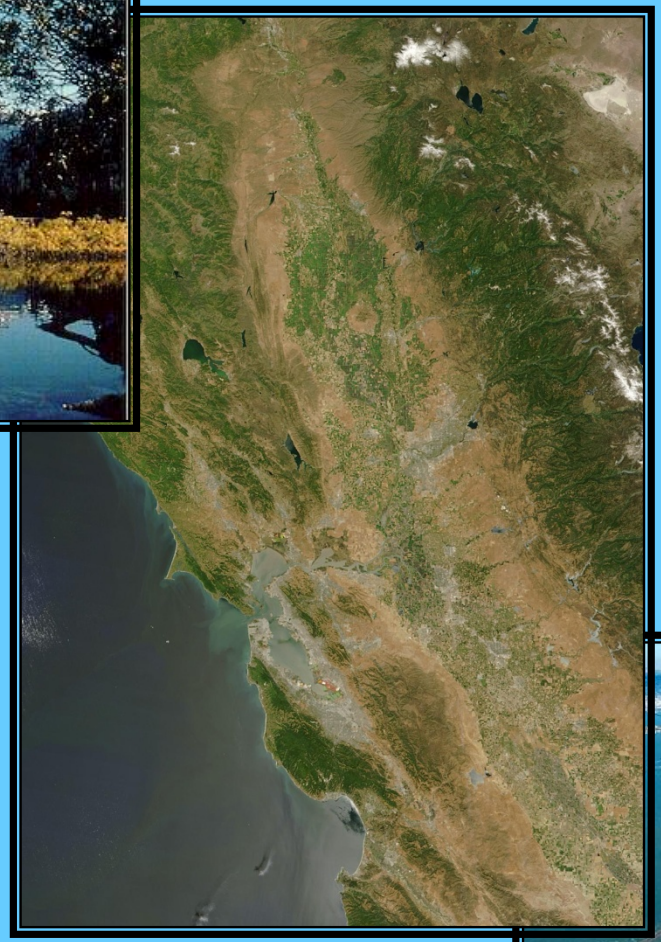
Migration & Survival of Juvenile Salmonids in California's Central Valley & San Francisco Estuary



2007 & 2008 Data

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CALFED BAY-DELTA PROGRAM

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

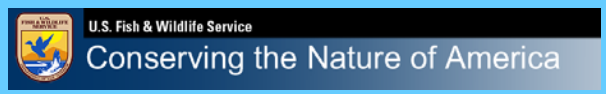
Natural & Anthropogenic Influences,
Battle Creek to Golden Gate

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

Bay Planning Coalition,
San Francisco, CA

ECORP Consulting, Inc.,
Rocklin, CA

Dredging & Disposal,
San Francisco Estuary



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

CA Dept. Water Resources,
Sacramento, CA

Water Exports & Pumping,
Delta

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: $\overline{X}$ = 27 ± 0.2 km/d

(1.25 – 114 km/d)

Time: ~ 17 days to C.I.

[1993-2005, n = 7,189]

Steelhead:

Rate: $\overline{X}$ = 17 ± 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

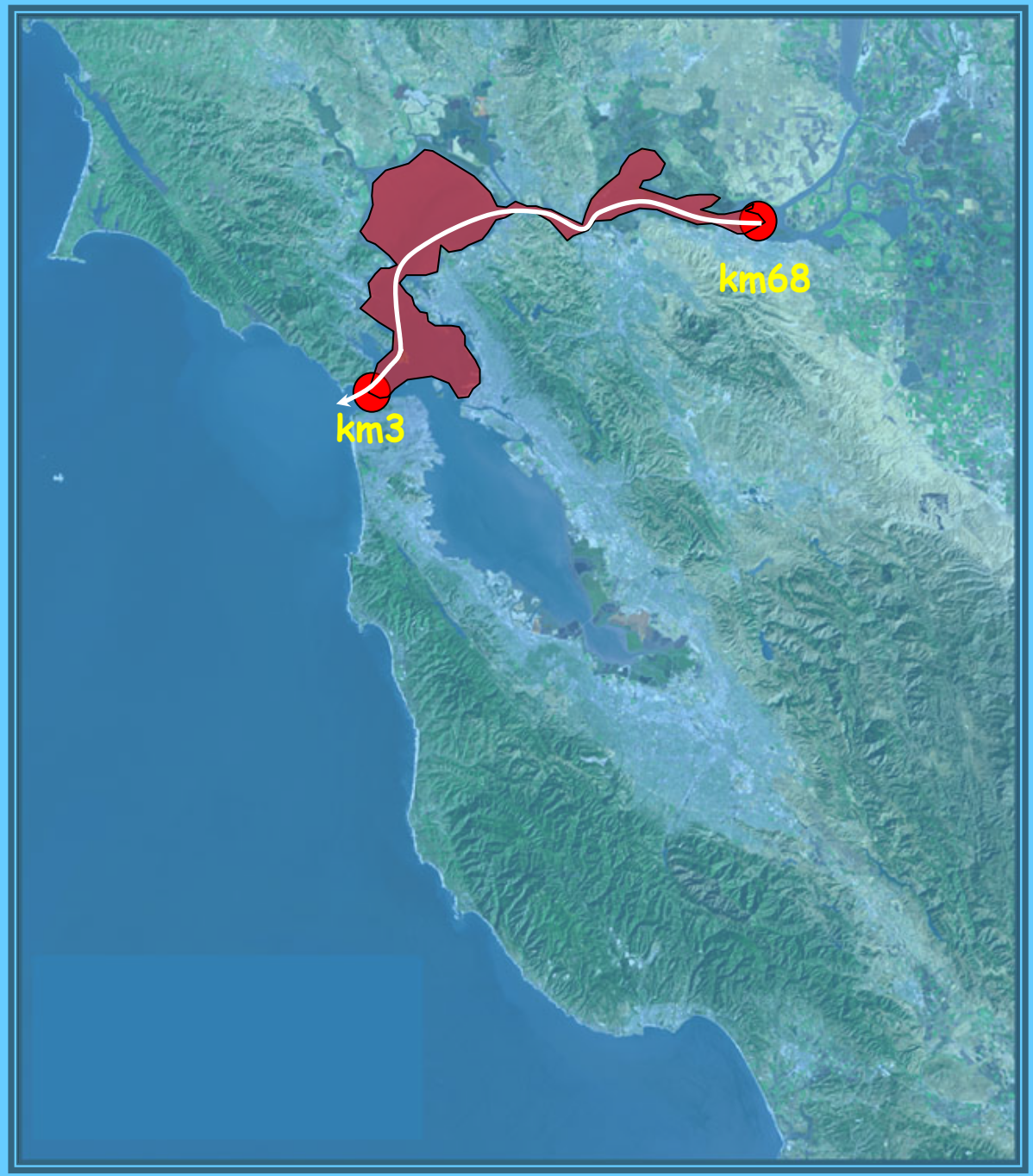
Fall Chinook Transit Time (days)

$\bar{x}$ age (km 3)
– $\bar{x}$ age (km 68)
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

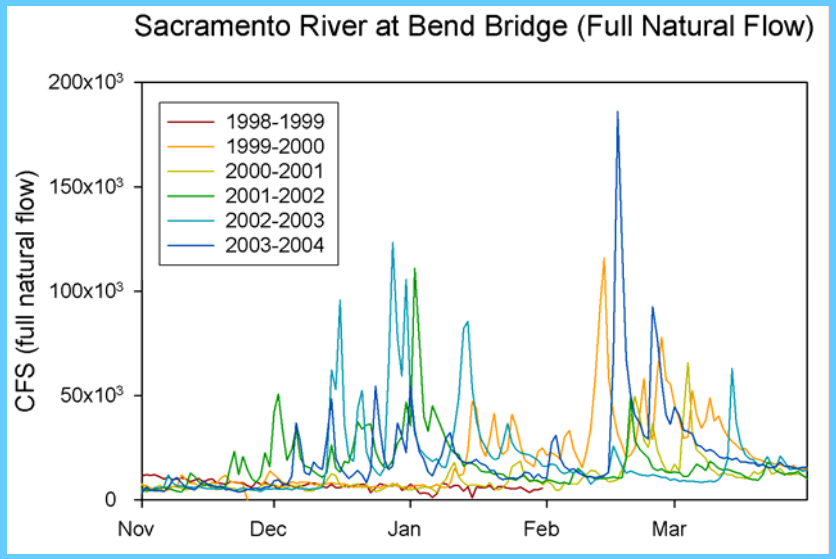
CWT data: 2 – 4 % in Sacramento River

[Battle Crk – Knights Ldg (381 km)]

(Snyder & Titus, 2000)

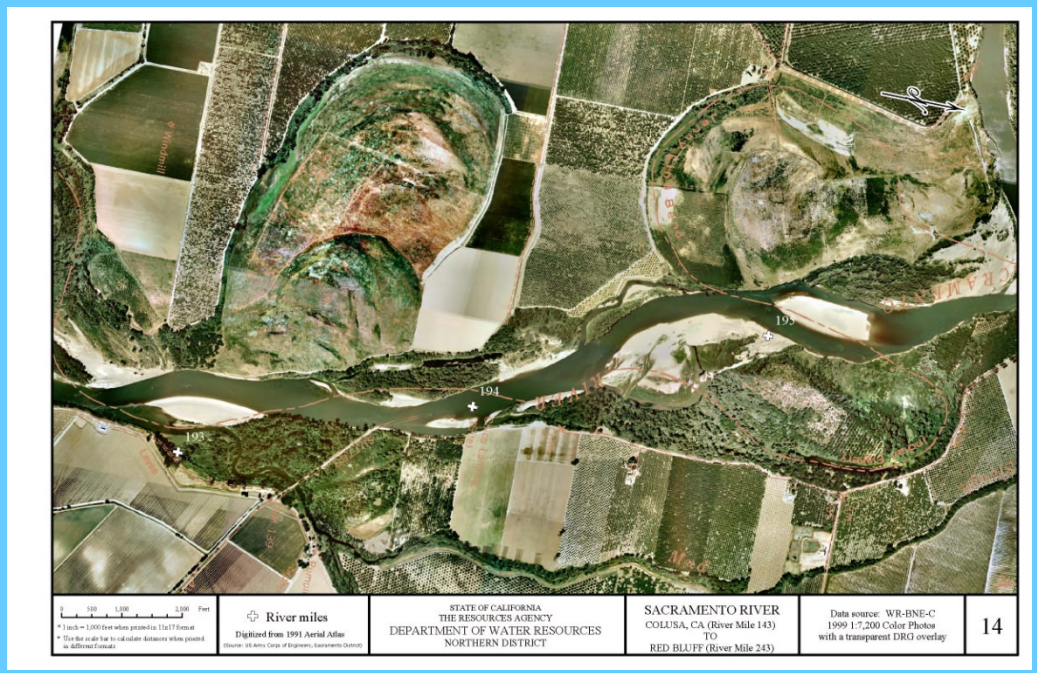
Study Design

- 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)

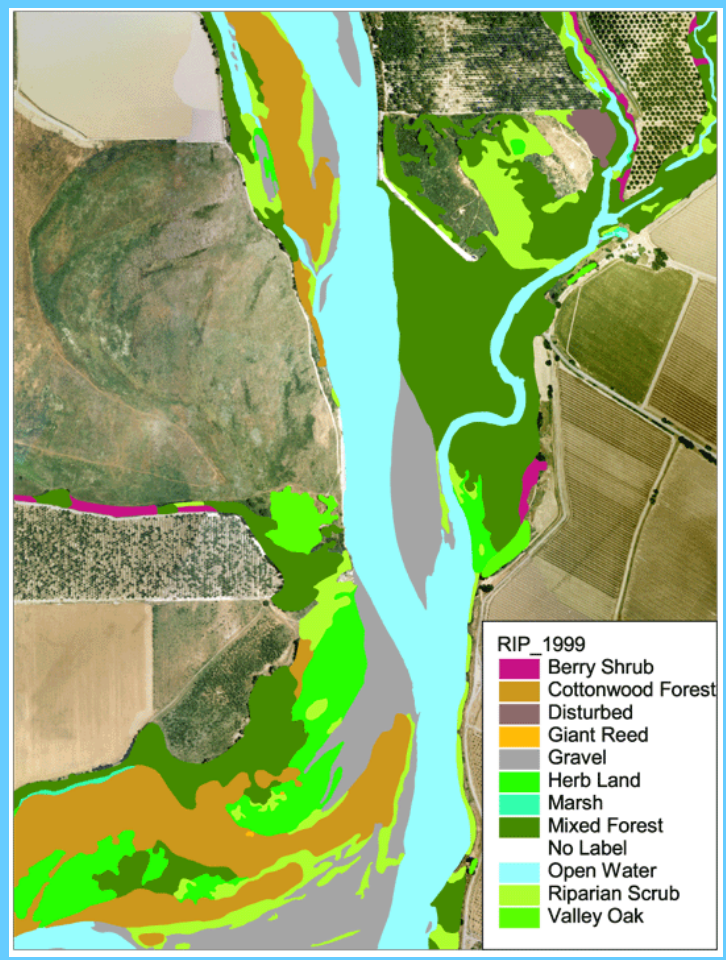


USGS flow data

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

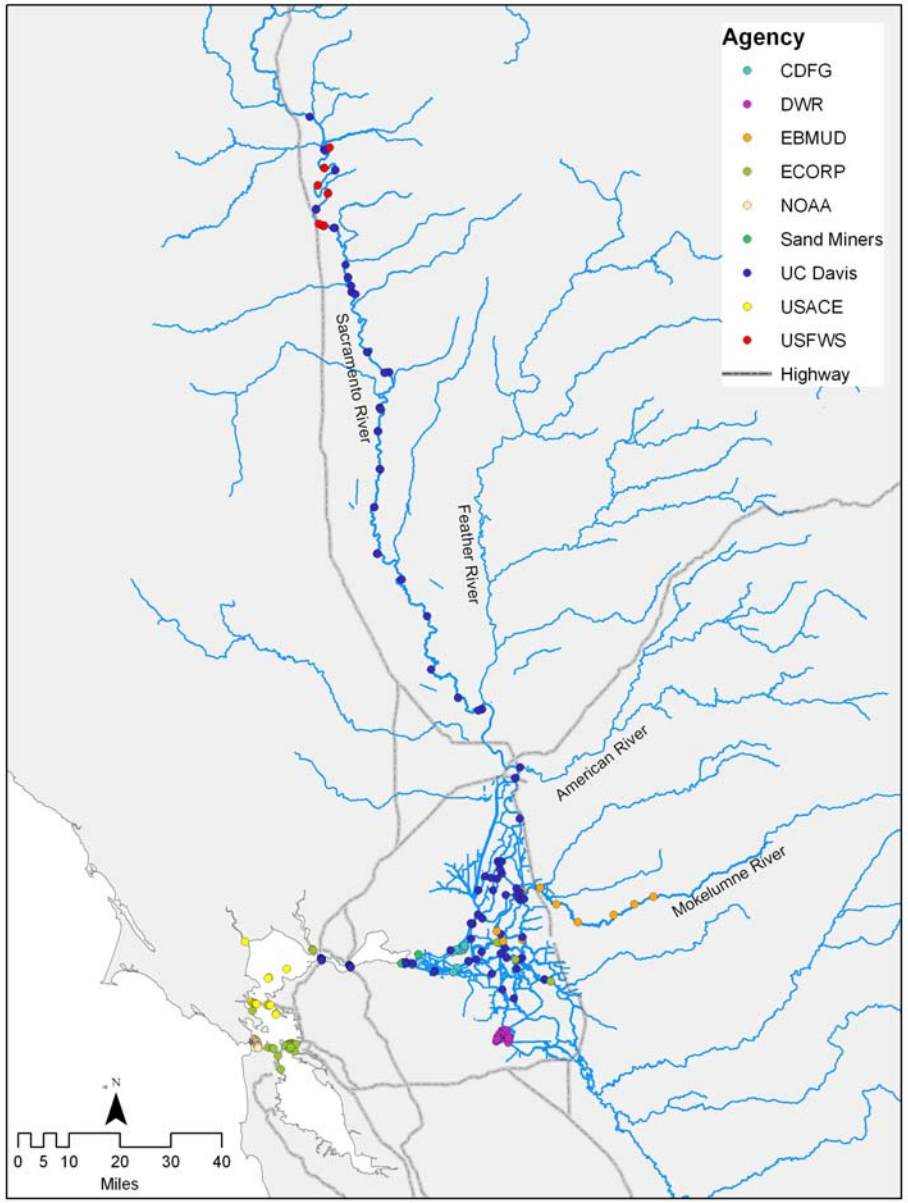


DWR Arial photos

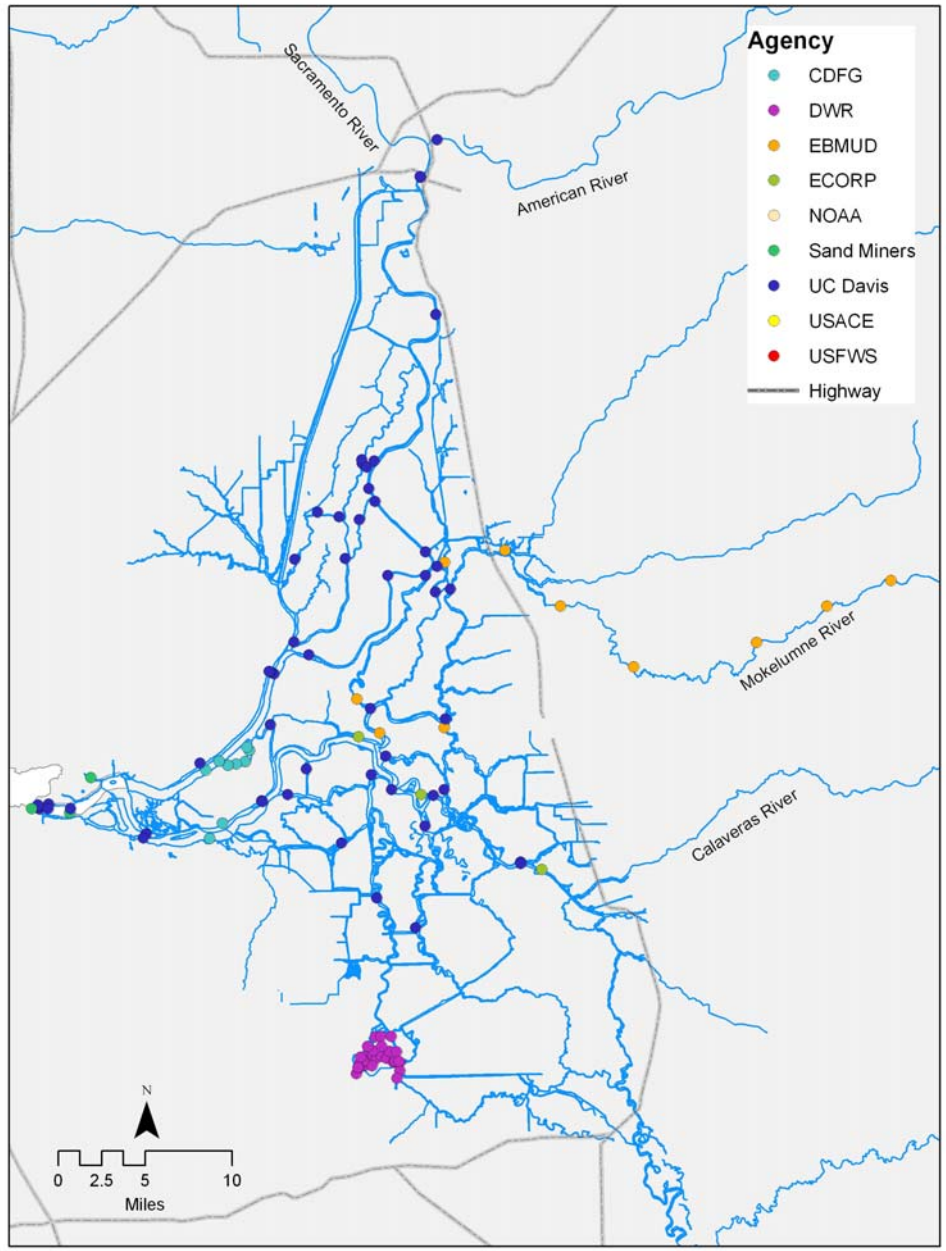


GIS CSU Chico

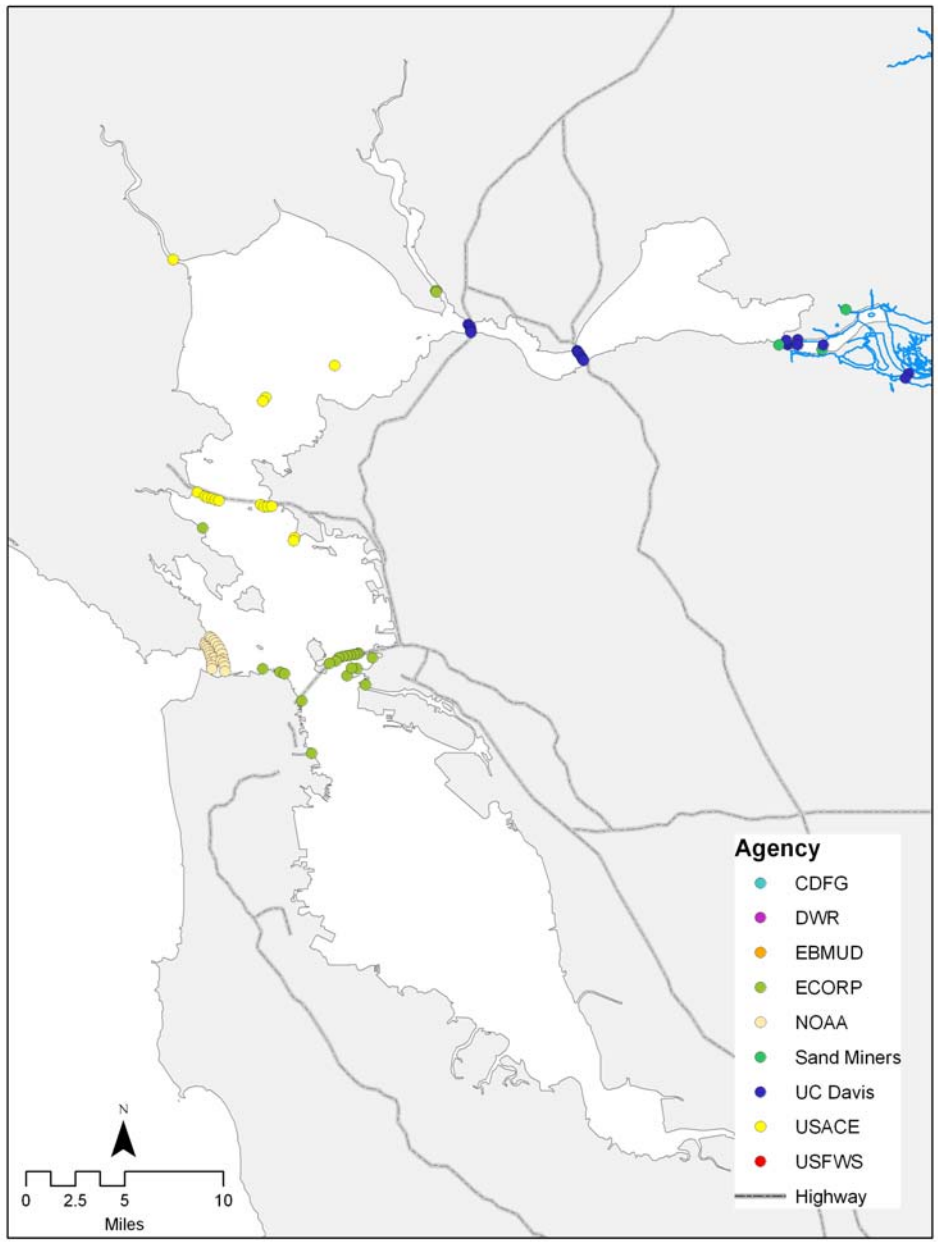
Receiver Locations



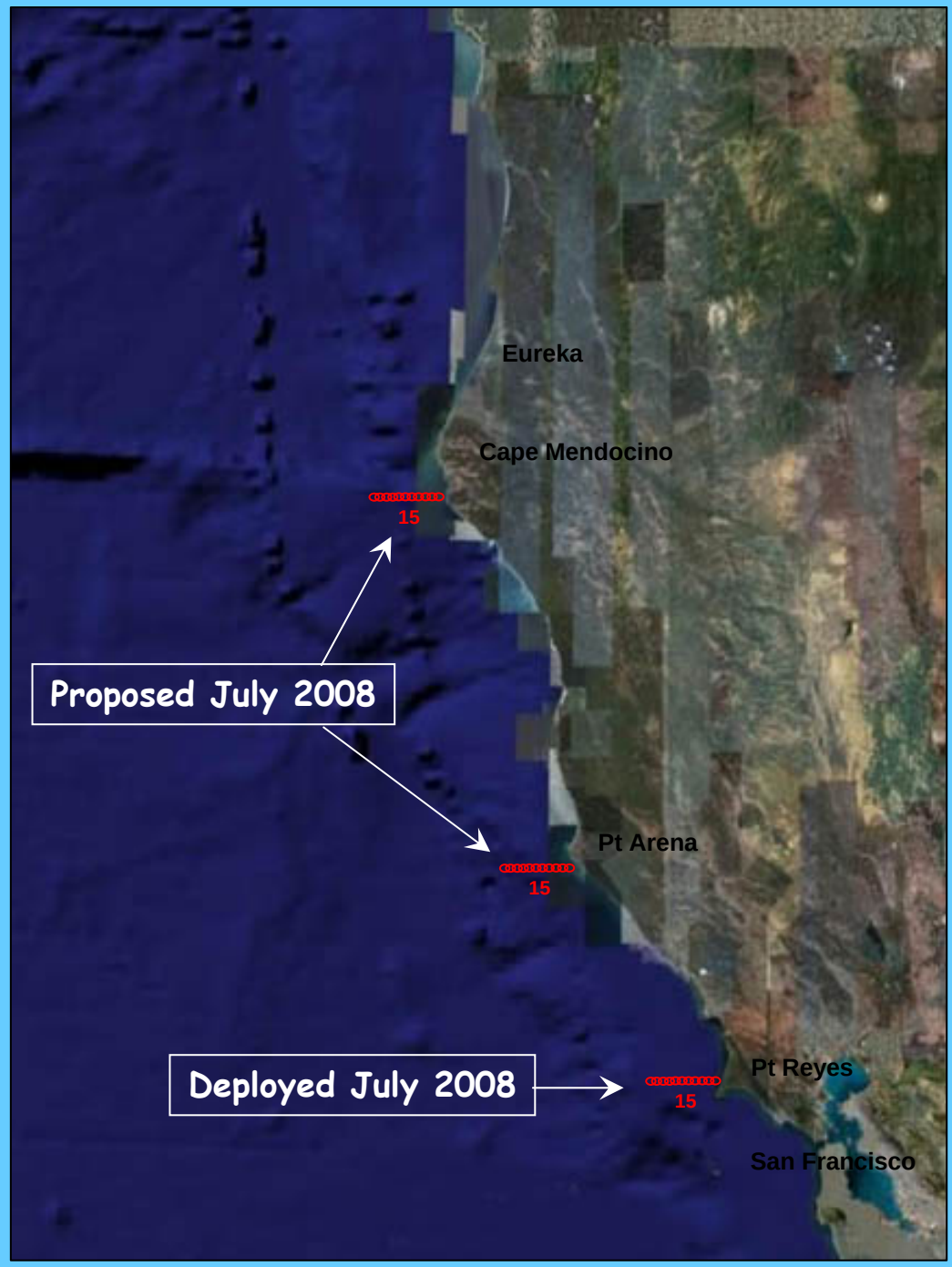
Receiver Locations
[Delta]



Receiver Locations [San Francisco Estuary]



Ocean Receiver Locations

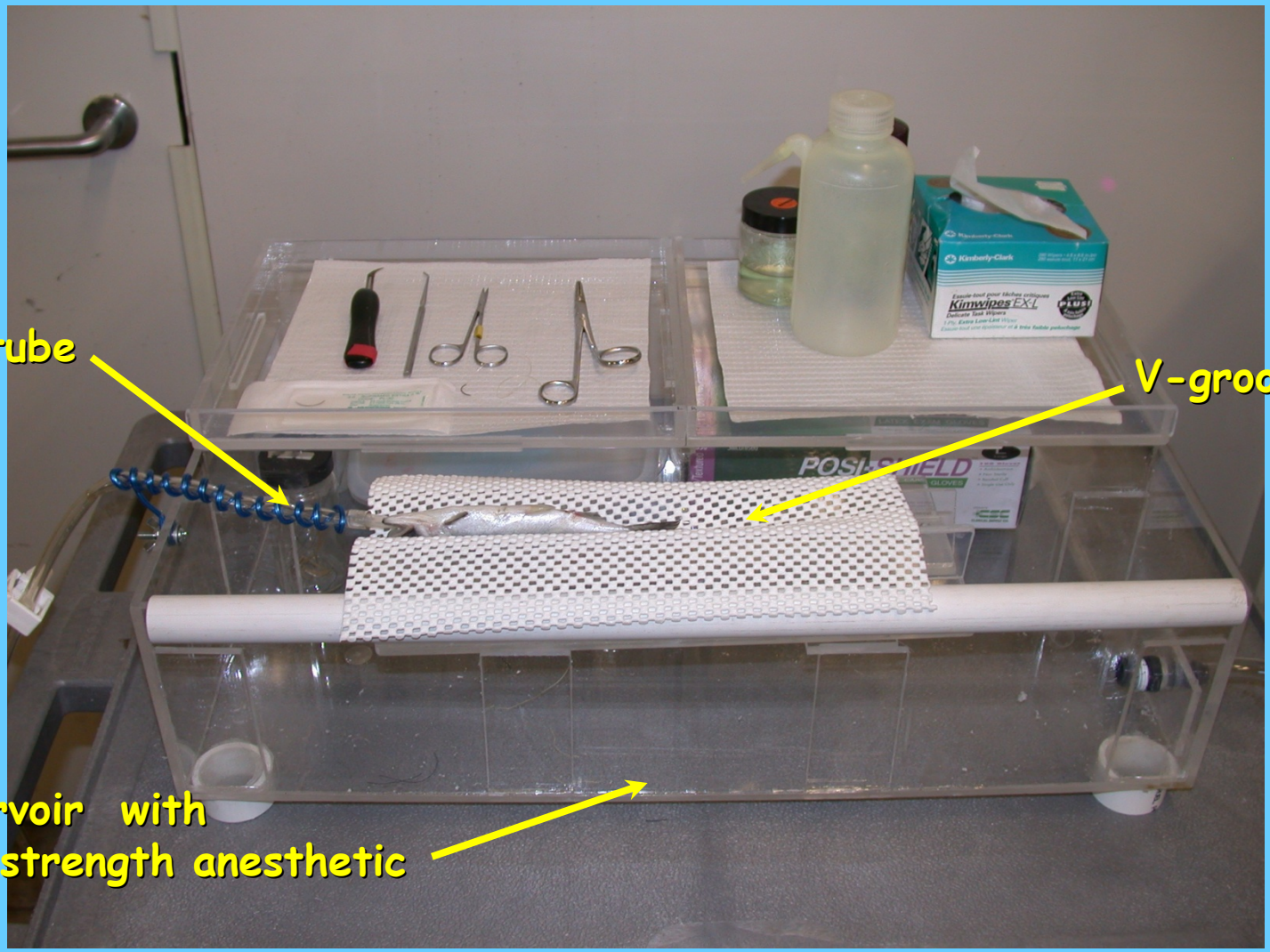


Vemco Technology

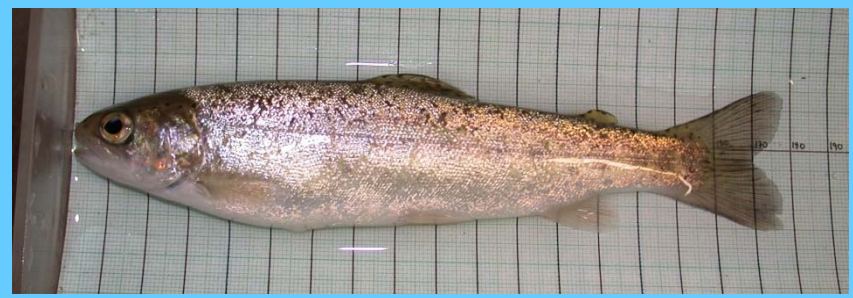
- **Ultrasonic transmitters**
  - Very small (7-9mm dia x 18.5-24mm, ~2-4g in air)
  - Uniquely coded signal
  - Battery life of ≥95-150 days
  - 69kHz works in fresh and salt water
  - Surgically implanted
  - Vemco V7& V9 tags (~$300 each)

- **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



Surgically implanting transmitters



Descriptive Salmon Statistics

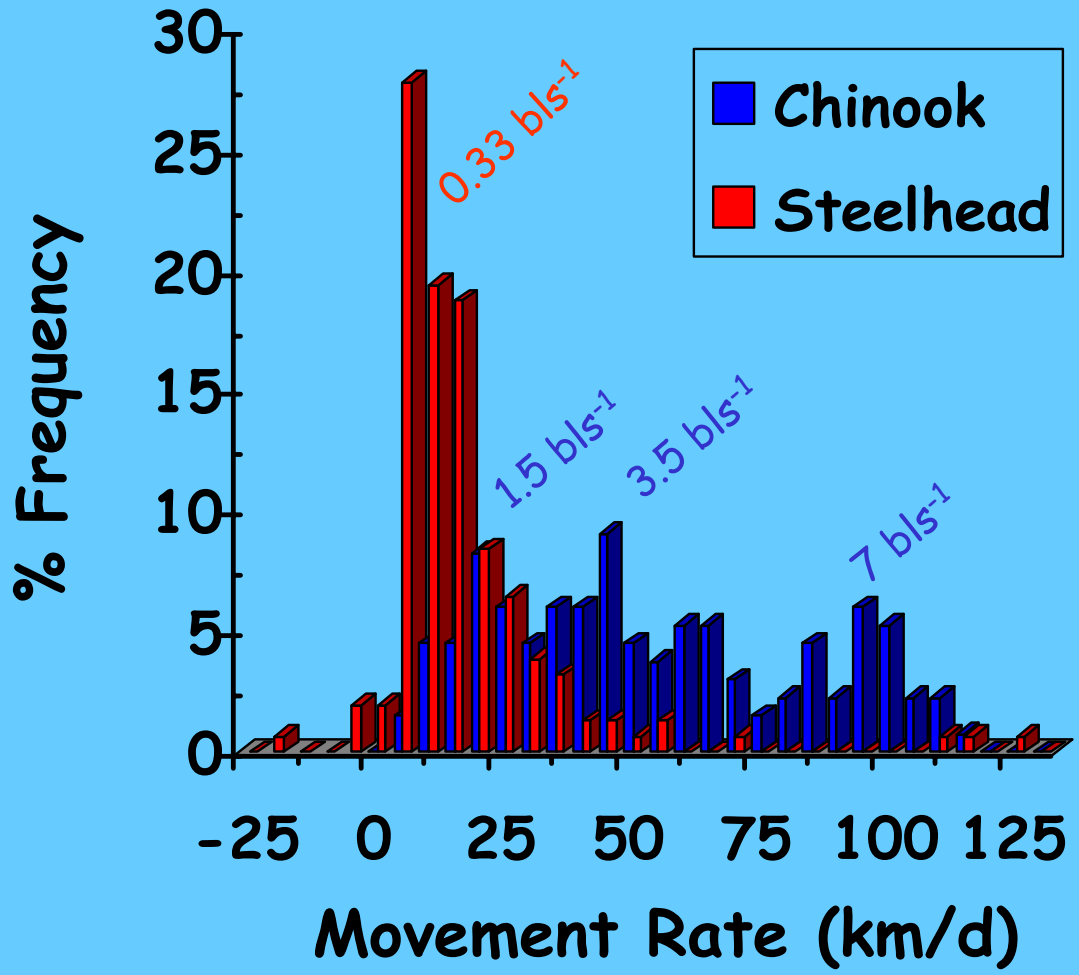
Late-fall Chinook Salmon

	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 ± 2.6 kmd^{-1}

[3.7 bls^{-1} (160 mm)]

min: 1.3 kmd^{-1}

max: 111 kmd^{-1}

Steelhead

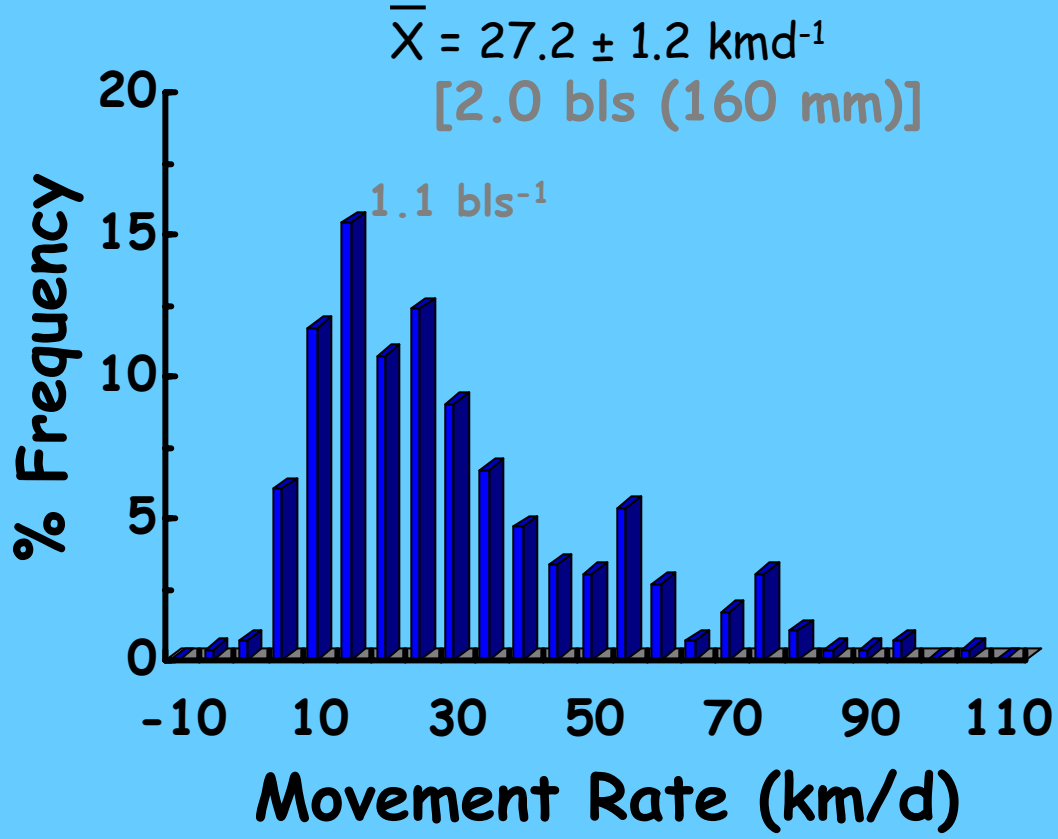
$\bar{x}$ = 14.0 ± 1.5 kmd^{-1}

[0.8 bls^{-1} (200 mm)]

min: -20.8 kmd^{-1}

max: 123 kmd^{-1}

Chinook Movement Rate 2008
All Release Sites – Golden Gate

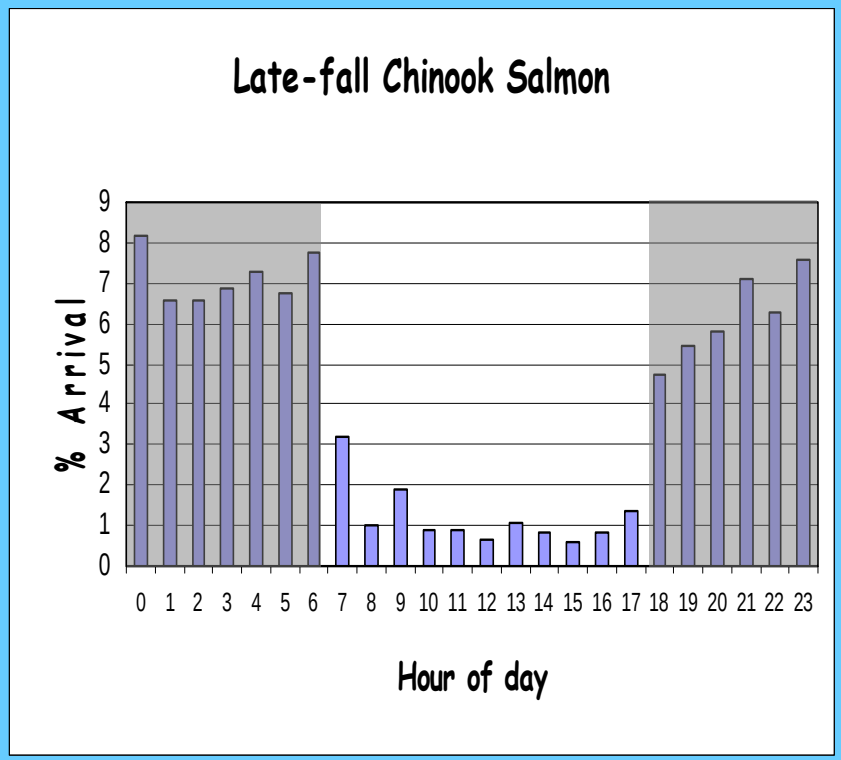


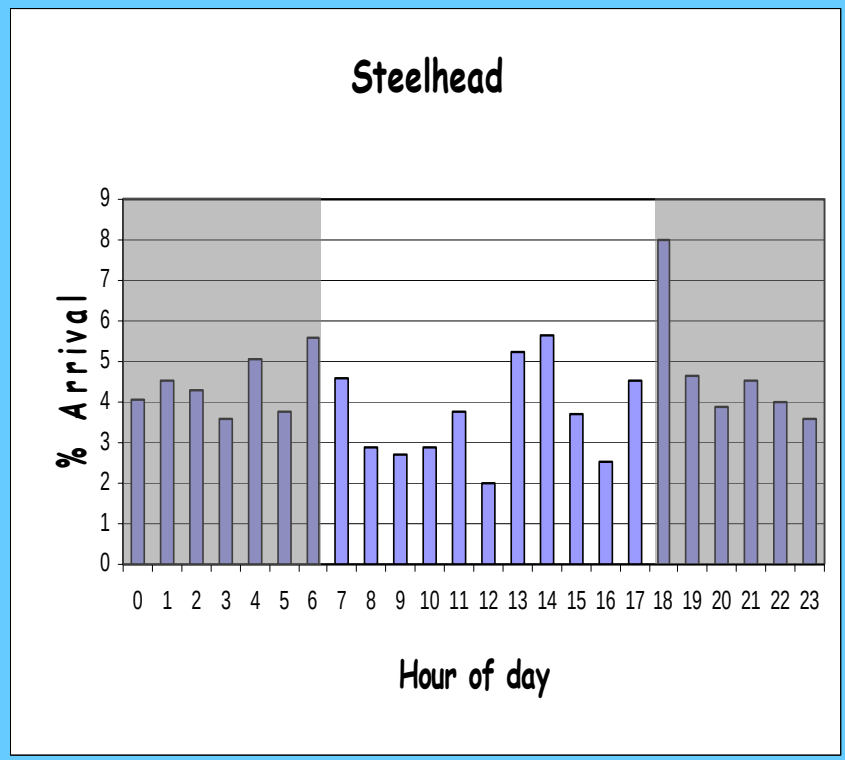
rkm 511
$\overline{x}$ = 37.8 ± 2.5 kmd^{-1}
[2.7 bls^{-1} (160 mm)]
min: -4.4 kmd^{-1}
max: 104 kmd^{-1}

rkm 402
$\overline{x}$ = 24.8 ± 1.7 kmd^{-1}
[1.8 bls^{-1} (160 mm)]
min: 1.1 kmd^{-1}
max: 72 kmd^{-1}

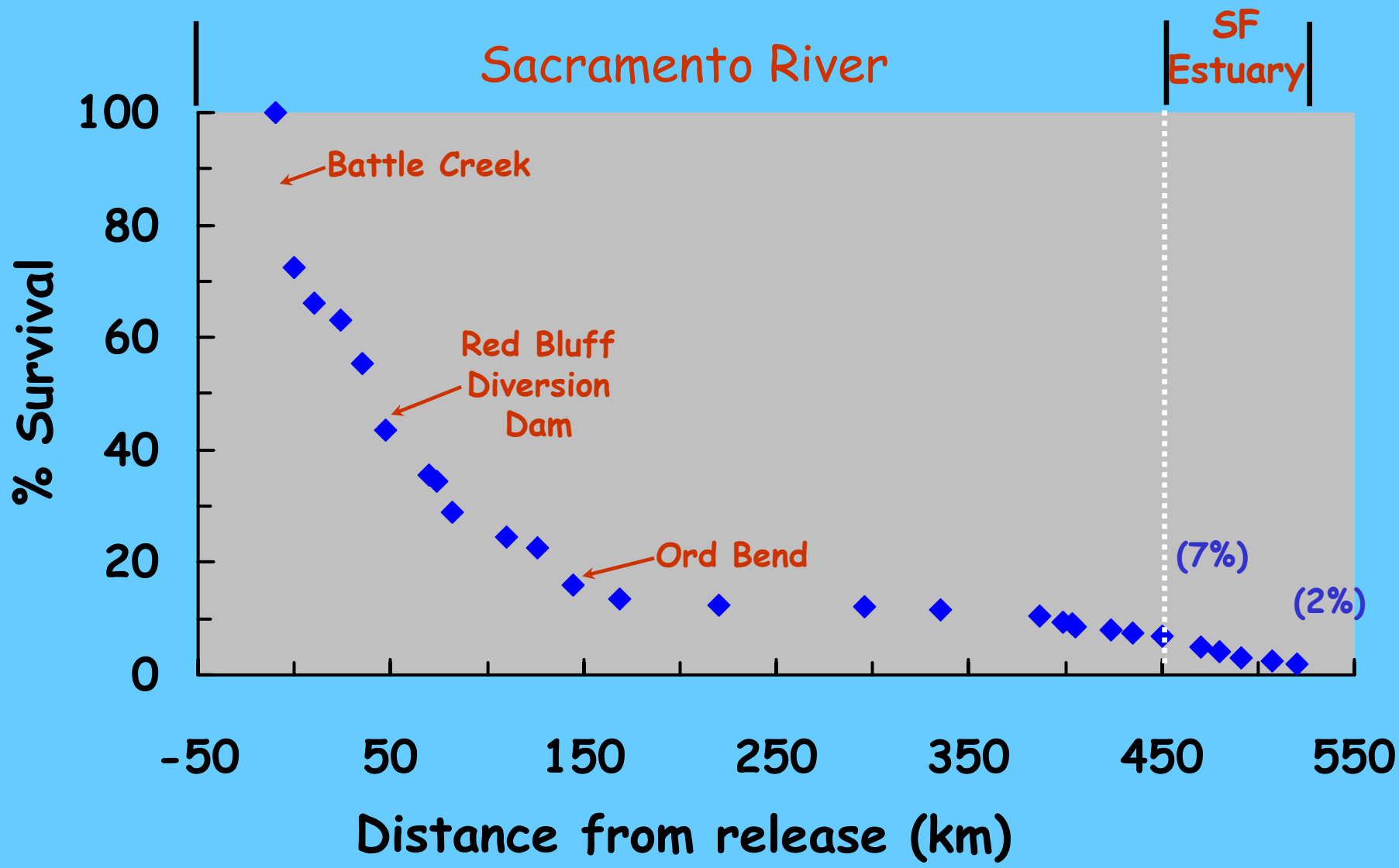
rkm 353
$\overline{x}$ = 18.9 ± 1.3 kmd^{-1}
[1.4 bls^{-1} (160 mm)]
min: -6.5 kmd^{-1}
max: 55 kmd^{-1}

Movement Patterns
Diel Movements

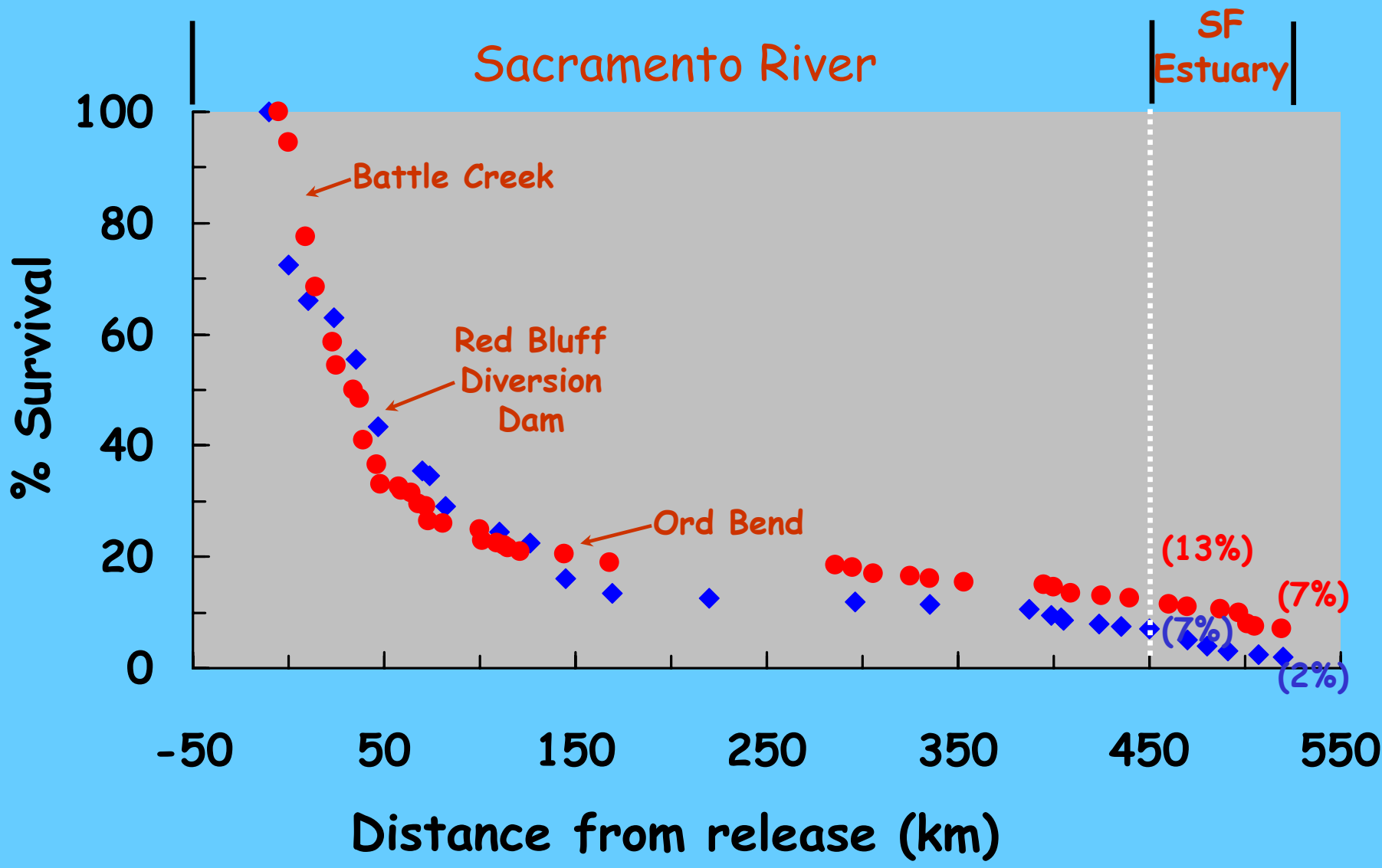




Late-fall Chinook Survival 2007



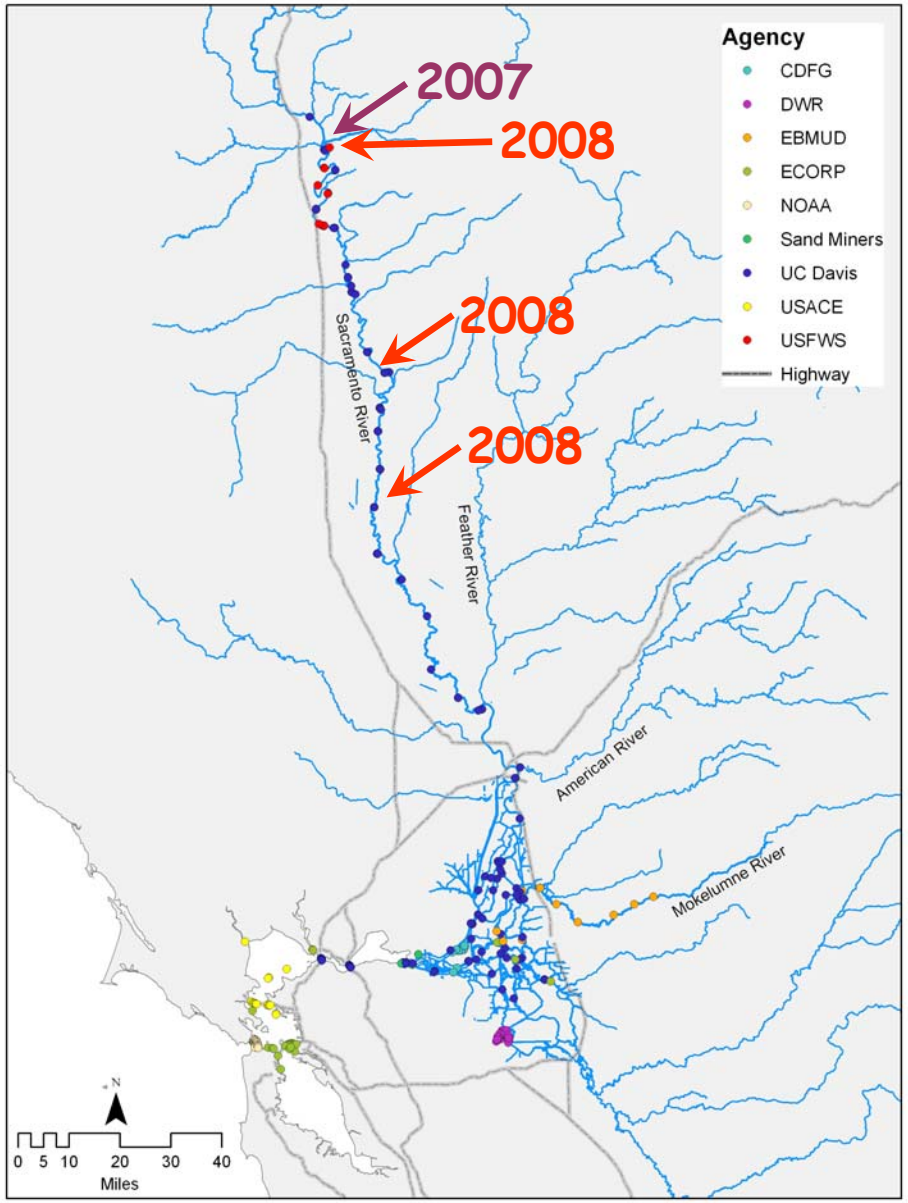
Late-fall Chinook & Steelhead Survival 2007

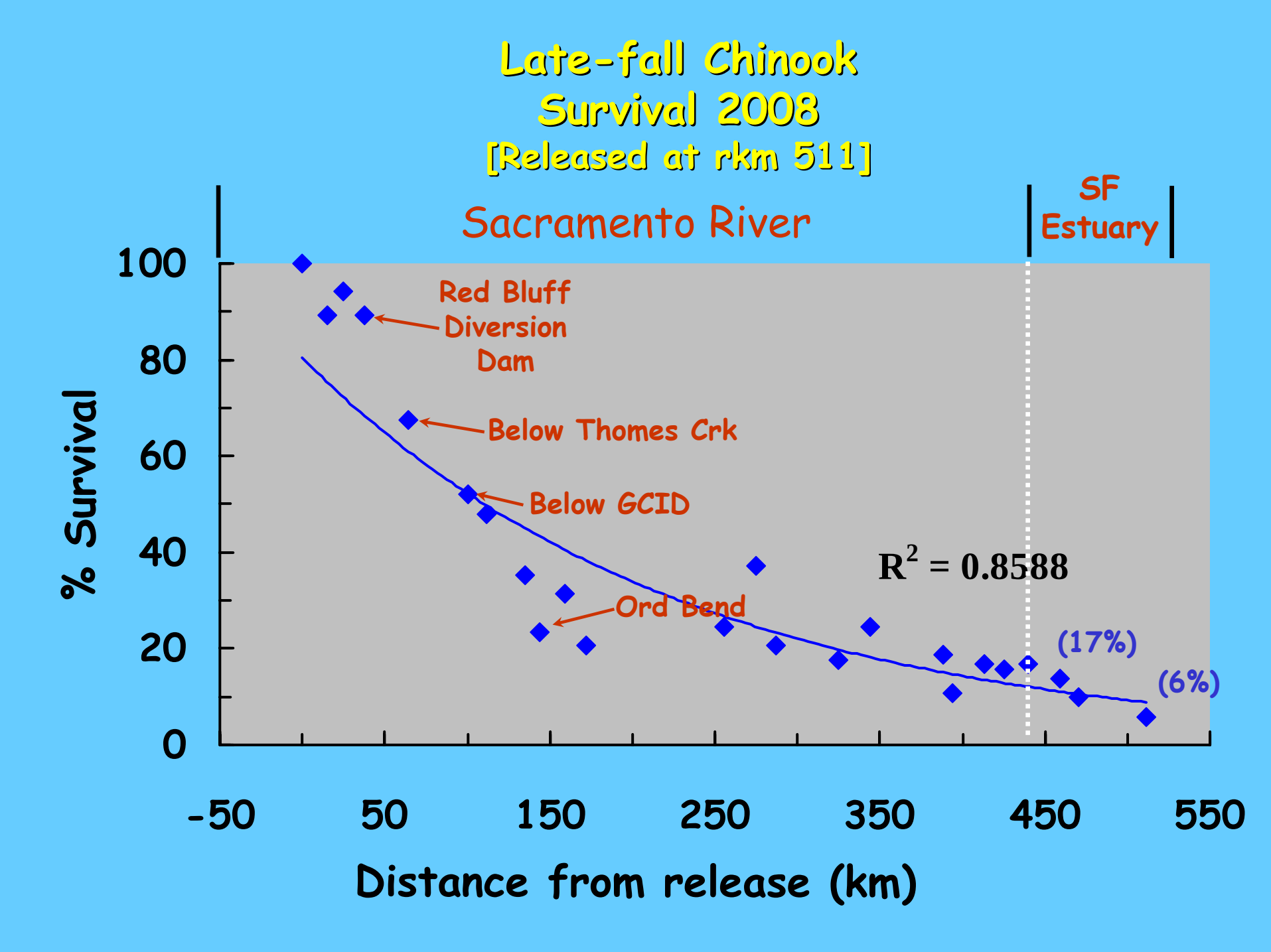


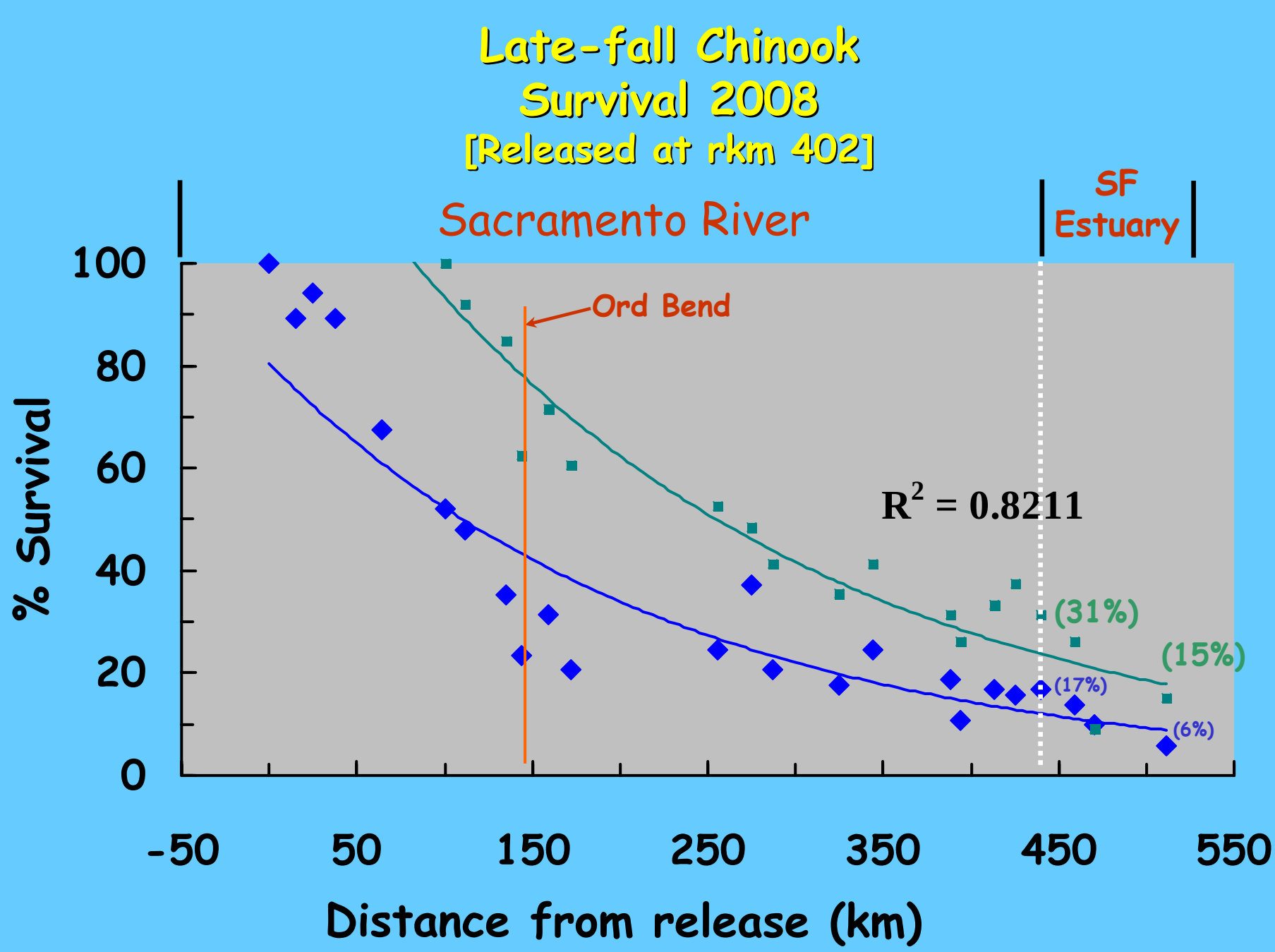
Changes in 2008

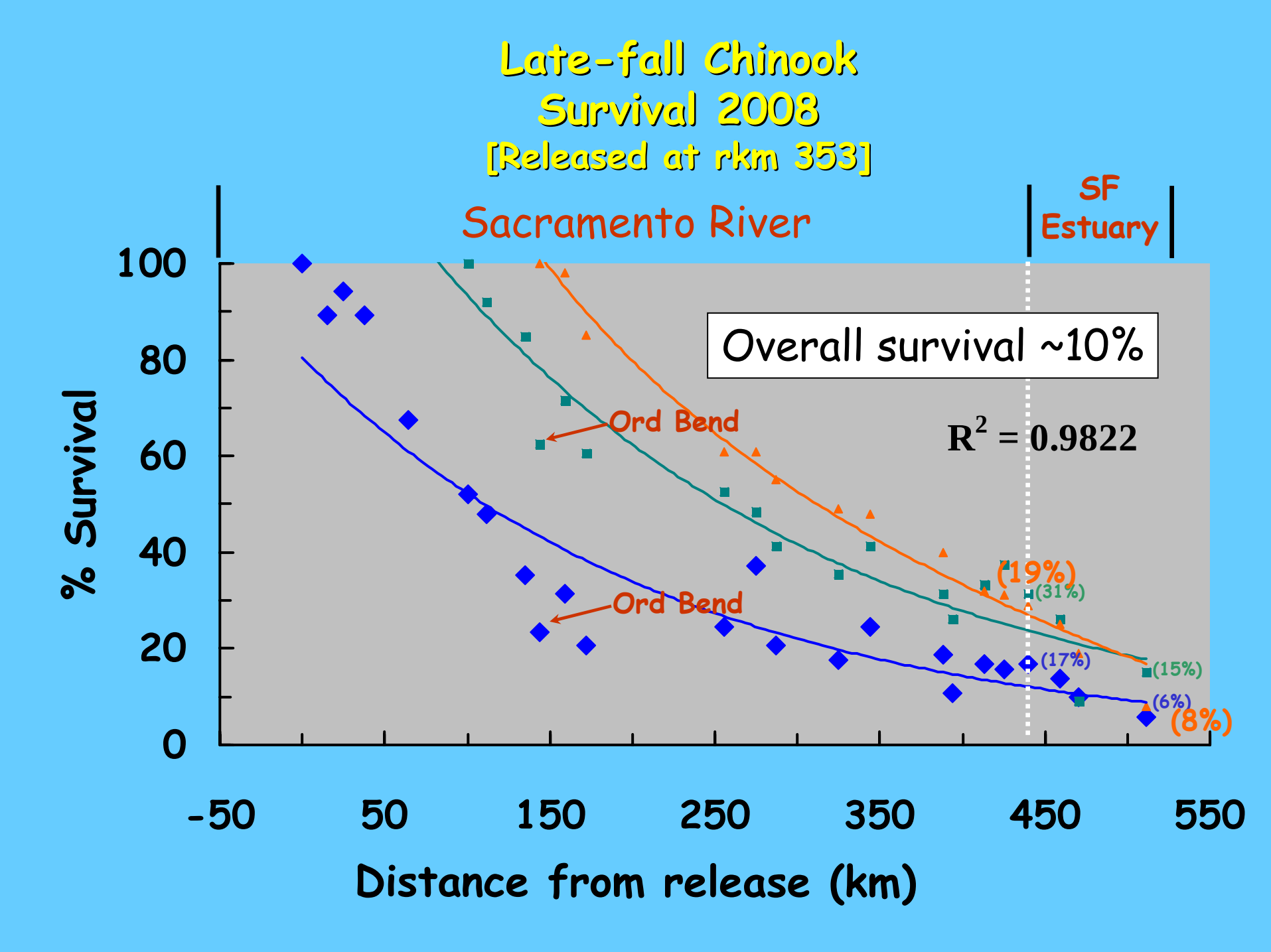
- Release strategy
  - Release 1/3 of each species at 1 of 3 sites (Sac River near Battle Creek, below RBDD, Butte City)
  - Release after dark
  - Release more fish together
- Released more tagged fish
  - Target: 300+ of each species
  - 350 steelhead & 770 Chinook for 2008
- Tags with greater ping 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

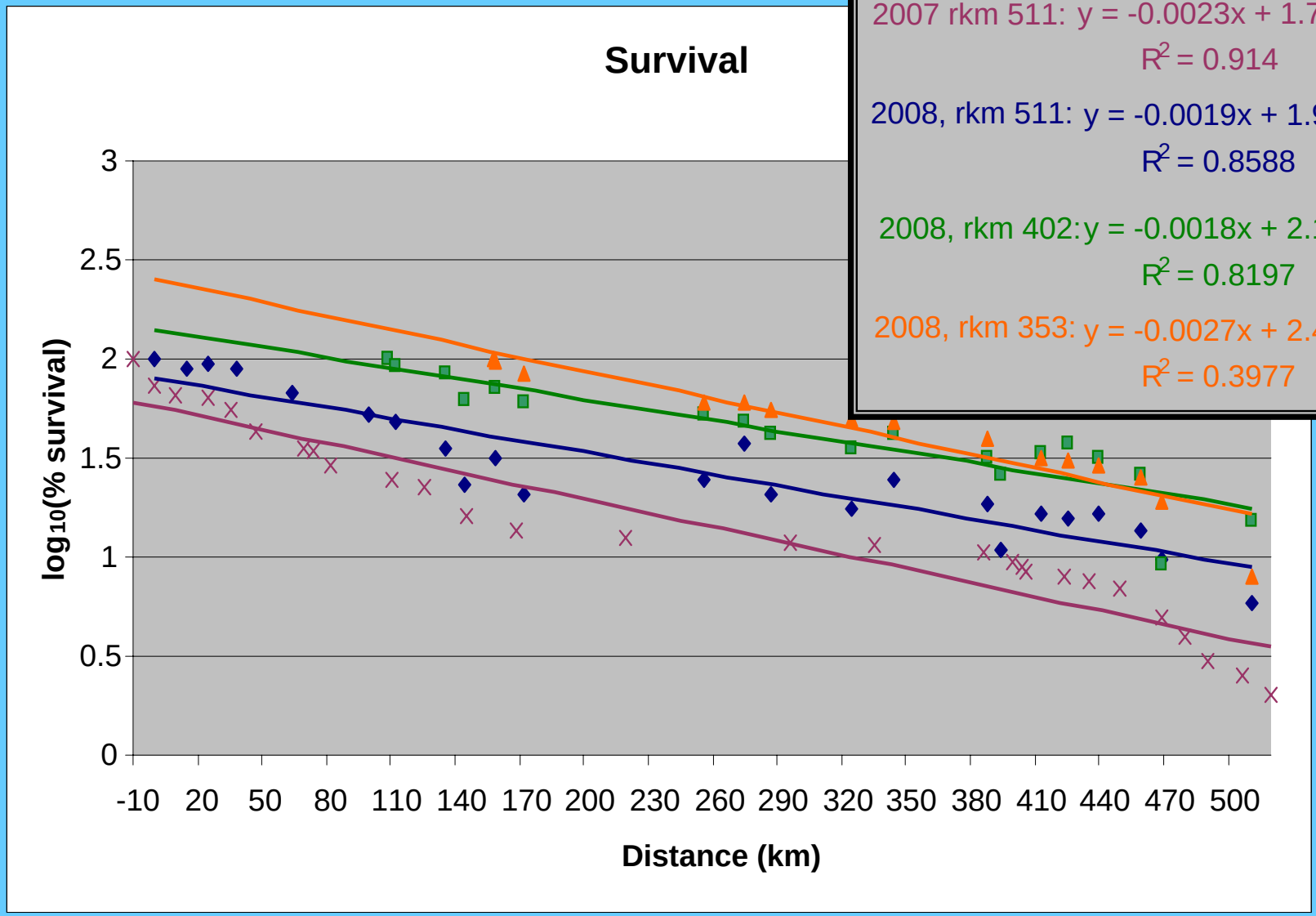
Release Locations




Late-fall Chinook
Survival 2008
[Released at rkm 511]
Sacramento River
SF
Estuary
Red Bluff
Diversion
Dam
Below Thomes Crk
Below GCID
Ord Bend
$R^2 = 0.8588$
(17%)
(6%)
% Survival
100
80
60
40
20
0
-50
50
150
250
350
450
550
Distance from release (km)

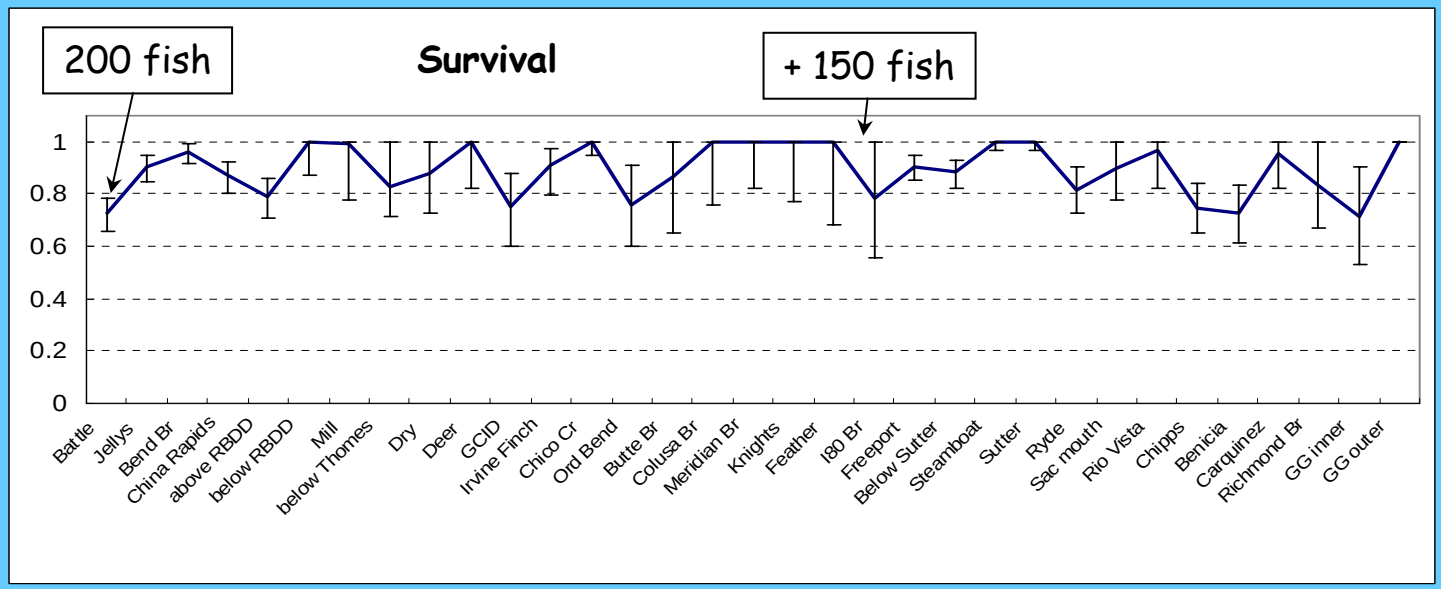

Late-fall Chinook
Survival 2008
[Released at rkm 402]
Sacramento River
SF
Estuary
Ord Bend
$R^2 = 0.8211$
(31%)
(15%)
(17%)
(6%)
% Survival
100
80
60
40
20
0
-50
50
150
250
350
450
550
Distance from release (km)

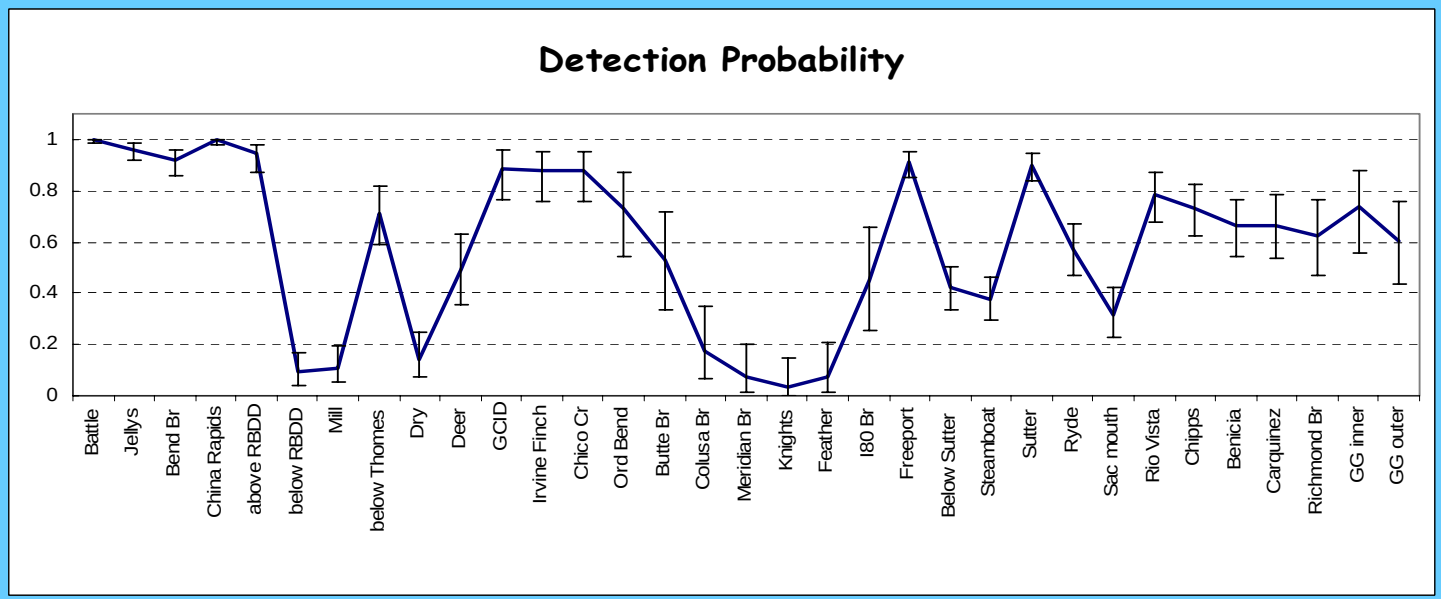

Late-fall Chinook
Survival 2008
[Released at rkm 353]
Sacramento River
SF Estuary
Overall survival ~10%
$R^2 = 0.9822$
Ord Bend
Ord Bend
(19%)
(31%)
(17%)
(15%)
(6%)
(8%)
% Survival
100
80
60
40
20
0
-50
50
150
250
350
450
550
Distance from release (km)



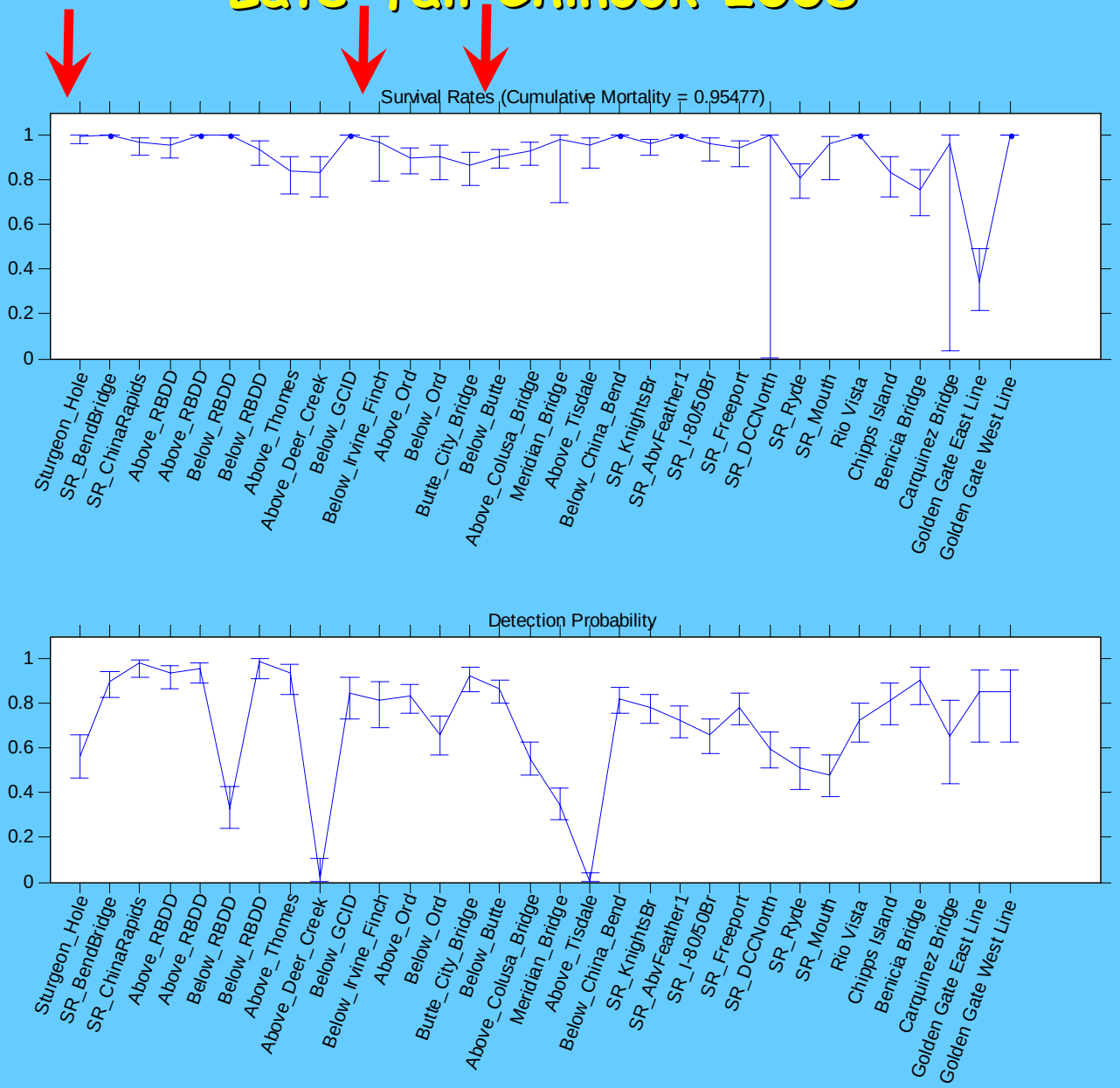
No difference in slopes among release sites in 2008
Difference between 2007 & 2008 at upper site P<0.05

Late-fall Chinook 2007 (final)





Late-fall Chinook 2008



Both Years Very Low-Flow!!

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