



Aquatic Research Section
Aquatic Data Analysis and Database Management
Annual Progress Report
April 1st, 2019 - March 31st, 2020

STATE OF COLORADO

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COLORADO DEPARTMENT OF NATURAL RESOURCES

Dan Gibbs, Executive Director

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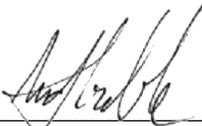
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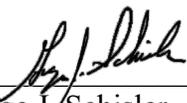
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Date: April 2, 2020

The results of the research investigations contained in this report represent work of the authors and may or may not have been implemented as Colorado Parks & Wildlife policy by the Director or the Wildlife Commission.

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Note: Due to complications surrounding COVID-19 and remote work access of archived folders residing on external USB drives in the Fort Collins office, time allocation analyses did not include time spent by temporaries on the various projects. This omission will be corrected in future reports.

Due to the unique timeframe associated with this report, which is different from both the agency's fiscal year and calendar year, where utilized in the text, RY2020 (Report Year) refers to the period between April 1st, 2019 and March 31st, 2020.

Overview

Our top priorities in the data management unit for this reporting cycle continued to be getting the new Creel application fully-tested and implemented, as well as to advance progress on the Fishes of Colorado Book. The Governor's Office of Information Technology (OIT) continued to be the major hurdle in getting any progress made on Creel. Testing was completed, and the application was signed off on with an email to OIT on December 4th, 2019. Since that date, issues with updated applications within Trans6 and AAHL have delayed moving the application to full production. Most recently, small changes to ADAMAS have delayed the move to production, but the move is anticipated to occur before the end of the month.

A related modification to the database was also completed and is ready within the Test environment. Database schema additions and a new automatic template upload procedure have been developed to allow for biologists associated with the Colorado River Recovery Program to upload their data into ADAMAS. After the data is in the database, I can parse out the necessary information and deliver it to the various entities for (1) Colorado Pikeminnow Estimate, (2) Roundtail chub Estimate, (3) Colorado Recovery Program Nonnative species removal programs, (4) STReAMS PIT tag database.

A final report entitled 'Overview of the Cache La Poudre River Fishery' was delivered to Northern Water and the Temperature Technical Advisory Committee (TAC) on June 17th, 2019. This report summarized the status and changes over time in the fisheries community of the transition zone of the Poudre River. This report will serve as a common basis of knowledge as various entities move forward with temperature standard proposals for the Poudre in response to various water projects and the expanded presence of Brown Trout into former warm water reaches.

Hydroacoustic surveys were performed on Horsetooth, Granby, and Blue Mesa Reservoirs again in 2019. The old sonar vehicle was replaced, thereby relieving safety concerns surrounding the towing of the sonar boat across the state. Perhaps most importantly, full sonar program funding was reinstated, and work began to upgrade equipment and fill the newly created sonar research associate position

Work continues on Fishes of Colorado, and while my ability to work on it comes and goes with various other demands, Dr. Woodling is consistently making good progress. We have been meeting at least monthly to review status, review new material, and discuss various topics concerning the book. I estimate that we are approximately 82% complete from a fish section perspective and will soon need to start thinking about all the material that will go at the beginning, the end, and in between the various fish sections.

Finally, I was elected as 'member-at-large' by members of the Organization of Fisheries and Wildlife Information Managers (OFWIM). This position is mainly responsible for the organization of the annual conference for the following year. However, because I am the only

member living in the host city for this year's conference, it appears that I will be assisting with the organization of this year's conference as well.

On the Horizon

As usual, this coming year promises to be a busy one. Hopefully, with Creel development finally off the pile, there will be time to address many of the other needs. Of course, work on the book will continue, hopefully with John Woodlins continued assistance. There will also be an intensive training period once the new research associate is hired to take over the bulk of the sonar duties. That being said, I fully expect to continue my role in monitoring and analyzing echo integration data for Rainbow Smelt on Horsetooth Reservoir, as this analysis is unique to the program and the state.

Another big project that came online towards the end of this reporting period is the upcoming review of all State-listed threatened and endangered aquatic species. Ryan Friebertshauser was able to develop a comprehensive template that we put forward as an example of how the review will be conducted, and we are just waiting for approval from the LT before moving forward.

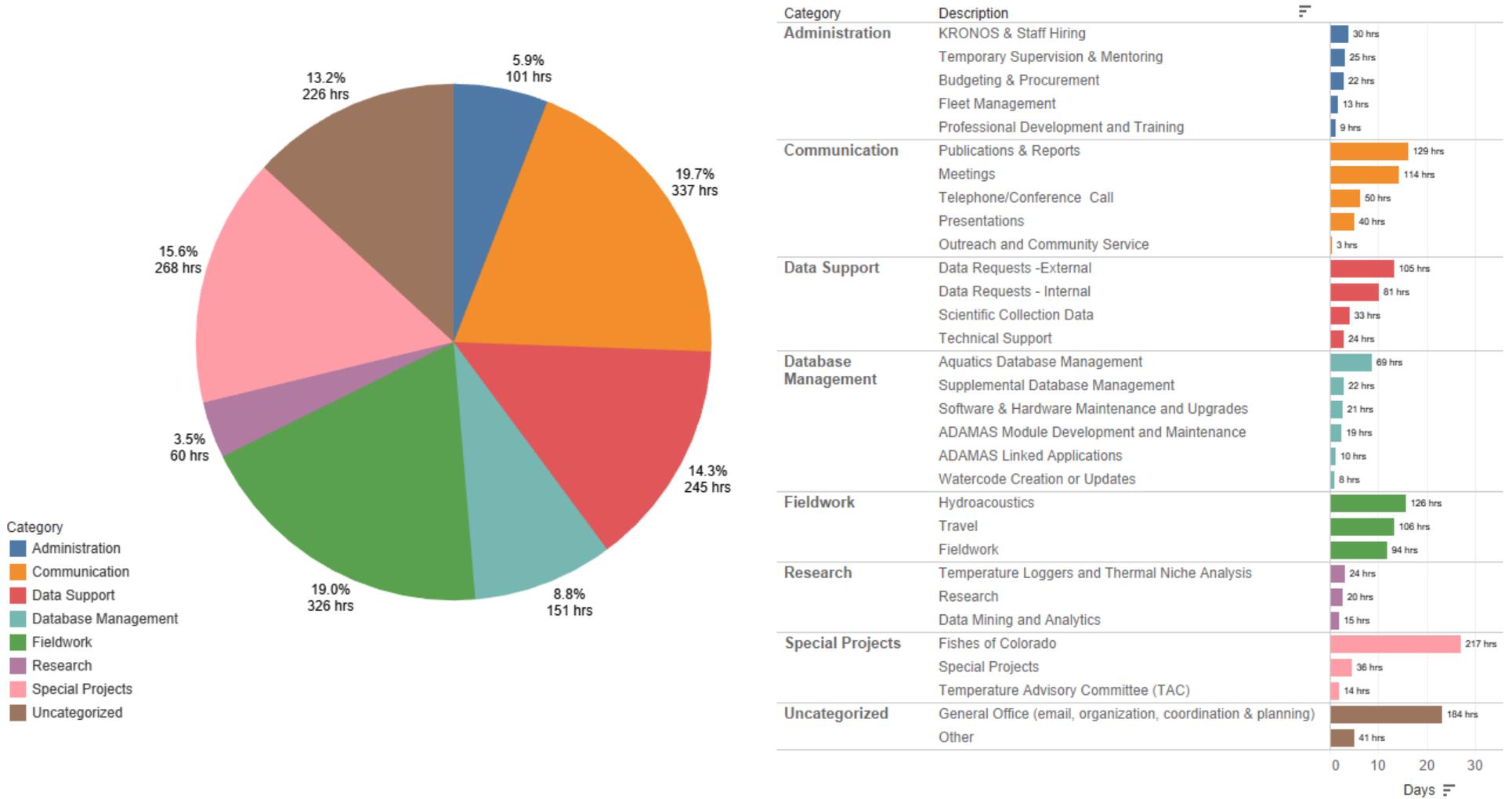
On the temporary employee front, I was just able to hire Alex Jouney, who replaces Ace Riverman, just before the moratorium on the hiring of temporaries was put into place. Alex will assist in a large backlog of data management issues. Originally he was scheduled to move over to Boyd Wright's crew in June to make way for Jane Van Vesseem, who was the top candidate during the job search. However, depending on how long the moratorium is in place, I may hang on to Alex for longer.

Water temperature continues to play a significant role in a lot of the water standards decisions and regulations, and I plan to continue my involvement with the TAC, as well as continued research into the realized thermal niches of Colorado fishes. We are in year two of an SCTF grant to place targeted temperature loggers out on the landscape and will continue with that work. Collaborating with Ryan Fitzpatrick and Cat Adams, close to 50 loggers have been purchased and modified to provide relative conductivity at the site. About a dozen have been installed to date, with plans to install the remainder this spring.

Two conferences loom large in 2020. The first will be the National AFS meeting in Columbus, Ohio, where I hope to present some of my thermal niche work, as well as participate in a session honoring my graduate advisor, Michael Jones, who will be retiring this year. The annual OFWIM conference will be held next door at the Hilton this year and I will be heavily involved in organizing and running that conference as well.

Finally, there was a lot of interest during the annual biologist's meeting to reinstate both the annual SciColl report for biologists, as well as the individual biologist Tableau Analysis workbooks, so I will be working to have those published to AQHatch soon.

Figure 1. Allocation of Data Analyst's time, April 1st, 2019 - March 31st, 2020.



Administration

I feel that for state government, the 6% (~100 hours) of overall time devoted to program administration and agency bureaucracy is not out-of-line. This category includes all staff hiring, KRONOS timekeeping, budgeting and expense tracking, fleet management, and mandatory professional development and training (i.e., OIT security modules). This category also accounts for any time spent mentoring or supervising temporary personnel.

Communication

Included under communication is meetings and conference calls, internal and external presentations, and written reports and publications. A total of 324 hours (19.1% of overall time) was devoted to communication during the period of this report. Next to fieldwork, this represented the most significant investment in time throughout this reporting period. Report writing and attending meetings accounted for the greatest portion within the category, mainly related to annual commitments in both areas.

As of late in 2018, funding for the aquatic data management program was changed from a Federal Aid Grant to CPW Game Cash. Concurrent with this switch, quarterly program reports to the Aquatic Research Chief were changed to a single annual report. These changes mean that a Federal Aid report for the data management program specifically will no longer be required, but due to the overlap in reporting periods, both an annual report and the F-239 Federal Aid report were submitted in 2020.

I. Publications and Reports

The authoring and review of various reports, publications, and white papers involved approximately 130 hours (or roughly 7%) of total time during RY2020. A total of 6 reports were authored or co-authored during the period of this report. Three of these are status or progress reports that are produced annually, whereas the other three were special reports or white papers.

The most significant amount of time was devoted to co-authoring (with Kyle Battige) a white paper on fishery within the transition zone of the Cache La Poudre River. This paper was submitted to the CLPR Transition Zone Working Group as one of five white papers describing the current and historical states of the Cache La Poudre River through Fort Collins.

Special Reports & White Papers:

Bachman, P., B. Beyea, H. Crockett, P. Foutz, T. Jackson, J. Logan, M. May, K. Reiner, J. Smith, K. Thompson, A. Treble, G. Wilcox, B. Wright, and R. Wertsbaugh. 2020. Biological Importance of Non-Adjacent Wetlands, and Ephemeral and Intermittent Streams in Colorado.

Treble, A. J. 2019. Statewide Fisheries Assessments and Surveys. Federal Aid Project F-86-R-32. Colorado Parks and Wildlife, Aquatic Wildlife Research Section. Fort Collins, Colorado.

Treble, A. J. 2019. Aquatic Data Analysis. Federal Aid Project F-239-R-26. Colorado Parks and Wildlife, Aquatic Wildlife Research Section. Fort Collins, Colorado.

Treble, A. J., and A. G. Hansen. 2019. Hydroacoustics-based estimates of rainbow smelt (*Osmerus mordax*) abundance in Horsetooth Reservoir: 2017-2019. Colorado Parks and Wildlife, Aquatic Research Section. Fort Collins, CO. 8pp.

Treble, A. J., and K. Battige. 2019. Poudre River White Paper #4: Overview of the Cache La Poudre River Fishery. Poudre River Transition Zone Working Group. Fort Collins, CO. 49pp.

Treble, A. J. 2020. Statewide Fisheries Assessments and Surveys. Federal Aid Project F-86-R-33. Colorado Parks and Wildlife, Aquatic Wildlife Research Section. Fort Collins, Colorado.

In addition to the work listed above, the following reports or publications were worked on:

- Reviewed, supplied data and provided comments to the Coldwater Stocking System Review
- Two quarterly aquatic data management progress reports were submitted to the aquatic research chief, prior to discontinuing quarterly reports in favor of this single annual report
- Provided review of Viera, Fitzpatrick, and Bachman paper
- Produced a brief summary report on the status of Longnose Dace and Speckled Dace on the West Slope for various CPW biologists and managers
- Authored an Overview of the CPW Aquatic Data Management and Data Request Process
- Reviewed drafts of Hydros Consulting's Cache La Poudre Basin and Stream Temperature white papers

Publication updates were also provided to several tracking documents within CPW research:

- i. Contributions to Management by Aquatic Research
- ii. 2019-2020 Publications and Presentation Google Sheet

https://drive.google.com/file/d/10HTfTiT7E_Qq9xH5tAgGo2EXwBJtmMYo/view?ts=5e55466f

- iii. Aquatic Research Project List

https://docs.google.com/document/d/1UIVrm_Kec_r_FfExcV5SUdskkRv9uI9/edit

II. Meetings

Often maligned, meetings are necessary to maintain coordination and pass on knowledge concerning what is going on in other parts of the agency. They also provide opportunities to promote ways in which the data management unit can assist other units. A total of 114 hours (or 6.7% of total time) was spent in meetings or this reporting period. There are a handful of meetings that I attend every year; these include:

- a) Annual aquatic biologists meeting (this year in Evergreen)

- b) Annual Coldwater reservoir coordination meeting (Buena Vista)
- c) The annual meeting of the CO/WY Chapter of AFS (Laramie)
- d) Annual Boreal Toad Recovery Program meeting (Denver Zoo)
- e) Temperature Advisory Committee (TAC) meetings

In addition to these meetings, other meetings of note include:

- Several meetings at Northern Water as part of the Cache La Poudre Transition Zone working group.
- Meetings with Boyd Wright to discuss the application for and use of YIP intern and Liz Krone between our two programs
- Database and OIT issue meetings with Brandon White and April Kraft
- Numerous meetings with Harry Crockett to discuss Boreal Toad data needs, the status of Colorado Herptile database, ongoing efforts to revisit the status of all aquatic listed species
- Coordination meeting with Adam Hansen relating to the reservoir hydroacoustics program and the hiring of a new research associate to fill that role
- Had several meetings with Kyle Battige to troubleshoot his 2019 Creel that was conducted by the City of Fort Collins on the Poudre River
- Meetings with Dave Graf to discuss the data needs of the various Basin Roundtables
- Meetings with staff at Fort Collins Hilton with regard to upcoming OFWIM meeting in October

III. Presentations

Internal Presentations:

- a) Treble, A. J. 2019. Data Management Update and Training Session. Annual CPW Biologist's Meeting, Salida, Colorado. January 24, 2019.
- b) Treble, A. J. 2019. Smelt Echo Integration Results from Horsetooth Reservoir. Coldwater Reservoir Management Meeting, Buena Vista, Colorado. March 5th, 2019.
- c) Treble, A. J. 2019. Thermal Niche of Colorado Fishes Overview. Annual CPW Biologist's Meeting, Salida, Colorado. January 23, 2019.
- d) Treble, A. J. 2020. Aquatic Data Management Program Update. Annual CPW Biologist's Meeting, Evergreen, Colorado. January 23, 2020.
- e) Treble, A. J. 2020. Smelt Echo Integration Results from Horsetooth Reservoir. Coldwater Reservoir Management Meeting, Buena Vista, Colorado. February 5th, 2020.

External Presentations:

- a) **Treble, A. J.** 2018. CPW Poudre River Fisheries Data. Poudre River Transition Zone Working Group. Northern Water, Berthoud, Colorado. October 31st, 2018.
- b) **Treble, A. J.** 2018. Revised Thermal Niche Analyses. Temperature Technical Advisory Committee (TAC). CDPHE, Denver, Colorado. October 29th, 2018.
- c) **Treble, A. J.** 2020. Using business intelligence software to analyze and disseminate 'Big Data' in fisheries management. Annual Meeting of the Colorado/Wyoming Chapter of the American Fisheries Society, Laramie, WY.

IV. Telephone/Conference Calls:

While more efficient than traveling to meetings, phone and conference calls still represent almost 3% of overall time spent. Most of these calls deal with organizational and coordination issues, technical support, and data requests and are not significant. Some more noteworthy calls over this reporting cycle include:

- Regular update and coordination calls with Woodling regarding Fishes of Colorado
- Monthly conference calls with OFWIM Conference Planning Committee
- Monthly conference calls with OFWIM ExComm
- Several conference calls to decide how to deal with requested fish from biologists versus available fish and allocation numbers negotiated by seniors
- Numerous data request and SciColl process and technical issue phone calls
- Fielded lots of Creel questions as we await new application to hit production
- Numerous phone calls with contributing authors working on Fishes of Colorado
- Coordination phone calls with Terry Robinson to check status and progress on development and testing of CREEL application and Upper Colorado River data module
- Conference calls with Kyle Battige and Jen Shannahan (City of Fort Collins) to coordinate Cache La Poudre Creel survey
- Numerous calls with Aquatic Seniors to discuss ongoing data requests

V. Outreach & Community Service:

Outreach and community service only accounted for about 3 hours this reporting cycle and consisted of two visits to Polaris Lab School's middle classes, where I gave presentations on being an aquatic biologist and answered questions about the career path that led me to my current position.

Data Support

I. Internal/External Data Requests

A total of 68 data requests from sources external to CPW were processed between April 1st, 2019 and March 31st, 2020, representing a little over 105 hours of work. This is down from the high of 82 requests in 2019, but still the third-highest number of requests on record (see Figure 3). In addition, numerous internal (CPW) requests were also handled as expeditiously as possible during this period, adding to an additional investment of over 81 hours in time. A detailed summary of the time and effort allocated to the data request process is provided in Figures 2 and 4.

A summary of the highlights related to data requests during RY2020 are provided below

- Provided on-the-fly data results for Mindi May during Clear Creek meeting at CDPHE
- Addressed countless upload issues with biologists, almost always related to bad data
- helped Brandon White with updating condition factor for undefined species in Trans6
- Summarize AAHL disease status for waters statewide for the Hatchery Section

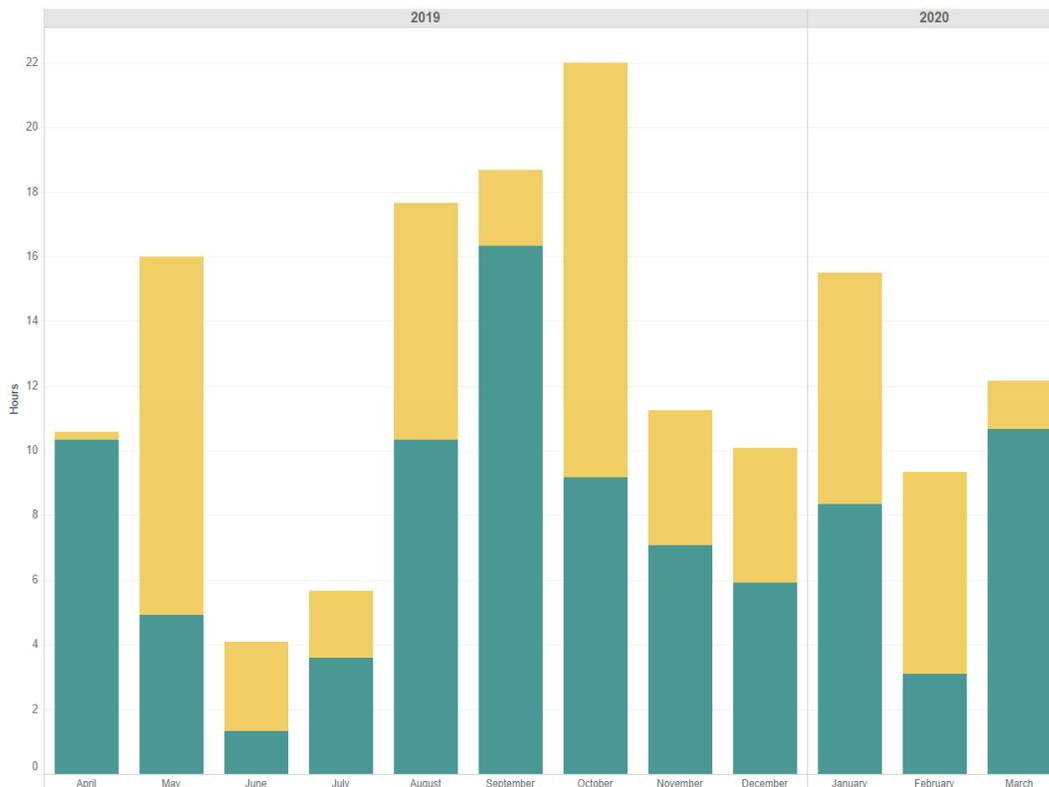


Figure 2. Monthly allocation of effort (hours) given to internal and external request for data.

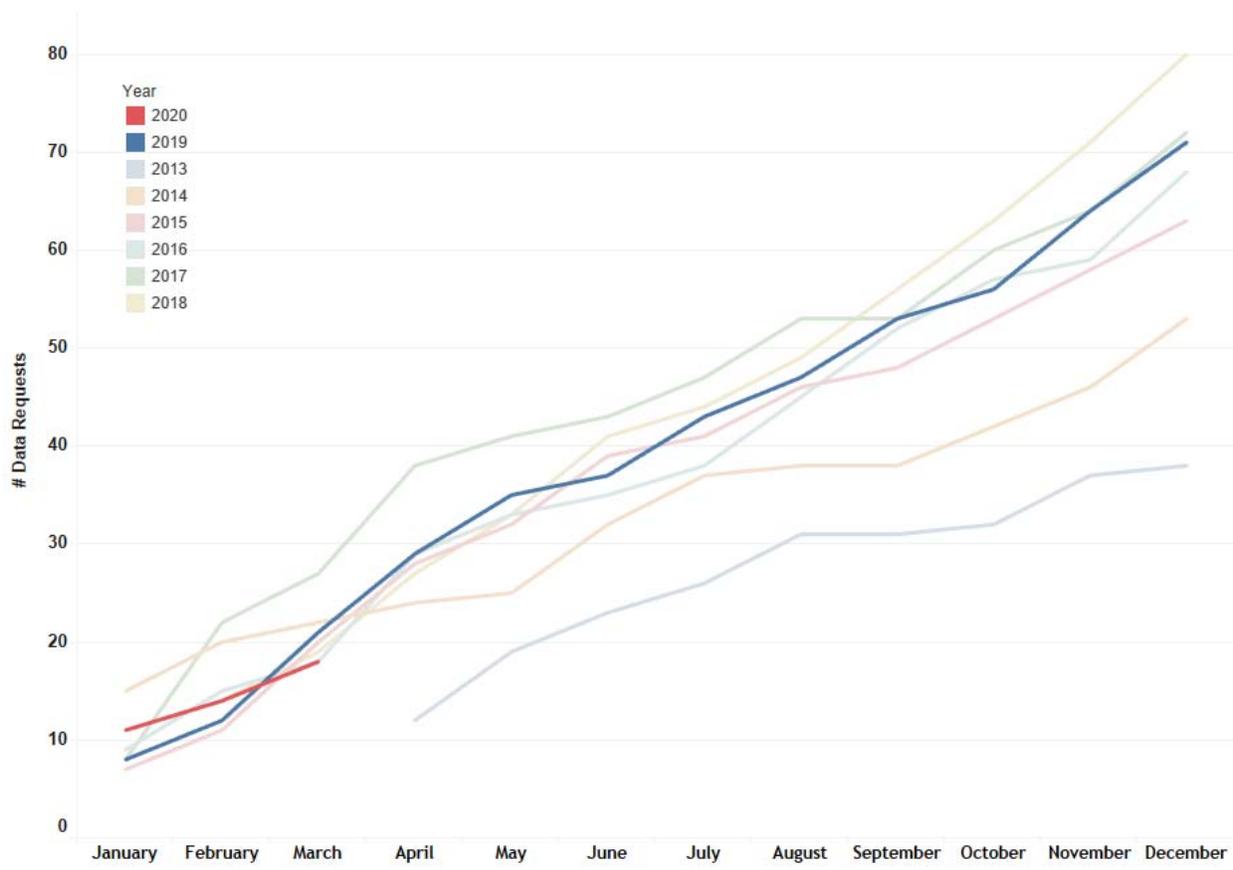


Figure 3. Cumulative external aquatic data requests by month over the past seven years.

II. Scientific Collection Data

A few 2019 Scientific Collection Permits are still trickling in, and not all of the data-in-hand has been uploaded yet. That being said, a total of 51 separate permits have submitted reports, for a grand total of 540 surveys added to the database. There were 878 surveys entered by this time last year, out of a total of 923 that were submitted for 2018. This equates to over 33 hours of effort to upload into ADAMAS. The amount of effort I have had to devote to uploading and QA/QCing SciColl data has increased dramatically this year (see Figure 5), although most of this increase can be explained by the untimely loss of temporary help, which forced me to take on more of this work myself.

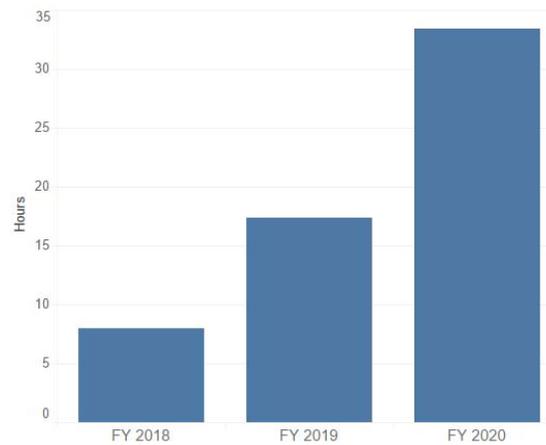


Figure 4. Comparison of effort devoted to SciColl surveys over the past three years.

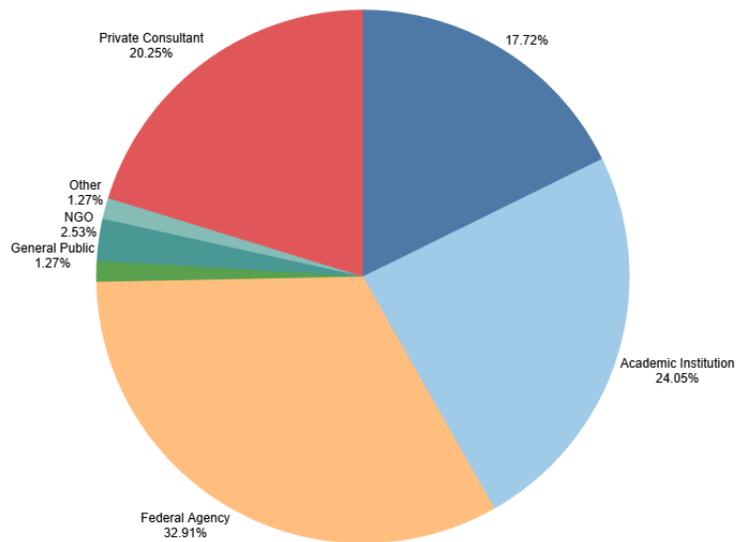
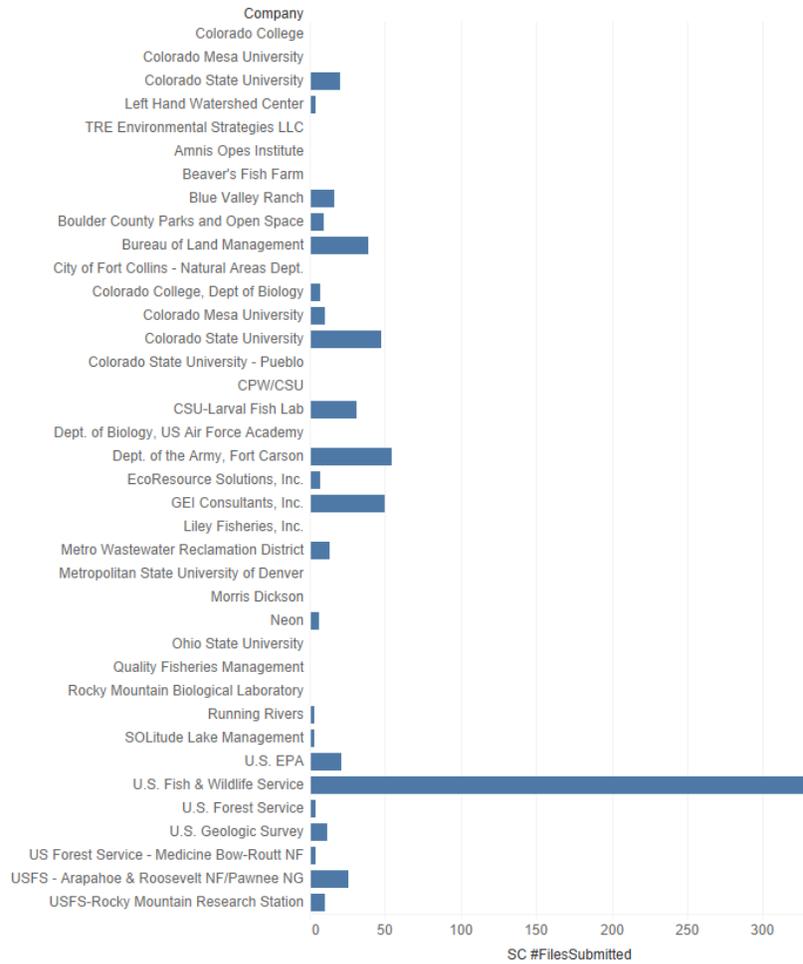


Figure 5. Sources of Scientific Collection Data over this reporting period.

III. Technical Support

The aquatic research data analyst is often the first point of contact by biologists, researchers, and other people within the agency when it comes to questions about aquatic data. In addition, due to contact and availability issues with OIT, the data analyst is often asked to assist in a wide variety of technical support issues. These requests are generally accommodated as expeditiously as possible, often meaning that other issues are put on hold until the support issue is resolved.

Some examples and highlights of technical support that was rendered during this reporting period are summarized below.

- Assisted numerous biologists to correct the Status Column in the SampleF table, allowing for analysis using multi-pass removals or mark/recapture methods
- Provided consultation to Pete Cadmus on data management for one of his studies
- Assisted Craig Workman with his Real Estate Microsoft Access front end and updating some of his queries and reports
- Assisted hatcheries with tracking down some data issues
- Provided digital fish images to Ted Smith at NASRF for decals on their hatchery trucks
- Individual sampling station creation for several biologists
- Had recurring difficulties with various users and having to update their DSN (datasource name) to get ADAMAS_Links running properly on people's machines
- Consulted with Jake Ivan (Terrestrial Research) about how to handle some SQL server issues they were having with their non-OIT-supported server.
- Helped Instream Flow Coordinator with use of Tableau InStream Flow interface
- Consulted with Julie McCarthy (EPA) concerning the development of the Colorado SQT
- Assisted several biologists with Creel Calendar Creation for the coming field season using the new Creel application
- Helped Brian Avila with the upload of pictures from the CO/WY AFS conference
- Helped Richer/Kondratieff temporaries with R set up and custom queries to pull in fisheries data from the server
- Dealt with numerous bad or missing records with numerous biologists
- Provided advice on how to utilize old CSAP creel application to biologists
- Attended several meetings and provided a review of NatureServ's Environmental Review Tool
- Helped Fitzpatrick reorganize data to match with Program MARK requirements
- Worked with Richer and Atwood to address discrepancies between existing ADAMAS data, Policky reports, and biomass estimates, and Jake-O-matic outputs
- Met with Mark Viera to provide him information on CPUE metrics in fisheries and how they might be utilized in bobcat harvest metrics

- Assisted biologists with re-mapping renamed network drives
- Numerous requests to OIT to keep various applications up-to-date in the software center
- Review of CDPHE's fish species list for consumption advisories
- Assisted Mindi May with an evaluation of using Daily Maximum Temperature in the Colorado Stream Quantification Tool (SQT)

Database Management

I. Aquatics Database Management

Regular ongoing maintenance and updates to the aquatics data platform is required to keep the system operating smoothly and to advance the analysis capabilities of the related applications. In addition to the primary data applications (Trans6 - Hatcheries, ADAMAS - Fisheries Surveys, AAHL - Fish Health Lab, CREEL - Creel Surveys), there are numerous supplemental data applications that link to these primary data sources and require various tables and views to be maintained in SQL Server Management Studio (SSMS) for them to function.

Data management represented an investment of about 151 hours, which equates to 8.8% of the total time budget for the year (not including temporaries and work-studies) (Figure 1.). Approximately half of the time (~70hrs) was directed at the primary data sources, with the other half (~80 hours) being split between supplemental data sources, linked applications, module development, maintenance, and watercode updates (Figure 1).

Some highlights of activities associated with the management of CPW's Aquatics Database in 2019 include:

- Worked with numerous biologists to identify and correct erroneous data
- Tracked down various SciColl permit holders to seek clarification or correction of questionable data received from the 2018 SciColl reports
- Update Species table to reflect current knowledge of native/nonnative status within each basin within the state
- Constantly updated CurrentSummary SQL script, which is used to summarize the entire database, and is the primary source used when filling data requests
- Worked with Grant to keep current the private property status for all of the sampling stations in the state
- Added new water temperature data from a variety of internal and external sources to the water temperature database module
- Further streamlined the flagging process for erroneous or questionable data
- Created new raw fish data view that automatically calculates relative weight, thereby simplifying many other views and linked data applications

- Updated the translation table for WQCDE/CDPHE water segments and CPW sampling stations

II. Aquatics Database Status

The aquatics Database continues to grow as additions from internal and external sources are added to it. A breakdown (by data project) of the surveys that were added to the database over the period of this report is provided in Table 1. The total number of various records added to the database, along with the current overall status of records in the database, is provided in Table 2.

| Data Project | #Surveys |
|---------------------------------------|----------|
| Aquatic Database | 5 |
| Aquatic Research | 23 |
| Northeast Region Fisheries Management | 237 |
| Northwest Region Fisheries Management | 190 |
| Scientific Collections Permit | 1,118 |
| Southeast Region Fisheries Management | 75 |
| Southwest Region Fisheries Management | 161 |
| Species Conservation | 88 |

Table 1. The number of surveys, by project, added to the database during RY2020. Note that due to the timing of this report, this may include SciColl surveys from both 2018 and 2019.

| <u>This reporting cycle:</u> | |
|---------------------------------------|-----------|
| Number of new surveys entered | 1,897 |
| Number of new sampling stations added | 234 |
| Number of new fish measured | 278,537 |
| Number of new fish enumerated | 429,373 |
| <u>Overall:</u> | |
| Total # of managed waters | 13,812 |
| Total # of sampling Stations | 18,801 |
| Total # of Surveys | 56,500 |
| Total # of measured fish | 4,198,949 |
| Total # of enumerated fish | 9,889,069 |

Table 2. Recent additions and the overall status of the aquatics database.

III. Supplemental Database Management

In addition to the central AquaticsT6 database and the directly-linked applications (Trans6, ADAMAS, AAHL, Creel), numerous supplemental databases have been developed to further support aquatics projects statewide. These databases typically are upgraded on a needs basis, but also require occasional maintenance to keep them current with the underlying database schemas. Examples of CPW aquatic supplemental databases include:

- (1) ADAMAS-Links
- (2) Boreal Toad Monitoring database
- (3) Statewide Reptile and Amphibian database
- (4) Water Temperature database
- (5) PIT tag database
- (6) Data Request and SciColl Tracking database
- (7) Fishes of Colorado Project Tracking database
- (8) Thermal Niche - Logger Placement database
- (9) Data Analyst and Data Temporaries Time Allocation databases

Highlights from the previous year of some of the work performed on Supplemental Databases include:

- Several functional updates to ADAMAS_Links, which allows for the querying and analysis of data across multiple surveys. ADAMAS_Links allows for the temporal and/or spatial aggregation of fisheries data that the ADAMAS application does not
- Boreal Toad Recovery Team partners submitted their annual breeding site reports, which were added to the Boreal Toad Monitoring database in time for the annual recovery team meeting. The database was then used to generate an overall monitoring and status report for Boreal Toad populations in Colorado
- A stand-alone extract of the Boreal Toad Monitoring database was created for Harry Crockett to distribute to Recovery Team members
- Ace Riverman programmed an automatic upload procedure for a new Toad Template in R; however, there are currently some issues that have not allowed us to utilize this yet.
- Created or updated several views in SSMS to support various improvements to biologist's Tableau workbooks
- Spent a fair bit of time weeding out some duplicate data from SciColl reports uploaded in 2018
- Updates and improvements were made to the Activity Log for both temporaries and myself
- Petitioned NAHERPS.com, Herpmapper.com, iNaturalist.com, and CitSci.org for Colorado reptile and amphibian data to add to Herps database
- Reptile and Amphibian species corrections and taxonomy research for current status in Herps database

IV. Software and Hardware Maintenance and Upgrades

Approximately 21 hours were spent over the period covered by this report obtaining OIT permissions and either installing or updating various hardware unique to the data management unit. A list of these software updates or additions of provided below.

- Tableau continues to be valuable data visualization and querying tool, but the company seems to put out an update every two weeks
- A subscription to Grammarly, an online grammar editor, was obtained to assist with editing Fishes of Colorado. Among other things, the program has excellent grammar and plagiarism algorithms to assist in editing.
- Numerous OIT and Windows updates
- Setting up new state iPhone and AppleID
- Switched over to a new computer in July, which took a fair bit of time to port over all programs and files, set-up backups, etc. I also had issues getting the docking station to work with the new computer, which took a lot of troubleshooting and consultation with OIT
- Aquatic Applications all needed to be tested and verified after OIT implemented a new firewall in August
- Multiple supplementary databases utilize ColumnHistory in Microsoft Access, which suddenly stopped working after a computer update. Had to uninstall the 64-bit version of MS Office and install 32-bit version to correct the problem
- Mendeley citation software updates
- Hoboware temperature logger software updates
- Purchased a new desktop for temporary (Ace at the time), which required some additional hardware components and a bit of time setting up to the network and external hard drives
- Troubleshooting network connectivity issues with Ryan Friebertshouser

V. ADAMAS Module Development and Maintenance

Perhaps one of the most notable accomplishments within this report is the completion of the development and testing phases of the new CREEL application. Almost 19 hours of my time was invested in this task, with many times more being allocated by Ace. Unfortunately, while this was completed in November and sent to OIT for implantation onto the production server, this has STILL not happened. Minor fixes to other aquatics data modules have delayed implantation, but hopefully, it will be on production and accessible to all biologists and researchers before the end of the fiscal year. While developing and testing the new application, a parallel analysis script was developed in SQL that was used to compare and verify outputs. This script will be invaluable when statewide analysis or request for creel data are required.

Other activities and accomplishments associated with the various ADAMAS modules is listed below.

- I worked with Terry Robinson (Tabertech Industries) to modify the aquatics database schema to accept data from the federal Colorado River Recovery Program. This included modification to allow for the archival of PIT tag data as well, which will allow for the melding of ADAMAS with the now-separate PIT tag database. A separate upload procedure, similar to the ones in place for the various SciColl templates, was also developed to efficiently upload Recovery Program data. The overall intent of these modifications is to streamline the reporting process for CPW biologists to the various federal projects (Colorado Pikeminnow Estimate, Rountail Chub Estimate, Nonnative Species Removal, STReaMS PIT tag monitoring database).
- Development and testing of R-ADAMAS, as R based querying and analysis package in R that mirrors the functionality of ADAMAS, with perhaps a less-slick user interface by arguable better graphical outputs. Unfortunately, I have not been able to get it to run on any computer since Ace's departure, but will work with Ace when time allows to get it up and running
- Worked on updating the UTM verification routine in ADAMAS with Terry to better identify surveys being entered with wrong UTM zone

VI. Watercode Creation or Updates

The creation of new watercodes for biologists and hatchery managers required about 8 hours of time total, spread out over the past year. A total of 27 new lakes, 12 new stream segments, six new coded fish units, and 3 canals/ditches were added to the growing list of 13,236 managed waterbodies in the state. A breakdown of the currently managed waters in the state is provided below in Table 3.

| <u>WaterTypeName</u> | <u>#Watercodes</u> |
|----------------------|--------------------|
| Stream | 8,724 |
| Lake | 4,422 |
| Fish unit | 61 |
| Wetland | 9 |
| Canal/Ditch | 20 |

Table 3. A summary of all managed waters held within CPW's Aquatics Database

ADAMAS-Linked Application Creation and Maintenance

- This should include ADAMAS links and biologist Tableau Workbooks, but will need to clean up Activity Log to Reflect that

Fieldwork

A total of 326 hours (~19.2% of overall time) was spent conducting fieldwork, which can be broken down into hydroacoustics, travel, and other fieldwork. This estimate is biased somewhat high, as the category includes travel of all kinds (i.e., to meetings), not just travel related to fieldwork.

Hydroacoustics:

A total of 126 hours (Sonar surveys to estimate Lake Trout and kokanee abundance on Lake Granby and Blue Mesa Reservoir continued in RY2020. Smelt integration surveys also continued on Horsetooth Reservoir, with several extra surveys occurring due to a defective integration motherboard, which was eventually diagnosed and replaced. Blue Mesa reservoir was also surveyed twice to provide estimates in August (when adult pre-spawn kokanee may still be in the reservoir) and in September, when all mature kokanee have left the reservoir and are on their way up to the Roaring Judy hatchery to spawn.

Highlights from the sonar program last year include:

- As of FY2020, funding for the sonar program has been restored, and the search is on for a research associate to take over many of the duties that had fallen to me during the 'SONAR Lite' program
- Finally had the old 1995 Chev 3500 replaced with a new (2019) F-350 diesel, which will be much safer and more capable of towing the sonar boat and all the equipment
- Worked with Adam Hansen to put together a position description and desired qualification list for the new research associate
- Spent a fair bit of time in discussion with BioSonics Inc. about the potential purchase of a new hydroacoustic system after HTI announced last year that they would be stopping all service/support for their existing units as of 2023. This new system appears to have all the features we need to generate both target tracking and echo-integration estimates and may, in fact, be a little easier to work with
- Purchased new truck cap for the new sonar truck
- In discussions with Colorado Boat Center about getting trim tabs and a davit installed on the sonar boat. Installation of a davit will make deploying the transducer and tow fin safer (for both operator and the transducer) and easier

Travel:

A total of 106 hours were spent traveling for meetings or for fieldwork. This amount is approximately 40 hours less than last year.

Other Fieldwork:

Helping other units out and staying connected with what is going on in the field is an important component of the data management program. Hands-on experience with how data is being collected in the field leads to a better understanding of the data itself and often leads to efficiencies in how the data is uploaded or analyzed.

Some highlights to the fieldwork that was assisted within FY2020 include:

- Assisting with the spawn operation for the Harrison broodstock out at the research hatchery
- Temperature logger download and replacement out on the Republican and Arikaree with Mandi Brandt
- Walleye spawn take operations at Cherry Creek Reservoir

- Assisted Jen Logan PIT tag Bluehead Suckers at NASRF
- Nonnative species removal on the Yampa River
- Greenback cutthroat spawn operations and set-up at Zimmerman Lake
- Gill netting surveys on Lake Dillon with Jon Ewert
- Flathead Chub PIT tagging photos for presentations and dissertation on Fountain Creek with Ryan Fitzpatrick
- Brown Trout Spawn operations up in North Park
- FWIN surveys and fish processing with Adam Hansen
- Traveling to Rawhide Power Plant with Schisler to attempt to confirm the presence of Bighead and/or Silver Carp within the cooling pond there



2019 North Park Brown Trout Spawning Crew.

Research

While the data management subunit spends the majority of time in support of other biologists/researchers and managing data from internal and external sources, the unit still falls within the aquatic research unit and strives to conduct meaningful research when time allows.

Thermal Niche Analysis:

Through my involvement with the Temperature Advisory Committee (CDPHE and WQCD), I have become interested in the realized thermal niches of fish species in Colorado. This involves using temperature loggers to measure water temperatures throughout the year at specific sites and then relating these temperatures to species that are found at those sites. In FY2020, I received an SCTF grant (\$38k) to support logger purchases, travel, and analysis of paired fish-temperature data. To date, 50 loggers have been purchased, and approximately

40 of those have been converted (light meter removed and relative conductivity wires soldered on).

A total of 24 hours (1.5% of overall time) was spent over the past year procuring and deploying temperature loggers, developing and updating a temperature logger database, and developing various analyses in SQL and Tableau. A presentation is planned for the 2020 National AFS meeting in Columbus on the topic as well.

Other Research:

Additional research is conducted as time allows, usually involved data-mining, statistical data exploration, or other research in support of biologists/aquatic researchers. Only 20 hours (1.2% of overall) was devoted to doing research, which I would like to see increased in the coming years. Some highlights of research-related work that was conducted over the past year include:

- Development of SQL tables and Tableau visualization to look at Longnose Sucker and White Sucker distributions thru time, focusing mainly on the West Slope (with Kevin Thompson)
- Developed analysis in SQL and Tableau to look at Brook Trout biomass versus July Mean Temperature with Woodling. Going to shelve a possible publication until after Fishes of Colorado
- Review of TITAN2 package in R, customized queries to format the data, several attempts to run the package to determine temperature thresholds of various fish species. Could not get the package to analyze our data?
- Explored use of FishMethods package in R to analyze CPW data
- Updates and additions to research citation library on Mendeley

Data Mining and Analytics:

Perhaps one of the more enjoyable aspects of the job is when there is time to delve into the database and use various analytical techniques to explore a question. Often these opportunities present themselves as a question posed by a biologist or researcher. Invariably the solution involves a lot of data filtering and manipulation, often involving a combination of Excel, SQL, ArcGIS, Tableau, and R.

Some projects of note from the past year include:

- Working with Ace to develop 'R-ADAMAS': an R package that mirrors the querying and analytical capabilities of ADAMAS. While the program is complete, we are having issues identifying some of the underlying packages that allow it to run on ALL computers. It currently only runs on the desktop machine that Ace programmed it on and we have not been able to get it to run on any others
- Development of various summary graphics for Josh Nehring as part of the Strategic Plan initiative.

- Re-worked the Tableau analysis that summarizes species associations used in Fishes of Colorado. This is still in development and the goal is to produce a summary table or graphic that can be referred to in the text, thereby eliminating the need for some lengthy descriptions in each of the species chapters.
- Development of 'Flathead Chub Distribution and Abundance through time' graphics (with Ryan Fitzpatrick)
- Started exploring Western Mosquitofish, Plains Topminnow, and Plains Killifish distribution and abundances thru time as part of a potential publication (with Boyd Wright and John Woodling)
- Updated the Tableau workbooks used to summarize the time allocation databases primarily used in the creation of this report
- Began development of various analyses to be used in the review of all state-listed species (with Harry Crockett)
- Developed a Hatcheries visualization in Tableau for use by the Hatcheries system and for use in future presentations
- Put together various analysis and visualizations for use in combing through the pile of FishVert.net voucher specimen database
- Developed custom biomass calculation and analysis scripts (SQL) for use in the Cache La Poudre Fisheries White Paper

Special Projects

This category captures those activities that have recurring, but likely not indefinite investments in time that do not fit neatly in any of the other categories. The subcategories involved will change from year-to-year depending on the current needs of the research unit or the agency.

A total of 266 hours (15.6% of overall) was devoted to special projects, ranking third behind Data Management and Fieldwork for time devoted to the category.

Fishes of Colorado:

Going into its third year, this project to update and publish a new version of the Fishes of Colorado continues to slowly plod along towards completion. The work of John Woodling continues to be an invaluable constant in the project, as other people's involvement comes and goes with their availability and other commitments. A summary of the status of the book is provided in Table 4.

| Development Stage | #Species | Score |
|---------------------------|----------|-------|
| Lit Review Completed | 2 | 2 |
| Rough draft Completed | 4 | 8 |
| Formatted draft Completed | 13 | 39 |
| Draft in Review | 47 | 188 |
| Draft is Finalized | 40 | 200 |
| | 106 | 82.5% |

Table 4. Status overview of the Fishes of Colorado project

This project continues to garner the most time devoted to it of any subcategory, despite this project often being placed 'on the backburner' when other commitments arise. A total of 215 hours (12.6% of total) were allocated to the book this year, not including the efforts of John Woodling, Liz Krone, or various contributing biologists and researchers.

Specific highlights concerning the ongoing work on the book are listed below:

- Burbot (*Lota lota*) were added to the list of species to be included in the book after they were identified in the Green River within Colorado by the USFWS
- Silver and Bighead Carp were added to the list of species to be included in the book after a journal article discussing their experimental introduction in Colorado, Pete Walker documented their presence in Cherry Creek, and their probable persistence in Rawhide Power Plant Reservoir was investigated.
- Lots of coordination meetings (and Mexican lunches) with Woodling
- Lots of data extracts and customized analyses for contributing authors
- Movement of current versions to Google Drive for file-sharing with contributors and editors. Addition of EditorialTrackingSheet to ensure everyone reviews the most recent drafts
- Regular updates to the Project tracking database to keep track of project status
- Another trip to NASRF to take fish pictures using photo aquarium



John Woodling, Liz Krone, and Andrew Treble taking photographs for Fishes of Colorado at Native Species Restoration

Temperature Advisory Committee (TAC) Involvement:

My involvement with the Temperature Advisory Committee arose from a need to support Mindi May with fisheries data to support her defense of agency interests in water quality meetings. I attend meetings, provide data and fisheries expertise, develop analytical tools for the group, and author white papers when necessary.

Much of my involvement with the group this year consisted of writing a white paper on the current and historical state of fisheries in the Cache La Poudre River. This work is already accounted for in the 'reports' section of this report. Other activities accounted for less than 1% of my overall time and included:

- Provided data and expert opinion to Mindi May concerning Greeley's Proposed Temperature Modification for the lower Cache La Poudre River
- Incorporated temperature data from a variety of outside sources into the CPW water temperature database
- Completed an extensive review of Aquatic Use for All defined segments in the state
- Attended fall and spring meetings of the TAC at CDPHE
- Participated in several meetings surrounding CDPHE/CPW/CSU Johnny Darter Temperature study
- Presented an overview of Thermal Niche Analysis in Colorado to TAC during fall meeting

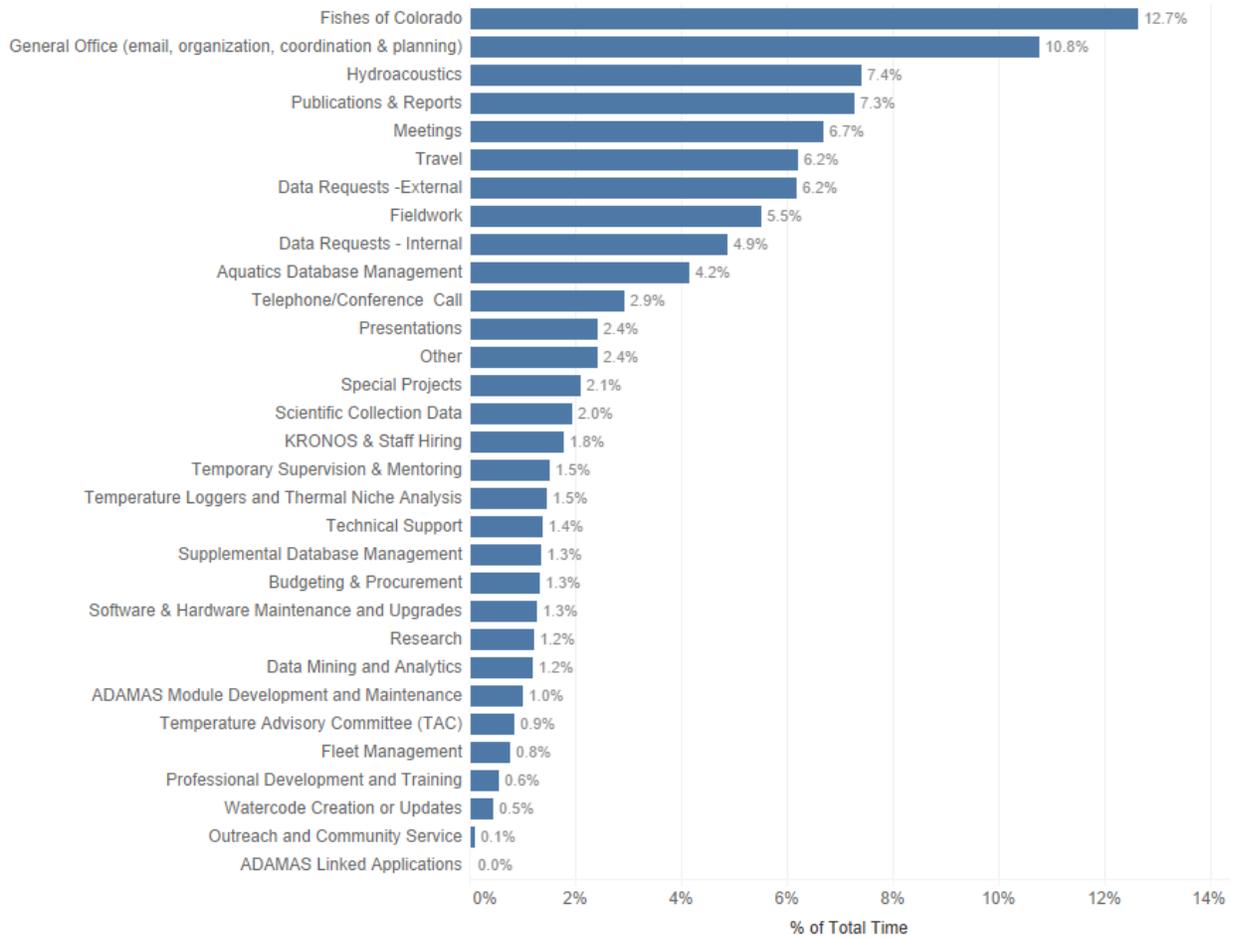
Other Special Projects:

A total of 35 hours (2.1%) total was spent on special projects other than Fishes of Colorado. These projects include:

- Organization of 2020 OFWIM conference in Fort Collins
- Preliminary site selection and organization of 2021 OFWIM Conference in Georgia
- Initial analyses and report templates for a review of all listed state aquatic threatened and endangered species
- Review of Modernization of Hatcheries Report and data aggregation.
- Development and submission of SCTF grant proposals

Appendices

Appendix A. Bar graph showing the percentage of time spent on individual sub-categories.



Appendix B. Status of individual fish chapters within Fishes of Colorado.

| <u>CommonName</u> | <u>AssignedAuthors</u> | <u>CurrentStatusDetails</u> |
|-------------------------------------|--|---|
| Lit Review & Author Only | | |
| MOTTLED SCULPIN | John Woodling (Kowalski?) | |
| PAIUTE SCULPIN | Woodling (Kowalski?) | Both Sculpins are a mess with not much to show. Genetics are cloudy. Nothing has been done on this species. |
| Rough Draft | | |
| BROOK STICKLEBACK | Woodling | Rough Draft in 'NeedsMoreWork' folder on Google drive. Woodling was working on revisions when the Corona Virus struck |
| COLORADO PIKEMINNOW | John Woodling (with Jim White & Jenn Logan?) | Rough draft in the 'Needs more attention' Folder on Google Drive. Woodlign was workign on revised drfat before the Corona Virus hit. |
| FLATHEAD CHUB | Woodling/Fitzpatrick | Needs to be formatted and run thru Grammarly. What to do with habitat figures: leave in or convert to verbal descriptions. |
| STRIPED KILLIFISH | Woodling | Needs formatting. Not much here to work with. What to do about pictures. |
| Formatted Draft | | |
| ATLANTIC SALMON | George Schisler | Small blurb on this species follows the small blurb on Chinook, which will be listed under 'Other Salmon Species' in the book. Perhaps a little more detail to add, but pretty much good. Likely, need an illustration added for both |
| Bighead Carp | Treble and Woodling | |
| BLUEGILL | Ben Swigle | |
| BRASSY MINNOW | Woodling & Krone | |
| COHO (SILVER) SALMON | George Schisler & Andrew Treble | Needs a bit more material. Annotated illustration need to be replaced using Coho specific. Need photos of some sort. Stocking points need to be added to database to generate a map |
| CREEK CHUB | Woodling | |
| Cutbow | Fethermen/Schisler | Just needs a few of the sections filled in or removed (because they are covered elsewhere). Maps, format and pictures are good. |
| FLANNELMOUTH SUCKER | Thompson | |
| HUMPBACK CHUB | Woodling & Travis Francis (Jenn Logan?) | |

| | | |
|-------------------------|-------------------------------|--|
| RAZORBACK SUCKER | Kevin Bestgen & Zelasko | Need to add the pictures from Kevin Thompson of his 2019 Cottonwood Creek |
| Silver Carp | Treble and Woodling | Needs Pictures, Map and run thru Grammarly |
| SPECKLED DACE | John Woodling & Andrew Treble | Older version needs to be checked for info that may have been dropped. Also need to update Mendeley with reference list |
| TIGER MUSKIE | Treble or Swigle | Currently working on finishing up formatted draft |
| <u>In Review</u> | | |
| AMERICAN EEL | Woodling & Myrick | Take John's recent draft and complete pictures, formatting and map. Run thru Grammarly. Send to David Cairns for review. Look for voucher specimens in FishVert. |
| ARCTIC CHAR | Woodling and Johnson? | This just needs to be cleaned up and shipped out for final comment |
| ARCTIC GRAYLING | Kehmeier & Battige | |
| BIGMOUTH BUFFALO | Woodling | Comments need to be addressed. Illustration needs annotation. Run thru Grammarly. Accept new changes from Woodling. |
| BLACK BULLHEAD | Woodling & Treble | |
| BLACKNOSE SHINER | Woodling | Needs annotated illustration, photos and to be put into 2-Column format, but it is close text wise. |
| BONYTAIL (CHUB) | (Crockett & Woodling & Jones) | |
| BROOK TROUT | Kendall Bakich/Yoichiro Kanno | John is still retooling this one. Need citation for picture #1 and should crop it for a closeup |
| BROWN TROUT | Woodling (Kowalski?) | Still needs Similar Species, angling, and citation sections completed. Still being worked on by Kowalski |
| CHANNEL CATFISH | Winkleman | Needs to be run thru grammarly. Need pictures added. |
| COMMON SHINER | Woodling & Wright | Still has comments to be addressed. Illustration needs ID characteristics. Recent pictures from NASRF should be added. |
| EMERALD SHINER | Ben Swigle | |
| FATHEAD MINNOW | Woodling | |
| FRESHWATER DRUM | Woodling | |
| GIZZARD SHAD | Woodling & Treble | |
| GOLDEN SHINER | Woodling & Tucker | |

| | | |
|---------------------------|--------------------------------|---|
| GOLDFISH | Woodling | Needs a picture added and formatted into 2-Column format |
| IOWA DARTER | Woodling | |
| KOKANEE (SOCKEYE) SALMON | Brett Johnson and Pat Martinez | Still need picture of Roaring Judy spawn operation. Review angling section and add gill lice specifics. Also talk about initial use of KOK was to grow monster lake strout. Fix photo credits |
| LONGNOSE DACE | Woodling and Treble | Two versions need to be combined and formatting finished. |
| MOUNTAIN SUCKER | Carl Medley | Needs a lot of work. Illustration needs annotation. Need a picture. Text needs editing and revisions. Numerous comments to be addressed |
| NORTHERN PIKE | Kevin Rogers | Still needs some formatting work and the illustration needs annotation. Angling section needs to be completed. Still waiting on picture from Rogers or Bestgen |
| NORTHERN PLAINS KILLIFISH | Woodling | Formatted draft needs further revisions, run thru Grammarly, and to be reviewed by Woodling, Foutz, Wright, and George |
| NORTHERN REDBELLY DACE | Woodling | In review by Woodling. Need to run thru Grammarly |
| ORANGESPOTTED SUNFISH | Woodling | This one is in pretty good shape. A few comments to address, then just standardizing citations and ADAMAS references |
| PLAINS MINNOW | Woodling & Foutz | Some comments still need to be addressee. Run thru Grammarly. Add photos from NASRF |
| PLAINS TOPMINNOW | Elizabeth Krone | Needs a photo or two, otherwise just standardized citations and ADAMAS references |
| QUILLBACK | Woodling & Brandt | Still a lot of questions, comments to address. Are we calling it native or not? Add pictures. |
| RED SHINER | Woodling | Just needs woodling to review. |
| REDSIDE SHINER | John Woodling | Needs work. Comments still to be addressed. Grammarly needs to be run. Illustration needs annotation. Photo needs caption and we need more photos. |
| RIO GRANDE SUCKER | Alves and Woodling | Still come comments to be adressed. Also should add new NASRF photos |

| | | |
|--------------------|-----------------------------|---|
| RIVER CARPSUCKER | Woodling & Brandt | Still comments to be addressed. Needs to be run thru Grammarly. Needs pictures |
| ROUNDTAIL CHUB | Crockett & Woodling & Jones | Lots of questions and comments still to address. Need to run thru Grammarly. Need to review photos and also look at new photos from NASRF. Annotated illustration needs to be re-done |
| SAND SHINER | Woodling | Several comments need to be addressed. Grammarly needs to be run. |
| SAUGER | Woodling & Ramsay | Still needs work. Comments to address. Diet section needs to be expanded. Grammarly needs to be run. Some citations missing. |
| SAUGEYE | Jim Ramsay | Needs citations? Needs to be run thru Grammarly. Needs photo credit |
| SHORTHEAD REDHORSE | Wright and Treble | Liz has taken it to a near final state, but it needs to be reviewed by a few |
| SMALLMOUTH BASS | Ben Swigle | Illustration needs to be re-done. Replace Ben's photo. Run thru Grammarly. |
| SPOTTED BASS | Ben Swigle | Illustration needs to be redone, Citations need to be filled out completely, Run thru Grammarly. Need more and better photos. Needs to be reviewed by someone... Tucker? |
| STONECAT | Wright & Krone | Species has been uploaded to Google drive and needs to be reviewed by woodling and Schisler. Also need to add these photos into the text. |
| SUCKERMOUTH MINNOW | Woodling & Wright | Need to clean up Liz's edits. Illustration needs annotation. Lots of comments and questions let to address. Add photos from recent NASRF trip. Run thru Grammarly |
| WALLEYE | Woodling & Kehmeier | Still some comments to address. Run thru Grammarly. Put into 2-Column Format |
| WHITE BASS | John Woodling & Ben Swigle | Citations are incomplete. Illustration needs ID characteristics. Add better photos. Combine native and colorado range sections; |
| WHITE CRAPPIE | Ben Swigle | Illustration ID characteristics need to be standardize. Citations are incomplete. Needs additional photos. Run thru Grammarly. Looks a little light on Material. Have Brandt review it. |

| | | |
|---------------------|-------------------------------|--|
| WHITE SUCKER | George | Still questions and comments to address. Run thru Grammarly. |
| YELLOW BULLHEAD | Woodling | Paul Foutz comments need to be incorporated. Versions need to be reconciled. Others comments to be addressed. Run thru Grammarly |
| Yellowfin Cutthroat | Rogers | Need official tomelleri image and annotation. Need to create a historic distribution map. |
| Final Draft | | |
| ARKANSAS DARTER | Woodling | Need to update citations in Mendeley. Text needs once over by John and George and then is DONE! |
| BIGMOUTH SHINER | Woodling | Needs another picture added and to be put into 2-column format. Also grammarly check. |
| BIGSCALE LOGPERCH | Treble & Woodling | Make sure to get Bestgen and Jackson references cited in the text somewhere |
| BLACK CRAPPIE | Ben Swigle | Adjust pictures, complete Angling section, run thru Grammarly. Waiting on Swigle for pics and angling section. Needs to be put back up on Google Drive when completed. |
| BLUE CATFISH | Treble, Woodling, & Winkleman | Just needs final review from George and John |
| BLUEHEAD SUCKER | Thompson/Hooley-Underwood | Final version awaiting George's review |
| BROWN BULLHEAD | Woodling & Treble | Just needs to be run thru Grammarly check. Also needs a picture or two |
| CENTRAL STONEROLLER | Woodling | Need to reverse George's length measurement revisions, putting metric first. Needs final run thru Grammarly and it is DONE! |
| COMMON CARP | Woodling | Woodling just needs to review and accept final version and we can be done with it. |
| FLATHEAD CATFISH | Woodling & Bennet | |
| GOLDEN TROUT | Andrew Treble | Complete |
| GREEN SUNFISH | Woodling | DONE!!!! |
| HORNYHEAD CHUB | Woodling | Basically done. Needs a picture or two from somewhere. Do we want to talk about why it disappeared and potentially reintroducing it? |
| JOHNNY DARTER | Woodling | Pretty much done. Need to standardize ADAMAS reference and add one more decent picture. Citations cleaned up. |

| | | |
|------------------------|--------------------------------|---|
| LAKE CHUB | Crockett & Woodling & Jones | Pretty much done. Standardize citations and how we reference ADAMAS |
| LAKE TROUT (MACKINAW) | Brett Johnson and Pat Martinez | |
| LARGEMOUTH BASS | Swigle/Myrick | Pretty much done. Just needs citations and ADAMAS reference standardized |
| LONGNOSE SUCKER | Tyler Swarr | Pretty much done. Need to standardize citations and how to cite ADAMAS |
| MOUNTAIN WHITEFISH | Rogers and Schisler | Done. Just need to redo the map to reflect nonnative status in the colorado. |
| MUSKELLUNGE | Swigle | DONE! |
| ORANGETHROAT DARTER | Woodling & Foutz | Woodling needs to add a citation on Page 2. |
| PALMETTO BASS (WIPER) | Mandi Brandt and John Woodling | needs final run thru grammarly and incorporate Carrie's info |
| PEPPERED CHUB | Woodling | Just needs standardized citations and ADAMAS references. Add a map. George needs to re-read it. Get photo from Uland. |
| PUMPKINSEED | Woodling | Illustration needs annotation. Whole document needs to be checked. Need photo citations |
| RAINBOW SMELT | Hansen | DONE. George and John still need to read. |
| RAINBOW TROUT | Fethermen & Schisler | Updated illustration and format; ran thru Grammarly. Sent off to George and Eric for final review |
| REDEAR SUNFISH | Woodling and Brandt | |
| RIO GRANDE CHUB | Woodling and Alves | One last citation question to clear up |
| RIVER SHINER | Woodling | Done. Could use some better pictures. |
| RUDD | Woodling | Needs final review and a picture or two |
| SACRAMENTO PERCH | Woodling & Treble | Also need to update text to include records in Arkansas. Go thru Inland Fishes of California when it arrives and update where necessary. Need to work in Federally Endangered status and reasons in there somewhere |
| SOUTHERN REDBELLY DACE | Woodling & Foutz | |
| SPOTTAIL SHINER | Woodling | Ad to similar species distinctions and run thru grammarly |
| STRIPED BASS | Woodling | Species associations (?), picture citation adjustments. Needs finaly Grammarly check. |

| | | |
|---------------------------------|------------------------------|---|
| TENCH | Woodling | Pretty much done. Final run thru Grammarly and could use another photo if possible |
| THREADFIN SHAD | Woodling & Krone | This one is completely finished and reviewed. Just needs a picture or two added |
| TIGER TROUT | Adam Hansen | Citations need to be entered into Mendeley. Schisler and Woodling to view |
| WESTERN MOSQUITOFISH | Woodling | Citations need to be updated in Mendeley. Could use another picture or two. Woodling needs to review Liz's edits. |
| WHITE AMUR (DIPLOID GRASS CARP) | Woodling/Brandt | Needs at least one picture and run thru Grammarly. |
| YELLOW PERCH | John Wooling (& Ben Swigle?) | George is working on incorporating latest revisions. Still needs to be run thru Grammarly |