





Migration & Survival of Juvenile Salmonids in California's Central Valley & San Francisco Estuary

2007 & 2008
Data



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Objectives

(1) To determine survival & movement patterns of Central Valley juvenile salmonids (3 yrs: 2007 - 2009)

(2) Relate movement & survival to environmental factors

- **Species:** late-fall Chinook salmon, steelhead
- **Origin:** Coleman National Fish Hatchery
- **Life Stage:** smolts (yearling)

Collaborators



University of California, Davis
 Dept. Wildlife, Fish & Cons. Biology
 &
 NOAA, NMFS, SWFSC
 Fisheries Ecology Division

Natural & Anthropogenic Influences,
 Battle Creek to Golden Gate



U.S. Army Corps of Engineers,
 San Francisco, CA

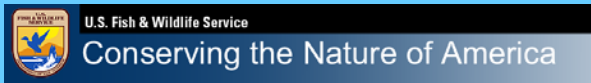


Bay Planning Coalition,
 San Francisco, CA

Dredging & Disposal,
 San Francisco Estuary



ECORP Consulting, Inc.,
 Rocklin, CA



U.S. Fish & Wildlife Service,
 Stockton, CA

Water Exports & Pumping,
 Delta



CA Dept. Water Resources,
 Sacramento, CA



East Bay Municipal Utility District,
 Lodi, CA

Ecosystem studies & hatchery,
 Mokelumne River



Hanson Environmental, Inc.,
 Walnut Creek, CA

Sand mining,
 Rivers confluence

Collaborators (cont'd)



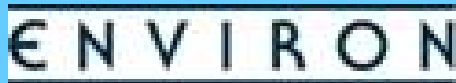
California Department of
Fish & Game

Ecological studies of steelhead &
resident rainbow trout in South Fork
of the Yuba River



H.T. Harvey & Associates

Impacts of levee repair in Delta
(contracted by DWR)



Environ Corporation

Fish behavior at artificial
reefs in San Francisco
Estuary

Movement Rate

[from CWT]

Late-fall Chinook:

Rate: $\bar{X} = 27 \pm 0.2$ km/d

(1.25 - 114 km/d)

Time: ~ 17 days to C.I.

[1993-2005, n = 7,189]

Steelhead:

Rate: $\bar{X} = 17 \pm 0.8$ km/d

(0.29 - 64 km/d)

Time: ~ 26.5 days to C.I.

[2000-2005, n = 242]



data from J. Speegle, U.S. FWS

Image by Tom Pearson

Fall Chinook 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

Transit Time:

24 ± 10 d [sd]

Migration Rate:

1.6 - 3.1 (8.1) km/d



Survival



CWT data: 2 - 4 % in Sacramento River

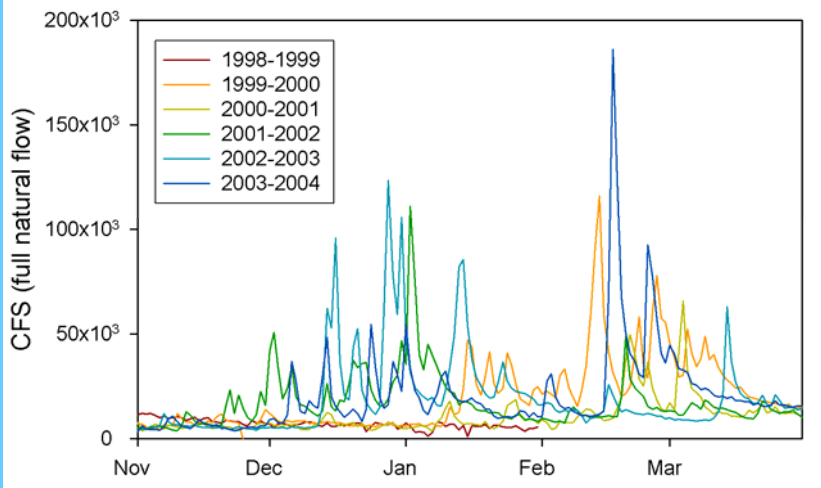
[Battle Crk - Knights Ldg (381 km)]

(Snyder & Titus, 2000)

Study Design

- Deploy receivers (Oct - Nov 2006)
- Surgically implant ultrasonic tags in fish (Dec-Jan 2007, 08, 09)
- Following holding period (survival, behavior, incision healing), release fish into Sacramento River
- Periodically retrieve data from receivers (~3 mo)
- Analyze data to:
 - determine survival and movement rates through system segments (river reaches, estuary bays)
 - identify important habitats (holding/nursery areas, high mortality)

Sacramento River at Bend Bridge (Full Natural Flow)

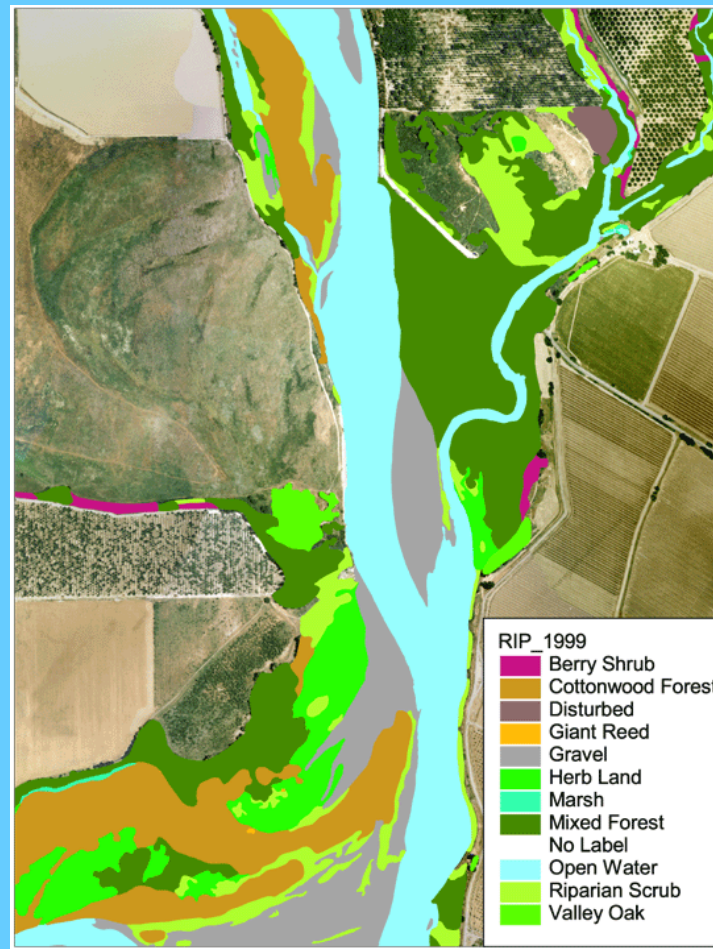


USGS flow data

● model effects of land use, water projects & hydrologic variables on survival & movement

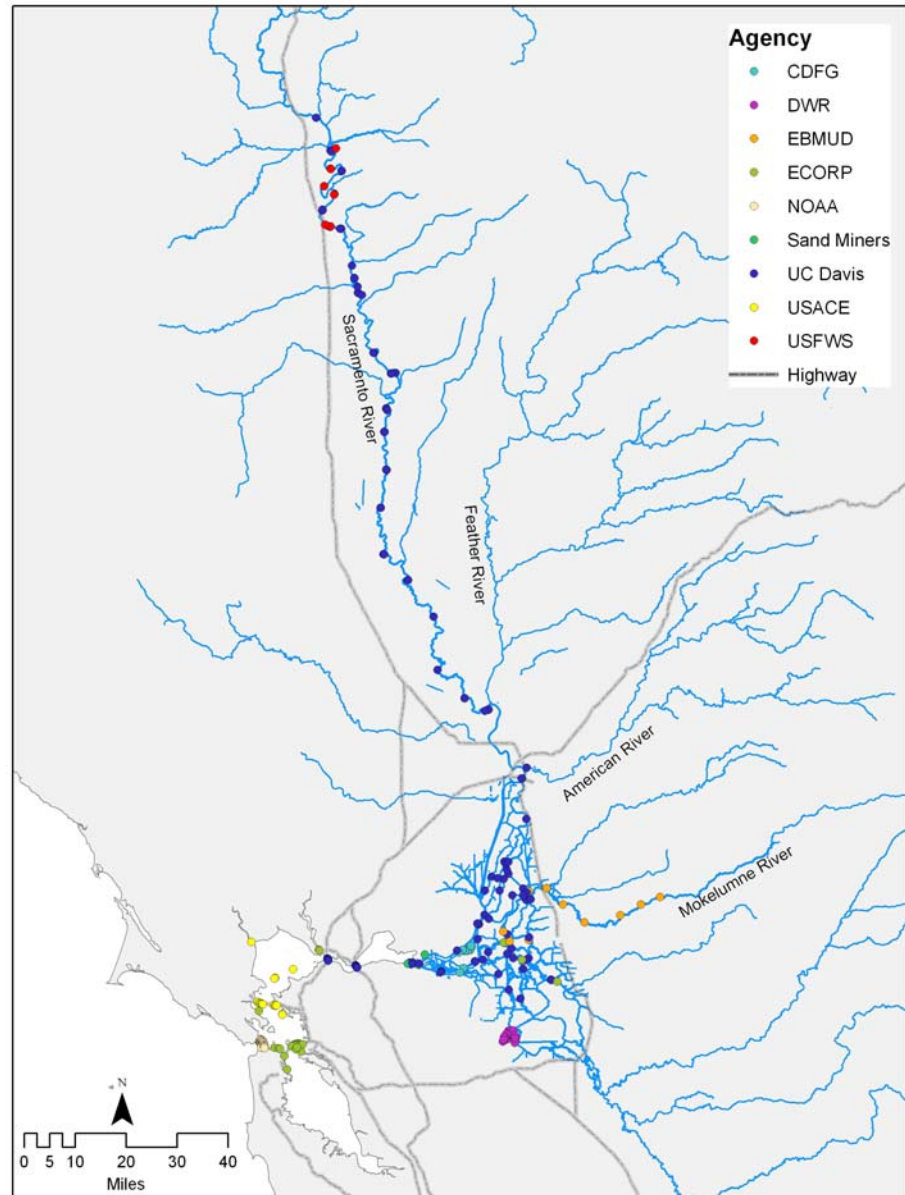


DWR Aerial photos

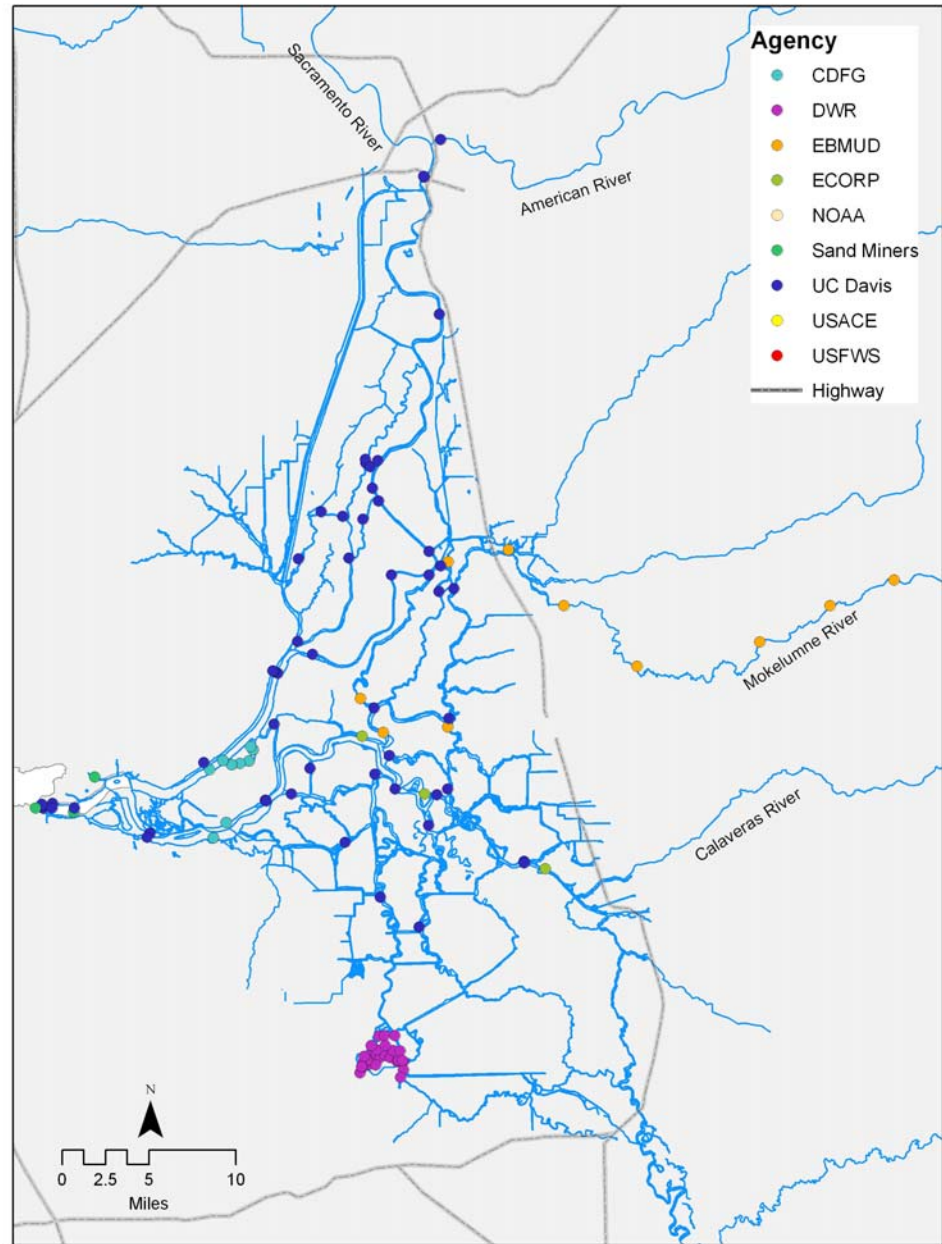


GIS CSU Chico

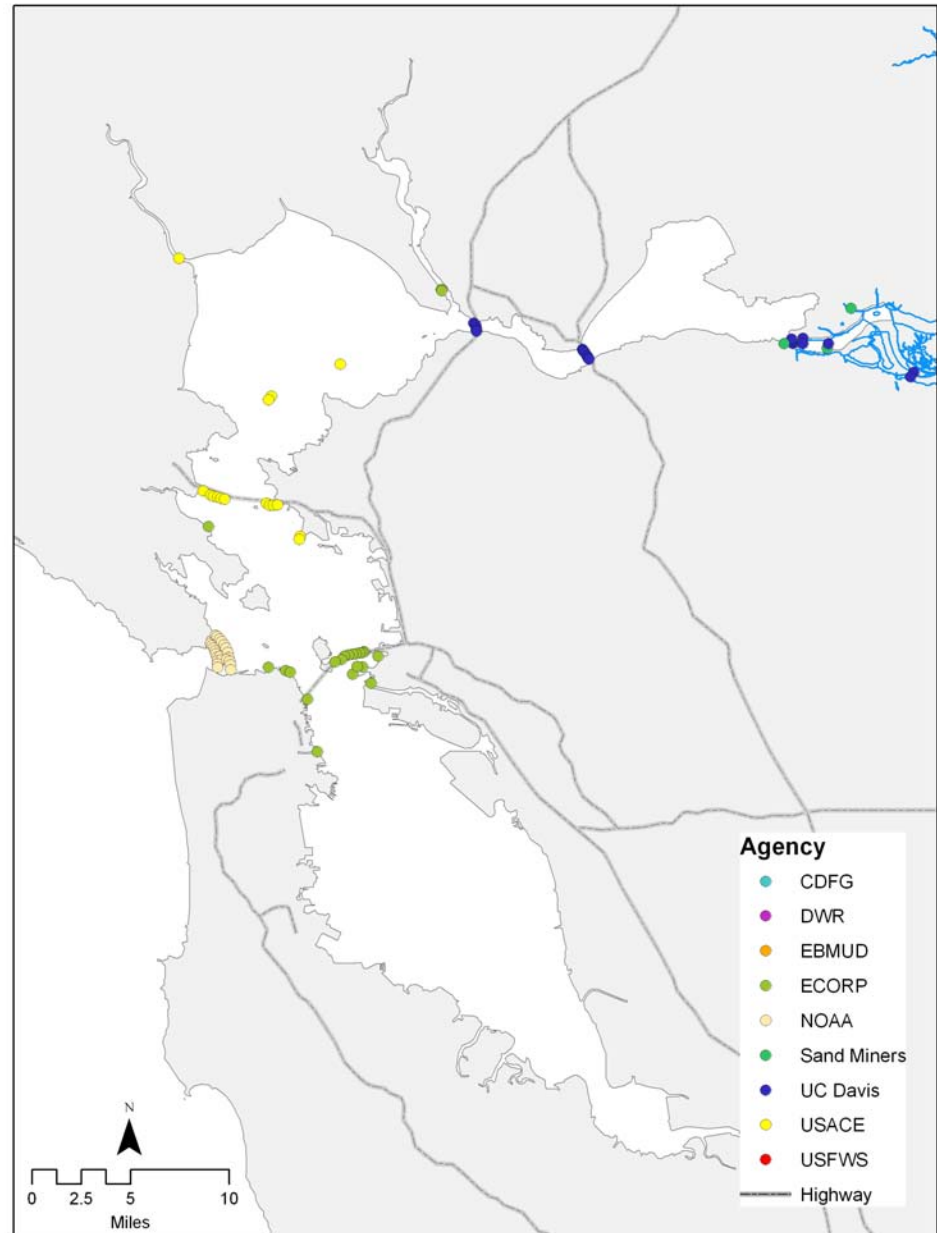
Receiver Locations



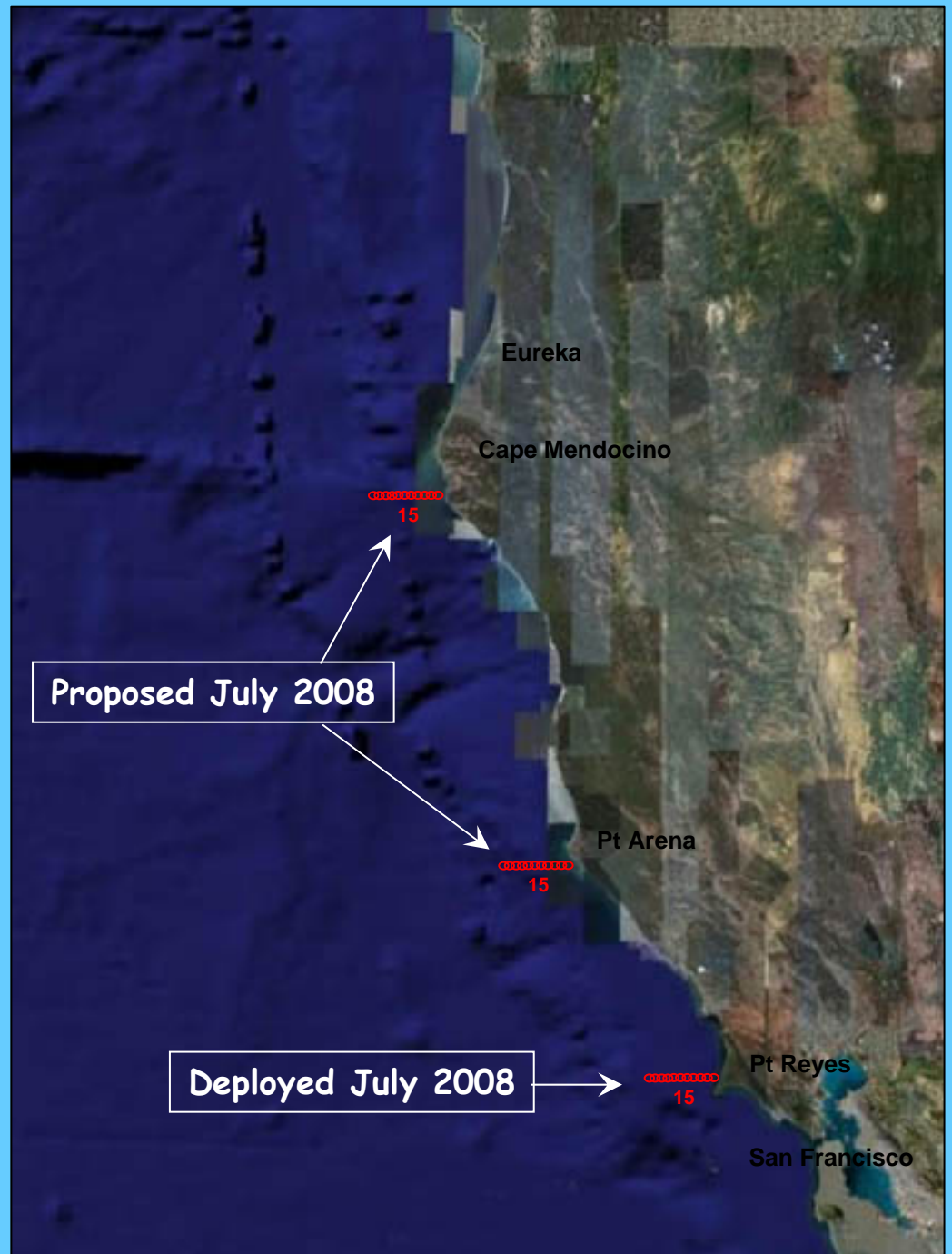
Receiver Locations [Delta]



Receiver Locations [San Francisco Estuary]



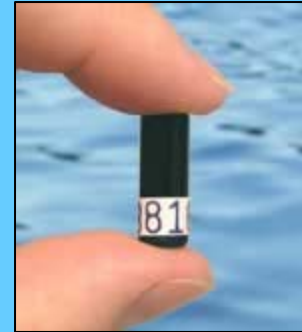
Ocean Receiver Locations



Vemco Technology

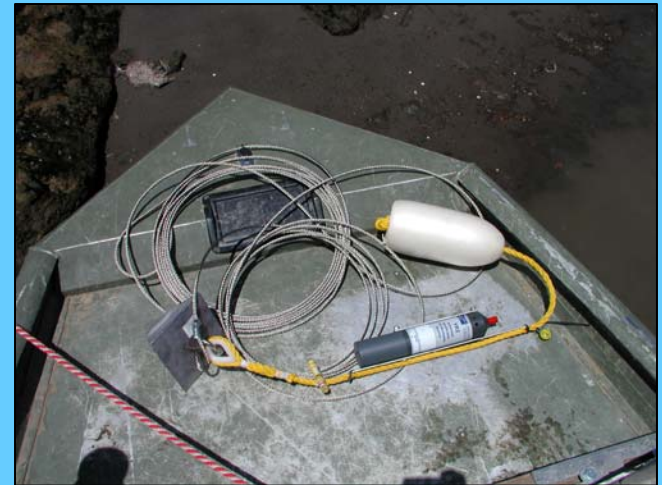
- **Ultrasonic transmitters**

- Very small (7-9mm dia x 18.5-24mm, ~2-4g in air)
- Uniquely coded signal
- Battery life of ≥ 95 -150 days
- 69kHz works in fresh and salt water
- Surgically implanted
- Vemco V7& V9 tags (~\$300 each)



- **Automated receivers**

- Records tag number and time
- Range of up to 300m, or more
- Easy to deploy and recover
- 12-15 mo battery life
- Vemco VR2 (~\$1,000 each)
- Temperature logger @ each site



Surgical Table

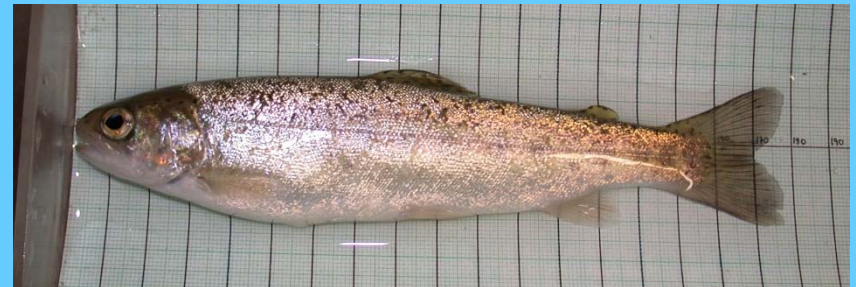


Mouth tube

V-groove

Reservoir with
half-strength anesthetic

Surgically implanting transmitters



Descriptive Salmon Statistics

Late-fall Chinook Salmon



	2007	2008
FL (mm)	165 (141-198)	169 (144-204)
Wt (g)	46.5 (22-82)	52.6 (31-102)
N	200	304
Tag wt (%)	3.4	3.2

Steelhead

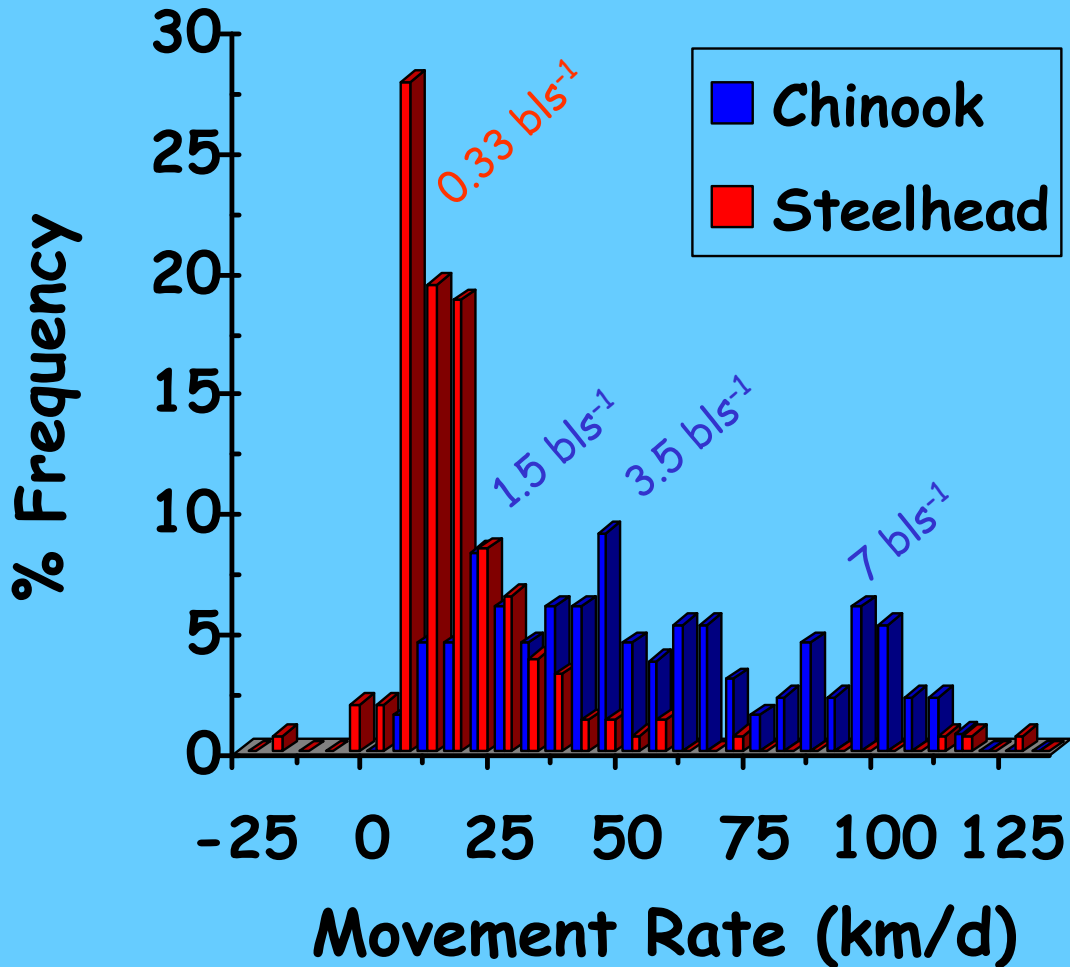


	2007	2008
FL (mm)	217 (158-264)	223 (138-262)
Wt (g)	112 (43-220)	117 (86-185)
N	200	304
Tag wt (%)	3.4	4.2

Movement Rate 2007

Battle Creek - Golden Gate

[520 km]



Chinook

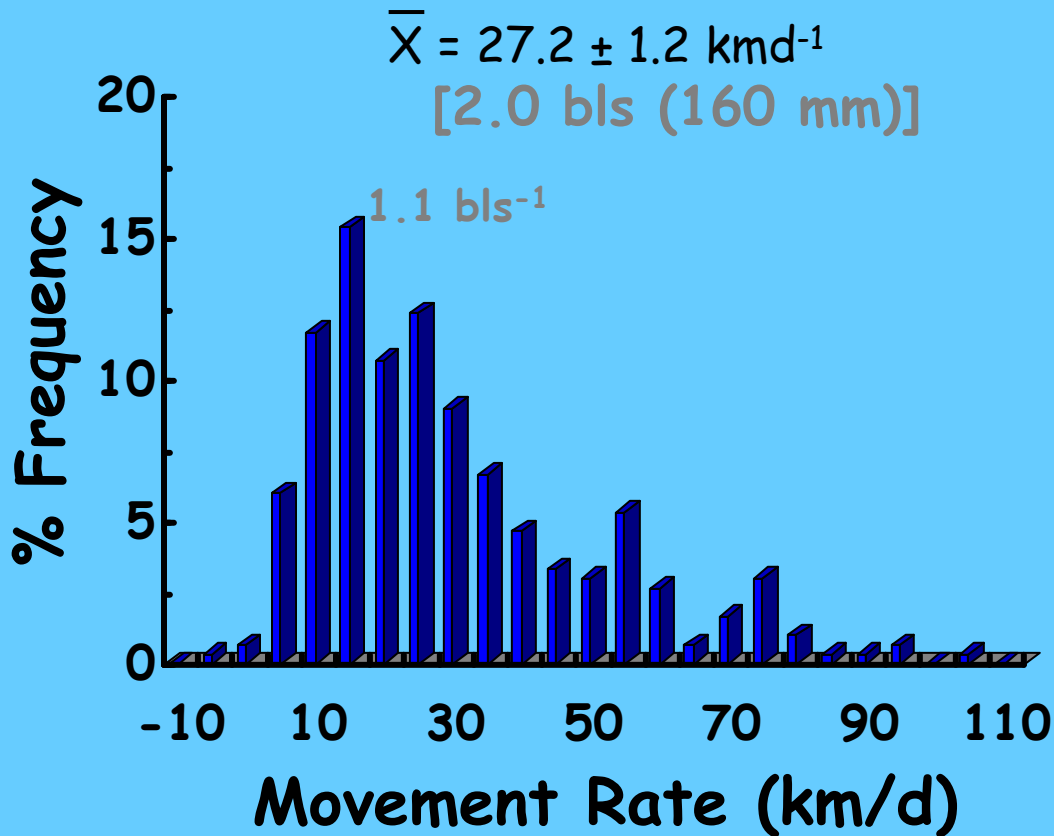
$\bar{x} = 50.7 \pm 2.6 \text{ km d}^{-1}$
 [3.7 bls⁻¹ (160 mm)]
 min: 1.3 km d⁻¹
 max: 111 km d⁻¹

Steelhead

$\bar{x} = 14.0 \pm 1.5 \text{ km d}^{-1}$
 [0.8 bls⁻¹ (200 mm)]
 min: -20.8 km d⁻¹
 max: 123 km d⁻¹

Chinook Movement Rate 2008

All Release Sites - Golden Gate



rkm 511

$\bar{x} = 37.8 \pm 2.5 \text{ km d}^{-1}$
[2.7 bls⁻¹ (160 mm)]
min: -4.4 km d^{-1}
max: 104 km d^{-1}

rkm 402

$\bar{x} = 24.8 \pm 1.7 \text{ km d}^{-1}$
[1.8 bls⁻¹ (160 mm)]
min: 1.1 km d^{-1}
max: 72 km d^{-1}

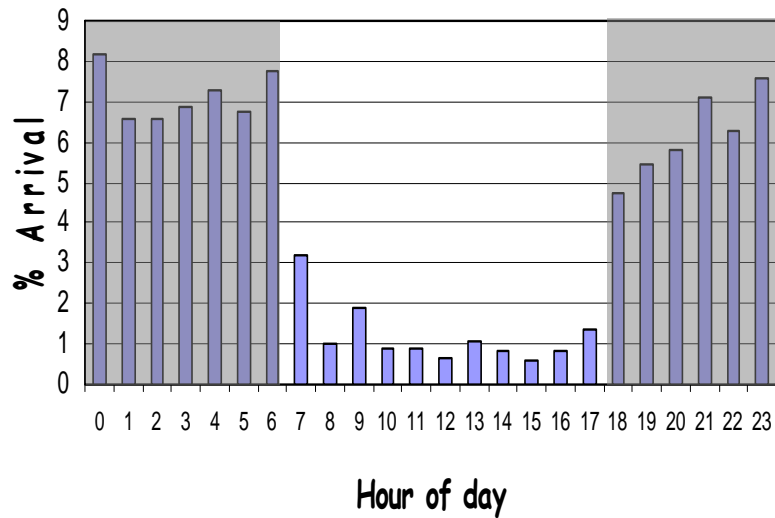
rkm 353

$\bar{x} = 18.9 \pm 1.3 \text{ km d}^{-1}$
[1.4 bls⁻¹ (160 mm)]
min: -6.5 km d^{-1}
max: 55 km d^{-1}

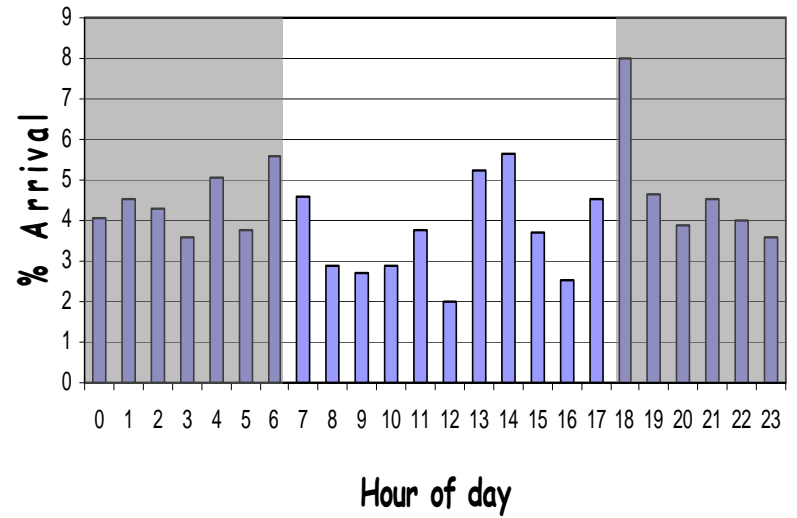
Movement Patterns

Diel Movements

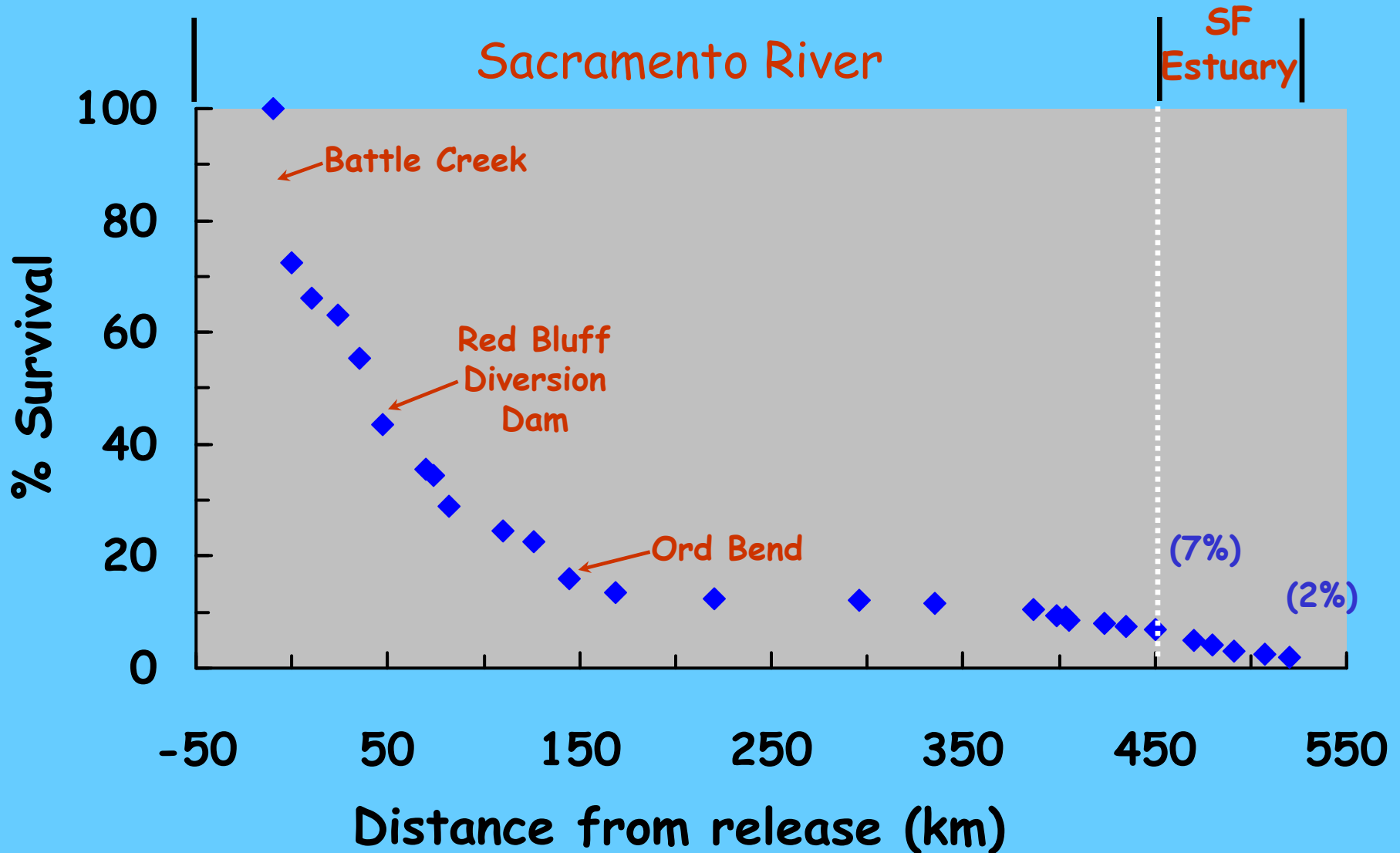
Late-fall Chinook Salmon



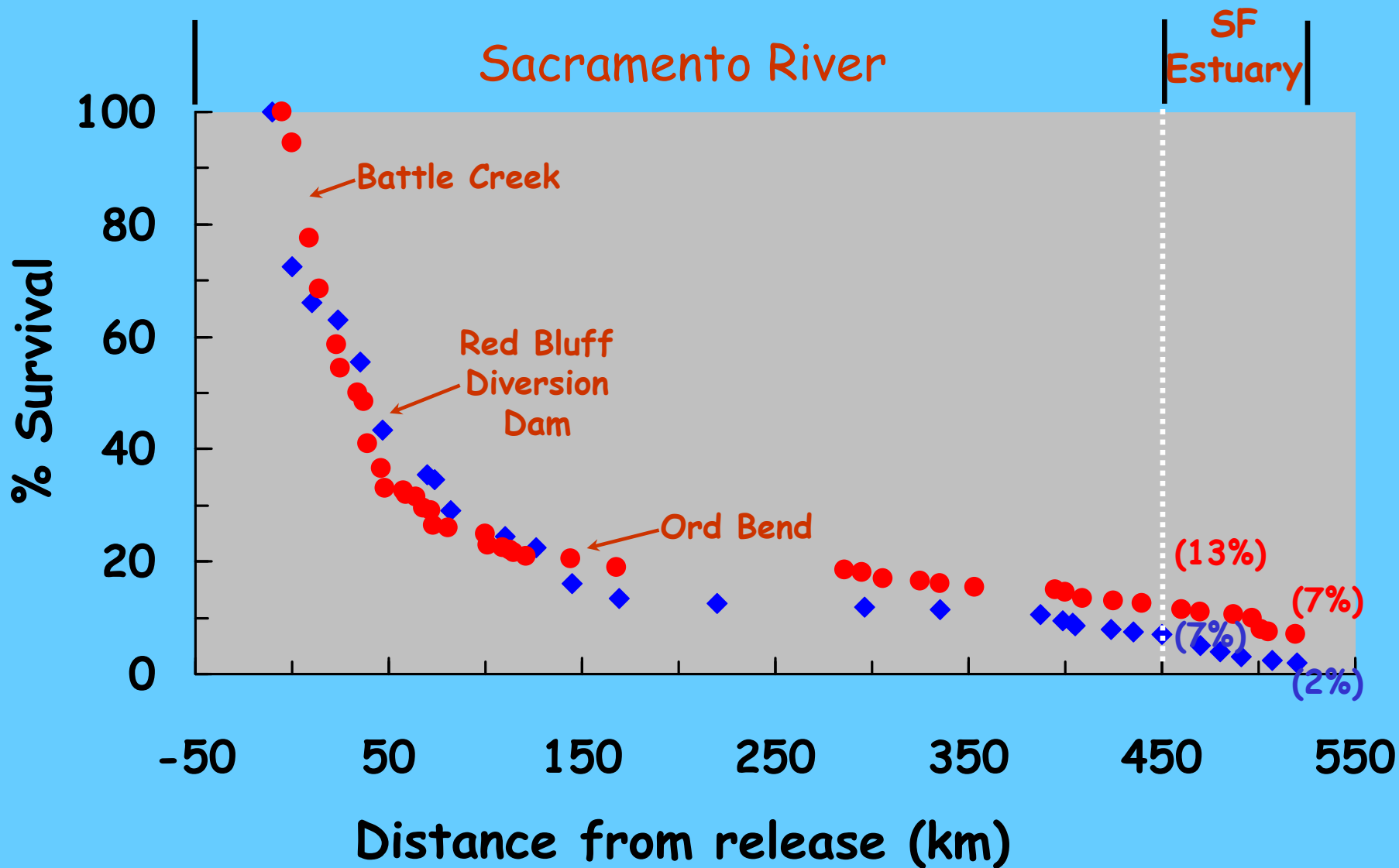
Steelhead



Late-fall Chinook Survival 2007



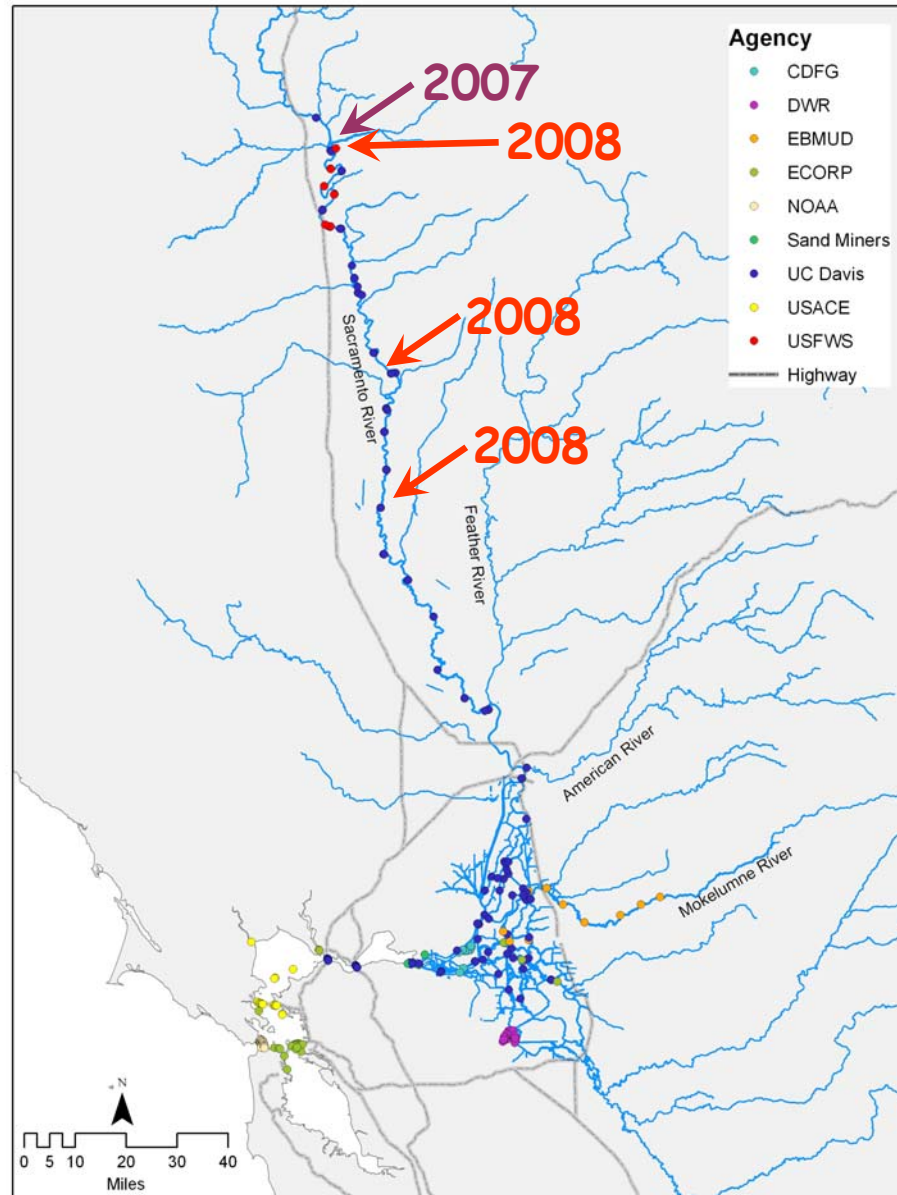
Late-fall Chinook & Steelhead Survival 2007



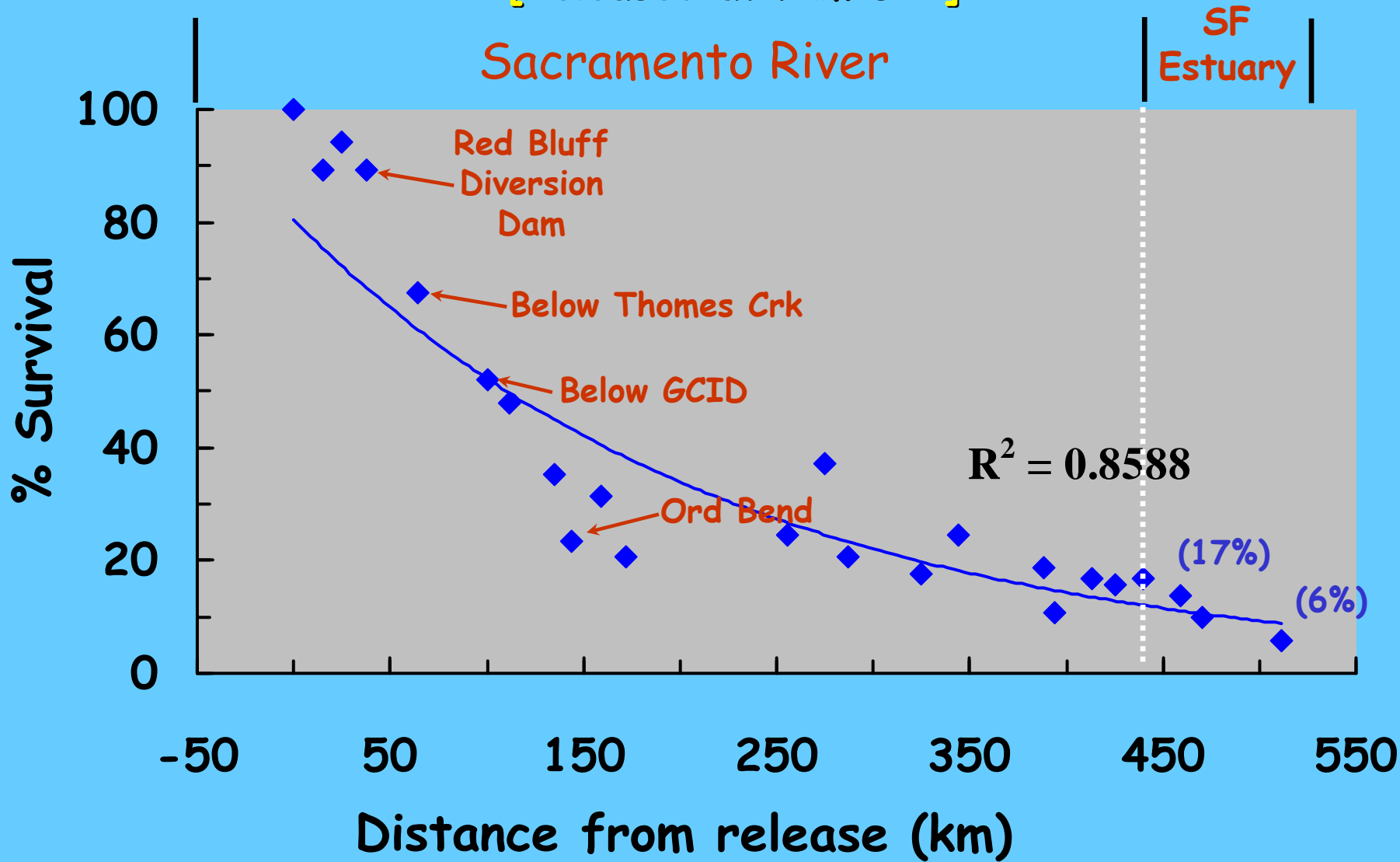
Changes in 2008

- Release strategy
 - Release 1/3 of each species at 1 of 3 sites (Sac River near Battle Creek, below RBDD, Butte City)
 - Release after dark
 - Release more fish together
- Released more tagged fish
 - Target: 300+ of each species
 - 350 steelhead & 770 Chinook for 2008
- Tags with greater ping rate
 - Chinook: V7-2L (30-90 sec) to (15-45 sec)
 - Steelhead: V9-1L (30-90 sec) to (15-45 sec)
- Move some receivers to more acoustically friendly locations
- Group several receivers in a design that increases detection probability

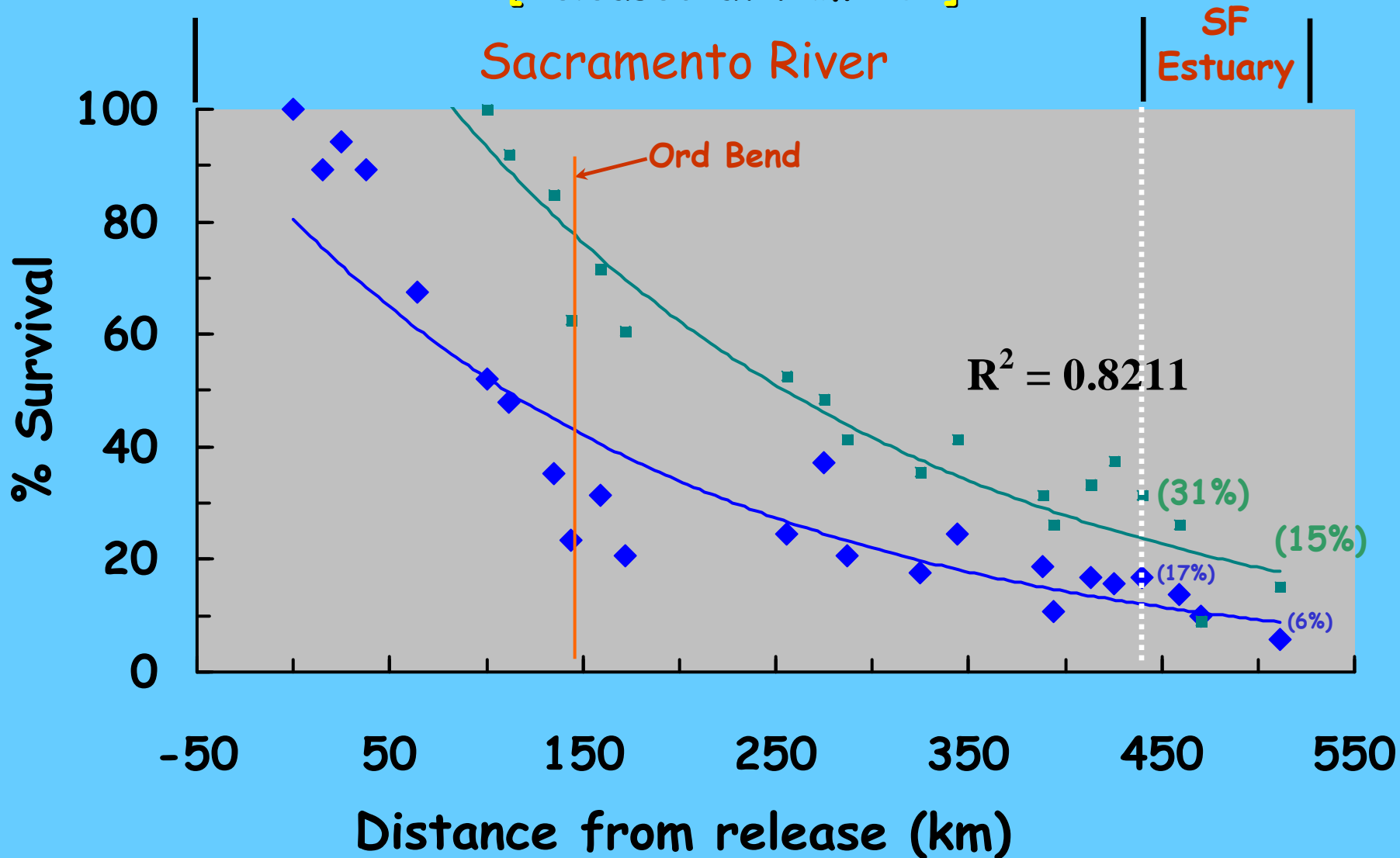
Release Locations



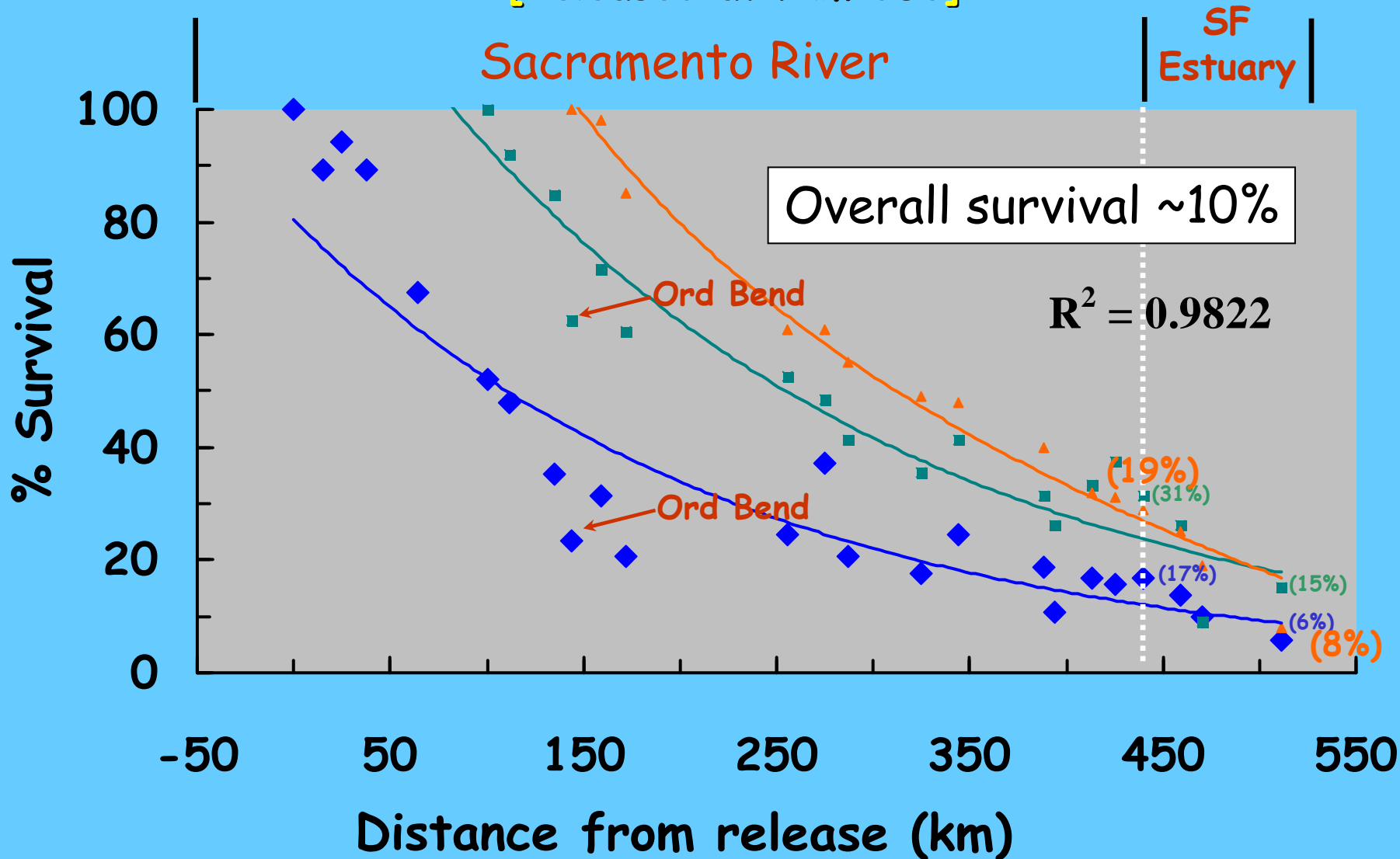
Late-fall Chinook Survival 2008 [Released at rkm 511]

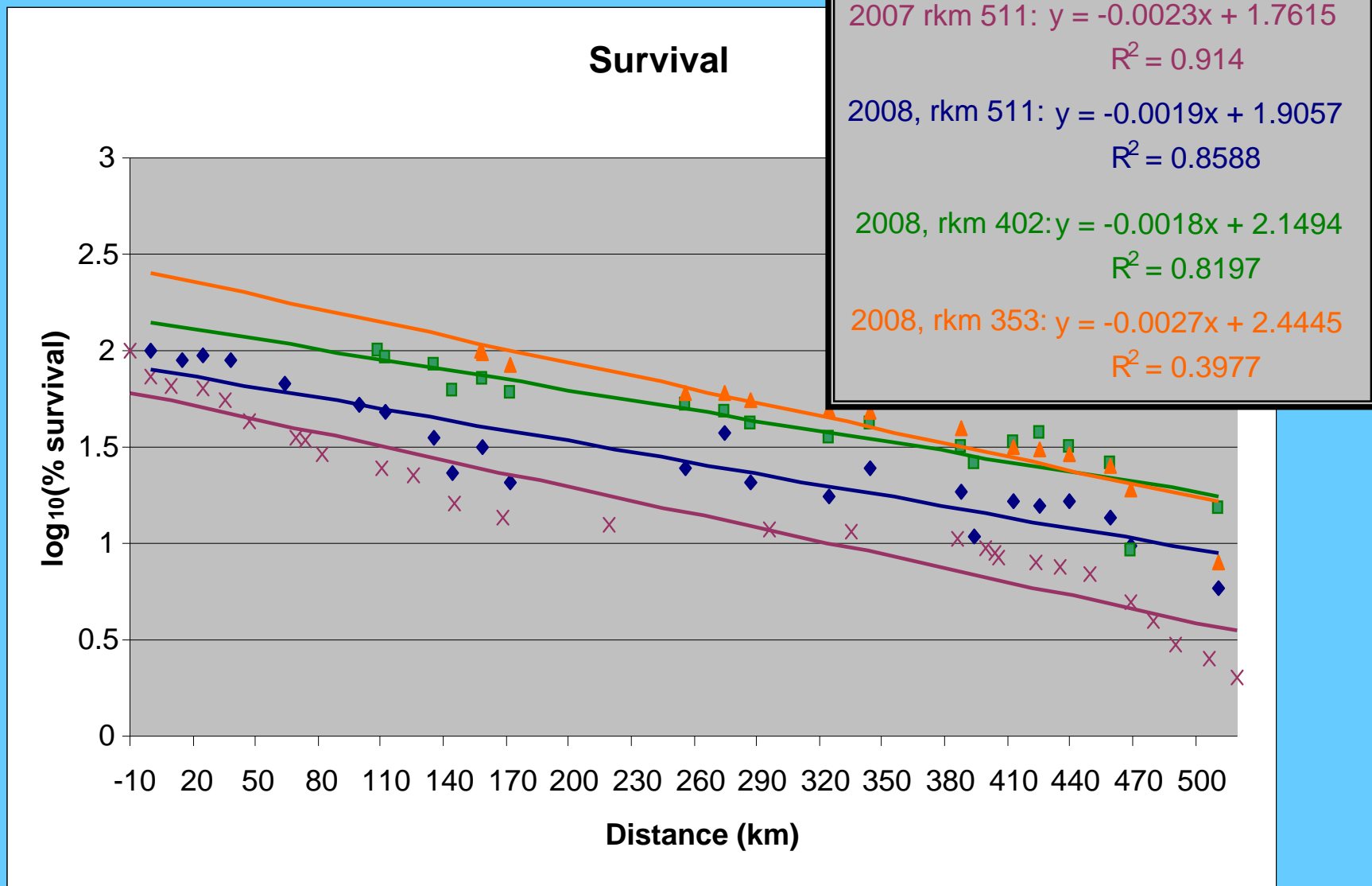


Late-fall Chinook Survival 2008 [Released at rkm 402]



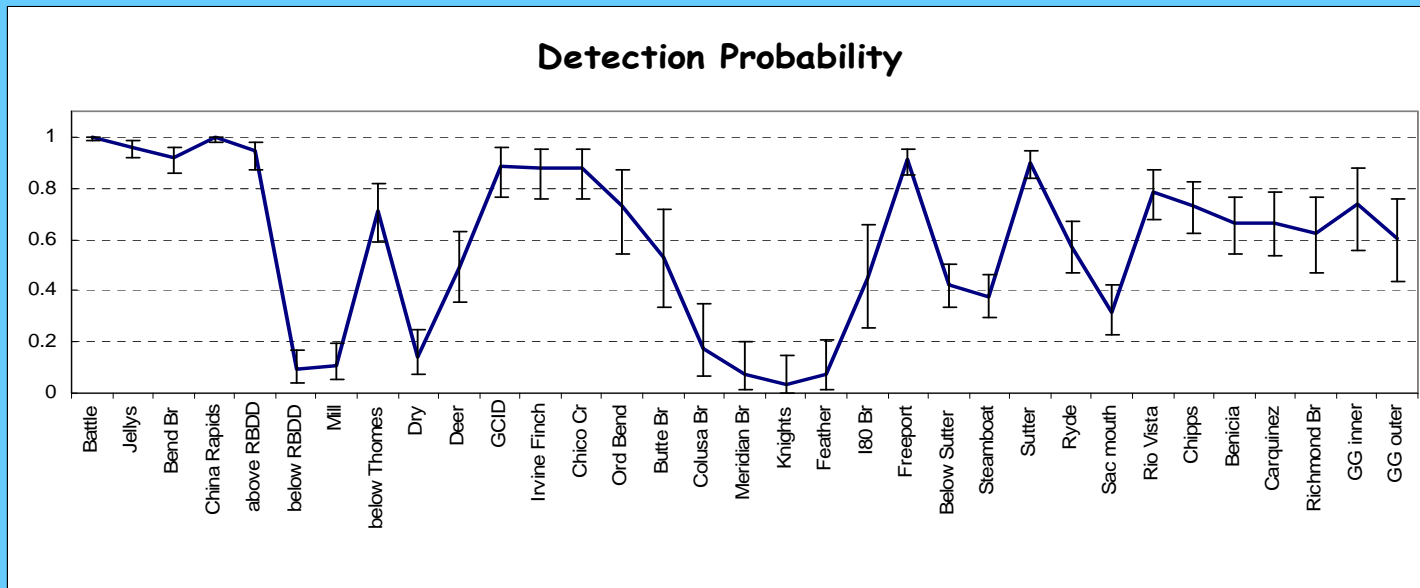
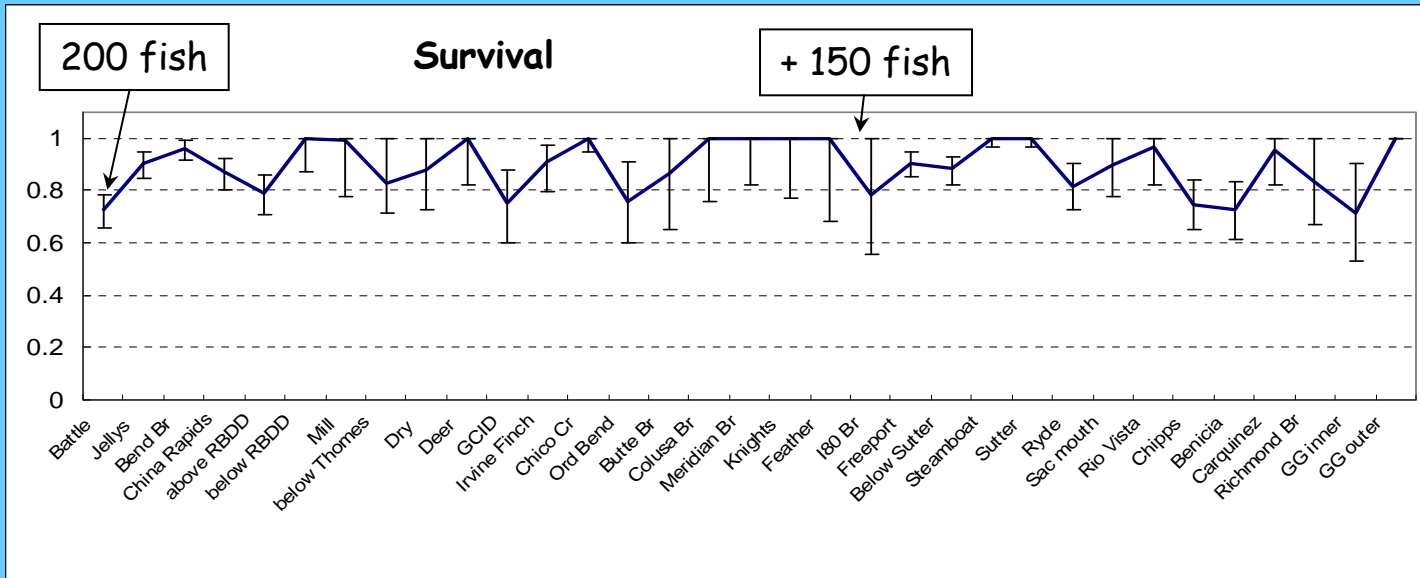
Late-fall Chinook Survival 2008 [Released at rkm 353]



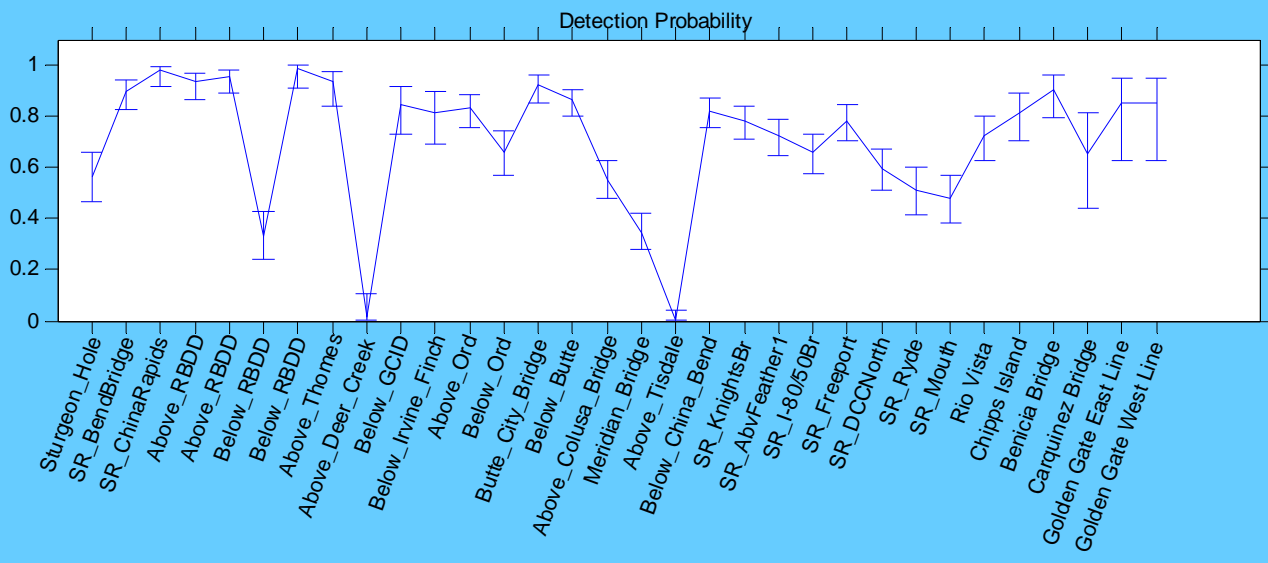
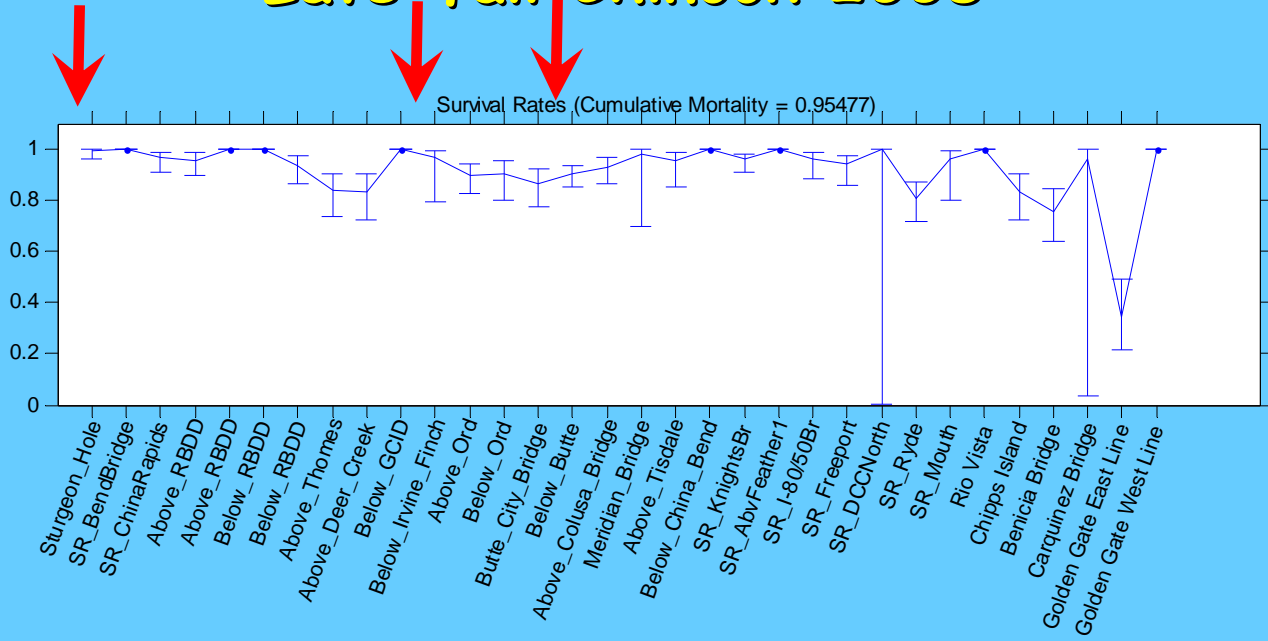


No difference in slopes among release sites in 2008
Difference between 2007 & 2008 at upper site $P < 0.05$

Late-fall Chinook 2007 (final)



Late-fall Chinook 2008



Both Years Very Low-Flow!!



<http://californiafishtracking.ucdavis.edu/index.html>