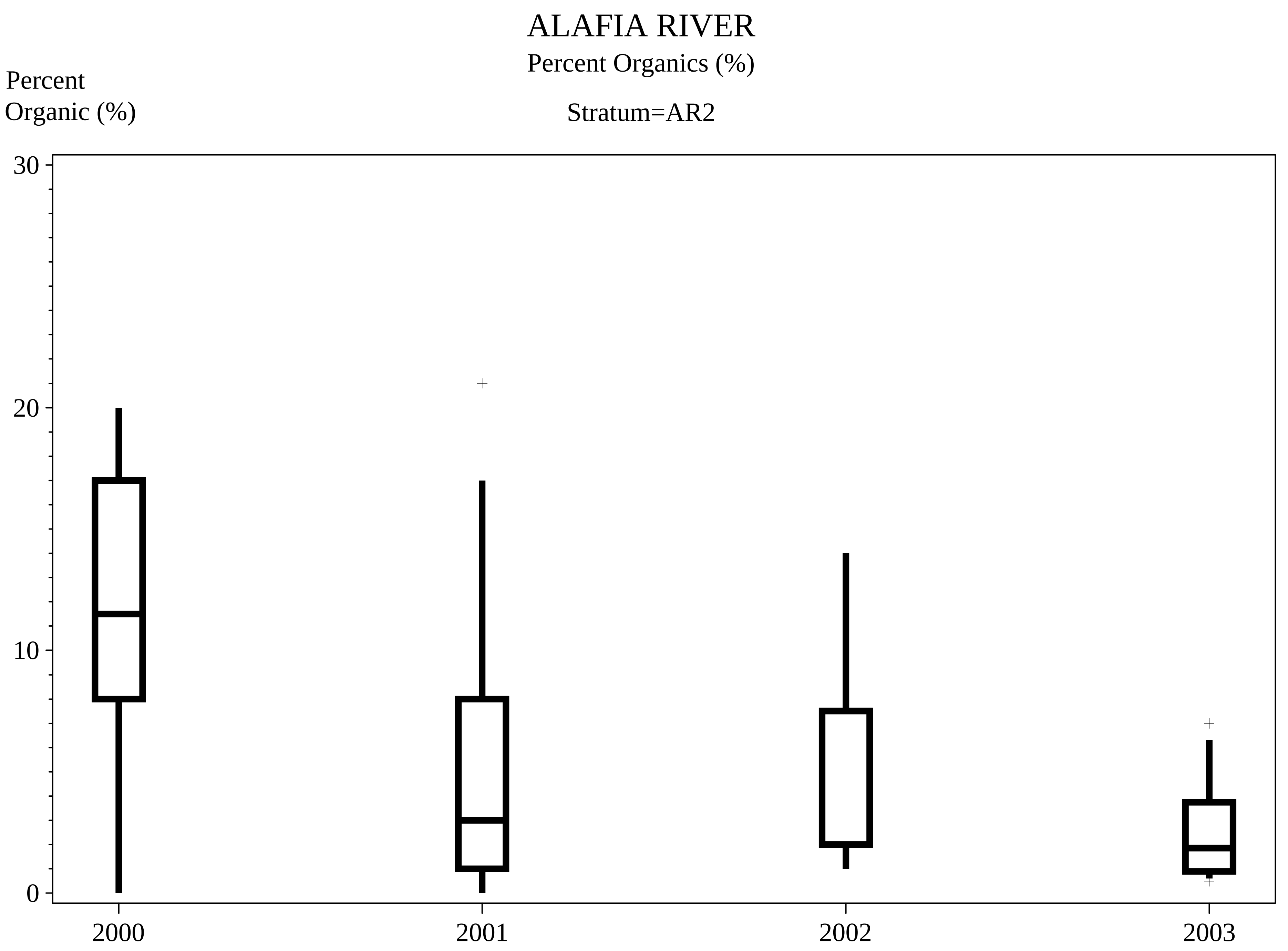
ALAFIA RIVER

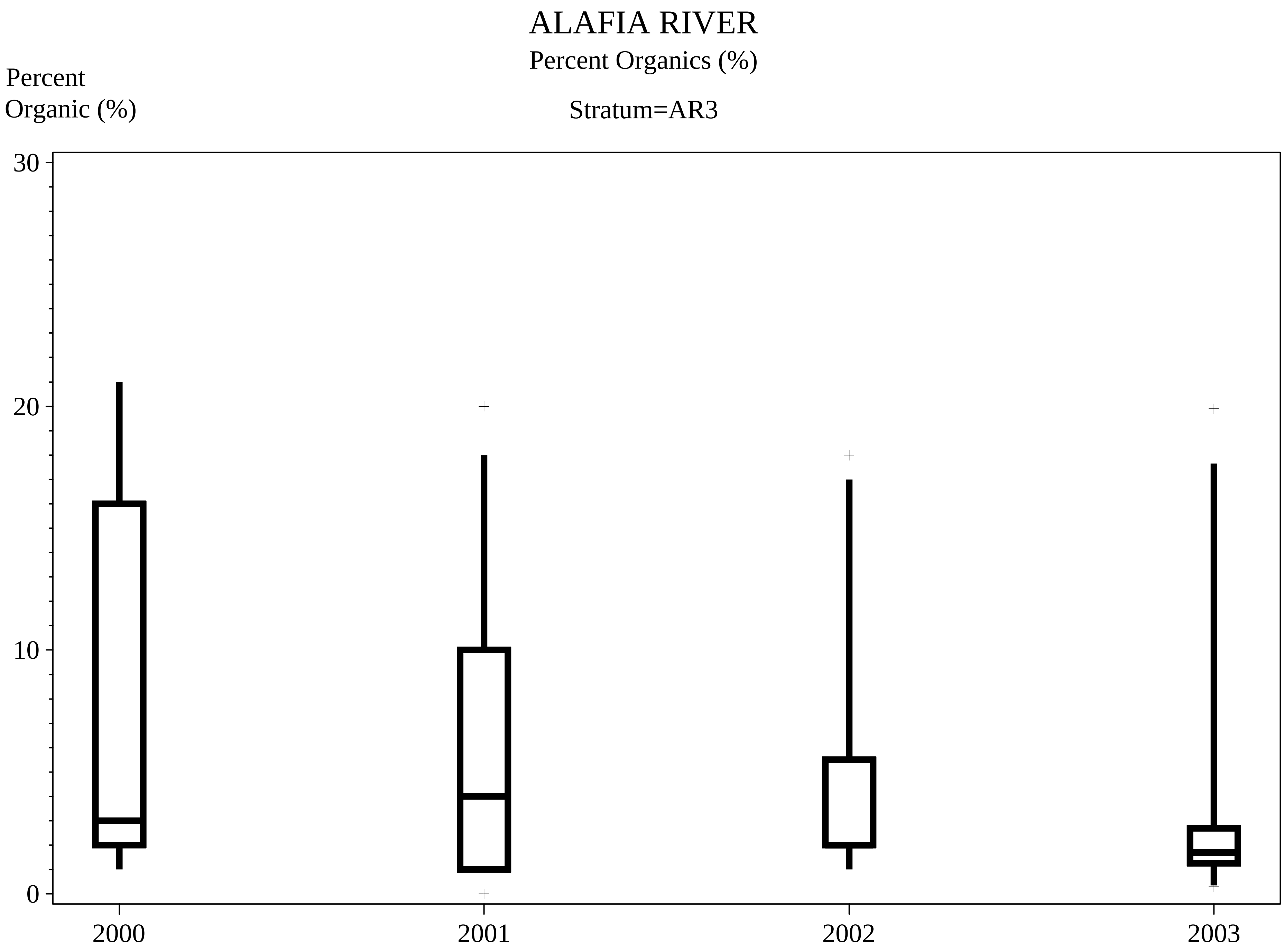
Percent Fines (%)

Stratum=AR7

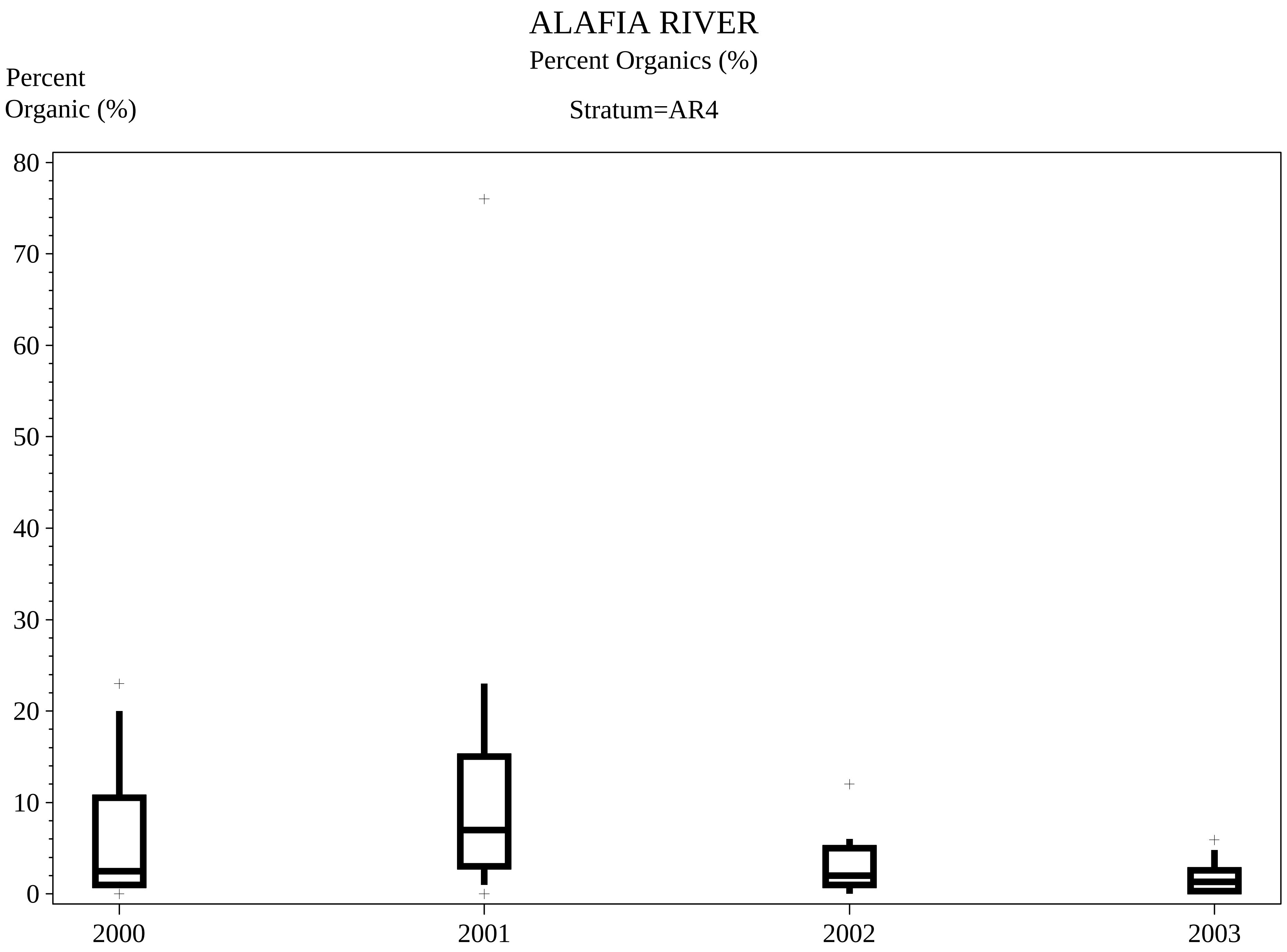



ALAFIA RIVER
Percent Organics (%)
Stratum=AR1
Percent
Organic (%)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2000
2001
2002
2003


ALAFIA RIVER
Percent Organics (%)
Stratum=AR2
Percent
Organic (%)
30
20
10
0
2000
2001
2002
2003



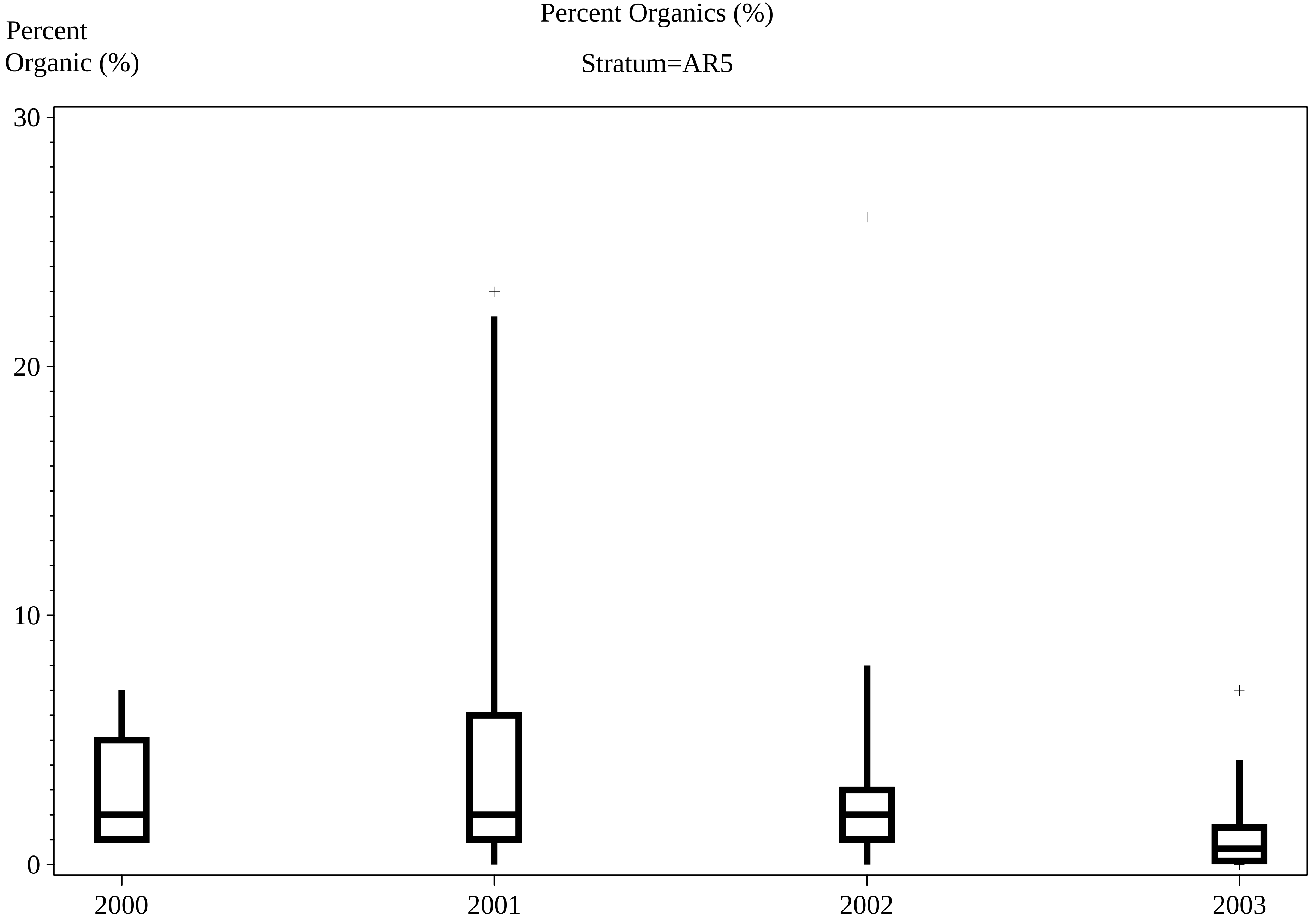
ALAFIA RIVER
Percent Organics (%)
Percent
Organic (%)
Stratum=AR3
30
20
10
0
2000
2001
2002
2003

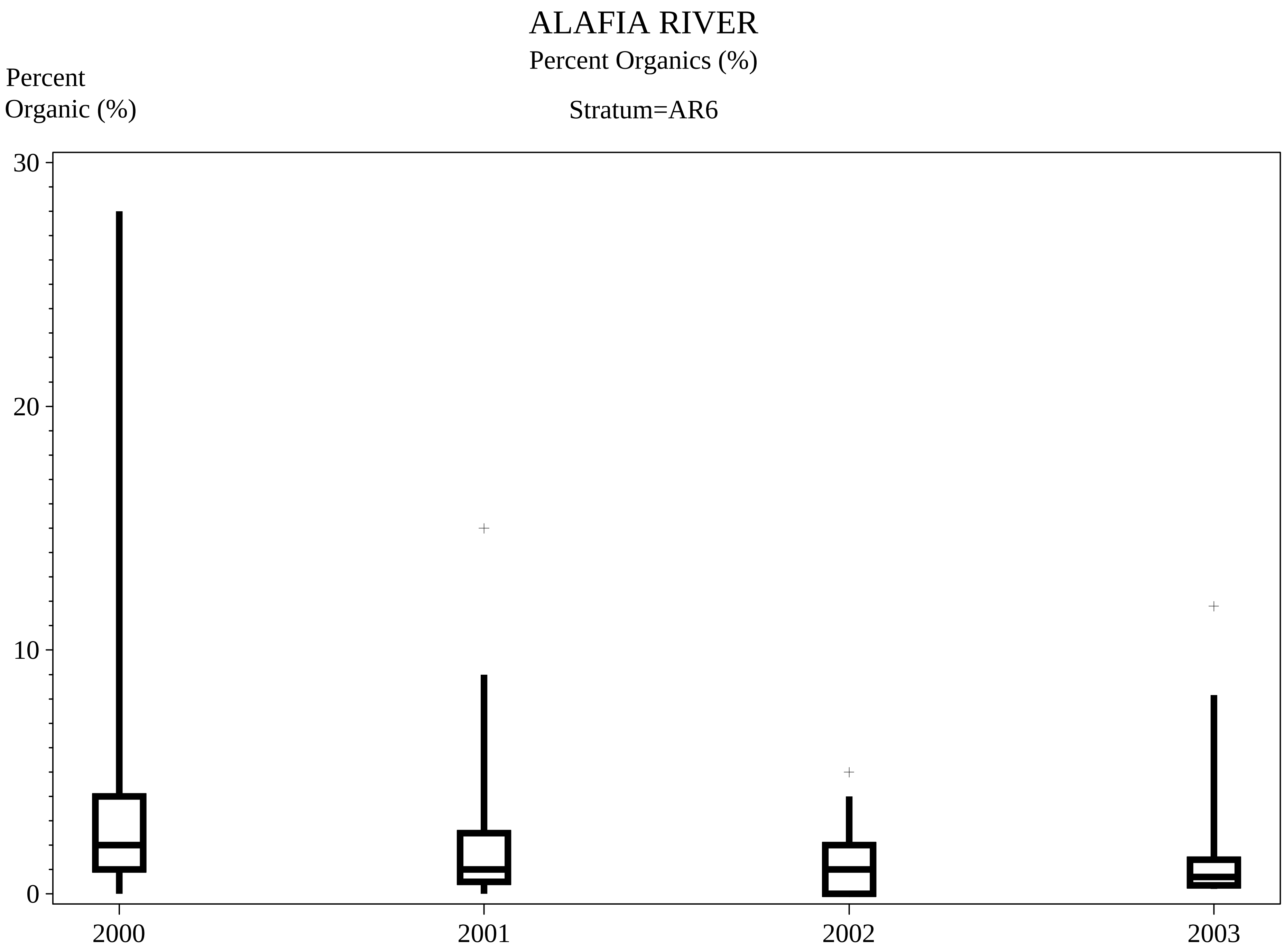

ALAFIA RIVER
Percent Organics (%)
Stratum=AR4
Percent
Organic (%)
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003

ALAFIA RIVER

Percent Organics (%)

Stratum=AR5



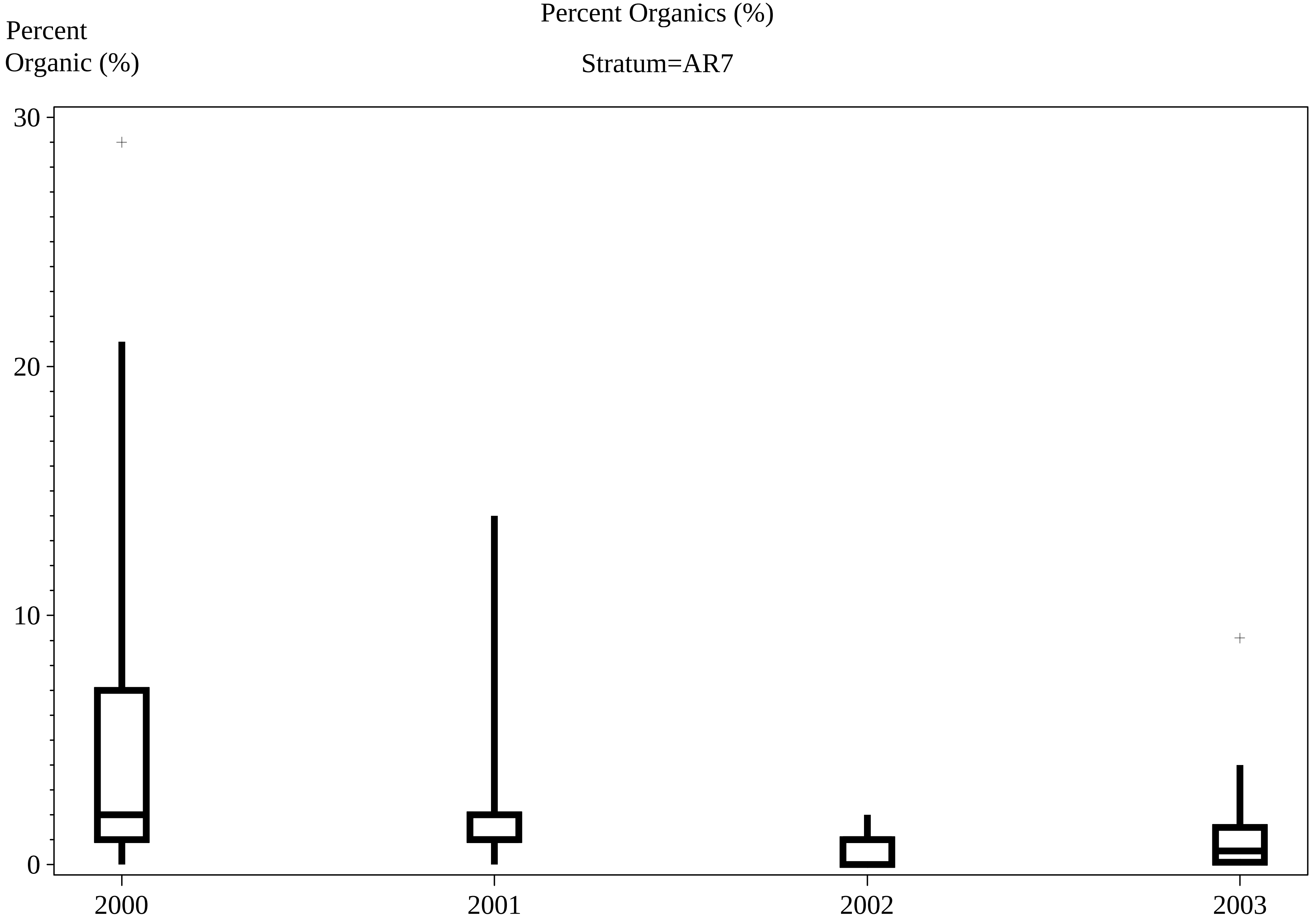


ALAFIA RIVER
Percent Organics (%)
Percent
Organic (%)
Stratum=AR6
30
20
10
0
2000
2001
2002
2003

ALAFIA RIVER

Percent Organics (%)

Stratum=AR7

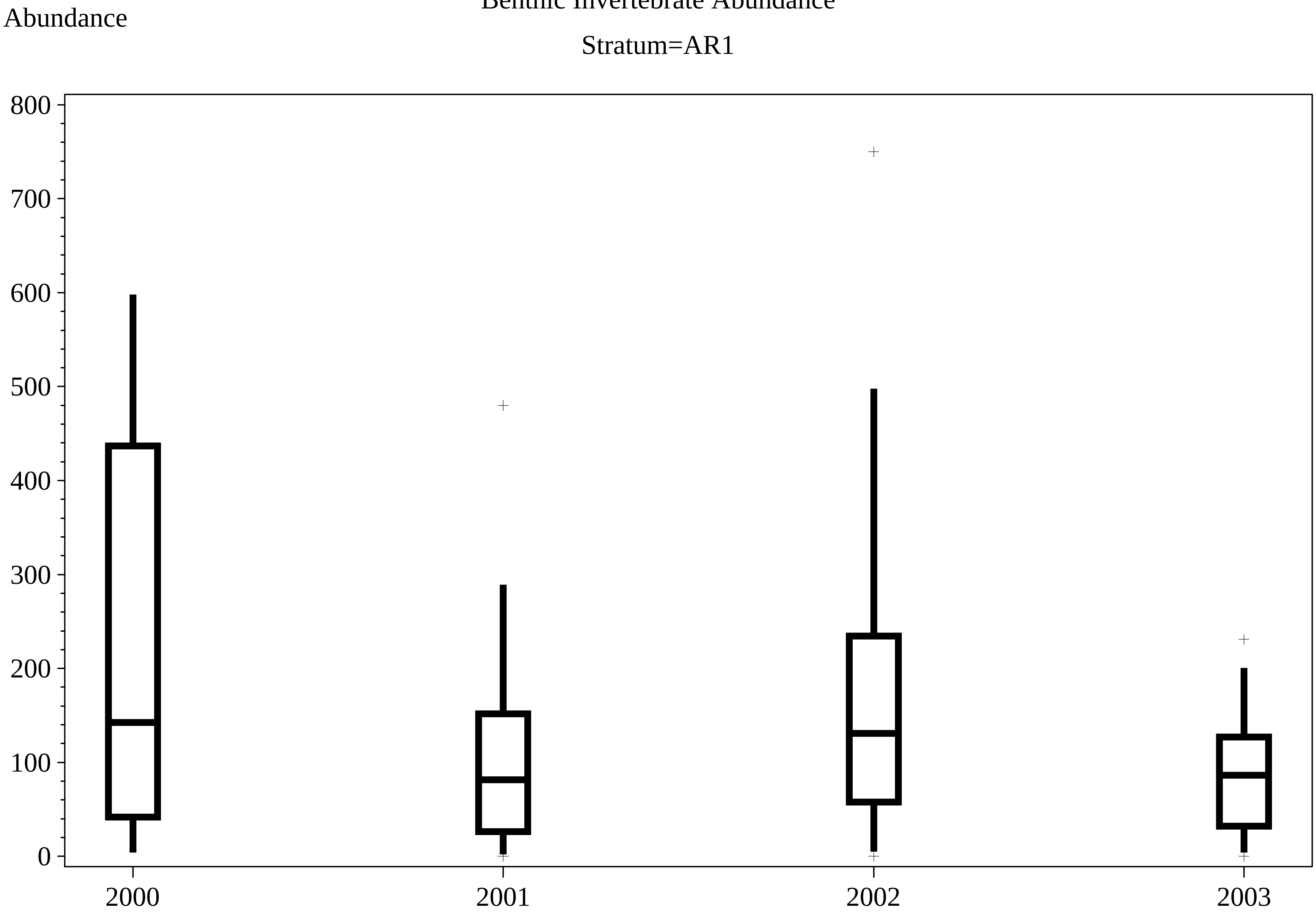


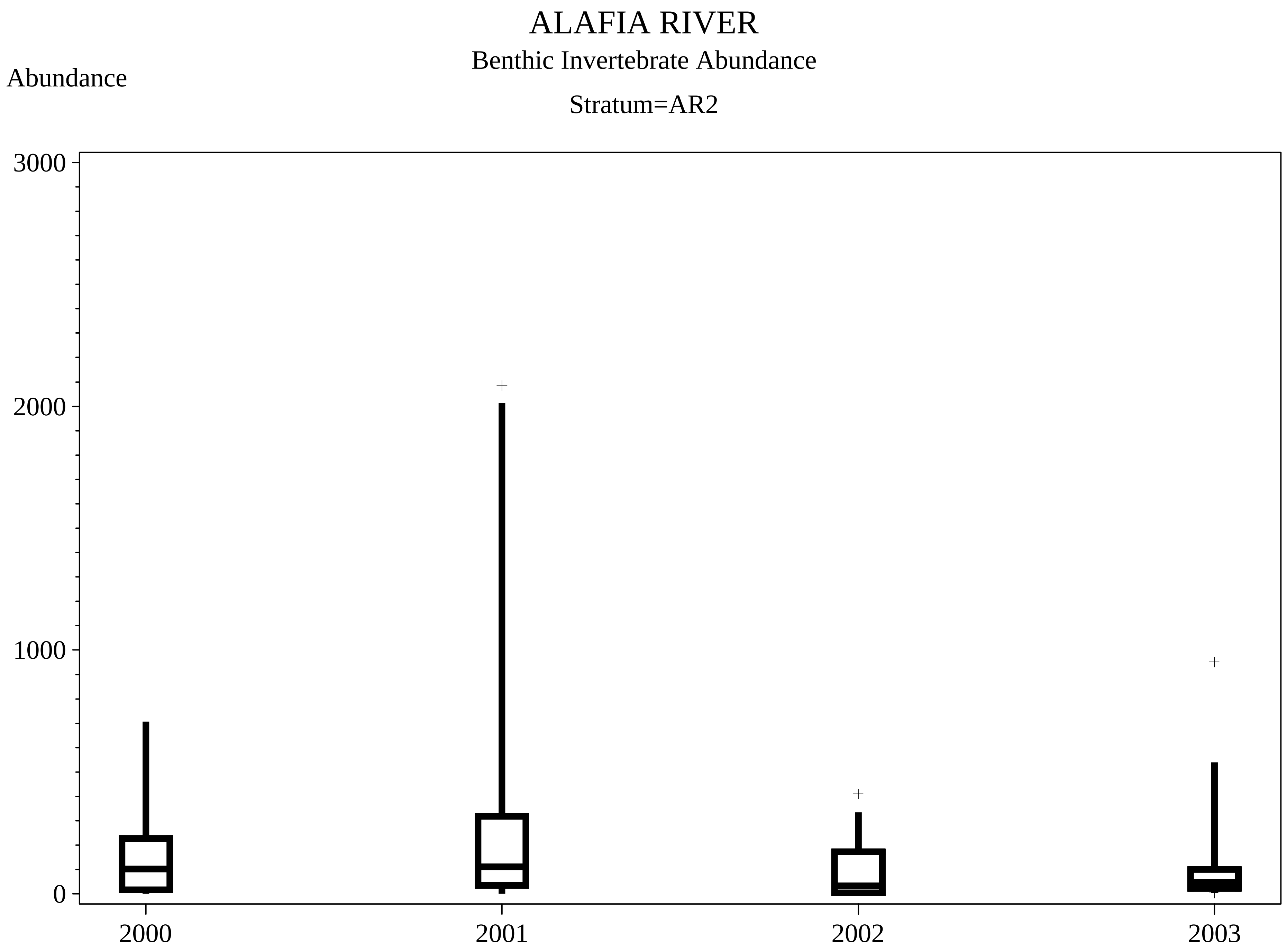
APPENDIX C:
BENTHIC BOXPLOTS

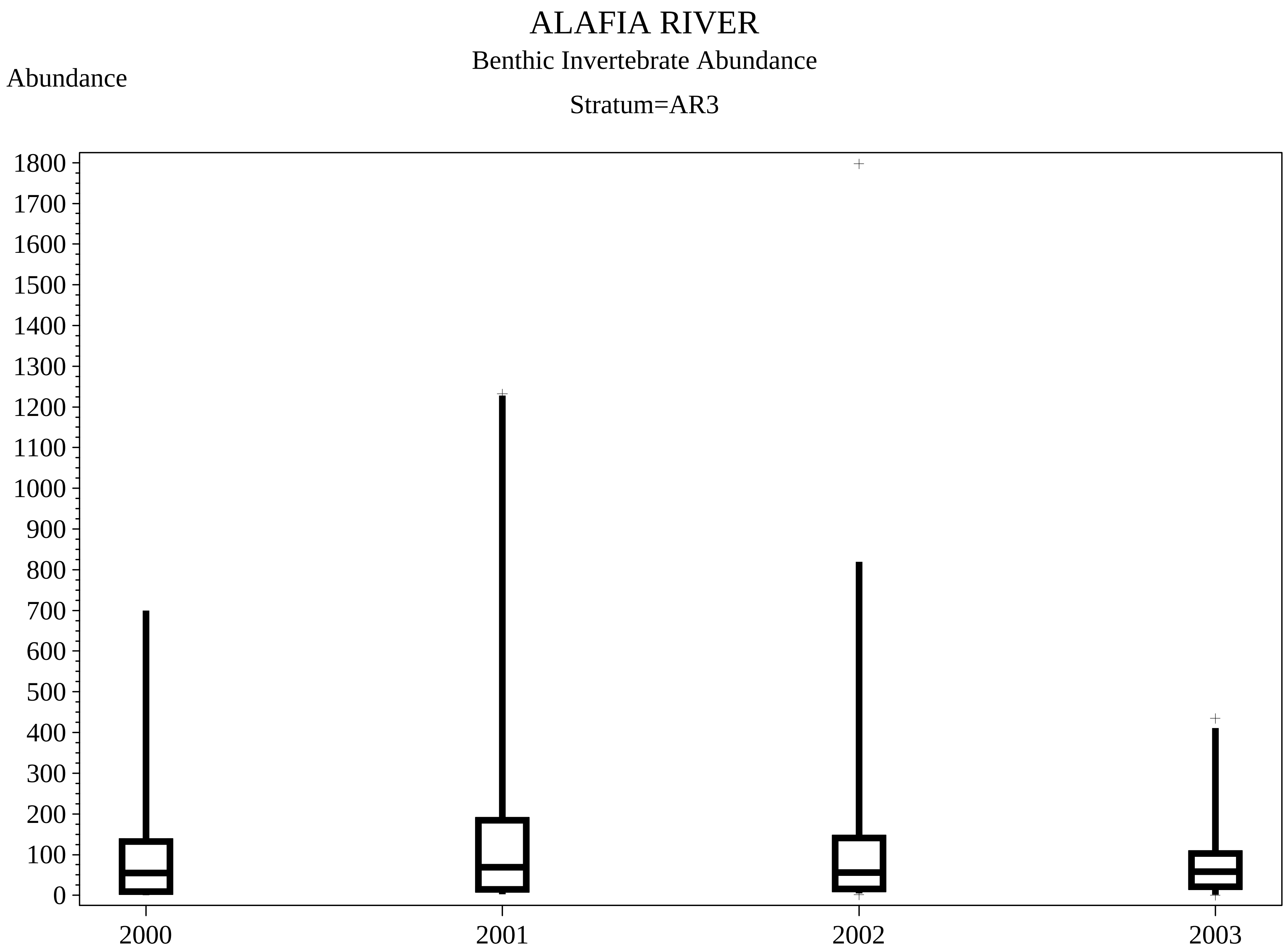
ALAFIA RIVER

Benthic Invertebrate Abundance

Stratum=AR1



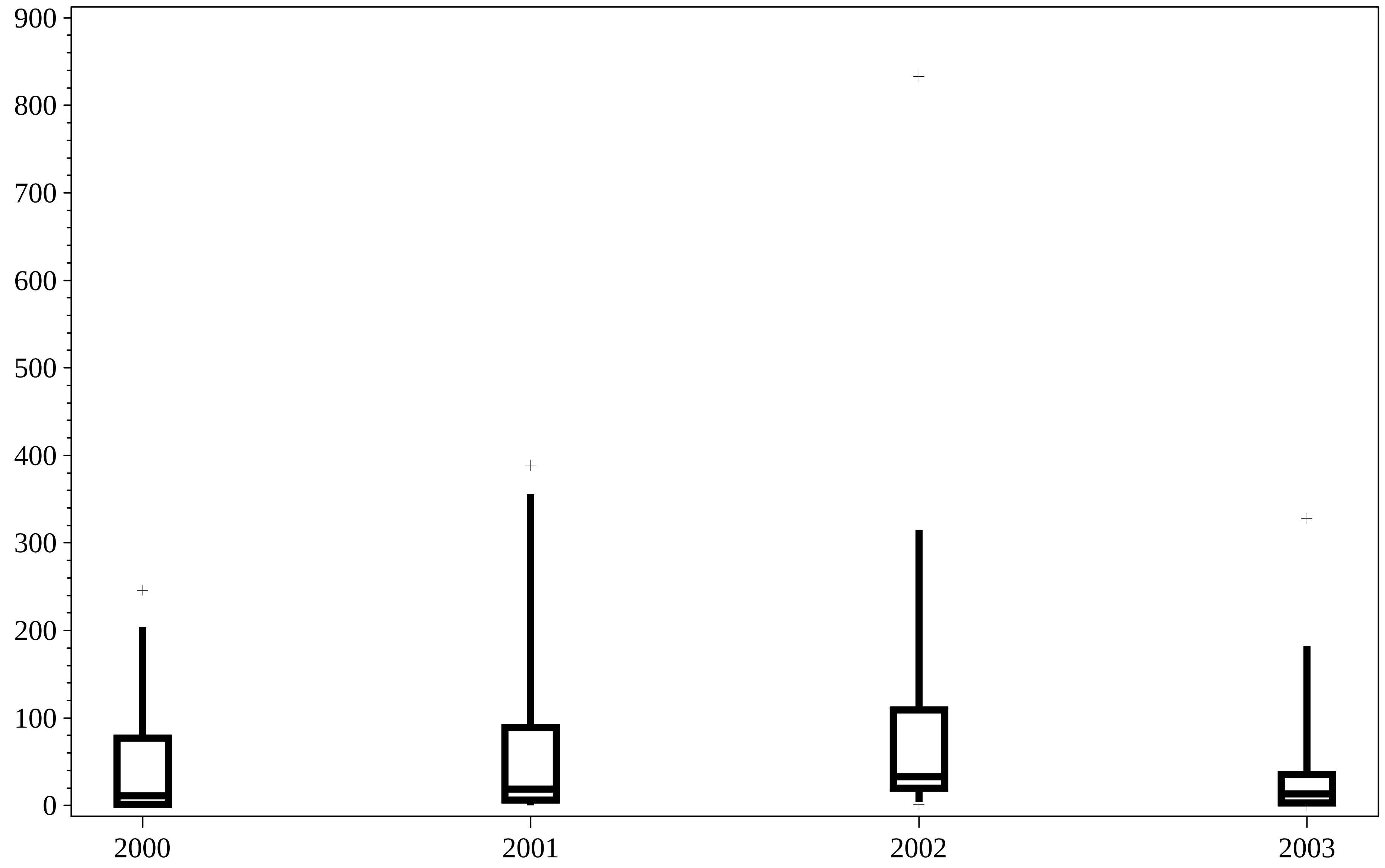

ALAFIA RIVER
Benthic Invertebrate Abundance
Stratum=AR2
Abundance
3000
2000
1000
0
2000
2001
2002
2003

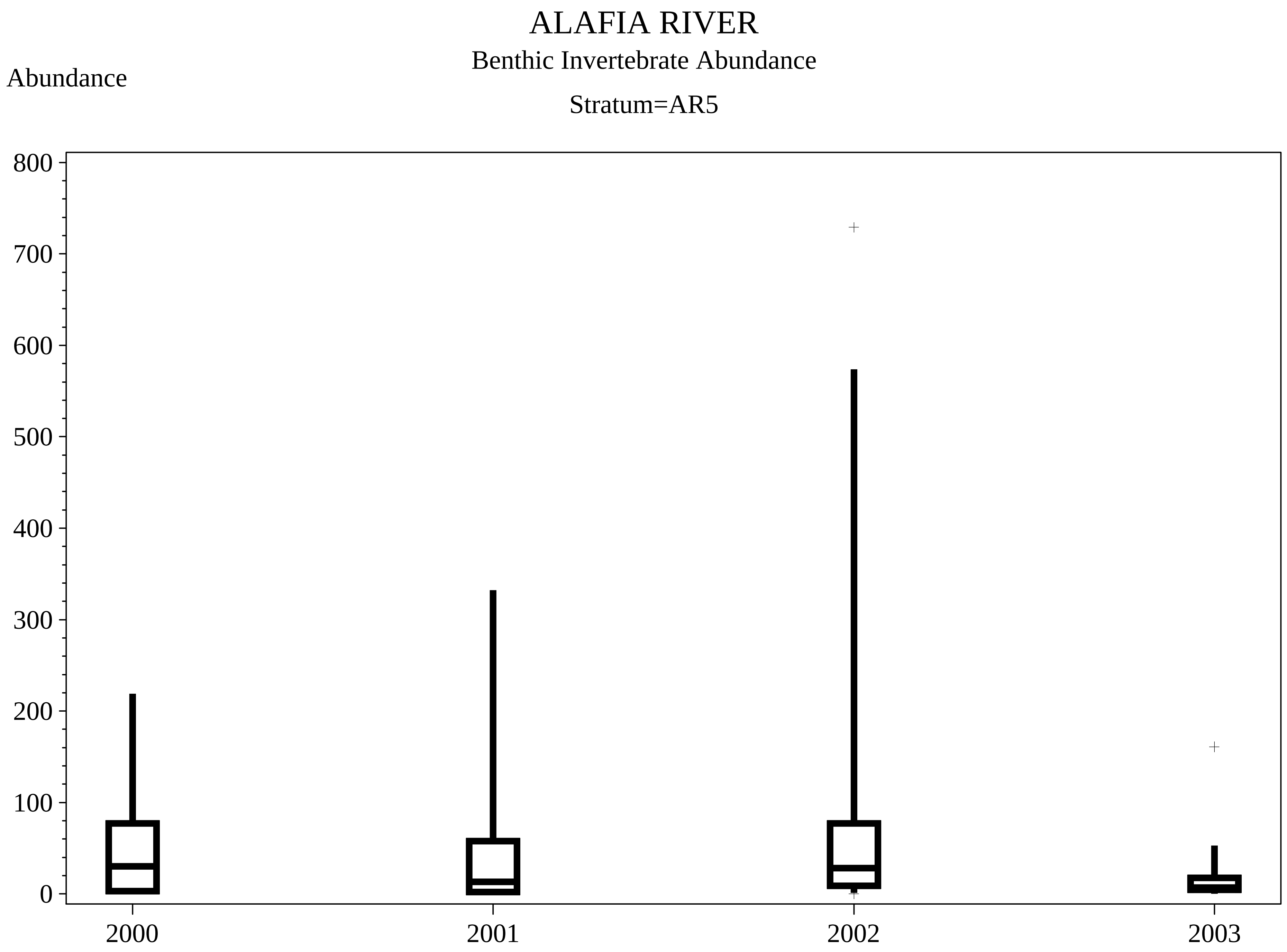

ALAFIA RIVER
Benthic Invertebrate Abundance
Stratum=AR3
Abundance
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2000
2001
2002
2003

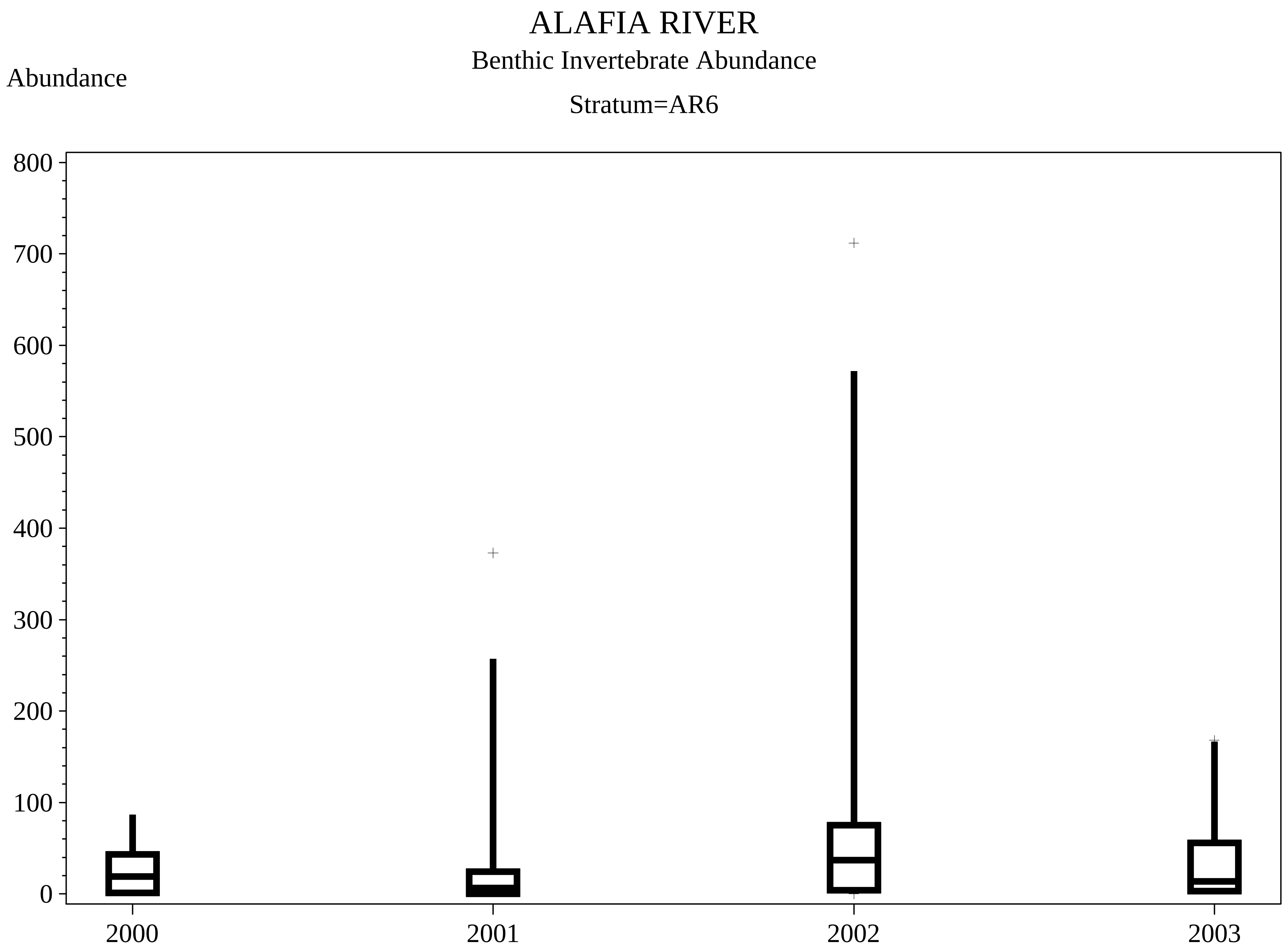
ALAFIA RIVER

Benthic Invertebrate Abundance

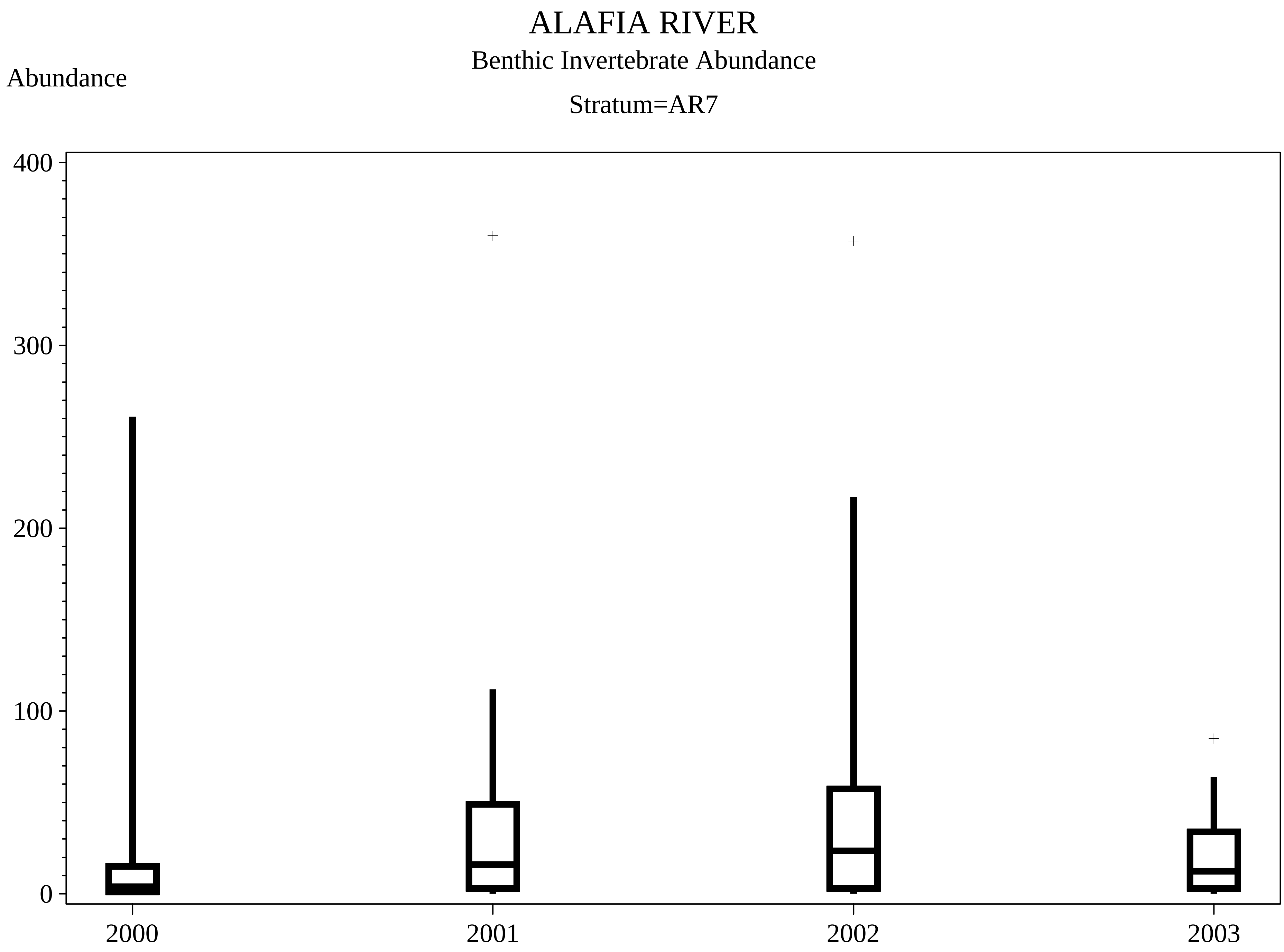
Stratum=AR4

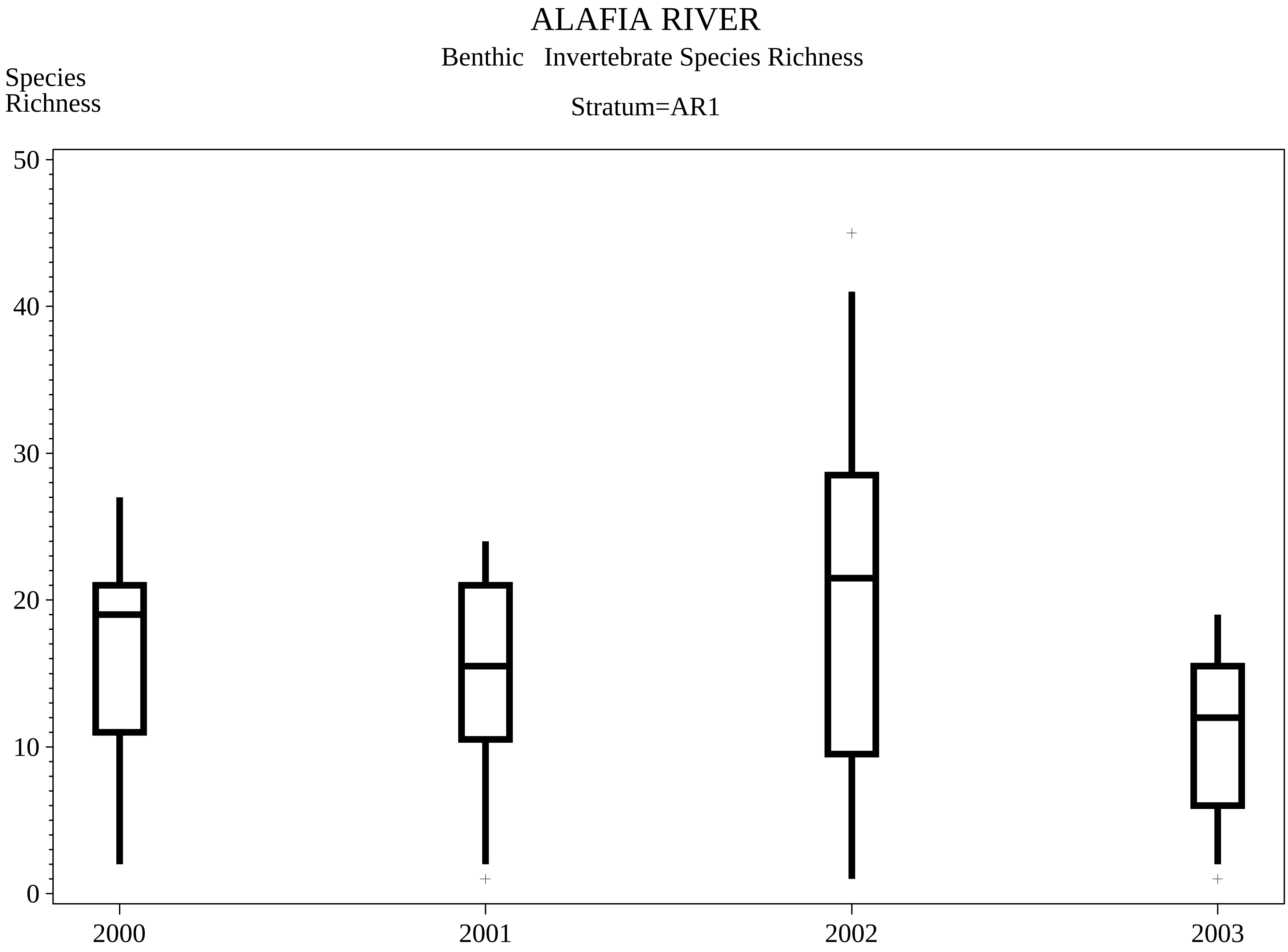



ALAFIA RIVER
Benthic Invertebrate Abundance
Stratum=AR5
Abundance
800
700
600
500
400
300
200
100
0
2000
2001
2002
2003



ALAFIA RIVER
Benthic Invertebrate Abundance
Abundance
Stratum=AR6
800
700
600
500
400
300
200
100
0
2000
2001
2002
2003

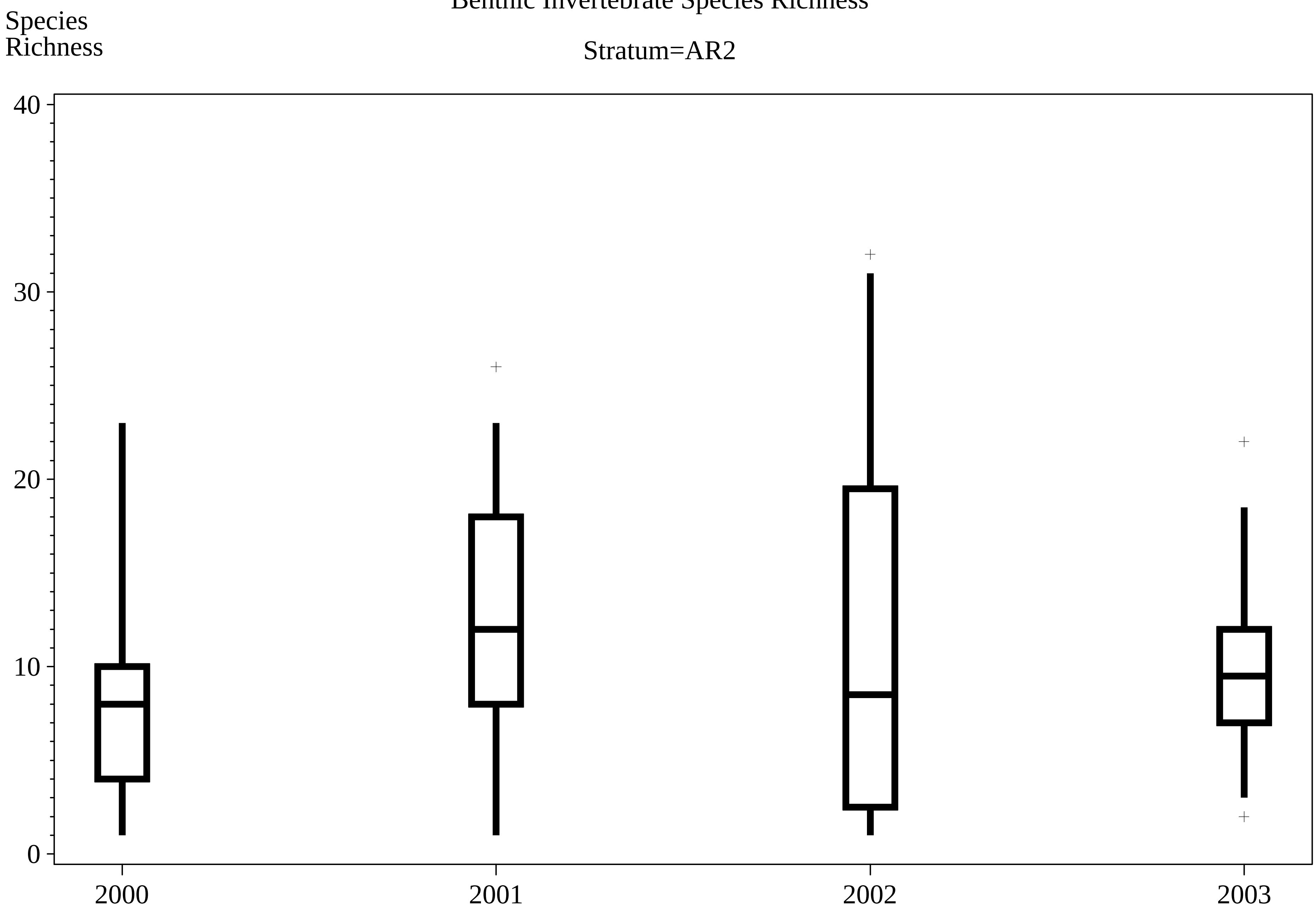

ALAFIA RIVER
Benthic Invertebrate Abundance
Stratum=AR7
Abundance
400
300
200
100
0
2000
2001
2002
2003


ALAFIA RIVER
Benthic Invertebrate Species Richness
Stratum=AR1
Species
Richness
50
40
30
20
10
0
2000
2001
2002
2003

ALAFIA RIVER

Benthic Invertebrate Species Richness

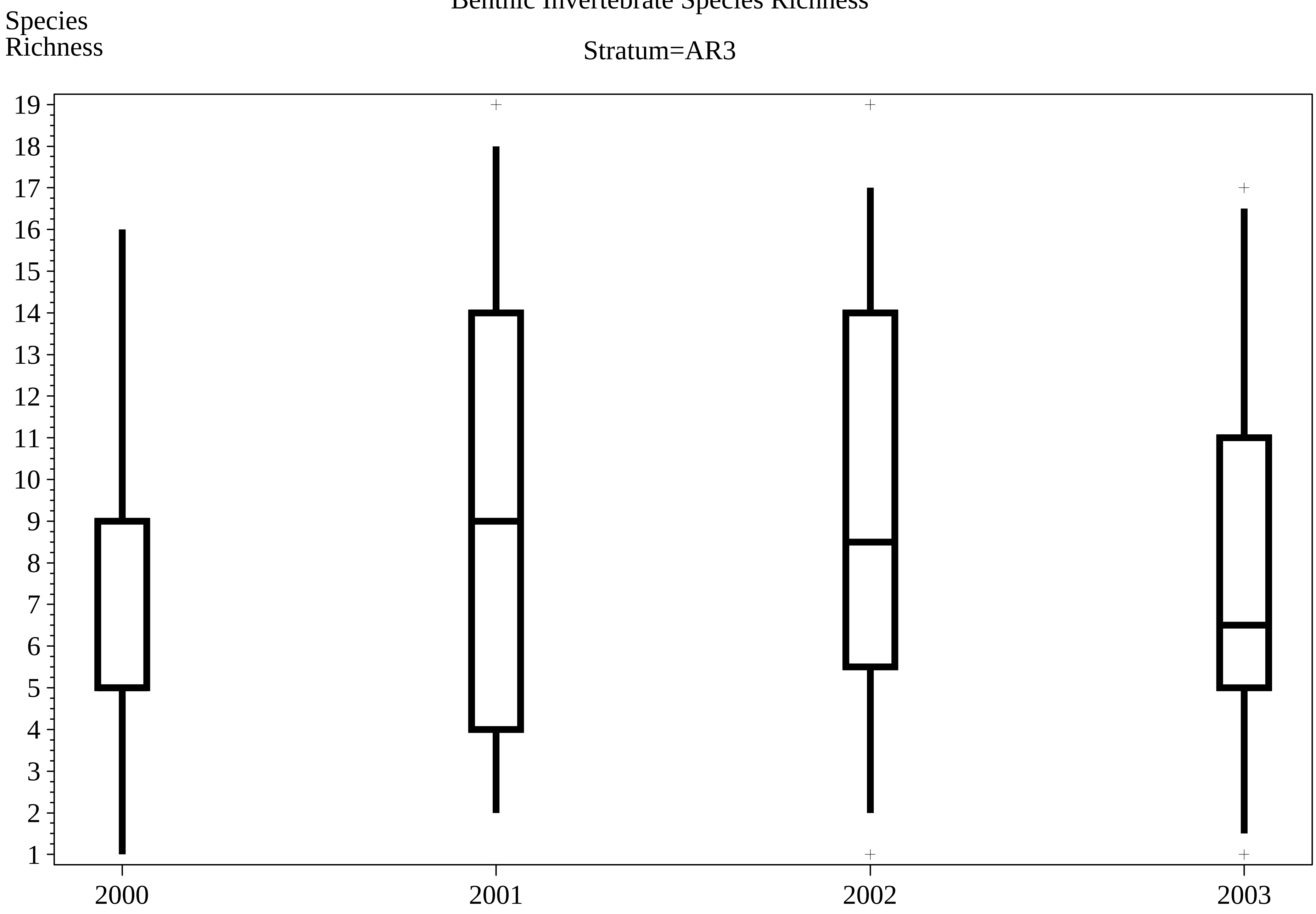
Stratum=AR2

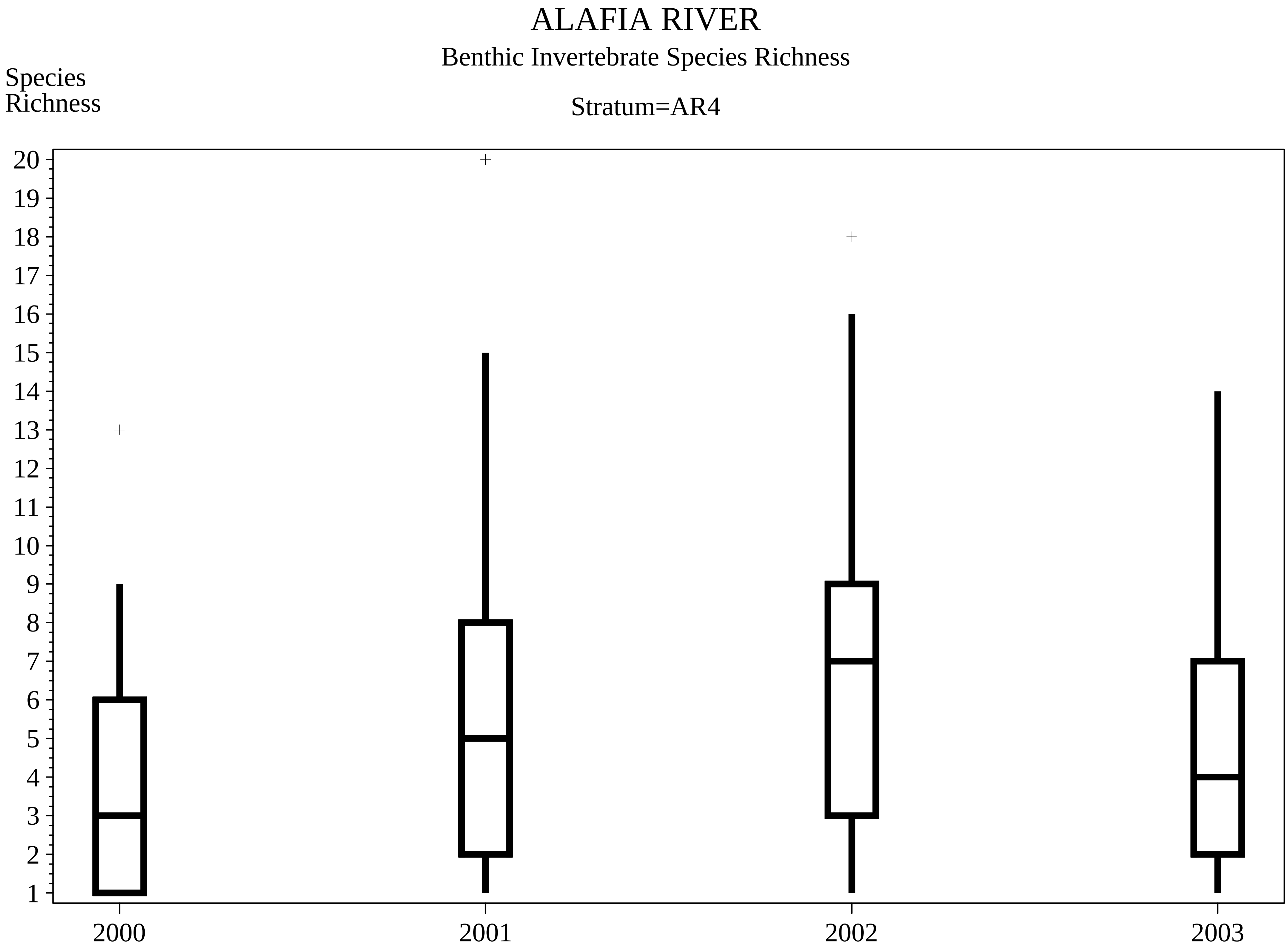


ALAFIA RIVER

Benthic Invertebrate Species Richness

Stratum=AR3

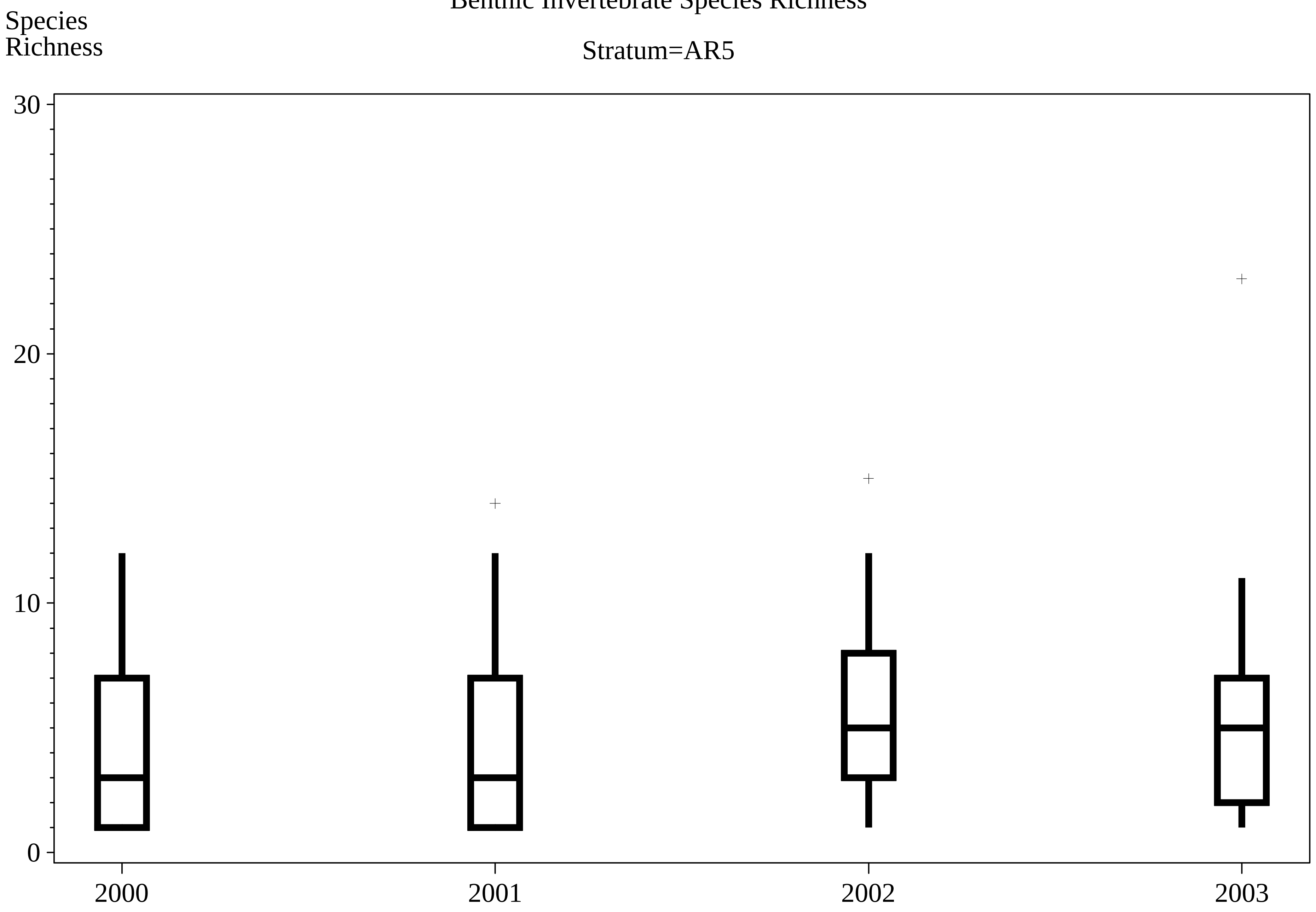


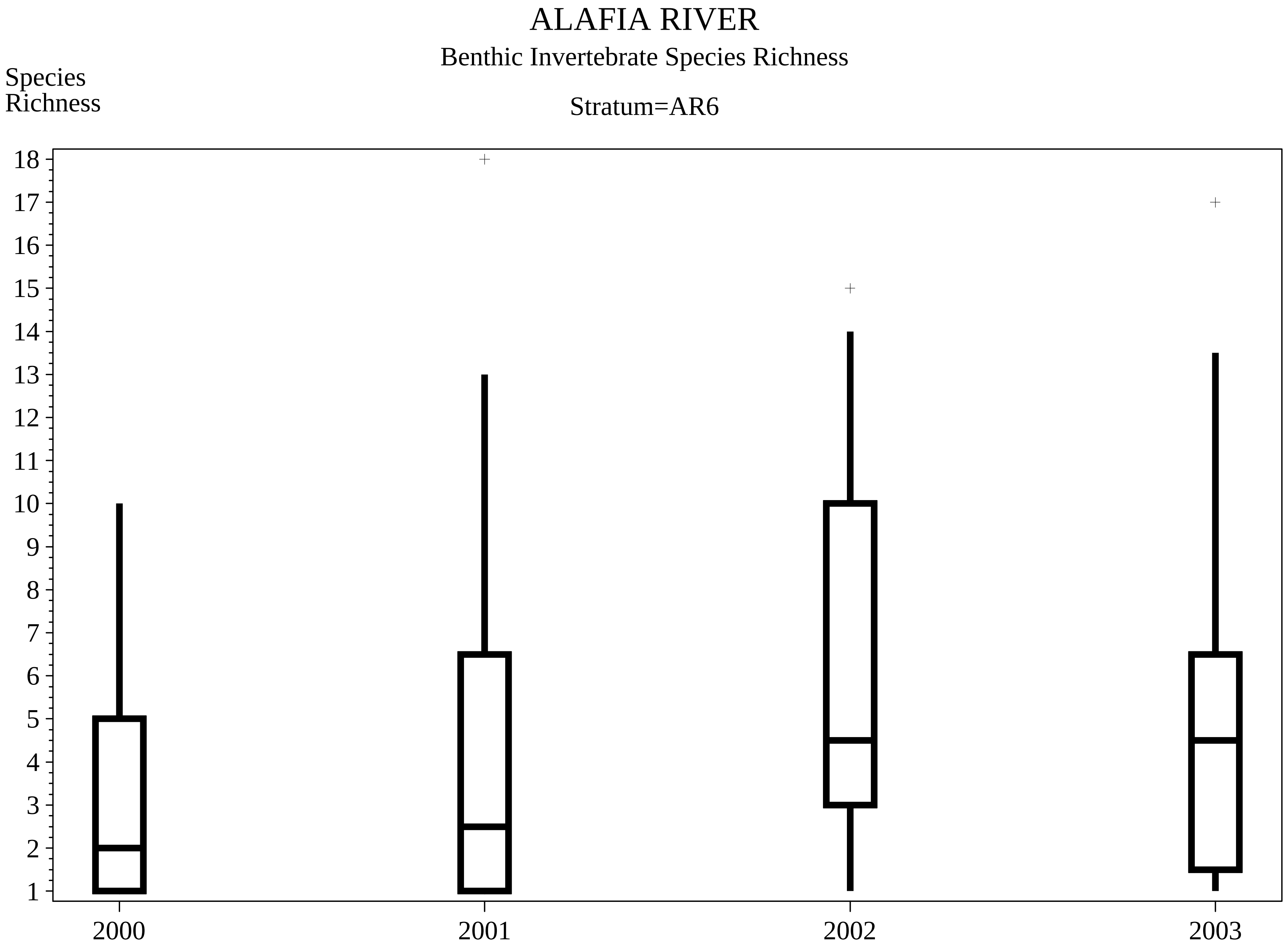

ALAFIA RIVER
Benthic Invertebrate Species Richness
Stratum=AR4
Species
Richness
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
2000
2001
2002
2003

ALAFIA RIVER

Benthic Invertebrate Species Richness

Stratum=AR5



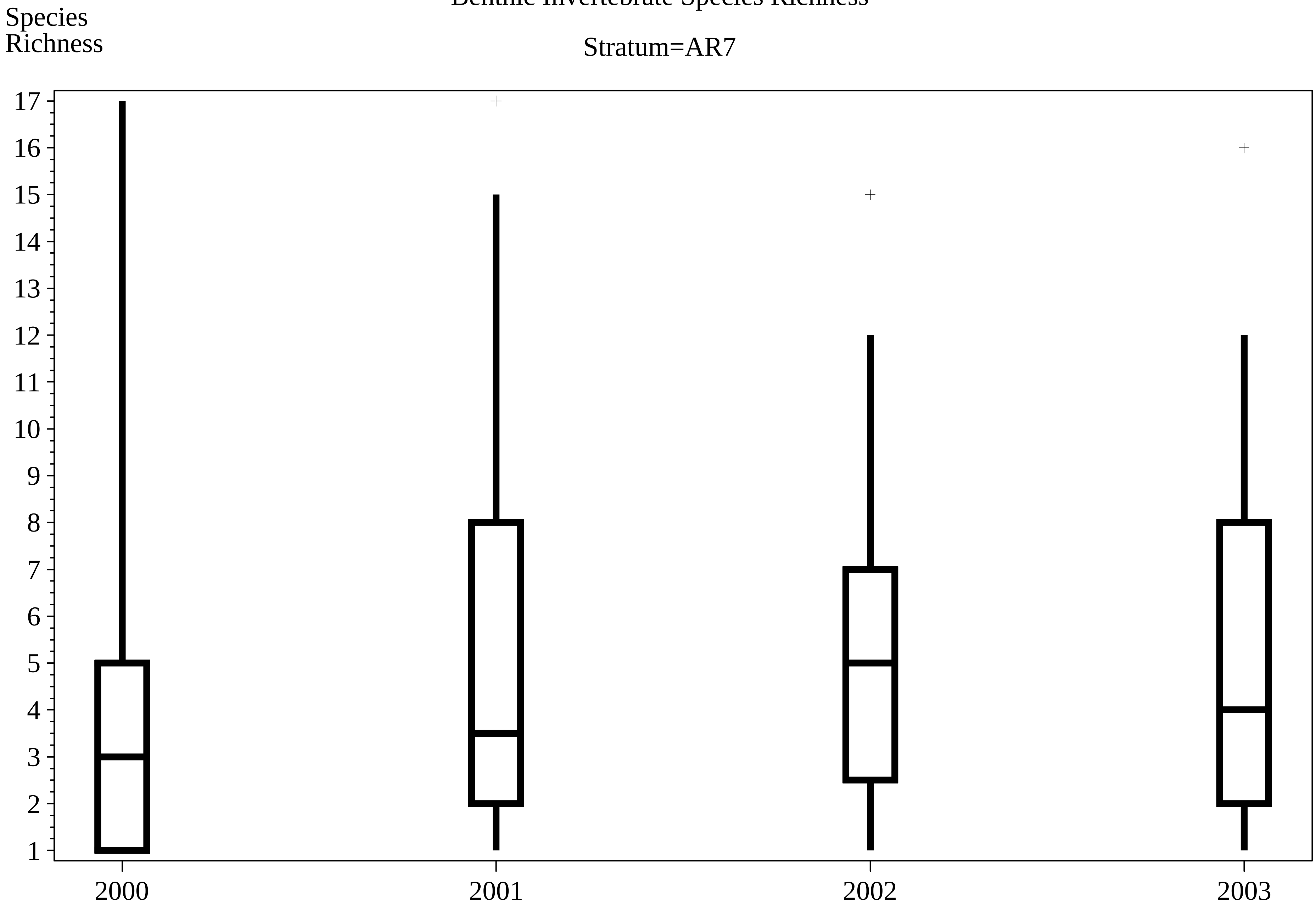


ALAFIA RIVER
Benthic Invertebrate Species Richness
Stratum=AR6
Species Richness
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
2000
2001
2002
2003

ALAFIA RIVER

Benthic Invertebrate Species Richness

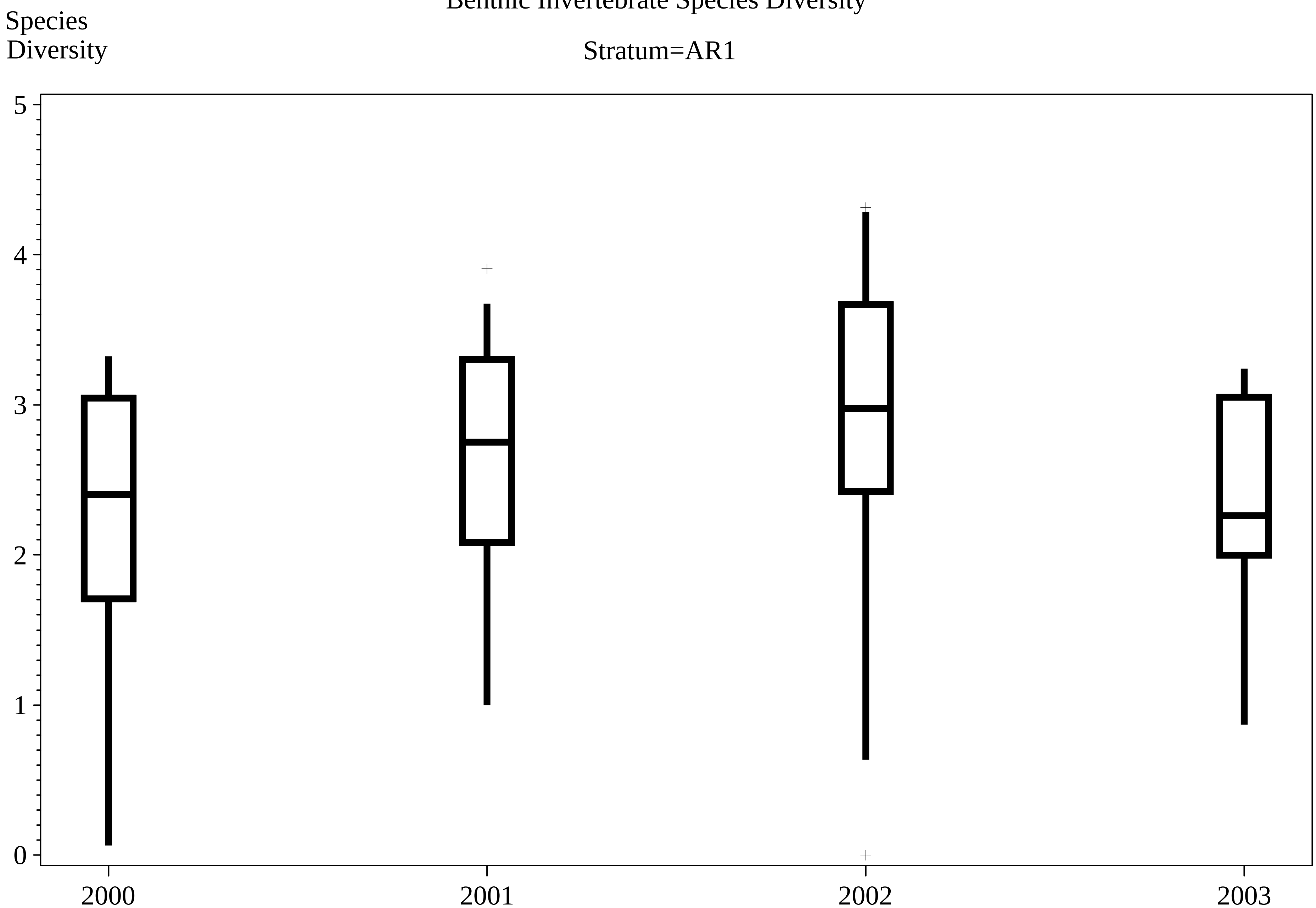
Stratum=AR7

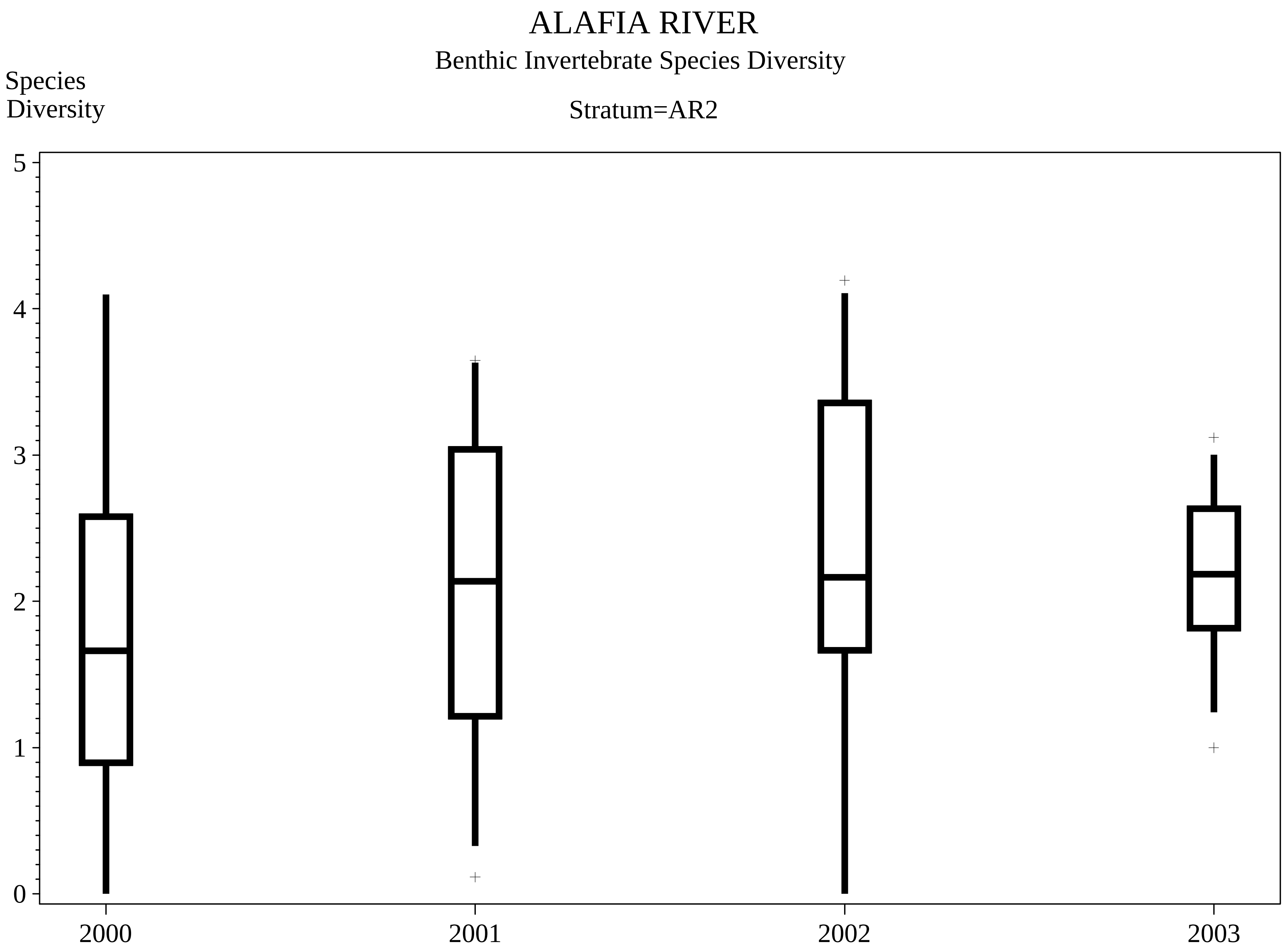


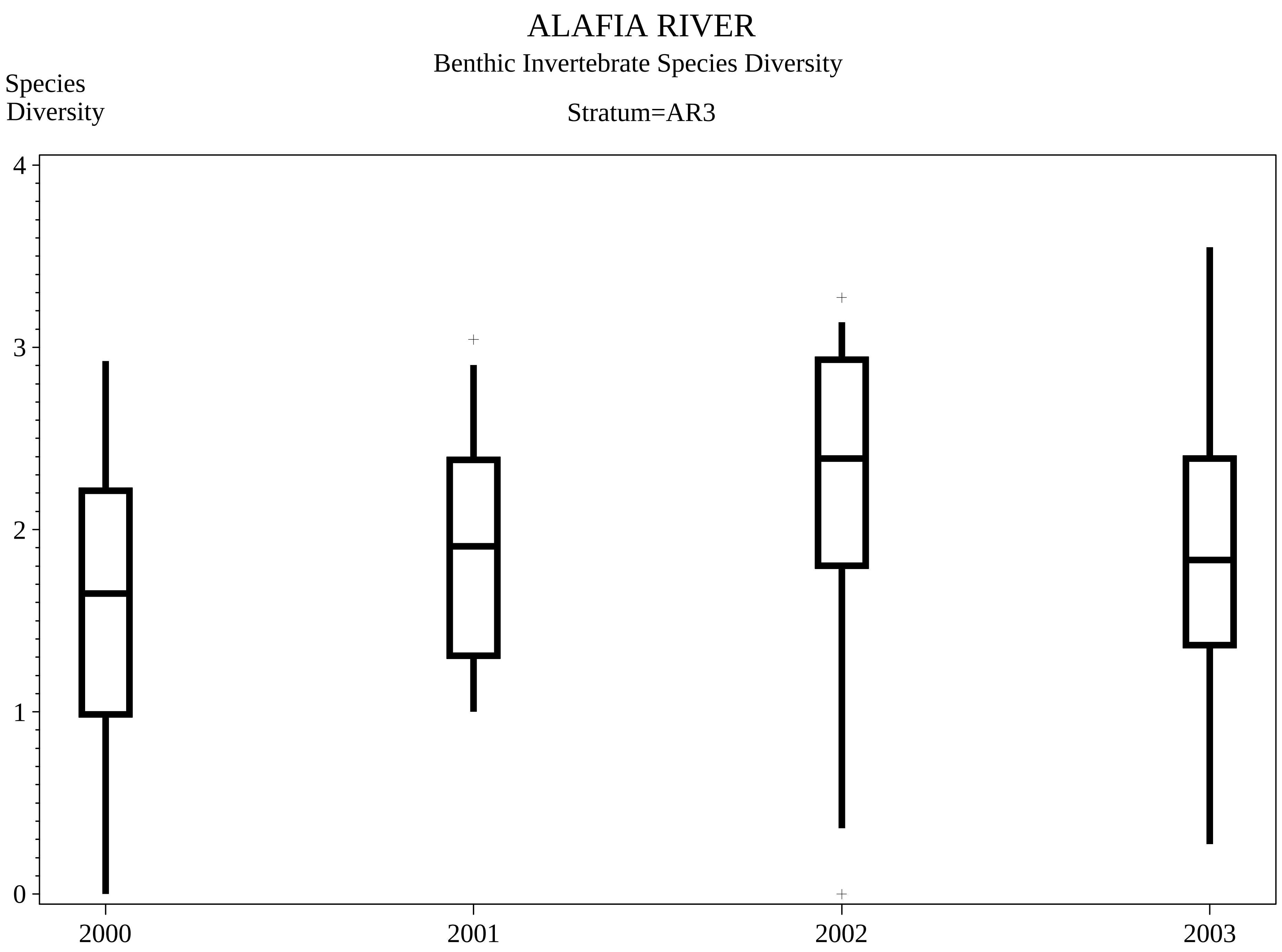
ALAFIA RIVER

Benthic Invertebrate Species Diversity

Stratum=AR1




ALAFIA RIVER
Benthic Invertebrate Species Diversity
Species
Diversity
Stratum=AR2
5
4
3
2
1
0
2000
2001
2002
2003

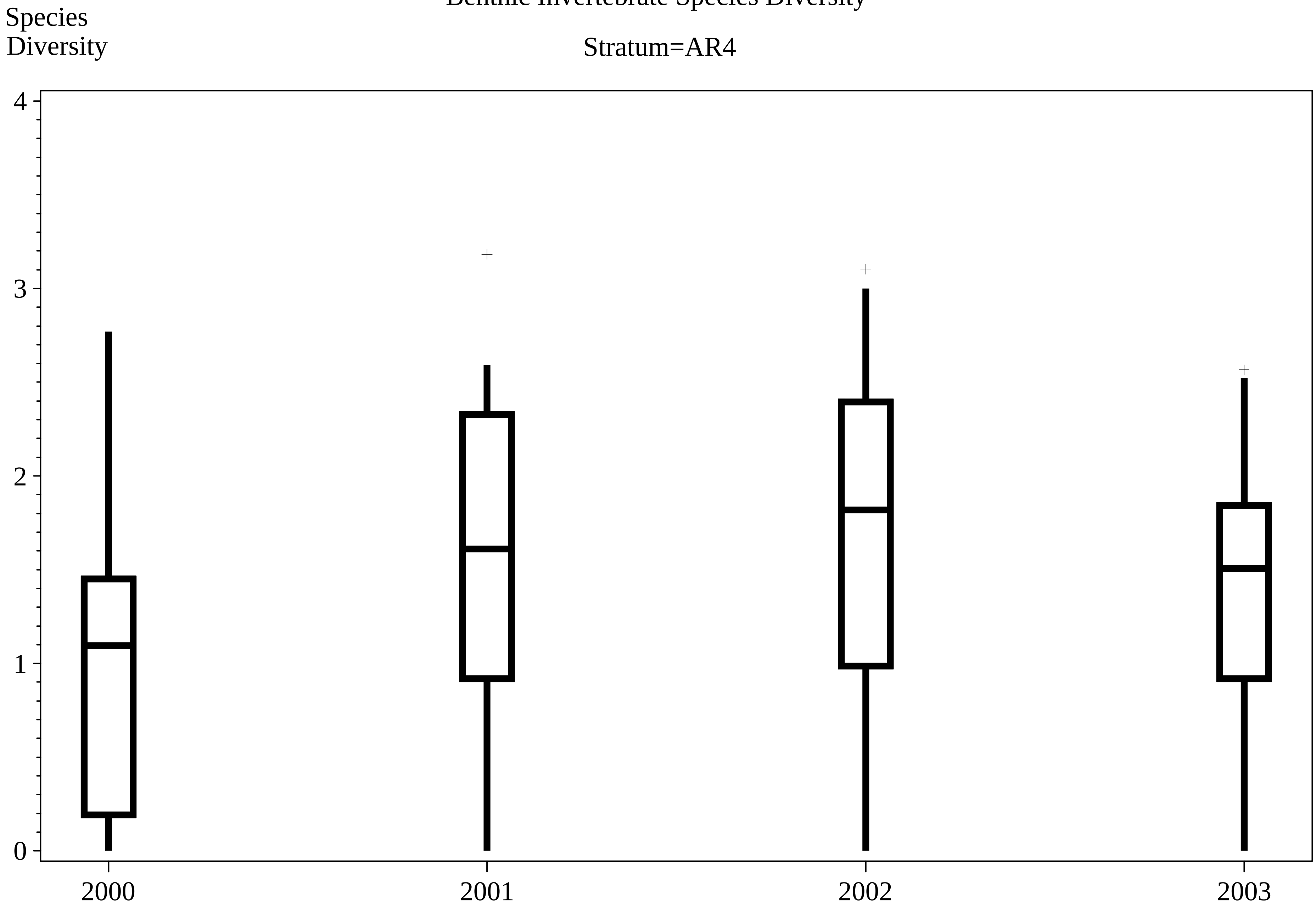


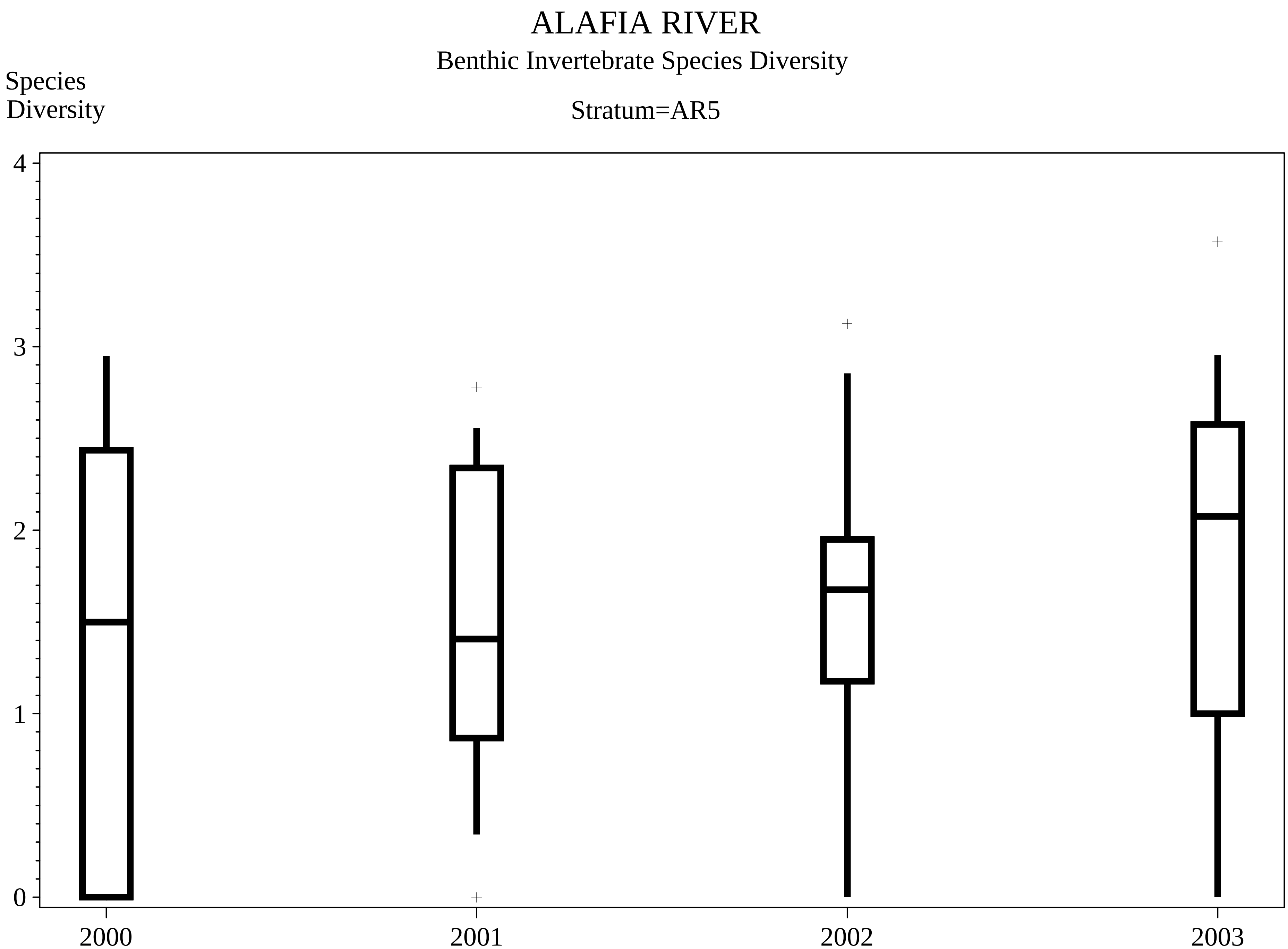
ALAFIA RIVER
Benthic Invertebrate Species Diversity
Species
Diversity
Stratum=AR3
4
3
2
1
0
2000
2001
2002
2003

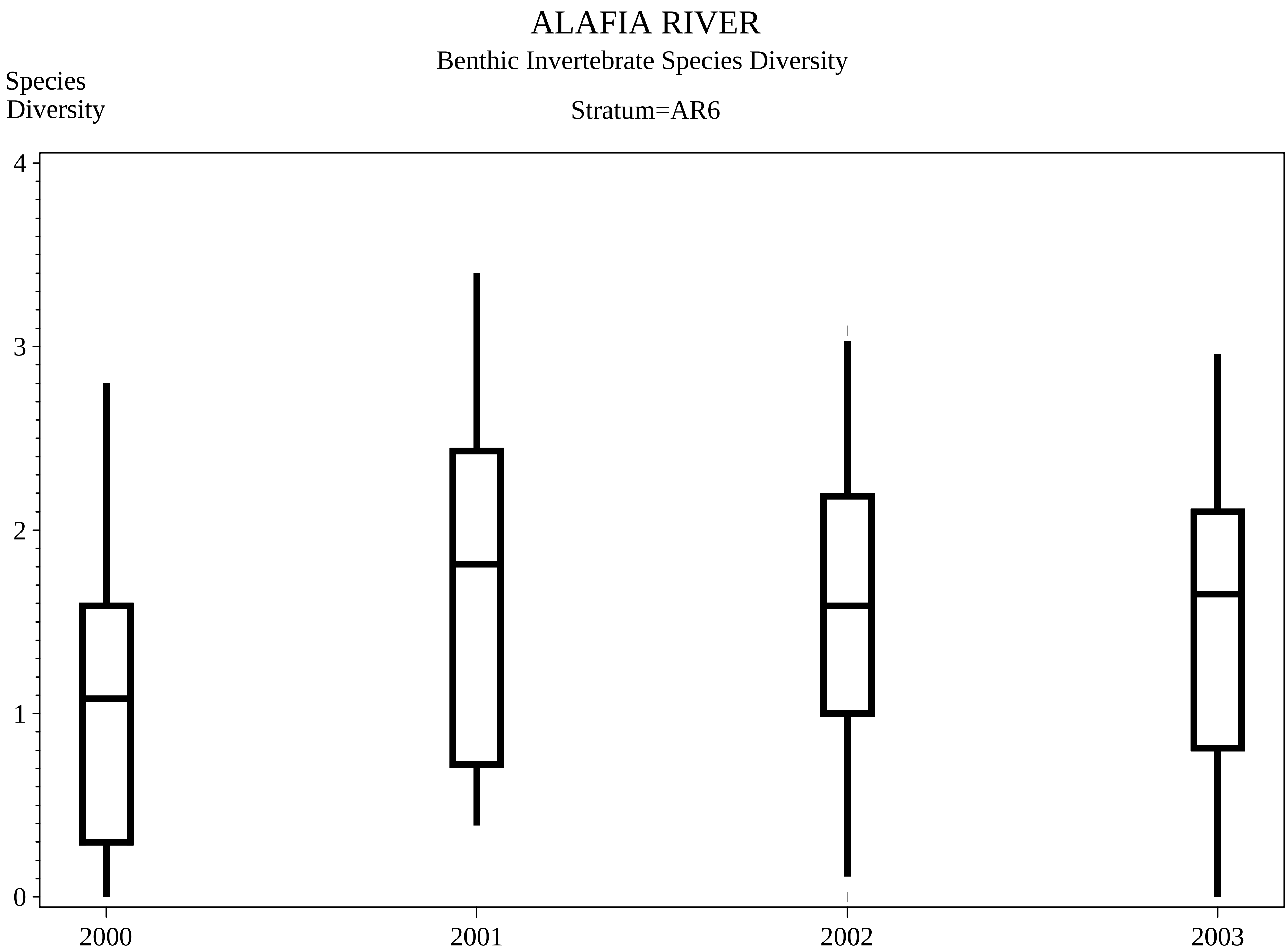
ALAFIA RIVER

Benthic Invertebrate Species Diversity

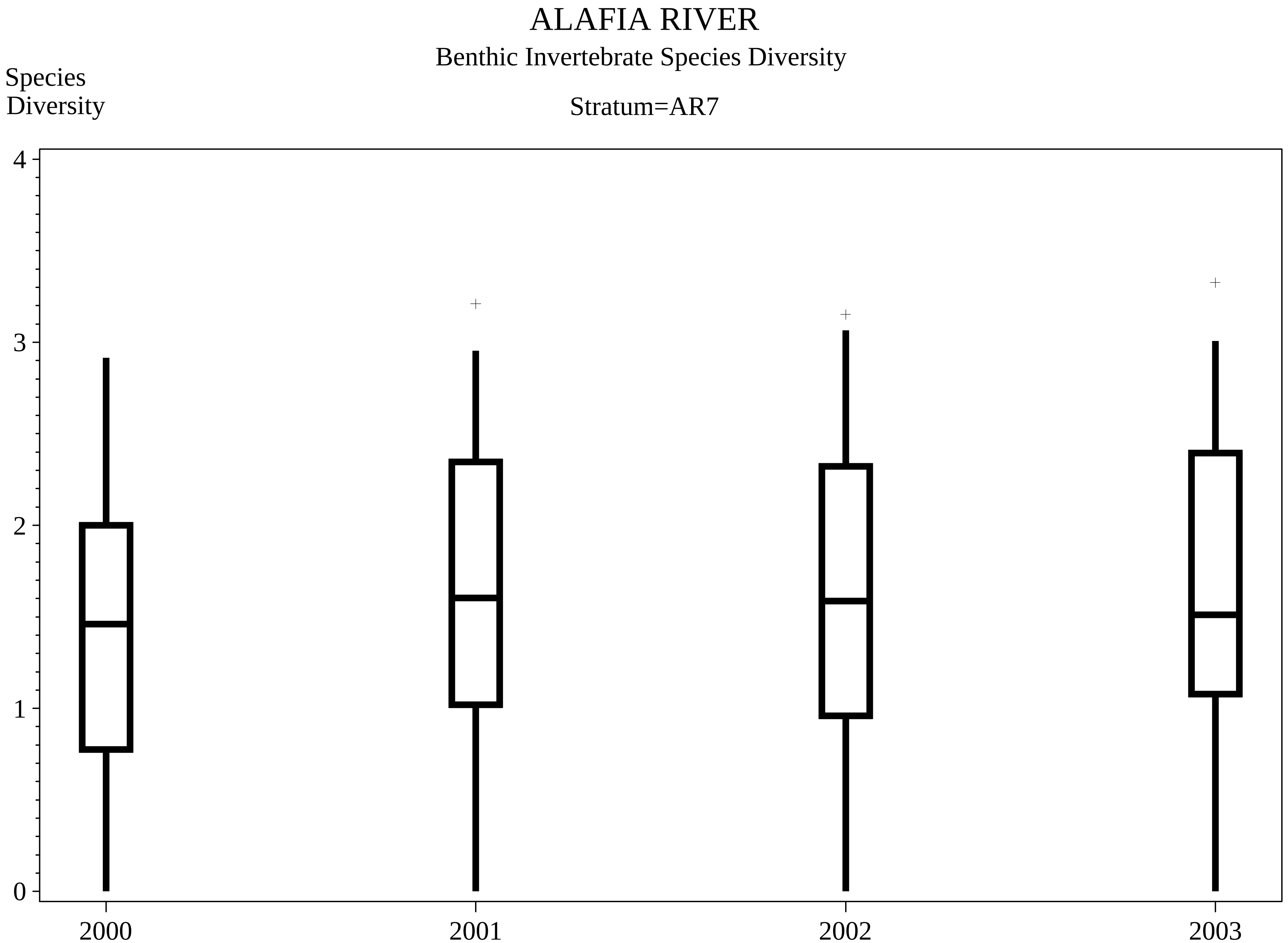
Stratum=AR4



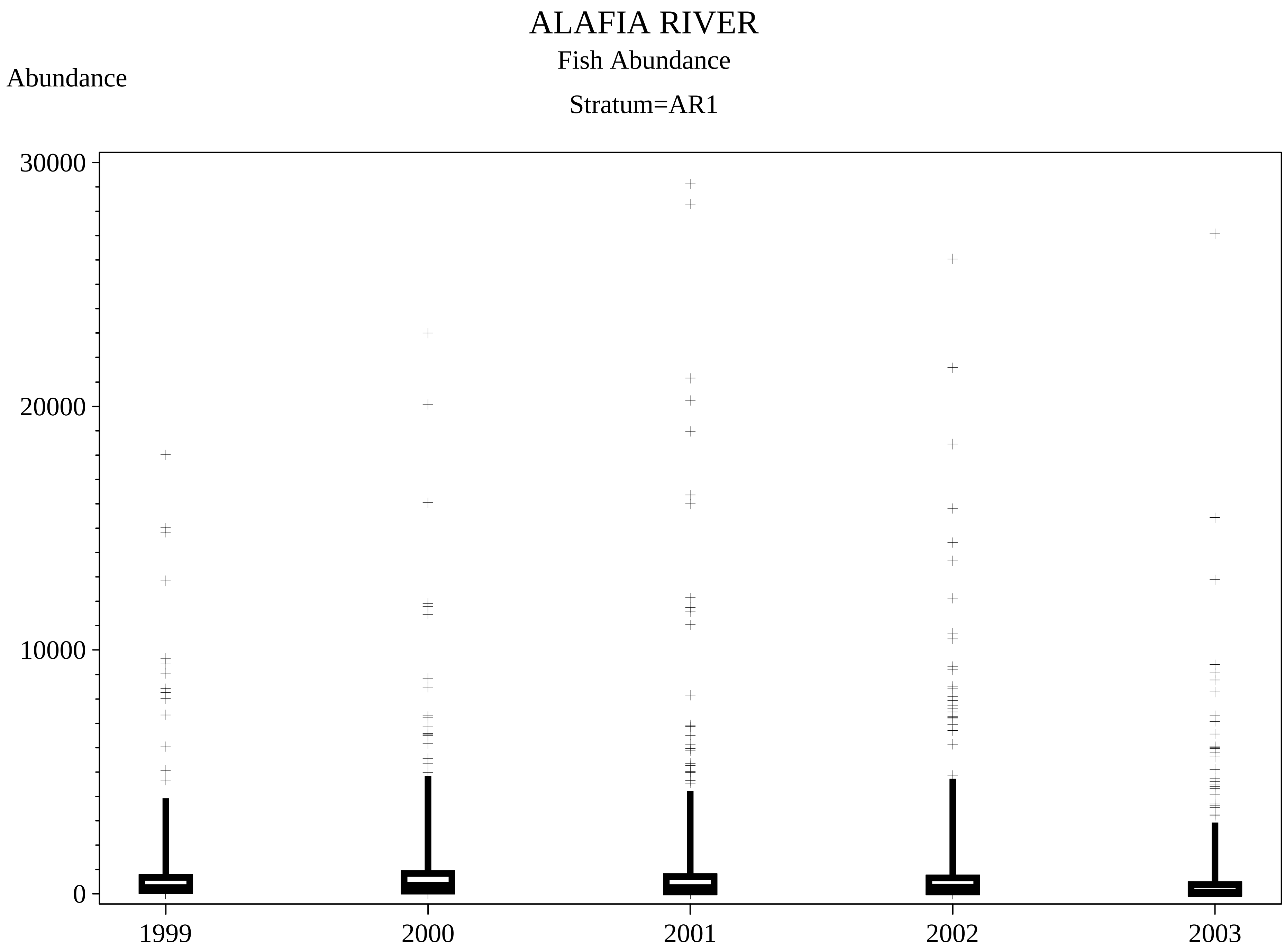

ALAFIA RIVER
Benthic Invertebrate Species Diversity
Stratum=AR5
Species
Diversity
4
3
2
1
0
2000
2001
2002
2003



ALAFIA RIVER
Benthic Invertebrate Species Diversity
Species
Diversity
Stratum=AR6
4
3
2
1
0
2000
2001
2002
2003


ALAFIA RIVER
Benthic Invertebrate Species Diversity
Stratum=AR7
Species
Diversity
0
1
2
3
4
2000
2001
2002
2003

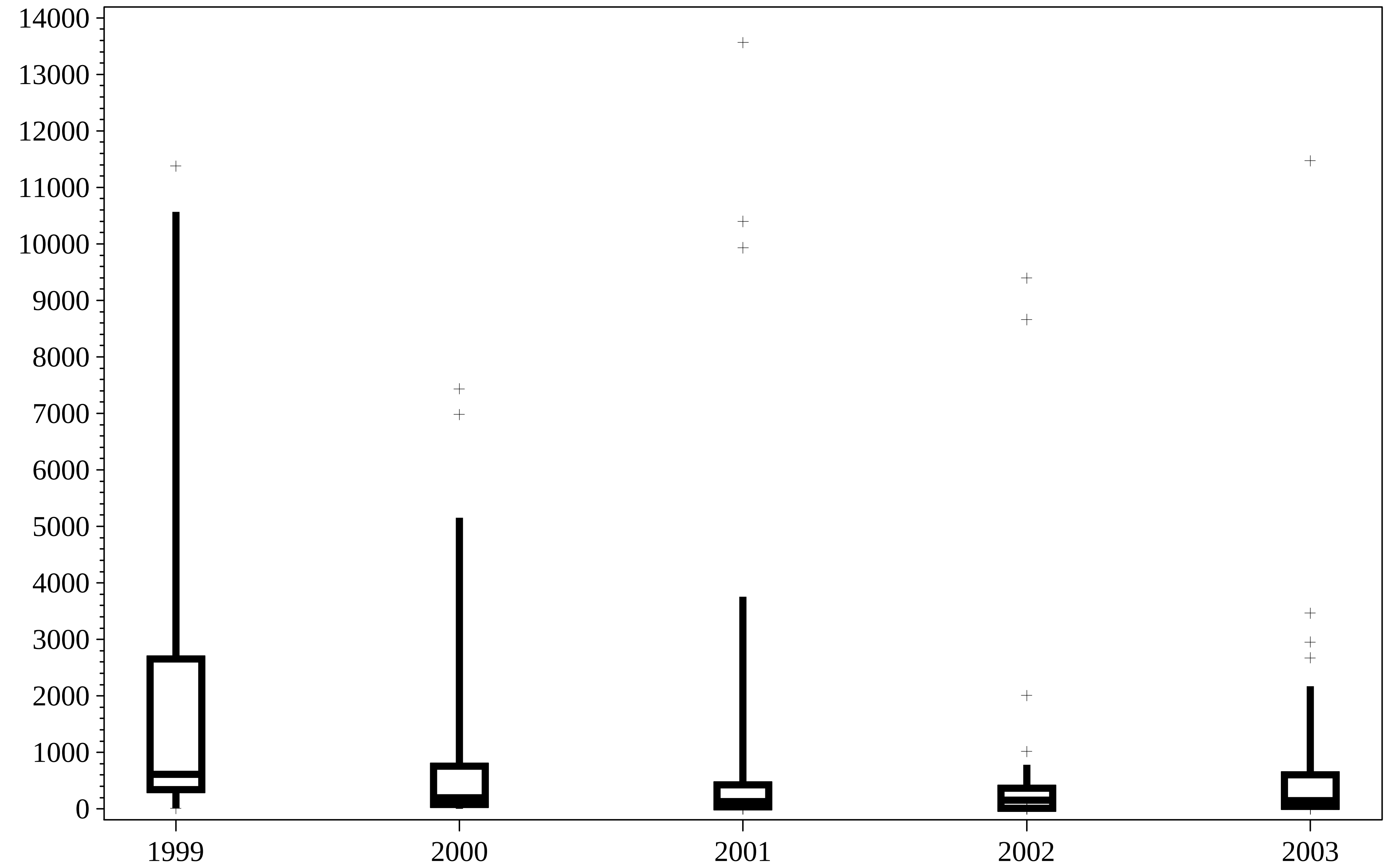
APPENDIX D:
FISH BOXPLOTS


ALAFIA RIVER
Fish Abundance
Stratum=AR1
Abundance
30000
20000
10000
0
1999
2000
2001
2002
2003

ALAFIA RIVER

Fish Abundance

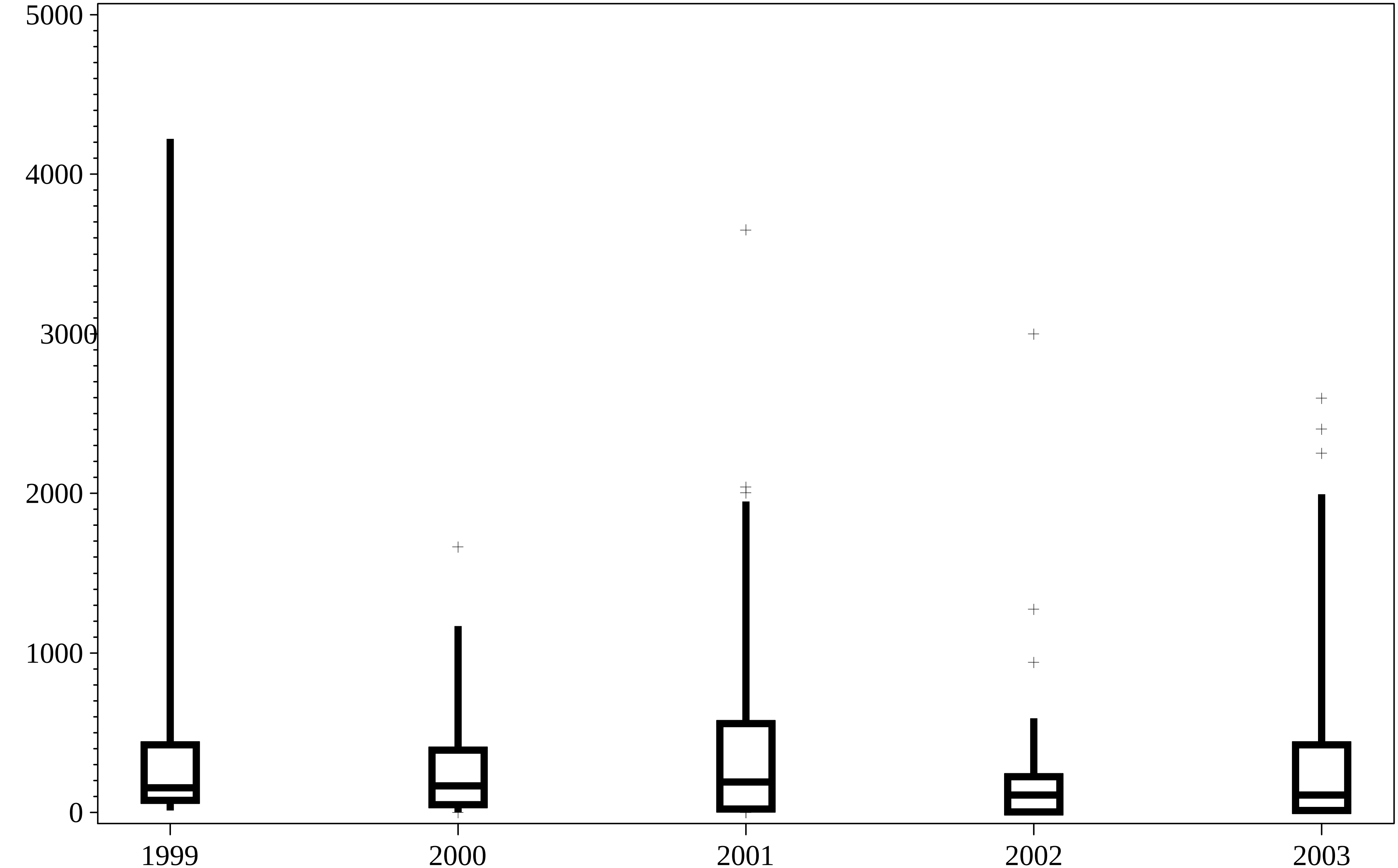
Stratum=AR2

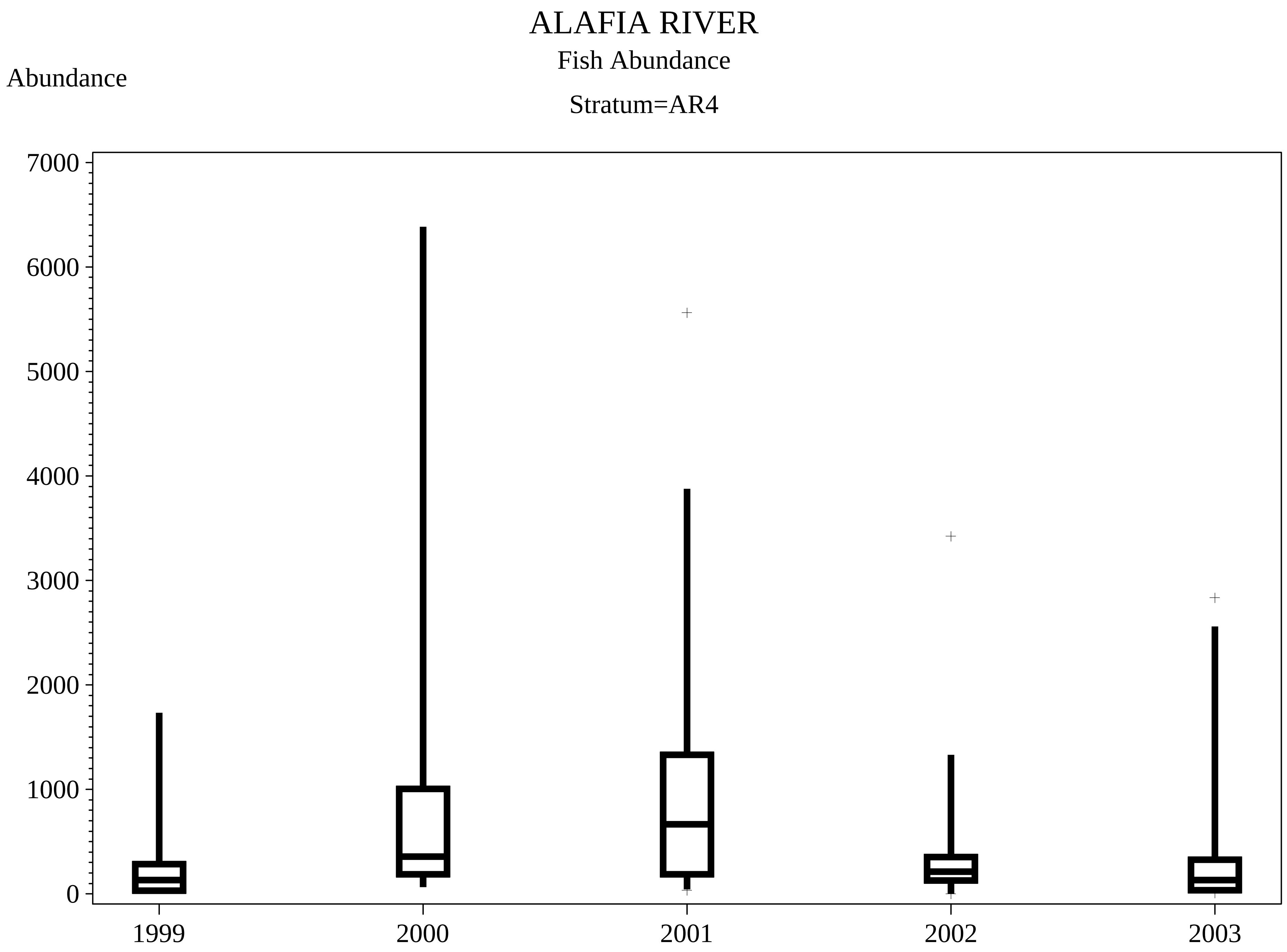


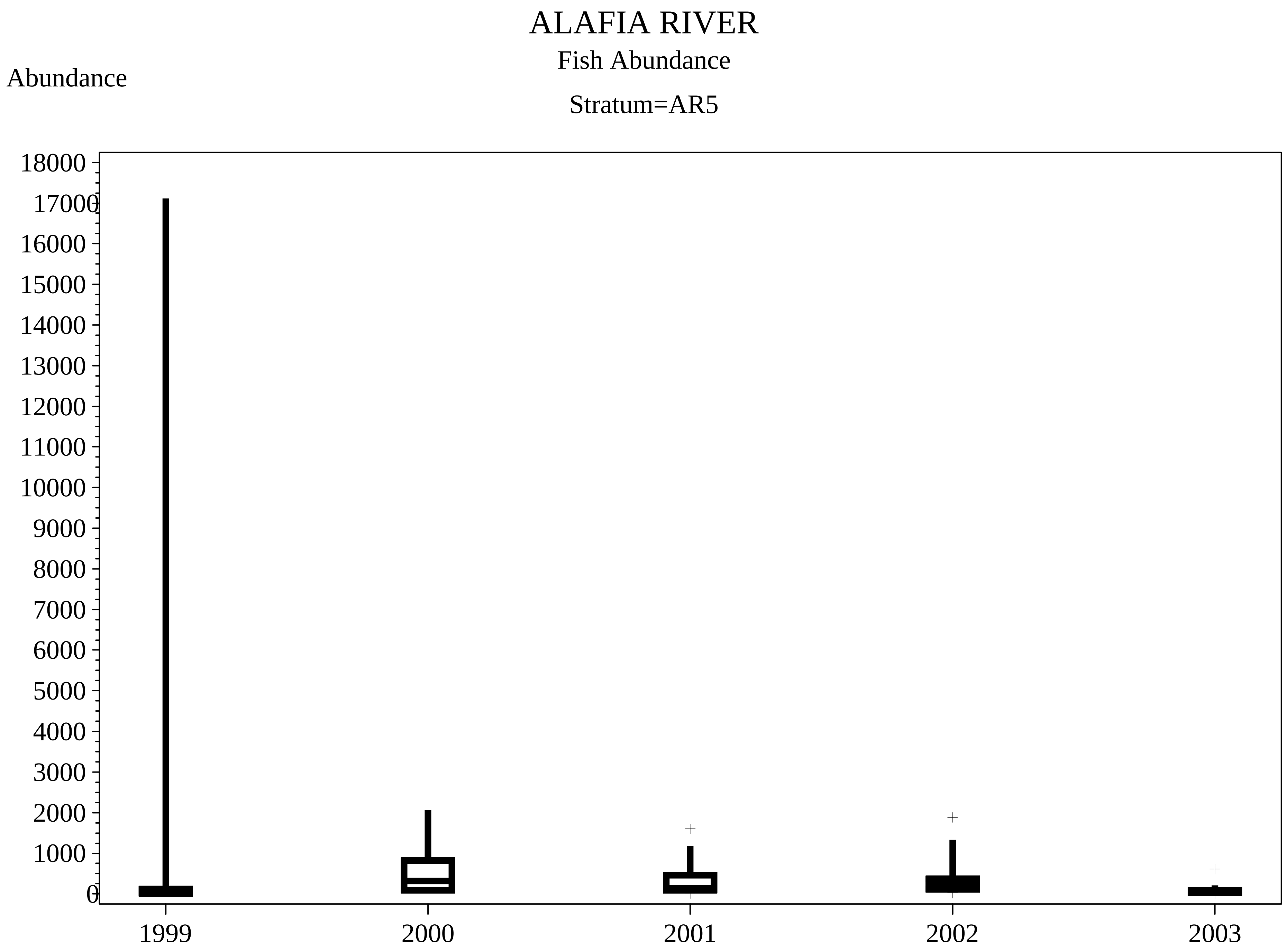
ALAFIA RIVER

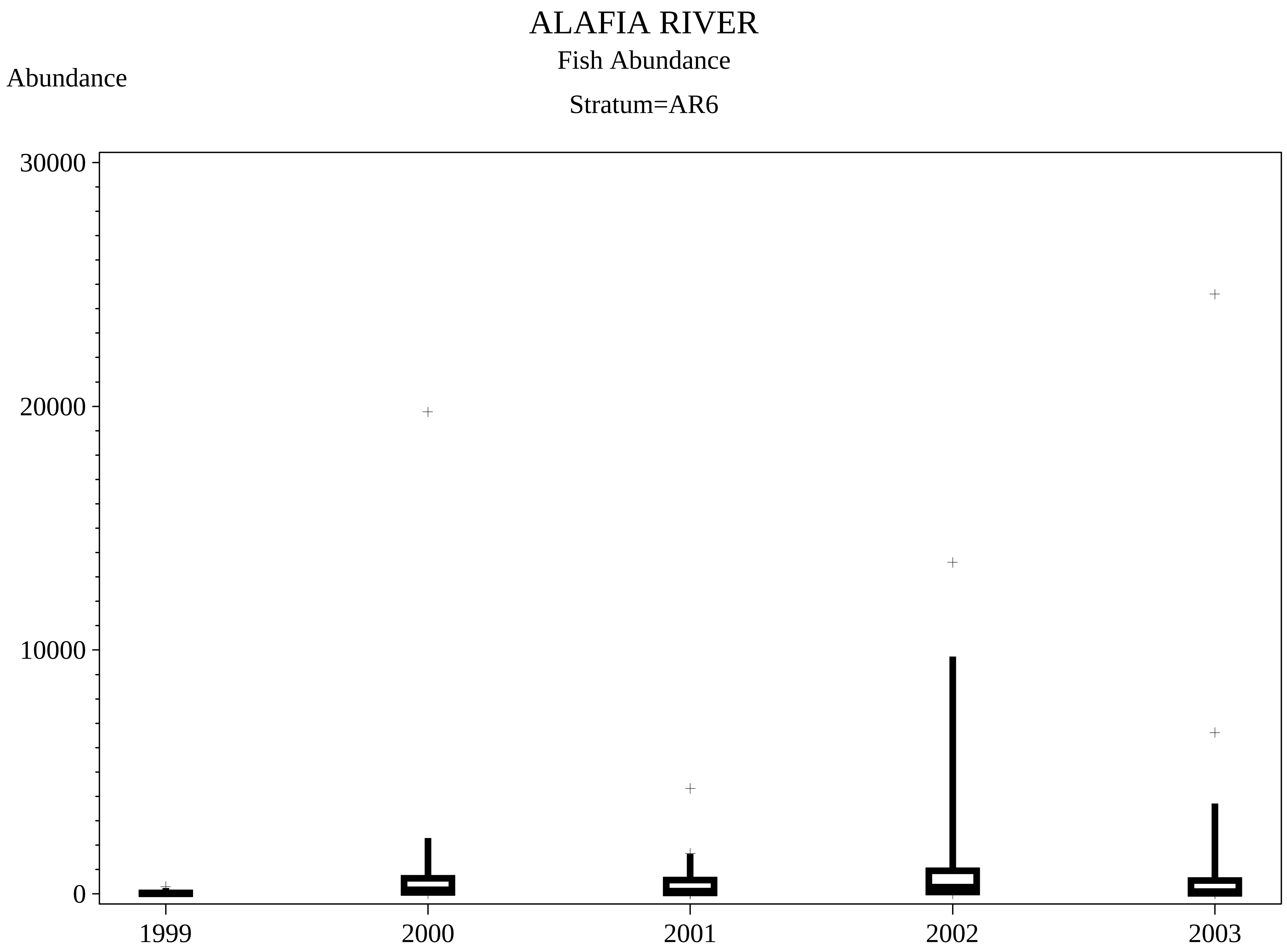
Fish Abundance

Stratum=AR3




ALAFIA RIVER
Fish Abundance
Stratum=AR4
Abundance
7000
6000
5000
4000
3000
2000
1000
0
1999
2000
2001
2002
2003

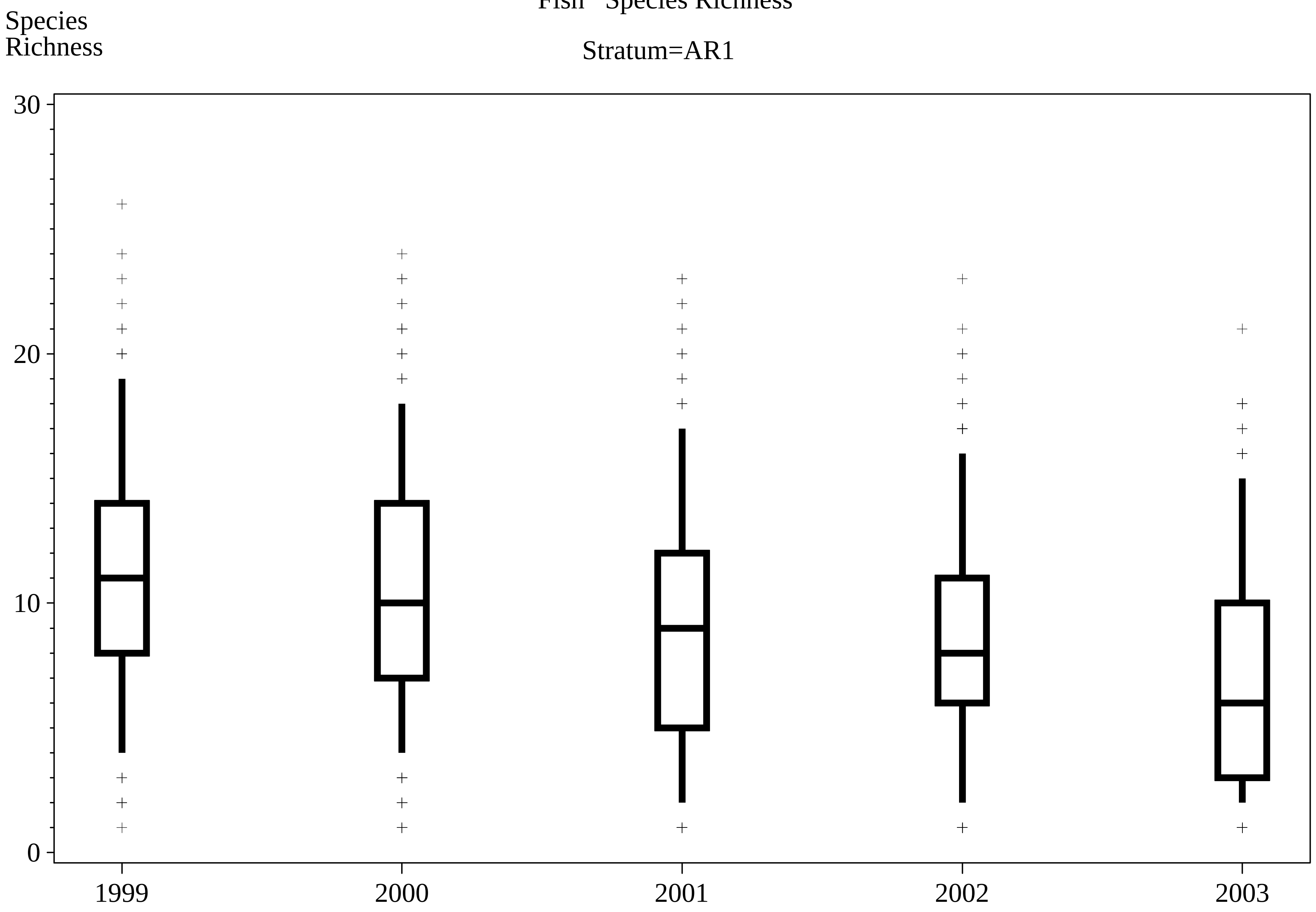

ALAFIA RIVER
Fish Abundance
Abundance
Stratum=AR5
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1999
2000
2001
2002
2003

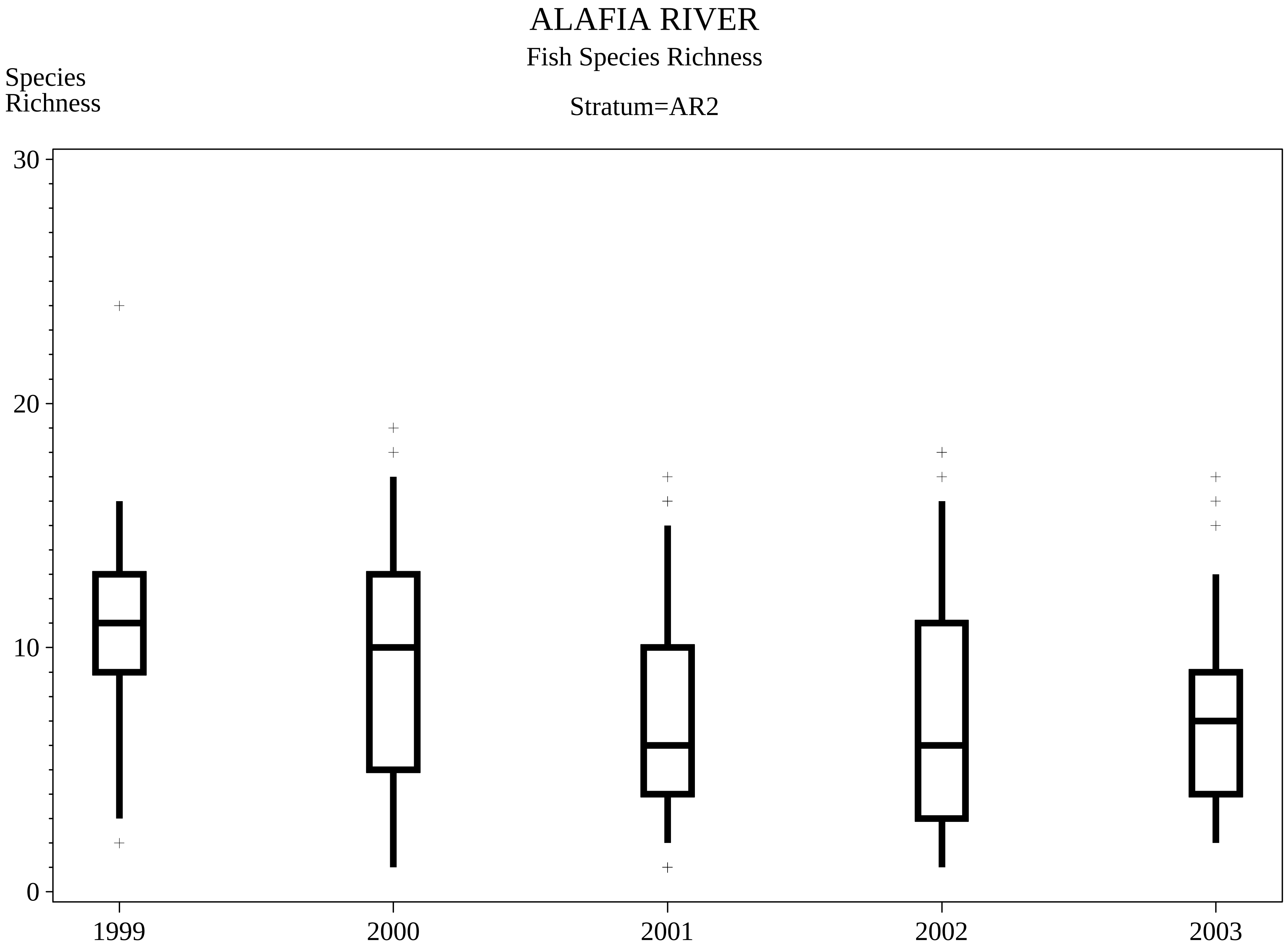

ALAFIA RIVER
Fish Abundance
Abundance
Stratum=AR6
30000
20000
10000
0
1999
2000
2001
2002
2003

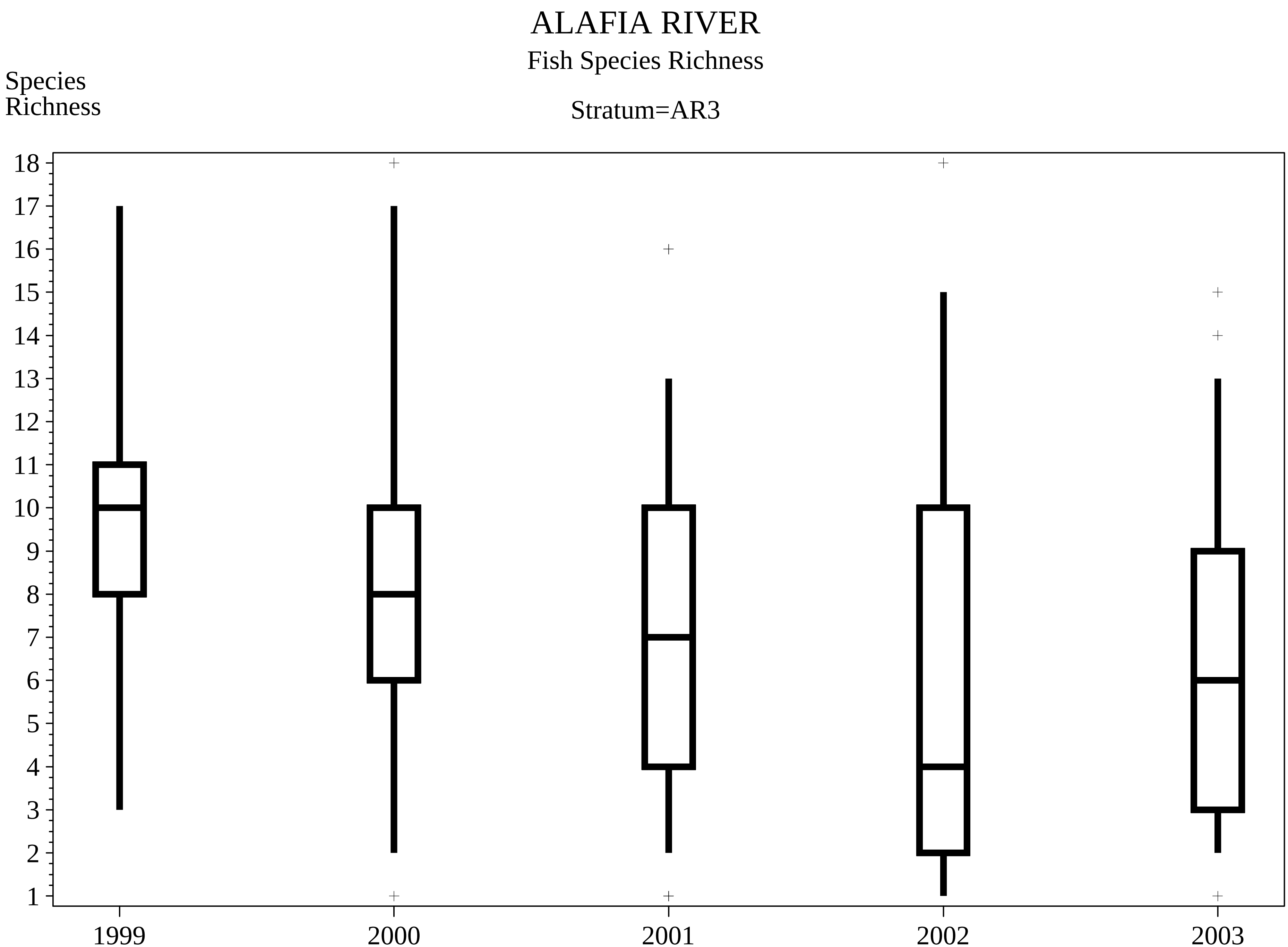
ALAFIA RIVER

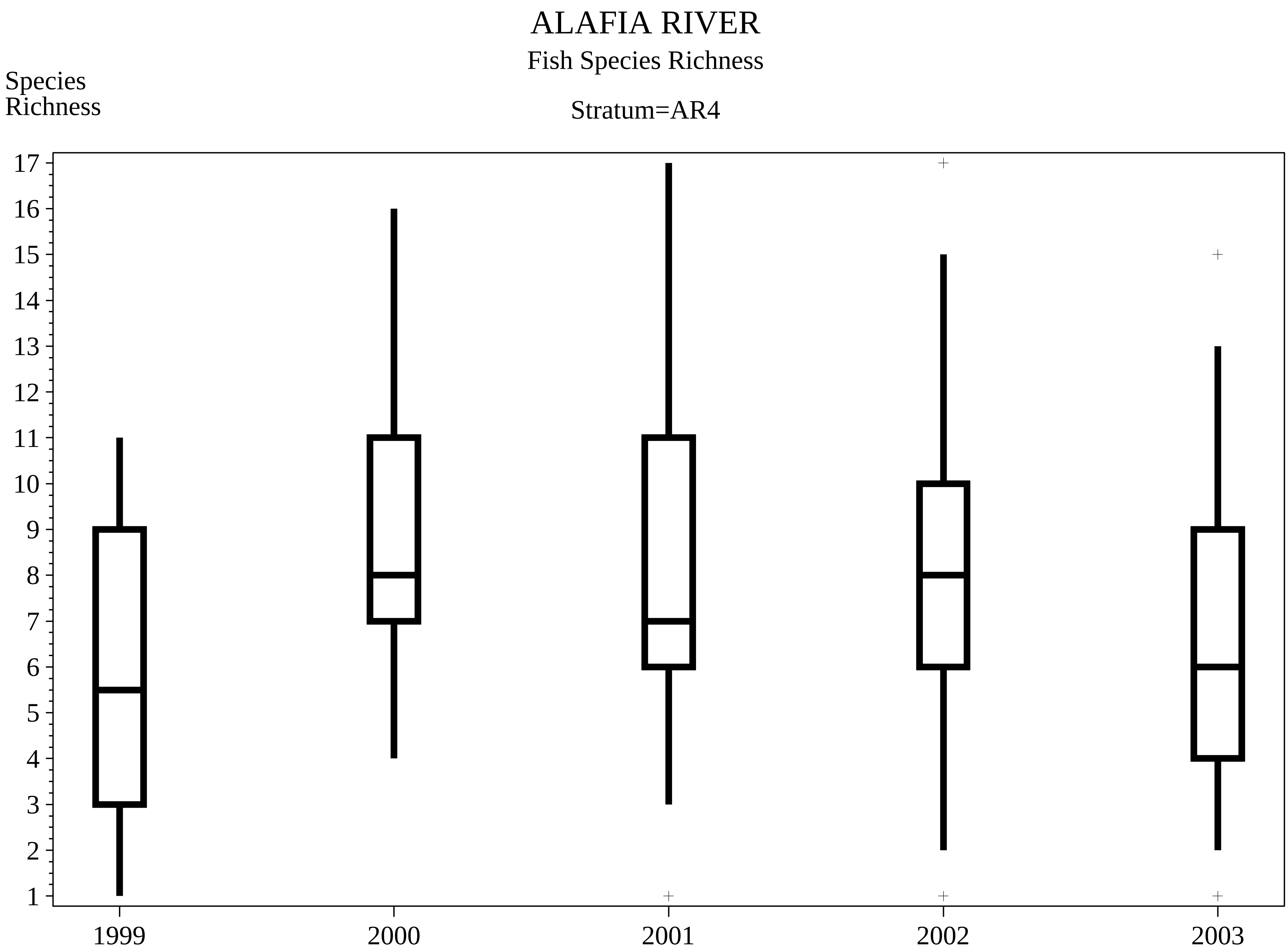
Fish   Species Richness

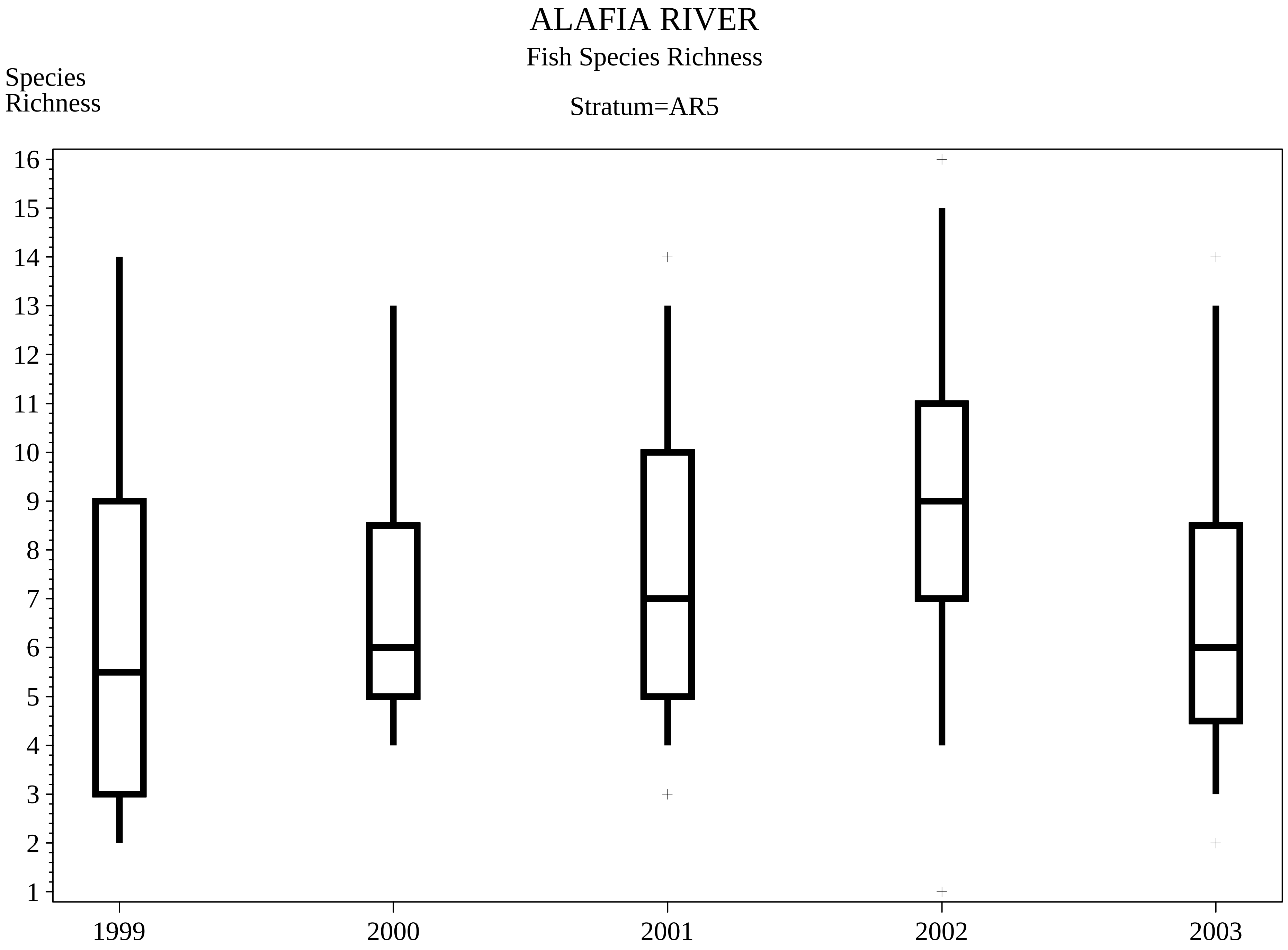
Stratum=AR1




ALAFIA RIVER
Fish Species Richness
Stratum=AR2
Species
Richness
30
20
10
0
1999
2000
2001
2002
2003


ALAFIA RIVER
Fish Species Richness
Stratum=AR3
Species
Richness
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1999
2000
2001
2002
2003


ALAFIA RIVER
Fish Species Richness
Stratum=AR4
Species
Richness
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1999
2000
2001
2002
2003

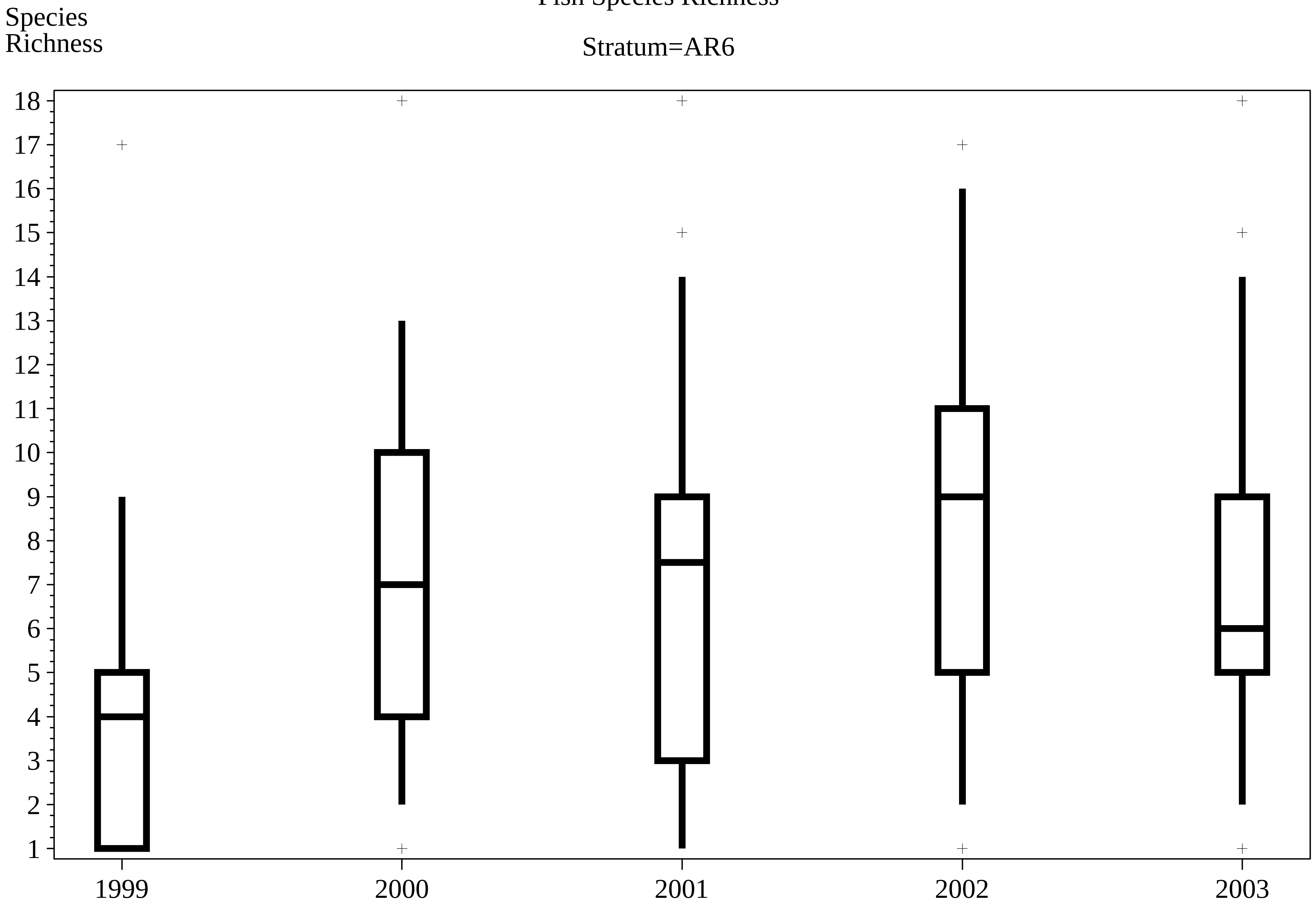


ALAFIA RIVER
Fish Species Richness
Species
Richness
Stratum=AR5
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1999
2000
2001
2002
2003

ALAFIA RIVER

Fish Species Richness

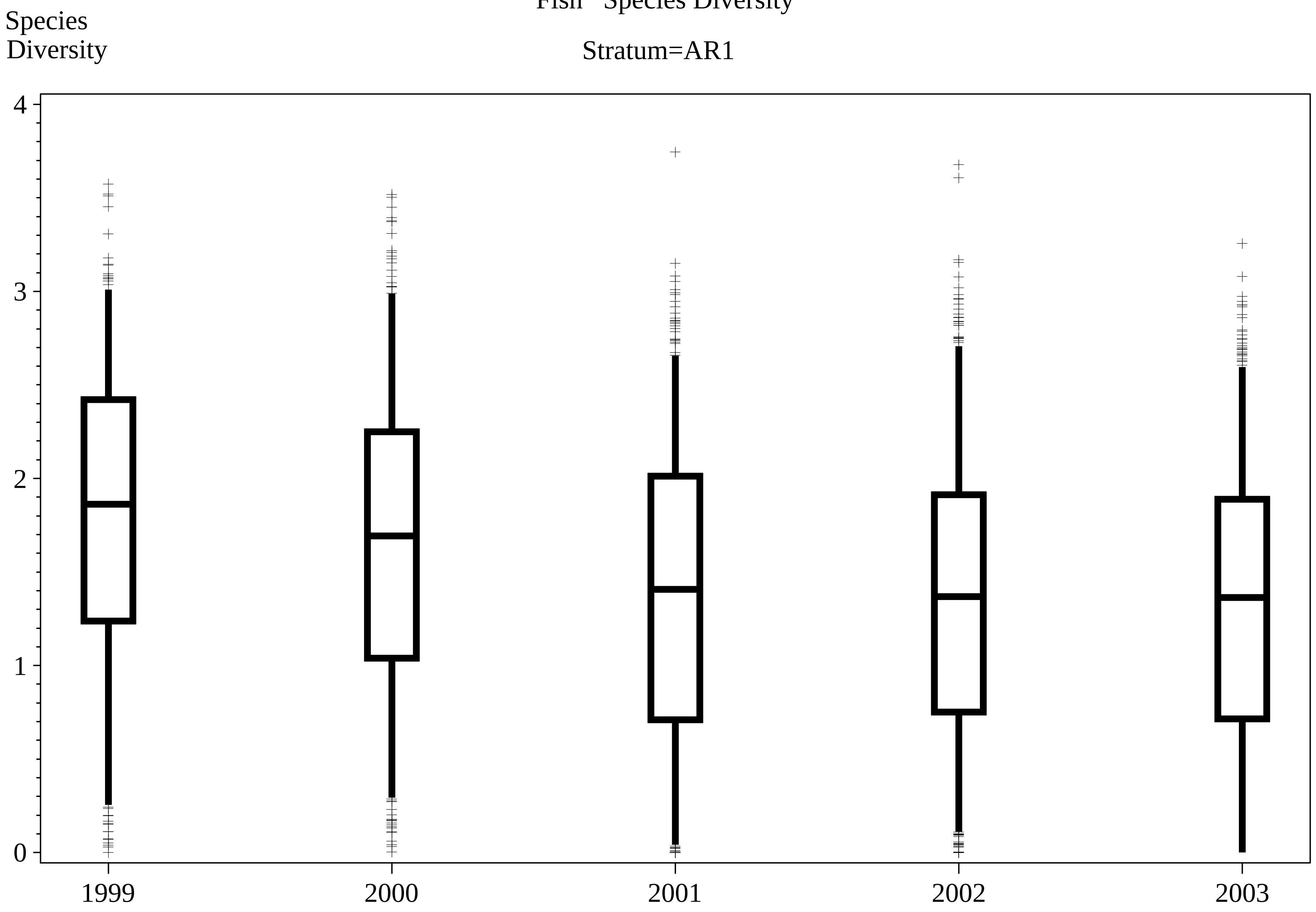
Stratum=AR6

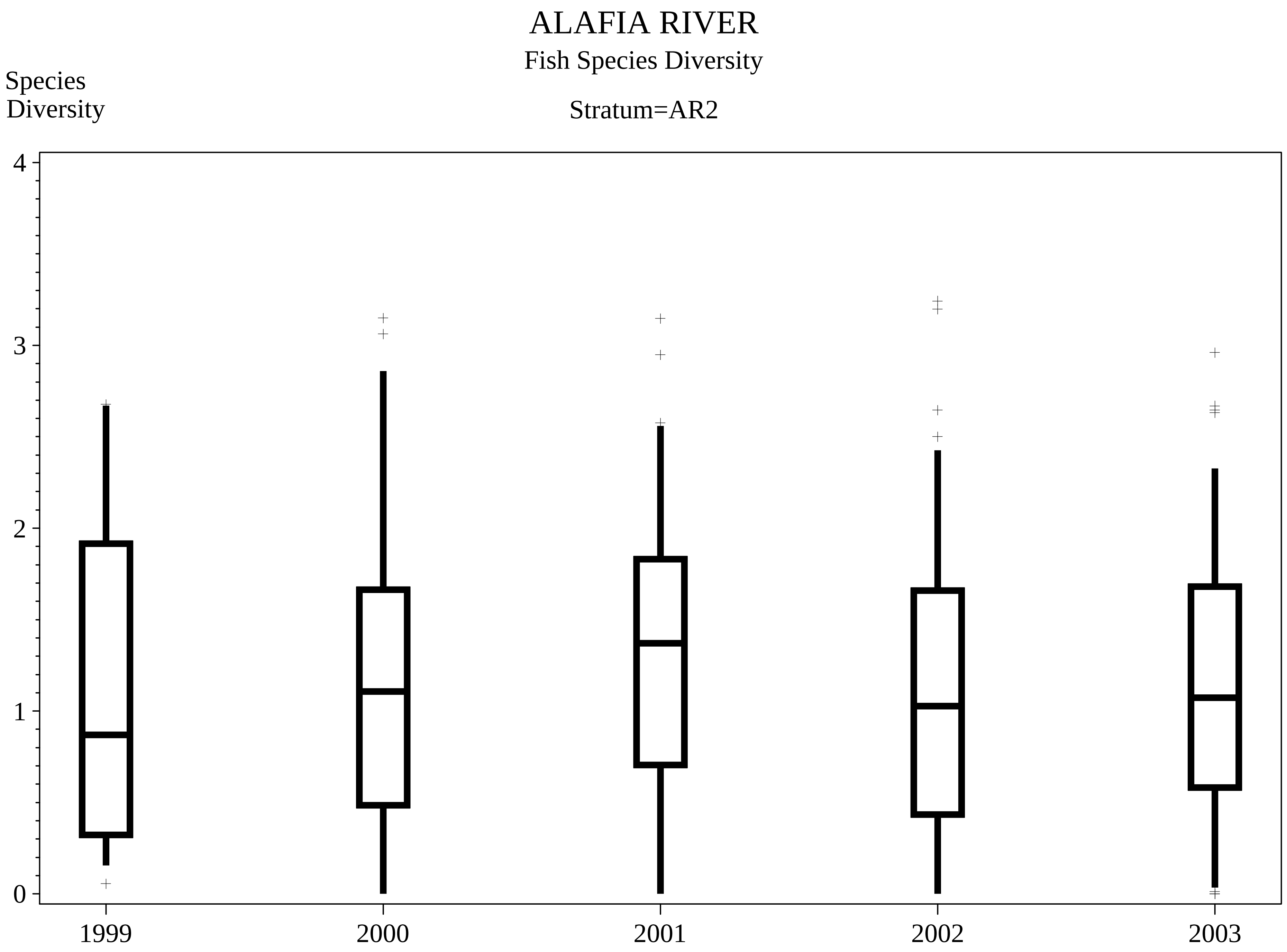


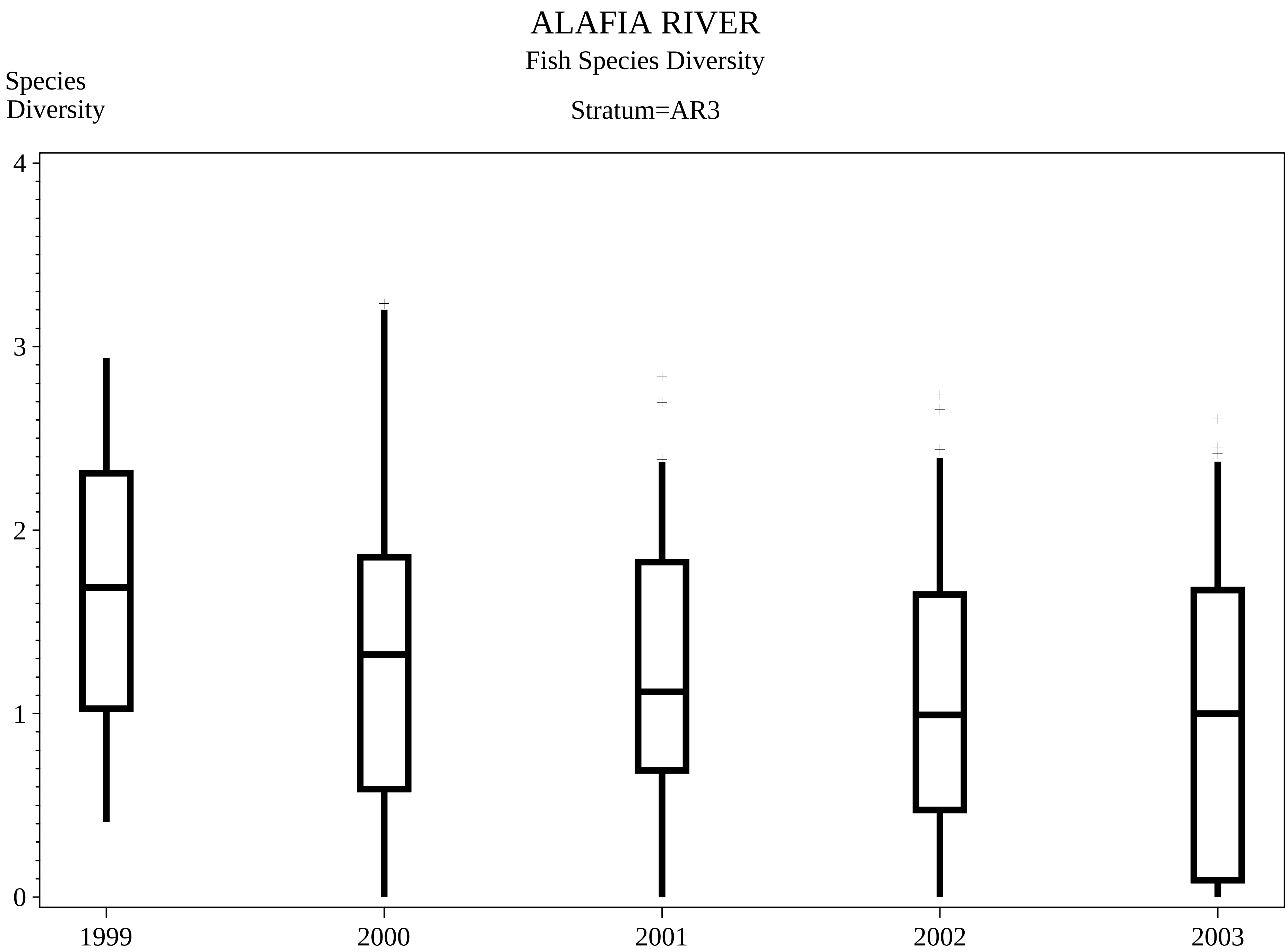
ALAFIA RIVER

Fish Species Diversity

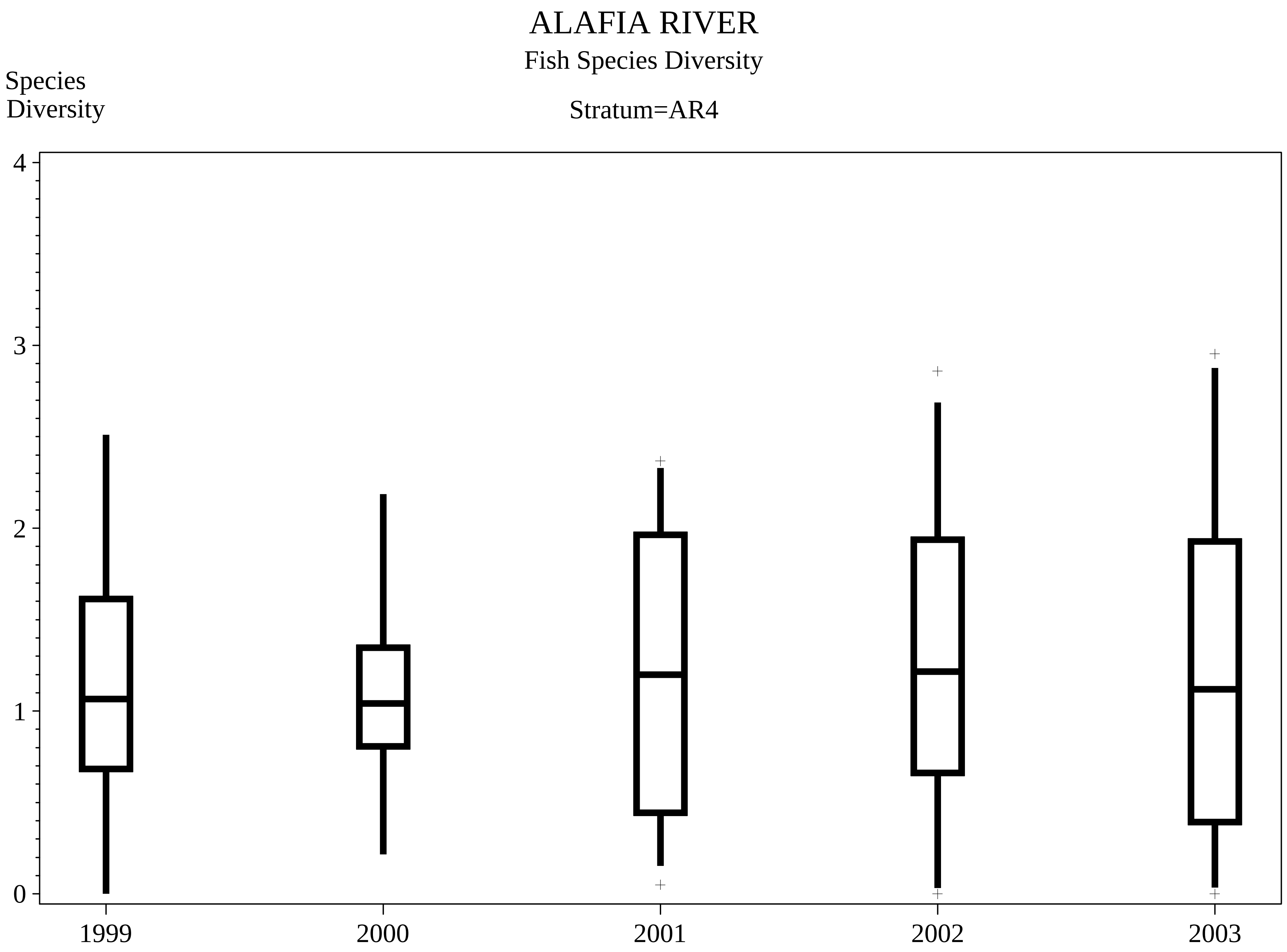
Stratum=AR1




ALAFIA RIVER
Fish Species Diversity
Stratum=AR2
Species
Diversity
4
3
2
1
0
1999
2000
2001
2002
2003



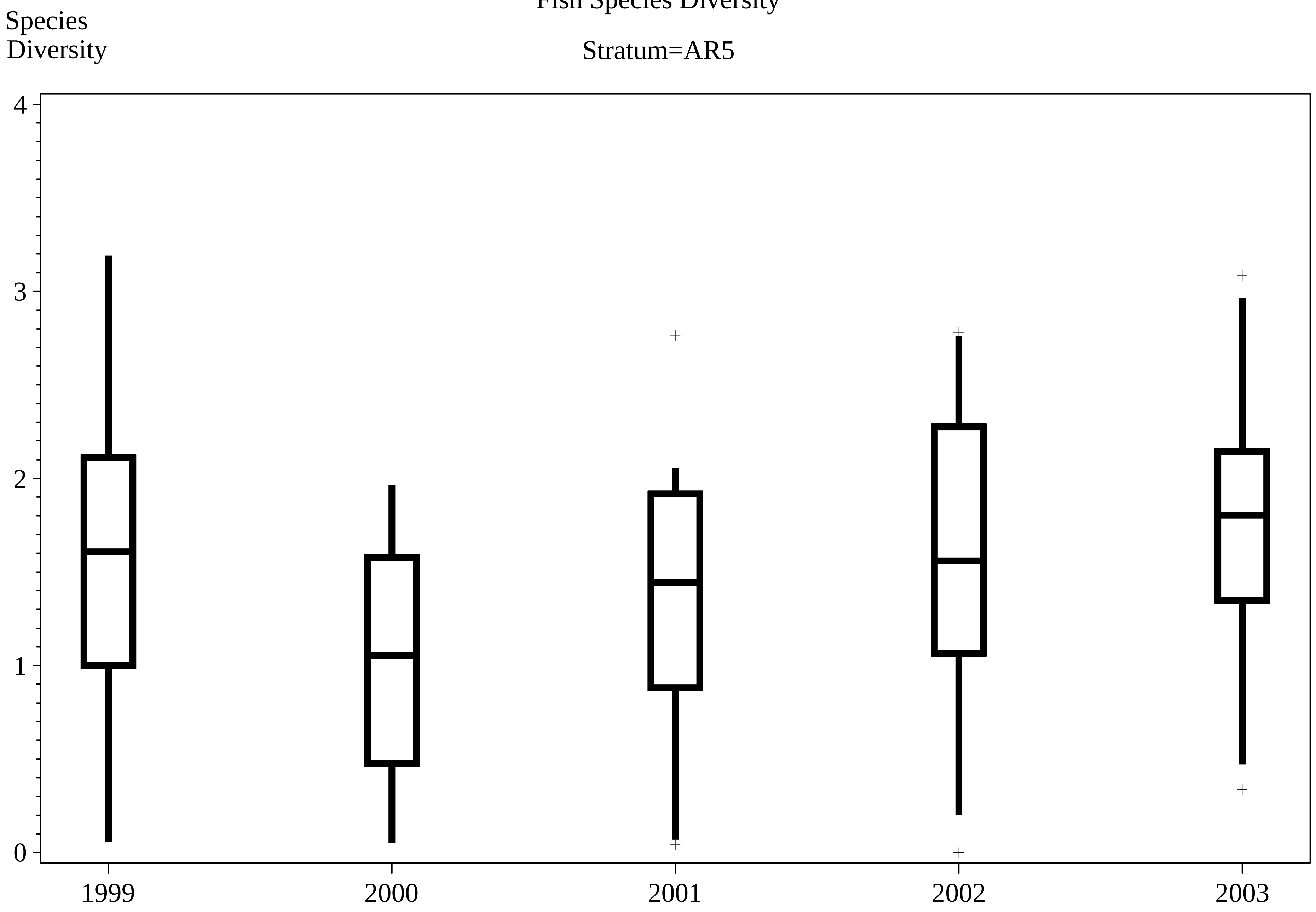
ALAFIA RIVER
Fish Species Diversity
Species Diversity
Stratum=AR3
0
1
2
3
4
1999
2000
2001
2002
2003

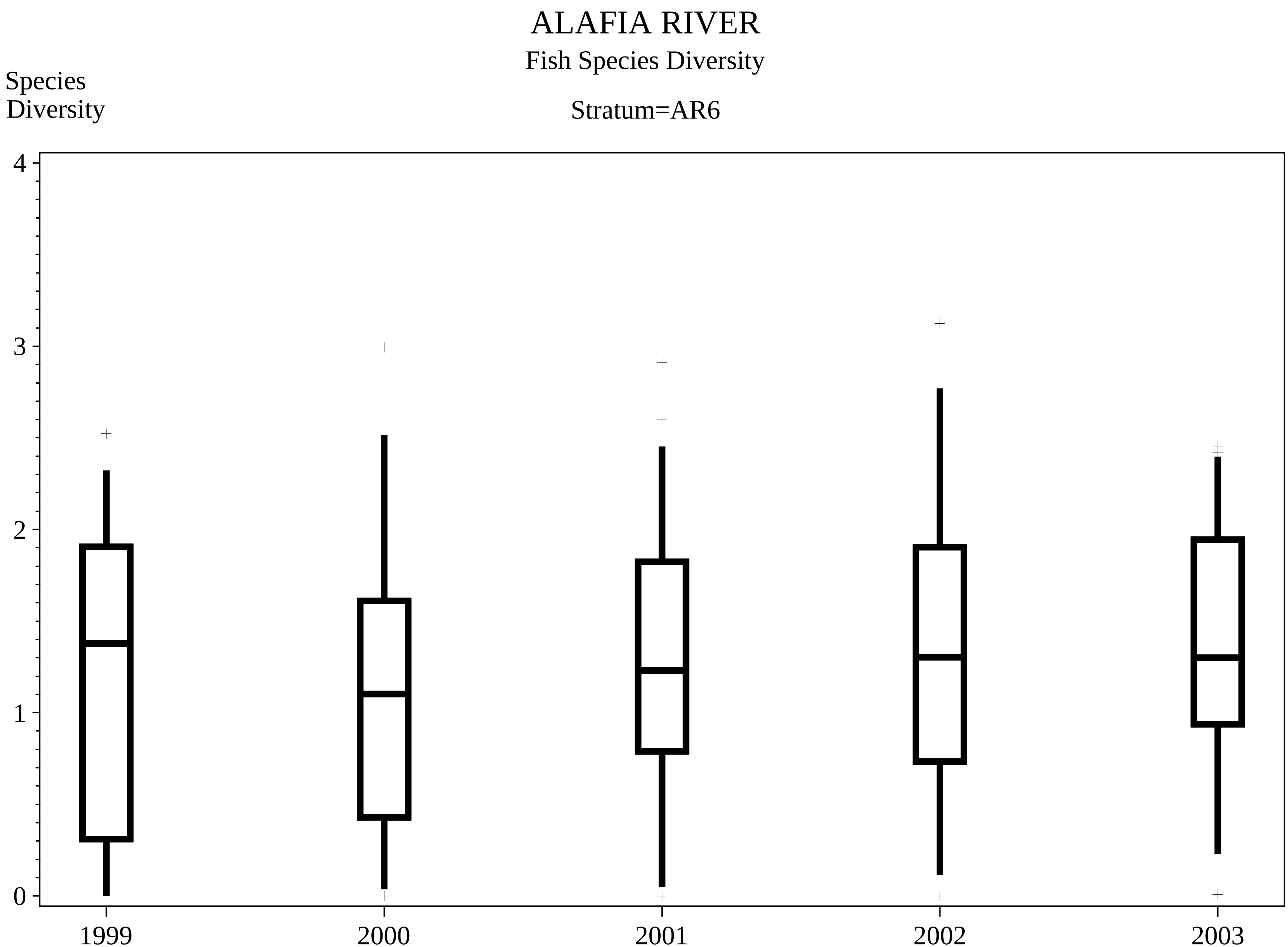

ALAFIA RIVER
Fish Species Diversity
Stratum=AR4
Species Diversity
4
3
2
1
0
1999
2000
2001
2002
2003

ALAFIA RIVER

Fish Species Diversity

Stratum=AR5



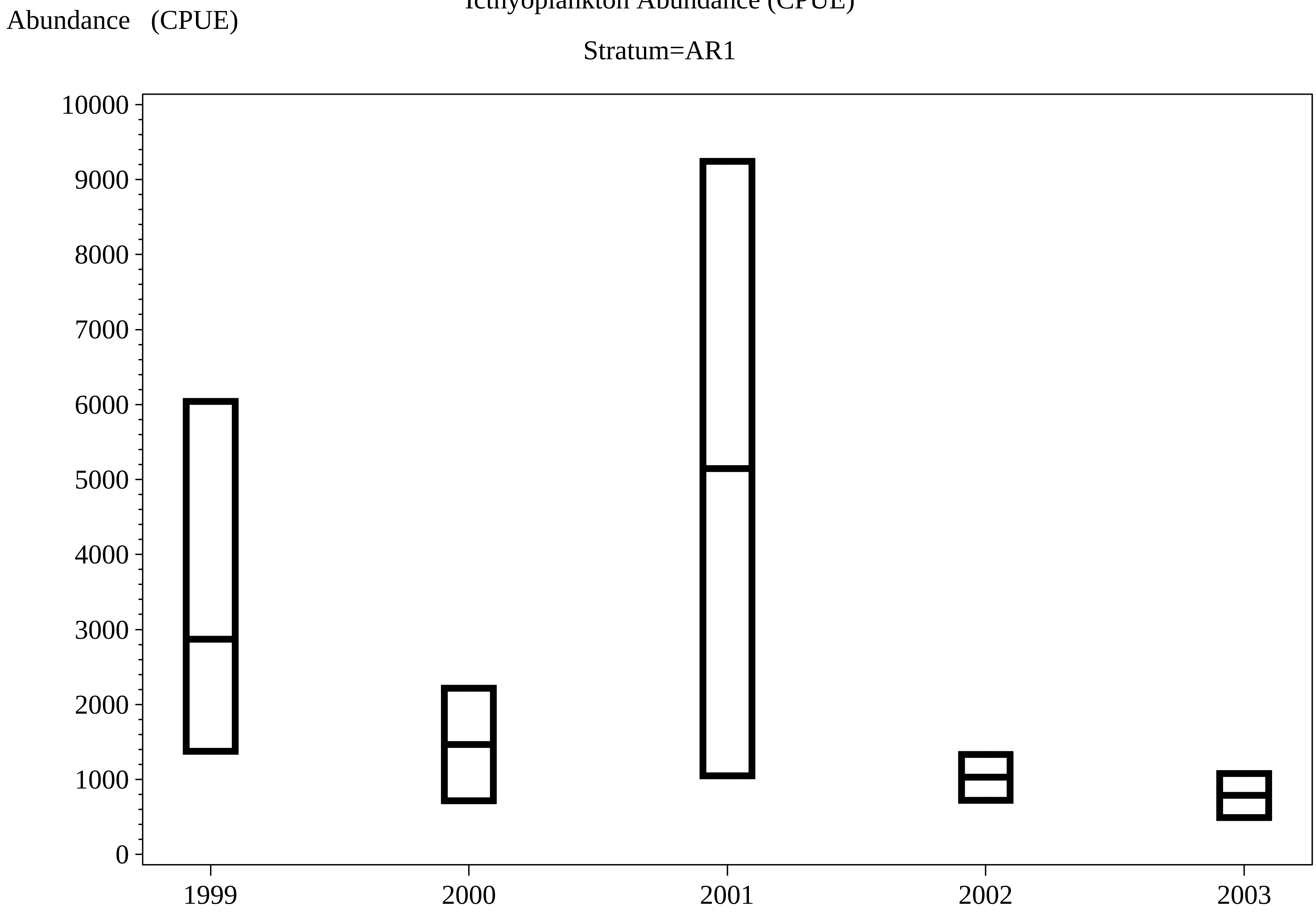

ALAFIA RIVER
Fish Species Diversity
Species
Diversity
Stratum=AR6
4
3
2
1
0
1999
2000
2001
2002
2003

APPENDIX E:
PLANKTON BOXPLOTS

ALAFIA RIVER

Icthyoplankton Abundance (CPUE)

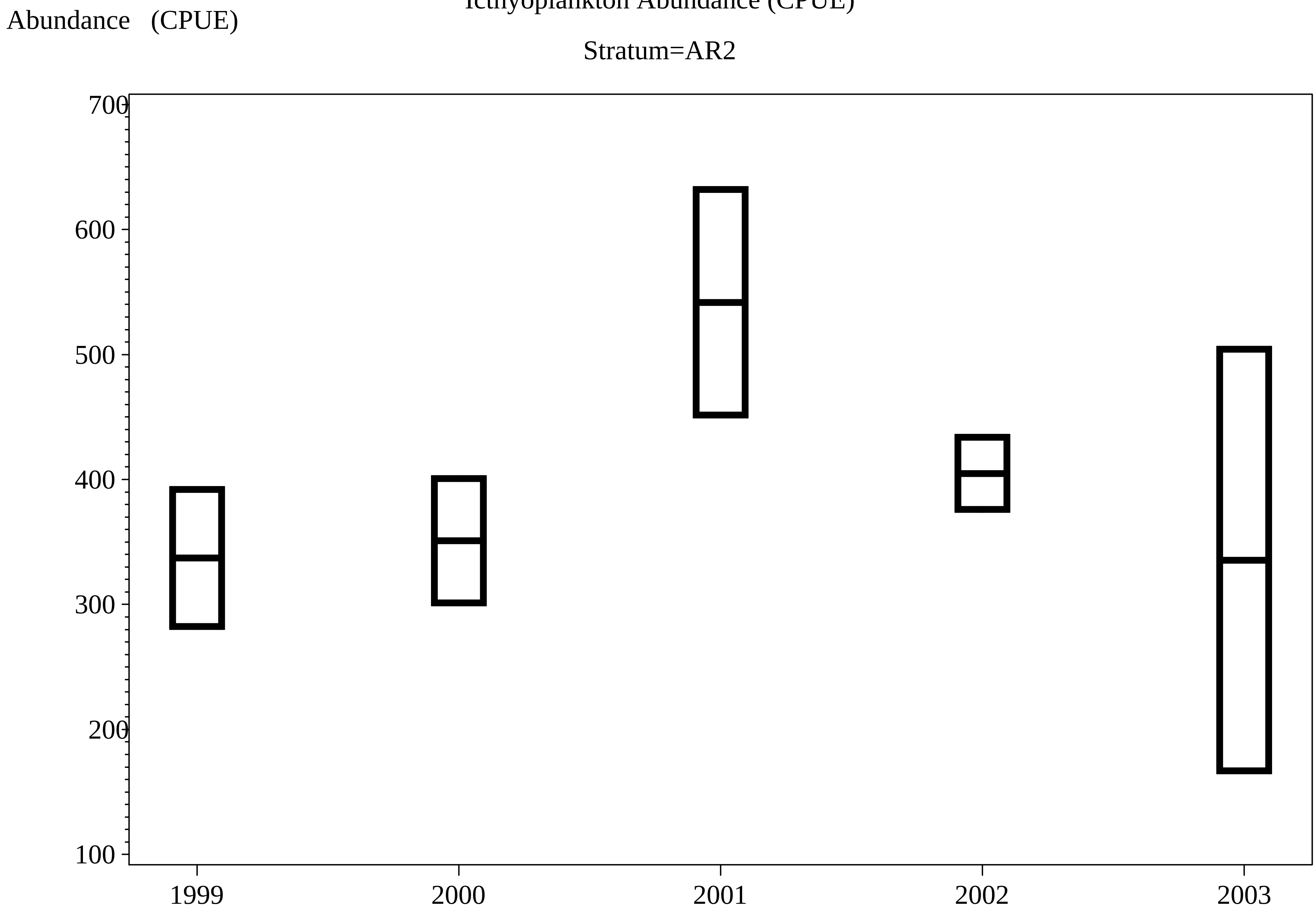
Stratum=AR1

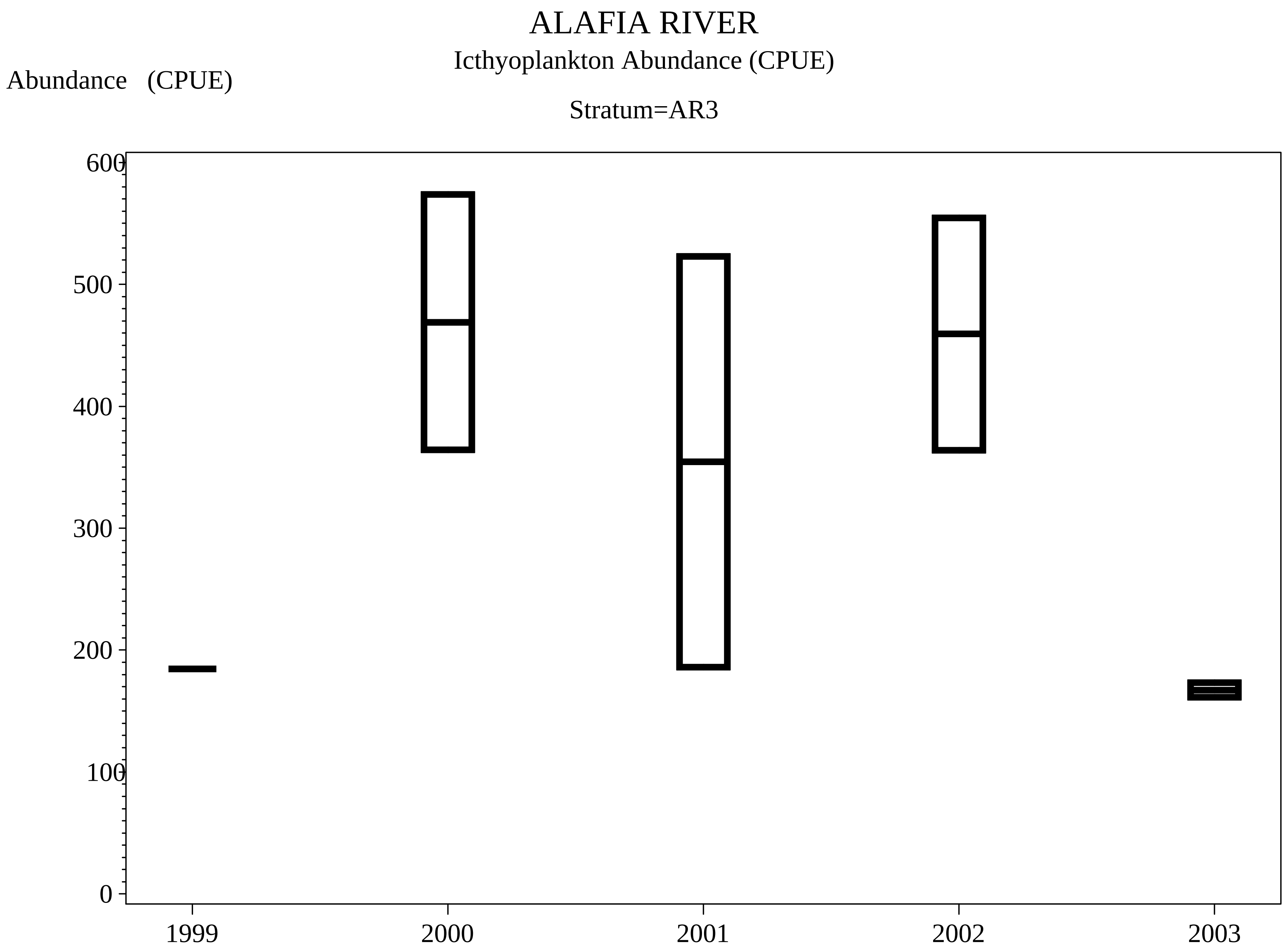


ALAFIA RIVER

Icthyoplankton Abundance (CPUE)

Stratum=AR2

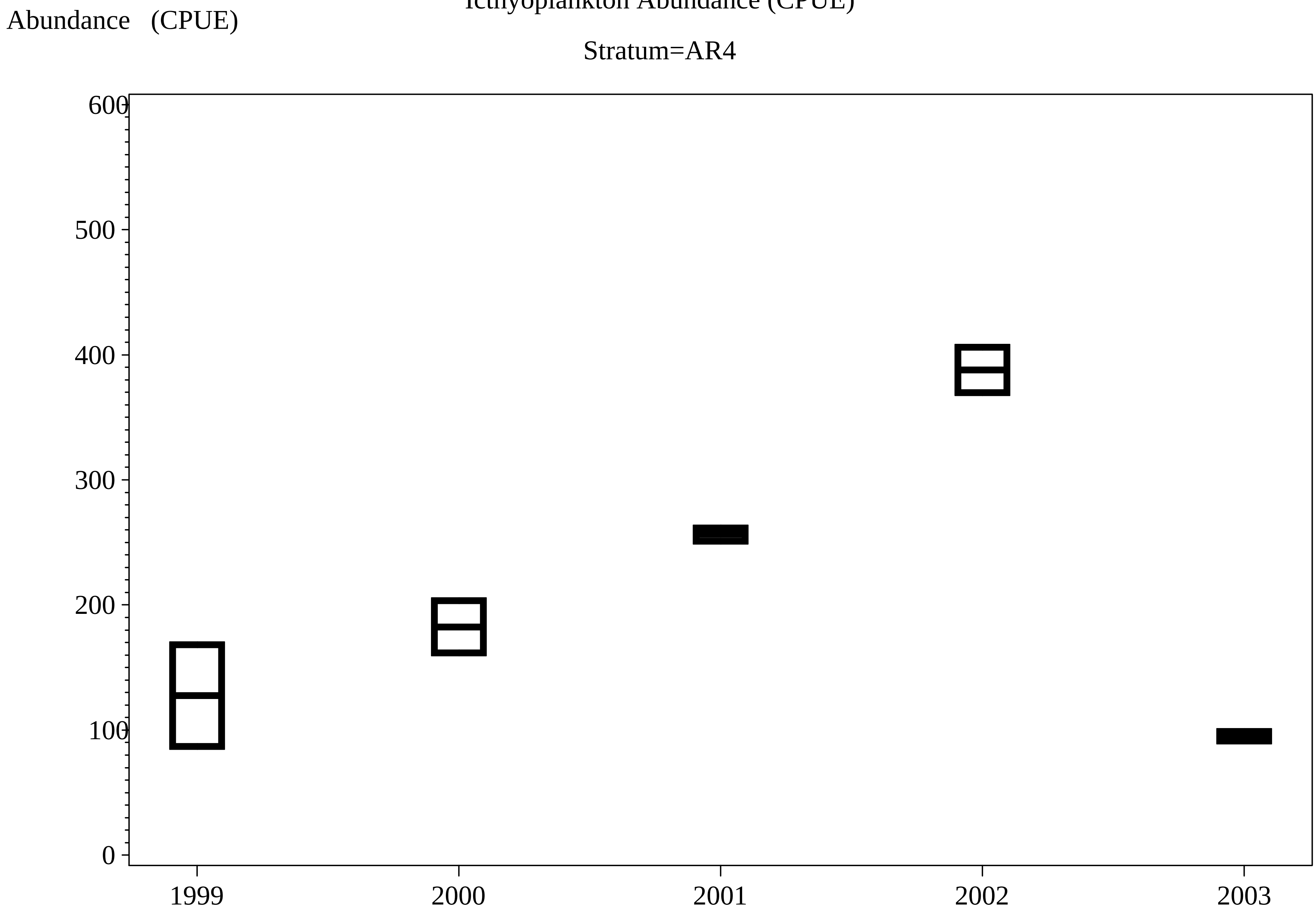


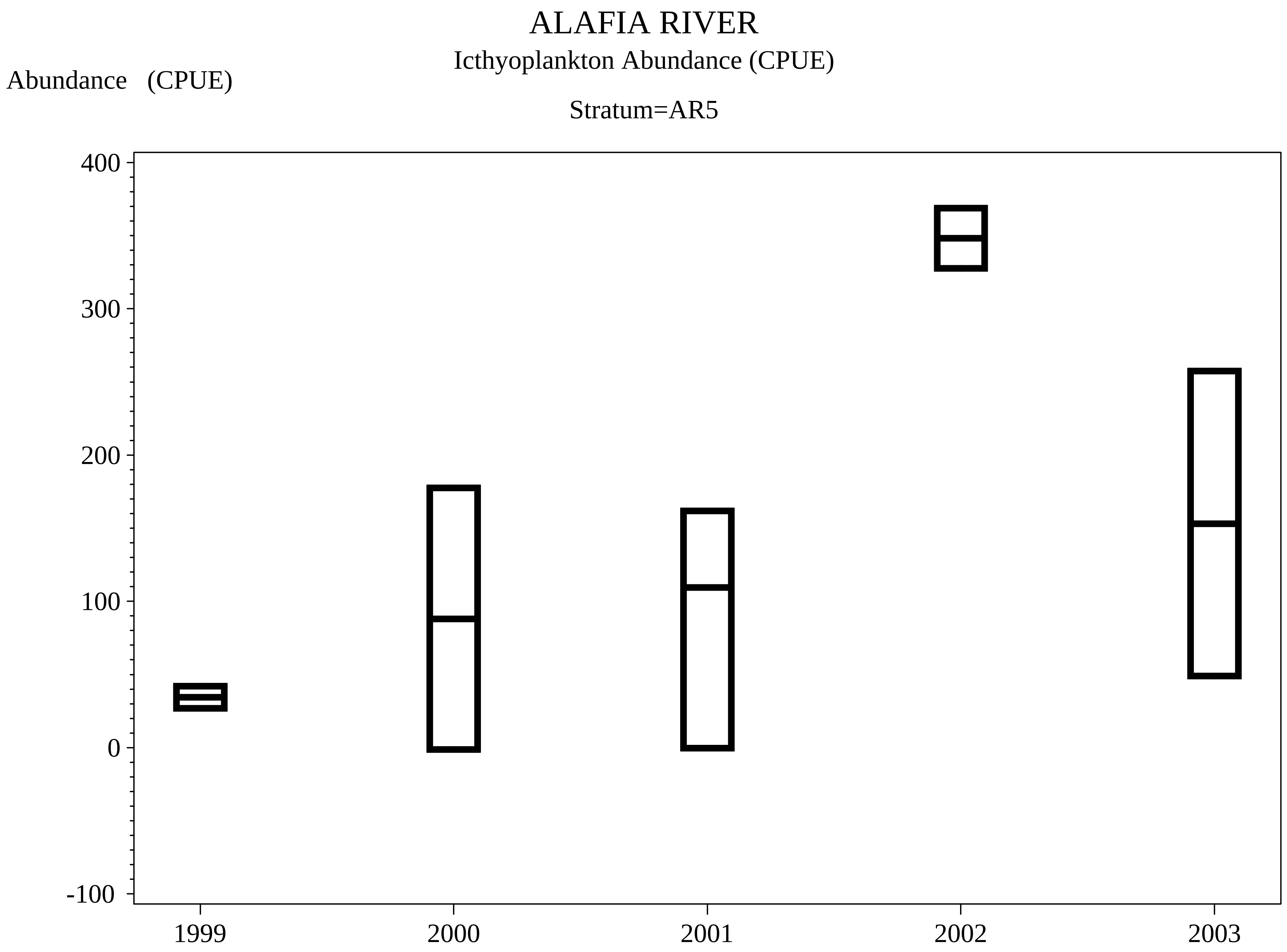

ALAFIA RIVER
Icthyoplankton Abundance (CPUE)
Abundance (CPUE)
Stratum=AR3
600
500
400
300
200
100
0
1999
2000
2001
2002
2003

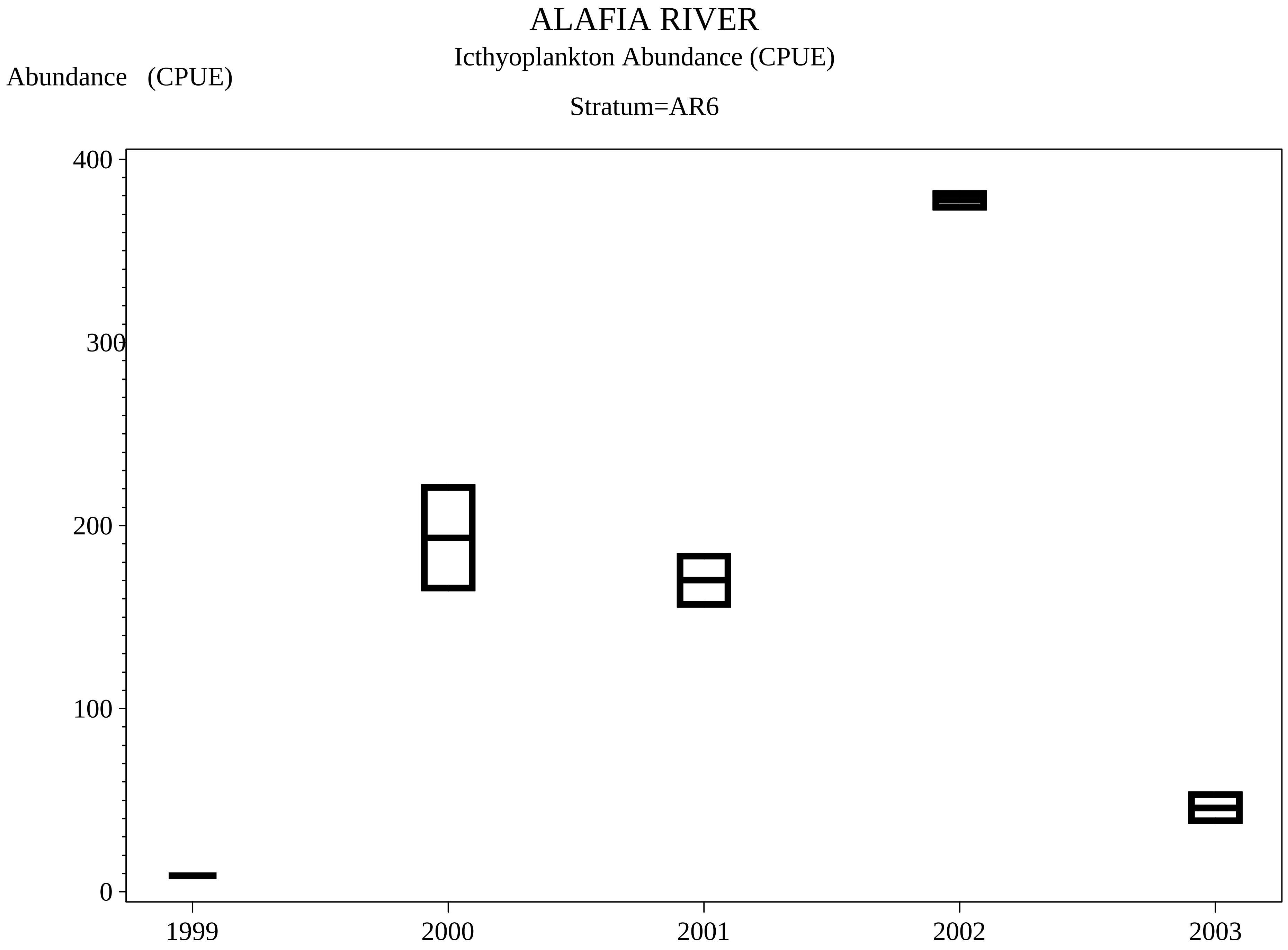
ALAFIA RIVER

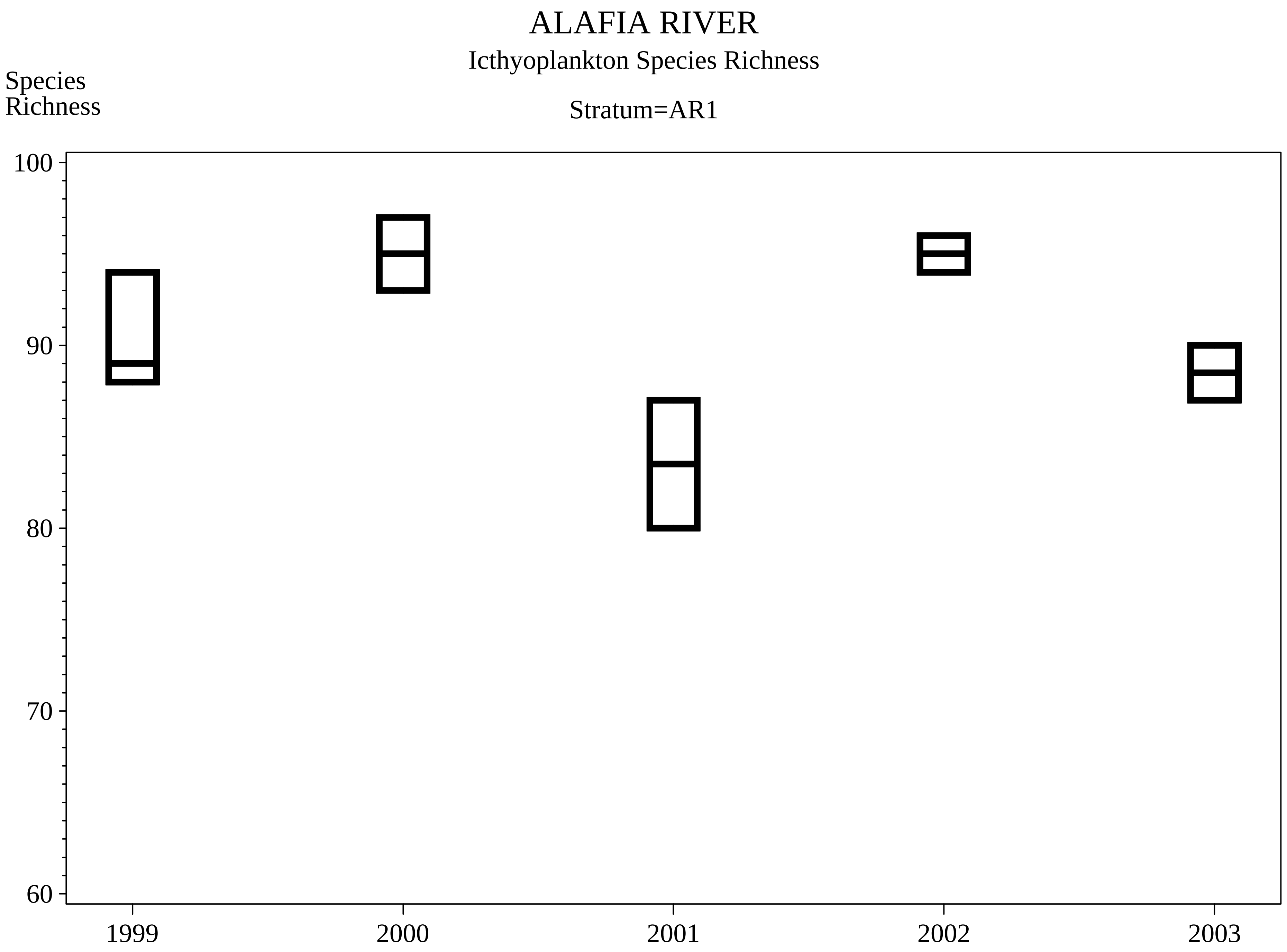
Icthyoplankton Abundance (CPUE)

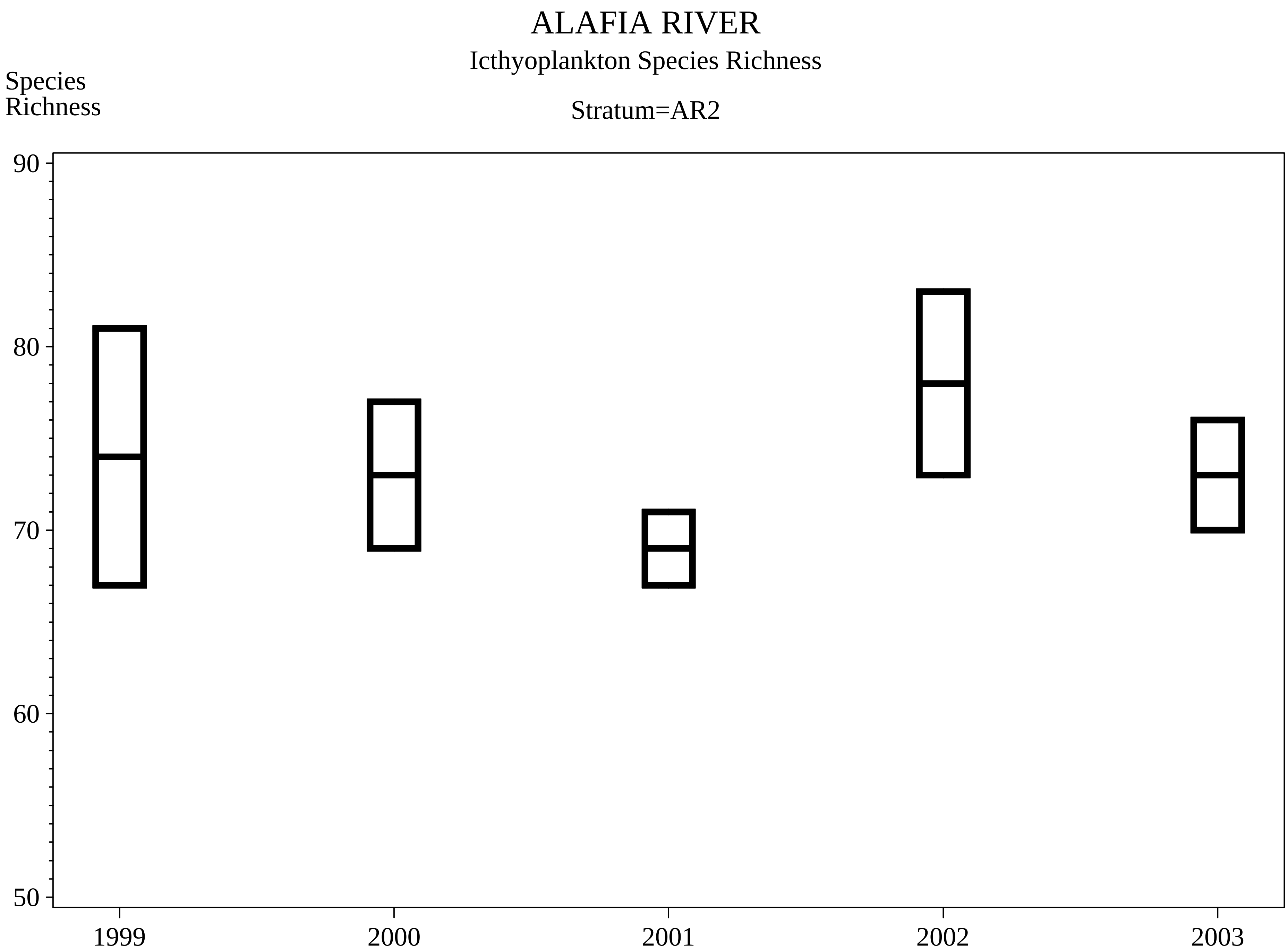
Stratum=AR4

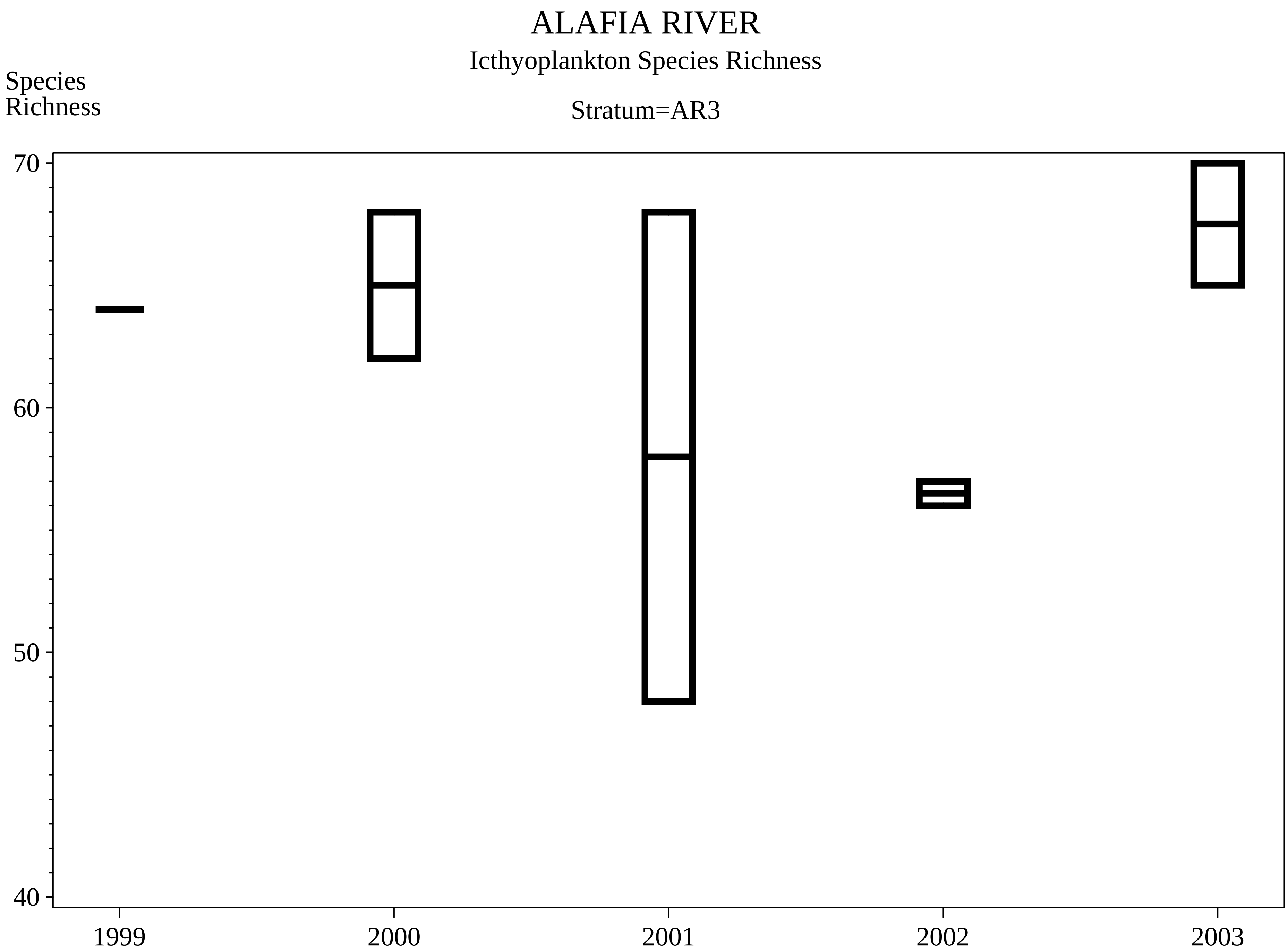



ALAFIA RIVER
Icthyoplankton Abundance (CPUE)
Abundance (CPUE)
Stratum=AR5
400
300
200
100
0
-100
1999
2000
2001
2002
2003

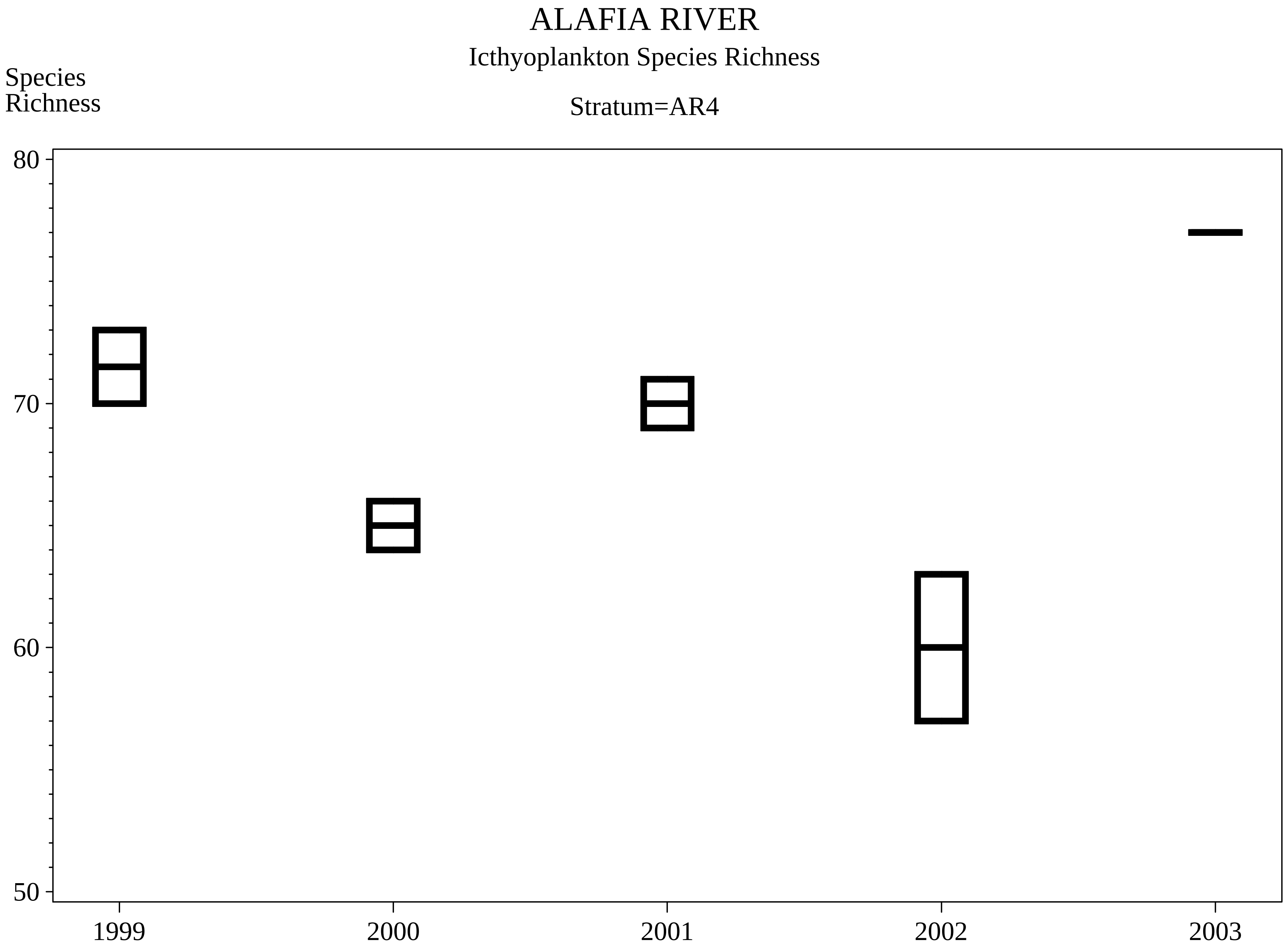

ALAFIA RIVER
Icthyoplankton Abundance (CPUE)
Abundance (CPUE)
Stratum=AR6
400
300
200
100
0
1999
2000
2001
2002
2003


ALAFIA RIVER
Icthyoplankton Species Richness
Species
Richness
Stratum=AR1
100
90
80
70
60
1999
2000
2001
2002
2003


ALAFIA RIVER
Icthyoplankton Species Richness
Stratum=AR2
Species
Richness
90
80
70
60
50
1999
2000
2001
2002
2003



ALAFIA RIVER
Icthyoplankton Species Richness
Stratum=AR3
Species Richness
70
60
50
40
1999
2000
2001
2002
2003

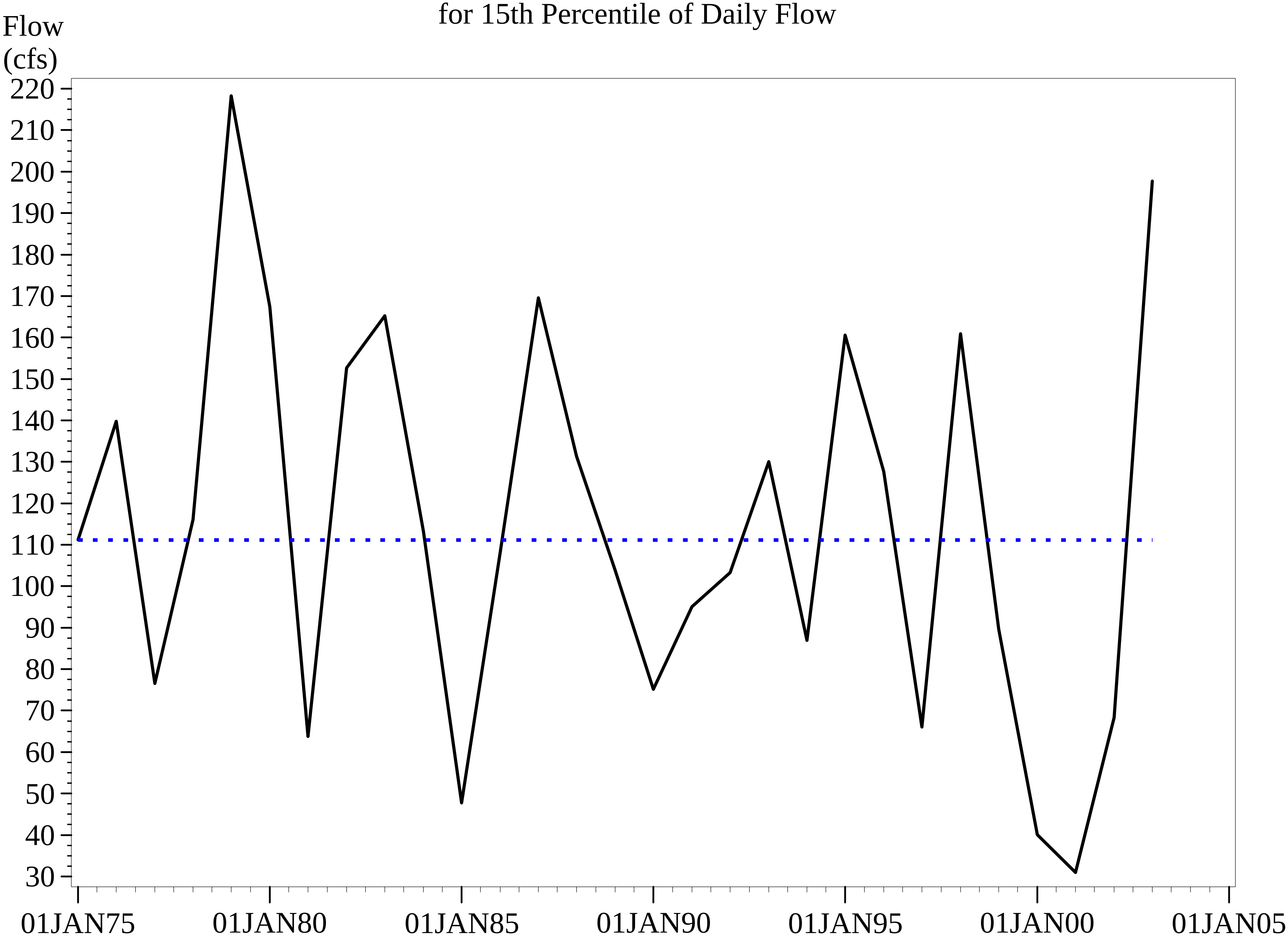

ALAFIA RIVER
Icthyoplankton Species Richness
Stratum=AR4
Species
Richness
80
70
60
50
1999
2000
2001
2002
2003


ALAFIA RIVER
Icthyoplankton Species Richness
Species
Richness
Stratum=AR5
80
70
60
50
40
30
20
1999
2000
2001
2002
2003

ALAFIA RIVER
Icthyoplankton Species Richness
Stratum=AR6
Species
Richness
80
70
60
50
40
1999
2000
2001
2002
2003

APPENDIX F:
FLOW TREND ANALYSIS

Alafia River at Bell Shoals 1975-2003 Trends Appendix
Annual Data Time Series with Trend Line
for 15th Percentile of Daily Flow



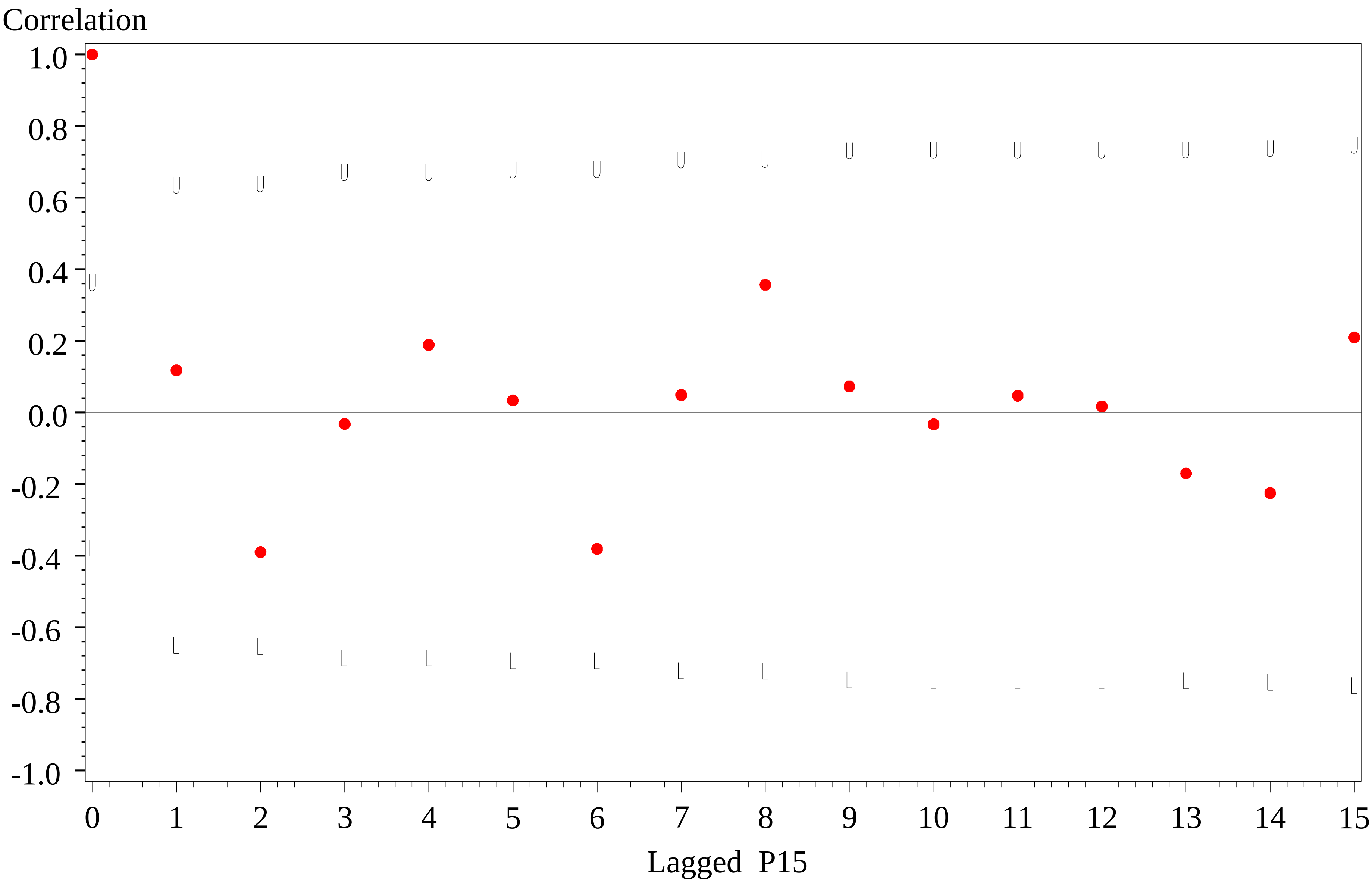
Alafia River at Bell Shoals 1975-2003 Trends Appendix

Autocorrelation Statistics for 15th Percentile of Daily Flow

Unadjusted for Seasonal Medians

Lagged Flow	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.186	0.371	-0.371
1	0.118	0.322	0.643	-0.643
2	-0.390	0.323	0.646	-0.646
3	-0.032	0.339	0.678	-0.678
4	0.189	0.339	0.678	-0.678
5	0.034	0.343	0.685	-0.685
6	-0.381	0.343	0.686	-0.686
7	0.049	0.357	0.714	-0.714
8	0.357	0.357	0.715	-0.715
9	0.073	0.369	0.739	-0.739
10	-0.033	0.370	0.740	-0.740
11	0.047	0.370	0.740	-0.740
12	0.017	0.370	0.740	-0.740
13	-0.170	0.370	0.741	-0.741
14	-0.225	0.373	0.746	-0.746
15	0.210	0.378	0.755	-0.755

Alafia River at Bell Shoals 1975-2003 Trends Appendix
Correlogram for 15th Percentile of Daily Flow
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

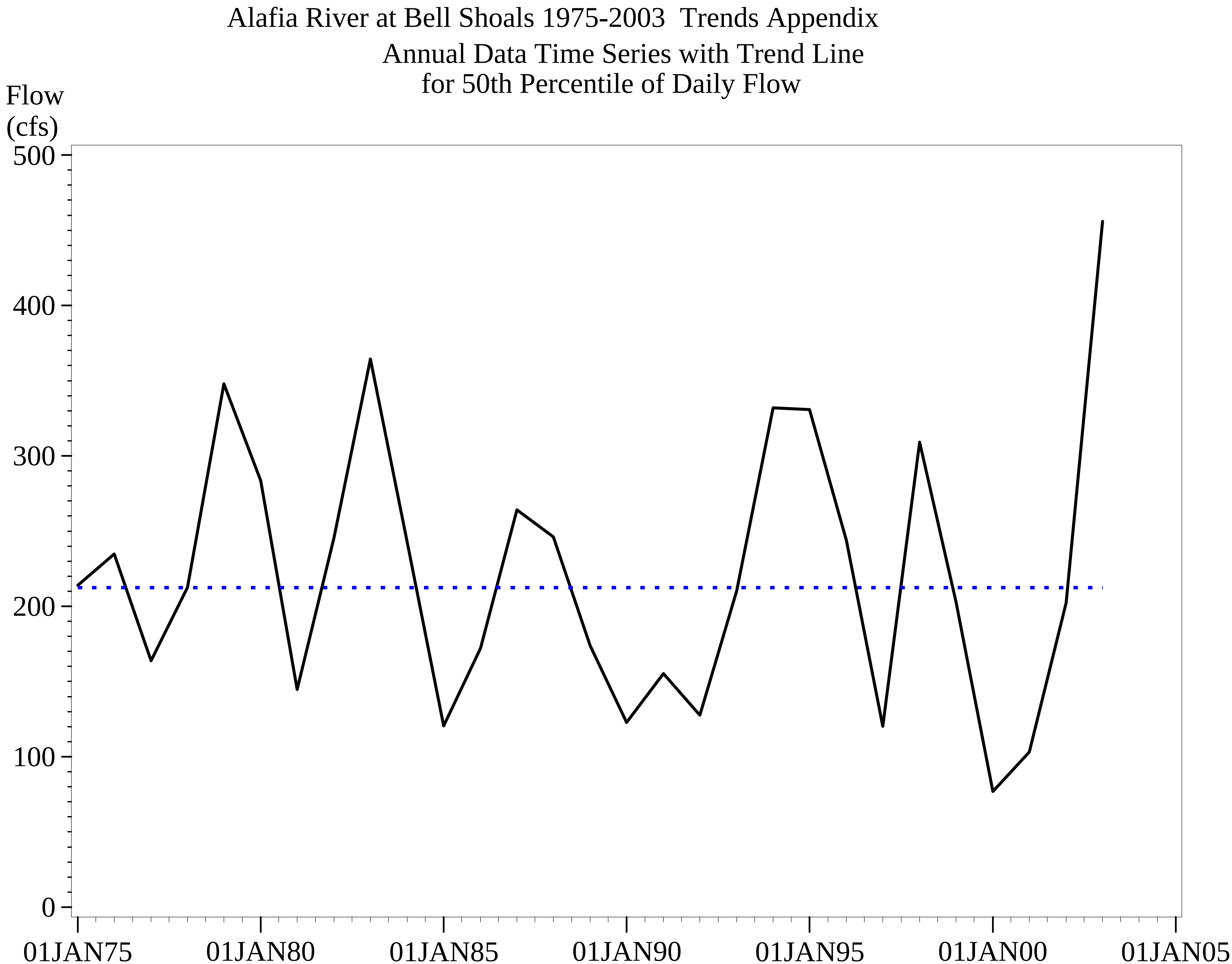
Alafia River at Bell Shoals 1975-2003 Trends Appendix

Kendall Tau Trend Test Statistics

for 15th Percentile of Daily Flow

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.202	0.129	0.129	-1.579


Alafia River at Bell Shoals 1975-2003 Trends Appendix
Annual Data Time Series with Trend Line
for 50th Percentile of Daily Flow
Flow
(cfs)
500
400
300
200
100
0
01JAN75
01JAN80
01JAN85
01JAN90
01JAN95
01JAN00
01JAN05

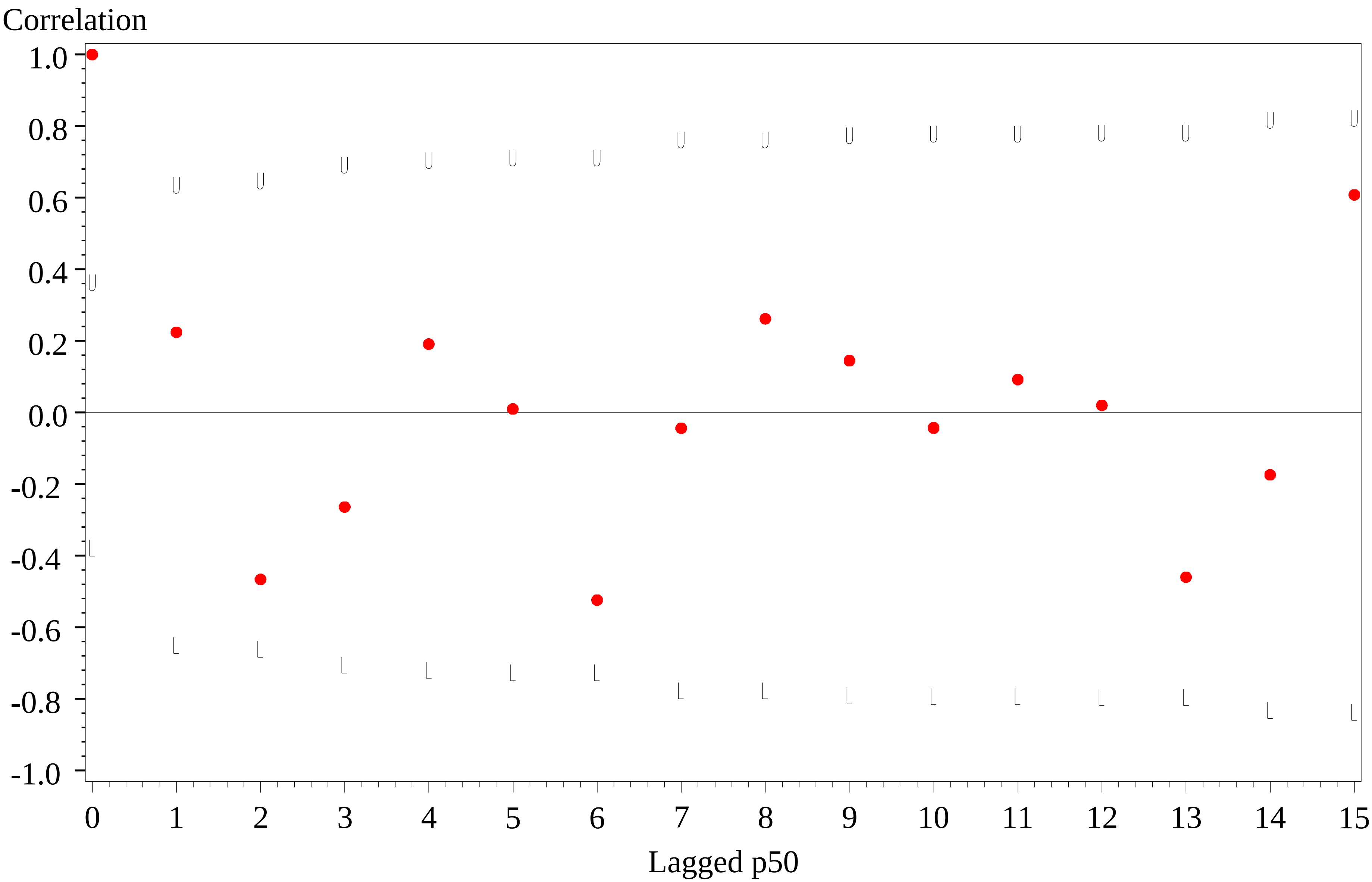
Alafia River at Bell Shoals 1975-2003 Trends Appendix

Autocorrelation Statistics for 50th Percentile of Daily Flow

Unadjusted for Seasonal Medians

Lagged Flow	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.186	0.371	-0.371
1	0.224	0.322	0.643	-0.643
2	-0.466	0.327	0.654	-0.654
3	-0.264	0.349	0.698	-0.698
4	0.191	0.356	0.712	-0.712
5	0.010	0.359	0.719	-0.719
6	-0.524	0.359	0.719	-0.719
7	-0.044	0.385	0.770	-0.770
8	0.262	0.385	0.770	-0.770
9	0.145	0.391	0.782	-0.782
10	-0.043	0.393	0.786	-0.786
11	0.092	0.393	0.786	-0.786
12	0.020	0.394	0.788	-0.788
13	-0.460	0.394	0.788	-0.788
14	-0.174	0.412	0.824	-0.824
15	0.608	0.415	0.829	-0.829

Alafia River at Bell Shoals 1975-2003 Trends Appendix
Correlogram for 50th Percentile of Daily Flow
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals 1975-2003 Trends Appendix

Kendall Tau Trend Test Statistics

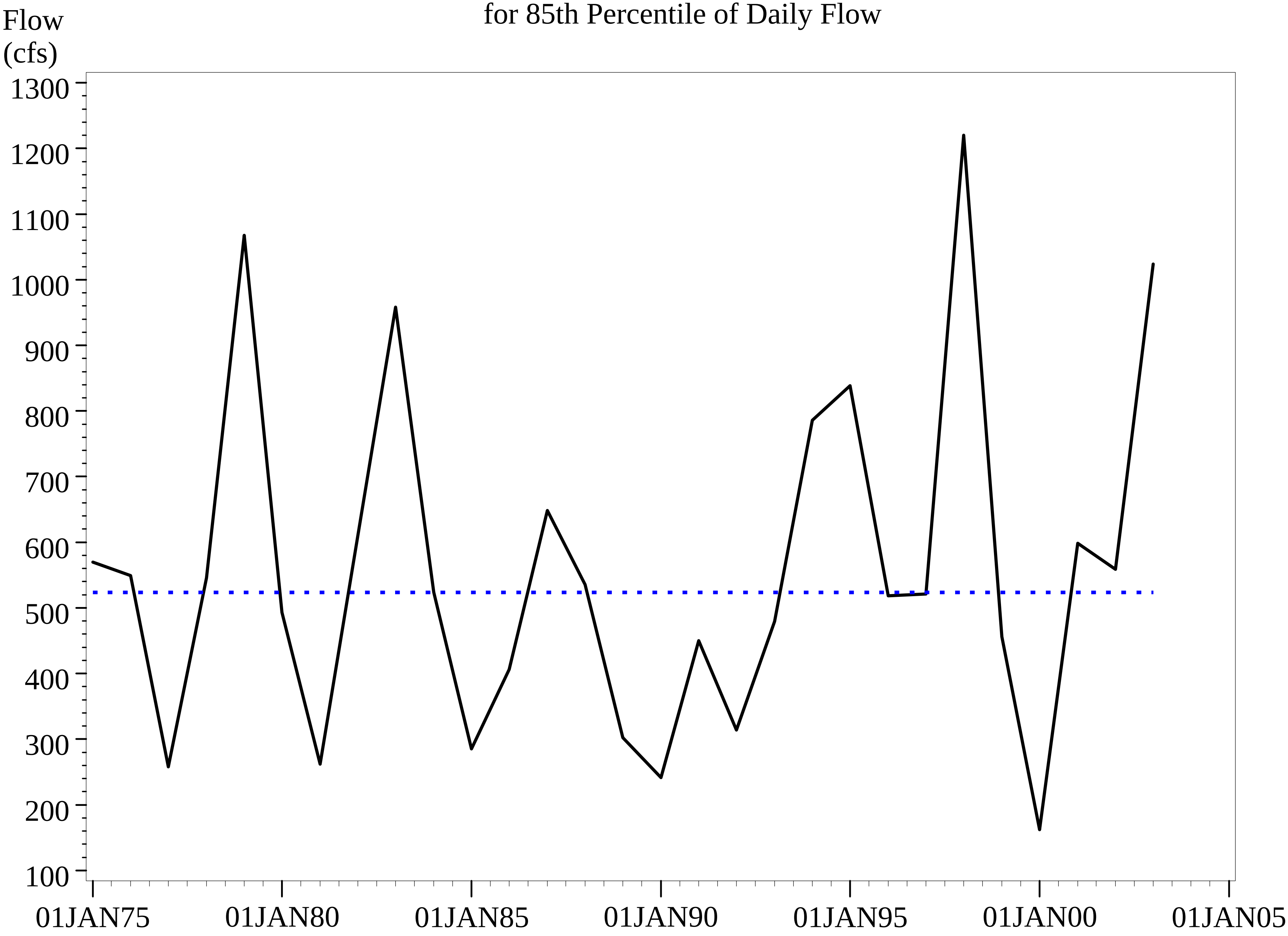
for 50th Percentile of Daily Flow

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.103	0.442	0.442	-1.426

Alafia River at Bell Shoals 1975-2003 Trends Appendix

Annual Data Time Series with Trend Line
for 85th Percentile of Daily Flow



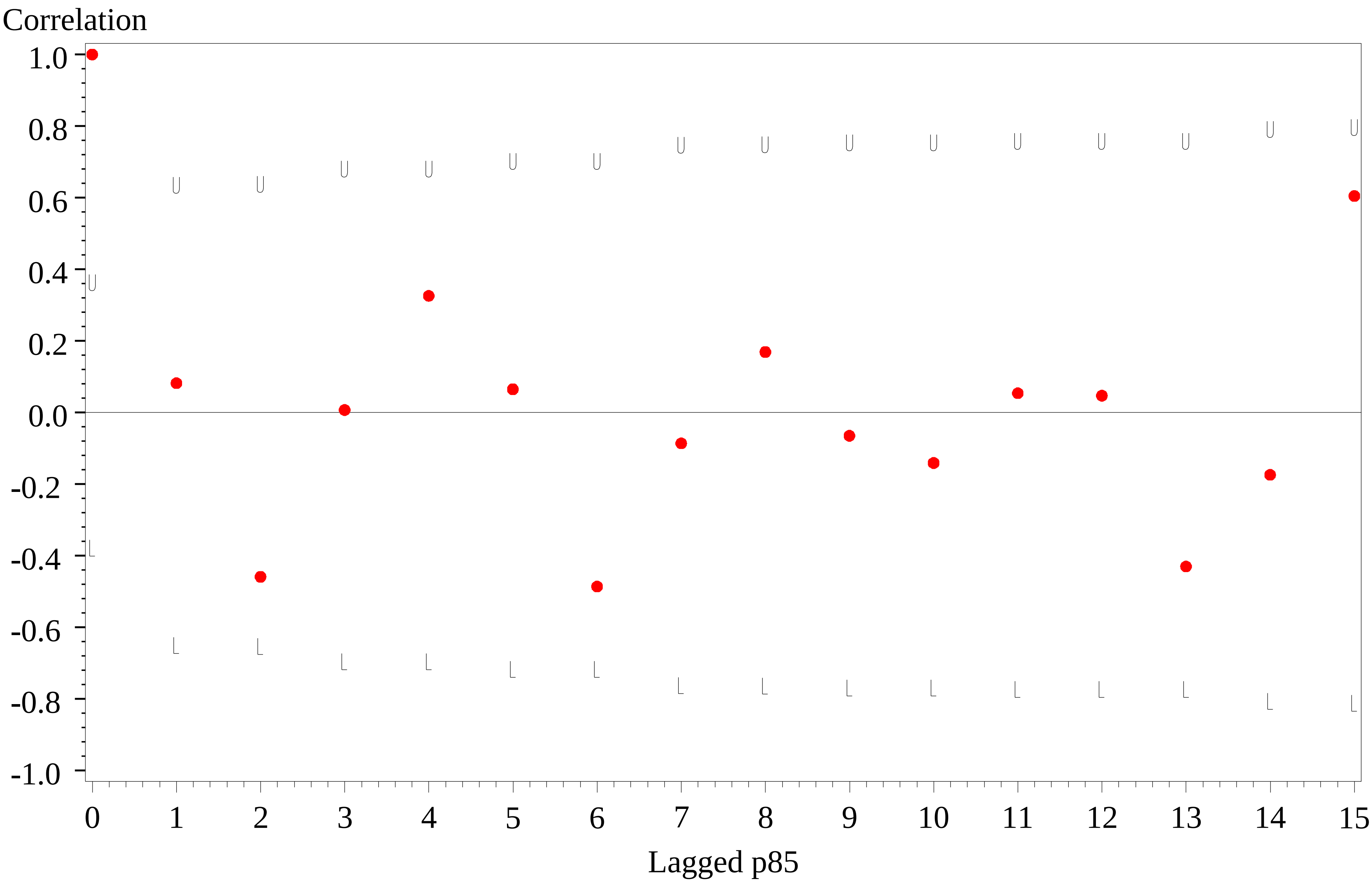
Alafia River at Bell Shoals 1975-2003 Trends Appendix

Autocorrelation Statistics for 85th Percentile of Daily Flow

Unadjusted for Seasonal Medians

Lagged Flow	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.186	0.371	-0.371
1	0.082	0.322	0.643	-0.643
2	-0.459	0.322	0.645	-0.645
3	0.007	0.344	0.688	-0.688
4	0.326	0.344	0.688	-0.688
5	0.065	0.355	0.709	-0.709
6	-0.486	0.355	0.710	-0.710
7	-0.086	0.377	0.755	-0.755
8	0.169	0.378	0.756	-0.756
9	-0.065	0.381	0.761	-0.761
10	-0.141	0.381	0.762	-0.762
11	0.054	0.383	0.765	-0.765
12	0.047	0.383	0.766	-0.766
13	-0.430	0.383	0.766	-0.766
14	-0.174	0.400	0.799	-0.799
15	0.605	0.402	0.804	-0.804

Alafia River at Bell Shoals 1975-2003 Trends Appendix
Correlogram for 85th Percentile of Daily Flow
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals 1975-2003 Trends Appendix

Kendall Tau Trend Test Statistics

for 85th Percentile of Daily Flow

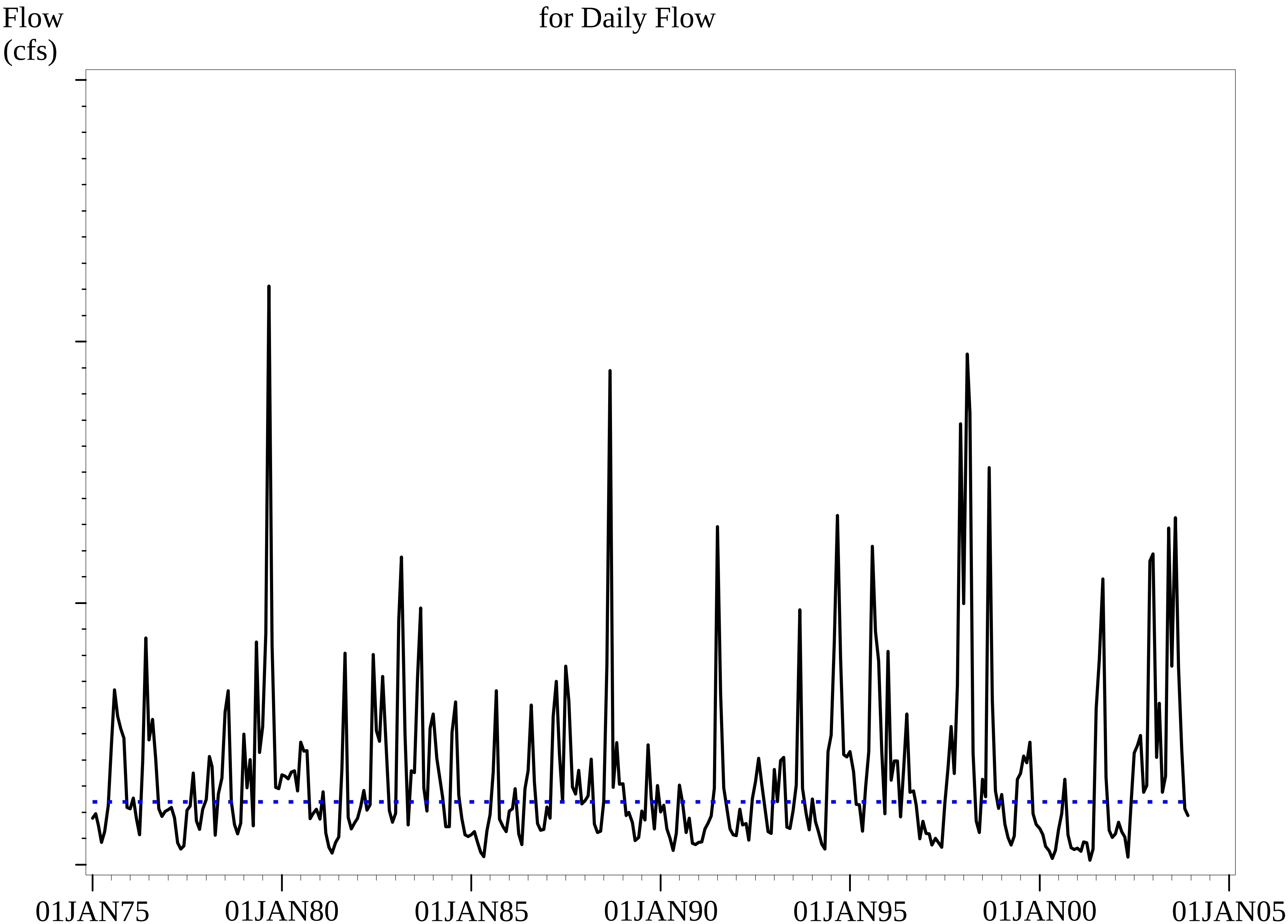
Unadjusted for Seasonal Medians

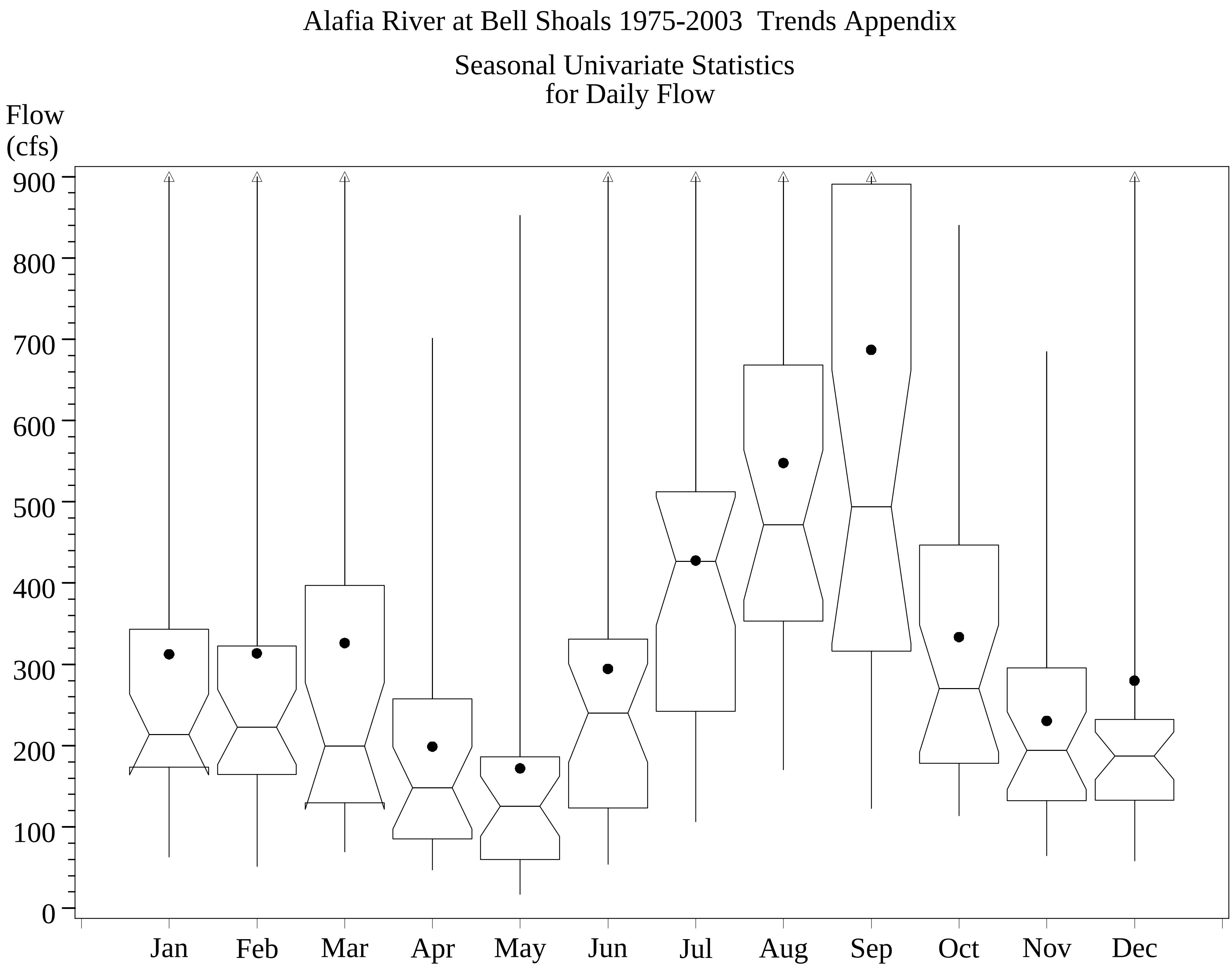
Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.064	0.639	0.639	2.91

Alafia River at Bell Shoals 1975-2003 Trends Appendix

Daily Data Time Series with Trend Line

for Daily Flow




Alafia River at Bell Shoals 1975-2003 Trends Appendix
Seasonal Univariate Statistics
for Daily Flow
Flow
(cfs)
900
800
700
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

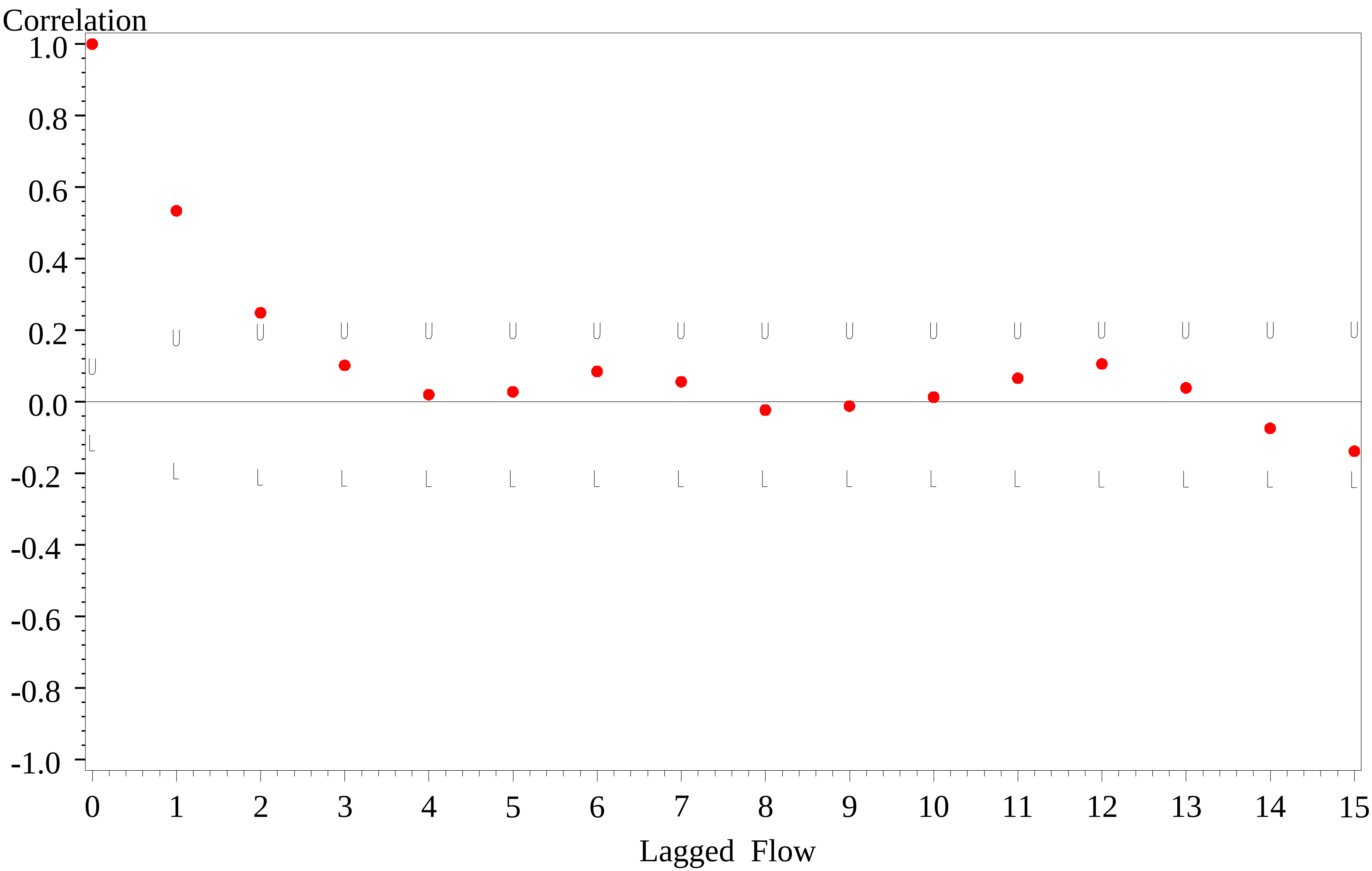
Alafia River at Bell Shoals 1975-2003 Trends Appendix

Autocorrelation Statistics for Daily Flow

Unadjusted for Seasonal Medians

Lagged Flow	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.534	0.093	0.186	-0.186
2	0.249	0.101	0.203	-0.203
3	0.102	0.103	0.206	-0.206
4	0.020	0.103	0.207	-0.207
5	0.028	0.103	0.207	-0.207
6	0.085	0.103	0.207	-0.207
7	0.056	0.104	0.207	-0.207
8	-0.023	0.104	0.207	-0.207
9	-0.012	0.104	0.207	-0.207
10	0.013	0.104	0.207	-0.207
11	0.066	0.104	0.207	-0.207
12	0.106	0.104	0.208	-0.208
13	0.039	0.104	0.208	-0.208
14	-0.074	0.104	0.208	-0.208
15	-0.138	0.104	0.209	-0.209

Alafia River at Bell Shoals 1975-2003 Trends Appendix
Correlogram for Daily Flow
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals 1975-2003 Trends Appendix

Kendall Tau Trend Test Statistics

for Daily Flow

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.036	0.349	0.668	-0.763

Alafia River at Bell Shoals 1975-2003 Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Daily Flow

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.035714	0.34887	0.66791	-0.76288

Alafia River at Bell Shoals 1975-2003 Trends Appendix

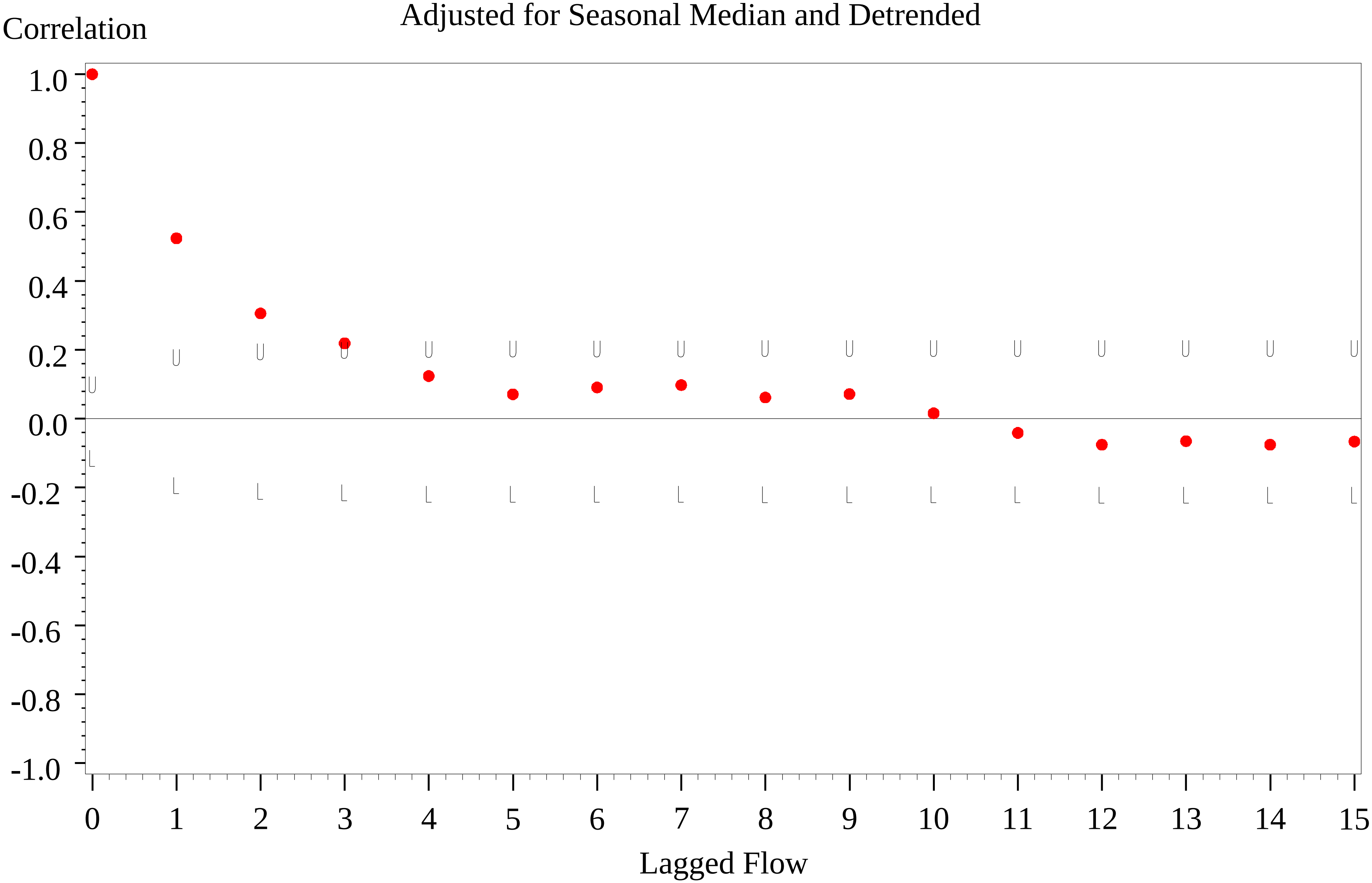
Autocorrelation Statistics for Daily Flow

Adjusted for Seasonal Median and Detrended

Lagged Flow	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.524	0.093	0.186	-0.186
2	0.306	0.101	0.202	-0.202
3	0.219	0.104	0.207	-0.207
4	0.124	0.105	0.210	-0.210
5	0.071	0.105	0.211	-0.211
6	0.091	0.106	0.211	-0.211
7	0.098	0.106	0.211	-0.211
8	0.062	0.106	0.212	-0.212
9	0.072	0.106	0.212	-0.212
10	0.016	0.106	0.212	-0.212
11	-0.041	0.106	0.212	-0.212
12	-0.075	0.106	0.213	-0.213
13	-0.065	0.106	0.213	-0.213
14	-0.075	0.107	0.213	-0.213
15	-0.066	0.107	0.213	-0.213

Alafia River at Bell Shoals 1975-2003 Trends Appendix
Correlogram for Daily Flow

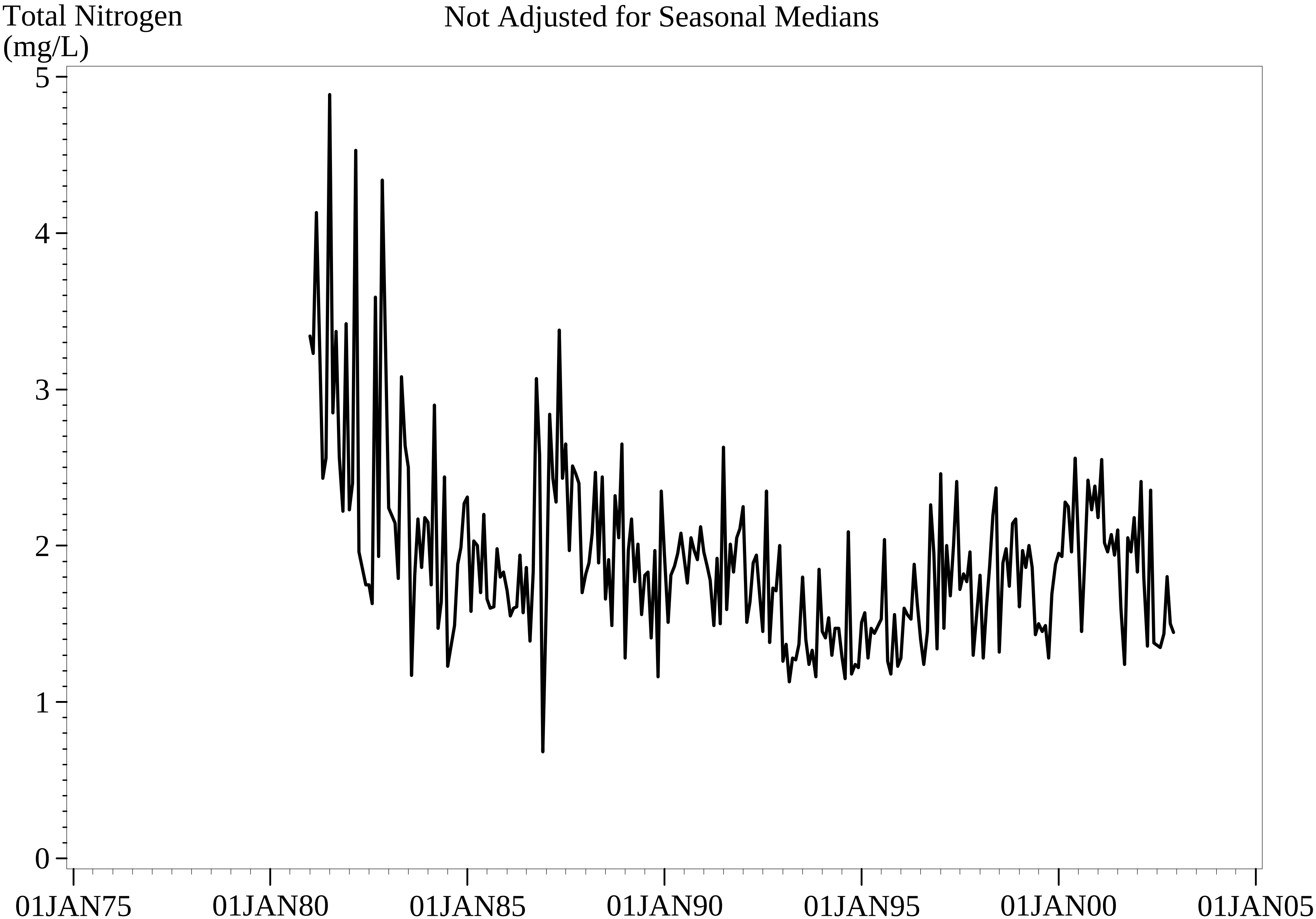
Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

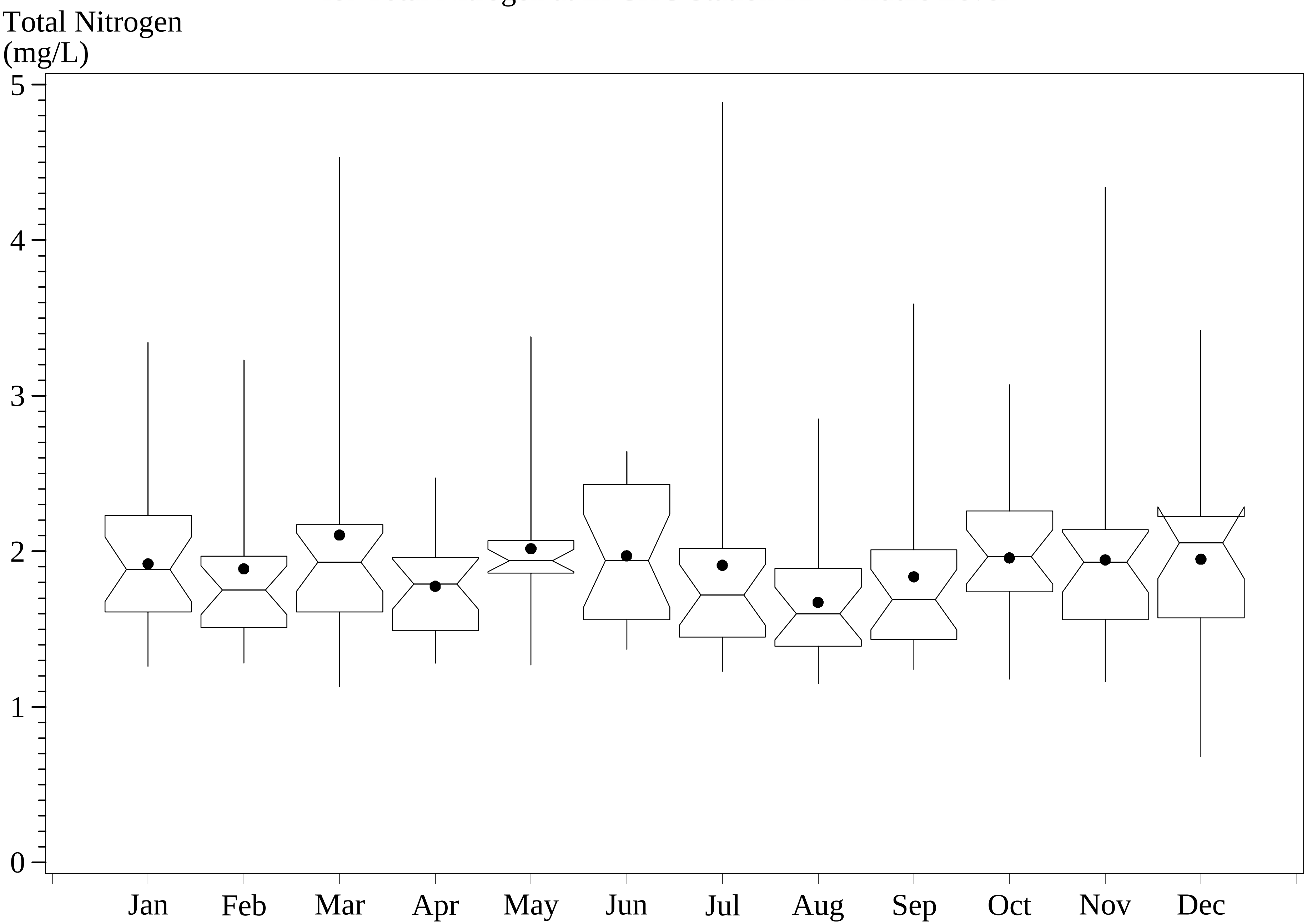
APPENDIX G:
NUTRIENT TREND RESULTS

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Total Nitrogen at EPCHC Station 114 Middle Level

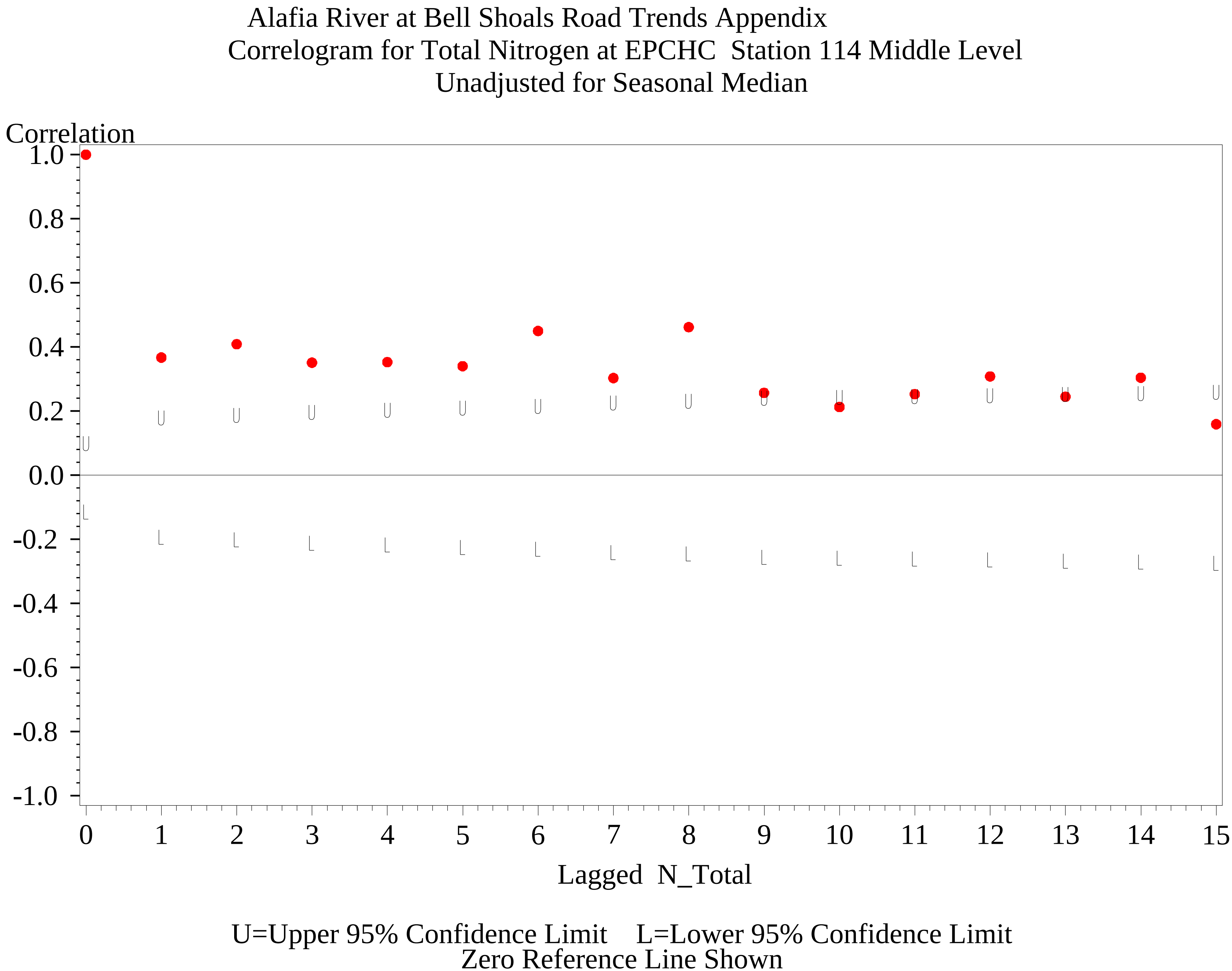


Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Total Nitrogen at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Lagged N_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.367	0.093	0.186	-0.186
2	0.409	0.097	0.194	-0.194
3	0.351	0.102	0.204	-0.204
4	0.353	0.105	0.210	-0.210
5	0.340	0.109	0.217	-0.217
6	0.450	0.112	0.223	-0.223
7	0.303	0.117	0.233	-0.233
8	0.462	0.119	0.238	-0.238
9	0.257	0.124	0.248	-0.248
10	0.213	0.125	0.251	-0.251
11	0.253	0.126	0.253	-0.253
12	0.308	0.128	0.256	-0.256
13	0.245	0.130	0.260	-0.260
14	0.304	0.131	0.263	-0.263
15	0.159	0.133	0.267	-0.267


Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Nitrogen at EPCHC Station 114 Middle Level
Unadjusted for Seasonal Median
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Lagged N_Total
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Total Nitrogen at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.205	0	0.043	-0.02

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Total Nitrogen at EPCHC Station 114 Middle Level

Adjusted for Seasonal Medians

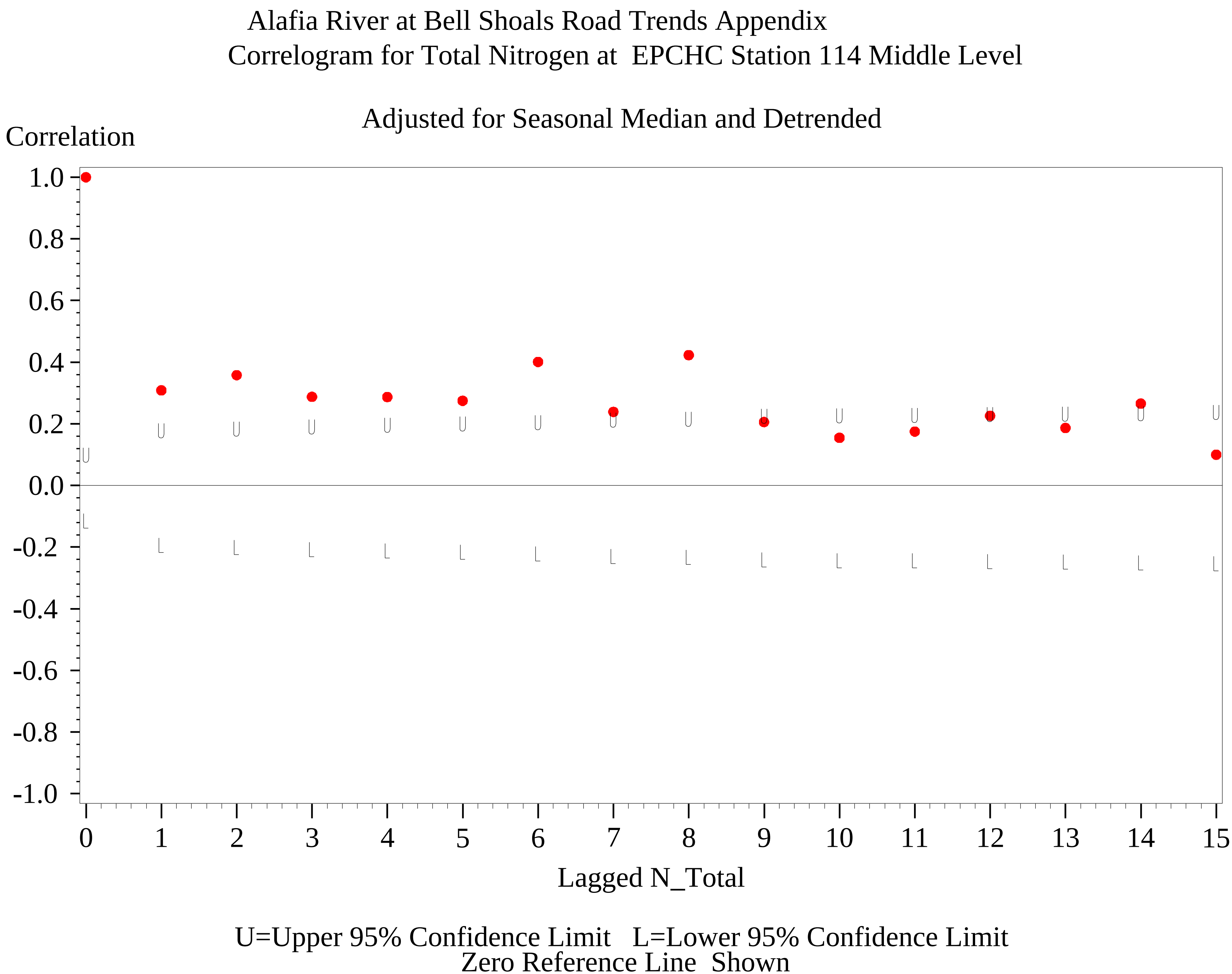
Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.20487	.000005576	0.043453	-0.02

Alafia River at Bell Shoals Road Trends Appendix

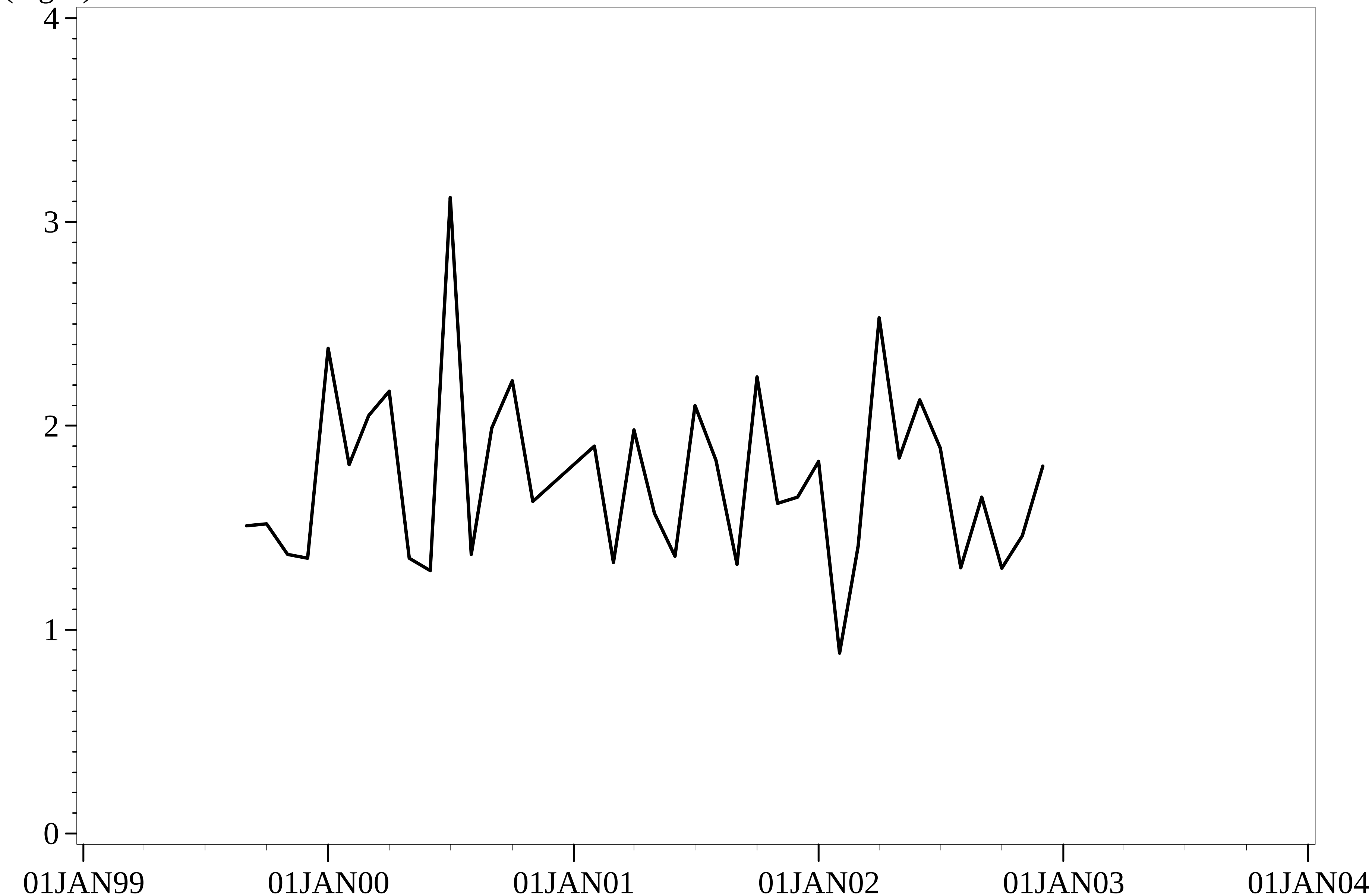
Autocorrelation Statistics for Total Nitrogen at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged N_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.309	0.093	0.186	-0.186
2	0.358	0.096	0.192	-0.192
3	0.288	0.100	0.199	-0.199
4	0.287	0.102	0.204	-0.204
5	0.275	0.104	0.208	-0.208
6	0.401	0.106	0.213	-0.213
7	0.239	0.111	0.221	-0.221
8	0.423	0.112	0.224	-0.224
9	0.206	0.117	0.233	-0.233
10	0.155	0.118	0.235	-0.235
11	0.175	0.118	0.236	-0.236
12	0.226	0.119	0.238	-0.238
13	0.187	0.120	0.240	-0.240
14	0.266	0.121	0.242	-0.242
15	0.100	0.123	0.245	-0.245

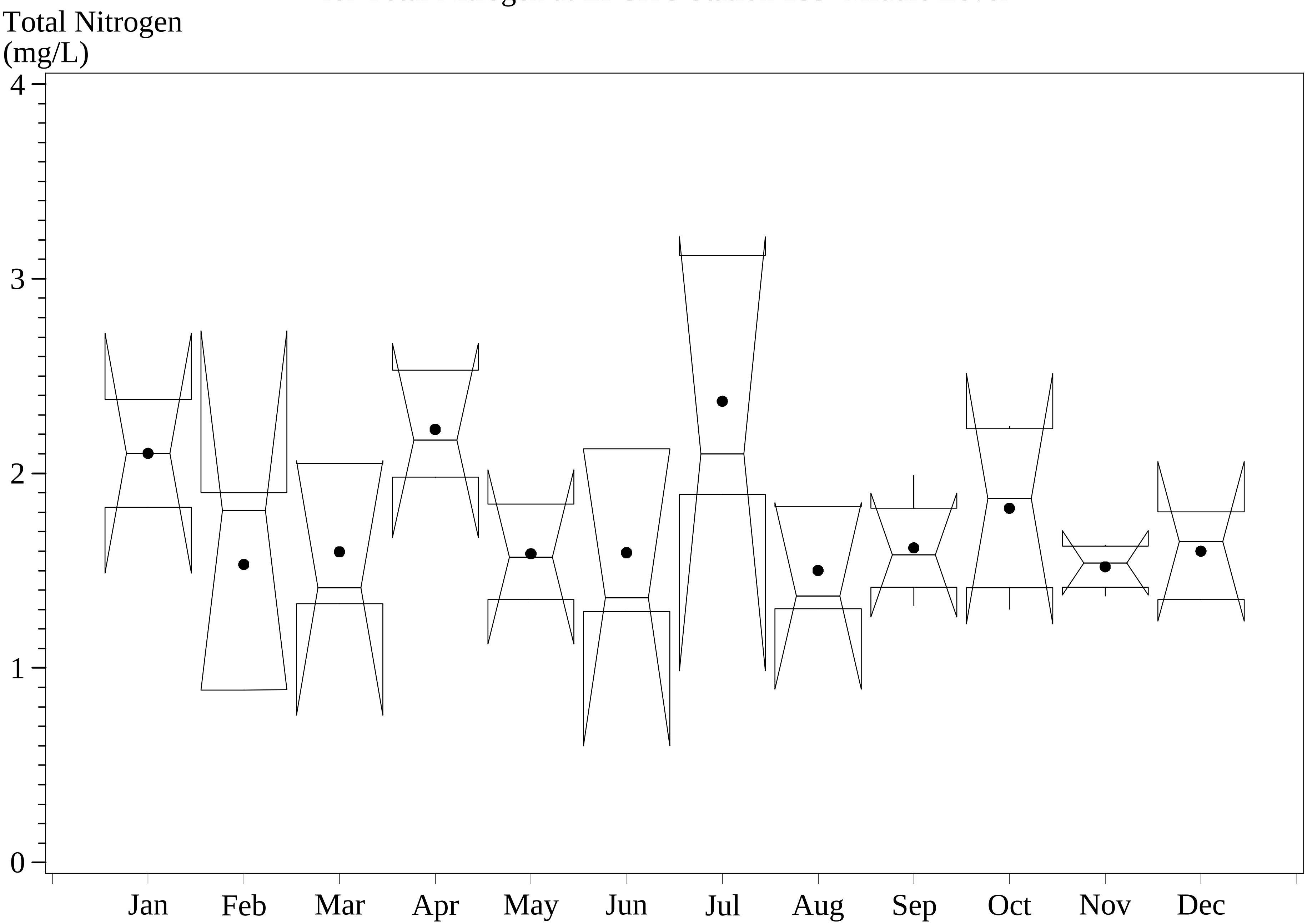

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Nitrogen at EPCHC Station 114 Middle Level
Adjusted for Seasonal Median and Detrended
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Lagged N_Total
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Total Nitrogen at EPCHC Station 153 Middle Level



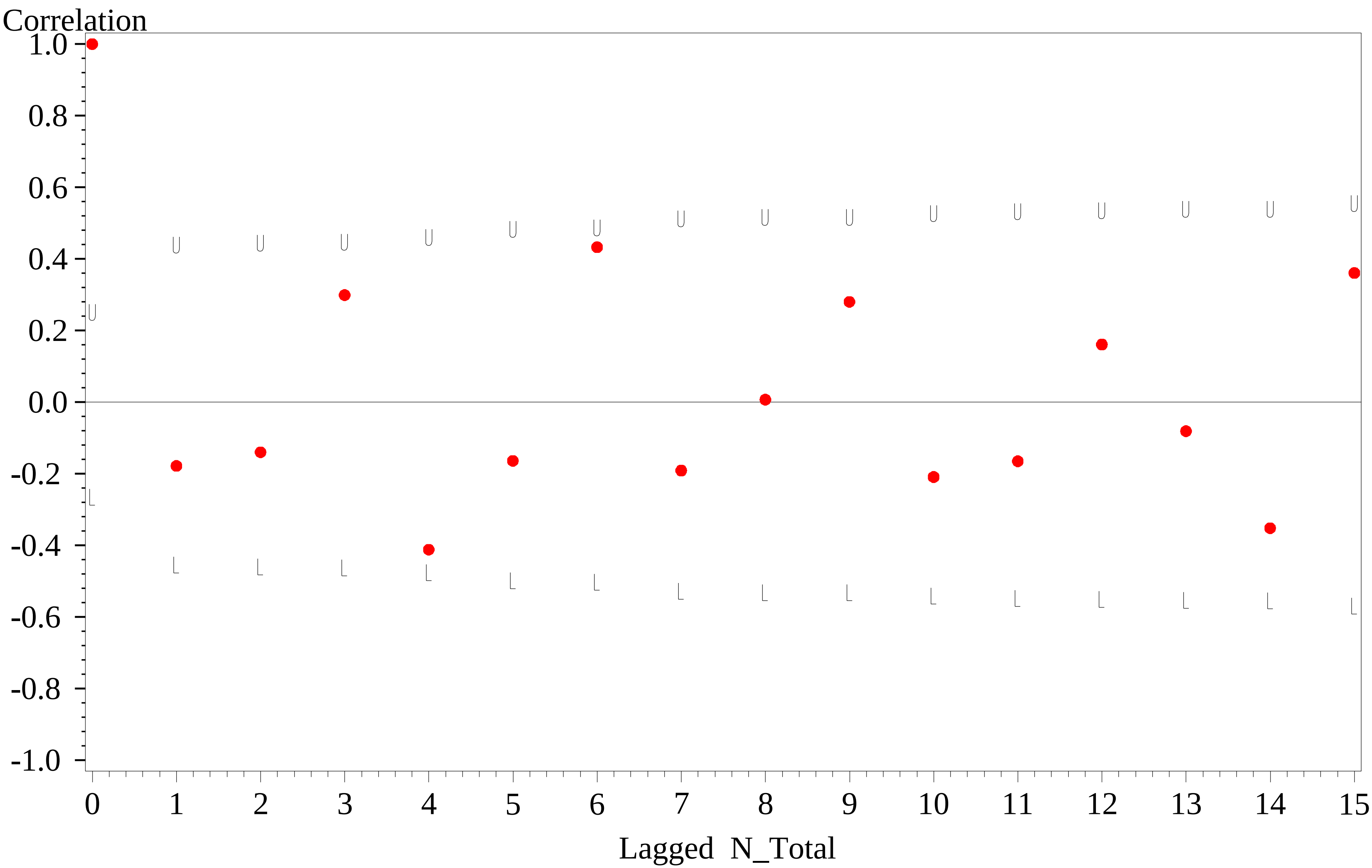
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Total Nitrogen at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged N_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	-0.178	0.224	0.447	-0.447
2	-0.140	0.226	0.452	-0.452
3	0.299	0.227	0.455	-0.455
4	-0.412	0.234	0.468	-0.468
5	-0.164	0.246	0.491	-0.491
6	0.433	0.247	0.495	-0.495
7	-0.191	0.260	0.520	-0.520
8	0.007	0.262	0.524	-0.524
9	0.280	0.262	0.524	-0.524
10	-0.209	0.267	0.534	-0.534
11	-0.165	0.270	0.540	-0.540
12	0.161	0.271	0.543	-0.543
13	-0.081	0.273	0.546	-0.546
14	-0.352	0.273	0.547	-0.547
15	0.361	0.281	0.562	-0.562

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Nitrogen at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Total Nitrogen at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.07	0.79	0.785	0.03

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Total Nitrogen at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.069767	0.78988	0.78485	0.03

Alafia River at Bell Shoals Road Trends Appendix

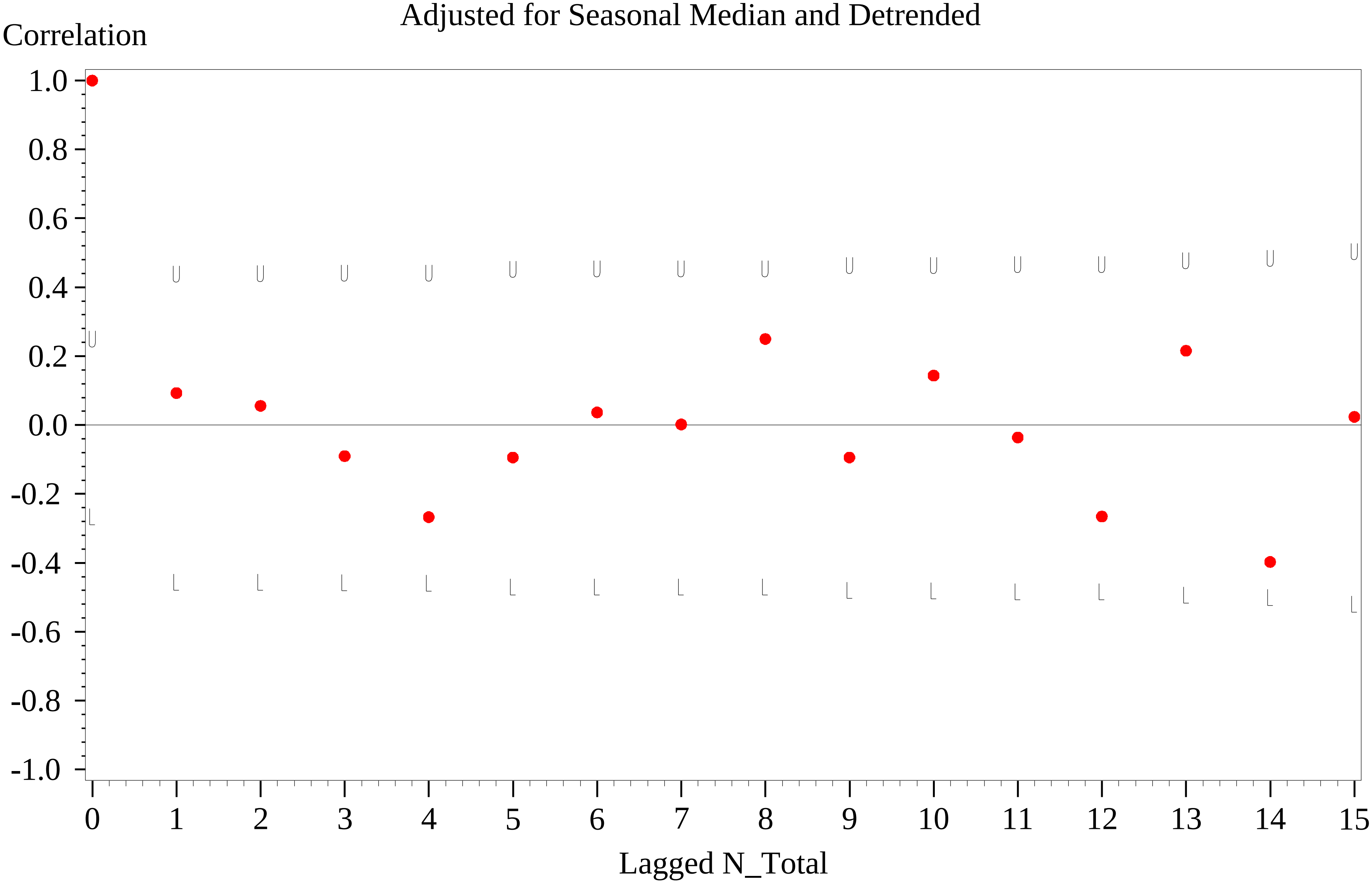
Autocorrelation Statistics for Total Nitrogen at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged N_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.093	0.224	0.447	-0.447
2	0.056	0.224	0.448	-0.448
3	-0.090	0.224	0.449	-0.449
4	-0.267	0.225	0.450	-0.450
5	-0.094	0.230	0.461	-0.461
6	0.037	0.231	0.462	-0.462
7	0.002	0.231	0.462	-0.462
8	0.250	0.231	0.462	-0.462
9	-0.094	0.236	0.471	-0.471
10	0.144	0.236	0.472	-0.472
11	-0.036	0.238	0.475	-0.475
12	-0.265	0.238	0.475	-0.475
13	0.216	0.243	0.485	-0.485
14	-0.397	0.246	0.492	-0.492
15	0.024	0.256	0.512	-0.512

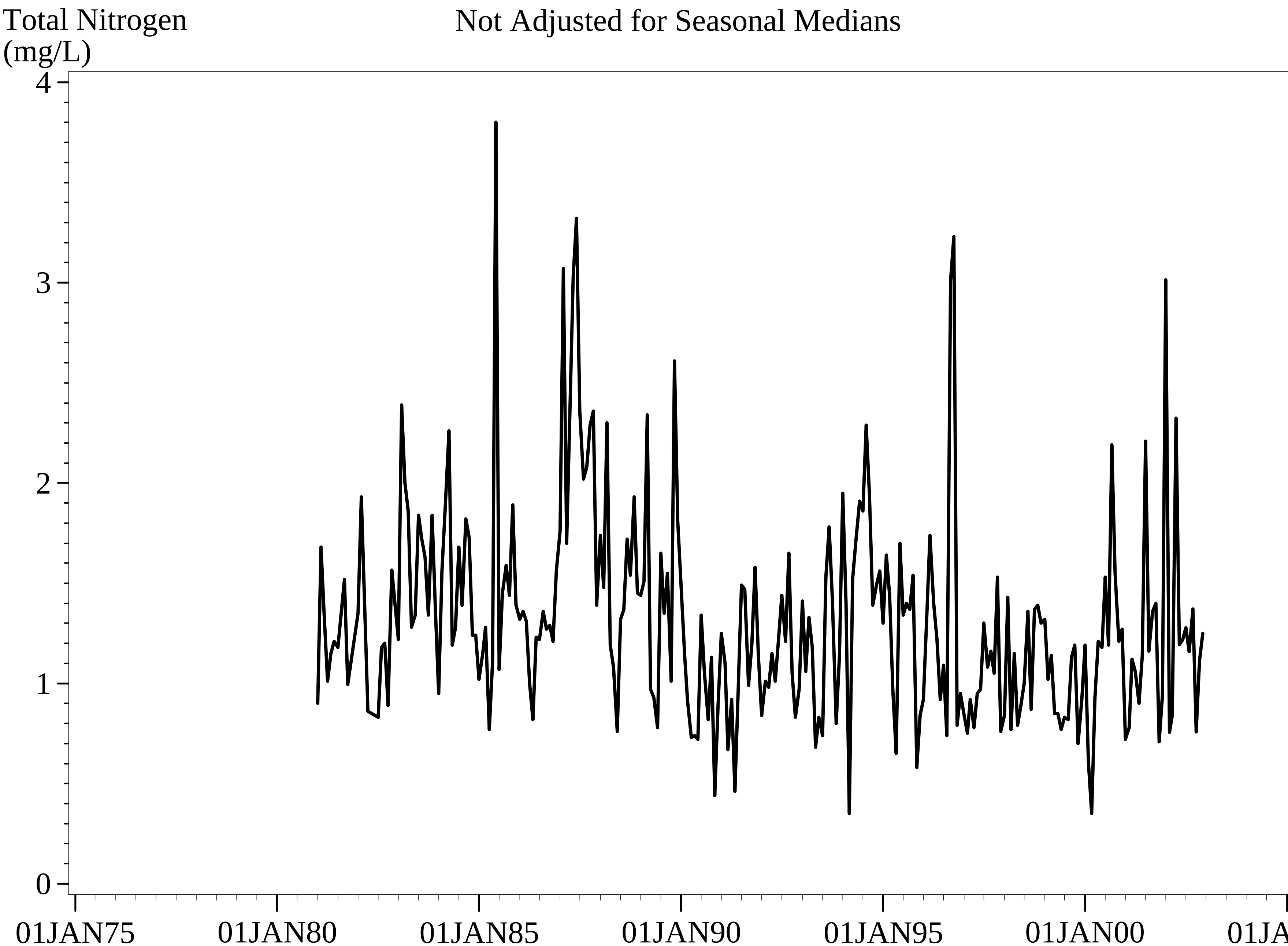
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Nitrogen at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended



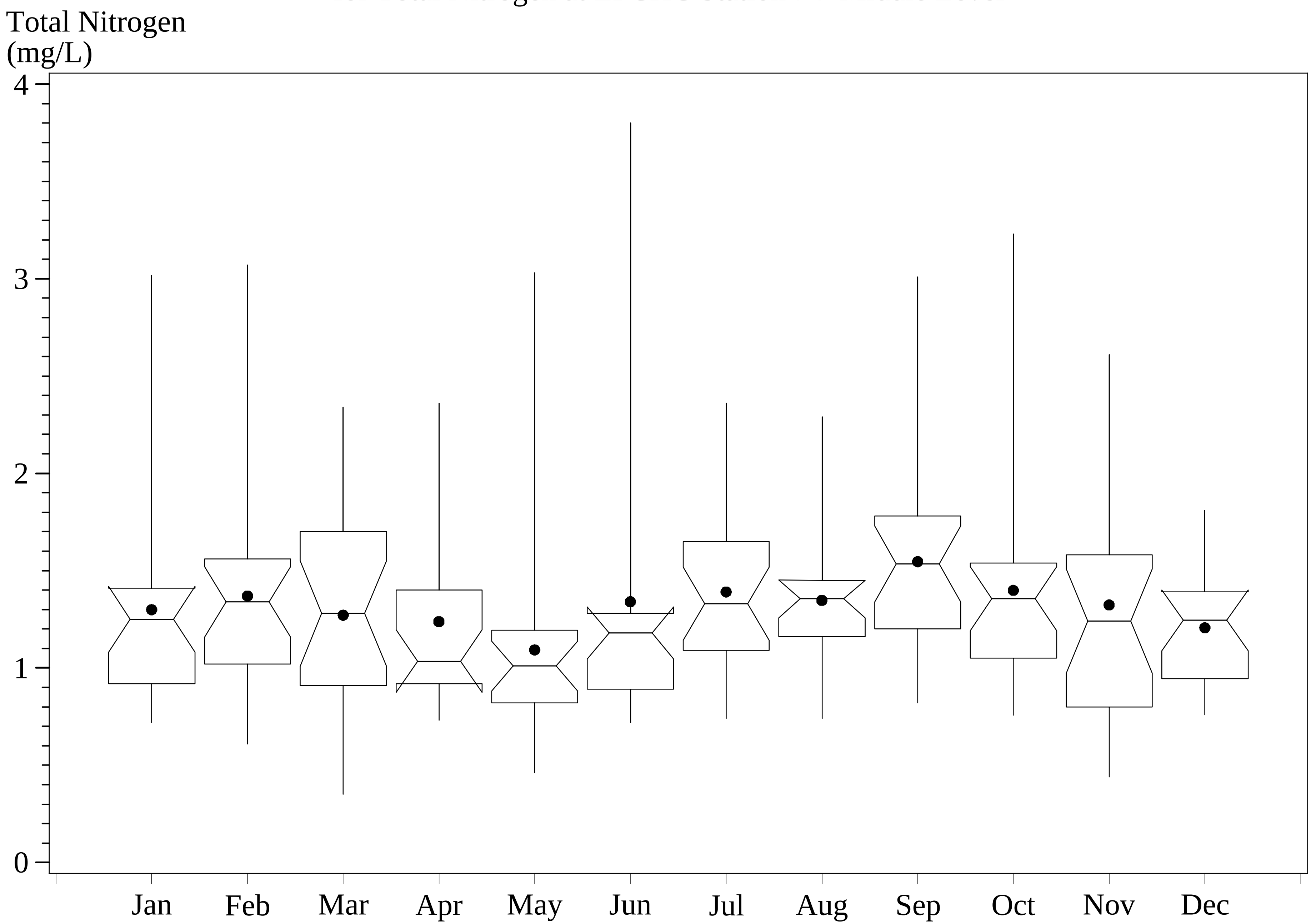
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Total Nitrogen at EPCHC Station 74 Middle Level



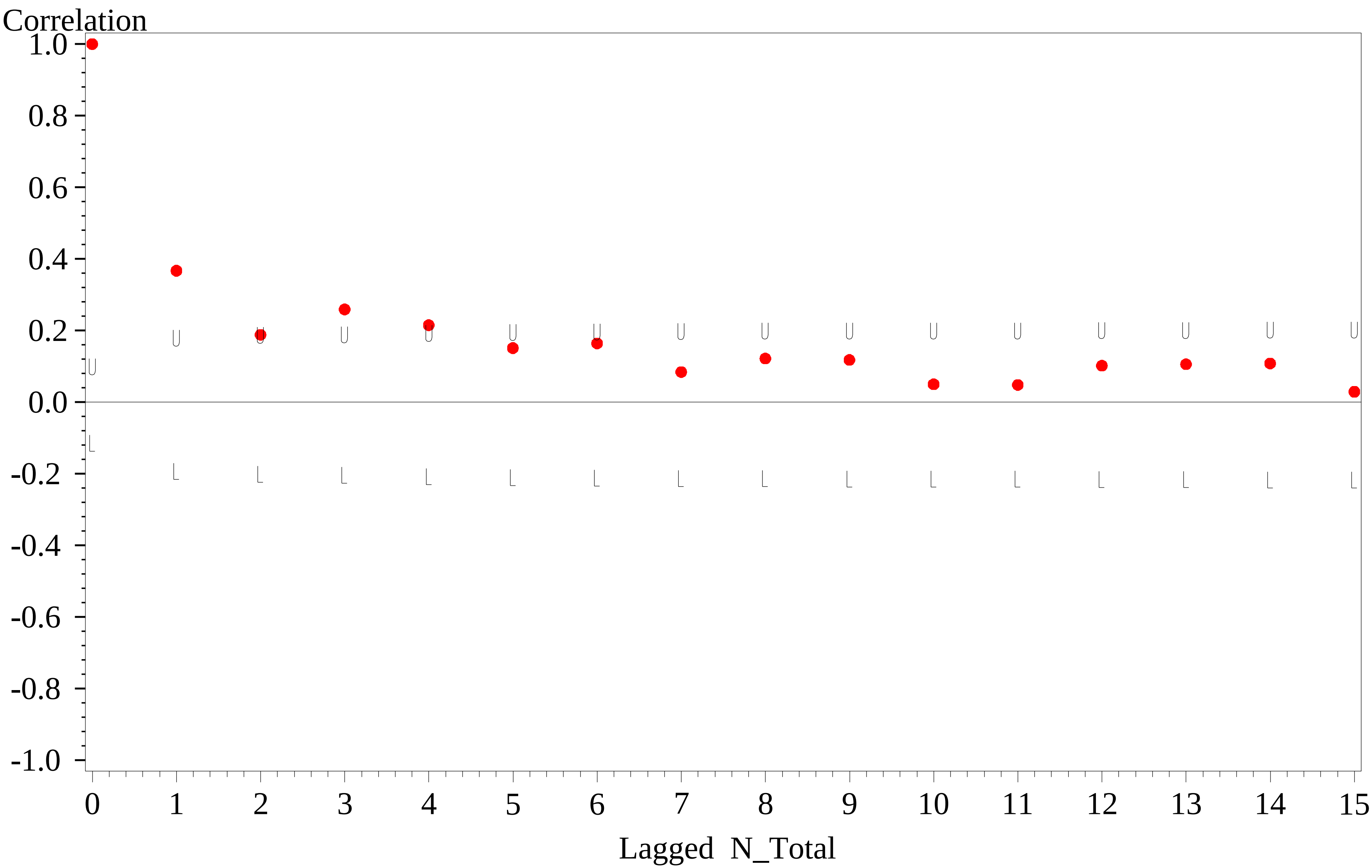
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Total Nitrogen at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged N_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.367	0.093	0.186	-0.186
2	0.188	0.097	0.194	-0.194
3	0.259	0.098	0.196	-0.196
4	0.215	0.100	0.200	-0.200
5	0.151	0.101	0.203	-0.203
6	0.164	0.102	0.204	-0.204
7	0.084	0.103	0.205	-0.205
8	0.122	0.103	0.206	-0.206
9	0.118	0.103	0.207	-0.207
10	0.050	0.104	0.207	-0.207
11	0.048	0.104	0.207	-0.207
12	0.102	0.104	0.208	-0.208
13	0.106	0.104	0.208	-0.208
14	0.108	0.104	0.209	-0.209
15	0.029	0.105	0.209	-0.209

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Nitrogen at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Total Nitrogen at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.182	0	0.05	-0.015

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Total Nitrogen at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.18241	.000052400	0.050202	-0.015

Alafia River at Bell Shoals Road Trends Appendix

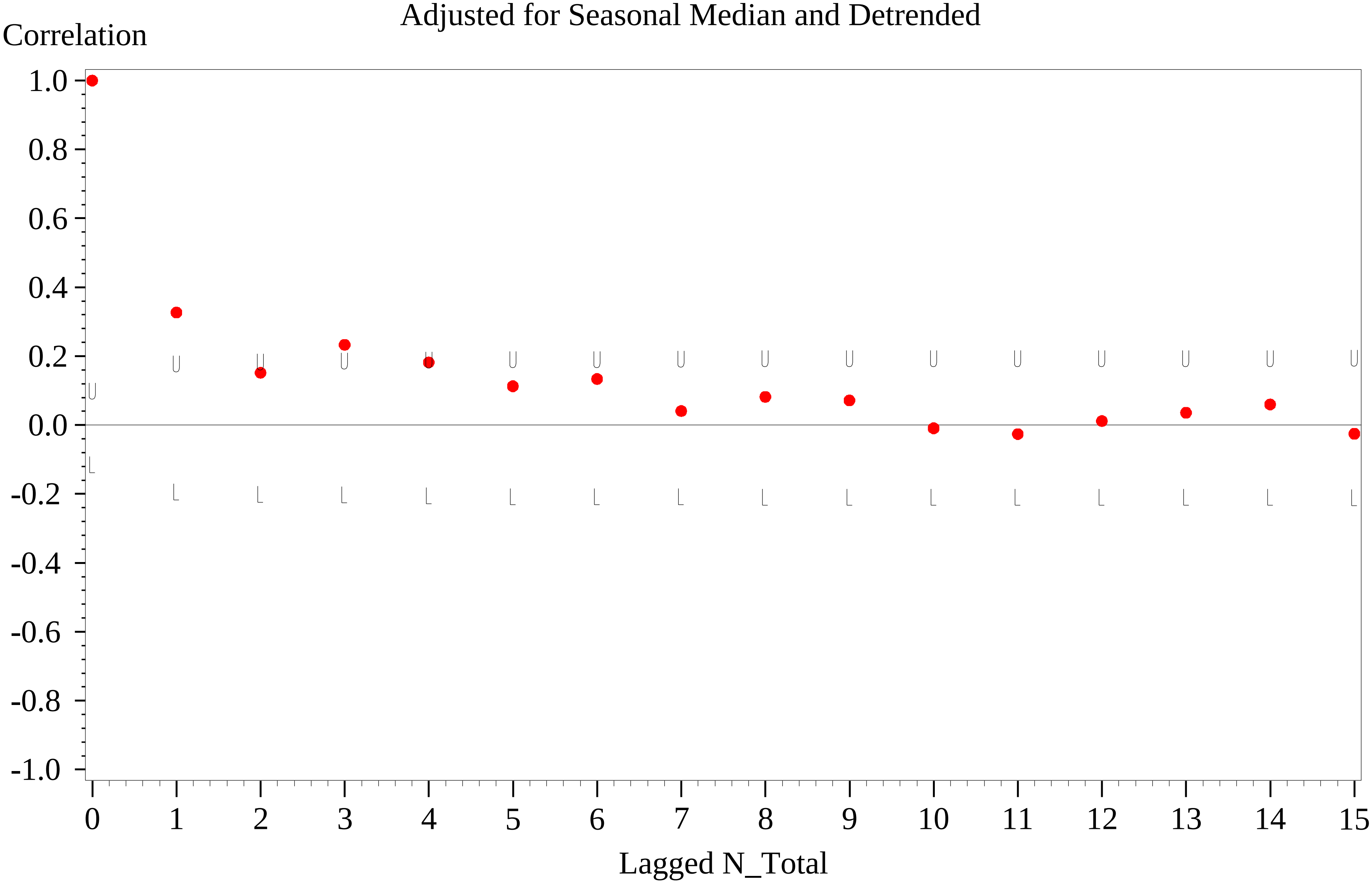
Autocorrelation Statistics for Total Nitrogen at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged N_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.327	0.093	0.186	-0.186
2	0.152	0.096	0.192	-0.192
3	0.233	0.097	0.194	-0.194
4	0.182	0.098	0.197	-0.197
5	0.113	0.099	0.199	-0.199
6	0.134	0.100	0.199	-0.199
7	0.041	0.100	0.200	-0.200
8	0.082	0.100	0.201	-0.201
9	0.072	0.100	0.201	-0.201
10	-0.009	0.101	0.201	-0.201
11	-0.026	0.101	0.201	-0.201
12	0.012	0.101	0.201	-0.201
13	0.036	0.101	0.201	-0.201
14	0.060	0.101	0.201	-0.201
15	-0.025	0.101	0.202	-0.202

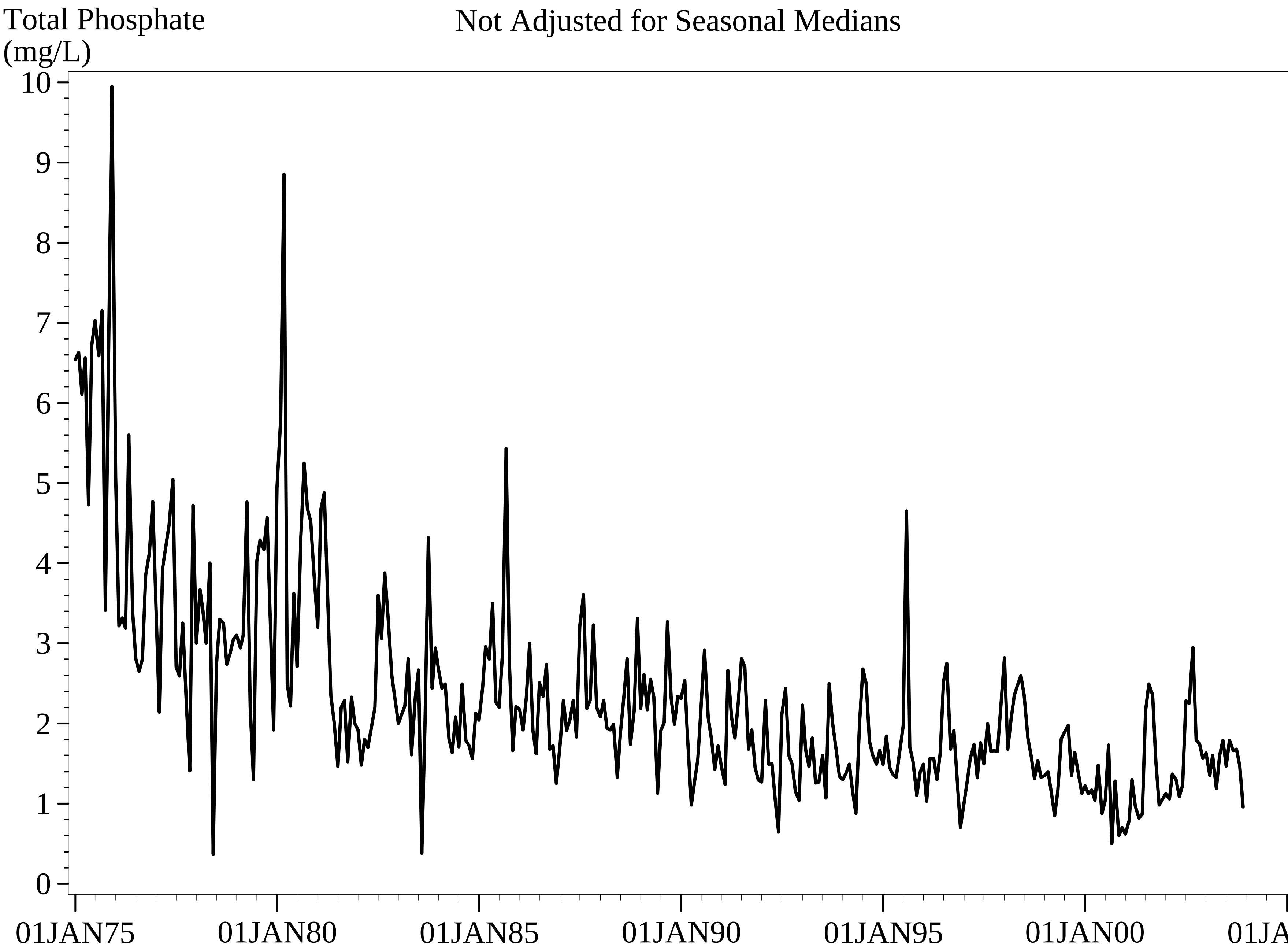
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Nitrogen at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

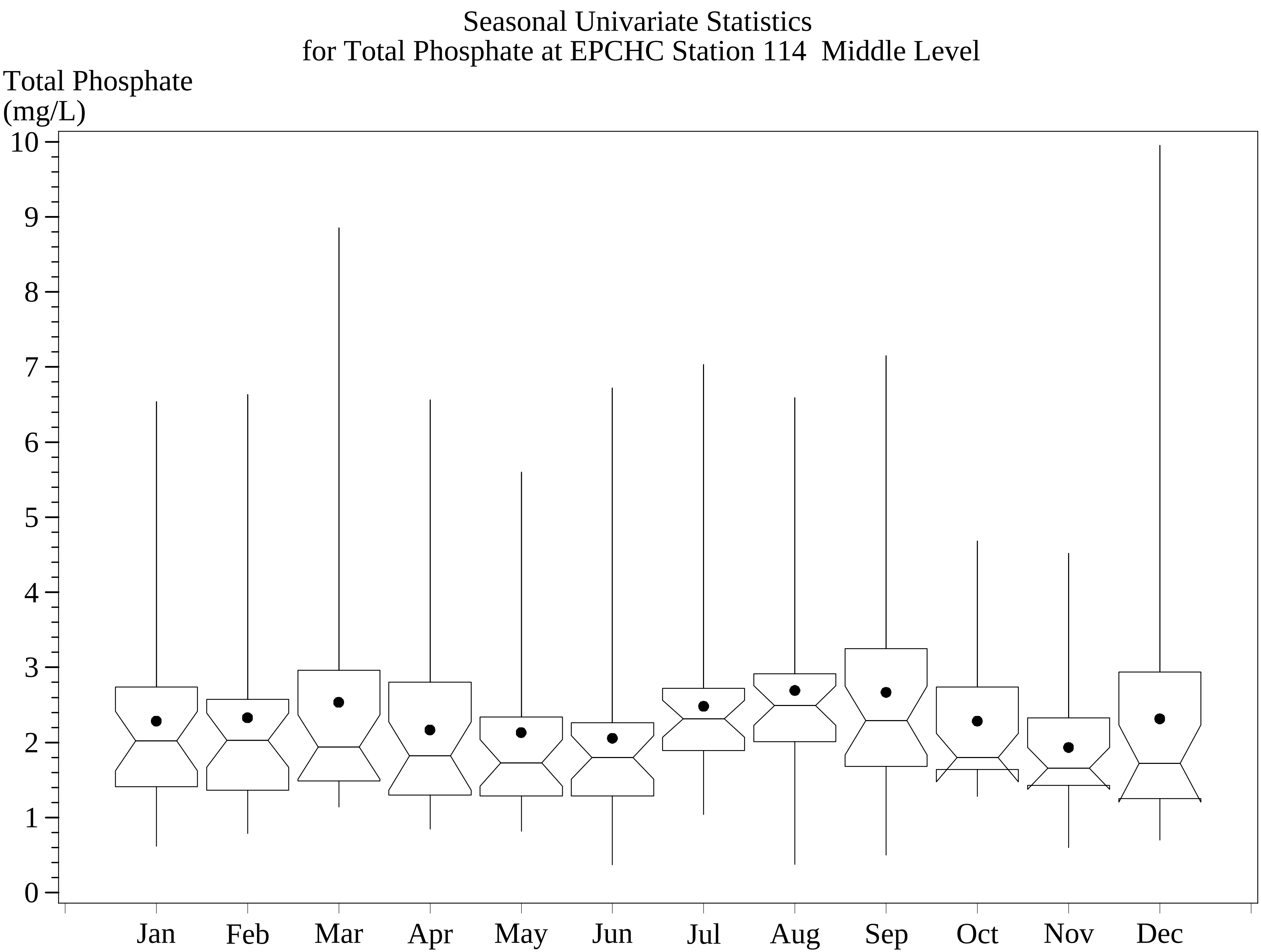


U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix



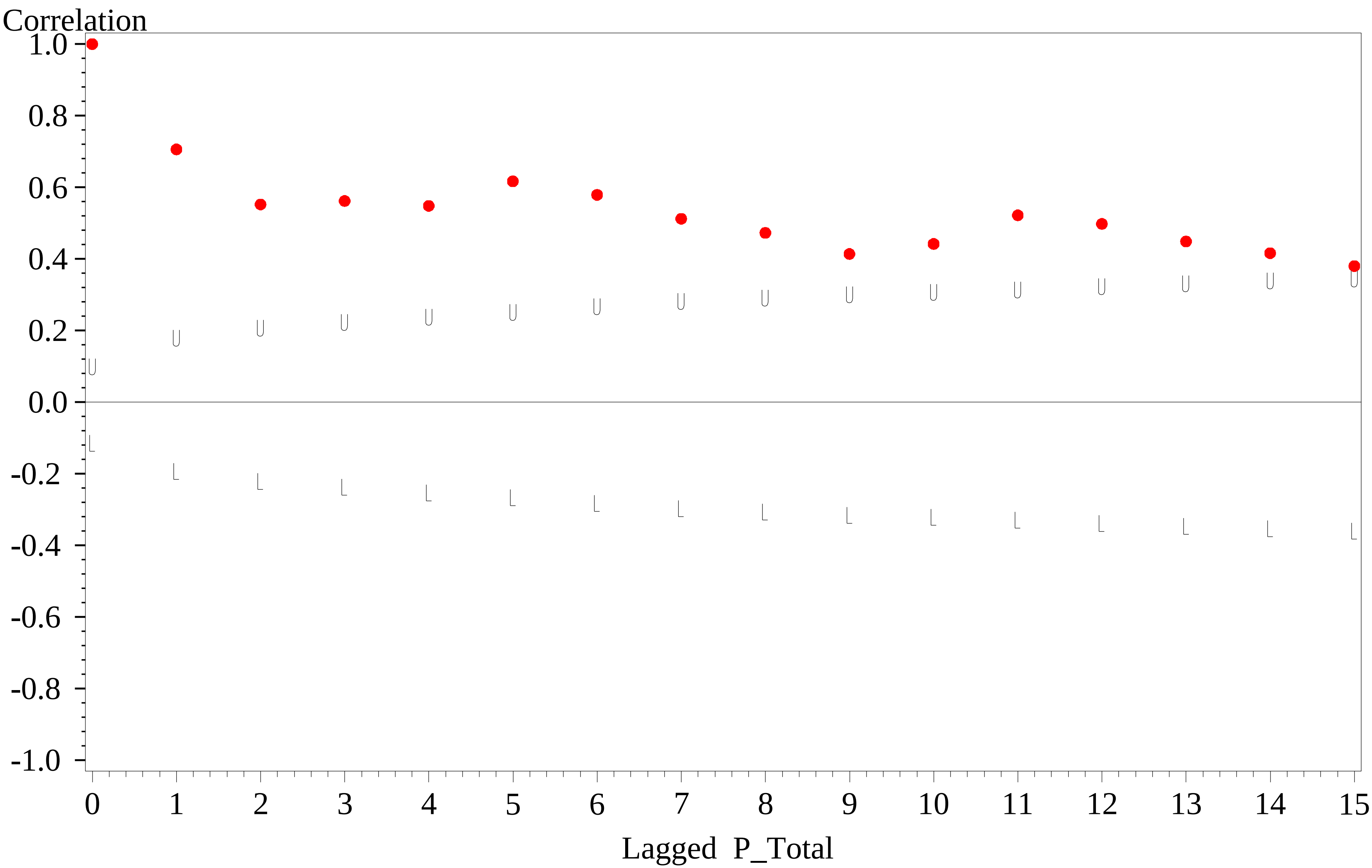
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Total Phosphate at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Lagged P_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.706	0.093	0.186	-0.186
2	0.552	0.107	0.214	-0.214
3	0.562	0.115	0.230	-0.230
4	0.548	0.123	0.245	-0.245
5	0.617	0.130	0.259	-0.259
6	0.579	0.138	0.275	-0.275
7	0.512	0.145	0.289	-0.289
8	0.473	0.150	0.299	-0.299
9	0.414	0.154	0.308	-0.308
10	0.442	0.157	0.314	-0.314
11	0.522	0.161	0.321	-0.321
12	0.498	0.165	0.331	-0.331
13	0.449	0.170	0.339	-0.339
14	0.416	0.173	0.346	-0.346
15	0.380	0.176	0.352	-0.352

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Phosphate at EPCHC Station 114 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Total Phosphate at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.526	0	0	-0.076

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Total Phosphate at EPCHC Station 114 Middle Level

Adjusted for Seasonal Medians

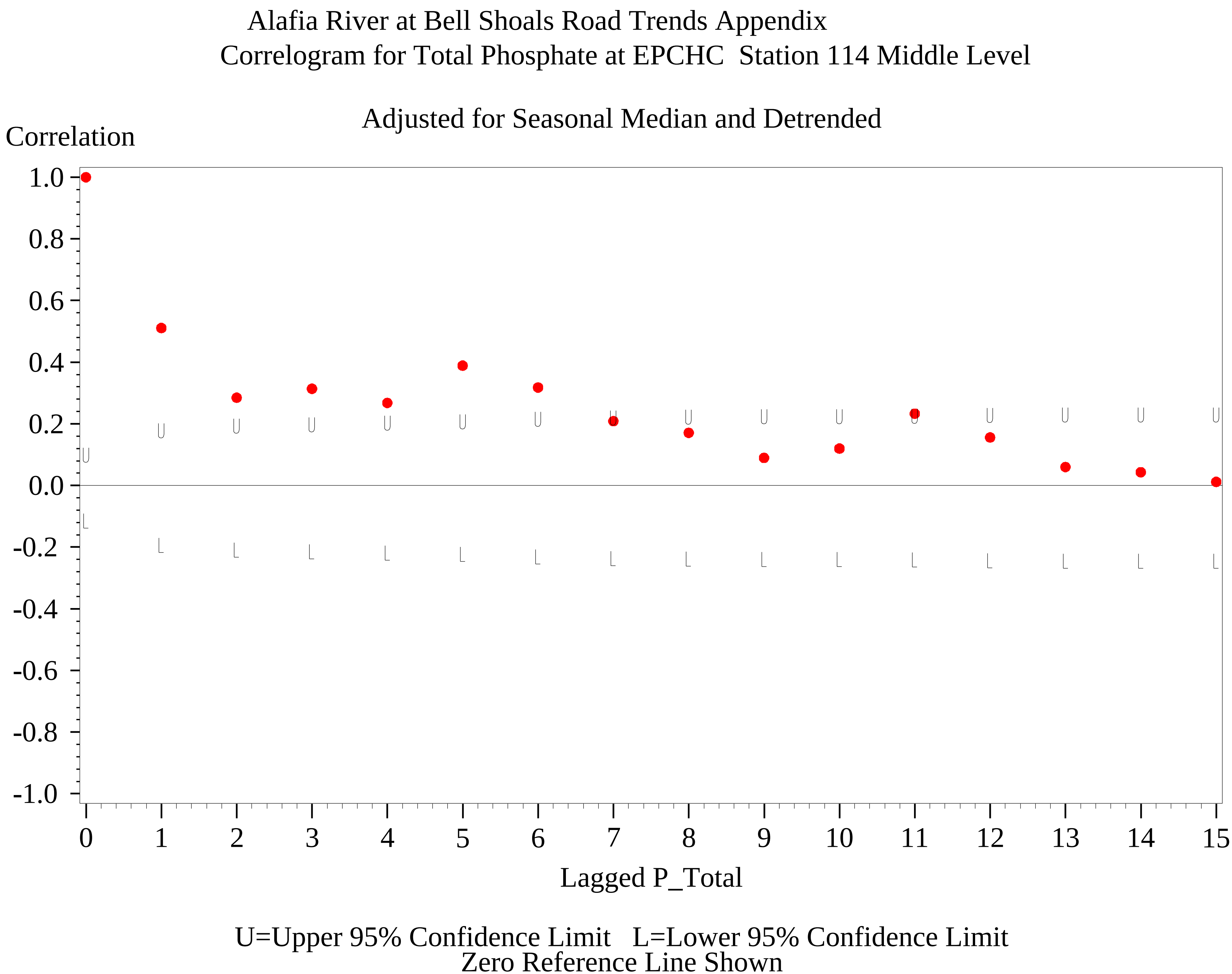
Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.52610	0	.000000201	-0.076111

Alafia River at Bell Shoals Road Trends Appendix

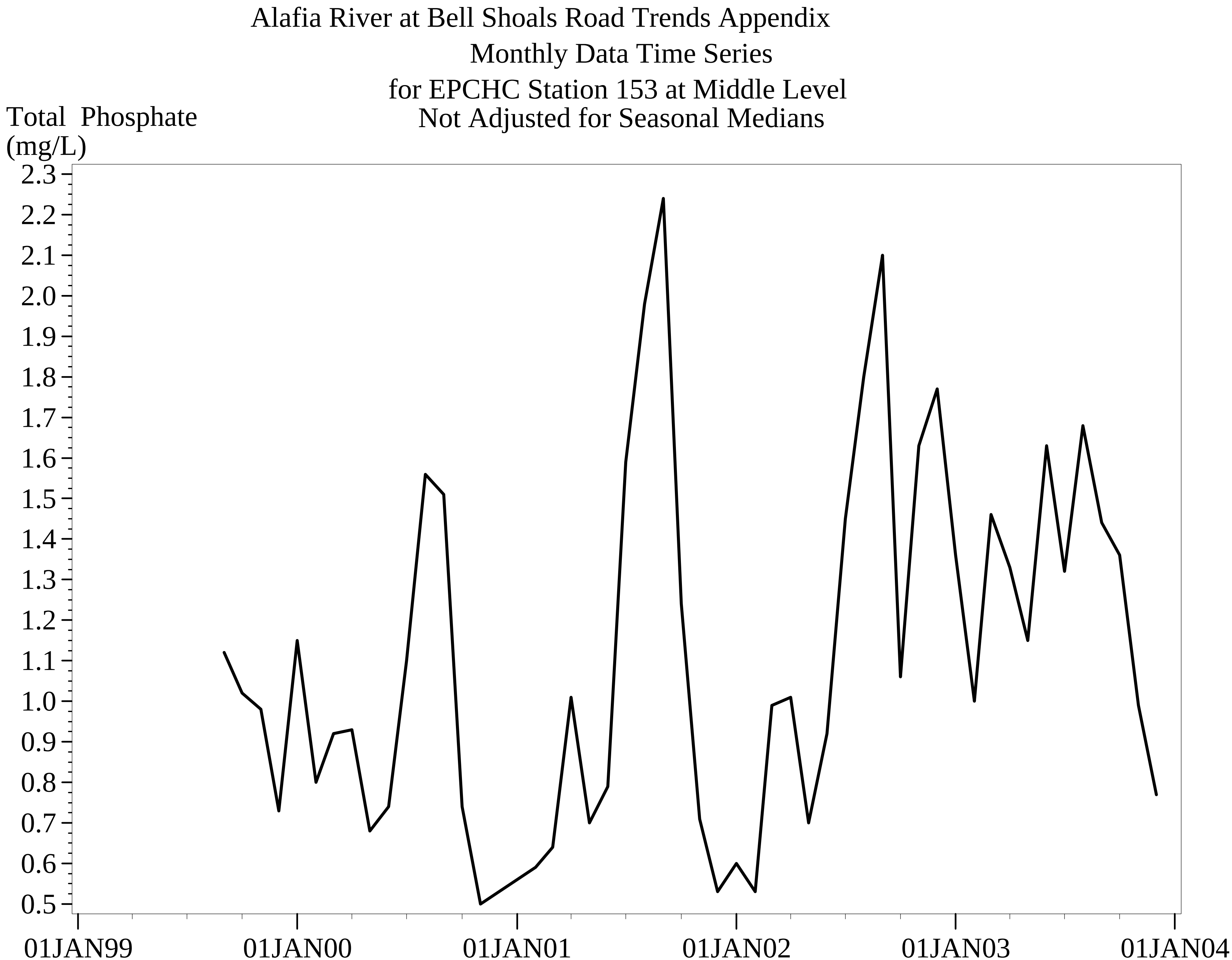
Autocorrelation Statistics for Total Phosphate at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged P_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.511	0.093	0.186	-0.186
2	0.285	0.101	0.201	-0.201
3	0.314	0.103	0.206	-0.206
4	0.268	0.106	0.211	-0.211
5	0.389	0.108	0.215	-0.215
6	0.318	0.112	0.223	-0.223
7	0.209	0.114	0.228	-0.228
8	0.171	0.115	0.230	-0.230
9	0.090	0.116	0.232	-0.232
10	0.120	0.116	0.232	-0.232
11	0.233	0.116	0.233	-0.233
12	0.156	0.118	0.236	-0.236
13	0.060	0.118	0.237	-0.237
14	0.043	0.118	0.237	-0.237
15	0.012	0.119	0.237	-0.237

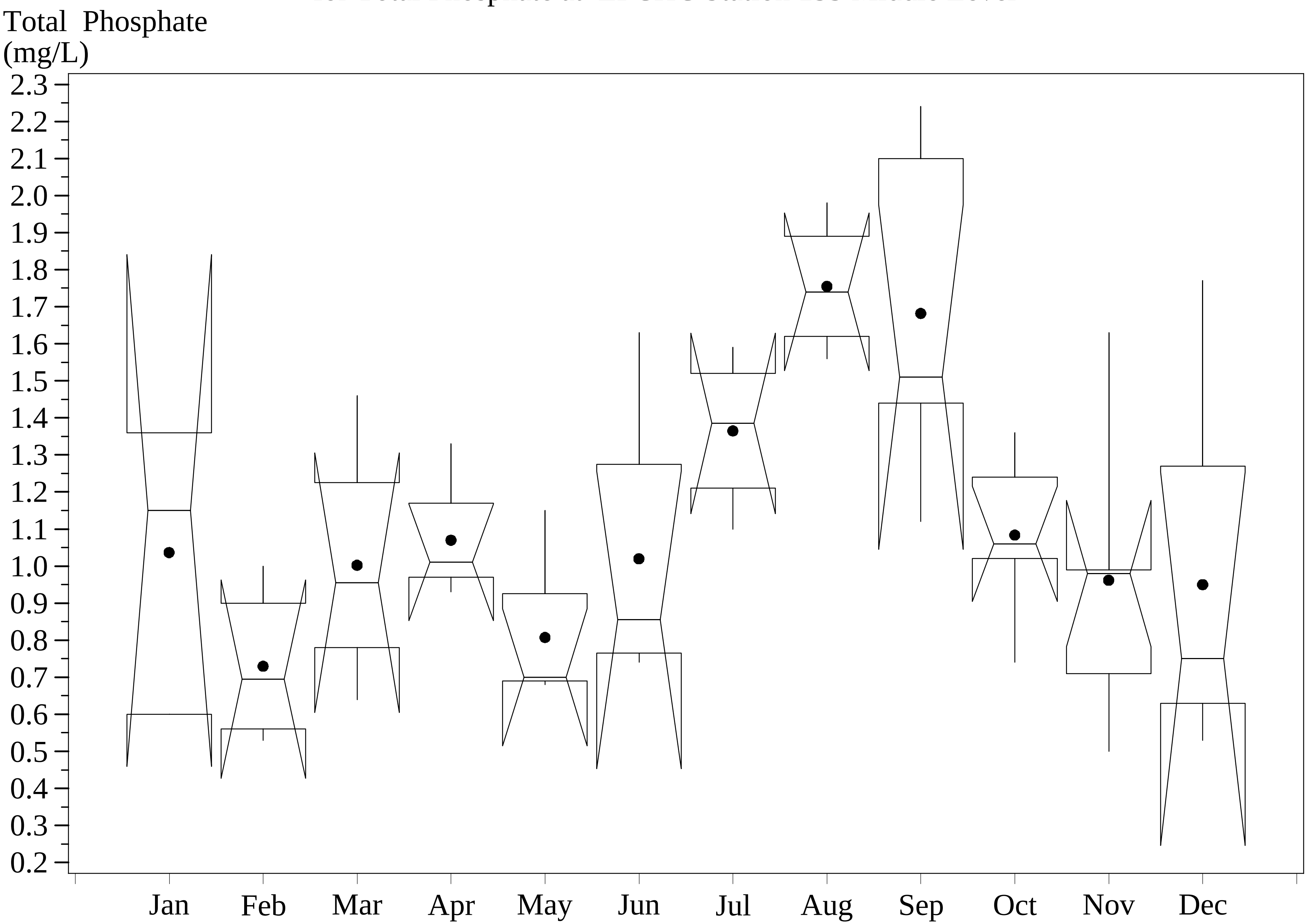


Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Phosphate at EPCHC Station 114 Middle Level
Adjusted for Seasonal Median and Detrended
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Lagged P_Total
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown


Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians
Total Phosphate
(mg/L)
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
01JAN99
01JAN00
01JAN01
01JAN02
01JAN03
01JAN04

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Total Phosphate at EPCHC Station 153 Middle Level



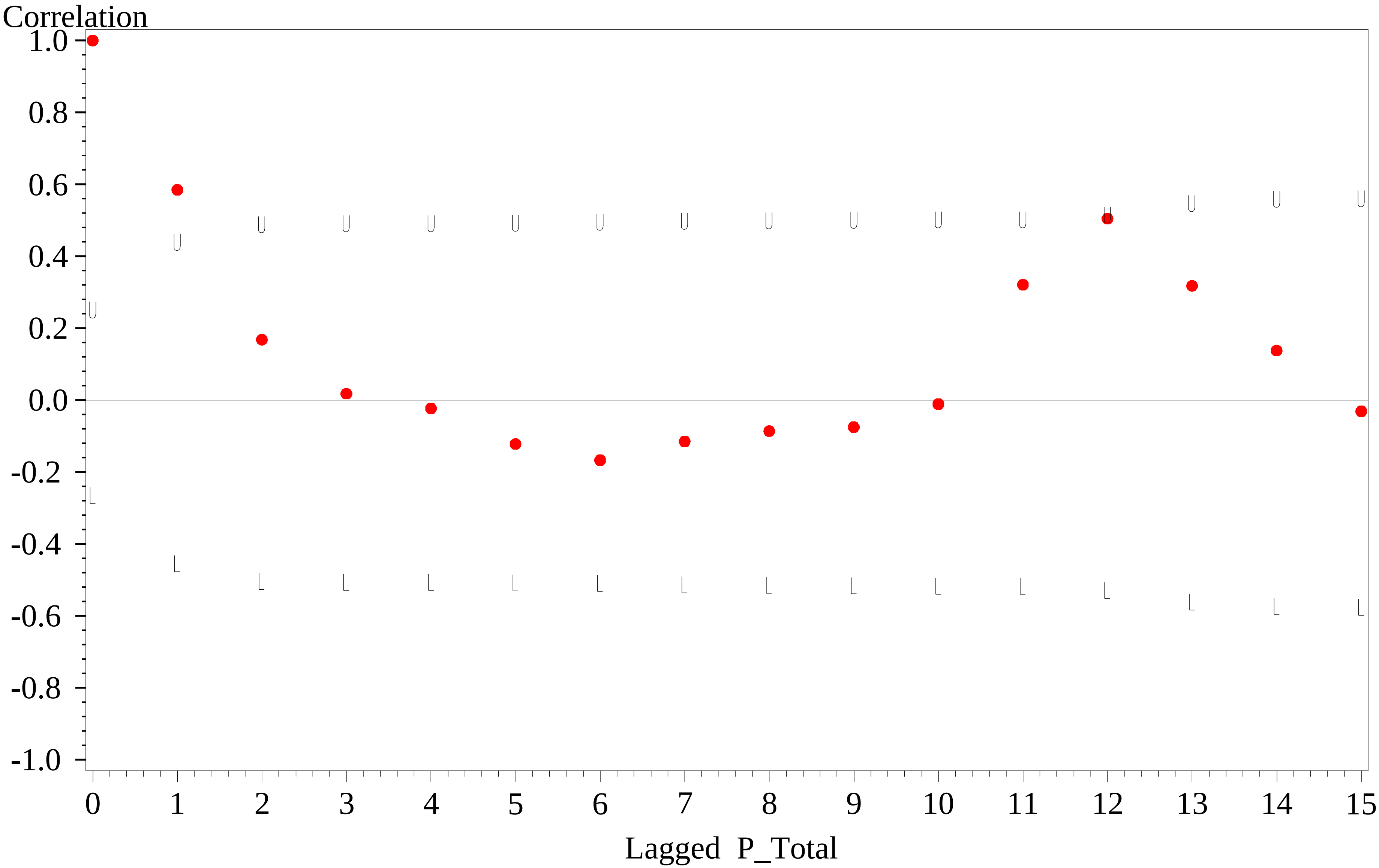
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Total Phosphate at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged P_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.585	0.224	0.447	-0.447
2	0.168	0.248	0.496	-0.496
3	0.018	0.250	0.499	-0.499
4	-0.023	0.250	0.499	-0.499
5	-0.122	0.250	0.500	-0.500
6	-0.167	0.251	0.502	-0.502
7	-0.115	0.253	0.505	-0.505
8	-0.086	0.253	0.507	-0.507
9	-0.075	0.254	0.508	-0.508
10	-0.011	0.254	0.509	-0.509
11	0.321	0.254	0.509	-0.509
12	0.505	0.261	0.522	-0.522
13	0.318	0.277	0.554	-0.554
14	0.138	0.283	0.566	-0.566
15	-0.031	0.284	0.568	-0.568

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Phosphate at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Total Phosphate at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.432	.002	0.099	0.09

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Total Phosphate at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.43210	.00199533	0.099098	0.09

Alafia River at Bell Shoals Road Trends Appendix

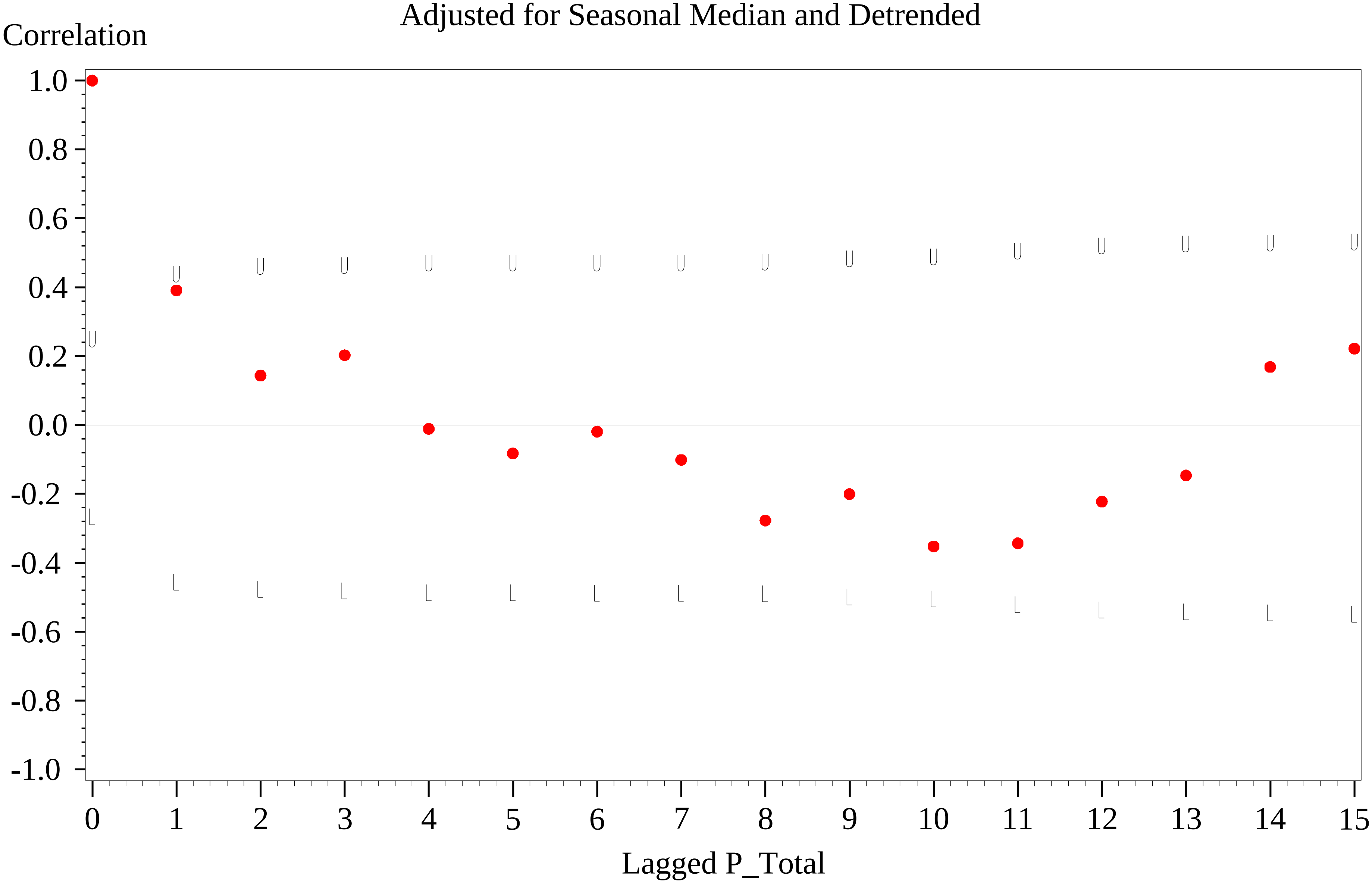
Autocorrelation Statistics for Total Phosphate at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged P_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.391	0.224	0.447	-0.447
2	0.144	0.235	0.469	-0.469
3	0.203	0.236	0.472	-0.472
4	-0.011	0.239	0.478	-0.478
5	-0.082	0.239	0.478	-0.478
6	-0.019	0.240	0.479	-0.479
7	-0.101	0.240	0.479	-0.479
8	-0.277	0.240	0.481	-0.481
9	-0.200	0.246	0.491	-0.491
10	-0.352	0.248	0.496	-0.496
11	-0.343	0.256	0.513	-0.513
12	-0.222	0.264	0.528	-0.528
13	-0.146	0.267	0.534	-0.534
14	0.169	0.268	0.537	-0.537
15	0.222	0.270	0.540	-0.540

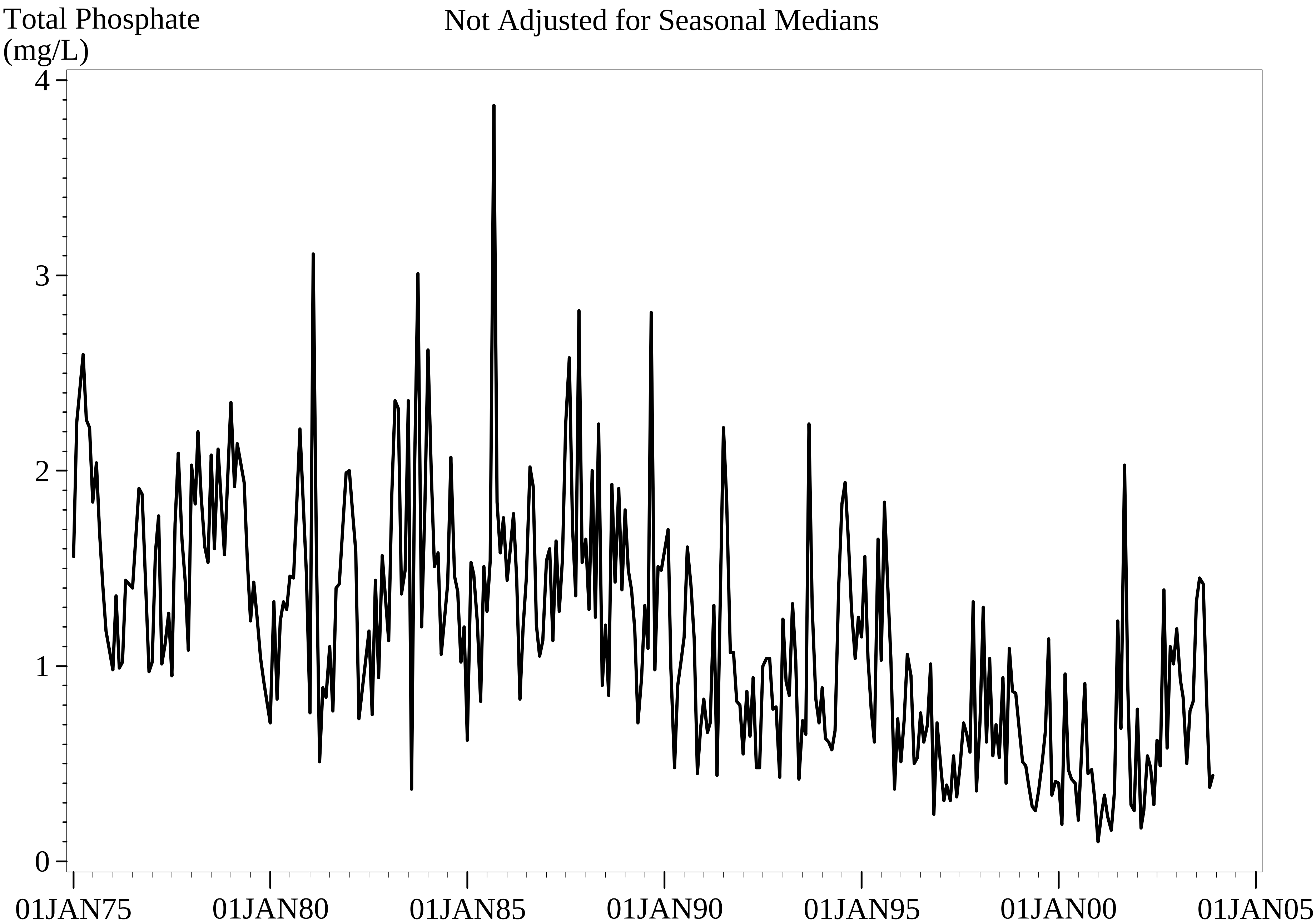
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Phosphate at EPCHC Station 153 Middle Level

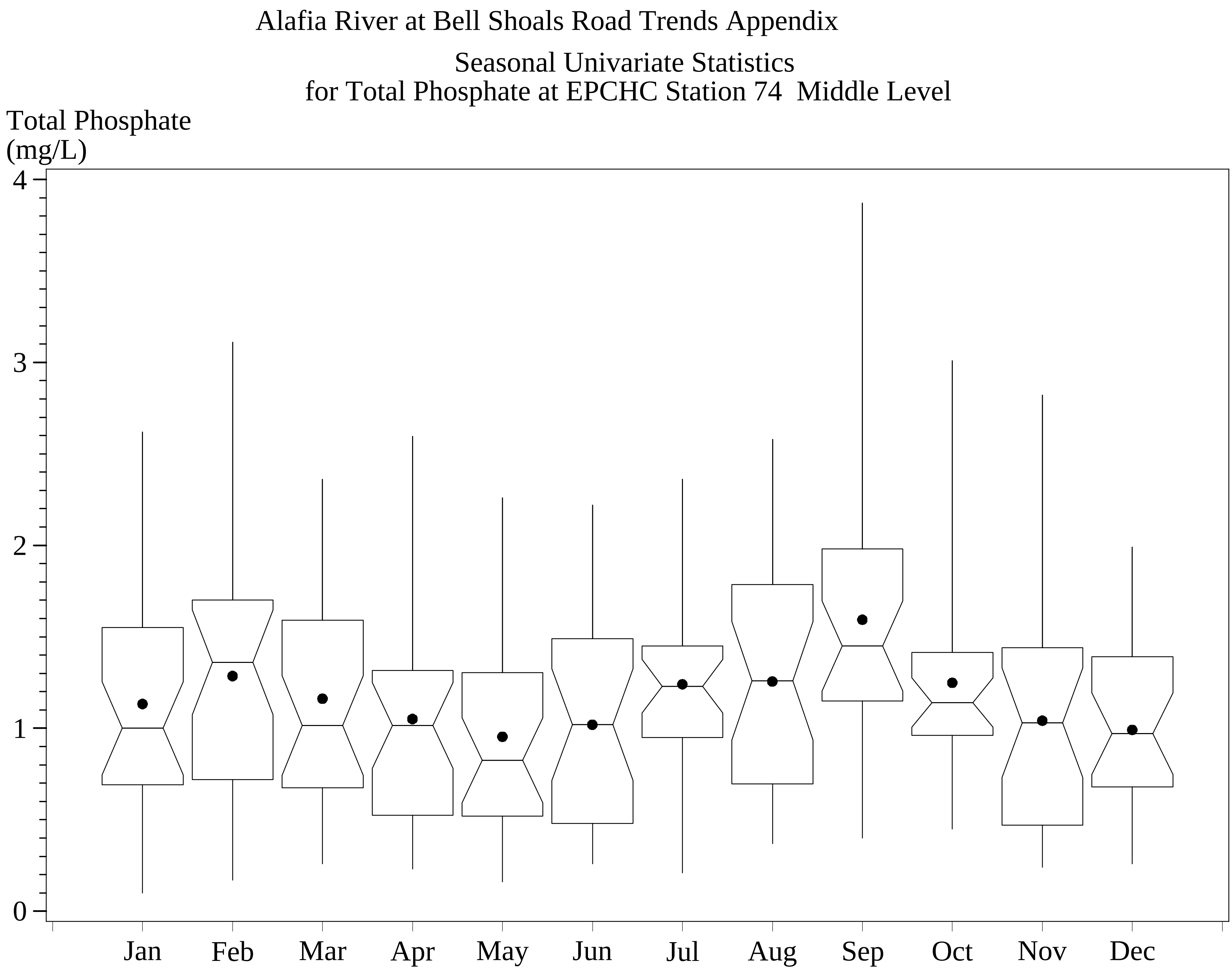
Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Middle Level
Not Adjusted for Seasonal Medians





Alafia River at Bell Shoals Road Trends Appendix
Seasonal Univariate Statistics
for Total Phosphate at EPCHC Station 74 Middle Level
Total Phosphate
(mg/L)
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

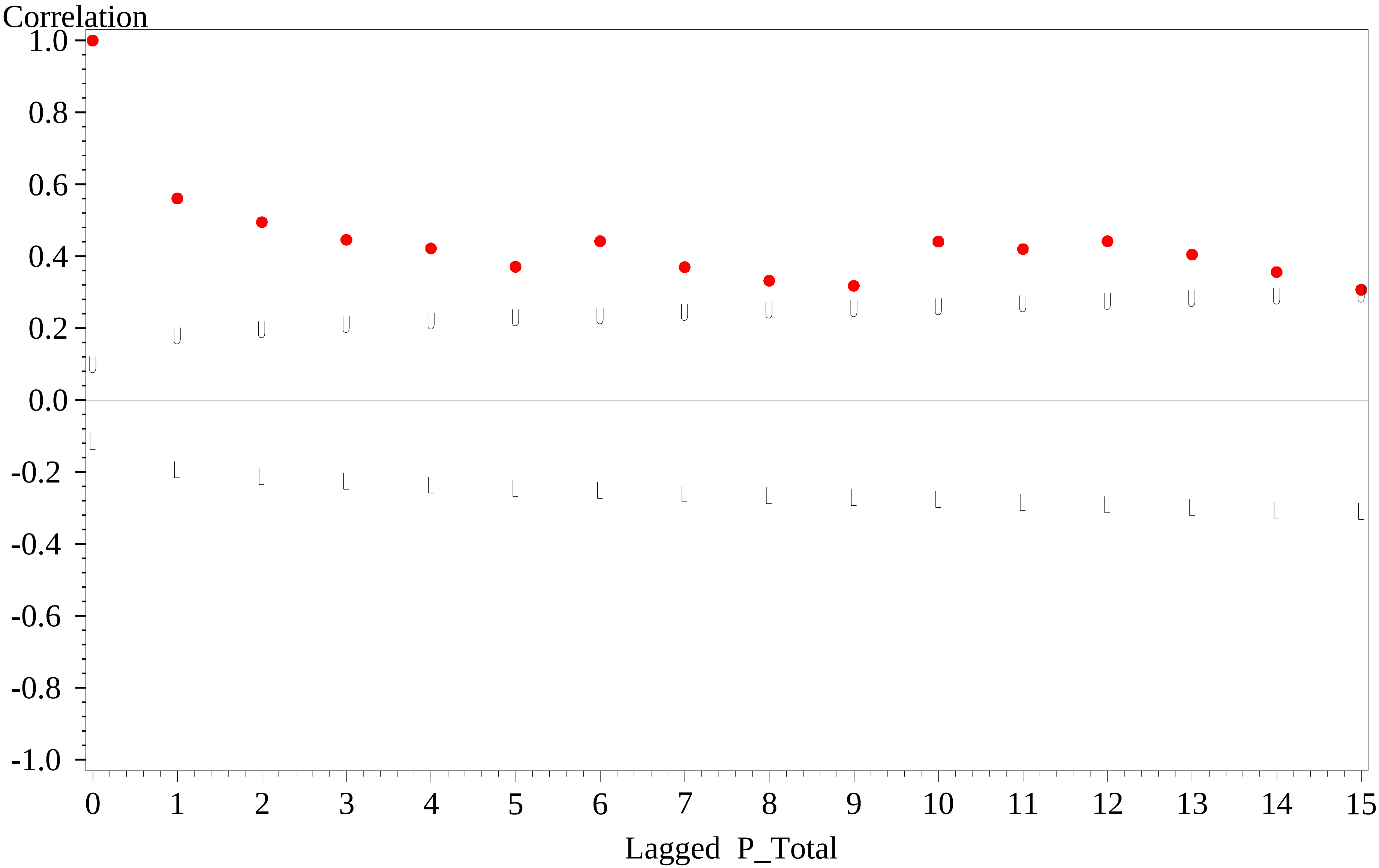
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Total Phosphate at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged P_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.561	0.093	0.186	-0.186
2	0.495	0.102	0.204	-0.204
3	0.446	0.109	0.218	-0.218
4	0.422	0.114	0.228	-0.228
5	0.371	0.118	0.237	-0.237
6	0.442	0.122	0.243	-0.243
7	0.370	0.126	0.252	-0.252
8	0.332	0.129	0.258	-0.258
9	0.318	0.132	0.263	-0.263
10	0.441	0.134	0.268	-0.268
11	0.420	0.138	0.276	-0.276
12	0.442	0.142	0.283	-0.283
13	0.405	0.146	0.291	-0.291
14	0.356	0.149	0.297	-0.297
15	0.307	0.151	0.302	-0.302

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Phosphate at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Total Phosphate at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.468	0	0	-0.043

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Total Phosphate at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

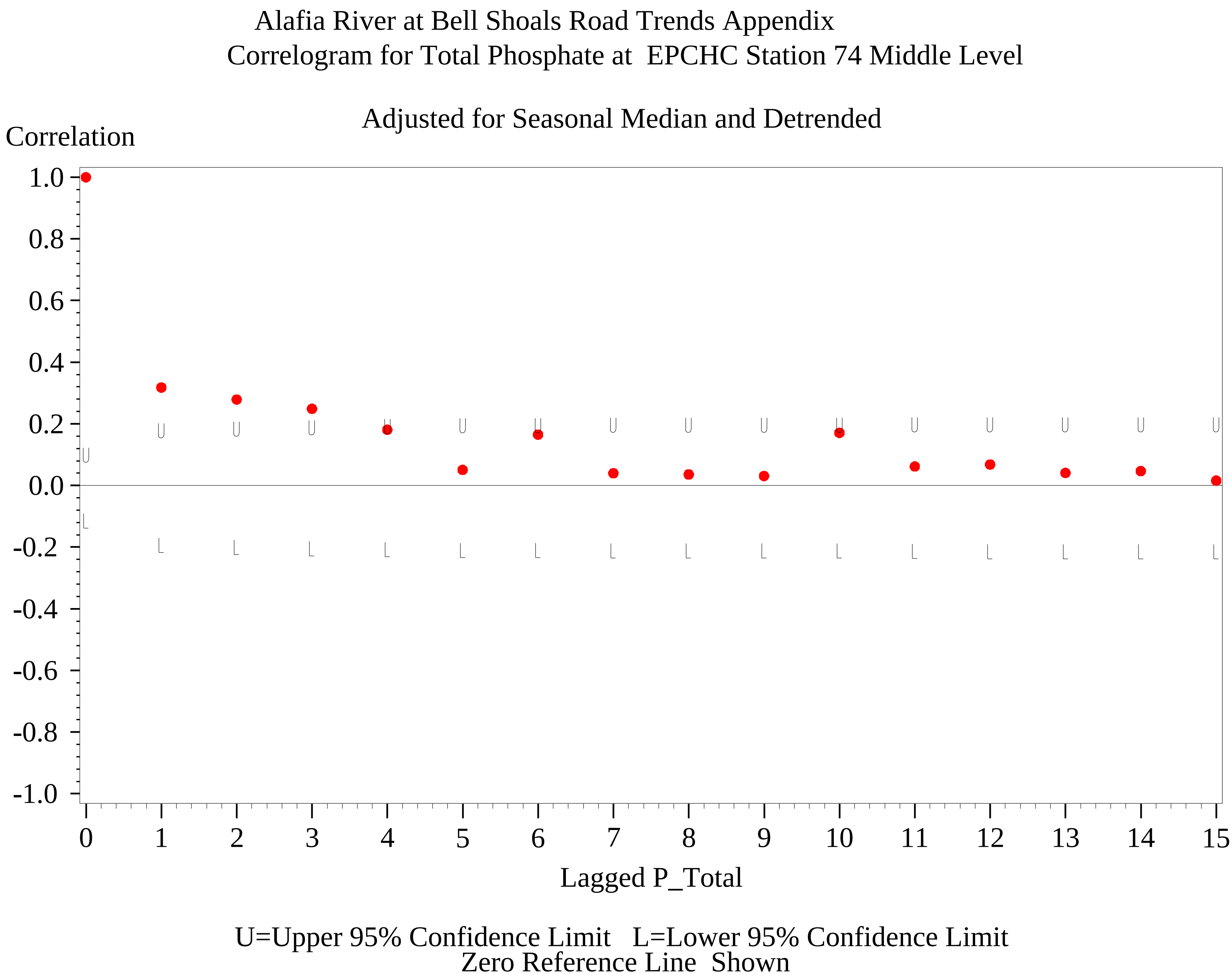
Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.46775	0	.000003158	-0.043246

Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Total Phosphate at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

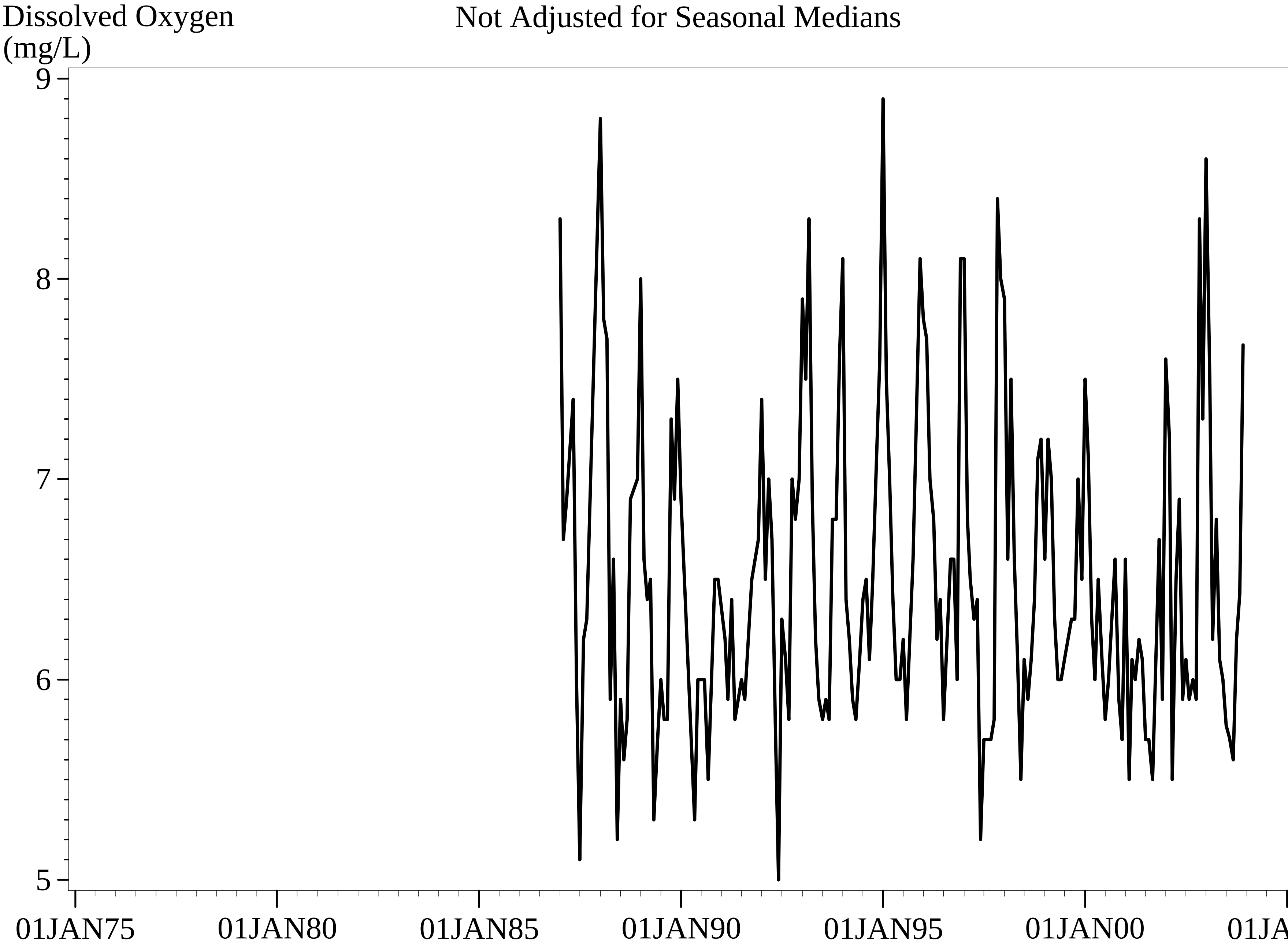
Lagged P_Total	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.318	0.093	0.186	-0.186
2	0.279	0.096	0.192	-0.192
3	0.249	0.098	0.196	-0.196
4	0.181	0.100	0.200	-0.200
5	0.051	0.101	0.202	-0.202
6	0.165	0.101	0.202	-0.202
7	0.040	0.102	0.204	-0.204
8	0.036	0.102	0.204	-0.204
9	0.031	0.102	0.204	-0.204
10	0.171	0.102	0.204	-0.204
11	0.062	0.103	0.205	-0.205
12	0.068	0.103	0.206	-0.206
13	0.041	0.103	0.206	-0.206
14	0.047	0.103	0.206	-0.206
15	0.016	0.103	0.206	-0.206



Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Total Phosphate at EPCHC Station 74 Middle Level
Adjusted for Seasonal Median and Detrended
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Lagged P_Total
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

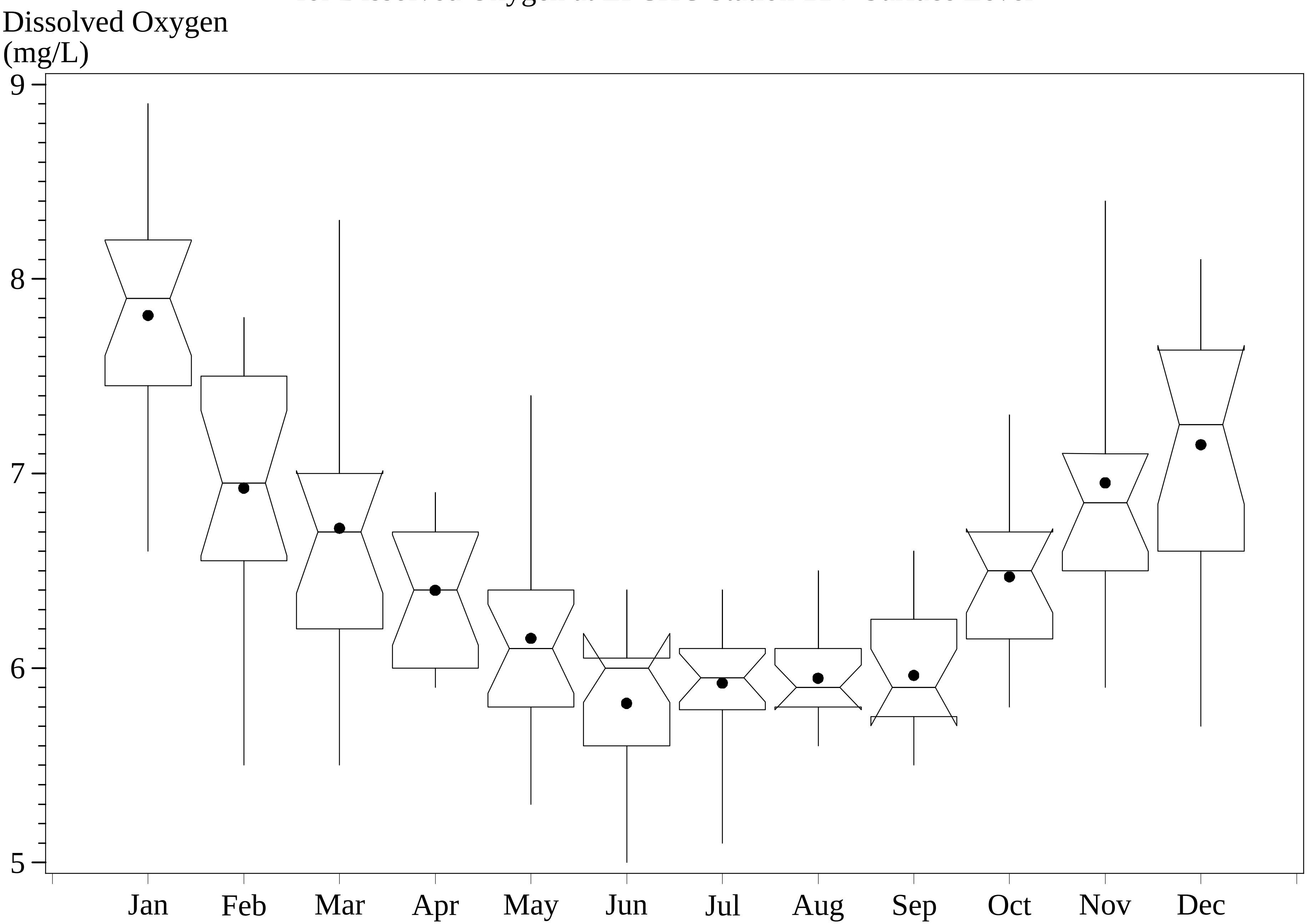
APPENDIX H:
DISSOLVED OXYGEN TREND RESULTS

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Surface Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 114 Surface Level



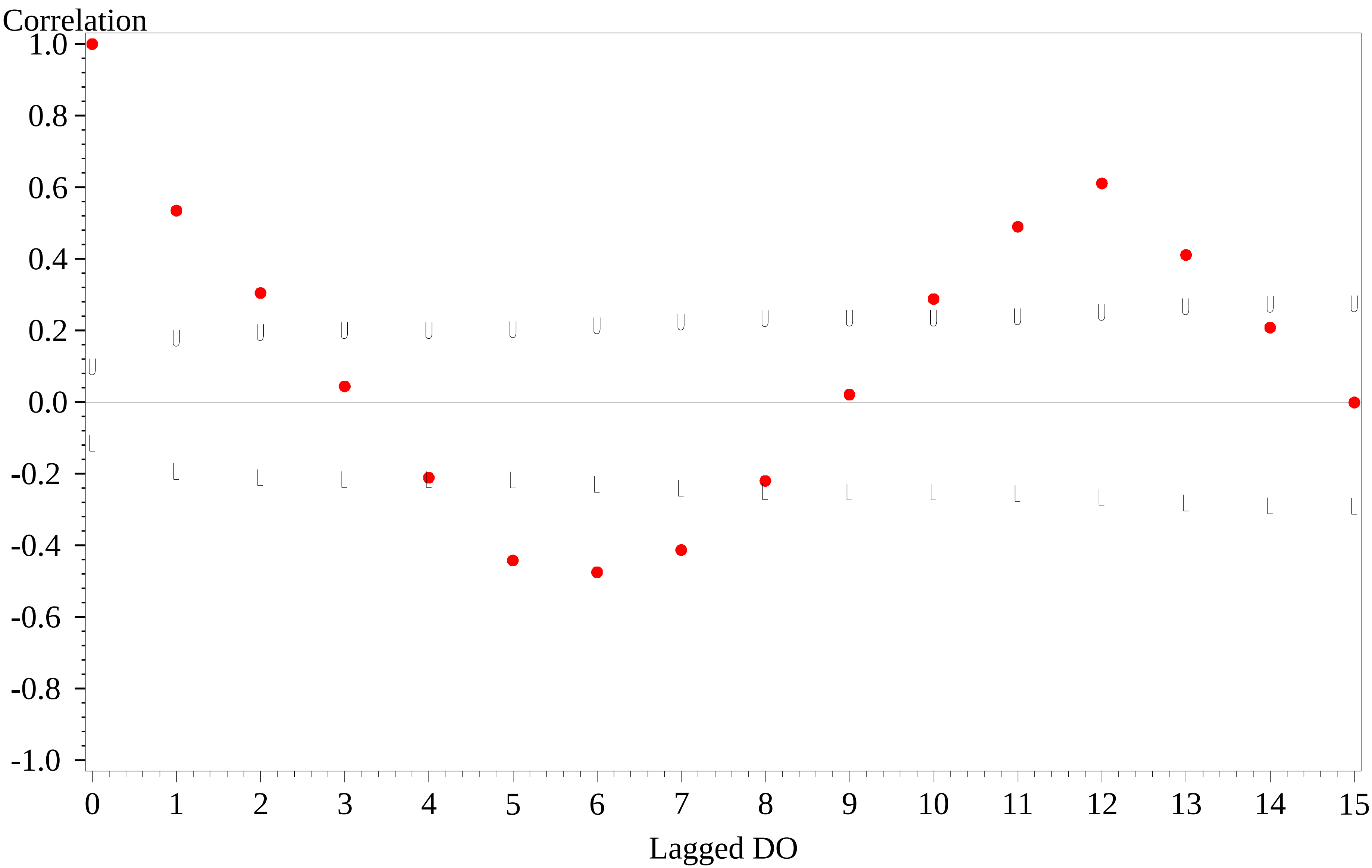
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 114 Surface Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.535	0.093	0.186	-0.186
2	0.305	0.101	0.203	-0.203
3	0.044	0.104	0.208	-0.208
4	-0.211	0.104	0.208	-0.208
5	-0.442	0.105	0.210	-0.210
6	-0.475	0.110	0.221	-0.221
7	-0.413	0.116	0.232	-0.232
8	-0.220	0.120	0.241	-0.241
9	0.021	0.121	0.243	-0.243
10	0.288	0.121	0.243	-0.243
11	0.490	0.123	0.247	-0.247
12	0.611	0.129	0.258	-0.258
13	0.411	0.137	0.274	-0.274
14	0.208	0.140	0.281	-0.281
15	-0.001	0.141	0.283	-0.283

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 114 Surface Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 114 Surface Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.041	0.453	0.587	0

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 114 Surface Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.040616	0.45265	0.58669	0

Alafia River at Bell Shoals Road Trends Appendix

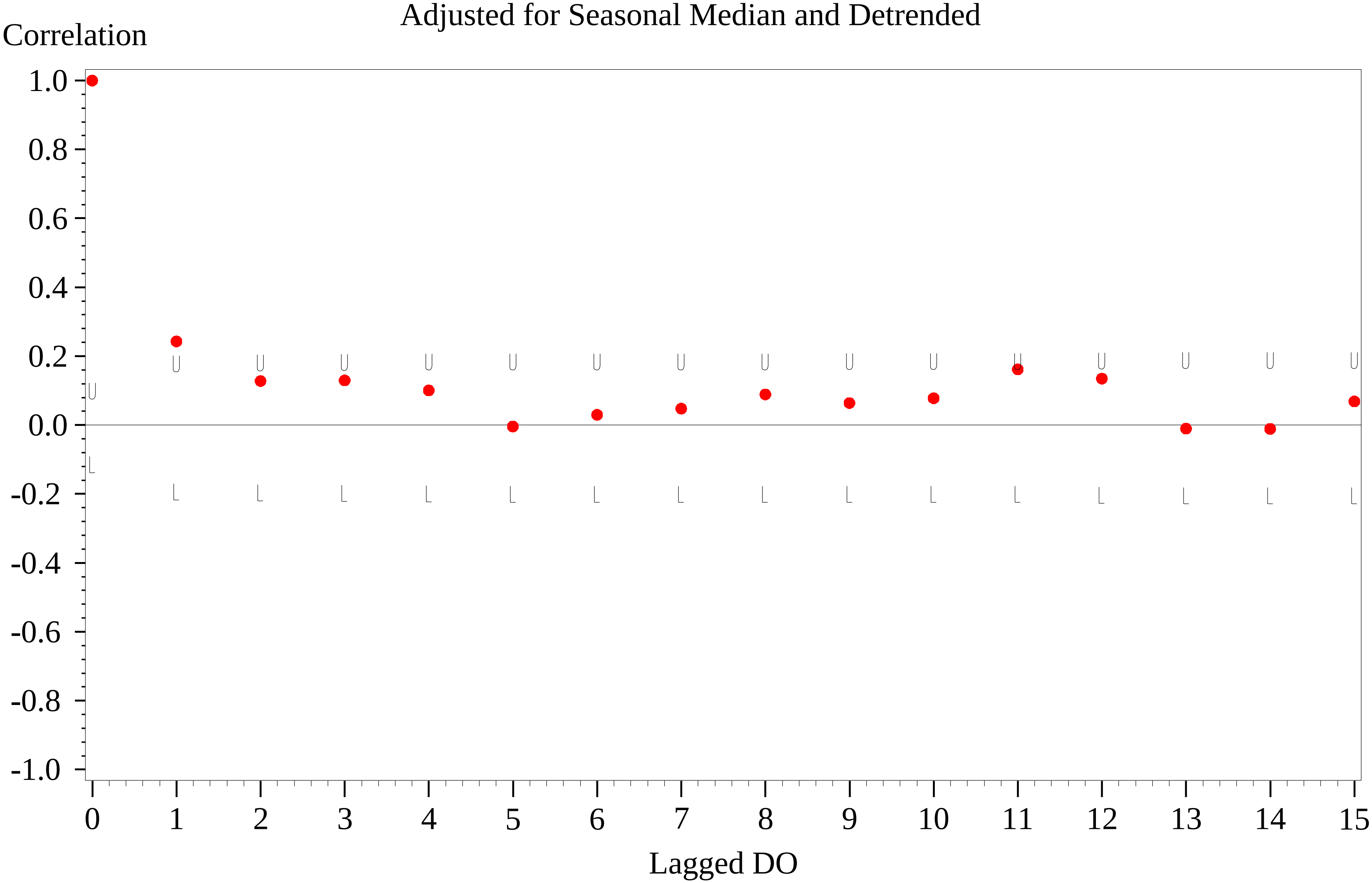
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 114 Surface Level

Adjusted for Seasonal Median and Detrended

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.243	0.093	0.186	-0.186
2	0.128	0.095	0.189	-0.189
3	0.130	0.095	0.190	-0.190
4	0.101	0.096	0.191	-0.191
5	-0.004	0.096	0.192	-0.192
6	0.030	0.096	0.192	-0.192
7	0.048	0.096	0.192	-0.192
8	0.089	0.096	0.192	-0.192
9	0.064	0.096	0.193	-0.193
10	0.078	0.096	0.193	-0.193
11	0.162	0.097	0.193	-0.193
12	0.135	0.097	0.195	-0.195
13	-0.010	0.098	0.196	-0.196
14	-0.011	0.098	0.196	-0.196
15	0.069	0.098	0.196	-0.196

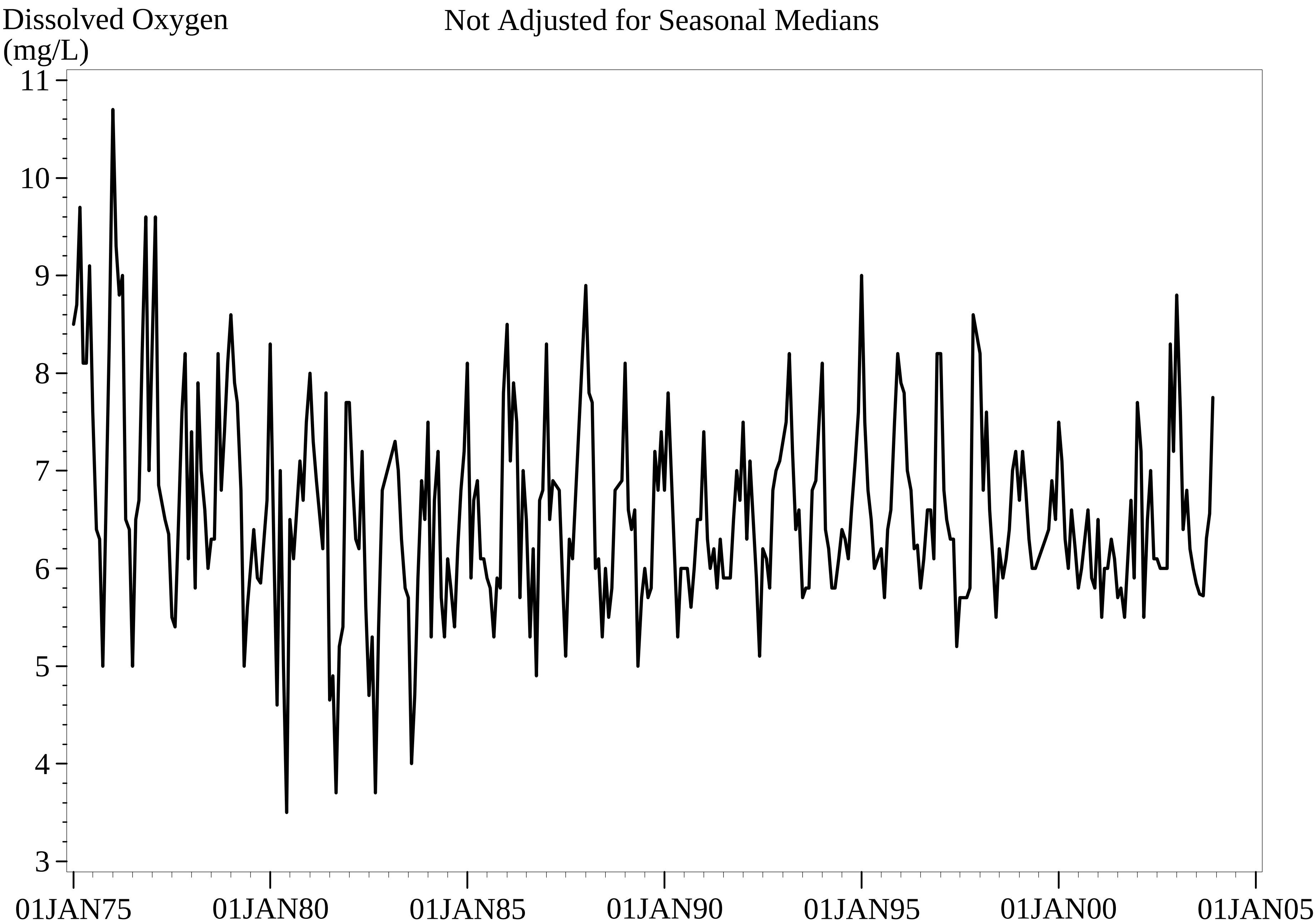
Alafia River at Bell Shoals Road Trends Appendix -
Correlogram for Dissolved Oxygen at EPCHC Station 114 Surface Level

Adjusted for Seasonal Median and Detrended



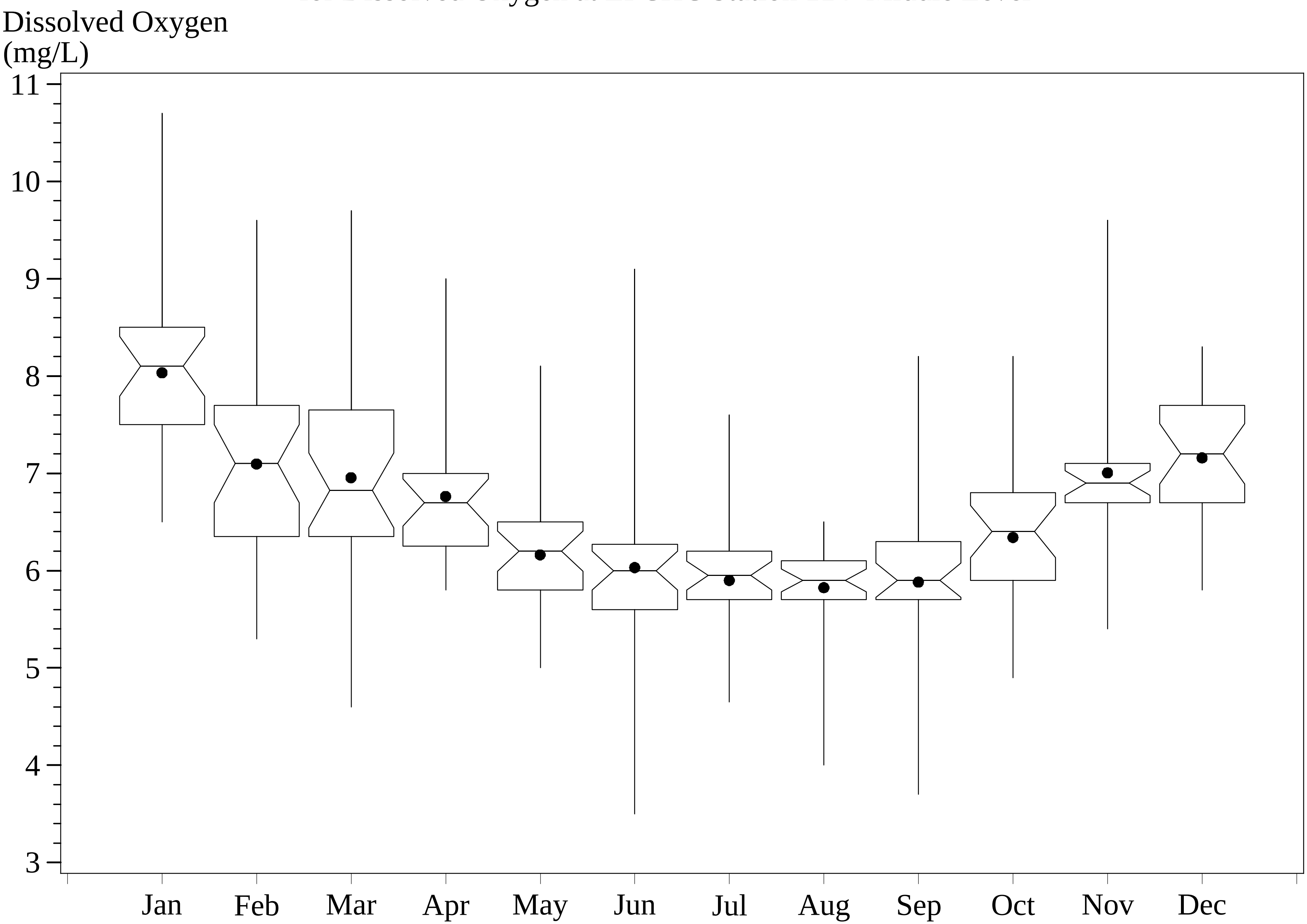
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 114 Middle Level



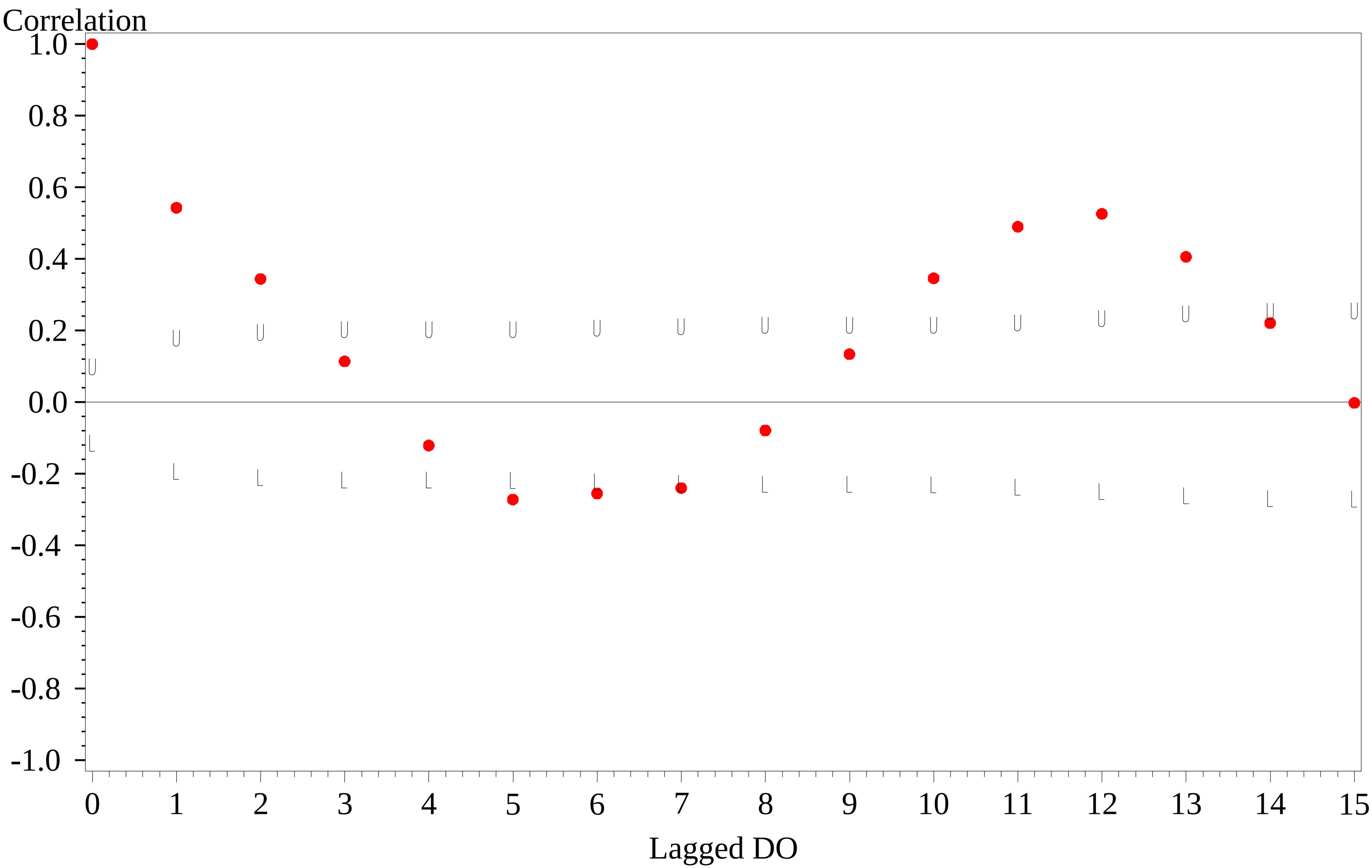
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.543	0.093	0.186	-0.186
2	0.344	0.102	0.203	-0.203
3	0.114	0.105	0.210	-0.210
4	-0.121	0.105	0.210	-0.210
5	-0.272	0.106	0.211	-0.211
6	-0.255	0.108	0.215	-0.215
7	-0.240	0.109	0.219	-0.219
8	-0.079	0.111	0.222	-0.222
9	0.134	0.111	0.222	-0.222
10	0.346	0.111	0.223	-0.223
11	0.490	0.114	0.229	-0.229
12	0.526	0.120	0.241	-0.241
13	0.406	0.127	0.254	-0.254
14	0.221	0.130	0.261	-0.261
15	-0.002	0.132	0.263	-0.263

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 114 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.094	0.017	0.136	-0.011

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 114 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.093909	0.016575	0.13643	-0.010526

Alafia River at Bell Shoals Road Trends Appendix

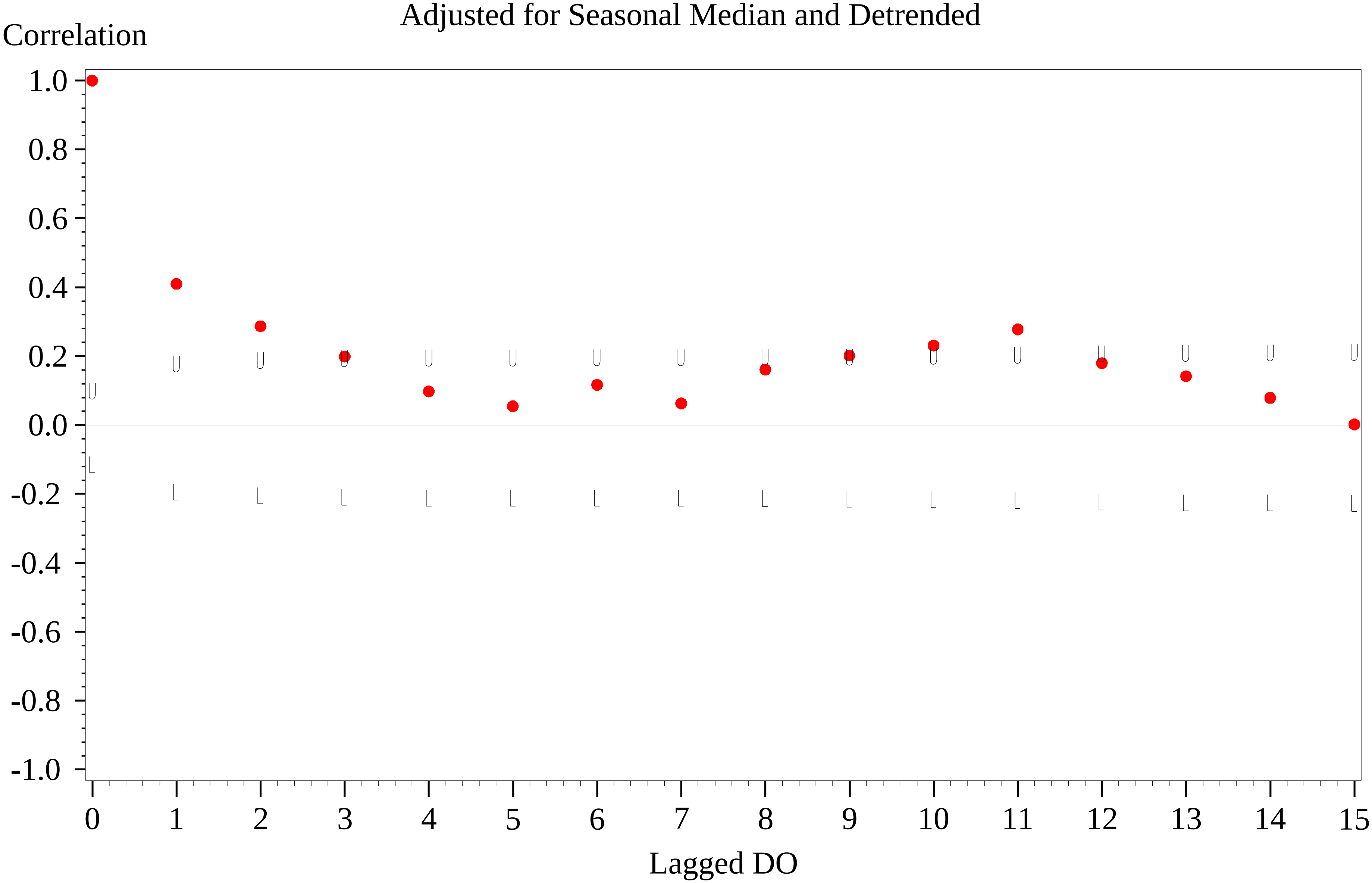
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.410	0.093	0.186	-0.186
2	0.287	0.098	0.196	-0.196
3	0.199	0.100	0.201	-0.201
4	0.098	0.101	0.203	-0.203
5	0.055	0.102	0.203	-0.203
6	0.117	0.102	0.204	-0.204
7	0.063	0.102	0.204	-0.204
8	0.161	0.102	0.205	-0.205
9	0.202	0.103	0.206	-0.206
10	0.231	0.104	0.208	-0.208
11	0.278	0.106	0.211	-0.211
12	0.180	0.108	0.215	-0.215
13	0.142	0.109	0.217	-0.217
14	0.079	0.109	0.218	-0.218
15	0.002	0.109	0.219	-0.219

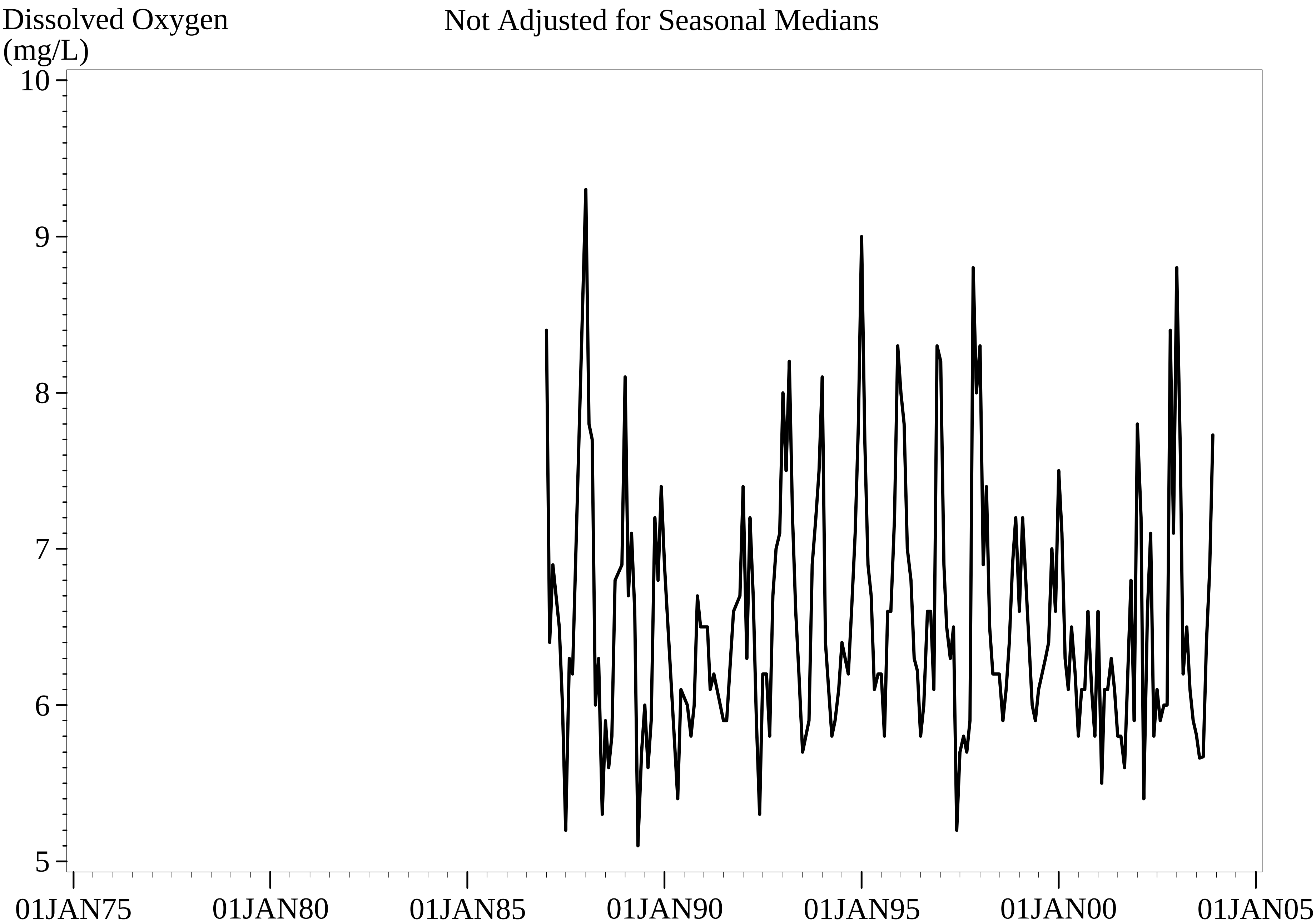
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended



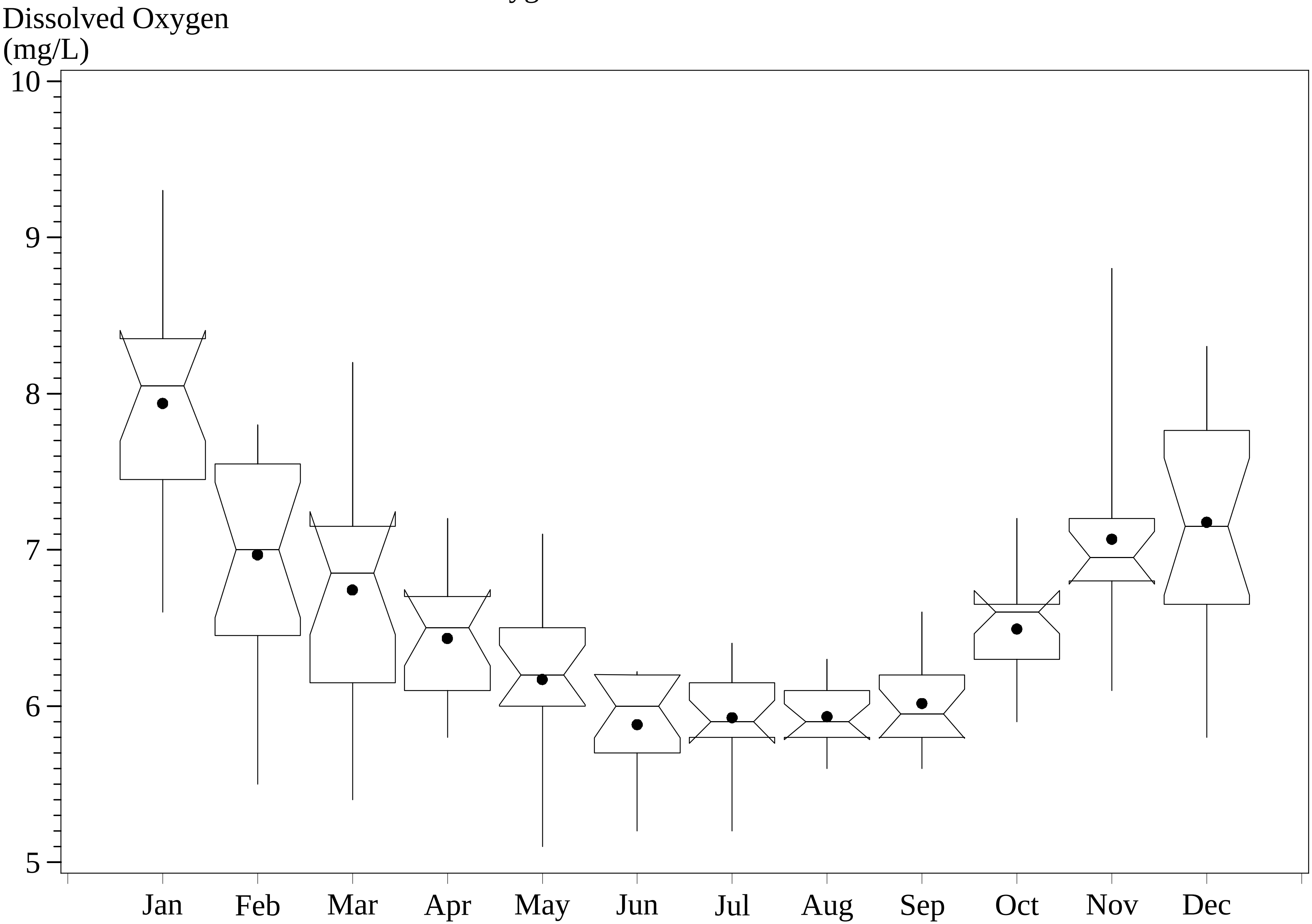
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Bottom Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 114 Bottom Level



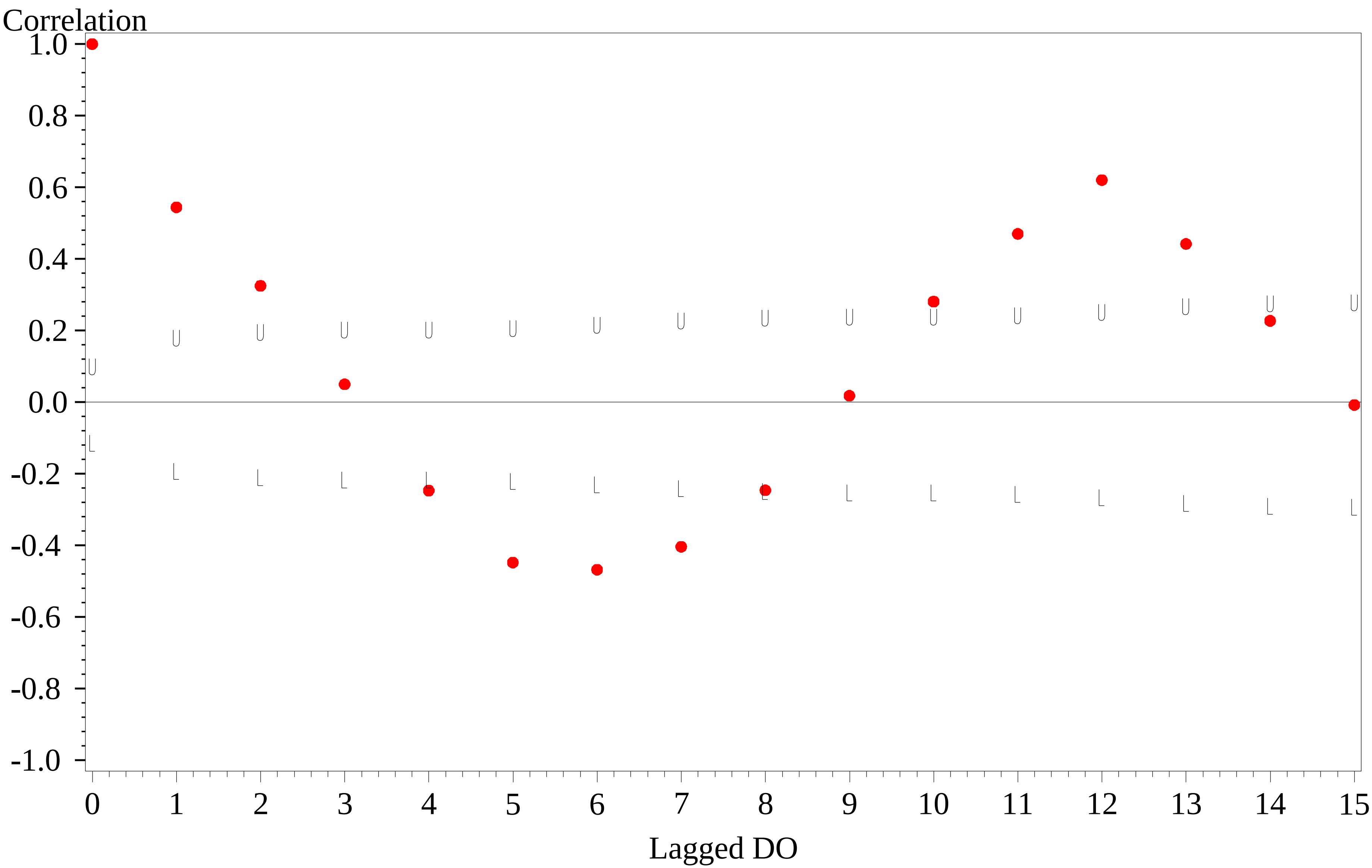
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 114 Bottom Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.544	0.093	0.186	-0.186
2	0.325	0.102	0.203	-0.203
3	0.050	0.105	0.209	-0.209
4	-0.247	0.105	0.209	-0.209
5	-0.448	0.106	0.213	-0.213
6	-0.468	0.112	0.223	-0.223
7	-0.404	0.117	0.234	-0.234
8	-0.246	0.121	0.242	-0.242
9	0.018	0.122	0.245	-0.245
10	0.281	0.122	0.245	-0.245
11	0.470	0.124	0.249	-0.249
12	0.620	0.129	0.259	-0.259
13	0.442	0.138	0.275	-0.275
14	0.227	0.142	0.283	-0.283
15	-0.008	0.143	0.285	-0.285

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 114 Bottom Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 114 Bottom Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.049	0.367	0.526	0

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 114 Bottom Level

Adjusted for Seasonal Medians

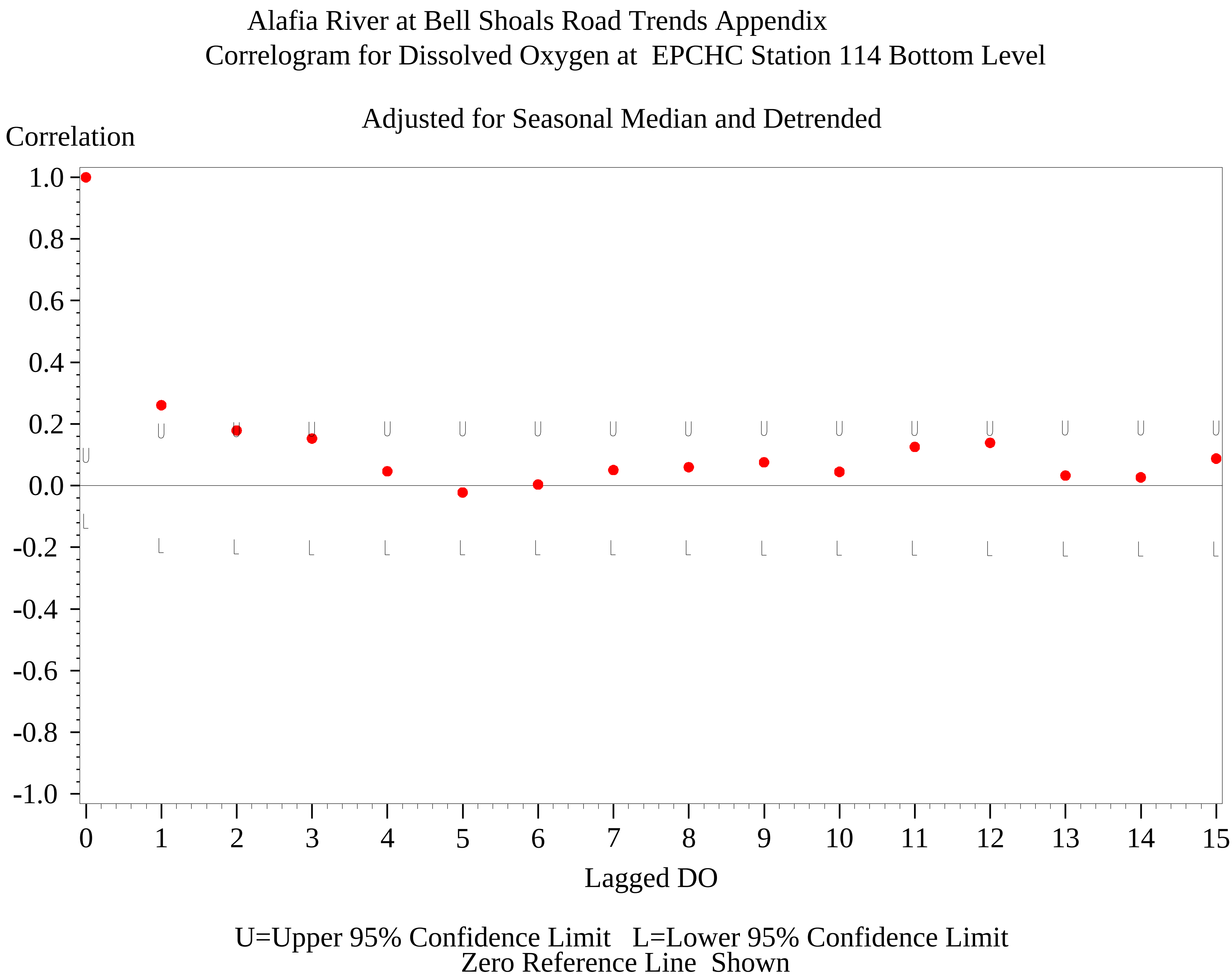
Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.048832	0.36707	0.52603	0

Alafia River at Bell Shoals Road Trends Appendix

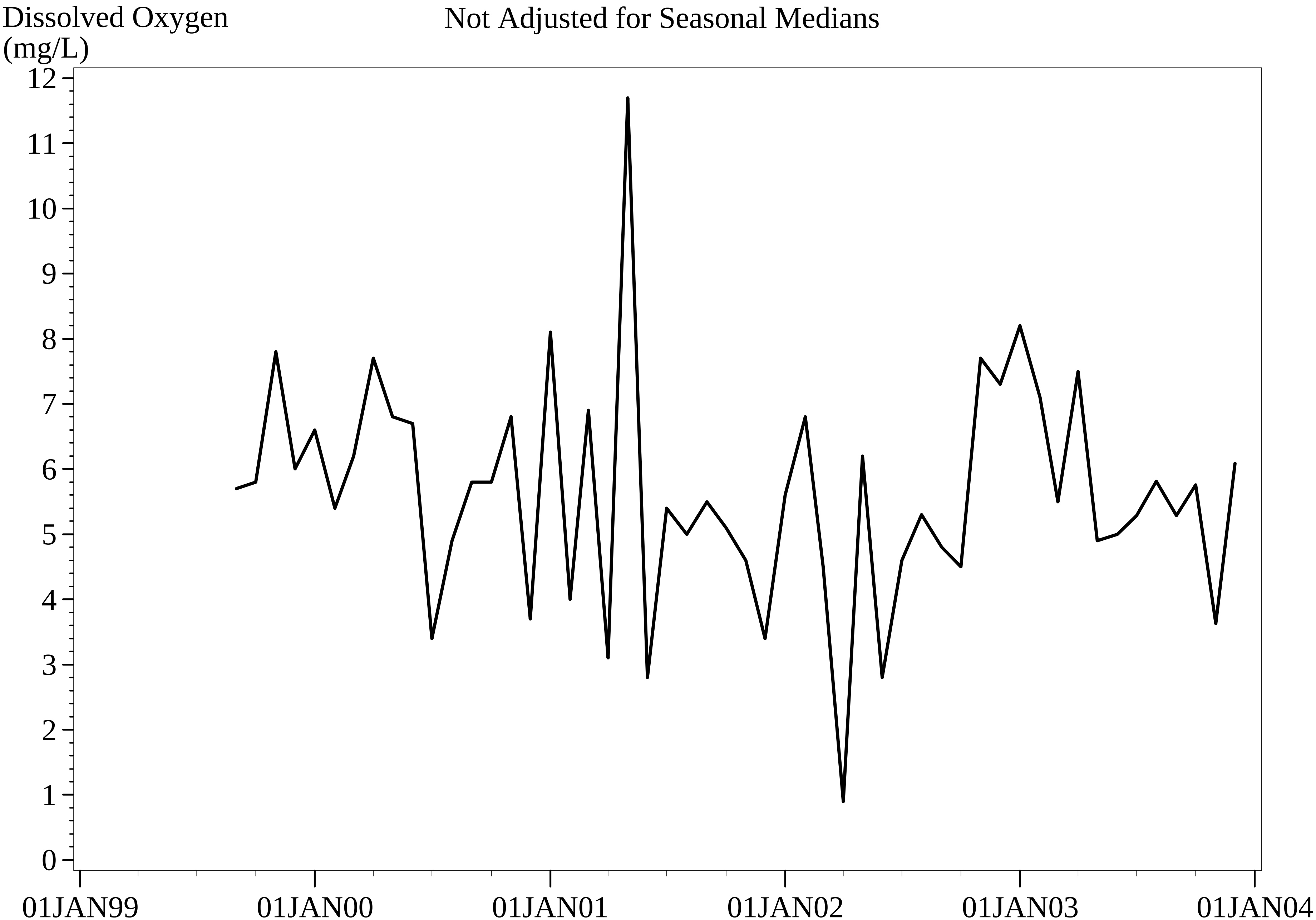
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 114 Bottom Level

Adjusted for Seasonal Median and Detrended

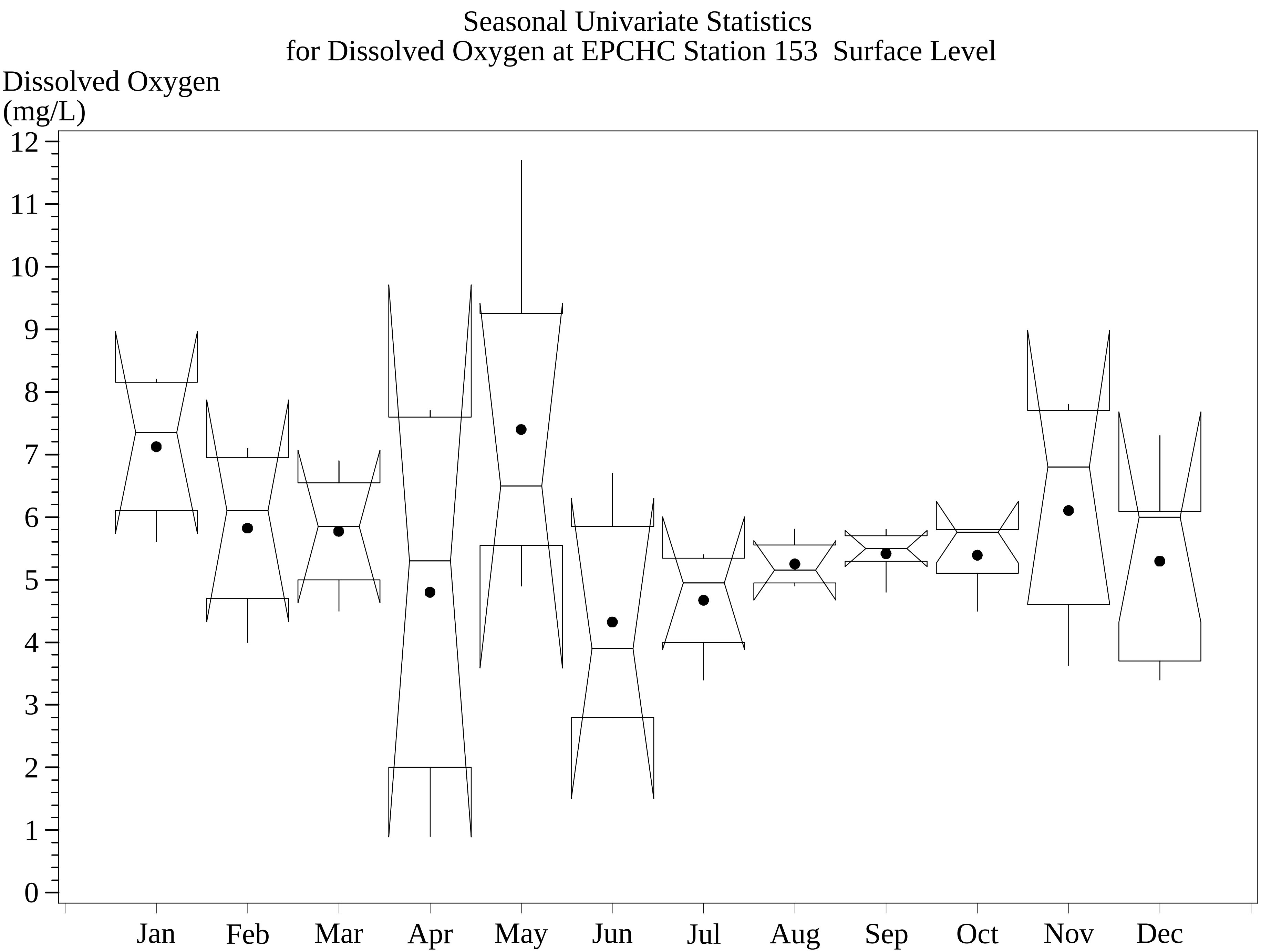
Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.261	0.093	0.186	-0.186
2	0.179	0.095	0.190	-0.190
3	0.153	0.096	0.192	-0.192
4	0.047	0.097	0.193	-0.193
5	-0.022	0.097	0.193	-0.193
6	0.004	0.097	0.193	-0.193
7	0.051	0.097	0.193	-0.193
8	0.060	0.097	0.193	-0.193
9	0.076	0.097	0.194	-0.194
10	0.045	0.097	0.194	-0.194
11	0.126	0.097	0.194	-0.194
12	0.139	0.098	0.195	-0.195
13	0.033	0.098	0.196	-0.196
14	0.027	0.098	0.196	-0.196
15	0.088	0.098	0.196	-0.196


Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 114 Bottom Level
Adjusted for Seasonal Median and Detrended
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Lagged DO
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Surface Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix



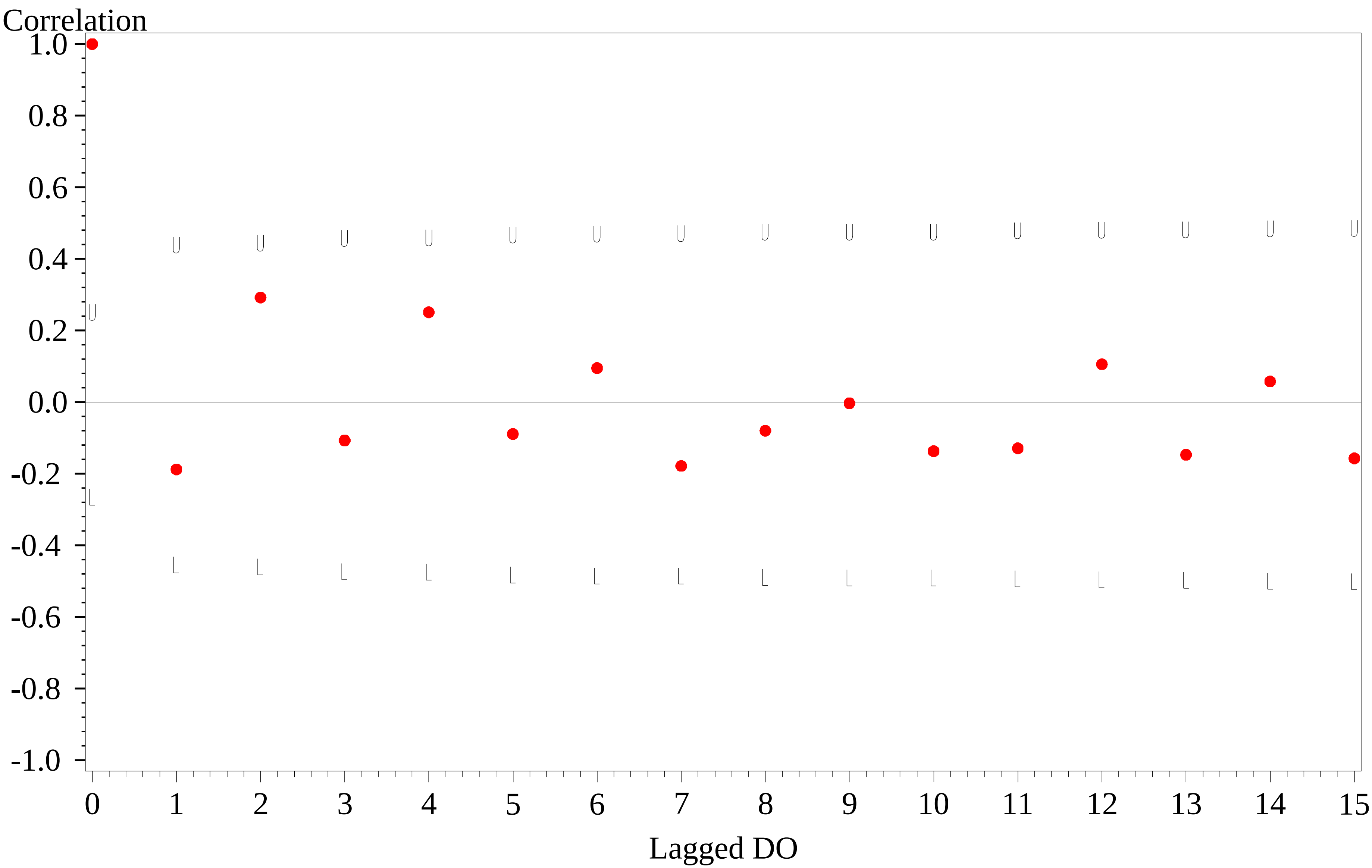
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 153 Surface Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	-0.188	0.224	0.447	-0.447
2	0.292	0.226	0.452	-0.452
3	-0.107	0.232	0.465	-0.465
4	0.251	0.233	0.467	-0.467
5	-0.089	0.238	0.475	-0.475
6	0.095	0.238	0.477	-0.477
7	-0.178	0.239	0.478	-0.478
8	-0.080	0.241	0.482	-0.482
9	-0.003	0.242	0.483	-0.483
10	-0.137	0.242	0.483	-0.483
11	-0.129	0.243	0.486	-0.486
12	0.106	0.244	0.488	-0.488
13	-0.147	0.245	0.489	-0.489
14	0.058	0.246	0.492	-0.492
15	-0.157	0.246	0.493	-0.493

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 153 Surface Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 153 Surface Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.114	0.437	0.437	-0.061

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 153 Surface Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.11364	0.43688	0.43688	-0.060833

Alafia River at Bell Shoals Road Trends Appendix

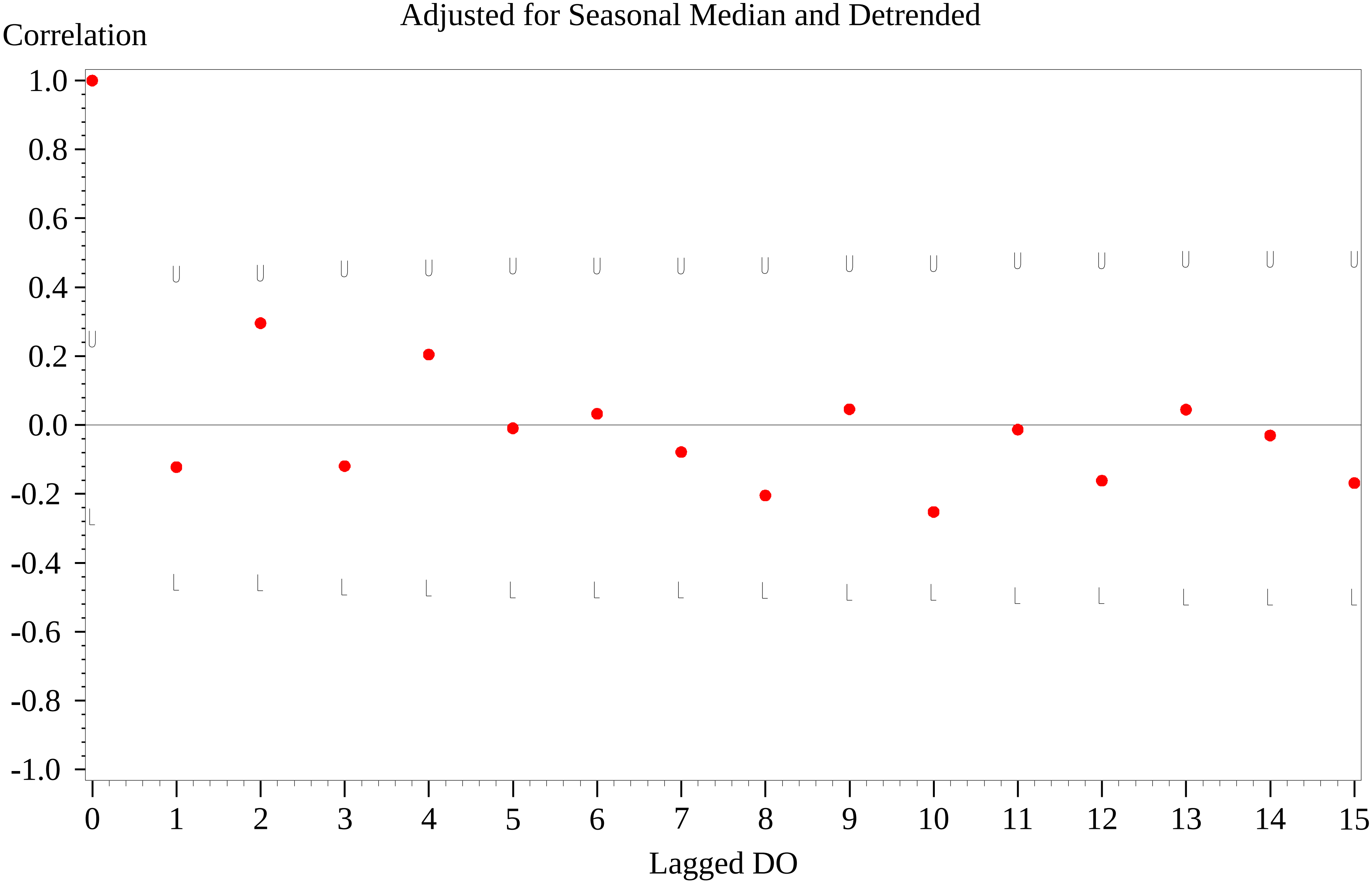
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 153 Surface Level

Adjusted for Seasonal Median and Detrended

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	-0.122	0.224	0.447	-0.447
2	0.296	0.225	0.449	-0.449
3	-0.119	0.231	0.462	-0.462
4	0.205	0.232	0.464	-0.464
5	-0.009	0.235	0.470	-0.470
6	0.033	0.235	0.470	-0.470
7	-0.078	0.235	0.470	-0.470
8	-0.204	0.236	0.471	-0.471
9	0.046	0.239	0.477	-0.477
10	-0.252	0.239	0.477	-0.477
11	-0.013	0.243	0.486	-0.486
12	-0.161	0.243	0.486	-0.486
13	0.045	0.245	0.490	-0.490
14	-0.030	0.245	0.490	-0.490
15	-0.168	0.245	0.490	-0.490

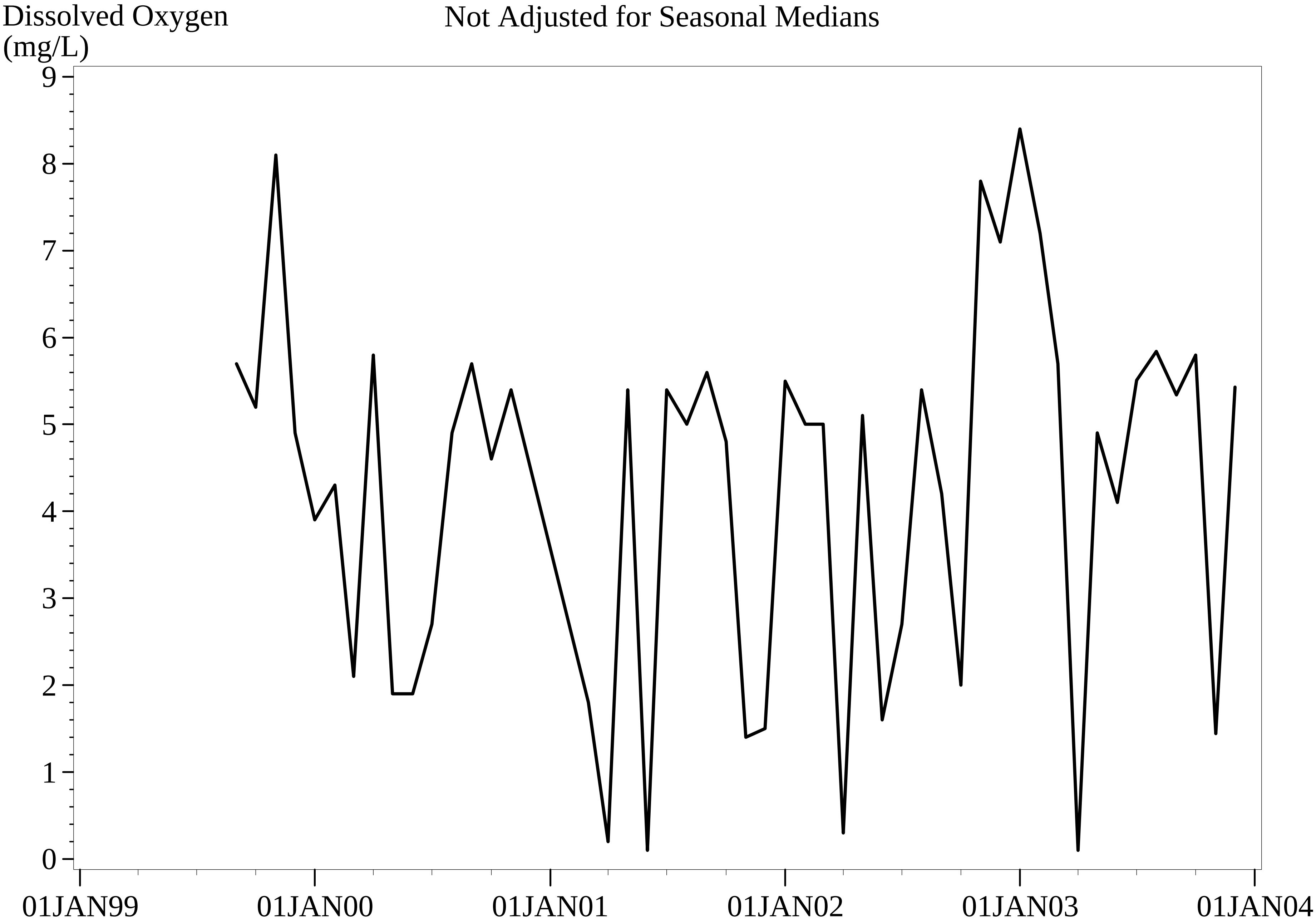
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 153 Surface Level

Adjusted for Seasonal Median and Detrended



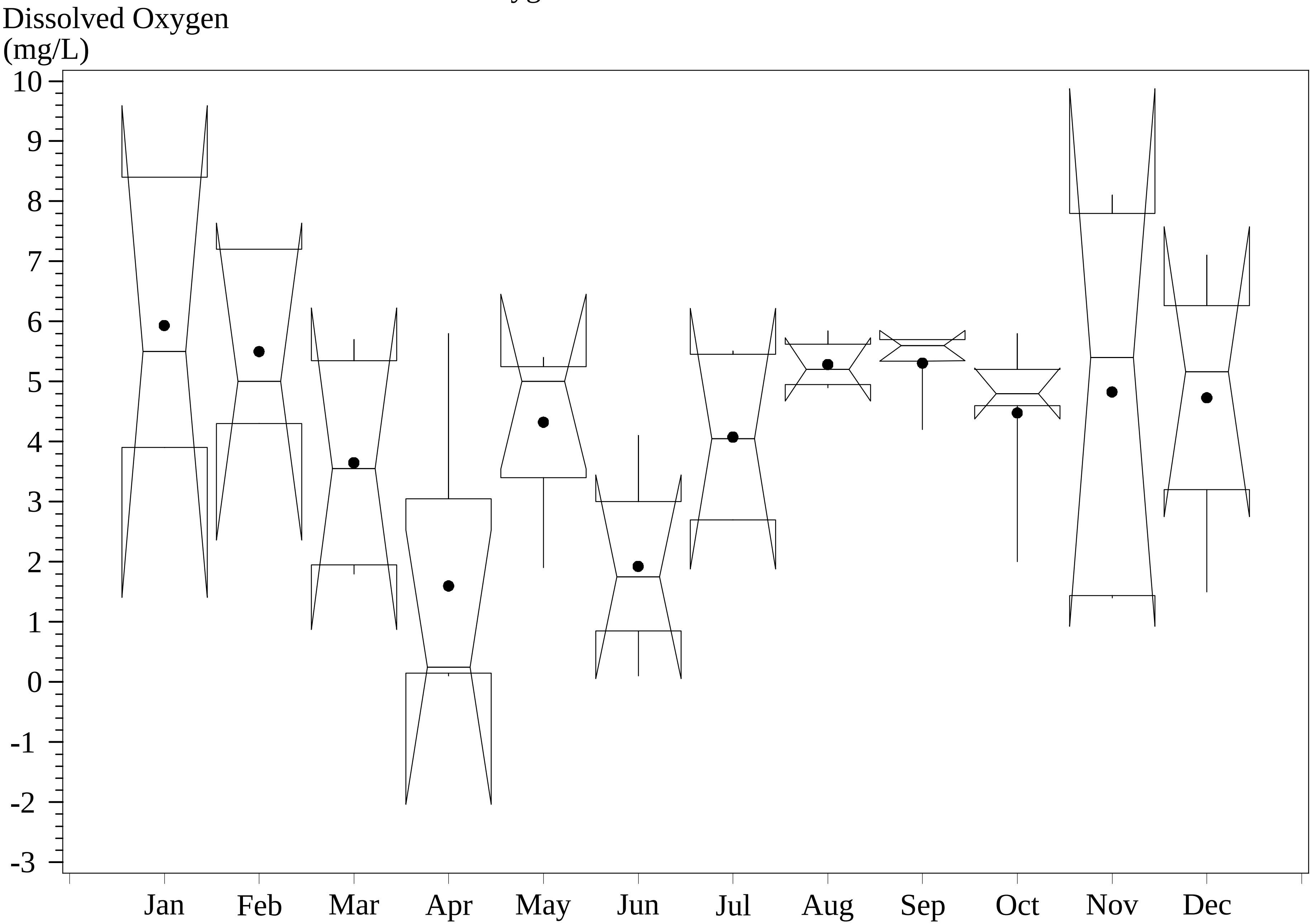
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 153 Middle Level



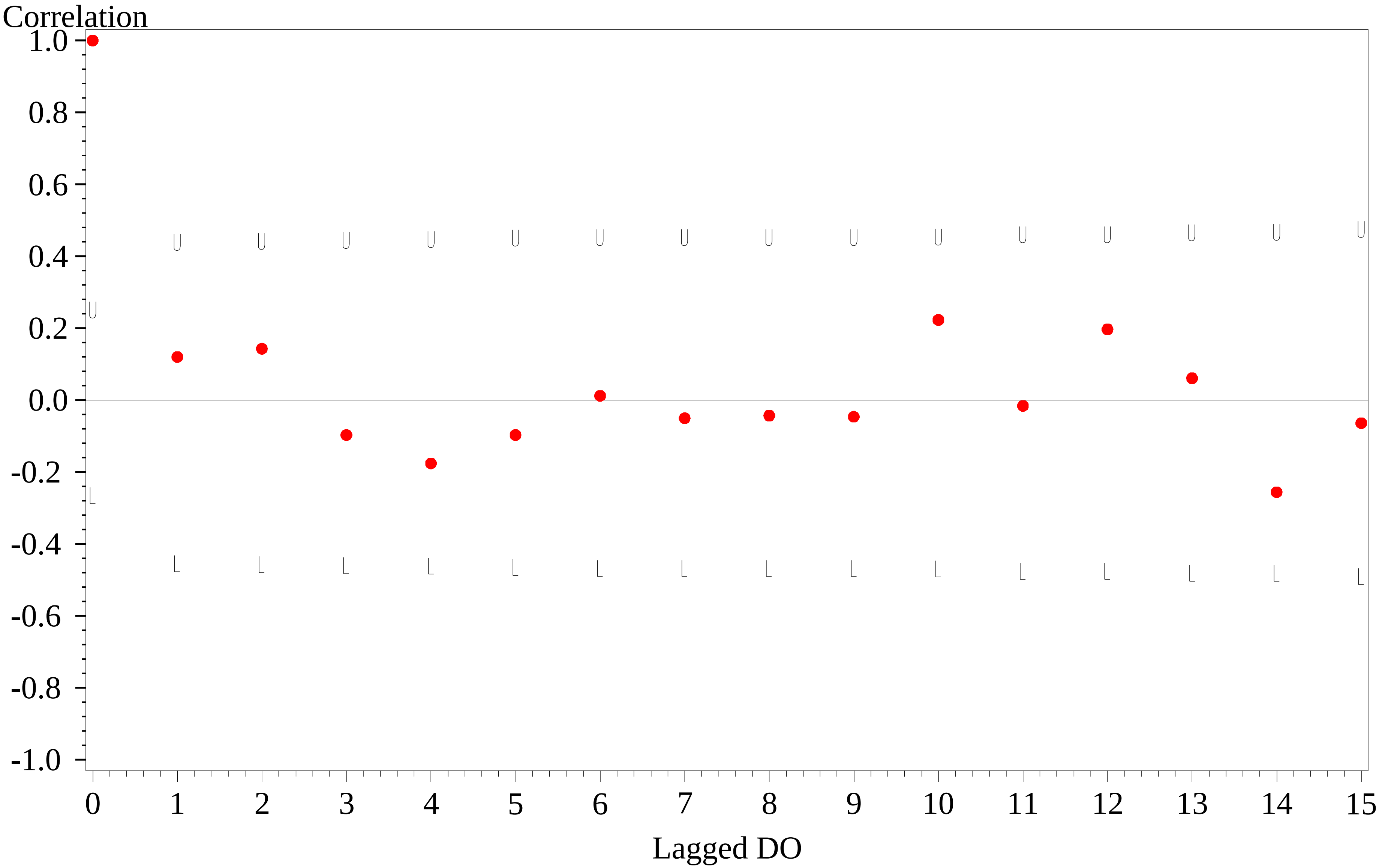
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.120	0.224	0.447	-0.447
2	0.143	0.225	0.449	-0.449
3	-0.097	0.226	0.452	-0.452
4	-0.176	0.227	0.454	-0.454
5	-0.097	0.229	0.458	-0.458
6	0.012	0.230	0.460	-0.460
7	-0.050	0.230	0.460	-0.460
8	-0.043	0.230	0.460	-0.460
9	-0.046	0.230	0.460	-0.460
10	0.223	0.230	0.461	-0.461
11	-0.016	0.234	0.468	-0.468
12	0.197	0.234	0.468	-0.468
13	0.061	0.237	0.473	-0.473
14	-0.256	0.237	0.474	-0.474
15	-0.064	0.241	0.483	-0.483

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.103	0.516	0.592	0.1

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Dissolved Oxygen at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.10256	0.51574	0.59208	0.1

Alafia River at Bell Shoals Road Trends Appendix

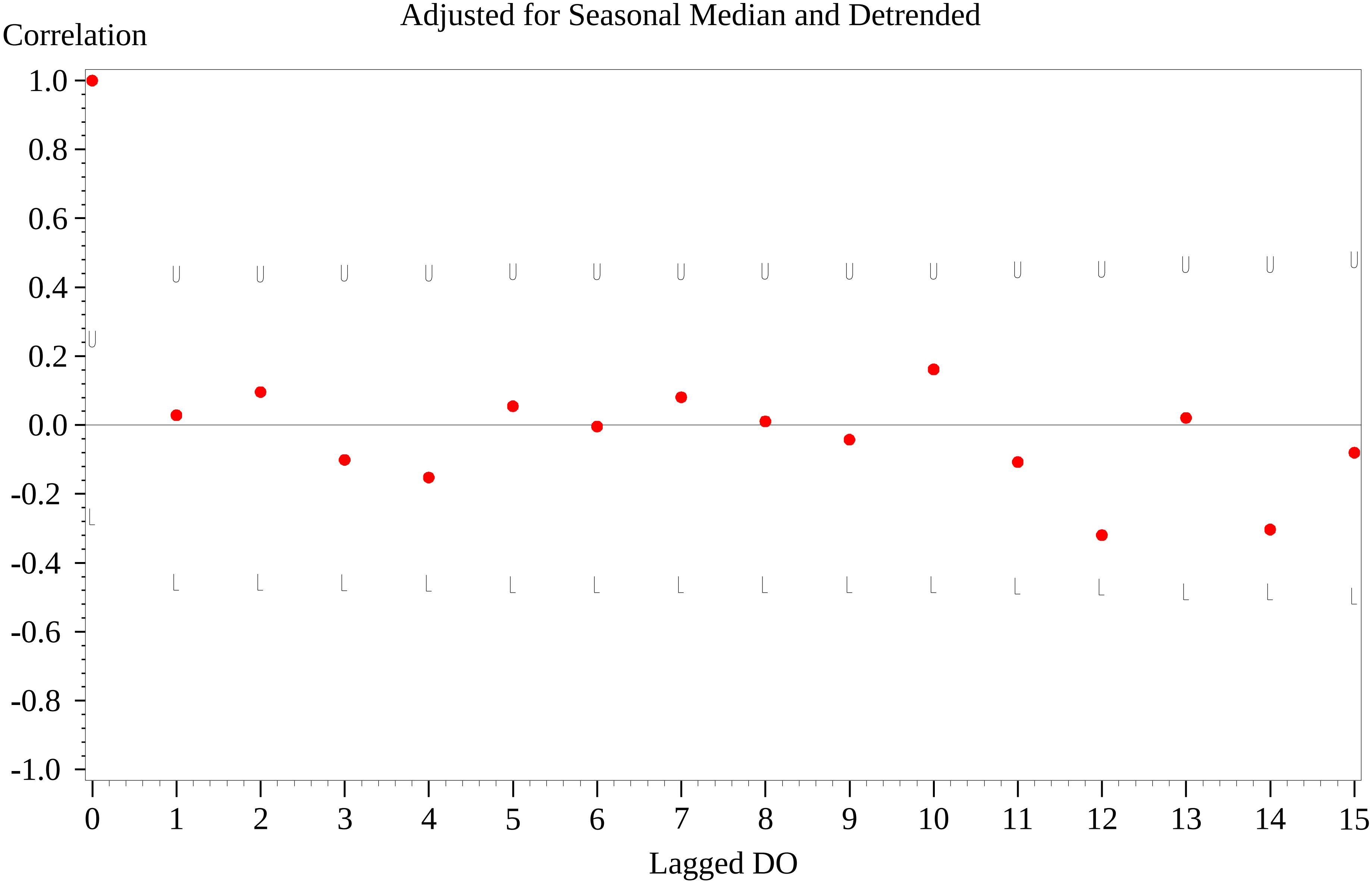
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.029	0.224	0.447	-0.447
2	0.096	0.224	0.447	-0.447
3	-0.101	0.224	0.449	-0.449
4	-0.152	0.225	0.450	-0.450
5	0.055	0.227	0.454	-0.454
6	-0.004	0.227	0.454	-0.454
7	0.081	0.227	0.454	-0.454
8	0.011	0.228	0.455	-0.455
9	-0.042	0.228	0.455	-0.455
10	0.162	0.228	0.455	-0.455
11	-0.107	0.230	0.459	-0.459
12	-0.319	0.230	0.461	-0.461
13	0.021	0.238	0.475	-0.475
14	-0.303	0.238	0.475	-0.475
15	-0.080	0.244	0.488	-0.488

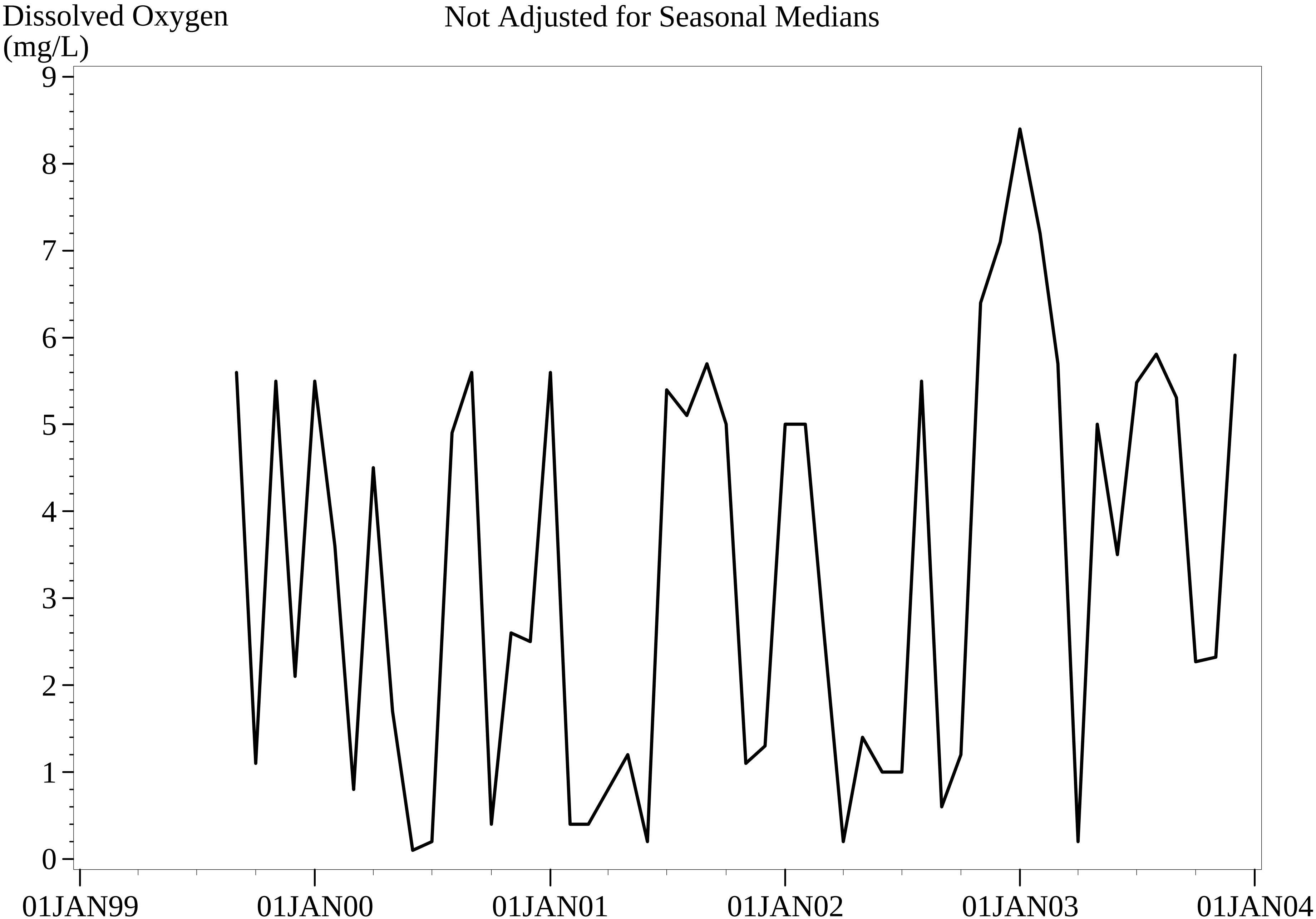
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 153 Middle Level

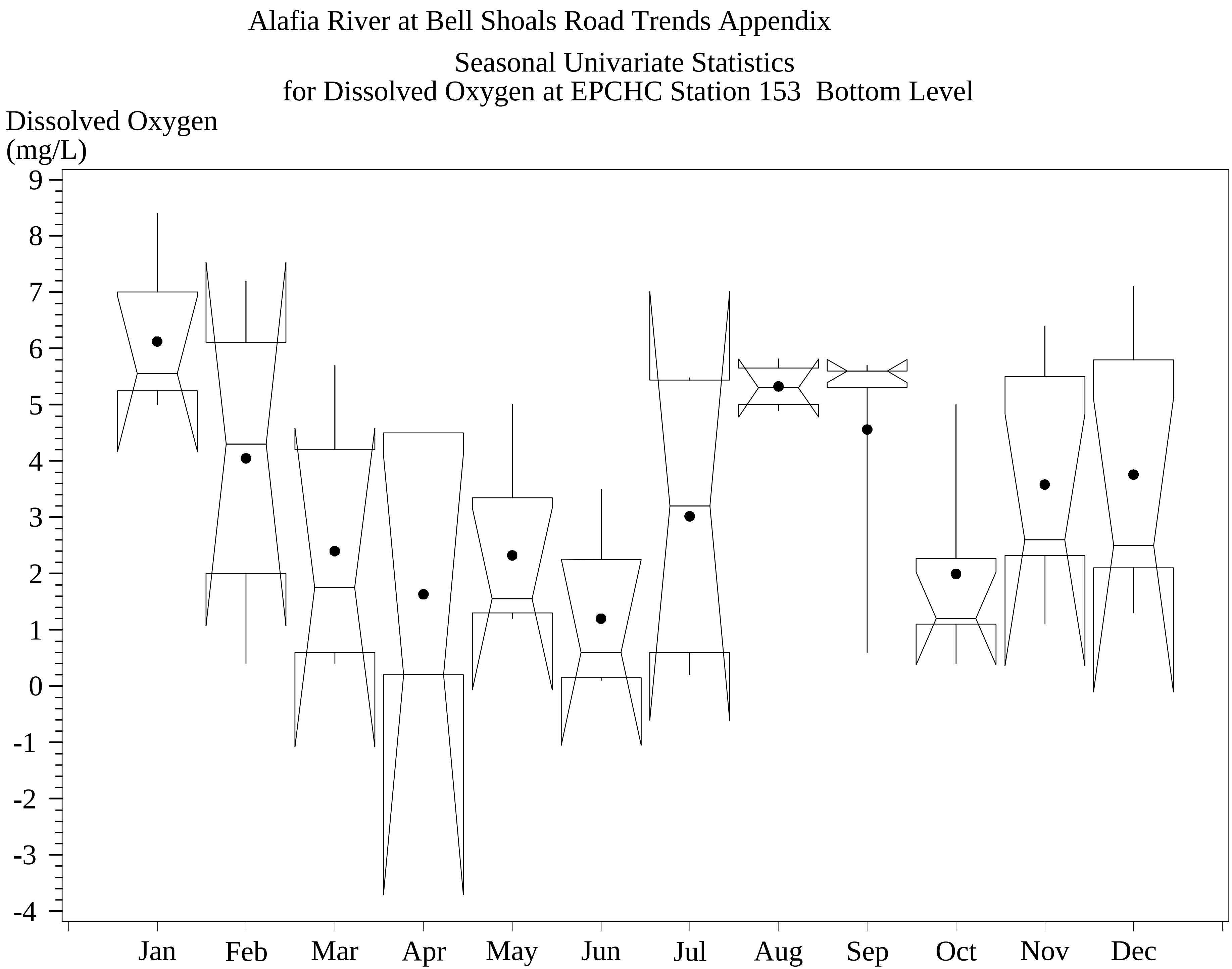
Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Bottom Level
Not Adjusted for Seasonal Medians





Alafia River at Bell Shoals Road Trends Appendix
Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 153 Bottom Level
Dissolved Oxygen
(mg/L)
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

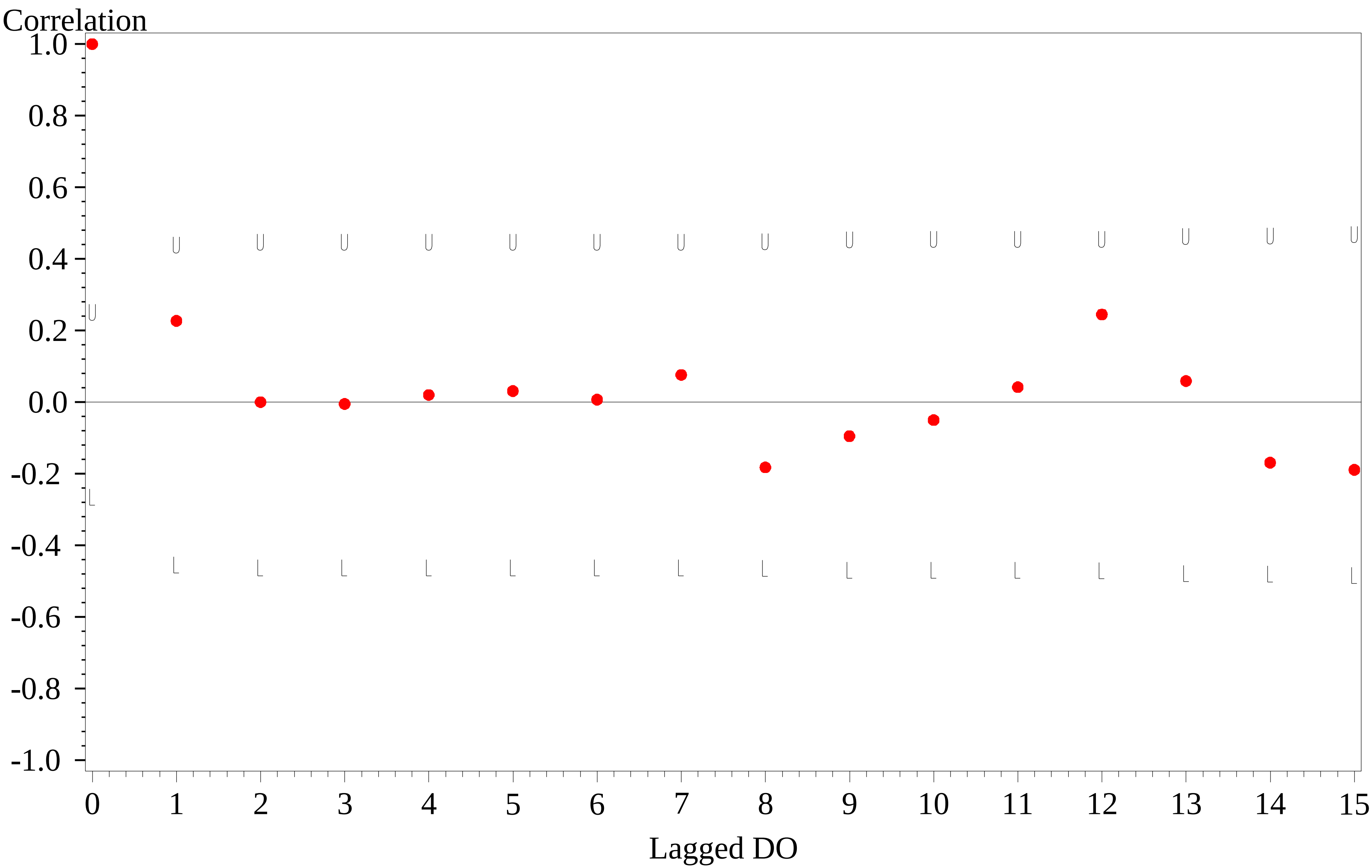
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 153 Bottom Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.227	0.224	0.447	-0.447
2	0.000	0.227	0.455	-0.455
3	-0.005	0.227	0.455	-0.455
4	0.020	0.227	0.455	-0.455
5	0.031	0.227	0.455	-0.455
6	0.007	0.228	0.455	-0.455
7	0.076	0.228	0.455	-0.455
8	-0.182	0.228	0.456	-0.456
9	-0.095	0.230	0.461	-0.461
10	-0.050	0.231	0.462	-0.462
11	0.042	0.231	0.462	-0.462
12	0.245	0.231	0.463	-0.463
13	0.059	0.236	0.471	-0.471
14	-0.169	0.236	0.472	-0.472
15	-0.189	0.238	0.476	-0.476

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 153 Bottom Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 153 Bottom Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.341	0.014	0.085	0.355

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 153 Bottom Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.34118	0.013691	0.085428	0.355

Alafia River at Bell Shoals Road Trends Appendix

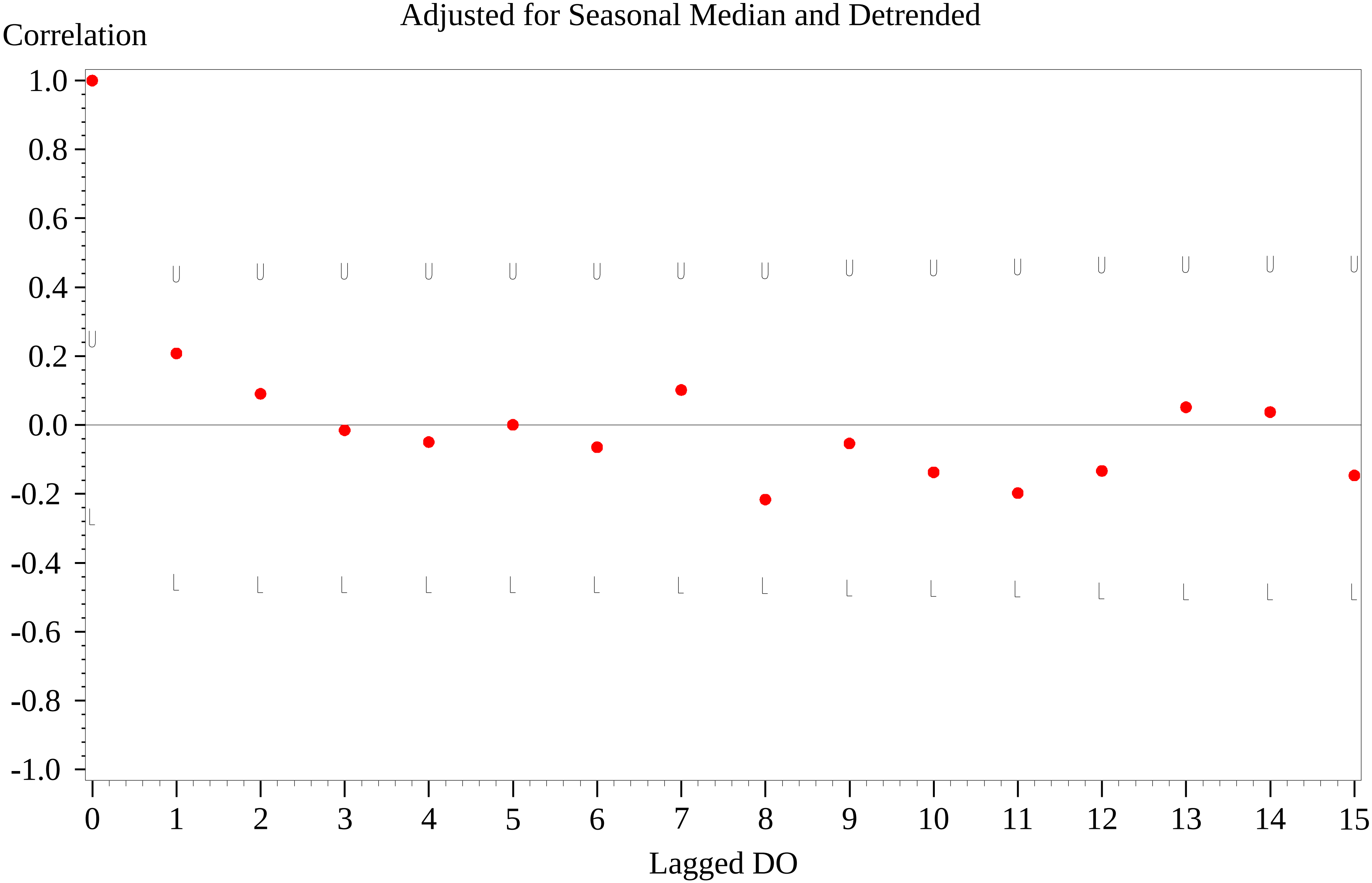
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 153 Bottom Level

Adjusted for Seasonal Median and Detrended

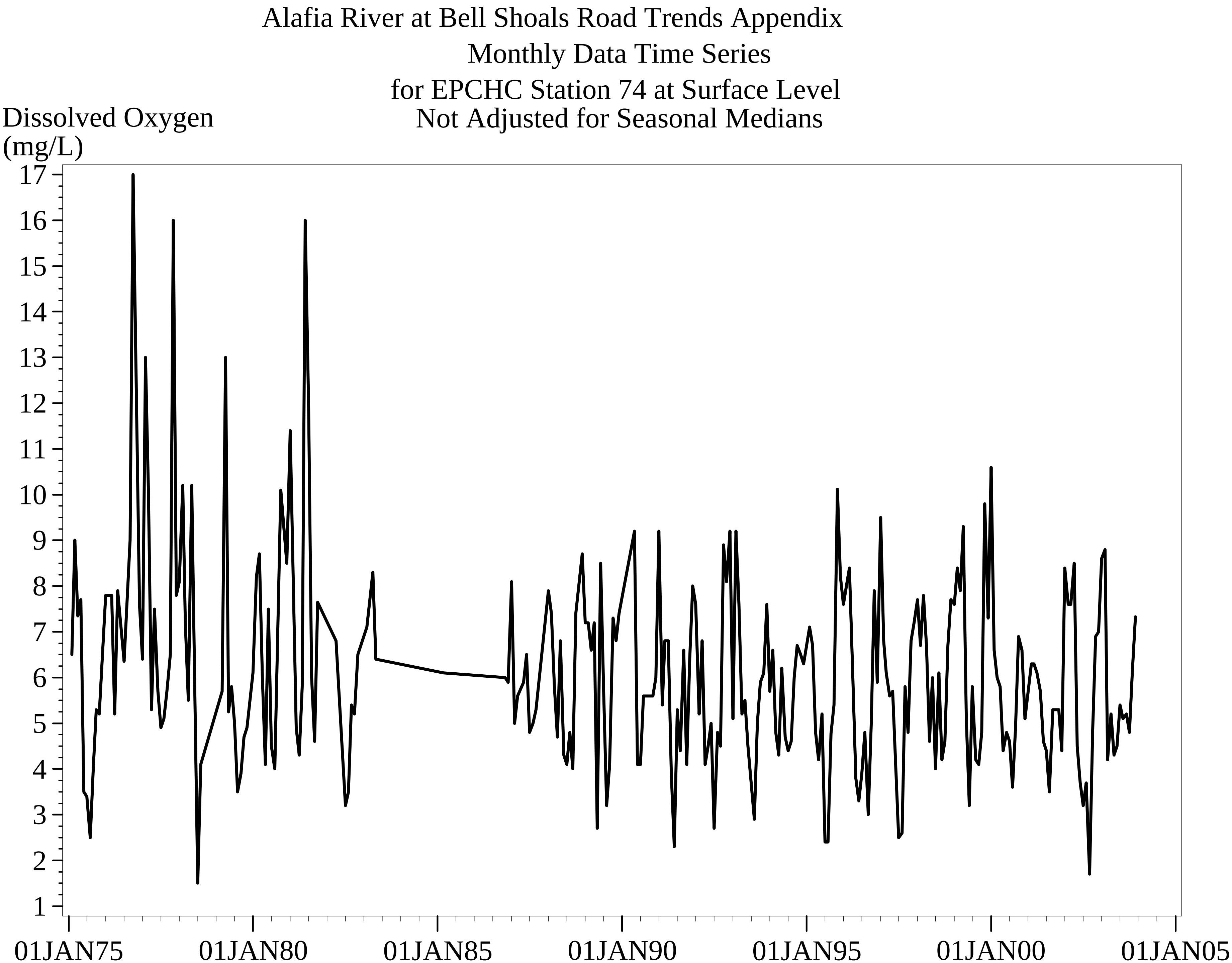
Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.208	0.224	0.447	-0.447
2	0.091	0.227	0.454	-0.454
3	-0.015	0.227	0.455	-0.455
4	-0.049	0.227	0.455	-0.455
5	0.001	0.228	0.455	-0.455
6	-0.064	0.228	0.455	-0.455
7	0.102	0.228	0.456	-0.456
8	-0.216	0.229	0.457	-0.457
9	-0.053	0.232	0.464	-0.464
10	-0.137	0.232	0.465	-0.465
11	-0.197	0.234	0.467	-0.467
12	-0.133	0.236	0.473	-0.473
13	0.052	0.238	0.475	-0.475
14	0.038	0.238	0.476	-0.476
15	-0.146	0.238	0.476	-0.476

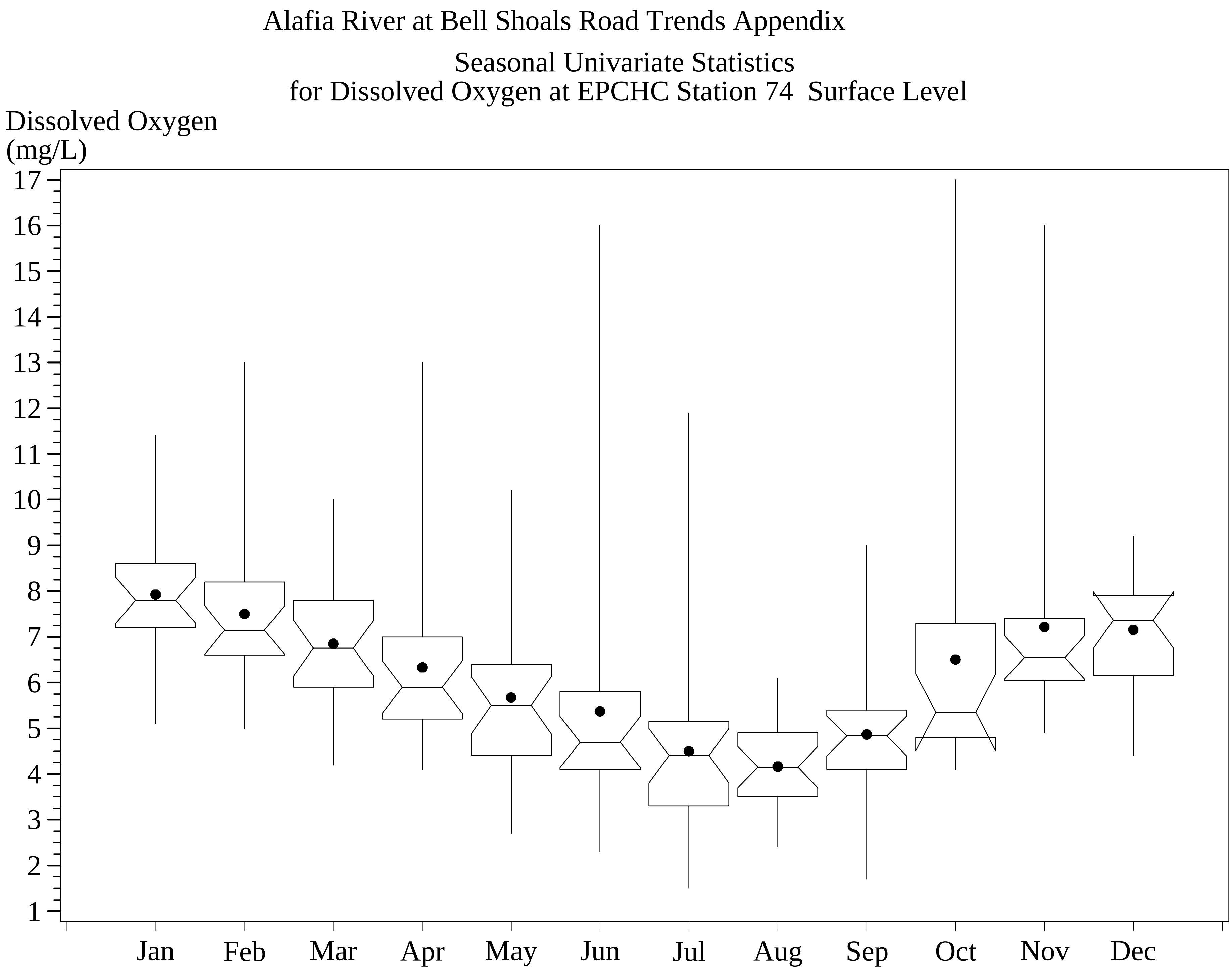
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 153 Bottom Level

Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown


Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Surface Level
Not Adjusted for Seasonal Medians
Dissolved Oxygen
(mg/L)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
01JAN75
01JAN80
01JAN85
01JAN90
01JAN95
01JAN00
01JAN05



Alafia River at Bell Shoals Road Trends Appendix
Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 74 Surface Level
Dissolved Oxygen
(mg/L)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

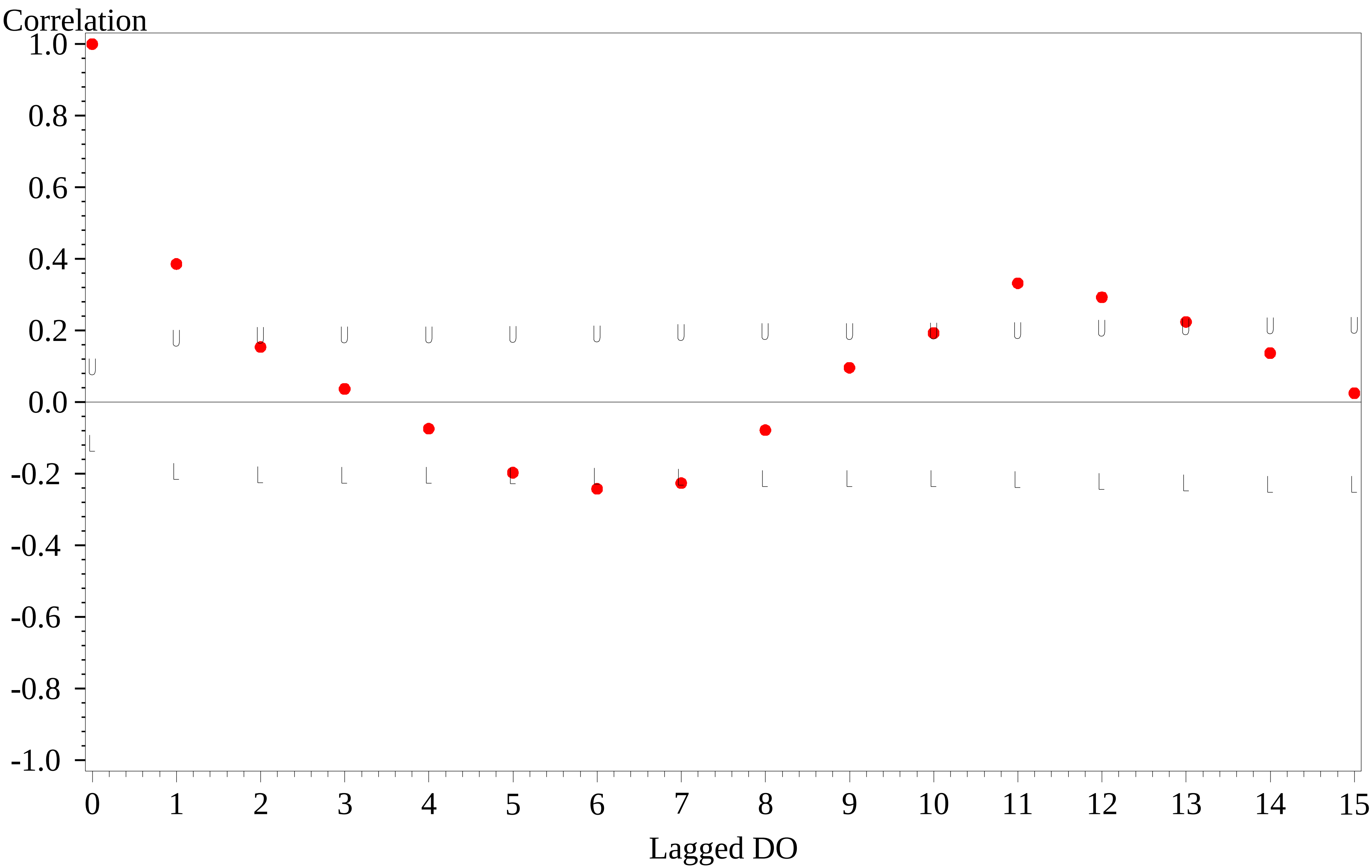
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 74 Surface Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.386	0.093	0.186	-0.186
2	0.154	0.097	0.195	-0.195
3	0.037	0.098	0.196	-0.196
4	-0.074	0.098	0.196	-0.196
5	-0.197	0.098	0.197	-0.197
6	-0.242	0.099	0.199	-0.199
7	-0.226	0.101	0.202	-0.202
8	-0.078	0.102	0.205	-0.205
9	0.096	0.103	0.205	-0.205
10	0.193	0.103	0.206	-0.206
11	0.332	0.104	0.208	-0.208
12	0.293	0.107	0.214	-0.214
13	0.224	0.109	0.218	-0.218
14	0.137	0.111	0.221	-0.221
15	0.025	0.111	0.222	-0.222

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 74 Surface Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 74 Surface Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.117	.008	0.011	-0.031

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 74 Surface Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.11720	.00774961	0.011148	-0.030769

Alafia River at Bell Shoals Road Trends Appendix

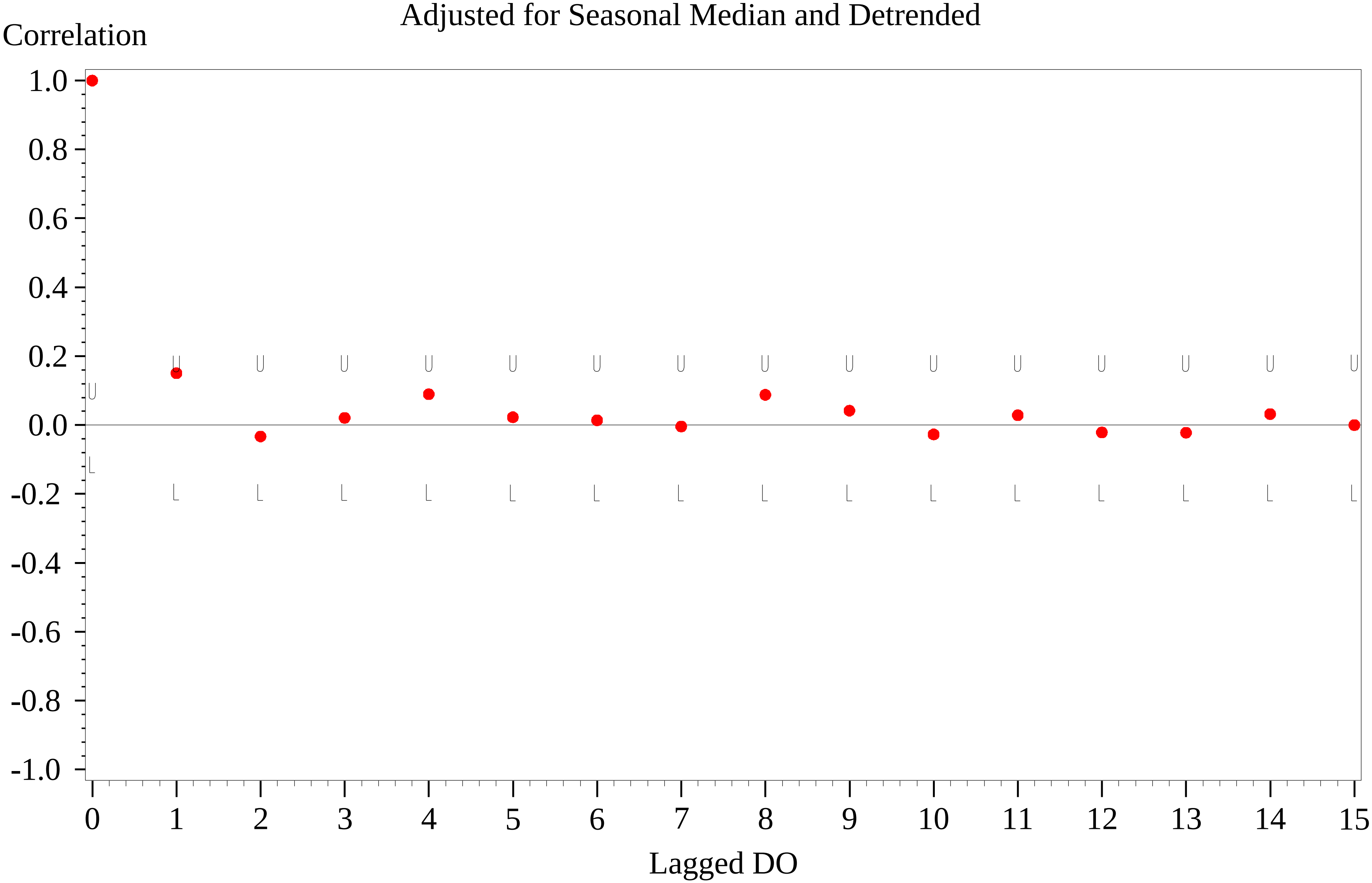
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 74 Surface Level

Adjusted for Seasonal Median and Detrended

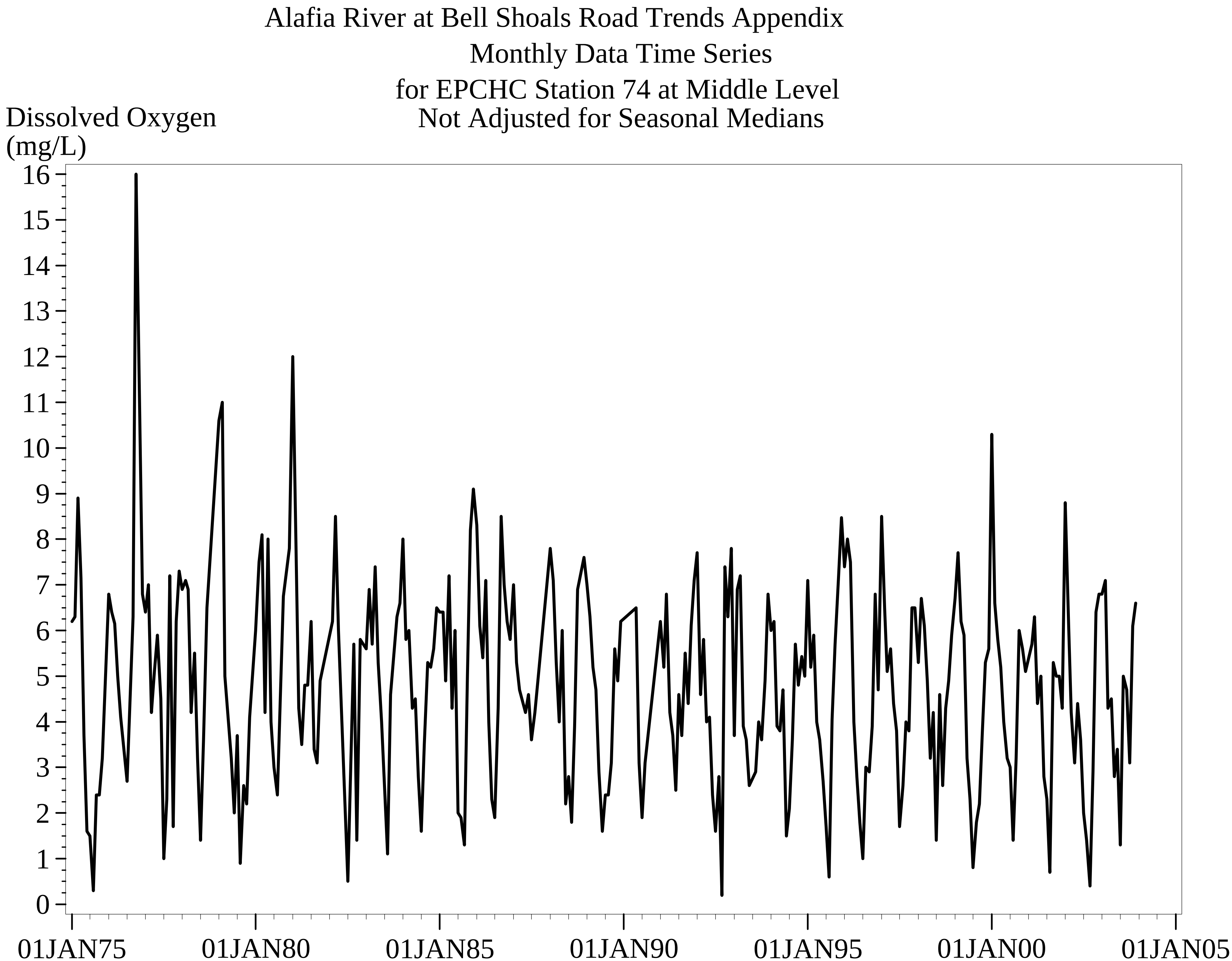
Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.151	0.093	0.186	-0.186
2	-0.033	0.094	0.187	-0.187
3	0.021	0.094	0.187	-0.187
4	0.090	0.094	0.187	-0.187
5	0.023	0.094	0.188	-0.188
6	0.014	0.094	0.188	-0.188
7	-0.004	0.094	0.188	-0.188
8	0.088	0.094	0.188	-0.188
9	0.042	0.094	0.188	-0.188
10	-0.027	0.094	0.188	-0.188
11	0.029	0.094	0.188	-0.188
12	-0.021	0.094	0.188	-0.188
13	-0.022	0.094	0.188	-0.188
14	0.032	0.094	0.188	-0.188
15	0.000	0.094	0.189	-0.189

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 74 Surface Level

Adjusted for Seasonal Median and Detrended



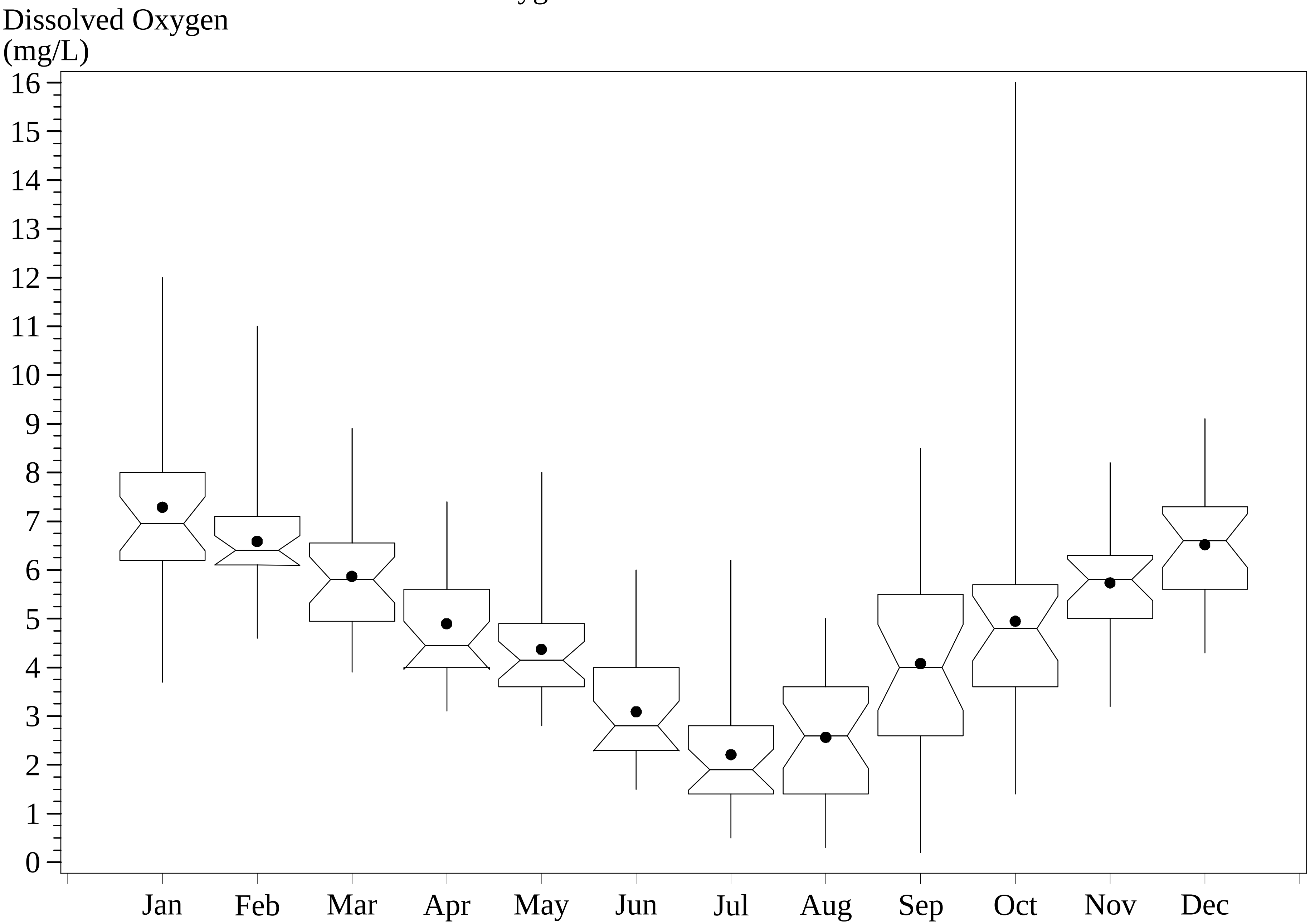
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown



Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Middle Level
Not Adjusted for Seasonal Medians
Dissolved Oxygen
(mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
01JAN75
01JAN80
01JAN85
01JAN90
01JAN95
01JAN00
01JAN05

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 74 Middle Level



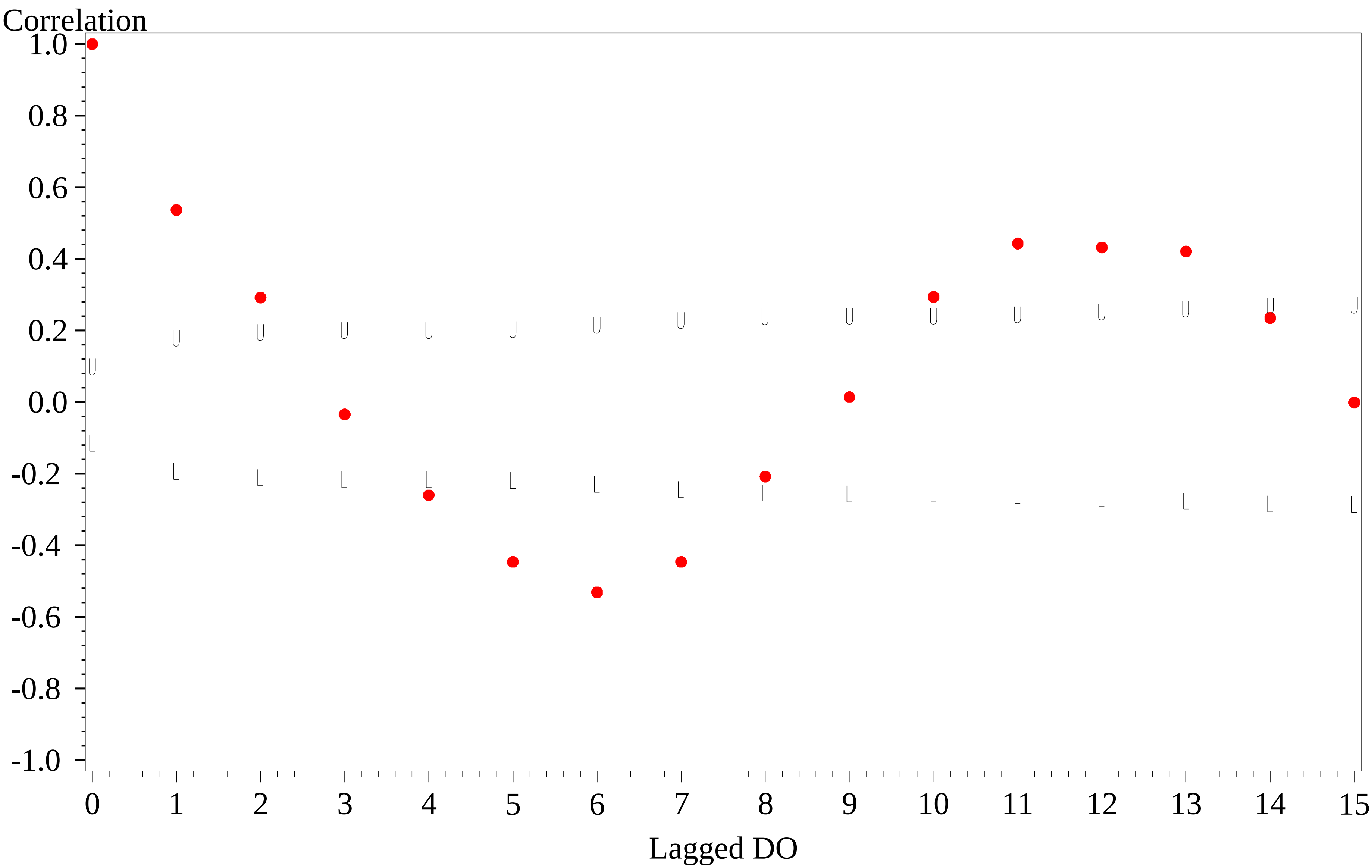
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.537	0.093	0.186	-0.186
2	0.292	0.101	0.203	-0.203
3	-0.034	0.104	0.208	-0.208
4	-0.260	0.104	0.208	-0.208
5	-0.446	0.106	0.211	-0.211
6	-0.531	0.111	0.222	-0.222
7	-0.446	0.118	0.236	-0.236
8	-0.208	0.123	0.246	-0.246
9	0.014	0.124	0.248	-0.248
10	0.294	0.124	0.248	-0.248
11	0.443	0.126	0.252	-0.252
12	0.432	0.130	0.260	-0.260
13	0.421	0.134	0.268	-0.268
14	0.235	0.138	0.276	-0.276
15	-0.001	0.139	0.278	-0.278

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.096	0.017	0.023	-0.024

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.096042	0.017041	0.023041	-0.023529

Alafia River at Bell Shoals Road Trends Appendix

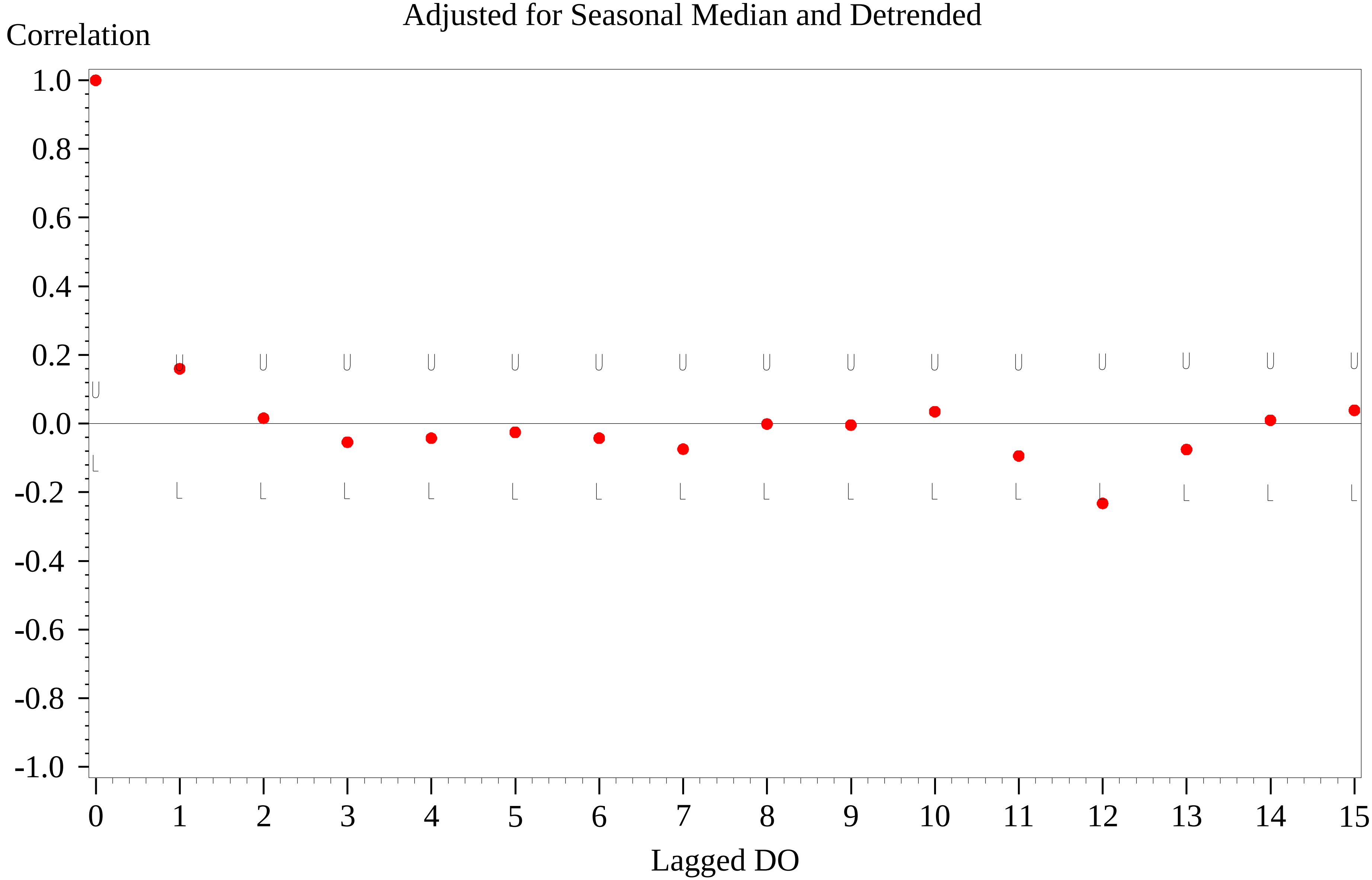
Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.160	0.093	0.186	-0.186
2	0.016	0.094	0.187	-0.187
3	-0.054	0.094	0.187	-0.187
4	-0.042	0.094	0.187	-0.187
5	-0.025	0.094	0.188	-0.188
6	-0.042	0.094	0.188	-0.188
7	-0.074	0.094	0.188	-0.188
8	-0.001	0.094	0.188	-0.188
9	-0.004	0.094	0.188	-0.188
10	0.035	0.094	0.188	-0.188
11	-0.094	0.094	0.188	-0.188
12	-0.232	0.094	0.189	-0.189
13	-0.075	0.096	0.192	-0.192
14	0.010	0.096	0.192	-0.192
15	0.039	0.096	0.192	-0.192

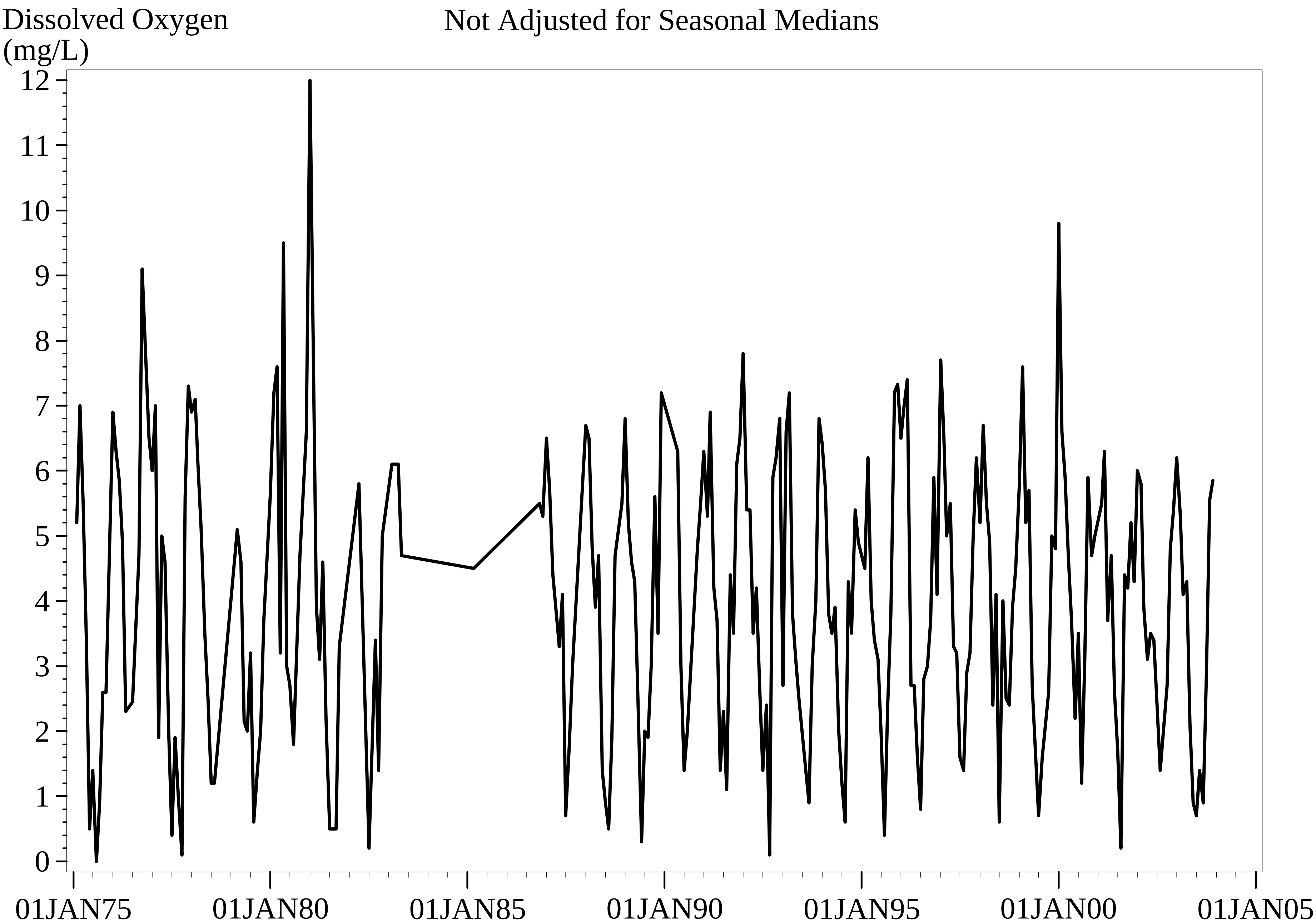
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended



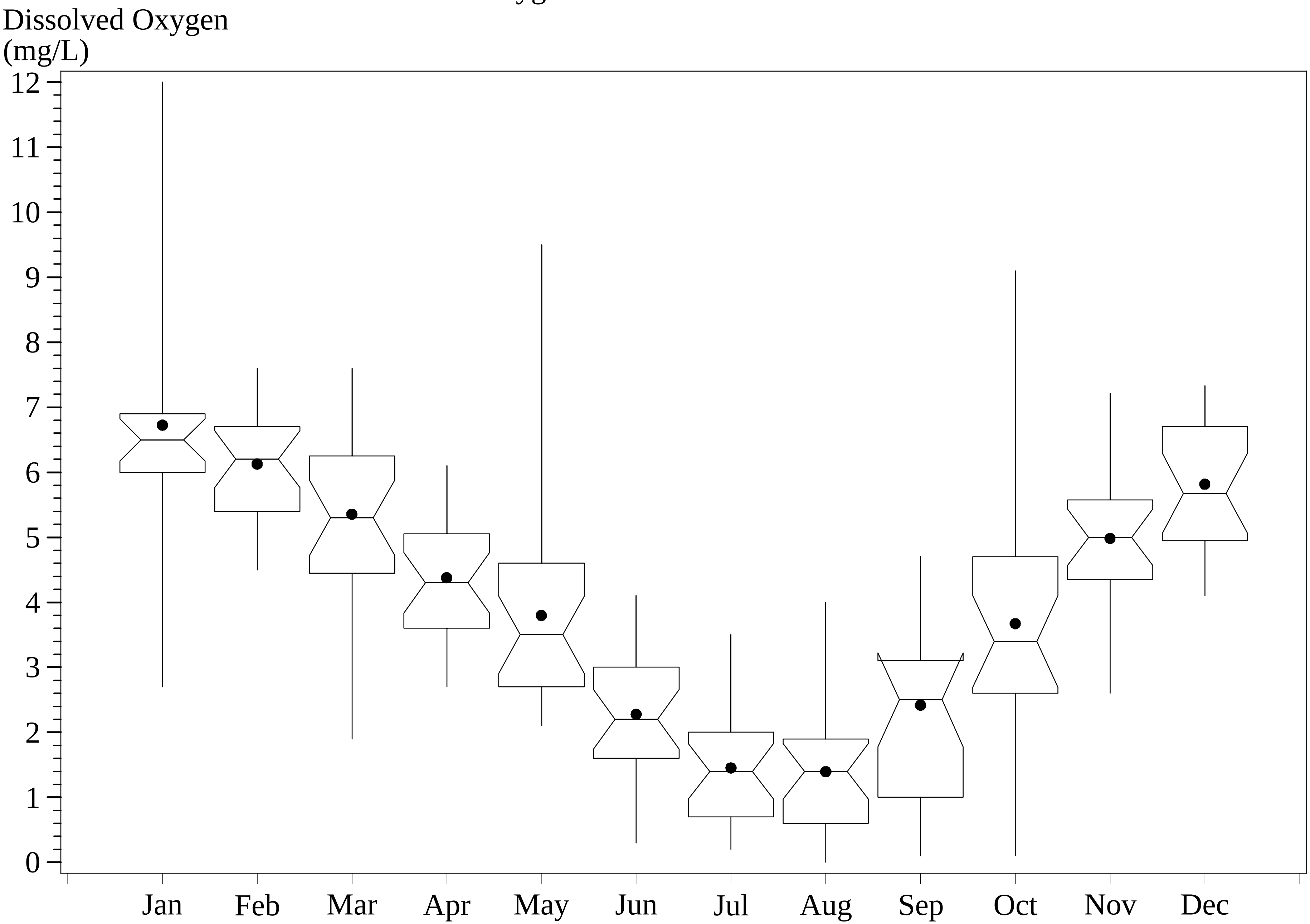
U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Bottom Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Dissolved Oxygen at EPCHC Station 74 Bottom Level

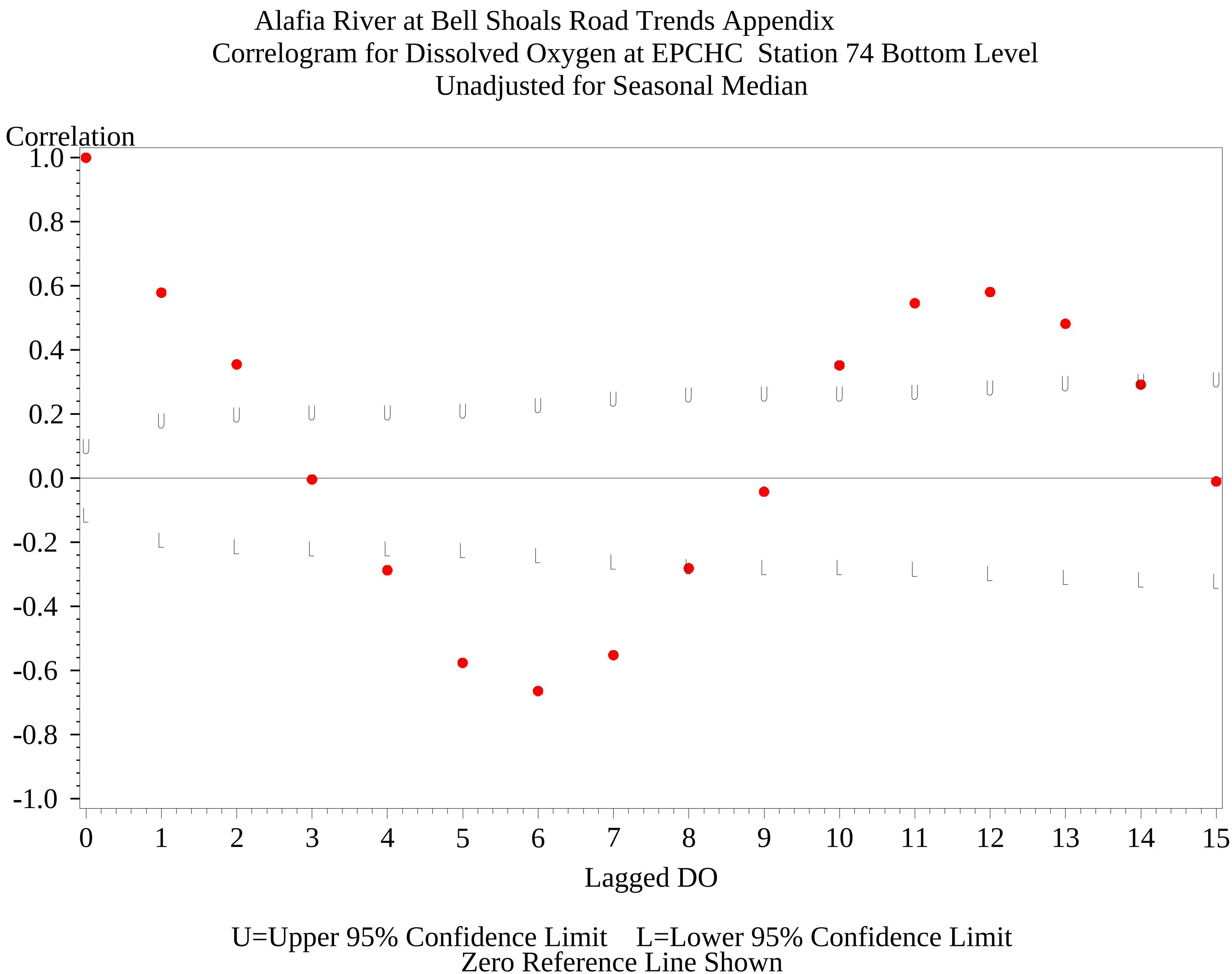


Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 74 Bottom Level

Unadjusted for Seasonal Medians

Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.579	0.093	0.186	-0.186
2	0.355	0.103	0.205	-0.205
3	-0.004	0.106	0.212	-0.212
4	-0.287	0.106	0.212	-0.212
5	-0.576	0.108	0.217	-0.217
6	-0.664	0.117	0.234	-0.234
7	-0.552	0.127	0.254	-0.254
8	-0.281	0.134	0.268	-0.268
9	-0.042	0.136	0.271	-0.271
10	0.352	0.136	0.271	-0.271
11	0.546	0.138	0.276	-0.276
12	0.581	0.144	0.289	-0.289
13	0.482	0.151	0.302	-0.302
14	0.292	0.155	0.310	-0.310
15	-0.010	0.157	0.314	-0.314


Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 74 Bottom Level
Unadjusted for Seasonal Median
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Lagged DO
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Dissolved Oxygen at EPCHC Station 74 Bottom Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.03	0.507	0.569	-.006

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Dissolved Oxygen at EPCHC Station 74 Bottom Level

Adjusted for Seasonal Medians

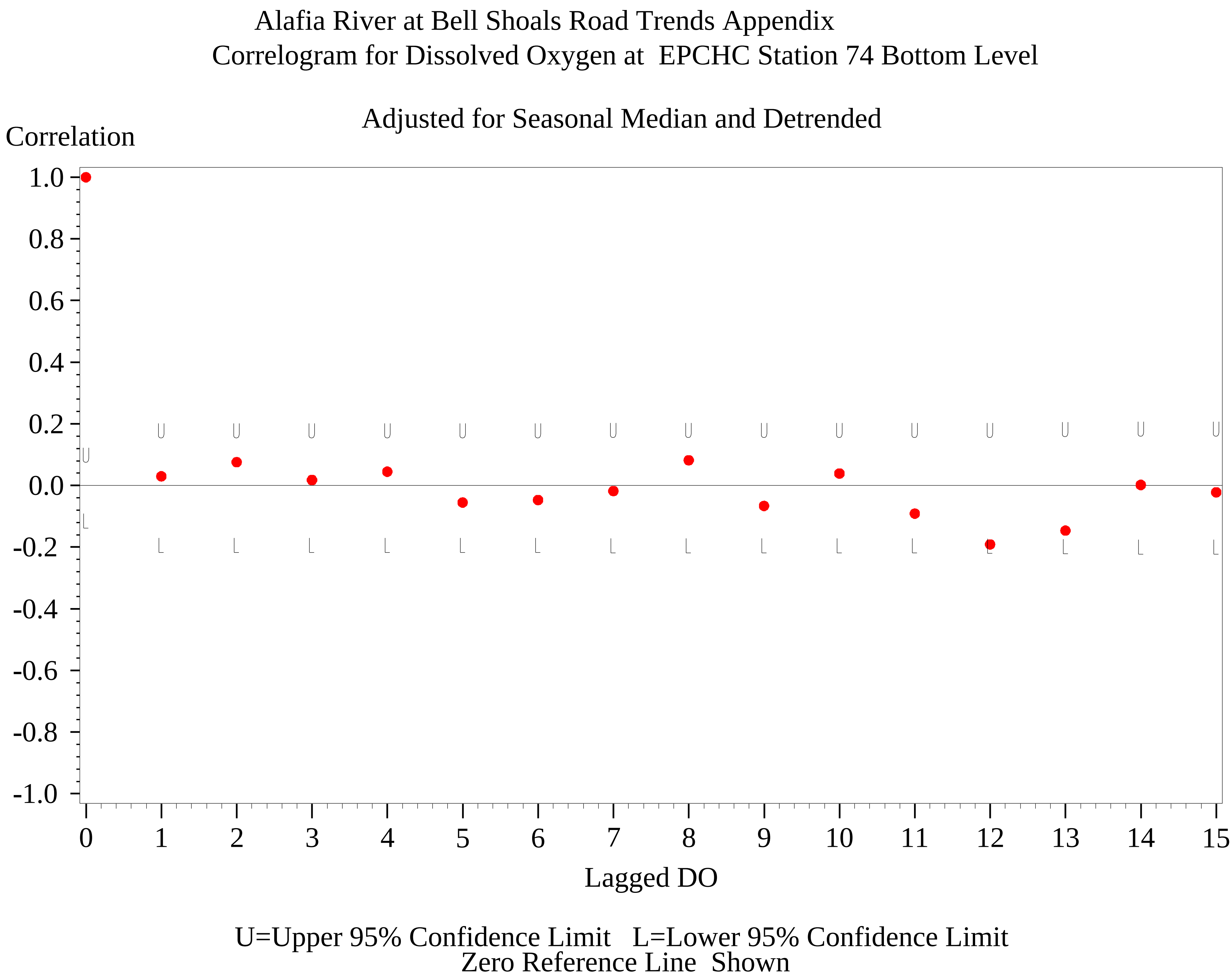
Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.029640	0.50688	0.56917	-.00571895

Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Dissolved Oxygen at EPCHC Station 74 Bottom Level

Adjusted for Seasonal Median and Detrended

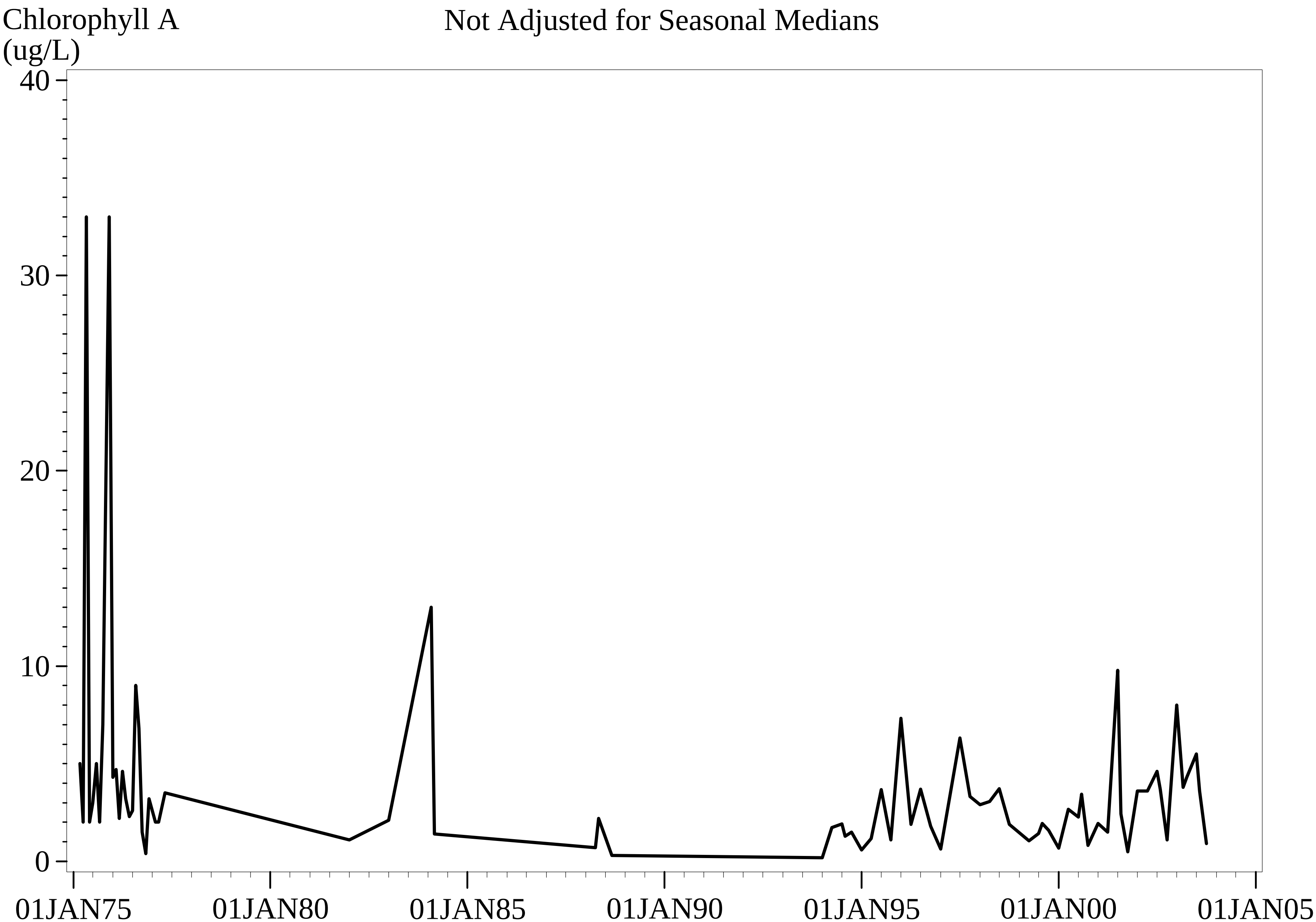
Lagged DO	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.030	0.093	0.186	-0.186
2	0.076	0.093	0.186	-0.186
3	0.018	0.093	0.186	-0.186
4	0.045	0.093	0.186	-0.186
5	-0.055	0.093	0.186	-0.186
6	-0.047	0.093	0.186	-0.186
7	-0.018	0.093	0.187	-0.187
8	0.082	0.093	0.187	-0.187
9	-0.066	0.094	0.187	-0.187
10	0.039	0.094	0.187	-0.187
11	-0.091	0.094	0.187	-0.187
12	-0.191	0.094	0.188	-0.188
13	-0.146	0.095	0.190	-0.190
14	0.002	0.096	0.191	-0.191
15	-0.022	0.096	0.191	-0.191



Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Dissolved Oxygen at EPCHC Station 74 Bottom Level
Adjusted for Seasonal Median and Detrended
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Lagged DO
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

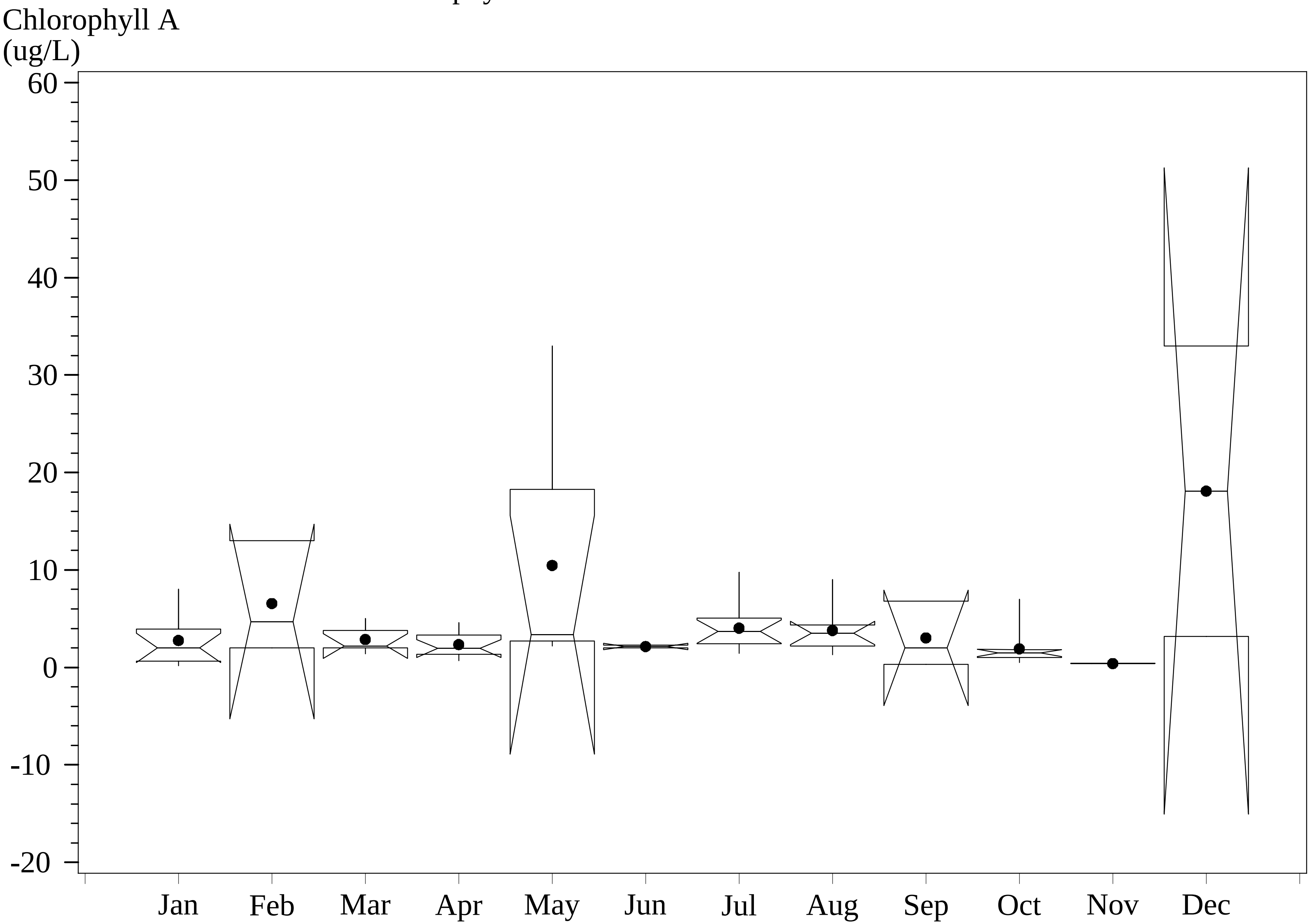
APPENDIX I:
CHLOROPHYLL TREND RESULTS

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll A at EPCHC Station 114 Middle Level



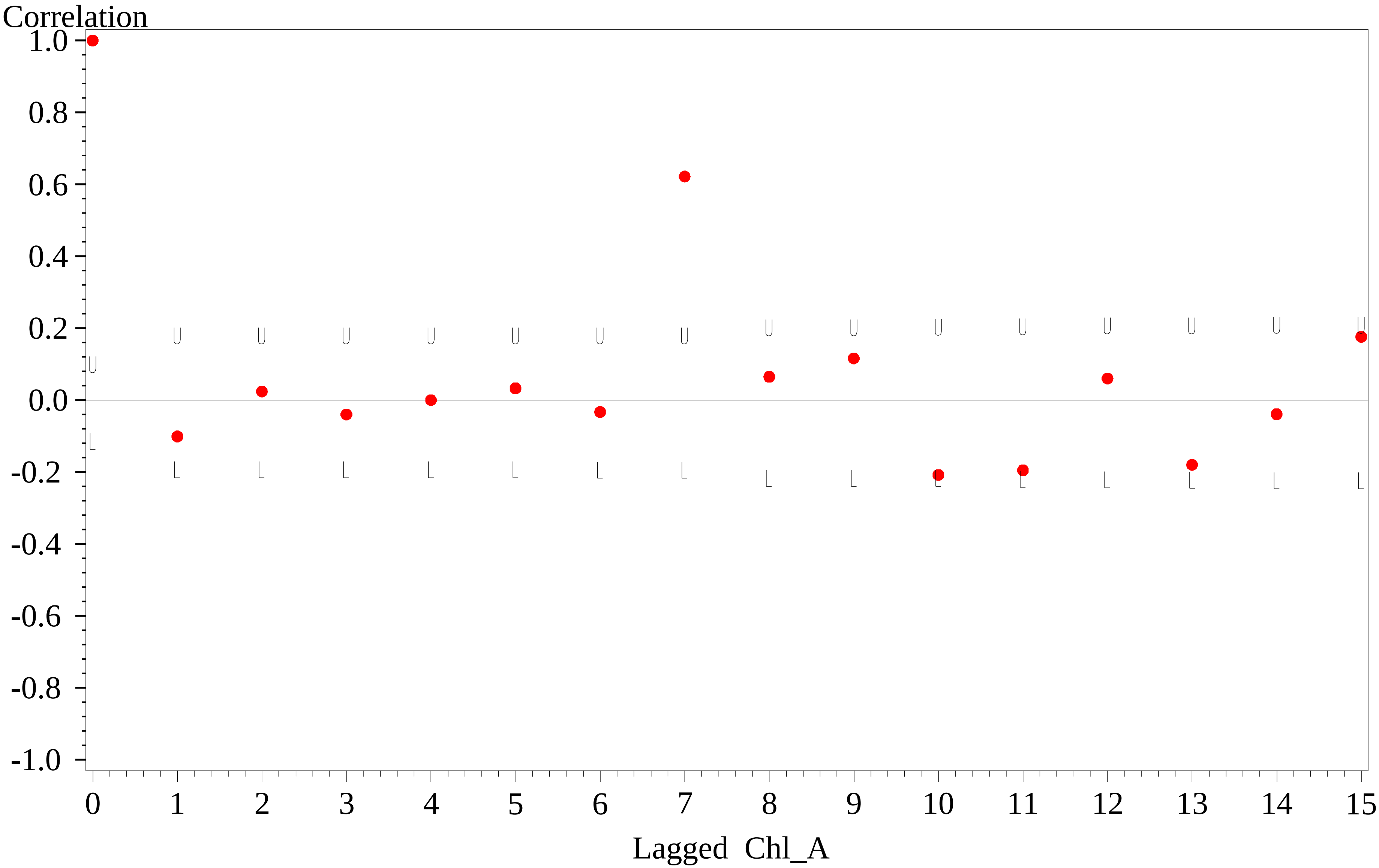
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll A at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_A	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	-0.101	0.093	0.186	-0.186
2	0.024	0.093	0.186	-0.186
3	-0.040	0.093	0.186	-0.186
4	0.000	0.093	0.186	-0.186
5	0.033	0.093	0.186	-0.186
6	-0.033	0.093	0.187	-0.187
7	0.622	0.093	0.187	-0.187
8	0.065	0.105	0.209	-0.209
9	0.116	0.105	0.209	-0.209
10	-0.208	0.105	0.210	-0.210
11	-0.195	0.106	0.212	-0.212
12	0.060	0.107	0.214	-0.214
13	-0.180	0.107	0.215	-0.215
14	-0.039	0.108	0.216	-0.216
15	0.176	0.108	0.216	-0.216

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll A at EPCHC Station 114 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll A at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.063	0.538	0.651	0.022

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Chlorophyll A at EPCHC Station 114 Middle Level

Adjusted for Seasonal Medians

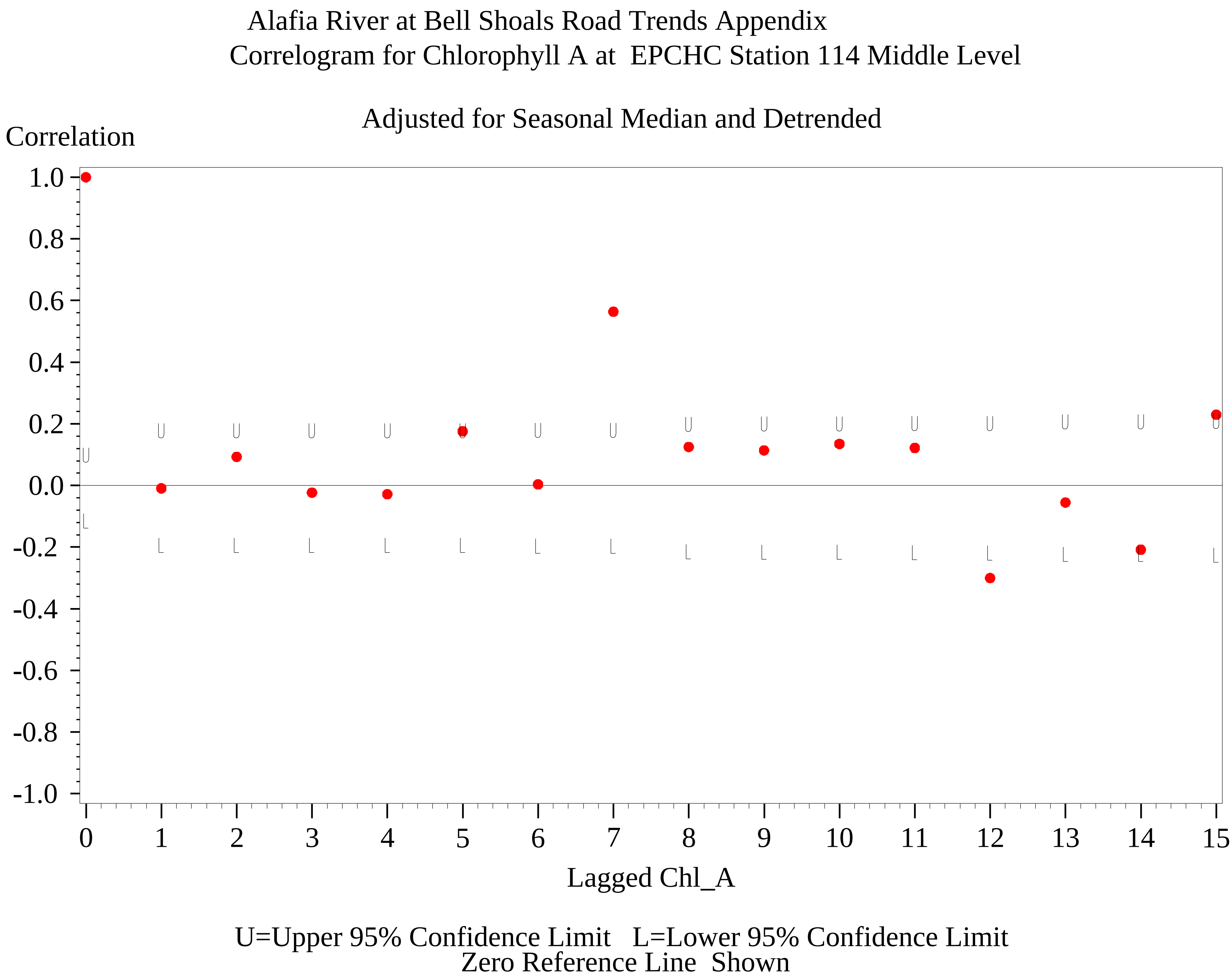
Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.060127	0.55915	0.67129	0.021633

Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll A at EPCHC Station 114 Middle Level

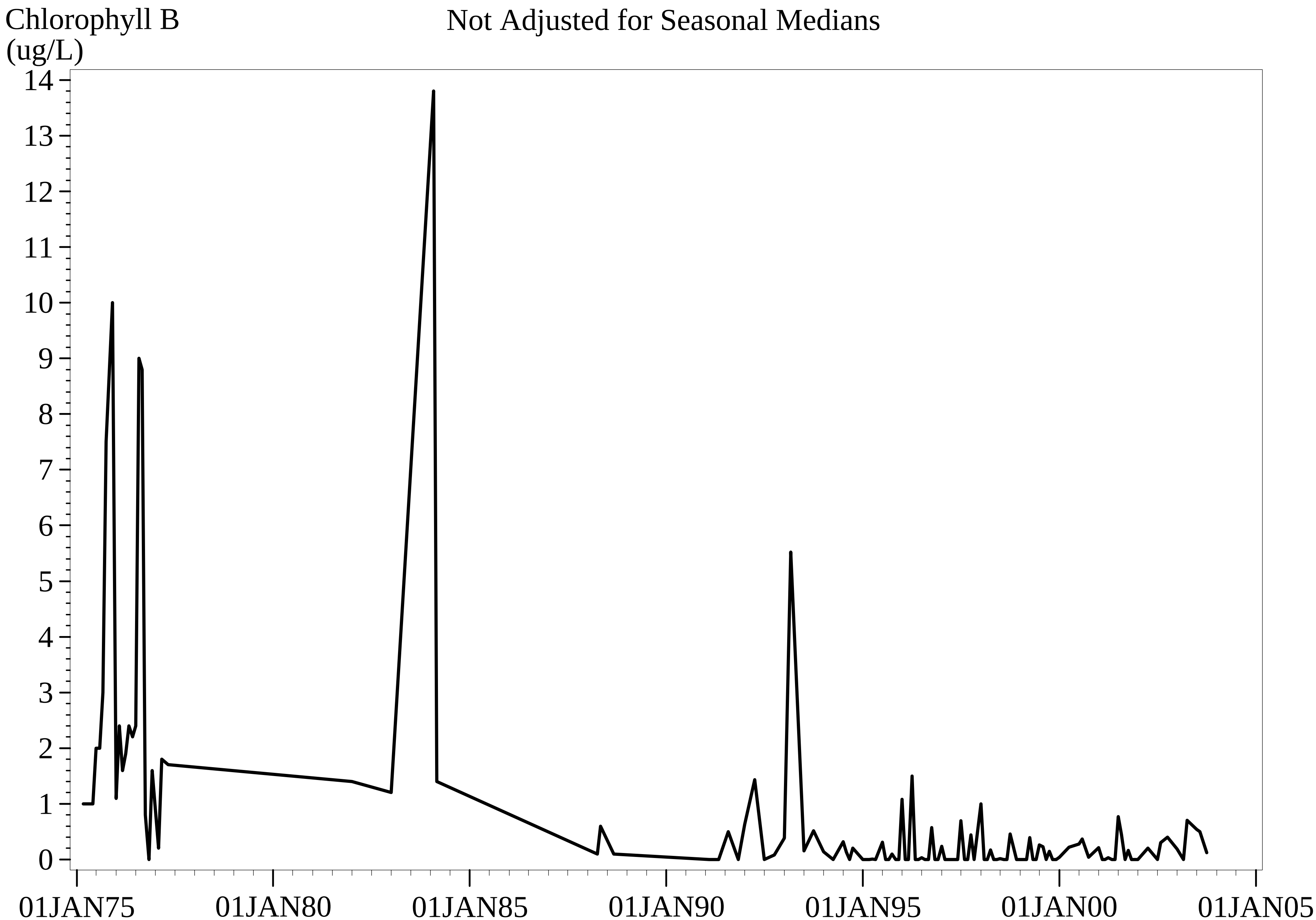
Adjusted for Seasonal Median and Detrended

Lagged Chl_A	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	-0.009	0.093	0.186	-0.186
2	0.093	0.093	0.186	-0.186
3	-0.023	0.093	0.186	-0.186
4	-0.028	0.093	0.186	-0.186
5	0.176	0.093	0.186	-0.186
6	0.004	0.094	0.188	-0.188
7	0.564	0.094	0.188	-0.188
8	0.125	0.103	0.207	-0.207
9	0.114	0.104	0.208	-0.208
10	0.135	0.104	0.208	-0.208
11	0.122	0.105	0.209	-0.209
12	-0.300	0.105	0.210	-0.210
13	-0.055	0.108	0.215	-0.215
14	-0.208	0.108	0.215	-0.215
15	0.230	0.109	0.217	-0.217



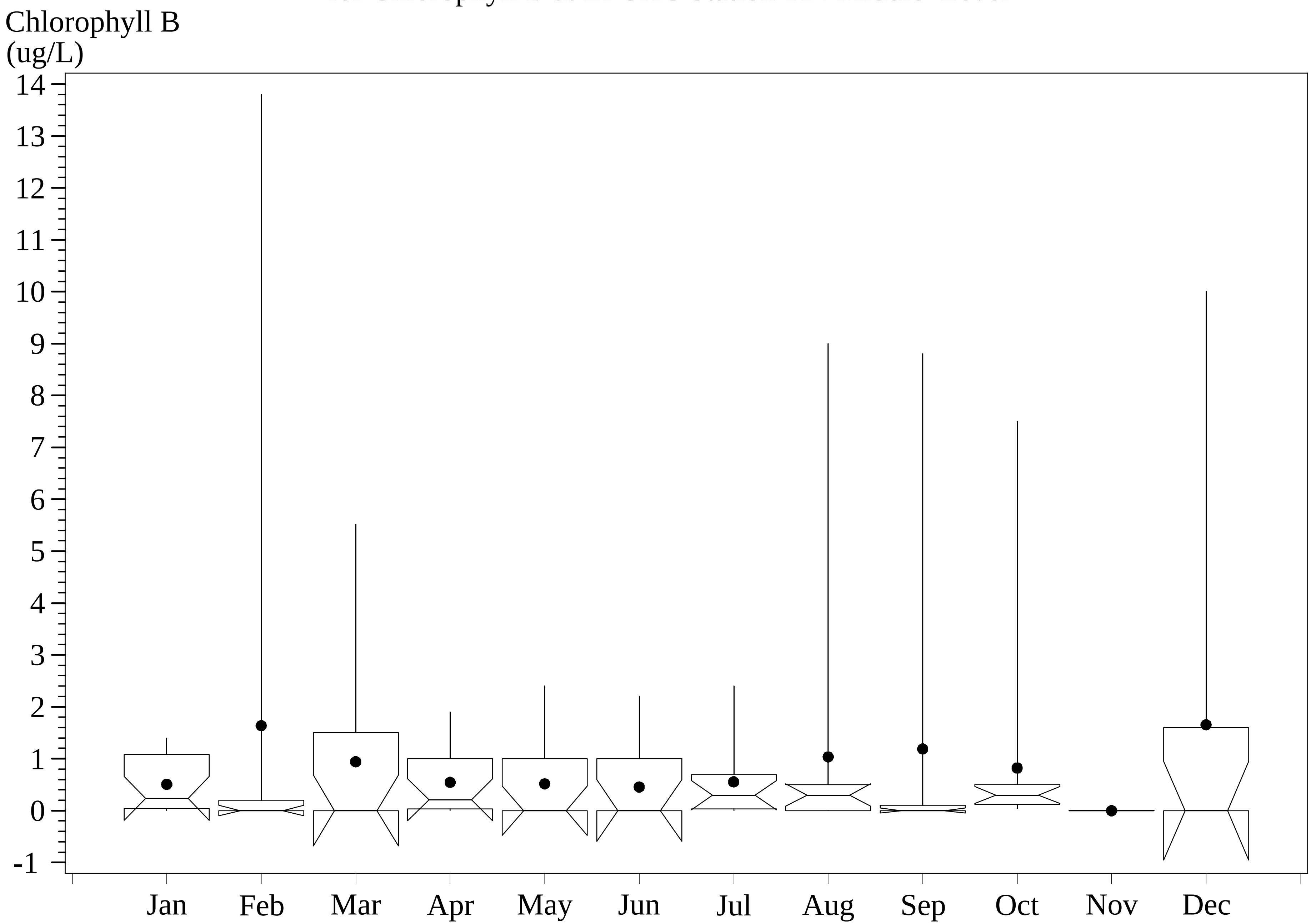
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll A at EPCHC Station 114 Middle Level
Adjusted for Seasonal Median and Detrended
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Lagged Chl_A
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll B at EPCHC Station 114 Middle Level



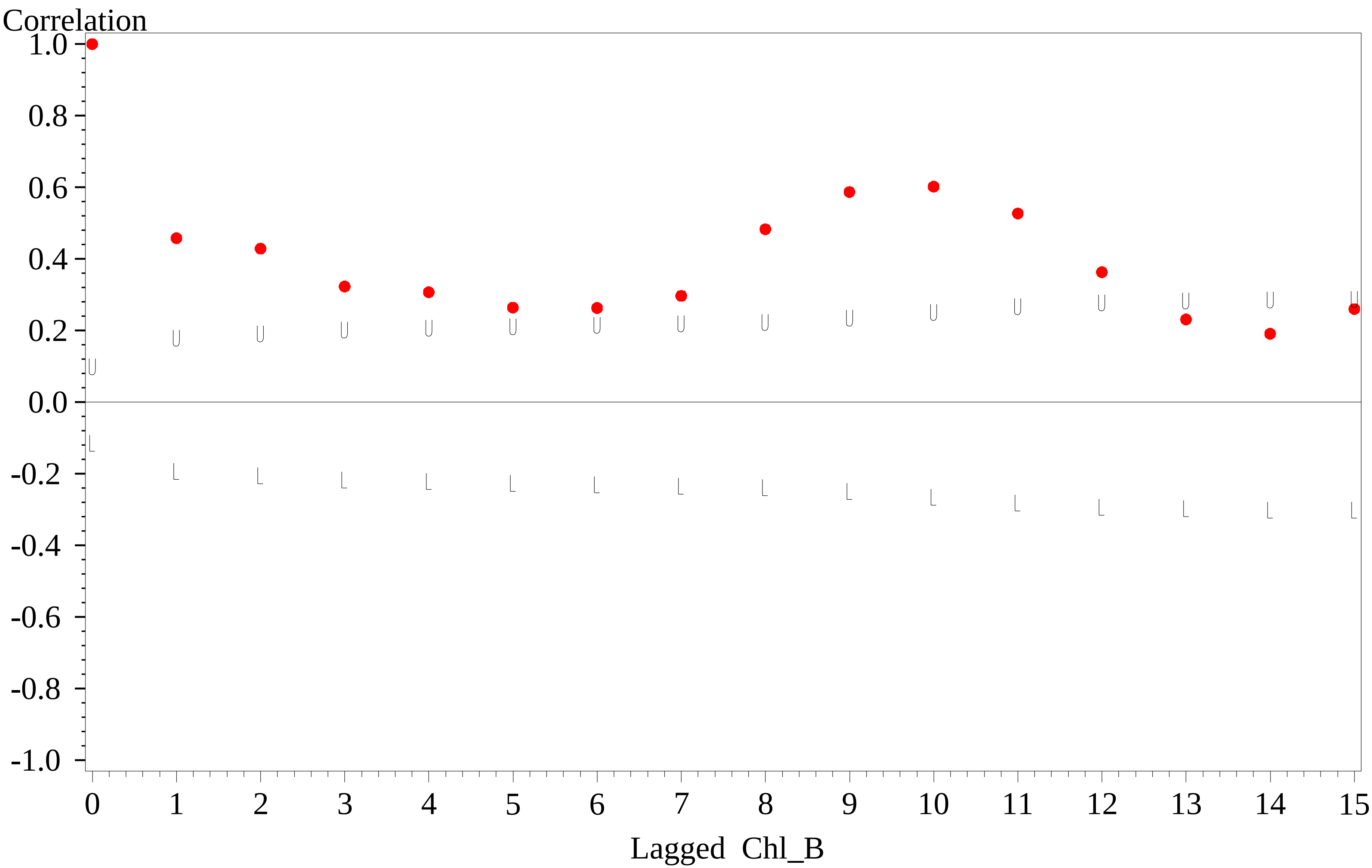
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll B at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_B	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.458	0.093	0.186	-0.186
2	0.429	0.099	0.198	-0.198
3	0.323	0.104	0.209	-0.209
4	0.307	0.107	0.214	-0.214
5	0.264	0.110	0.219	-0.219
6	0.263	0.111	0.223	-0.223
7	0.297	0.113	0.227	-0.227
8	0.483	0.115	0.231	-0.231
9	0.587	0.121	0.242	-0.242
10	0.602	0.129	0.258	-0.258
11	0.527	0.137	0.274	-0.274
12	0.363	0.143	0.285	-0.285
13	0.231	0.145	0.290	-0.290
14	0.191	0.146	0.293	-0.293
15	0.260	0.147	0.294	-0.294

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll B at EPCHC Station 114 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll B at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.314	0	0.014	-0.015

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Chlorophyll B at EPCHC Station 114 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.31370	.000001014	0.014379	-0.014722

Alafia River at Bell Shoals Road Trends Appendix

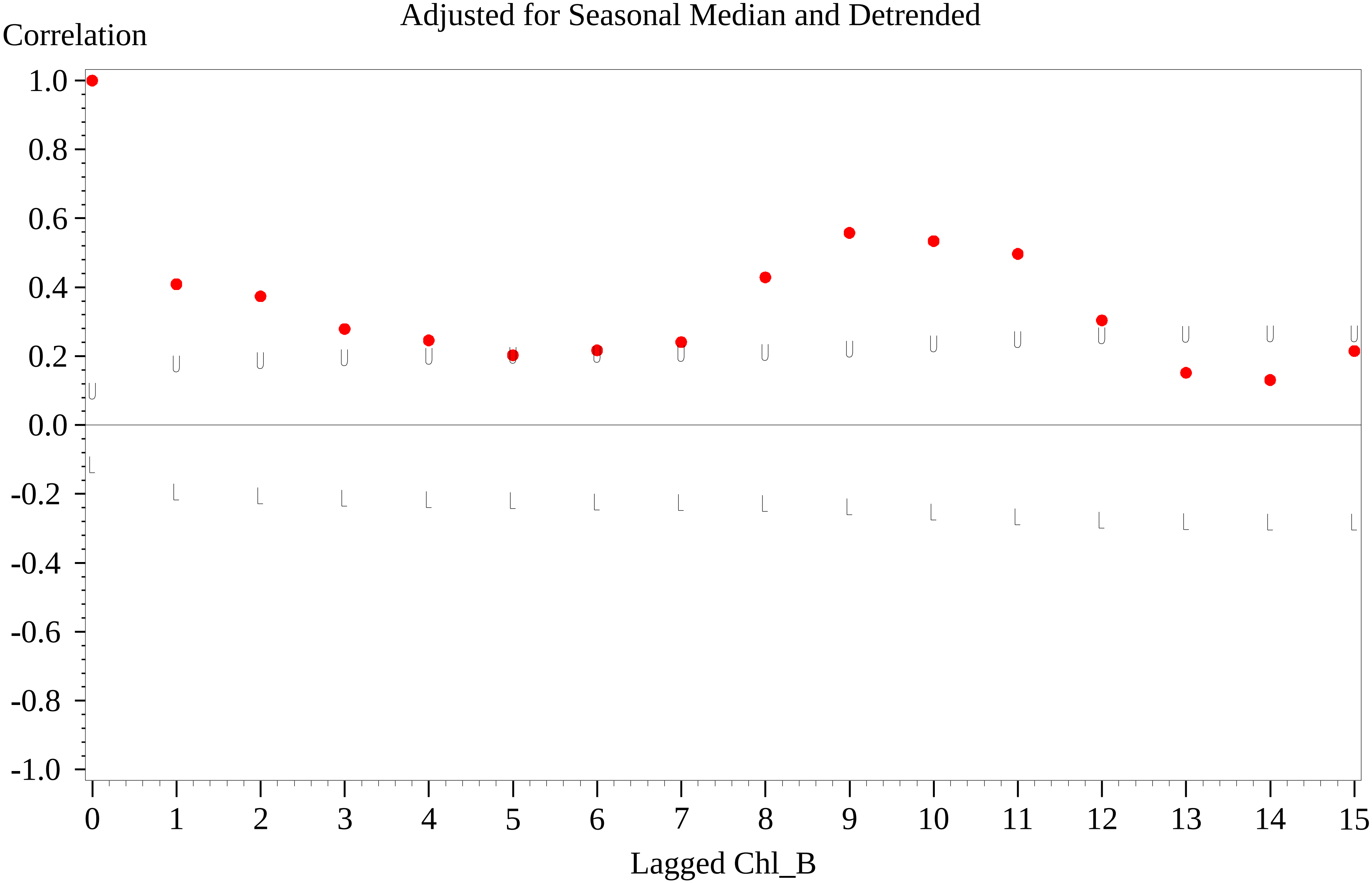
Autocorrelation Statistics for Chlorophyll B at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended

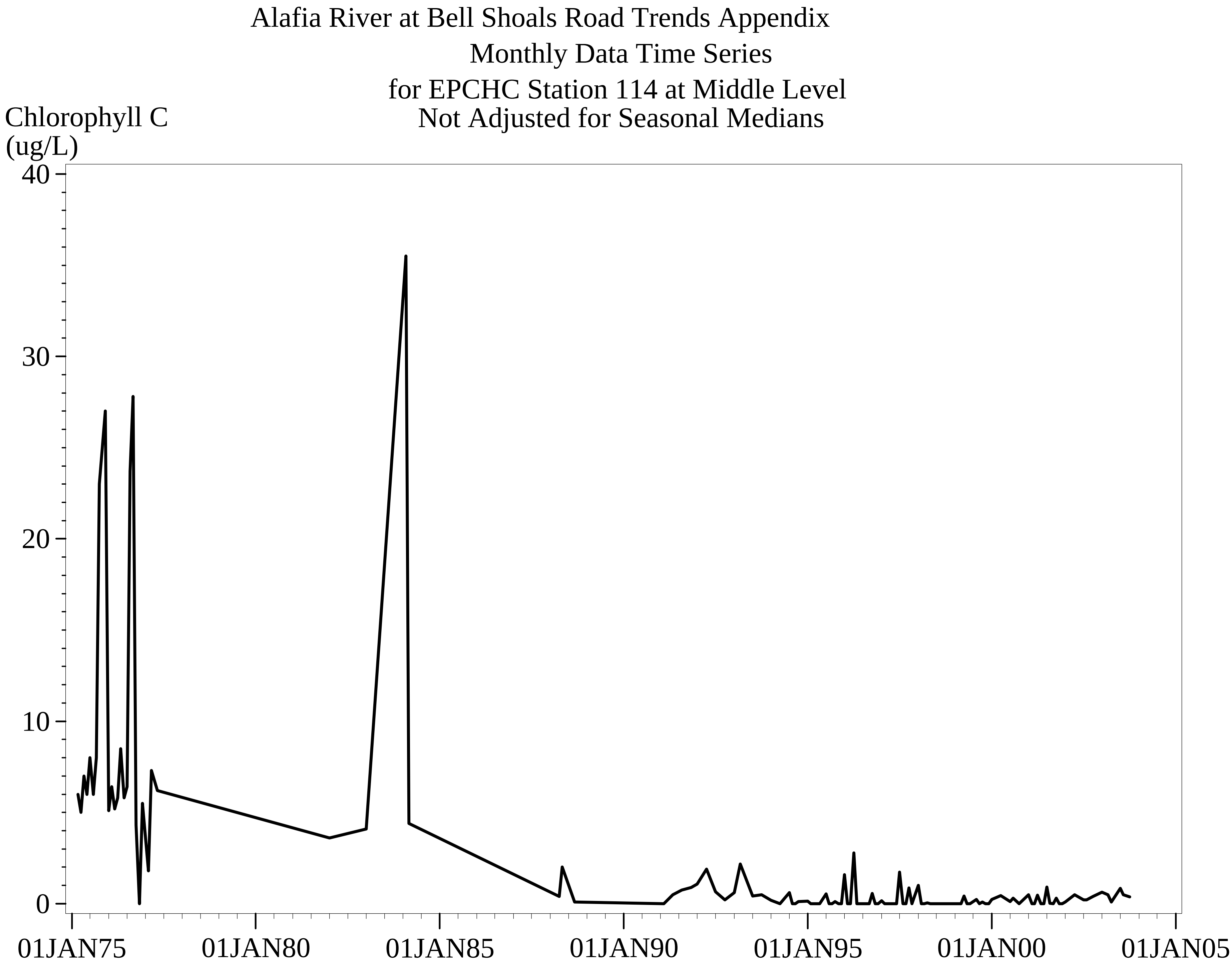
Lagged Chl_B	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.409	0.093	0.186	-0.186
2	0.374	0.098	0.196	-0.196
3	0.279	0.102	0.204	-0.204
4	0.246	0.104	0.208	-0.208
5	0.203	0.106	0.211	-0.211
6	0.217	0.107	0.214	-0.214
7	0.241	0.108	0.216	-0.216
8	0.429	0.110	0.219	-0.219
9	0.558	0.114	0.229	-0.229
10	0.534	0.122	0.244	-0.244
11	0.497	0.128	0.257	-0.257
12	0.304	0.134	0.268	-0.268
13	0.152	0.136	0.272	-0.272
14	0.131	0.136	0.273	-0.273
15	0.215	0.137	0.273	-0.273

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll B at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended



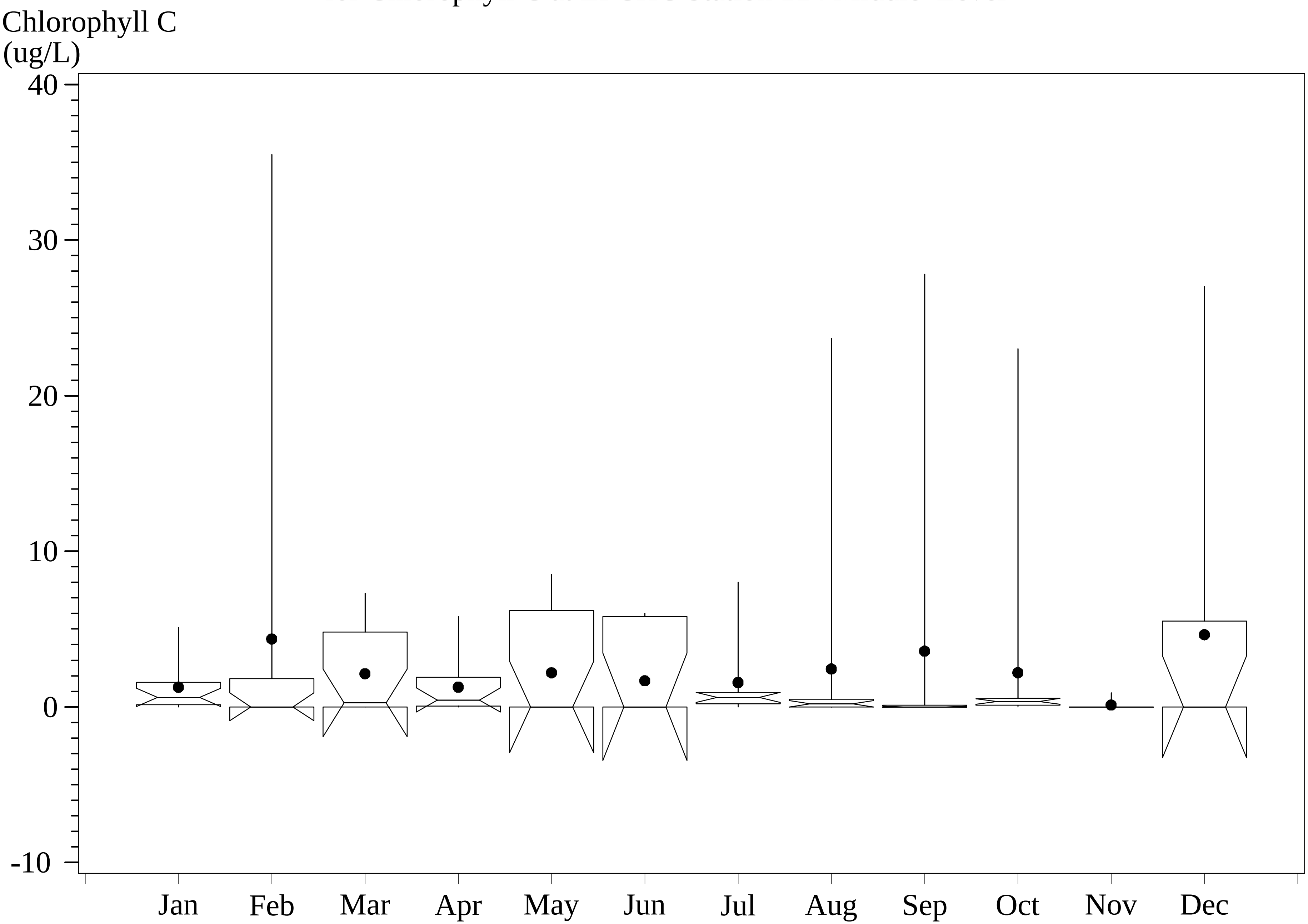
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown



Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Middle Level
Not Adjusted for Seasonal Medians
Chlorophyll C
(ug/L)
40
30
20
10
0
01JAN75
01JAN80
01JAN85
01JAN90
01JAN95
01JAN00
01JAN05

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll C at EPCHC Station 114 Middle Level



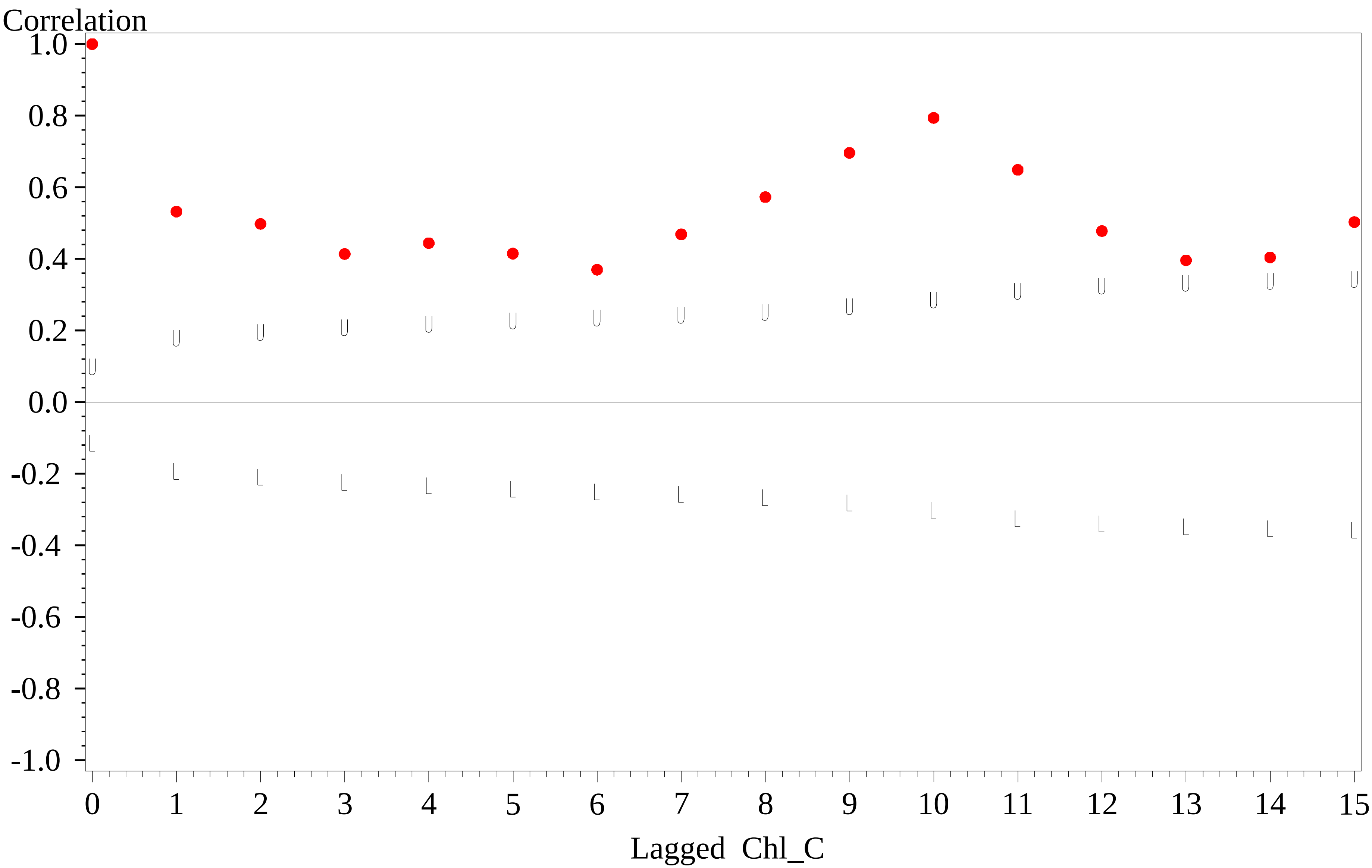
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll C at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_C	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.532	0.093	0.186	-0.186
2	0.498	0.101	0.202	-0.202
3	0.414	0.108	0.216	-0.216
4	0.444	0.113	0.225	-0.225
5	0.415	0.117	0.235	-0.235
6	0.370	0.122	0.243	-0.243
7	0.469	0.125	0.250	-0.250
8	0.573	0.130	0.259	-0.259
9	0.696	0.137	0.274	-0.274
10	0.794	0.147	0.293	-0.293
11	0.649	0.159	0.317	-0.317
12	0.478	0.166	0.332	-0.332
13	0.396	0.170	0.340	-0.340
14	0.404	0.173	0.345	-0.345
15	0.503	0.175	0.350	-0.350

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll C at EPCHC Station 114 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll C at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.354	0	0.013	-0.073

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Chlorophyll C at EPCHC Station 114 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.35425	5.1508E-8	0.013388	-0.0727

Alafia River at Bell Shoals Road Trends Appendix

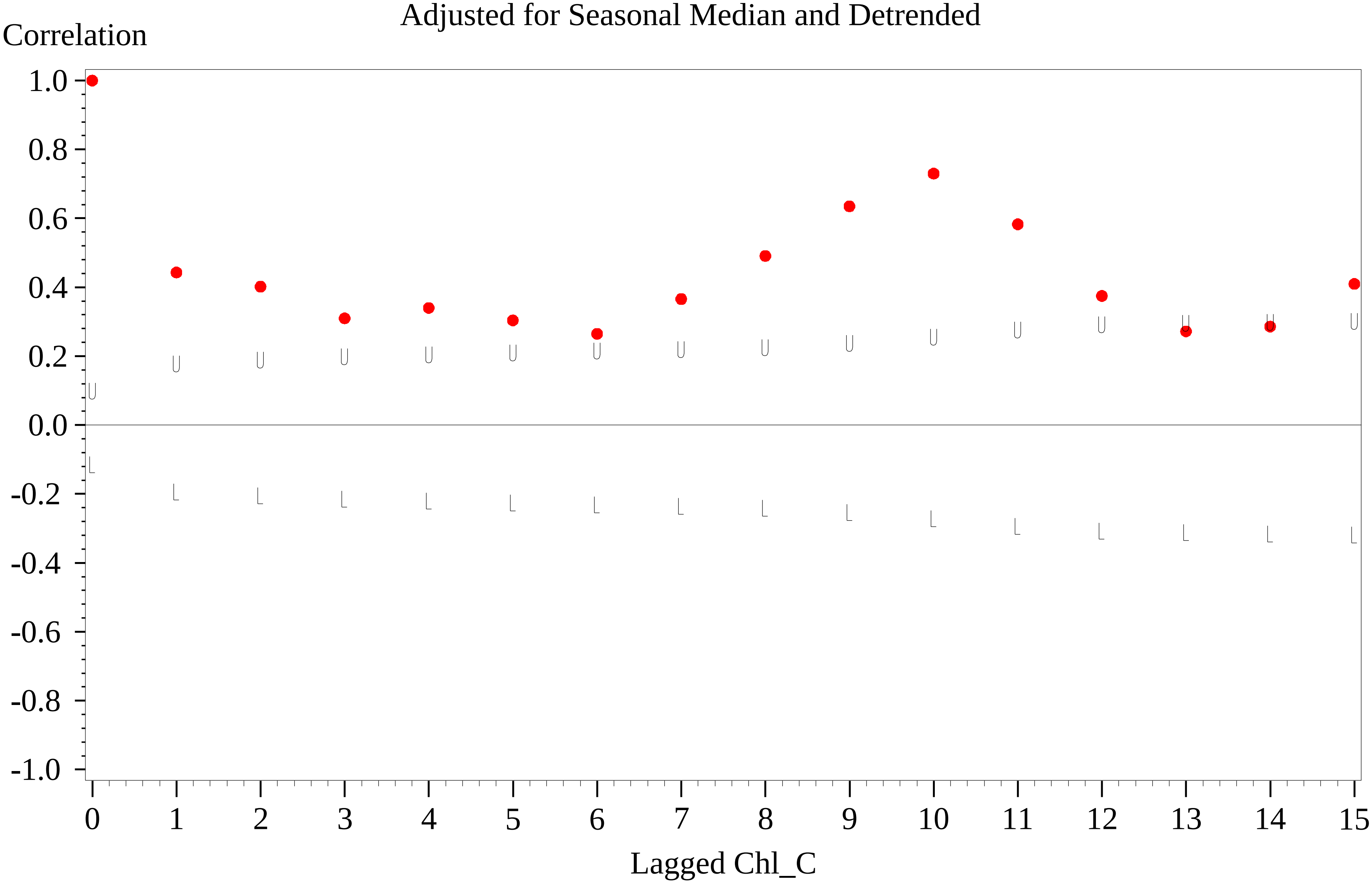
Autocorrelation Statistics for Chlorophyll C at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Chl_C	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.443	0.093	0.186	-0.186
2	0.402	0.099	0.197	-0.197
3	0.310	0.103	0.207	-0.207
4	0.340	0.106	0.212	-0.212
5	0.304	0.109	0.218	-0.218
6	0.265	0.111	0.223	-0.223
7	0.366	0.113	0.227	-0.227
8	0.491	0.117	0.233	-0.233
9	0.635	0.122	0.245	-0.245
10	0.730	0.132	0.263	-0.263
11	0.583	0.143	0.285	-0.285
12	0.375	0.149	0.299	-0.299
13	0.272	0.152	0.304	-0.304
14	0.286	0.153	0.307	-0.307
15	0.410	0.155	0.310	-0.310

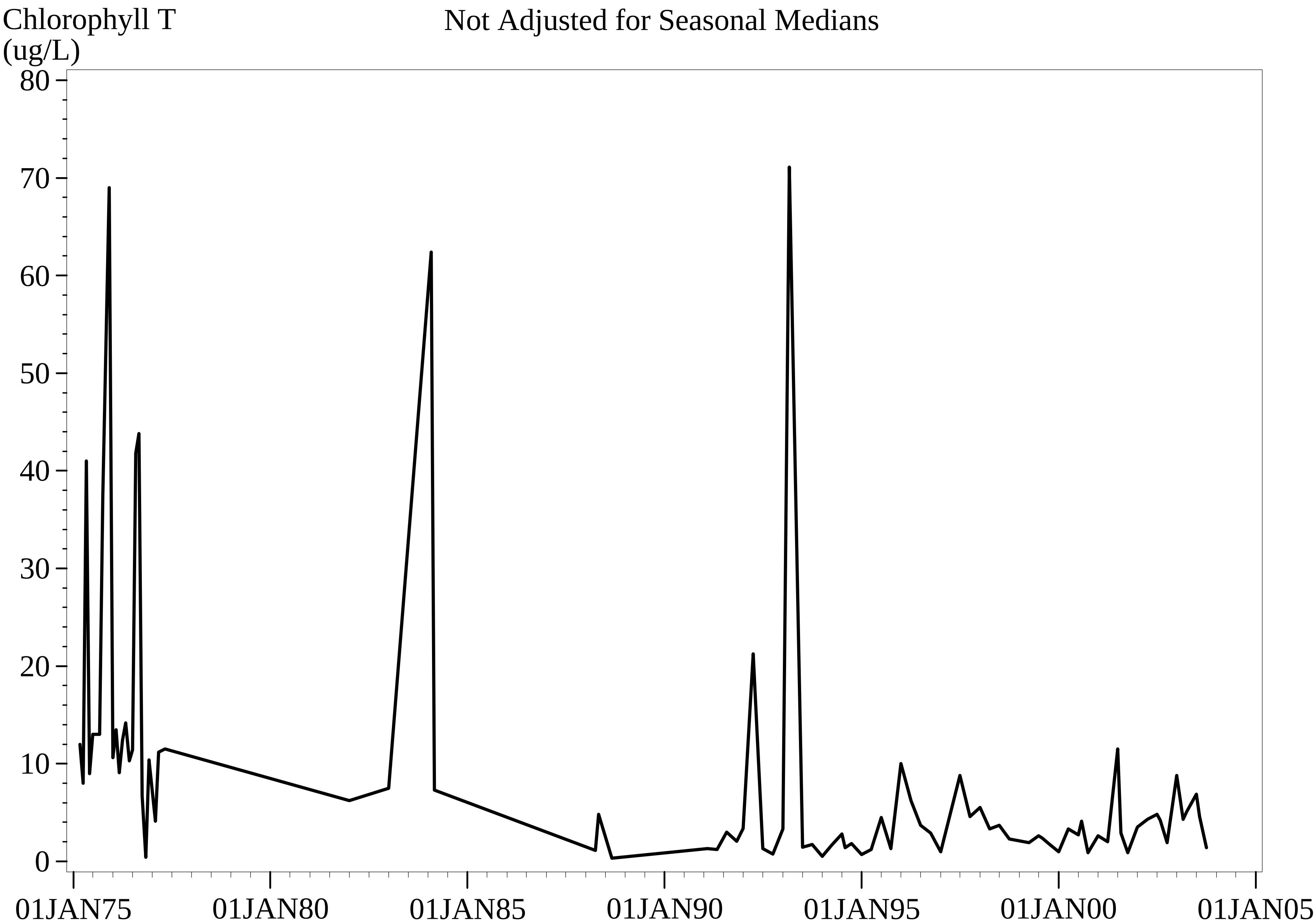
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll C at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended



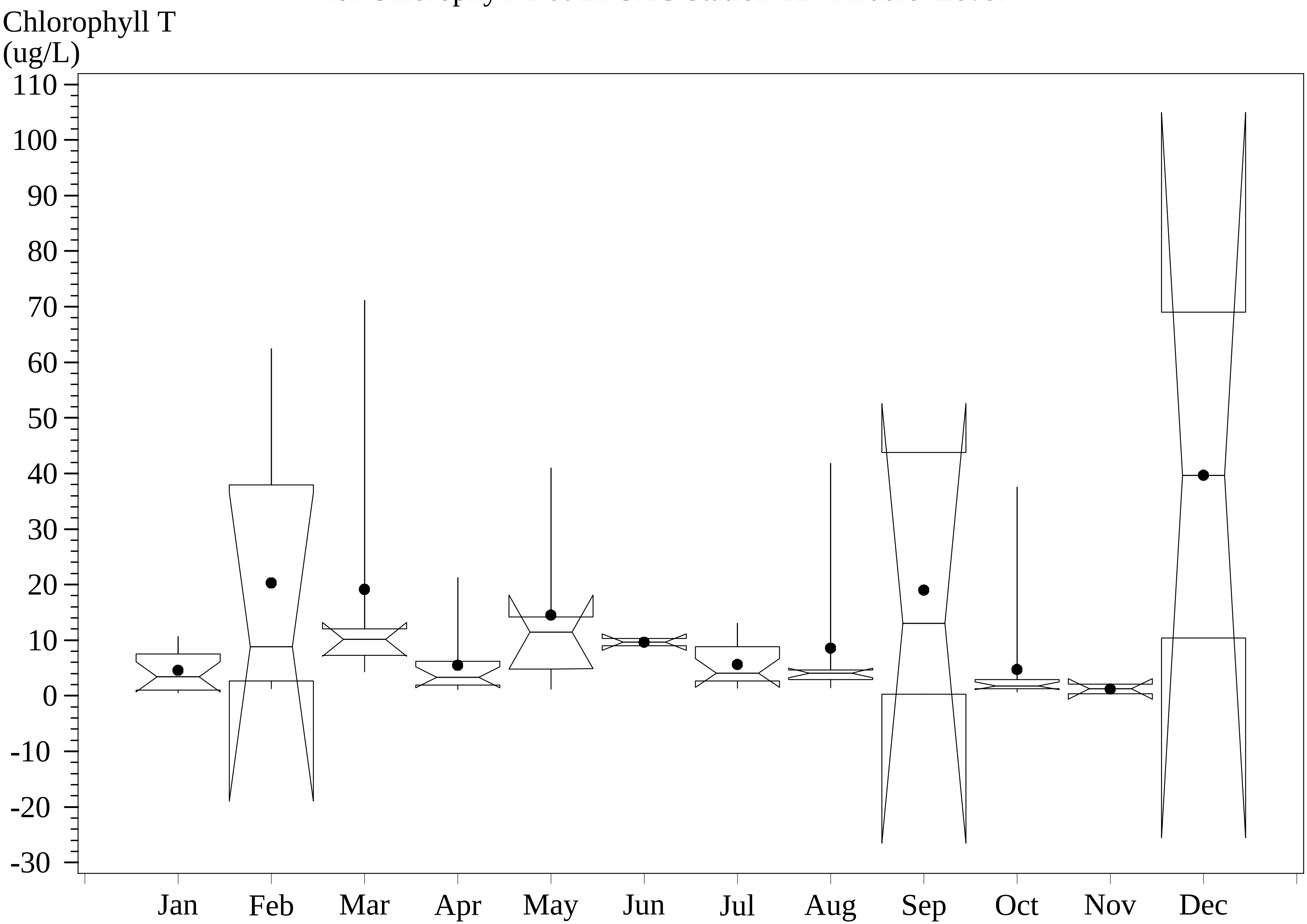
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 114 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll T at EPCHC Station 114 Middle Level



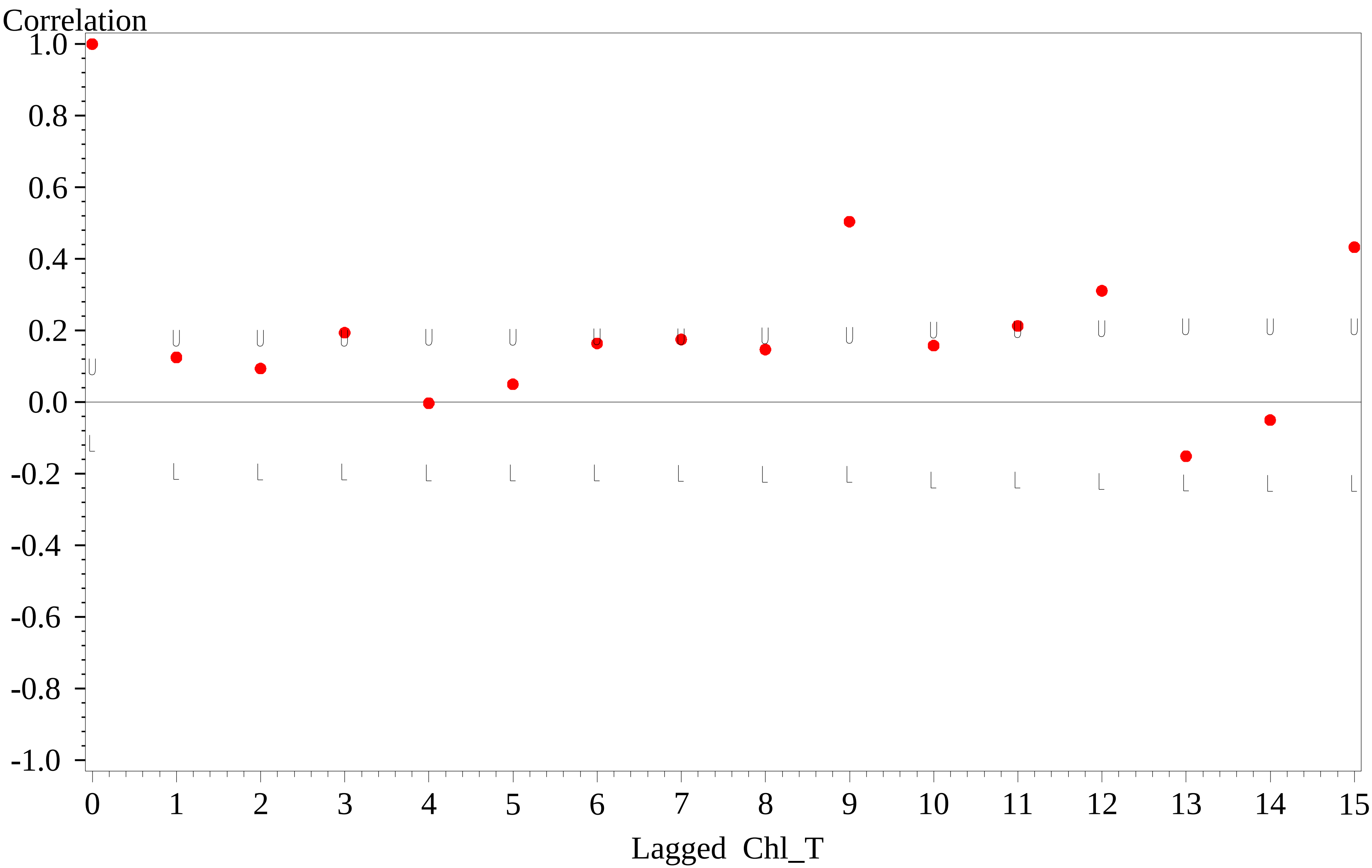
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll T at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_T	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.125	0.093	0.186	-0.186
2	0.094	0.093	0.187	-0.187
3	0.194	0.094	0.187	-0.187
4	-0.003	0.095	0.189	-0.189
5	0.050	0.095	0.189	-0.189
6	0.164	0.095	0.190	-0.190
7	0.175	0.096	0.191	-0.191
8	0.147	0.097	0.193	-0.193
9	0.504	0.097	0.194	-0.194
10	0.158	0.104	0.209	-0.209
11	0.213	0.105	0.210	-0.210
12	0.311	0.106	0.213	-0.213
13	-0.151	0.109	0.218	-0.218
14	-0.050	0.110	0.219	-0.219
15	0.433	0.110	0.219	-0.219

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll T at EPCHC Station 114 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll T at EPCHC Station 114 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.106	0.242	0.461	-0.105

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Chlorophyll T at EPCHC Station 114 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.10613	0.24245	0.46088	-0.10460

Alafia River at Bell Shoals Road Trends Appendix

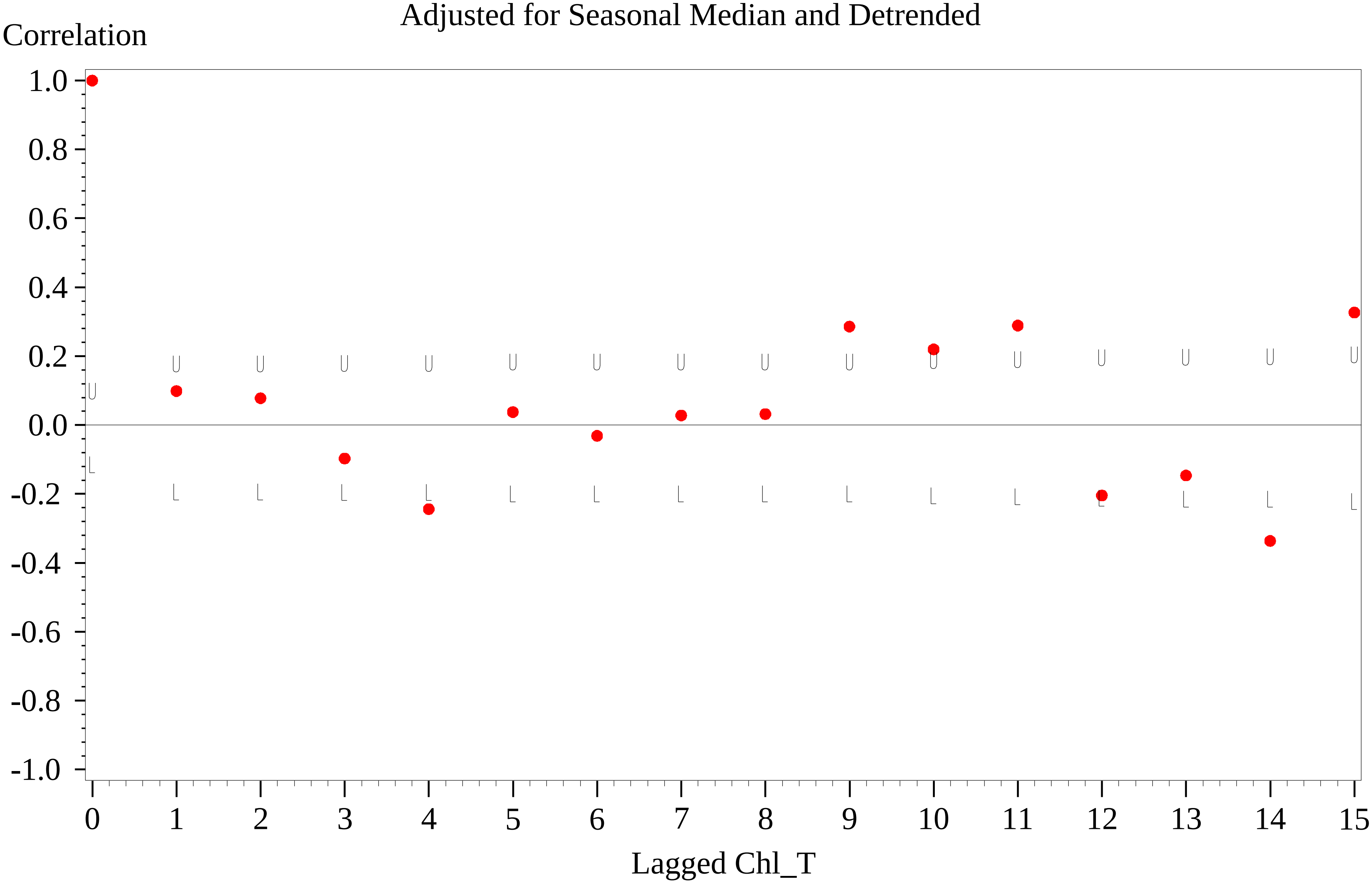
Autocorrelation Statistics for Chlorophyll T at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended

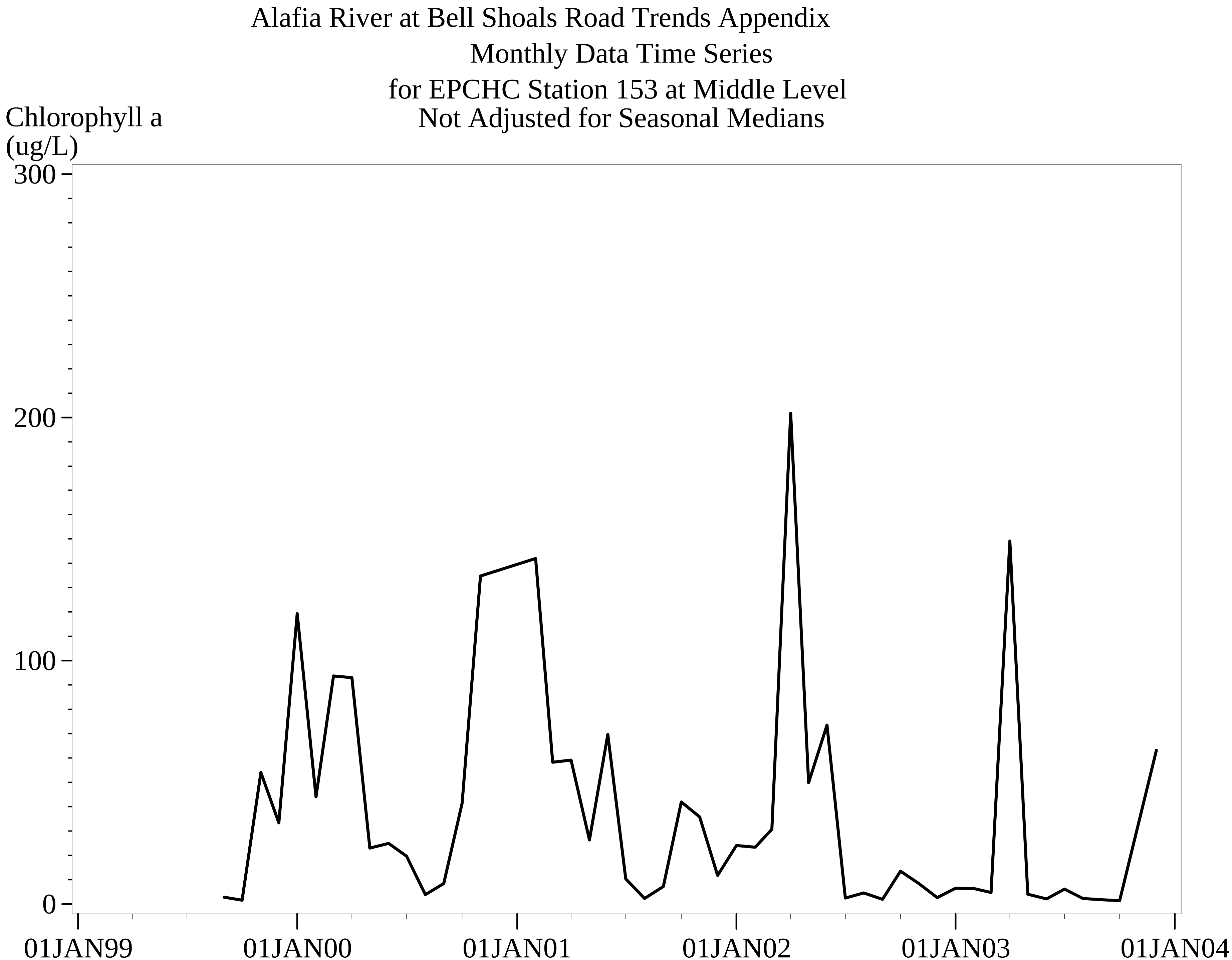
Lagged Chl_T	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.099	0.093	0.186	-0.186
2	0.078	0.093	0.186	-0.186
3	-0.097	0.093	0.187	-0.187
4	-0.244	0.094	0.187	-0.187
5	0.038	0.095	0.191	-0.191
6	-0.031	0.095	0.191	-0.191
7	0.028	0.096	0.191	-0.191
8	0.032	0.096	0.191	-0.191
9	0.286	0.096	0.191	-0.191
10	0.220	0.098	0.196	-0.196
11	0.289	0.099	0.199	-0.199
12	-0.204	0.102	0.204	-0.204
13	-0.146	0.103	0.206	-0.206
14	-0.336	0.104	0.207	-0.207
15	0.327	0.107	0.213	-0.213

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll T at EPCHC Station 114 Middle Level

Adjusted for Seasonal Median and Detrended

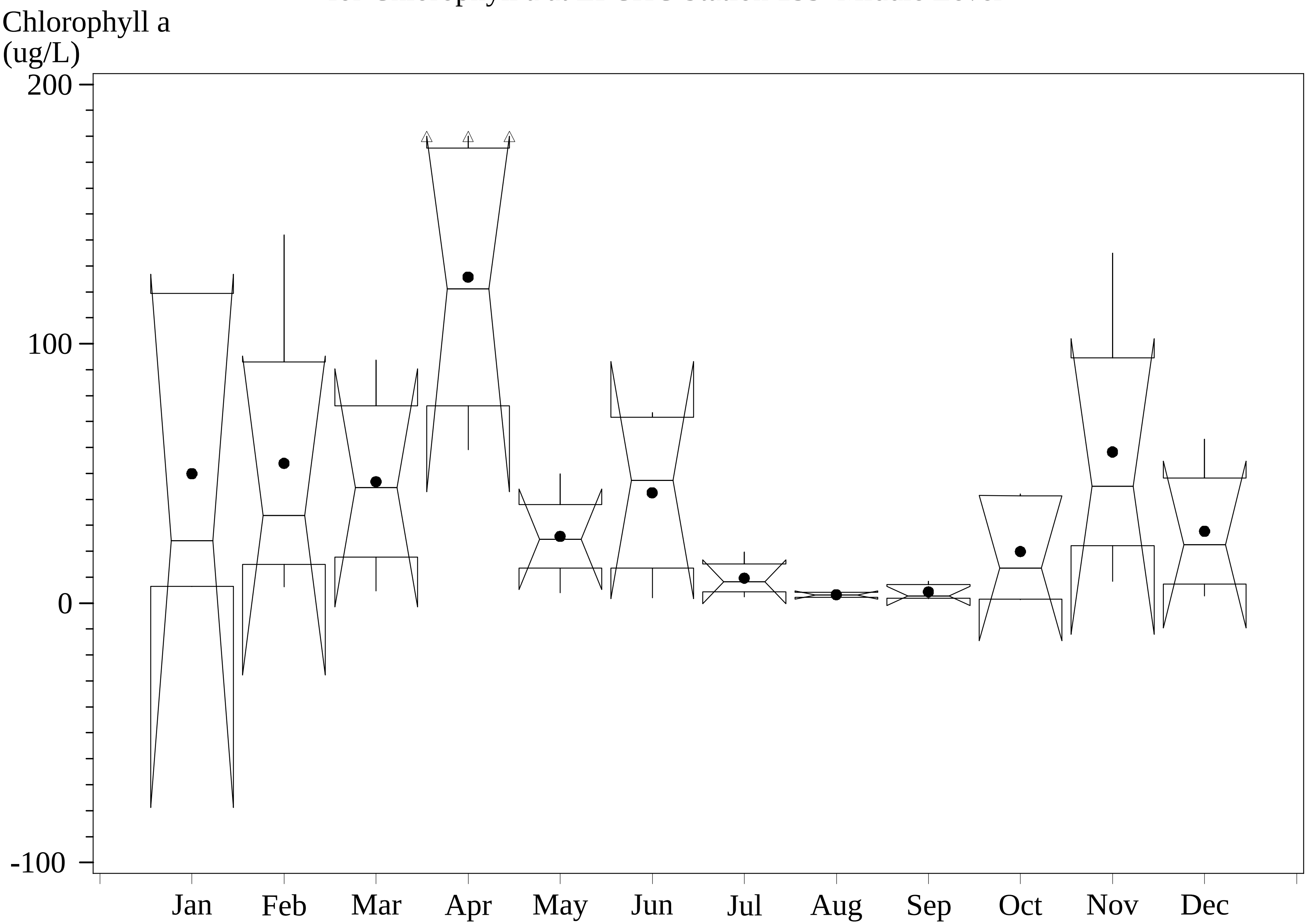


U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown


Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians
Chlorophyll a
(ug/L)
300
200
100
0
01JAN99
01JAN00
01JAN01
01JAN02
01JAN03
01JAN04

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll a at EPCHC Station 153 Middle Level

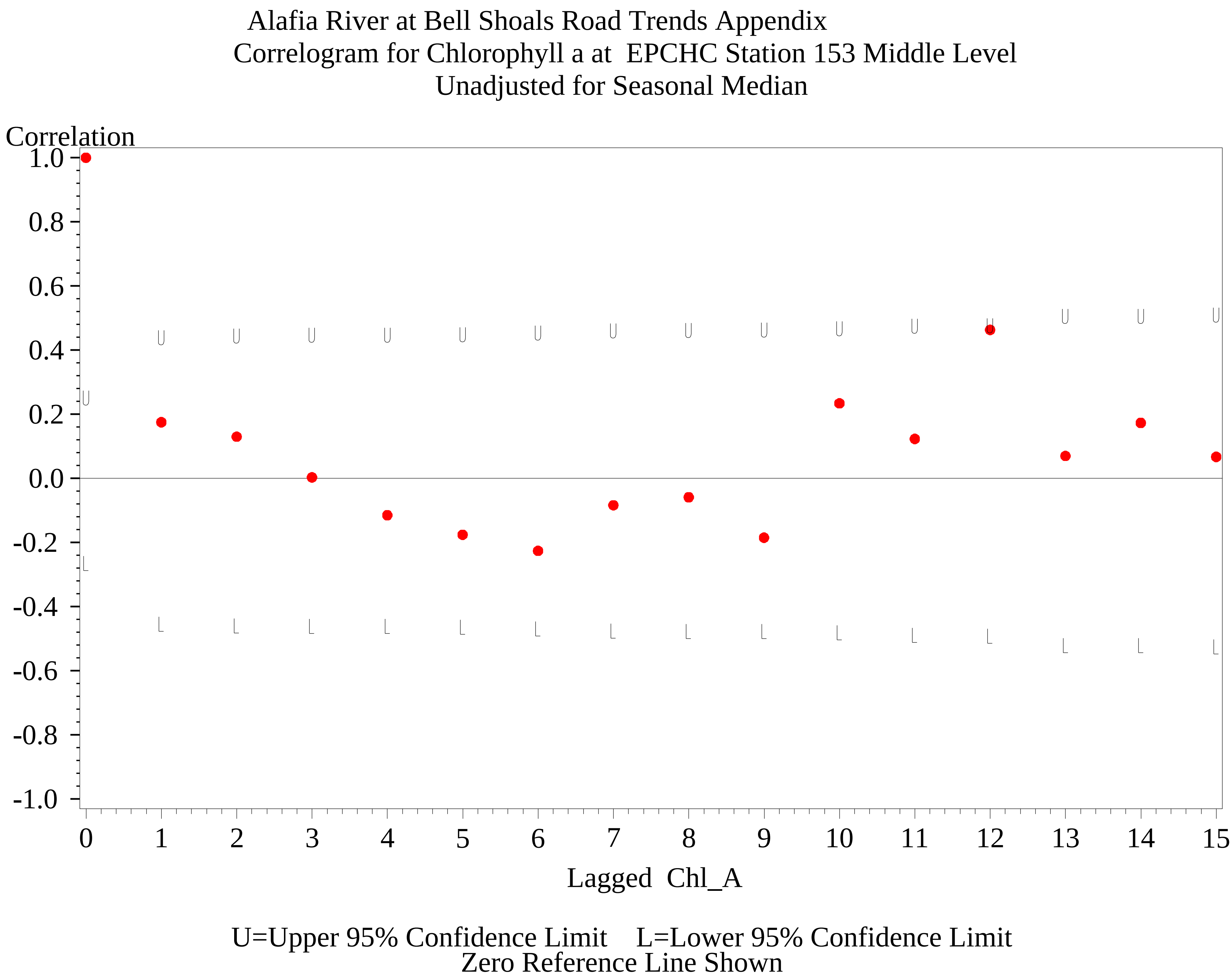


Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll a at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_A	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.175	0.224	0.447	-0.447
2	0.130	0.226	0.452	-0.452
3	0.003	0.227	0.454	-0.454
4	-0.115	0.227	0.454	-0.454
5	-0.176	0.228	0.456	-0.456
6	-0.226	0.230	0.461	-0.461
7	-0.084	0.234	0.468	-0.468
8	-0.059	0.235	0.469	-0.469
9	-0.185	0.235	0.470	-0.470
10	0.234	0.237	0.474	-0.474
11	0.123	0.241	0.482	-0.482
12	0.463	0.242	0.484	-0.484
13	0.070	0.256	0.513	-0.513
14	0.173	0.257	0.513	-0.513
15	0.067	0.259	0.517	-0.517



Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll a at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Lagged Chl_A
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll a at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.351	0.015	0.122	-5.214

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Chlorophyll a at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.35065	0.015329	0.12178	-5.215

Alafia River at Bell Shoals Road Trends Appendix

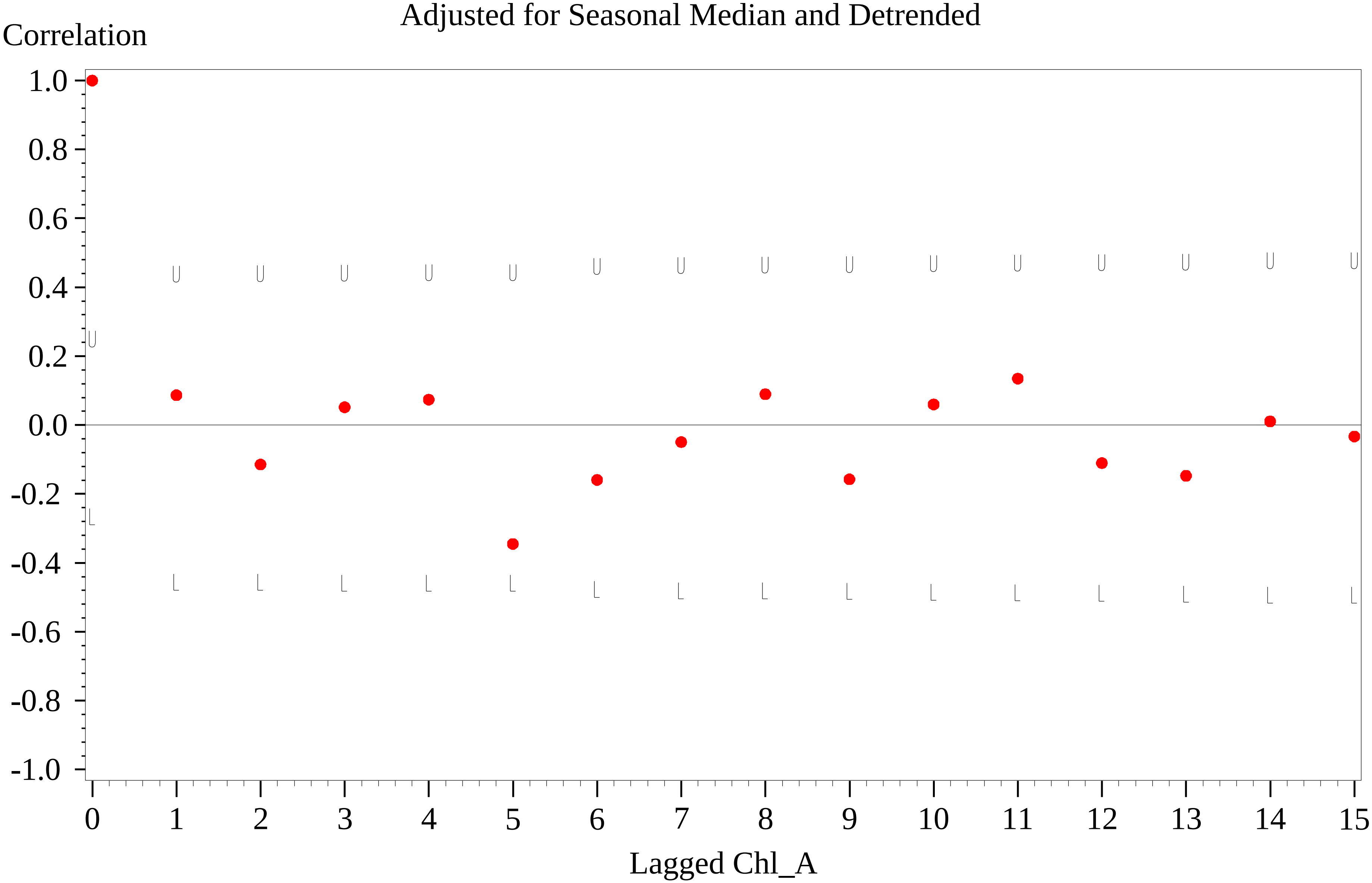
Autocorrelation Statistics for Chlorophyll a at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Chl_A	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.087	0.224	0.447	-0.447
2	-0.114	0.224	0.448	-0.448
3	0.052	0.225	0.450	-0.450
4	0.074	0.225	0.451	-0.451
5	-0.345	0.226	0.451	-0.451
6	-0.159	0.234	0.469	-0.469
7	-0.049	0.236	0.472	-0.472
8	0.090	0.236	0.473	-0.473
9	-0.157	0.237	0.474	-0.474
10	0.060	0.239	0.477	-0.477
11	0.135	0.239	0.478	-0.478
12	-0.110	0.240	0.480	-0.480
13	-0.147	0.241	0.482	-0.482
14	0.011	0.242	0.485	-0.485
15	-0.033	0.242	0.485	-0.485

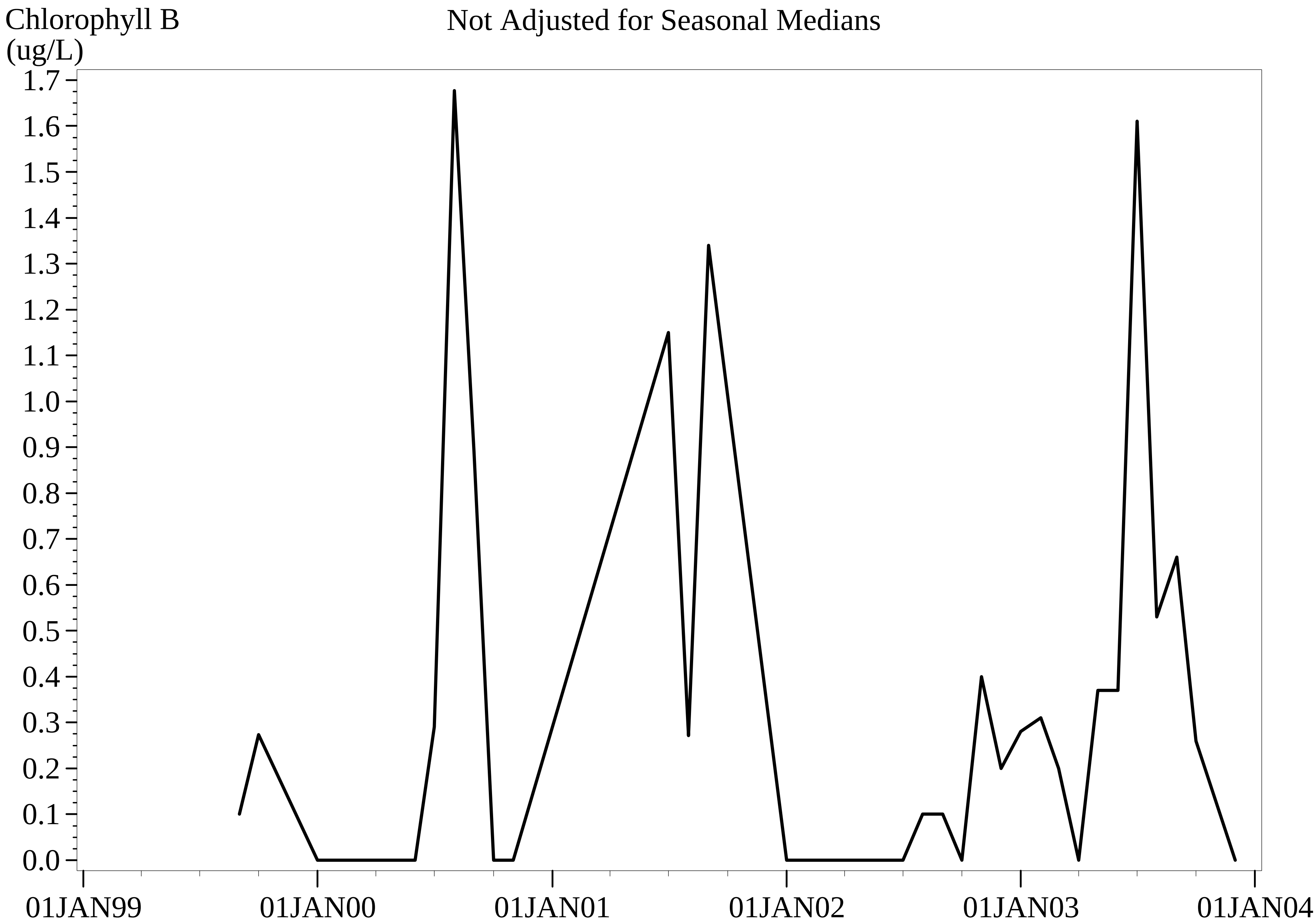
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll a at EPCHC Station 153 Middle Level

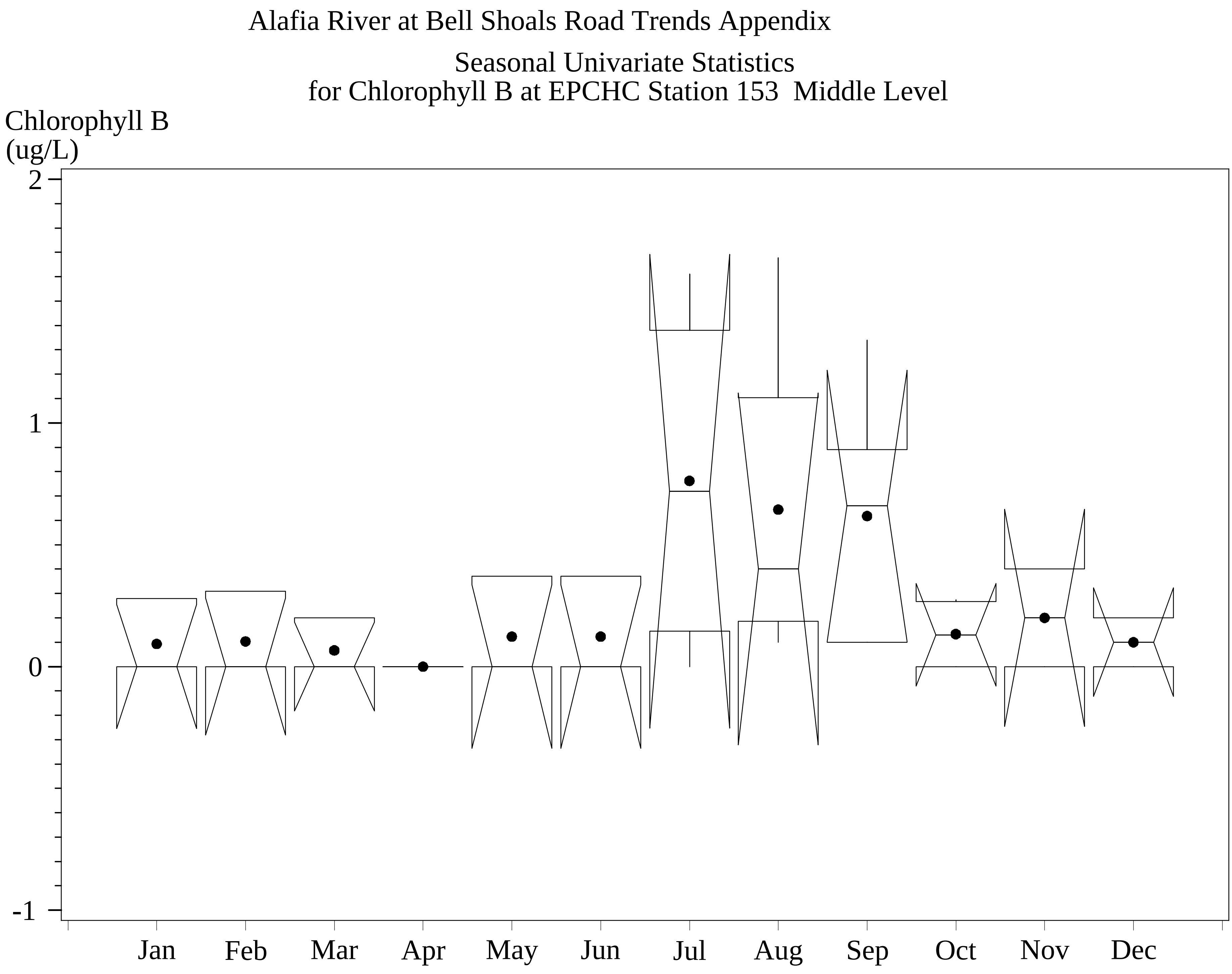
Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians





Alafia River at Bell Shoals Road Trends Appendix
Seasonal Univariate Statistics
for Chlorophyll B at EPCHC Station 153 Middle Level
Chlorophyll B
(ug/L)
2
1
0
-1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

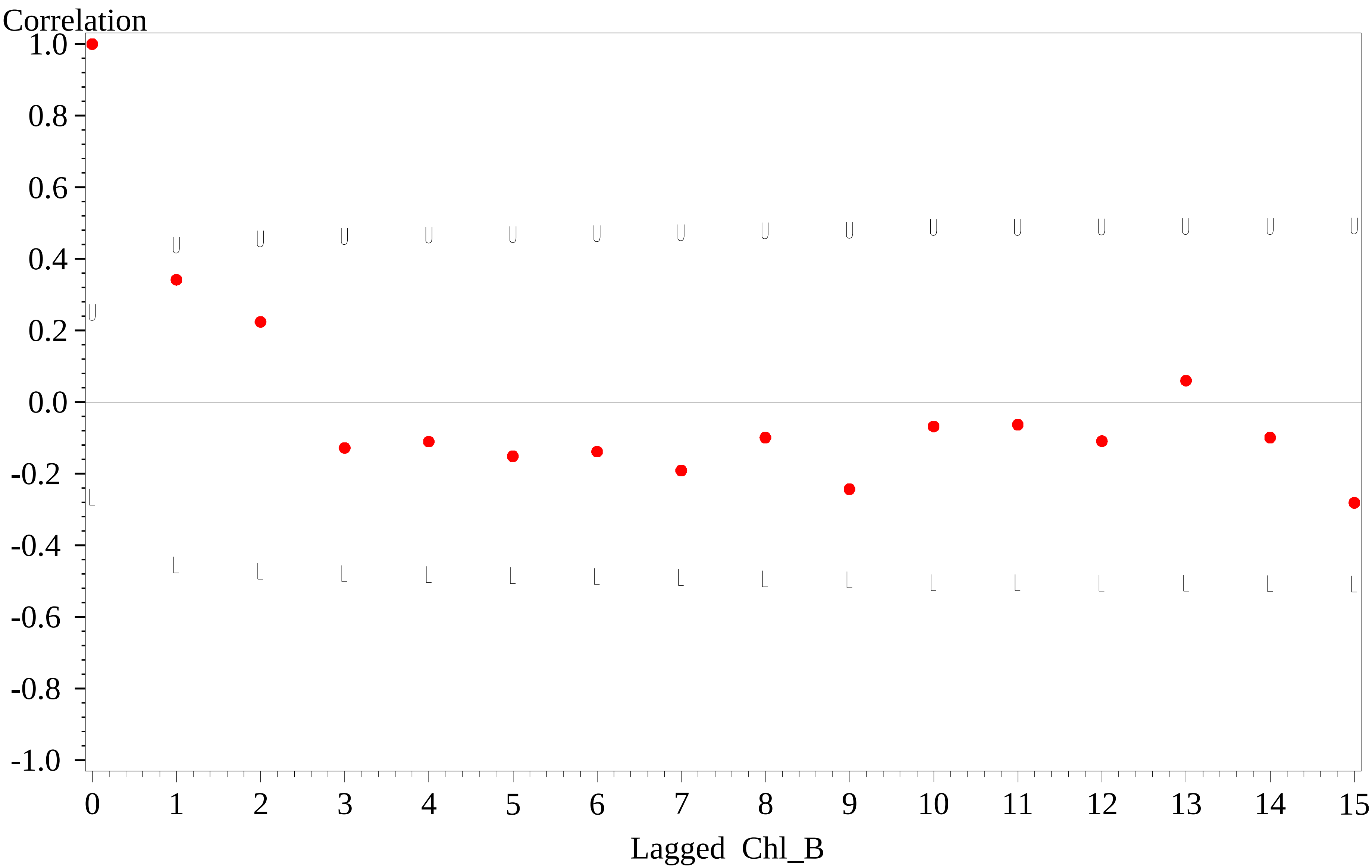
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll B at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_B	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.342	0.224	0.447	-0.447
2	0.224	0.232	0.464	-0.464
3	-0.128	0.236	0.471	-0.471
4	-0.110	0.237	0.474	-0.474
5	-0.151	0.238	0.476	-0.476
6	-0.138	0.239	0.479	-0.479
7	-0.191	0.241	0.481	-0.481
8	-0.099	0.243	0.486	-0.486
9	-0.243	0.244	0.488	-0.488
10	-0.068	0.248	0.496	-0.496
11	-0.063	0.248	0.496	-0.496
12	-0.109	0.248	0.497	-0.497
13	0.060	0.249	0.498	-0.498
14	-0.099	0.249	0.499	-0.499
15	-0.281	0.250	0.500	-0.500

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll B at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll B at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.208	0.229	0.498	0.033

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Chlorophyll B at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.20833	0.22910	0.49833	0.033333

Alafia River at Bell Shoals Road Trends Appendix

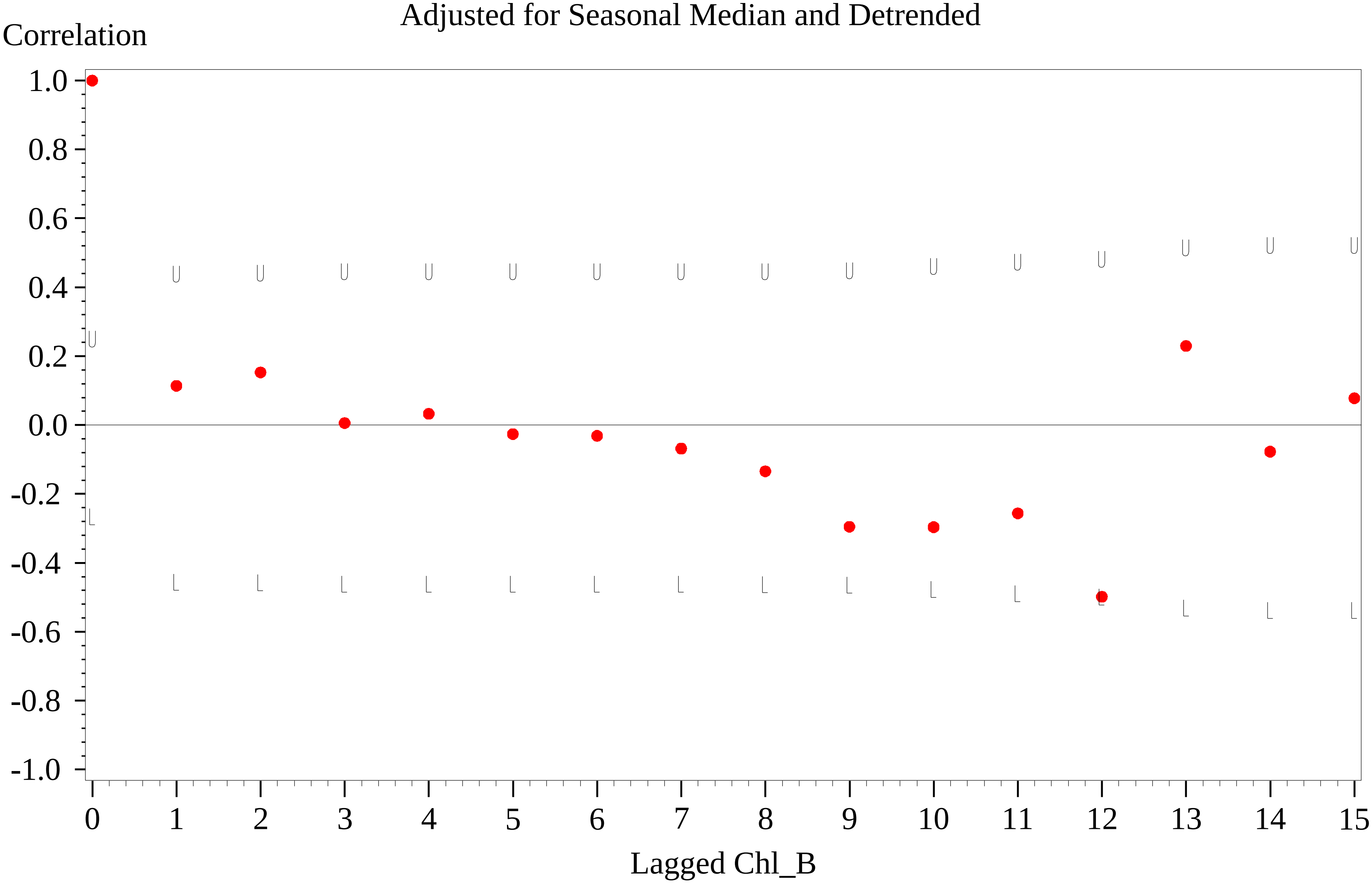
Autocorrelation Statistics for Chlorophyll B at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Chl_B	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.114	0.224	0.447	-0.447
2	0.153	0.225	0.449	-0.449
3	0.006	0.226	0.453	-0.453
4	0.033	0.226	0.453	-0.453
5	-0.026	0.226	0.453	-0.453
6	-0.031	0.226	0.453	-0.453
7	-0.068	0.227	0.453	-0.453
8	-0.134	0.227	0.454	-0.454
9	-0.295	0.228	0.456	-0.456
10	-0.296	0.234	0.469	-0.469
11	-0.256	0.241	0.481	-0.481
12	-0.498	0.245	0.490	-0.490
13	0.230	0.261	0.523	-0.523
14	-0.077	0.265	0.530	-0.530
15	0.078	0.265	0.530	-0.530

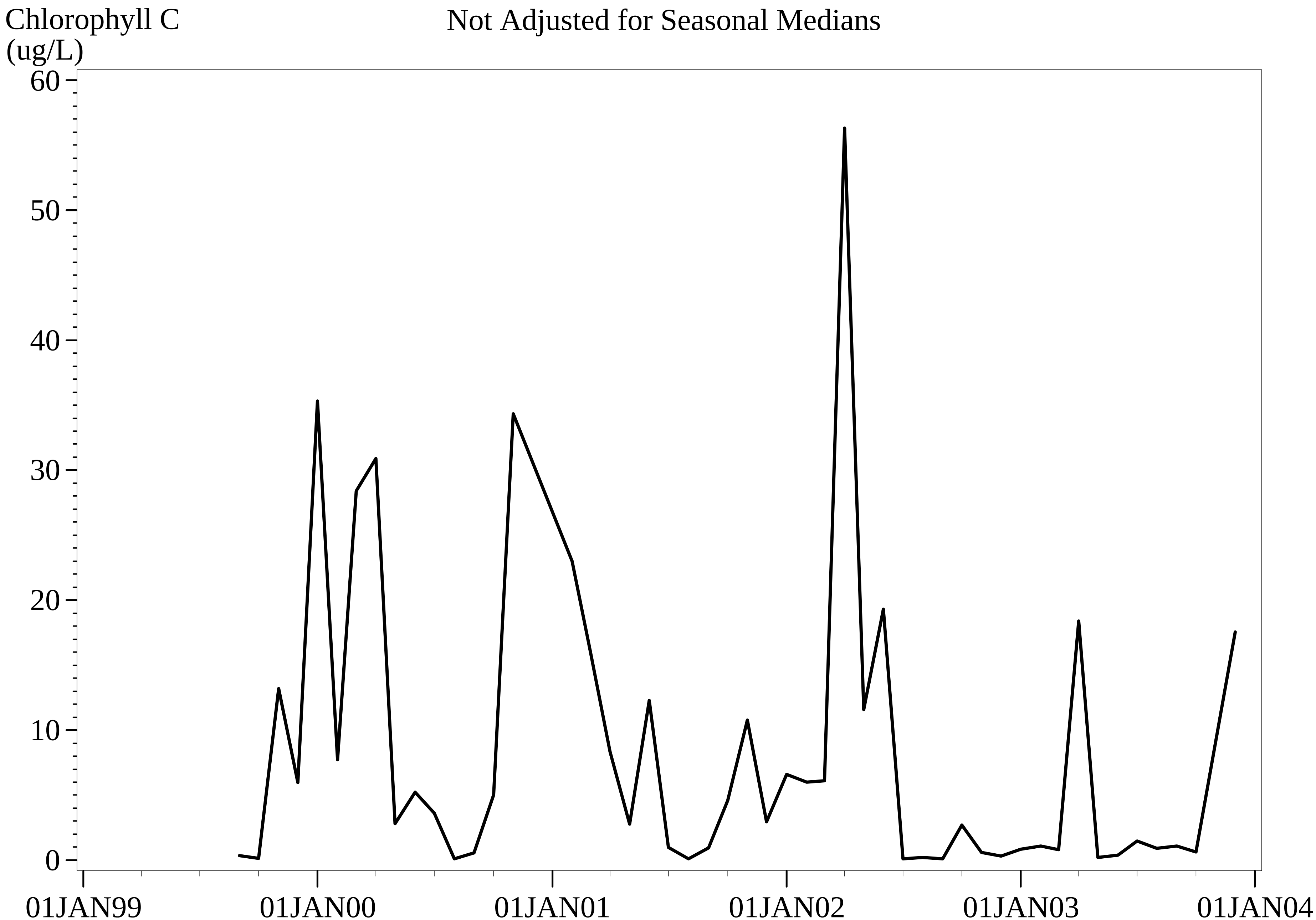
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll B at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended



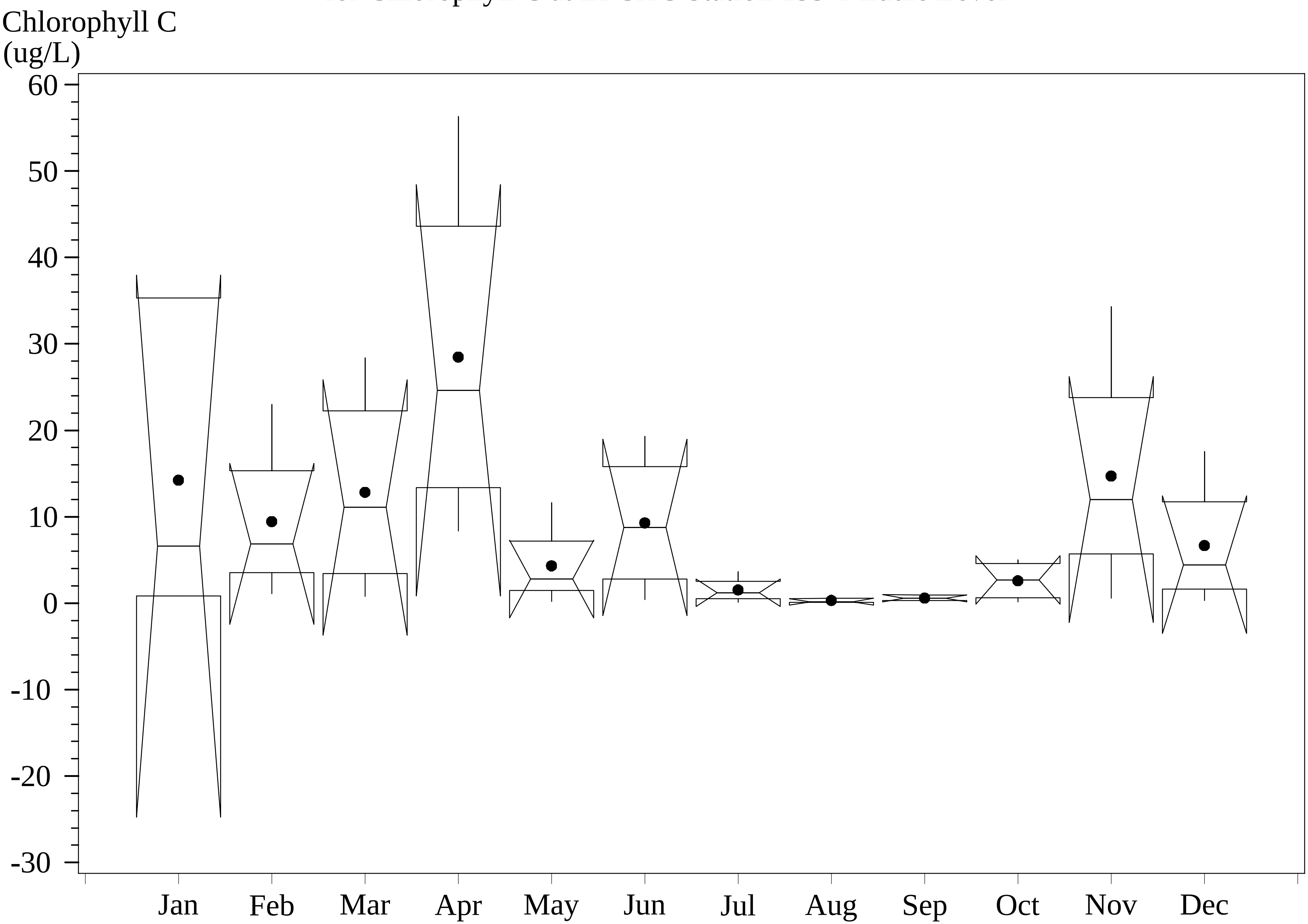
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll C at EPCHC Station 153 Middle Level



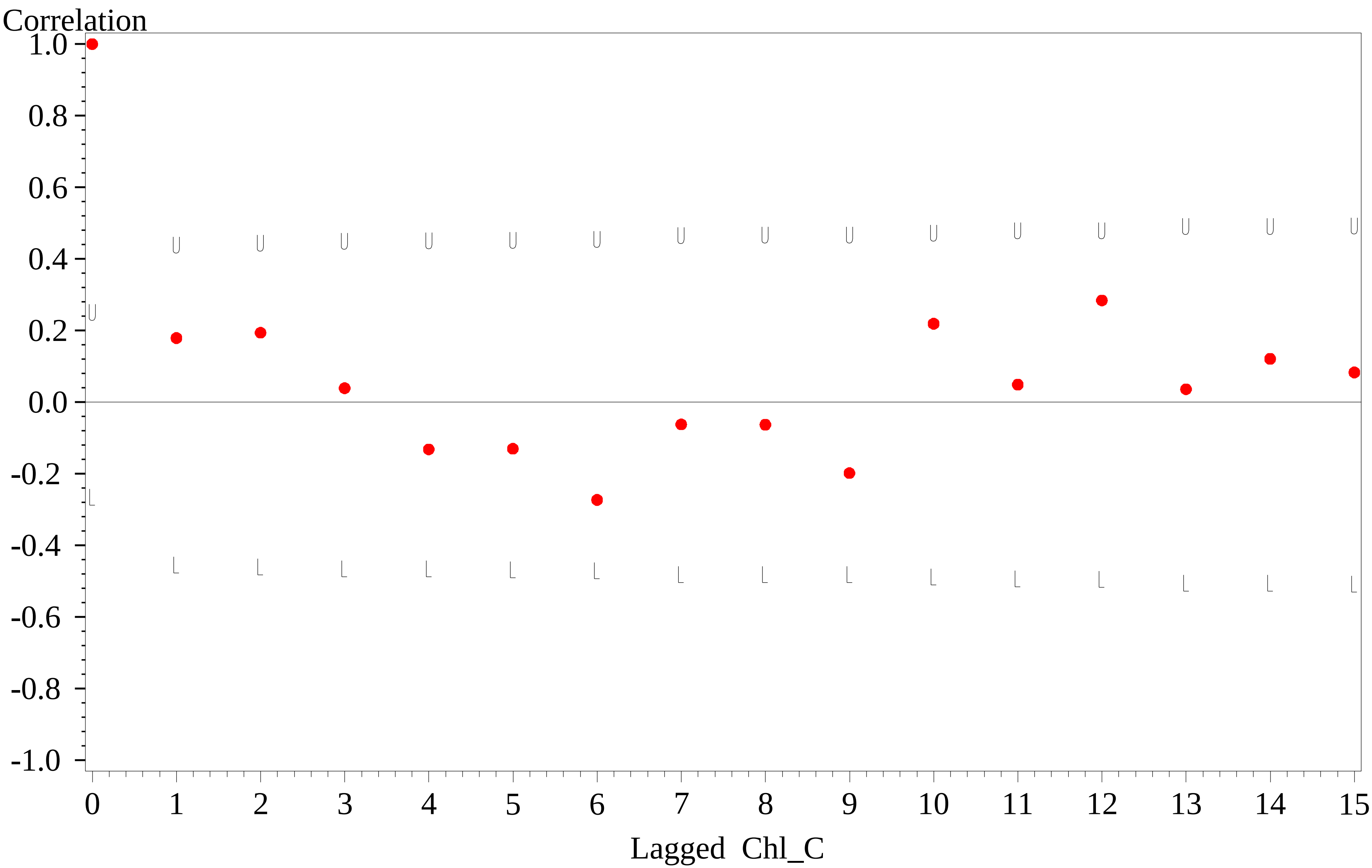
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll C at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_C	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.179	0.224	0.447	-0.447
2	0.194	0.226	0.452	-0.452
3	0.039	0.229	0.457	-0.457
4	-0.132	0.229	0.458	-0.458
5	-0.130	0.230	0.460	-0.460
6	-0.273	0.231	0.463	-0.463
7	-0.062	0.237	0.473	-0.473
8	-0.063	0.237	0.474	-0.474
9	-0.198	0.237	0.474	-0.474
10	0.219	0.240	0.480	-0.480
11	0.049	0.243	0.486	-0.486
12	0.284	0.243	0.487	-0.487
13	0.036	0.249	0.498	-0.498
14	0.121	0.249	0.498	-0.498
15	0.083	0.250	0.500	-0.500

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll C at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll C at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.169	0.263	0.275	-0.86

Seasonal Kendall Tau Trend Test Statistics for Chlorophyll C at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.16883	0.26314	0.27531	-0.86

Alafia River at Bell Shoals Road Trends Appendix

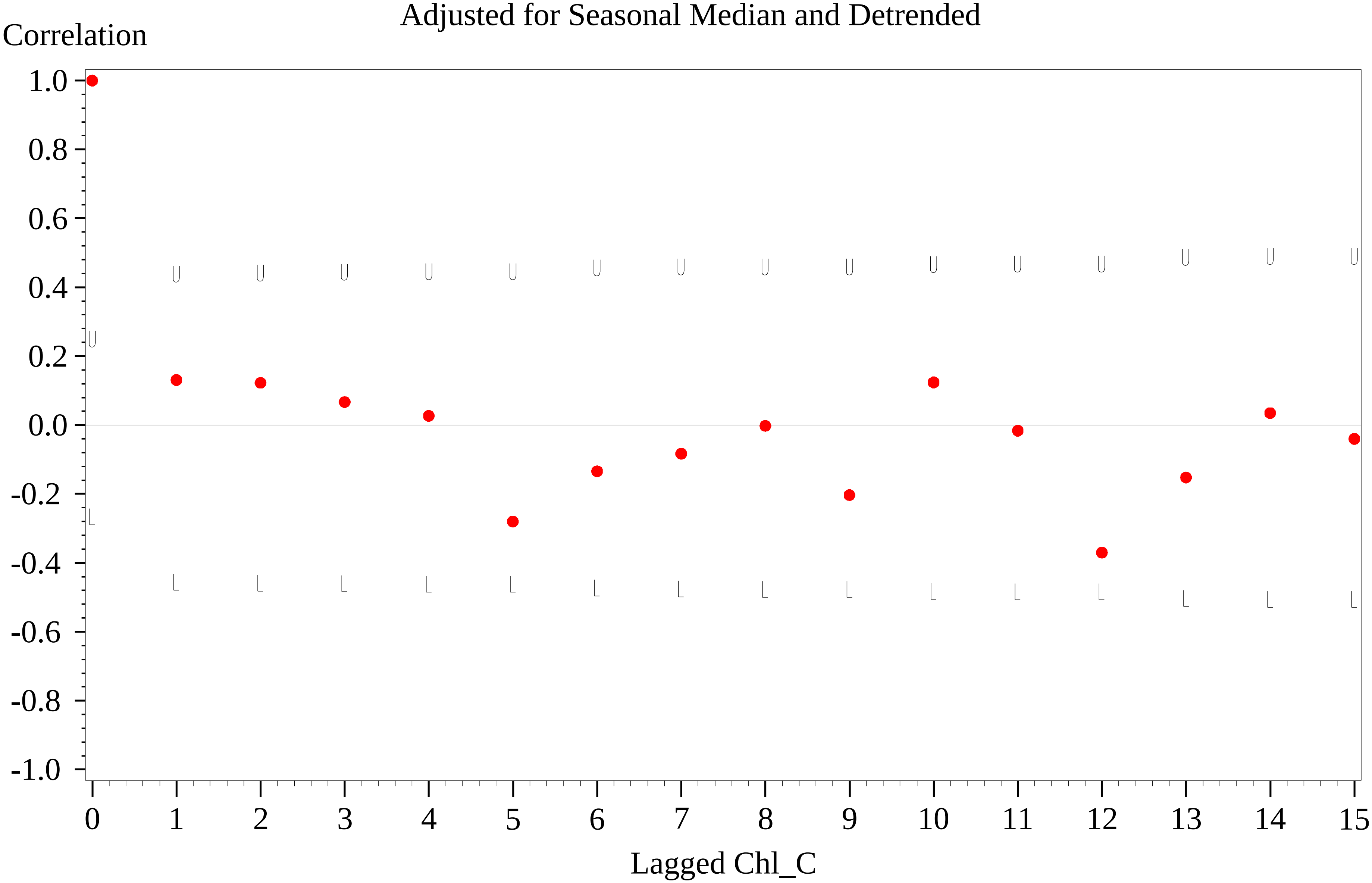
Autocorrelation Statistics for Chlorophyll C at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Chl_C	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.131	0.224	0.447	-0.447
2	0.123	0.225	0.450	-0.450
3	0.067	0.226	0.452	-0.452
4	0.027	0.226	0.453	-0.453
5	-0.280	0.226	0.453	-0.453
6	-0.134	0.232	0.464	-0.464
7	-0.083	0.233	0.467	-0.467
8	-0.002	0.234	0.468	-0.468
9	-0.203	0.234	0.468	-0.468
10	0.124	0.237	0.474	-0.474
11	-0.016	0.238	0.476	-0.476
12	-0.370	0.238	0.476	-0.476
13	-0.152	0.247	0.495	-0.495
14	0.035	0.249	0.498	-0.498
15	-0.040	0.249	0.498	-0.498

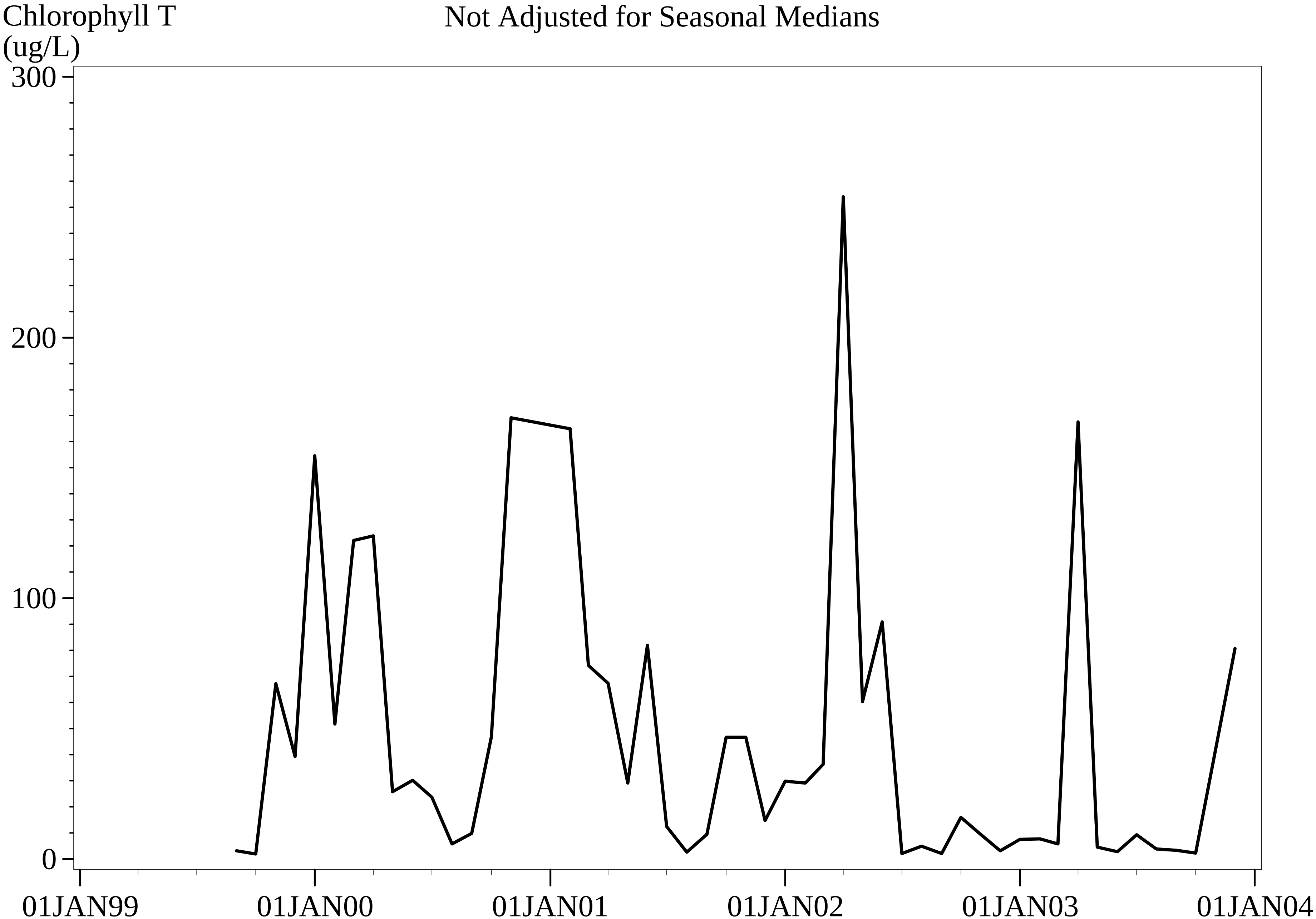
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll C at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

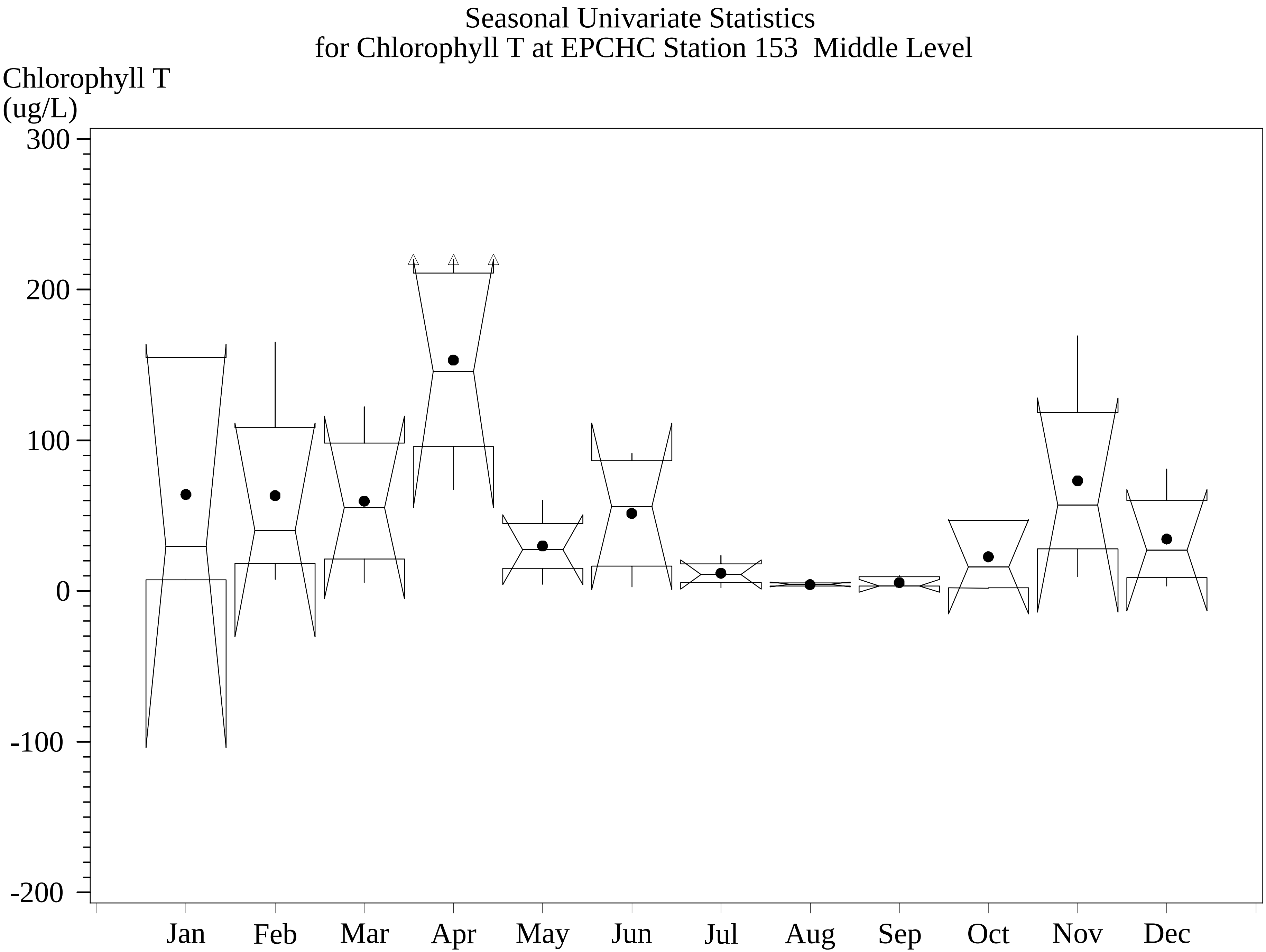


U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix



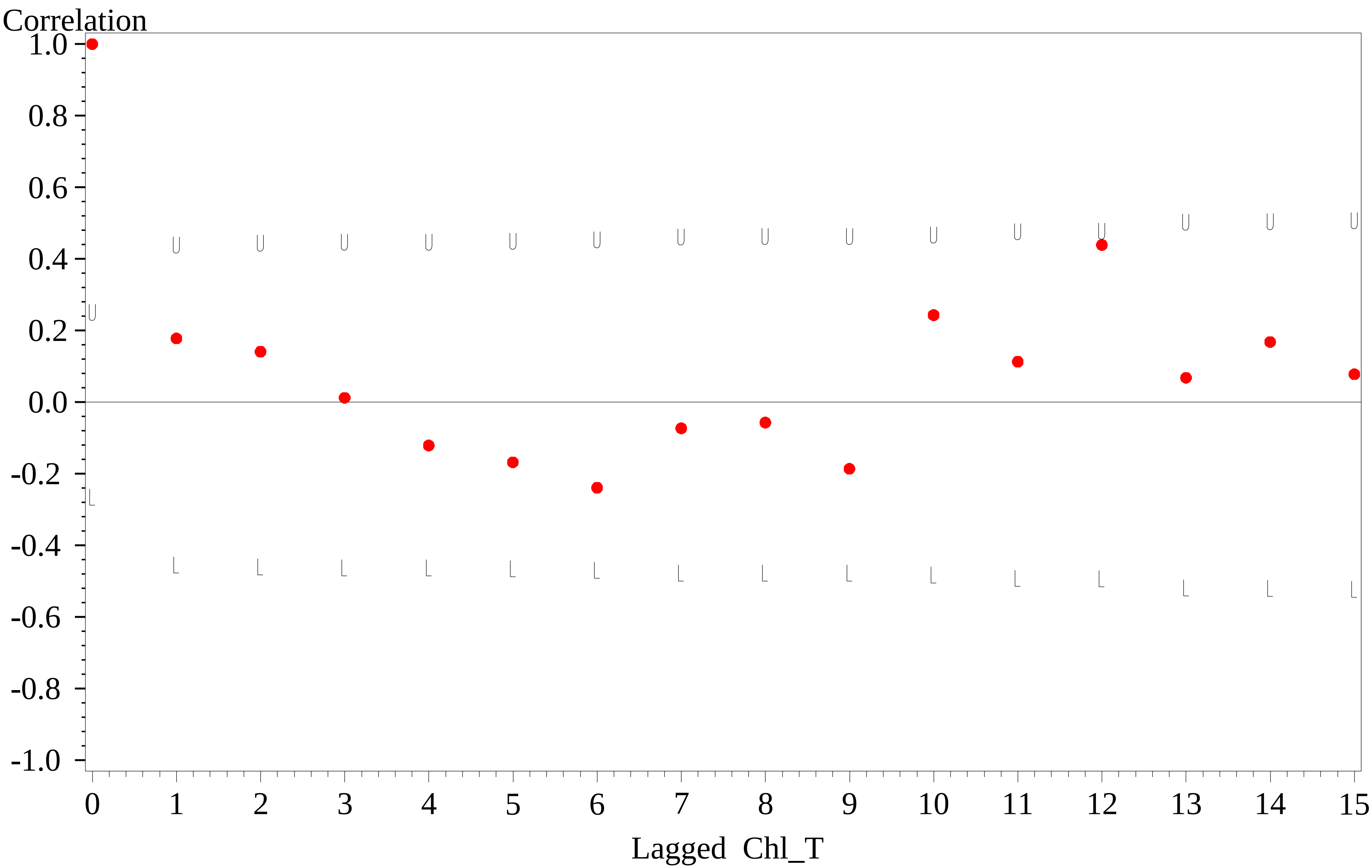
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll T at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_T	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.178	0.224	0.447	-0.447
2	0.141	0.226	0.452	-0.452
3	0.012	0.227	0.455	-0.455
4	-0.121	0.227	0.455	-0.455
5	-0.168	0.229	0.457	-0.457
6	-0.239	0.231	0.461	-0.461
7	-0.073	0.235	0.469	-0.469
8	-0.057	0.235	0.470	-0.470
9	-0.186	0.235	0.470	-0.470
10	0.243	0.238	0.475	-0.475
11	0.113	0.242	0.484	-0.484
12	0.439	0.243	0.485	-0.485
13	0.068	0.256	0.511	-0.511
14	0.168	0.256	0.512	-0.512
15	0.078	0.258	0.515	-0.515

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll T at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll T at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.325	0.025	0.147	-7.033

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Chlorophyll T at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.32468	0.025220	0.14733	-7.03333

Alafia River at Bell Shoals Road Trends Appendix

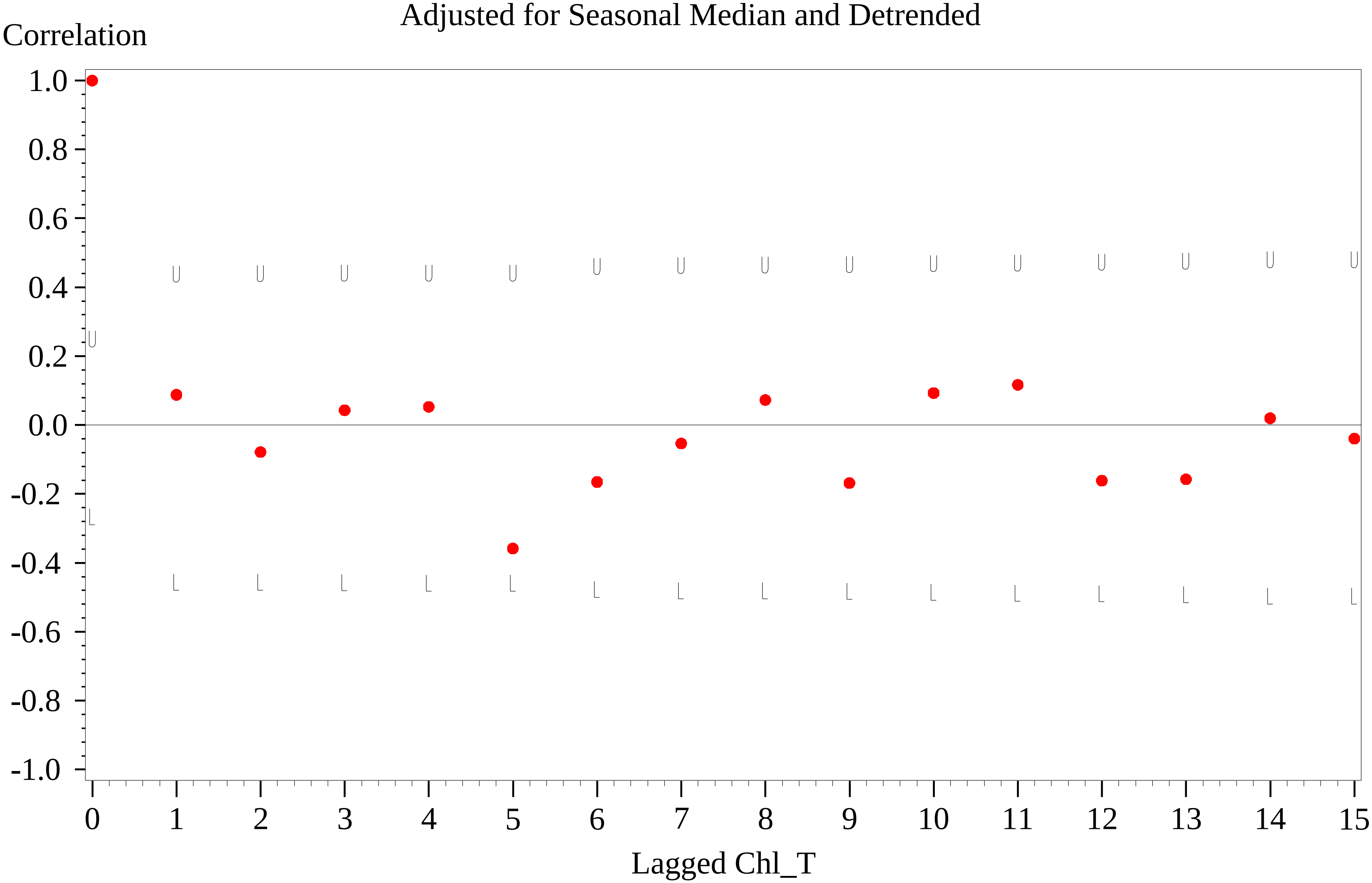
Autocorrelation Statistics for Chlorophyll T at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

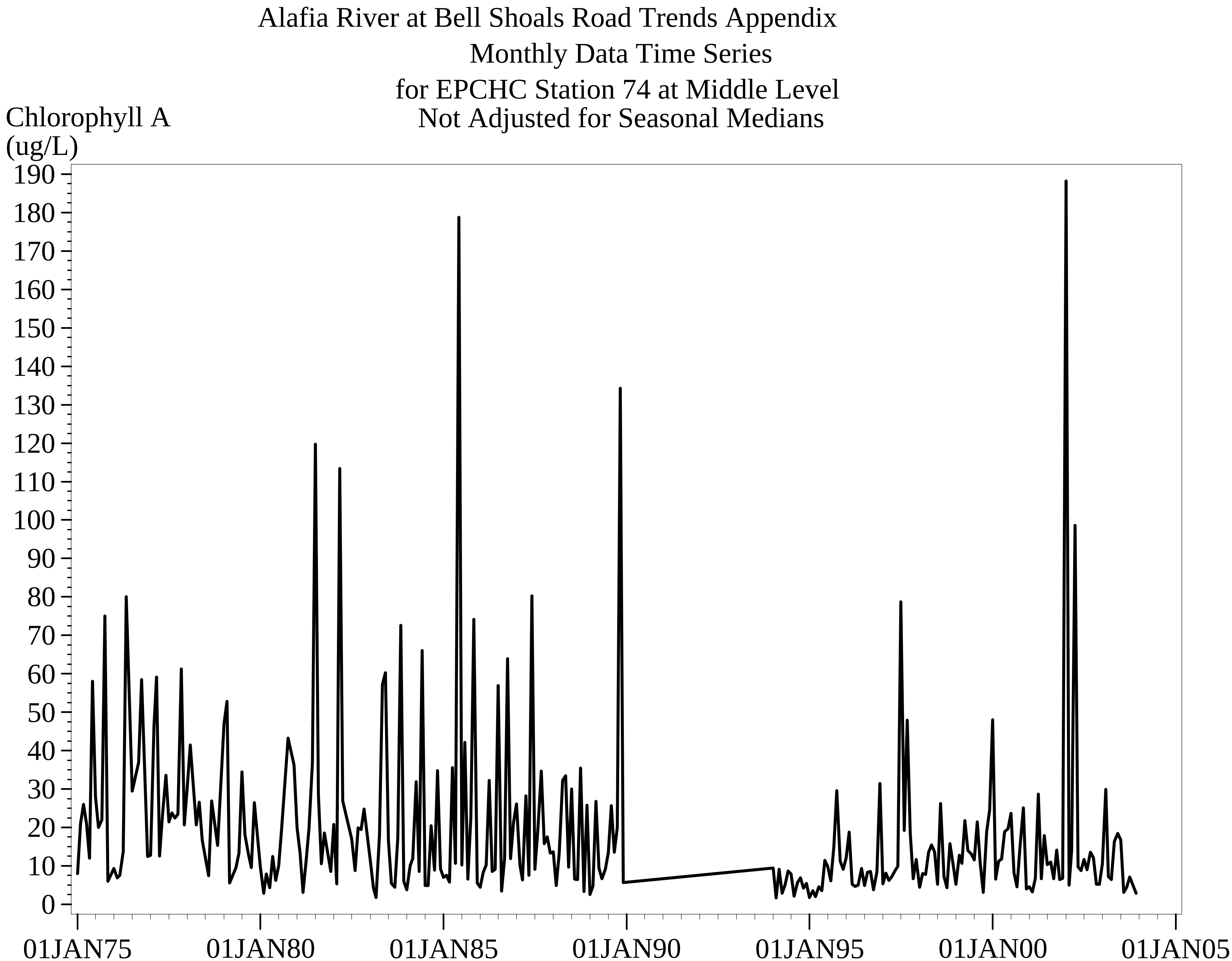
Lagged Chl_T	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.088	0.224	0.447	-0.447
2	-0.078	0.224	0.448	-0.448
3	0.043	0.225	0.449	-0.449
4	0.053	0.225	0.450	-0.450
5	-0.358	0.225	0.450	-0.450
6	-0.165	0.234	0.469	-0.469
7	-0.053	0.236	0.472	-0.472
8	0.073	0.236	0.473	-0.473
9	-0.168	0.237	0.474	-0.474
10	0.093	0.239	0.477	-0.477
11	0.117	0.239	0.479	-0.479
12	-0.161	0.240	0.481	-0.481
13	-0.157	0.242	0.484	-0.484
14	0.020	0.244	0.488	-0.488
15	-0.039	0.244	0.488	-0.488

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll T at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

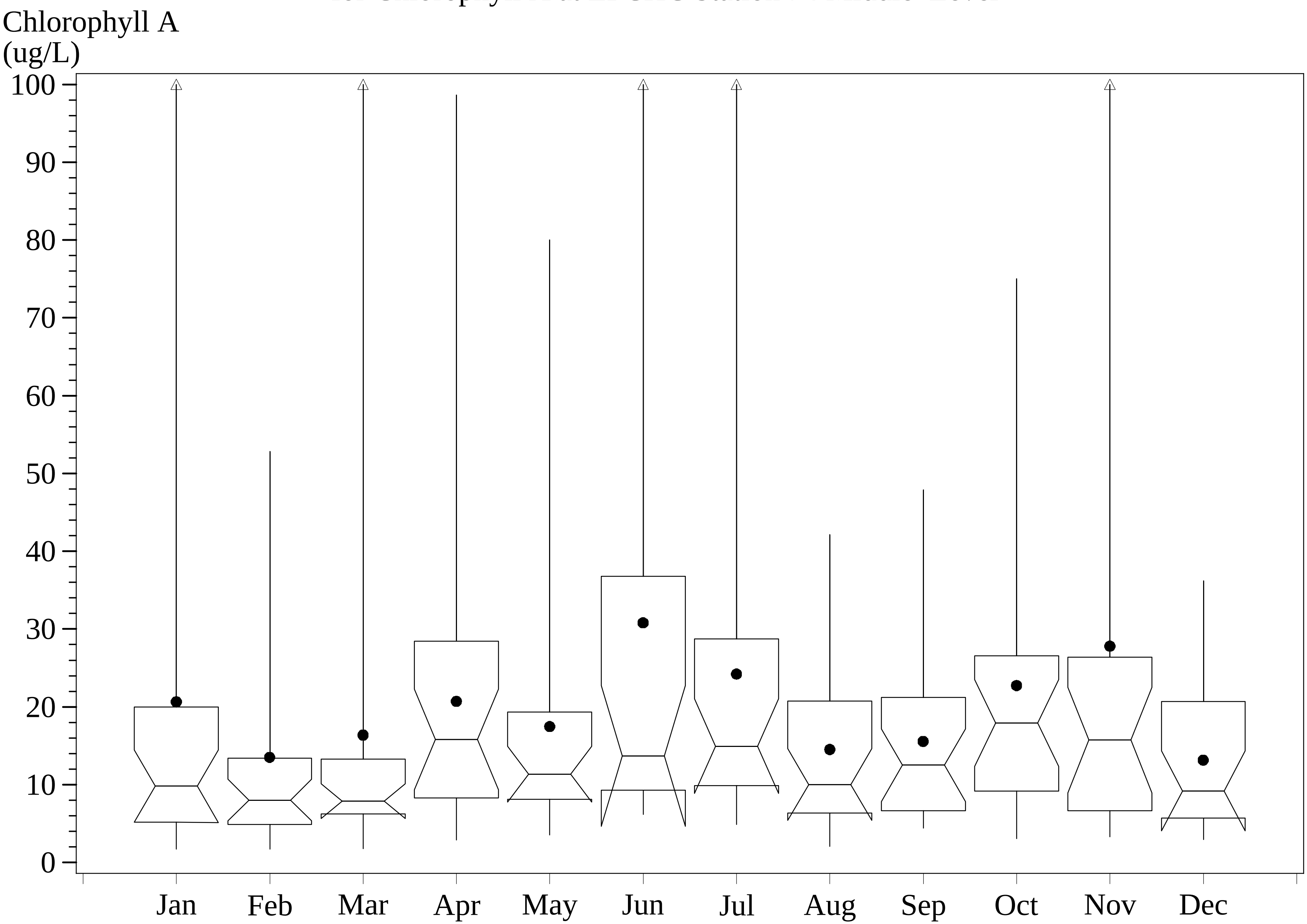


U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown


Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Middle Level
Not Adjusted for Seasonal Medians
Chlorophyll A
(ug/L)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
01JAN75
01JAN80
01JAN85
01JAN90
01JAN95
01JAN00
01JAN05

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll A at EPCHC Station 74 Middle Level



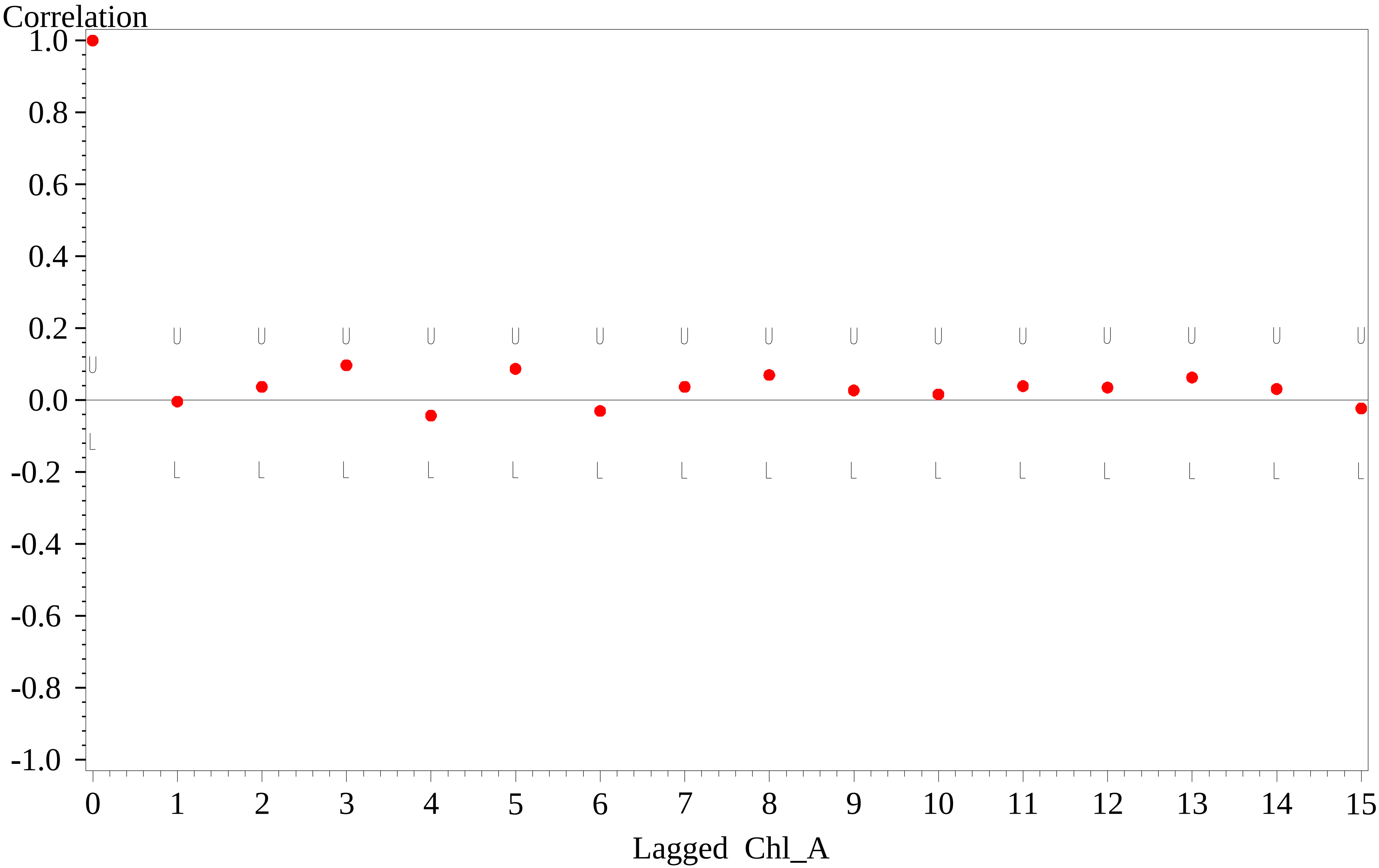
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll A at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_A	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	-0.004	0.093	0.186	-0.186
2	0.037	0.093	0.186	-0.186
3	0.097	0.093	0.186	-0.186
4	-0.043	0.093	0.186	-0.186
5	0.087	0.093	0.186	-0.186
6	-0.030	0.093	0.187	-0.187
7	0.037	0.093	0.187	-0.187
8	0.070	0.094	0.187	-0.187
9	0.027	0.094	0.187	-0.187
10	0.016	0.094	0.187	-0.187
11	0.039	0.094	0.187	-0.187
12	0.035	0.094	0.188	-0.188
13	0.063	0.094	0.188	-0.188
14	0.031	0.094	0.188	-0.188
15	-0.023	0.094	0.188	-0.188

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll A at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll A at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.196	0	.003	-0.31

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Chlorophyll A at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.19573	.000004459	.00315378	-0.30952

Alafia River at Bell Shoals Road Trends Appendix

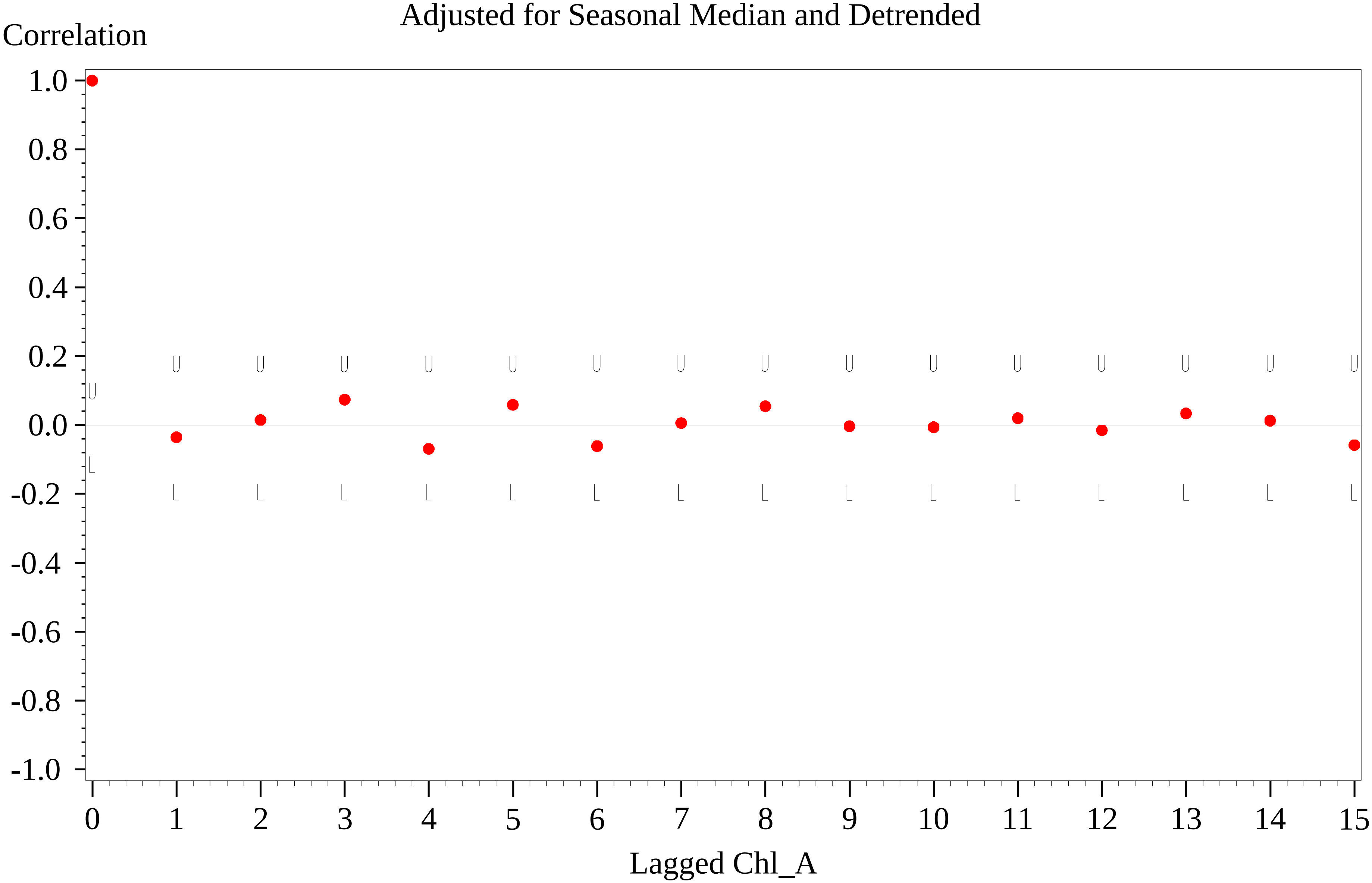
Autocorrelation Statistics for Chlorophyll A at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Chl_A	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	-0.035	0.093	0.186	-0.186
2	0.015	0.093	0.186	-0.186
3	0.074	0.093	0.186	-0.186
4	-0.069	0.093	0.186	-0.186
5	0.059	0.093	0.186	-0.186
6	-0.061	0.093	0.187	-0.187
7	0.006	0.093	0.187	-0.187
8	0.055	0.093	0.187	-0.187
9	-0.003	0.094	0.187	-0.187
10	-0.006	0.094	0.187	-0.187
11	0.020	0.094	0.187	-0.187
12	-0.015	0.094	0.187	-0.187
13	0.034	0.094	0.187	-0.187
14	0.013	0.094	0.187	-0.187
15	-0.058	0.094	0.187	-0.187

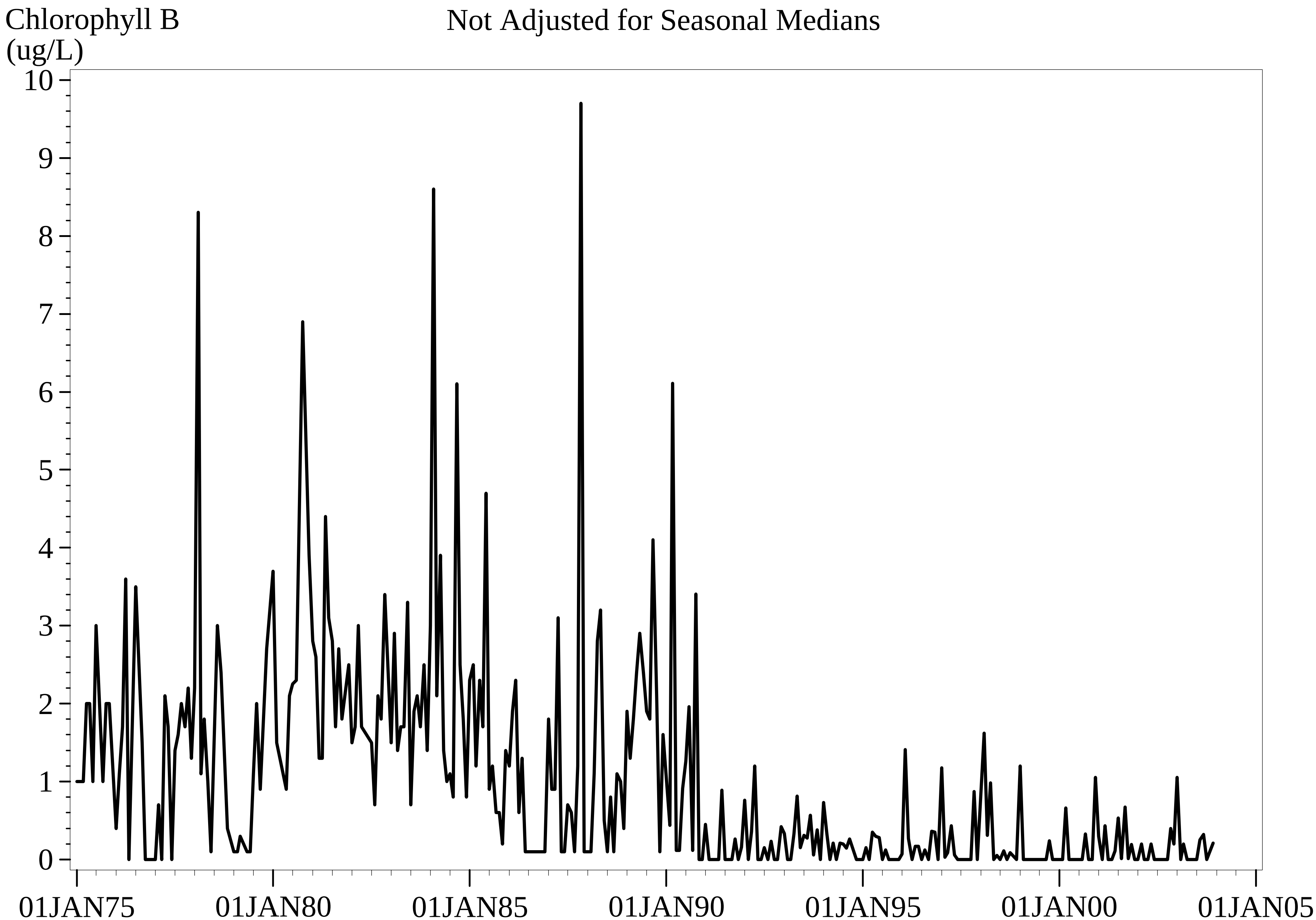
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll A at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended



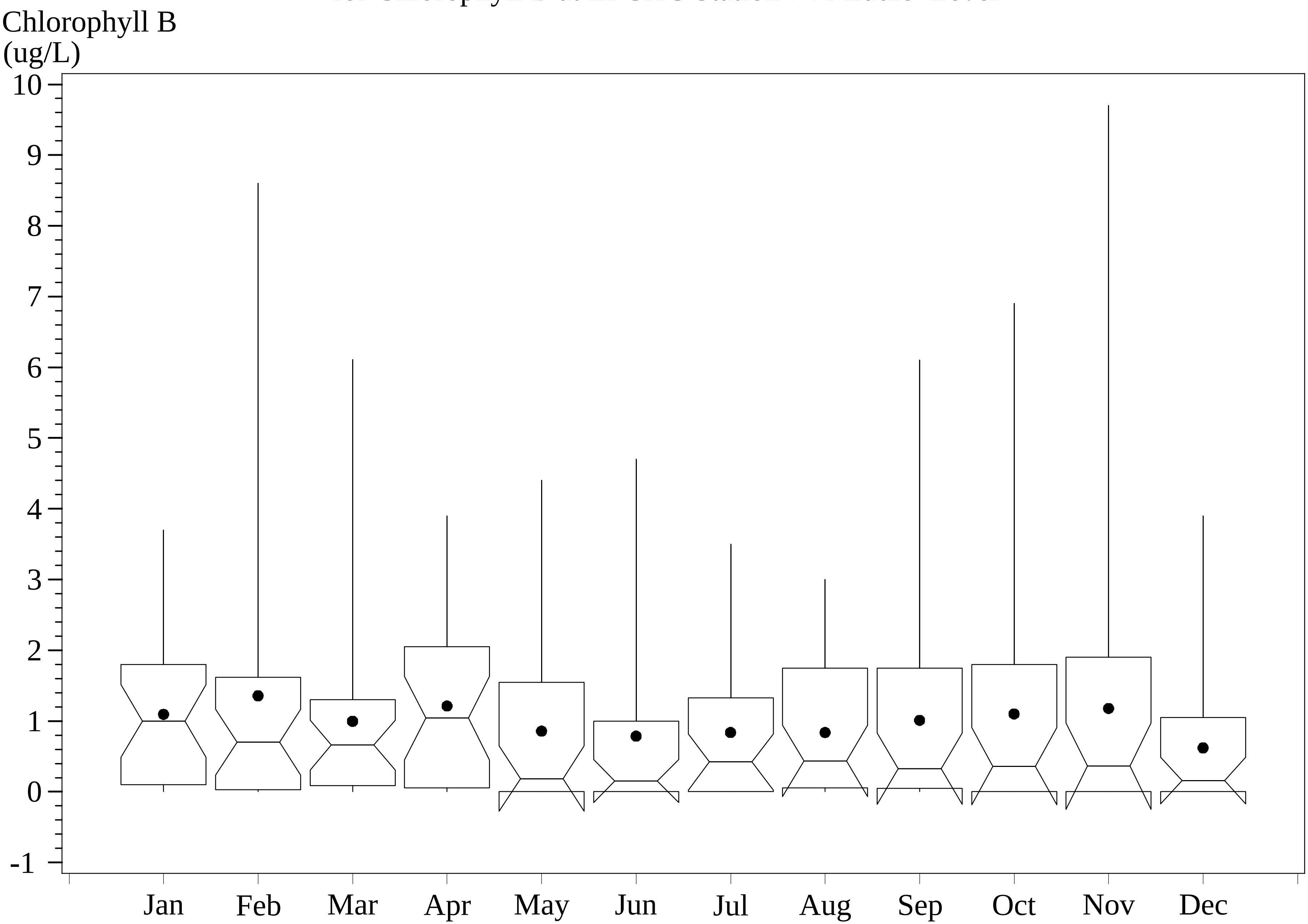
U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll B at EPCHC Station 74 Middle Level



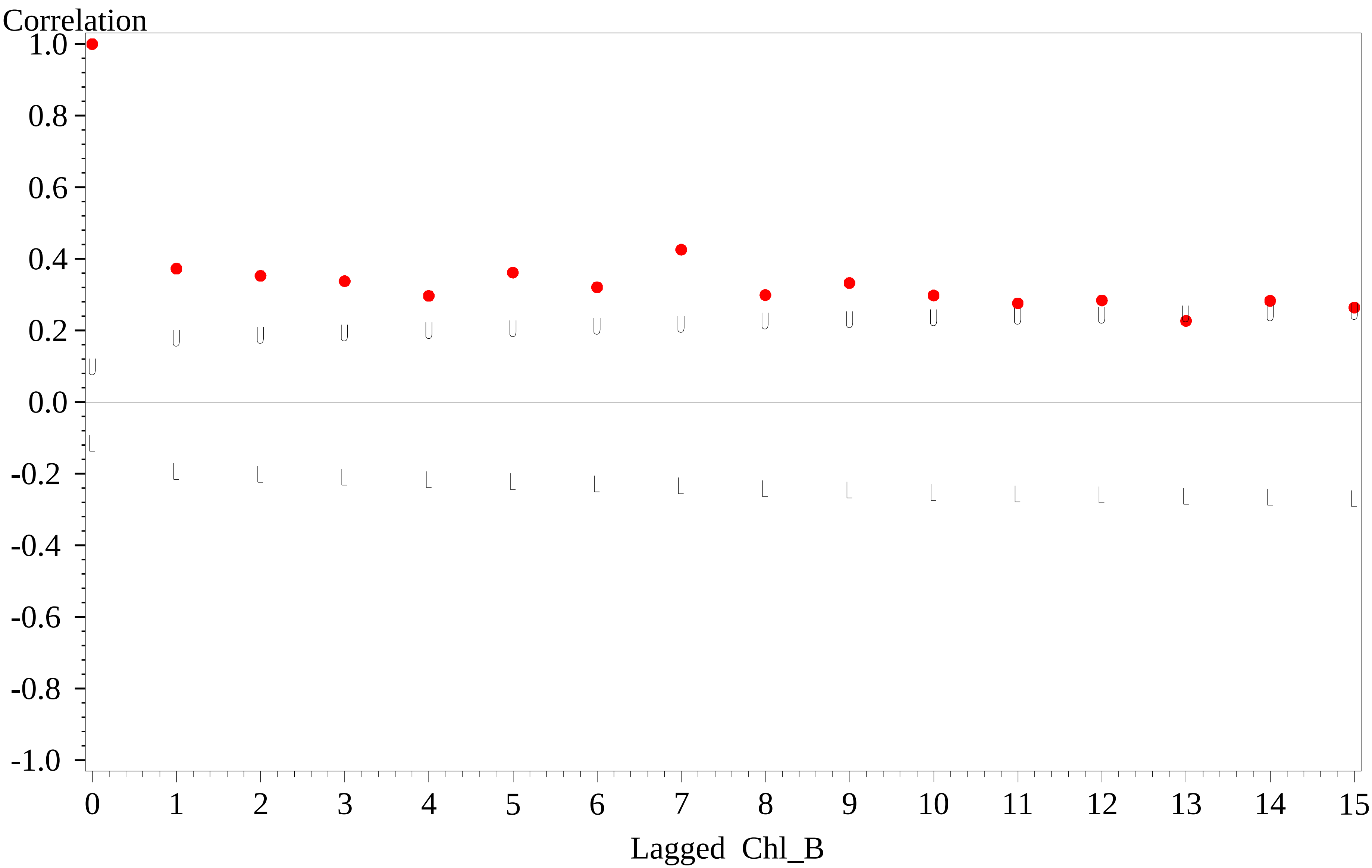
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll B at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_B	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.373	0.093	0.186	-0.186
2	0.353	0.097	0.194	-0.194
3	0.338	0.101	0.201	-0.201
4	0.297	0.104	0.208	-0.208
5	0.362	0.106	0.213	-0.213
6	0.321	0.110	0.220	-0.220
7	0.426	0.112	0.225	-0.225
8	0.299	0.117	0.234	-0.234
9	0.333	0.119	0.238	-0.238
10	0.298	0.122	0.244	-0.244
11	0.276	0.124	0.248	-0.248
12	0.284	0.126	0.251	-0.251
13	0.227	0.127	0.255	-0.255
14	0.283	0.129	0.257	-0.257
15	0.264	0.130	0.261	-0.261

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll B at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll B at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.435	0	0	-0.058

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Chlorophyll B at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.43454	0	.000009691	-0.058333

Alafia River at Bell Shoals Road Trends Appendix

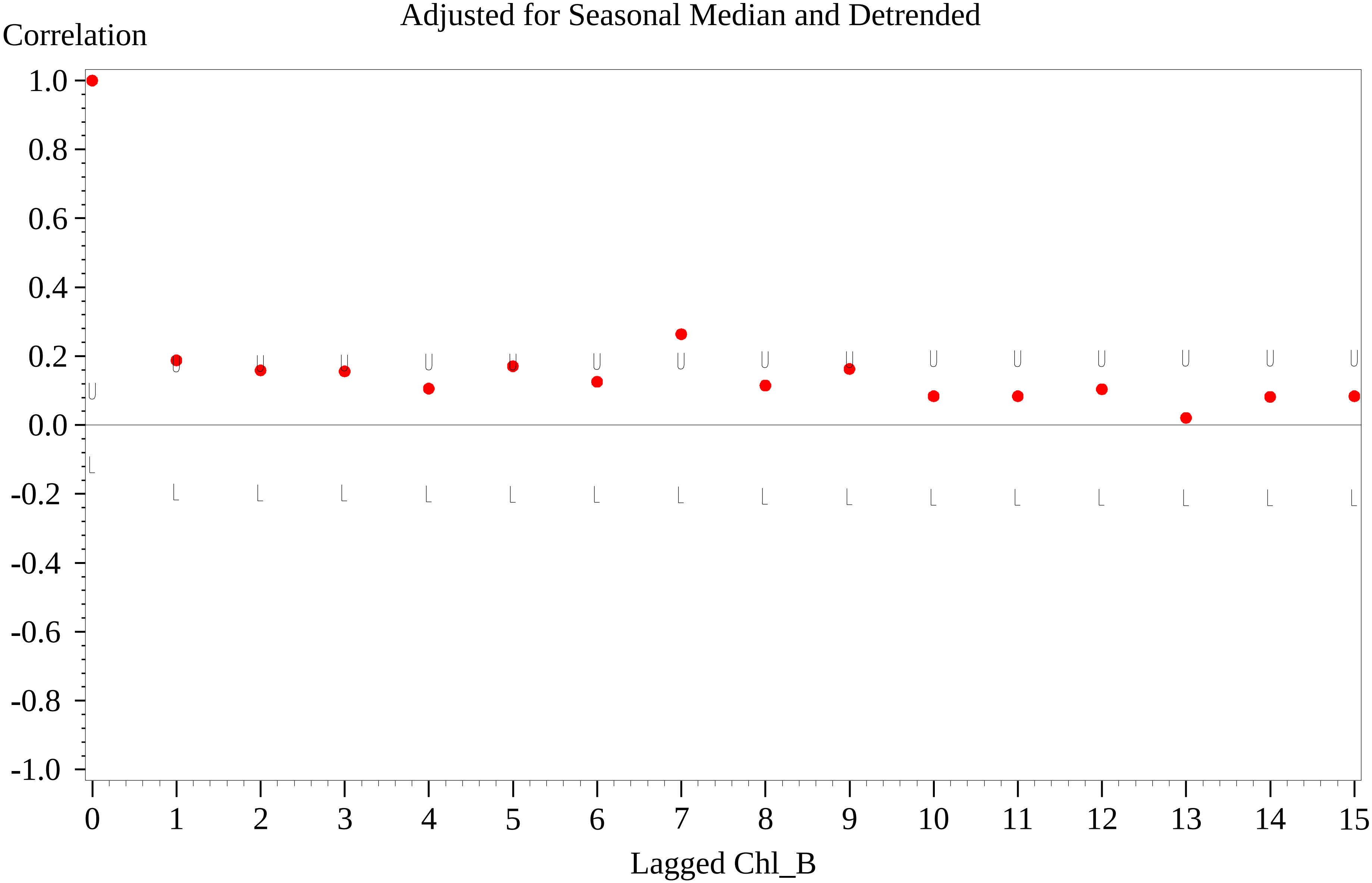
Autocorrelation Statistics for Chlorophyll B at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Chl_B	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.188	0.093	0.186	-0.186
2	0.159	0.094	0.188	-0.188
3	0.156	0.095	0.189	-0.189
4	0.106	0.095	0.191	-0.191
5	0.171	0.096	0.192	-0.192
6	0.126	0.097	0.193	-0.193
7	0.264	0.097	0.194	-0.194
8	0.115	0.099	0.198	-0.198
9	0.163	0.100	0.199	-0.199
10	0.084	0.100	0.201	-0.201
11	0.084	0.100	0.201	-0.201
12	0.104	0.101	0.201	-0.201
13	0.021	0.101	0.202	-0.202
14	0.082	0.101	0.202	-0.202
15	0.084	0.101	0.202	-0.202

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll B at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended



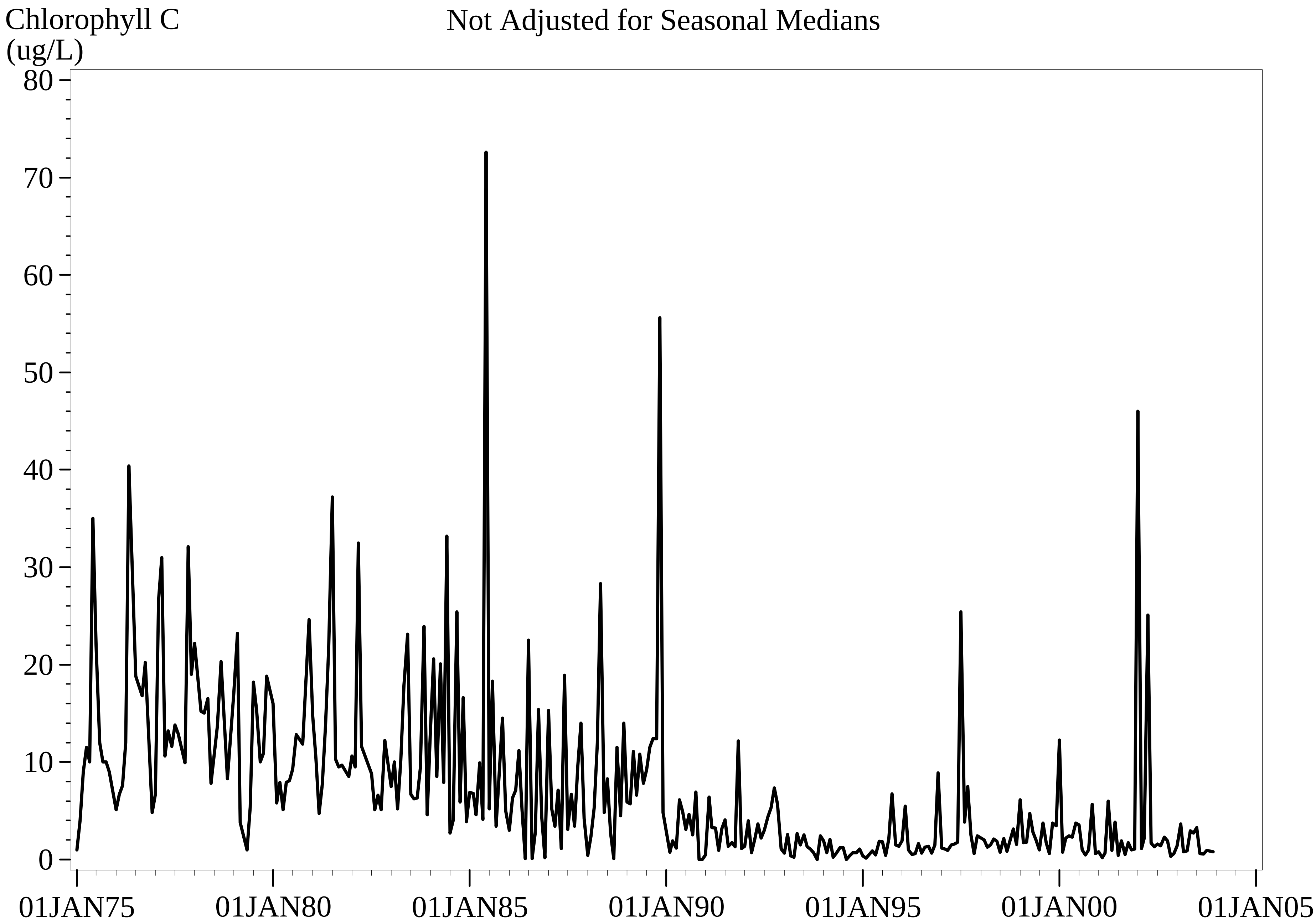
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Monthly Data Time Series

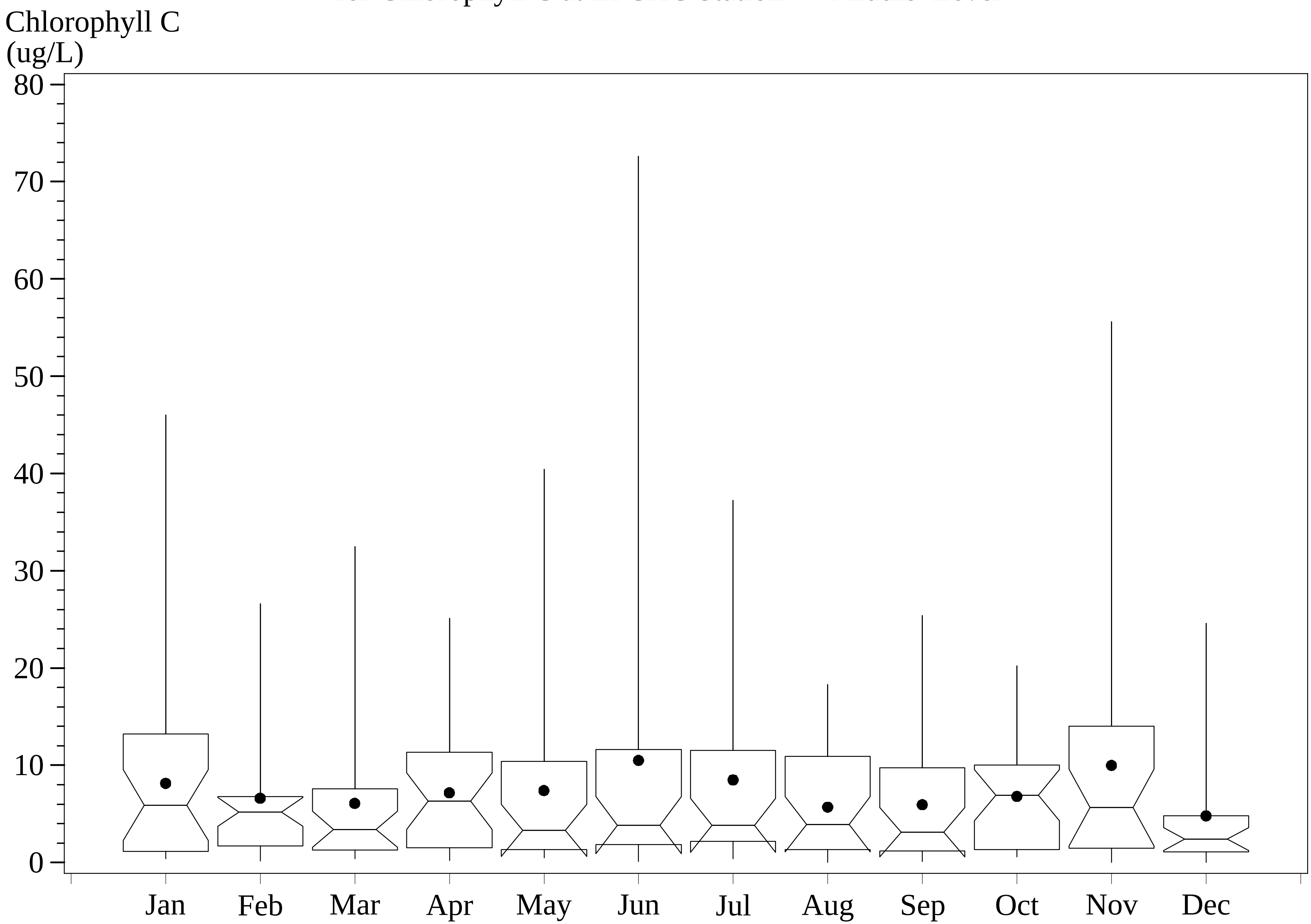
for EPCHC Station 74 at Middle Level

Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll C at EPCHC Station 74 Middle Level



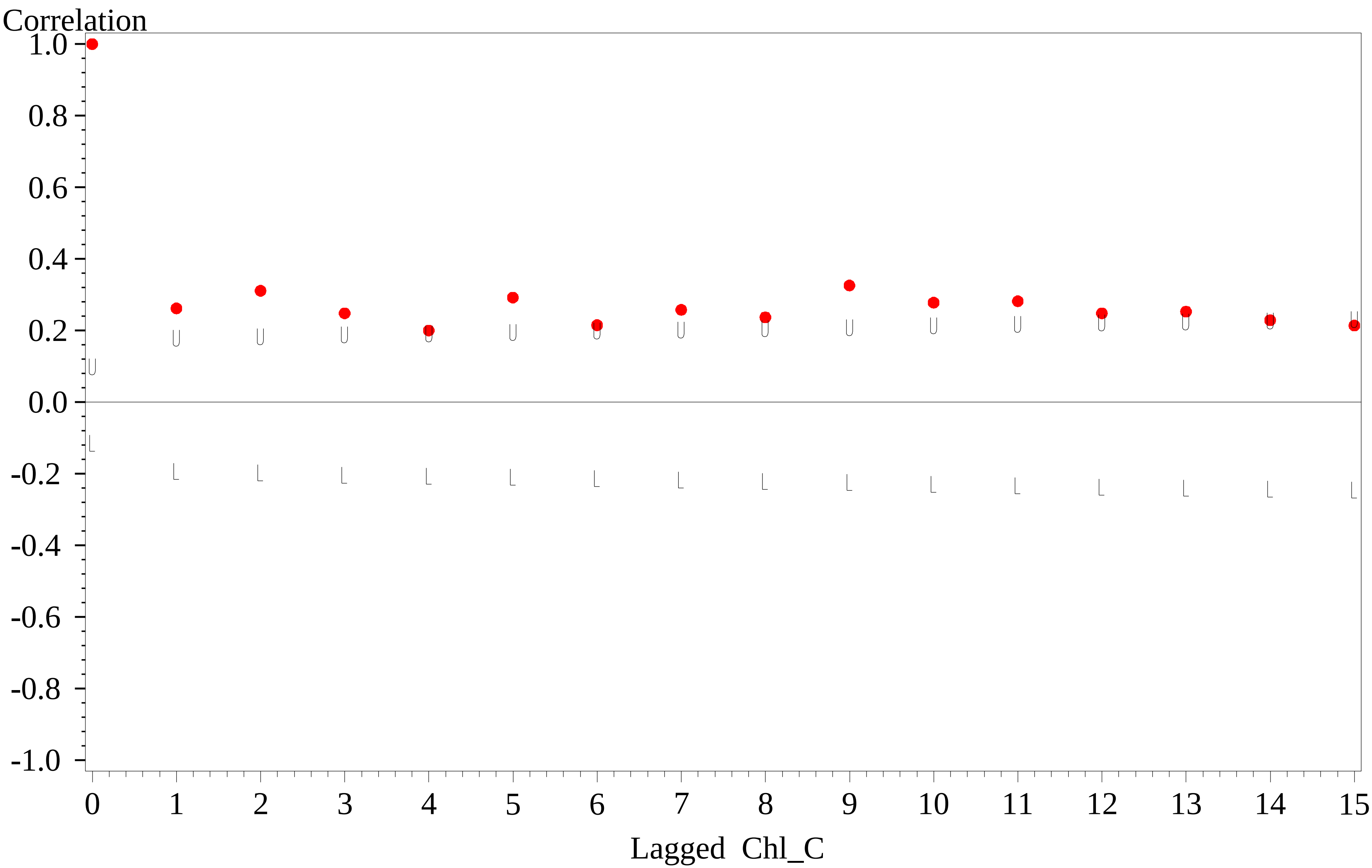
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll C at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_C	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.262	0.093	0.186	-0.186
2	0.311	0.095	0.190	-0.190
3	0.248	0.098	0.196	-0.196
4	0.200	0.100	0.199	-0.199
5	0.292	0.101	0.202	-0.202
6	0.215	0.103	0.206	-0.206
7	0.258	0.104	0.209	-0.209
8	0.237	0.106	0.213	-0.213
9	0.326	0.108	0.216	-0.216
10	0.278	0.111	0.221	-0.221
11	0.282	0.113	0.225	-0.225
12	0.248	0.115	0.229	-0.229
13	0.253	0.116	0.232	-0.232
14	0.229	0.118	0.235	-0.235
15	0.214	0.119	0.238	-0.238

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll C at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll C at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.49	0	0	-0.396

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Chlorophyll C at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.48955	0	.000001199	-0.3955

Alafia River at Bell Shoals Road Trends Appendix

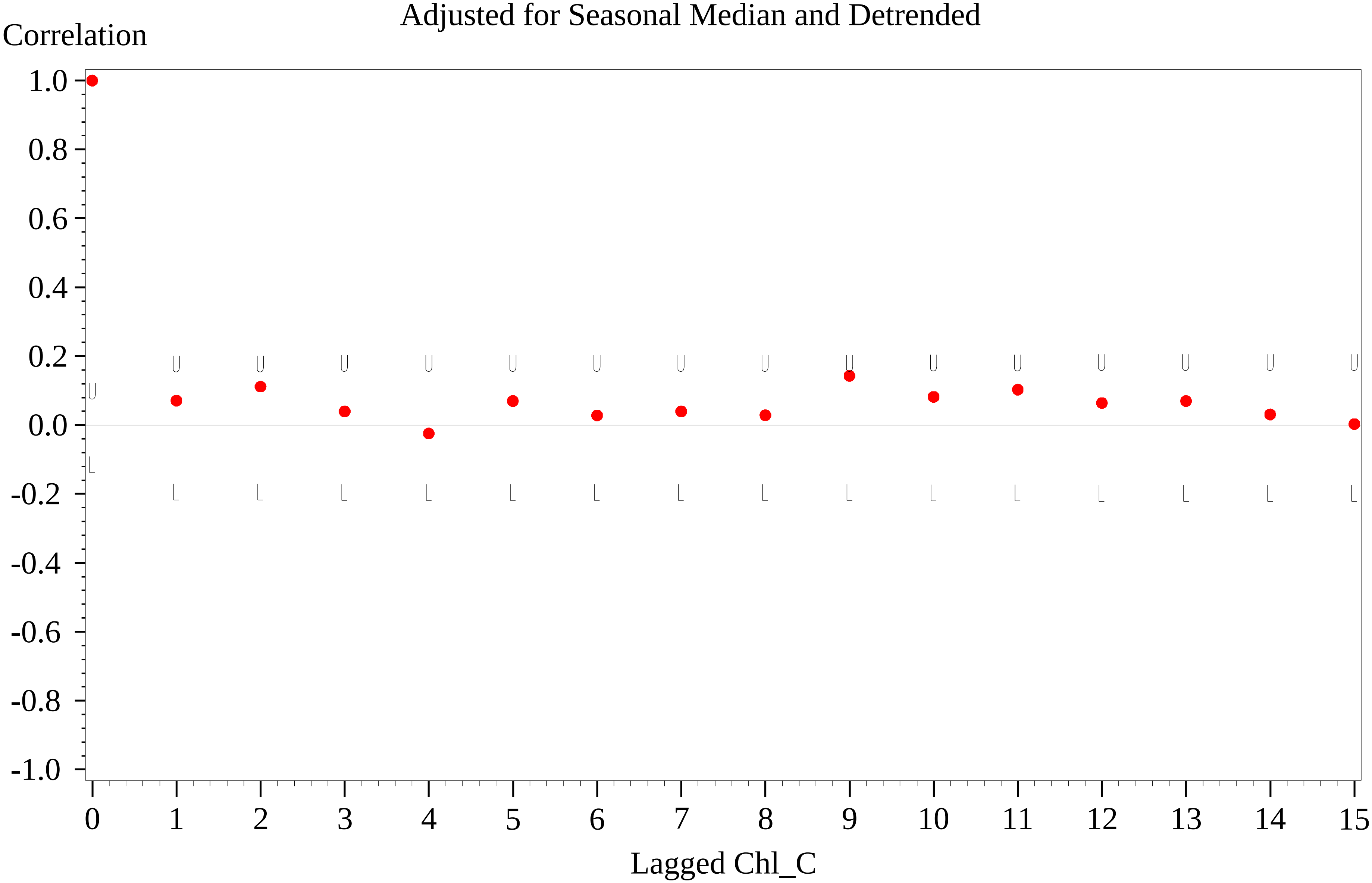
Autocorrelation Statistics for Chlorophyll C at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

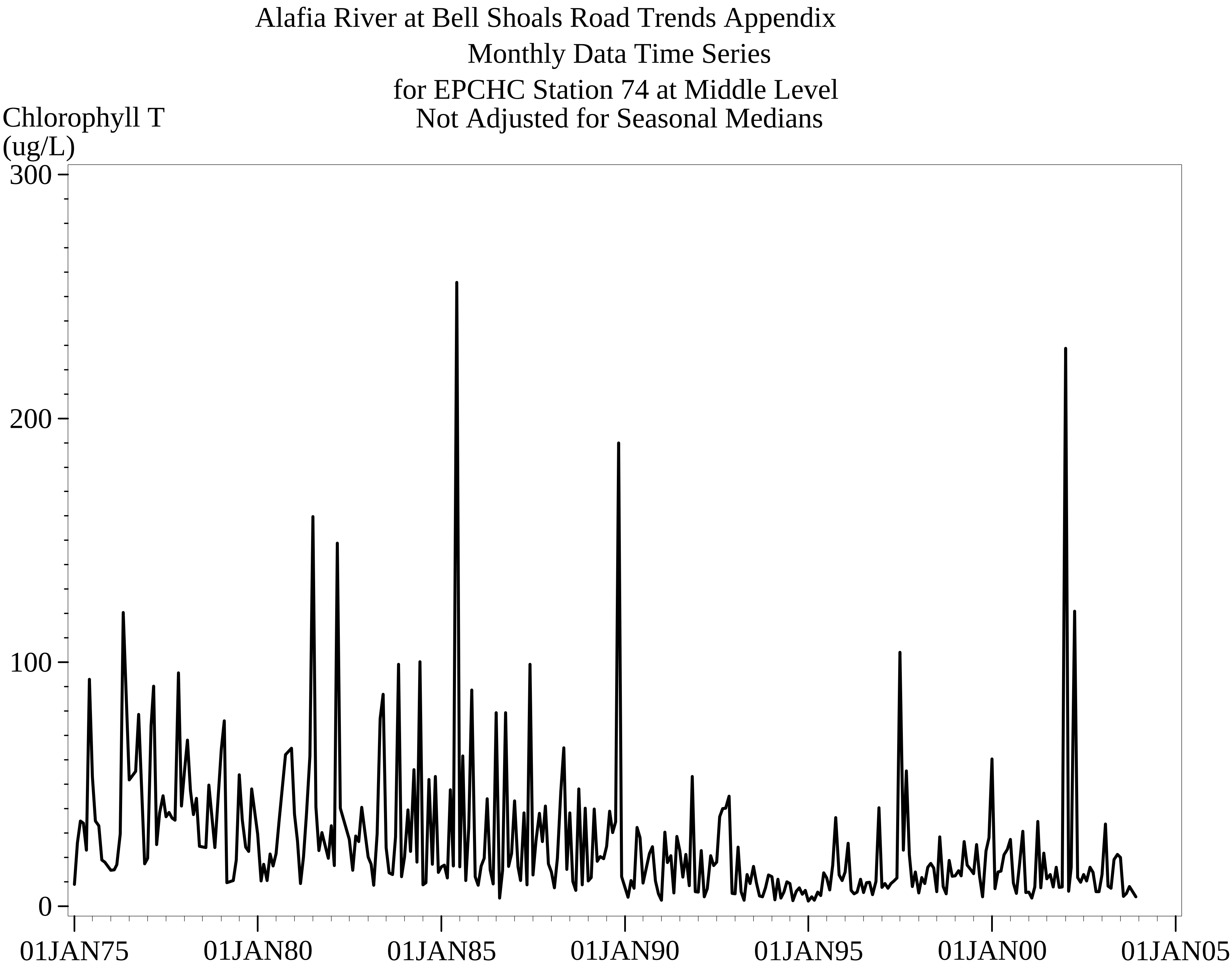
Lagged Chl_C	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.071	0.093	0.186	-0.186
2	0.112	0.093	0.186	-0.186
3	0.040	0.093	0.187	-0.187
4	-0.024	0.093	0.187	-0.187
5	0.070	0.093	0.187	-0.187
6	0.028	0.094	0.187	-0.187
7	0.040	0.094	0.187	-0.187
8	0.029	0.094	0.187	-0.187
9	0.143	0.094	0.187	-0.187
10	0.082	0.094	0.189	-0.189
11	0.103	0.095	0.189	-0.189
12	0.064	0.095	0.190	-0.190
13	0.070	0.095	0.190	-0.190
14	0.031	0.095	0.190	-0.190
15	0.003	0.095	0.190	-0.190

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll C at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended



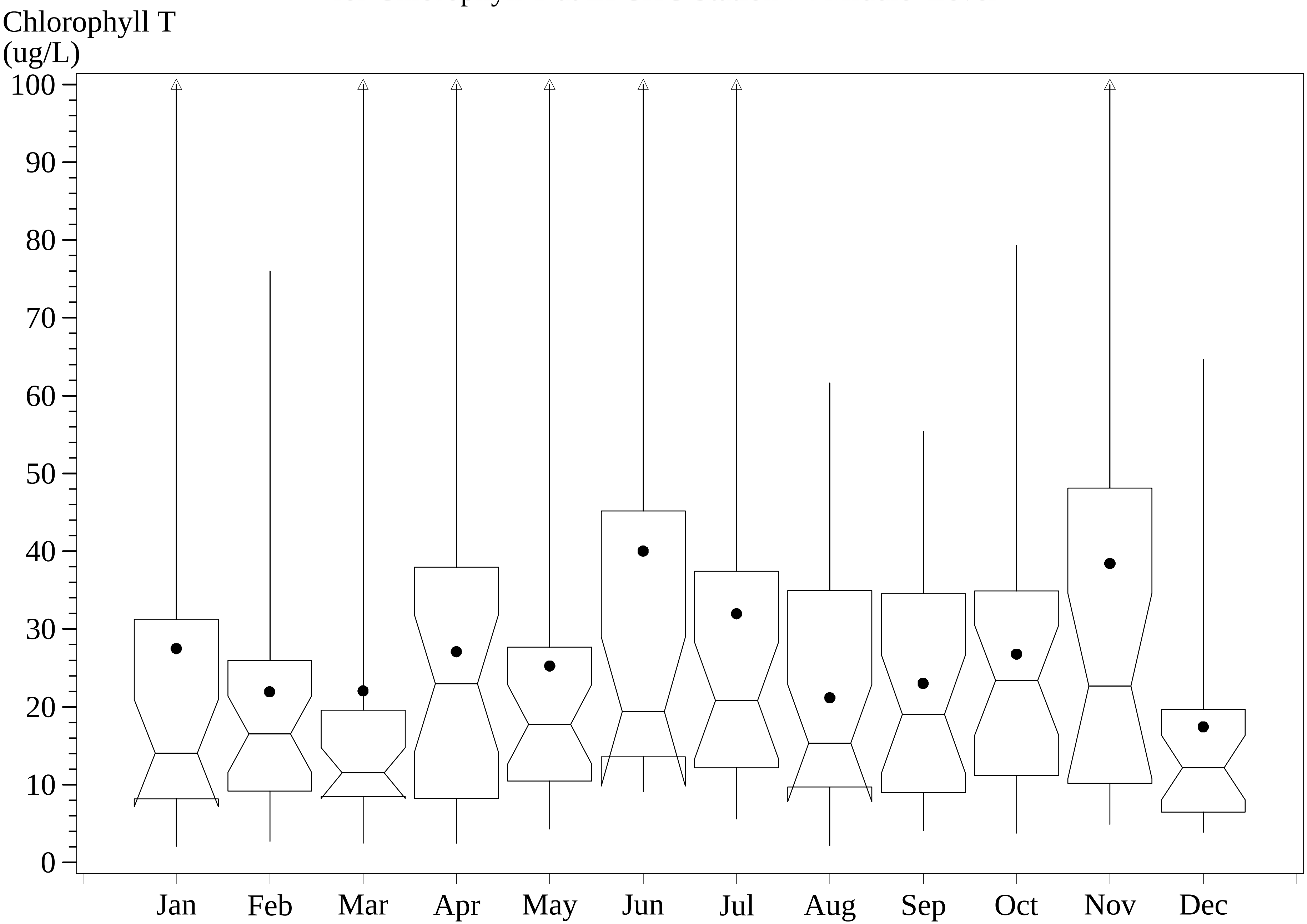
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown



Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Middle Level
Not Adjusted for Seasonal Medians
Chlorophyll T
(ug/L)
300
200
100
0
01JAN75
01JAN80
01JAN85
01JAN90
01JAN95
01JAN00
01JAN05

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Chlorophyll T at EPCHC Station 74 Middle Level



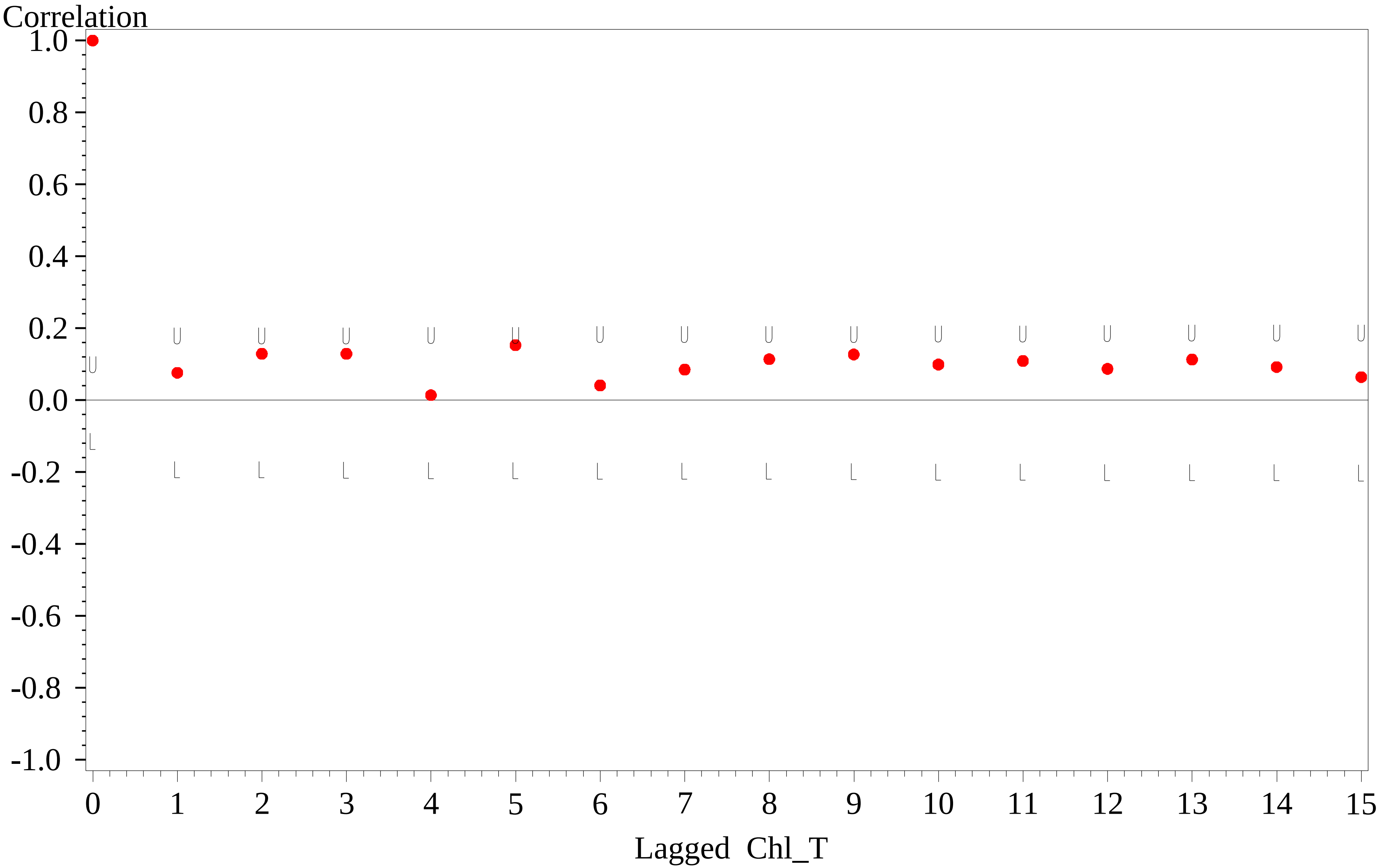
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Chlorophyll T at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged Chl_T	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.076	0.093	0.186	-0.186
2	0.129	0.093	0.186	-0.186
3	0.129	0.094	0.187	-0.187
4	0.014	0.094	0.188	-0.188
5	0.153	0.094	0.188	-0.188
6	0.041	0.095	0.190	-0.190
7	0.085	0.095	0.190	-0.190
8	0.114	0.095	0.190	-0.190
9	0.127	0.095	0.191	-0.191
10	0.099	0.096	0.192	-0.192
11	0.109	0.096	0.192	-0.192
12	0.087	0.097	0.193	-0.193
13	0.113	0.097	0.194	-0.194
14	0.092	0.097	0.194	-0.194
15	0.064	0.097	0.195	-0.195

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll T at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Chlorophyll T at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.339	0	0	-0.775

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Chlorophyll T at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.33908	0	.000018542	-0.775

Alafia River at Bell Shoals Road Trends Appendix

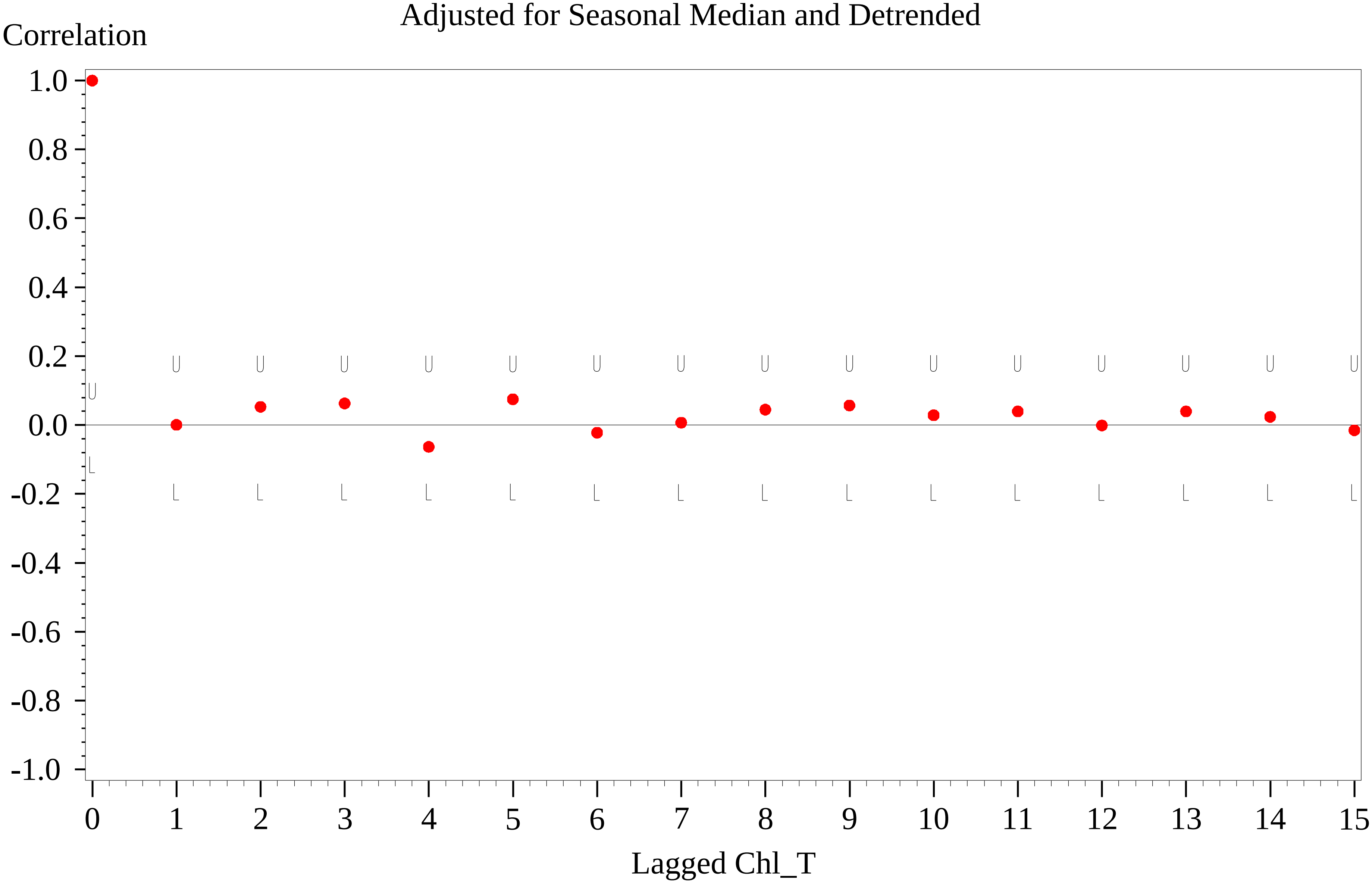
Autocorrelation Statistics for Chlorophyll T at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Chl_T	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.001	0.093	0.186	-0.186
2	0.053	0.093	0.186	-0.186
3	0.063	0.093	0.186	-0.186
4	-0.063	0.093	0.186	-0.186
5	0.075	0.093	0.186	-0.186
6	-0.022	0.093	0.187	-0.187
7	0.007	0.093	0.187	-0.187
8	0.045	0.093	0.187	-0.187
9	0.057	0.093	0.187	-0.187
10	0.029	0.094	0.187	-0.187
11	0.040	0.094	0.187	-0.187
12	-0.001	0.094	0.187	-0.187
13	0.040	0.094	0.187	-0.187
14	0.024	0.094	0.187	-0.187
15	-0.015	0.094	0.187	-0.187

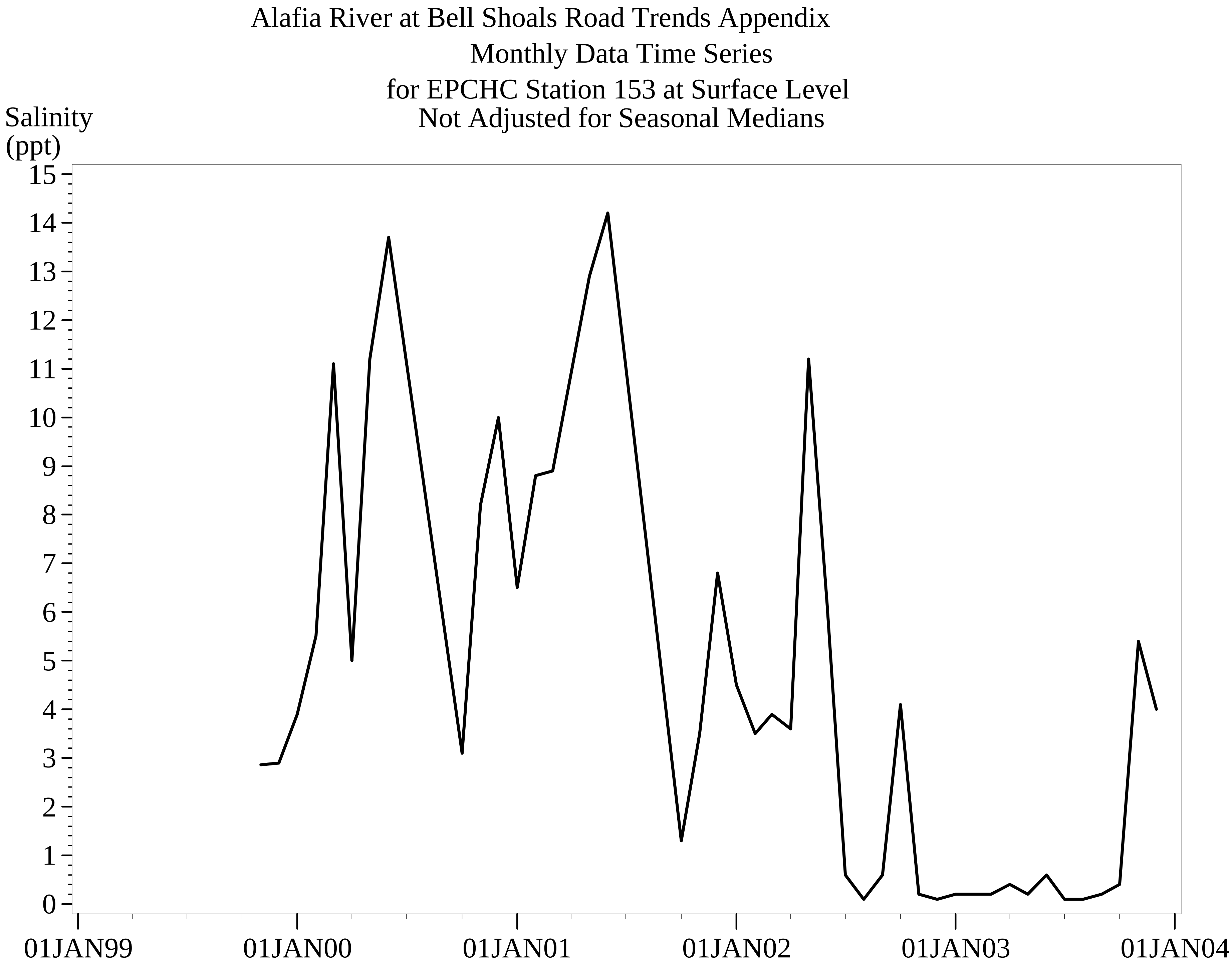
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Chlorophyll T at EPCHC Station 74 Middle Level

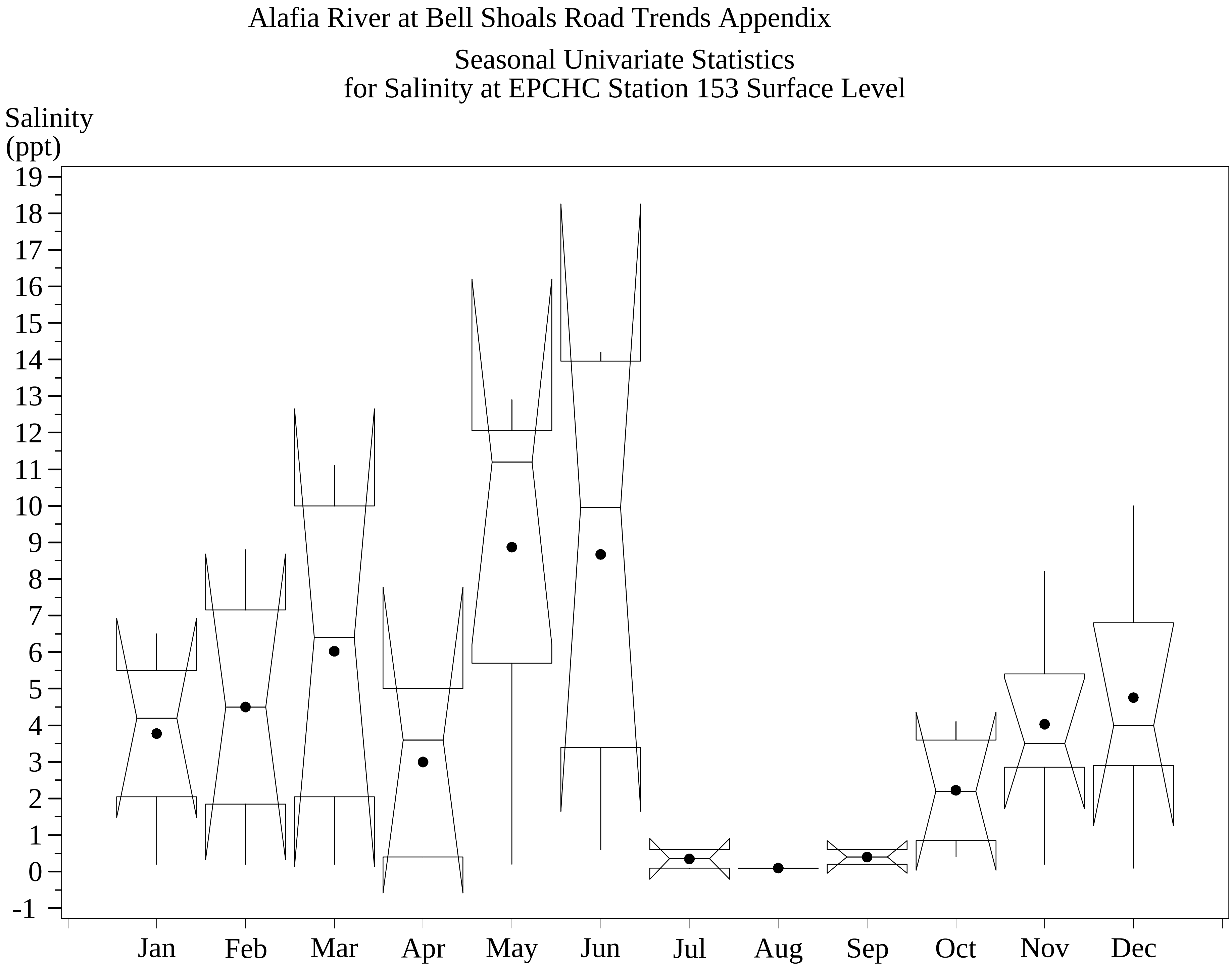
Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

APPENDIX J:
SALINITY TREND RESULTS


Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Surface Level
Not Adjusted for Seasonal Medians
Salinity
(ppt)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
01JAN99
01JAN00
01JAN01
01JAN02
01JAN03
01JAN04


Alafia River at Bell Shoals Road Trends Appendix
Seasonal Univariate Statistics
for Salinity at EPCHC Station 153 Surface Level
Salinity
(ppt)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

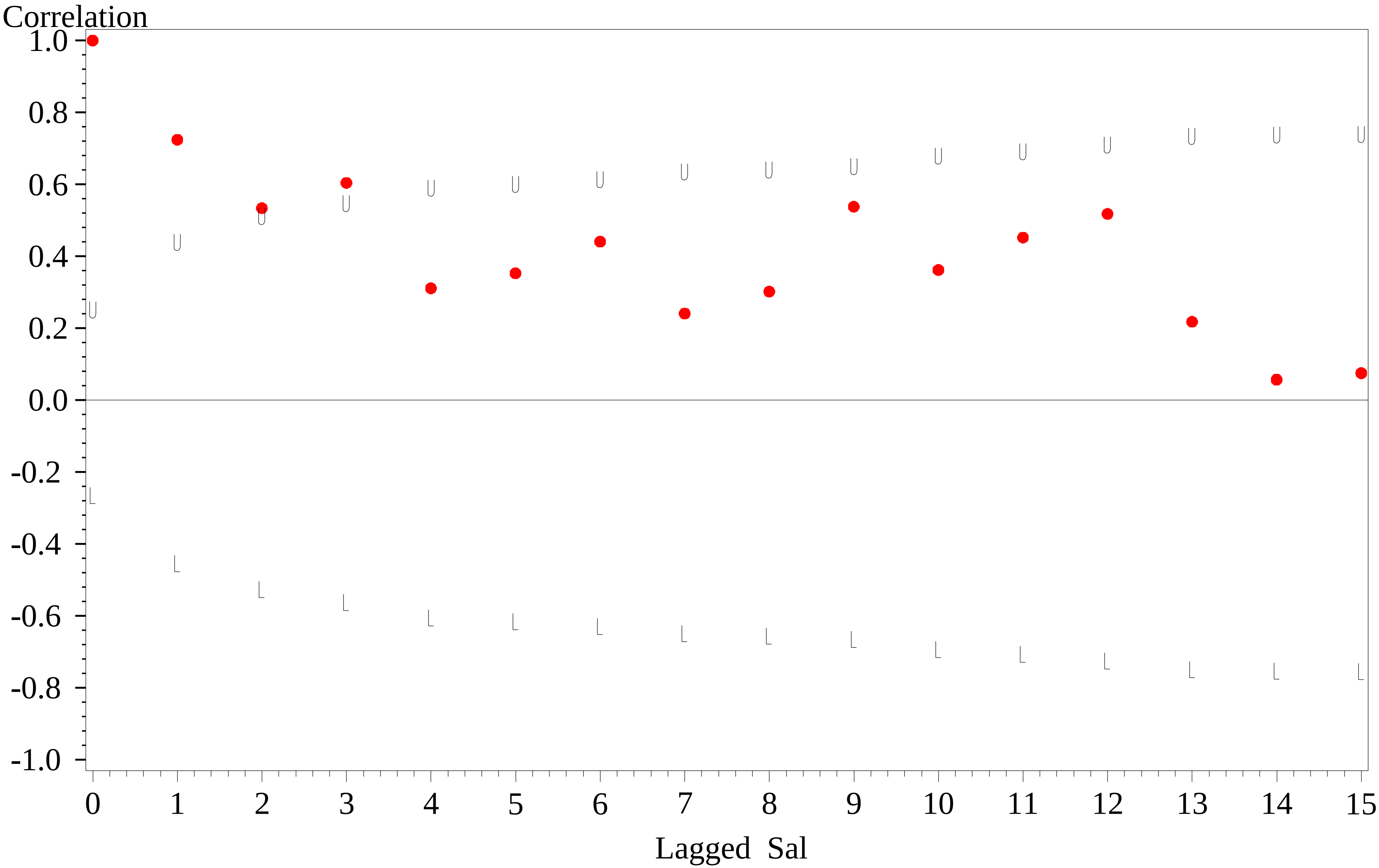
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Salinity at EPCHC Station 153 Surface Level

Unadjusted for Seasonal Medians

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.724	0.224	0.447	-0.447
2	0.534	0.260	0.519	-0.519
3	0.604	0.277	0.555	-0.555
4	0.311	0.299	0.597	-0.597
5	0.353	0.304	0.608	-0.608
6	0.441	0.311	0.621	-0.621
7	0.241	0.321	0.642	-0.642
8	0.302	0.324	0.648	-0.648
9	0.538	0.329	0.657	-0.657
10	0.362	0.343	0.686	-0.686
11	0.452	0.349	0.699	-0.699
12	0.518	0.359	0.718	-0.718
13	0.218	0.371	0.742	-0.742
14	0.057	0.373	0.746	-0.746
15	0.075	0.373	0.747	-0.747

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 153 Surface Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Salinity at EPCHC Station 153 Surface Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.452	.004	0.158	-1.735

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Salinity at EPCHC Station 153 Surface Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.45161	.00442628	0.15777	-1.735

Alafia River at Bell Shoals Road Trends Appendix

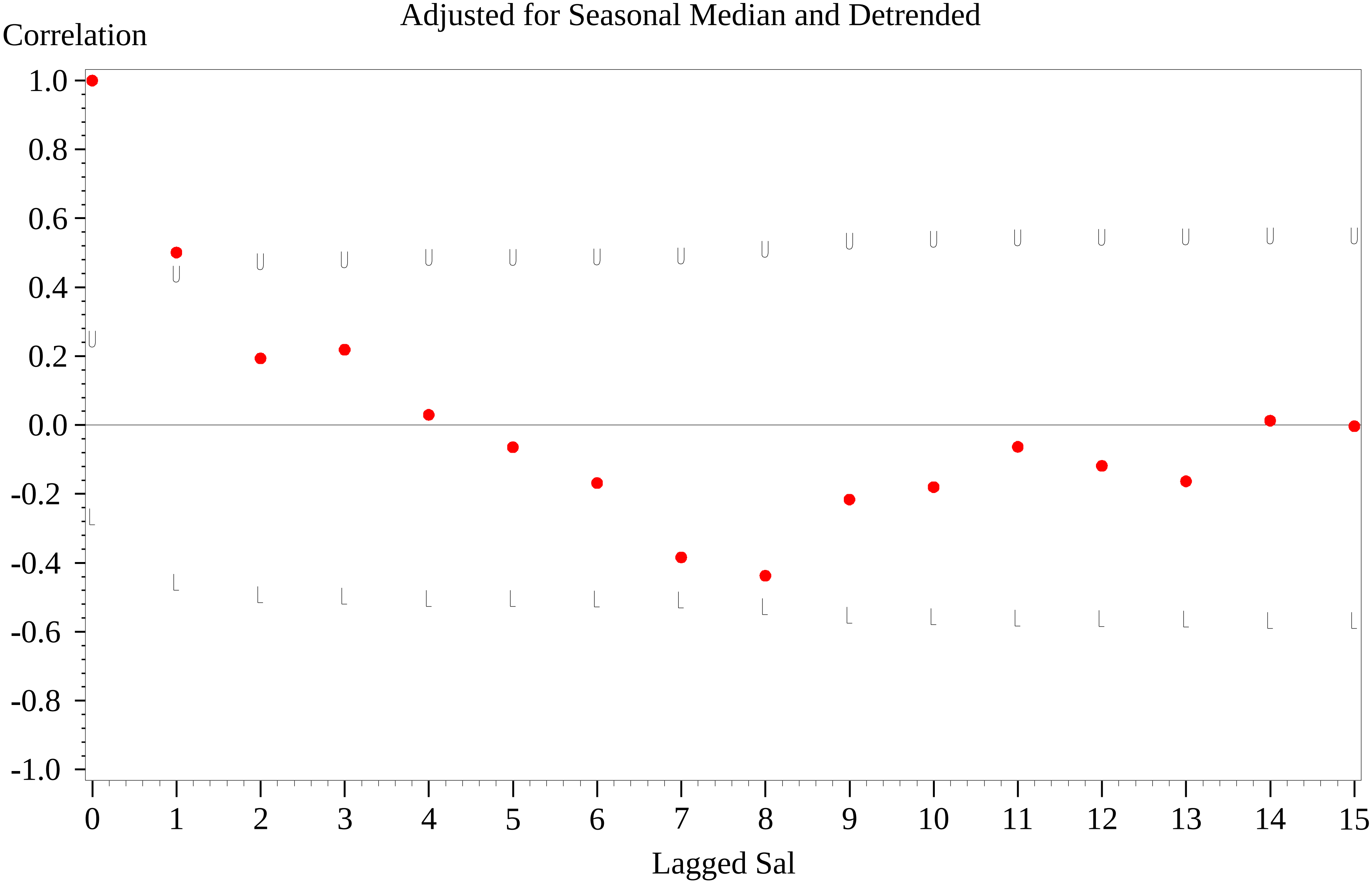
Autocorrelation Statistics for Salinity at EPCHC Station 153 Surface Level

Adjusted for Seasonal Median and Detrended

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.501	0.224	0.447	-0.447
2	0.194	0.242	0.483	-0.483
3	0.219	0.244	0.488	-0.488
4	0.030	0.247	0.495	-0.495
5	-0.064	0.248	0.495	-0.495
6	-0.168	0.248	0.496	-0.496
7	-0.384	0.250	0.499	-0.499
8	-0.437	0.259	0.519	-0.519
9	-0.216	0.271	0.543	-0.543
10	-0.180	0.274	0.548	-0.548
11	-0.063	0.276	0.552	-0.552
12	-0.118	0.276	0.553	-0.553
13	-0.163	0.277	0.555	-0.555
14	0.013	0.279	0.558	-0.558
15	-0.003	0.279	0.558	-0.558

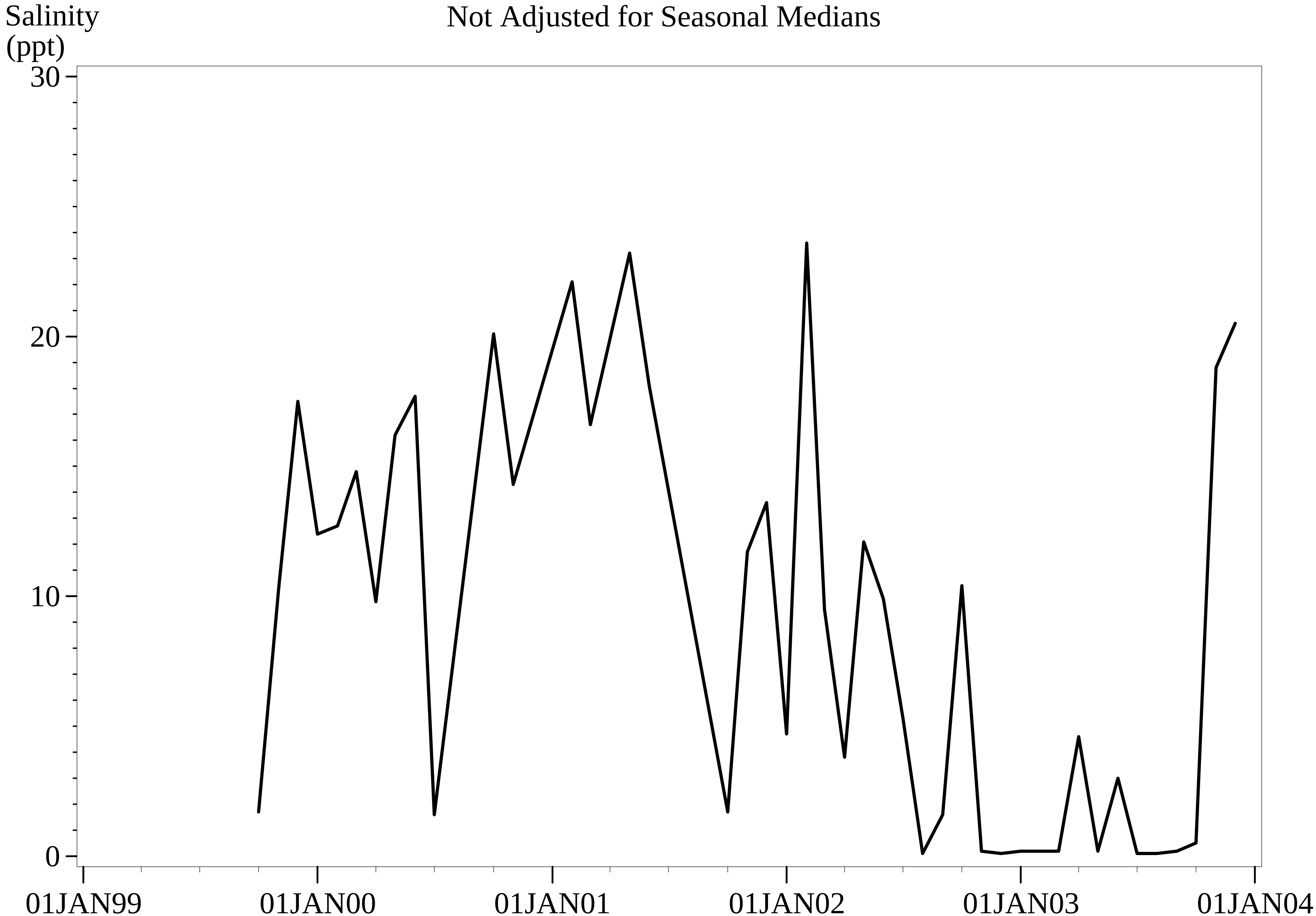
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 153 Surface Level

Adjusted for Seasonal Median and Detrended



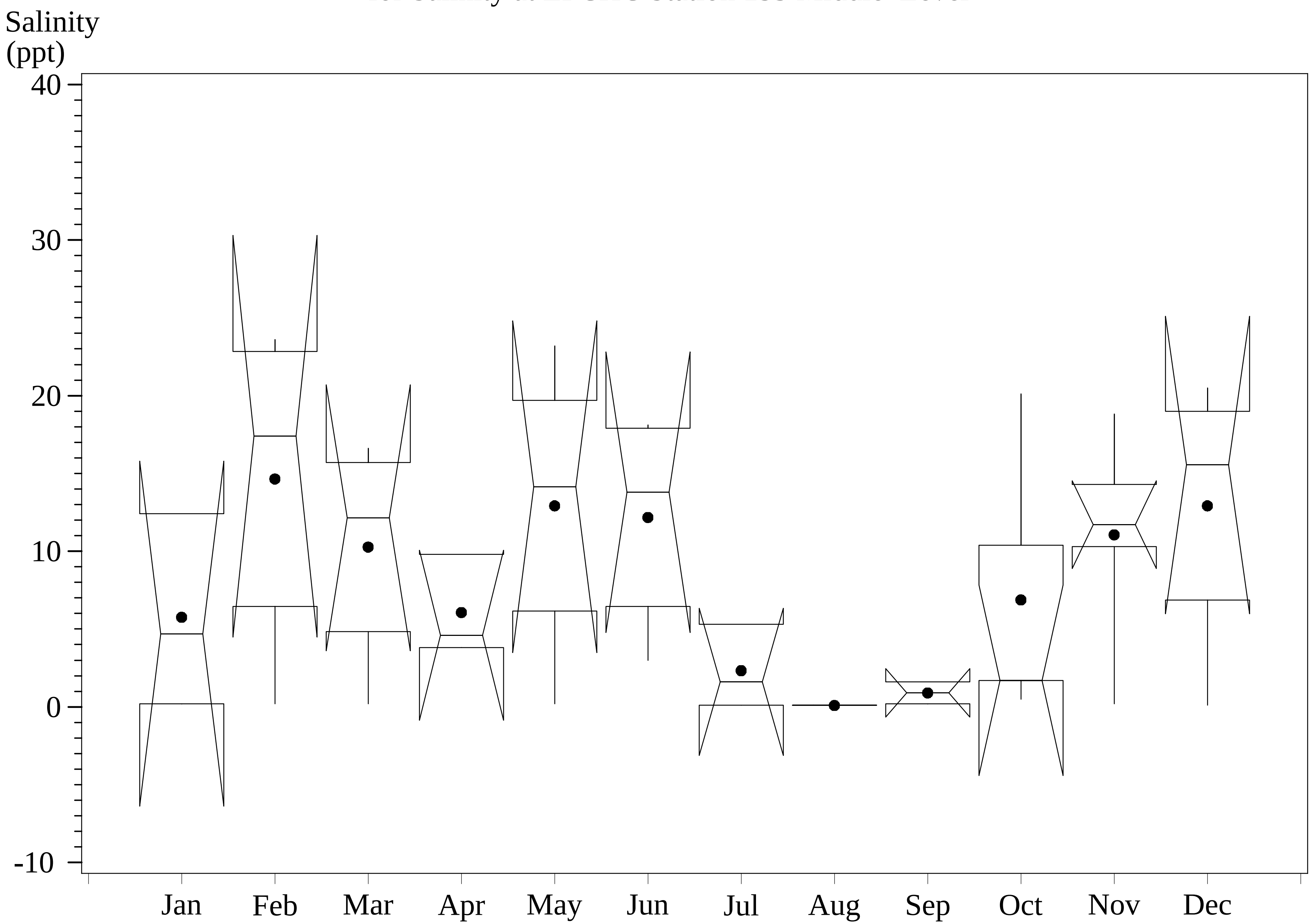
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Middle Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Salinity at EPCHC Station 153 Middle Level



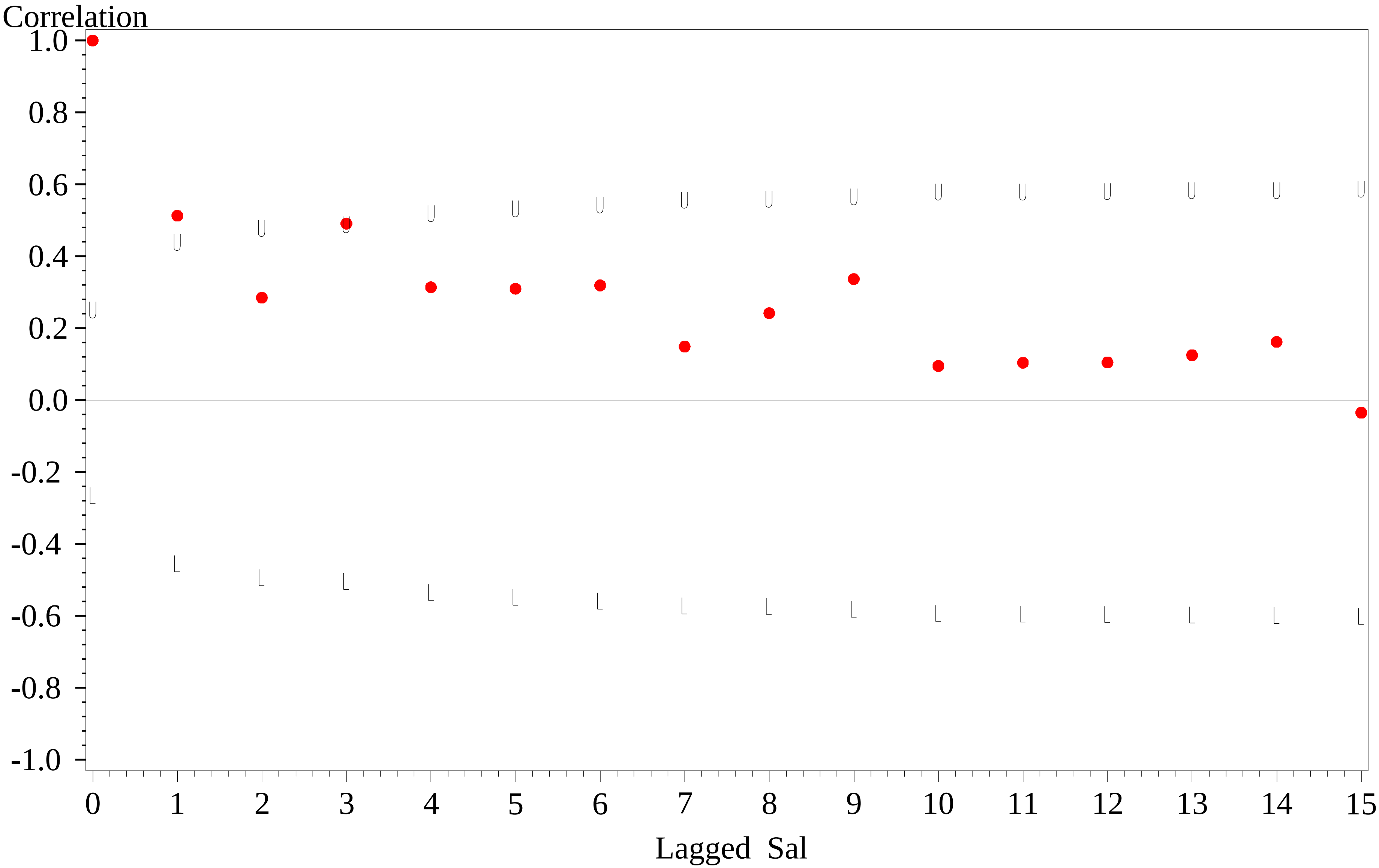
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Salinity at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.513	0.224	0.447	-0.447
2	0.285	0.242	0.485	-0.485
3	0.491	0.248	0.496	-0.496
4	0.314	0.264	0.527	-0.527
5	0.310	0.270	0.540	-0.540
6	0.319	0.276	0.551	-0.551
7	0.149	0.282	0.564	-0.564
8	0.242	0.283	0.566	-0.566
9	0.337	0.286	0.573	-0.573
10	0.095	0.293	0.586	-0.586
11	0.104	0.294	0.587	-0.587
12	0.105	0.294	0.588	-0.588
13	0.125	0.295	0.590	-0.590
14	0.162	0.296	0.591	-0.591
15	-0.035	0.297	0.594	-0.594

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 153 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Salinity at EPCHC Station 153 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.311	0.055	0.184	-2.65

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Salinity at EPCHC Station 153 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.31148	0.054549	0.18412	-2.65

Alafia River at Bell Shoals Road Trends Appendix

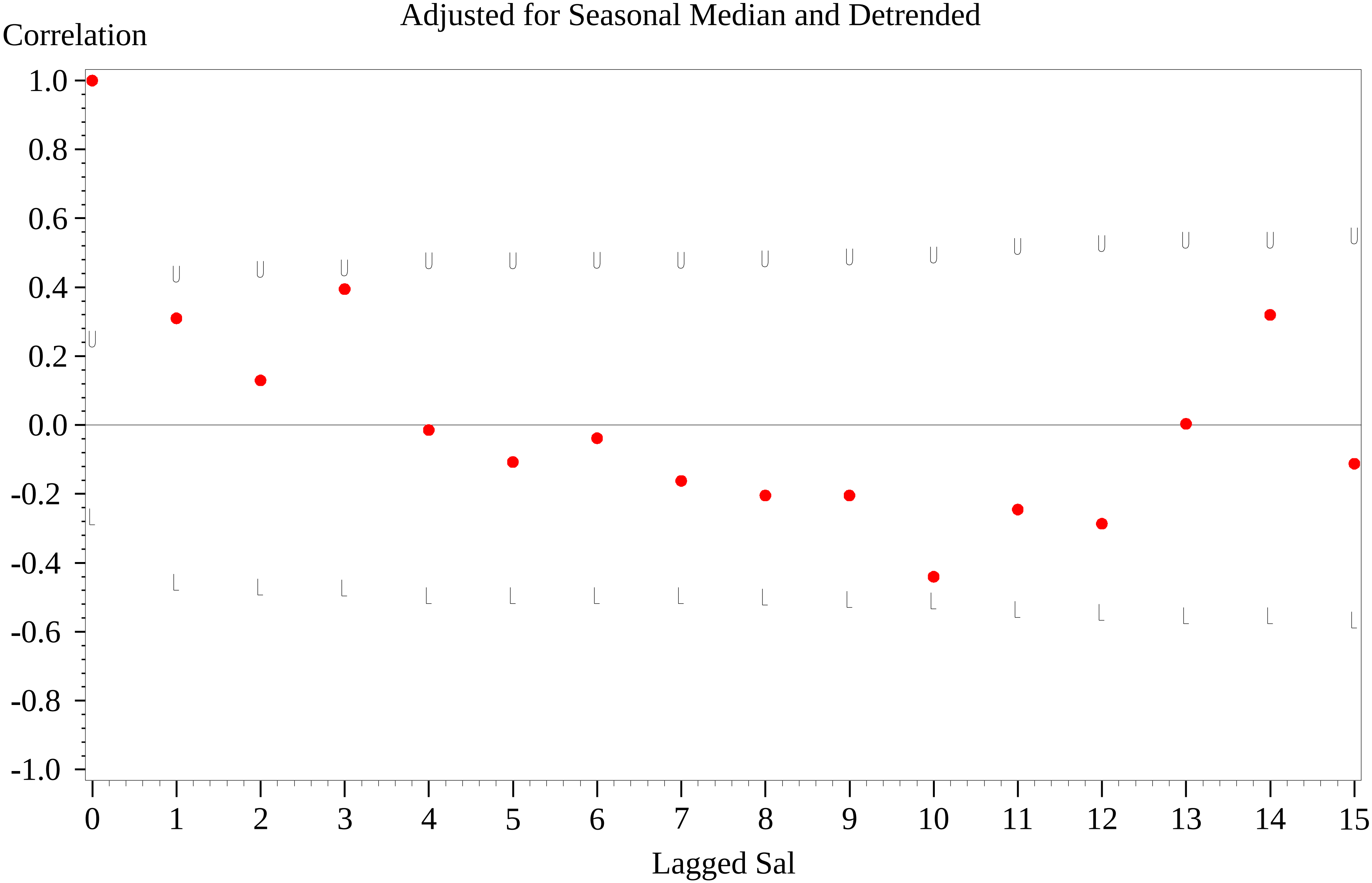
Autocorrelation Statistics for Salinity at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.310	0.224	0.447	-0.447
2	0.130	0.231	0.461	-0.461
3	0.395	0.232	0.464	-0.464
4	-0.014	0.243	0.486	-0.486
5	-0.107	0.243	0.486	-0.486
6	-0.038	0.244	0.487	-0.487
7	-0.162	0.244	0.487	-0.487
8	-0.204	0.245	0.491	-0.491
9	-0.204	0.248	0.497	-0.497
10	-0.440	0.251	0.502	-0.502
11	-0.245	0.264	0.527	-0.527
12	-0.286	0.267	0.535	-0.535
13	0.004	0.272	0.545	-0.545
14	0.320	0.272	0.545	-0.545
15	-0.112	0.279	0.557	-0.557

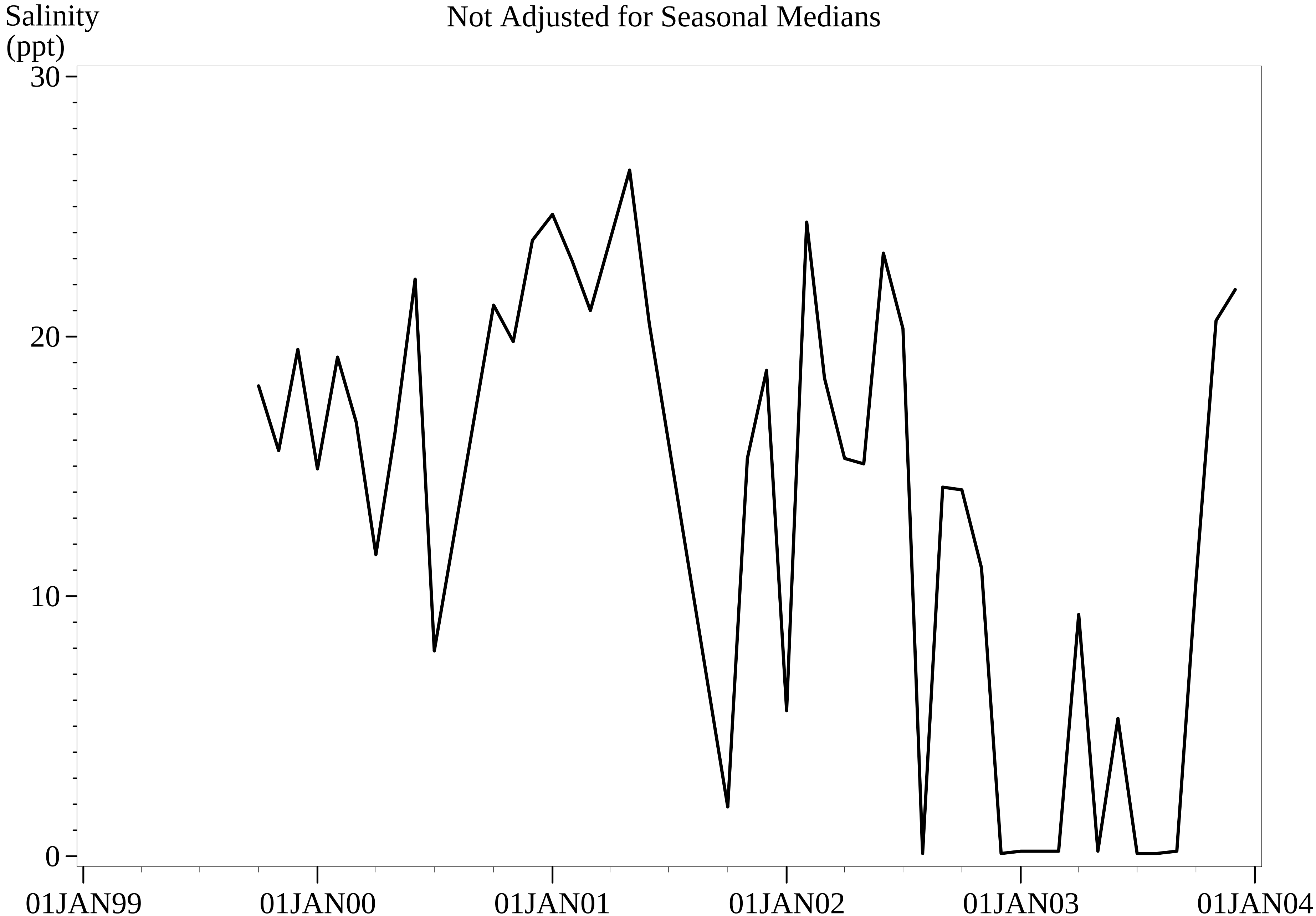
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 153 Middle Level

Adjusted for Seasonal Median and Detrended



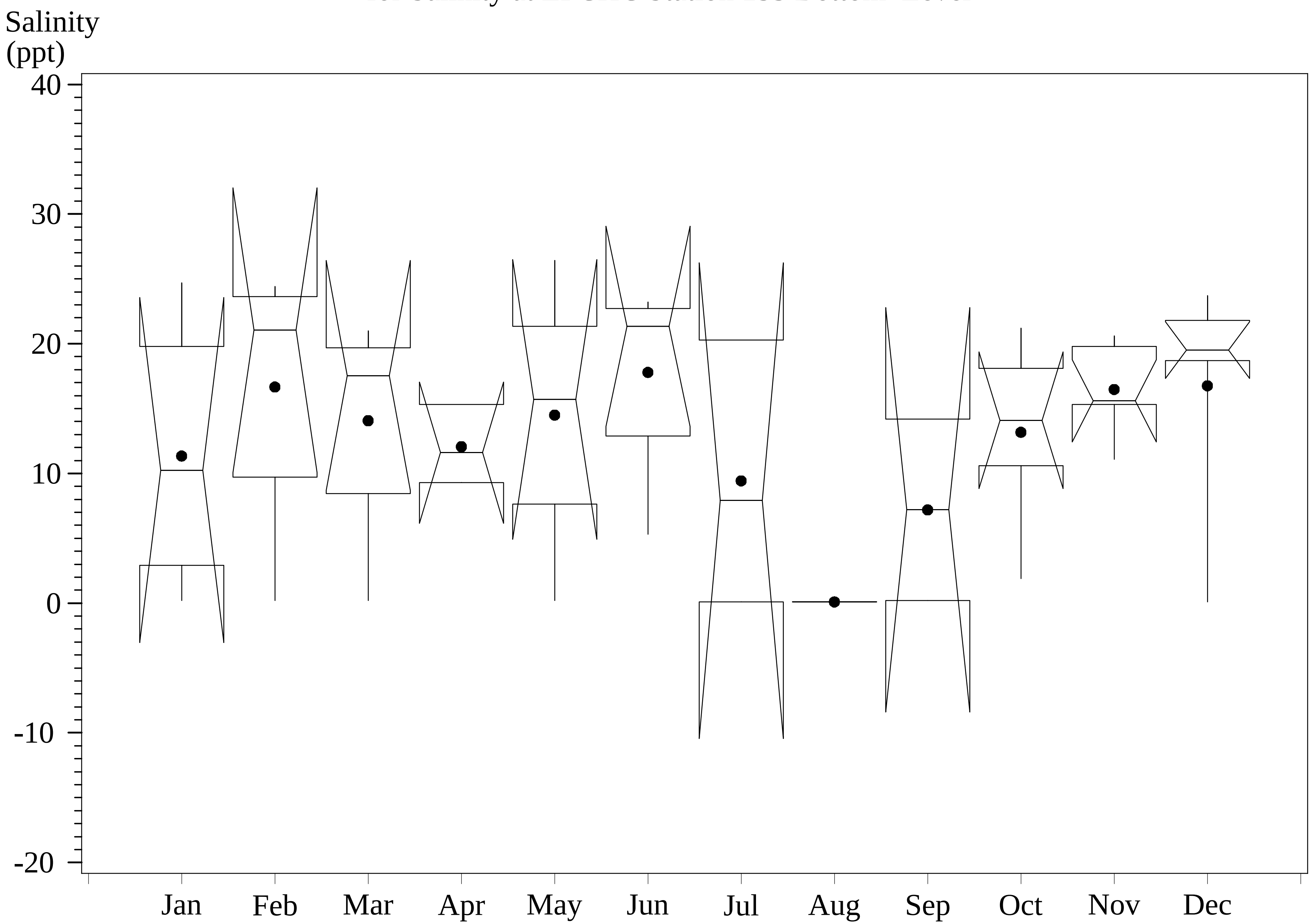
U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 153 at Bottom Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Salinity at EPCHC Station 153 Bottom Level



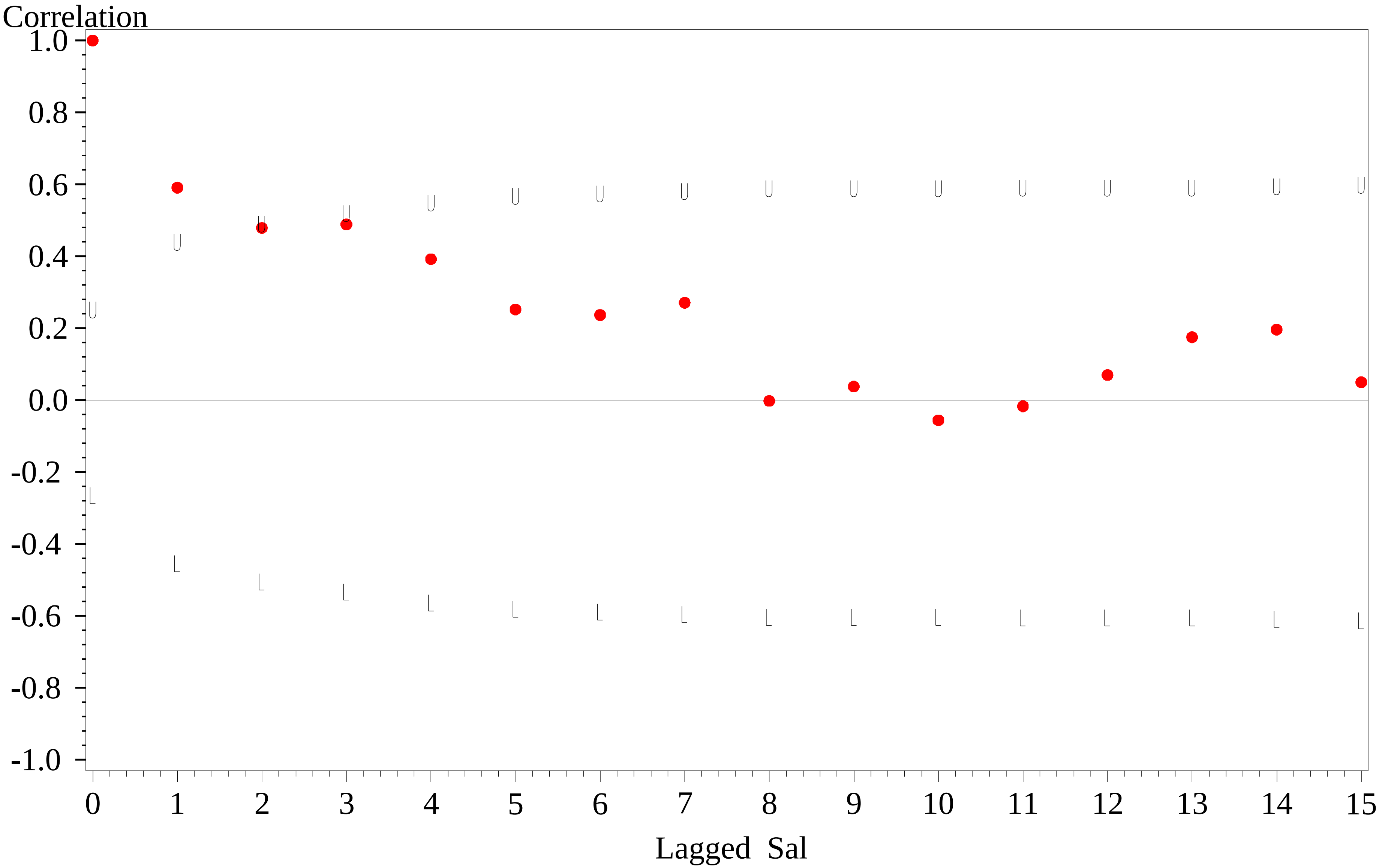
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Salinity at EPCHC Station 153 Bottom Level

Unadjusted for Seasonal Medians

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.591	0.224	0.447	-0.447
2	0.479	0.248	0.497	-0.497
3	0.489	0.263	0.526	-0.526
4	0.392	0.278	0.556	-0.556
5	0.252	0.287	0.574	-0.574
6	0.237	0.291	0.581	-0.581
7	0.271	0.294	0.588	-0.588
8	-0.002	0.298	0.596	-0.596
9	0.038	0.298	0.596	-0.596
10	-0.056	0.298	0.596	-0.596
11	-0.017	0.298	0.597	-0.597
12	0.070	0.298	0.597	-0.597
13	0.175	0.299	0.597	-0.597
14	0.196	0.300	0.601	-0.601
15	0.050	0.302	0.605	-0.605

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 153 Bottom Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Salinity at EPCHC Station 153 Bottom Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.309	0.047	0.134	-2.6

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Salinity at EPCHC Station 153 Bottom Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.30882	0.047308	0.13422	-2.6

Alafia River at Bell Shoals Road Trends Appendix

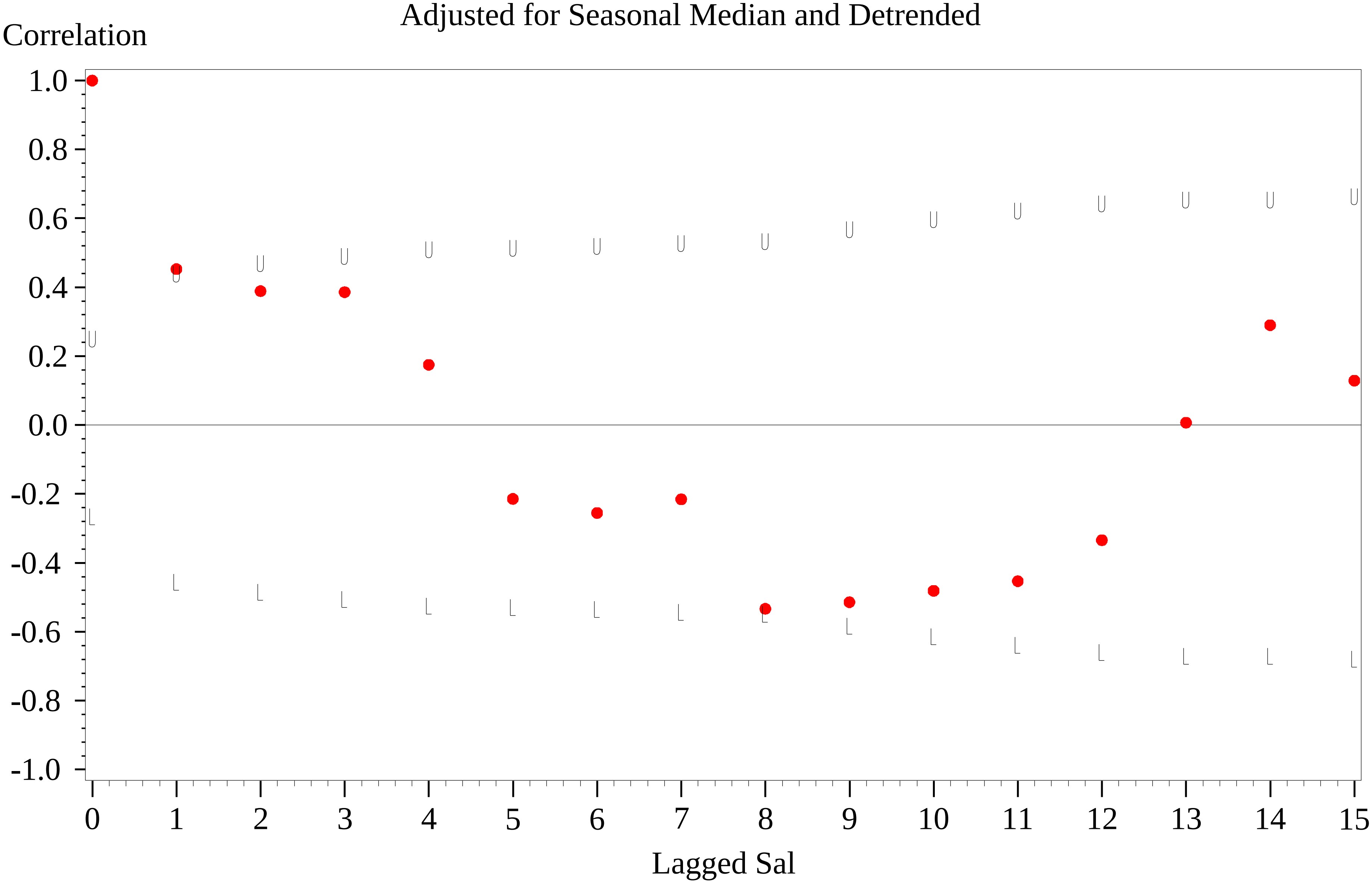
Autocorrelation Statistics for Salinity at EPCHC Station 153 Bottom Level

Adjusted for Seasonal Median and Detrended

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.129	0.258	-0.258
1	0.453	0.224	0.447	-0.447
2	0.389	0.238	0.477	-0.477
3	0.386	0.249	0.498	-0.498
4	0.175	0.259	0.517	-0.517
5	-0.214	0.261	0.521	-0.521
6	-0.255	0.263	0.527	-0.527
7	-0.215	0.268	0.535	-0.535
8	-0.533	0.270	0.541	-0.541
9	-0.514	0.287	0.575	-0.575
10	-0.481	0.302	0.605	-0.605
11	-0.453	0.315	0.630	-0.630
12	-0.334	0.325	0.651	-0.651
13	0.007	0.331	0.662	-0.662
14	0.290	0.331	0.662	-0.662
15	0.129	0.335	0.671	-0.671

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 153 Bottom Level

Adjusted for Seasonal Median and Detrended



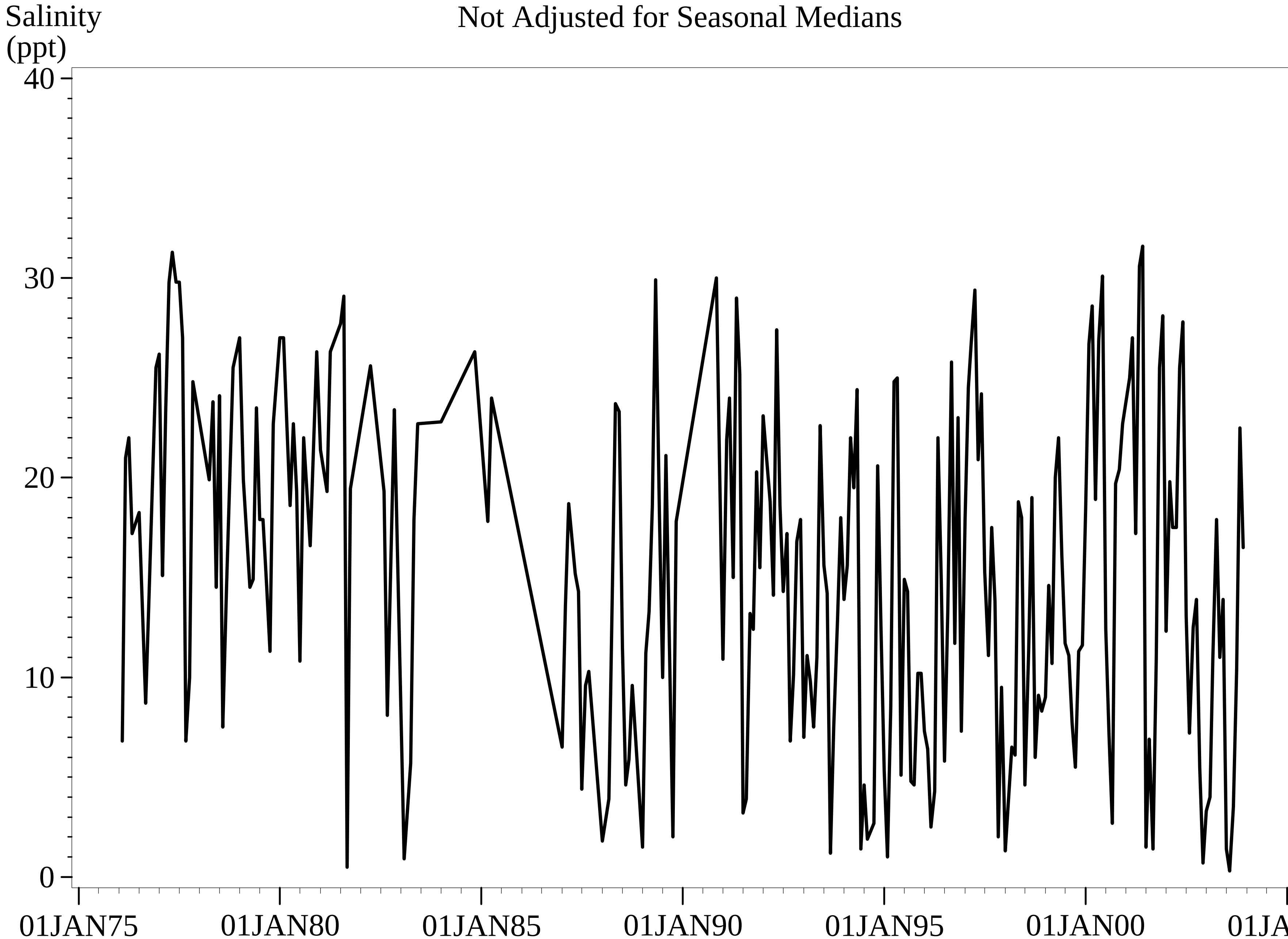
U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Monthly Data Time Series

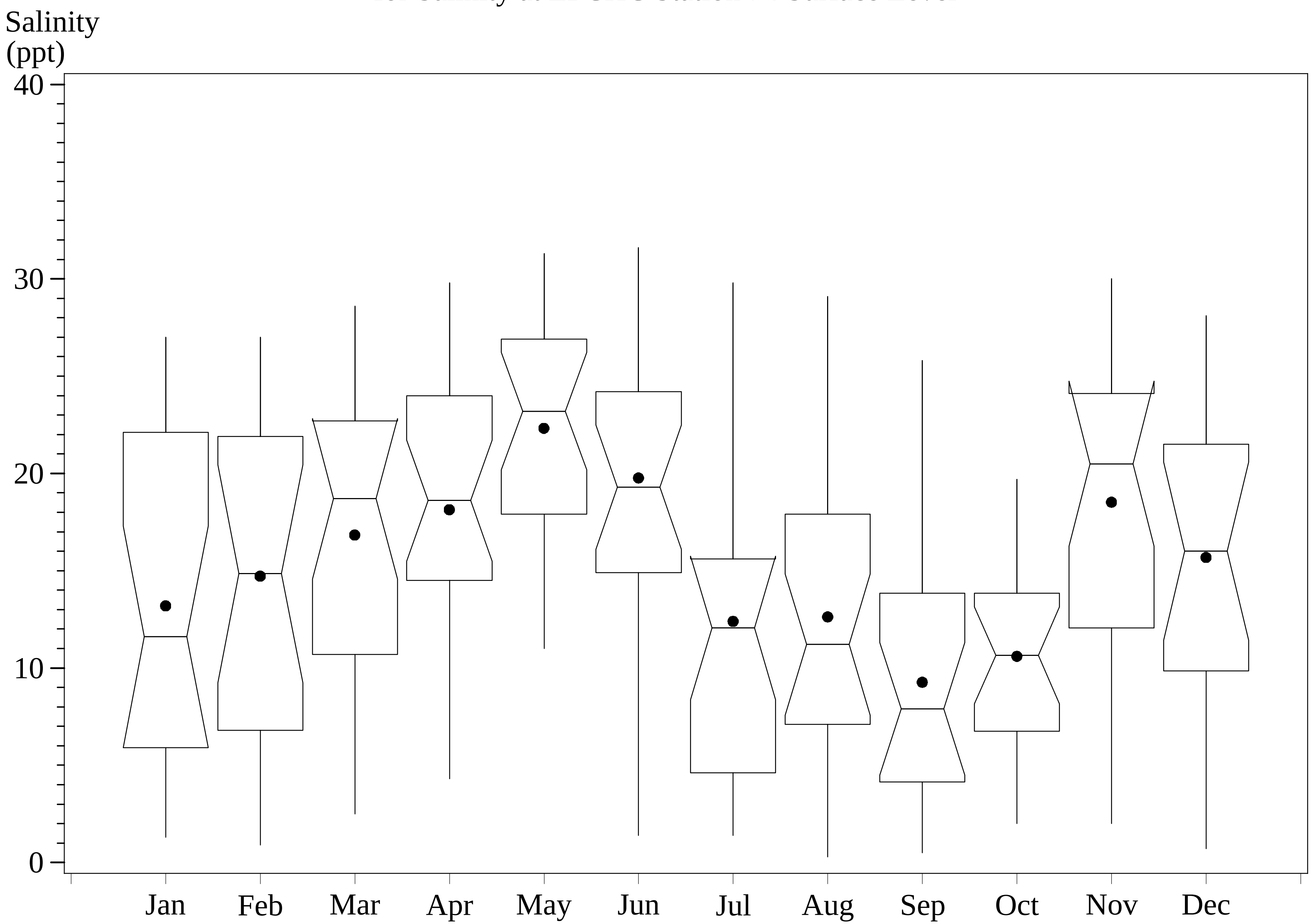
for EPCHC Station 74 at Surface Level

Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Salinity at EPCHC Station 74 Surface Level



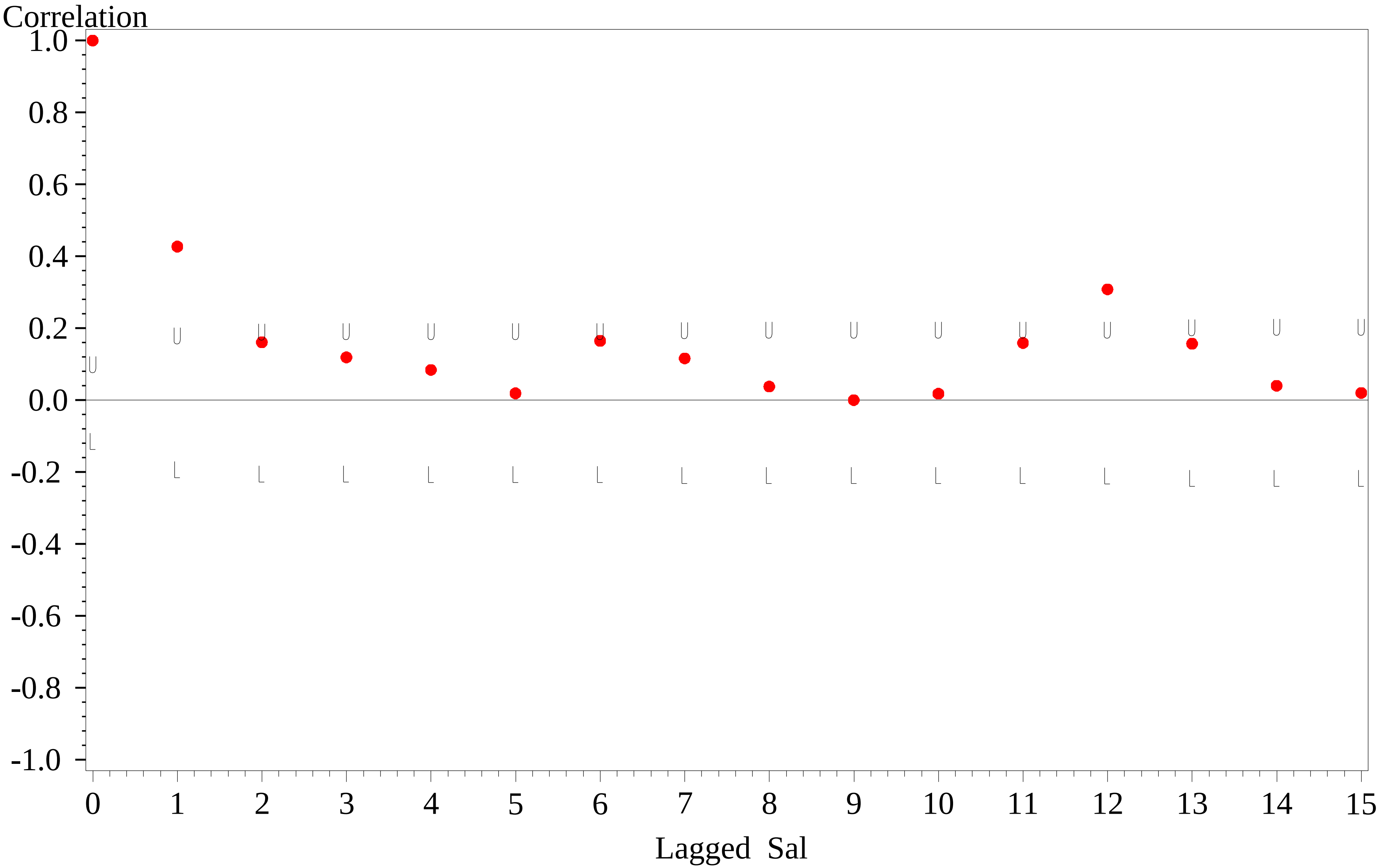
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Salinity at EPCHC Station 74 Surface Level

Unadjusted for Seasonal Medians

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.427	0.093	0.186	-0.186
2	0.161	0.098	0.197	-0.197
3	0.119	0.099	0.198	-0.198
4	0.084	0.099	0.199	-0.199
5	0.019	0.100	0.199	-0.199
6	0.165	0.100	0.199	-0.199
7	0.116	0.100	0.201	-0.201
8	0.038	0.101	0.202	-0.202
9	0.000	0.101	0.202	-0.202
10	0.018	0.101	0.202	-0.202
11	0.159	0.101	0.202	-0.202
12	0.308	0.102	0.203	-0.203
13	0.157	0.104	0.209	-0.209
14	0.040	0.105	0.210	-0.210
15	0.020	0.105	0.210	-0.210

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 74 Surface Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Salinity at EPCHC Station 74 Surface Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.182	0	0.02	-0.262

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Salinity at EPCHC Station 74 Surface Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
-0.18216	.000089350	0.020429	-0.26154

Alafia River at Bell Shoals Road Trends Appendix

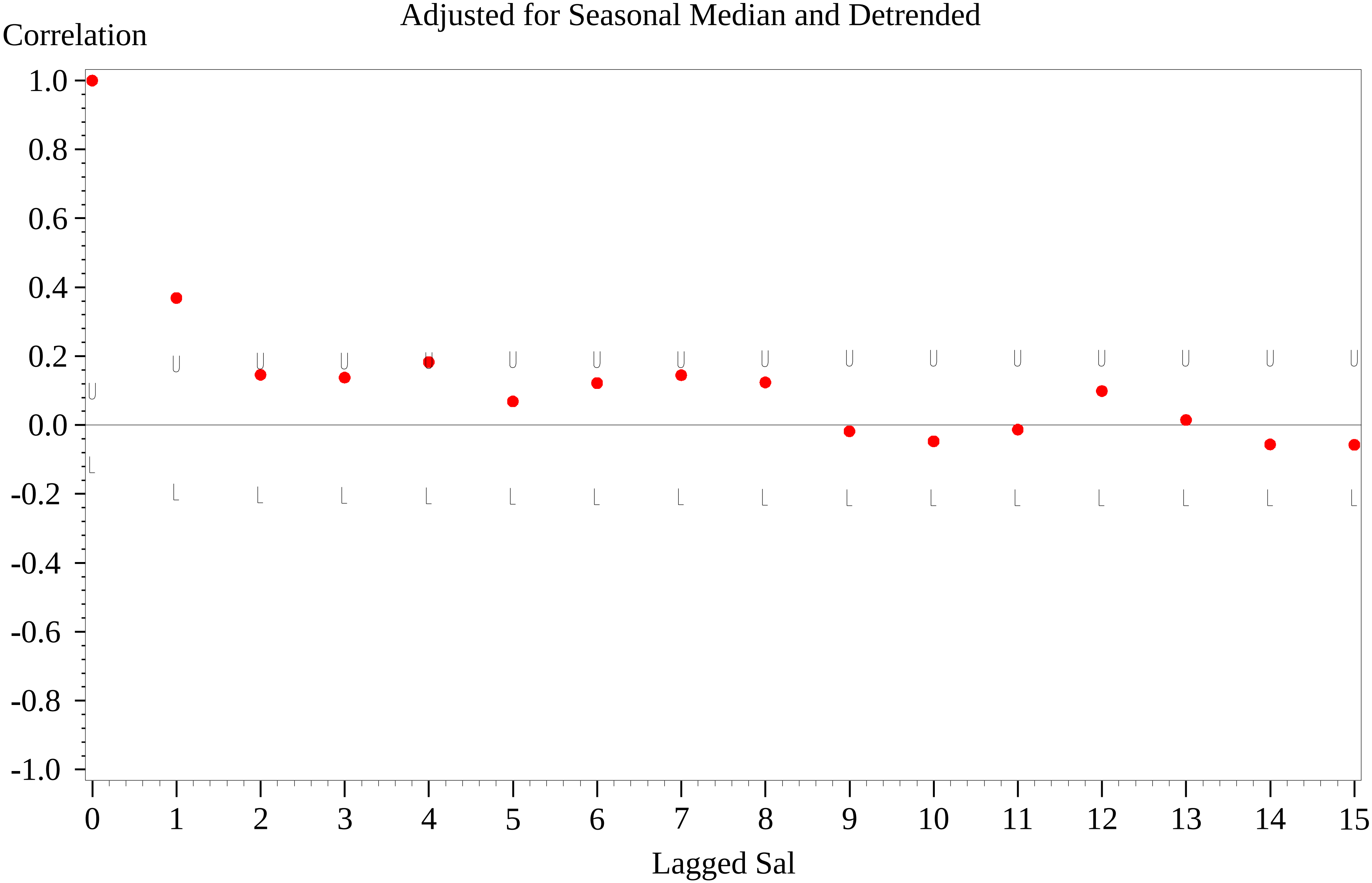
Autocorrelation Statistics for Salinity at EPCHC Station 74 Surface Level

Adjusted for Seasonal Median and Detrended

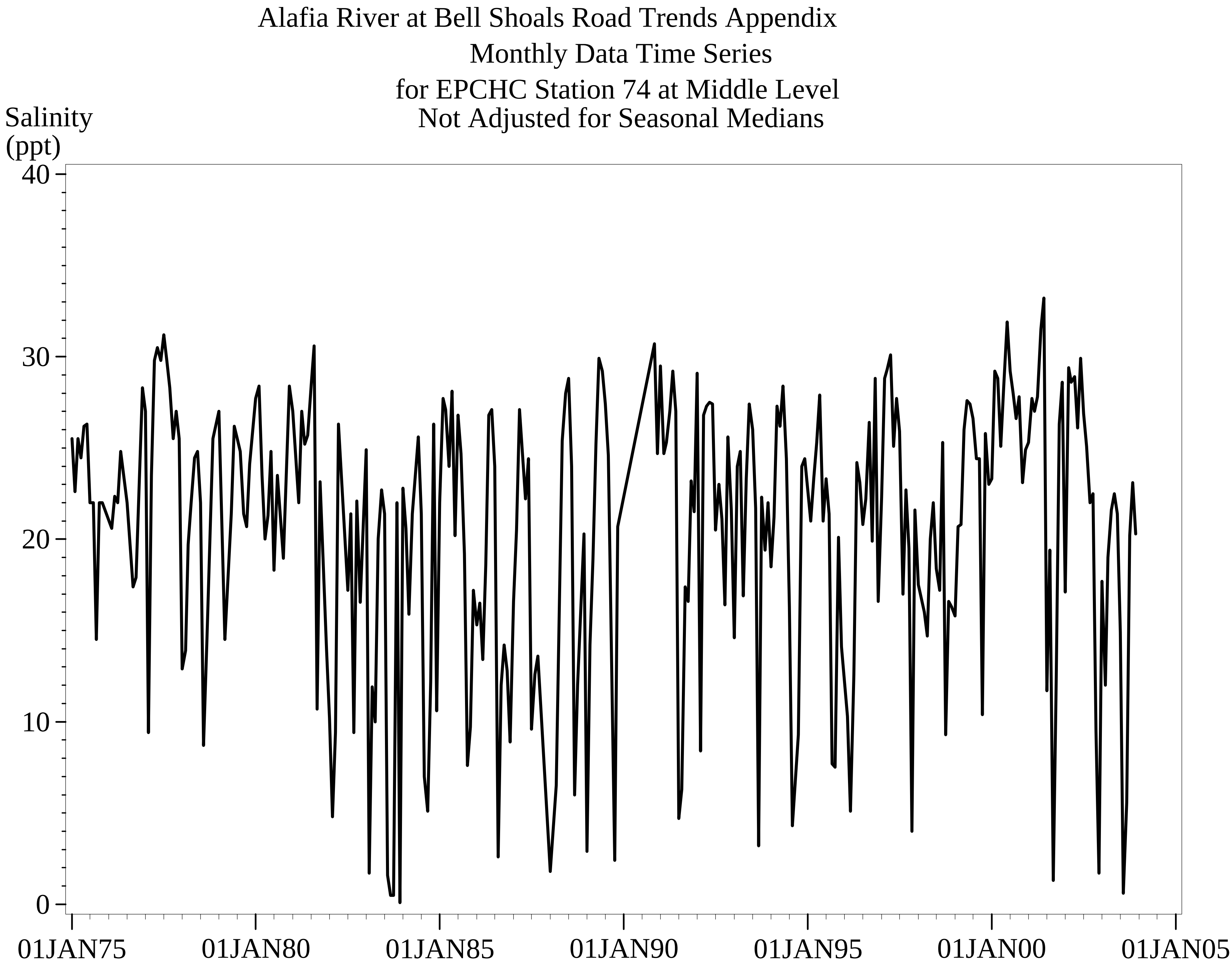
Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.369	0.093	0.186	-0.186
2	0.146	0.097	0.194	-0.194
3	0.138	0.098	0.195	-0.195
4	0.183	0.098	0.196	-0.196
5	0.069	0.099	0.198	-0.198
6	0.122	0.099	0.199	-0.199
7	0.145	0.100	0.199	-0.199
8	0.124	0.100	0.201	-0.201
9	-0.018	0.101	0.202	-0.202
10	-0.047	0.101	0.202	-0.202
11	-0.013	0.101	0.202	-0.202
12	0.099	0.101	0.202	-0.202
13	0.015	0.101	0.202	-0.202
14	-0.056	0.101	0.202	-0.202
15	-0.057	0.101	0.202	-0.202

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 74 Surface Level

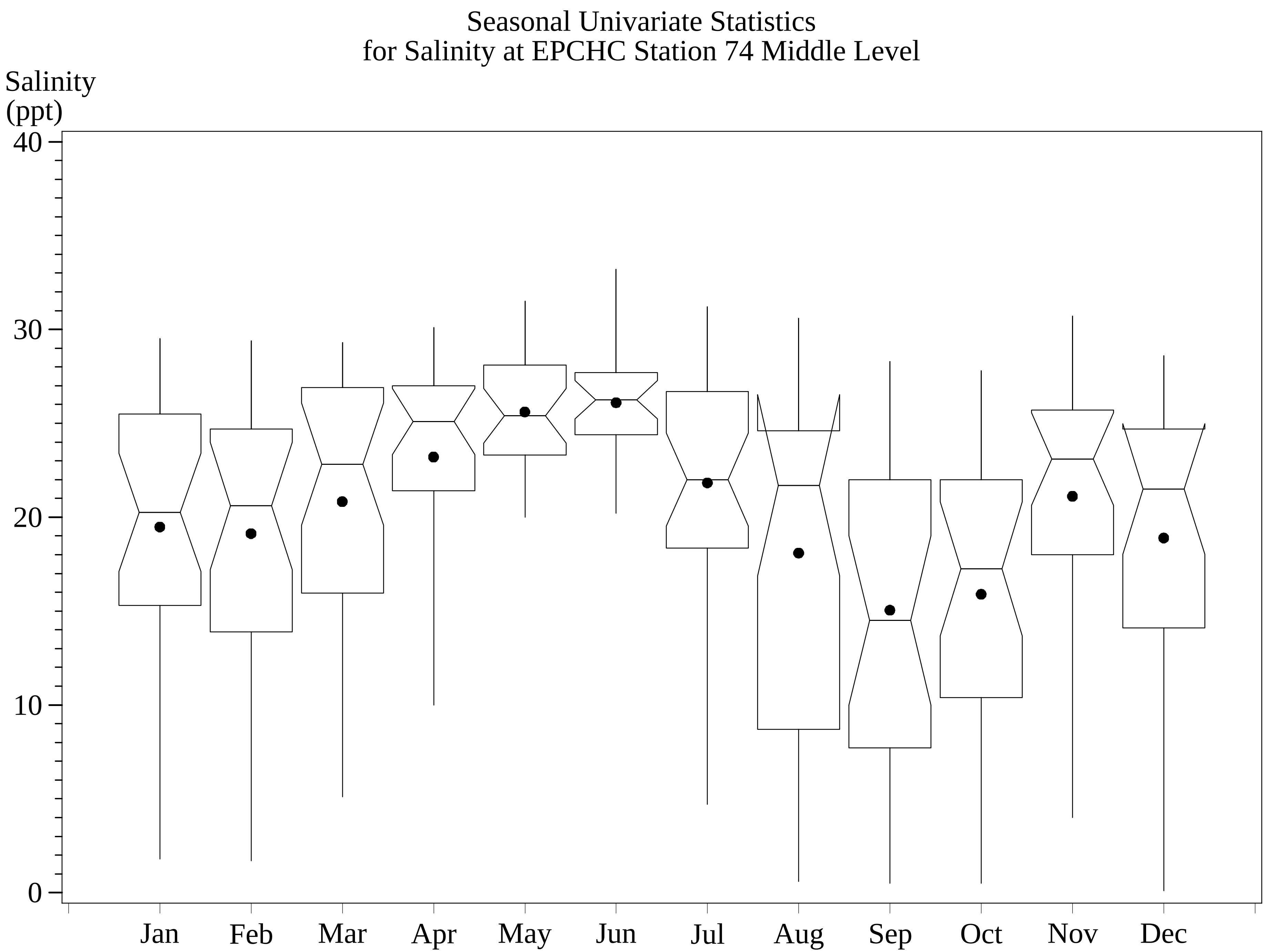
Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown


Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Middle Level
Not Adjusted for Seasonal Medians
Salinity
(ppt)
40
30
20
10
0
01JAN75
01JAN80
01JAN85
01JAN90
01JAN95
01JAN00
01JAN05

Alafia River at Bell Shoals Road Trends Appendix



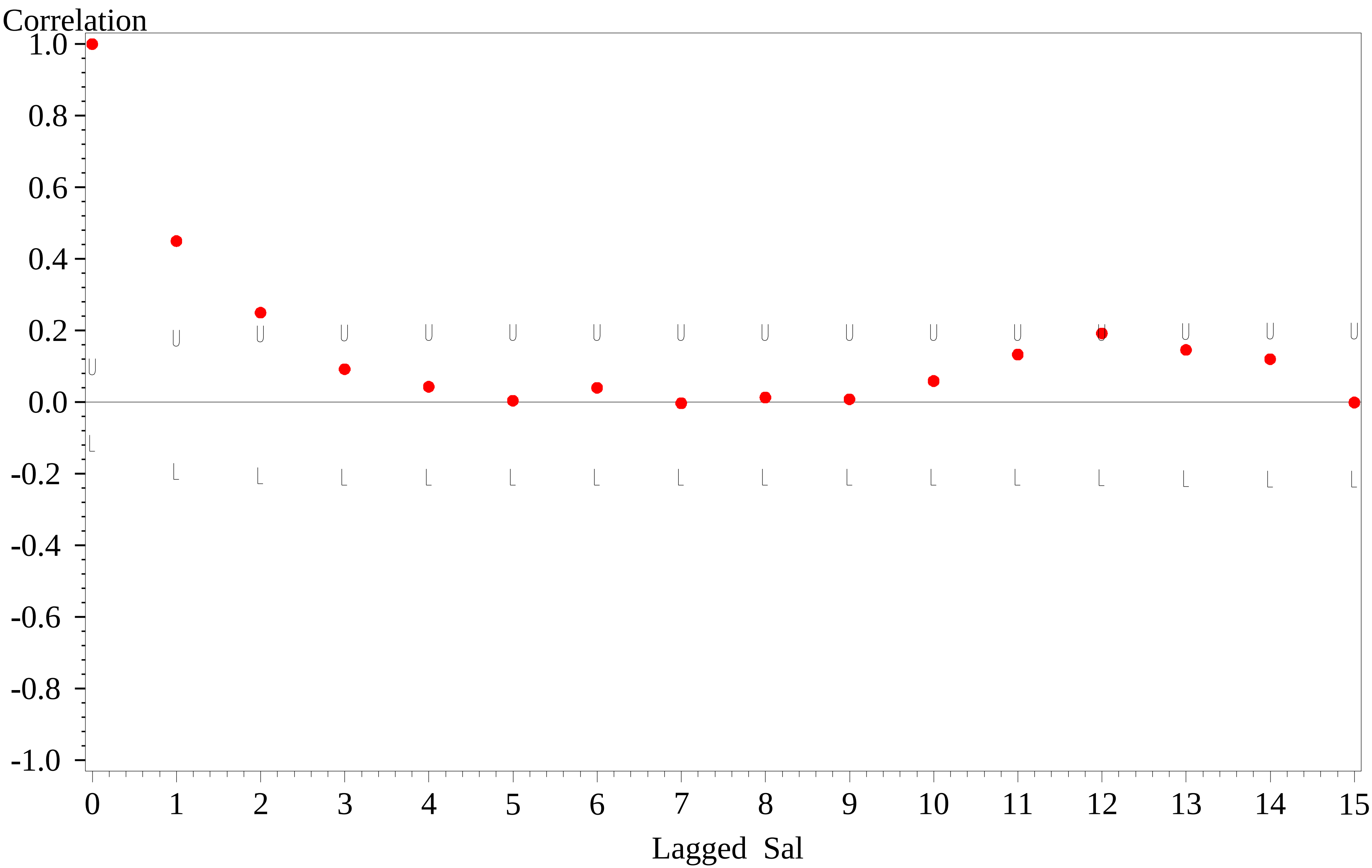
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Salinity at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.450	0.093	0.186	-0.186
2	0.250	0.099	0.198	-0.198
3	0.092	0.101	0.201	-0.201
4	0.043	0.101	0.202	-0.202
5	0.004	0.101	0.202	-0.202
6	0.040	0.101	0.202	-0.202
7	-0.003	0.101	0.202	-0.202
8	0.013	0.101	0.202	-0.202
9	0.008	0.101	0.202	-0.202
10	0.059	0.101	0.202	-0.202
11	0.133	0.101	0.202	-0.202
12	0.192	0.102	0.203	-0.203
13	0.146	0.103	0.205	-0.205
14	0.120	0.103	0.207	-0.207
15	-0.001	0.104	0.207	-0.207

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 74 Middle Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Salinity at EPCHC Station 74 Middle Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.031	0.443	0.682	0.027

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics for Salinity at EPCHC Station 74 Middle Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.031331	0.44263	0.68194	0.027273

Alafia River at Bell Shoals Road Trends Appendix

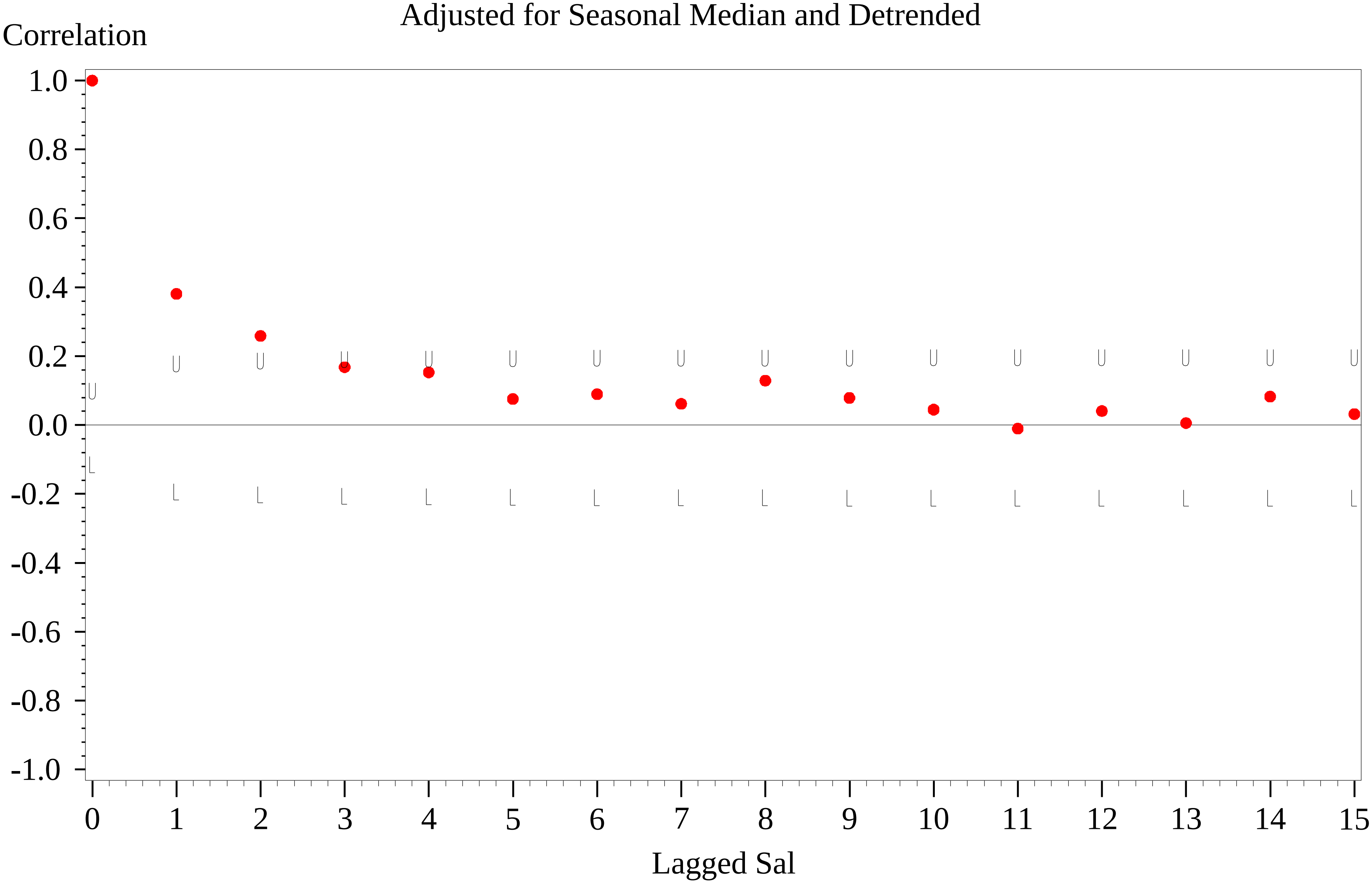
Autocorrelation Statistics for Salinity at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.381	0.093	0.186	-0.186
2	0.259	0.097	0.194	-0.194
3	0.168	0.099	0.198	-0.198
4	0.153	0.100	0.200	-0.200
5	0.076	0.101	0.201	-0.201
6	0.090	0.101	0.202	-0.202
7	0.062	0.101	0.202	-0.202
8	0.129	0.101	0.202	-0.202
9	0.079	0.102	0.203	-0.203
10	0.045	0.102	0.204	-0.204
11	-0.010	0.102	0.204	-0.204
12	0.041	0.102	0.204	-0.204
13	0.006	0.102	0.204	-0.204
14	0.083	0.102	0.204	-0.204
15	0.032	0.102	0.204	-0.204

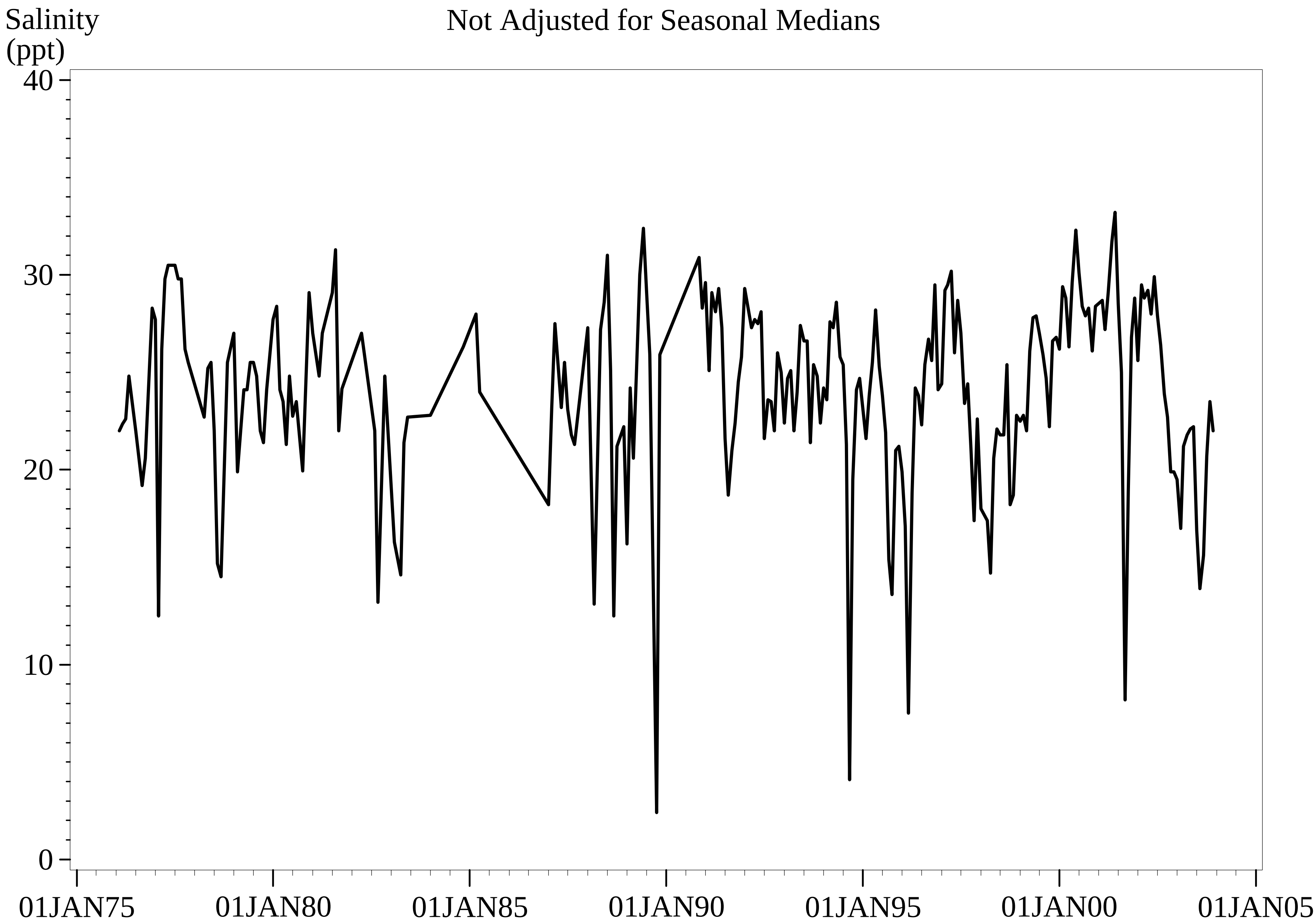
Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 74 Middle Level

Adjusted for Seasonal Median and Detrended



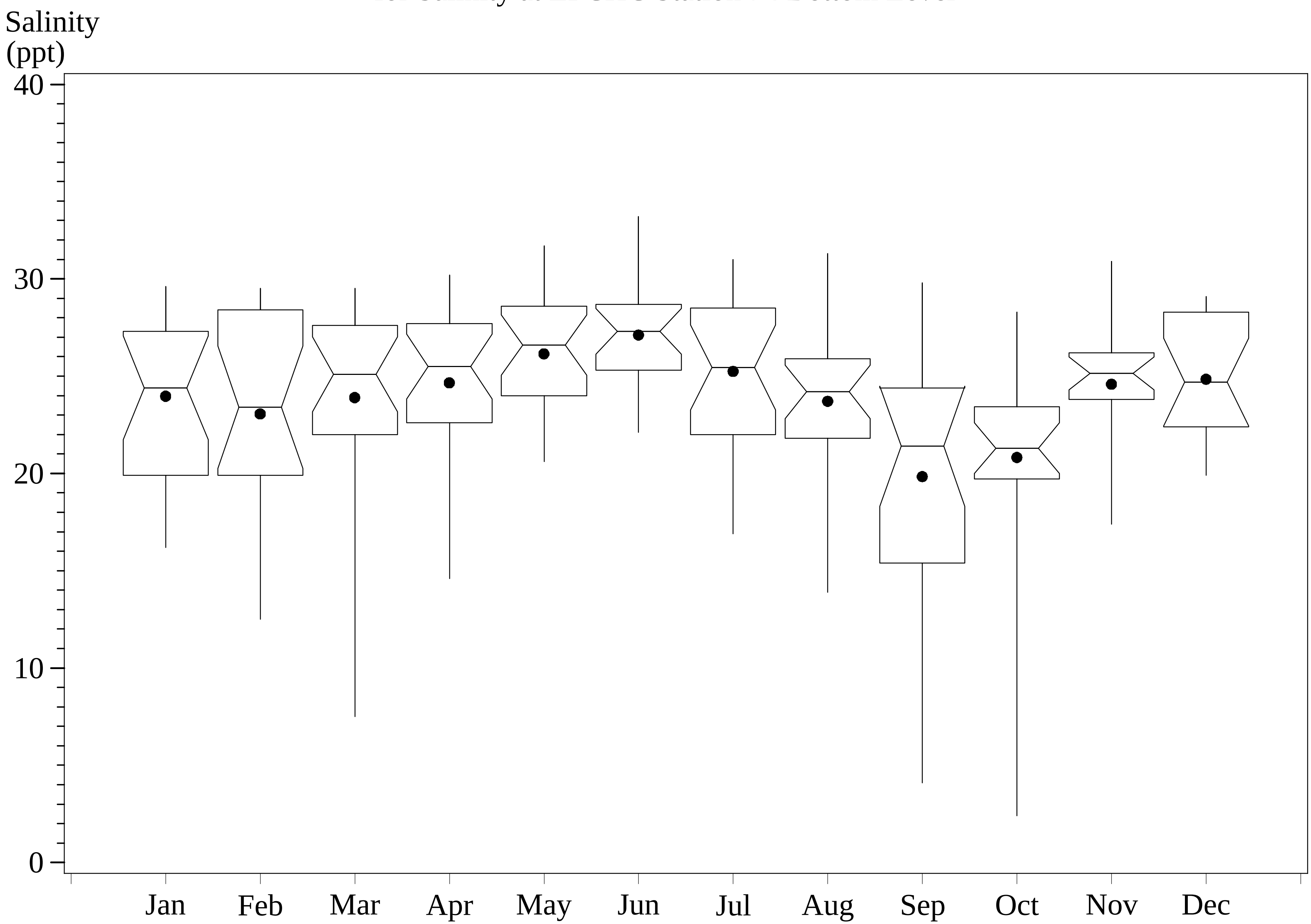
U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix
Monthly Data Time Series
for EPCHC Station 74 at Bottom Level
Not Adjusted for Seasonal Medians



Alafia River at Bell Shoals Road Trends Appendix

Seasonal Univariate Statistics
for Salinity at EPCHC Station 74 Bottom Level



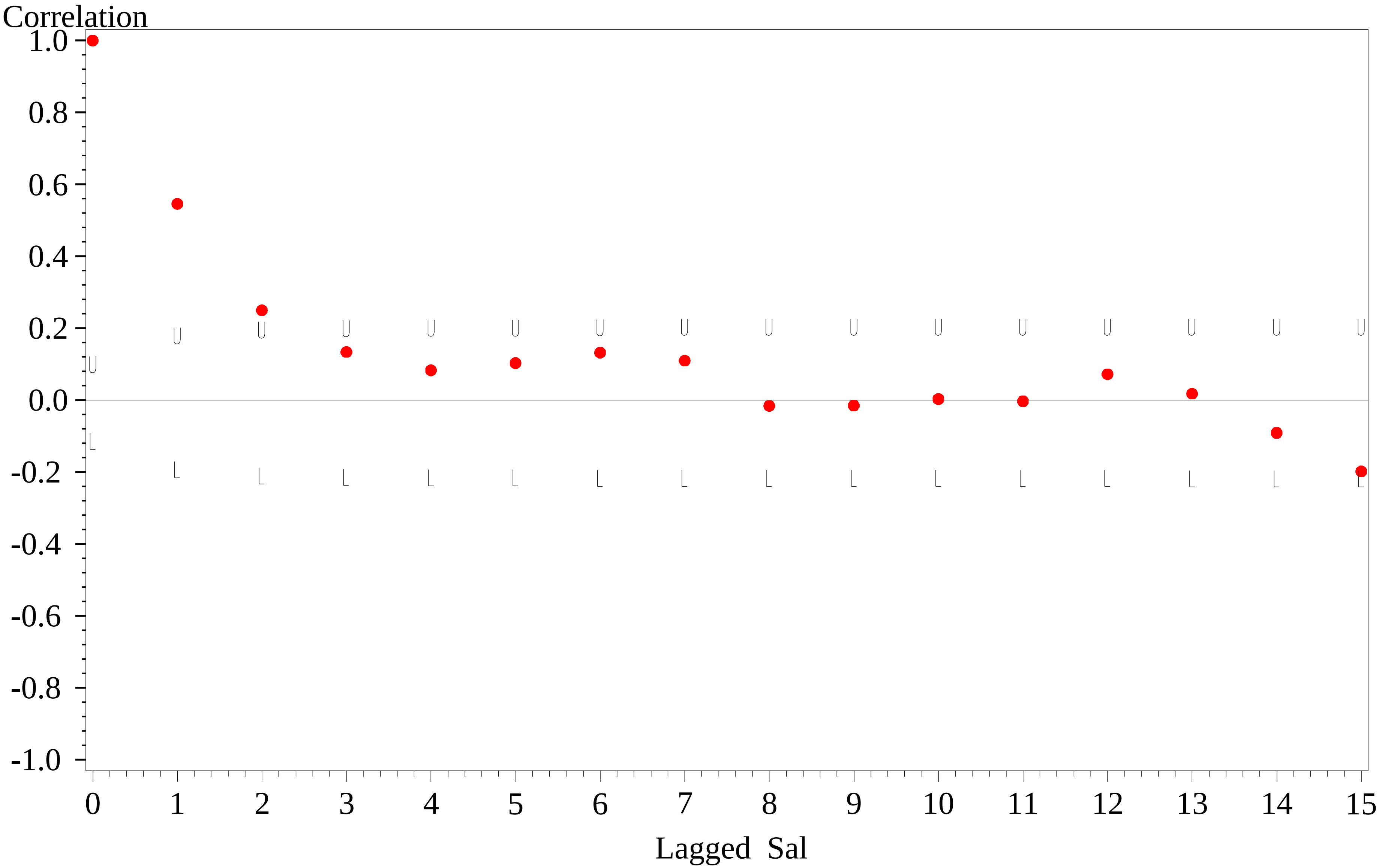
Alafia River at Bell Shoals Road Trends Appendix

Autocorrelation Statistics for Salinity at EPCHC Station 74 Bottom Level

Unadjusted for Seasonal Medians

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.546	0.093	0.186	-0.186
2	0.250	0.102	0.203	-0.203
3	0.134	0.103	0.207	-0.207
4	0.083	0.104	0.208	-0.208
5	0.103	0.104	0.208	-0.208
6	0.132	0.104	0.209	-0.209
7	0.110	0.105	0.210	-0.210
8	-0.016	0.105	0.210	-0.210
9	-0.015	0.105	0.210	-0.210
10	0.003	0.105	0.210	-0.210
11	-0.003	0.105	0.210	-0.210
12	0.072	0.105	0.210	-0.210
13	0.018	0.105	0.211	-0.211
14	-0.091	0.105	0.211	-0.211
15	-0.198	0.106	0.211	-0.211

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 74 Bottom Level
Unadjusted for Seasonal Median



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Alafia River at Bell Shoals Road Trends Appendix

Kendall Tau Trend Test Statistics

for Salinity at EPCHC Station 74 Bottom Level

Unadjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.026	0.585	0.781	0.02

Alafia River at Bell Shoals Road Trends Appendix

Seasonal Kendall Tau Trend Test Statistics
for Salinity at EPCHC Station 74 Bottom Level

Adjusted for Seasonal Medians

Tau Statistic	P-Value Without Serial Correlation	P-Value With Serial Correlation	Slope Statistic
0.025662	0.58506	0.78078	0.02

Alafia River at Bell Shoals Road Trends Appendix

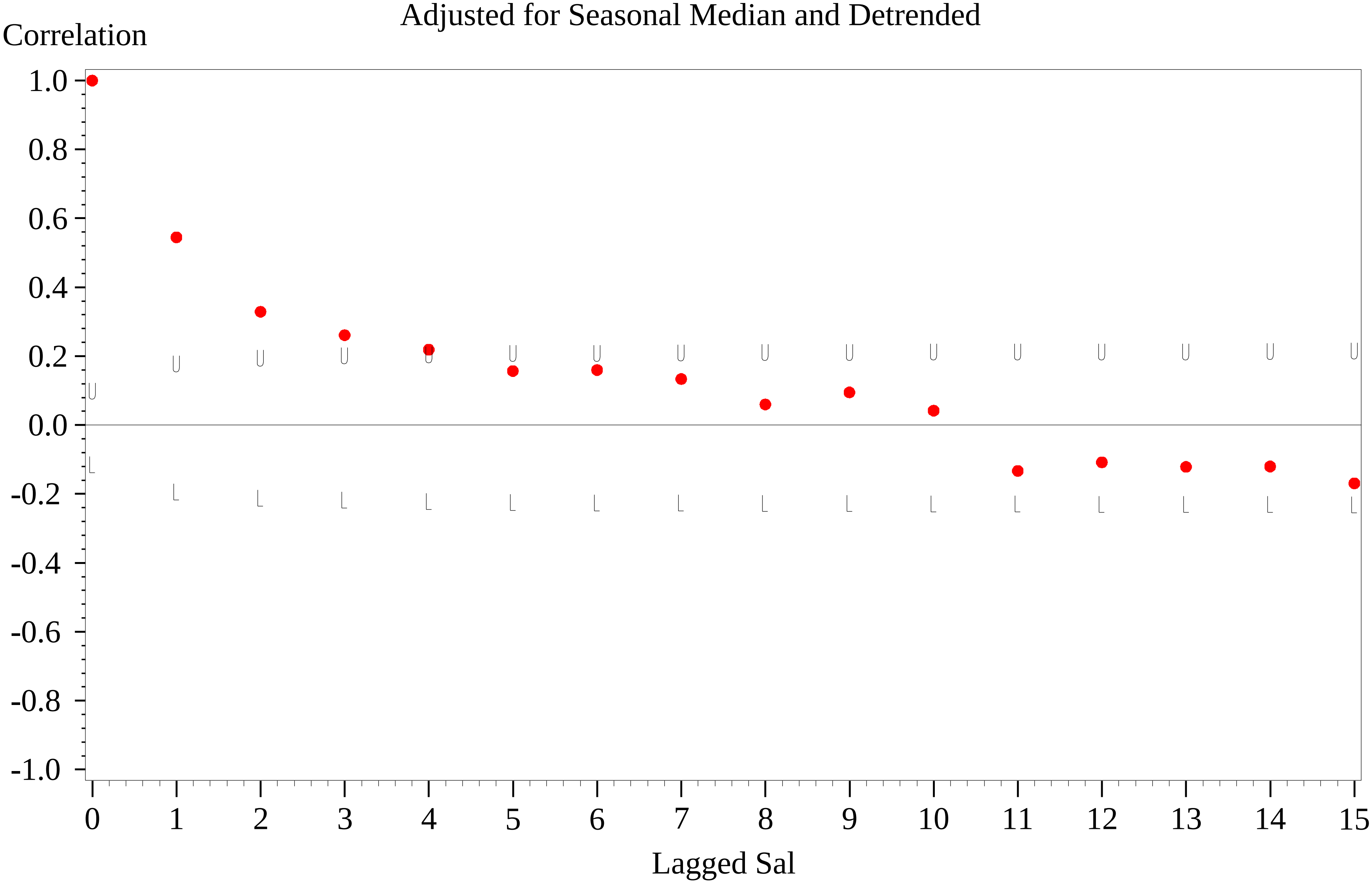
Autocorrelation Statistics for Salinity at EPCHC Station 74 Bottom Level

Adjusted for Seasonal Median and Detrended

Lagged Sal	Correlation	Standard Error	Upper Limit	Lower Limit
0	1.000	0.054	0.107	-0.107
1	0.545	0.093	0.186	-0.186
2	0.329	0.102	0.203	-0.203
3	0.261	0.105	0.209	-0.209
4	0.219	0.106	0.213	-0.213
5	0.157	0.108	0.216	-0.216
6	0.160	0.108	0.217	-0.217
7	0.134	0.109	0.218	-0.218
8	0.060	0.110	0.219	-0.219
9	0.095	0.110	0.219	-0.219
10	0.042	0.110	0.220	-0.220
11	-0.133	0.110	0.220	-0.220
12	-0.108	0.110	0.221	-0.221
13	-0.121	0.111	0.221	-0.221
14	-0.120	0.111	0.222	-0.222
15	-0.169	0.111	0.223	-0.223

Alafia River at Bell Shoals Road Trends Appendix
Correlogram for Salinity at EPCHC Station 74 Bottom Level

Adjusted for Seasonal Median and Detrended



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

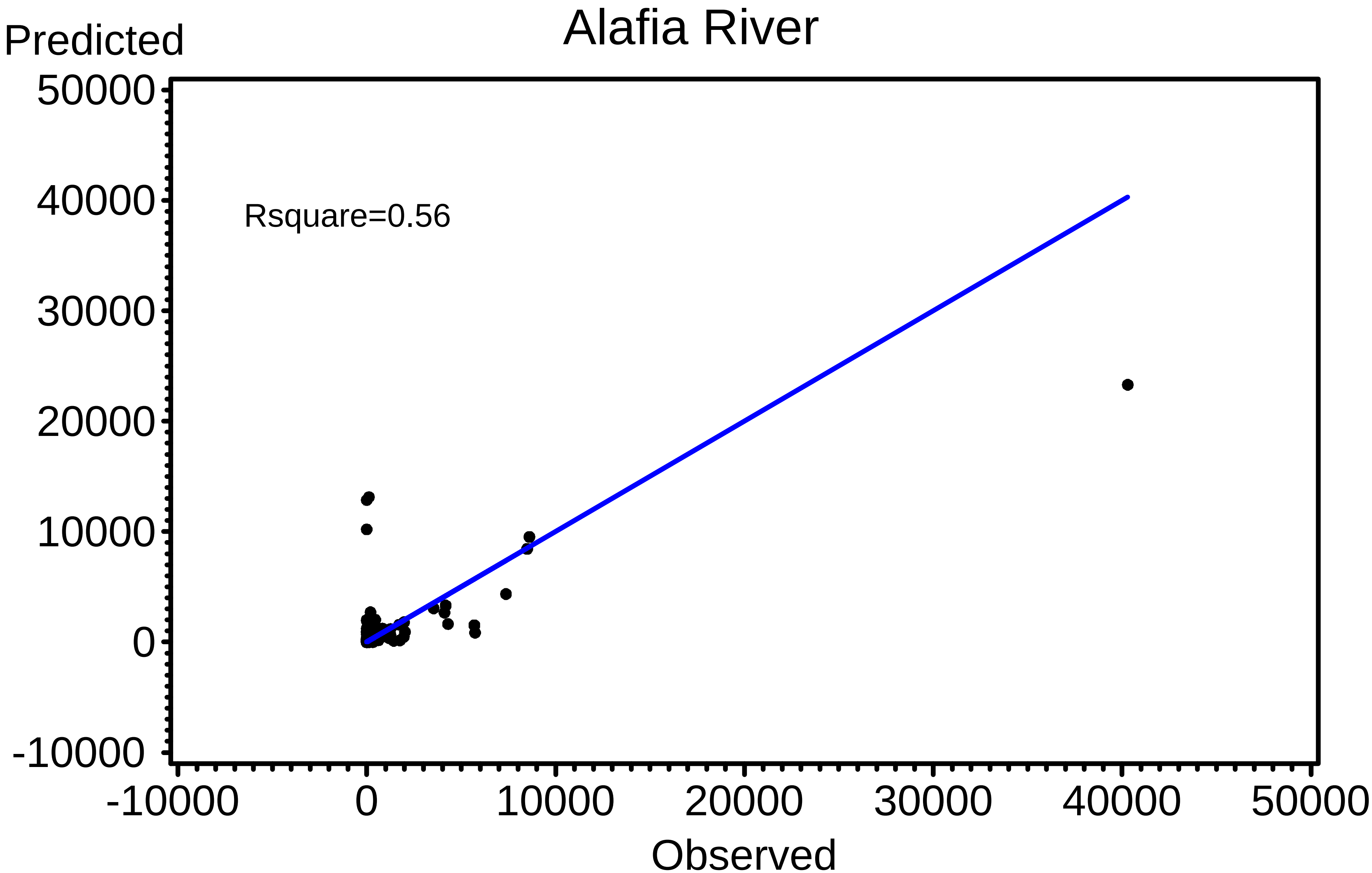


Figure K-1 Predicted vs. Observed Plots for Bay Anchovy (#/100m2)
All Regions of the Alafia River

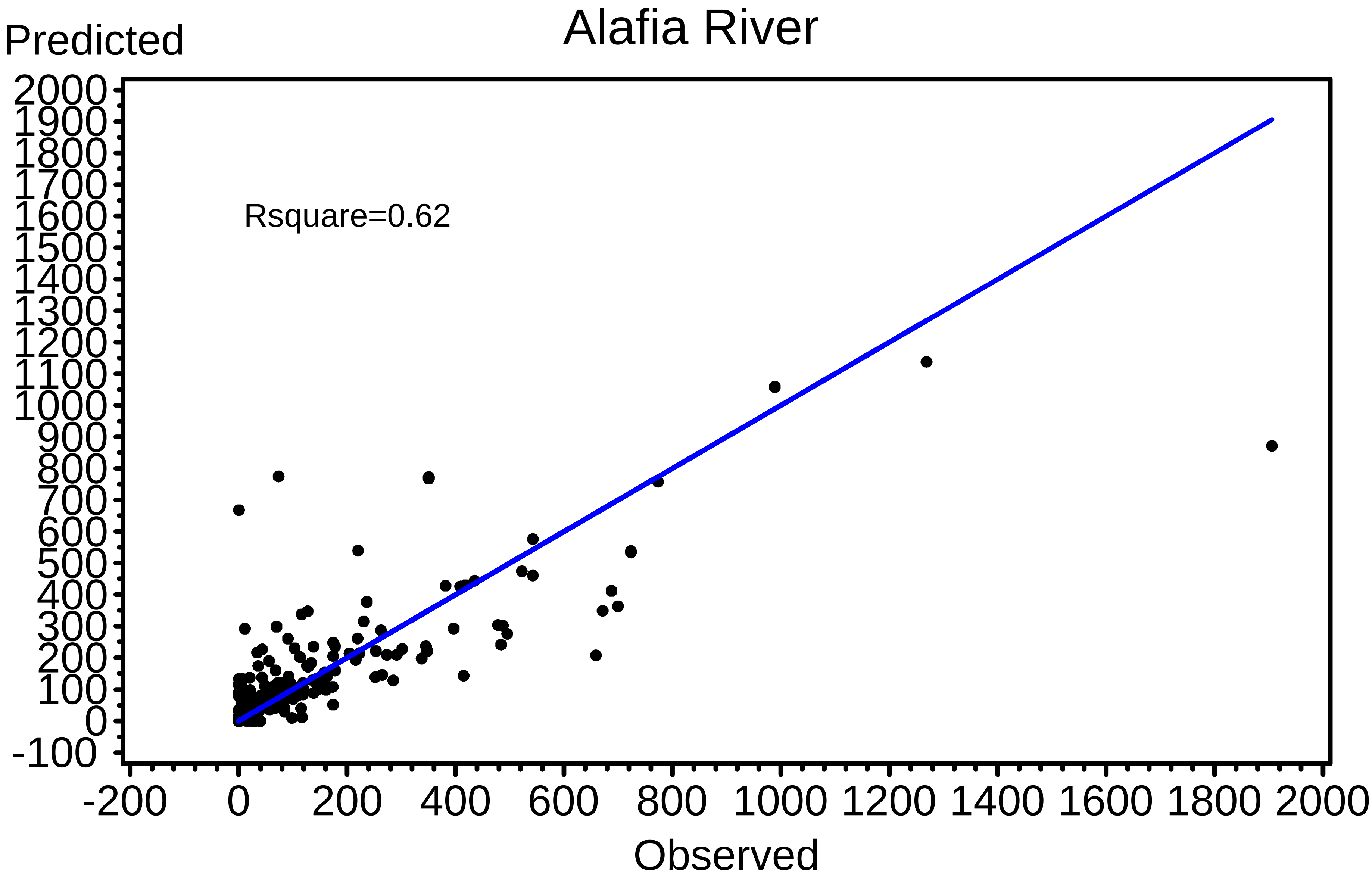


Figure K-2 Predicted vs. Observed Plots for Silversides (#/100m2)
All Regions of the Alafia River

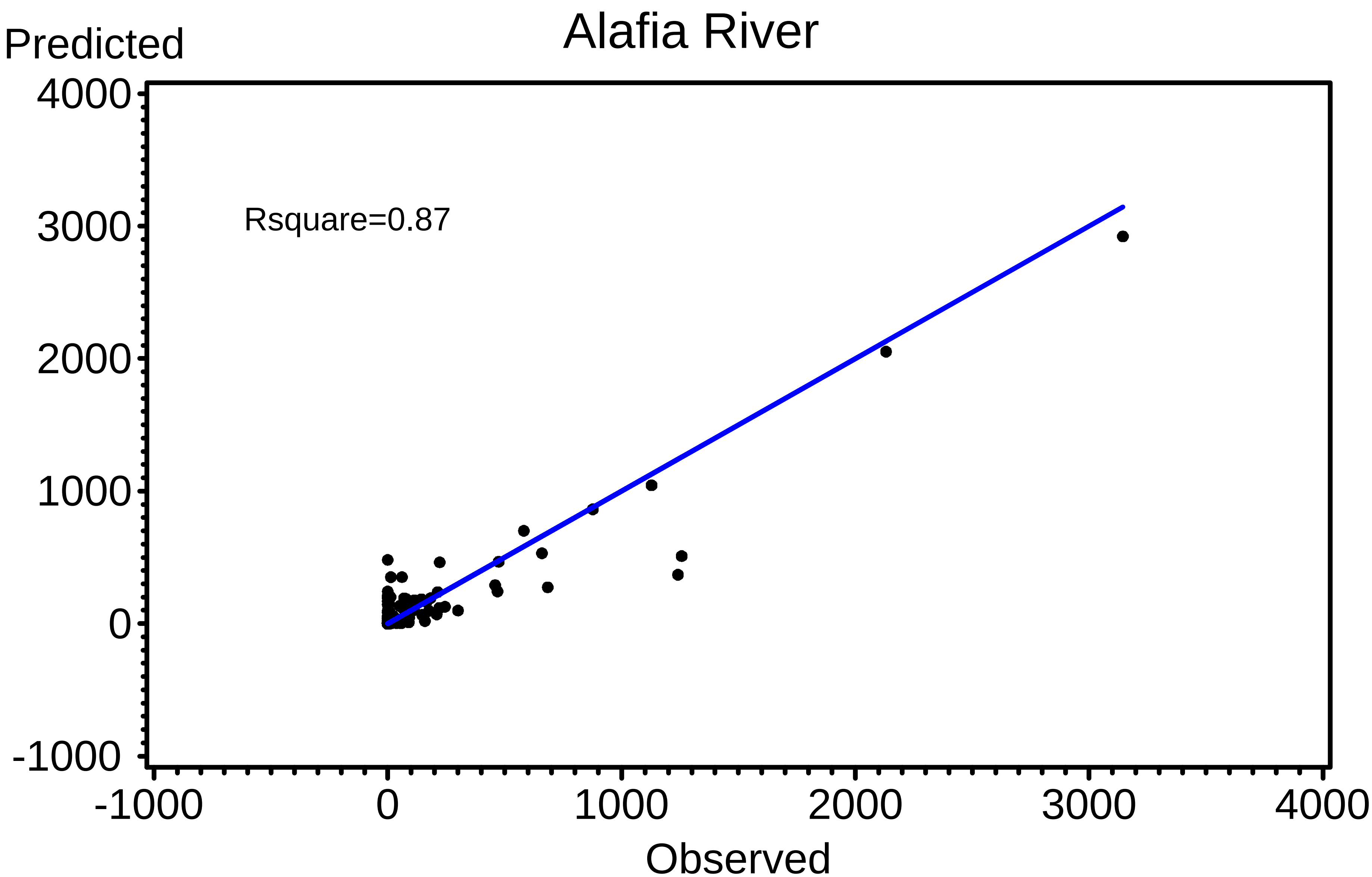


Figure K-3 Predicted vs. Observed Plots for Grass Shrimp (#/100m2)
All Regions of the Alafia River

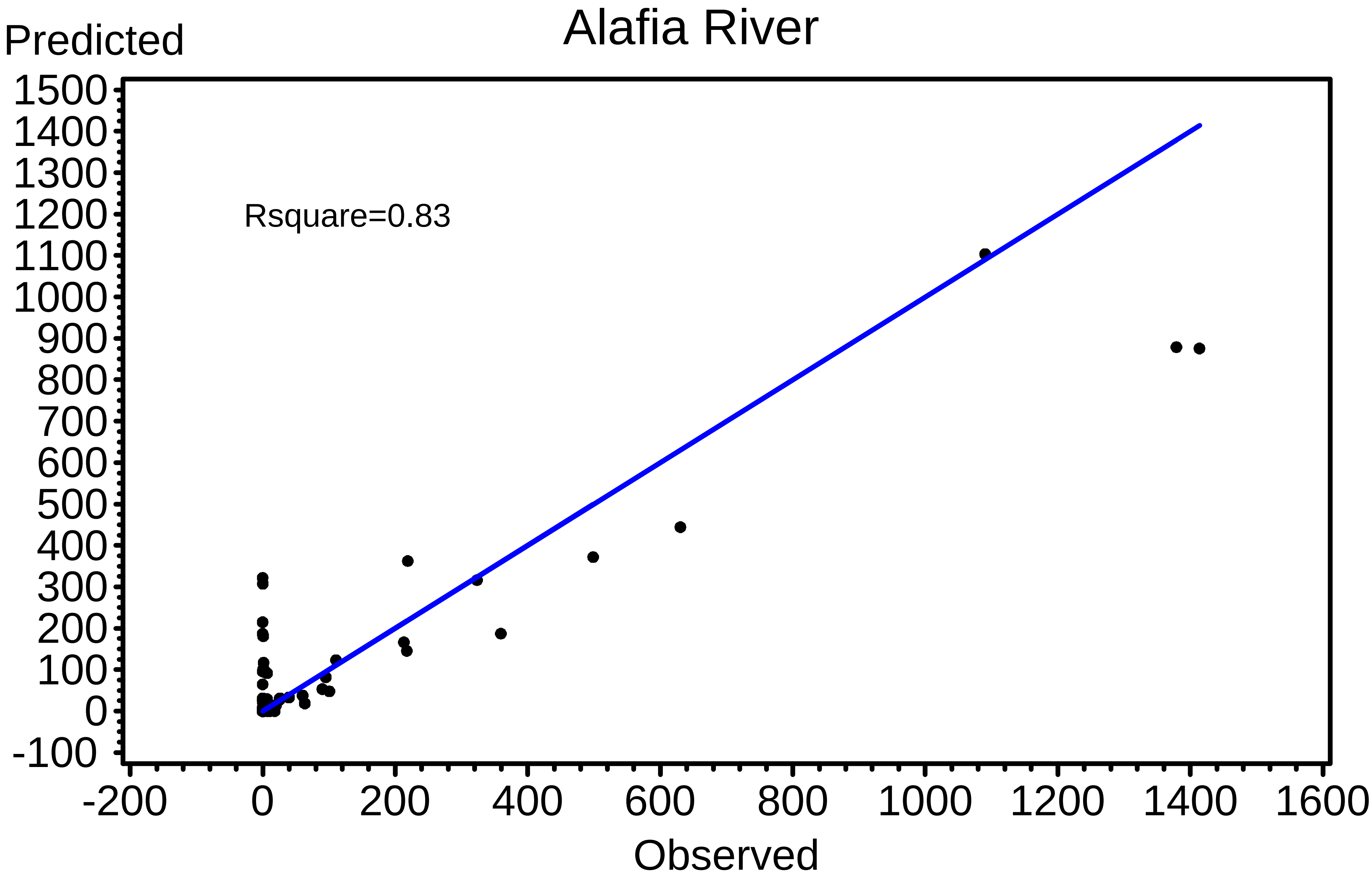


Figure K-4 Predicted vs. Observed Plots for Spot (#/100m2)
All Regions of the Alafia River

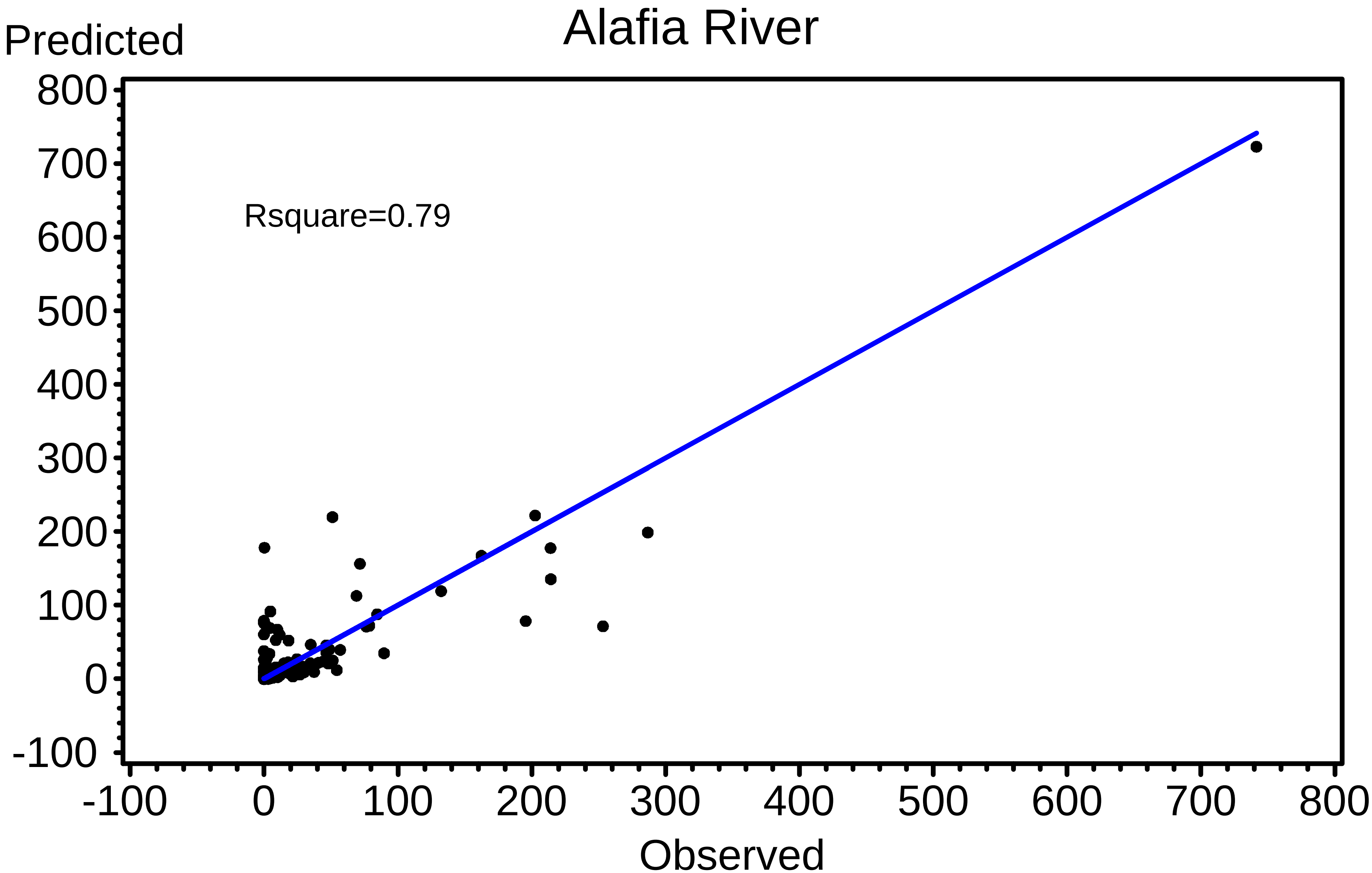


Figure K-5 Predicted vs. Observed Plots for Mojarras (#/100m2)
All Regions of the Alafia River

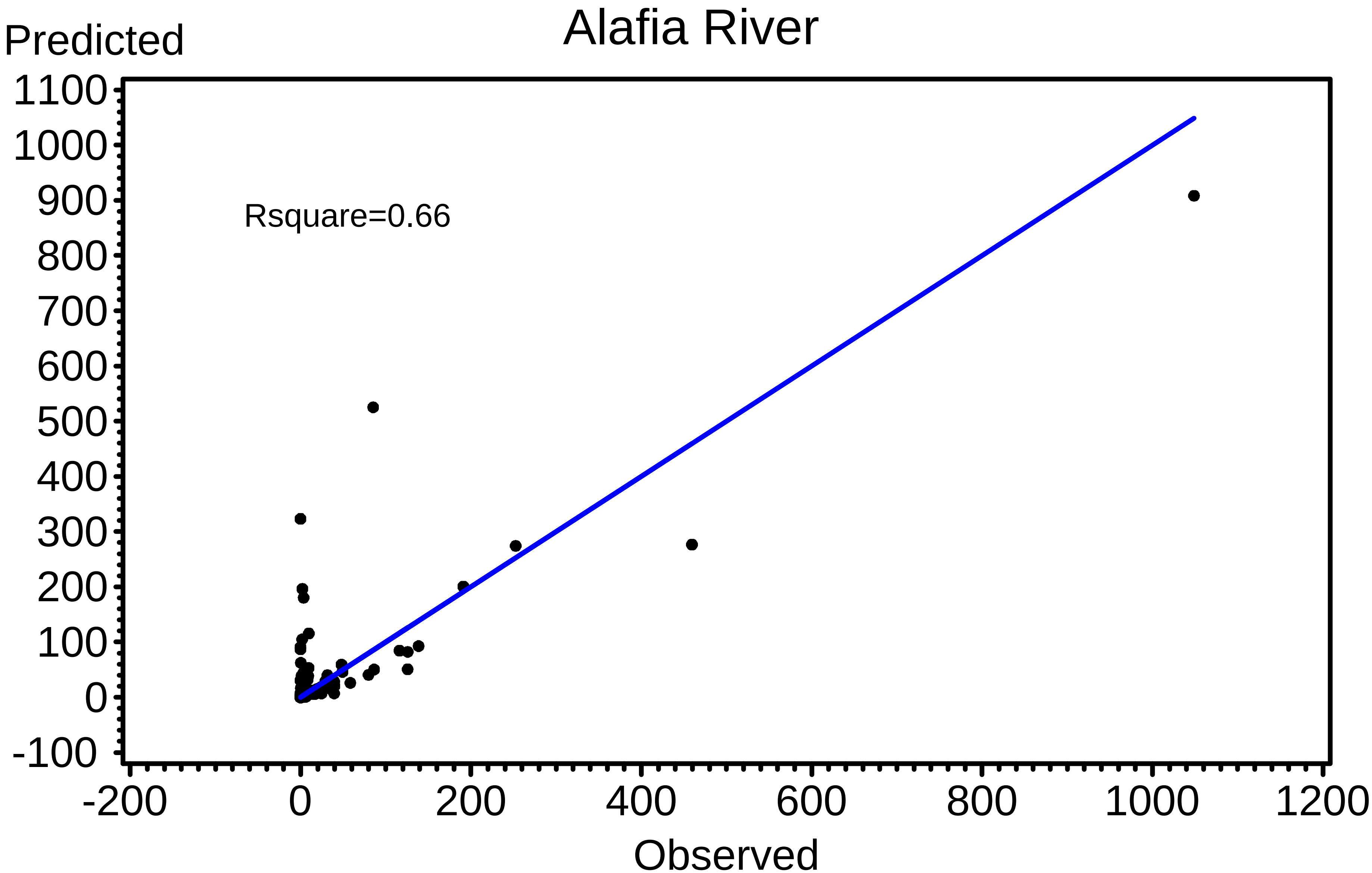


Figure K-6 Predicted vs. Observed Plots for Pinfish (#/100m2)
All Regions of the Alafia River

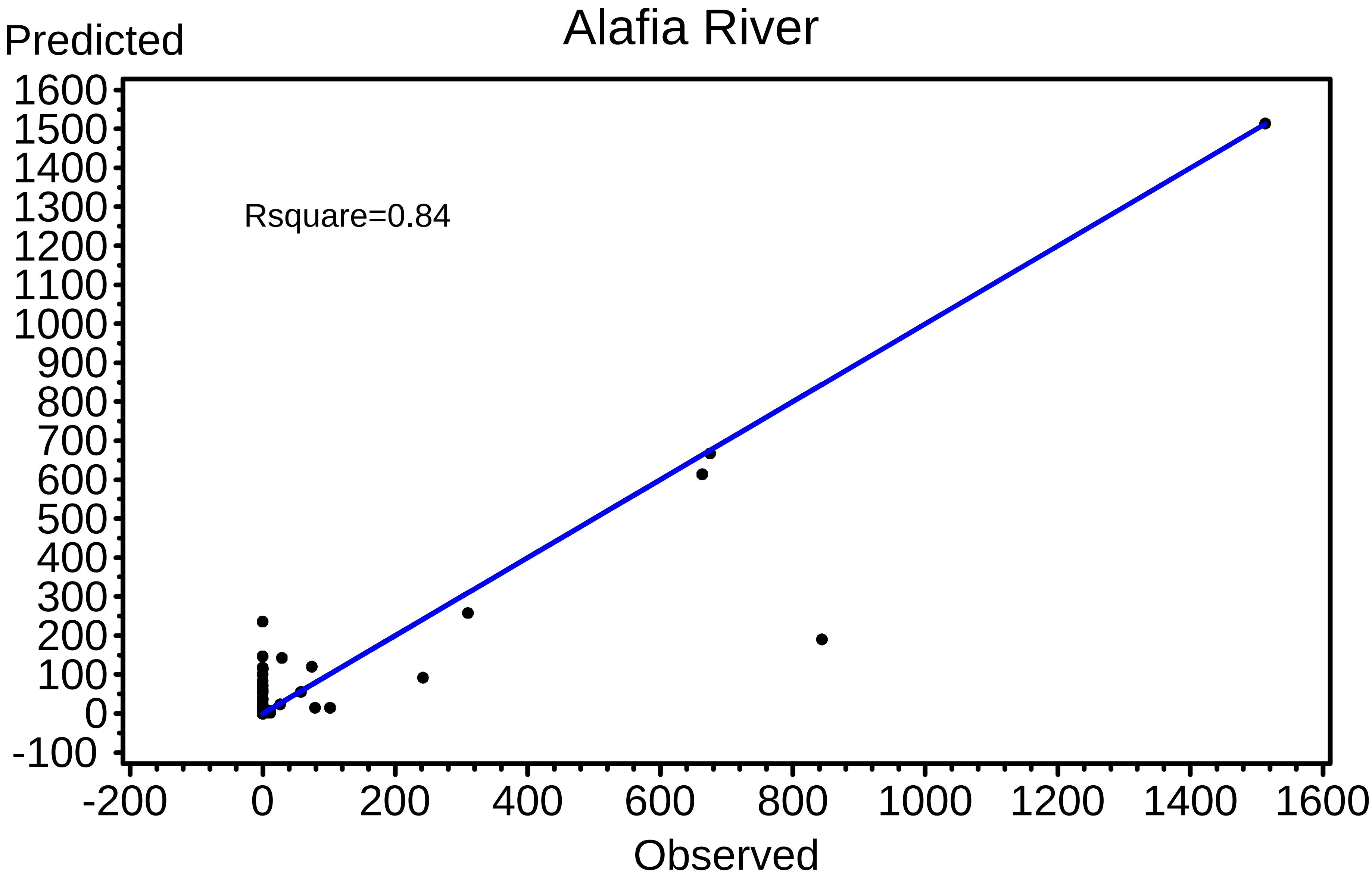


Figure K-7 Predicted vs. Observed Plots for Menhaden (#/100m2)
All Regions of the Alafia River

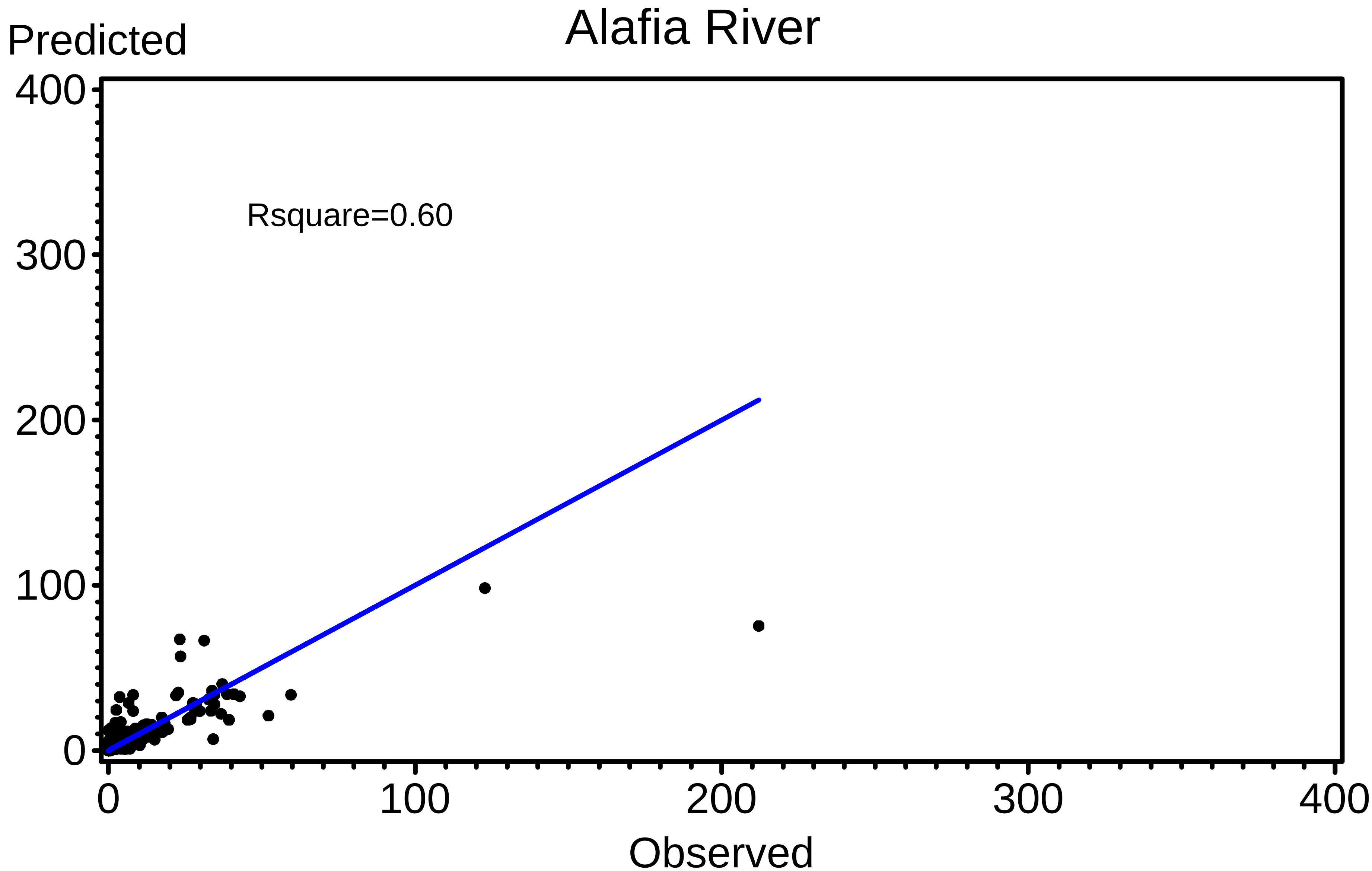


Figure K-8 Predicted vs. Observed Plots for Hogchoker (#/100m2)
All Regions of the Alafia River

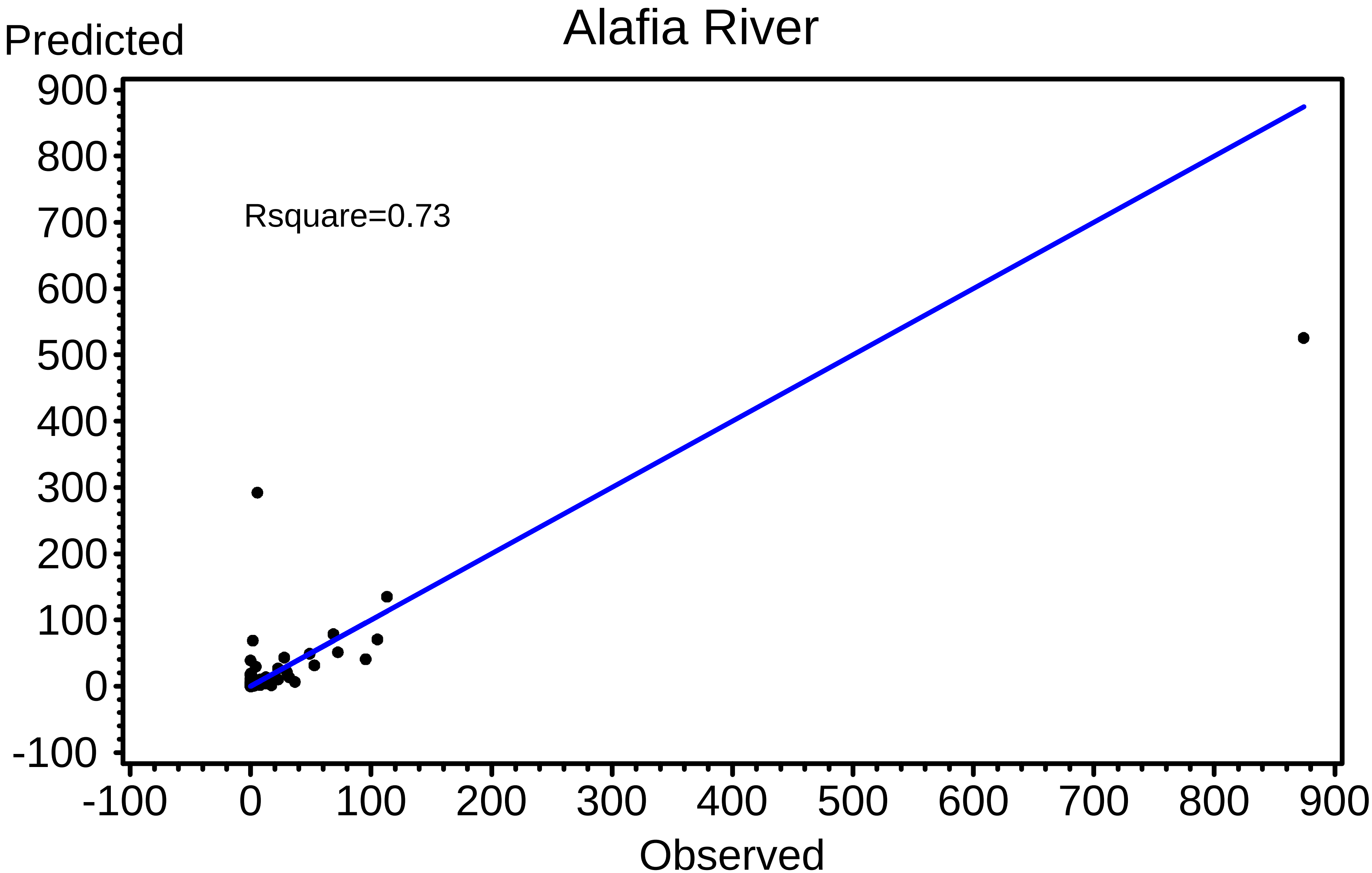


Figure K-9 Predicted vs. Observed Plots   for Striped Mullet (#/100m2)
All Regions of the Alafia River

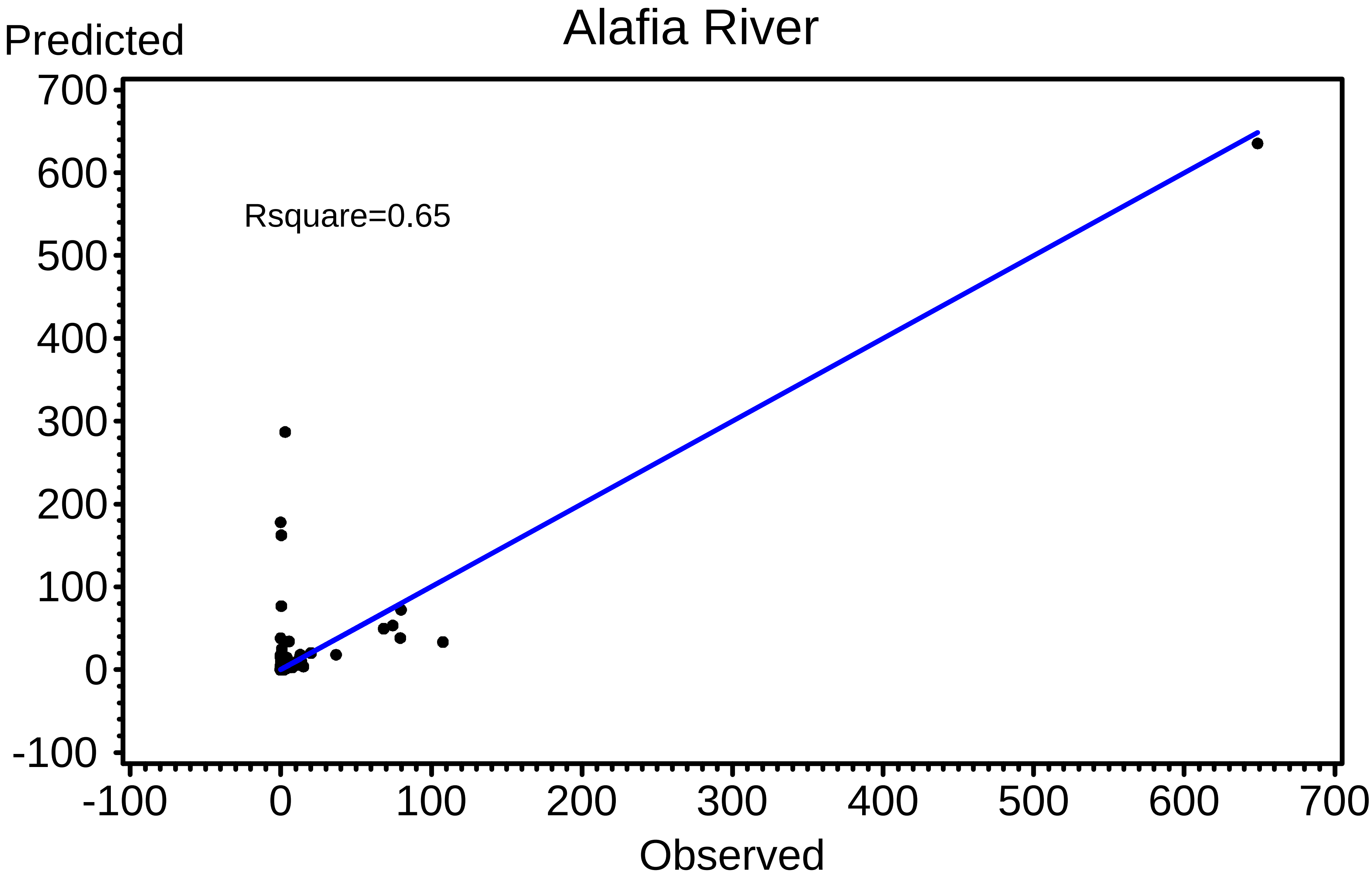


Figure K-10 Predicted vs. Observed Plots for Silver Perch (#/100m2)
All Regions of the Alafia River

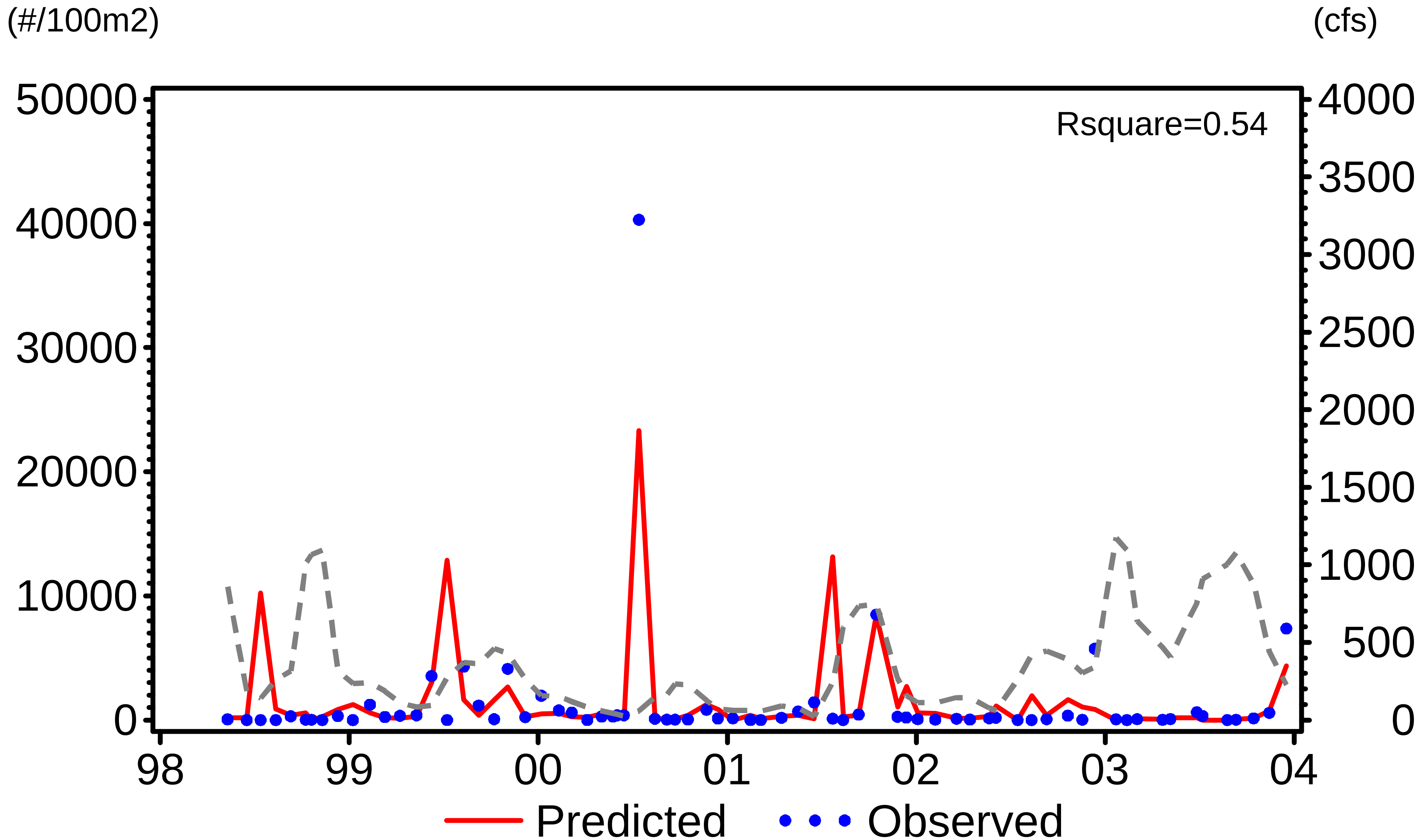


Figure L-1 Predicted vs. Observed Plots for Bay Anchovy
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

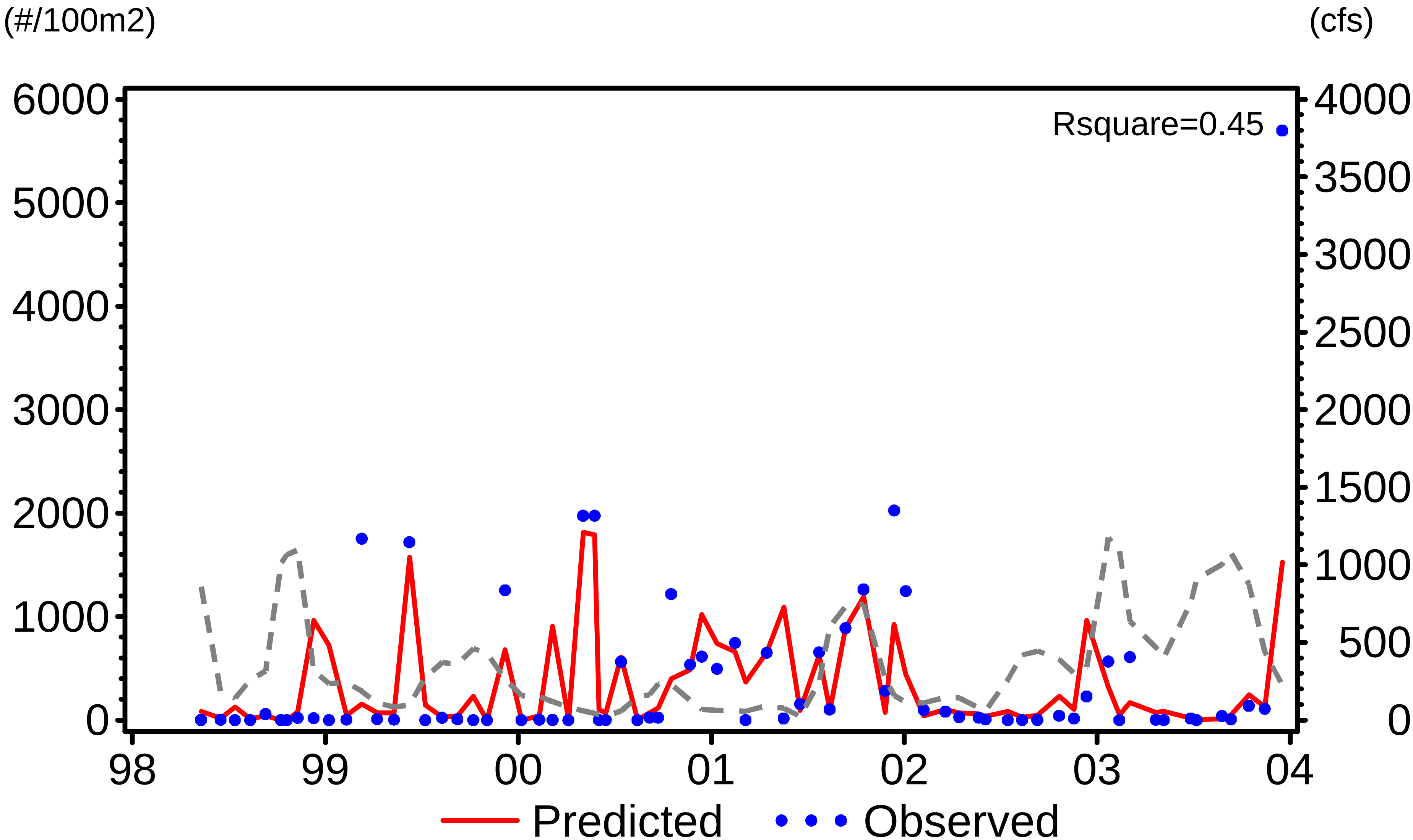


Figure L-2 Predicted vs. Observed Plots for Bay Anchovy
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

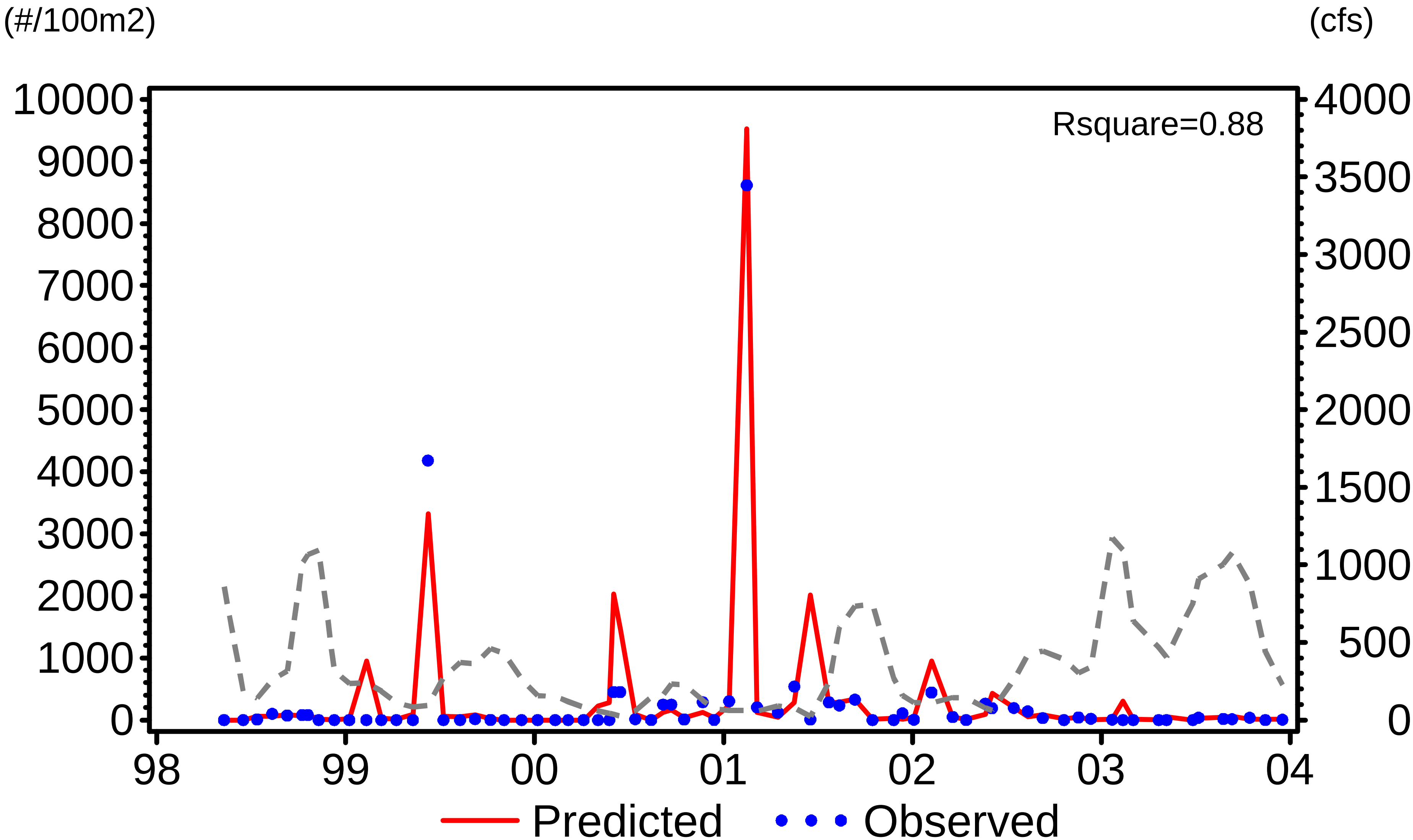


Figure L-3 Predicted vs. Observed Plots for Bay Anchovy
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

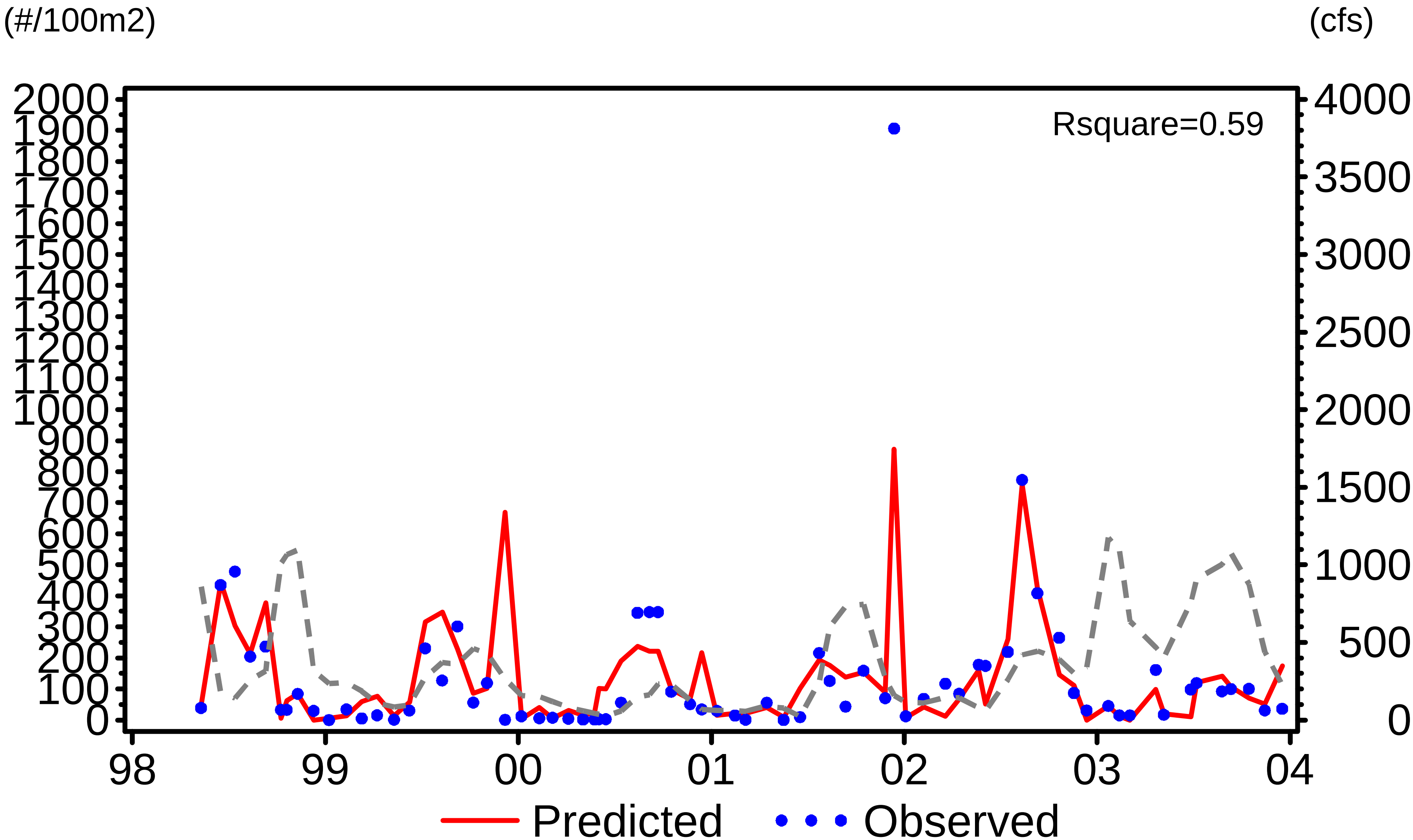


Figure L-4 Predicted vs. Observed Plots for Silversides
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

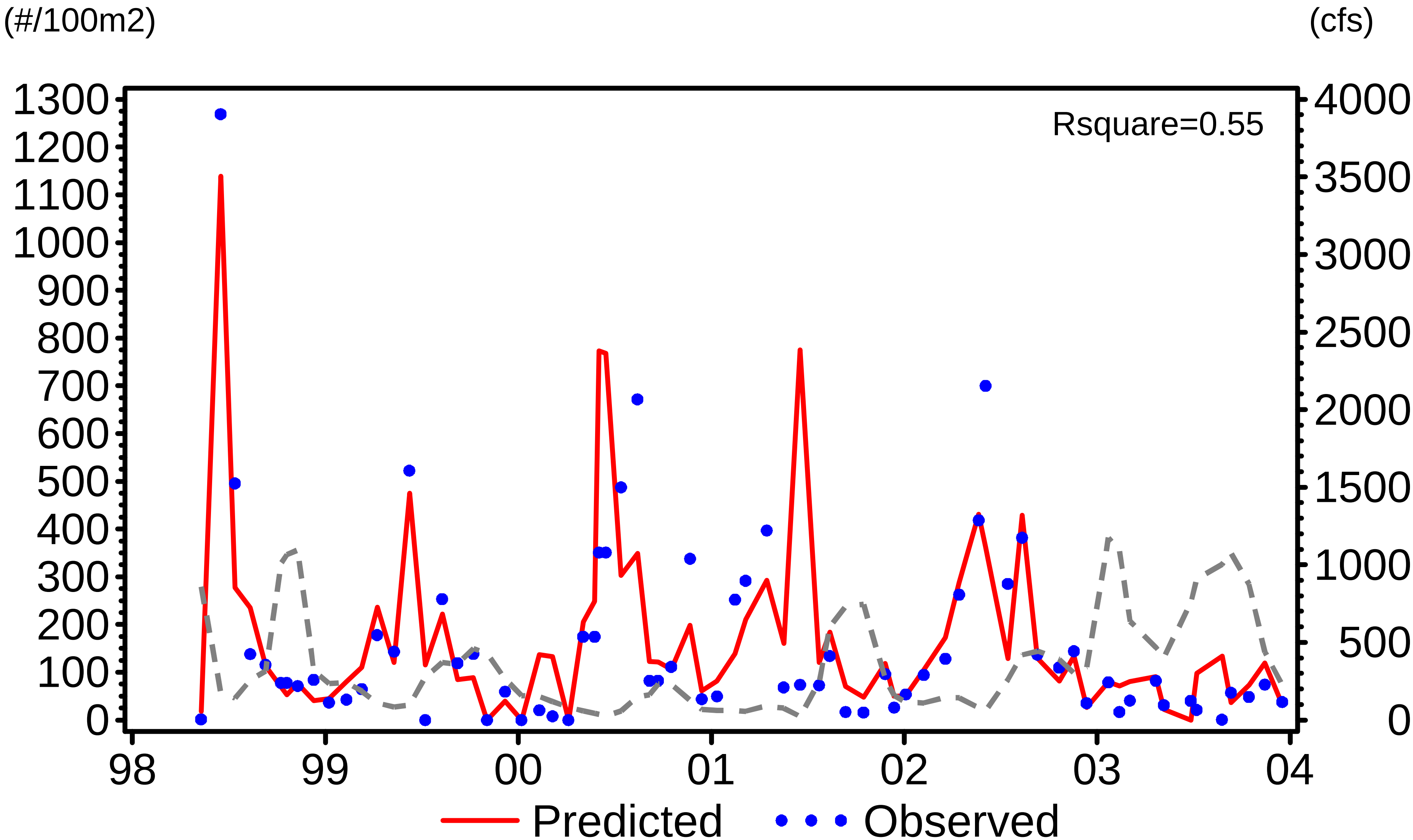


Figure L-5 Predicted vs. Observed Plots for Silversides
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

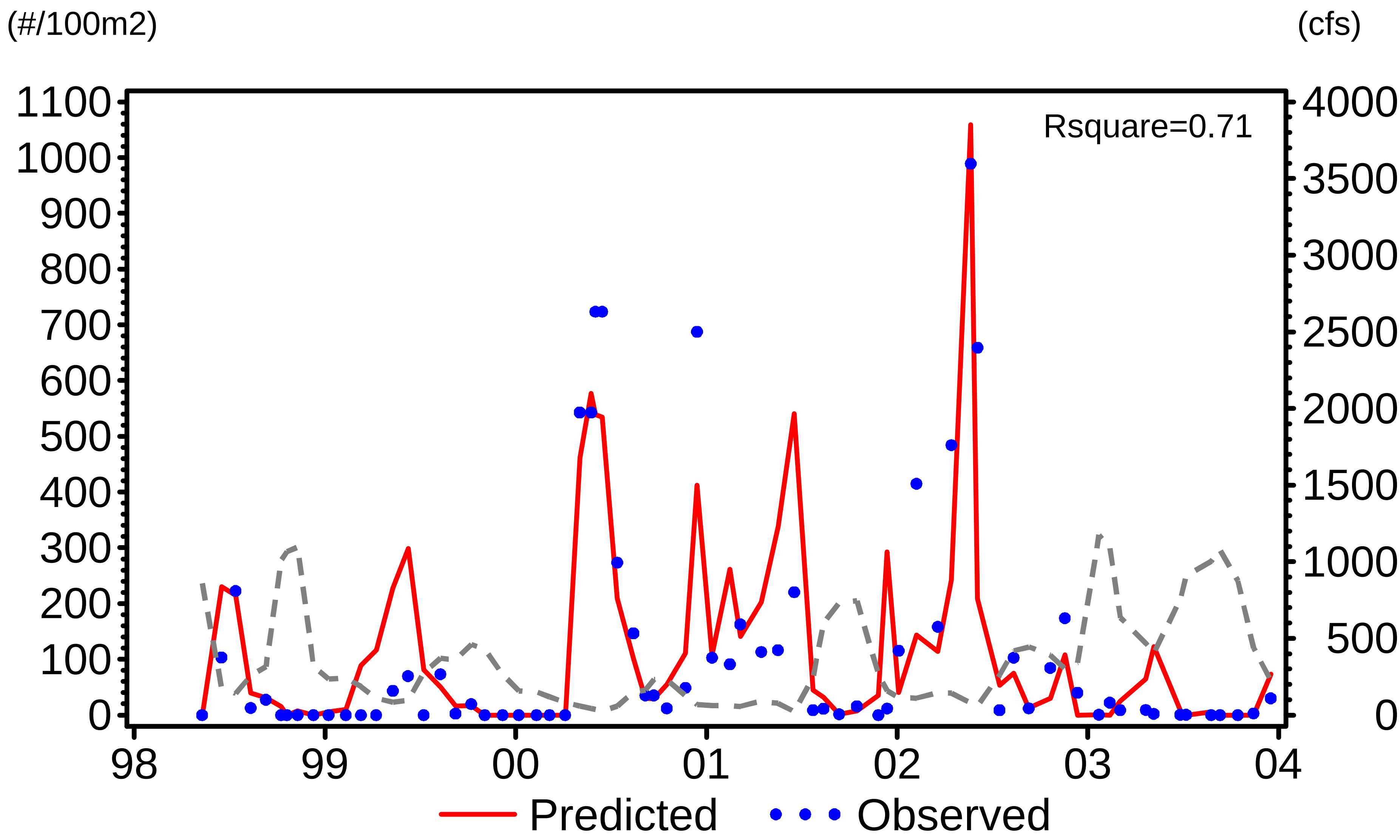


Figure L-6 Predicted vs. Observed Plots for Silversides
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

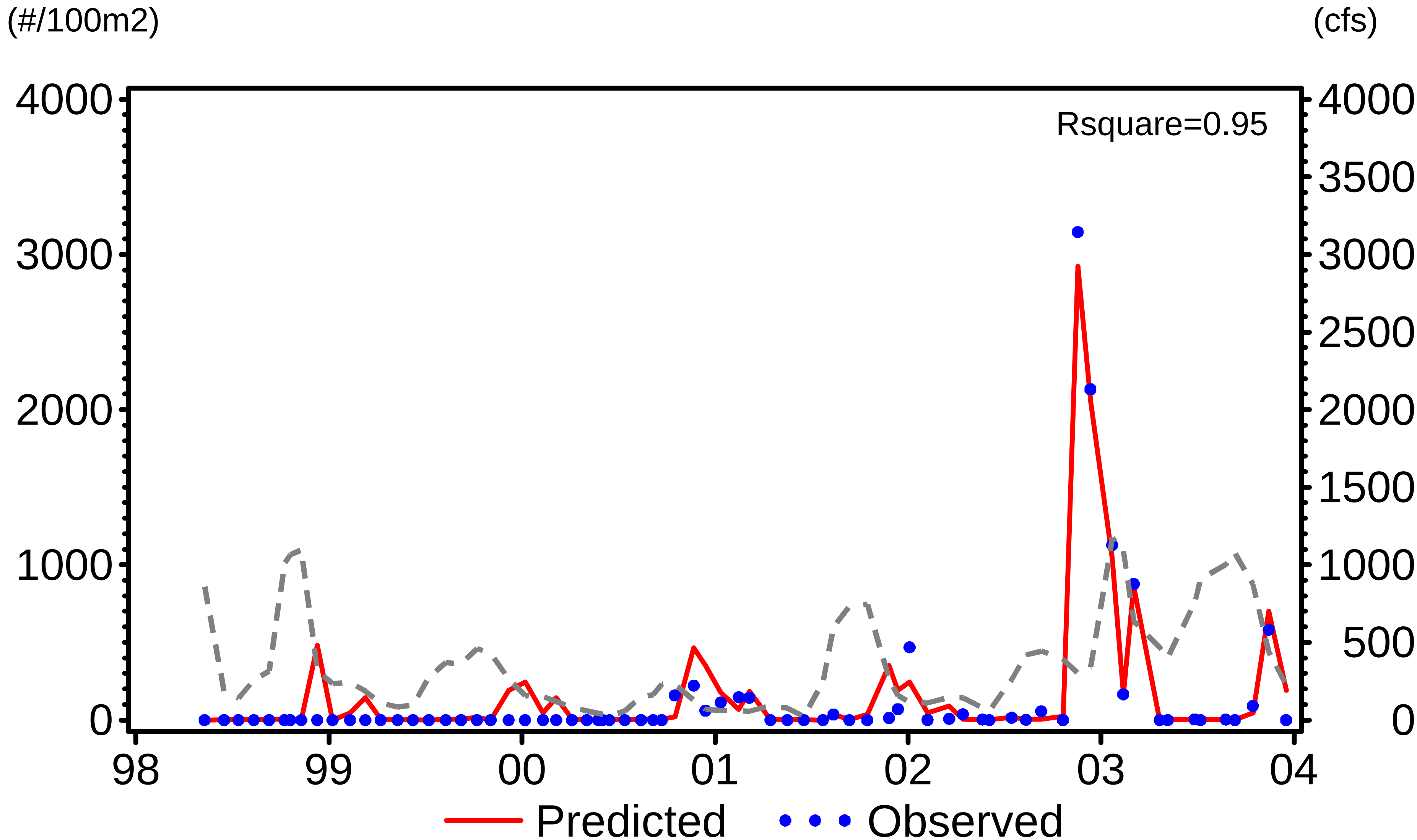


Figure L-7 Predicted vs. Observed Plots for Grass Shrimp
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

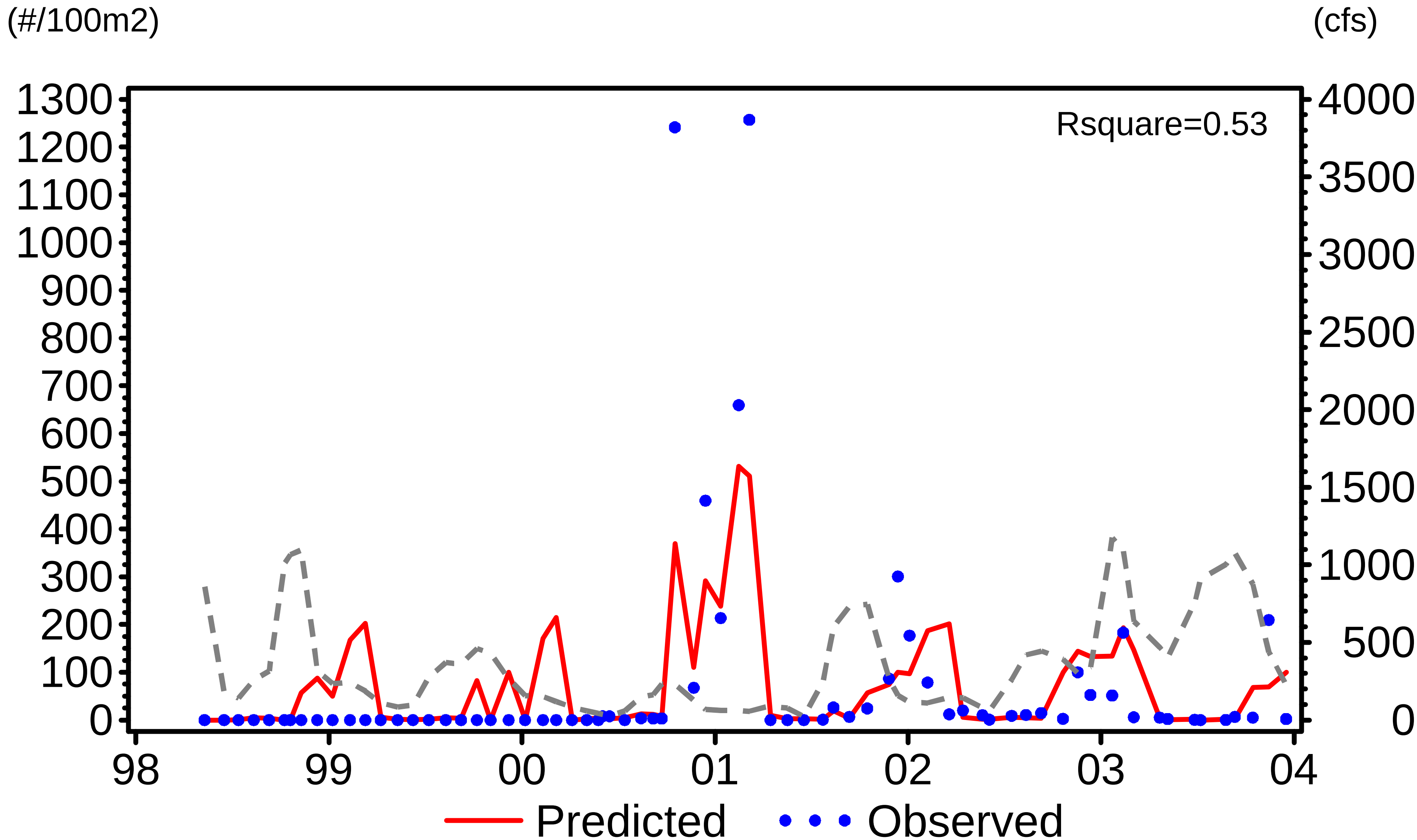


Figure L-8 Predicted vs. Observed Plots for Grass Shrimp
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

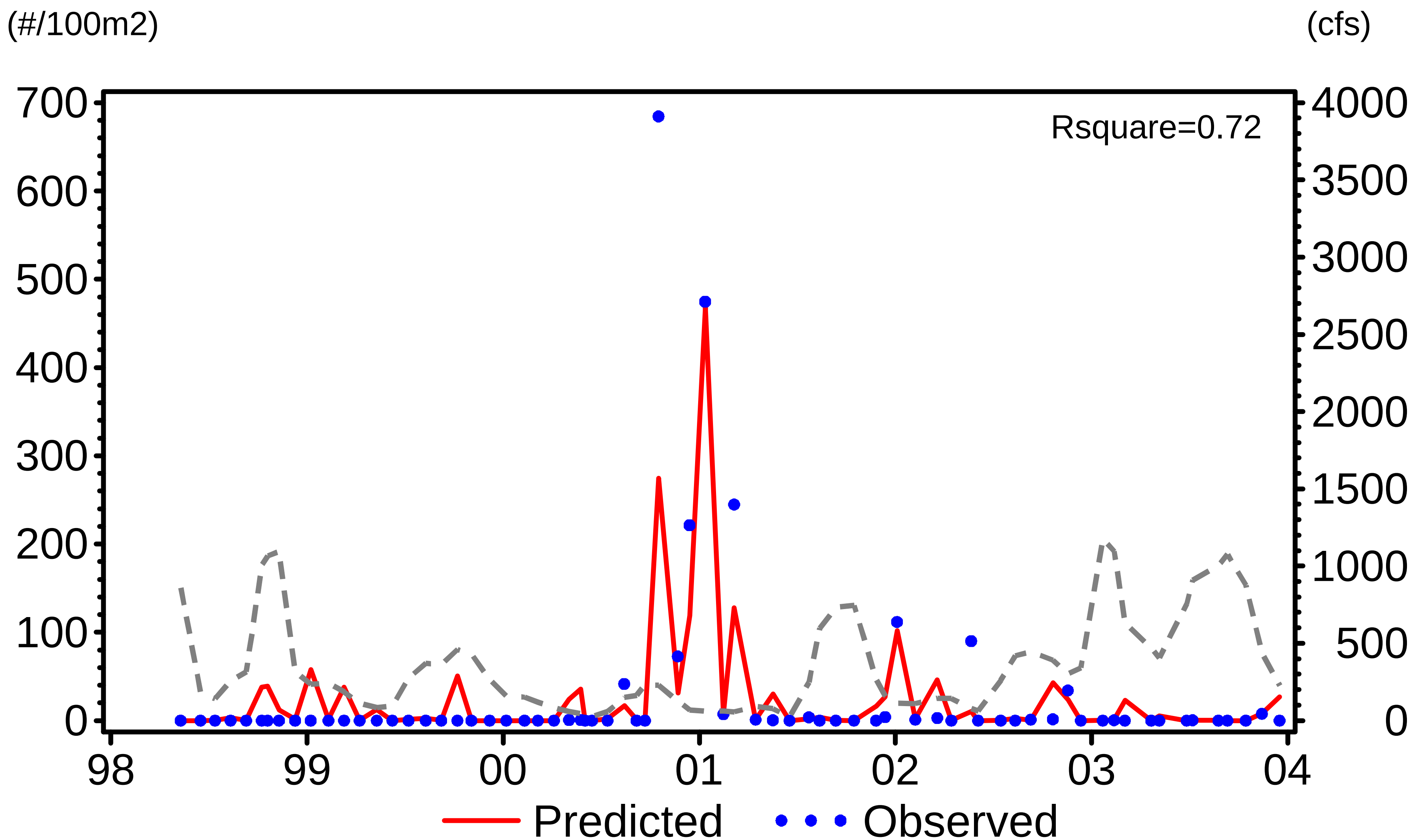


Figure L-9 Predicted vs. Observed Plots for Grass Shrimp
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

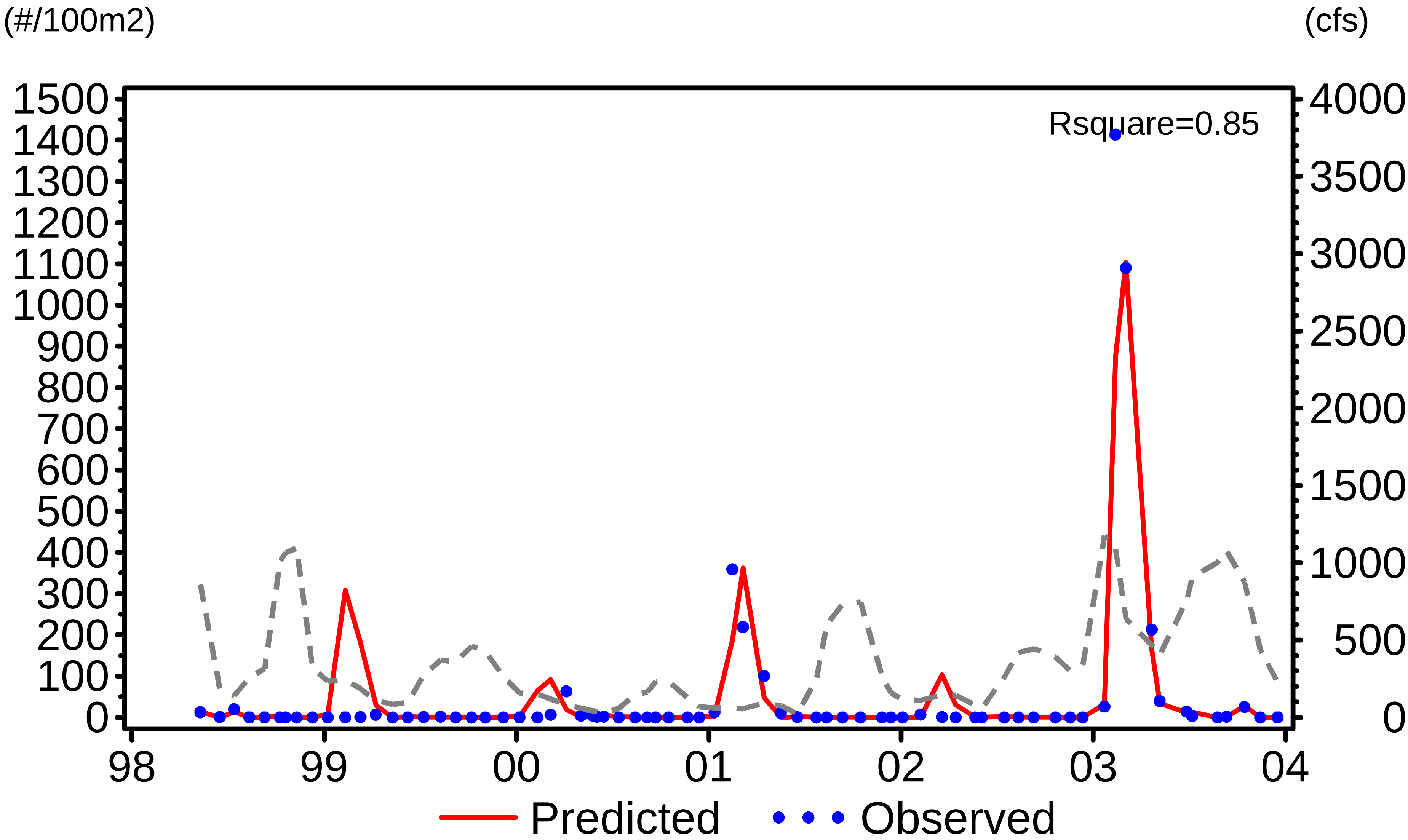


Figure L-10 Predicted vs. Observed Plots for Spot
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

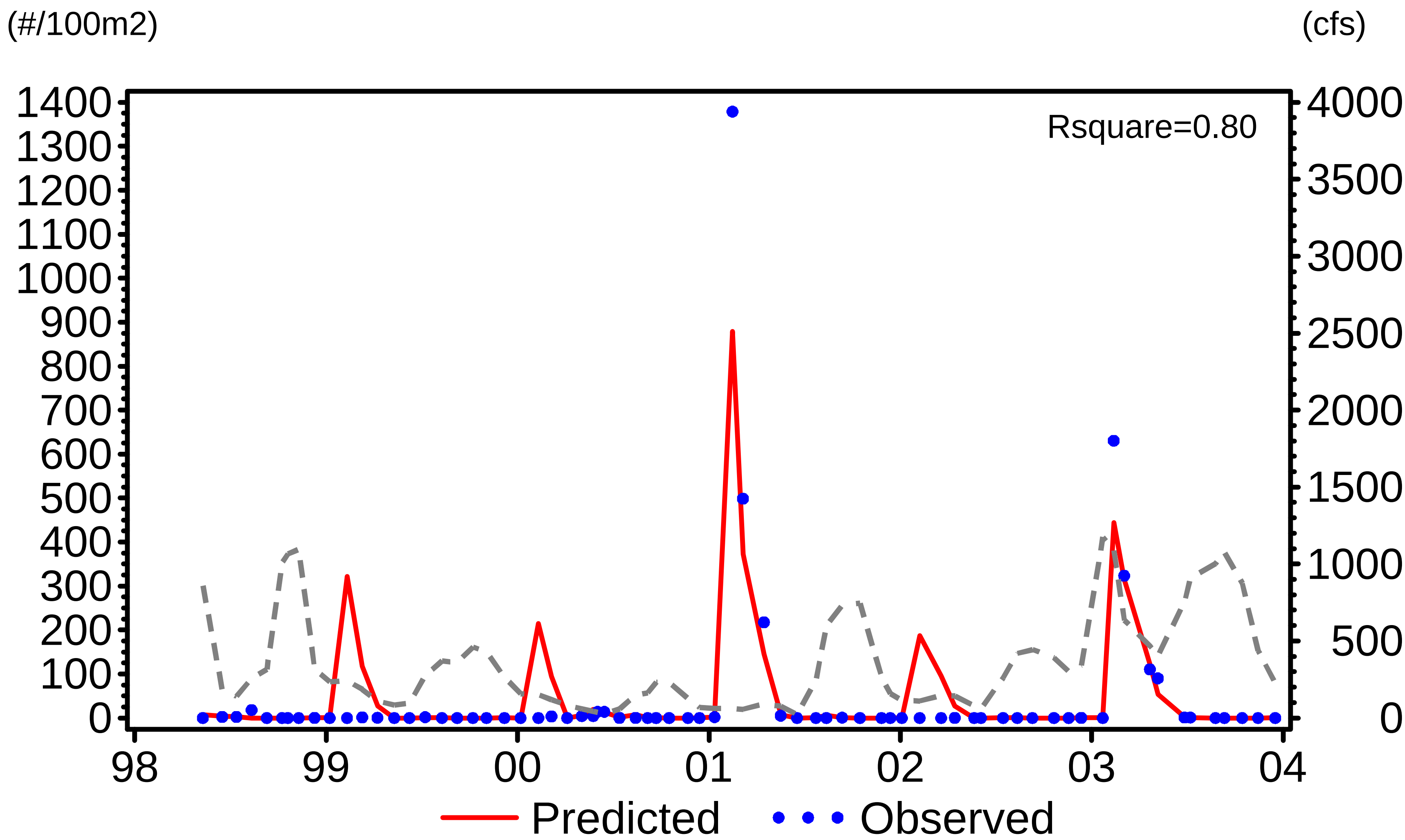


Figure L-11 Predicted vs. Observed Plots for Spot
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

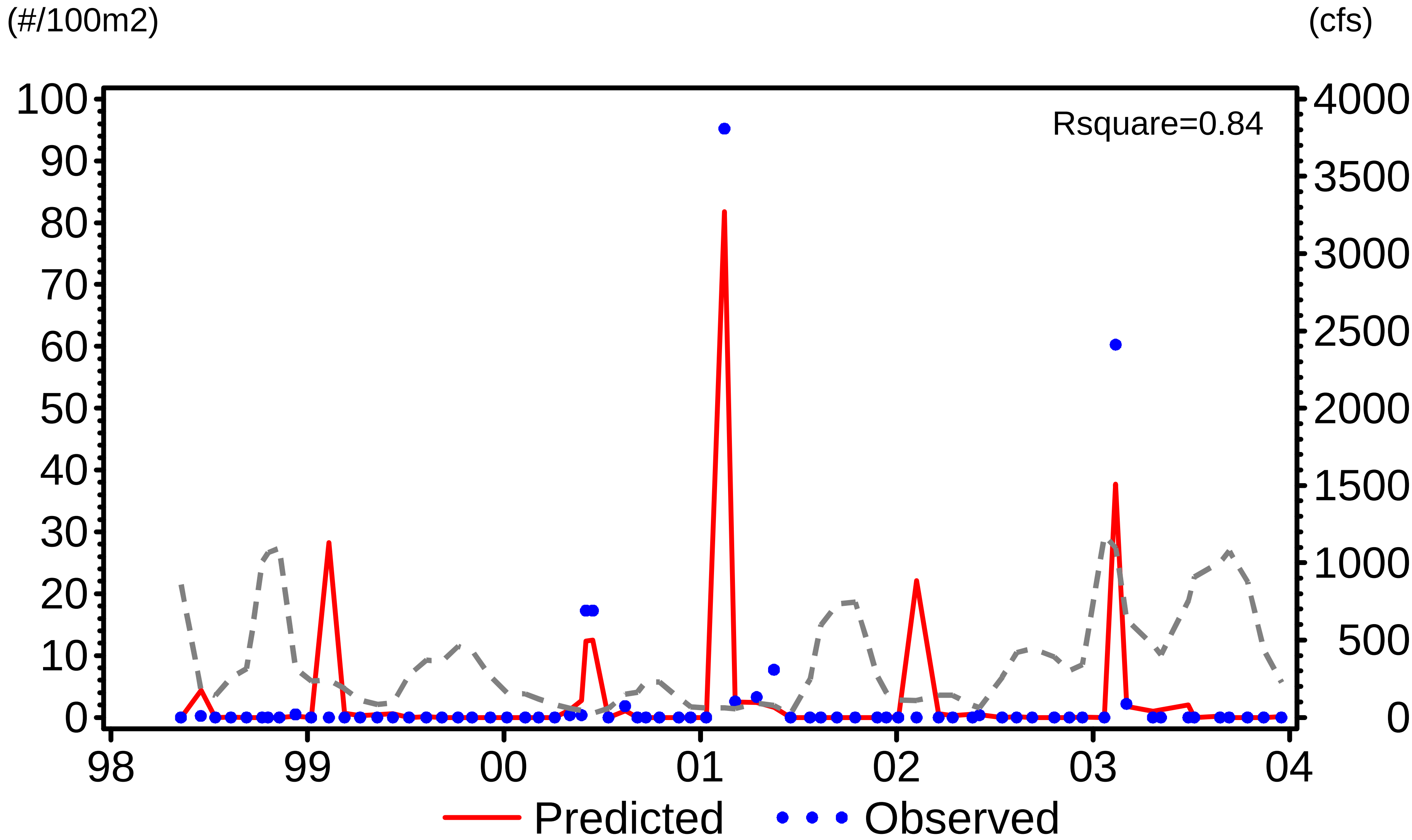


Figure L-12 Predicted vs. Observed Plots for Spot
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

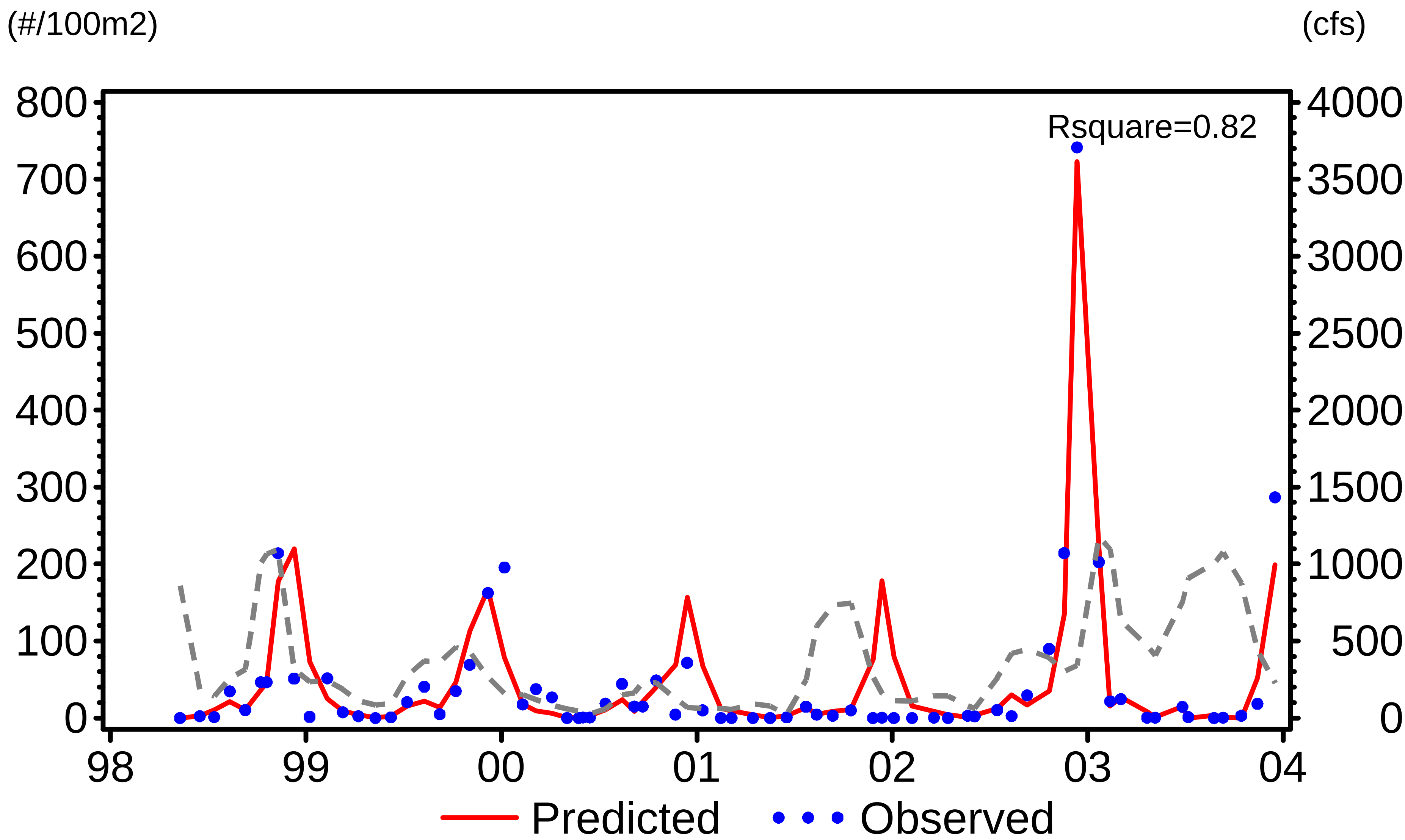


Figure L-13 Predicted vs. Observed Plots for Mojarras
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

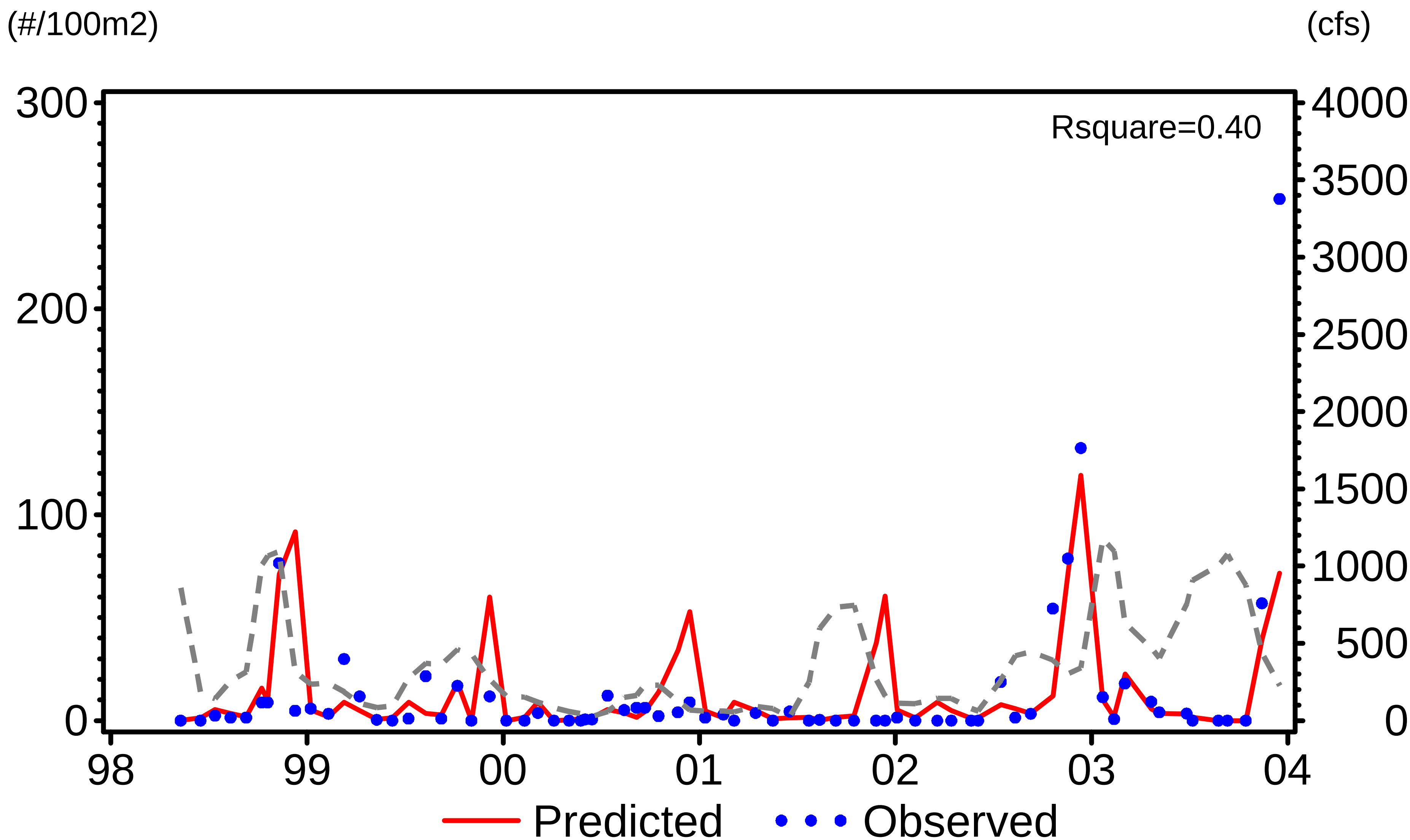


Figure L-14 Predicted vs. Observed Plots for Mojarras
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

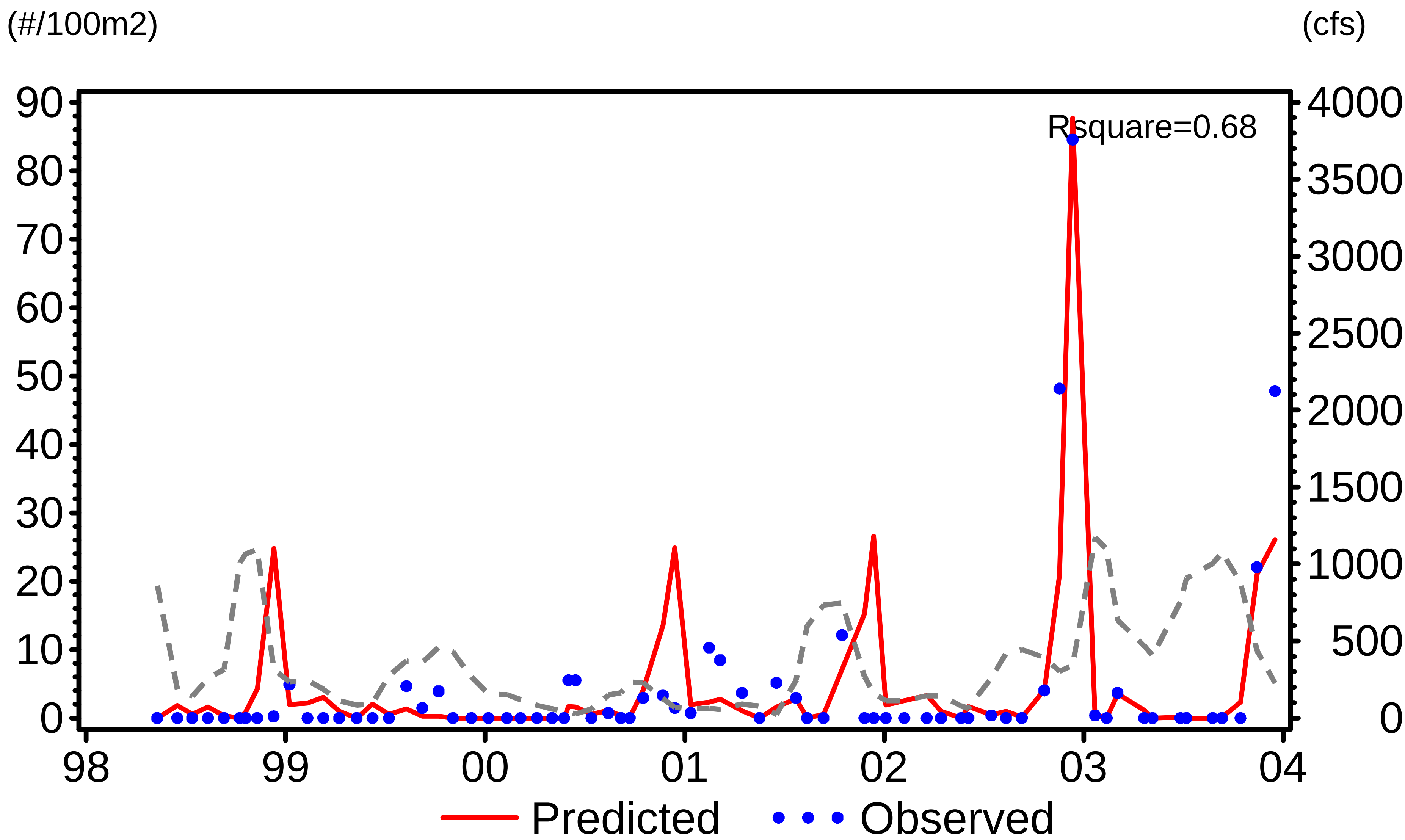


Figure L-15 Predicted vs. Observed Plots for Mojarras
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

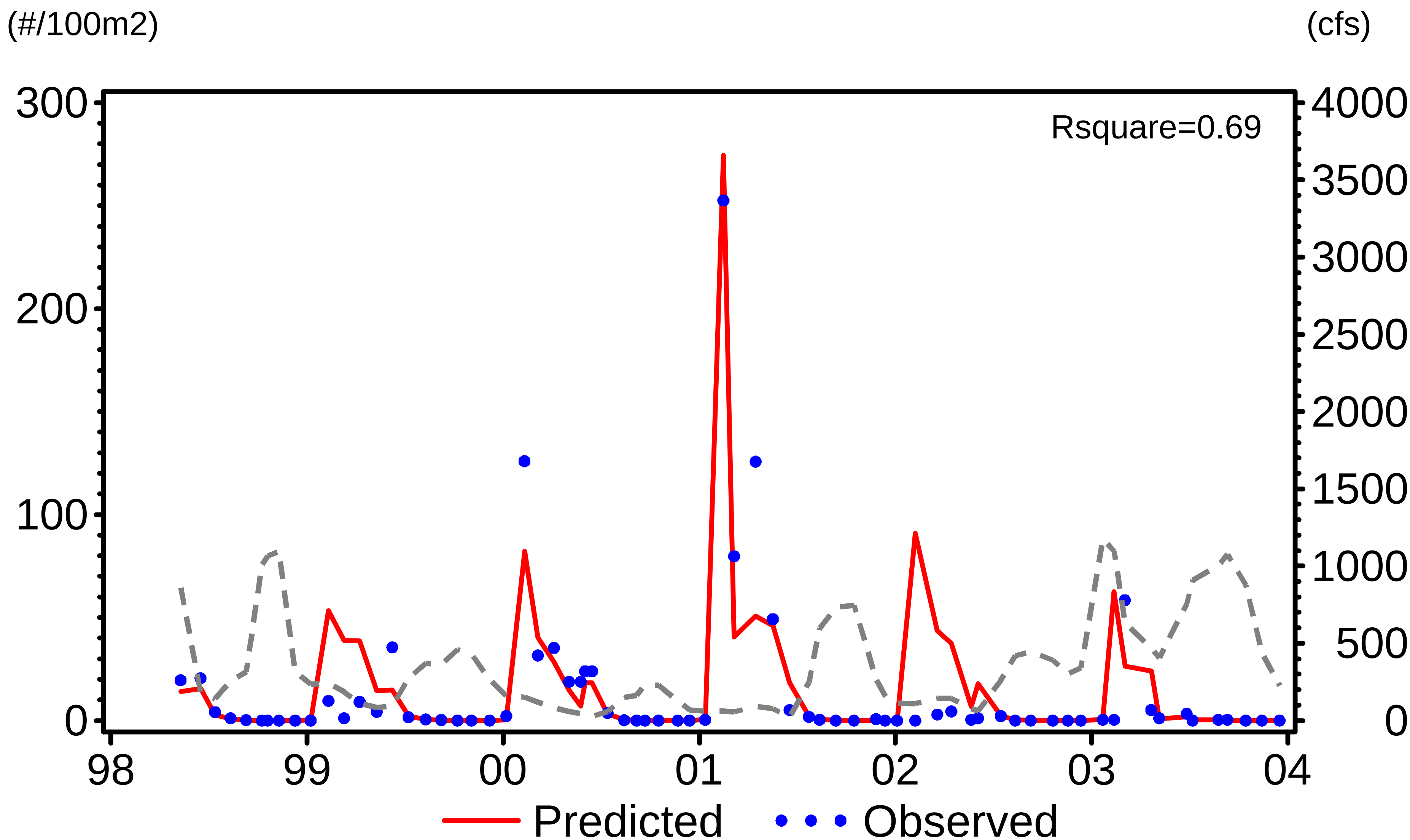


Figure L-16 Predicted vs. Observed Plots for Pinfish
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

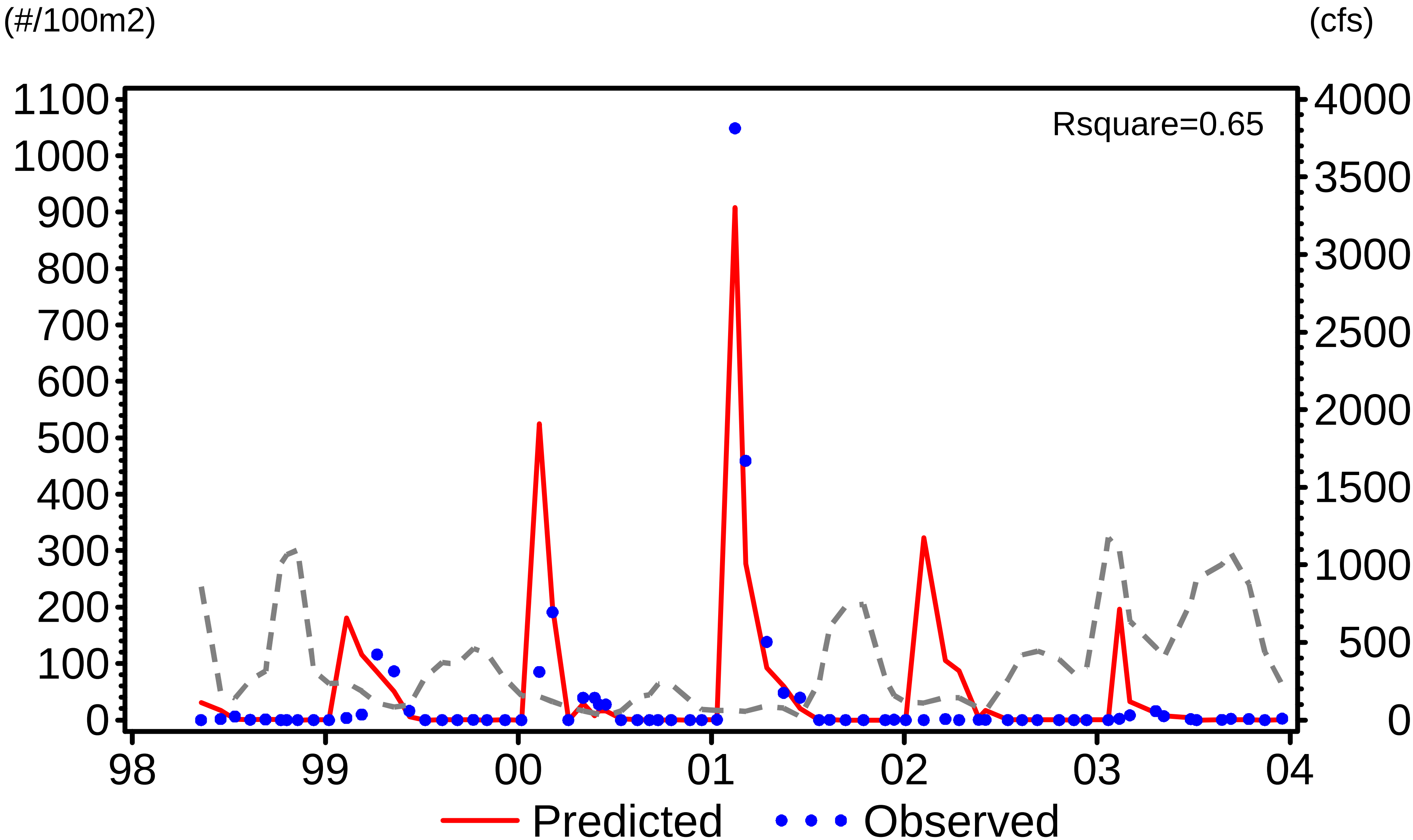


Figure L-17 Predicted vs. Observed Plots for Pinfish
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

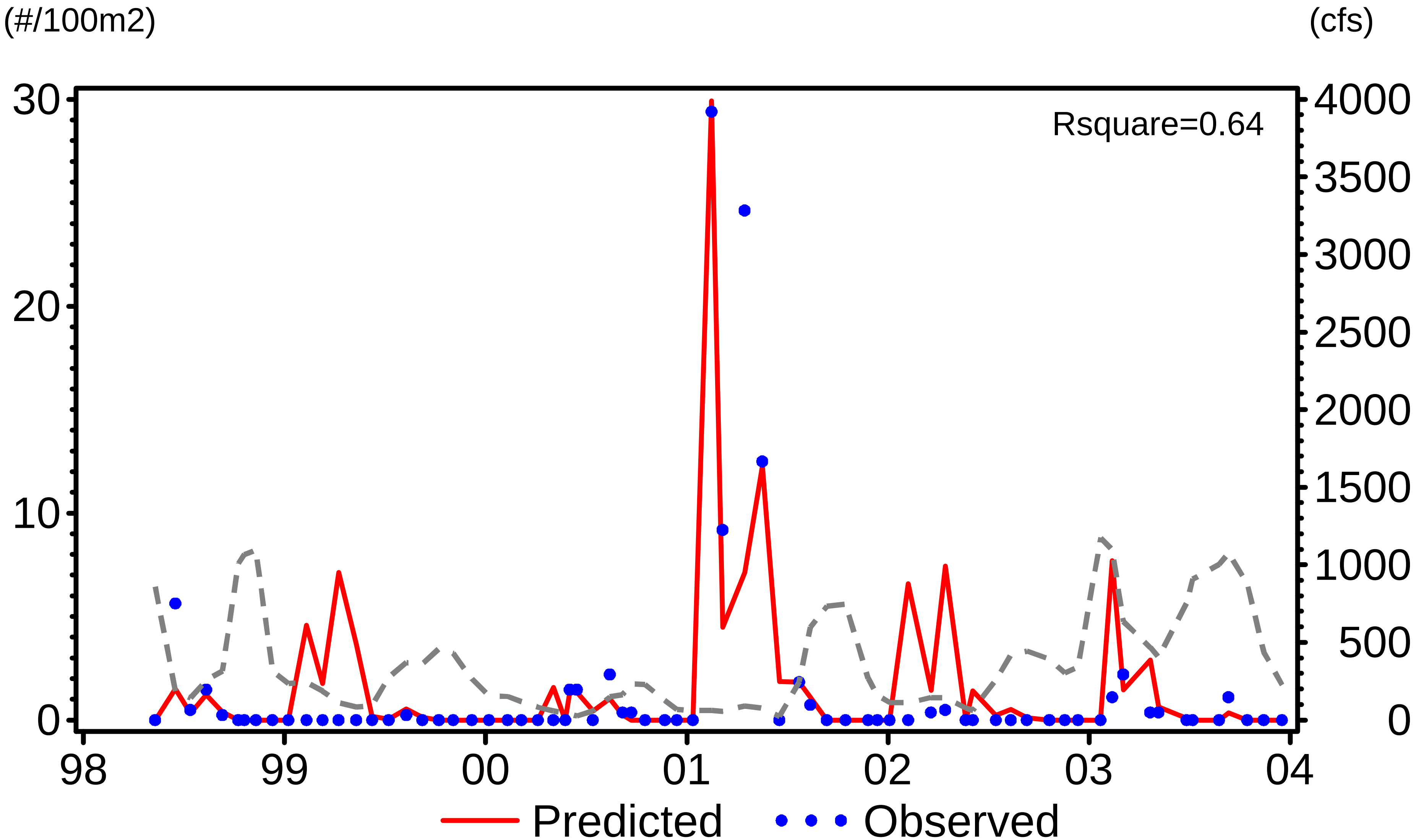


Figure L-18 Predicted vs. Observed Plots for Pinfish
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

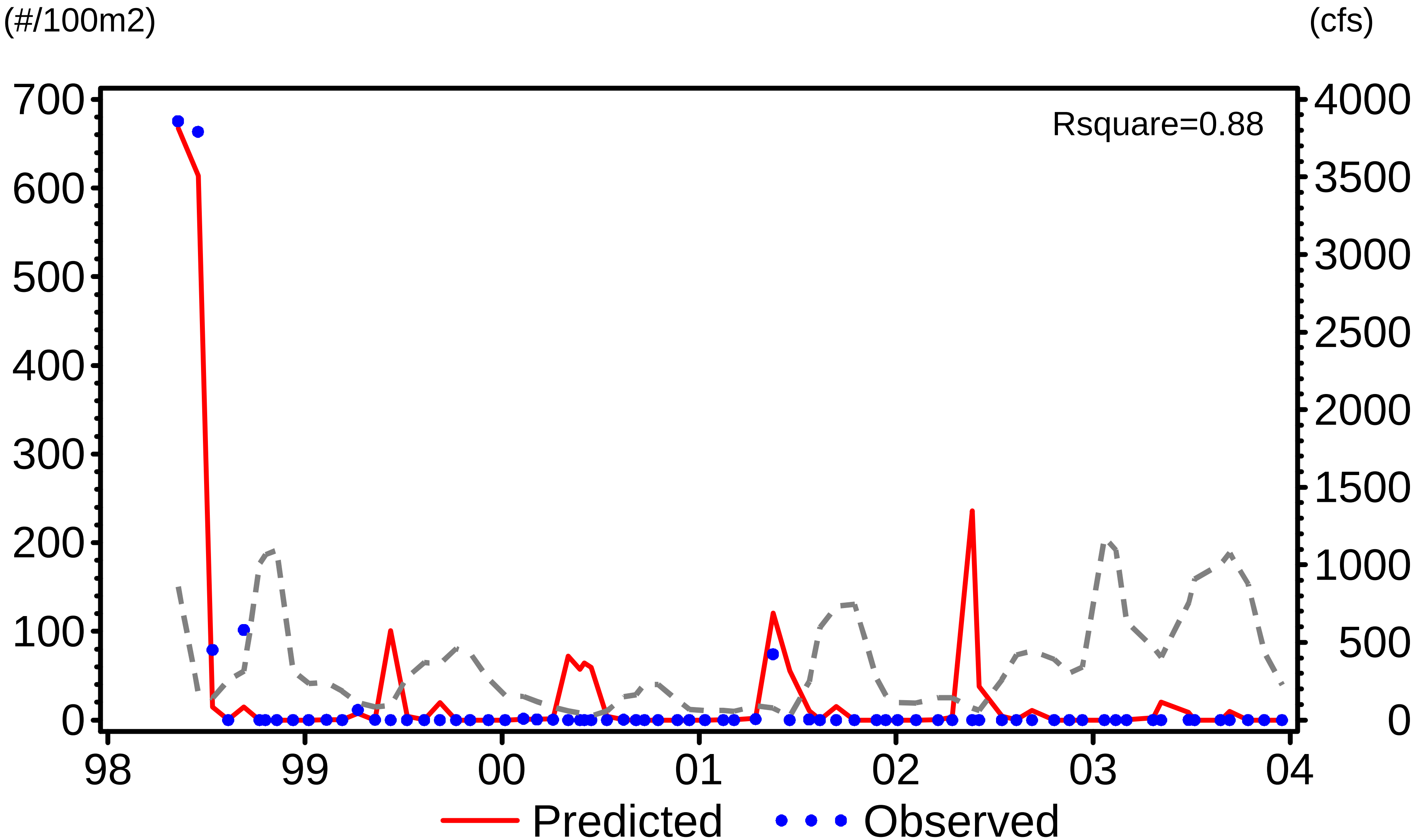


Figure L-19 Predicted vs. Observed Plots for Menhaden
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

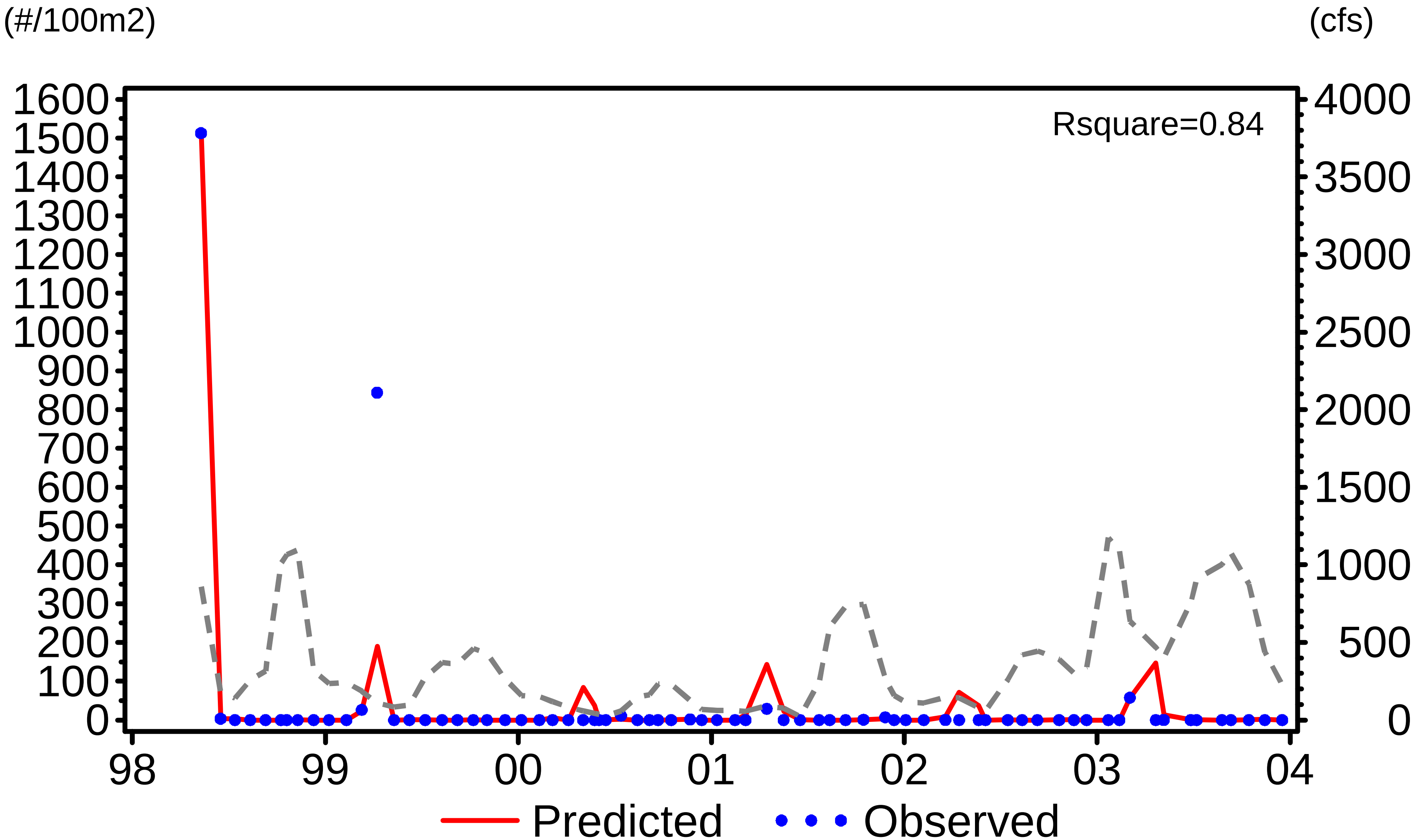


Figure L-20 Predicted vs. Observed Plots for Menhaden
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

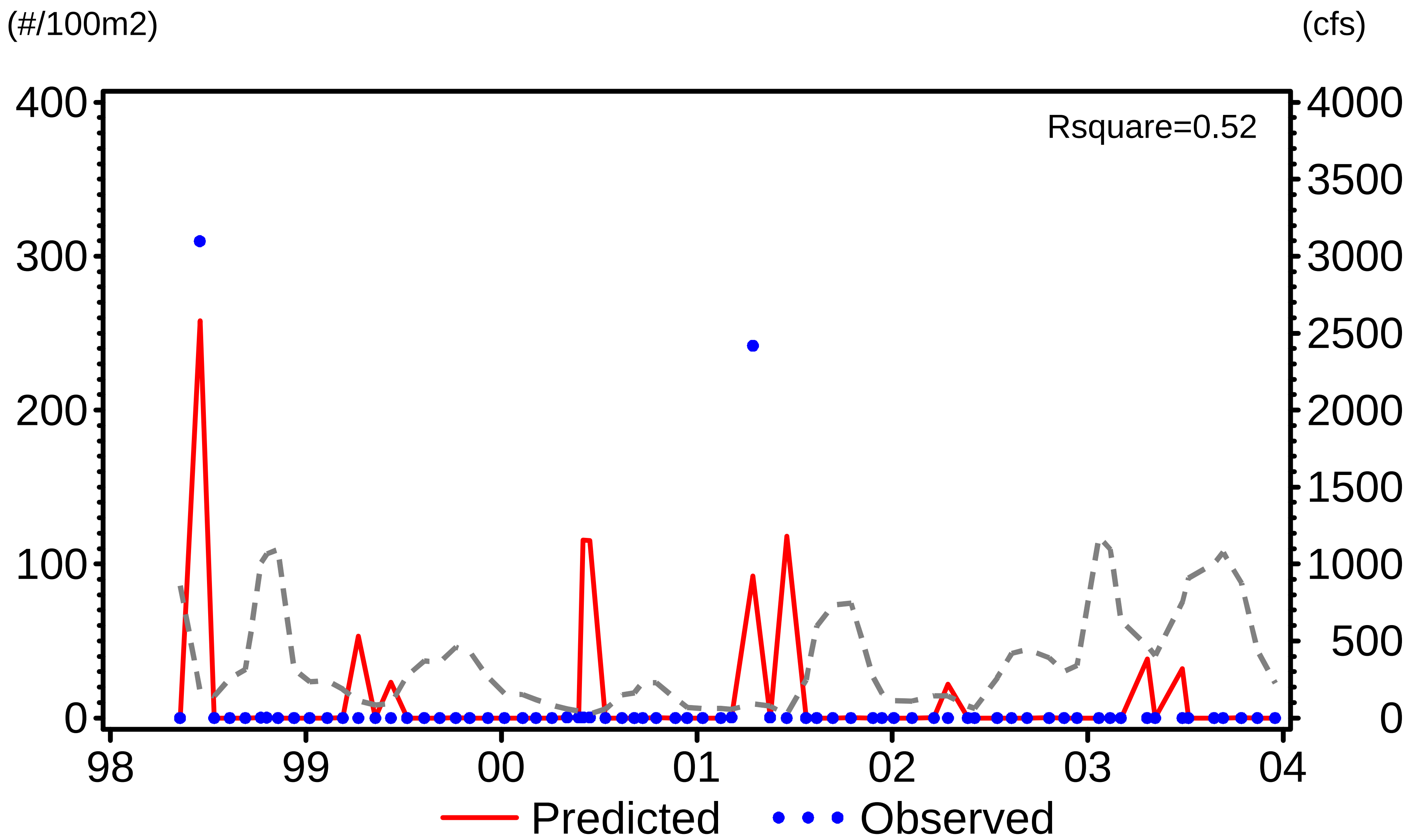


Figure L-21 Predicted vs. Observed Plots for Menhaden
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

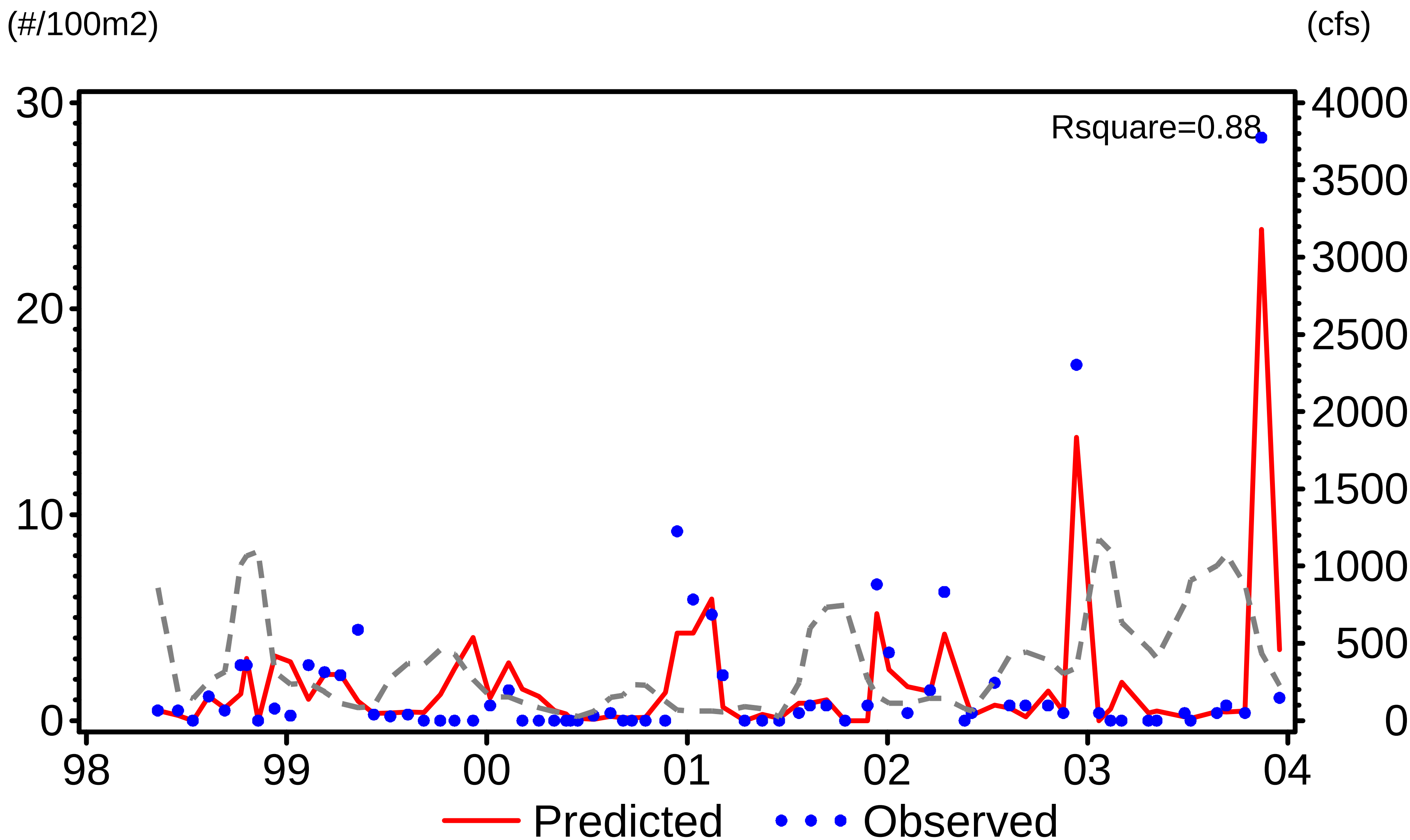


Figure L-22 Predicted vs. Observed Plots for Hogchoker
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

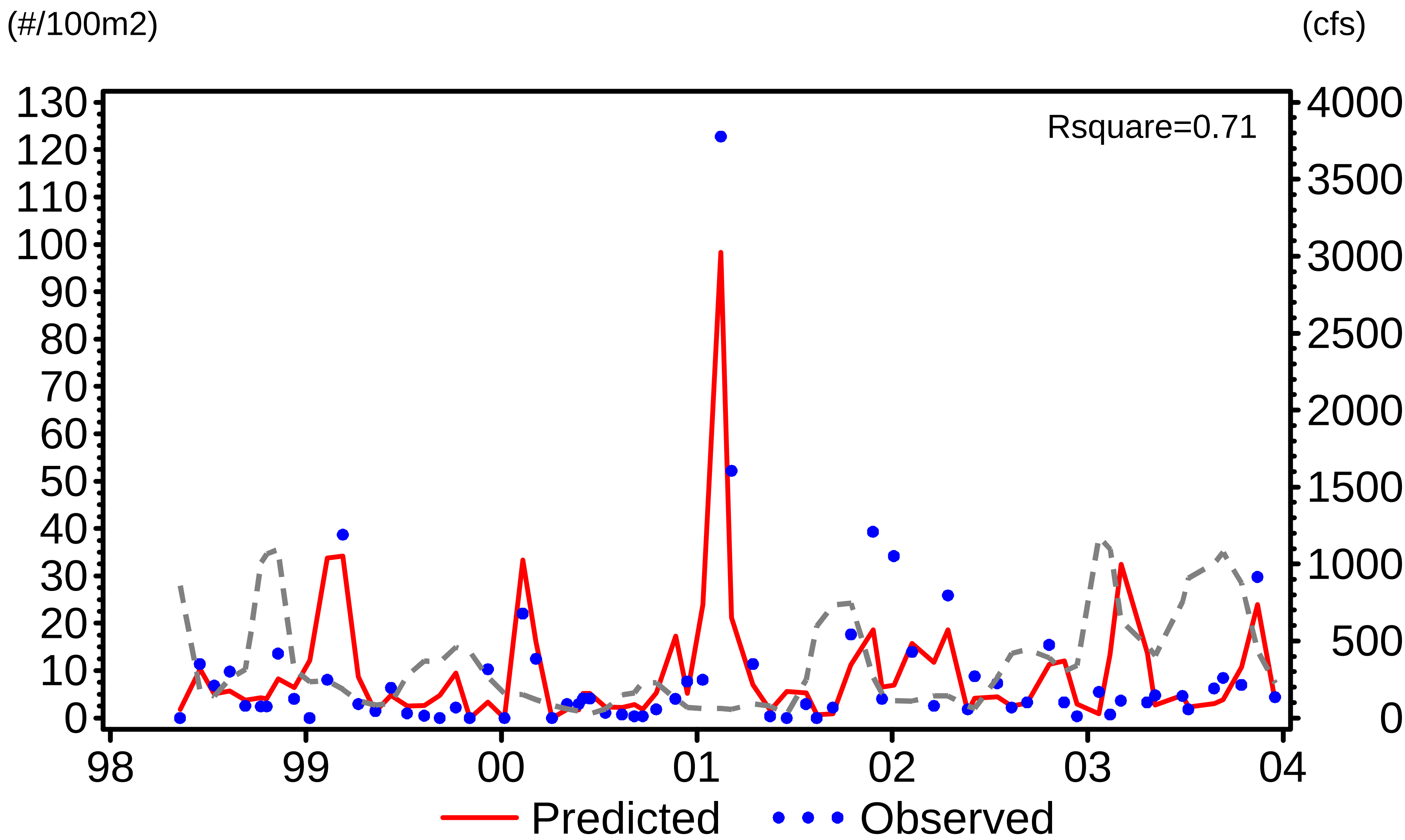


Figure L-23 Predicted vs. Observed Plots for Hogchoker
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

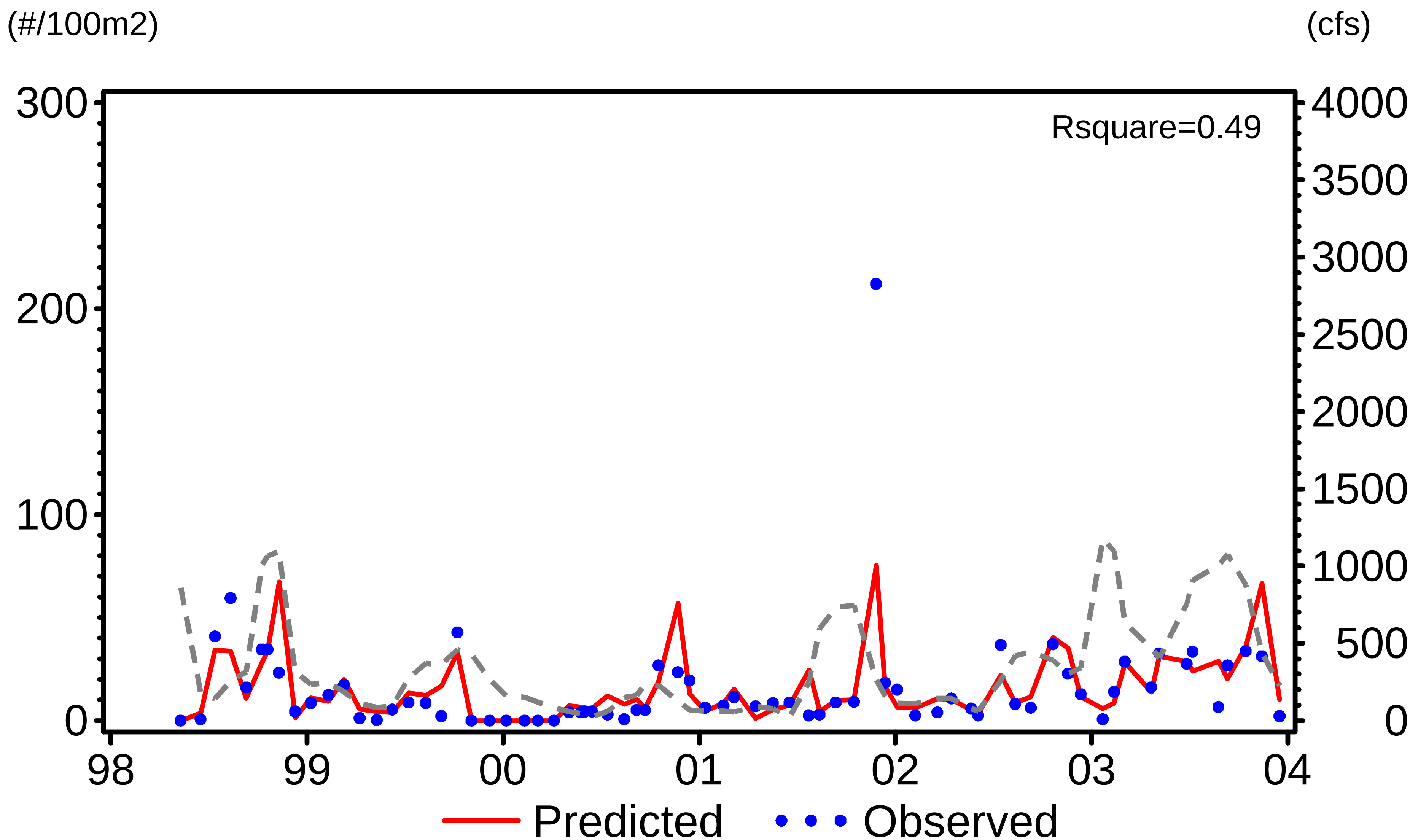


Figure L-24 Predicted vs. Observed Plots for Hogchoker Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

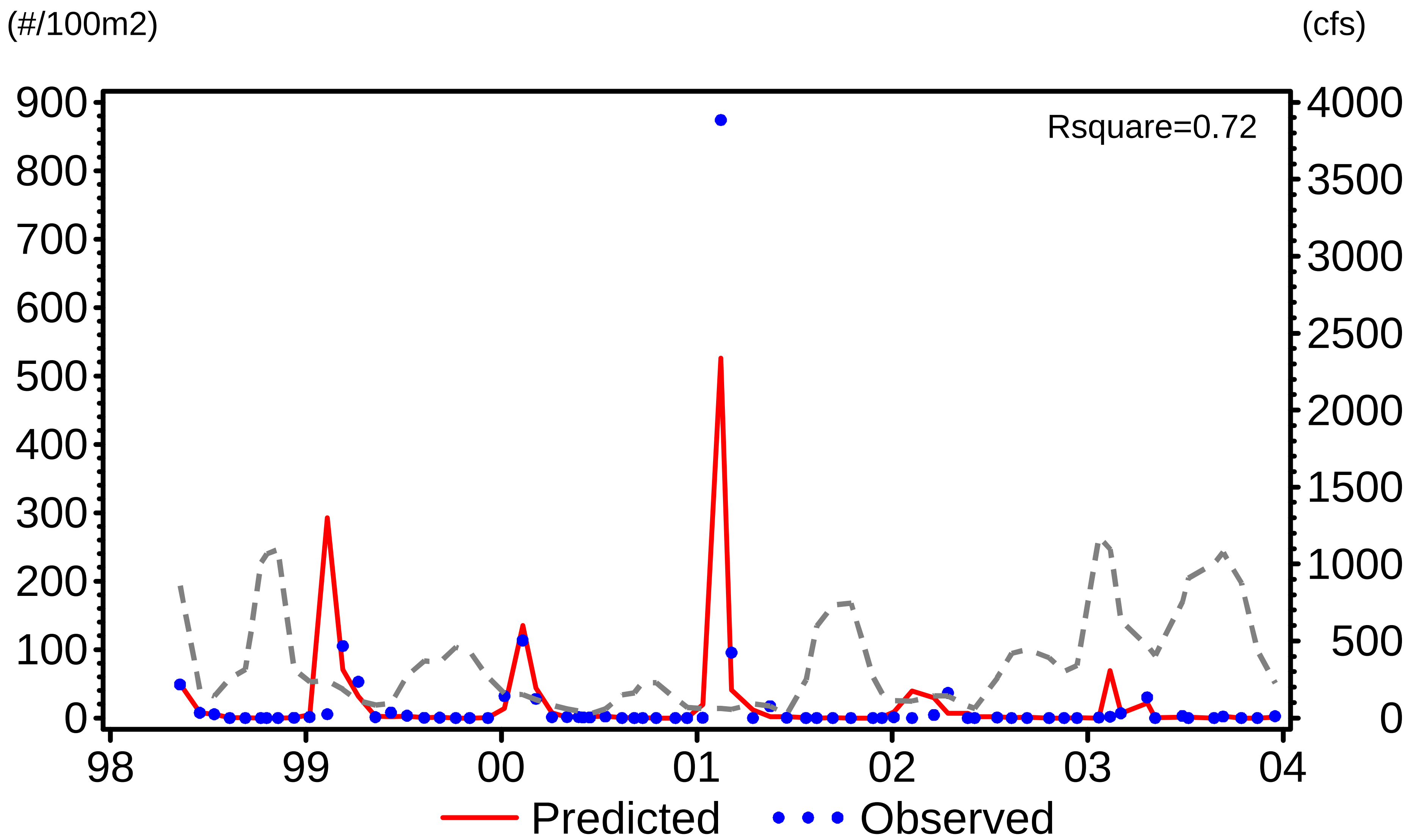


Figure L-25 Predicted vs. Observed Plots for Striped Mullet
Lower Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

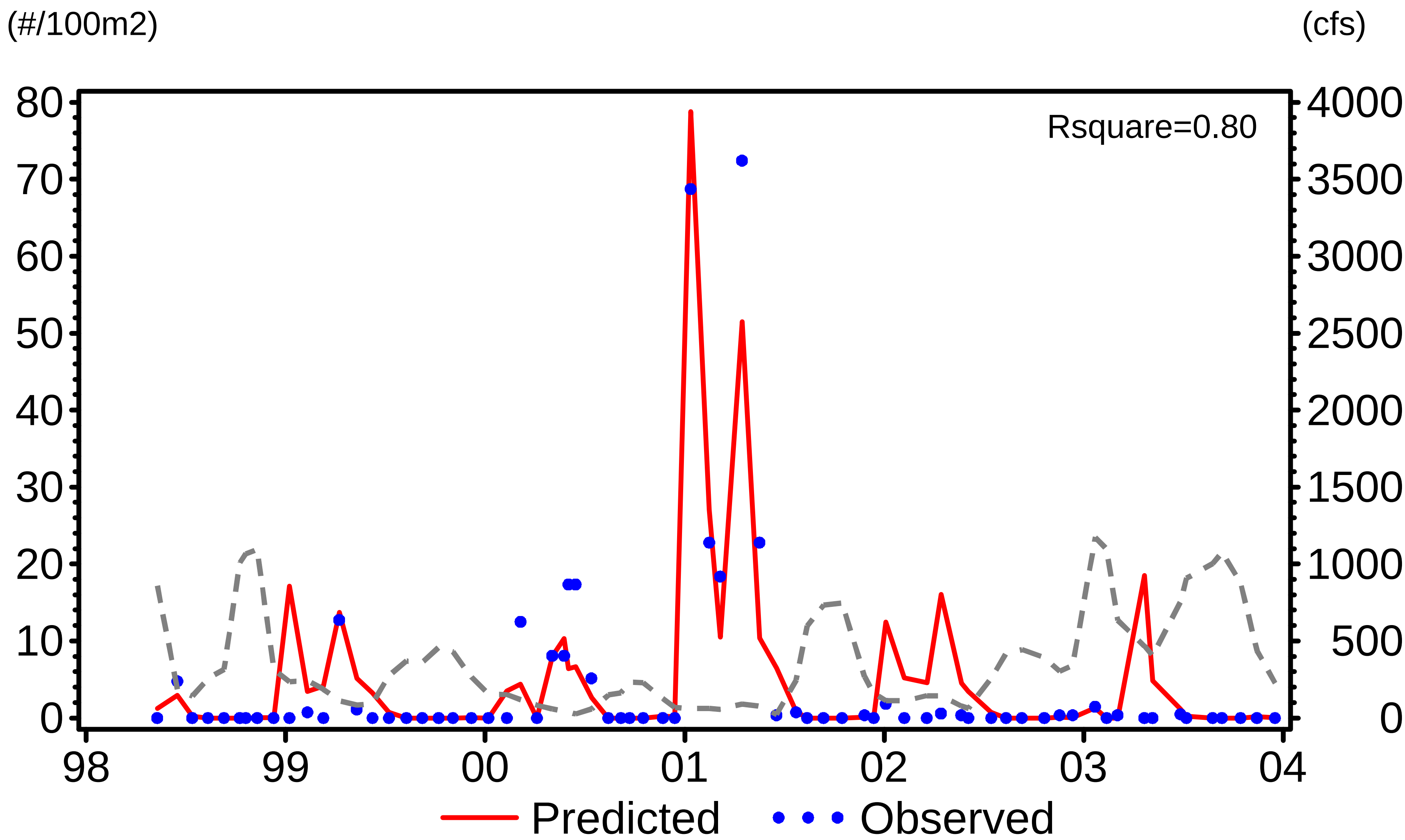


Figure L-26 Predicted vs. Observed Plots for Striped Mullet
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

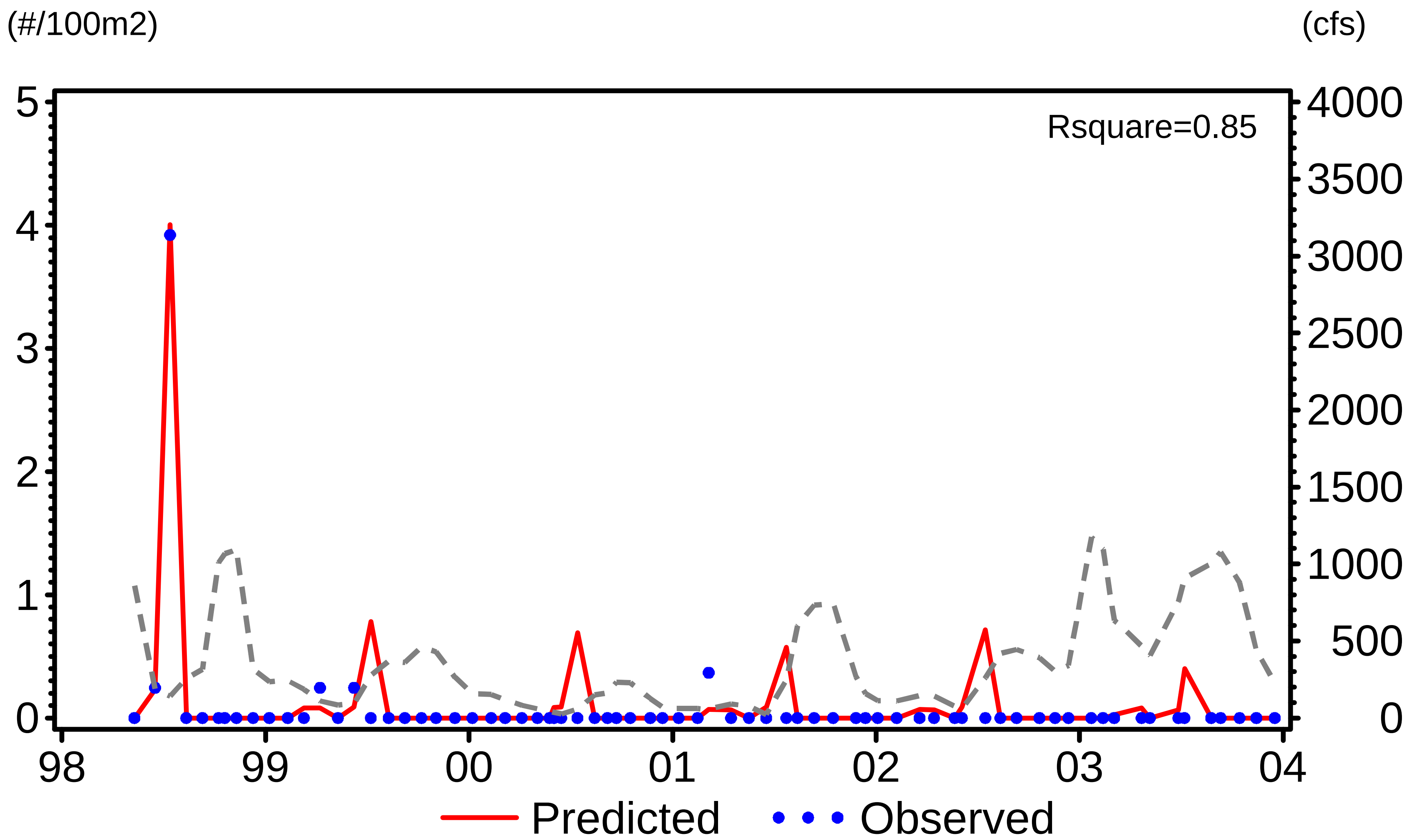


Figure L-27 Predicted vs. Observed Plots for Striped Mullet
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

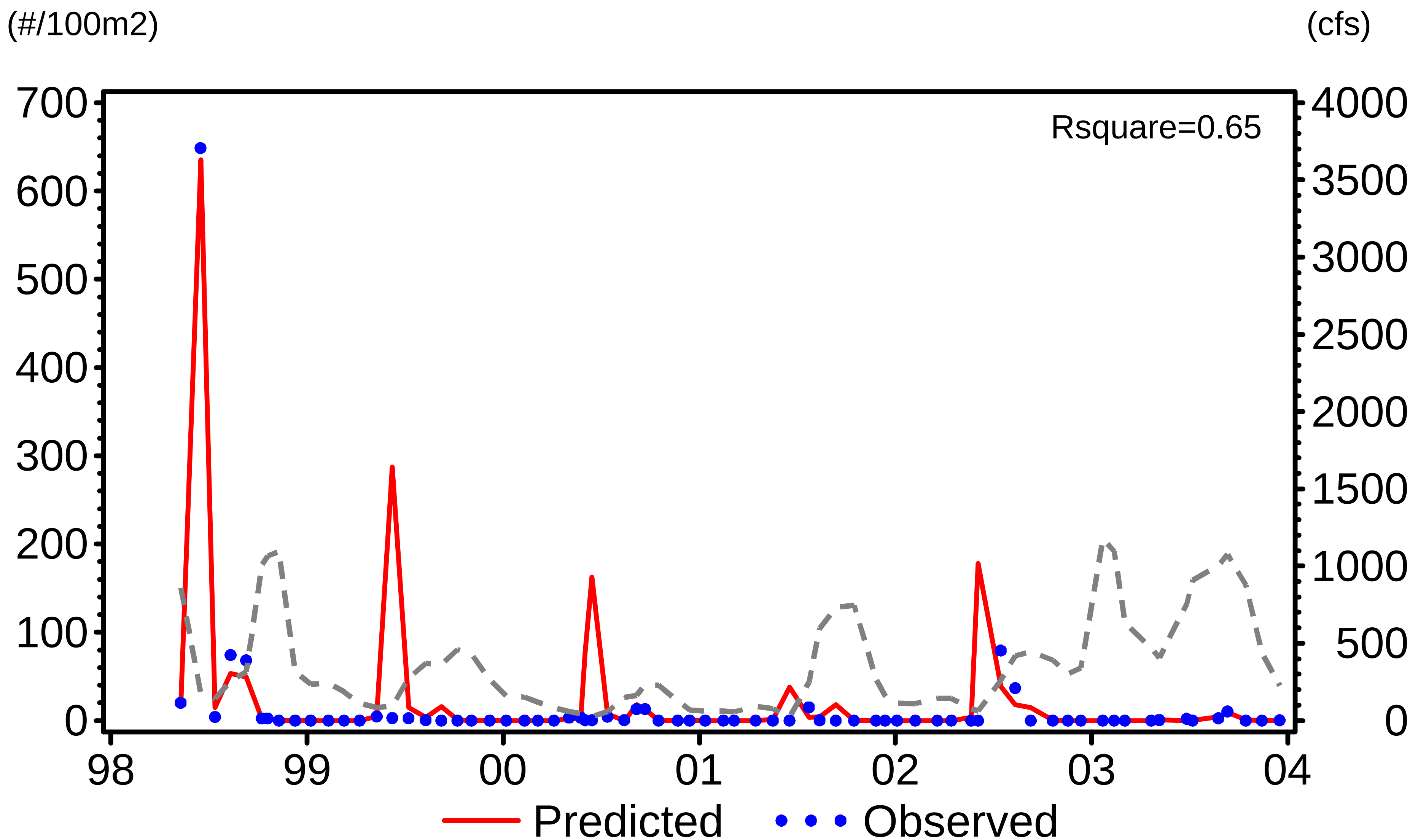


Figure L-28   Predicted vs. Observed Plots for Silver Perch
Lower Region of the Alafia River

Note: grey line =   previous 60 day average flow at Bellshoals Road

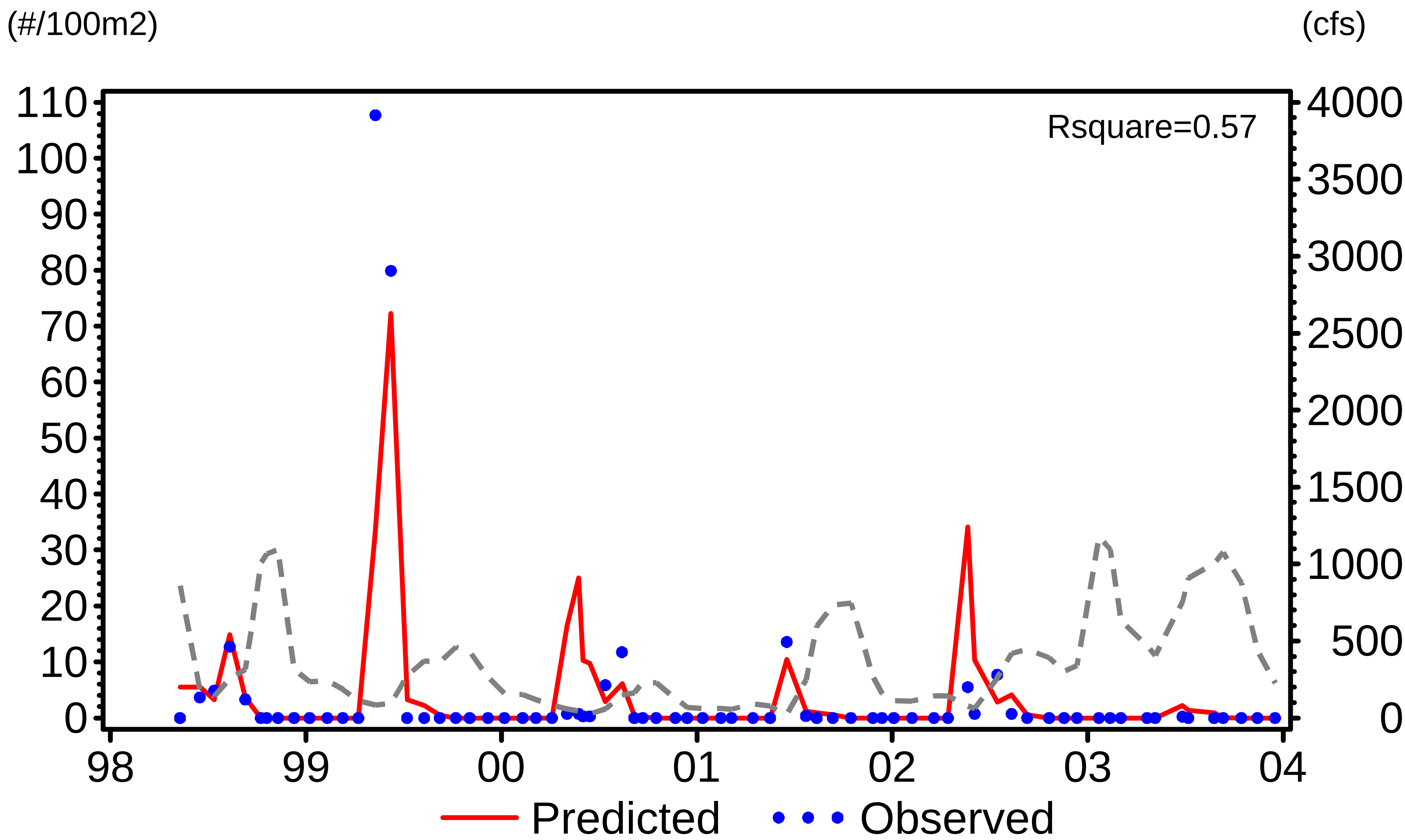


Figure L-29 Predicted vs. Observed Plots for Silver Perch
Middle Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

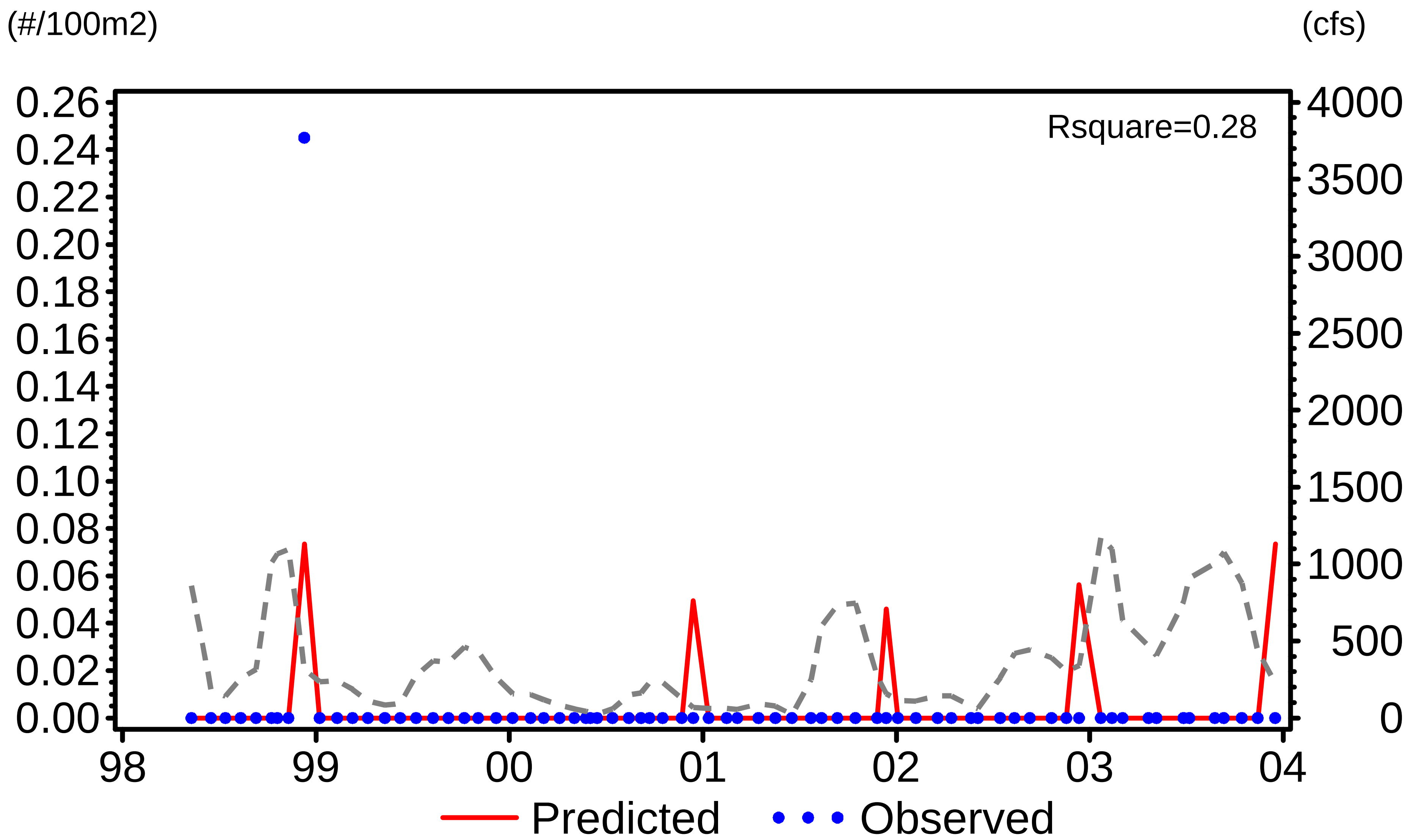


Figure L-30 Predicted vs. Observed Plots for Silver Perch
Upper Region of the Alafia River

Note: grey line = previous 60 day average flow at Bellshoals Road

APPENDIX M:
DATA SOURCES

I.. FLOW DATA:

1. United States Geological Survey (USGS)

Daily stream flow data for the period of record were obtained from the United States Geological Survey gage at Lithia (02301500). Flow used in this project was the estimated flow at Bell Shoals Road, which increases flow at Lithia to account for flows generated from the ungaged watershed area downstream between Lithia and Bell Shoals, and the contribution of Lithia Springs. The estimated Bell Shoals flow was used to remain consistent with flow data used in water withdrawal permitting for Tampa Bay Water's Water Use Permit.

The equation used to estimate the flow at Bell Shoals Road was:

$$Flow_{\text{Bell Shoals Rd}} = Flow_{\text{Lithia}} \times [(335\ m2 + 39.2\ m2)/335\ m2] + Flow_{\text{Lithia Springs}}$$

II. WATER QUALITY DATA:

1. Environmental Protection Commission of Hillsborough County (EPCHC)

The Environmental Protection Commission of Hillsborough County conducts a long-term ambient monitoring program for water quality. The goal of this program is to determine whether the level of water pollution is increasing or decreasing in the county and in Tampa Bay, and it has been in continuous operation since the early 1970's.

The EPCHC has been reviewing the monitoring program to determine any efforts that can be made to reduce sampling effort, and approaches this review process conservatively so as to not jeopardize the integrity of the long term database

Metrics:

- biological oxygen demand,
- chlorophylls (a, b, c, and total),
- fecal coliform,
- total coliform,
- color,
- conductivity,
- station depth,
- sample depth,
- Secchi disk depth,
- fluoride,
- metals (Pb, Fe, Ca, Mg, Na, K),
- nitrogen (NH4, Kjeldahl, NO2, NO3, organic),
- dissolved oxygen,
- dissolved orthophosphate,
- total phosphate,
- salinity,
- total suspended solids,
- air and water temperature, and
- turbidity.

Sampling Approach:

The EPCHC employs a systematic sampling approach using a series of relatively evenly spaced and fixed stations. Water quality samples are collected from a series of fixed stations throughout Tampa Bay in both Hillsborough and Pinellas County waters, and in the Hillsborough County tributaries to Tampa Bay. Some of the fixed stations are located in areas where they record relatively ambient conditions, and some of the fixed stations are located closer to point sources of pollutants.

III. BIOLOGICAL DATA:

1. Ichthyoplankton – Tampa Bay Water Hydrobiological Monitoring Program (HBMP)

Excerpt from the HBMP Year 3 Report (PBS&J, 2003):

Zooplankton data collected as part of the HBMP include invertebrate zooplankton (e.g., crab zoea) and ichthyoplankton (e.g., fish eggs and larvae). Zooplankton sampling is conducted monthly in the Alafia, Palm, and Hillsborough Rivers, and McKay Bay, by Dr. Ernst Peebles of the University of South Florida, Department of Marine Science, under contract to PBS&J. Zooplankton are sampled by towing a 500 µm Nitex mesh, 0.5 m mouth diameter, conical (3:1) plankton net. Standard deployment consists of a three-step oblique tow that divides the net's fishing time equally between bottom, mid-depth, and surface waters. The tow duration is 5 minutes at a boat speed of 1.0-1.5 m/s. Due to variability in ambient flow velocities and net clogging, the volume of water sampled during each tow ranges from approximately 30 to 70 cubic meters. Each tow is initiated from a fixed station located within the sampling strata of each reporting unit. A hexagonal grid system was overlaid on McKay Bay to create sampling strata for this non-linear reporting unit. Zooplankton sampling is conducted at night to minimize the effects of net avoidance. Sampling is conducted in all river strata except Alafia River stratum AR-7, and Hillsborough River stratum HR-6, due to the shallow water and the high incidence of bottom snags (e.g., rocks and logs). Additional information on the collection and processing of zooplankton samples is provided in the HBMP Quality Assurance and Quality Control Plan (PBS&J, 2002).

Zooplankton sampling was initiated in 2000. During the pre-operational period (May 2000 through December 2002), a total of 372 zooplankton samples were collected and processed for the Alafia River. Figure 3-5a shows the distribution of these samples by river kilometer. This figure illustrates that initiating zooplankton tows at fixed points within each sampling stratum results in some river kilometers (e.g., RKm 3, 5, 6, and 9) not being sampled. In addition, sample distribution in those river kilometers that were sampled was not even, with river kilometers 4, 7, and 8 being sampled most frequently. It should be noted that sample distribution by stratum was essentially even throughout the pre-operational period, and the uneven distribution of the sampling effort by river kilometer is a function of the fixed tow initiation points.

2. Fish – Tampa Bay Water Hydrobiological Monitoring Program (HBMP)

Excerpt from the HBMP Year 3 Report (PBS&J, 2003):

Fish data collected as part of the HBMP include juveniles and adults captured using two different types of gear: seine nets and trawl nets. Fish sampling is conducted monthly in the Alafia, Palm, and Hillsborough Rivers, and McKay Bay, by the Florida Marine Research Institute, Fisheries Independent Monitoring (FIM) program, under contract to PBS&J. Within the sampling strata of each reporting unit, two 21-m seines and one 6.1-m otter trawl samples are collected. Fish sampling generally follows standard FIM protocols with a few additions. Trawl nets are towed for five minute at idle speed over a distance of approximately 0.1 nautical mile. Seine net hauls with the 21-m seine are conducted using boat set seine procedures in the rivers, and offshore seine procedures in McKay Bay. The selection of sampling sites is made following a stratified-random design. In each of the rivers, primary sample sites within each stratum are selected from points that define a line down the middle of the river. An octagonal grid system was overlaid on McKay Bay to create this non-linear reporting unit. Fish sampling is conducted in all river strata except Alafia River strata AR-7 and the upper portion of AR-6, and Hillsborough River stratum HR-6, due to the high incidence of bottom snags (e.g., rocks and logs). Additional information on the collection and processing of zooplankton samples is provided in the HBMP Quality Assurance and Quality Control Plan (PBS&J, 2002).

Fish sampling was initiated in May 2000. During the pre-operational period (May 2000 through December 2002), a total of 519 fish samples were collected and processed in the Alafia River. Figure 3-6a shows the distribution of these samples by river kilometer. This figure indicates that sample distribution by river kilometer was fairly even up to RKm 11 where the total number of samples declines. This is due to logistical problems in sampling Alafia River stratum AR-6. When samples cannot be obtained in AR-6 due to excessively low or high water levels, or bottom snags, the sampling protocol calls for additional sampling in AR-5. The affect of this sampling protocol is shown in Figure 3-6a by the high number of samples in RKm 10.

3. Fish – Florida Fish and Wildlife Research Institute Fisheries Independent Monitoring Program (FWRI FIM)

Fish biological data were obtained from the Florida Marine Research Institute's Fisheries- Independent Monitoring Program (FMRI FIM). The FIM program directly samples the fish population, independent of commercial or recreational fisheries and records information on species abundance, length, and environmental/habitat variables at the sample site. Since 1996, monthly stratified-random sampling has been conducted year-round using several types of seines and trawls. Sampling is conducted throughout Tampa Bay and extends into the tidal portions of river tributaries (Figure 3.1.2). Due to changes in FIM's sampling program design in 1996, data collected before that time were precluded from our analysis due to concerns over consistency and comparability, as was suggested by FMRI staff (personal communication Tim MacDonald). Data from 1996 and 1997 were eliminated due to the reduced extent of sampling sites compared with later years. Additionally, data was collected during 2000-2002 as part of the HBMP program, mentioned previously. As a result, five years of fish biological data (1998-2002) were used for this study.

The Florida Marine Research Institute's (FMRI) Fisheries-Independent Monitoring Program (FIMP) was initially developed to assess the recruitment of resource species that use estuarine and near-coastal waters as nursery areas. The program is a long-term fisheries-independent monitoring of pre-fishery life stages of finfish stocks. However, it also collects information on other fishes and macroinvertebrates.

Metrics:

- Length-frequency,
- Age structure,
- Reproductive condition,
- Estimates of relative abundance
- Water temperature,
- Salinity,
- Conductivity, and
- Qualitative habitat data are also collected (i.e., presence of sponges in trawls, macroalgae).

Sites are randomly selected using a probability based stratified sampling design.