**CDI SSF Category 4: Community Innovation (SSF4)**

**Project Title:** Developing Tools for the Analysis and Visualization of Fish Telemetry Data with River Parameter Data

**Principal Investigators:**

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Curtis V. Price, USGS South Dakota Water Science Center, 1608 Mt. View Rd., Rapid City, SD 57702. Phone: (605) 394-3242, Fax (605) 355-4523, Email: cprice@usgs.gov.

Marybeth Brey, Center for Fisheries, Aquaculture, & Aquatic Sciences, 1125 Lincoln Drive, 173 Life Sciences II, Southern Illinois University, Carbondale, Illinois 62901-6511. mbrey@siu.edu.

**Fiscal Contact:**

Kelly A. Welborn, USGS Illinois Water Science Center, 1201 W. University Ave, Urbana, IL 61801. Phone: (217) 328-9710, Fax (217) 328-9770, Email: kwelborn@usgs.gov.

**Collaborators:**

James E. Garvey, Director, Center for Fisheries, Aquaculture, & Aquatic Sciences, 1125 Lincoln Drive, 173 Life Sciences II, Southern Illinois University, Carbondale, Illinois 62901-6511. Phone: (618) 453-5611, Fax (435) 797-1100, jgarvey@siu.edu.

Alta Harris, Western Fisheries Research Center- Klamath Falls Field Station, 2795 Anderson Ave., Suite 106, Klamath Falls, OR 97603-7863. Phone: 541-273-8689, Email: aharris@usgs.gov

**Abstract:**

Biologists routinely utilize telemetry methods to track the movement of fish. In fisheries science, small transmitters are implanted into fish and fixed receivers record the position, date, and time of tagged fish as they pass the underwater receivers. This information can be used by biologists to track the movement of fish, identify preferred habitat, and understand the life history of a species.

Fish telemetry data can be difficult to process and analyze. While the data structure (date/time/ location) may be simple, the large volumes of data generated and the temporal and spatial components can be cumbersome to process and interpret.

Visualization tools are needed to effectively analyze fish telemetry data. Visualization tools can efficiently merge the temporal and spatial aspects of tracking fish with changing river conditions. Visualization tools give biologists the context for understanding fish behavior and thus a more complete picture of the life history. This information can be used to design fishery management plans, develop species restoration plans, or design strategic controls for invasive species.
USGS researchers in Oregon have recently collaborated to develop a data model for fish telemetry data. They developed a generic web database application to store fish telemetry data for several cooperating agencies working with tagged fish in the Lower Klamath Basin.

Researchers at Southern Illinois University have utilized fish telemetry methods since 2009 to track the movement of Asian carp within the Illinois River. This invasive species pose a serious threat to the Great Lakes ecosystem and the USGS is working closely with other federal and state agencies to develop control strategies to prevent the species from becoming established in the Great Lakes.

**Total funding amount requested:** $49,229

**Total In-Kind Funding:** $20,392

**Specific Datasets Use/Impacted/Exposed**

NWIS- USGS National Water Information System. The national database for thousands of sites in all 50 states and territories of the US.

KRB- Klamath River Basin PIT tagging database. A multi-species database of PIT tag information from multiple agencies collaborating on fish telemetry studies in the Klamath River Basin.

Southern Illinois University PIT tagging database

**Geographic/geologic/ecosystem/habitat/taxonomic/other context:**

US national, fisheries, invasive and endangered species

**Expected Product(s) Generated**

Web-based visualization tools, GIS Data Layers, USGS Fact Sheet
General Public Summary

Biologists utilize telemetry methods to track the movement of fish. In fisheries science, small transmitters are implanted into fish and fixed receivers in a river record the position, date, and time of tagged fish as they pass the underwater receivers. This information is used to track the movement of fish, identify preferred habitat, and provide other valuable information to effectively manage the fishery.

Fish telemetry data is difficult to process and analyze. While the data structure (date, time, location) may be simple, the large volumes of data generated and the temporal and spatial components can be cumbersome to process and interpret.

Visualization tools are needed to effectively analyze fish telemetry data. Combining fish telemetry data with river gage data such as water level, flow, temperature and water quality, biologists can study the movement of the fish in response to the physical river environment.

This project combines the knowledge and skill sets of a team of researchers with backgrounds in biology, river hydrology, geographical information systems, and database management to develop web-based visualization tools that will advance the understanding of fisheries science and contribute to the management of both native and invasive species.
**Scope:** This project will develop web-based visualization tools to enable biologists to better visualize fish telemetry data in conjunction with river gage data and analyze the movement of fish both spatially and temporally in response to river conditions.

The project is a collaboration of scientists with a common need for the development of visualization tools for fish telemetry data. USGS and SIU researchers working with Asian carp in Illinois have the same data visualization needs as USGS and other researchers working with fish telemetry data from endangered sucker species in the Klamath River Basin in Oregon and northern California. This collaboration is the result of common needs and goals first identified in the CDI proposal process.

The project integrates the metrics biologist develop from fish telemetry data (date/time, location, distance moved, etc.) with measured river gage data hydrologists collect so that the combined temporal and spatial analysis gives a better understanding of a species within its riverine environment.

The visualizations tools will be developed working with two existing fish telemetry databases (USGS-Klamath River Basin data and SIU-Illinois River Basin data).

A standardized database framework for fish telemetry data called KRB was recently developed by USGS researchers in Oregon (Western Fisheries Research Center-Klamath Falls Field Station) and Colorado (Powell Center-Fort Collin). The KRB database framework will be used to insure the visualization tools are applicable to a wide range of telemetry datasets. The KRB database provides a standardized framework for the efficient storage of fish telemetry data.

River gage data such as stage, discharge and water quality are readily available from existing USGS databases (NWIS) and the visualization tools will utilize the USGS gage data for this project. The Klamath River Basin database provides a standardized database framework from which the telemetry data may be accessed for analysis using readily available geographic information system (GIS) tools.

A multi-step process will be followed to 1) evaluate the data model, 2) outline the needs of biologists in terms of visualizing data, 3) determine what tools will be used, 4) develop the web-based visualization tools, and 5) beta-test the web-based visualization tools.

The project combines the biologists existing knowledge of the life history of fish species with the hydrologists knowledge of river conditions to better understand the species in its riverine environment. Biologists identify specific life history behavior for some species with the physical in a river based upon field observations. For example, spawning for some species is linked to flood events, however, the link is often based upon field observations. River gage data quantifies the river conditions (level, flow, water temperature, dissolved oxygen levels, pH, specific conductance, turbidity, suspended sediment load, etc.) during those field observations to give a broader context to the species life history. These questions and this information will guide the development of the web-based visualization tools.
Technical Approach: The project will proceed in step-wise manner;

1. Evaluate the existing data model used by the Klamath River basin groups.
2. Identify what questions can be answered through visualization.
3. Determine what visualization tools are needed (GIS map layers, timeseries graphics, plots, animations, etc.)
4. Develop the web-based visualization tools using current web-development practices (client-side/server-side scripting). Depending on the application framework, some of this development could be performed in a GIS desktop environment.
5. Insure that the application will run for other datasets using SIU Asian carp dataset as beta test.

The first step will be to evaluate the existing data model. The existing data model used in the Klamath River Basin database will be examined in detail to address any potential issues for data access and visualization. Project staff will evaluate the structure of the database in terms of efficient access for web-based visualization.

The second step will be to outline the needs of the biologist in terms of visualization tools. What questions can be answered through visualization? The project combines the biologists existing knowledge of the life history of fish species with the hydrologists knowledge of river conditions to better understand the species in its riverine environment. For example, do the fish favor certain river reaches at certain times of the year? Do fish movement patterns correlate with river parameters? Does the data help identify spawning locations? This type of information can be used to manage desirable native species or help develop control strategies for invasive species. These questions and this information will guide the development of the web-based visualization tools.

The third step relies on the experience of our GIS specialist as to know what types of data visualization are available for this type of data. Can we utilize GIS tools to combine spatial information with timeseries data from river gages?

The fourth step is for the biologists/hydrologists/GIS specialists to work with web programmers that can develop the visualization tools. These tools will efficiently retrieve data from the database (first step) and display it to biologists and other researchers in a web browser to help with the analysis of the fish telemetry data (second step). The tools will also allow the user to download the data in a common format (for example xml) for import into desktop analysis programs such as spreadsheets.

The fifth and final step is to beta test the web application with real world data to insure that the application is useable. A seamless workflow is required; from the input and formatting of raw field telemetry data to the selection of GIS map layers to the display of timeseries animations; the application workflow must run smoothly for the scientists to benefit from the visualizations. A final evaluation will measure the value of the application to analyze real fish telemetry data.

Project Experience: This project brings together a small group of scientists with a wide range of experience and skills that often do not interface directly. The collaboration started within the Illinois
River Asian carp group discussions about the movement and spawning of fish in possible response to environmental triggers such as river conditions. The biologists described the large volumes of fish telemetry data that are collected and the difficulties of working with the data. Thus began a series of discussions to address the need for better visualization of the fish telemetry data with river gage data.

The project team biologists working on the Illinois River with tagged invasive Asian carp are from Southern Illinois University include Dr. Jim Garvey and doctoral student Marybeth Brey. The SIU biologists, under Dr. Garvey’s guidance, have spent the past 5 years tracking tagged Asian carp and other species in the Illinois River as part of a multi-agency effort to fight the spread of Asian carp. The SIU biologists are the leading researchers working on Asian carp in the Illinois River.

Two project team members are from the USGS-Illinois Water Science Center. Jim Duncker is a hydrologist with over 25 years of experience working on the Chicago Area Waterway System and the Illinois River. Jim specializes in hydroacoustic flow measurement in complex hydraulic settings. Mitch Harris is the IL-WSC lead biologist and specializes in the design of biological databases (USGS-BioData).

Curtis Price is a member of the USGS Enterprise GIS team, which supports GIS applications throughout the Bureau. He has been providing GIS data development and project support for geospatial projects across the USGS in that role since 1990. Curtis resides in the USGS-South Dakota Water Science Center.

Alta Harris is an ecologist with the USGS Western Fisheries Research Center-Klamath Falls Field Station. Alta is an experienced system administrator working with fish telemetry data from multiple agencies in the Klamath River basin. She has assisted multiple telemetry projects with data management techniques and has written custom software applications to assist in the storage, retrieval and access of telemetry data.

The project needs a team member to write the web-based visualization tools. We are looking for this position to be filled by either a CDI-recommendation or a contract person. The Klamath Basin database was developed as a contracted effort from multiple agencies working with the USGS Powell Center in Ft. Collins, Colorado, and the Powell Center staff may be available for programmer support. Also, the USGS- Illinois Water Science Center is located on the campus of the University of Illinois and routinely contracts with web-programmers from the university community.

Overall, this project team consists of a group of individuals with varying backgrounds and unique skill sets that collectively can develop the visualization tools that will benefit many working with fish telemetry data.

Commitment to Effort

Researchers at both the USGS Western Fisheries Research Center-Klamath Basin Field Station and Southern Illinois University have on-going telemetry projects that will incorporate the web-based visualization tools into their studies. Once approved for distribution, the web-based visualization tools developed by this project will be made available to the wider community of fisheries biologists.
of support for this proposal confirm the commitment of the Illinois state agency partners and the USGS Midwest Region for the development of the visualization tools.

Further development of the visualization tools may result from the application of these tools in other telemetry studies. Telemetry equipment and methods are growing in use beyond fisheries science and the same data management and visualization tools may be beneficial to those fields as well.

**Budget Justification:**

The project budget was developed to maximize funding on the technical development of the visualization tools. The principle funding category is thus salary for project team members with the emphasis on development of the visualization tools. Initial collaboration and discussions amongst the project team was accomplished by teleconference and Webex. This demonstrated the ability of the team members to work together on the project from their various geographic office locations (Illinois, South Dakota, and Oregon). Developing web-based visualization tools lends itself to opportunities for remote collaboration. The project travel budget is limited to present project results at an annual CDI conference meeting (Denver, Colorado or Reston, Virginia).

Salaries: Salaries include six project team members and 1 contracted web programmer. Salaries for USGS-ILWSC staff are not part of the federal funding request, but will be part of the matching funds. This leverages the CDI funds to benefit the product development by maximizing salary of team members outside the USGS-ILWSC. Dr. Jim Garvey, SIU is supporting the project as a technical advisor and reviewer and will not charge for his time. Dr. Garvey oversees the work of biologist Marybeth Brey in all aspects of the SIU fish telemetry work in the Illinois River.

Travel: Travel costs include airfare and per diem for 3 project staff to attend the annual CDI conference. Travel costs for the USGS-ILWSC staff will be part of the matching funds, with CDI funds use to cover the travel costs of 1 project member.

Other Direct Costs: Publication cost estimate of $4000 is for the EPN costs of a USGS Fact Sheet describing the development and use of the web-based visualization tools.

Total Direct Costs:    $35,305
Indirect Costs:        $13,924
GRAND TOTAL:          $49,229 (Federal requested)     $20,392 (Matching funds)
Timeline:

**March 30, 2014:** Teleconference/Webex meeting of all project team members to outline duties, timelines, etc. Establish weekly conference call/Webex schedule. Begin evaluation of KRB data model and web application development frameworks.

**April 7, 2014:** Compile list of biologist’s analytical needs. Complete evaluation of existing KRB data model in terms of data access and compatibility with web-based visualization tools.

**April 15, 2014:** Identify fish telemetry and GIS data and map services to be used to develop and pilot application for the Klamath River Basin and Illinois River Basin.

**April 21, 2014:** Establish structure and appearance of web tool. Begin web programming for data access/display of WATSTORE river gage data and fish telemetry data.

**May 15, 2014:** Continue development programming code. Iterative feedback of programming with biologists/hydrologists input.

**June 15, 2014:** Preliminary review of tool development to-date.

**July 15, 2014:** Compile web-based code as final product. Begin beta-testing of visualization tools.

**August 15, 2014:** Complete beta testing of web-visualization tools.

**Sept. 1, 2014:** Complete USGS Fact Sheet. Summarize project for CDI annual report.
Appendix: Curriculum Vitae

Jim Duncker, Hydrologist

EMPLOYER: USGS-ILLINOIS WATER SCIENCE CENTER
Email: jduncker@usgs.gov
Phone: (217) 328-9710
Fax: (217) 328-9770

EDUCATION

AREAS OF EXPERTISE
- Chicago Area Waterway System
- Project Chief of HSPF rainfall-runoff modeling studies in Du Page and Lake Counties.
- Project team member of a joint USEPA-USGS HSPF watershed modeling study for the proposed Crandon Mine project.
- Project chief for the Lake Michigan Diversion Accounting project.
- Experienced in the collection of hydro-acoustic techniques for discharge measurements.
- Experienced in surface-water-quantity and meteorological data collection.
- Project chief of bathymetric surveys of Chicago River, Lake Calumet.
- Instrumentation coordinator for the USGS-Illinois Water Science Center.

Highlighted Publications


Mitchell A. Harris, Ecologist

EMPLOYER: USGS-ILLINOIS WATER SCIENCE CENTER
Email: maharris@usgs.gov; Phone: (217) 328-9710; Fax: (217) 328-9770

EDUCATION


CURRENT PROJECTS
Lower Illinois River Basin Study Unit of the National Water-Quality Assessment Project
Upper Illinois River Basin Study Unit of the National Water-Quality Assessment Project
Development of Civil Engineering Class: Field Methods for Hydrologic and Environmental Studies

AREAS OF EXPERTISE
Stream biomonitoring
Stream ecology
Aquatic macroinvertebrate, fish, and algae community sampling
Fish tissue and streambed sediment contaminant sampling
Geomorphic analysis of streams
Database management

PUBLICATIONS


SELECTED PRESENTATIONS

Curtis Price, Physical Scientist

USGS South Dakota Water Science Center, Rapid City, South Dakota
Email: cprice@usgs.gov
Phone: (605) 394-3242
profile.usgs.gov/cprice

EDUCATION
B.S. (1983) University of Puget Sound (Geology)
A.M (1985) Dartmouth College (Geology)

AREAS OF EXPERTISE

- Geographic Information Systems (GIS) technology and applications
  (ArcGIS Desktop technical lead for USGS Enterprise GIS team)
- Relational and geospatial database design and development
- Raster data analysis, image processing, and remote sensing
- Python

Highlighted Publications

http://pubs.usgs.gov/sir/2012/5194/

http://qurl.com/dddd3 (10.0-compatible version)

http://pubs.er.usgs.gov/usgspubs/ds/ds240


http://qurl.com/52kt7
Alta Harris, Ecologist

EMPLOYER: USGS-Western Fisheries Research Center – Klamath Falls Field Station
Email: aharris@usgs.gov
Phone: (541) 273-8689
Fax: (541) 273-8692

EDUCATION

AREAS OF EXPERTISE
- System Administrator for Klamath River Basin PIT tagging database, housing millions of encounters for over 130,000 fish submitted by six contributing research agencies.
- Web Developer for Klamath River Basin PIT tagging database
- Developed and maintain field data entry programs for collection of PIT tagging data on Windows CE devices
- System administrator for PIT tagging and radio telemetry databases at the Klamath Falls Field Station housing millions of encounter events for over 120,000 fish.
- Developed and maintain custom application to access Klamath Falls Field Station PIT tagging data stored in an SQL server database management system.
- Responsible for data storage and retrieval of all research projects at the Klamath Falls Field Station.

Highlighted Publications

Name: James E. Garvey

Title: Associate Professor of Zoology and Associate Director, Fisheries and Illinois Aquaculture Center

173 Life Sciences II
Fisheries and Illinois Aquaculture Center
Department of Zoology
Southern Illinois University – Carbondale
jgarvey@siu.edu; http://www.science.siu.edu/zoology/garvey/index.html

Education
1998  Post-Doctoral Fellow, Queens University, Ontario
1997  Ph.D., Zoology, The Ohio State University, Ohio

Professional Experience

2005-  Associate Director, Fisheries and Illinois Aquaculture Center, Southern Illinois University
2005-  Associate Professor, Department of Zoology, Southern Illinois University
2000-2005  Assistant Professor, Department of Zoology, Southern Illinois University
1998-2000  Assistant Professor, Division of Biology, Kansas State University
1997-1998  Postdoctoral Fellow, Department of Biology, Queens University, Ontario
1997  Research Associate, Department of Zoology, The Ohio State University
1996-1997  Presidential Fellow, Graduate School, The Ohio State University
1990-1996  Graduate Research Associate, Department of Zoology, The Ohio State University
1990-1996  Graduate Teaching Associate, Department of Zoology, The Ohio State University
1988-1990  Research Technician, Department of Zoology, Miami University
1988  Student Researcher, School for Field Studies, St. John, U.S. Virgin Islands

Fields of Research Competence

Aquatic ecology, fish ecology, basic and applied fish biology, limnology, food web dynamics, life history modeling. My current research follows three basic themes:

1. Understanding how bioenergetics and various life history characteristics of fishes and other ectotherms vary along environmental gradients to affect population dynamics and community interactions in lakes and rivers.

2. Determining the relative impact of abiotic and biotic characteristics of aquatic systems on the movement and spatial distribution of fishes through effects on physiology and biotic interactions.

3. Exploring the impact of spatial scale on species interactions, with particular relevance to the invasion potential of exotic species.

Technical Reports (Selected reports available at http://fishdata.siu.edu)

Garvey, J.E., E.J. Heist, R.C. Brooks, D.P Herzog, R.A Hrabik, and K.J. Killgore. 2006. Current status of the Pallid Sturgeon (Scaphirhynchus albus) in the Middle Mississippi River: Habitat,


January 14, 2014

Douglas Yeskis
Director, Illinois Water Science Center
U.S. Geological Survey
1201 W. University Ave., Suite 100
Urbana, IL 61801-2347

Dear Mr. Yeskis:

This letter is to express the support of the Midwest Regional office for the proposal being submitted to the USGS Community for Data Integration titled “Developing Tools for the Analysis and Visualization of Fish Telemetry Data with River Parameter Data” by the Illinois Water Science Center of the USGS and Southern Illinois University (SIU). The proposed work will provide a web-based visualization tool that will allow resource managers to more easily track fish movement, especially in response to water and atmospheric changes. This USGS visualization tool would certainly be of great value in the Great Lakes to address the Asian carp threat. The information and data could be widely shared among the state and federal partners of the Asian Carp Regional Coordinating Committee, the group that is guiding the Asian carp efforts in the Great Lakes and is led by the President’s Council on Environmental Quality.

The Midwest Region office of the USGS supports this collaborative USGS/SIU proposal to develop a web-based visualization tool for fish tracking in response to surface water and atmospheric changes. We believe this proposed work will assist in the state and federal goals of controlling of Asian carp movement into the Great Lakes. If you have any questions, please feel free to contact me.

Sincerely,

[Signature]

Dr. Leon Carl
Regional Director, USGS Midwest Region
Douglas Yeskis  
Director, Illinois Water Science Center  
U.S. Geological Survey  
1201 W. University Ave., Suite 100  
Urbana, IL 61801-2347

Dear Mr. Yeskis:

This letter is to express our support for the proposal being submitted to the USGS Community for Data Integration titled “Developing Tools for the Analysis and Visualization of Fish Telemetry Data with River Parameter Data” by the Illinois Water Science Center of the USGS and Southern Illinois University (SIU). The proposed work will provide a web-based visualization tool that will allow resource managers to more easily track and report fish movement, especially in response to water and atmospheric changes. This will be of great benefit to the Illinois Department of Natural Resources (IDNR) for our Asian carp control activities. This could provide cost savings to our fish removal activities, hopefully optimizing the timing and location of those activities.

The IDNR supports this collaborative USGS/SIU proposal to develop a web-based visualization tool for fish tracking in response to surface water and atmospheric changes. We believe this proposed work will assist in the state and federal goals of controlling of Asian carp movement into the Great Lakes. If you have any questions, please feel free to contact me at 217.557.0719 or by email kevin.irons@illinois.gov.

Sincerely,

Kevin Irons  
ANS/Aquaculture Program Manager  
Illinois Department of Natural Resources