Western Alaska LCC

Interim Performance Report

1. PROJECT INFORMATION

Title	Response of an Arctic Freshwater Ecosystem to Climate and Land-use Change
Award number	*F13AC00646*
Report period	*8/01/2013 – 9/30/2014*
Project End Date	*9/30/2017*
Report submission date	*3/31/2015*
Author(s) of Report	Chris Arp

Principal Investigator(s), Co-Principal Investigators and Recipient Organization(s):

Principal Investigator: Dr. Christopher D. Arp, Assistant Research Professor, Water and Environmental Research Center, University of Alaska Fairbanks, cdarp@alaska.edu, 907-474-2783
Co-Investigators: Anna Liljedahl (UAF), Matthew Whitman (BLM), Debora Nigro (BLM), Ben Jones (USGS), Mark Wipfli (USGS/UAF), Vladimir Alexeev (UAF), and Chris Hiemstra (CRREL)

2. PROJECT OVERVIEW

a. Briefly (4-5 sentences) describe both the research purpose and the underlying need for this research.

This research focuses on the natural linkage among surface-water availability, connectivity, and temperature that operate as a coupled system, which physically mediates habitat and trophic dynamics of Arctic freshwater ecosystems. In the Fish Creek Watershed (FCW) these interrelated processes form a shifting mosaic of freshwater habitats across the landscape that can be classified, mapped, understood, and modeled in response to past and future climate and land-use change in a spatial and temporal context. We are developing scenarios of freshwater habitat change in this context to provide managers and scientists with a flexible template to evaluate a range of potential responses to climate and land-use change. This study is using a phased approach resulting in an integrated landscape-scale and spatially explicit model template for managers, scientists, and other stakeholders, which can be enhanced through more focused biological studies that are already being planned.

b. List the objective(s) of the project, exactly as described in your Statement of Work.

*Guidelines for Final Reporting are available at https://westernalaskalcc.org/projects/SitePages/piresources.aspx

1. Meet among Fish CAFÉ team and plan details of project by 1 December 2013.

2. Develop a data management plan in coordination with Arctic LCC staff by 1 February 2014 (Arp, Jones, Alexeev, Hiemstra, and Liljedahl).

3. Develop an initial classification system and classify aquatic habitat units (i.e. stream-lake system and surrounding catchment or channel-lake system and connecting floodplain) for the Fish Creek Watershed using existing geospatial datasets and related landscape classifications by 1 February 2014 (Arp and Jones).

4. Develop a human footprint geospatial dataset using archived remote sensing and map data, reports, and other information by 1 March 2014 (Jones, Arp, and Whitman).

5. Compile regional fish survey data into geospatial database linked to the initial aquatic habitat classification by 1 March 2014 (Whitman and Wipfli).

6. Characterize biophysical regimes, phenology, and ranges of interannual variability (algal and macrophyte productivity, wetted area, albedo, ice thickness, etc.) of representative number of each aquatic habitat unit class using high spatial and temporal resolution remote sensing products and geospatial models (i.e. Worldview-2, Landsat 8, TerraSAR-X) by 1 November 2014 (Jones, Hiemstra, and Arp).

7. Characterize biophysical regimes (productivity, dissolved oxygen, waterlevels, ice, light penetration, etc.) of a representative number of each aquatic habitat unit class with field monitoring and synoptic surveys by November 2014 (Arp, Jones, Hiemstra, and Whitman).

8. Characterize landform and biological history, development, and succession for select habitat classes using paleoecological methods by March 2015 (Jones and Gaglioti).

9. Use the outcomes from 2-4 to refine the initial classification system and produce a final aquatic habitat unit classification for the Fish Creek watershed made available as GIS database and map with a corresponding report or journal manuscript by 1 February 2015 (Jones and Arp with co-authorship from other team members).

10. Conduct fish and bird surveys on a representative set of aquatic habitat classes to describe habitat use and functions by 1 November 2015 (Whitman, Nigro, and Wipfli).

11. Organize, quality control, and provide existing historical climate and hydrological datasets from stations in the Fish Creek watershed to modeling groups (climate, snow, and hydrology) by 1 April 2014 (Arp, Alexeev, Liljedahl, and Hiemstra).

12. Develop historic (1950 to 2012) and future (2012 to 2100) climate datasets from a limited area climate model (WRF) at 3-5 km resolution for the Fish Creek Watershed by 1 November 2014 (Alexeev).

13. Develop historic (1950 to 2012) and future (2012 to 2100) snow distribution datasets using SnowModel at 1 km resolution for Fish Creek Watershed by 1 November 2014 and at 5 m resolution for several catchments (10-30 km2) corresponding to hydrologic modeling components by 1 November 2015 (Hiemstra and Liston).

14. Develop a lake thermal module in WaSiM that is coupled to the rest of the heat and mass transfer modules by 1 November 2015 (Liljedahl).

15. Determine a set of land-use and climate change scenarios to investigate using climate, snow, and hydrology modeling frameworks within the aquatic habitat unit classification system 1 December 2015 (everyone with involvement of managers and other stakeholders).

16. Develop schematic watersheds/scenarios that include different lake characteristic/distribution, which are to be forced with present (last 1-3 yrs), historic (1950 to 2012) and future (2012 to 2100)

climate data. The model experiments will be calibrated and tested against recently (CALON) measured water temperatures/levels. Resulting in a report or manuscript with corresponding simulation datasets due date 1 May 2016 (Liljedahl).

17. Develop regional hydroclimatic scenarios that represent potential drivers of habitat change or functionality based on analysis of climate and snow modeling results including identification of scenario probability presented as a report or manuscript with corresponding datasets by May 2016 (Alexeev and Hiemstra).

18. Synthesize the hydrologic modeling results for individual aquatic habitat unit classes to describe historic and future projected ranges of variability and ecosystem change to be incorporated within the geospatial database by 1 Aug 2016 (Liljedahl, Arp, Jones, Hiemstra, and Alexeev).

19. Analyze and interpret scenario simulation results in the context of aquatic habitat unit geographic, physical, and biological characteristics and processes to assess the status and predict the responses of Arctic freshwater ecosystems to climate and land-use change in report to Arctic LCC by 1 September 2016 (Arp with input from everyone).

3. PROGRESS SUMMARY

a. Describe report period progress.

This project was initiated with a three-day group workshop in November 2014 to plan and integrate research components including refinement of hypotheses and objectives, study area, field monitoring and studies, modeling activities, and outreach. Several separate meeting were conducted during the spring of 2014 to further define field objectives and methods and also integration of modeling and data sharing. A preliminary geospatial analysis and classification was completed in the Spring 2014 by Ben Jones, which was used in selection of study sites for fish, bird, and aquatic habitat studies. In April 2014, focus study ecosystems were visited to measure snow depth, ice thickness, and water chemistry and instrument new study lakes with sensors. In June 2014, Deb Nigro (BLM) conducted a pilot survey of loon presence and habitat that allowed her to determine an appropriate study design to be conducted in the following year. Fish surveys were conducted on 10 of 16 study lakes in July and August including additional genetic sampling for the NPS, UAF, and ADF&G. Synoptic surveys of lake hydrology, water chemistry, and food webs were conducted two times in June, and again in July and August on all lakes. This work included servicing and downloading sensors at all study lakes. Additional intensive work was conducted in a small catchment (Crea Creek) in April and throughout the summer to collect data to be used in hydrologic modeling of this system. The majority of lab analyses were completed by the end of September and data quality control, organization, and analysis was ongoing through the end of this report date.

b. Describe preliminary results.

Geospatial analysis and classification of water bodies in the Fish Creek Watershed using a combination of satellite imagery and digital elevation models (DEMs) identified 4361 water bodies greater than 1 ha. These were classified according to multiple categories of interest in describing aquatic habitat including ice regime (Figure 1) and stream connectivity (Figure 2).

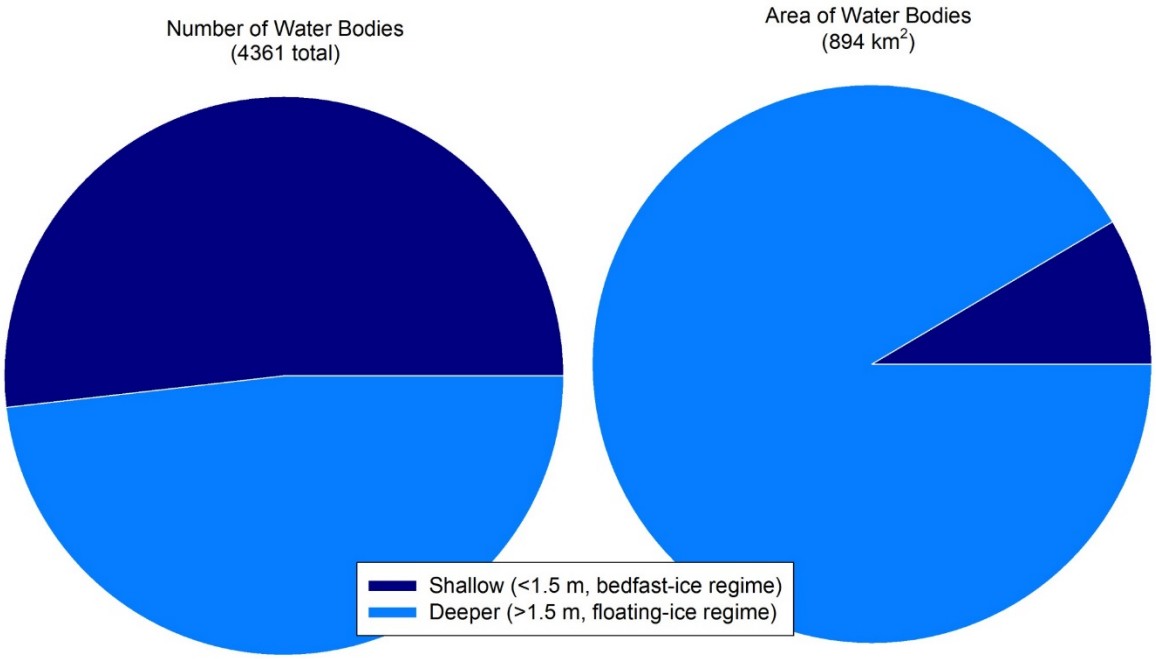

Figure 1. The proportion of lakes in the Fish Creek Watershed with bedfast-ice and floating-ice regimes by number and surface-area.

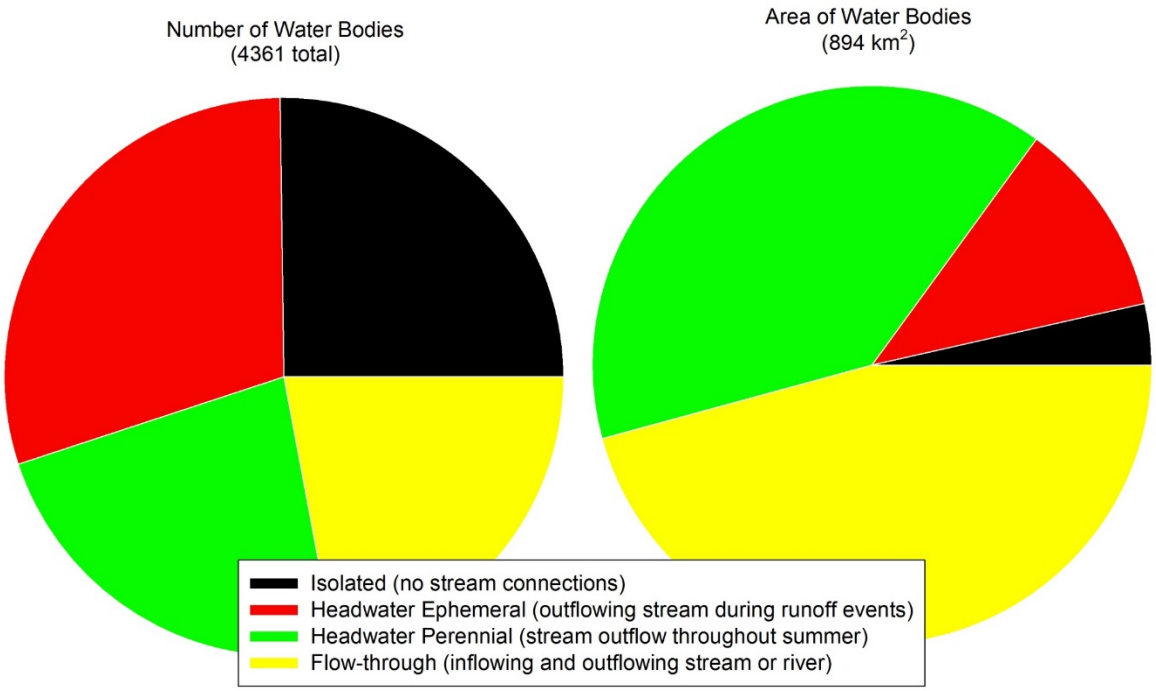

Figure 1. The proportion of lakes in the Fish Creek Watershed classified according to connections with streams by number and surface-area.

This preliminary classification served importantly in selecting study lakes for more detailed field monitoring and sampling, and provided critical guidance in designing the loon study.

Hydrologic monitoring and analysis of lake connectivity provided useful field verification of the geospatial classification showing where the system worked well and were refinements were needed (Table 1).

Table 1. Peak discharge (Qmax) and stream connectivity regimes during the summer of 2014 showing the duration of stream-lake connection by surface water (blue) and estimated passage by large fish (green) in relation to mapped connectivity classes.

Outlet	Connectivity Class	Qmax_L/s	mid-June	late-June	mid-July	mid-August
FC-R0066	flowthrough	1079				
MC7916	flowthrough	700				
Ini-006	ephemeral	535				
Hannahbear	flowthrough	415				
FC-L9819	perennial	350				
FC-L9820	ephemeral	310				
FC-L9811	flowthrough	195				
Ini-004	perennial	160				
INI-001	perennial	57				
Ini-003	perennial	50				
FC-M9925	perennial	16				
INI-005	ephemeral	8				
Ini-002	ephemeral	4				
Lonely Wolf	ephemeral	1				
Crazybear	isolated	0				
Duckfish	isolated	0				

More indepth monitoring and mapping in the Crea Creek watershed, a site scheduled for petroleum development and intended for hydrologic modeling, was used to understand changes in connectivity and fish passage in a drought year (2007) compared to a wet year (2013) (Figure 3).

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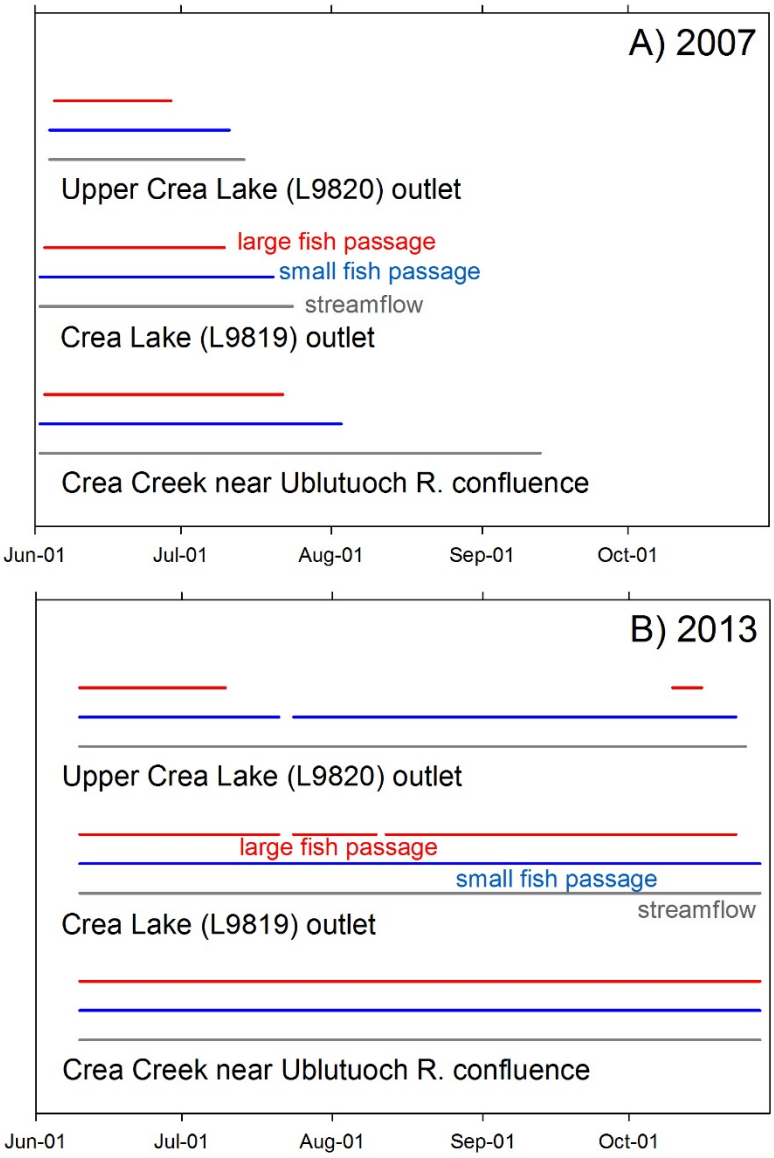

Figure 3. Duration and timing of surface-water connectivity (grey lines) and passage for small fish (blue line) and large fish (red line) through the summers of 2007 (a) and 2013 (b) at different location in the Crea Creek Watershed.

Additional hydrologic analyses indicated the importance of ice-out timing and its relation to lake ice regimes in controlling lake evaporation rates and potential sensitivity of differing aquatic habitats to climate variability (Figure 4).

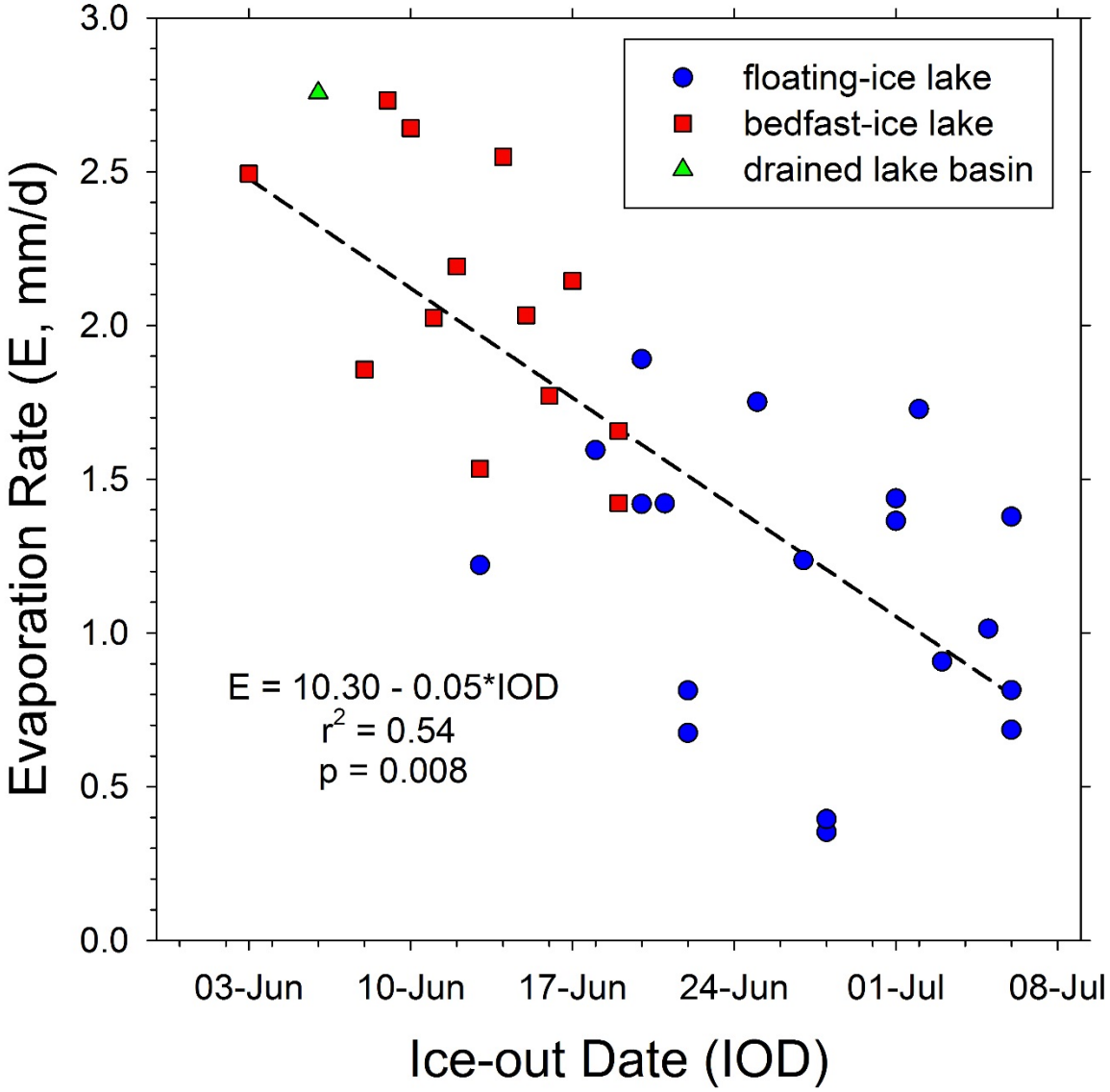

Figure 4. Lake evaporation rate (1-June to 10-August) in relation to ice-out date on the Arctic Coastal Plain including multiple lakes in the Fish Creek Watershed in 2012-2014.

Preliminary results from studies of aquatic forage base (plankton) show a strong relations to fish presence and the use of lakes by loons during the summer of 2014 (Figure 5). Comparing these among lakes as classified indicates that connectivity and ice regimes are key landscape aspects explaining how aquatic ecosystems function in fish and bird habitat.

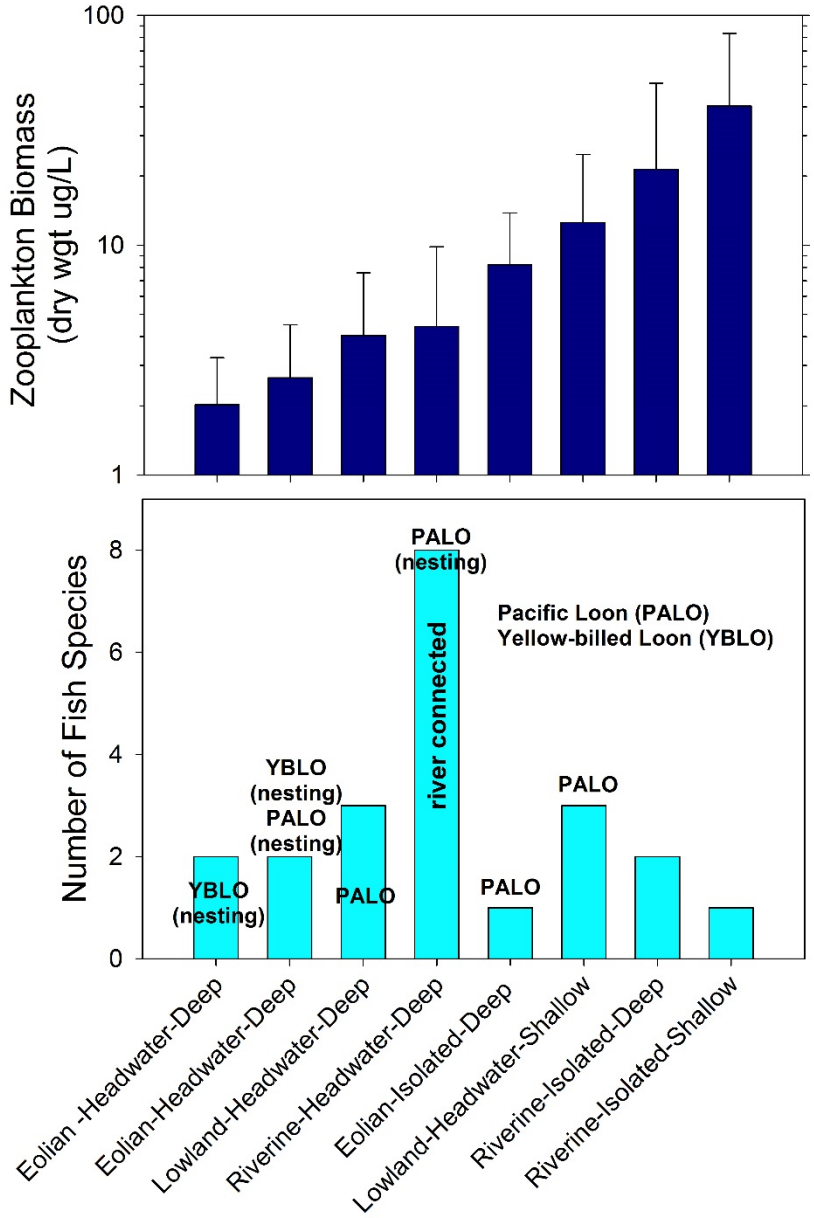

Figure 5. A subset of study lakes in the Fish Creek Watershed organized by surface geology, connectivity, and ice regime (depth) compared to zooplankton biomass (upper panel) and fish species numbers and loon (YBLO = yellow-billed loons, PALO = pacific loons) habitat use.

c. Publications, conference papers, and presentations.

Jones, B. M., A. Gusmeroli, C. D. Arp, T. Strozzi, G. Grosse, B. V. Gaglioti, and M. S. Whitman. 2013. Classification of freshwater ice conditions on the Alaskan Arctic Coastal Plain using ground penetrating radar and TerraSAR-X satellite data. *International Journal of Remote Sensing* 34(23): 8253-8265.

Arp, C. D., B. M. Jones, A. K. Liljedahl, M. S. Whitman, and M. S. Wipfli. 2014. Response of an Arctic freshwater ecosystem to climate and land-use change: interdisciplinary research in the Fish Creek Watershed, northern Alaska, U.S.A. *Joint Aquatic Sciences Meeting*, Portland, OR.

Arp, C. D., V. Alexeev, C. Hiemstra, B. Jones, A. Liljedahl, D. Nigro, M. Whitman, and M. Wipfli. 2013. Response of an Arctic freshwater ecosystem to climate and land-use change: new interdisciplinary research in the Fish Creek Watershed. *Alaska Chapter of the American Fisheries Society*, Fairbanks, AK.

d. Education and outreach.

A briefing was given to members of the Subsistence Advisory Council meeting in February 2014 in Fairbanks regarding the objective of the Fish CAFÉ project.

e. Other products resulting from the project.
Nothing to Report.

f. Data management.
No updates to report.

g. Describe any concerns you may have about your project's progress.
No updates to report.

h. Request for LCC assistance.
Arctic LCC did provide assistance with respect to the first issue and likely is already aware of the second issue.

4. PROGRESS STATUS

a. Overall progress

Overall, I am very pleased with the progress made during this period give the complexity of this project. The geospatial analysis was completed in a timely manner and provided an important framework for the 2014 fieldwork and particularly in guiding the development of the bird studies. The summer field work went better than expected with some interesting results, some of which will have immediate impact in terms of products and management. The modeling work has been slow to progress, but efforts have picked up since this reports end date giving me greater confidence that this will be an important and well integrated component of this study. Particularly, the ability of Dr. Liljedahl to hire a post-doc (Dr. Anne Gadeake) dedicated to watershed modeling is an important step. Additionally the project has built a number of collaborations that will benefit the project including with the National Park Service (both with fish and bird studies), ADF&G, UAF, and USGS (genetic analysis of fish samples), Climate Science Center (funding a student to study lake trout and climate change in Fish Creek Watershed), NSF (funded a new study focused on lake ice that provides additional funding to field work and modeling that benefits this project), and Alaska EPSCoR (which provides extra funding for watershed modeling in Crea Creek and acquired high resolution imagery and LiDAR data for that area).

During the next reporting period had a project meeting, which was very successful in terms of sharing results, integrating the next steps, and developing a plan to take the project to the end with a scenarios analysis approach integrated with an outreach program. Field work is planned for the spring and

summer of 2015 including refinement of habitat and food web characterization, additional field verification of the watershed habitat classification, implementation of loon surveys and behavioral studies, and completion of fish surveys. Both climate and watershed modeling work is anticipated to advance significantly during this time as well. We will have a brief project meeting in the fall, have a DOI stakeholder workshop in the spring 2016 and work towards a special session at a special Arctic conference this next spring as well to attempt to reach a wide array of stakeholders interested in Arctic Freshwater habitats and climate and land-use change.

b. How can the LCC highlight the value of this project?

The information you provide here will help us highlight your work to the partnership community. It will also assist us in gauging the effectiveness of the LCC's activities.

The Fish CAFÉ Project has done a very nice job of becoming integrated with other projects, which is described in Figure 6.

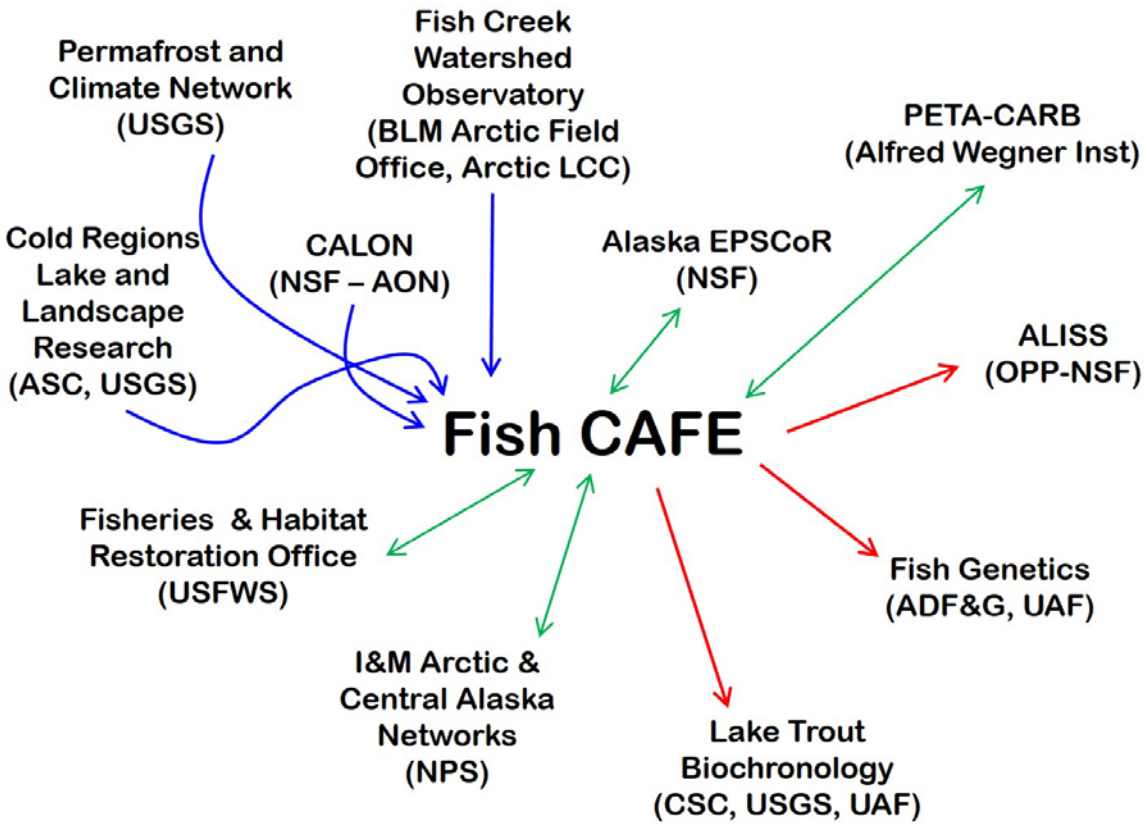

Figure 6. Relationship of the Fish CAFÉ project to other science and management activities. Blue arrows are programs that provided the foundation for Fish CAFÉ to start, green arrows are collaborative relationships with other programs that developed as Fish CAFÉ has progressed, and red arrows are projects or collaborations that started because of Fish CAFÉ.