Aquatic Macroinvertebrate Sampling at Fish Spring National Wildlife Refuge:
Diverse Needs for Migratory, Wintering and Breeding Waterfowl, Wading Birds, Shorebirds, and Other Priority Species

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INTRODUCTION / BACKGROUND

Fish Springs National Wildlife Refuge (NWR) is a 17, 992 acre Refuge located in Juab county, western Utah. Located within the eastern portion of the Pacific Flyway and the Great Basin, Fish Springs NWR comprises approximately 10,000 acres of spring-fed wetlands in an otherwise arid landscape making it an important stopover for many migratory birds.

Fish Springs NWR manages its wetland habitats using a constructed impoundment system (Figure-1). This system consists of nine management units where water in each unit is individually manipulated: one large unit extending fully across the southernmost end of the impoundment system with the remaining eight units positioned east or west of a central water delivery canal. A gravity-flow delivery system provides for efficient water impoundment or dewatering of each unit.

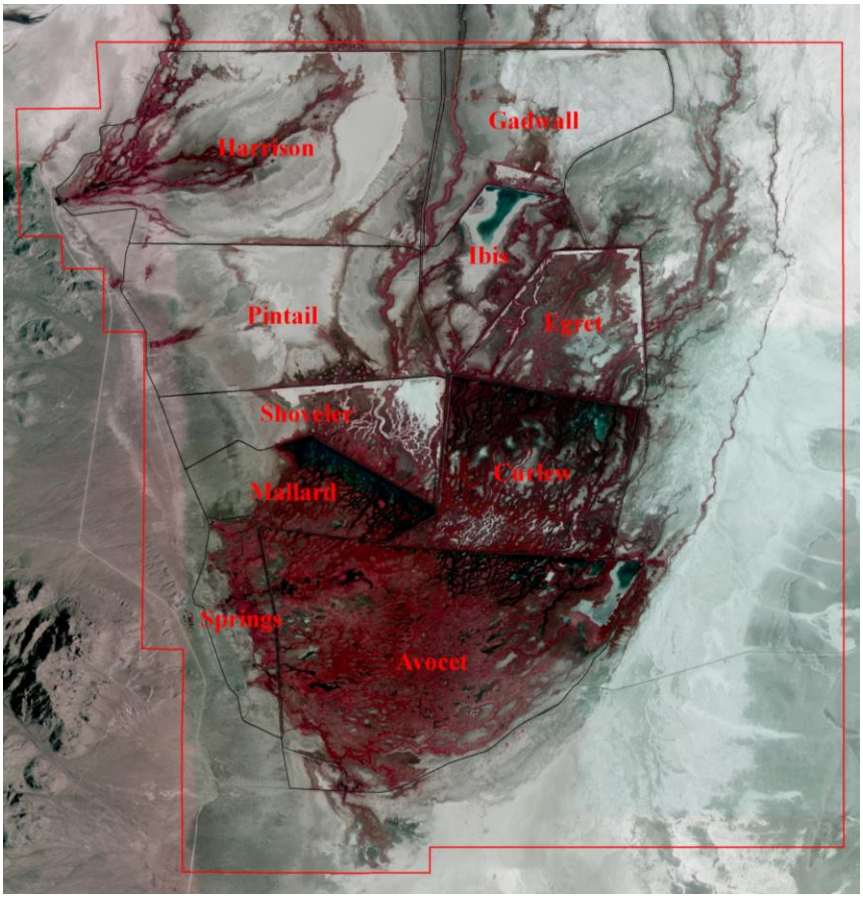

Figure-1. Basic refuge map of Fish Springs NWR showing the refuge boundary and impounded water management units.

Due to the brackish artesian waters of the springs, edaphic qualities of the substrate, manipulated water delivery and hydro-periods, and seasonal ET water loss within the managed wetlands, a gradual and substantial gradient in water quality exists with increasing levels of salt concentration in the direction of water flow to the north and east. Correspondingly, wetland habitat community types also vary greatly across the Refuge. Wetland community types include permanently flooded spring basins, semi-permanently flooded open water and emergent marsh (bulrush and cattail), vast wet meadows, seasonally flooded open water and expanses of salt grass, as well as intermittently flooded halophytes and alkali mudflat.

Prior to the Comprehensive Conservation Plan (CCP) in 2004, habitat management was focused primarily on waterfowl production. Refuge-wide water management strategies were uniformly employed across the Refuge to support and enhance waterfowl production despite highly variable site differences. The CCP set forth new management direction for supporting a wider diversity of migratory bird species by managing for diverse habitats. However, water management strategies of the CCP remained unchanged from those designed to support waterfowl production and details of implementing new management direction were to be stepped-down to a HMP within five years.

Recent development of a Habitat Management Plan (HMP) has provided necessary updating to the CCP as well as specific habitat management strategies under the CCP's general guidance. As such, the HMP sets forth new water management strategies for providing a diversity of wetland habitat types in support of highly varied seasonal needs by priority resources of concern (ROC).

STATEMENT OF NEED

Many species of waterfowl and waterbirds utilize different wetland types throughout the different seasons (i.e. breeding vs migration or wintering). Habitat selection is based not only on vegetation type and cover, but also individual species morphology, water depth and water quality (Safran et al. 1997). We also know that water quality as determined by salinity, duration, etc. directly impacts aquatic macroinvertebrate production and community structure (Euliss and Mushet 2006, Longcore et al. 2006).

Targeted HMP management requires a better understanding of how prescribed water management, including depth and duration, influence water quality, food production (i.e. aquatic macroinvertebrates) and habitat use by priority ROC throughout all seasons. The CCP/HMP goals, objectives, and strategies reveal information gaps that need addressed in order to make the best management decision to support seasonal uses of ROC species in a diversity of habitat types.

Investigation of aquatic macroinvertebrates was conducted at Fish Springs in the early 1980s and then again in the 1990s. The majority of the research focused on open water semi-permanent pools within the four southernmost management units nearest the South Springs Complex. The work of the early 1980s focused on a comprehensive inventory within that limited area of the Refuge. Alternatively, the work of the 1990s in this same area focused on demonstrating the effects of rotational drawdown management on invertebrate production and did not provide a comprehensive inventory (i.e. most studies utilized emergence traps and benthic invertebrates were not sampled).

These four southern impoundments (Figure-1) have water managed with 4-year rotational drawdown of their open water pools to provide semi-permanent wetland habitat with moderately brackish water (3,000 to

5,000µS). The water management utilized in these southern units as well as the water quality found there is strikingly different from other wetland habitats located throughout the refuge. The most profound difference includes the four northernmost units (Pintail, Harrison, Gadwall and Ibis). These four northern pools when managed by HMP prescription provide expansive shallow water habitat with conductance of 15,000 to 60,000µS, receding throughout the breeding season to provide un-vegetated mudflat shoreline.

Prior to the new water prescriptions of the HMP, seasonal hydroperiod of the four northern pools (with the exception of Gadwall Pool) had been managed by design to most benefit Canada goose production. Similarly, seasonally flooded pools to the east (Egret and Curlew main pools) had also been managed for waterfowl production, but they are now targeted sites for managing flooded and saturated salt grass habitat for the long-billed curlew (*Numenius americanus)*. Given these three areas of highly different wetland habitat types (Table-1) and different water management between the northern and southern impoundments, we expect significantly important variation in aquatic macroinvertebrate communities that will not have been captured within the limited historical data provided by the earlier studies.

Table 1: Wetland habitat categories representing substantially varied habitats supporting a variety of migratory bird species. Species listed include priority resources of concern identified in the HMP.

	Habitat Categories		**Resources of Concern (ROC) / Priority Species**
PHASE I ***(funding request)***	Mudflat Shoreline	Seasonal[2]	***Snowy Plover**, ***American Avocet**, Long-billed Dowitcher
	Impoundment Pools (Open Water)	Seasonal[2]	***American Avocet**, American Wigeon, Gadwall, Northern Pintail, Redhead, Tundra Swan
PHASE II *(future funding requested)*	Flooded Saltgrass	Seasonal[2]	***Long-billed Curlew**, White-faced Ibis, Northern Pintail
PHASE III *(future funding requested)*	Flooded Emergent	Seasonal[2]	Virginia Rail, American Bittern, White-faced Ibis, American Wigeon, Gadwall, Northern Pintail
		Semi-Permanent[1]	
	Impoundment Pools (Open Water)	Semi-Permanent[1]	American Wigeon, Gadwall, Northern Pintail, Redhead, Tundra Swan

***Identifies avian **species** of high conservation concern found at Fish Springs NWR. No aquatic macroinvertebrate food source information is available for the mudflat shoreline, flooded saltgrass and flooded emergent habitats at Fish Springs NWR.*

[1] *High water quality (3,200-6,000µS); largely organic (peat) soils.*
[2] *Low water quality (6,001-40,000µS); largely inorganic/alkali soils.*

We are lacking understanding of these differing site conditions and the impact of our changed water management strategies on the taxonomic variation and production of aquatic macroinvertebrates as a food source for the newly targeted ROC species. Obtaining this information is highly necessary to successfully stepping-down more detailed management of the HMP and soon to be developed Inventory and Monitoring Plan (IMP).

OBJECTIVES

There are two components to this study:

(1) The first component will investigate the response of aquatic macroinvertebrate diversity and biomass to water level management in seasonal wetland habitat for development of HMP strategies, and

(2) The second component is a descriptive study looking at targeted ROC species detection and non-detection site selection for foraging.

Due to limited staffing, the geographic area and number of available wetland habitats found within Fish Springs NWR, this project is separated into three phases (Table-1):

A. **Phase-1** (funding request)

As the highest priority, Phase-1 will focus on wetland habitats that provide foraging to priority ROC avian wetland species of highest conservation concern at Fish Springs NWR. These species include snowy plover, and American avocet and long-billed dowitchers (*Limnodromus scolopaceus*). Sampling will be conducted from March to the end of November within the 'Phase-1' category identified in Table-1.

B. **Phase-2** (future funding requested)

As a supplemental priority, Phase-2 will focus on the remaining habitats for which there is no historical data which provide foraging for species of highest concern such as the long-billed curlews and other ROCs such as the white-faced ibis (*Plegadis chihi*). Sampling will be conducted from March to the end of November within the 'Phase-2' category identified in Table-1, using methodology consistent with that utilized in 'Phase-1' whenever possible.

C. **Phase-3** (future funding requested)

The last phase will focus on the remaining open water habitats for which we have some data, but whose data is incomplete and/or whose methodology are not compatible with methodology utilized within Phases 1 & 2 of this study. It will also focus on the flooded emergent habitat found around these pools for which we have little or no data. ROCs who frequently utilize these remaining habitats include all our ROC waterfowl species as well as the American bittern (*Botaurus lentiginosus*) and Virginia rail (*Rallus limicola*). Sampling will be conducted from March to the end of November within the 'Phase-3' category identified in Table-1, using methodology consistent with that utilized in 'Phase-1' whenever possible.

METHODS

The methodology listed below is intended to be utilized in Phase-1 of this study. If needed, due to habitat constraints or other variables, changes in the methodology may be made or additional collection methods incorporated.

Study Site

Phase-1 of this study will focus within the seasonal mudflats and the four seasonal (open water) impoundment pools (Harrison, Pintail, Gadwall and Ibis, Figure-1) located in the northern portion of the Refuge. Throughout the summer, each of these pools will be drawn down at different times throughout the breeding season. The plan is to stagger the drawdowns to maximize shoreline, shallow water, and food availability for waterbirds for as long as possible.

Sampling, Sorting and Identification of Aquatic Macroinvertebrates

Sampling will begin in March and continue through the end of November or until the study site no longer has measureable water available. Sample collection will take place early in the morning and be completed prior to 2:00 pm.

Site Selection

When pool levels are at optimum/maximum water management levels, the impoundment pools will be stratified into five water depth categories, 0-2", 2-6", 6-12", 12–24", and 24+" based upon documented feeding preferences of target ROC species (Poole, 2005). Prior to the first visit, but no more than a week prior, a random point will be selected within each stratum in each impoundment for sampling. If a randomly selected point is not within the strata's depth category, e.g., due to unknown bathymetric variation, at the start of sampling (when impoundments will be at/near optimal pool) a different point will be selected. This will result in a minimum of five sites per impoundment, and one site per depth category. These sites will remain as fixed sampling sites until such time as they are dry. As the water levels drop, each fixed site will move into the next depth category. We will be looking at how depth influences production both within and between the targeted management pools. Each pool will be sampled a minimum of 8 times throughout the sampling period. Total number of samples per pool will depend upon when the pool goes dry. Pools lasting longer throughout the season will have more sampling efforts. The number of samples per depth per pool will depend upon the rate of the draw down.

All selected sites will be marked with a fixed marker where feasible. Additional forage site sampling will occur each day an impoundment's fixed-random sites are sampled. Prior to visiting the fixed random sites, the impoundment will be surveyed for ROC use. Number, species, and activity will be recorded for all ROC. Active feeding sites will be noted and their position identified for sampling. We will use a GPS, compass and a laser pointer to mark all foraging sites. A GPS measurement will be taken at the current observation point as will a compass heading and a distance. This will allow us to easily map the foraging site in ArcMap. Additionally, the individual measuring the location will stand in place until another researcher walks to the location the birds were seen foraging. This will serve as the center point in the 5-subsample collection of the aquatic macroinvertebrates (See – Macroinvertebrate Sample Collection). Up to 5 ROC macroinvertebrate samples (see below) will be collected for comparison with the fixed-random site samples. Each ROC sample will be randomly paired with one of the fixed-random sites.

Macroinvertebrate Sample Collection

The randomly selected fixed sites will be sampled at least once every 3-weeks. We do not want to space out sampling further than every 3 weeks due to how rapidly water levels and water quality can change as a result of water management practices and evaporation. Samples (fixed-random and forage sites) will be collected utilizing a 12" 500 micron D-frame sweep net. Collections efforts will closely follow those used by the State of Utah's Department of Environmental Quality for collecting aquatic macroinvertebrates within a wetland as a component in their mulit-metric index (MMI) tool to assess wetland condition (see *Standard Operating Procedure for the Collection of Macroinvertebrates in Wetlands, Willard Spur 2011 Monitoring Activities; Revision 1).*

Sweep samples will be collected at each site. Due to the known variance of aquatic macroinvertebrates (abundance and diversity of macroinvertebrates can vary between one specific location and another within close proximity due to water depth, SAV presence/quantity, changes in substrate, etc.) , each 'sweep' will consist of 5 sub-samples that will be combined to make once complete sample. The first sub-sample will be taken at the randomly selected point. The permanent marker for this point will serve as the "mid-point" of the first sweep. This will be the 'centroid' point. The remaining four sub-samples will be taken a distance of 3 meters away from the centroid point. Whenever possible, sub-samples will be placed using cardinal directions. The N-S/E-W (0^o, 45^o, 90^o, and 135^o) and directions will be used except in such cases that a sub-sample will be located in a 'dry' area. In those instances, NE/SW and NW/SE (22^o, 67^o, 112^o, and 157^o) cardinal directions will be used. When moving to a sampling location, all effort will be made to minimize disturbance to a sampling area. When possible, a low draft boat will be used to access sites using minimal paddling and drift to get to a sampling location.

Each 'sweep' will consist of three figure-eight 1-m passes. Each figure eight will measure 1-m from end to end and will be repeated three times prior to removing the net from the water. When water depth permits, the first sweep will be just below the surface to just above the substrate. The second sweep will be along the top of the substrate. The second sweep will include tapping the substrate at the beginning, middle and end of the sweep to help dislodge invertebrates within the surface substrate. When the water is too shallow, both sweeps will follow the protocol outlined for the second sweep above. Sweeps will be measured using a floating 1-meter stick. In addition, a benthic sample will be taken using a 5-cm diameter core sampler pushed 10-cm into the substrate. Collection and washing methods will follow those outlined in Safran et al. 1997. Date, temperature, and weather conditions will be recorded for each sample.

All wet samples will immediately be transferred into a waiting bucket in which all materials collected will be stored until returning to the lab. Upon returning to the lab, samples will be sorted using methods outlined within the *Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory – Processing, Taxonomy, and Quality Control of Benthic Macroinvertebrate samples, Open File Report OD-212* (Moulton et al., 2000). This will include using the outlined sub-sampling methodology included within the report. All aquatic invertebrates included within the selected sub-samples (as well as any large-rare organisms) will be identified to the lowest taxonomic level possible. Sub-samples and large-rare organisms will then be dried within a convection oven for 17 hours at 60^oC. Each subsample will then be weighed and recorded. Total biomass per sample will be extrapolated following similar methods of outlined within the USGS Report for species diversity and composition. The remainder of all samples (that were not utilized as a selected sub-

sample) will be stored in a 70% ethanol solution with an appropriate label. All samples will be placed within a flammable storage cabinet kept at the Refuge.

Water Quality and Depth

Water depth and depth category will be measured at each sample site each time a sample is collected. Additionally, a YSI meter will be used to measure temperature, conductivity, pH and salinity for each sample that is collected.

By collecting the above data, we will build a picture of specific seasonal site conditions showing current seasonal aquatic macroinvertebrate production within the northern pools, including how composition changes seasonally, per the water management prescription. We will also monitor how ROC species respond to water levels and macroinvertebrate production resulting from the water management actions. Understanding of these interactions will enable us to make better water management decisions in support of our priority ROC.

SAV Percent Cover

Presence/absence of SAV will be recorded. All SAV species present will be recorded. Prior to sample collection, a 1-m^2 floating PVC grid will be utilized to calculate SAV percent cover at each collection site. Although data will be collected at a specific point as opposed to a transect, methods to determine percent cover will closely follow that outlined in *Standard Operating Procedure for Determining Percent Cover of Aquatic Vegetation in Wetlands, Willard Spur 2011 Monitoring Activities; Revision 1*.

Sampling, Sorting and Identification of Emergent Macroinvertebrates

Snowy Plover (SNPL) are one of our ROCs of highest concern. In addition to foraging in the shallow water and mudflats for invertebrates within the wet soil, they are also known to eat invertebrates flying about the mudflats as well. In order to identify emergent species in areas where SNPLs are foraging, sticky tape traps will be placed along the edge of the water to capture emergent macroinvertebrates. In keeping with past successful plover sticky trap sampling (Elias et al. 2000), sticky traps will be placed out prior to entering the water for in-water sampling collection and will remain out for 3-hours. Traps will also be placed in locations where SNPL are observed to be actively feeding. Traps from observed feeding sites will be paired with non-feeding site sticky traps placed at randomly selected locations along the shoreline. These traps will be mobile and will be moved to follow the receding water line for each collection effort. A sub-sampling method in keeping with the USGS guidelines for the biomass sampling will be utilized to calculate biomass and diversity.

Avian Use

The management prescription for northern impoundment pools is aimed at maximizing habitat for shorebirds and wading birds (hereafter collectively referred to as waterbirds) while the management prescription for southern units is geared towards managing to support waterfowl species. While each management prescription is geared towards supporting a specific suite of species, each prescription provides incidental habitat for ROC species from the non-target suite. As such, our sampling efforts in the northern units will focus on waterbird ROC foraging while documenting waterfowl ROC presence/use on the pool.

Prior to macroinvertebrate sample collection, a scope and binoculars will be used to identify and current ROC use within the pool and surrounding mudflats. As listed in Table 1, waterbird ROC species for 'Phase 1' include SNPL, American Avocets (*Recurvirostra americana*) and Long-billed Dowitchers. All waterbird ROCs will be counted and recorded. Feeding sites of waterbird ROCs will be noted and when possible visited for additional sample collection. If multiple ROC waterbird groups/individual ROC species are present and actively foraging, a minimum of one sample per ROC species will be taken prior to multiple ROC samples for one species. If multiple waterbird ROC species are present at the time of sampling at least one of the 5 targeted macroinvertebrate samples will be collected at one of the document foraging sites for each species present. Once one sample site has been selected for each foraging waterbird ROC species present, the rest remaining samples will be distributed evenly between the remaining foraging waterbird ROC groups/individuals. For example, if there are multiple foraging groups of each of the following - snowy plovers, American avocets and long-billed dowitchers, one macroinvertebrate sample will be taken for each species represented taking up 3 of the 5 allotted samples. The remaining 2 samples will be divided among the ROC species currently foraging based upon need (i.e. early in the season we may distribute the remaining samples as evenly as possible, later in the season we may only have a few samples for a specific species but many for the others and therefore when possible we will collect as many as possible for that species). The number of individuals feeding at each sample location will also be recorded. If a waterbird ROC group/individual is present but not actively foraging, the number, location and activity will be noted. Waterfowl ROC presence, numbers and activity (foraging, sleeping, etc.) will also be noted.

Sampling will take place only if birds are observed feeding immediately prior to sampling indicating the presence of preferred prey species in the area. For the purpose of this study we will assume successful foraging if a bird is observed actively foraging .Although their presence and behavior will inherently agitate the water and substrate in their immediate vicinity to a small degree, the sampling methodology is designed to capture aquatic macroinvertebrates in the water column as well as the top of the substrate. As such, while inherently the presence of the birds and the fact they have been foraging in the area will impact the sample collected, our sampling methods will still allow us to collect all species present. Sampling will take place in 5 locations (see above sampling protocol) around the selected sampling site allowing us to gain a fuller picture of the selected feeding site.

DATA ANALYSIS

This project is broken into two components. For the first component, we anticipate using mixed-effects models to model 1) total invert biomass, and 2) biomass of preferred taxa (as defined by ROC forage preference) in response to environmental variables (water depth, salinity, and specific conductivity), management unit, and sampling date (the latter to account for temporal trends in invertebrate biomass) using mixed-effects models to account for repeated sampling of random plots. Model selection will follow Zuur et al. (2009) and be conducted in R using package lme4.

The second component will identify ROC forage preference (for use in Component 1) by comparing aquatic macroinvertebrate community composition between use (forage plots) and non-use (random plots). We anticipate using a dissimilarity index to calculate differences in macroinvertebrate communities between use and non-use sites. We will explore differences between use (forage plots) and non-use (random plots) sites using generalized linear models with binomially-distributed errors and a log link. Variables will include invertebrate biomass, preferred invertebrate biomass, and sampling date.

BUDGET

Phase 1		
Item	**Quantity**	**Total Cost**
GS-05 Bio Tech (5mo)	1	$14,400.00
GS-05 Bio Tech (4mo)	1	$11,400.00
Supplies	misc.	$2,009.75
	G. Total	$27,809.75

Phase 2		
Item	**Quantity**	**Total Cost**
GS-05 Bio Tech (5mo)	1	$14,400.00
GS-05 Bio Tech (4mo)	1	$11,400.00
Supplies	misc.	$1,500.00
	G. Total	$27,300.00

Phase 3		
Item	**Quantity**	**Total Cost**
GS-05 Bio Tech (5mo)	1	$14,400.00
GS-05 Bio Tech (4mo)	1	$11,400.00
Supplies	misc.	$1,500.00
	G. Total	$27,300.00

In-Kind Contributions (First Year)		
Item	**Quantity**	**Total Cost**
GS-05 Bio Tech (1mo)	1	$3,000.00
GS-05 Add. Employee Cost (5mo)	2	$1,440.00
Interns (8 months)	3	$7,200.00
Field Supplies	misc.	$1,901.76
Lab Supplies	misc.	$2,496.24
Storage Equipment	misc.	$854.80
	G. Total	$16,892.80

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