ECOLOGY OF THE
CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

Classroom, Demonstration and Field Topics

Classroom Topics

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Biology
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Trish Tatarian
Greg Tatarian
(Norm Scott)
2018

ECOLOGY OF THE
CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

MANAGEMENT GUIDELINES

Selected and Annotated Bibliography of the Biology and Management of the California Red-Legged Frog (*Rana draytonii*) – on the website - elkhornsloughctp.org

Scoring Ponds and Small Streams as Breeding Habitat for California Red-Legged Frogs (*Rana draytonii*) – included in your packet

Stockpond Management for the Benefit of California Red-Legged Frogs (*Rana draytonii*) – on the website - elkhornsloughctp.org

SPECIFIC ARTICLES

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Bullfrogs and Red-legged Frogs

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Movements

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WEBSITE: www.californiaherps.com/
Lots of nice pictures of all frog stages and habitats, with pretty accurate text.

ECOLOGY OF THE

CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

IMPORTANT POINTS

- **Water regimes -- Mediterranean climate**
- **Habitat types used by frogs**
- **Population dynamics**
- **Identify breeding sites**
- **Manage larval survival**
- **Manage populations, not individuals**
- **Start with clear management objectives**

RECENT TAXONOMIC CHANGES

SIERRAN CHORUS FROG (formerly PACIFIC TREE FROG)

Hyla regilla >> Pseudacris sierra

WESTERN TOAD

Bufo boreas >> Anaxyrus boreas

BULLFROG

Rana catesbeiana >> Lithobates catesbeianus

CALIFORNIA RED-LEGGED FROG

Rana aurora draytonii >> Rana draytonii

MOUNTAIN YELLOW-LEGGED FROG

Rana muscosa

SIERRA MADRE YELLOW-LEGGED FROG

Rana muscosa

SIERRA NEVADA YELLOW-LEGGED FROG

Rana sierrae

Gosner Embyro/Tadpole Staging System

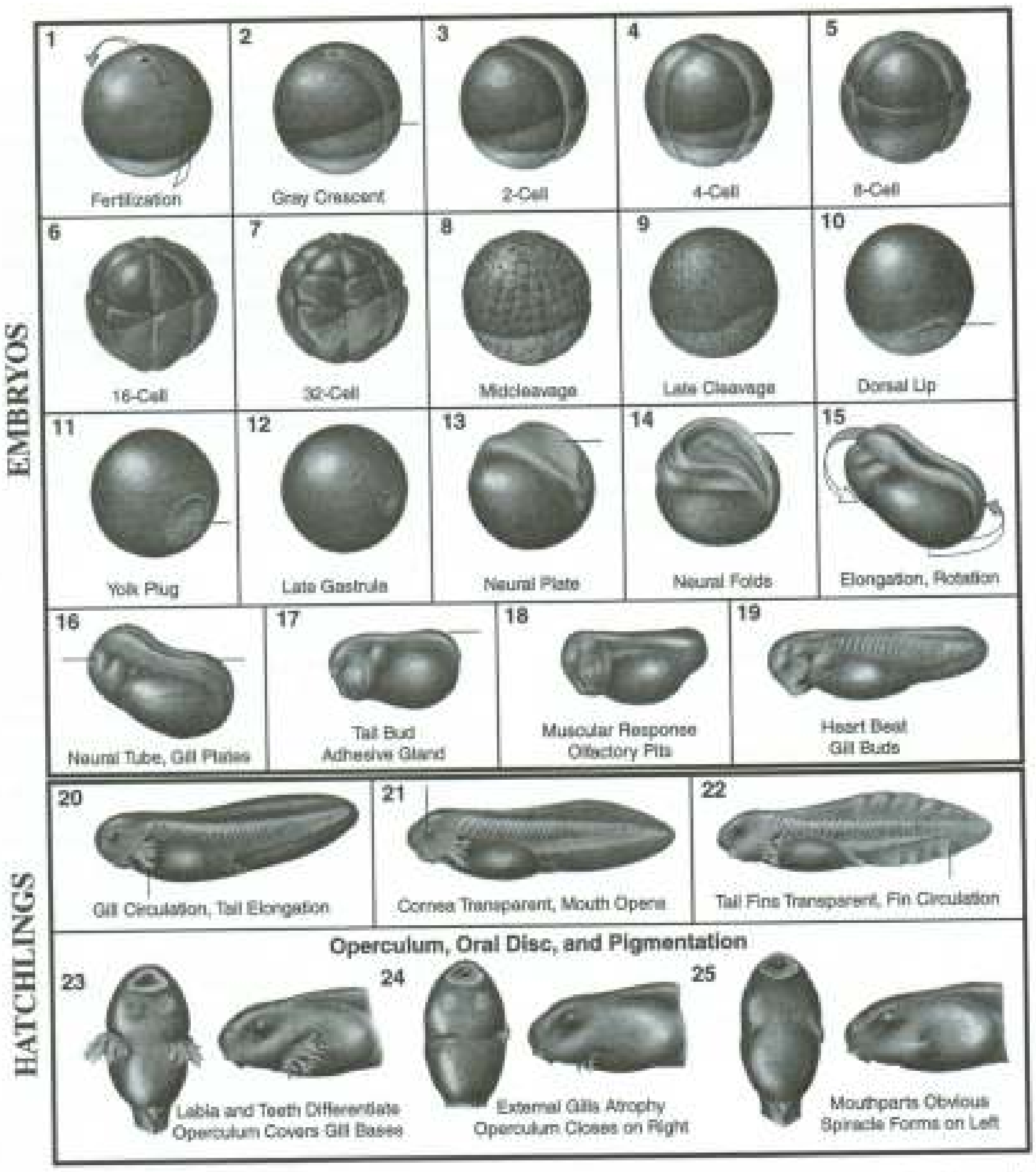
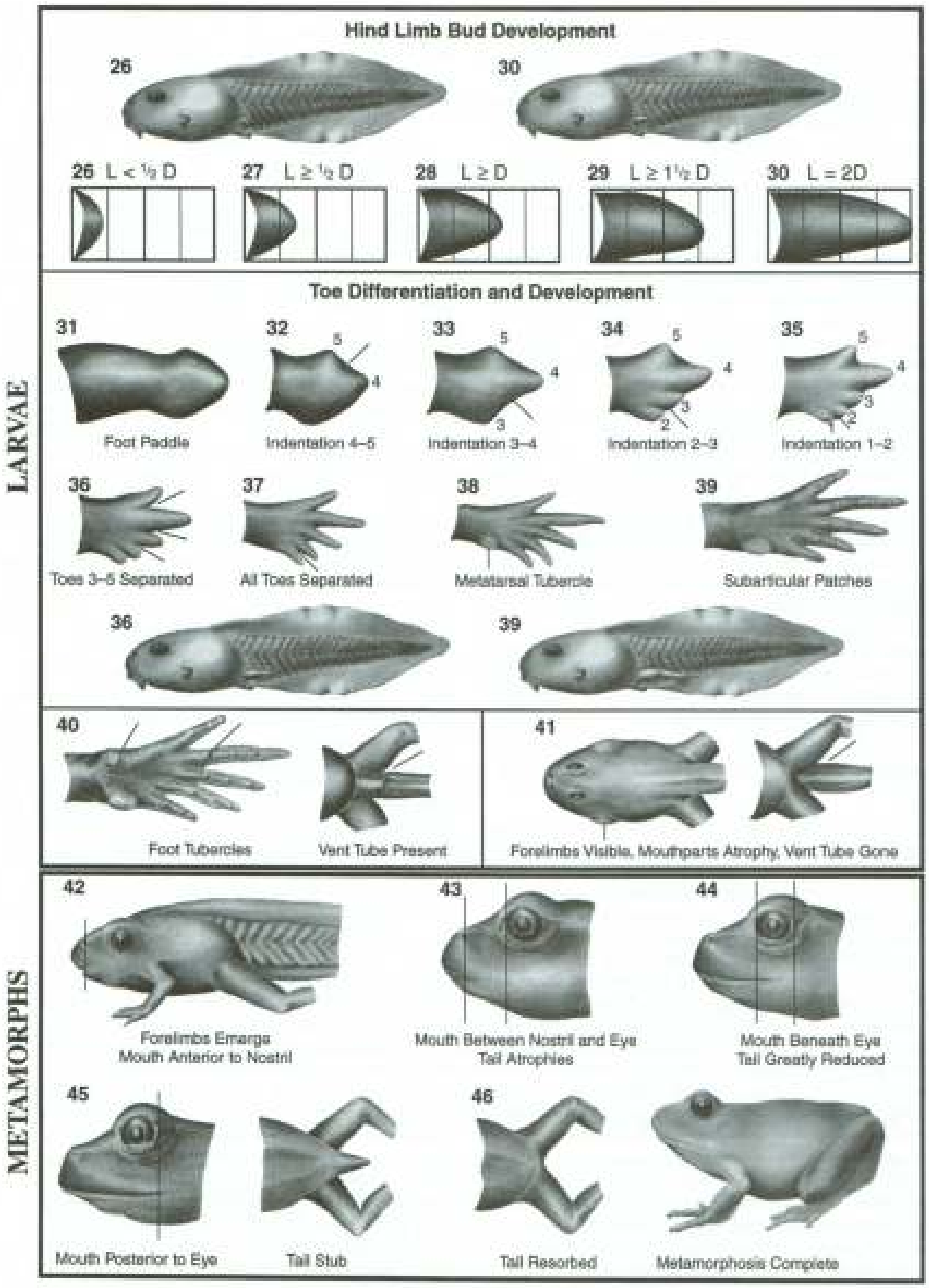


Fig. 2.1. The Gosner (1960) staging system recommended for use with exotrophic tadpoles; developmental stages are based on *Bufo valliceps* raised at 25° C. Translations to other staging systems are shown in table 2.1. Embryos: stages 1–19, 41.8 h (6.2%) developmental time. After fertilization (stage 1) and release of the second polar body (2), the zygote undergoes cleavage to stage 9 without an increase in size. Germ layers begin to form during gastrulation (10–12), which is followed by neural tube formation (13–15). Sensory structures appear during stages 16–19 and somitogenesis occurs in stages 18–19). Hatching may occur as early as stage 16. Hatchlings: stages 20–25, 73.5 h (11.0%) developmental time. This period represents the transition from a relatively immobile embryo to an active, feeding tadpole; external gills atrophy and the spiracle forms. Structures associated with feeding and swimming appear and pigments begin to form larval color patterns. Tadpoles: stages 26–41, 384 h (57.6%) developmental time. This is the longest part of the larval period and is marked by growth and limb development. Metamorphs: stages 41–46, 168 h (25.2%) developmental time. During this crucial period the tadpole loses its larval characteristics and takes on adult structures; the tail begins to atrophy (43), larval feeding structures are replaced by adult jaws and tongue (41–43), and forelimbs and hind limbs become functional. This period typically is marked by a passage from the aquatic to the terrestrial environment. Metamorphosis is complete (46) when the tadpole has become a froglet. Original drawings of stages 1–25 were provided by Linda Trueb (Duellman and Trueb 1986); depictions of stages 26–46 were redrawn by Kate Spencer; additional drawings were prepared by Ty Thierry.

Scanned from McDiarmid, R. and R. Altig. 1999. Tadpoles: The Biology of Anuran Larvae.

Gosner Embyro/Tadpole Staging System



TERMINOLOGY APPLIED TO
CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

Age - Calculated from the time of egg fertilization. Assumed to be 1 April in the population models from San Simeon area.

Egg - Technically an unfertilized ovum, but in our common usage, it refers to an early embryo through gastrulation, before the embryo starts to noticeably elongate.

Embryo - Stages from egg fertilization until the frog breaks free of the jelly coat in the egg mass and becomes a free-swimming tadpole.

Tadpole - A larval frog, from hatching until it starts to lose its tail and becomes a metamorph.

Larva - Tadpole.

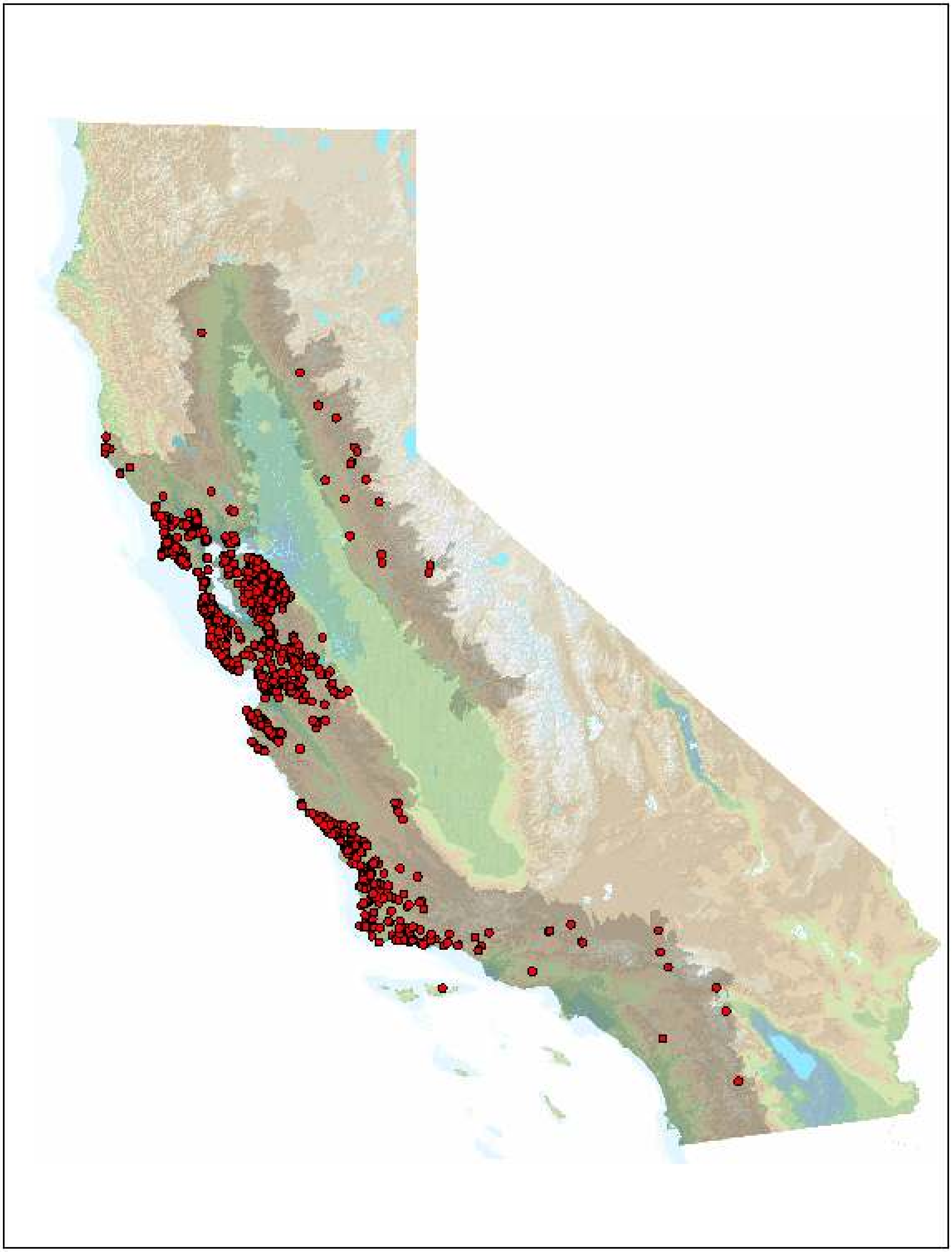
Metamorph - Normally for red-legged frogs, the period from the time it loses its tail at about 5 months of age until it is about 10 months old. In tadpoles with delayed development, metamorphosis may occur 12 or more months after egg laying.

Froglet - An informal term for a small, young frog.

Juvenile - A frog from the time it starts metamorphosis until it is able to breed. This term includes the metamorph stage. On average this is from about 5 months of age to 2years.

Adult - A frog that is capable of breeding. In the red-legged frogs that we studied, this was two years of age for most males and probably the same for some females.

N.J. Scott
G.B. Rathbun
April 2010



California red-legged frog range and current distribution (March 2018).

ANNUAL CYCLE OF CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

Calling and Egg-Laying - (November) December through April (June)
There is some indication that egg-laying is somewhat earlier in the northern part of the range (Bay Area, Santa Cruz County) than in the south, and that it is delayed in streams and rivers. An exceptionally early record for eggs in November was preceded by unusually heavy rainfall (Storer 1925), and eggs have been recorded in June near the Carmel River after heavy winter flows (Reis, pers. comm.).

Hatching and Tadpole Stage—mostly through September
Hatching takes 2-3 weeks, depending on water temperature. Metamorphs (except for overwintering tadpoles—see below) can be found as early as June, with a peak of metamorphosis in August at most sites. In some scattered areas, tadpoles that overwinter are rarely or commonly found (Fellers, et al. 2001). These tadpoles usually transform the following spring. At Los Vaqueros, Contra Costa County 12% of the ponds were found to contain overwintering tadpoles (Alvarez, et al. 2004).

Metamorphs
Immediately after metamorphosis, froglets can be commonly found around the natal pond, but they soon disperse, often to shallow-water habitats with good cover. Here they are safe from adult frogs that might eat them.

Juveniles
Juvenile frogs are rarely found in ponds with adults. They disperse widely, and can often be found in small bodies of water 100s of meters from the natal pond. Observations support the idea that juvenile frogs are the principle source of propagules for isolated, previously uninhabited, ponds. Most males and a few females reproduce during the second spring following metamorphosis (2-yrs old), and all probably reproduce at the end of their 3rd year.

Adult Cycle
Adults, if they are not already at the breeding site, move to one during the winter, often starting with the first heavy rains (November-December; Bulger et al. 2003). They may take several months for the journey. Males tend to remain at the breeding site during the whole breeding season, but many females abandon the pond soon after egg-laying. If the adult frog leaves the breeding site, it moves to a summer habitat and stays there over the dry season. All adults may wander widely during winter rains.

DURATION OF LIFE STAGES

Calling..1-2 months
Egg..2-3 weeks
Tadpole.............usually 4-6 months, some to 1 year
Juvenile...20-32 months

Adult.........................majority 1 year, maximum 7+ years

N. Scott
G. Rathbun
May 2005

POPULATION DATA FOR
CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

Scott and Rathbun - San Simeon Area (1992-1999)

Age in Years	Sample Size	Survivorship Percent
0 (eggs)		2.0 *
0.5 (metamorphs)	81	9.9
1	8	
End of First Year		
1	536	25.4
2 (first breeding)	136	34.6
3	47	38.3
4	18	33.3
5	6	33.3
6	2	0
7	0 **	0

*** Literature data**

**** Two older frogs were more than 7 years old**

SCORING PONDS AND SMALL STREAMS AS BREEDING HABITAT FOR CALIFORNIA RED-LEGGED FROGS (*Rana draytonii*)

This scoring system is based on our experience, the experience of others, and the literature. We have arranged the analysis from large scale (surrounding biotic factors) to small scale (the pond itself). It is highly subjective and the scores indicate which factors we believe to be most important to red-legged frog breeding and which factors seem to be less important.

The system is probably not suitable for large rivers and lakes, complex aquatic systems, or those influenced by sea water (e.g., Russian River, Pescadero Marsh, San Simeon Creek lagoon). Intermediate scores can be applied subjectively. Maximum score is 52.

Physical Parameters		Points	Points
*Pool/Pond Duration	Tadpole habitat present through August	5	
	Does not hold water through July in most years	0	
*Water Flow	Low (ponds or pools in creek)	5	
	High (streams or rivers)	0	
*Pond Nutrients	High level (livestock, sewage, etc.)	5	
	Low level (deep well, spring water)	1	
Urban Proximity	Further than 1 km	2	
	Closer than 200 m	1	
*Distance to other Breeding Areas	Two or more breeding sites within 500 m	5	
	No other breeding sites within 2 km	0	
Pond Persistence	Intermittent - Dries up in fall at least every 2-4 years	2	
	Perennial - Never dries up	1	
Aquatic Vegetation	Mosaic of open and vegetated water	5	
	Choked with vegetation	2	
	No vegetation (a rocky cobble substrate can substitute for vegetation in a stream)	0	
*Exotic Fishes	No fish	5	
	Mosquitofish, crayfish, or exotic predatory fish with some escape cover	3	
	Exotic predatory fish and little escape cover	0	

Physical Parameters		Points	Points
Refugia	Vegetation/structure	5	
	No vegetation/structure	0	
*Bullfrogs	None	3	
	Abundant and reproducing	1	
Frog Habitat Presence			
Egg and Tadpole Rearing Area	Greater than 0.25 acres	5	
	Less than 0.25 acres	2	
Summer Water Temperatures	Above about 80 F	5	
	Below about 60 F	0	
*Metamorph Habitat	Shallow water micro-habitat with good emergent cover and few or no adult red-legged frogs or bullfrogs	3	
	No cover and abundant adult frogs or other predators	0	
*Summer/Juvenile Refuges	At site or within 200 m	2	
	More than 2 km away	0	

Most successful ponds that we have scored are in the low to mid 40s. Red-legged frogs probably will not consistently breed in habitats that score zero for one or more of the factors with an asterisk, or if the overall score is less than about 30.

Trish Tatarian
Greg Tatarian
(Norman J. Scott)
March 2018

SURVEY EQUIPMENT TO BE USED DURING SURVEYS FOR CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

NON-PERMITTED SURVEYS

Lights/Headlamps

Binoculars

Waders

Data Recorder

Decontamination Equipment

PERMITTED SURVEYS

Float tubes

Dip Nets

Tadpole Traps

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*)

Greg Tatarian, Wildlife Research Associates
Trish Tatarian, Wildlife Research Associates

Updated 2/22/2018
Updated 4/24/2017
Revised 2/6/2017
Revised 2/11/2016
Updated 2/10/2015
Revised 4/28/2014
2/25/2013

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 the proper lights and 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.

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 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 35, 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.