COLORADO LAKE AND RESERVOIR FOOD WEB ECOLOGY PROJECT SUMMARY

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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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COLORADO LAKE AND RESERVOIR FOOD WEB ECOLOGY PROJECT SUMMARY

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PROJECT OBJECTIVE: To address problems facing lake and reservoir managers throughout Colorado with a focus on important sport fisheries; to collect data and conduct experiments to provide information to managers that will improve fisheries and fish communities in lakes and reservoirs throughout Colorado.

RESEARCH PRIORITY:

Tiger muskellunge (*Esox lucius* x *E. masquinongy*) as white sucker control agents

OBJECTIVES:

Determine the effectiveness of tiger muskellunge as biological control agents of undesirable white sucker populations in Colorado.

INTRODUCTION:

Suppression of undesirable fish species that negatively influence preferred species is common. One species often targeted for suppression is the white sucker (*Catostomus commersonii*). White suckers have been shown to compete with salmonid species including popular sport fish such as rainbow trout (*Oncorhynchus mykiss*), an important sport fish in Colorado. Rainbow trout diets have been found to overlap considerably with white suckers, and decreased growth rates of stocked rainbow trout in the presence of suckers have been observed. Reduced rainbow trout survival has been attributed to reductions in available benthos following the introduction of white suckers, and rainbow trout yield has been shown to decrease in systems where white suckers have been introduced. This type of information, combined with anecdotal evidence, has made white sucker control a common management practice in systems where they are abundant while salmonid species are desired by anglers.

Removals of white suckers have been conducted across the United States and Canada. A mass mechanical removal of white suckers was evaluated in five temperate lakes in Quebec. It was demonstrated that removals may induce compensatory responses in white suckers (e.g., increased individual growth rates, decreased age at maturity, increased mean adjusted fecundity). This indicates that these compensatory responses were related to the intensity of the removal effort; the more intense the removal, the more intense the response. Further, the compensatory responses observed for white suckers occurred more rapidly than any population gains observed for brook trout present within the five systems. Thus, if suppression of white suckers is considered as a management strategy, these potential responses should be considered, given that suppression attempts may result in the growth of white sucker populations without continuous effort or complete eradication.

Fish removal efforts can be costly and time-consuming; an alternative management practice to suppress undesirable fish species efficiently is to introduce piscivores that have the potential to effectively control the undesirable population. For example, sterile esocids such as tiger muskellunge (hybrids of northern pike *Esox lucius* and muskellunge *E. masquinongy*) are often stocked as biological control agents to suppress white sucker populations. Biological control (i.e., tiger muskellunge introductions) of undesirable species has the benefit of being less labor intensive compared to mechanical removals. Suppression can occur across days, seasons and even years following stocking because effort (predation on white suckers) is essentially continuous. Perhaps one drawback to this approach is the potential for predation by tiger muskellunge on desirable sport fish species like rainbow trout, rather than the intended, undesirable species. In this context, the effectiveness of tiger muskellunge as white sucker control agents have not been thoroughly evaluated.

METHODS:

This study evaluated tiger muskellunge consumption of white suckers in five Colorado reservoirs (Big Creek, Clear Creek, DeWeese, Parvin and Pinewood reservoirs: Table 1) using stable carbon and nitrogen isotopes. Detailed methodology of this study can be found in the manuscript referenced below.

Table 1. Study systems.

Reservoir	County	Area (ha)	Elevation (m)
Big Creek	Jackson	147	2734
Clear Creek	Chaffee	164	2708
De Weese	Custer	129	2337
Parvin	Larimer	27	2499
Pinewood	Larimer	37	2006

RESULTS AND DISCUSSION:

This Research Priority is complete. A final manuscript related to this work has been published in the scientific peer reviewed literature (journal of Lake and Reservoir Management) within this reporting period.

- **Lepak, J.M.,** Cathcart, C.N., and Stacy, W.L. 2014. Tiger muskellunge predation on stocked salmonids intended for recreational fisheries. Lake and Reservoir Management. 30:250-257.

This manuscript describes tiger muskellunge prey preference in five Colorado reservoirs. Stable isotope analyses were used to evaluate tiger muskellunge (northern pike, *Esox lucius* L., x muskellunge, *E. masquinongy*) predation on stocked salmonids, *Oncorhynchus* spp. relative to naturally reproducing white suckers, *Catostomus commersonii*, in five Colorado (USA) reservoirs. Stable isotope analyses indicated that tiger muskellunge consumed primarily stocked salmonids (53–84% by mass). These results suggest that stocking salmonids into systems that contain tiger muskellunge (and potentially other predators) may result in losses of stocked fish to predation. In addition to the information provided in Lepak et al. (2014), we developed a median tiger muskellunge diet proportion, estimated across all five study systems in Colorado (Figure 1).

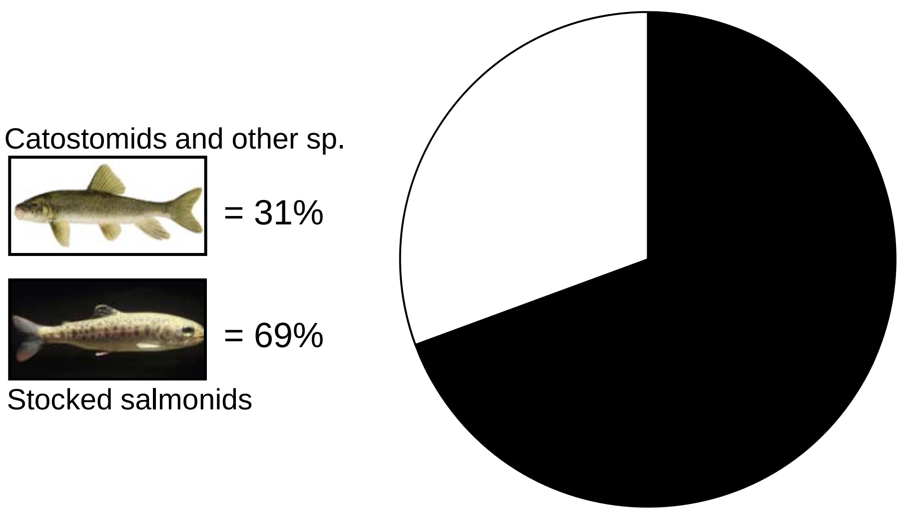


Figure 1. Estimate median tiger muskellunge diet proportions across all five study systems.

ACKNOWLEDGEMENTS:

I would like to thank my coauthors; C. N. Cathcart, and W. L. Stacy. I would also like to thank M. Avery, D. Dreiling, Researchers and Biologists and their crews (particularly K. Davies, E. Fetherman, M. McGree, G. Policky, G. Schisler, and B. Swigle) for field support.

RESEARCH PRIORITY:

Investigating standardized gillnetting techniques in Colorado water bodies

OBJECTIVES:

Conduct summer profundal index netting (SPIN) to obtain lake trout (*Salvelinus namaycush*) population estimates in Grand Lake and Taylor Park Reservoir.

INTRODUCTION:

Estimating fish abundance is an essential part of fisheries management. Often, harvest regulations and other management decisions that influence fish community and food web structure rely heavily on the knowledge of how many fish are present within a given system. Capture-mark-recapture studies are one of the most common and reliable methods for estimating fish population sizes and answering other questions related to fisheries. Although this method is useful, it can be extremely labor intensive, and to obtain precise estimates, one must often mark a large proportion of the fish in a population in order to have recapture rates at or above 30%. In some systems, this may take a period of years depending on the life history of the species of interest.

To avoid labor-intensive sampling that is often constrained by available time, personnel and resources, fisheries biologists and researchers have developed methods to estimate what is referred to as “relative abundance”. These approaches can be conducted using several gear types (e.g., gillnets, electrofishing, trapping, etc.) and generally involve a standardized effort. Using the catch rates from these methods, a “catch-per-unit-effort” (CPUE) can be calculated for comparison over time and across systems. Thus, comparisons of CPUE can indicate whether a particular system has more or less fish in a given year or whether a particular system has more or less fish relative to another. Although this can be useful, these types of approaches do not provide an estimate of the number of individuals in a system. Thus, although these qualitative sampling methods offer guidance for fisheries managers, they do not provide quantitative measures on which to base management decisions.

I was asked to investigate the potential for using standardized sampling techniques for developing fish population indices in Colorado. The biologists across the state use a variety of methods to sample fish and obtain CPUE’s for comparison across systems and time. However, since several methods and gear types are used for fish sampling in many cases, it can be difficult to compare CPUE’s across the landscape. At the same time, it can be very important to continue standardized historic sampling efforts in a given system for comparison to previous data. When new methods are developed and implemented, one can lose the ability to compare these methods to past efforts unless the new and old methods are conducted simultaneously for calibration. Thus, although I have explored a new technique for fish sampling, I do not recommend forgoing any historical long-term data collection without serious consideration. However, new, alternative methods may provide additional information not formerly available using other techniques.

METHODS:

I explored the utility of a quantitative method for sampling lake trout (*Salvelinus namaycush*) developed by the Ontario Ministry of Natural Resources. Specifically, this method is referred to as summer profundal index netting, (SPIN) and focuses on capturing lake trout in such a way that allows us to utilize lake trout data from 700-800 other systems to estimate population size, rather than obtaining relative abundance data. Briefly, the method involves using 64 m X 1.8 m gill nets with eight panels with stretch mesh sizes of 57, 64, 70, 76, 89, 102, 114 and 127 mm in random order. Nets are set along the bottom in random orientation and sites are depth stratified and selected at random. The SPIN manual has an interchangeable rope design which allows for nets to be set in 2, to over 80 m of water which was useful and versatile, and may be used for other netting efforts. Sampling is conducted when surface temperatures exceed 18°C and nets are set for two hours. Netting for this project was conducted from 8 to 12 August, 2011. For further sampling details, see Sandstrom and Lester (2009). The power of this particular method is the use of data from hundreds of systems as a calibration tool to characterize lake trout densities that can then be used to estimate lakewide abundance, versus techniques that provide estimates of relative abundance through time and across systems.

During the 2013 field season, SPIN (summer profundal index netting) sampling was conducted in Grand Lake (in collaboration with Jon Ewert) and Taylor Park Reservoir (in collaboration with Dan Brauch) to obtain lake trout population estimates. These results were compared to the results obtained from the same sampling design in Blue Mesa Reservoir in 2011.

RESULTS AND DISCUSSION:

Grand Lake SPIN results:
Sampling was completed over the course of two days (7 and 8 July 2013), during which 36 nets were set capturing a total of 87 lake trout ranging in size from 253 mm to 872 mm (mean = 419 mm ± 107 mm S.D.). These results produced a lake trout abundance estimate of 2,452 lake trout ≥ 253 mm (lower 68% confidence interval = 1,974; upper 68% confidence interval = 2,996). The 68% confidence bounds around this estimate included a mark-recapture estimate of catchable lake trout of approximately 2,200 lake trout that was conducted by anglers over the winter season of 2012 with the help of Biologist Jon Ewert.

Taylor Park Reservoir SPIN results:
Sampling was completed over the course of two days (12 and 13 August 2013), during which 36 nets were set capturing a total of 271 lake trout ranging in size from 270 mm to 1,034 mm (mean = 416 mm ± 94 mm S.D.). These results produced a lake trout abundance estimate of 11,950 lake trout ≥ 270 mm (lower 68% confidence interval =

9,871; upper 68% confidence interval = 14,341). The catch rates (number of fish per net) were higher in Taylor Park Reservoir than in any other reservoir sampled thus far.

SPIN result comparisons across systems:
Perhaps the best way to compare these results across reservoirs is by looking at the lake trout population estimates, mean and range of sizes, and the lake trout density. The following table (Table 2) provides these metrics where estimates are lakewide numbers of lake trout vulnerable to the gear.

Table 2. Results-to-date from lake trout SPIN sampling in Colorado. LCL is the 68% lower confidence limit, UCL is the 68% upper confidence limit, L is total length and density is in number of lake trout per hectare.

System	Estimate	LCL	UCL	Mean L (mm)	S.D. of L	Density
Blue Mesa Reservoir	34,071	27,144	41,929	437	110	11.14
Grand Lake	2,452	1,974	2,996	419	107	12.40
Taylor Park Reservoir	11,950	9,871	14,341	416	94	19.61

Based on these data, Blue Mesa Reservoir has the largest lake trout population followed by Taylor Park Reservoir and Grand Lake. The mean sizes of lake trout captured in each system overlapped and were not significantly different, however, notable fish (> 800 mm) were captured in all three systems; 6 in Taylor Park Reservoir (868 mm weighing 8,500 g; 890 mm weighing 8,700 g; 908 mm weighing 7,000 g; 911 mm weighing 9,300 g; 920 mm weighing 8,200 g; 1,034 mm weighing 15,500 g), 4 in Blue Mesa Reservoir (804 mm weighing 5,000 g; 884 mm weighing 8,500 g; 910 mm weighing 14,750 g; 996 mm weighing 13,750 g), and 2 from Grand Lake (848 mm weighing 6,741 g; 872 mm weighing 7,527 g).

Because of these results, there has been discussion of continuing these efforts in the future, and Blue Mesa and Granby reservoirs are scheduled to be sampled during the 2014 field season. Thus far, lake trout population estimates have been matching well with *a priori* expectations and independent population estimates, though it is acknowledged that few data are available to confirm these observations.

ACKNOWLEDGEMENTS:

I would like to extend my thanks to D. Brauch and J. Ewert and their crews. Without their efforts this work would not have been possible. I would also like to thank M. Avery, C. Craft, B. Johnson, N. Lester, W. Pate, S. Sandstrom, E. Vigil, and B. Wolff for project support and consultation.

REFERENCES:

Sandstrom, S., and Lester, N. 2009. Manual of Instructions for Summer Profundal Index Netting (SPIN): a Lake Trout Assessment Tool. Ontario Ministry of Natural Resources. Peterborough, Ontario. Version 2009.1. 22 pp. + appendices.

RESEARCH PRIORITY:

Streamlining fish aging techniques

OBJECTIVES:

Using otolith weights for age interpretation of kokanee salmon *Oncorhynchus nerka.*

INTRODUCTION:

Estimating ages of individuals in fish populations is crucial for effectively managing sport fisheries. Currently, the most widely accepted approach for age determination in fish is using thin sectioned otoliths for interpretation. This method is considered to be the most accurate, but is labor-intensive, and requires the interpreter to determine age subjectively. Determining fish age using otolith weights is an attractive method because it requires relatively little training, is non-subjective, and is much faster when compared to other fish aging techniques. We added to the literature on this topic by publishing Lepak et al. (2012) about applying this technique to kokanee salmon in Colorado. We have continued to use this approach (described below).

METHODS:

Briefly, otoliths were weighed as indicators of fish age. A machine learning approach (Random Forest) was used to incorporate otolith weight, fish length, fish sex, day of capture, year of capture and system of capture in a model to predict fish age. The model was calibrated with ages interpreted from a small subset of sectioned otoliths. See Lepak et al. (2012) for more details. The abstract for this manuscript is as follows:

Abstract:
Estimating ages of individuals in fish populations is crucial for determining characteristics necessary to effectively manage sport fisheries. Currently, the most accepted approach for fish age determination is using thin sectioned otoliths for interpretation. This method is labor-intensive, requires extensive training, and subjectively determines age. Several studies have shown that otolith mass increases with age, yet use of otolith weights to determine fish age is relatively underutilized. However, determining fish age using otolith weight requires relatively little training, is relatively non-subjective, and is faster compared to other aging techniques. We collected kokanee salmon (*Oncorhynchus nerka*) in 2004 from four reservoirs, and from 2000 – 2009 in one reservoir, to evaluate the efficacy of using otolith weights to determine fish ages. We used a machine learning technique to predict kokanee salmon ages using otolith weight and various other covariates. Our findings suggest this method has potential to significantly reduce time and financial resources required to age fish. We conclude that using otolith weights to determine fish age may represent an efficient and accurate approach for some species.

RESULTS AND DISCUSSION:

Estimated ages of adult kokanee salmon (N = 492, both otoliths weighed for most fish) from the Blue Mesa Reservoir 2013 spawning run were provided to Area Biologist, Dan Brauch on 28 March, 2014.

REFERENCES:

Lepak, J.M., Cathcart, C.N., and Hooten, M.B. 2012. Otolith weight as a predictor of age in kokanee salmon (*Oncorhynchus nerka*) from four Colorado reservoirs. Canadian Journal of Fisheries and Aquatic Sciences. 69(10):1569-1575

ACKNOWLEDGEMENTS:

I would like to thank D. Brauch and his Technicians for their efforts in the field. D. Dreiling, R. Formas, and Cody Tyler conducted much of the laboratory work. I also thank my coauthors as listed above.

<u>RESEARCH PRIORITY:</u>

Chemical cues of predation induce anti-predator behavior in naïve rainbow trout: implications for increasing post-stocking survival of hatchery-reared fish

OBJECTIVES:

To use various chemical cues to increase anti-predator behavior and post stocking survival of a highly domesticated strain of rainbow trout (Hofer; whirling disease resistant).

INTRODUCTION:

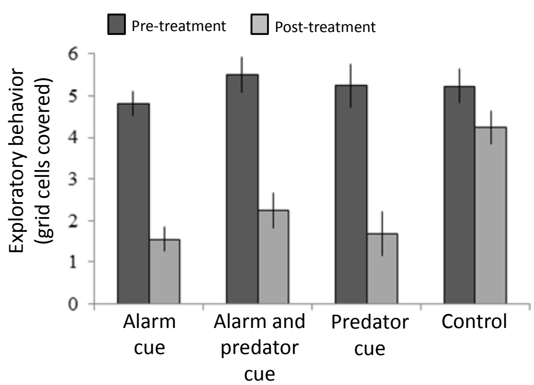
This project was conducted and written with the assistance of Christopher Kopack, currently a CPW Technician. This report section was prepared by C. Kopack and J. Lepak. E. Fetherman (CPW) was an important collaborator as well L. Angeloni and D. Broder (CSU). Many fisheries management agencies allocate significant proportions of available resources to rear fish for stocking in lakes, rivers, and reservoirs. However, hatchery-reared fish can have relatively low survival when released into natural habitats. Manipulation of the hatchery rearing environment can potentially enhance fitness-related traits, like anti-predator behavior, and subsequently influence fish survival in the wild. We investigated behavioral shifts in captive, hatchery-reared rainbow trout *Oncorhynchus mykiss* in response to chemical cues associated with predation. The German Rainbow (GR: Hofer) strain of rainbow trout was used, which is resistant to whirling disease but particularly susceptible to predation. This species was selected because of its importance as a management tool, however, other species (e.g., threatened or endangered species) could also benefit from these approaches.

METHODS:

We exposed individual rainbow trout to alarm cues from conspecifics, kairomones from brown trout *Salmo trutta* predators, a combination of the two cues and a water control. Behavioral metrics were recorded both before and after a one time exposure to these cues. Upon completion of these observations, the GR's from each treatment were placed in a predator encounter tank and allowed to enter and exit a protective structure in the presence of a brown trout.

RESULTS AND DISCUSSION:

Fish exposed to these cues exhibited changes in behavior expected to reduce predation risk, including a reduction in time spent actively swimming and an increase in time spent frozen, with the greatest response in those exposed to conspecific alarm cues (Figure 2). Fish exposed to a predator increased their time spent in the protective structure with the control spending the least amount of time inside. If these behaviors translate to increased survival rates of this highly domesticated strain in the wild, implementation of this rapid, simple and low cost treatment during rearing could increase survival of hatchery-reared fish, potentially increasing efficiency of stocking programs for recreational purposes as well as native fish restoration and conservation.



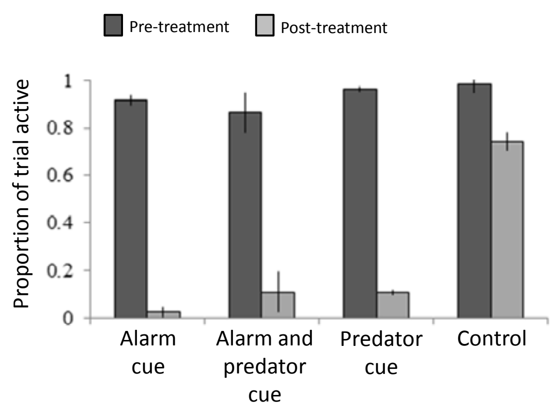
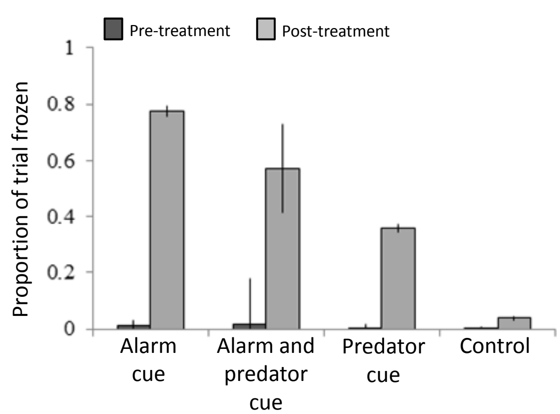


Figure 2. Behavioral responses of Hofer rainbow trout to anti-predator training. Responses are reduced exploratory behavior (panel a.), reduced proportional activity (panel b.), and increased time spent frozen (panel c.) from Kopack et al. (In Review: Fisheries Research).



This project is complete and has been presented in the form of several poster presentations and a submitted manuscript that is currently in review at the scientific journal, Fisheries Research:

- Kopack, C., Broder, E.D., **Lepak, J.M., Fetherman, E.R.,** and Angeloni, L.M. Chemical cues of predation induce anti-predator behavior in naïve rainbow trout: implications for training hatchery-reared fish. In Review: Fisheries Research.

The abstract is as follows:

Abstract:
Many fisheries management agencies allocate significant proportions of available resources to rear fish for stocking in lakes, rivers, and reservoirs. However, hatchery-reared fish can have relatively low survival when released into natural habitats. Manipulation of the hatchery rearing environment can potentially enhance fitness-related traits, like anti-predator behavior, and subsequently influence fish survival in the wild. We investigated behavioral shifts in captive, hatchery-reared rainbow trout *Oncorhynchus mykiss* in response to chemical cues associated with predation. The German Rainbow (GR) strain of rainbow trout was used, which is resistant to whirling disease but particularly susceptible to predation. We exposed individual rainbow trout to alarm cues from conspecifics, kairomones from brown trout *Salmo trutta* predators, and a combination of the two cues. Fish exposed to these cues exhibited changes in behavior expected to reduce predation risk, including a reduction in time spent actively swimming and an increase in time spent frozen, with the greatest response in those exposed to conspecific alarm cues. If these behaviors translate to increased survival rates of this highly domesticated strain in the wild, implementation of this rapid, simple and low cost treatment during rearing could increase survival of hatchery-reared fish, potentially increasing efficiency of stocking programs for recreational purposes as well as native fish restoration and conservation.

ACKNOWLEDGEMENTS:

We thank coauthors (E.D. Broder, E.R. Fetherman, L.M Angeloni) and S. Brinkman, C. Craft, R. Fitzpatrick, D. Laughlin, C. Myrick, K. Peters, and E. Vigil for project support.

RESEARCH PRIORITY:

Routine kokanee population assessments and improvement of SONAR methodology for estimating fish abundance

OBJECTIVES:

To complete multiple historical SONAR surveys, disseminate that information to relevant Area Biologists and Senior Biologists, and to improve our ability to estimate kokanee salmon egg take and abundance.

INTRODUCTION:

An economically important component of many Colorado fisheries is the kokanee salmon (*Oncorhynchus nerka*). This species (representing ~$30 million dollars in revenue annually to the state of Colorado) must be sustained by the annual collection of eggs and raising kokanee salmon in the state hatchery system until they are stocked as fry. Since they represent such a large portion of the state's economy, significant effort is put towards the collection and propagation of kokanee salmon eggs. In order to maximize the cost/benefit of these efforts, it is helpful to estimate the numbers of adult kokanee salmon that will be spawning in a given system in a given year, and to subsequently estimate the potential number of eggs that these salmon will supply to the hatchery system.

The most effective and widespread method for estimating kokanee salmon population size in Colorado waters is the use of SONAR (sound navigation and ranging) surveys, otherwise known as hydroacoustic surveys. These surveys use sound waves projected from a transducer to enumerate the number of fish within the water column. These surveys are non-invasive, less labor intensive and reduce sampling bias when compared to more traditional gear types (e.g., gillnets, electrofishing, trapping, etc.). Hydroacoustic surveys are used extensively to assess marine fish stocks, and their application to lake and reservoir systems is increasing in conjunction with research and advances in SONAR technology.

Colorado uses hydroacoustic surveys to estimate kokanee salmon population size in many water bodies. The aim of hydroacoustic surveys is to determine the relative abundance of kokanee salmon to predict future egg take. However, we are still in the process of refining this technique and adapting its capabilities to better suit our needs in Colorado. For example, hydroacoustic surveys are excellent for enumerating fish numbers, however, verifying species composition must be done by other means such as trawl or gillnet samples. Currently, the ability to distinguish individual fish species with SONAR technology is hindered by the variation in target strength (the strength of a returning sound echo) among species and within individuals of the same species. Target strength of returning sound echoes depends on internal fish physiology (i.e., the shape and orientation of the swimbladder) as well depth, stomach fullness, fish length and species (see Love 1970 for details on the equation used to estimate fish length from target strength). Thus, it is important to improve hydroacoustic survey design and data collection by gaining a better understanding of fish species target strength variability. Specifically, the need for precise estimates of target strength values/ranges of kokanee salmon in the wild is paramount for reducing uncertainty in abundance and future egg take estimates in Colorado. In the past this has proven difficult, primarily because lake and reservoir systems in Colorado contain more species then just kokanee salmon.

Continuing hydroacoustic surveys will allow us to better detect, and prepare for, increasing or decreasing trends in annual kokanee salmon abundance and egg take. Data collected are summarized and provided to Area Biologists to aid in various management decisions (e.g., kokanee salmon stocking density, harvest regulations and egg take effort allotment). Further, if it is possible to refine SONAR surveys through a better understanding of target strength variability, it will allow us to reduce the amount of uncertainty associated in estimates of kokanee salmon abundance and future egg take.

METHODS:

Procedure 1. Conduct multiple historical SONAR surveys:

SONAR surveys have been conducted historically throughout Colorado in waters that contain kokanee salmon. These surveys continued for comparison with data collected in the past. Primarily nighttime surveys were conducted when lakes and reservoirs were thermally stratified (corresponding to the summer months) during the new moon phase. Stratification aids in the separation of hydroacoustic targets by fish species because of their differing thermal preferences. Furthermore, kokanee salmon tend to school based on visual cues, and during low-light conditions they are dispersed spatially which makes them easier to enumerate (i.e., fish are spread out and more distinguishable from one-another).

Surveys were conducted using a personal computer-controlled Hydroacoustic Technology Inc. (HTI) 243 split-beam scientific echosounder with a 15 degree down-looking transducer mounted in a towed fin. This equipment was operated from a 22 foot Hewes Craft Sear Runner. Historical standardized transects were followed using a Garmin 165 global positioning system. Data are then processed using Echoscape (HTI Inc.) coupled with program HACH (developed by Dr. Kevin Rogers, CPW).

Procedure 2. Refine SONAR surveys to better develop a kokanee salmon target strength to length relationship:

Target strength variability makes it difficult to determine kokanee salmon size from hydroacoustic data. In addition, systems in Colorado tend to have many species, which causes interference when attempting to estimate kokanee salmon-specific lengths based on their target strengths. Lake Nighthorse, located near Durango, Colorado, presented a unique opportunity to evaluate estimates of target strength values/ranges of kokanee salmon in the wild. Very few fish were stocked in Lake Nighthorse initially, and a large proportion of them were kokanee salmon. We conducted SONAR surveys in conjunction with gillnetting surveys to attempt to verify kokanee salmon lengths estimated with SONAR data.

RESULTS AND DISCUSSION:

Procedure 1 (historical surveys):
Historical surveys were conducted and the annual report describing these results has been made available to Aquatic Biologists on the Colorado Parks and Wildlife Q-drive. The report is entitled: 2013 Hydroacoustic Survey of Colorado Waters, 87 pages, and was prepared by Michael Avery, Research Associate, Colorado State University. M. Avery also contributed to the SONAR section of this report. Twelve surveys were completed during this reporting period (Table 3).

Table 3. SONAR survey locations, dates, and purpose.

Reservoir	Survey date	Purpose
Green Mountain	7/8/2013	Historical
Elevenmile	7/9/2013	Historical
Cheesman	7/10/2013	Historical
Dillon	8/1/2013	Historical
Blue Mesa	8/7/2013	Historical
Williams Fork	8/8/2013	Historical
Lake Nighthorse	8/10/2013	Experimental
Dillon	8/20/2013	Experimental
Dillon	8/21/2013	Experimental
Granby	9/5/2013	Historical
Wolford Mountain	9/6/2013	Historical
Horsetooth	11/5/2013	Historical

Procedure 2 (refining target strength to length relationship):
This portion of research has been presented with challenges. Prior to October 2013, all fish captured during pelagic gillnetting surveys in Lake Nighthorse were kokanee salmon with the exception of a white sucker *Catostomus commersonii*. In October 2013, 40 rainbow trout were capture along with 68 kokanee salmon. The assumption that we were surveying primarily only kokanee salmon was violated. There was significant location and size overlap in these species (Figure 3). Unfortunately, we were unable to differentiate size classes of kokanee salmon > 20 cm (i.e., no peaks were observed when evaluating target strength frequency distribution), likely due to a combination of individual target strength variability and size overlap in multiple species. We were able to estimate kokanee salmon length from target strength relatively well with Love's

equation when fish were < 200 mm. However, beyond that length, this relationship was not upheld, and variance in target strength increased greatly, making fish length estimates uncertain by up to 200% or potentially more when using target strength (SONAR data) to derive fish length (compared to gillnetting data collected simultaneously) (Figure 4).

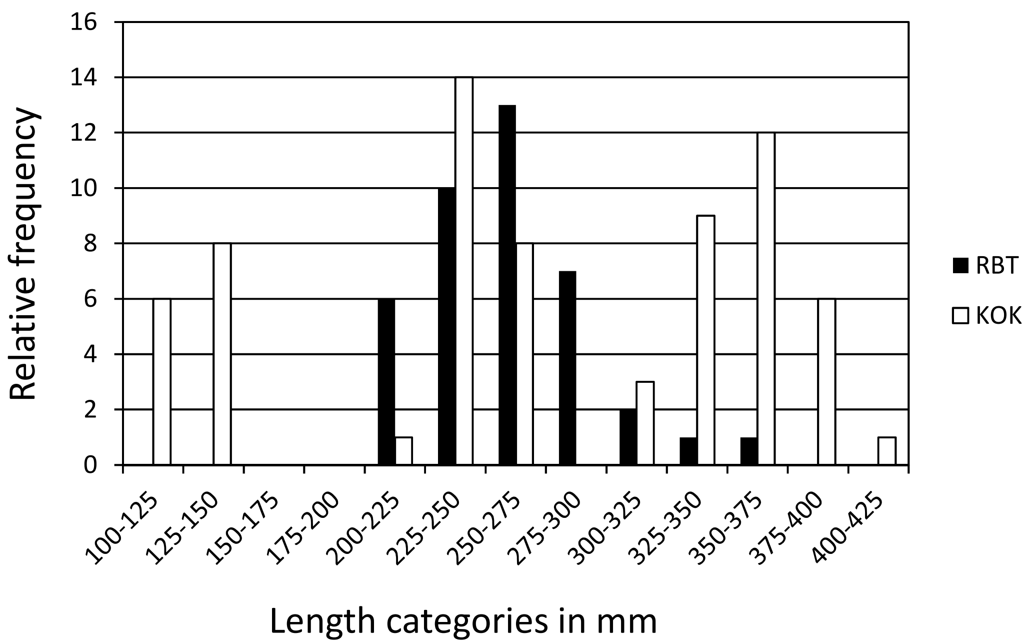


Figure 3. Length frequency distribution of rainbow trout (RBT) and kokanee salmon (KOK) captured in suspended and vertical multi-mesh gillnets in October 2013 in Lake Nighthorse.

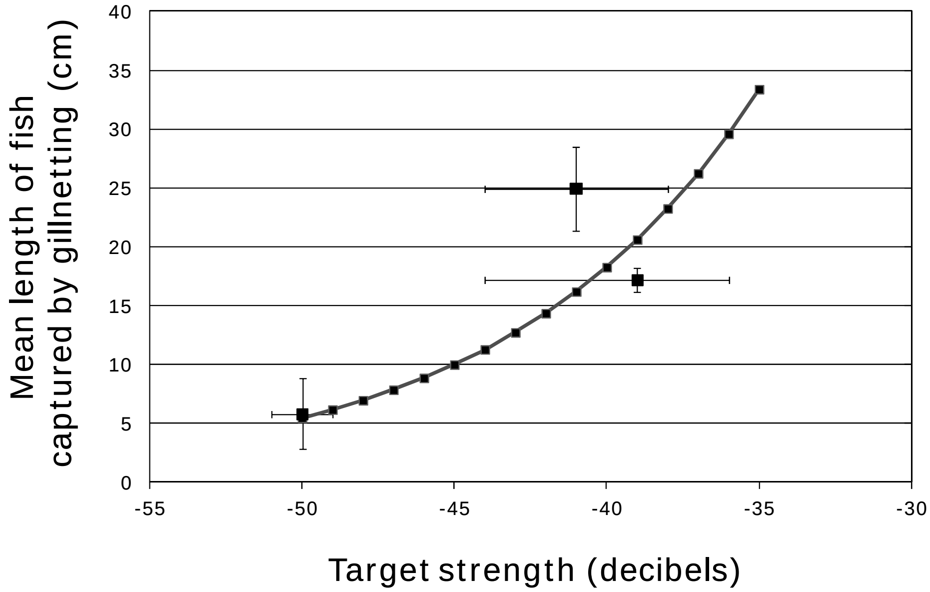


Figure 4. Mean lengths of netted kokanee salmon versus lengths estimated using Love's equation (Love's 1971). Points represent different sampling dates and the solid line is Love's equation.

All SONAR surveys have been discontinued indefinitely due to resource limitation.

REFERENCES:

Love, R.H,. 1970. Dorsal-aspect target strength of an individual fish. Journal of the Acoustical Society of America. 49:816-823.

ACKNOWLEDGEMENTS:

I would like to thank M. Avery for his tireless efforts during his Research Associateship. These data were collected under his direction, and he was an integral part of what is presented in this report section.

RESEARCH PRIORITY:

Collect and archive zooplankton and Mysis samples

OBJECTIVES:

To monitor zooplankton (for community structure and density information when needed) and Mysis (for density and biomass information when needed) populations and archive samples for future analysis.

INTRODUCTION:

This project was conducted and written with the assistance of Estevan Vigil. Zooplankton and Mysis data provide valuable information about the interactions between zooplankton, Mysis and kokanee salmon populations. Understanding these interactions allow us to determine the effects that these species have on each other and how these will in turn affect overall community structure, kokanee population size and individual growth. These collections also provide a baseline for understanding the potential influence of natural and anthropogenic perturbations including climate change, introduced species and community shifts. These sorts of events often act at the base of food webs first and work upwards. Thus, evaluating the potential changes associated with these perturbations is vital for making appropriate management decisions in the face of ecosystem changes.

METHODS:

Zooplankton were collected during the day from standardized sites in lakes and reservoirs that contain Mysis and kokanee salmon populations (and other potentially important reservoirs). We used oblique tows from depths of 0-10 m with a Clarke-Bumpus metered sampler (153 µm mesh net) with two replicates per site. Samples were placed in carbonated water (to reduce bursting) and preserved in 70% ethanol and held in 4 ounce Whirl-Pak bags. Zooplankton identification and individual and density measurements were conducted as described in detail in multiple Coldwater Reports prepared by P. Martinez.

Mysis were collected at night on the new moon in standardized sites in lakes and reservoirs of interest (those with Mysis and kokanee salmon populations). Collections were conducted with a 1 m diameter, 3 m long conical net with 500 µm mesh. The net was lowered to the bottom at every site and retrieved at 0.37 m/s with a battery-powered winch. Duplicate samples were be collected at each site and preserved in 70% ethanol and held in 18 ounce Whirl-Pak bags. Mysis densities were calculated from these samples and individuals were measured from the tip of the rostrum to the tip of the telson, excluding setae.

Due to interest overlap and the need to collaborate to meet program goals, we have begun to collaborate with Dr. Brett Johnson at Colorado State University to complete some of our zooplankton and Mysis surveys. As a result this new collaboration, Dr. Johnson's Laboratory has these data (e.g., Blue Mesa and Dillon reservoirs) which are being made available to CPW in conjunction with another project.

RESULTS AND DISCUSSION:

The zooplankton and Mysis data obtained during this reporting period by CPW can be found in Tables 4-13 below.

In each length frequency table the abbreviations are: Aa = *Alona affinis,* Bl = *Bosmina longirostris*, Dgm = *Daphnia mendotae*, Dp = *Daphnia pulicaria*, Dp spp. = unidentified *Daphnia spp.*, Db = *Diaphanosoma brachyurum*, Dbt = *Diacyclops b. thomasi*, Ln = *Leptodiaptomus nudus*, and Me = *Mesocyclops*. All other samples not presented here were archived for later identification if necessary.

Table 4. Elevenmile Reservoir zooplankton density data.

Elevenmile - 23 July 2013 - Mean *Daphnia* density = 9.0 /L										
Zooplankton Species	Bouy line (0-10m)			Bird Island (0-10m)			Marina West (0-10m)			Mean no./L
	a	b	mean	a	b	mean	a	b	mean	
unindentified *Daphnia spp.*	3.1	3.9	3.5	2.3	4.0	3.1	1.7	1.7	1.7	2.8
Daphnia mendotae	3.9	0.9	2.4	2.1	3.7	2.9	1.1	1.0	1.0	2.1
Daphnia pulicaria	2.3	5.0	3.7	2.6	5.3	4.0	3.7	5.8	4.8	4.1
Diacyclops b. thomasi	15.2	15.5	15.3	3.0	4.7	3.9	1.1	1.2	1.1	6.8
Leptodiaptomus nudus	0.0	0.9	0.5	14.9	22.1	18.5	9.5	17.0	13.2	10.7
Mesocyclops edax	4.9	3.7	4.3	0.0	0.0	0.0	1.7	1.5	1.6	2.0
Mean total no./L	29.6			32.4			23.5			28.5

Table 5. Elevenmile Reservoir zooplankton length frequency data.

Length class in mm	**Elevenmile - 23 July 2013**					
	Dbt	**Dgm**	**Dp**	***Dp* spp.**	**Ln**	**Me**
0.1						
0.2	6					
0.3	27					
0.4	45				1	2
0.5	34	2	3	2	1	4
0.6	19	3	1	1	4	4
0.7	11	5	2	1	2	4
0.8	9	8	2	0	3	3
0.9	1	2	10	1	1	0
1.0	3	3	14	1	0	2
1.1		4	9	1	1	
1.2		3	9	1	1	
1.3		2	6	2	1	1
1.4		2	5	0		
1.5		3	4	1		
1.6		2	3	2		
1.7		1	5	2		
1.8		1	3	1		
1.9		1	6	2		
2.0		2	13	0		
2.1		3	4	0		
2.2			8	2		
2.3			3			
2.4			3			
2.5			0			
2.6			1			
2.7			1			
Totals	155	47	115	20	15	20
Mean length	0.7	1.5	1.5	1.6	0.9	0.8

Table 6. Granby Reservoir zooplankton density data.

Granby - 5 September 2013 - Mean *Daphnia* density = 2.1/L																
Zooplankton Species	P1 (0-10m)			P2 (0-10m)			P3 (0-10m)			P4 (0-10m)			P5 (0-10m)			Mean no./L
	a	b	mean	a	b	mean	a	b	mean	a	b	mean	a	b	mean	
unindentified *Daphnia spp.*	1.83	lost	0.92	0.56	0.70	0.63	lost	1.30	0.65	1.14	1.31	1.23	lost	0.77	0.39	0.8
Daphnia mendotae	0.00	lost	0.00	0.16	0.06	0.11	lost	0.35	0.18	0.14	0.08	0.11	lost	0.39	0.20	0.1
Daphnia pulicaria	3.36	lost	1.68	1.60	1.53	1.57	lost	1.83	0.92	1.35	1.15	1.25	lost	1.31	0.66	1.2
Diacyclops b. thomasi	5.04	lost	2.52	8.48	4.54	6.51	lost	6.26	3.13	6.40	7.31	6.86	lost	7.50	3.75	4.6
Leptodiaptomus nudus	0.61	lost	0.31	1.52	1.60	1.56	lost	0.26	0.13	0.71	1.85	1.28	lost	0.70	0.35	0.7
Diaphanosoma brachyurum	2.29	lost	1.15	0.48	0.77	0.63	lost	0.78	0.39	0.78	1.15	0.97	lost	0.00	0.00	0.6
Mean total no./L	6.6			11.0			5.4			11.7			5.3			8.0

Table 7. Granby Reservoir zooplankton length frequency data.

Length class in mm	Granby - 5 September 2013					
	Dbt	Dgm	Dp	*Dp* spp.	Ln	Db
0.1						
0.2					1	
0.3	7				1	1
0.4	15	1	2		13	1
0.5	29	0	2	4	21	3
0.6	61	0	7	2	7	7
0.7	79	4	13	3	6	6
0.8	43	5	21	1	4	4
0.9	19	4	10	2	2	5
1.0	1	1	24	2	0	3
1.1	1	1	19	3	2	
1.2		0	26	4	2	
1.3		1	14	5		
1.4		0	14	1		
1.5		2	44	3		
1.6			7	3		
1.7			5	0		
1.8			2	2		
1.9			11	2		
2.0			10	4		
2.1			15	1		
2.2		1	15	4		
2.3			13	2		
2.4		1	9	1		
2.5			16			
2.6			1			
Totals	255	21	300	49	59	30
Mean length	0.7	1.1	1.5	1.4	0.6	0.7

Table 8. Taylor Park Reservoir zooplankton density data.

Taylor Park - 22 August 2013 - Mean *Daphnia* density = 2.0/L																
Zooplankton Species	P1 (0-10m)			P2 (0-10m)			P3 (0-10m)			P4 (0-10m)			P5 (0-10m)			Mean no./L
	a	b	mean	a	b	mean	a	b	mean	a	b	mean	a	b	mean	
unindentified *Daphnia spp.*	0.60	0.95	0.78	0.30	0.17	0.24	1.32	0.98	1.15	1.23	lost	0.62	1.18	0.60	0.89	0.7
Daphnia mendotae	0.22	0.65	0.44	0.08	0.11	0.10	0.45	0.64	0.55	0.68	lost	0.34	0.28	0.54	0.41	0.4
Daphnia pulicaria	0.97	1.66	1.32	0.47	0.16	0.32	1.17	0.98	1.08	1.36	lost	0.68	1.30	1.14	1.22	0.9
Diacyclops b. thomasi	2.17	3.09	2.63	1.51	1.12	1.32	1.32	2.66	1.99	1.50	lost	0.75	1.63	1.41	1.52	1.6
Leptodiaptomus nudus	1.23	2.20	1.72	0.77	0.42	0.60	1.29	2.66	1.98	4.02	lost	2.01	5.53	6.02	5.78	2.4
Alona affinis	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.02	0.00	lost	0.00	0.00	0.00	0.00	0.0
Mean total no./L	6.9			2.6			6.8			4.4			9.8			6.1

Table 9. Taylor Park Reservoir zooplankton length frequency data.

Length class in mm	Taylor Park - 22 August 2013					
	Dbt	Dgm	Dp	*Dp* spp.	Ln	Aa
0.1						
0.2					1	
0.3	3				2	
0.4	13		1		22	1
0.5	14		0		30	
0.6	34	3	3	3	37	
0.7	43	11	4	5	15	
0.8	28	26	6	6	15	
0.9	14	13	18	10	10	
1.0	5	7	22	11	7	
1.1		4	17	1	10	
1.2		3	12	3	4	
1.3		0	9	1	1	
1.4		1	4	2	0	
1.5		0	8	1	1	
1.6		0	5	0	0	
1.7		0	7	2	0	
1.8		1	8	1	0	
1.9		3	14	2	0	
2.0		0	8	0	0	
2.1		2	9	0	1	
2.2		1	17	2		
2.3		1	15	3		
2.4		0	8	1		
2.5		2	3	2		
2.6			2			
Totals	154	78	200	56	156	1
Mean length	0.7	1.1	1.6	1.3	0.7	0.5

Table 10. Granby Reservoir Mysis density data.

Granby Reservoir - 4 September 2013 - 10 Stations - Mean *Mysis* /m² = 186.44											
Sample number	Sampling stations (water depth in meters)										Data summary
	Stratum I		Stratum II				Stratum III				
	M1(49.25m)	M2(39.0m)	M5(26.1m)	M3(19.2m)	M6(17.5m)	M9(13.15m)	M4(10.65m)	M8(8.95m)	M10(8.9m)	M7	
#1	1283	291	262	65	116	24	28	2	147	0	2218
#2	835	483	264	113	142	17	5	0	90	0	1949
Sum	2118	774	526	178	258	41	33	2	237	0	4167
Mean	1059	387	263	89	129	20.5	16.5	1	118.5	0	208.35

Table 11. Granby Reservoir Mysis length frequency data.

Granby Reservoir- 4 September 2013																		
Station - sample #	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Totals
M1-2	0	13	17	12	63	58	53	61	56	92	64	86	105	79	41	27	8	835
M2-2	0	0	12	23	23	27	35	32	46	68	34	66	48	32	1	3	0	447
M5-1	0	3	6	13	28	16	25	14	22	16	21	24	38	21	12	3	1	263
M3-1	0	0	2	2	3	9	10	13	12	10	2	2	0	0	0	0	0	65
M6-1	1	1	2	4	9	6	15	20	25	21	7	1	1	2	1	0	0	116
M9-2	0	0	1	0	0	0	1	6	6	3	0	0	0	0	0	0	0	17
M4-1	0	0	1	0	2	1	5	5	5	7	1	0	0	0	1	0	0	28
M8-1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2
M10-2	1	1	2	5	4	6	9	17	26	12	5	2	0	0	0	0	0	90
M7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	2	18	43	59	133	123	153	168	199	229	134	181	192	134	56	33	9	1863
Percent	0.1%	1.0%	2.3%	3.2%	7.1%	6.6%	8.2%	9.0%	10.7%	12.3%	7.2%	9.7%	10.3%	7.2%	3.0%	1.8%	0.5%	100.0%

Table 12. Taylor Park Reservoir Mysis density data.

Taylor Park Reservoir - 11 August 2013 - 10 Stations - Mean *Mysis* /m² = 91.17											
Sample number	Sampling stations (water depth in meters)										Data summary
	Stratum I		Stratum II				Stratum III				
	M2(32.7m)	M6(26..25m)	M4(24.7m)	M1(22.95m)	M5(10.2m)	M9(10.15m)	M10(8.9m)	M8	M7	M3	
#1	92	228	224	Lost	26	4	2	0	0	0	576
#2	137	500	137	119	22	14	2	0	0	0	931
Sum	229	728	361	119	48	18	4	0	0	0	1507
Mean	114.5	364	180.5	119	24	9	2	0	0	0	116.14

Table 13. Taylor Park Reservoir Mysis length frequency data.

Taylor Park - 11 August 2013																		
Station - sample #	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Totals
M2-2	3	11	5	8	3	8	9	15	7	8	6	19	8	22	4	1	0	132
M6-1	0	18	18	27	11	33	19	39	29	4	8	8	4	5	4	1	0	228
M4-2	2	11	11	16	19	24	31	30	15	3	10	18	10	14	0	0	0	214
M1-2	0	1	2	15	12	12	25	19	5	1	4	6	9	7	0	0	1	118
M5-1	0	2	2	7	4	8	2	0	1	0	0	0	0	0	0	0	0	26
M9-2	2	2	1	5	1	2	2	0	0	0	0	0	0	0	0	0	0	15
M10-2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
Totals	7	45	39	78	52	87	88	103	57	16	28	51	31	48	8	2	1	735
Percent	1.0%	6.1%	5.3%	10.6%	7.1%	11.8%	12.0%	14.0%	7.8%	2.2%	3.8%	6.9%	4.2%	6.5%	1.1%	0.3%	0.1%	100.0%

ACKNOWLEDGEMENTS:

We also thank Kyle Christianson, Devin Dreiling, Christopher Kopack, and Cody Tyler for field and laboratory support.

<u>RESEARCH PRIORITY:</u>

Distribution and effects of gill lice on fish in Colorado

OBJECTIVES:

To determine where fish populations infected with gill lice are located in Colorado and better understand how gill lice affect these populations. This should help inform management of native and sport fish in Colorado.

INTRODUCTION:

This project was conducted and written with the assistance of Estevan Vigil. This report section was prepared by E. Vigil and J. Lepak. Gill lice (*Salmincola* spp.) are parasitic copepods that target fishes (primarily salmonids). Gill lice limit oxygen exchange through gill filaments on which they are attached (Gunn 2010) and negatively impact fish behavior, immune system function, growth, warm water tolerance, and most importantly, survival (Pawaputanon 1980).

Salmincola have been found to infest cutthroat trout (*Oncorhynchus clarkii*), kokanee salmon (*Oncorhynchus nerka*), mountain whitefish (*Prosopium williamsoni*), and rainbow trout (*Oncorhynchus mykiss*) among other species (Hoffman 1999). In Colorado specifically, gill lice have been documented on cutthroat trout, kokanee salmon, and rainbow trout (Walker 1999; Barndt and Stone 2003; Gunn 2010). These fishes represent ecologically and economically important salmonid species in Colorado. Native cutthroat trout in particular have been designated as Colorado's state fish, and pure lineages of cutthroat trout have recently been found to have limited distributions (Metcalf et al. 2012). Mountain whitefish are also a species of concern in Colorado and have experienced recent population declines (Schisler 2010). Thus, gill lice infestations represent a threat to sustaining native cutthroat trout and mountain whitefish populations in Colorado. Despite the potential negative effects on cutthroat trout and mountain whitefish from gill lice infestations, these species have not been sampled in Colorado for the purpose of identifying populations with gill lice infestations. Currently little is known about gill lice, *Salmincola californiensis* is the only known species of gill lice in the state but little work has been done with this specific species. A better understanding of the life history of *Salmincola californiensis* is necessary understand the potential effects gill lice have on salmonids in the state.

METHODS:

Distribution of gill lice in Colorado:

All CPW aquatic biologists and researchers were given a kit with data sheets and instructions on how to inspect fish for gill lice. In addition to data collected by colleagues, we conducted gill lice surveys on multiple water bodies throughout the state. All locations where gill lice where found were added to a Google Earth map. When over 30 potential fish hosts (salmonids or coregonids) of different size classes were inspected at a location, but no gill lice were found, the location was considered a gill lice-free water.

We also inspected (dual trained observers) preserved cutthroat trout specimens (N=801) from a previous study conducted by the Larval Fish Laboratory at Colorado State University. These preserved cutthroat trout specimens were sampled from forty-nine different locations across 4 different states (AZ, CO, NM, and WY).

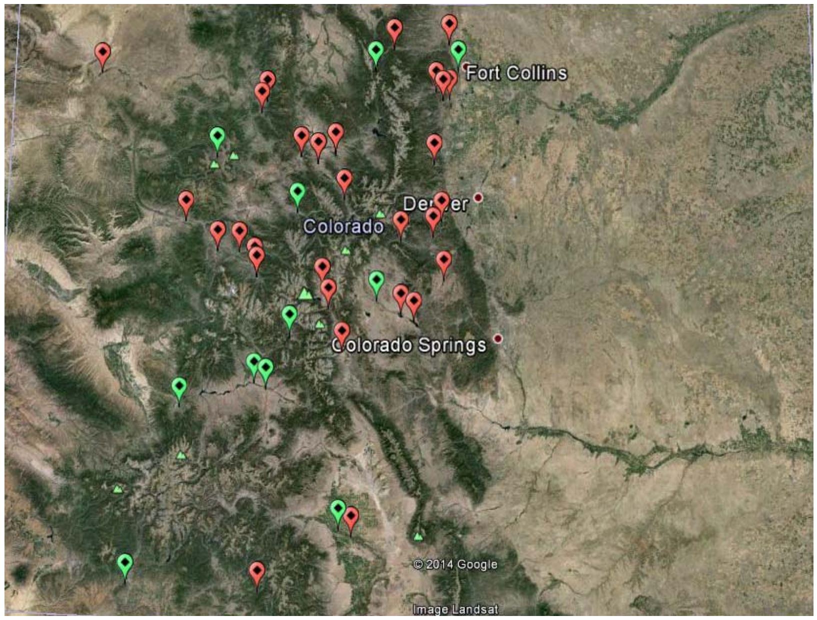
Gill lice experiment:
Gravid female gill lice were obtained from one rainbow trout collected from Parvin Lake on 30 October 2013. Individual gill lice (N = 20, each with two pigmented egg sacs) were assigned randomly to one of two water temperature treatments; cold (approximately 4.3 °C) or warm (approximately 16.7 °C). An individual egg sac was removed from each of the 20 individual gill lice and placed in their assigned cold or warm treatments. Each of the remaining eggs sacs (one from each individual gill lice, 20 in total) was placed in an intermediate (medium) temperature treatment (approximately 13.9 °C). In other words, the completed design resulted in 10 egg sacs being placed in the cold treatment with their corresponding paired egg sacs (from the same individual lice) being placed in the medium treatment, and 10 egg sacs being placed in the warm treatment with their corresponding paired egg sacs (from the same individual lice) being placed in the medium treatment for a total of 40 egg sacs used in the experiment.

This paired design allowed for stronger inference to be made between egg sacs in the cold and warm treatments with their corresponding egg sacs in the medium treatment. Each separate egg sac was incubated at the assigned temperature in individual glass jars. Jars were inspected daily, and the hatch date was recorded. After hatching had occurred non-swimming gill lice were removed daily, when no swimming gill lice were left in the jar the date was recorded.

RESULTS AND DISCUSSION:

Distribution of gill lice in Colorado:
A map has been developed of locations where salmonids have been inspected for gill lice (Figure 5). Where salmonids are present (primarily the West Slope and Front Range), gill lice infestations appear to be a common occurrence in most places where fish have been inspected. We acknowledge that this is a qualitative approach, however, the widespread distribution of infected waters is noteworthy. Gill lice have been observed throughout the state, and several of these locations are near areas where sensitive salmonid populations exist.

Figure 5. Current confirmed gill lice distribution in Colorado. Locations where gill lice were found are shown in red and locations where lice were not observed are shown in green. Map courtesy of Google Earth © 2014 Google.



Of the preserved 801 adult cutthroat trout inspected for gill lice from CSU's Larval Fish Laboratory, no gill lice were found on any of the specimens from any of the 49 locations across the four states (AZ, CO, NM and WY).

Gill lice experiment:
Temperature had a direct effect on gill lice survival and hatching. Gill lice incubated at warmer temperatures hatched earlier than those at cooler temperatures. Gill lice also lived longer than previously reported ("about 2 days") (Kabata 1973), even up to 13 days without a fish host (Figure 6).

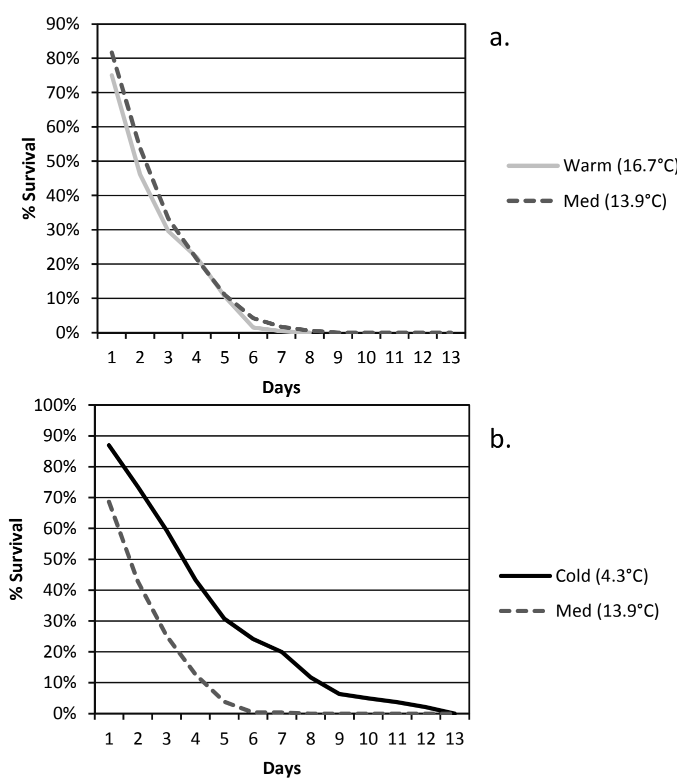


Figure 6. Longevity of free swimming copepodids without a fish host. Panel a shows mean juvenile gill lice survival time of paired warm (solid gray line) and medium (dashed gray line) temperature treatments. Panel b shows mean juvenile gill lice survival time of paired cold (solid black line) and medium (dashed gray line) temperature treatments.

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REFERENCES:

Barndt, S., and Stone, J. 2003. Infestation of *Salmincola californiensis* (Copepoda: Lernaeopodidae) in wild coho salmon, steelhead, and coastal cutthroat trout juveniles in a small Columbia River tributary. Transactions of the American Fisheries Society 132:1027-1032.

Gunn, C. 2010. Salmonicola in Colorado (*Salmincola californiensis/edwardsii*) biosheet. Research Report. Colorado Division of Wildlife Aquatic Animal Health Laboratory. Brush, CO.

Hoffman, G.L. 1999. Parasites of North American freshwater fishes. Second Edition. Comstock Publishing Associates, Ithaca, New York.

Metcalf, J.L., Love Stowell, S., Kennedy, C.M., Rogers, K.B., Epp, J., Keepers, K., Cooper, A., Austin, J.J., and Martin, A.P. 2012. Historical stocking records and a comparison of 19th to 21st century DNA reveals the extent of human-induced changes to native diversity and distribution of cutthroat trout. Molecular Ecology (available online).

Pawaputanon, K. 1980. Effects of parasitic copepod, *Salmincola californiensis* (Dana, 1852) on juvenile sockeye salmon, *Oncorhynchus nerka* (Walbaum). Ph.D. dissertation, University of British Columbia, Vancouver.

Schisler, G.J. 2010. Effects of whirling disease (*Myxobolus cerebralis*) exposure on juvenile mountain whitefish (*Prosopium williamsoni*). Research Report. Colorado Division of Wildlife Fish Research Section. Fort Collins, CO.

Walker, P. 1999. The "Trout Louse," *Salmincola sp.* A parasitic copepod in Colorado fisheries. Research Report. Colorado Division of Wildlife Aquatic Animal Health Laboratory.

RESEARCH PRIORITY:

Investigating fish marking techniques to help address a variety of fisheries management questions

OBJECTIVES:

Refine fish marking and detection techniques using oxytetracycline.

INTRODUCTION:

This project was conducted and written with the assistance of Intern, Adam Friedel. This report section was prepared by A. Friedel and J. Lepak. Marking fish (individually or in groups) is a crucial component for answering many questions related to fisheries. For example, batch marking and recapturing fish can help determine the prevalence of natural reproduction, population size and population growth. Marking fish with individual identifiers can help determine individual growth, movement, survival and other demographic characteristics at the individual and population level. Initially, investigation was focused on fish marking techniques to aid in the assessment of walleye (*Sander vitreus*) fry versus fingerling success after stocking, wiper (*Morone saxatilis* x *M. chrysops*) stocking success, and balancing walleye and wiper stocking in systems in an effort to support sympatric populations. The focus is now more broad since marking fish with oxytetracycline might be applied to other species (e.g., rainbow trout) to evaluate survival post-stocking and if natural reproduction is occurring in the wild. During this project, we attempted to mark fish in more natural environments than tanks used previously and further refine oxytetracycline detection techniques.

METHODS:

Fish collection and marking:
We collected yellow perch (*Perca flavescens*), and smallmouth bass (*Micropterus dolomieu*), from Lon Hagler Reservoir (Larimer County, CO) by beach seine on 6 June 2014. Fish were transported by truck in a cooler with approximately 45 L of lake water to the CPW Fort Collins Service Center, Fort Collins, CO. Fish were later placed in two coolers (treatment and control) with 30 L of well water from the Bellvue Hatchery (Bellvue, CO). An aeration stone was placed in each cooler to ensure adequate levels of dissolved oxygen. A silicon-based surfactant (ProLine® defoamer) was added to each cooler at a concentration of 0.013 mL/L to prevent foaming.

We used an OTC marking protocol developed by Brooks et al. (1994) and refined by the Minnesota Department of Natural Resources (see Logsdon et al. 2004). Briefly, this method involves adding OTC (Pennox® 343 soluble powder; 76% OTC) to the treatment water at 700 mg/L and then bringing the pH of the solution up to approximately 6.8 using an appropriate amount of sodium phosphate, dibasic, anhydrous buffer depending on the water alkalinity. The ratio of buffer to OTC should be near or less than 1:1. Fish are then placed in the solution for six hours and removed after treatment. For this preliminary testing, fish were kept at low densities low in order to decrease mortality that could have occurred due to crowding.

Identical numbers of individuals of the same species were randomly divided between the two coolers (control and treatment) and remained there for six hours. Fish were then netted and clipped (treatment = right pelvic fin and control = left pelvic fin) for later identification. Fish are being held together in aerated pens with automated feeders in a pond at the Fort Collins CPW Service Center until sampling in the next reporting period.

Refining oxytetracycline detection techniques:
We were fortunate to collaborate on this project with Jeff Schuckman and Brad Newcomb from Nebraska Game and Parks through a connection with Ken Kehmeier (CPW). We prepared walleye otoliths using a variety of mounting techniques they suggested and experienced the most success with super glue. These walleye were a subset of fish from the experiment described briefly here:

In 2012, we placed 20 marked (as described above) walleye in each section of 20 gallon tanks divided into thirds. (60 fish total per tank; Figure 7). We also had the same number and design for control (unmarked) walleye. To evaluate mark retention, we had a full light treatment, a covered treatment (some refuge from light offered by blacking out the bottom of the tanks and providing floating structure (plastic garden edging material), and a treatment that remained in the dark (See the following Figure for study design).

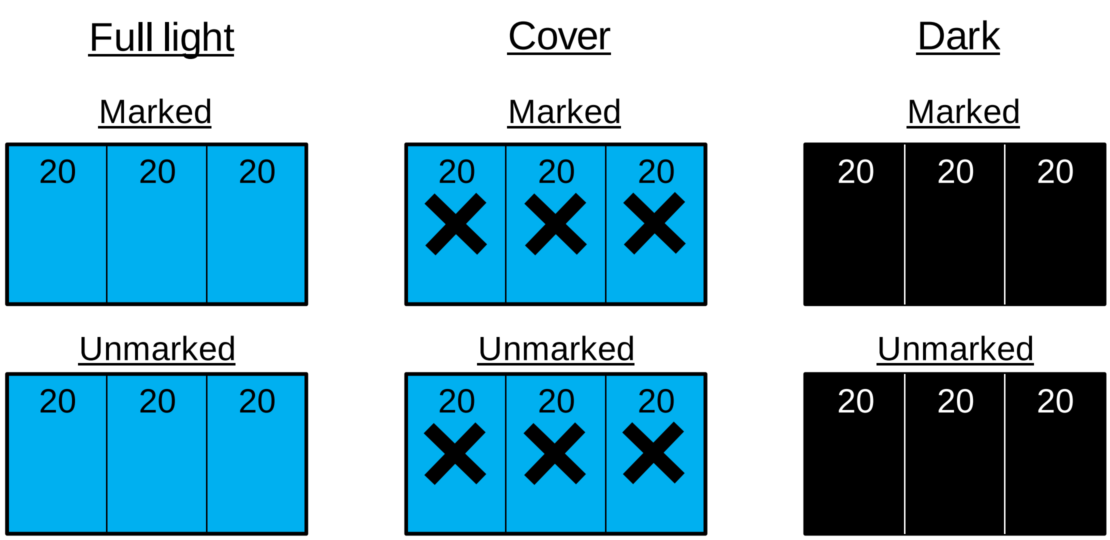

Figure 7. Walleye trial design (overhead view with N's listed in each tank section).

Otoliths from marked and unmarked individuals (N = 9 and 9 respectively) from throughout this experiment (over the course of 4 months) were prepared and then transported to Nebraska for mark identification.

RESULTS AND DISCUSSION:

Although the majority of the work for this project was completed during this reporting period, the results from the sample preparation were obtained after the reporting period. We will include these results in detail in the next report, however, we felt it was important to include a few brief results related to these efforts. Of the 18 walleye otoliths prepared and inspected from the experimental design described above, there was 100% agreement between four readers (2 trained and 2 untrained) about whether or not otoliths were from marked individuals. There was one exception to this, and this case was where two readers categorized the otolith as being marked, while the other two were unable to classify the otolith as marked or not marked, and all four readers said the otolith needed slightly more preparation. The otolith was polished briefly and all four readers agreed it was from a marked individual, which it was. These results show promise and the image below is an example of the yellow coloration versus the green background of a marked otolith under magnification (Figure 8).

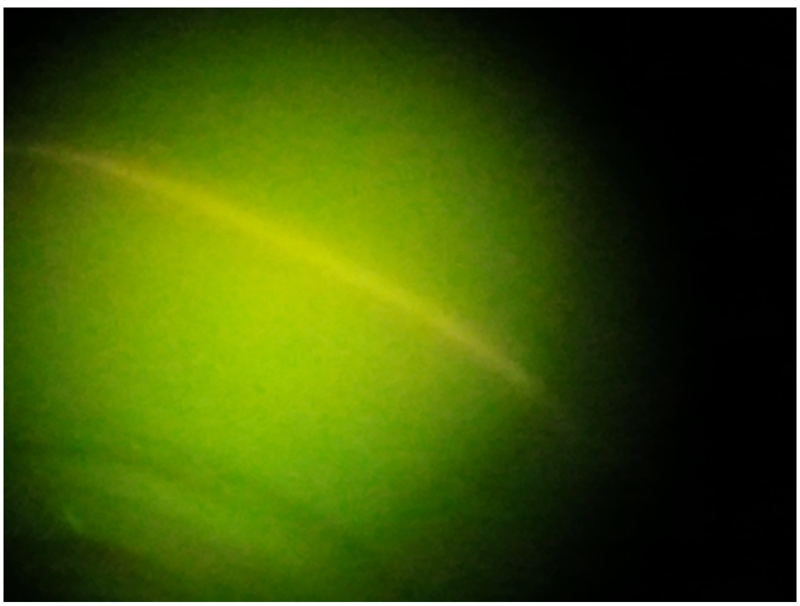

Figure 8. Magnified otolith marked with oxytetracycline (yellow band).

Our future work will focus on verification and application of this method at more broad scales in lake, reservoir and perhaps stream environments.

ACKNOWLEDGEMENTS:

We thank Brad Neuschwanger, Steve Brinkman, Kevin Bestgen, and the Minnesota Department of Natural Resource's hatchery personnel for their assistance and input throughout this project. We also thank Ben Swigle, Chris Craft, Kurt Davies, Estevan Vigil and Michael Avery for logistic support. Finally, we thank Jeff Schuckman and Brad Newcomb of Nebraska Game and Parks in particular for project support and advice.

REFERENCES:

Brooks, R.C., Heidinger, R.C., and Kohler, C.C. 1994. Mass-marking otoliths of larval and juvenile walleye by immersion in oxytetracycline, calcein, or calcein blue. North American Journal of Fisheries Management. 14:143-150.

Logsdon, D.E., Pittman, B.J., and Barnard, G.C. 2004. Oxytetracycline marking of newly hatched walleye fry. North American Journal of Fisheries Management. 24:1071-1077.

RESEARCH PRIORITY:

Enhancing trophy largemouth bass and walleye angling opportunities in Colorado

OBJECTIVES:

Evaluate potential management options to enhance trophy largemouth bass and walleye catches across Colorado lakes and reservoirs.

INTRODUCTION:

This project was conducted and written with the assistance of Kyle Christianson. This report section was prepared by K. Christianson and J. Lepak. Trophy fish are often an important component of fisheries. Largemouth bass (*Micropterus salmoides*) and walleye (*Sander vitreus*) are some of the most popular trophy species in Colorado. Tournaments and other angling for these species provide an economic benefit to the state and maintain and enhance interest in fisheries, as well as recruit young anglers. Organizations have initiated programs to sustain public interest in trophy fisheries such as the “Sharelunker” and “Master Angler” programs. Thus, these relatively large, rare fish are given a disproportionately large amount of attention and emphasis when captured. Identifying specific factors that best predict where large fish occur, or might occur, could be useful for managers depending on their objectives (e.g., desired population size, age structure, angler catch rates, trophy potential).

METHODS:

We analyzed existing CPW sampling data in two ways with two species (largemouth bass and walleye) to evaluate the best predictors of where large fish were sampled. We analyzed data collected by CPW from 2003-2013 in 209 lakes and reservoirs to test the effects of 19 metrics we hypothesized could have predictive potential to identify where large largemouth bass and walleye have been sampled in Colorado. The response variable for each species was the longest fish in sampled in each system.

Largemouth bass data:
For a system to be included in the largemouth bass dataset it had to meet one of two criteria; 1) at least one largemouth bass sampled exceeded 457 mm (Master Angler length) or 2) ≥ 50 LMB were sampled over this same time period. This ensured that if a large fish was not sampled, the system was still considered adequately sampled for large fish (Wilde and Pope 2004).

Walleye data:
Similarly, one of two criteria needed to be met to include a system in the dataset; 1) at least one walleye sampled that exceeded 533 mm or 2) ≥ 50 walleye were sampled over this same time period. A 533 mm cutoff was used because this is the longest minimum harvest threshold used by CPW managers. A Master Angler length of 660 mm as a cutoff was not used, as that eliminated more that 50% of the systems included in the dataset.

We used a traditional linear regression approach, and a least squares mean was determined for each angling regulation to 'make all things equal' for comparison of this important management tool. We then used a less traditional random forest approach (Breiman 2001; Cutler et al. 2007) to simultaneously evaluate a variety of correlated factors (19: e.g., harvest regulations, angling pressure, stocking history, system size and elevation) as predictors of which systems were most likely to support trophy-sized largemouth bass and walleye.

RESULTS AND DISCUSSION:

Using the traditional statistical analysis and the more sophisticated approach, both supported our expectations that harvest regulations were good predictors of the size of the largest largemouth bass sampled in a particular system from 2003-2013. The regulations associated with the largest fish were the most restrictive; catch and release and an 18" minimum length limit. However, there were very few examples (N = 13 and N =2 respectively) of those types of water bodies in Colorado that we could include in this analysis. The vast majority of the water bodies fell into the 2 categories (N = 53; 15 inch minimum length limit and N = 70; no minimum length limit) that are associated with the smallest fish (below Master Angler size of 457 mm). Importantly, these represent the majority of the systems in Colorado that support largemouth bass fisheries.

Using the traditional statistical analysis and the more sophisticated approach, both supported our expectations that salmonid stocking would be a good predictor of the size of the largest walleye sampled in a particular system from 2003-2013. Further, as expected, the angling regulations associated with the largest fish were the most restrictive (N = 7, an 18 minimum length limit or bag and/or possession limit < 5) while systems with the more common regulation (N = 48, no minimum length limit and statewide bag and possession limit) were associated with shorter maximum lengths.

Random forest predictions suggested that increasing harvest regulation restrictions could increase the maximum size of largemouth bass and walleye that systems in Colorado could support, and that eliminating salmonid stocking would likely reduce maximum sizes of walleye. We note that although we have low sample size for some of the angling regulation categories, our results supported our expectations. We caution that these data represent rare events, as these analyses are focused on trophy fish. One must keep in mind that trophy fisheries are not always a primary management goal, and different objectives must be taken into account when developing management strategies. However, this approach represented a means to incorporate information from many correlated factors with predictive power in individual models, and other response variables (e.g., proportional stock density, angler catch rates, population growth rates) could be selected and applied to address other research questions. Further, this approach may be used to identify particular systems where more detailed information (e.g., sport fish age and growth, forage base, population demographics) could be used to better inform management decisions.

ACKNOWLEDGEMENTS:

We thank project collaborators and coauthors C. Myrick, A. Treble, and B. Swigle for their assistance and input throughout this project.

REFERENCES:

Breiman, L. 2001. Random forests. Machine Learning. 45:5-32.

Cutler, D.R., Edwards, Jr., T.C., Beard, K.J, Cutler, A., Hess, K.T., Gibson, J., and Lawler, J.J. 2007. Random forests for classification in ecology. Ecology. 88:2783-2792.

Wilde, G.R., and Pope, K.L. 2004. Anglers' probabilities of catching record-size fish. North American Journal of Fisheries Management 24:3.

TECHNICAL SUPPORT:

Essentially all of my research is directly focused on answering questions related to lake and reservoir fisheries issues (e.g., management, community structure, angler satisfaction, etc.) posed by Senior Aquatic Staff and Area Biologists. It has been my responsibility to concentrate my efforts on addressing these issues and subsequently disseminating my findings to the relevant personnel. A large percentage of my time has been devoted to working together with biologists in the field to collect the samples required to characterize lake and reservoir food web structures and interactions within their fisheries. I have also been involved with University personnel advising two graduate level students and a research associate with projects focusing on various overlapping aspects of my research priorities developed by Senior Aquatic Staff and Area Biologists. The final step of the research process is to provide descriptions of the analysis and findings of my work. This includes providing biologists with management options or predictions of potential outcomes of system perturbations (natural and anthropogenic) and also general descriptions of how important processes are influencing lake and reservoir ecosystems. Thus, my efforts in the field and in the laboratory have been combined and communicated through reports, invited presentations and the preparation of manuscripts for publication. These materials were made available to Senior Aquatic Staff and Area Biologists as they are developed. Thus, effectively all of my time has been focused on providing technical support (in the form of help with field work and preparing and disseminating my research findings) for Senior Aquatic Staff and Area Biologists.

Support (some completed, others discussed or in progress) includes:

TECHNICAL ASSISTANCE SIDE PROJECTS AND COLLABORATIONS

- **Atkinson** – Catamount and Stagecoach mercury analysis on northern pike and other species (Complete)
- **Battige** – Elkhead mercury project and the issues with rainbow trout stocking there, revisit northern pike fish consumption advisory (Complete)
- **Brandt** – Fish Marking (oxytetracycline), Striper model in Pawnee using bioenergetics, largemouth bass regulation project (Discussed)
- **Brauch** – Otoliths to weigh for kokanee salmon aging, Taylor Park lake trout aging and stable isotopes (Partially complete)
- **Davies** – Horsetooth Reservoir mercury food web project (mercury/food web work), largemouth bass regulation project, walleye regulation project, fish marking (oxytetracycline) (Partially complete)
- **Ewert** – Dillon: Mysis and plankton, Granby: Mysis, plankton and food web structure with isotopes, Grand: Mysis, plankton and food web structure with isotopes, gill lice project, nutrient restoration project (Partially complete)
- **Fetherman** – Help with rainbow trout strain project in Parvin in conjunction with the gill lice project and predator recognition project (Partially complete)
- **Gardunio** – Investigate the potential for splake and brown trout to control sucker populations and their interactions with Mysis (Discussed)
- **Martin** – Provide insight into Lake Management Plans being developed and track

diets (with stable isotopes) of tiger muskellunge intended to control northern pike populations (Partially complete)

- **McGree** – Potentially marking (oxytetracycline) smallmouth bass for future identification in the wild (Discussed)
- **Nehring** – PCE fish consumption advisory investigation in Willow Springs Reservoir (Complete)
- **Policky** – Gill lice project in Clear Creek along with discussion of future management strategies there potentially using predator recognition to enhance salmonid fisheries (Discussed)
- **Richer –** Help with the remapping of Watson Lake and with multiple off-channel ponds impacted by the flood (Discussed)
- **Spohn** – Gill lice response to decreased KOK stocking density in 11-mile, monitoring for gill lice in surrounding waters (Partially complete)
- **Swigle** – Largemouth bass regulation project, walleye regulation project, fish marking (oxytetracycline) (Partially complete)

ADDITIONAL RESEARCH/COLLABORATION:

The Research Priorities being addressed here have resulted in internal collaborations as well as collaborations with several other Agencies/Institutions/Entities in the form of manuscript publishing and development, and presentations. Currently Dr. Jesse Lepak is an affiliate faculty member at Colorado State University and is a member of one Graduate Student committee. Dr. Lepak is enrolled in FW696 to serve as a full co-advisor for students. Completion of several projects and the start of several more have occurred since the last reporting period. The outcomes of these collaborations are listed below:

1) Publication:

In collaboration with Dr. Brett Johnson and William Pate at Colorado State University, and Dan Brauch, a manuscript has been accepted for publication:

- Pate, W.M., Johnson, B.M., **Lepak, J.M.,** and **Brauch, D.** Management for coexistence of Kokanee and trophy Lake Trout in a montane reservoir. In Press: North American Journal of Fisheries Management.

Abstract:
Kokanee *Oncorhynchus nerka* and Lake Trout *Salvelinus namaycush* are stocked in lakes and reservoirs throughout the western United States and Canada for sport fishing. However, where they co-occur unsustainable predation by Lake Trout can lead to declines in Kokanee abundance and Lake Trout growth and body condition. Such declines occurred at Blue Mesa Reservoir, Colorado. In 2009 managers began removing Lake Trout (409-740 mm TL), attempting to sustain the hatchery-dependent Kokanee population while still providing a trophy Lake Trout fishery. To evaluate this and other strategies for achieving dual management goals, we developed age-structured Kokanee

and Lake Trout population models and linked them to a bioenergetics model of Lake Trout predation. We found that the existing level of Lake Trout removal (*u* = 0.231, ages 4-9) was insufficient to prevent further decline and ultimately the extirpation of the Kokanee population. If removal of age-4 to 9 lake trout was intensified (*u* = 0.381) the Kokanee population would persist, but removal would need to be increased to *u* = 0.631 to allow Kokanee to return to their historic abundance. Focusing removal on age-4 Lake Trout (u = 0.481) would allow persistence of Kokanee and would leave more trophy Lake Trout for anglers suggesting that the two goals are compatible under some circumstances. However, management costs of balancing Kokanee with trophy Lake Trout are high and put both fisheries at risk unless Lake Trout abundance is controlled.

2) Publication:

In collaboration with E. Fetherman, the following publication was put out in press during this reporting period:

- **Fetherman, E.R.**, and **Lepak, J.M.** 2013. Back-calculation of capture probability and estimating gear efficiency using known population abundances. Fisheries Research. 147:284-289.

Abstract:
Removal abundance (*N*) estimation methods are commonly used in fisheries but if capture probability (*p*) is not accurately estimated accurate estimates of *N* cannot be obtained. Further, if adequate depletions are not achieved during removal, this must be addressed to improve data collection and estimation procedures. Here, two disparate research projects are used as case studies to illustrate: 1) a method in Program MARK for back-calculating *p* estimated by the removal method following depletion failure; and 2) a Program MARK modeling approach used to estimate efficiency of gear deployed in removal studies. In the first case study, a depletion failure occurred in white sucker *Catostomus commersonii* populations sampled concurrently with rainbow trout *Oncorhynchus mykiss* populations using a weighted seine. Back-calculation of closed capture-recapture estimates of *p* was used to account for depletion failure and obtain per-pass estimates of *p* for both species. The second case study describes a pilot experiment to determine the efficacy of two removal gears deployed to estimate *N* of fathead minnows *Pimephales promelas* in cattle troughs. Back-calculation of *p* was used to select the appropriate gear to complete removal estimates in future studies. Results indicate that using Program MARK to back-calculate estimates of *p* allows researchers to detect problems associated with capture that may have resulted in depletion failure. Further, the method allows for comparisons of gear efficiency prior to full-scale experimentation.

3) Page proofs and notification during this reporting period that this manuscript will be published in issue 59 (1), Southwestern Naturalist:

- Hargis, L.N., **Lepak, J.M., Vigil, E.M.**, and **Gunn, C.** 2013. Prevalence and intensity of the parasitic copepod (*Salmincola californiensis*) on kokanee salmon (*Oncorhynchus nerka*) in a Colorado reservoir. In Press: Southwestern Naturalist.

Abstract:
Copepods of the genus *Salmincola* (gill lice) parasitize salmonids. We collected kokanee salmon (*Oncorhynchus nerka*) from a Colorado reservoir to identify the species of gill lice present and investigate intensity and prevalence of infestations. We observed increasing intensity and prevalence with fish age. Our study adds to limited knowledge of *Salmincola* infestations in Colorado and the West.

4) Mercury collaboration reporting:

A Project Report Appendix based on data collected during the 2012 and 2013 field seasons is being prepared for the Colorado State University collaborators of the Mercury Non-Point Source project (B. Johnson and B. Wolff). This portion of the report entitled, Predictors of Mercury Contamination in Colorado Sport Fish: Implications for Informing TMDL Development and the Protection of Human and Ecological Health, will provide an approach to predict where Hg concentrations might be rapidly changing in sport fish across the landscape. The Appendix and other Report Sections are being combined for submission to complete the project. The data were provided to the Colorado Department of Public Health and Environment and resulted in changes in Elkhead and Horsetooth reservoir fish consumption advisories, restricting advice on northern pike in Elkhead Reservoir, and relaxing advice on walleye in Horsetooth Reservoir due to changes in forage base.

5) Manuscript in review:

In collaboration as a committee member for Devin Olsen, the following manuscript was submitted for scientific peer review to Journal of Fish Biology:

- Olsen, D., Johnson, B., **Lepak, J.**, Olson, C., and Silver, D. Introduction of Arctic Charr *Salvelinus alpinus* in Colorado: outcomes and considerations for future introductions. In Review: Journal of Fish Biology.

6) Manuscript in review:

In collaboration with Dr. Brett Johnson and Brian Wolff, a manuscript was submitted for scientific peer review to the journal of Science of the Total Environment:

- Johnson, B.M., **Lepak, J.M.,** and Wolff, B.A. Effects of prey assemblage on mercury bioaccumulation in a piscivorous sport fish. In Review: Science of the Total Environment.

7) Mysis in high lakes:

We are currently collaborating with Dr. Brett Johnson and Kyle Christianson on a project evaluating Mysis interactions in food webs. This project also information about zooplankton and Mysis populations as described earlier.

8) Western North American Mercury Synthesis collaboration:

Further funding has been obtained to continue and extend this collaborative effort.

9) Presentations:

External presentations:

- **Lepak, J.M.**, Eagles-Smith, C., Marvin-DiPasquale, M., Sunderland, E., and Weiner, J. Spatiotemporal differences in food web structure and resulting mercury contamination in sport fish. Western Division American Fisheries Society Annual Meeting. Mazatlan, Mexico. April, 2014.

- Vigil, E., and **Lepak, J.M.** Temperature Effects on Hatching and Viability of Juvenile Gill Lice. Poster presentation. Western Division American Fisheries Society Annual Meeting. Mazatlan, Mexico. April, 2014.

- Broder, E.D., Kopack, C., **Lepak, J.M., Fetherman, E.R.,** and Angeloni, L.M. Chemical cues of predation induce anti-predator behavior in naïve rainbow trout: implications for training hatchery-reared fish. Poster presentation. Western Division American Fisheries Society Annual Meeting. Mazatlan, Mexico. April, 2014.

- Johnson, C., Johnson, B.M., **Lepak, J.M.** Burckhardt, J., and Neebling, T. Use of Summer Profundal Index Netting to Estimate Lake Trout Abundance in Wyoming and Colorado Waters. Colorado-Wyoming American Fisheries Society Annual Meeting. Laramie, Wyoming. March 2014. (C. Johnson presenter).

- Vigil, E., and **Lepak, J.M.** Gill lice in Colorado. Colorado-Wyoming American Fisheries Society Annual Meeting. Laramie, Wyoming. March 2014. (E. Vigil presenter)

- Vigil, E., and **Lepak, J.M.** Temperature Effects on Hatching and Viability of Juvenile Gill Lice. Poster presentation. Colorado-Wyoming American Fisheries Society Annual Meeting. Laramie, Wyoming. March 2014. **BEST PROFESSIONAL POSTER AWARD.** (E. Vigil presenter).

- Kopack, C., Broder, E.D., **Lepak, J.M., Fetherman, E.R.,** and Angeloni, L.M. Chemical cues of predation induce anti-predator behavior in naïve rainbow trout: implications for training hatchery-reared fish. Poster presentation. Colorado-Wyoming American Fisheries Society Annual Meeting. Laramie, Wyoming. March 2014. (C. Kopack presenter).

- **Christianson, K., Lepak, J.M., Treble, A.,** Myrick, C., and **Swigle, B.** Evaluating and enhancing trophy largemouth bass opportunities in Colorado. Colorado-Wyoming American Fisheries Society Annual Meeting. Laramie, Wyoming. March 2014. (K. Christianson presenter).

- **Christianson, K., J. M. Lepak, A. Treble,** C. Myrick, and **B. Swigle.** Colorado State University Student Chapter of the American Fisheries Society Meeting. Evaluating and enhancing trophy largemouth bass opportunities in Colorado. Fort Collins, Colorado. February 2014. (K. Christianson presenter).

- **Lepak, J.M.,** and B.M. Johnson. Northern Water Conservancy District. Nutrient balance restoration. Berthoud, Colorado. February 2014.

- Kopack, C., Broder, E.D., **Lepak, J.M., Fetherman, E.R.,** and Angeloni, L.M. Front Range Student Ecological Symposium. Chemical cues of predation induce anti-predator behavior in naïve rainbow trout: implications for training hatchery-reared fish. Poster presentation. Fort Collins, Colorado. February 2014. **BEST STUDENT POSTER AWARD.** (C. Kopack presenter).

- **Lepak, J.M.** Fisheries Research from Two Different Perspectives: Science and Art. Colorado State University Student Chapter of the American Fisheries Society Meeting. Fort Collins, Colorado. November 2013.

- **Lepak, J.M.** Fisheries Management to remediate mercury contamination in sport fish. Environmental Protection Agency, Region 9 Mercury Seminar. September 2013. International online attendance.

- Eagles-Smith, C., D. Evers, M. Marvin-DiPasquale, J. Weiner, J. Ackerman, G. Aiken, C. Alpers, C. Cline, C. Dassuncao, J. Davis, C. Eckley, J. Elliott, C. Flanagan, J. Fleck, M. Gustin, A. Jackson, D. Jaffe, P. Johnson, D. Krabbenhoft, **J. M. Lepak,** A. Luengen, K. Morris, K. Siitari, A. Steffen, R. Stewart, E. Sunderland, M. Turnquist, F. Villatoro, J. Webster, A. Wilson, and G. Wright. Mercury Cycling, Bioaccumulation, and Risk across Western North America: a landscape scale synthesis. Invited poster presentation. International Conference on Mercury as a Global Pollutant. Edinburgh, Scotland. July-August 2013. (Poster presentation).

Internal presentations:

- **Fetherman, E.R., Lepak, J.M.,** Kopack, J., Broder, E.D., and Angeloni, L.M. Chemical cues of predation induce anti-predator behavior in Hofer rainbow trout: implications for training hatchery-reared fish. Great Plains Fishery Workers Workshop. Fort Collins, Colorado. February 2014. (E. Fetherman presenter).

- Vigil, E., and **Lepak, J.M.** There is a Louse in the House. Great Plains Fishery Workers Workshop. Fort Collins, Colorado. February 2014. (E. Vigil presenter).

- **Christianson, K., Lepak, J.M., Treble, A.,** Myrick, C., and **Swigle, B.** Evaluating and enhancing trophy largemouth bass opportunities in Colorado. Great Plains Fishery Workers Workshop. Fort Collins, Colorado. February 2014. (K. Christianson presenter).

Other internal communications:

- Summer profundal index netting (SPIN) for lake trout population estimates in Grand Lake and Taylor Park Reservoir. Internal report disseminated on 25 October, 2013. Prepared by **J.M. Lepak**.