Final

Impingement and Entrainment Sampling for the Proposed Bell Bend Nuclear Power Plant at the SSES Circulating Water Supply System Intake Structure, Luzerne County, Pennsylvania

Submitted to:
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INTRODUCTION

This report presents the results of Impingement and Entrainment (I & E) sampling conducted by Normandeau Associates, Inc. and Ecology III at the existing Susquehanna Steam Electric Station (SSES) circulating water supply system intake structure pumphouse (CWIS) on the Susquehanna River (Figure 1). The I & E study plan was accepted by AREVA NP and UniStar Nuclear and was an addition to ongoing environmental studies to support the Bell Bend Nuclear Power Plant Combined License Application (COLA) Environmental Report (ER).

SSES withdraws water from the North Branch of the Susquehanna River for cooling water purposes. The river in the vicinity of the SSES CWIS is about 800-feet wide. The SSES intake structure is located on the west bank of the river and is parallel to river flow. The intake substructure consists of two water entrance chambers (11 x 11-ft) that house the traveling screens and two pump chambers. Each pump chamber houses two makeup pumps with maximum pumping rates of 13,500 gallons per minute (gpm) each. River water is drawn into the chambers, passes beneath a skimmer wall and then through 1.25-inch vertical bar screens (1-inch opening between bars) followed by 3/8-inch mesh wire traveling screens before entering a common wet pit area which houses the four makeup pumps. The intake flow velocity is perpendicular to and less than the river velocity. With three pumps in operation the velocity of water through both intake structure passages is 0.37 feet per second (ft/s) through the entrance openings, 0.58 ft/s through the clean bar screen openings at minimum river level, and 0.64 ft/s through the clean traveling screen openings at minimum river level.

Additional information describing the SSES‘s intake structure is available in EPA 316(b) Phase II Documentation for Susquehanna Steam Electric Station (PPL Susquehanna 2005).

Impingement occurs when fish and other aquatic organisms become trapped on intake screens at the entrance to an intake system. Entrainment occurs when aquatic

organisms, suspended in the water column, pass through the intake screens and are transported through the cooling water system. Impinged organisms are typically larger than the mesh size of the screening equipment and conversely entrained organisms are typically smaller than the mesh size of the screening equipment.

The one-year I & E study was initiated on April 22, 2008. Impingement and entrainment sampling was conducted to provide estimates of the species composition and number of organisms that may possibly be impinged and entrained at the future intake of the proposed BBNPP which is to be located approximately 300 feet downstream of the SSES CWIS (Figure 1). Impingement and Entrainment samples were collected on a weekly basis. The following sections describe the I & E study and results.

METHODS

Entrainment

The sampling frequency of the entrainment monitoring program was based on guidance provided by EPRI in *Entrainment Abundance Monitoring Technical Support Document* (EPRI 2005) and agency-approved entrainment studies conducted recently by Normandeau. Entrainment sampling was performed once per week from April 22 to August 13, 2008 and then again from March 17 to April 17, 2009. Both sampling periods conform to the spawning season for riverine fish species that live in the Susquehanna River in the vicinity of SSES. The additional sampling in 2009 was initiated one month earlier than 2008 to acquire additional entrainment data for fish that potentially begin to spawn earlier in the spring and which may not have been adequately sampled for in 2008.

Two entrainment samples were collected after sunset during each weekly sampling event. The first sample for each weekly sampling event began at approximately, but no earlier than, one hour after sunset. The second sample was collected starting about 2 hours after the first sample was completed. The samples were collected at either

SSES's submerged upstream or downstream intake openings at the River, so that the water from which the samples were taken was irreversibly committed to entering the power plant cooling system. At least one river water make-up pump for either Unit 1 or 2 was in operation during the entrainment sample. The operational status of the pumps determined where the entrainment sample was obtained. Samples were collected with a 4-inch pump that obtained sample water through a 4-inch diameter suction line positioned at mid-depth just in front of one of the intake openings through which river water entered into the pumphouse. Total target volume of each sample was approximately 28,000 gallons (100 m^3).

The intake pipe conveyed the sample water through a calibrated in-line flow meter and then to the pump. The throttle on the pump was adjusted to ensure a minimum pumping rate of approximately 240 gallons (0.9 m^3) per minute as measured on the in-line flow meter. Thus, a total of about 110 minutes or some 2 hours of pumping occurred to obtain a single sample. From the flow meter the sample was discharged through the 4-inch pipe into a plankton net (500-micron mesh) suspended in a large tank of water such that the velocity of water exiting the hose was reduced greatly before encountering the mesh of the net. The 500-micron mesh net was fine enough to capture the eggs, larvae and juveniles of all fishes likely to be encountered at SSES. The contents of the plankton net were rinsed down from the outside with ambient water and carefully transferred to sample containers. The samples were immediately preserved with 10 percent buffered formalin, labeled (both inside and out) and sent to Normandeau's laboratory for analysis.

The entire sample was processed for ichthyoplankton (eggs and larvae), and juvenile fish. Samples were sorted under magnification to ensure that all organisms were removed. The removed specimens were identified to the lowest taxon possible (generally species), and counted. Larvae and juveniles were categorized by life stage as prolarvae (yolk-sac larvae), postlarvae (post yolk-sac larvae), young-of-the-year (YOY), yearling or older, and unknown. The unknown life stage indicated that the larvae were damaged or the life stage could not be determined. Many of the unknown

life stage larvae were either prolarvae or postlarvae. The separation of these two life stages can be difficult if the specimens are damaged. A maximum of 20 individuals for each species and life stage category was measured for total length to the nearest 0.1 mm (nearest 1.0 mm for juvenile fish) within each sample.

In situ water quality measurements were collected in the Susquehanna River in front of the SSES CWIS. A calibrated YSI Sonde (Model 650) was used to determine water temperature, pH, dissolved oxygen, and conductivity prior to and after the collection of each entrainment sample.

Fish entrainment estimates were calculated for each week of sampling. These estimates were based upon the mean density of each taxon which was calculated from the two entrainment samples collected during each week. Density was calculated by dividing the actual number of each taxon in a sample by the volume of water filtered through the sampling net. Mean density for each week was determined by summing the density of each taxon in the two samples and dividing by two. To estimate entrainment for the week mean density was multiplied by the total volume of water withdrawn from the river by the SSES CWIS for a 7 day period. A standard volume of 40,500 gallons per minute (PPL, 2006) which equates to 58.32 million gallons per day (mgd) was used for the total volume of water withdrawn from the river by the SSES CWIS. The estimated weekly entrainment for each taxon was then summed for the entire sample period to determine the estimated number of fish entrained.

Impingement

The impingement monitoring program was based on guidance provided by Electric Power Research Institute (EPRI) in *Impingement Abundance Monitoring Technical Support Document* (EPRI 2004) and on Normandeau's experience performing several recent impingement sampling studies at other cooling water intake structures in Pennsylvania and elsewhere. Impingement sampling was performed over one 24-hour sampling event per week beginning on April 22, 2008 and continued until April 20, 2009.

Weekly sampling events were scheduled for the same day each week to assure regular spacing of the events. If either planned or unanticipated events interfered with this schedule, an adjustment of a day or two was necessary. At least one river water make-up pump for SSES Unit 1 or 2 was in operation during impingement sampling. Note that impingement sampling was suspended from June 11 to August 11 as a result of intake maintenance.

Each 24-hour sampling event was subdivided into 12-hour, predominantly day/night periods to the extent feasible to allow for determination of day/night differences and to ensure that debris or large numbers of fish did not overflow the sampling baskets. Each sampling event was initiated by operation of the screens for at least 15 minutes to clean them of previously impinged organisms. After the cleaning run, a clean basket with mesh size of 0.125-inch was installed in the debris trough serving each SSES Unit. The basket was used to capture the debris and impinged organisms from the screen cleanings during the impingement sampling event

For each sample collection period, all fish were separated from the debris, identified to species, and enumerated. All fish were measured for total length to the nearest millimeter. If there were two size groups for a species (e.g., young of the year and older) then each size group was enumerated separately. Condition of impinged fish was categorized as alive, dead (freshly killed), dead (injured), or dead & decomposing (e.g. rotting, fungus covered). The determination was made based on visual inspection of the fish.

Other aquatic and/or semi-aquatic species observed in the impingement samples (including crustaceans, invertebrates, amphibians, reptiles, waterfowl and/or aquatic / semi-aquatic mammals), were also documented.

In situ water quality measurements were collected in the Susquehanna River in front of the SSES CWIS. A calibrated YSI Sonde (Model 650) was used to determine water

temperature, pH, dissolved oxygen, and conductivity prior to and at the completion of each 12-hr impingement sampling event.

Total impingement was calculated by first determining the daily impingement rate over the entire study period. Daily impingement rate was determined by dividing the total number of fish and crayfish impinged by the number of sampling days. Daily impingement was then multiplied by 365 days to determine the total annual impingement, assuming the SSES and its CWIS were fully operational for the entire period.

RESULTS

Water Quality and River Discharge

Entrainment 2008

Susquehanna River water temperature during the 2008 entrainment sampling program ranged from 11.9 to 27.7 ºC (Table 1). Water temperature during the start of the study was cool, actually decreasing slightly from April to the end of May. From the end of May through mid-June water temperature increased and then cooled slightly by mid-August (Figure 2). Water temperatures were coolest in April and May and warmest during July.

Susquehanna River water pH during the 2008 entrainment sampling program ranged from 6.9 to 8.6 (Table 1). Values for pH were generally greater than 8 during April and May and decreased to between 7 and 8 (except for one sample date which was below 7) for the remainder of the study period (Figure 3).

Susquehanna River water conductivity during the 2008 sampling program ranged from 247 to 395 microsiemens per centimeter (µS/cm) (Table 1). Conductivity was lower in April and May and generally increased during the beginning of June and then remained stable until the end of July (Figure 4). Conductivity decreased during the end of July,

coincident with higher river flows, and then generally increased until the end of the sampling period.

Dissolved oxygen (DO) in the Susquehanna River during the 2008 sampling program ranged from 5.9 to 12.4 milligrams per liter (mg/l) (Table 1). The observed DO values generally decreased from the beginning of the sampling period through mid-July and then were variable through the end of the study period (Figure 5).

Susquehanna River discharge data was available from the USGS gaging station located in Wilkes-Barre, Pennsylvania, which is approximately 20 miles upstream of the SSES. Mean daily discharge data was downloaded for both the 2008 entrainment sampling period and for the period of record at the Wilkes-Barre Station (1899 to 2007). The period of record mean flows are useful for comparing the 2008 flows to long-term flows in the River.

River discharge during the 2008 entrainment sampling period ranged from 2,030 to 13,500 cubic feet per second (cfs). Flows were above 10,000 cfs for much of April and May and then generally decreased through the end of July (Figure 6). On July 26 flows increased to 11,000 cfs and then steadily decreased through the end of the study period. No flood events occurred during the 2008 entrainment sampling program.

Flows in 2008 followed a pattern similar to the period of record mean flows with higher flows in the spring generally decreasing through the summer. Mean flows in 2008 were lower than the period of record mean flows for most of the study period.

Entrainment 2009

During the 2009 entrainment sampling period Susquehanna River water temperature ranged from 5 to 8.8 ºC. Temperatures during 2009 were lower than 2008 as result of sampling occurring one month earlier than during 2008. For 2009 pH ranged from 7.6 to 8.3, comparable to the values observed during the 2008 entrainment study. Susquehanna River conductivity ranged from 185 to 251 µS/cm during the study period.

Conductivity during 2009 was lower than values observed during the 2008 program. Dissolved oxygen measured in the Susquehanna River ranged from 11.5 to 13.5 mg/l. Values for DO in 2009 were comparable to those observed during 2008. River discharge during the 2009 sampling period ranged from 11,500 to 31,200 cfs. Flows were lower than the period of record mean for the entire sample period. Two small spates occurred during the sample period, one in mid-March and one in the beginning of April.

Impingement Sampling

Susquehanna River water temperature during the impingement sampling program ranged from 0.5 to 27.8 ºC (Table 2). Water temperatures were coolest in January and February and warmest during June and August (Figure 7). During the initial months of the study period temperatures were relatively stable ranging between 15-18 ºC. Then from June through July temperatures rapidly increased. From mid-September through the winter months temperatures steadily declined. Water temperature then increased sharply from mid-March to the end of the sampling program.

Susquehanna River water pH during the impingement sampling program ranged from 6.6 to 8.7 (Table 2). Most values for pH were between 7 and 8 (Figure 8).

Susquehanna River water conductivity during the impingement sampling program ranged from 144 to 471 µS/cm (Table 2). Conductivity was generally highest in the summer and fall and lowest in the spring and winter (Figure 9).

Dissolved oxygen in the Susquehanna River during the 2008 sampling program ranged from 8.0 to 17.7 mg/l (Table 2). The observed DO values were generally between 8 and 12 mg/l from April through October and then were greater than 12 mg/l from November through March (Figure 10).

River discharge during the impingement sampling period ranged from 1,340 to 75,500 cfs. Flows were above 10,000 cfs for much of May and then decreased below 5,000 cfs

from June through October (Figure 11). From November through the end of the sample period flows were generally greater than 10,000 cfs with several high flow events during this interval.

Flows during the sample period followed a pattern similar to the period of record mean flows. Mean flows during April through mid-October were lower than the period of record mean flows. Flows from mid-October through March were comparable to the period of record with the exception of several spates that occurred during this interval.

Entrainment

2008 Sampling Program

Thirty-four entrainment samples were collected during the 17 week sampling period which extended from April 22 to August 13. Average sample volume was 29,353 gallons (standard deviation 383 gallons) with a total of 997,986 gallons filtered for the entire period. The first sample of each day began at around 21:00 hours and the second at about 01:00 hours.

A total of 17 species and 3,039 fish was collected in the 34 samples (Table 3). Quillback (27.2%), Cyprinidae (17.6%), unidentified darter (12.6%), channel catfish (12.1%), common carp (11.4%), and white sucker (9.4%) were the numerically most abundant taxa. Other species that were collected include brown bullhead, chain pickerel, margined madtom, shield darter, rock bass, smallmouth bass, walleye, tessellated darter, banded darter, and yellow perch.

Temporal variation in fish entrainment was evident with a majority of the fish being collected from the first week in May to mid-June (Table 4, Figure 12). Few fish were collected in entrainment samples during April. The number of entrained fish was variable during July and August with two larger collections occurring during the first week in July and the first week of August. The single largest entrainment sample collection occurred on May 6 when 250 individuals were collected.

Of the entrained fish, 1,346 were measured for total length. A majority of these were Cyprinidae, quillback, and unidentified darter (Table 5). Mean length for entrained fish was 9.8 mm (standard deviation of 6 mm). Most of the entrained fish ranged in total length from 5 to 20 mm (Figure 13). The overall length range for entrained fish was between 4 mm (Cyprinidae) and 76 mm (shield darter) (Table 5).

A majority (55.9%) of the entrained fish were larvae in the post yolk-sac life stage (Table 6). Yolk-sac larvae was the second most abundant life stage, comprising 17.0% of all individuals, with the numbers of YOY and the unknown life stage also being substantial, 14.1% and 12.9%, respectively. Only four yearling-plus individuals were collected, and no fish eggs were collected in the entrainment samples.

The overall estimated number of fish entrained was 13,324,384 individuals (Table 7). Cyprinidae was estimated to be the most abundant taxon entrained comprising 21.5% of the total entrainment estimate. Other abundant taxa included channel catfish (19.3%), quillback (16.2%), unidentified darter (12.3%), white sucker (9.8%), and common carp (6.7%).

A brief discussion of entrainment characteristics for abundant taxa and recreationally important species (RIS) follows. Taxa are artificially grouped into two categories: (RIS) and Non-RIS. Non-RIS include forage species and species not typically targeted by most anglers.

RIS

Channel catfish

A total of 367 channel catfish was collected during 2008 entrainment sampling. All of the individuals were YOY. Channel catfish was collected from the end of June to the first week in August in a total of 10 samples (Figure 14). Most of the individuals were collected during a two-week period from the end of June to the first week in July. Estimated channel catfish entrainment for the 2008 sample period was 2,570,361

individuals. Mean total length of channel catfish was 16.9 mm and ranged between 14 and 23 mm.

Smallmouth bass

A total of 62 smallmouth bass was collected in entrainment samples. Sixty of these were post yolk-sac larvae and two YOY individuals were also collected. Smallmouth bass was collected from the first week in June to the second week in July in a total of seven samples (Figure 15). Most of the individuals were collected on June 10 and 11. Estimated entrainment of smallmouth bass was 427,672 individuals. Smallmouth bass ranged in total length between 9 and 55 mm with mean length of 14.4 mm.

Walleye

Thirty-seven walleye were collected in entrainment samples. Of these, 31 were post yolk-sac larvae and six were yolk-sac larvae (Table 6). Walleye was collected from the last week in April through the first week in May in a total of five samples. Most of the individuals were collected on April 29 and 30 (Figure 16). Walleye entrainment was estimated at 171,869 individuals over the study period. Total length of walleye ranged between 9.5 and 15.6 mm with mean length of 11.0 mm.

Rock bass

A total of 41 rock bass was collected in entrainment samples. Forty individuals were yolk-sac larvae and one YOY was collected. Rock bass was collected from the second week in June to the third week in July in a total of 10 samples (Figure 17). Over half of the individuals were collected on June 10 and 11. Estimated rock bass entrainment was 285,177 individuals. Rock bass mean total length was 7.8 mm with range between 6.4 and 14.0 mm.

Yellow perch

Fifty-two yellow perch was collected during the 2008 entrainment sampling program. Two life stages were present with a majority of the individuals being post yolk-sac larvae (n=48) and only a few (n=4) yolk-sac larvae were collected. Yellow perch was collected

sporadically throughout the study from the end of April to the second week in July (Figure 18). A majority of the individuals were collected during the last two weeks in June. Yellow perch entrainment was estimated to be 308,528 individuals during the study period. Mean total length of yellow perch larvae was 7.7 mm with range between 5.9 and 13.4 mm.

Non-RIS

Common carp

A total of 345 carp was collected in entrainment samples during 2008. Of which, 179 were post yolk-sac larvae, 161 were unknown life stage, and five were yolk-sac larvae. Carp was collected in a total of seven samples from June 3 to July 30 (Figure 19). Most of the carp were collected during two sampling events on June 3 and 4 in which 195 and 139 individuals were collected, respectively. The estimated carp entrainment during the study period was 894,149 individuals. The mean total length of carp larvae was 6.6 mm with the length range between 5.3 and 10.1 mm.

Cyprinidae

For the purposes of categorizing entrained organisms this grouping encompasses the native minnows including spottail, spotfin and common shiners. Of the total of 535 cyprinids collected during 2008, 495 were post yolk-sac larvae and 40 were yolk-sac larvae. Cyprinids were collected from the end of April through the end of the sampling period in a total of 25 samples (Figure 20). A majority of the cyprinids were collected during the last four sample collections in August. Cyprinids comprised 97% of the all fish entrained during this interval. This group was the most frequently occurring taxon during the sampling period and nearly half of the individuals were collected during August. Estimated entrainment of cyprinids was 2,863,110 individuals during the study period. Cyprinid total length ranged from 4 to 14.5 mm with mean length of 6.1 mm.

Quillback

Quillback was the most abundant fish in entrainment samples with a total of 828 individuals collected. Over half of the individuals (n=433) were post yolk-sac larvae with

nearly equal numbers of yolk-sac larvae (n=202) and unknown life stage (n=190). The only other life stage collected was YOY, with a total of three individuals. Quillback was collected from the first week in May to the second week in June in a total of 12 samples (Figure 21). The largest single sample collection occurred on May 7 when a total of 196 individuals was collected. The estimated entrainment of quillback was 2,164,020 individuals over the sample period. Total length range of quillback larvae ranged from 5.4 to 21 mm with mean length of 8.9 mm.

Unidentified darter

This grouping includes larval darters that were unable to be identified to species and likely includes three species (tessellated, shield and banded darter). A total of 382 unidentified darter was collected in entrainment samples. Of these, 246 were yolk-sac larvae, 105 were post yolk-sac larvae, and 31 were unknown life stage. This group was collected from the third week in April to the second week in June in a total of 14 samples (Figure 22). Estimated entrainment of unidentified darter was 1,644,738 individuals over the sample period. Mean total length of this group was 5.8 mm with length range between 4.4 and 10.4 mm.

White sucker

A total of 286 white sucker was collected in entrainment samples. A majority of these individuals were post yolk-sac larvae (n=256) with YOY (n=19) and yolk-sac larvae (n=11) also being collected. White sucker was collected from the last week in April to the third week in June in a total of 15 samples, with most of the individuals being collected in June (Figure 23). Estimated entrainment of white sucker over the study period was 1,299,692 individuals. Mean total length of white sucker was 16.6 mm with range between 8.7 and 35 mm.

2009 Sampling Program

A total of 10 entrainment samples was collected during the 5-week sampling period, March 17 through April 17. Average sample volume was 29,124 gallons (standard

deviation 286 gallons) with a total of 291,239 gallons filtered for the entire period. The first sample of each day began around 21:00 hours and the second around 01:00 hours.

A single Catostomidae egg was collected in entrainment samples during the 2009 sampling program. The egg was collected on April 17, the last entrainment sampling event during 2009. Based on the catostomid species collected in the 2008 entrainment sampling program it is likely the egg was either a white sucker or quillback. Estimated entrainment during the 2009 sampling period was 7,022 catostomid eggs.

Impingement

Impingement sampling was performed on 45 days from April 20, 2008 to April 22, 2009, with sampling suspended from June 11 through August 11 due to intake maintenance. Each weekly 24-hr sampling event was subdivided into a 12-hr sample for "day" and a 12-hr sample for "night". However, these periods were not strictly characterized by daylight or darkness (seasonal variations in the timing of sunrise and sunset were not accounted for). The day sample usually was started at approximately 08:00 hours and the night sample at approximately 20:00 hours.

Over the entire sampling period a total of 398 fish and crayfish was collected (Table 8). Crayfish (*Orconectes* sp.) was the dominant organism, with 220 individuals representing 55.3% of the total number collected. The remainder of the impingement catch was composed of 178 fish representing 18 species. The most abundant fish was bluegill, representing 11.1% of the total. Other fairly abundant fish, as a percentage of the total impingement, were rock bass (8.5%), channel catfish (7.8%), tessellated darter (4.5%), and spotfin shiner (4.0%). Other species that represented at least 1% of the total catch included spottail shiner, margined madtom, smallmouth bass, white crappie, and white sucker.

The impingement catch was low throughout the study period with little week-to-week variation (Figure 24). Impingement catch was highest during a period from mid-February through April. A maximum of 42 fish and crayfish was collected during a

single 24-hr sampling period on March 31. Fish or crayfish were collected on each collection date except for December 30.

For comparison of impingement over time, impingement catch was evaluated by month and species (Table 9). The largest monthly total catch occurred in March when 104 individuals were collected. Of these, 78 were crayfish and 26 were fish. Crayfish was collected in all months except January. Crayfish impingement was relatively high in August 2008 and March and April 2009. Fish impingement was greatest in November when 33 fish were collected, of these 27 were bluegill. Other months with relatively high fish impingement were October (n=27), February (n=29), and March (n=26).

Similar numbers of organisms were collected during the day (47%) and at night (53%). Most of impinged organisms were either alive (39%) or fresh dead (55%) with few organisms dead and decomposing (6%) and no fish categorized as injured and dead. Mean total length and total length ranges of fish collected during impingement sampling are given in Table 10. Overall, impinged fish ranged in total length from 40 mm (bluntnose minnow) to 381 mm (northern hog sucker).

It is unlikely that the suspension of sampling from June to August had a major impact on the overall results of the impingement study. During this period there was little chance of the sampling missing an important species or large impingement event. There are no fish species that would have been present during this time period only and not during the remainder of the year (e.g. migratory species). Higher impingement events typically occur during periods when water temperatures sharply decrease or in association with major flooding events. Neither of these situations occurred during the suspension of impingement sampling.

Impingement was estimated for the entire year (365 days) from April 2008 to April 2009. The total annual impingement at SSES was 3,228 fish and crayfish. This equates to an average of 8.8 fish and crayfish per day and approximately 264 fish and crayfish per

month (30 days). Average estimated impingement for fish only was 3.95 per day, 120 per month and 1,442 per year.

No endangered, threatened, or species of special concern were collected in the impingement or entrainment samples. In addition, no migratory species (American shad or American eel) were collected in the impingement or entrainment samples.

REFERENCES

EPRI. 2004. Impingement Abundance Monitoring Technical Support Document. EPRI Report No. 1008470. Palo Alto, CA.

EPRI. 2005. Entrainment Abundance Monitoring Technical Support Document. EPRI Report No. 1011280. Palo Alto, CA.

PPL Susquehanna. 2005. Appendix A, EPA 316(b) Phase II Documentation. NPDES Renewal Application. Permit No. PA 0047325. PPL Susquehanna, LLC.

PPL Susquehanna. 2006. Susquehanna Steam Electric Station Extended Power Uprate Supplemental Environmental Report, March 2006.

Table 1. Descriptive statistics for temperature, pH, conductivity, and dissolved oxygen measured in the Susquehanna River at the SSES CWIS during entrainment sample collections, April 22 to August 13, 2008.

	Temperature (°C)		
Month	mean	minimum	maximum
April	15.4	14.3	16.8
May	15.3	11.9	19.3
June	23.4	21.3	27.2
July	25.5	22.9	27.7
August	24.2	22.2	26

	pH		
Month	mean	minimum	maximum
April	7.8	7.3	8.1
May	8.3	8	8.6
June	7.7	7.3	8
July	7.7	6.9	8
August	7.8	7.5	7.9

	Conductivity (µS/cm)		
Month	mean	minimum	maximum
April			
May	262.3	247	284
June	356.1	333	372
July	351.5	249	395
August	329.1	308	349

	Dissolved Oxygen (mg/l)		
Month	mean	minimum	maximum
April	11.0	10.6	11.7
May	11.1	10.3	11.9
June	9.3	7.8	10.8
July	8.2	5.9	8.9
August	9.6	6.9	12.4

Table 2. Descriptive statistics for temperature, pH, conductivity, and dissolved oxygen measured in the Susquehanna River at the start of each impingement sample, April 22, 2008 to April 20, 2009.

	Temperature (°C)		
Month	Mean	Minimum	Maximum
January	1.5	0.7	2.5
February	1.1	0.5	1.7
March	4.4	1.2	8.8
April	12.1	8.3	16.8
May	16.0	12.7	19.9
June	24.3	19.9	27.8
August	23.6	22.1	24.6
September	20.8	18.1	24.5
October	13.3	10	16.4
November	6.8	3.4	8.5
December	3.8	1.4	5.5

	Dissolved Oxygen (mg/l)		
Month	Mean	Minimum	Maximum
January	14.6	12.6	16.5
February	14.6	13.6	15.9
March	13.1	11.5	14.1
April	11.2	9.5	12.1
May	11.1	9.9	11.6
June	9.4	9	10
August	9.8	8.2	12.1
September	9.7	8	11.9
October	11.2	9.1	12.4
November	12.4	11.4	14.4
December	15.1	12.8	17.7

	pH		
Month	Mean	Minimum	Maximum
January	7.5	6.8	8
February	8.0	7.4	8.6
March	8.2	8	8.3
April	7.5	6.8	8.1
May	8.0	7	8.6
June	7.3	7	7.9
August	8.1	7.6	8.7
September	7.8	7.1	8.4
October	7.3	6.6	7.7
November	7.5	6.7	7.9
December	7.3	6.8	7.8

	Conductivity (µS/cm)		
Month	Mean	Minimum	Maximum
January	299.1	235.1	352
February	330.0	272	396
March	206.7	144	258
April	242.2	188	289
May	260.8	236	281
June	351.3	329	374
August	357.0	342	378
September	416.9	363	454
October	431.7	392	471
November	316.8	256	376
December	229.6	189	299

Table 3. Total number and percent composition of fish entrained at the SSES CWIS, April 22 to August 13, 2008.

Common Name	Scientific Name	Total Number	Percent Composition
banded darter	*Etheostoma zonale*	2	0.1
brown bullhead	*Ameirus natalis*	2	0.1
common carp	*Cyprinus carpio*	345	11.4
chain pickerel	*Esox niger*	2	0.1
channel catfish	*Ictalurus punctatus*	367	12.1
Herrings	Clupeidae	1	<0.1
Minnows	Cyprinidae	535	17.6
Sunfishes	*Lepomis sp.*	5	0.2
margined madtom	*Noturus insignis*	10	0.3
Perches	Percidae	46	1.5
quillback	*Carpiodes cyprinus*	828	27.2
rock bass	*Ambloplites rupestris*	41	1.3
shield darter	*Percina peltata*	1	<0.1
smallmouth bass	*Micropterus dolomieu*	62	2.0
spottail shiner	*Notropis hudsonius*	27	0.9
tessellated darter	*Etheostoma olmstedi*	1	<0.1
unidentified fish	-	7	0.2
unidentified darter	-	382	12.6
walleye	*Sander vitreus*	37	1.2
white sucker	*Catostomus commersoni*	286	9.4
yellow perch	*Perca flavescens*	52	1.7
Total		3,039	

Table 4. Actual number of fish collected in each entrainment sample at the SSES CWIS, April 22 to August 13, 2008.

Date	Actual number entrained
4/22/2008	2
4/23/2008	0
4/29/2008	16
4/30/2008	34
5/6/2008	250
5/7/2008	246
5/13/2008	48
5/14/2008	46
5/20/2008	140
5/21/2008	162
5/27/2008	198
5/28/2008	197
6/3/2008	206
6/4/2008	177
6/10/2008	203
6/11/2008	219
6/17/2008	25
6/18/2008	22
6/24/2008	90
6/25/2008	143
7/1/2008	34
7/2/2008	142
7/8/2008	28
7/9/2008	25
7/15/2008	24
7/16/2008	14
7/22/2008	9
7/23/2008	39
7/29/2008	23
7/30/2008	19
8/5/2008	35
8/6/2008	104
8/12/2008	70
8/13/2008	49
Total	3,039

Table 5. Descriptive statistics for total length of entrained fish collected at the SSES CWIS, April 22 to August 13, 2008.

	Total Length (mm)				
Taxon	Mean	Minimum	Maximum	Standard Deviation	Total Number
banded darter	59.0	46	72	18.4	2
brown bullhead	15.5	15	16	0.7	2
common carp	6.6	5.3	10.1	0.7	54
chain pickerel	15.5	13.7	17.2	2.5	2
channel catfish	16.9	14	23	1.3	112
Clupeidae	15.7	15.7	15.7		1
Cyprinidae	6.1	4	14.5	1.9	300
Lepomis sp.	6.2	4.7	9.8	2.4	4
margined madtom	15.2	13	21	2.3	10
Percidae	7.1	5.2	10	1.4	40
quillback	8.9	5.4	21	2.0	239
rock bass	7.8	6.4	14	1.2	40
shield darter	76.0	76	76		1
smallmouth bass	14.4	9	55	8.5	40
spottail shiner	20.6	14.3	28	4.1	26
tessellated darter	52.0	52	52		1
unidentified darter	5.8	4.4	10.4	0.8	218
walleye	11.0	9.5	15.6	1.1	35
white sucker	16.6	8.7	35	4.3	170
yellow perch	7.7	5.9	13.4	1.8	49
Total	9.8	4	76	6.0	1,346

Table 6. Total number of each taxon collected by life stage in entrainment samples at the SSES CWIS, April 22 to August 13, 2008.

	Life Stage					
Taxon	Unknown	Yolk-sac larvae	Post yolk-sac larvae	YOY	Yearling plus	Total
banded darter	0	0	0	0	2	2
brown bullhead	0	0	0	2	0	2
common carp	161	5	179	0	0	345
chain pickerel	0	1	1	0	0	2
channel catfish	0	0	0	367	0	367
Clupeidae	0	0	1	0	0	1
Cyprinidae	0	40	495	0	0	535
Lepomis sp.	0	0	5	0	0	5
margined madtom	0	0	0	10	0	10
Percidae	3	3	40	0	0	46
quillback	190	202	433	3	0	828
rock bass	0	0	40	1	0	41
shield darter	0	0	0	0	1	1
smallmouth bass	0	0	60	2	0	62
spottail shiner	0	0	4	23	0	27
tessellated darter	0	0	0	0	1	1
unidentified fish	7	0	0	0	0	7
unidentified darter	31	246	105	0	0	382
walleye	0	6	31	0	0	37
white sucker	0	11	256	19	0	286
yellow perch	0	4	48	0	0	52
Total Number	392	518	1,698	427	4	3,039
Percent Composition	12.9	17.0	55.9	14.1	0.1	

Table 7. Estimated number of each taxon entrained and percent composition at the SSES CWIS, April 22 to August 13, 2008.

Taxon	Estimated Number Entrained	Percent Composition
banded darter	13,778	0.1
brown bullhead	13,799	0.1
common carp	894,149	6.7
chain pickerel	13,635	0.1
channel catfish	2,570,361	19.3
Clupeidae	7,042	0.1
Cyprinidae	2,863,110	21.5
Lepomis sp.	42,151	0.3
margined madtom	69,502	0.5
Percidae	312,507	2.3
quillback	2,164,020	16.2
rock bass	285,177	2.1
shield darter	7,042	0.1
smallmouth bass	427,672	3.2
spottail shiner	160,030	1.2
tessellated darter	6,838	0.1
unidentified fish	48,744	0.4
unidentified darter	1,644,738	12.3
walleye	171,869	1.3
white sucker	1,299,692	9.8
yellow perch	308,528	2.3
Total	13,324,384	

Table 8. Total number and percent composition of fish and crayfish collected in impingement samples from the SSES CWIS traveling screens, April 22, 2008 to April 20, 2009.

Common Name	Scientific Name	Total Number	Percent Composition
crayfish	*Orconectes sp.*	220	55.3
bluegill	*Lepomis macrochirus*	44	11.1
rock bass	*Ambloplites rupestris*	34	8.5
channel catfish	*Ictalurus punctatus*	31	7.8
tessellated darter	*Etheostoma olmstedi*	18	4.5
spotfin shiner	*Cyprinella spiloptera*	16	4.0
spottail shiner	*Notropis hudsonius*	5	1.3
margined madtom	*Noturus insignis*	4	1.0
smallmouth bass	*Micropterus dolomieu*	4	1.0
white crappie	*Pomoxis annularis*	4	1.0
white sucker	*Catostomus commersoni*	4	1.0
yellow perch	*Perca flavescens*	3	0.8
banded darter	*Etheostoma zonale*	2	0.5
pumpkinseed	*Lepomis gibbosus*	2	0.5
walleye	*Sander vitreus*	2	0.5
bluntnose minnow	*Pimephales notatus*	1	0.3
brown trout	*Salmo trutta*	1	0.3
northern hog sucker	*Hypentelium nigricans*	1	0.3
unidentified fish	-	1	0.3
yellow bullhead	*Ameiurus natalis*	1	0.3
Total		398	

Table 9. Number of each fish and crayfish collected during each month of impingement sampling at the SSES CWIS, April 22, 2008 to April 20, 2009.

Taxon	April 2008	May	June	August	September	October	November	December	January	February	March	April 2009
banded darter							2					
bluegill						11	27	1		3	1	1
bluntnose minnow									1			
brown trout			1									
channel catfish	5	8			4		1	1	6	2	3	1
crayfish	9	21	13	30	10	5	19	3		2	78	30
margined madtom				1		2	1					
northern hog sucker		1										
pumpkinseed										1	1	
rock bass		4	1		3	10	1		4	1	5	5
smallmouth bass			1	1						2		
spotfin shiner									1	9	6	
spottail shiner				1						4		
tessellated darter	3	2	1			1		1	1	3	6	
unknown fish										1		
walleye										2		
white crappie							1	3				
white sucker										1	3	
yellow bullhead		1										
yellow perch		2									1	
Total	17	39	17	33	17	29	52	9	13	31	104	37

Table 10. Mean, minimum, and maximum total length of fish collected in impingement samples from the SSES CWIS traveling screens, April 22, 2008 to April 20, 2009.

	Total Length (mm)		
Taxon	Mean	Minimum	Maximum
banded darter	57	53	61
bluegill	53	32	131
bluntnose minnow	40	40	40
brown trout	292	292	292
channel catfish	82	47	184
margined madtom	53	42	66
northern hog sucker	381	381	381
pumpkinseed	136	121	151
rock bass	82	45	220
smallmouth bass	195	93	282
spotfin shiner	79	44	103
spottail shiner	50	41	57
tessellated darter	56	35	76
walleye	178	176	180
white crappie	92	84	99
white sucker	99	67	112
yellow bullhead	218	218	218
yellow perch	145	92	223

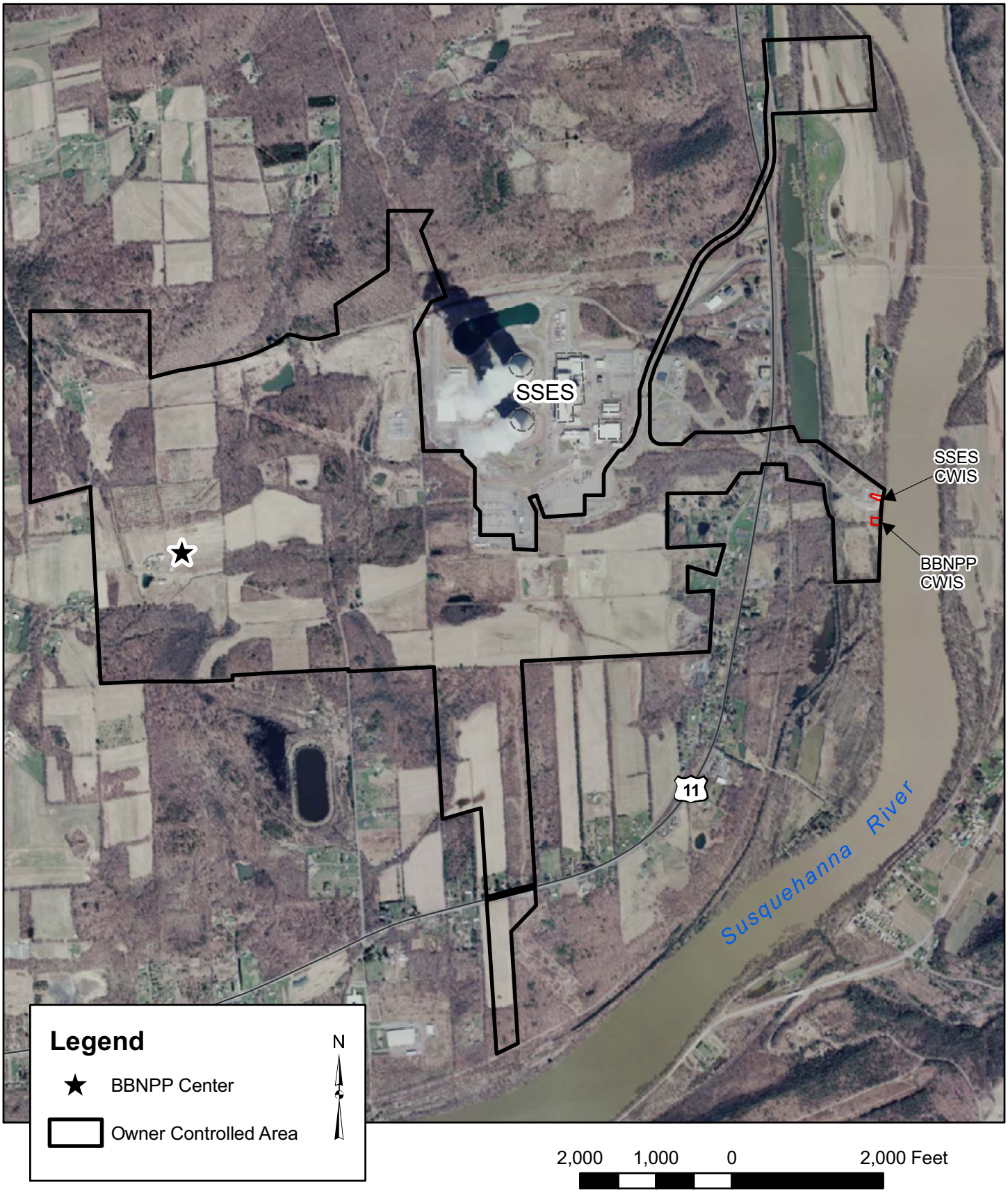

Figure 1.
Location of the SSES CWIS
and the proposed location of the BBNPP CWIS.

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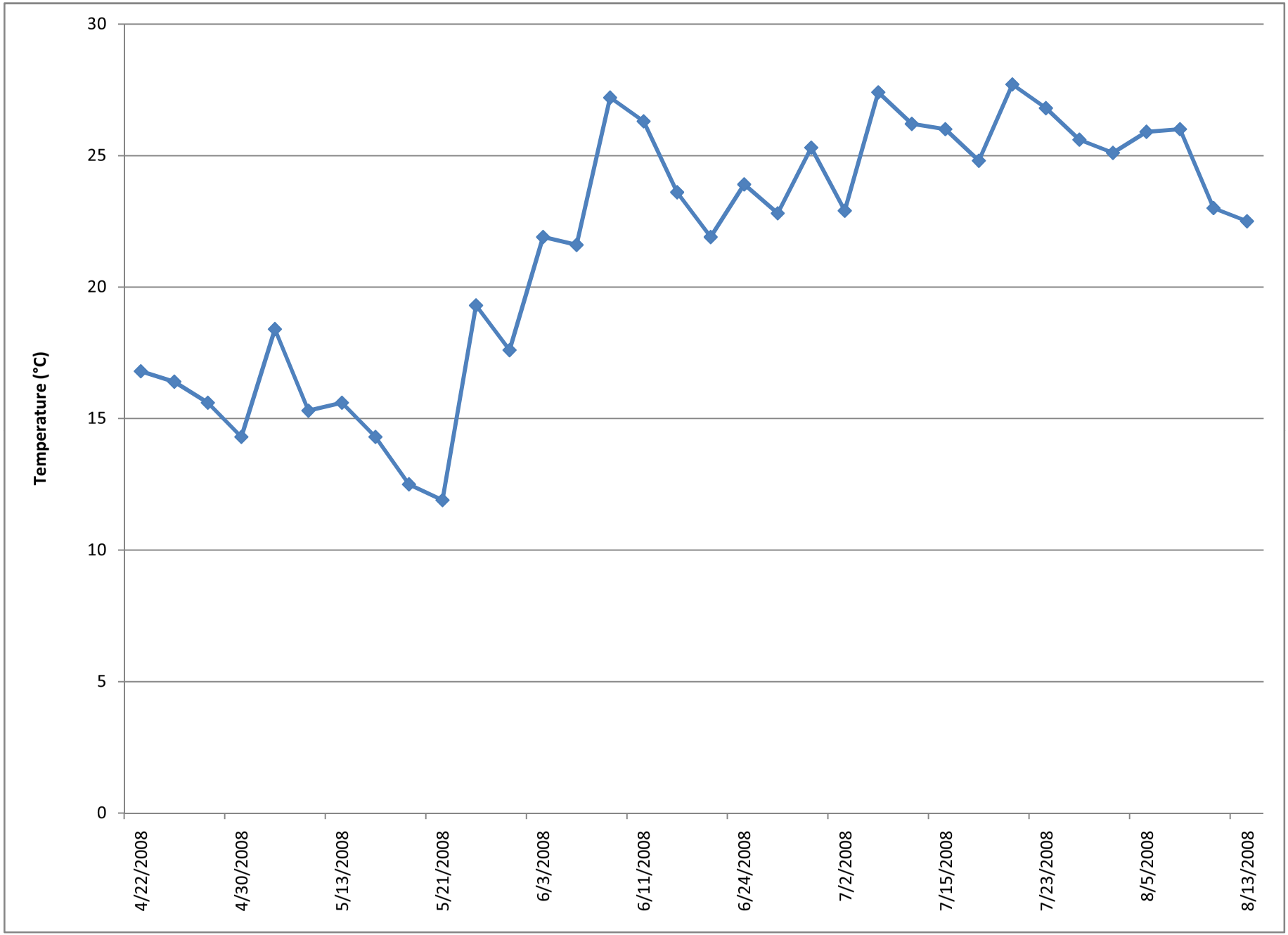

Figure 2. Susquehanna River water temperature measured at the start of entrainment sampling at the SSES CWIS, April 22 to August 13, 2008.

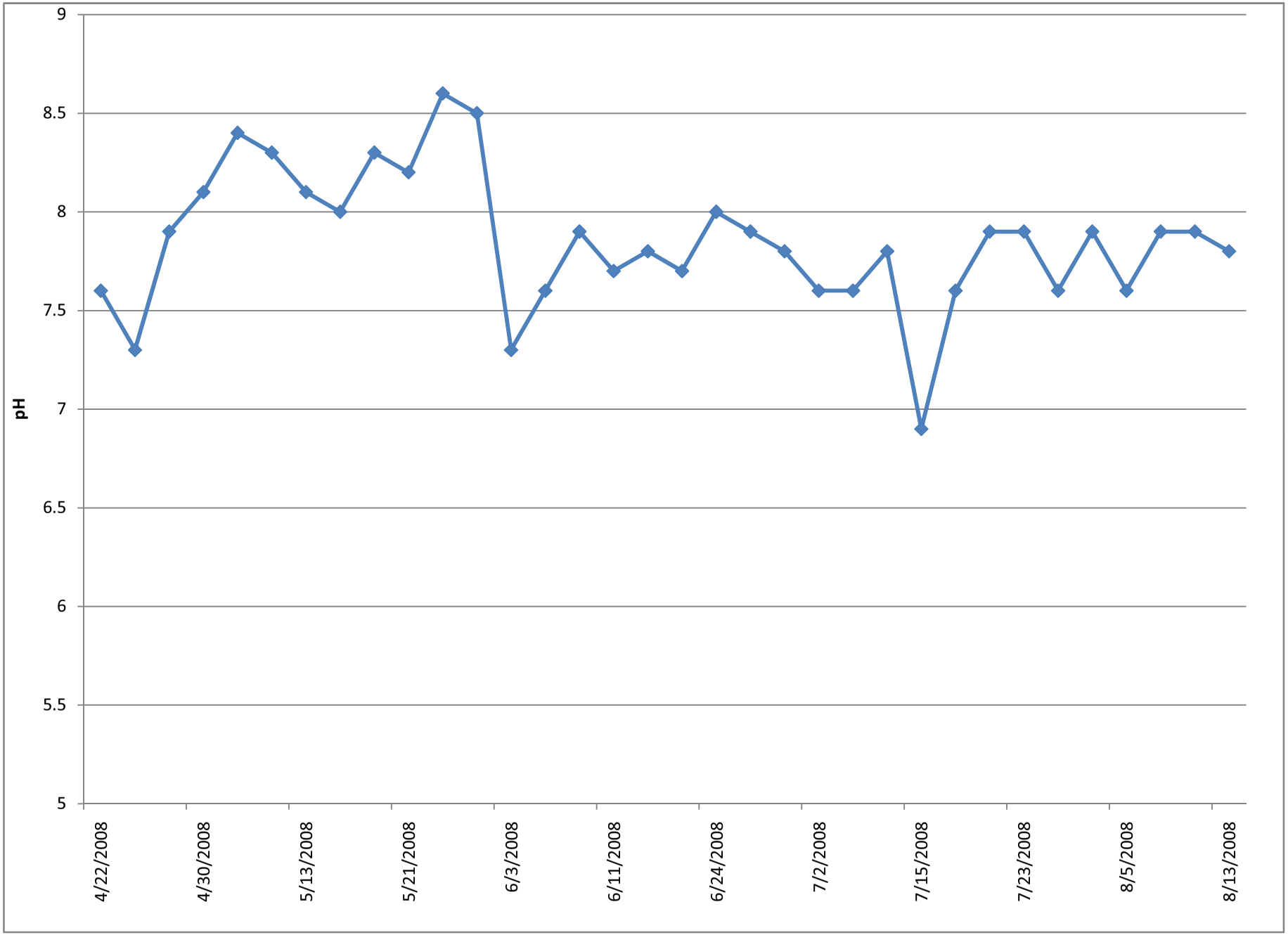

Figure 3. Susquehanna River pH measured at the start of entrainment sampling at the SSES CWIS, April 22 to August 13, 2008.

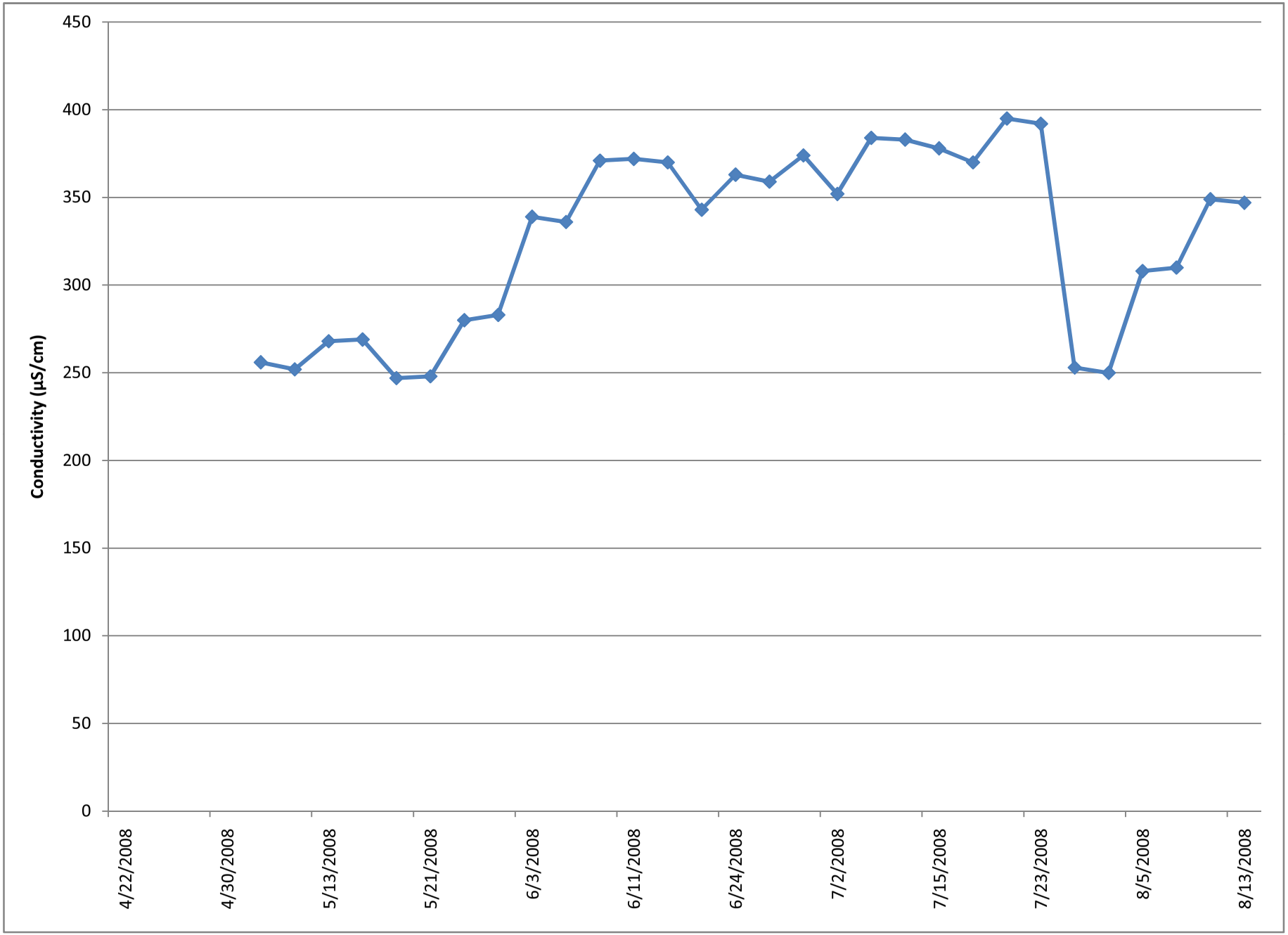

Figure 4. Susquehanna River conductivity measured at the start of entrainment sampling at the SSES CWIS, April 22 to August 13, 2008.

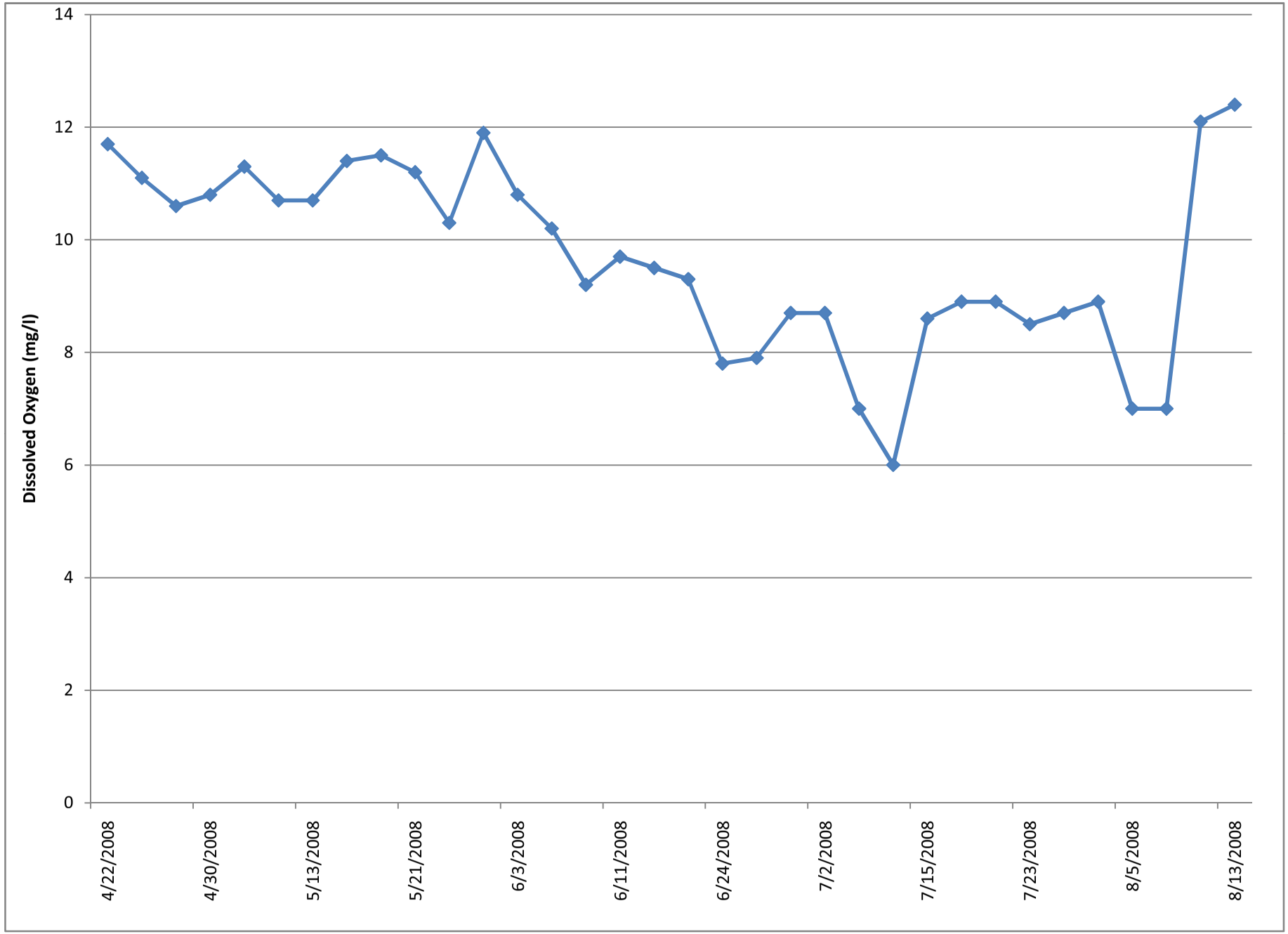

Figure 5. Susquehanna River dissolved oxygen measured at the start of entrainment sampling at the SSES CWIS, April 22 to August 13, 2008.

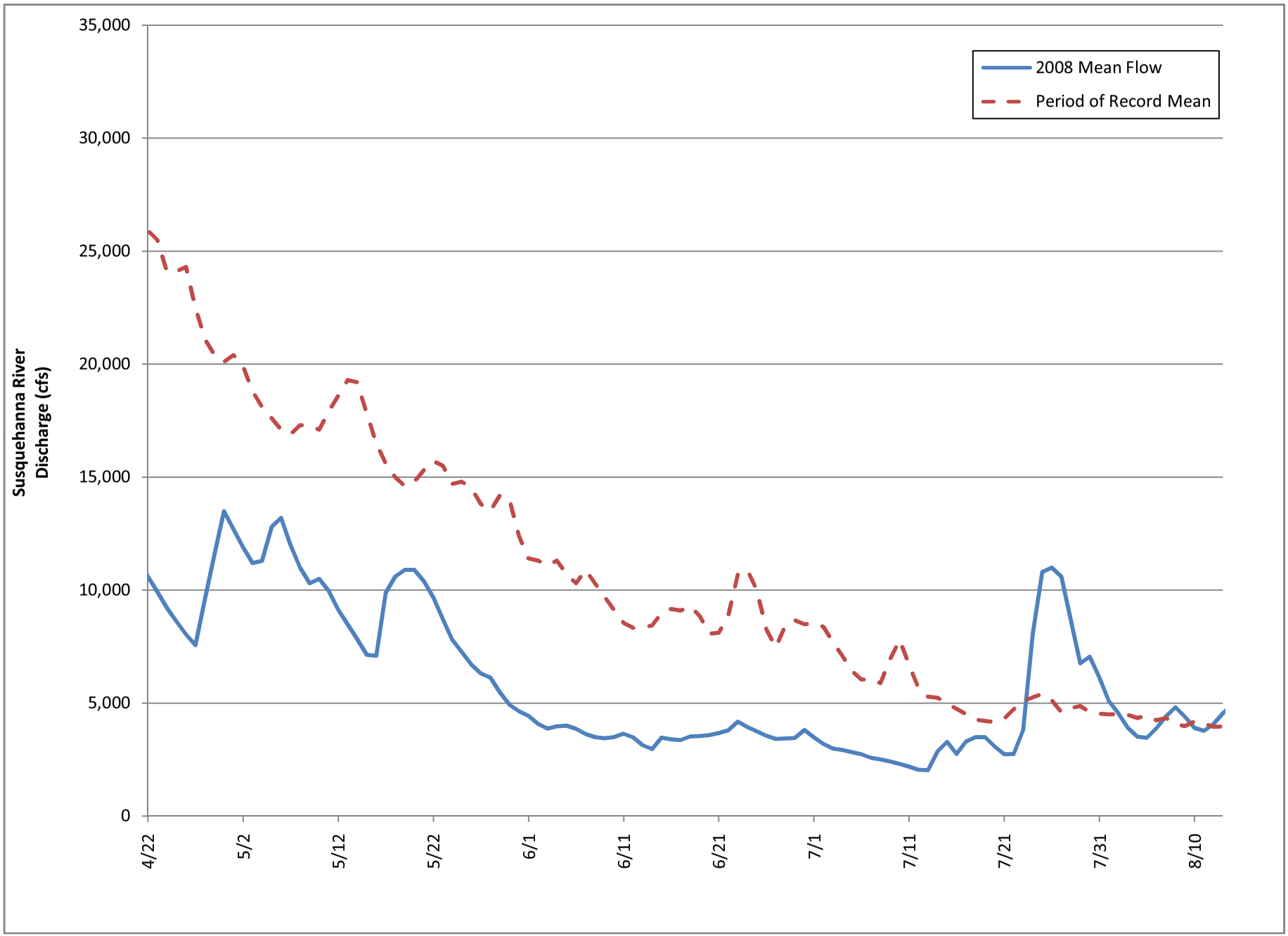

Figure 6. Susquehanna River discharge measured at the USGS Wilkes Barre gaging station for 2008 entrainment sampling period and for the period of record, April 22 to August 13.

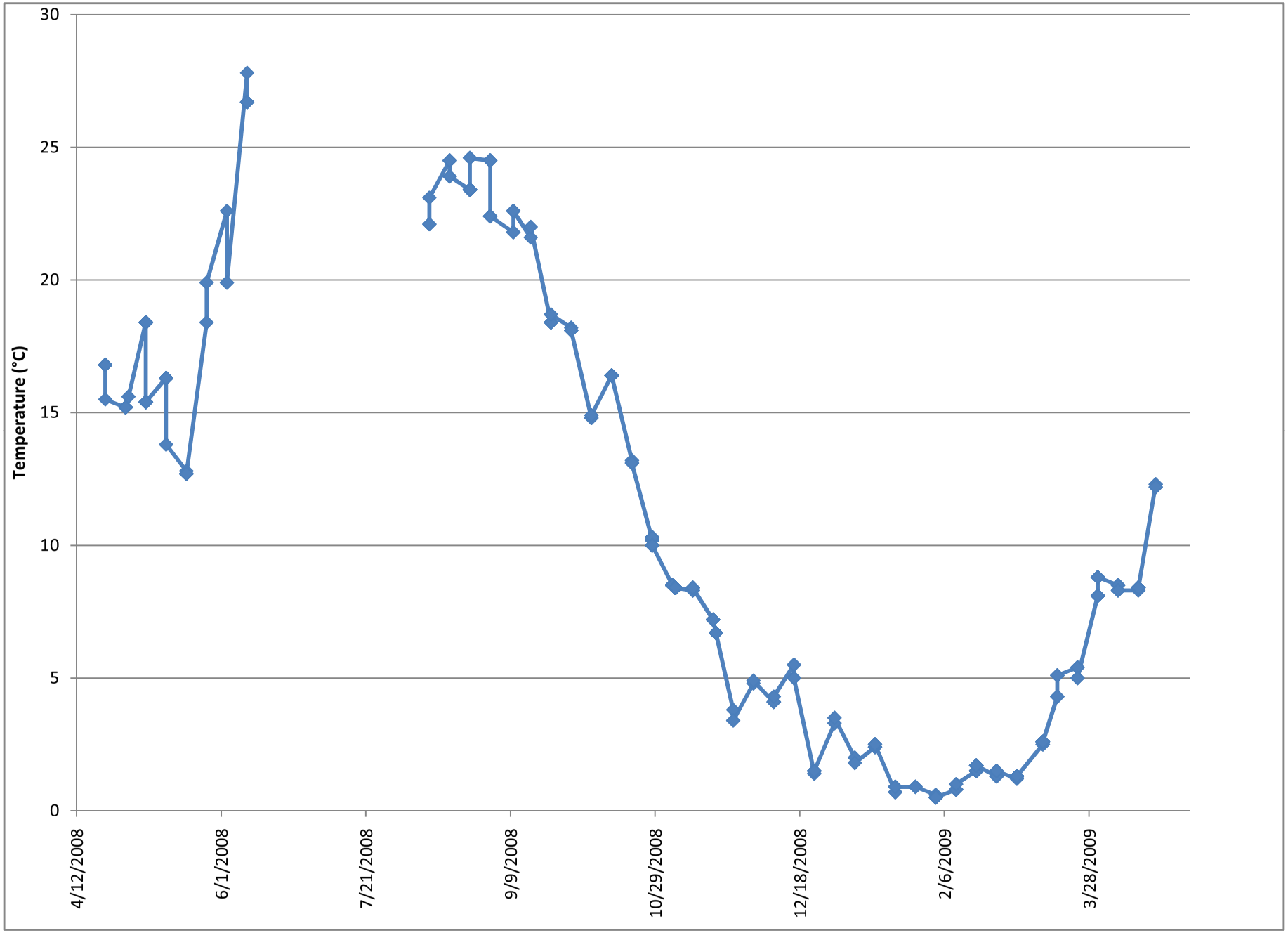

Figure 7. Susquehanna River water temperature measured at the start of impingement sampling at the SSES CWIS, April 22, 2008 to April 20, 2009.

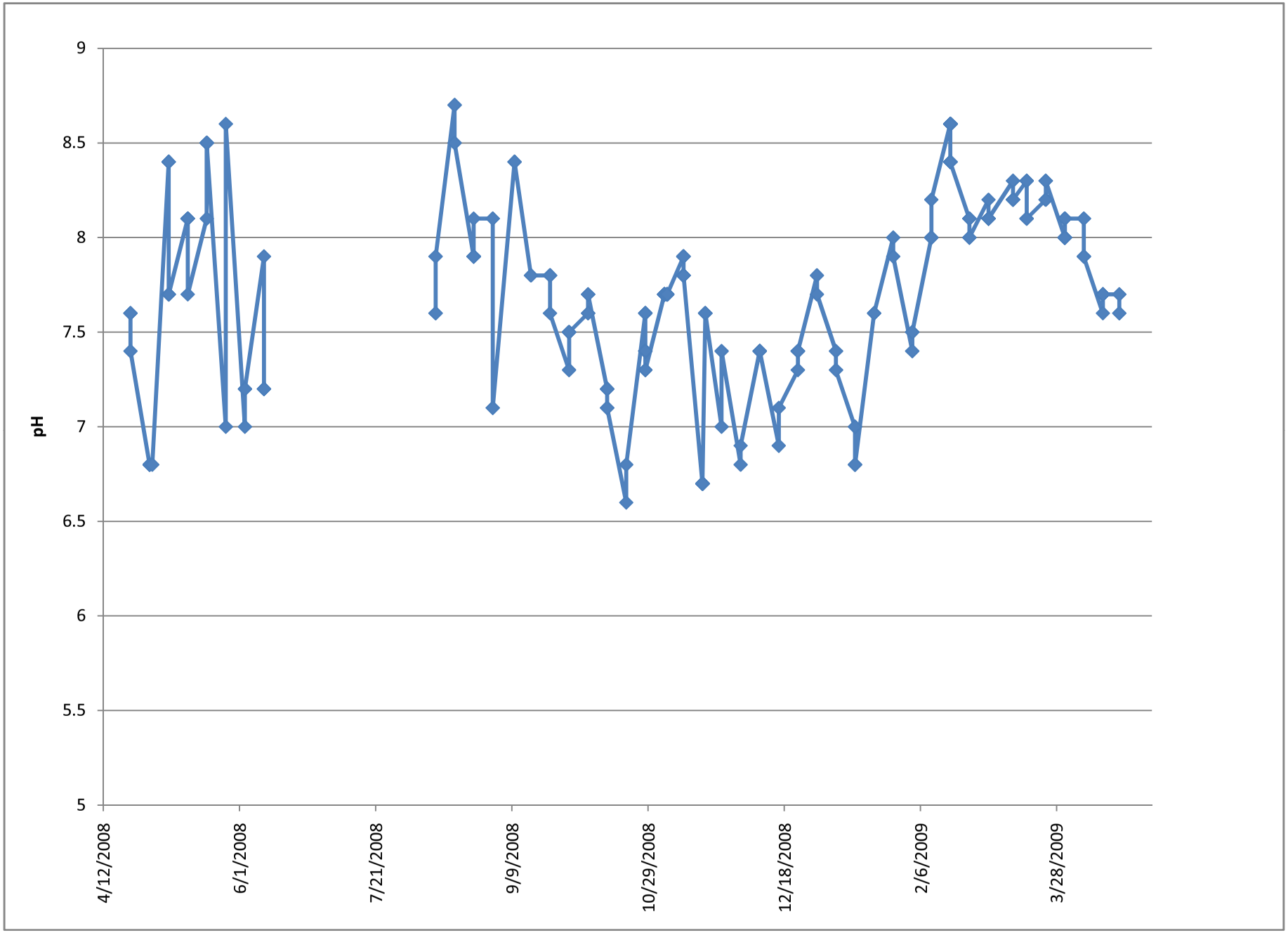

Figure 8. Susquehanna River water pH measured at the start of impingement sampling at the SSES CWIS, April 22, 2008 to April 20, 2009.

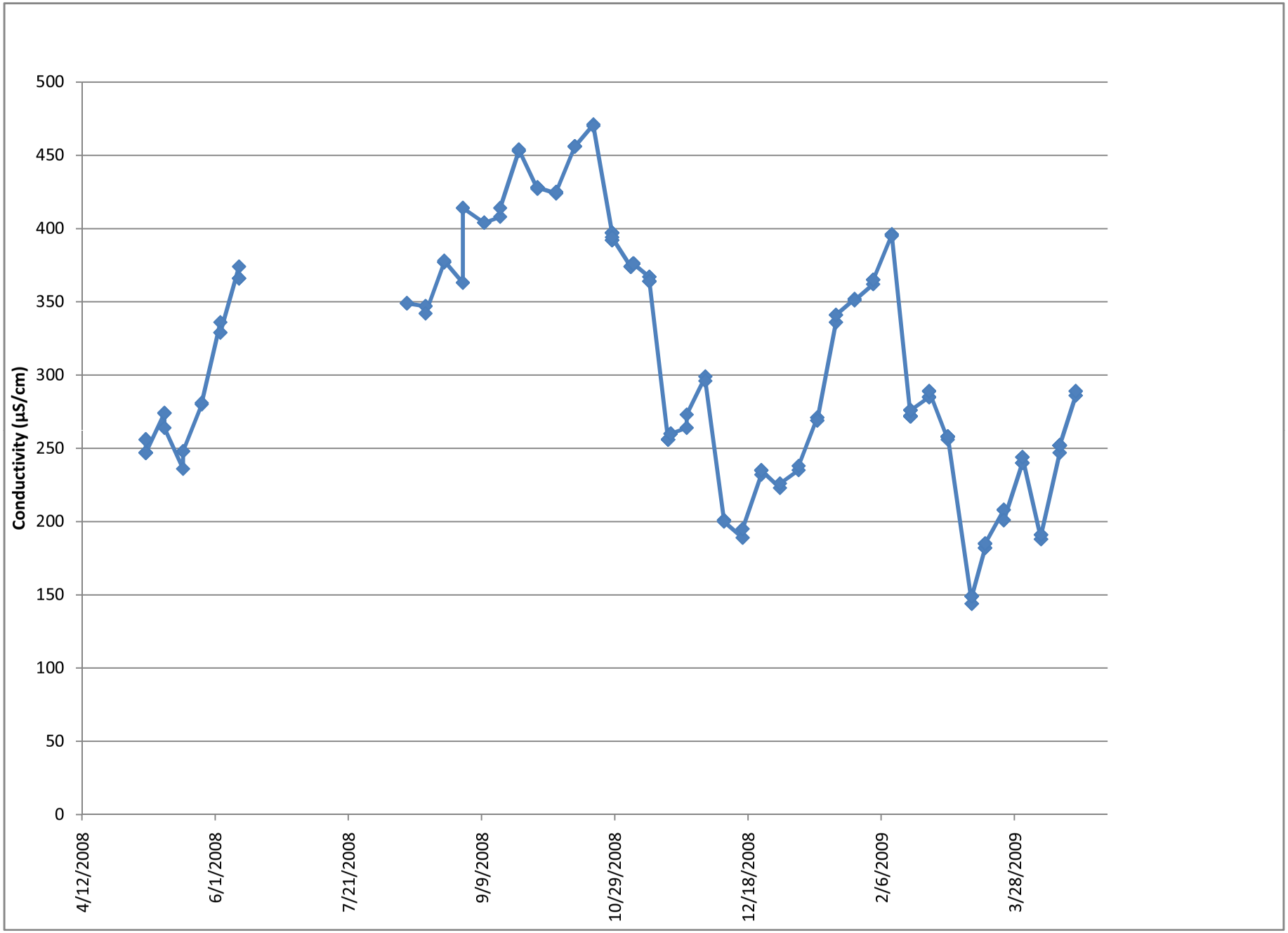

Figure 9. Susquehanna River water conductivity measured at the start of impingement sampling at the SSES CWIS, April 22, 2008 to April 20, 2009.

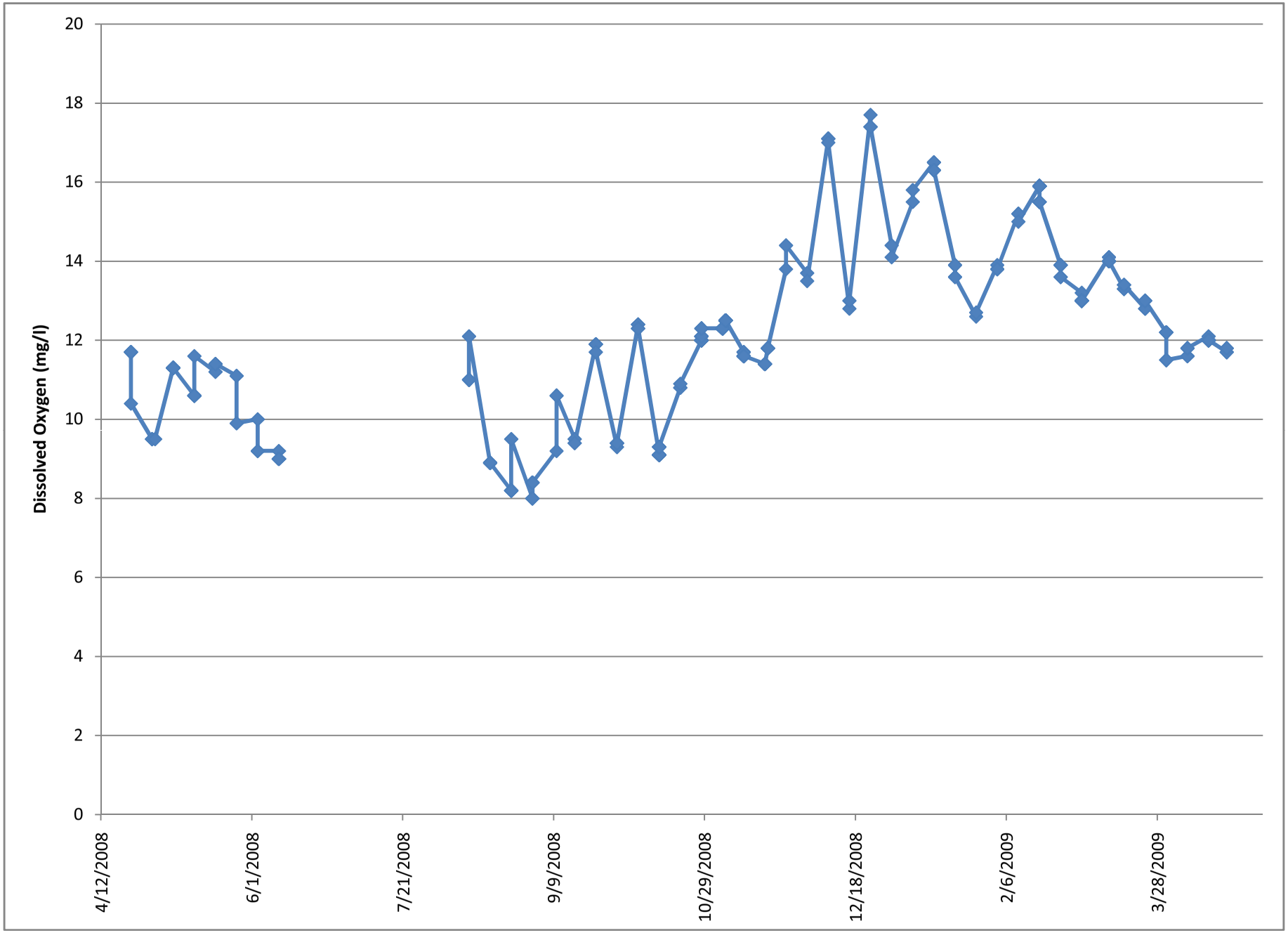

Figure 10. Susquehanna River water dissolved oxygen measured at the start of impingement sampling at the SSES CWIS, April 22, 2008 to April 20, 2009.

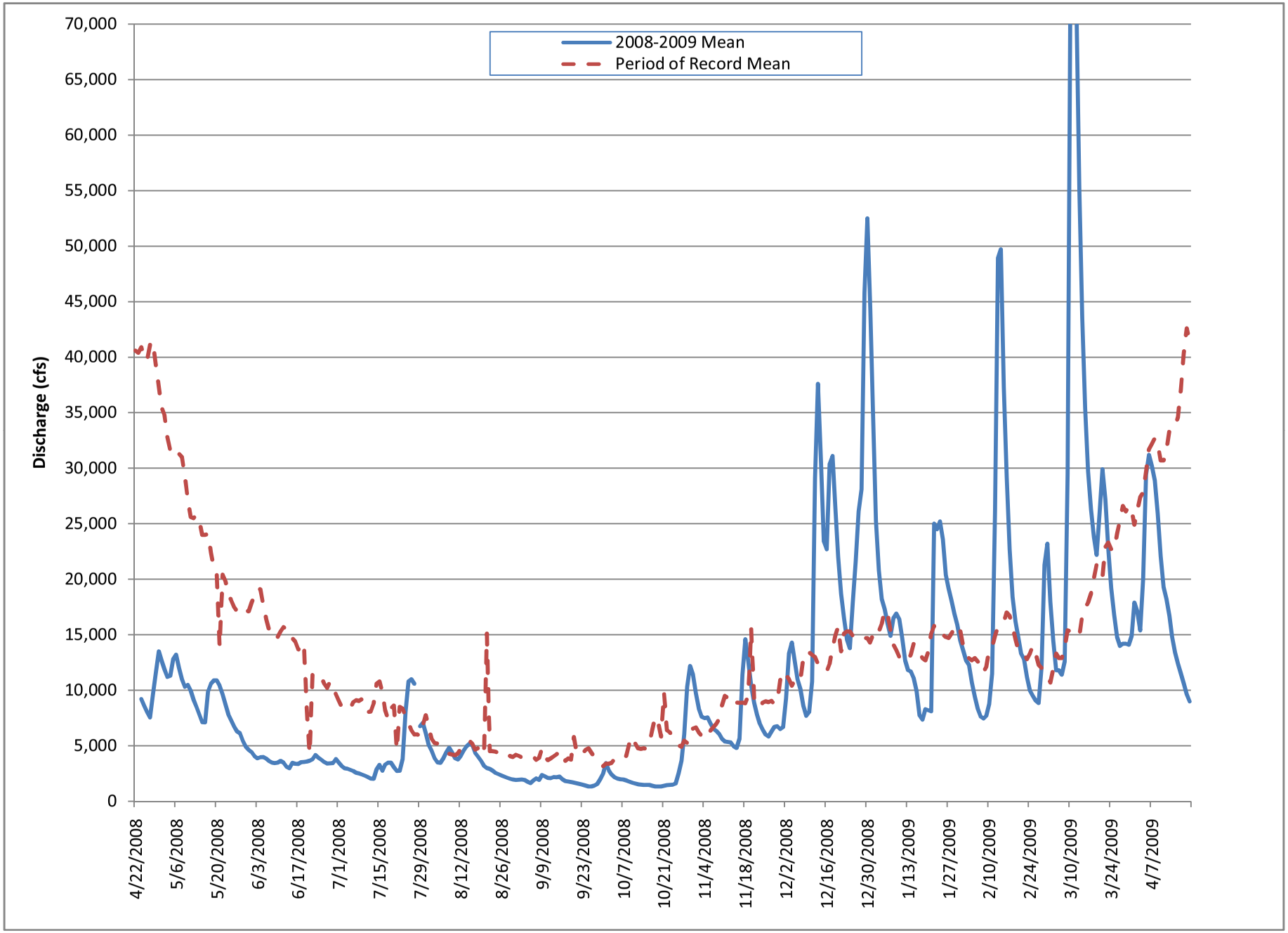

Figure 11. Daily mean and Period of Record mean discharge of Susquehanna River measured at the USGS Wilkes Barre gage, April 22, 2008 to April 20, 2009.

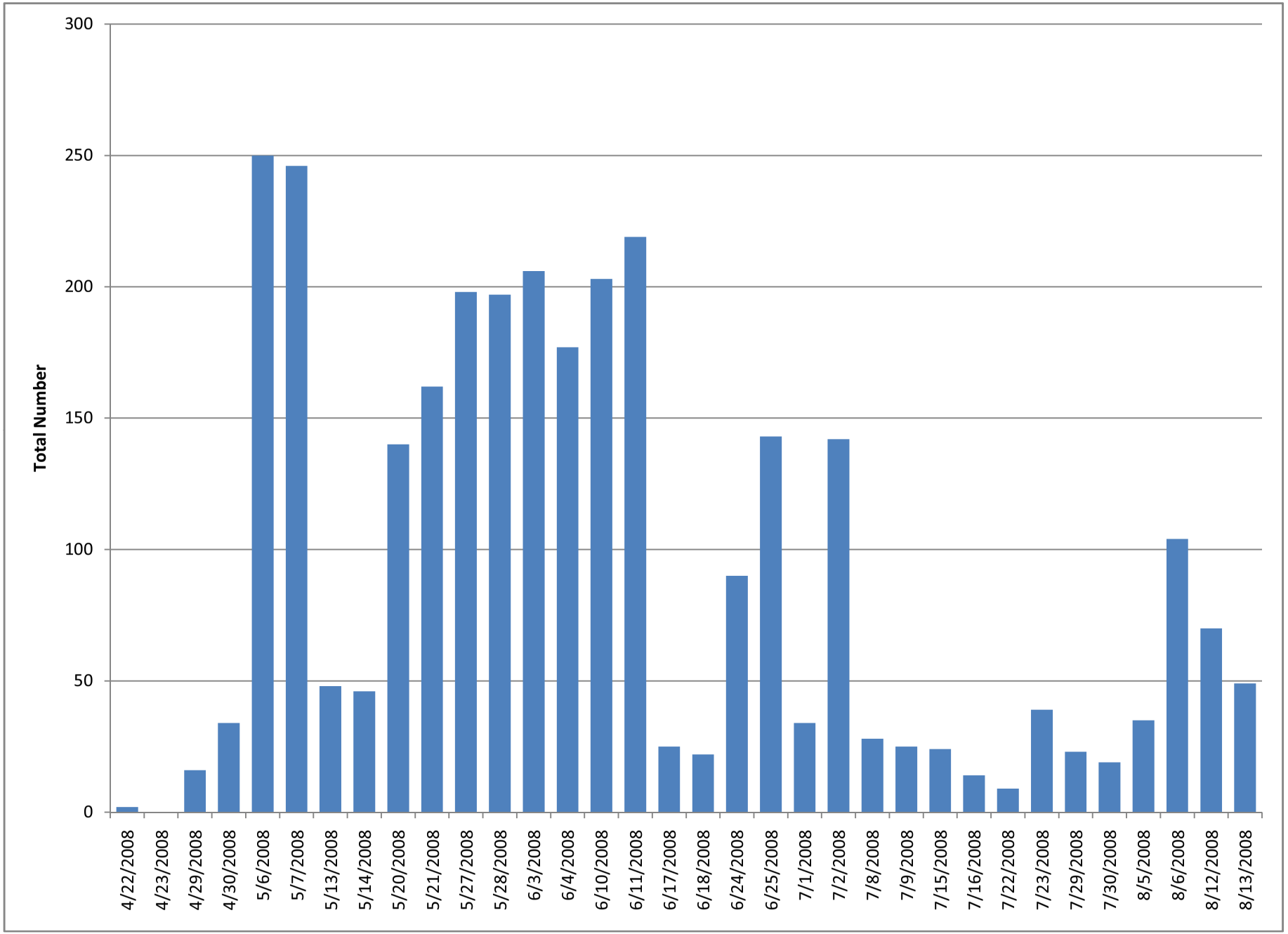

Figure 12. Total number of fish collected in each entrainment sample at the SSES CWIS, April 22 to August 13, 2008.

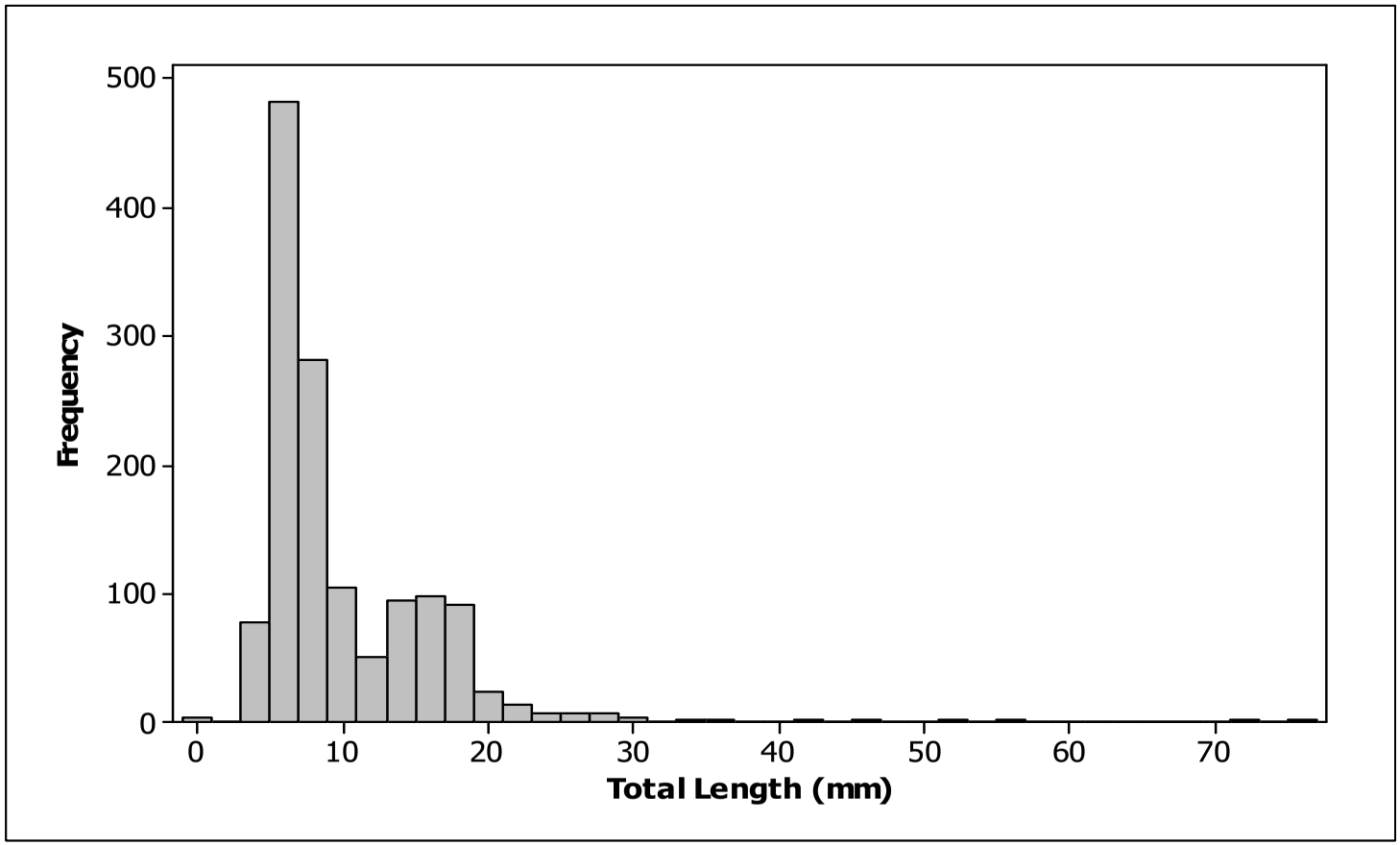

Figure 13. Length-frequency distribution of fish collected in entrainment samples at the SSES CWIS, April 22 to August 13 2008.

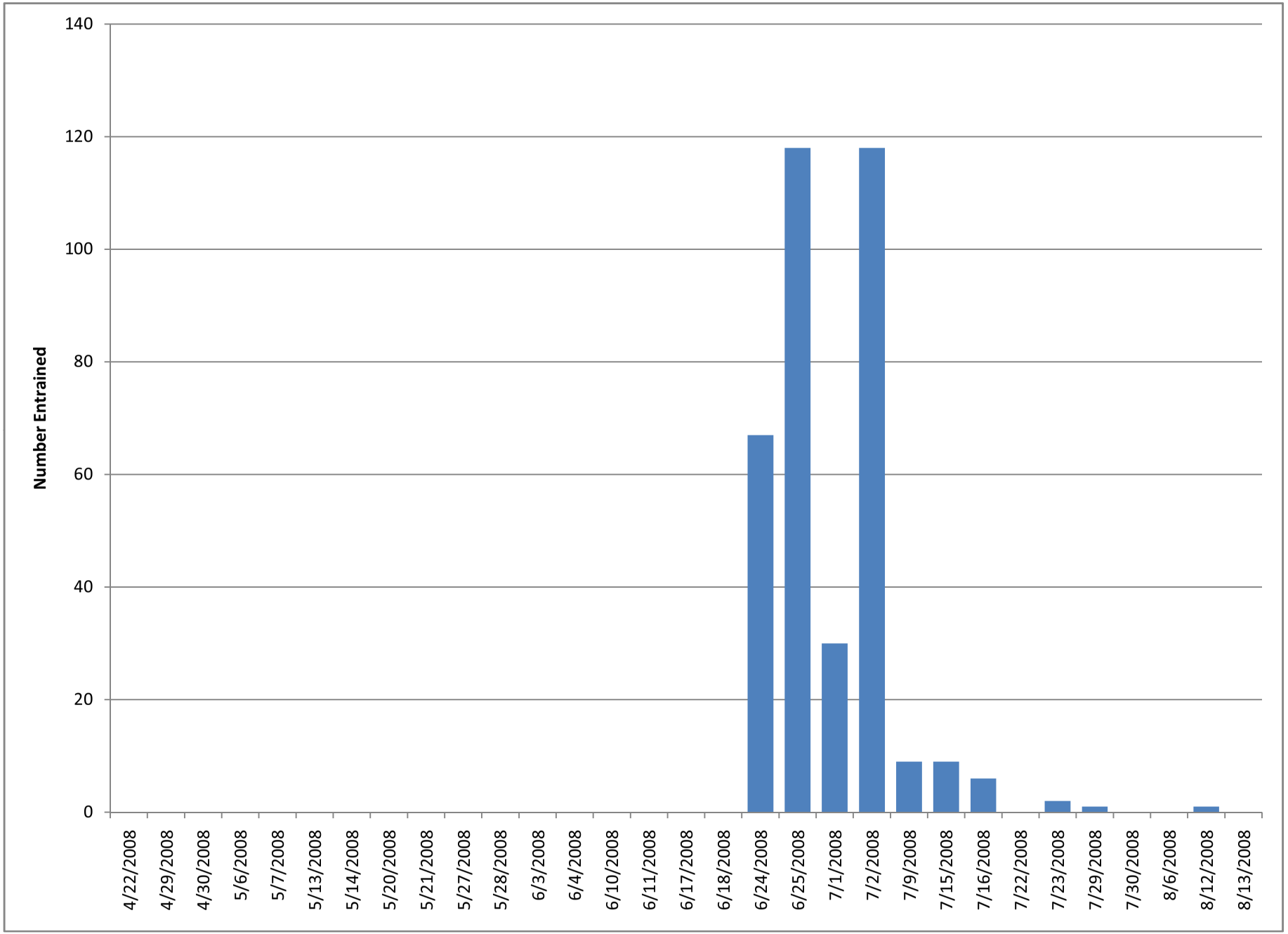

Figure 14. Number of channel catfish collected in each entrainment sample through time at the SSES CWIS during 2008.

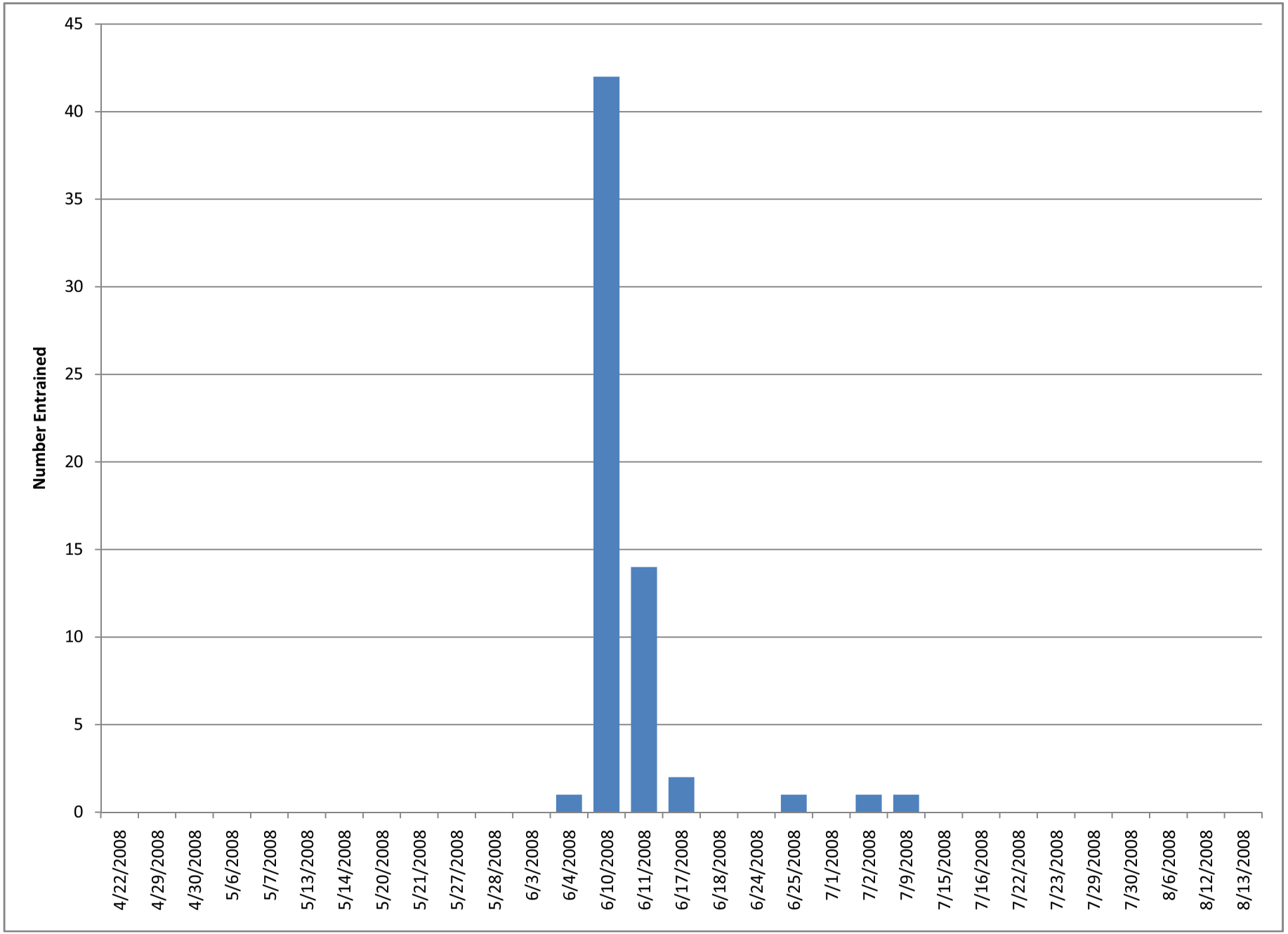

Figure 15. Number of smallmouth bass collected in each entrainment sample through time at the SSES CWIS during 2008.

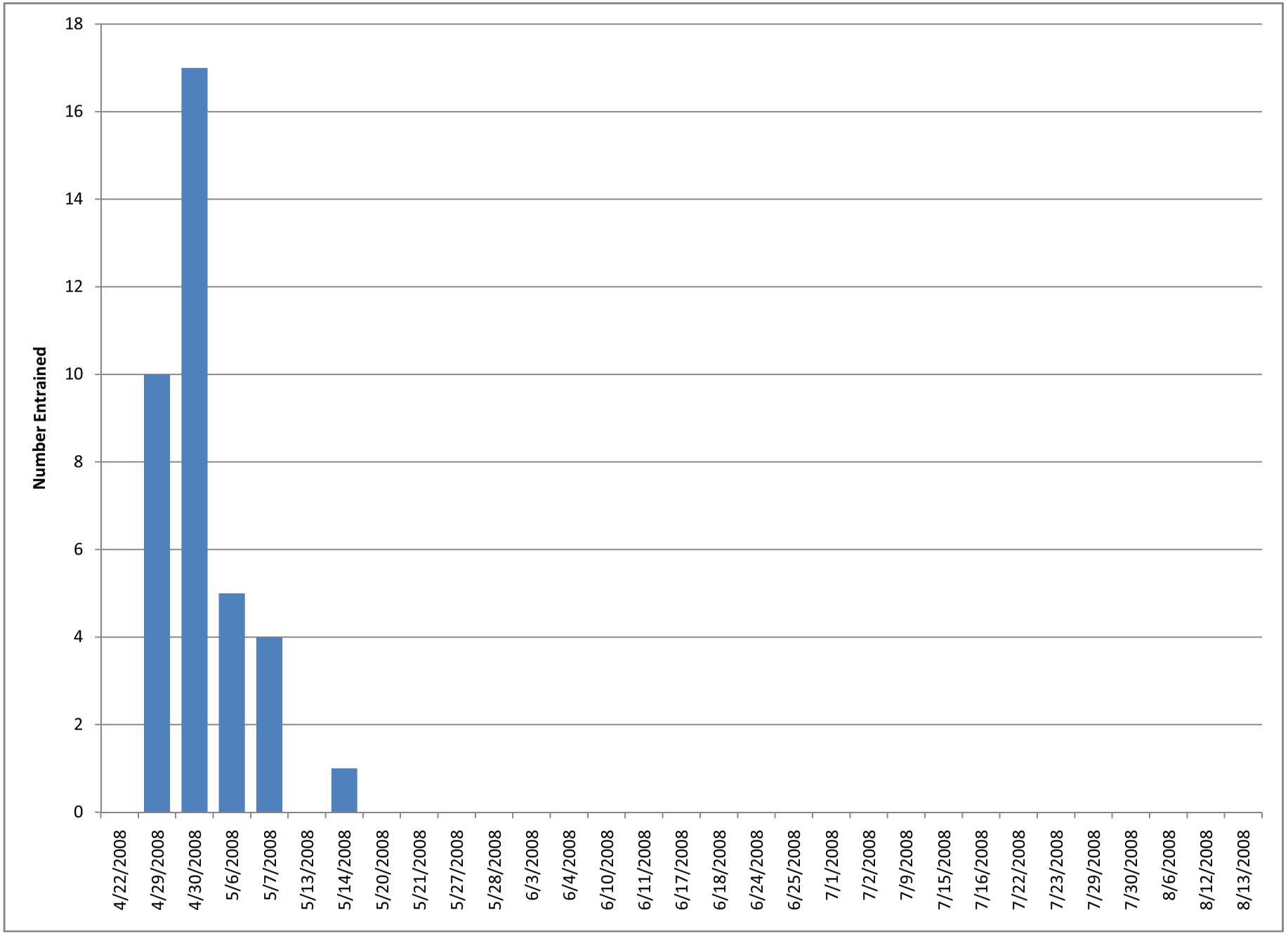

Figure 16. Number of walleye collected in each entrainment sample through time at the SSES CWIS during 2008.

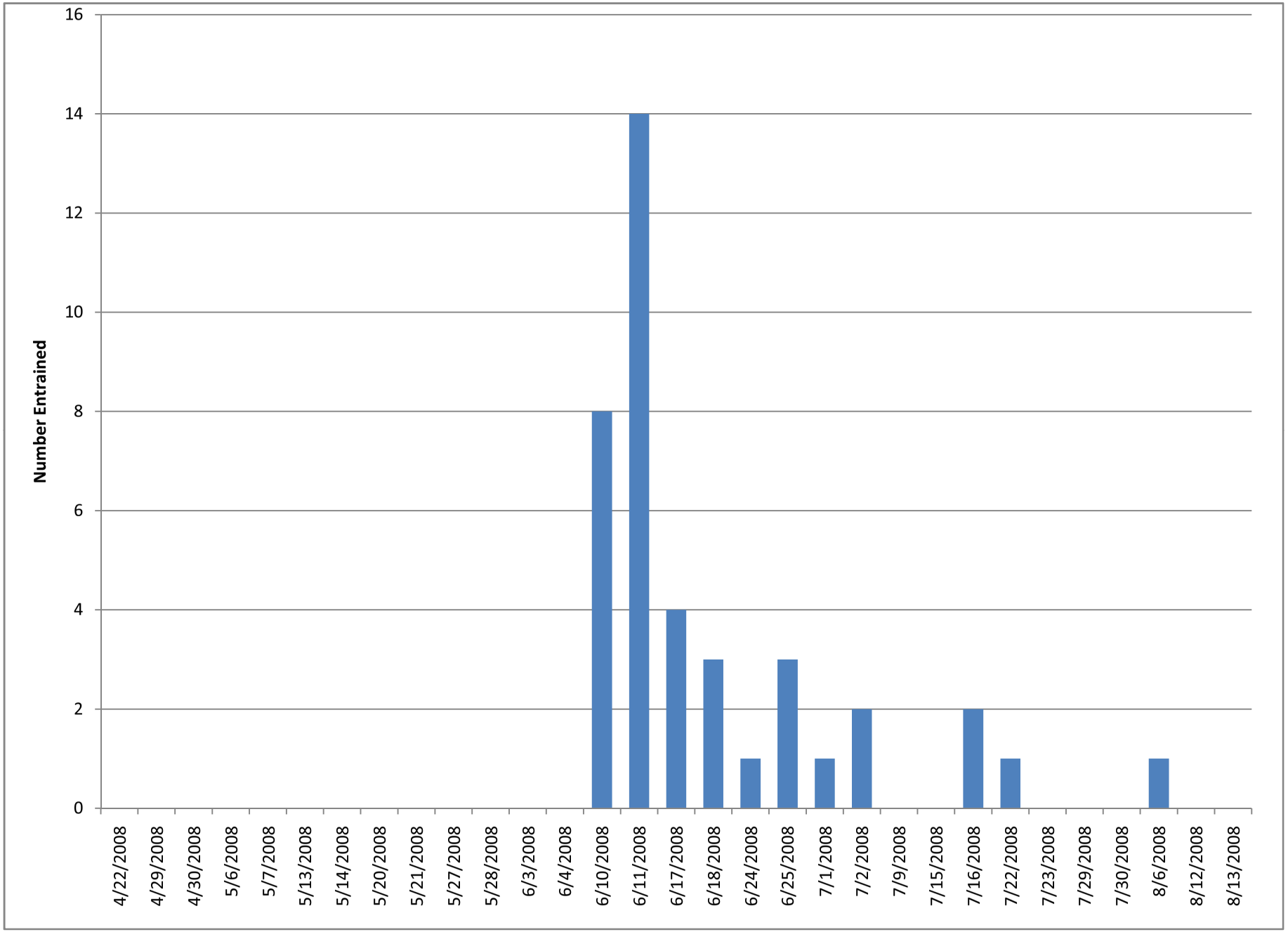

Figure 17. Number of rock bass collected in each entrainment sample through time at the SSES CWIS during 2008.

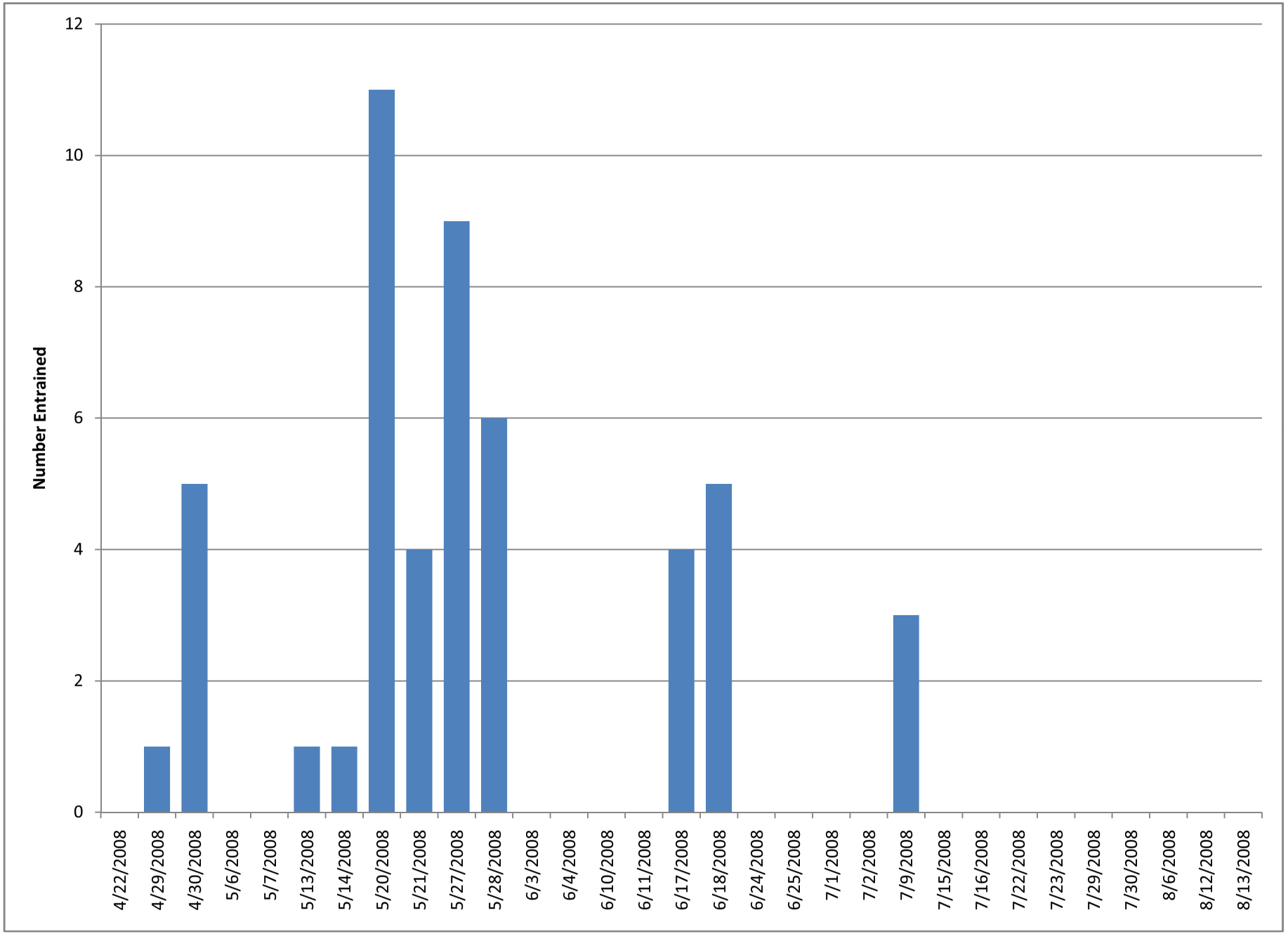

Figure 18. Number of yellow perch collected in each entrainment sample through time at the SSES CWIS during 2008.

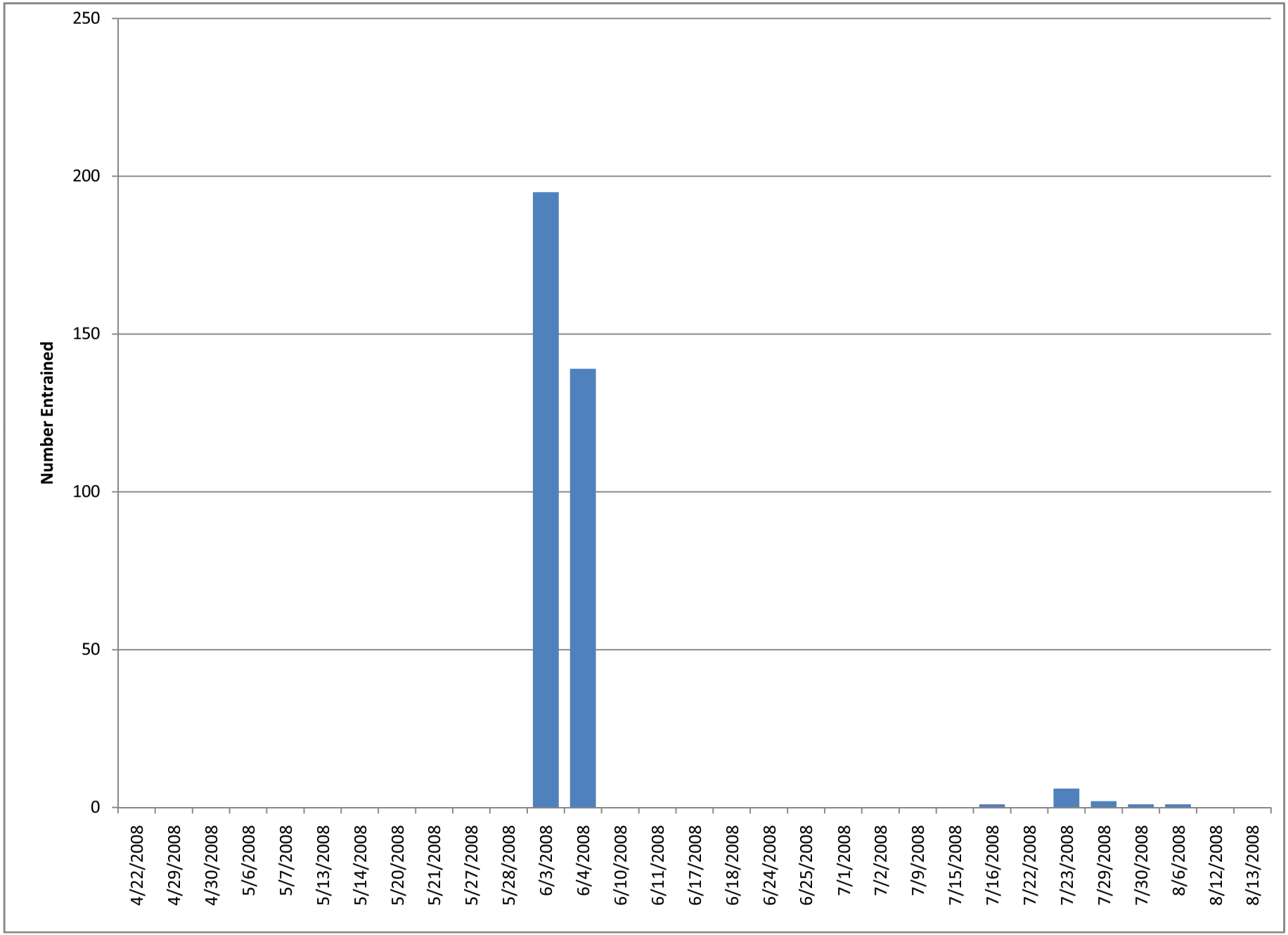

Figure 19. Number of carp collected in each entrainment sample through time at the SSES CWIS during 2008.

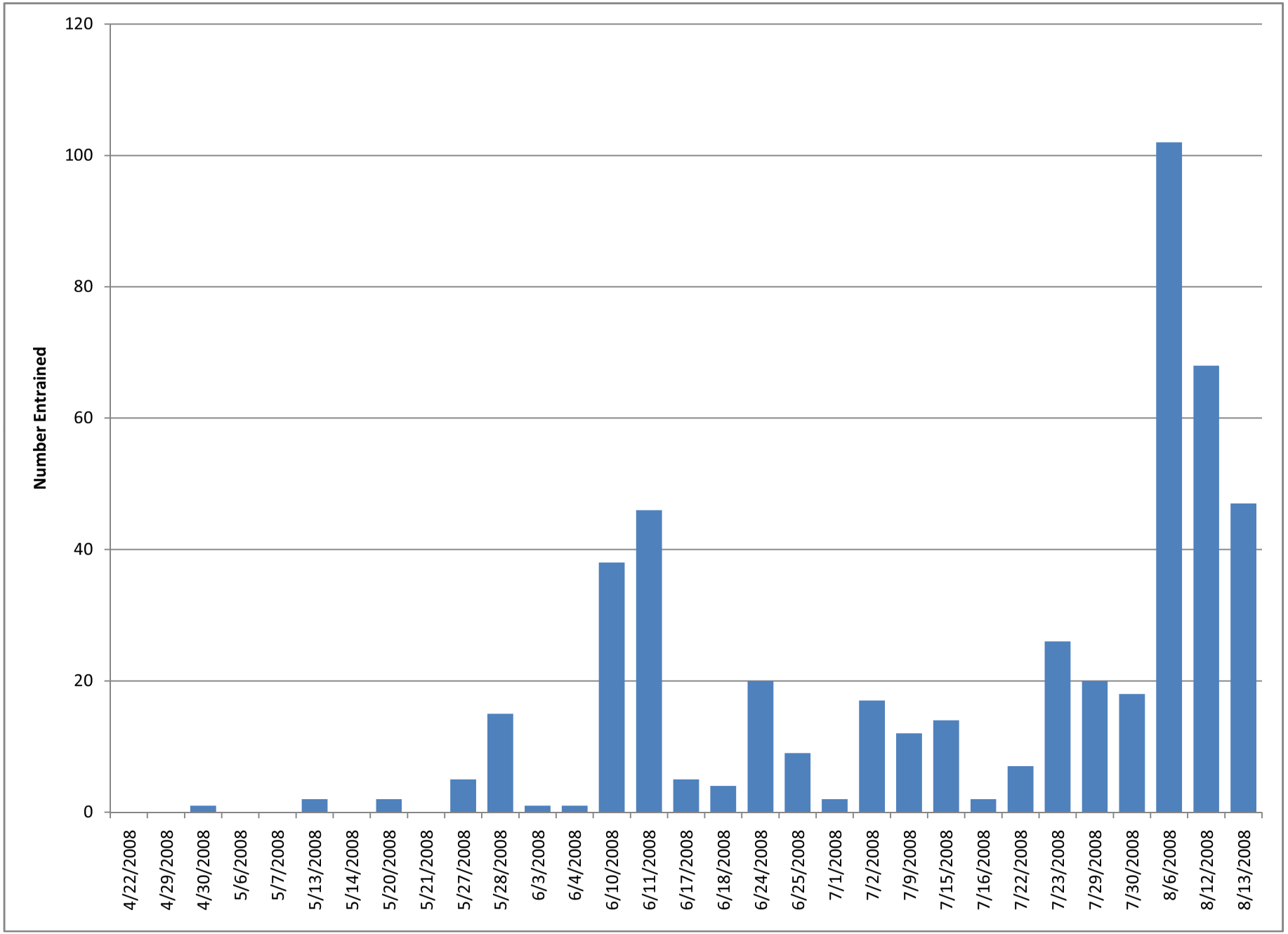

Figure 20. Number of Cyprinidae collected in each entrainment sample through time at the SSES CWIS during 2008.

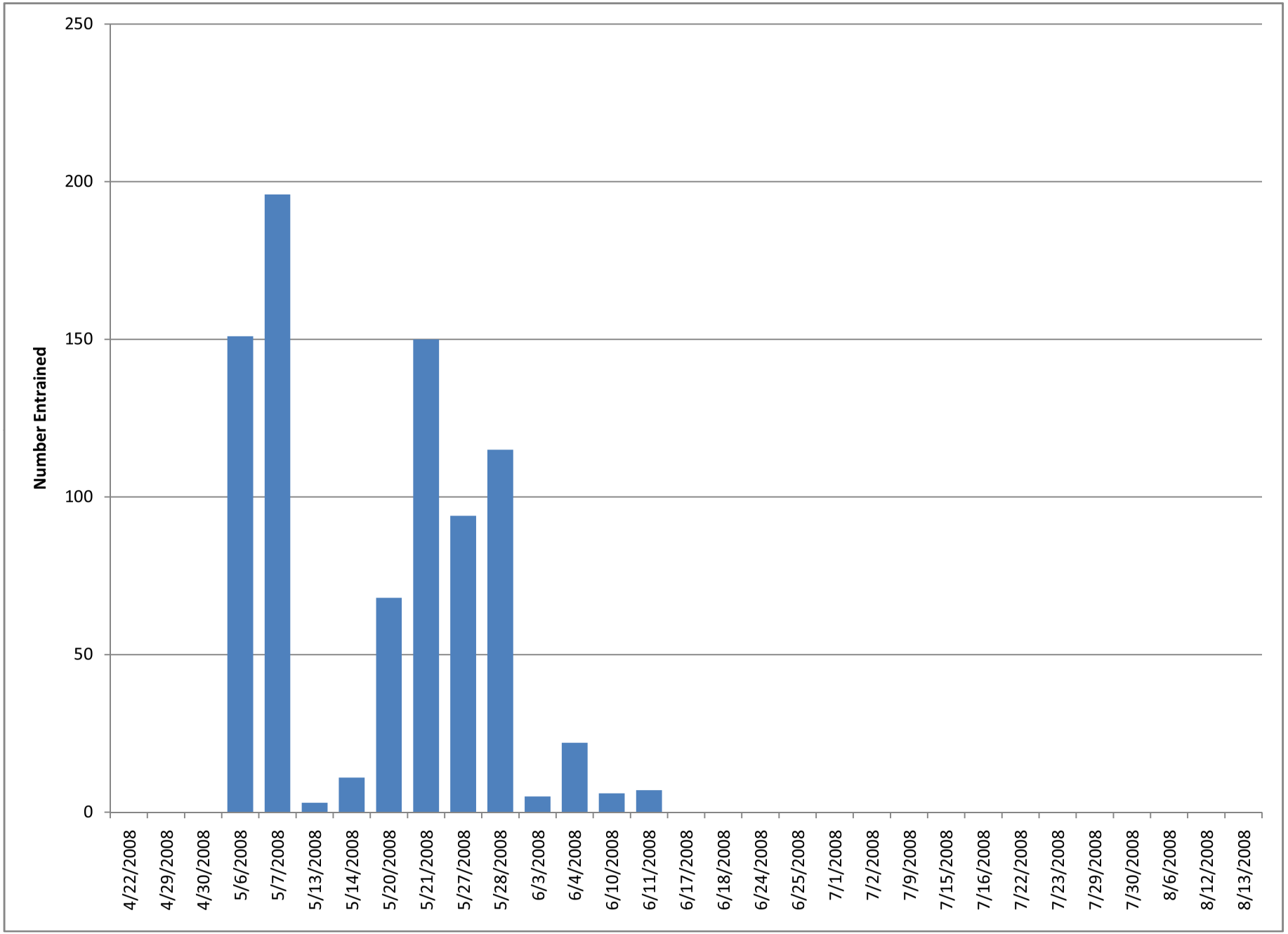

Figure 21. Number of quillback collected in each entrainment sample through time at the SSES CWIS during 2008.

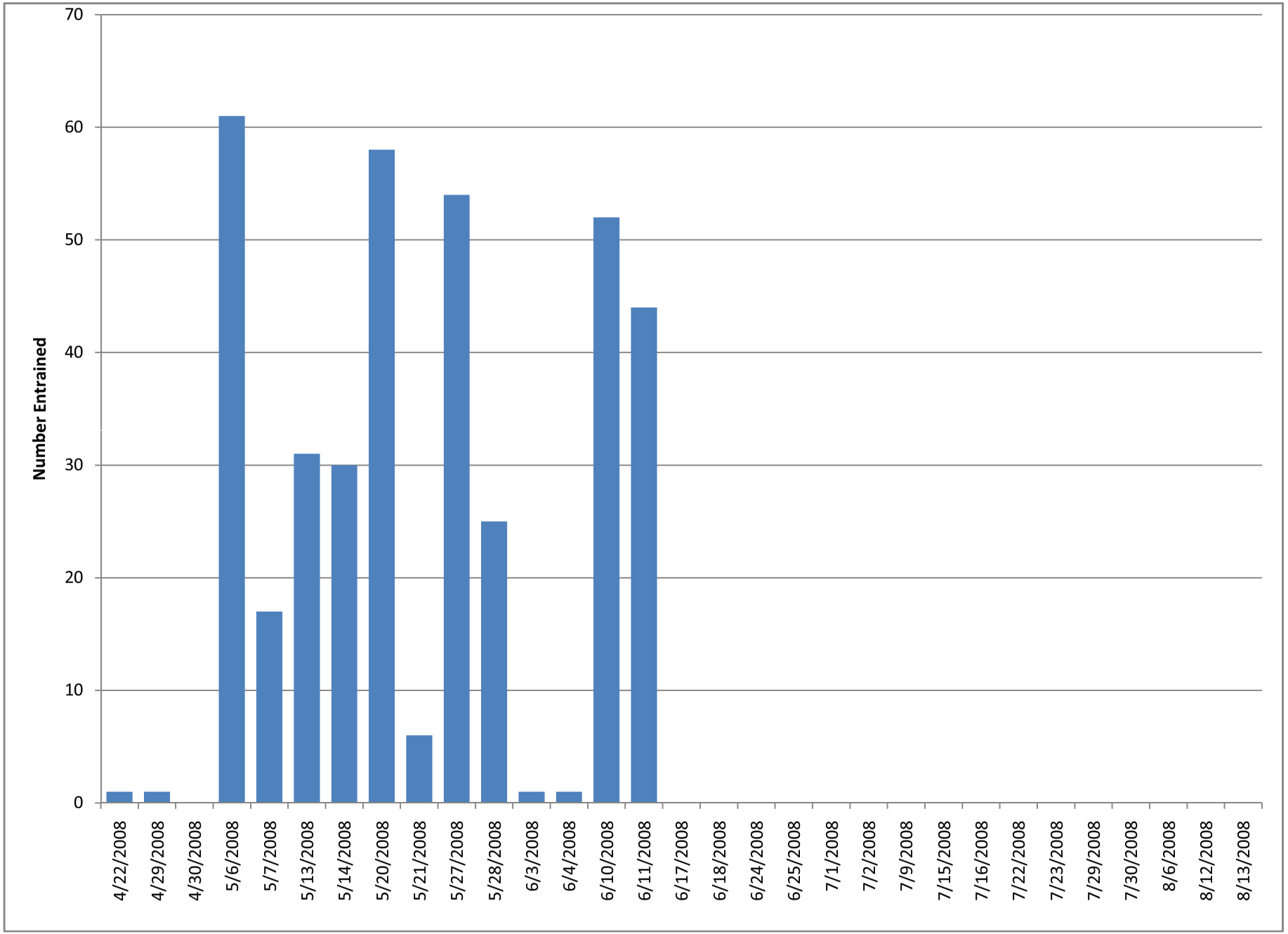

Figure 22. Number of unidentitifed darter collected in each entrainment sample through time at the SSES CWIS during 2008.

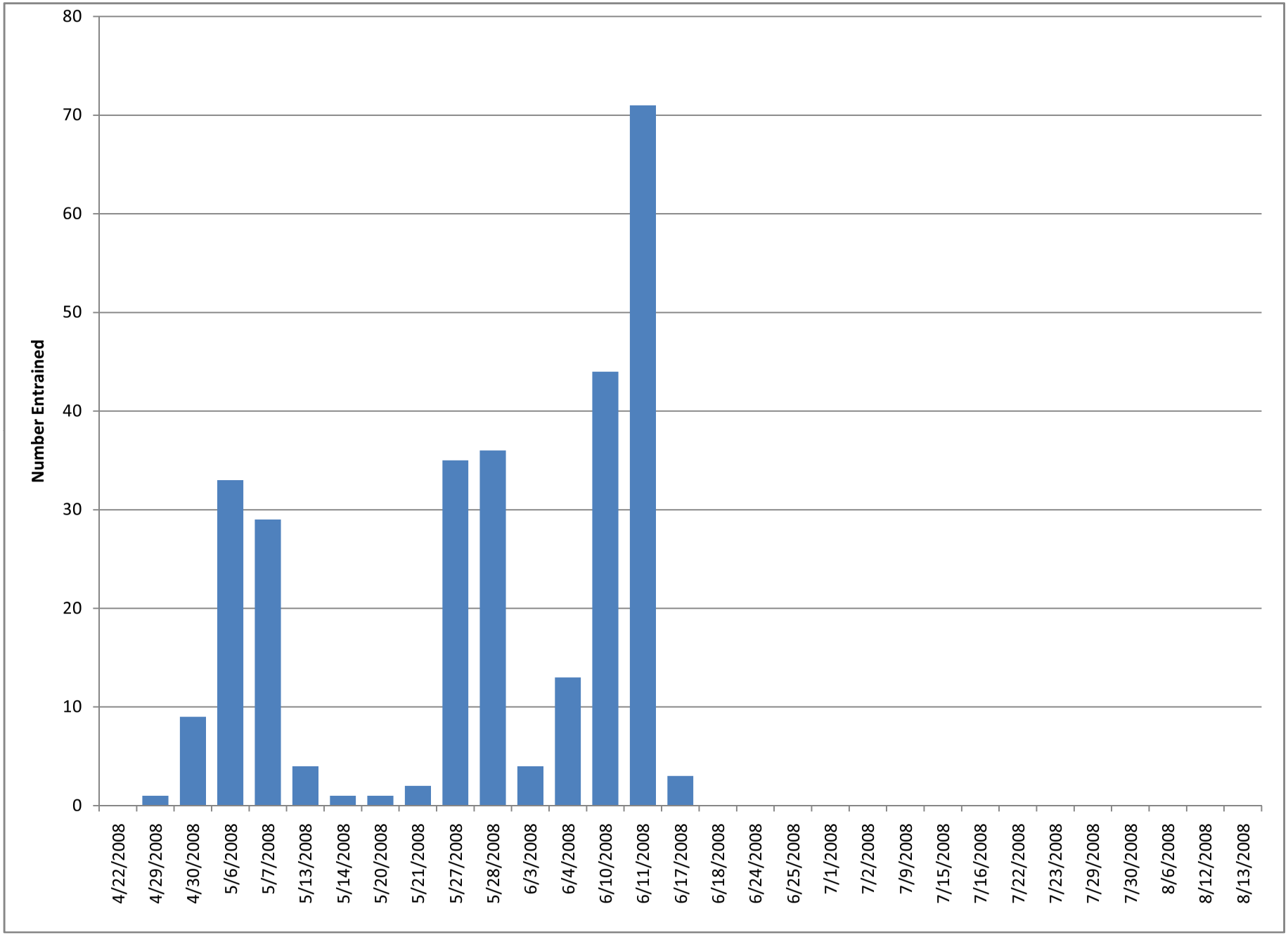

Figure 23. Number of white sucker collected in each entrainment sample through time at the SSES CWIS during 2008.

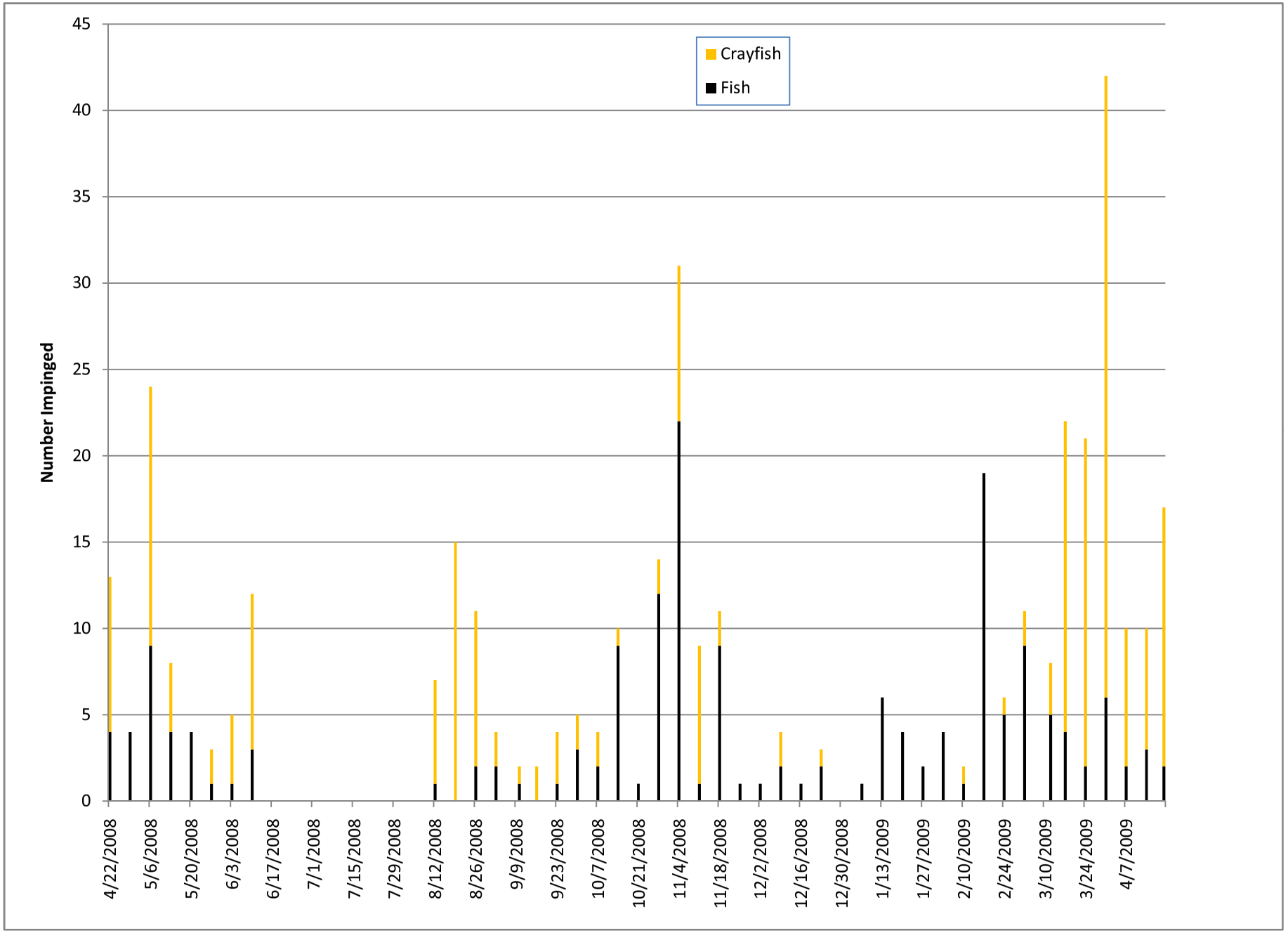

Figure 24. Total number of fish and crayfish impinged for each sampling event (24-hr period) at the SSES CWIS, April 22, 2008 to April 20, 2009.