

Survival & Migratory Patterns of Central Valley Juvenile Salmonids

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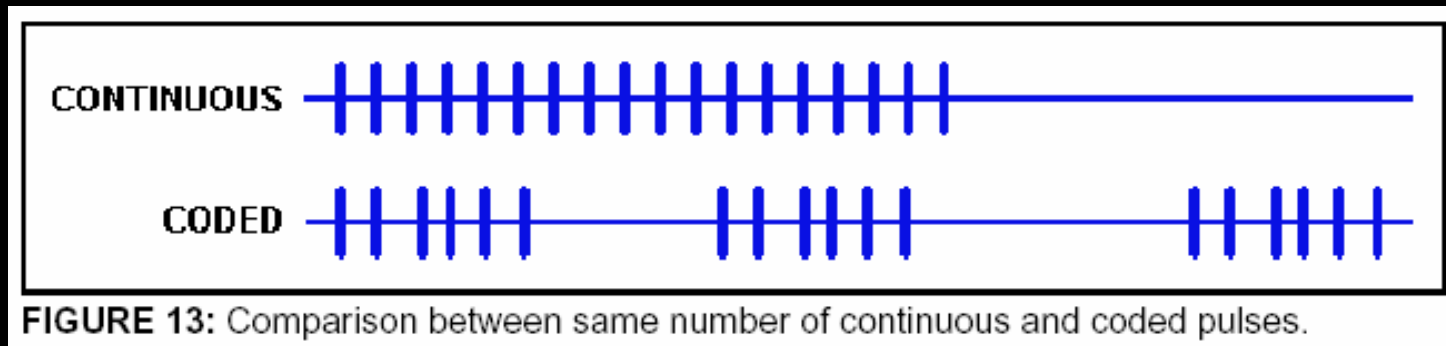
Objectives

1. Describe reach-specific rates of survival and movement
2. Explain variations in these rates

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- Species: steelhead,
late-fall Chinook salmon
 - Origin: Coleman Nat'l Fish Hatchery
 - Life Stage: smolts (yearling)
 - Years: 2007-2009

The Vemco technology

Transmitter Types:



Random Off Times:

Increased battery life

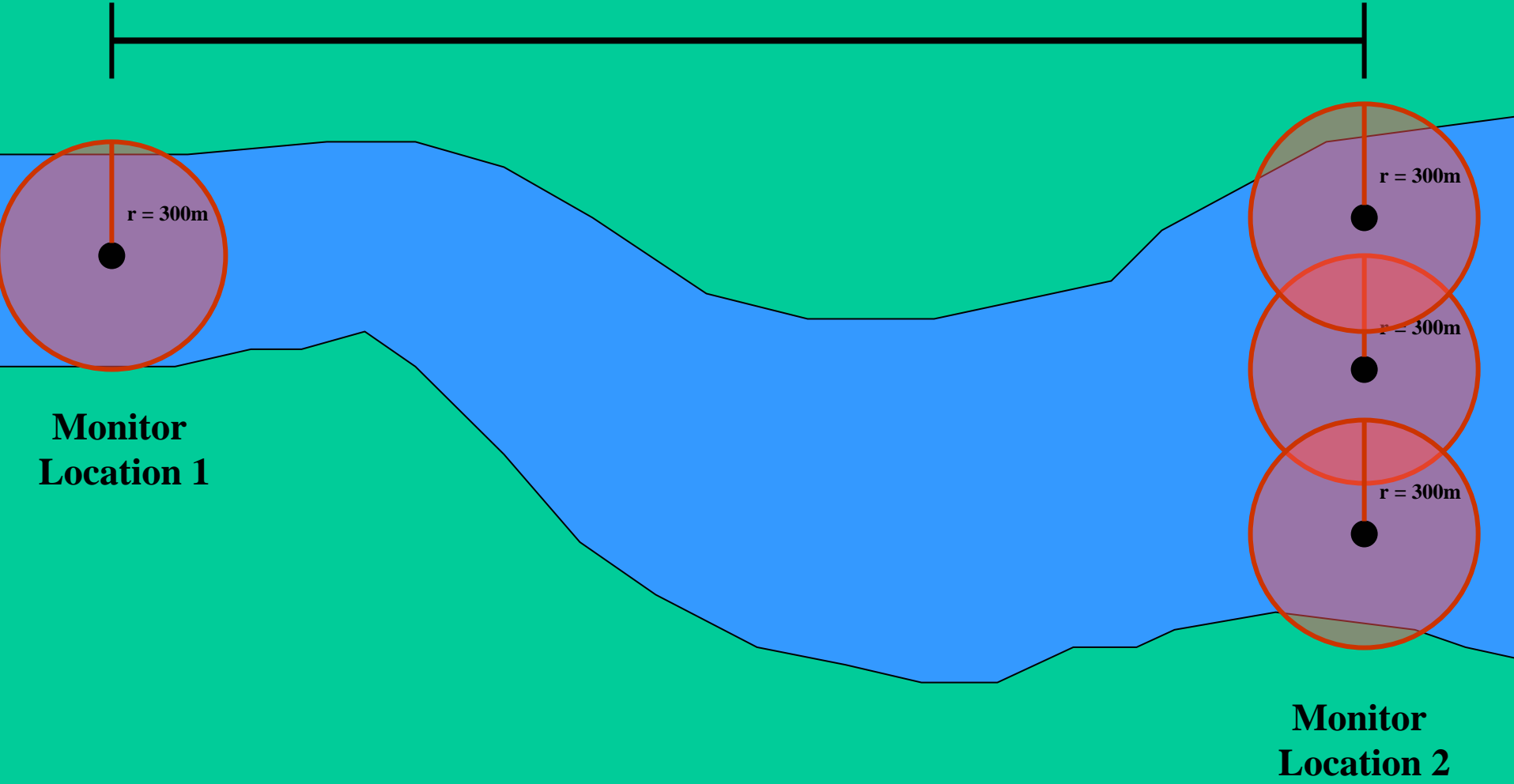
Allows multiple detections at one receiver

The Vemco technology

- **Ultrasonic transmitters**
 - Very small (7mm dia x 20mm, ~2g in air)
 - Uniquely coded
 - Battery life of 44-160 days
 - 69kHz works in fresh and salt water
 - Surgically implanted
 - Vemco V7 tag (~\$300 each)
- **Automated receivers**
 - Records tag number and time
 - Range of up to 300m
 - Easy to deploy and recover
 - 12-15 mo battery life
 - Vemco VR2 (~\$1,000 each)
 - Temperature logger at each location



Reach



Advantages of proposed system:

- Ease of “recapture”
- Inexpensive monitoring stations that work unattended for months at a time
- Tags are individually coded
- Open expandability

Overall: Movement and survival rates can be determined at a very fine scale (river segments)

Disadvantages of proposed system:

- Tags small, but could be smaller (max FL ~ 120mm)
- Each tag is relatively expensive ~ \$300
- Must retrieve receivers to get data

Overall: Relatively few fished tagged but potentially yielding large amounts of information

Movement

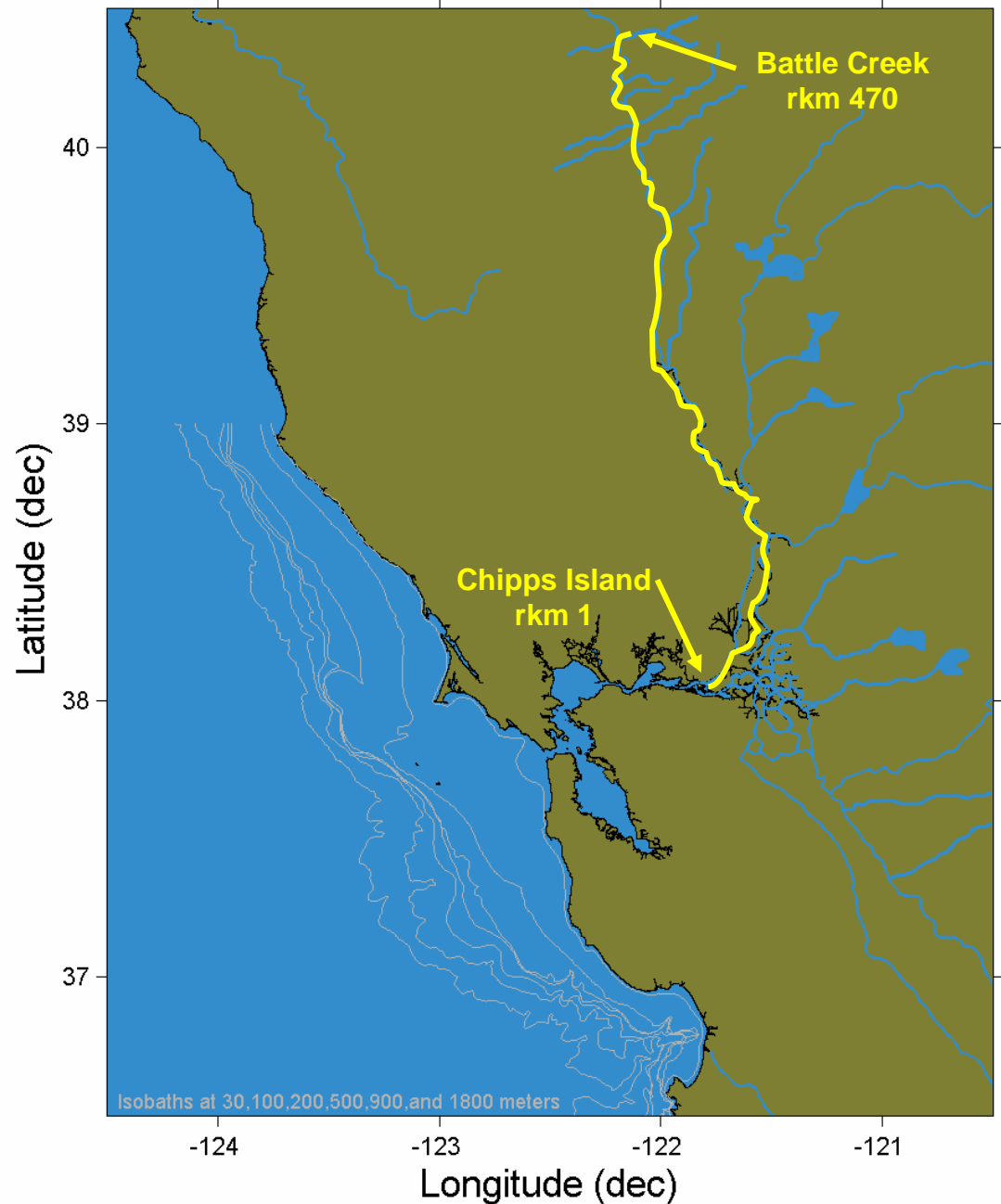


Late-fall juvenile Chinook salmon released at Battle Creek and recovered at Chipps Island*

1998 – 2003 Years
835 CWT fish recovered
Travel Time:
Mean of 22.5 days
Range of 5-150 days
Recovery Fork Length:
140.8 mm (15.8 mm SD)

Migration Rate = 20.9 km/d

Data from:
Bay Delta and Tributaries (BDAT) Project
<http://baydelta.water.ca.gov/>



Movement

Fall-run juvenile Chinook Salmon Transit Time (days)

$$\frac{\bar{x} \text{ age (km 3)} - \bar{x} \text{ age (km 68)}}{\text{transit time}}$$

1995 - 28
1996 - 24
1997 - 40*
1998 - 8
1999 - 28
2000 - 22
2001 - 21

Migration Rate:

1.6 - 3.1 (8.1) km/d

*(MacFarlane & Norton 2002)



Map courtesy USGS and PG&E

Survival



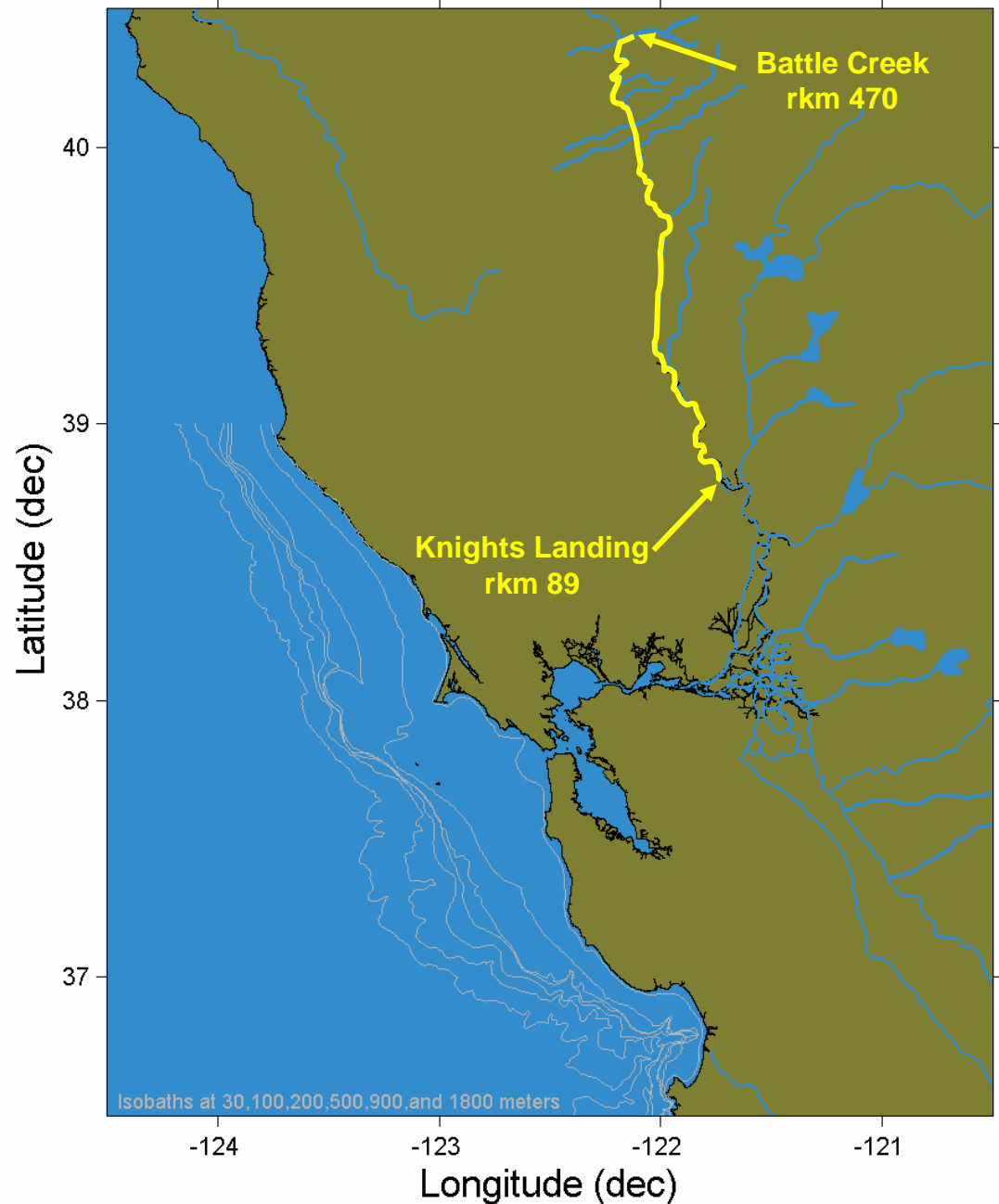
Late-fall juvenile Chinook

Snider & Titus 2000

- Battle Creek to Knights Landing (180 rkm)
- CWT, RST and trap efficiency
- Estimated 2.3%
- Underestimate – unknown portion of fish diverted thru Sutter Bypass at high flows

Brandes and McLain 2001

- Survival Index lower if fish migrated through Interior Delta



Central Valley Salmonid Juvenile Movement and Survival: Some current knowledge

From release to ocean

Sac R. SF Estuary

Chinook Salmon

Estimated time: 22.5 d 40 d

Estimated survival: (>) 2.3% ?

Transmitter battery life > 63.5 days

Movement



Yearling steelhead released at Bend Bridge and recovered at Chipps Island*

2000 – 2003 Years
53 CWT fish recovered
Travel Time:

Mean of 54.4 days

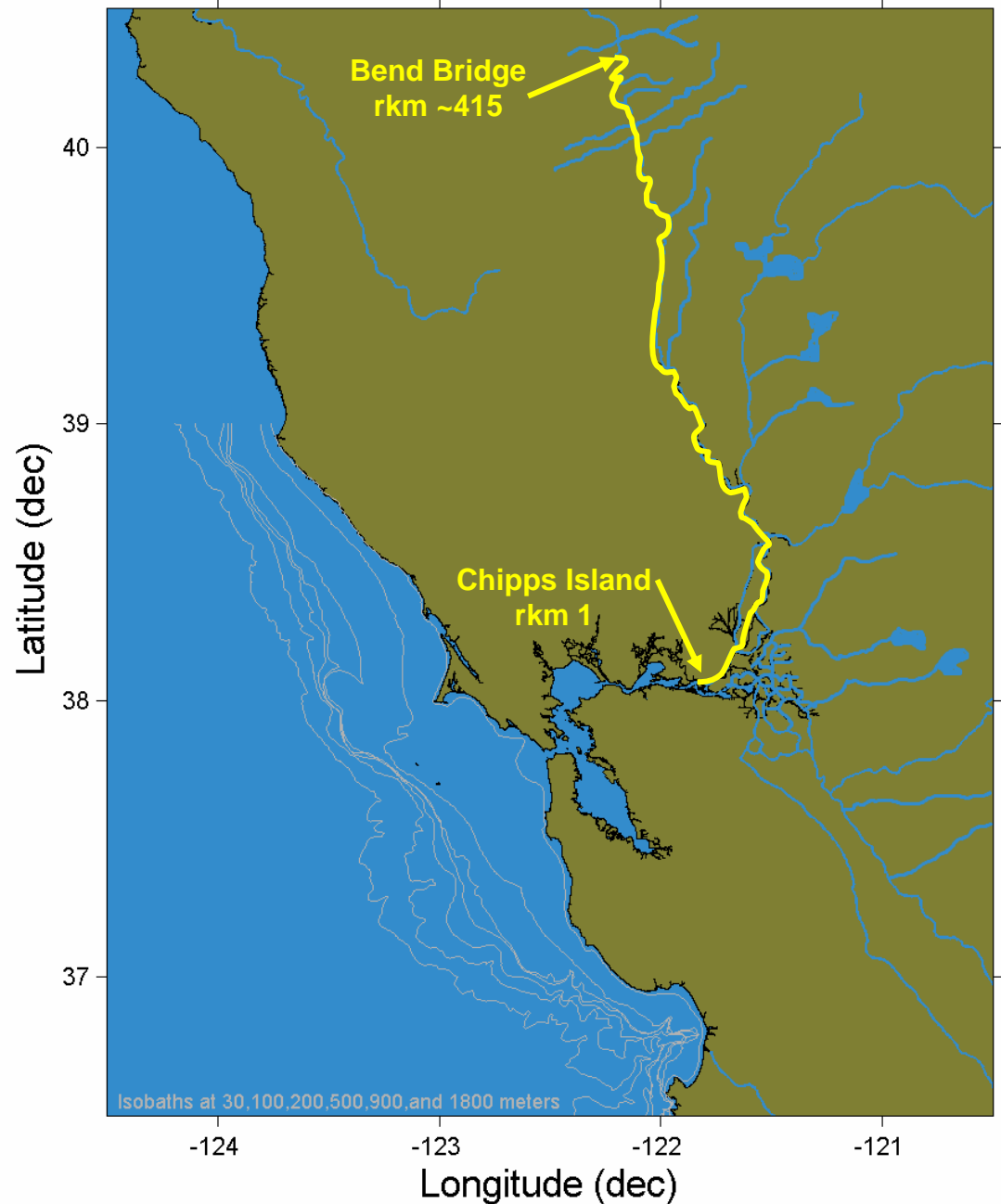
Range of 11-123 days

Recovery Fork Length:

225.3 mm (24.3 mm SD)

Migration Rate = 7.6 km/d

Data from:
Bay Delta and Tributaries (BDAT) Project
<http://baydelta.water.ca.gov/>



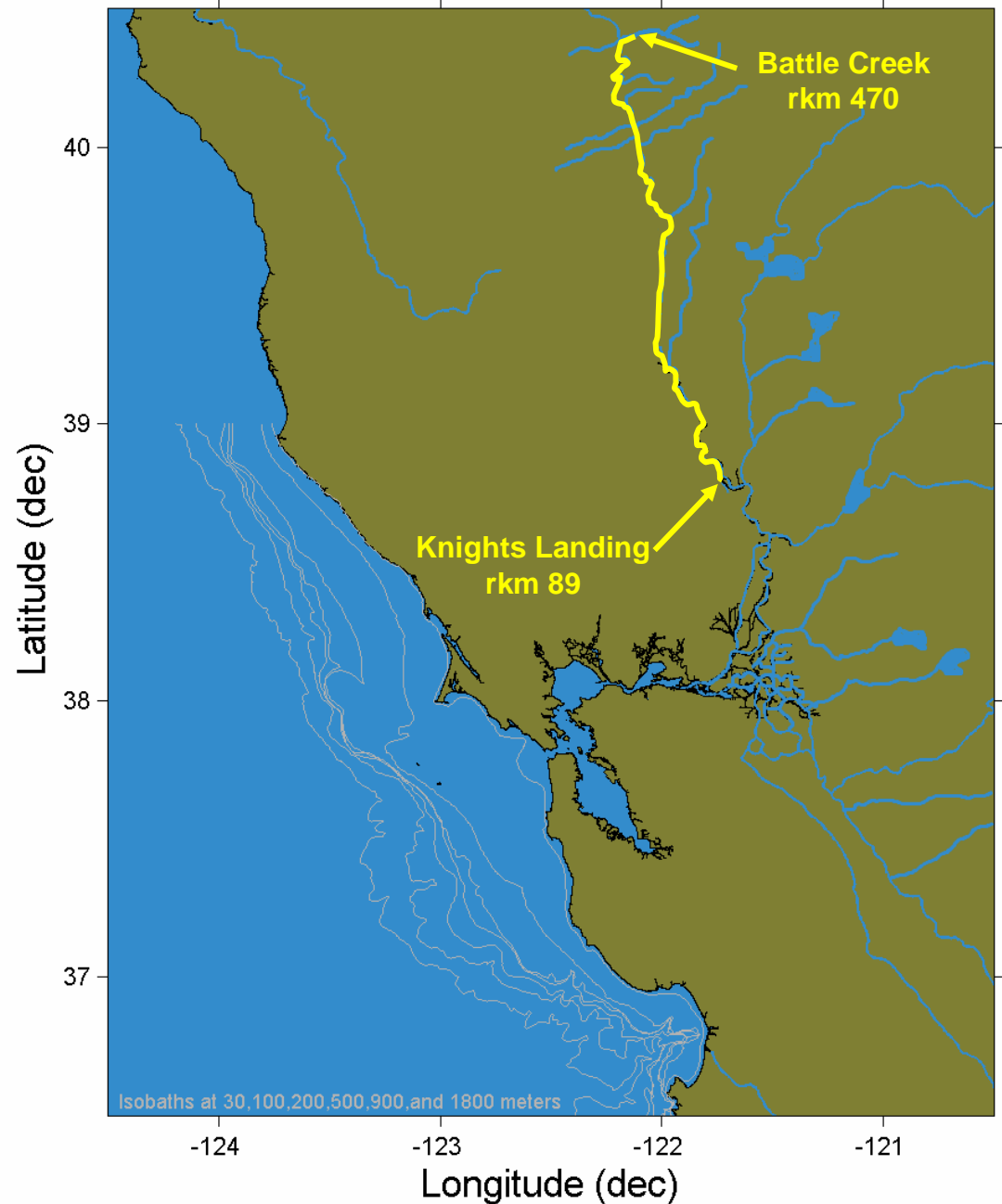
Survival



Yearling Steelhead

Snider & Titus 2000

- Battle Creek to Knights Landing (180 rkm)
- CWT, RST and trap efficiency
- Estimated 4.1%
- Underestimate – unknown portion of fish diverted thru Sutter Bypass at high flows



Central Valley Salmonid Juvenile Movement and Survival: Some current knowledge

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Yearling steelhead

Estimated time: 54.4 d ?

Estimated survival: (>) 4.1% ?

Central Valley Salmonid Juvenile Movement and Survival: Some current knowledge

From release to ocean

Sac R. SF Estuary

Chinook Salmon

Estimated time: 22.5 d 40 d

Estimated survival: (>) 2.3% ?

Transmitter battery life > 63 days

Yearling steelhead

Estimated time: 54.5 d ~97 d

Estimated survival: (>) 4.1% ?

Transmitter battery life > 152 days

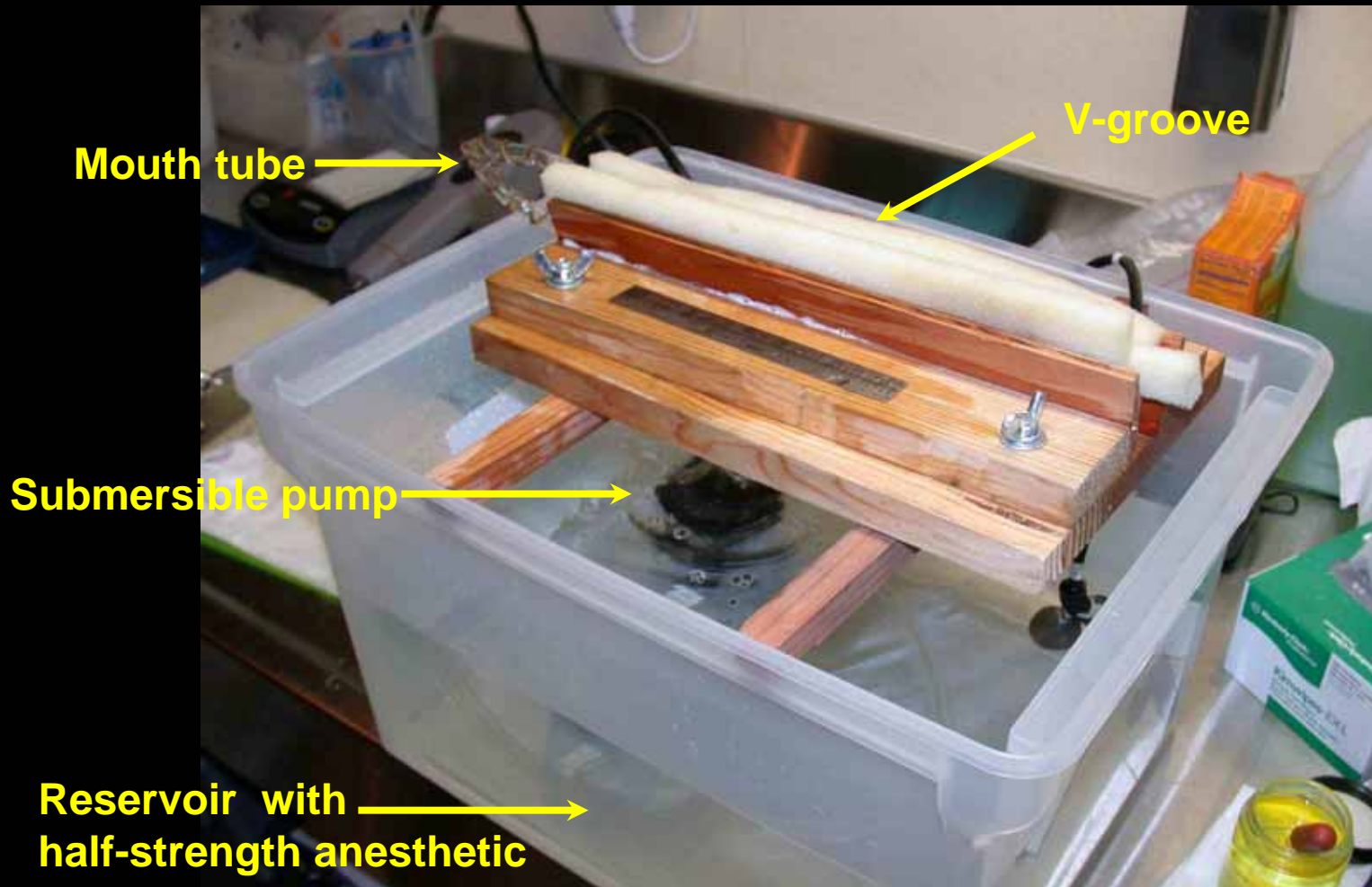
Battery life

Species	Fork Length (mm)	Weight (g)	Vemco Transmitter	Weight of Transmitter (g)	% of Body Weight	Life of Transmitter (30-90 sec)
Steelhead	190	78	V7-4L (7 x 20.5 mm)	1.8 (air)	2.3	177d
Late-fall Chinook	150	37	V7-1L (7 x 17.5 mm)	1.4 (air)	3.7	50d 61d*

*(@ 40-120sec)

Pilot Study: Surgically implanting transmitters

Prototype surgical table



Pilot Study: Surgically implanting transmitters



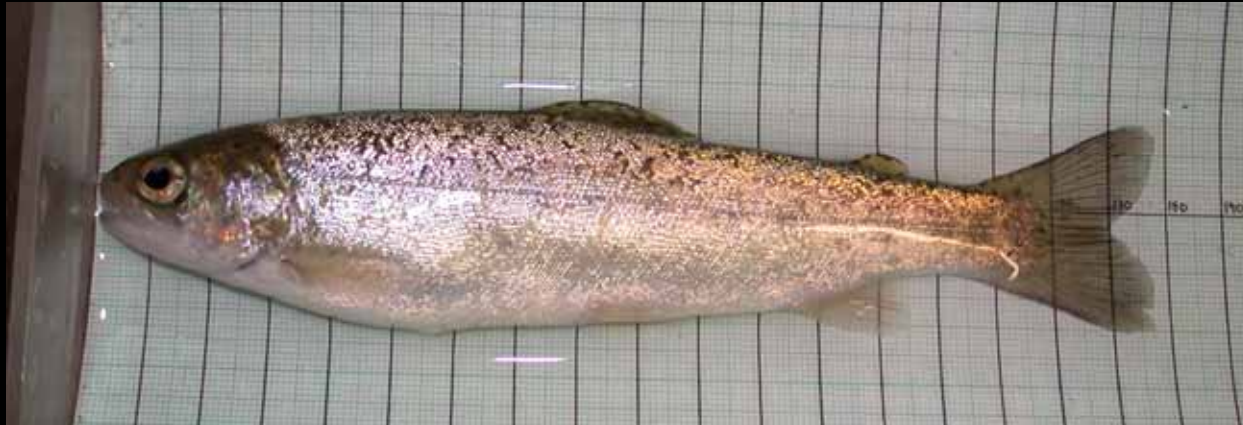
Pilot Study: Surgically implanting transmitters



Pilot Study: Surgically implanting transmitters



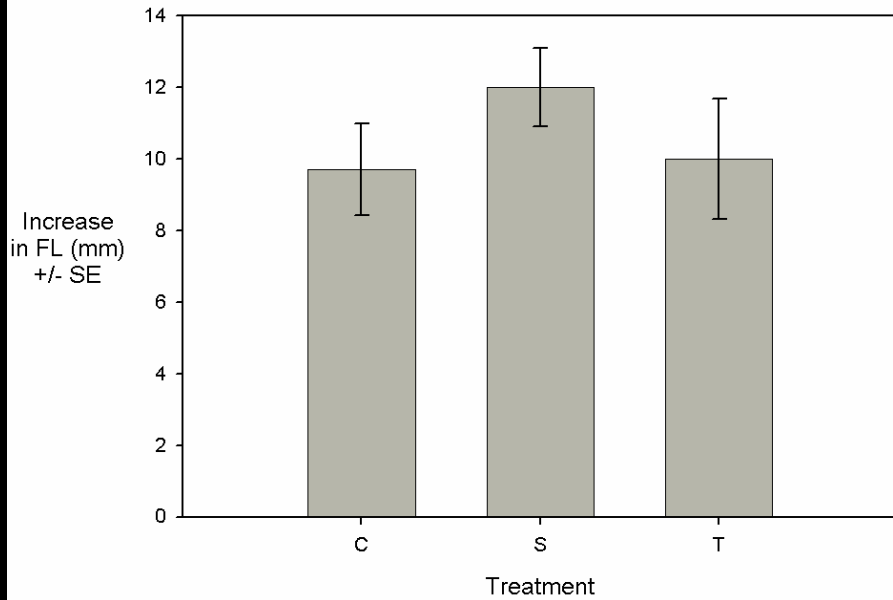
Pilot Study: Surgically implanting transmitters



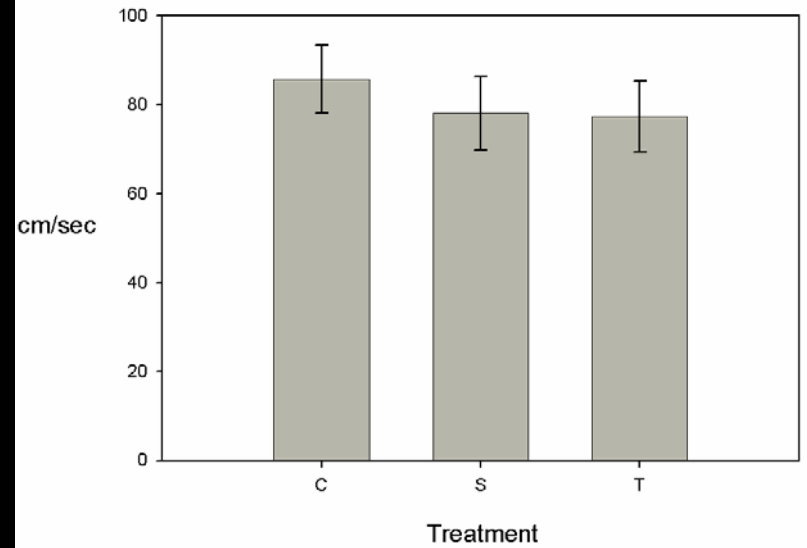
Steelhead 30-days after tag implantation

Pilot Study: Surgically implanting transmitters

Growth (FL) 30 days after surgery



Swimming Performance - Maximum critical speed

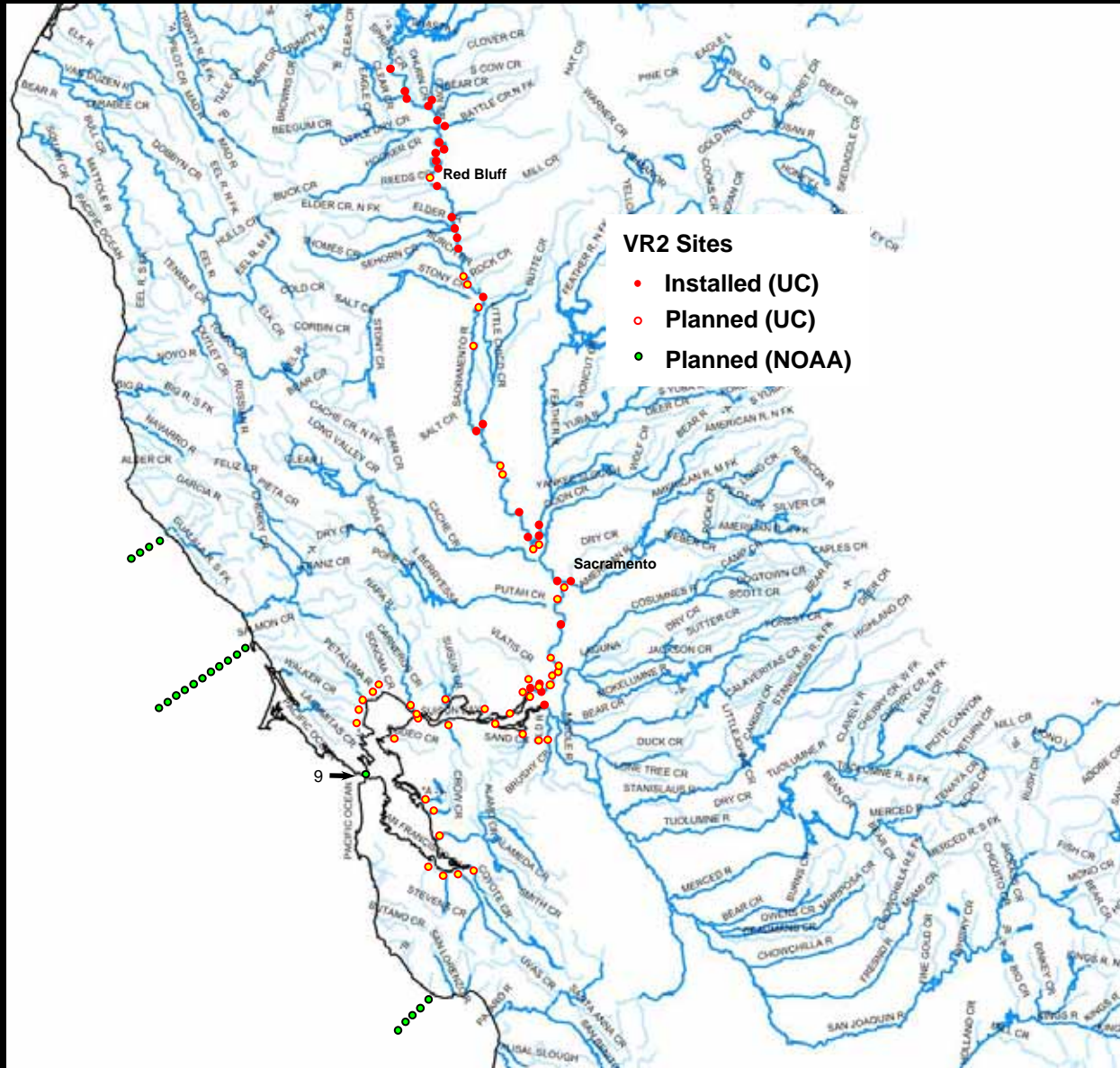


6 fish per treatment; ave FL = 160mm

Methods

- **Tag 200 Chinook and 200 steelhead per year for 2007, 2008, and 2009.**
- **Release 10 Chinook and 10 steelhead per day for 20 days during January**
- **Record reach-specific movement patterns and survival with over 70 monitoring locations from Battle Creek to Golden Gate**

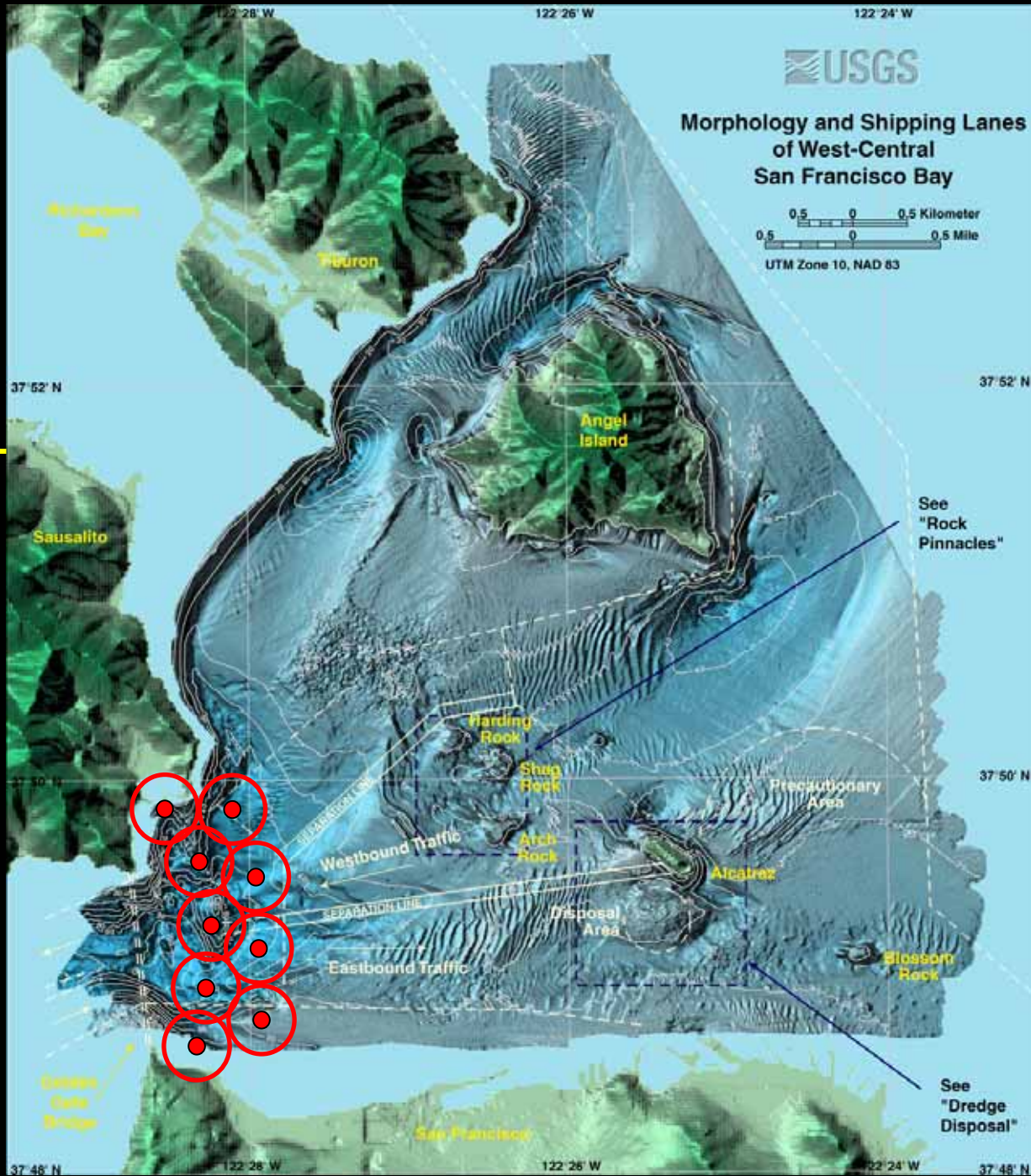
Monitor (node) Locations



Leaving the system:

The Golden Gate Line

- 9 VR2 receives
- Acoustic releases





Generalized Analysis: Movement

Question:

**Does migration rate vary among reaches,
and if so, why?**

Null: migration rates are constant

**Model migration rates and physical factors
using multiple linear regression**

Generalized Analysis: Survival

Question:

Does survival rate vary among reaches, and if so, why?

Detections arise from combined effect of:

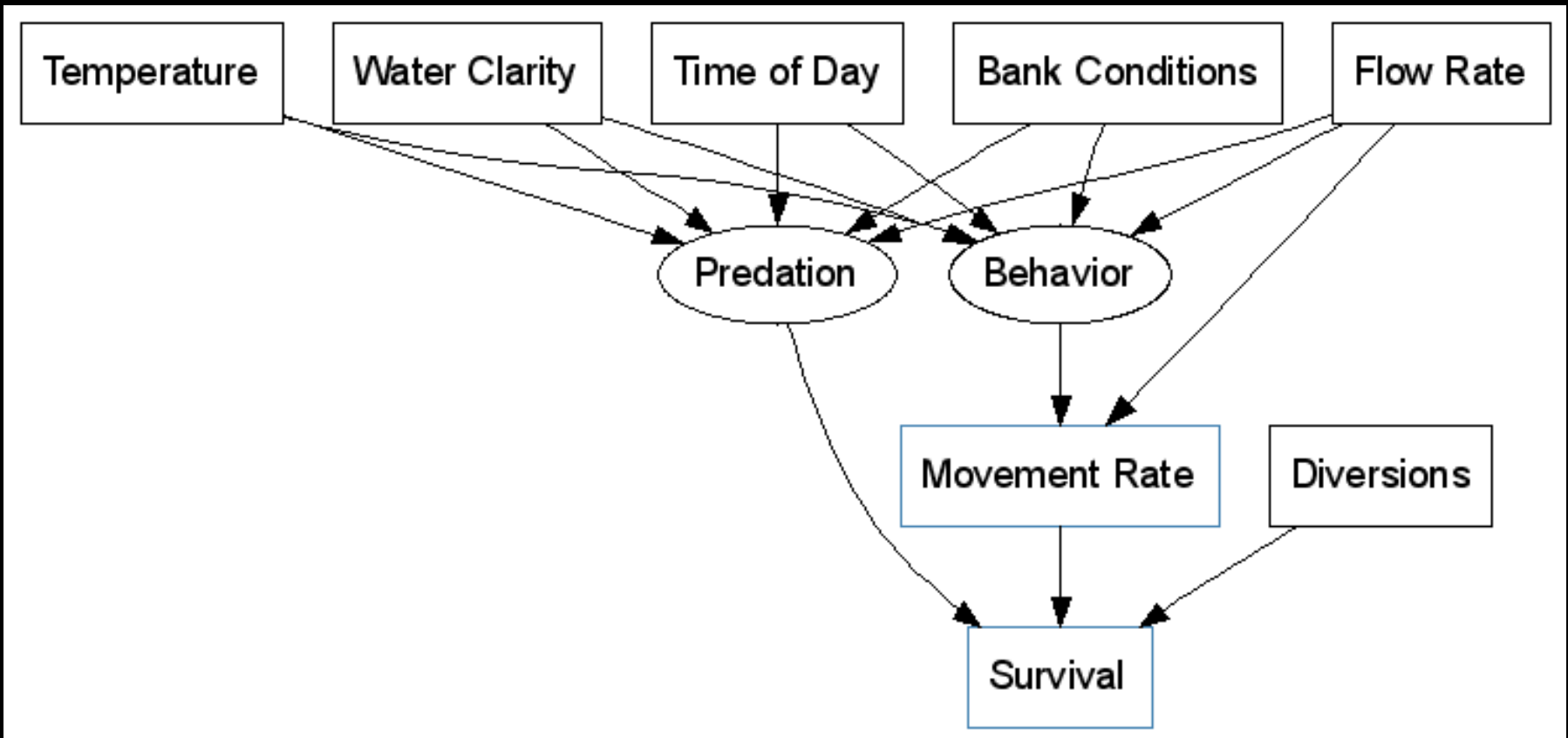
Probability of survival to that point

Probability of detection given survival

Infer probabilities using maximum likelihood method

Use standard mark recapture model such as Cormack-Jolly-Seber for multiple live recaptures

Model of factors that determine movement and survival



Sources for data on physical factors

Variable	Source	Description
Water velocity	USGS	model local velocities with gage data velocities
Water temperature	various UC Davis	hydrodynamic model outputs measured by each hydrophone mooring
Riparian vegetation	CDF	25 m resolution, derived from black and white air photos and Landsat TM
	ACoE	0.6 m resolution, derived from color air photos
Rip-rap	ACoE	0.6 m resolution, derived from color air photos

Dealing with 'What ifs?'

What if survival is really high?

Define longer reaches

What if survival is really low?

Release some groups well below Battle Creek

What if a fish gets eaten by a predator?

Tags 'behavior' may be unusual compared to most other tags – assume tagged fish was eaten

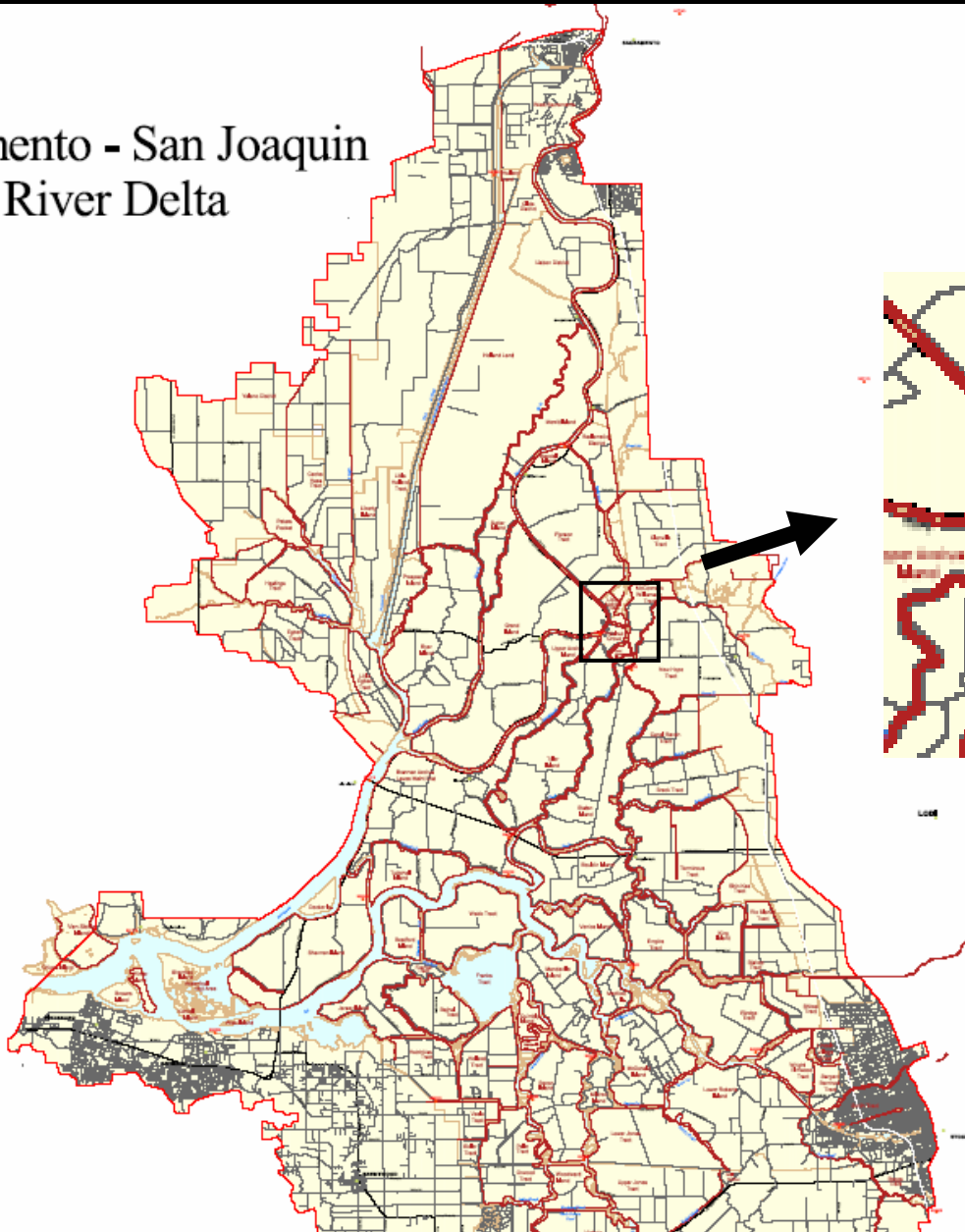
Future Conclusions

More information on smolt migration and survival

A better understanding of sources and contributing factors to mortality (inferred)

A big first step

Sacramento - San Joaquin River Delta



The Delta



**The next big
step**