Criteria for the Selection and Use of Light Sources and Binoculars for Visual Encounter Surveys of Adult and Sub-Adult California Red-legged Frogs (*Rana draytonii*)

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INTRODUCTION

Regulatory

Visual Encounter Surveys (VES) are a key component of the current U.S. Fish and Wildlife Service (USFWS) protocol for conducting surveys of the Federally-listed (Threatened) adult California red-legged frogs (*Rana draytonii*), as identified in the Revised Guidance on Site Assessment and Field Surveys for the California Red- legged Frog (USFWS 2005). This method is used to determine presence or absence of individuals and must be conducted nocturnally *using a light source and binoculars* (USFWS 2005). No capture, handling or contact of frogs, tadpoles, or larvae is legal to conduct without the appropriate permits; however, *no permit is required* to conduct USFWS protocol-level VES for *R. draytonii*.

Methodology

Visual Encounter Surveys are used to conduct surveys of adult and sub-adult frogs by detecting eye shine that reflects toward the observer. The use of lights with certain characteristics described in this document, together with binoculars, increases detection rate; it also increases the detection distance from the observer to the frog, reducing the need to enter water bodies and associated vegetation, thereby reducing risk of trampling adults, larvae, or egg masses, and with experience, in many instances can provide the observer enough detail to determine species. For these reasons, the protocol requires the use of *a light source and binoculars*.

Recent technological advances in portable light technology have provided herpetologists and other biologists who study nocturnal taxa with an ever-increasing selection of this critical tool. Coupled with a good set of binoculars, and with the proper training and practice, these two tools are invaluable when conducting VES. There are advantages and disadvantages to the myriad lights that are now available, which are discussed in this document.

One significant advantage of properly-conducted VES, as stated earlier, is avoidance or minimization of the risk of direct injury or mortality to various life stages of *R. draytonii* (or other vegetation and amphibian species present in the pond). It is not always possible to avoid entering water bodies to conduct surveys,

whether because vegetation obscures or blocks the observer's view of the survey area, or because the size of the water body demands it; however, the proper selection and use of lights and binoculars permits the biologist to work at greater distances from the pond's interior or edge. This minimizes the potential for disturbance, harm, or mortality to frogs, tadpoles, larvae, and habitat that could occur when entering the pond or bank vegetation and is precisely why it was written into the USFWS protocol for this listed species.

TECHNICAL DISCUSSION - LIGHTS

Suitability of Lights for VES

Because visual encounter surveys occur first at a distance from the frogs, the selection of the correct light source and appropriate binoculars becomes one of the most important aspects of successfully accomplishing an accurate and complete survey. Adequate illumination of the animal is critical to properly view the morphological characteristics of the amphibians for which you are conducting surveys.

The following excerpt from the Revised Guidance (USFWS 2005) provides recommendations and sets limitations for lights:

> *"Nighttime surveys shall be conducted with a Service-approved light such as a Wheat Lamp, Nite Light (sic) or sealed beam light that produces less than 100,000 candle watt. Lights that the Service does not accept for surveys are lights that are either too dim or too bright. For example, Mag-Light-type lights and other types of flashlights that rely on 2 or 4 AA/AAA's, 2 C's or 2D batteries. Lights with 100,000 candle watt or greater are too bright and also would not meet the Services requirements."*

The intention of these upper and lower limits of illumination is obvious; insufficient light will likely result in false negative survey results, while there is concern that excessively bright lights could harm the eyes of *R. draytonii* and other amphibians, although research on that effect is lacking.

LED vs. Incandescent: Please note that when the Revised Guidance was published 13 years ago, few LED lights were available, and very few, if any, were satisfactory. Wheat Lamps and Nite Lites were at that time widely available, but few were up to the task of providing the best beam focus and light intensity that new generation LED lights can provide. Light and battery technology has advanced rapidly in the years since the 2005 protocol was written, and now extremely bright, white LED lamps with highly efficient reflectors or fresnels are commonly available. Incandescent lights are still available and are useful; however, the newest LED lights produce light in wavelengths that are more visible to the human eye, making it unnecessary to use lights as bright as the 100,000 candlepower (395-Lumen) limitation set by the 2005 protocol. The new LED lights also consume less energy, so batteries last much longer during use, which is a significant advantage over incandescent bulb lights. In addition, LED lighting continues to decline in price, making these excellent field tools at an affordable cost.

Interpreting Brightness Ratings

At the time the USFWS protocol was written in 2005, light manufacturers typically used candlepower as a brightness rating. However, it is widely understood today that candlepower ratings vary widely among manufacturers, and that a more uniform measure of the amount of light emitted by a source is

represented as Lumens. Although there is no absolute correlation between candlepower and Lumens, **the USFWS limitation of 100,000 "candle watt"** (sic – should have been "candlepower") **roughly translates to about 393 Lumens**, based on equivalence of light output measurements provided by Streamlight, the manufacturer of one of the lights used in the formulation of the 2005 USFWS protocol. **Lights should be selected which have at least one intensity setting, or a maximum intensity, below the approximate 393-Lumen upper limitation in the protocol.**

Best Light Characteristics for Visual Encounter Surveys

Basic Criteria: We recommend selecting the best quality, high-output LED flashlights you can afford, because they are generally well constructed, have well-designed reflectors and/or Fresnel, and are rechargeable (some with Ni-MH or even Lithium-ion batteries). They are also compact, lightweight, sometimes waterproof, or water-resistant, and can be slipped into a flashlight ring or holder when both hands are needed (e.g. walking through vegetation, deep water, handling nets or gigs, etc.).

We consider these three features to be most important for conducting CRF VES:

1. *Rechargeability:* We strongly recommend rechargeable lights to reduce battery costs, because although LED technology provides increased use times, VES may last 4-6 hours each night in some instances. At a minimum, the battery in your light should last for 2-3 hours between recharging, which is significantly longer than the 40 minutes that is typical for high-capacity, high-intensity incandescent lights with equivalent light intensity ratings, or higher-Lumen LED lights that may last only 2-3 hours on a charge. Even with this longer life, it may be necessary to carry either multiple lights or extra, recharged batteries, when conducting longer surveys.

2. *Adjustable Light Output*: When the first version of this document was written in 2013, Cree model C4 LED lights were about the brightest flashlight LED on the market, and are still used in many flashlights and light conversion units. One year later, there were much brighter individual bulbs, such as the Cree XM-LED, and lights with multiple bulbs which provide enormous amounts of illumination. By 2016, LEDs pushing out 1,000-Lumens became available, and there are so many different makes, models, and intensities available to make it more difficult to choose the proper light now than just a few years previously. *Caution: most high-intensity LED lights now far exceed what is allowed or required for our purposes and may be harmful to amphibians.*

   To adequately detect eye shine in *R. draytonii* when using binoculars, we recommend selecting a flashlight rated between 160-393 Lumens. This is roughly equivalent to between about 40,000 to 100,000 candlepower. With the current crop of lights, this will require a light to have multiple settings for added flexibility, appropriate intensity, and increased battery life.

   Flashlights with these ratings are readily available from various manufacturers, many with two or more output settings for *CAUTION: If brighter flashlights are selected, only those with several output settings should be selected, to conform to the USFWS Protocol, and avoid harm to amphibians' eyes. If you use an LED light that exceeds the allowable 393-Lumen limit for VES, the light must have adjustable output settings at or below the allowable limit!*

3. *Tight, Focused Beam*: A wide-angle light is less effective for VES, and can often be distracting to the biologist. A wide-pattern beam will disperse more light around the frog, reflecting less light back to the observer. Atmospheric or ground-level fog (typical in some areas at ponds or other water bodies) will further disperse light which is then reflected to the binoculars, which reduces subject contrast.

Can I Use a Bright LED Headlight Instead of a Flashlight?

We recommend using two different types of lights when conducting VES for *R. draytonii* or other amphibian species;

1) Flashlights for long and medium-range work in combination with binoculars, and;

2) Headlamps for moving through the survey area and for close-up work.

There are two basic limitations with using just a headlamp to conduct VES; brightness (too low or too high), and parallax error when using with binoculars. Headlamps are optimal for walking around the survey area, approaching the pond and/or amphibians, manipulating survey equipment, or other close-distance tasks. Flashlights are optimal when conducting VES because they can be placed in line with the axis of the biologist's binoculars, and often have a more focused beam than headlamps.

Headlamps commonly used for camping, hiking or other uses (i.e., Apex, Petzl, Black Diamond, Princeton Tec, etc.), at 50-100 Lumens, do not provide enough light intensity or focus to adequately detect amphibian eye shine at any practical distance, and would be less effective than the Mag-Light types or others that were stated in the 2005 protocol to be unacceptable. Incandescent headlamps have been largely replaced with bright LED versions, and there are new models and features flooding the market every day. Headlamps that feature brightness level controls are very useful (even critical with lights that exceed the 393-Lumen limit). The most useful headlamps provide the ability to change the beam from wide-angle to spot.

High-Lumen LED headlamps have become available in recent years; however, these are not best suited for conducting VES in combination with binoculars, due to parallax error and obstruction of the beam by hands or binoculars. Angle of incidence is equal to angle of reflectance, so introducing parallax error reduces reflected eye shine directly into the biologist's binoculars. Prior to the 2005 protocol, headband, hat- or helmet-mounted Wheat lamps and Nite Lites - high-capacity, lower-wattage incandescent light systems commonly used for hunting, trapping, and caving - were often used for wildlife and amphibian surveys. These lights can now be obtained in brightness ratings from about 350-600+ Lumens. Some of the newer Nite Lites are available in high intensity LED, which can make them useful for general herpetological surveys, bullfrog management, etc. when it is necessary to have both hands free. However, these lights are generally optimized for helmets or hats, so some reconfiguring or adaptation is generally needed to use them in the most efficient way. They are not optimal for conducting VES because they are difficult to place in line with the viewing axis of your binoculars, due to their configuration, as with headband-mounted headlamps, as discussed above.

How Much Will a Light Cost?

A high-quality rechargeable light with an optimally tight, focused beam will cost between $100-150, depending on features, included chargers, etc. This is equivalent to about 1-2 hours of field time costs, but such a light will provide years of service, and added survey efficiency and success that will save many multiples of cost for those who regularly conduct VES for CRF. Do not scrimp if you are serious about maximizing your survey results and accurate identification in the field.

Can You Recommend a Brand or Model?

We recommend you make your decision based on the 3 basic features detailed above; *rechargeability, tight, focused beam, and adjustable light output settings*.

We have been using Streamlight flashlights for many years now, and still prefer them to most other brands and models because of their optimal beam, adjustability, and rechargeability. Streamlight now manufactures several different models of LED flashlights that are suitable for CRF VES surveys. The lights with optimally tight, focused beams best suited for VES are:

Strion HPL - https://www.streamlight.com/en/products/detail/index/strion-hpl
Stinger HPL - https://www.streamlight.com/en/products/detail/index/stinger-hpl
Stinger DS HPL - https://www.streamlight.com/en/products/detail/index/strion-ds-hpl
Ultrastinger LED - https://www.streamlight.com/en/products/detail/index/ultrastinger-led

These models can be purchased with AC, DC, or both chargers. ***However, these lights well exceed the acceptable limit when used in the high setting, and must be used in the medium setting to be within the acceptable intensity limit for VES.*** Streamlight offers other rechargeable models, although these do not have beams as tight and well-focused, so light scatter will be greater with these units, however *some of these* can be used in the high setting without exceeding the acceptable light intensity limits for VES. Current models are:

Stinger DS LED - https://www.streamlight.com/en/products/detail/index/stinger-ds-led
Stinger Classic LED - https://www.streamlight.com/en/products/detail/index/stinger-classic-led
Polystinger LED - https://www.streamlight.com/en/products/detail/index/polystinger-led
Stinger LED HL - https://www.streamlight.com/en/products/detail/index/stinger-led-hl

Maglite offers rechargeable lights with fairly tight, focused beams, but can be bulky and heavy.
http://maglite.com/shop/flashlights/rechargeable.html

Fenix makes a wide range of lights, some with fairly good beam focus, but may not be rechargeable and many exceed the acceptable intensity limit at high settings. Many other manufacturers and models are available, with more coming onto the market every few months.

TECHNICAL DISCUSSION - BINOCULARS

Selection and Use of Binoculars During Visual Encounter Surveys

Lights are used to reflect amphibian eye shine that is *viewed through binoculars*. The use of binoculars is *required* under the 2005 survey protocol to adequately detect amphibian eye shine. *Surveys conducted without the use of binoculars will call into question the validity of the survey* (USFWS 2005).

The selection of binoculars should be made with the same consideration for quality and effectiveness as your lights. We recommend full-size binoculars, such as 7 x 50, 8 x 40, or 8 x 42. *Compact binoculars are not recommended*. We recommend using roof-prism binoculars only, as opposed to porro- prism models. Roof-prism binoculars gather and transmit more light than porro-prism designs, and are more compact, making them easier to use while holding your flashlight against them. Use the highest-quality waterproof binoculars you can afford – you will notice the difference, compared to lower-quality units. For those times when you must force your way through vegetation, deep water, or will be leaning toward the water, the use of binocular harnesses can be helpful. We typically tuck our binoculars into our waders to keep them under control and out of the water.

The most effective angle of the light is in the same approximate plane as your binoculars, so that the greatest amount of light reflected off the amphibian's retina is visible through the binoculars. Depending on the size and format of your lights, you might hold your light immediately above, below, or adjacent to the binoculars. For an earlier discussion on this technique, see:

Corben, C. and G.M. Fellers. 2001. A technique for detecting eye shine of amphibians and reptiles. Herpetological Review 32(2): 89-91.

The proper selection and use of lights and binoculars is critical to conducting effective, accurate amphibian surveys, because they permit visual observation of identifying characteristics at a safe distance. Following the guidance in this document will aid in the selection of the best equipment for conducting efficient, successful amphibian Visual Encounter Surveys without use of excessive light.