

**Yaqui chub**  
**(*Gila purpurea*)**

**5-Year Review Addendum**

**U.S. Fish and Wildlife Service**  
**San Bernardino National Wildlife Refuge**  
**Douglas, Arizona**  
**October 2020**

**5-YEAR REVIEW ADDENDUM**  
**Yaqui chub (*Gila purpurea*)**

**1.0 GENERAL INFORMATION**

**1.1. Reviewers (list primary reviewers of species information below)**

**Lead Regional or Headquarters Office:** *(Contact name(s), Office, phone numbers)*

David R. Stewart, Ph.D., Regional Statistician (Biology), Division of Biological Sciences, Refuges (505) 248-6642

Angela D. Anders, Ph.D., Branch Chief, Recovery and Restoration, Ecological Services (505) 248-7953

Janess Vartanian, Recovery Biologist, Recovery and Restoration, Ecological Services (505) 248-6657

**Lead Field Office:** San Bernardino National Wildlife Refuge, Douglas, AZ; (520) 364-2104

Bill Radke, Refuge Manager (520) 364-2104

**1.2. Addendum:**

The U.S. Fish and Wildlife Service (Service or USFWS) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species once every 5 years to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information available since the species was listed or last reviewed. An addendum may be necessary if we become aware of information that was not incorporated into the review that is substantial enough to potentially affect a status recommendation, received within a reasonably short time frame following the completion of a 5-year review. This addendum ensures the 5-year review incorporates the best available scientific and commercial data and accurately reflects the current threats to and status of the species.

**1.3. Amended Information and Current Species Status**

**1.3.1. Biology and Habitat\***

**1.3.1.1. New information on the species' biology and life history:**

N/A

**1.3.1.2. Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends**

N/A

**1.3.1.3. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):**

N/A

**1.3.1.4. Taxonomic classification or changes in nomenclature:**

N/A

**1.3.1.5. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):**

N/A

**1.3.1.6. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):**

Earman et al. (2003) delineated catchment area, recharge and flow rates, storage volumes, and other attributes of the underground aquifers for portions of the watershed that included San Bernardino National Wildlife Refuge (NWR)/Leslie Canyon NWR. Since the mid-1990's, the USFWS also worked to identify and quantify the volume of water required to sustain the existing wetland ponds found throughout the San Bernardino NWR. For the past few decades, the annual impact to the aquifer appeared to be minimal, and the aquifer has demonstrated a pattern of natural recharge and indicated long-term sustainability.

Habitat conditions in the U.S. had thus likely been stabilized for the Yaqui chub. Wetland habitats had been restored and expanded, watershed integrity had been maintained, and conservation easements were being pursued in the region, prior to the construction of 19 miles of border security infra-structure in fall 2019 (see Section 1.3.1.7). We have now completed analysis that shows a direct statistical link between pumping at the border security infra-structure well and wells at San Bernardino NWR. The long-term effects of pumping approximately 4,000,000 gallons of water per month are unknown. However, in the short-term, from December 2019 to May 2020, the USFWS has observed ponds that support Yaqui chub populations reduce in size, often drying entirely, and other impacts such as declines in pressure readings and consequently reduced artesian flows at wells located at San Bernardino NWR. Through at July 2020, two refuge wells now have zero artesian flow, and all others are experiencing decreasing flow. The average gallons per day or per month at Glenn Ranch Well continue to change through time, and the threat continues into the future with the construction contract period (sometime in 2021, now, with contract modification to blast through the Peloncillo Mountains on the east side of the Valley), and though solar-powered submersible pumps are being

installed in refuge wells, it is unknown of the impacts and whether these pumps will ensure sustainability of artesian flow given pumping.

**1.3.1.7. Other:**

Currently, the construction of 25 miles of border security infra-structure (30-foot tall pedestrian barrier supported by a 10-foot deep concrete footing) across the San Bernardino Valley between the United States and Mexico identifies the need to utilize 700,000 gallons of water each day of construction (Department of Homeland Security and Environmental Protection Agency, email communication August 8, 2019). This equated to over 4,000,000 gallons of water in the month of December 2019. If the identified volume of water is withdrawn from the San Bernardino Valley groundwater aquifer, negative influences to the artesian flows that support all San Bernardino NWR wetlands are anticipated, and the future status of Yaqui chub potentially jeopardized. The construction period has been extended several months into 2021.. Two refuge wells now have zero artesian flow, and all others are experiencing decreasing flow.

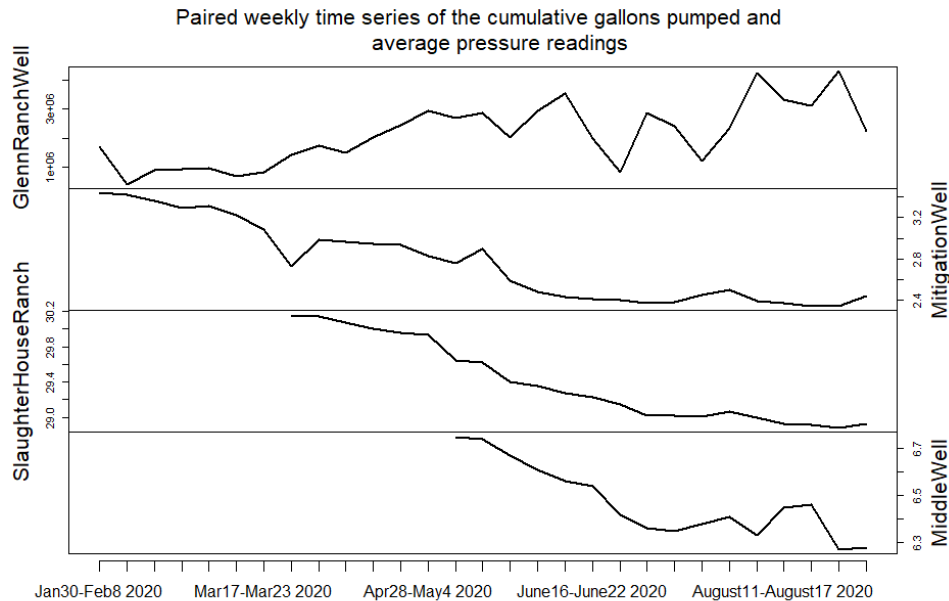
**1.3.2. Amended Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):**

**1.3.2.1. Present or threatened destruction, modification or curtailment of its habitat or range:**

The listing package for Yaqui chub numerated habitat destruction and modification as the greatest threats to the species' continued existence. The potential for habitat destruction in the U.S. escalated significantly during 2019 with the construction of border security infra-structure composed of a 30-foot tall pedestrian barrier along the international border. The design for the barrier incorporates a 10-foot deep concrete footing across 19 miles of the San Bernardino Valley, requiring an identified 700,000 gallons of water each day to support the necessary concrete production (Department of Homeland Security and Environmental Protection Agency, email communication August 8, 2019). Habitat destruction in Mexico is also considered great due to overall water withdrawal for agriculture and municipal uses (Miller et al. 2005, Fagan et al. 2005).

In the short term, the wetland ponds that have long supported Yaqui chub populations are drying because of reduced artesian flow. Recently, the USFWS developed a time series using data from the border security well (Glenn Ranch Well) located two miles from San Bernardino NWR and from a well located on the Refuge (Mitigation Well) to determine how on-the-ground effects due to pumping for infra-structure construction are impacting the Refuge wells. This allows us to determine if there is a direct statistical link with the border security infrastructure project and the loss in artesian flow resulting in ponds drying. We found that as the gallons produced per time period increase over time at the

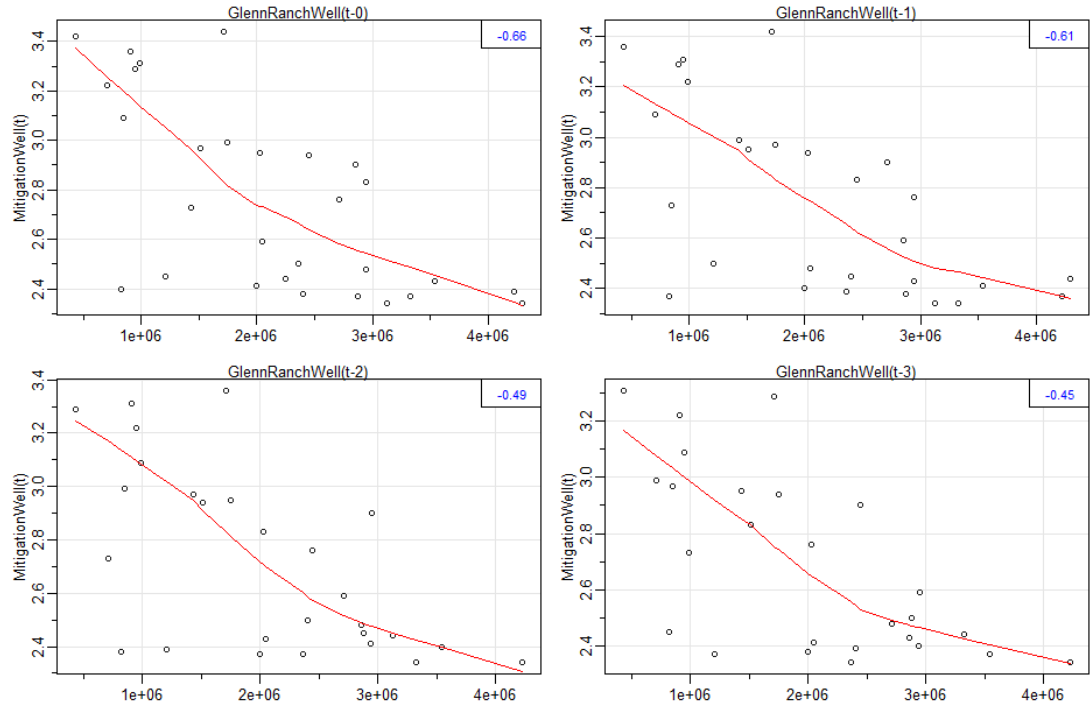
border security well, the average pressure readings at Mitigation Well (located at San Bernardino NWR), Middle Well (located at San Bernardino NWR), and Slaughter House Ranch Well decline significantly.



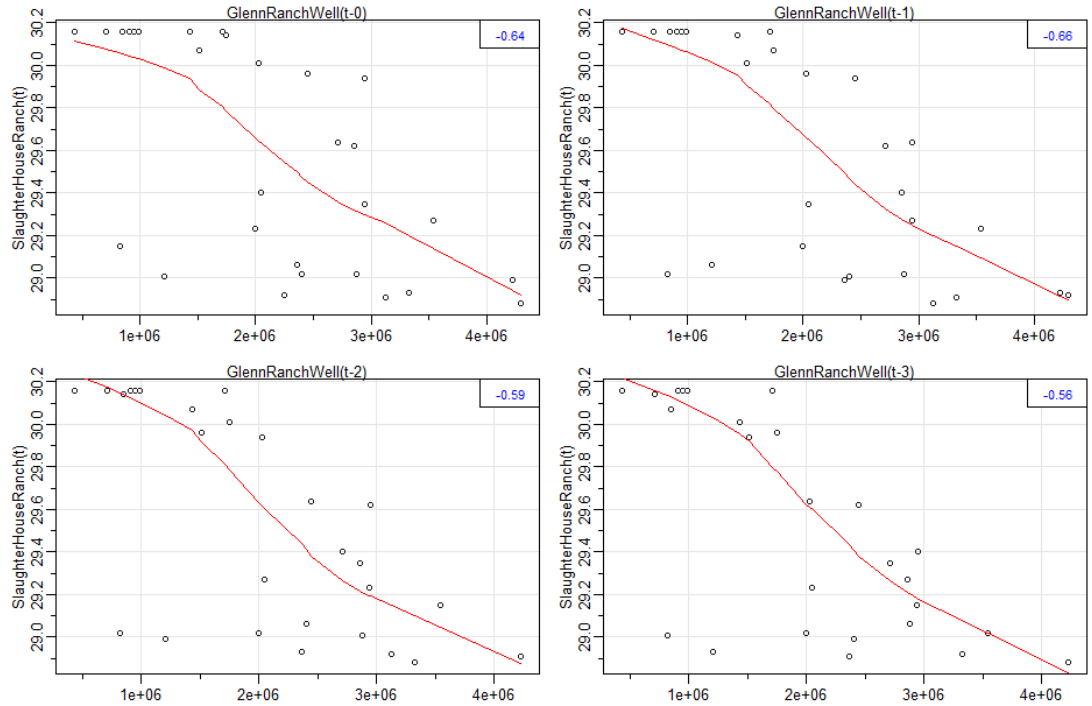
**Figure 1:** Time series of cumulative gallons per period from Glenn Ranch Well (top) and average pressure readings from Mitigation Well (located at San Bernardino NWR (2<sup>nd</sup> row)), Slaughter House Ranch Well (conservation easement located near San Bernardino NWR (3<sup>rd</sup> row)), and Middle Well (located at San Bernardino NWR (4<sup>th</sup> row)) from November 2019 to September 2020.

Figure 1 shows that as the weekly gallons produced increases over time at Glenn Ranch Well, the average weekly pressure readings at Mitigation Well decline significantly. Additionally, negative declines at both Slaughter House Ranch Well and Middle Well are also present. Next, we used a statistical method (cross correlation analysis) that tracks the movements between Glenn Ranch Well and those located in and around the Refuge to determine if the observed pumping at one well negatively affects the other. In this analysis, we sought to understand how pumping at Glenn Ranch Well affects pressure at Mitigation Well, Slaughter House Ranch Well, and Middle Well. Therefore, we are mostly interested in the cross-correlation at zero to negative lags (i.e., when the weekly cumulative gallons predate inferred weekly pressure readings). This implies a lagged effect between them, such that pumping from Glenn Ranch Well affects pressure at the other wells sometime after or within that same week. The cross-correlation analysis allows us to determine what lag to use in the dynamic linear model. Given that data are on a weekly time step, the lag is on a current week or 1- or 2-week delay.

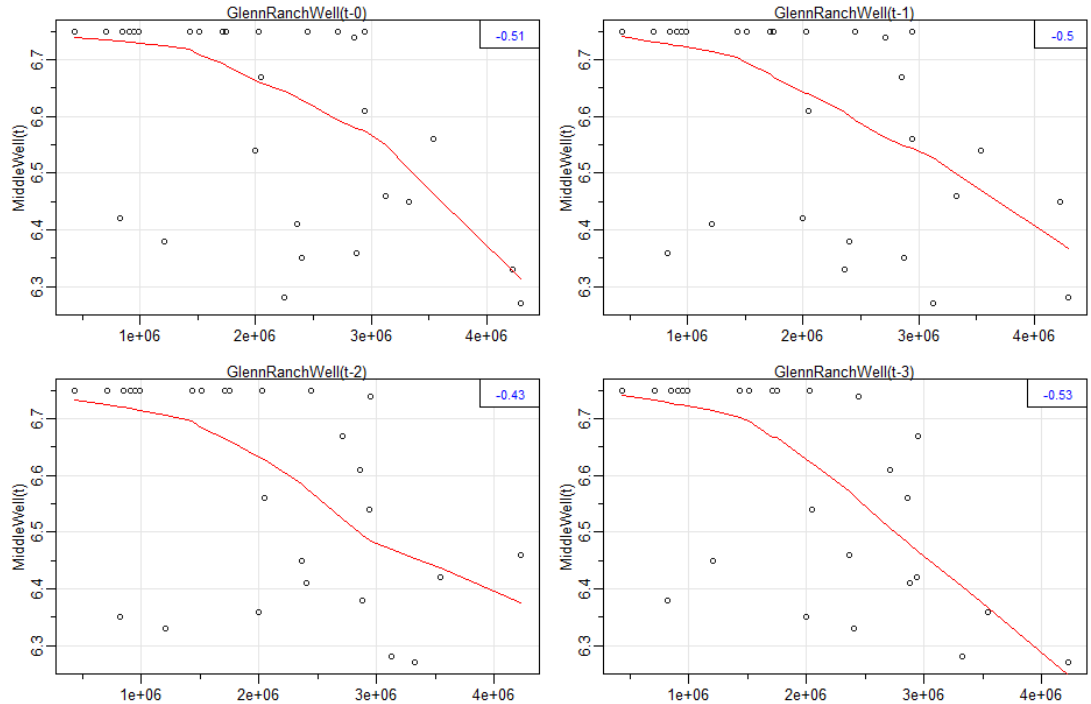
The highest cross correlation between Glenn Ranch Well and Mitigation Well was at 0 (the same week), and thus indicates that a high producing week at Glenn Ranch Well will lead to a below average value of “pressure” about that same week at Mitigation Well (Figure 2). Additionally, the highest cross-correlations between Glenn Ranch Well and Slaughter House Ranch Well and Middle Well were between -1 and -3 weeks. This means that these analysis can detect activities at Glenn Ranch Well, likely explaining the immediate impacts observed not only at Mitigation Well but also at two newly monitored wells (i.e., Slaughter House Ranch Well and Middle Well) (Figures 3 and 4).



**Figure 2.** Lag plot between the current weeks pumping (t-0) to a lag of three (t-3) weeks pumping at Glenn Ranch Well and pressure readings at Mitigation Well located at San Bernardino National Wildlife Refuge. The correlations (top right hand corner) range from -0.45 to -0.66, meaning that the relationship is significantly negative.



**Figure 3.** Lag plot between the current weeks pumping (t-0) to a lag of three (t-3) weeks pumping at Glenn Ranch Well and pressure readings at Slaughter House Ranch Well. The correlations (top right hand corner) range from -0.56 to -0.66, meaning that the relationship is significantly negative.



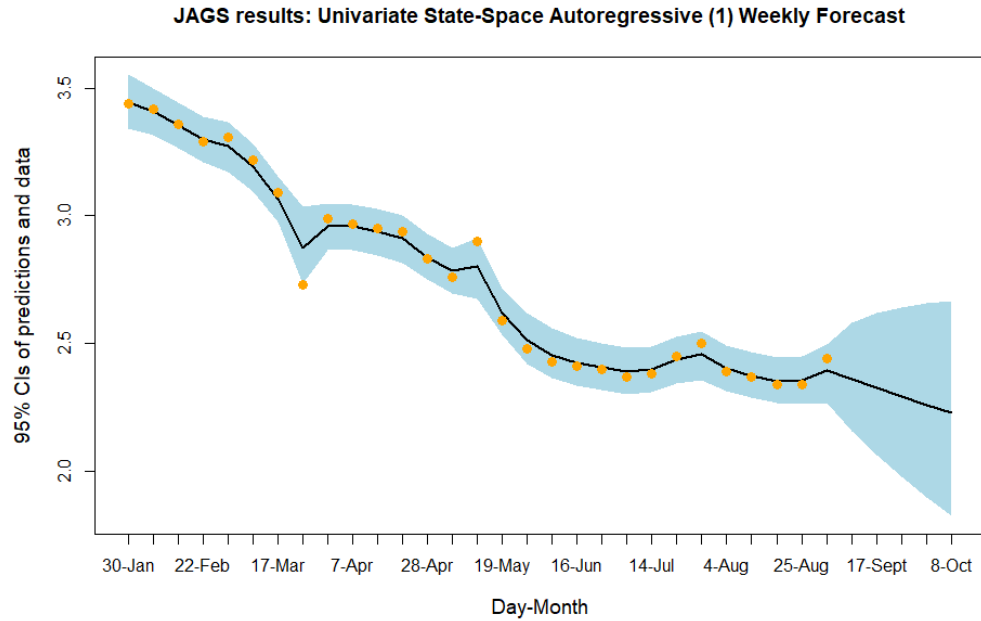
**Figure 4.** Lag plot between the current weeks pumping (t-0) to a lag of seven (t-3) weeks pumping at Glenn Ranch Well and pressure readings at Middle Well at San Bernardino NWR. The correlations (top right hand corner) range from -0.43 to -0.53, meaning that the relationship is significantly negative.

To determine whether these relationships are statistically significant using the identified lags for Mitigation Well, Slaughter House Ranch, and Middle Well, we modeled the time series as a dynamic linear model. That is, we developed a set of models in which we related pumping from, say, the same week from Glenn Ranch Well with the same week’s average pressure readings at Mitigation Well in accordance with the cross-correlation analysis (Figures 2-4). We also did this for the other two wells, respectively. From the statistical models, all coefficients were statistically significant. Irrespective of the well, there is a significantly negative trend among the pressure readings at each of these wells and cumulative pumping activities at Glenn Ranch Well.

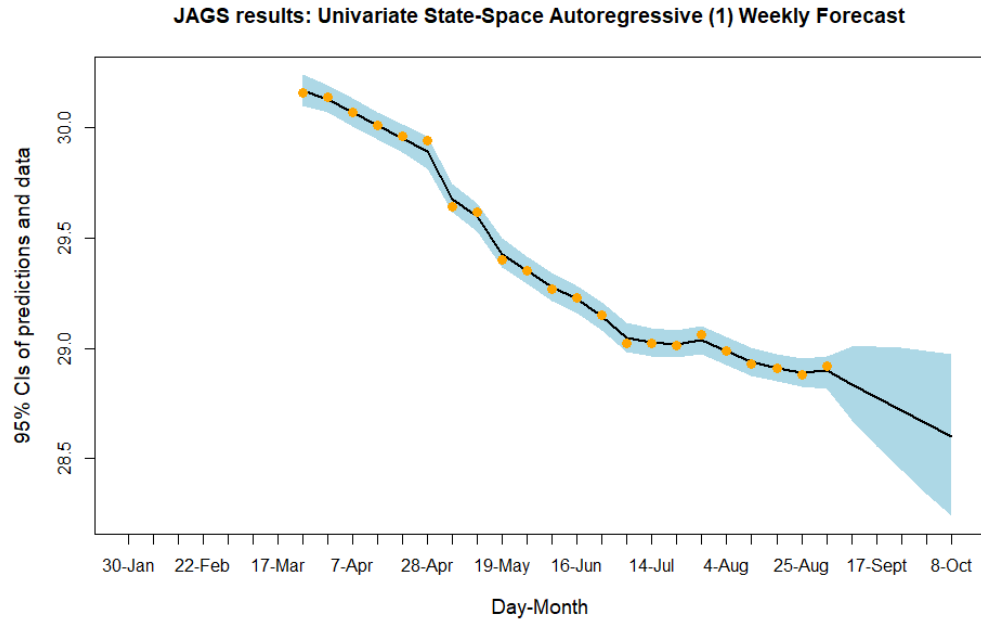
In Figure 2, the correlation value for the time series ranges between -0.50 to -0.70. The  $R^2$  values for the dynamic statistical models (the linear model discussed above) that describes the relationship between the highest lag and pumping (e.g., lag of one week) ranged between 0.37 and 0.42. This means that between 37% and 44% of the variation observed in pressure readings at these wells is explained by the current or past week's pumping at Glenn Ranch Well. The results from the statistical model that represent the overall best model for each well are presented below.

Well	Lag	Coefficients	Estimate	Standard Error	p-value	$R^2$
Mitigation Well	Current week (t-0)	Intercept	3.268	1.23E-01	<2.0e-16	0.42
	Current week (t-0)	Slope	-2.39E-07	5.18E-08	8.86E-05	
Slaughter House Ranch Well	Three weeks (t-1)	Intercept	3.03E+01	1.64E-01	<2.0e-16	0.44
	Three weeks (t-1)	Slope	-3.27E-07	6.94E-08	7.29E-05	
Middle Well	Six weeks (t-3)	Intercept	6.809	6.44E-02	<2e-16	0.37
	Six weeks (t-3)	Slope	-1.15E-07	2.89E-08	5.77E-04	

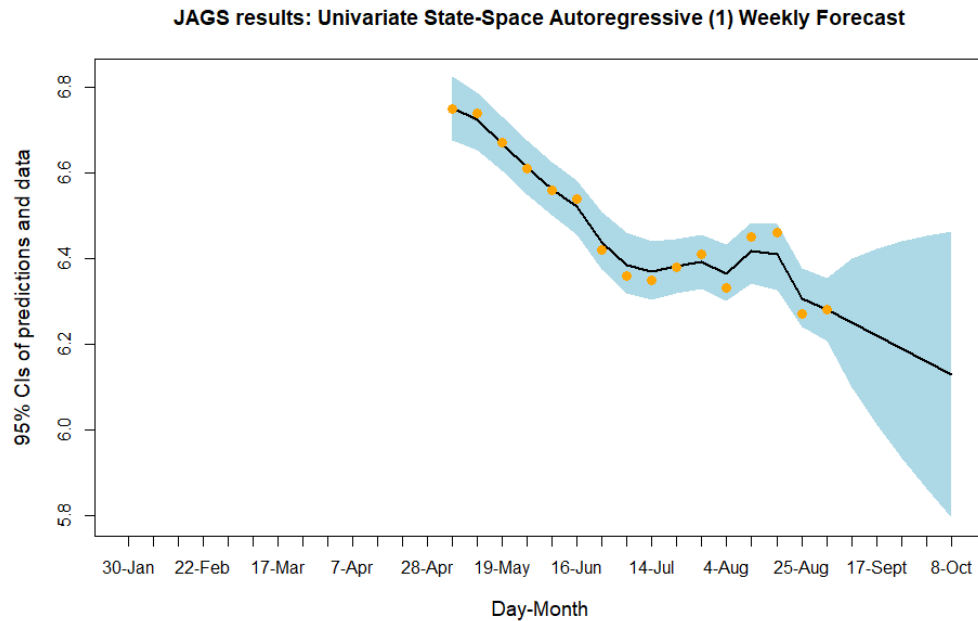
Lastly, we fit an autoregressive time series model of order 1 (i.e., AR(1)), which incorporates a parameter that controls the degree to which the data varies to project through time. Autoregressive order 1 models typically only account for uncertainty due to process error (also interpreted as natural variation). Therefore, we fit a Bayesian state space model with an autoregressive order-1 error to account for both process error and observation error (also interpreted in measurement error in pressure readings) by constructing a model that estimates the unseen states, such as the first pressure reading in the time series, to the observed data. The models fit the data well and indicate a significant decline in weekly average pressure readings since January (or since the first recorded pressure reading) (Figures 5-7).



**Figure 5.** Bayesian state-space model with process model autoregressive (AR(1)) model predictions (black line), 95% credibility bounds (blue polygon), and average weekly pressure readings (orange points) for Mitigation Well located at San Bernardino NWR. Day-Month represents the first day of the weekly readings. The black line with no associated observations (orange points) represents the forecast of average weekly pressure readings to the week of October 8<sup>th</sup>.



**Figure 6.** Bayesian state-space model with process model autoregressive (AR(1)) model predictions (black line), 95% credibility bounds (blue polygon), and average weekly pressure readings (orange points) for Slaughter House Ranch Well. Day-Month represents the first day of the weekly readings. The black line with no associated observations (orange points) represents the forecast of average weekly pressure readings to the week of October 8<sup>th</sup>.



**Figure 7.** Bayesian state-space model with process model autoregressive (AR(1)) model predictions (black line), 95% credibility bounds (blue polygon), and average weekly pressure readings (orange points) for Middle Well located at San Bernardino NWR. Day-Month represents the first day of the weekly readings. The black line with no associated observations (orange points) represents the forecast of average weekly pressure readings to the week of October 8<sup>th</sup>.

Conclusion: These analyses provide continued evidence that pumping at Glenn Ranch Well is significantly impacting wells located at San Bernardino National Wildlife Refuge, leading to immediate and significant loss in pressure. Our analyses indicate that the activities at Glenn Ranch Well can be detected at less than a week and up to six weeks after pumping. This correlates with why some ponds at the Refuge are void of water, and why it is so difficult to maintain water levels at 11 of 21 ponds that currently have threatened and endangered fish species. Additionally, our forecasts indicate that the consequences of the activities at Glenn Ranch Well will be observed in the foreseeable future, meaning that pressure readings will continue to be too low to support historical pond water levels. And thus, the current state at the Refuge and what it takes by staff to support the species and ponds will continue into the future.

**1.3.2.2. Overutilization for commercial, recreational, scientific, or educational purposes:**

N/A

**1.3.2.3. Disease or predation:**

N/A

**1.3.2.4. Inadequacy of existing regulatory mechanisms:**

N/A

**1.3.2.5. Other natural or manmade factors affecting its continued existence:**

N/A

**1.4. Synthesis**

Earman et al. (2003) delineated catchment area, recharge and flow rates, storage volumes, and other attributes of the underground aquifers for portions of the watershed that included San Bernardino NWR/Leslie Canyon NWR. Since the mid-1990's, the USFWS also worked to identify and quantify the volume of water required to sustain the existing wetland ponds found throughout the refuge. For the past few decades, the annual impact to the aquifer appeared to be minimal, and the aquifer has demonstrated a pattern of natural recharge and indicates long-term sustainability. This is expected to change in 2020 following construction of 25 miles of border security infrastructure in the San Bernardino Valley, which includes the anticipated withdrawal of over 700,000 gallons of water per day to support concrete production during the construction period (Department of Homeland Security and Environmental Protection Agency, email communication August 8, 2019). From November 2019 through September 2020, the amount of pumping has significantly increased through time. These data, along with mean pressure readings from Mitigation Well and Middle Well on San Bernardino NWR, as well as readings from Slaughter House Ranch (a conservation easement near San Bernardino NWR), are represented in the Table below: Cumulative gallons of water removed per week from Glenn Ranch Well and associated weekly pressure ( $\psi$ ) readings at Mitigation Well, Slaughter House Ranch and Middle Well from November 2019 to September 2020..

Period	Glenn Ranch Well (cumulative gallons per week)	Mitigation Well (average $\psi$ per week)	Slaughter House Ranch (average $\psi$ per week)	Middle Well (average $\psi$ per week)
November 2019	2731400	3.54		
December 2019	1510900	3.64		
January 1 – 29 2020	1805700	3.63		
January 30 – February 8 2020	1713500	3.44		
February 9 – 14 2020	427400	3.42		
February 15 – 21 2020	901400	3.36		
February 22 – 28 2020	NA (944000)	3.29		
February 29 – March 3 2020	986600	3.31		
March 4 – 16 2020	705000	3.22		
March 17 – 23 2020	844000	3.09		
March 24 – 30 2020	1430400	2.73	30.16	
March 31 – April 6 2020	1746200	2.99	30.14	
April 7 – 14 2020	1506100	2.97	30.07	
April 15 – 20 2020	2026400	2.95	30.01	
April 21 – 27 2020	2444300	2.94	29.96	
April 28 – May 4 2020	2946100	2.83	29.94	
May 5 – 12 2020	2710700	2.76	29.64	6.75
May 13 – 18 2020	2857400	2.90	29.62	6.74
May 19 – June 1 2020	2044500	2.59	29.40	6.67
June 2 – June 8 2020	2940200	2.48	29.35	6.61
June 9 – June 15 2020	3543300	2.43	29.27	6.56
June 16 – June 22 2020	1993100	2.41	29.23	6.54
June 23 – July 6 2020	820900	2.40	29.15	6.42
July 7 – July 13 2020	2875300	2.37	29.02	6.36
July 14 – July 20 2020	2403200	2.38	29.02	6.35
July 21 – July 27 2020	1207000	2.45	29.01	6.38
July 28 – August 3 2020	2358600	2.59	29.06	6.41
August 4 – August 10 2020	4227300	2.39	28.99	6.33
August 11 – August 17 2020	3327700	2.37	28.93	6.45
August 18 – August 24 2020	3127000	2.34	28.91	6.46
August 25 – August 30 2020	4298600	2.34	28.88	6.27
August 31 – September 9 2020	2248000	2.44	28.92	6.28

The short-term effects of this water withdrawal are known. Due to the water withdrawal from the aquifer as of July 30, 2020, at least two refuge wells no longer support artesian flow, and all other refuge wells have decreasing head pressure which is contributing to decreased flow in support of refuge wetlands. The long-term effects of continued water extraction are unknown; it is unclear whether or not the aquifer will rebound from the withdrawals that are currently occurring, or how long such a process may take. The 5-year status review conducted for Yaqui chub in 2019 recommended downlisting the species to threatened because the USFWS had been able to establish more than 35 self-sustaining populations, decreased and even eradicated threats of nonnative aquatic species, and secured the aquifer and well rights needed to ensure that enough water was available to support the ponds that multiple listed species, including the Yaqui chub. However, given the unexpected and current levels of groundwater extraction and the uncertainties of this developing situation, we are amending the previous recommendation to downlist to threatened, and instead recommend no change in status from endangered.

## 2.0 RESULTS

**2.1. Recommended Classification:** Keep the species listing status as Endangered

- Downlist to Threatened**  
 **Uplist to Endangered**  
 Delist (*Indicate reasons for delisting per 50 CFR 424.11*):  
      *Extinction*  
      *Recovery*  
      *Original data for classification in error*  
 **No change is needed**

**2.2. New Recovery Priority Number (indicate if no change; see Appendix E):**

No Change (RPN 5)

## 3.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The foremost recommendation is to determine how pumping for construction of border security infra-structure has impacted the long-term sustainability of the aquifer that supports the wetland ponds that Yaqui chub inhabit. Revised management may require an extensive analysis of the aquifer, development of infra-structure to install pumps, and reconfiguration of wetland ponds to ensure that Yaqui chub continue to be supported on San Bernardino NWR. In addition, we need to update our knowledge of Yaqui chub population status in the Rio Yaqui, Mexico, where no new data have been collected since 1994 (Rio Bavispe area; Abarca et al. 1995) and no system-wide surveys have been conducted since those of Hendrickson et al. (1981). The Yaqui chub has a geographic range that includes very little of Sonora, Mexico (only the headwaters within a few miles of the international border). Yaqui chub populations should be monitored to evaluate response to border construction and associated water withdrawal.

When possible, given workloads, a Species Status Assessment should be conducted to guide the development of a recovery plan revision. We recommend that a separate recovery plan be written for the Yaqui chub and that the species not be included in a bundled plan. A new plan should provide up-to-date information on populations of this small desert cyprinid.

**U.S. FISH AND WILDLIFE SERVICE**  
**5-YEAR REVIEW ADDENDUM of Yaqui chub**  
**(*Gila purpurea*)**

**Current Classification:**

**Recommendation resulting from the 5-Year Review Addendum:** Endangered

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

**Appropriate Listing/Reclassification Priority Number, if applicable:** N/A

**Review Conducted By:** Division of Biological Sciences and San Bernardino National Wildlife Refuge

**REGIONAL OFFICE APPROVAL:**

**Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service,  
Albuquerque, New Mexico**

Approve \_\_\_\_\_