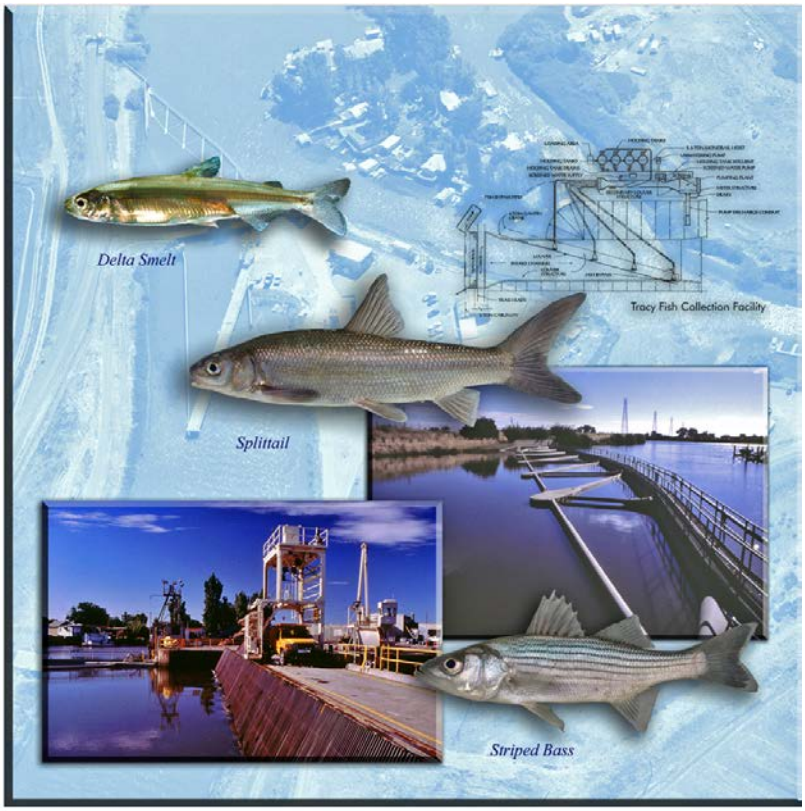
RECLAMATION

Managing Water in the West

Tracy Technical Bulletin 2019-1

Nighttime Light Levels near the Proposed Brannan Island Fish Release Site



U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region

March 2019

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1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
March 2019		

4. TITLE AND SUBTITLE
Nighttime Light Levels near the Proposed Brannan Island Fish Release Site

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Michael J. Horn

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Bureau of Reclamation
Technical Service Center, Fisheries and Wildlife Resources
P.O. Box 25007, Denver, CO 80225-0007

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Bulletin 2019-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Bureau of Reclamation,
Tracy Fish Collection Facility
16650 Kelso Road, Byron, CA 94514

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Available from the National Technical Information Service (NTIS)
Operations Division, 5285 Port Royal Road, Springfield, VA 22161

13. SUPPLEMENTARY NOTE

14. ABSTRACT

The purpose of this study was to evaluate light levels for a proposed Bureau of Reclamation fish release site on Brannan Island to determine if ambient light levels associated with a nearby highway bridge have the potential to impact fish. Light levels from the Highway 160 Bridge reached background night time levels of 0.0046 lux at a distance of 65 m. The effect of the artificial lights on fish residing in or released to the area immediately surrounding the release site are likely negligible. Moonlight is brighter than water surface light levels at the proposed release site. The only light of real significance on the bridge is associated with the mid-channel control house.

15. SUBJECT TERMS
artificial light, light measurement, release site, fish predation

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
					J. Carl Dealy
a. REPORT	**b. ABSTRACT**	**a. THIS PAGE**		16	**19b. TELEPHONE NUMBER** *(Include area code)*
					209-836-6236

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by

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Cover

Fish photography by René Reyes, Tracy Fish Collection Facility, Tracy, California.
Design by Doug Craft.

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Executive Summary

Artificial lighting is used to illuminate the nighttime environment for a variety of reasons, notably for security and safety. Studies have shown artificial lighting can have significant negative impacts on fish populations by contributing to increases in predation as well as impacting developmental stage, migration, and other behaviors. The purpose of this study was to evaluate light levels for a proposed Bureau of Reclamation fish release site on Brannan Island to determine if ambient light levels associated with a nearby highway bridge have the potential to impact fish. Light measurement surveys were completed on the 28th and 29th of August, 2018. Light levels from the Highway 160 Bridge reached background night time levels of 0.0046 lux at a distance of 65 m. The effect of the artificial lights on fish residing in or released to the area immediately surrounding the release site are likely negligible. Moonlight is brighter than water surface light levels at the proposed release site. The only light of real significance on the bridge is associated with the mid-channel control house.

Introduction

Artificial light is often used to allow adequate vision for functional, safety, and security reasons. Historically not much consideration was given to any potential environmental consequences this may have had. In recent years numerous studies have shown artificial lighting, outside the normal light-dark cycle, can have strong negative consequences for a variety of organisms (Mougeot and Bretagnolle 2000, Navarra and Nelson 2007). How artificial lights impact survival or behavior is an important consideration for projects where light levels during and after construction might be different than the typical light-dark cycle, such as lights installed on or near structures for safety or aesthetic reasons, or to allow work to continue after dark (Table 1).

Table 1. – Typical light levels under given conditions.

Condition	Illumination (lux)
Sunlight	107527
Full Daylight	10752
Overcast Day	1075
Very Dark Day	107
Twilight	10.8
Deep Twilight	1.08
Full Moon	0.108
Quarter Moon	0.0108
Starlight	0.0011
Overcast Night	0.0001

Plans are currently being developed for a new fish release site in the Sacramento San Joaquin Delta of California to provide an additional release location for fish captured and truck-transported from the Bureau of Reclamation's (Reclamation) Tracy Fish Collection Facility. The proposed fish release site will release fish into Threemile Slough just upstream of its confluence with the Sacramento River and the Highway 160 Bridge linking Brannan Island with Sherman Island (Figures 1 and 2). There are numerous advantages to the proposed site: 1) it is spatially separated from other release sites, but well within the range of fish transport, 2) depth and sweeping flows at the site may be advantageous to released fish, as upon release, currents may prevent both predators and released fishes from congregating near the outlet pipe, 3) the proposed location on Threemile Slough has been used in the past for fish releases, and is Reclamation-owned property.

The proposed release site is close enough (40 m) to the Highway 160 Bridge that lights on the bridge could have a potential influence on fishes being released (Figure 1). Navigation lights and bridge deck lights shining indirectly on the water might provide enough of an increase over background light levels to impact predation levels and/or behavior and movement of fish in the

near vicinity. Turbidities in Threemile Slough which can be as high as 25 NTU (Nephelometric Turbidity Units) during runoff events may help mitigate impacts of light penetration at times, but there are currently no measurements of light levels in the area. The purpose of this investigation was to measure light levels near the proposed release site at the water surface and at multiple depths, and based on the scientific literature relate observed levels to the visual system of common predatory species and of fishes being released.

Figure 1. – Picture of Highway 160 Bridge at Brannan Island. Top image is late afternoon picture of bridge, lower image is at full dark showing red marker lights and deck lights. Bright light at far right on second image is associated with the control house on the bridge.

Methods

Light measurement surveys were completed on the 28th and 29th of August, 2018. On both sampling dates measurements were collected after astronomical twilight, the time after which full darkness is considered achieved (sun is greater than 18 degrees below the horizon). On August 28th light measurement was under a full moon within an hour of it appearing above the horizon. On August 29th measurements were taken after astronomical twilight, but just prior to moonrise. Skies were cloudless both nights. A daytime water column reference profile was collected the afternoon of August 29th.

All light readings were collected in Threemile Slough between the public launch ramp at Brannan Island, and the Threemile Slough side of the Highway 160 Bridge. Readings were made using an American Lighting Technologies ILT 2400 light meter with water proof sensor, deployed off the side of a boat. Coordinate locations for each sample were marked using a Garmin Oregon 450T handheld GPS. Just prior to measurement all boat lights including navigation lights were briefly turned off to minimize impacts of outside light sources.

Two sets of light profiles, each with two replicates, were collected every 1 m vertically in the water column to a depth the light meter reached its lower measurement limit. On 8/29/2018, night time light Profile A was collected at a site just offshore (20 m) of the proposed release site (38° 06.381' N, 121° 42.012' W, Figure 2). On 8/28/18, night time light Profile B was collected near mid-channel and upstream into the slough (38° 06.308' N, 121° 41.894' W, Figure 2). Daytime Profile C was collected further up the slough on the outside of the bend where the deepest water was found (38° 06.287' N, 121° 41.775' W, Figure 2).

Figure 2. – Location of proposed release site relative to the Highway 160 Bridge. Yellow star represents approximate proposed location of release site. White lines indicate mobile light transects (T1, T2) and stars indicate profiling points. The white star at lower right (Profile C) represents late afternoon profile during daylight hours. Middle star (Profile B) represents the location of sampling 8/28/2018 under full moon and the white star near release site (Profile A) represents the location of sampling 8/29/2019 prior to moon rise. Arrow indicates point of brightest light associated with control structure on bridge.

Strong night time winds and fast currents associated with tidal flushing, which are typical for the area, limited the boat operator's ability to hold the boat on station for any length of time, thus limiting the number of accurate stationary vertical profiles that could be collected. Therefore, data were also collected in continuous transect mode immediately near the bridge to allow for better boat positioning. Two transects were collected parallel to the Highway 160 Bridge on the release site side of the bridge: transect 1 approximately 10 m upstream of the bridge and transect 2 approximately 65 m upstream of the bridge (Figure 2). In transect mode, the light unit recorded a continuous stream of data at the water surface and the output file returned an average value as well as maximum and minimum values during the transect.

Results and Discussion

Measurable light impacts associated with the Highway 160 Bridge did not extend far from the bridge itself. Two mobile transects completed prior to moonrise show light levels were not uniform across the transect. Mean transect light level at 10 m upstream of the bridge was 0.073 lux, minimum values of 0.008 lux were recorded between lights, and the highest water surface light level (0.369 lux) occurred immediately under the center of the bridge where one exceptionally bright control house light was located (Figure 1). A value of 0.369 lux is typical of light levels somewhere between a full moon and deep twilight. The second transect, 65 m from the bridge, had a maximum light level reading of 0.006 lux, averaging 0.0046 lux, with minimum value of 0.004 lux. At this distance, light levels were similar to background night time levels in the area prior to moonrise. For comparison, the streetlights used to light the Brannan Island boat launch measured 33 lux at ground level. This indicates the bridge lights are much dimmer in comparison to other nearby light sources.

Offshore of the proposed release site, light data indicate a newly risen full moon has a greater impact on local light levels than lights associated with the Brannan Island Bridge. A profile collected prior to moonrise had a maximum surface brightness of 0.009 lux which was only slightly higher than several surface measurements taken further away from the bridge under similar conditions (0.006-0.008 lux) (Figure 3). Immediately after full moonrise, surface values averaged near 0.014 lux, similar to surface values collected at random reference locations out of sight from the bridge. Moonlight conditions would be expected to get much brighter as the moon rise progressed throughout the night and would likely bring surface light readings closer to those in Table 1. With a surface value of 0.009 lux, light levels were essentially at zero between 3 and 4 m water depth. With a surface value of 0.014 lux, light was essentially non-existent by 4 m.

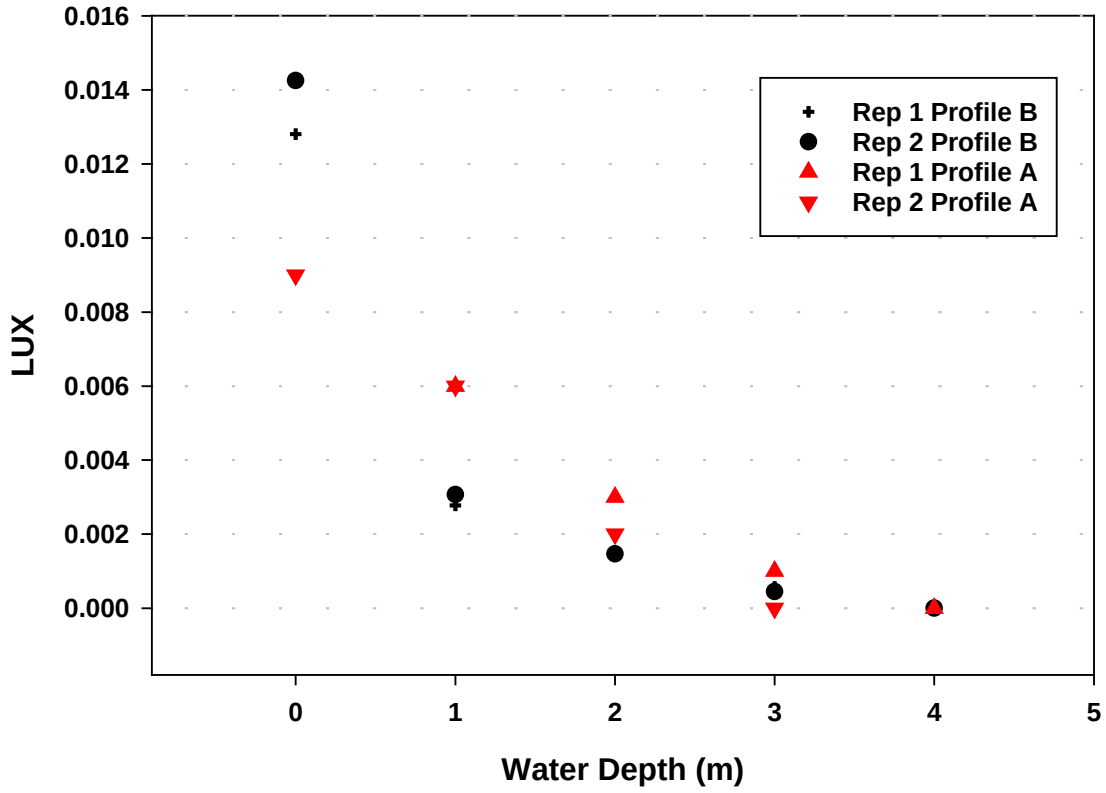

Figure 3. – Night light level profile following moon rise on 8/28/2018 (Profile B) and just prior to moon rise on 8/29/2018 (Profile A). Where readings are the same for each repetition, only one point is displayed. Repetitions at 1 m at Profile A were higher than those at Profile B even though surface light was lower. It is suspected there might have been some reflection off the aluminum boat hull due to orientation with the current.

A profile of light levels collected mid-afternoon indicated that while light levels decrease exponentially in water column there is more than enough light (5 lux) at depth that any fishes present in the area would not be light limited (Figure 4). This study did not have equipment available to enable a spectral description of the bridge lights. Species such as salmonids are more blue adapted and exhibit higher light sensitivity in that region of the spectrum (Rader et al. 2007).

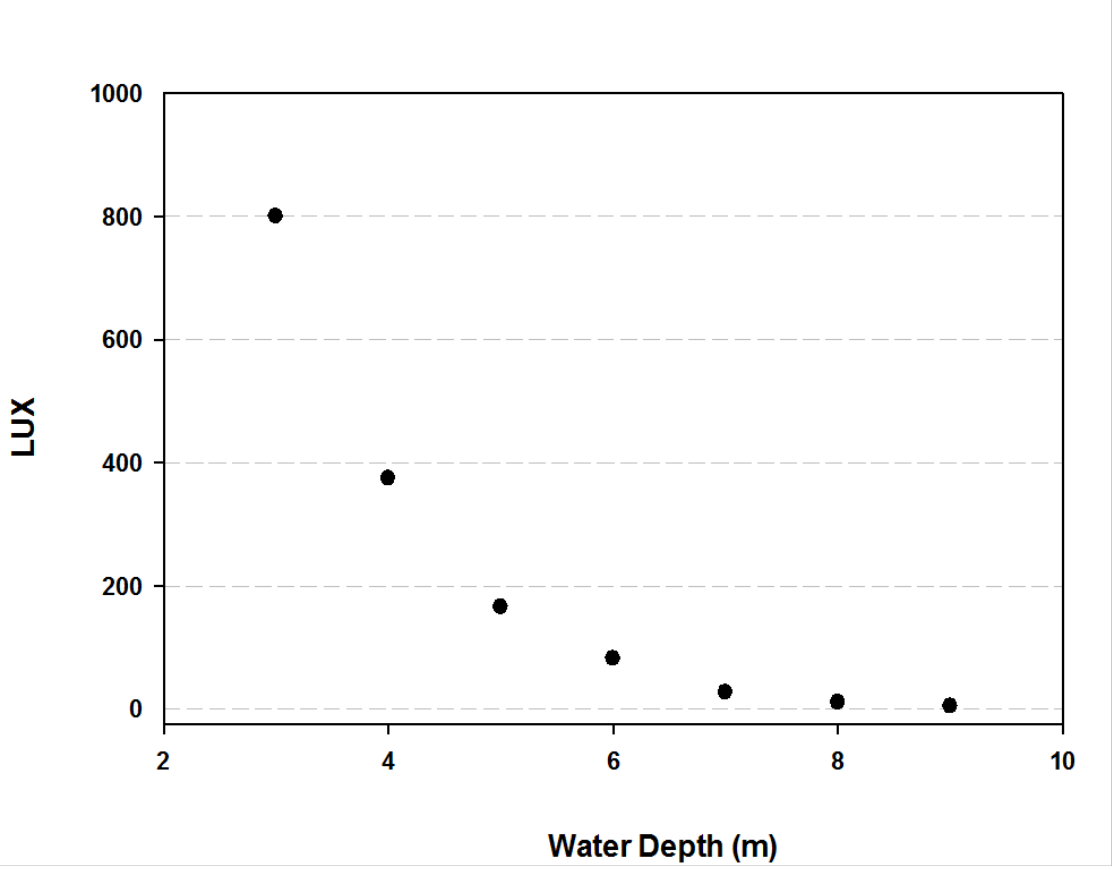

Figure 4. – Daytime light as measured in late afternoon near Brannan Island Bridge (Profile C). At 9 m (maximum depth) light was still 4.75 lux, which is sufficient light for visual predation by common predators. For scaling purposes, large magnitude light levels from the surface to 3 m were not plotted. Surface, 1 m, and 2 m light levels were 19,000, 8,900, and 3,450 lux.

Common predatory species found in the study area are likely able to feed down to 2-3 m anywhere in the area under conditions of ambient lighting and moonlight present in the area under clear nights, and even on nights prior to moonrise when the weather is clear. Largemouth Bass (*Micropterus salmoides*) feed with near 100% capture effectiveness at light levels as low as 0.003 lux, which was what was observed down to about 2 m at night regardless of the bridge influence. The light level threshold for Largemouth Bass feeding is estimated to be 0.00016 lux (McMahon and Holonov 1995). Northern Pikeminnow (*Ptychocheilus oregonensis*) on the Columbia River have also shown to be very effective predators under low light conditions and have a higher capture rate of juvenile salmon under low light (0.03 lux or darker) when compared to higher light levels (Peterson and Gadomski 1994). Once light levels increased above 0.4 lux predation declined by almost 50% indicating that at these levels salmonid vision is effective enough to allow them to avoid predators. Once light levels were above one lux, any further increase in light did not change predation level.

Surprisingly there is not a lot of literature detailing the effects of light on Striped Bass (*Morone saxatilus*) feeding, though it is well known they are effective night feeders, at least during crepuscular periods. Miranda et al. 2010 in their study of a release site about 3 km downstream of the Highway 160 Bridge indicated Pikeminnow and Black Basses (species of the genus

Micropterus) were likely the predominate predators in the area. Other studies have similarly shown an abundance of centrarchids in the Delta and their potential to have a major impact as predators (Nobriga and Feyrer 2007). Striped bass tend to be more seasonally present, though previous studies suggested they were a principal predator at release sites (Pickard et al. 1982).

Data for this study were collected at a time of year when the maximum amount of light penetration might be expected in the water column. Late summer flows in the Sacramento River tend to be of low relative turbidity when compared to other seasons when, due to high runoff events, turbid water conditions often exist. Gauge data (USGS 11455420 Sac. River at Rio Vista) near the study site indicated turbidity averaged around 4 NTU during the sampling period and was among the lowest observed values for the year. During winter and early spring, turbidity near Brannan Island varies between about 5 and 25 NTU depending on water conditions (2018 data). Further, the two nights of study were cloud free, and one night included sampling under a full moon about an hour following moonrise. Cloudy overcast nights would be expected to further reduce light levels below those measured.

Conclusions

In summary, the effect of light levels emitted from the Highway 160 Bridge on fish residing in or released to the area immediately surrounding the release site are likely negligible. Moonlight is brighter than water surface light levels at the proposed release site. The only light of real significance on the bridge is associated with the mid-channel control house. This source likely provides sufficient lighting in the immediate area to increase vision, but it is cast over a relatively small area, and based on typical flows under the bridge, most released fish would likely be swept past the area before entering mid-channel. Fish would also have to be nearer the surface as light would not extend very deep in the water column. Further there is no infrastructure other than the bridge pilings which are not directly under the control house, so there is little to no holding area for predatory fishes. Studies have found impacts to migration and changes in predation at other bridges and along light stream corridors, but light levels for those studies were several orders of magnitude higher than what was measured in the current study (Celedonia et al. 2011, Prinslow et al. 1979, Riley et al. 2012, WSDOT 2001). During a recent study sponsored by Reclamation, California Department of Fish and Wildlife identified sources of potential predator contact points on the Sacramento River as identified by light sources with a reading of 0.5 lux or higher. Using this lighting threshold, the Highway 160 Bridge would not have been identified as an area of concern if the study included locations that far downstream.

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