Biology and Conservation of the Santa Cruz long-toed salamander (*Ambystoma macrodactylum croceum*)

A workshop on historical and contemporary ecology, natural history and conservation

Pete Trenham, ptrenham@yahoo.com
Wesley Savage, wksavage@lehigh.edu

Workshop Goals

1. Explain key elements of SCLTS biology/life history
2. Discuss the complexities of conserving populations in a highly fractured, fragmented and altered landscape
3. Provide an open forum for discussion

Workshop Topics I
Evolution of the SC Long-Toed Salamander

- Evolutionary relationships among long-toed salamanders
- Historical biogeography

Workshop Topics II
Ecology and life history

- How to identify SCLTS eggs, larvae, and adults
- Life cycle, demography, and population dynamics
- Predators and prey
- Habitats and ecology
- Movement (Allaback & Laabs), populations, metapopulations, and landscapes
- Population genetic structure and spatial relationships
- Conservation genetics

Workshop Topics III
Surveys, Monitoring, and Management

- Strategies for detection, minimization of harm, conservation, management, and recovery
- What has been learned about movement around ponds
- What kinds of management plans have been implemented

Workshop Topics IV
Threats, mitigation efforts, conservation

- Threats to all life stages
- Past mitigation efforts
  - Conservation easements
  - Habitat conservation plans
  - Critical habitat
  - Reserves and public lands
  - Private lands
- Strategies for recovery

Ending Discussion: Conservation needs and goals

- Protection to maximize
  - Greatest number of breeding habitats
  - Greatest number of individuals at each location
  - The quality and size of upland habitat
    - essential for breeding pond water quality
    - Maximizing larval → juvenile recruitment
    - terrestrial life stages

Workshop Topics I
Evolutionary history

- Evolutionary relationships among long-toed salamanders
- Historical biogeography
- Population genetic structure and spatial relationships
- Conservation genetics

Focal species for this workshop

- **Amphibian ("two lives")**
  - aquatic eggs, coated by PS gel
  - Thin, permeable skin for water balance (they do not drink)
- **Salamander**
  - four legs and a tail, all life stages, two habitats
- **Mole salamander**
  - Family Ambystomatidae (typically occupy small mammal burrows), costal grooves

What's in a name?

- Genus ***Ambystoma***: (*anabystoma*) to cram into the mouth. Possibly derived from *Amblystoma,* blunt mouth (Greek)
- species ***macrodactylum***: long toe (Greek)
- subspecies ***croceum***: saffron colored, referring to the dull orange dorsal pattern coloration (Latin)

Basic description of the long-toed salamander

A smaller species of the mole salamanders (*Ambystoma*), dorsal surface is dark gray to black with a yellow, orange-to-red, tan or olive green dorsal stripe, which is broken up into pronounced blotches in two subspecies.
(modified from Stebbins 1951)

The sides have some white speckling/flecking. The ventral side is usually a translucent gray, and black primarily only in one subspecies.
(modified from Petranka 1998)

… they do not really have unusually *long toes …*

Taxonomy & diversity of long-toed salamanders, *Ambystoma macrodactylum*

- 5 geographically variable subspecies (lineages)
- Morphologically & geographically recognizable as different forms
- Represent a widespread species that diversified into different evolutionary lineages due to long-term ecological and evolutionary events

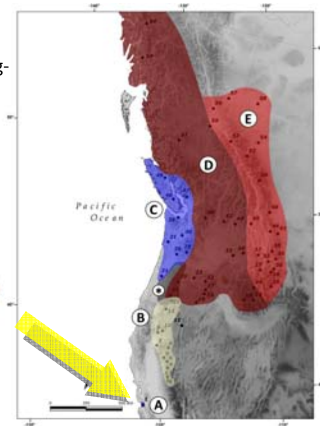
***A. m. columbianum* not shown**

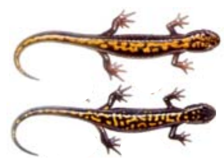
Taxonomy of long-toed salamanders: *Ambystoma macrodactylum* subspecies descriptions

Three dorsal-banded forms:
"Northern" or "Central": *A. m. columbianum* (not depicted)
Eastern: *A. m. krausei*
Western: *A. m. macrodactylum* (the typological form)

Two broken pattern forms:
Santa Cruz: *A. m. croceum* ("saffron" colored)
Southern: *A. m. sigillatum*

The geographic range of long-toed salamanders spans a great diversity of ecological and elevational gradients.
…
Santa Cruz lineage is the exception.

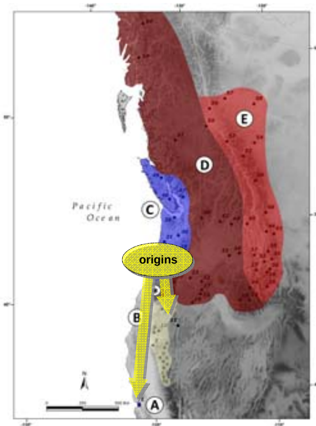




SCLTS descended from a northern, coastal lineage

A long-range change in coastal habitat left a relictual lineage in Santa Cruz

The closest relative to SCLTS is *not* in the Sierra Range



Phylogenetic relationships of long-toed salamanders

Eastern

Central

Western

Southern

So what does this mean?

The Santa Cruz long-toed salamander is a genetically distinct taxon, an endemic and relictual lineage that was "left behind". It is unique in color pattern, biochemistry, allopatric distribution, and small range/global population size.

This information is the basis for…

Protection of The Santa Cruz long-toed salamander, (*Ambystoma macrodactylum croceum*)

Discovery:
(1954) Valencia Lagoon

Federal protection:
(1967) Endangered Species Protection Act
(1973) Endangered Species Act

State Protection:
(1971) California Endangered Species Act

SCLTS Distribution Maps (range is extremely limited and fragmented)

californiaherps.com

USGS ARMI Atlas
Not range, but potential niche

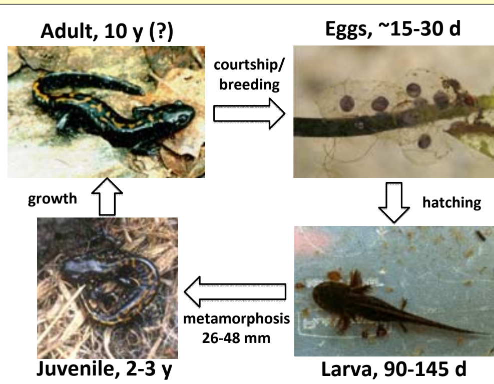
Workshop Topics II
Ecology and life history

- Life cycle and how to identify SCLTS eggs, larvae, and adults
- Habitats and ecology
- Demography and population dynamics
- Predators and prey
- Movement (Allaback & Laabs), populations, metapopulations, and landscapes
- Regional population genetics and conservation

Life cycle and morphology – Main points

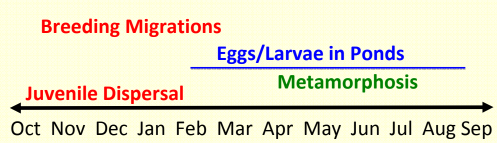
- Adults migrate to ponds during fall and winter rains
  - Present at ponds relatively briefly (usually only for days)
- Embryos potentially detectable December-March
  - Eggs attached to vegetation singly or in small clumps
- Larvae mainly detectable March-June
  - sometimes until August
  - Too small to catch or identify before April (?)
  - Coloration extremely variable (black morphs, white morphs), but no stripes
- Metamorphosis begins as early as May
  - Metamorphs vary widely in color and size
  - Some present in pond edges through summer

Santa Cruz long-toed salamander life cycle



SCLTS Life Cycle is similar to CTS

Timing varies among sites due to pond duration and rain. Generally, the first fall rains involve outward bound movements of juveniles born the prior winter, and a relaxed inward bound movement of reproductive males, then females arrive as rains begin to fill temporary ponds.



Breeding habitat: wetlands

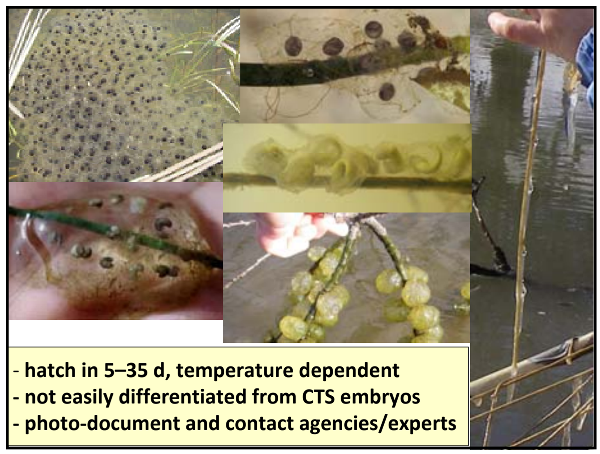
- Seasonal and permanent ponds
  - Larvae use submerged root structures of California bulrush (*Schoenoplectus californicus*) and emergent vegetation for cover
- Gulches, sloughs, catchment basins
- Willow stands typically associated with breeding ponds
- Breeding documented in ponds with fish
  - Sculpins, catfish, also Bullfrogs (not fish)

Identification/Morphology: Eggs

- **Embryos**
  - Attached to vegetation or other submerged materials
  - Attached singly or in small clusters
  - Each enclosed in an individual membrane
    - tapioca-like
  - Mostly clear, but also grey
  - Detectable mainly Dec-Jan
  - Ask Mark Allaback…

Identification: Eggs

- Deposited in shallow water (< 0.5 m) either singly, or in small clusters of a few to a > 20 eggs
- Eggs are attached to vegetation (floating, emergent, standing, submerged, logs, branches)
- Clutch size per female: ~ 215 – 411 (Anderson 1967)

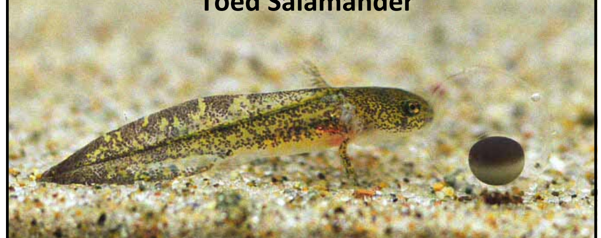


- hatch in 5–35 d, temperature dependent
- not easily differentiated from CTS embryos
- photo-document and contact agencies/experts

Identification: Larvae

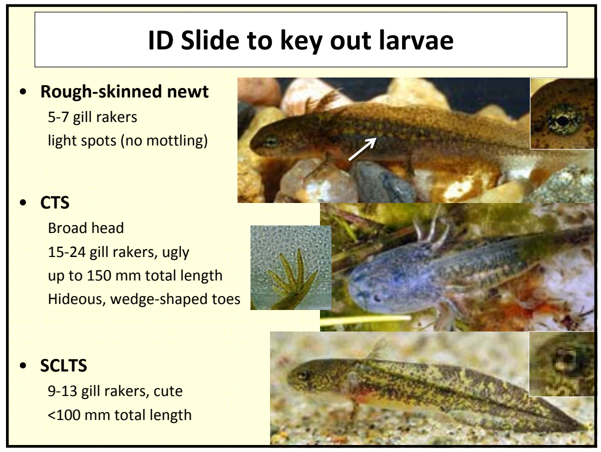
- Fish-like; four legs; feathery external gills;
  - ~12 - 90 mm (total length); color variable
- Challenges in identification
  - especially at small sizes
- Confusion with larvae of other species
  - Co-occur with California tiger salamanders in Harkin's Slough drainage, west of HWY 1
  - Co-occur with newts in Freedom area, east of HWY 1
- Larval period can be short in duration (~50 d)
  - pond conditions may lengthen it

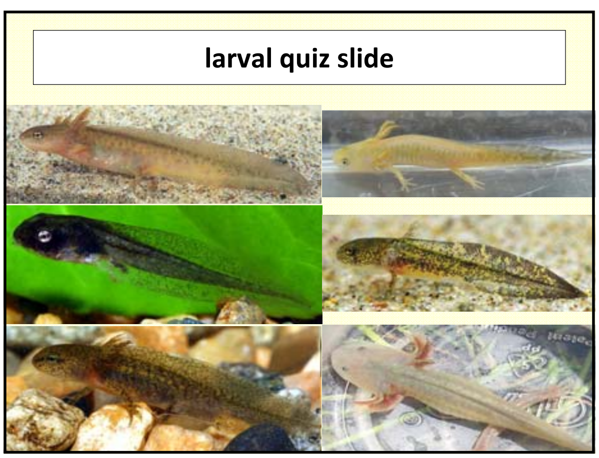
Embryonic and Larval Santa Cruz Long-Toed Salamander

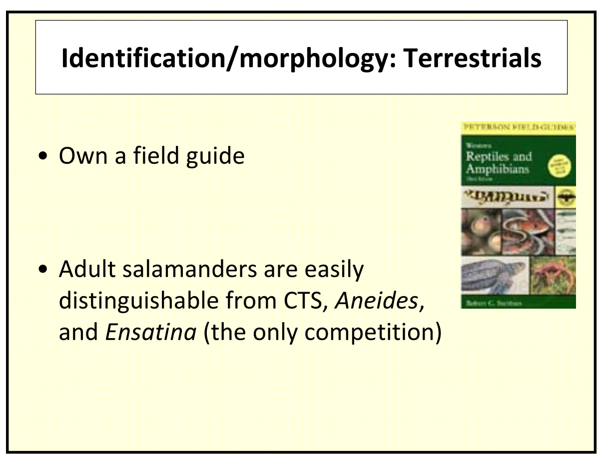


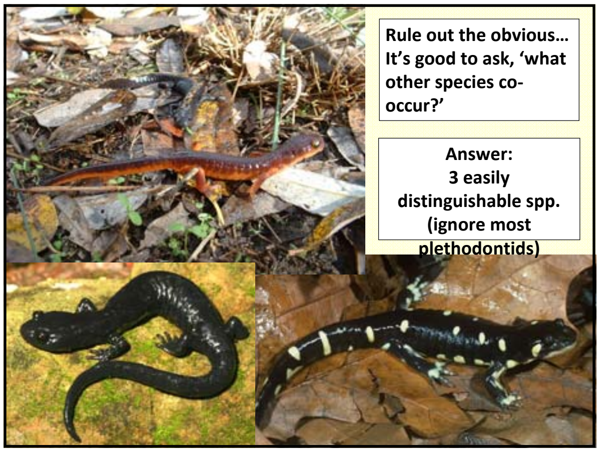
Color patterns vary from mottled (above) to a uniformly-colored dark morph that is slate grey-blue with an iridescent blue belly, and even completely white (rare)


dark morph
Identification: Larvae
Typical, mottled morph
Rare, white morph


ID Slide to key out larvae
Rough-skinned newt
5-7 gill rakers
light spots (no mottling)
CTS
Broad head
15-24 gill rakers, ugly
up to 150 mm total length
Hideous, wedge-shaped toes
SCLTS
9-13 gill rakers, cute
<100 mm total length

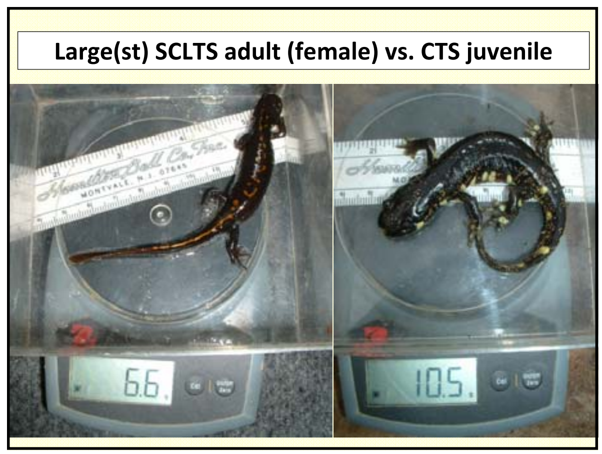

larval quiz slide


Identification/morphology: Terrestrials
Own a field guide
Adult salamanders are easily distinguishable from CTS, *Aneides*, and *Ensatina* (the only competition)
Reptiles and Amphibians

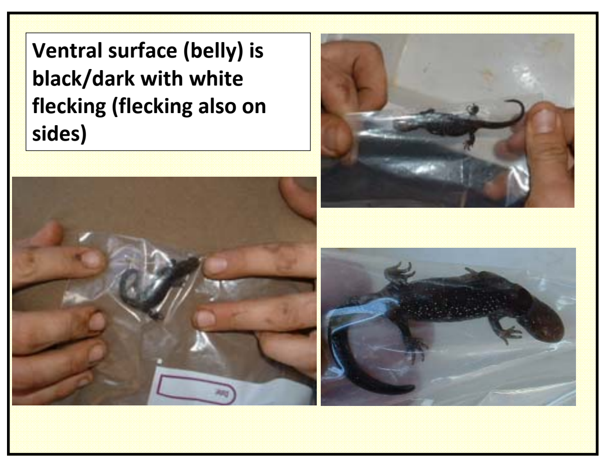

Rule out the obvious… It's good to ask, 'what other species co-occur?'
Answer:
3 easily distinguishable spp. (ignore most plethodontids)


SCLTS juvenile vs. CTS juvenile
2.1
10.5

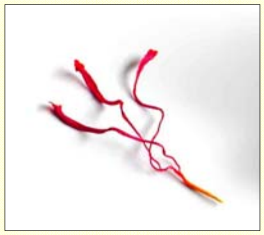

SCLTS juvenile vs. SCLTS adult
2.1
6.4


Large(st) SCLTS adult (female) vs. CTS juvenile
6.6
10.5


SCLTS adult (male) vs. CTS adult
4.7
36.8


Ventral surface (belly) is black/dark with white flecking (flecking also on sides)

- Dorsum is black with broken pattern of dull orange, maybe yellow blotches
  - Blotches are color of saffron flower threads
  - brightest in juveniles, weakest in breeding males



Coloration may be adaptation to local habitat

Cryptic patterning against senescing willow leaves

Brightness, pattern and quantity of blotches varies

Sex differences

- Three kinds:
  - Male ♂
  - Female ♀
  - Undetermined (juveniles, etc.) ?

Breeding Adults: Males ♂

- Swollen vent
- Bladed, eel-like tail fin
- Body is slender and tail is elongate
- "Saffron" color patches are drab

Breeding Adults: Females ♀

- No/minor swelling at vent
- No prominent tail fin (demure tail)
- Visibly swollen with egg masses = gravid
- Blotches appear brighter than males

Sex of non-breeding animals can be difficult and next to impossible to assign with confidence, but these individuals are usually encountered during outward-bound dispersal

Question: When might this kind of encounter occur? ?

Identification/Morphology

- Metamorphs (recently transformed)
  - Clearly distinguishable color pattern
  - Remnant gill stubs disappear rapidly, and gone on land
  - 26 to 48 mm long
    - 1.0 – 1.8 inches
  - Quite small and fragile
- Juveniles (after 1st summer)
  - Resemble adults, but smaller
  - Dorsal patterns vary in number of blotches and color becoming more prominent through growth
  - Adults 4 – 8.9 cm snout-vent length
    - 1.6 – 3.5 inches

Terrestrial species quiz slide

SCLTS Habitat Basics

- Aquatic Breeding Habitat
  - Seasonal ponds and sloughs* (main historic habitats)
  - Constructed ponds (e.g., Valencia, Elkhorn, Tucker Seascape, Buena Vista, etc.)
  - Ditches (e.g., Shadow Mere Rd. area near Palmer Pond
- Upland Habitat
  - Willow stands identify moist soils which provide refuges for adults and juveniles (at ponded areas, edges)
  - Oak woodlands, mostly
  - Sometimes chaparral and shrublands, but likely only during migrations

Wetland Breeding Habitats

- Two types: permanent and seasonal
- Most known breeding habitats are seasonal wetlands; but some permanent waters support breeding
- Breeding habitats range from <0.1 to 65 acres (discuss this one: McCluskey)
- permanent ponds have more larval predators/competitors and also parasites

Upland Habitat Basics

- After metamorphosis, SCLTS are rarely detected, & almost always underground
- Occupy mainly ground crevices and other burrows
  - Emerge to move to pond or another burrow
  - Emerge only at night, usually when raining
- Aestivation has not been observed (anecdotes)
- Because little is known about this species we could make logical extensions from similar species (e.g., CTS). But only to gain an idea…

Upland Habitat: where?

- this is still being discovered for SCLTS because not enough studies
- A number of breeding habitats have insufficient terrestrial habitat to support a stable population
- No habitat corridors connect major breeding clusters

Habitat Main Points

- Breeding habitat is ponds
  - Ponds must hold water until at least June
  - Permanent ponds are **not** good habitat (deformities)
  - Small ponds produce fewer metamorphs & higher inbreeding (WKS will include data)
- Uplands are the primary SCLTS habitat
  - Live underground in burrows, crevices, willow roots
  - Come to surface rarely
  - They do not *always* stay near the pond

FWS/DFG Sampling Protocols

- If “suitable” breeding habitat exists on site…
  - dipnetting to detect larvae
    - 2 yrs; 2x per yr (Mar 15 - Apr 1; Apr 15 – May 1)
    - ≤1/4 inch mesh nets
    - <1/2 acre = 1 hour; >1/2 acre = 2 hours
  - drift fence sampling for adults and juveniles
    - if larvae not detected in year 1
    - Jan 1 – Feb 28 (or Mar 31); during periods of heavy rain
    - check every 12 hours
    - pitfalls non-galvanized #10 (or larger) cans

Sampling Protocols – ISSUES

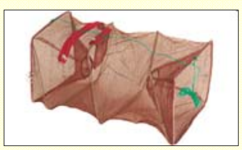
- 1) "suitable" habitat – holds water to May 31
  - shorter hydroperiod may be sufficient
- 2) dipnetting
  - survey dates are good
  - 1/4 inch mesh (may be too large)
  - dipnetting alone may be insufficient (minnow traps)
- 3) drift fence sampling
  - January start will likely miss juveniles
  - traps must be open on rainy nights
  - location and amount of fencing is flexible
- 4) what if no "suitable" breeding habitat?

Aquatic Sampling

- SCLTS breeding habitat is complex and difficult to sample
- dip nets
- 1/8" mesh or smaller
- minnow seines (less useful due to habitat complexity)

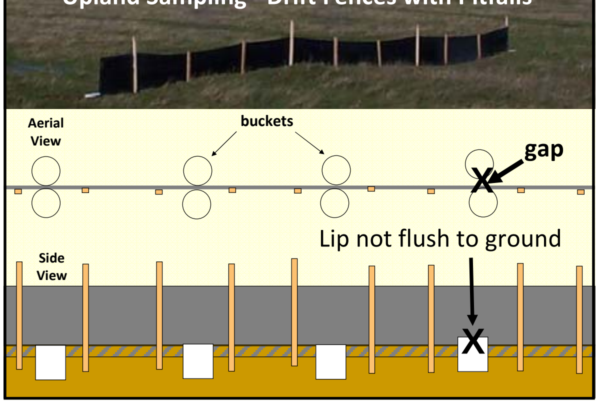
Minnow Traps

- use when you cannot reliably sample a pond with dip nets
  - deep water, deep muck, heavily vegetated
- use many traps (N > 10)
- check 2x daily (to minimize mortality)
- use floats to prevent mortality
  - e.g., of red-legged frogs
- stake traps in place and attach flagging



Sometimes larval detection requires getting wet…
(deep water seining at Tucker Pond)

Upland Sampling - Drift Fences with Pitfalls



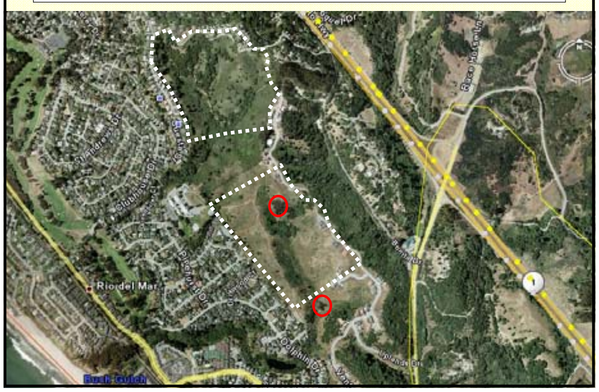
- Information tags
- Bucket divider
- Buried bottom edge
- Protective cover over bucket lid to deter predation
- Handling with latex gloves
- small PVC pipe for cover
- Not shown: Foam pieces for moisture, rope tassels for small mammal escapes, small perforations for drainage

- **Permit Requirements**
  - need CDFG (scientific collecting permit plus protected species permission)
    - Optimistically, this take ~3-6 months
    - Realistically, up to 15 months (anecdotal cases)
  - USFWS (10a1a recovery permit) permissions
  - develop/document your experience with SCLTS and other amphibians
- **General Sampling Guidance**
  - even at known occupied sites, SCLTS can be difficult to detect
    - failure to detect = elimination of habitat without compensation
  - use additional methods to increase likelihood of detection
    - surveys for embryos
    - walking surveys and road cruising on rainy nights
    - cover boards

Drift fence study design

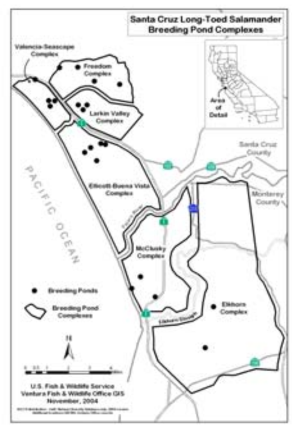
- **What is the goal of installing drift fences?**
  - **Maximize captures with "least effort"?**
    - Target specific areas around a feature of known presence
  - **Detecting presence/movement patterns?**
    - Needs of most consulting/agency biologists
- **When planning, plan for the worst…**
    - "Think storm"
    - (Doesn't hurt to consider poison oak too)

Discuss Survey Designs For These Two Parcels



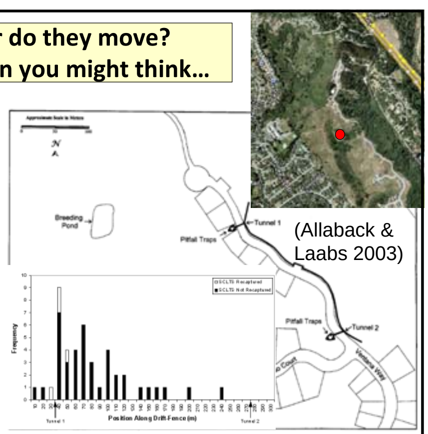
Population Basics

- ~22 known breeding ponds
- Valencia Lagoon (1978)
  - ~2500 adults bred
  - 2200 juveniles emerged
- Seascape 1 (1999-2003)
  - ~ 2000-3000 adults bred;
  - 288-4330 juveniles emerged
- Zmudowski Pond
  - ~19 adults bred (2002)
  - ~13 captures (2003)
- typically 0-5% of embryos survive to metamorphosis!



How far do they move?
Farther than you might think…

- Seascape
  - 26-36 % went > 335m
- Willow Canyon
  - up to 800 m
- Valencia
  - 90 % went <125 m
- likely depends on multiple factors

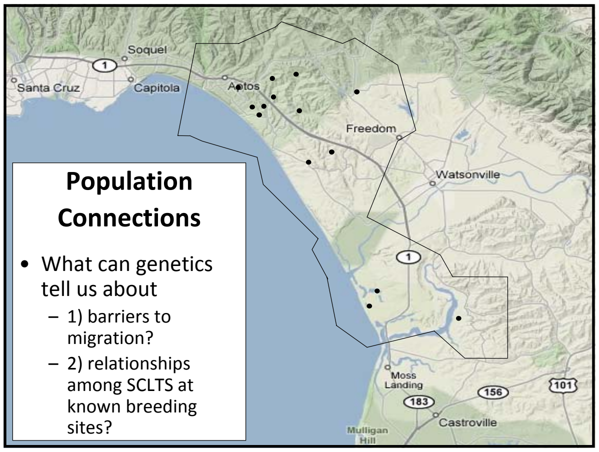


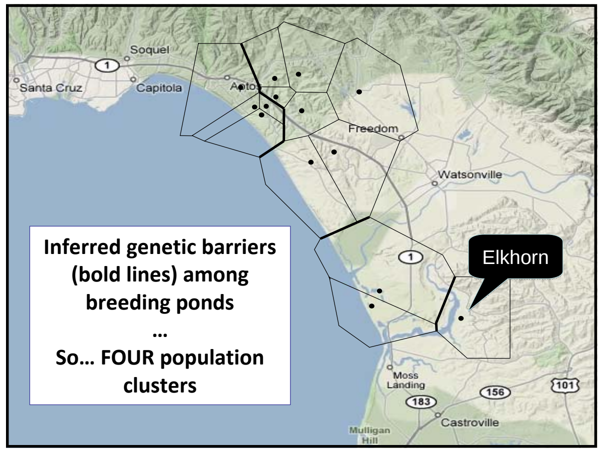
(Allaback & Laabs 2003)

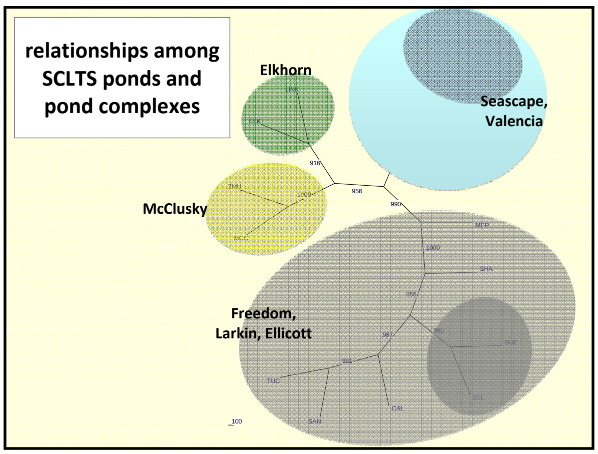
Figure 1. Locations of road tunnels and drift fencing at Seascape Uplands, Santa Cruz County, CA.

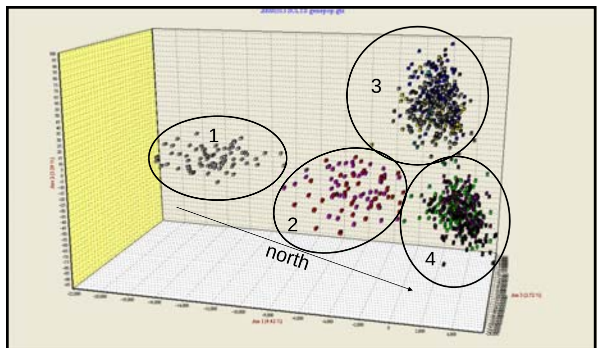
Demography

- Embryos = 300 per female (Anderson 1967)
- Juveniles emerging = 0 – 6 per female
- Survival to metamorphosis = 0 - 2%
  - can be limited by pond size (density dependent)
- Post-metamorphic survival
  - Little, if any data available
- if each female produces TWO adults during her lifetime, population size will not change
  - (says little about breeding success & next gen.)









1: ELK **2: MCC, ZMU**
3: ELL, TUC, BUE, MER, SHA, CAL, SAN **4: SPA, SPB, SPC, VAL**

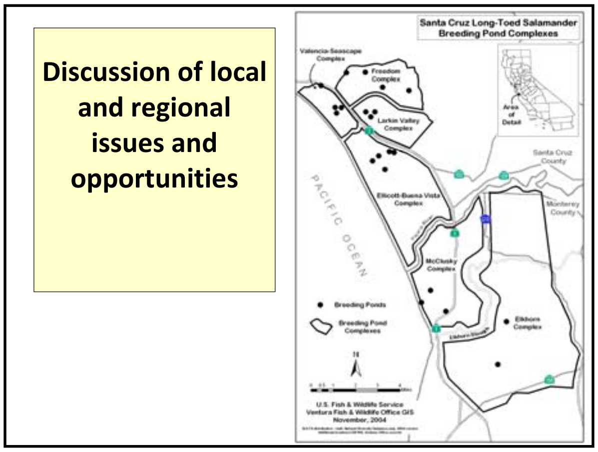
Population and Landscape Summary

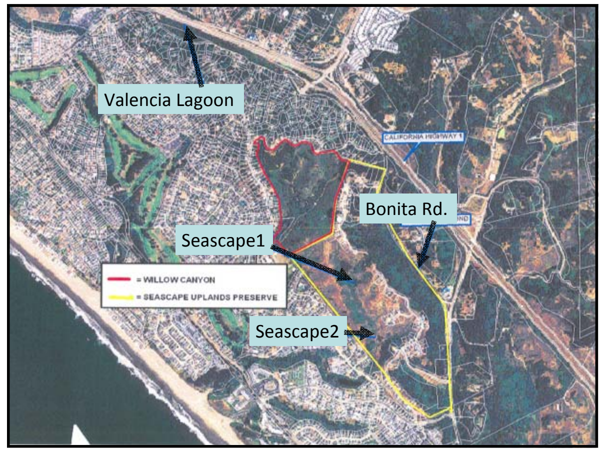
- SCLTS are capable of producing impressive numbers of offspring, given the right habitat conditions
- Some individuals can live 10 (?) years (unk.)
- Most don't survive (hatching, metamorphosis)
- Population size is more sensitive to upland survival than to larval survival
- Given good habitat, even single breeding ponds may be able to support viable populations…
  - but is this viable for long term management goals?

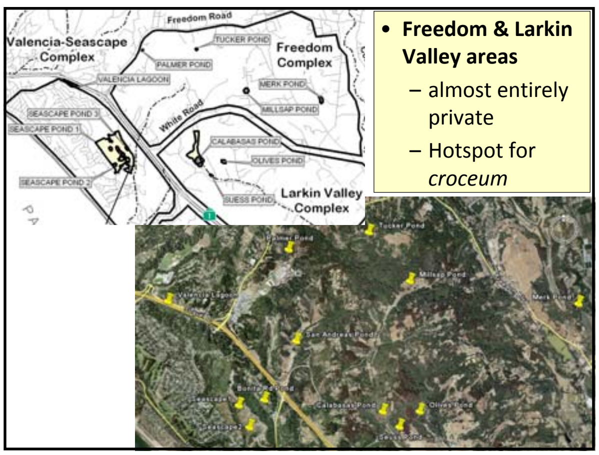
Main Conservation Issues

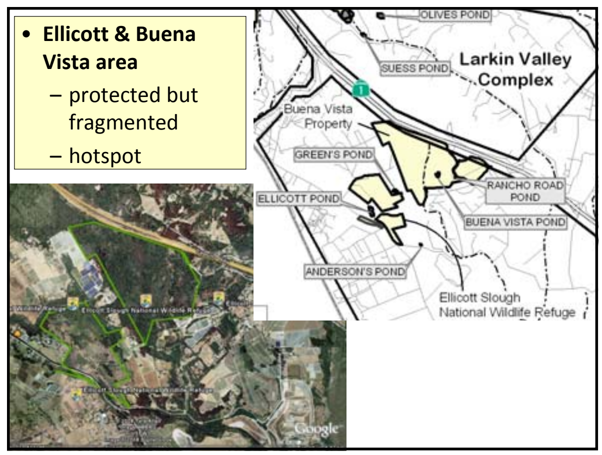
- Few sites (~20 known breeding sites)
- Breeding habitat degradation
  - siltation, water quality, water supply
- Extreme conversion of upland habitat
- Habitat fragmentation/isolation
- Roads (fragment habitat and increase mortality)

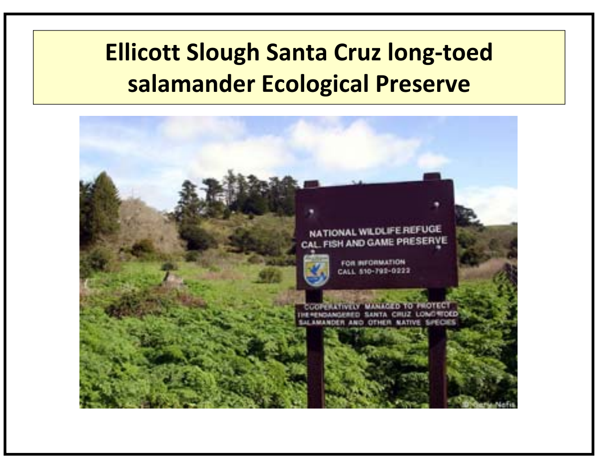
- Other issues
  - Predators (fishes, bullfrogs, crayfish)
  - Malformations
  - Bd (chytrid fungus)
  - Contaminants (pesticides, runoff from roads)


Discussion of local and regional issues and opportunities
Santa Cruz Long-Toed Salamander Breeding Pond Complexes
PACIFIC OCEAN

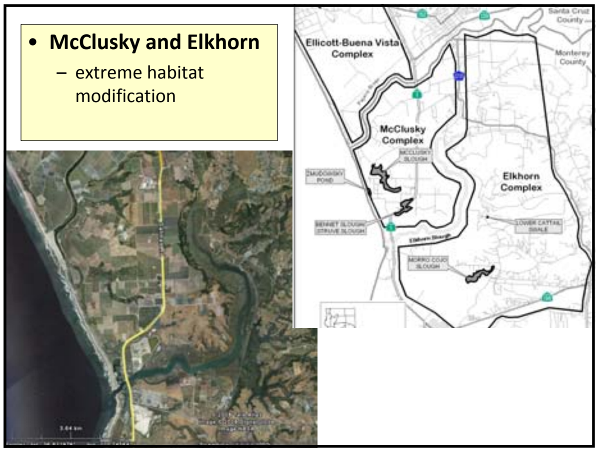

Valencia Lagoon
Bonita Rd.
Seascape1
Seascape2
= WILLOW CANYON
= SEASCAPE UPLANDS PRESERVE


Freedom Road
Valencia-Seascape Complex
Freedom Complex
Larkin Valley Complex
White Road
• Freedom & Larkin Valley areas
– almost entirely private
– Hotspot for *croceum*


• Ellicott & Buena Vista area
– protected but fragmented
– hotspot
Larkin Valley Complex
OLIVES POND
SUESS POND
Buena Vista Property
GREEN'S POND
ELLICOTT POND
RANCHO ROAD POND
BUENA VISTA POND
ANDERSON'S POND
Ellicott Slough National Wildlife Refuge

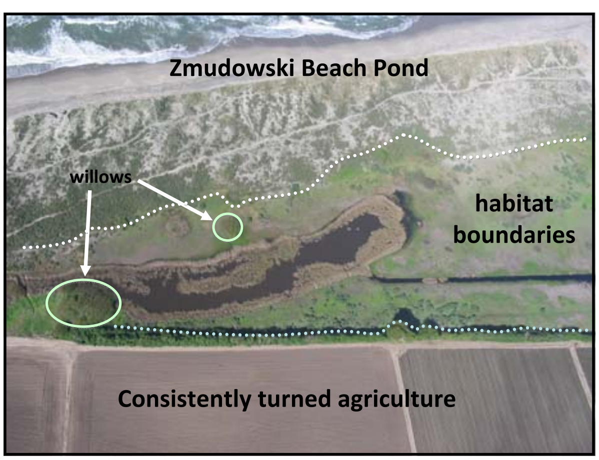

Ellicott Slough Santa Cruz long-toed salamander Ecological Preserve
NATIONAL WILDLIFE REFUGE
CAL. FISH AND GAME PRESERVE

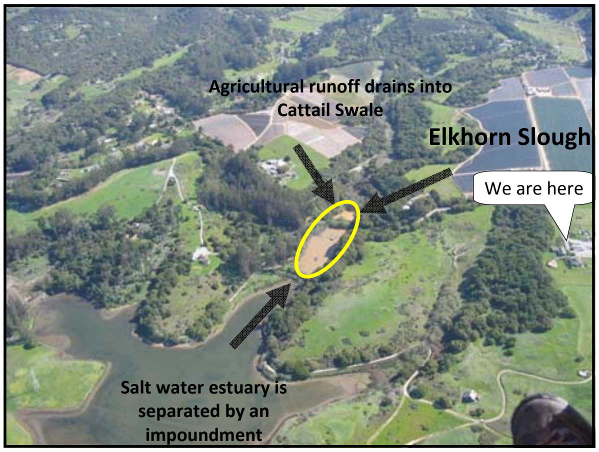

Buena Vista Pond (dried up)
Ellicott Slough Pond (dried up)


• McClusky and Elkhorn
– extreme habitat modification
Ellicott-Buena Vista Complex
McClusky Complex
Elkhorn Complex


McCluskey Slough
Zmudowski Pond
Bennett Struve Pond
Extinct population?
Lower Cattail Swale
Elkhorn Slough
Moro Cojo


McCluskey Slough
Zmudowski Pond
Bennett Struve Pond


Zmudowski Beach Pond
willows
habitat boundaries
Consistently turned agriculture



Avoidance and Minimization

- Habitat management issues: discing, mowing, burning, trenching, herbicides, agriculture, pond repair, road maintenance, irrigation, etc.
- Upland habitats
  - Avoid burrows and any cracks/crevices if possible
  - Limit activities to daylight hours
  - Limit activities to dry season
  - Disturb only part of site at a time, including pond area
- Aquatic habitats
  - Only conduct work after pond has dried (not a guarantee)
- Develop the beneficial effects of projects
  - Could the habitat be improved as a result of the project?

Conservation Strategies

- Protect/enhance occupied landscapes
  - As large as possible, given restricted range of SCLTS
  - Consider the benefits of additional breeding habitat
- Maintain habitat connectivity
  - Minimize effects of new or improved roads
  - Minimize barriers: agricultural canals/ponds/fields, train tracks (e.g., Ellicott); large-scale development that consumes natural habitat
- Create new corridors
  - Enhance potential for movement

Managing Aquatic Habitat for SCLTS

- Create additional ponds (e.g., Seascape)
- Eliminate predators by drying (e.g., Tucker Pond)
- Modify/manage pond to make long lasting, but ephemeral
- Maintain existing berms/remove excessive siltation (e.g, Ellicott drying)
- Allow modest livestock grazing (esp. vernal pools) to remove vegetation *in* ponds

SCLTS Basics - Review

- Aquatic Habitat – breeding
  - Ponds *should* be temporary, but not too temporary
  - Larger, longer lasting ponds are better
- Upland Habitat – the rest of their lives
  - On land occupy terrestrial burrows & crevices
  - ~2-5 year sub-adult phase
  - Move hundreds of meters from ponds
- Landscape Considerations
  - More ponds = more security against local extinction
  - Ideally want ponds separated by <<2 km for movement
- Weather/Rainfall
  - drives migrations and population dynamics

Summary elements I

- Due to restricted range and the small number of sites, impacts to populations likely to reduce recovery potential
- Maintaining large areas of continuous or interconnected habitat is critical
- SCLTS is primarily terrestrial, but breeding ponds are essential
- SCLTS are present in uplands year-round, and dispersed across regional uplands

Summary elements II

- At least a 0.25 mile buffer around breeding habitats is a starting point for population protection (not avoidance) (Trenham)
- Upland habitat is not simply aestivation habitat
- Ponds should regularly hold water until **at least through June**
- Large ponds are critically important for population sustainability
- Permanent ponds are not usually good (fish & non-natives)
- Habitat loss and fragmentation are the main threats

Additional Issues – Discussion Topics

- Monitoring SCLTS populations
- Metapopulation dynamics
- Mosquitofish (catfish, other spp.)
- Climate variation
- Species range
- CNDDB records
- **QUESTIONS?**

Advice For FWS, CA DFG Reports (CNDDB)

- **Provide Complete Information**
  - Dates, times, and coordinates of sampled site
  - Rainfall/temperature data for area during study period
  - Records of all animals (& life stages) captured/observed
  - Photographs of representative specimens
  - Photographs of sampling apparatus
  - Records of all communications with FWS, DFG
  - For aquatic sampling calculations of the total effort expended/area covered each time

Workshop Acknowledgements

- **Grey Hayes and Elkhorn Slough Foundation**
- **David Laabs, Mark Allaback, Dana Bland**
- **DFG and FWS personnel**
- **You, the participants**
- **ESA 1973**