TEMPERATURE, DISSOLVED-OXYGEN, AND NUTRIENT MONITORING IN THE SUSQUEHANNA RIVER – SUMMER 2008

A Project Proposal

Submitted by:
The U.S. Geological Survey

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EXECUTIVE SUMMARY

Problem Statement

The Susquehanna River and its tributaries are widely known for their high-quality fishing for smallmouth bass. But in the summers of 2005 and 2007, die-offs of mostly young smallmouth bass were observed in the Susquehanna River, the Juniata River, and the West Branch Susquehanna River. In both years, the dead and dying fish were colonized by infections of the bacterial disease known as Columnaris. It is not clear whether these infections were opportunistic occurrences on fish that were otherwise stressed or whether the bacterial infections were the primary causative agent in the die-offs. Both the summers of 2005 and 2007 were characterized by little rainfall, low flow conditions, and high temperatures. Stress from these environmental conditions is suspected to have played a key role. Investigations are needed to try to pinpoint the causative agent (or agents) in the smallmouth bass mortalities.

This proposal outlines a study to be conducted during the summer of 2008 to assess high temperatures and low dissolved-oxygen concentrations as possible causative agents in the smallmouth bass die-offs.

Objectives

1. To characterize long-term temperature and dissolved oxygen regimes in critical reaches of the Susquehanna River system.

2. To evaluate water quality of juvenile smallmouth bass microhabitats and determine whether stressful conditions exist in these areas that are not characteristic of the mid-channel habitat of the River.

3. To compare temperature and dissolved oxygen regimes in the Susquehanna River with temperature and dissolved oxygen regimes in the Delaware River and the Allegheny River.

4. To identify patterns of nutrient concentrations in microhabitats in the Susquehanna River system.

Products

1. Quality-assured and published continuous-monitoring and synoptic survey water-quality data for the critical summer period from several sites in the Susquehanna River and its tributaries.

2. A framework and infrastructure for long-term continuous water-quality monitoring data from two key sites in the Susquehanna River Basin.

3. A published scientific report detailing major findings of the study.

Budget

The proposed work is estimated to require $250,000 over three state fiscal years. Of that amount, the USGS will provide $50,000 depending on the availability of federal funds. Total funds in the amount of $200,000 are requested from Pennsylvania Fish and Boat Commission (PFBC) to support the work.

BACKGROUND

During the summers of 2005 and 2007, smallmouth bass in the main stem of the Susquehanna River and in a few of the major tributaries to the River were observed to be dead or dying. Figure 1 shows locations where diseased fish were observed in those years. Affected individuals were colonized by high levels of *Flavobacterium columnare* and aerommonad bacteria. Predominately, young-of -the-year fish were affected while older fish were not. It is not clear whether the bacterial infections are the root of the problem or whether these are opportunistic infections encouraged by stress from some other factor. There is a need to establish a cause for the die-off of this important gamefish. These mortality events have caused angler concerns and economic impacts.

Similar smallmouth bass die-offs did not occur in the Delaware River or the Allegheny River during 2005 or 2007. These river systems share many attributes of the Susquehanna River. They are at the same latitude; they are similar in size to some sections of the Susquehanna River; they have strong populations of smallmouth bass.

Preliminary hypotheses about the cause for the stress have pointed to stressful water temperatures and low dissolved oxygen (DO) levels. But, there are no existing continuous-recording dissolved oxygen or temperature monitors in the stream reaches where the dead fish were observed. Thus, there has been no definitive information to support or refute the hypothesis that stressful temperature and dissolved-oxygen conditions are responsible for the fish mortality. In the summer of 2007, the Pennsylvania Fish and Boat Commission deployed a limited number of water-quality monitors in an attempt to provide data to bear on the issue. Some of the data from this effort supported the idea that low dissolved oxygen concentrations may be a contributing factor.

While the 2007 efforts by the Fish and Boat Commission were informative, they were not designed to be definitive. Those 2007 measurements need to be confirmed and augmented with a more intensive, longer-term effort to document temperature and dissolved-oxygen levels in the Susquehanna River system. This proposal offers suggestions for that effort.

If the causative agent for the Susquehanna River fish kills indeed turns out to be low dissolved-oxygen concentrations, then the question becomes what is causing the low DO. Two possibilities exist; (1) in-stream processes and (2) external inputs. The largest oxygen-demanding in-stream process is respiration from algae and rooted aquatic plants. Algal and plant growth is stimulated by nutrients. Therefore, there is a need to evaluate nutrient concentrations in the Susquehanna River and its tributaries. This proposal allows for an examination of nutrient concentrations in microhabitats. However, it does not cover other needed nutrient monitoring including a broad geographical picture of nutrient concentrations in the Susquehanna River Basin or an evaluation of nutrient concentrations over a growing season.

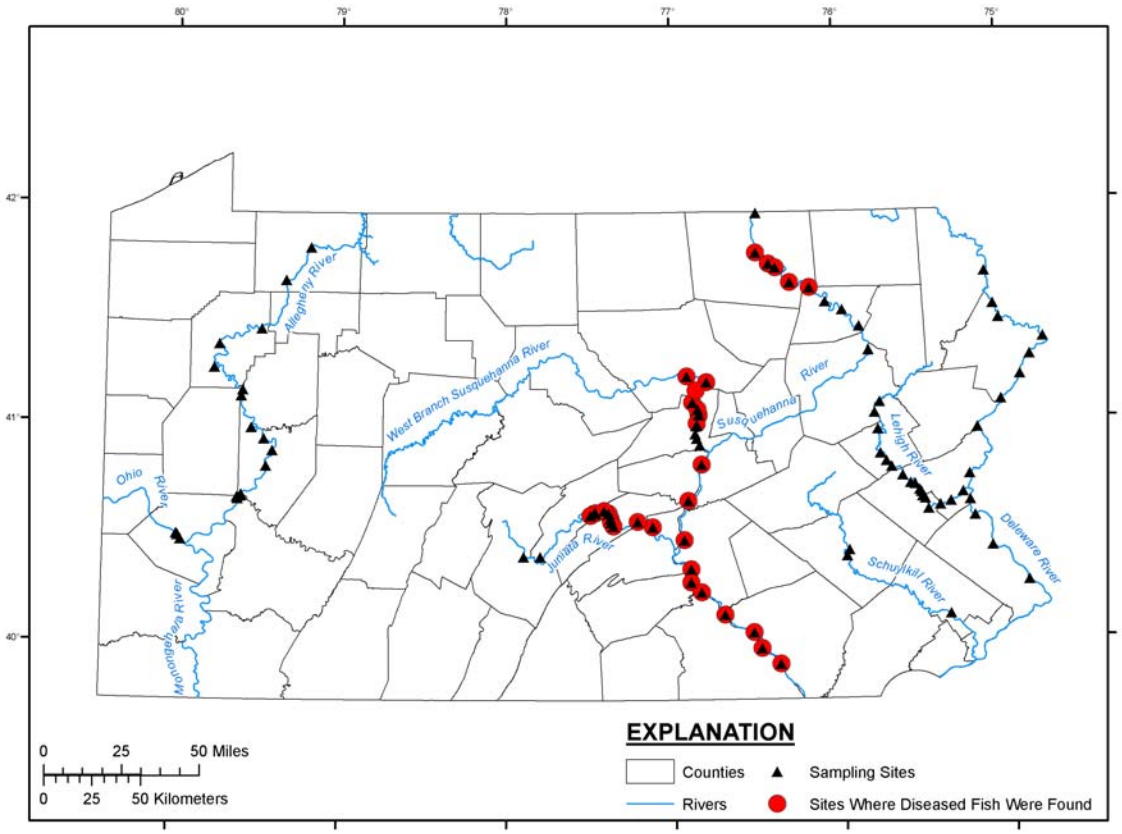

Figure 1: Pennsylvania Fish and Boat Commission sampling sites for smallmouth bass with sites where diseased fish were found in 2005 and 2007.

OBJECTIVES AND SCOPE OF WORK

Objectives

The primary objectives of the proposed project are:

1. To characterize long-term temperature and dissolved oxygen regimes in critical reaches of the Susquehanna River system.

2. To evaluate water quality of juvenile smallmouth bass microhabitats and determine whether stressful conditions exist in these areas that are not characteristic of the mid-channel habitat of the River.

3. To compare temperature and dissolved oxygen regimes in the Susquehanna River with temperature and dissolved oxygen regimes in the Delaware River and the Allegheny River.

4. To identify patterns of nutrient concentrations in microhabitats in the Susquehanna River system.

Scope

We propose using continuous water-quality monitors to evaluate long-term temperature and dissolved oxygen regimes. These monitors will provide a long-term record of temperature and DO extremes during critical periods. Eventually, data from these monitors can be used for year-to-year comparisons of river conditions. Other monitors will be deployed in clusters on a short-term basis during the summer months to evaluate localized variability (micro-habitats). Additionally, water-quality monitors already operating in the Delaware and Allegheny Rivers will provide insight about why fish are stressed in the Susquehanna River, but not in the Delaware or Allegheny Rivers. Nutrient monitoring will also be performed at the microhabitat scale, to complement the dissolved and temperature monitoring in these locations.

The focus of the work will be temperature, dissolved oxygen, and nutrients. Other factors may be involved in the smallmouth bass die-offs. For example some toxic agent or some genetic trait isolated to the Susquehanna River bass may be at the root of the issue. But, scientists concerned with the problem have not identified any likely factors other than water temperature and dissolved oxygen. Therefore, this proposal is limited to temperature, dissolved oxygen, and nutrient monitoring.

Most of the work will occur in the summer of 2008. Identification of microhabitats and comparisons between the Susquehanna River and the Delaware and Allegheny River will all be completed in the summer of 2008. Nutrient surveys in microhabitats will also occur in 2008. Long-term continuous monitoring for temperature and DO will extend indefinitely into the future, providing additional support is found for that work.

A formal USGS report detailing the findings of the study will be prepared. The report will be due to the Fish and Boat Commission on September 30, 2009.

Approach

Objective 1: Characterize Long-Term Temperature and Dissolved Oxygen Regimes in the Susquehanna River

We propose to install continuous-recording water-quality monitors for long-term (several years) operation at strategic locations in areas where smallmouth bass die-offs have been observed. These monitors will operate in an unattended mode and collect temperature and dissolved oxygen measurements during the most critical periods of the year. Data from these monitors can then be matched to records of fish stress and mortality to determine whether stressful temperature and dissolved oxygen levels trigger fish die-offs.

Data from these monitors would also provide a public information benefit. The temperature and DO data collected by the monitors would be posted on the World Wide Web for use by anglers.

Tasks included in this objective are:

- Locating target sites for monitor deployment.
- Installing the continuous monitors.
- Servicing the monitors and downloading the data.
- Analyzing the data by comparing stressful conditions against fish mortality.
- Reporting the results.

Locating Sampling Sites

The U.S. Geological Survey maintains five continuous-record streamflow gages in that part of the Susquehanna River Basin most affected by the fish die-offs. These gages are listed in Table 1. Co-locating the water-quality monitors at an existing USGS gage provides the capability to transmit the data from the monitors over the World Wide Web in near-real time. This capability will provide a warning signal to Fish and Boat Commission staff when river conditions are approaching stressful levels. It will also serve to inform the public about current river conditions and help to gain their support for the work.

Table 1. Existing continuous-monitoring USGS streamflow gages in the part of the Susquehanna River Basin most heavily affected by smallmouth bass die-offs.

Stream name	Location	County	USGS station number	Drainage area (mi^2)	Years of streamflow record
Susquehanna River	at Danville, Pa.	Montour	01540500	11,220	108
Susquehanna River	at Sunbury, Pa.	Snyder	01554000	18,300	70
Juniata River	at Mapleton Depot, Pa.	Huntingdon	01563500	2,030	70
Juniata River	at Newport, Pa.	Perry	01567000	3,354	108
Susquehanna River	at Harrisburg, Pa.	Dauphin	01570500	24,100	117

We propose adding continuous-record water-quality monitors at two locations, one on the main stem of the Susquehanna River and one on the Juniata River. The USGS streamflow gage on the Susquehanna River at Harrisburg is strategically located for the study, and the existing USGS intake at this station is ideally positioned on the east side of City Island, near the center of the River. Even though the river is not well-mixed at Harrisburg, we recommend a continuous monitor for the Harrisburg location. Over time, the year-to-year variations at this location should provide evidence of high temperature and low dissolved-oxygen conditions and would offer insight into he issue of smallmouth bass disease. Data from this monitor would be posted in near-real time to the World Wide Web.

We propose installing a water-quality monitor in the Juniata River at the USGS gage at Newport. The gaging station intake is near the west bank of the river. The water-quality monitor would communicate directly with the instrumentation in the gage house, thereby providing the capability for real-time relay of the data to the World Wide Web.

The continuous-record water-quality monitors would be operated annually for six months, from April through September. This period includes the most critical time for potential temperature and DO problems and it brackets the time when the fish die-offs occurred in 2005 and 2007. Temperature and DO problems are not expected to occur in the colder months so there is little benefit to operate the monitors during October through March.

Having a long-term record of temperature and DO will allow managers to compare hot, dry years with cool, wet years and correlate environmental conditions with smallmouth bass die-offs. The work described in this proposal covers installation for these monitors and operation for the first year, but does not cover the long-term operation of these monitors. We believe that a consortium of public agencies may be interested in supporting the long-term operation and maintenance of these monitors. That consortium could include the Pennsylvania Fish and Boat Commission, the Pennsylvania Department of Environmental Protection, the Susquehanna River Basin Commission, and the U.S. Geological Survey. The Susquehanna River Basin Commission has been leading an effort to establish continuous water-quality monitoring in the Susquehanna River as part of an early-warning system for drinking water facilities. Perhaps that effort could be combined with the present proposal to benefit both projects.

Continuous Monitor Installation and Operation

The USGS would be responsible for installing, operating, and maintaining the continuous monitors and posting the data in near-real time on the Web. Operating continuous monitors is a challenge. The monitors are prone to fouling and drift. Frequent maintenance is necessary, so monitors would be serviced bi-weekly, or more frequently, if malfunctions occur. Data adjustments are often needed. The USGS has ample experience with the trials and tribulations of keeping continuous monitors operating. We maintain more than 20 monitors on a routine basis in the Delaware and Ohio River Basins. There are four continuous monitors already in service in the Susquehanna River Basin, but they are in upstream regions of the Basin, away from the sections of the River that experienced fish die-offs.

Data Analysis and Reporting

Data analysis and reporting will be a joint task involving the Pennsylvania Fish and Boat Commission and the U.S. Geological Survey. The analysis will include matching recorded observations from the water-quality monitors against the life history requirements for smallmouth bass and long-term records of bass mortality. Graphical analyses will be used heavily for the analysis. Statistical comparisons are expected to be minimal.

This component of the work is an investment in the future. It will take several years of data before meaningful analyses will be possible. Therefore, there is no short-term reporting requirement for this component of the work except for publishing the data in the USGS Pennsylvania Water Science Center Annual Report and making the data available on the USGS Web site.

Objective 2: Evaluate Water Quality in Micro-Habitats

Inexpensive waterproof temperature recorders are now commercially available for continuous temperature monitoring. We propose to place up to six temperature recorders in each of two pools in the River to document spatial variations in temperature within a pool. Large temperature variations over the area of the pool, with stressful temperatures in near shore or backwater areas, would support the theory that temperature is a causative factor for the smallmouth die-offs.

Inexpensive dissolved oxygen recorders are not available. Therefore, it is impractical to place a large number of dissolved oxygen recorders in a pool to document spatial DO variations. However, for each of the two pools under study, we propose to place one multi-parameter water-quality monitor in mid stream and another monitor in a near-shore location likely to function as a nursery area for juvenile smallmouth bass. These two monitors would serve to document differences between midstream and near shore dissolved-oxygen levels. The monitors would operate continuously in an unattended mode, but for only a short time period (perhaps two months) when die-offs are likely to occur. To save money, we anticipate renting the monitors for this task instead of purchasing them.

Further, we propose to conduct a detailed water-quality profile for each of the two pools under investigation. Profiling involves making measurements of pH, specific conductance, dissolved oxygen, and temperature at many points across the width of the river and at several depths at each of the cross-section points. The profiling would be conducted on two occasions, once in June to correspond with the time when previous fish mortality has been observed and once in the hottest part of the summer when flows are lowest (August). There would be two profiles for each pool under study, one in the heat of the day when temperatures are expected to be highest and one during darkness in the early morning hours when DO is expected to be lowest. So, in total, each pool under study would have four profiles conducted:

- June, daytime
- June, nighttime
- August daytime
- August nighttime

Finally, we propose to conduct two intensive nutrient surveys in the two pools selected for the microhabitat work. These surveys would be conducted concurrently with the water-quality profiling described above. The nutrient surveys would include both water-column samples and sediment samples, with randomized sampling points based on a grid overlay of the pool to be monitored. Proposed nutrient monitoring is detailed later in this proposal.

Locating the Sampling Sites

The micro-habitat work needs to be conducted at specific locations where fish stress is expected to occur. The USGS will work in conjunction with staff from the Fish and Boat Commission to identify pools or reaches of the Susquehanna River and/or the Juniata River where fish die-offs occurred in 2005 and 2007. Based on the information from 2005 and 2007, we will select two pools where stressful conditions are expected to occur.

Monitor Installation and Operation

The USGS would be responsible for installing, retrieving, and downloading data from the continuous temperature monitors and the continuous water-quality monitors. The monitors would remain active only for a couple of months, the months having conditions most likely to induce stress in the smallmouth bass.

Water-quality profiling will be the responsibility of the USGS. Support from the Fish and Boat Commission in the form of boat transportation may be needed. Acoustic Doppler Current Profiling (ADCP) units would guide field personnel to the sampling points. Multi-parameter water-quality monitors would record the observations.

Nutrient sampling would be the responsibility of the USGS. Analytical services would be provided by the DEP Bureau of Laboratories.

Data Analysis and Reporting

Data analysis and reporting will be a joint task involving the Pennsylvania Fish and Boat Commission and the U.S. Geological Survey. Graphical analyses will be important to denote differences between near-shore locations and mid-channel locations. Analyses for the profiling data will involve three-dimensional graphical isopleths for temperature and dissolved oxygen. Nutrient data for sediments will be compared with nutrient data for the water column.

The USGS will take the lead in preparing this part of the report with input from the Fish and Boat Commission.

Objective 3: Compare Susquehanna River with Delaware and Allegheny Rivers

During the summers of 2005 and 2007, smallmouth bass in Susquehanna River exhibited mortality, but those in the Delaware River and the Allegheny River did not. Perhaps bottom-release reservoirs in the Delaware and Allegheny River Basins contribute to a cooler water temperature, and consequently higher dissolved-oxygen concentrations, in these rivers compared to the Susquehanna River. Perhaps the wide, shallow character of the Susquehanna River makes it more susceptible to warming than the Delaware or the Allegheny Rivers. Perhaps weather patterns such as cloud cover contribute to warmer conditions in the Susquehanna River compared to the Delaware and Allegheny Rivers. Regardless, documentation is needed to verify whether temperature and dissolved oxygen conditions are more stressful in the Susquehanna River than in the Delaware and the Allegheny Rivers. We propose to monitor temperature and dissolved oxygen in the Delaware and Allegheny Rivers concurrently with temperature and DO monitoring in the Susquehanna River and then to compare the three. A warmer environment having lower dissolved oxygen concentrations in the Susquehanna River would lend credence to the idea that temperature and DO contribute to the Susquehanna River fish mortality.

Locating the Sampling Sites

Existing USGS continuous-monitoring locations in the Delaware and Allegheny Rivers can be used for comparisons with the Susquehanna River, so no new monitoring sites will need to be established. Continuous-monitoring for temperature and dissolved oxygen is on-going on the Delaware River at Trenton, N.J. and on the Allegheny River at Lock and Dam No. 3 at Acmetonia, Pa. These sites will have lower volumes of flow than in the Susquehanna River and, therefore, will not perfectly mimic locations in the Susquehanna River Basin where the detailed micro-habitat studies will be conducted, but they should suffice for temperature and DO comparisons.

Monitor Installation and Operation

Continuous water-quality monitors are already installed in the Delaware River and the Allegheny River. The USGS operates these sites in cooperation with the Delaware River Basin Commission and the U.S. Army Corps of Engineers. The monitors operate continuously in an unattended mode. Bi-weekly maintenance visits by USGS personnel help to ensure high-quality data. But for comparison with the Susquehanna River data, additional checks will be made against a NIST-certified thermometer and additional DO checks will be made against a zero-DO solution.

Data Analysis and Reporting

Data analysis and reporting will be the primary responsibility of the U.S. Geological Survey. The analysis will involve graphical and statistical comparisons for temperature and dissolved oxygen among the three streams. The USGS will take the lead in preparing this part of the report.

Objective 4: Identify Patterns of Nutrient Concentrations in Microhabitats in the Susquehanna River System

If low dissolved oxygen concentrations are indeed a cause of the observed smallmouth bass mortalities, then the cause of the low concentrations needs to be identified. One obvious cause would be high nutrient concentrations that cause excessive algal and rooted aquatic plant productivity. Therefore, an objective of the proposed work is to survey patterns of nutrient concentrations in microhabitats in the Susquehanna River. Intensive monitoring for nutrients in two selected pools will provide information regarding the existence of nutrient microhabitats.

Locating the Sampling Sites

Two pools will be selected for the intensive nutrient monitoring. One pool on the Susquehanna River and one pool on the Juniata River will be the same pools used for the intensive temperature and dissolved-oxygen monitoring.

Sample Collection

Water samples and sediment samples will be collected by USGS staff at several near-shore sampling locations within each pool. Exact sampling locations will be selected at random based on a sampling grid. Depth-integrated collection technology will be used for these samples. Samples will be collected two times over the course of the study, once in the May-June time frame when smallmouth bass mortality has been observed in the past and once in the July-August time-frame when water temperatures are expected to be hottest and flows lowest.

Laboratory Analysis

Nutrients in both water and sediment will be analyzed by the Pennsylvania Department of Environmental Protection Bureau of Laboratories. Nutrient species targeted for analysis are listed in Table 2.

Table 2. Nutrient analyses needed for the synoptic surveys for nutrients, weekly sampling for nutrients and the documentation of nutrient microhabitats.

Parameter	Analyzed in water samples?	Analyzed in sediment samples?
Total phosphorus	yes	yes
Filtered phosphorus	yes	no
Nitrite plus nitrate nitrogen	yes	no
Nitrite nitrogen	yes	no
Total Kjeldahl nitrogen	yes	no
Ammonia nitrogen	yes	no
Total nitrogen	yes	yes
BOD	yes	no

Data Analysis and Reporting

Data analysis and reporting will be the primary responsibility of the U.S. Geological Survey. The analysis will involve primarily graphical presentations of nutrient concentrations showing variability in nutrient concentrations within each pool. The USGS will take the lead in preparing this part of the report.

Quality Assurance and Quality Control

Rigorous quality-assurance and quality-control measures will be adopted including written protocols, standardization of field instruments, and uniform, pre-printed field data-collection sheets. Maintenance and routine service for the water-quality monitors will be preformed in accordance with the guidelines in USGS Techniques and Methods Manual for Continuous Water-Quality Monitors (Wagner, and others, 2006).

All field thermometers and thermisters will be calibrated against a NIST-certified thermometer. This step is critical because we will be comparing temperature data from site to site within and among river basins.

Calibrations of DO meters will be checked with a zero DO solution. This step is necessary because the standard calibration for dissolved oxygen measurement is a one-point calibration at saturation. We anticipate encountering DO concentrations at the study sites that are considerably lower than saturation, perhaps as low as 3 or 4 mg/L. Meters will need to return a reading of less than or equal to 0.3 mg/L in the zero DO solution or else they will be replaced.

Field meters will be used to check the performance of the continuous monitors. Field meters will be calibrated daily and will be considered to be “correct.” Continuous monitors will be serviced on a two-week schedule. When field-meter readings and monitor readings do not concur, data from the monitor will be adjusted using the computer software program Automated Data Processing System (ADAPS) that is part of the USGS National Water Information System (U.S. Geological Survey, 2003).

Equipment blanks, field blanks, replicate samples, and standard reference samples will be submitted routinely to provide quality assurance for sampling and laboratory procedures.

COLLABORATION

Collaboration will be critical for the success of the project. The U.S. Geological Survey will need input from Fish and Boat Commission staff to help identify sampling sites where fish die-offs have been observed in the past. The Fish and Boat Commission has two water-quality sondes that will be loaned to the project. Fish and Boat Commission personnel may also be needed to provide boat transportation for deploying water-quality monitors, servicing these monitors, and for water-quality profiling.

The Pennsylvania Department of Environmental Protection (DEP) staff also will be called on to support the effort. Staff from DEP could provide valuable field observations about sampling sites, locations where fish stress is observed, and access points. DEP owns two water-quality monitors will be borrowed for the project. And, most importantly, DEP analytical services will be a key component of the project. The DEP Black Fly Program may support some of the nutrient analyses. DEP has indicated that aerial fly-overs to picture documentation of the extent of filamentous algal growth will be provided to support the project.

The U.S. Fish and Wildlife Service office in Lamar, Pennsylvania has a Fish Health Unit that could provide valuable support for the study. At the time this proposal is being prepared, Fish and Wildlife Service interests have not been assessed, but past collaboration with this group of scientists has been productive.

Finally and most importantly, the Pennsylvania Fish and Boat Commission will need to support the study with their own investigations of fish stress and fish kills. These investigations will include on-site evaluations during fish-kill incidents and follow-up laboratory studies of bacterial infections. The PFBC is planning to set up a hotline to collect reports of fish mortality from anglers and other river users. This information will be used to better define the scope and extent of the fish mortality. These studies will help to document the geographical extent of the problems and the timing of the fish die-offs.

PRODUCTS

The following products are anticipated from the study.

1. Electronic versions of all data generated by the project will be stored in the USGS on-line web-accessible data base known as the National Water Information System (NWIS). All data in NWIS are available through Web portals to cooperating agencies and to the public. These data can also be accessed on-line through the Pennsylvania Water Science Center Annual Data Report. In addition, electronic and paper copies of the data will be provided to the cooperating agencies.

2. A published scientific report will detail major findings of the study. This report will be a formal USGS peer-reviewed report, due to the cooperator on September 30, 2009.

PROJECT TIMELINE

The project will run from April 1, 2008, to September 30, 2009 (Table 3).

Project Activity	Calendar Year 2008												Calendar Year 2009											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Planning phase																								
Project planning meeting																								
Equipment purchase																								
Coord. w/ cooperating agencies																								
Data collection phase																								
Select locations																								
Install long-term monitors																								
Collect long-term data																								
Install monitors in pools																								
Collect data from pools																								
Collect Algh, Del. data																								
Conduct profile work																								
Nutrients in pools																								
Report preparation phase																								
Report planning meeting																								
Compile data																								
Analyze results																								
Write draft report																								
Report reviews																								
Report review meeting																								
Revise report																								
Publish report																								
Add data to NWIS database																								
Transmit data to F&BC.																								

BUDGET

The estimated total funding needed for the project is $250,000. The USGS will contribute $50,000 of this amount to the project. Budget categories and the amount of funding required are broken down in Table 4.

Table 4. Funds needed to conduct the study of dissolved oxygen, temperature, and nutrients.

Cost category	Funds needed		
	Federal FY 2008	Federal FY 2009	Total
Obj. 1 – Long term temperature and DO	$77,000	$8,000	$85,000
Obj. 2 – Microhabitats	67,000	11,000	78,000
Obj. 3 – Compare Delaware, Allegheny	6,000	3, 000	9,000
Obj. 4 -- Nutrients			
Microhabitats	20,000	8,000	28,000
Report	0	50,000	50,000
TOTAL FUNDING REQUIRED	**$170,000**	**$80,000**	**$250,000**

Funds to conduct the proposed work will be provided primarily by the Pennsylvania Fish and Boat Commission and its partners. The USGS will contribute federal matching funds from the Federal-State Cooperative Program. These funds are subject to the availability of funds. Funding sources for the project are listed in Table 5.

Table 5. Funding sources for the proposed study of dissolved oxygen, temperature, and nutrients.

Organization	Federal FY 2008	Federal FY 2009
PFBC	$145,000	$55,000
USGS	25,000	25,000
ANNUAL TOTALS	$170,000	$80,000
TOTAL FUNDING		**$250,000**

Budget categories and the amount of funding required are broken down by state fiscal year in Table 6.

Table 6. Funds needed to conduct the study of dissolved oxygen, temperature, and nutrients, by state fiscal year.

Cost category	Funds needed			
	State FY 2008	State FY 2009	State FY 2010	Total
Obj. 1 – Long term temperature and DO	$52,000	$31,000	$2,000	$85,000
Obj. 2 – Microhabitats	40,000	36,000	2,000	78,000
Obj. 3 – Compare Delaware, Allegheny	5,000	3, 000	1,000	9,000
Obj. 4 -- Nutrients				
Microhabitats	16,000	10,000	2,000	28,000
Report	0	28,000	22,000	50,000
TOTAL FUNDING REQUIRED	**$113,000**	**$108,000**	**$29,000**	**$250,000**

Funding sources for the project are listed by state fiscal year in Table 7.

Table 7. Funding sources for the proposed study of dissolved oxygen, temperature, and nutrients, by state fiscal year.

Organization	State FY 2008	State FY 2009	State FY 2010	Total
PFBC	$88,000	$83,000	$29,000	$200,000
USGS	25,000	25,000	0	50,000
ANNUAL TOTALS	$113,000	$108,000	$29,000	
TOTAL FUNDING				**$250,000**

RELEVANCE AND BENEFITS

The proposed work will address a major issue for Pennsylvania recreational fishing. The smallmouth bass is a highly sought-after species, valued by many recreational anglers. In addition, a small industry consisting of fishing guides, sporting goods stores, and tackle manufacturers, derives substantial revenues from smallmouth bass fishing. The fishing public is demanding answers to the causes for the smallmouth bass die-offs.

Results of the study will provide the cooperator with evidence supporting or refuting the theory that DO and temperature are major factors in the recent smallmouth bass mortalities. Having this knowledge will allow for rational management strategies to be developed and implemented.

Specific benefits to the USGS provided by the proposed work are opportunities to:

1. Expand the current data base of water-quality monitoring in surface waters.

2. Provide new data-collection locations for continuous water-quality monitoring that will fill in existing gaps in the Pennsylvania data-collection network.

REFERENCES

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