Longfin Smelt Spatiotemporal Domain

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## Load and process Longfin Smelt data

Grab Longfin Smelt data from the integrated fish dataset (LTMRdata package by Sam Bashevkin et al.) and produce one fish data per row. I will exclude fish with no length measurement. Note that unmeasured fish that were collected alongside measured fish were converted to have fish length per LTMRdata documentation. I converted count to integer however, since the process that Sam implemented created decimal points for counts.

Surveys included in this calculation:

1. San Francisco Bay Study
2. Suisun Marsh Study
3. Fall Midwater Trawl
4. Spring Kodiak Trawl
5. Delta Juvenile Fish Monitoring Program
6. Enhanced Delta Smelt Monitoring
7. 20-mm Survey
8. Smelt Larval Survey
9. Summer Townet Survey

#Use deltafish to load data  
surv <- open\_survey()  
fish <- open\_fish()  
  
# filter for taxa of interest  
fish\_longfinsmelt <- fish %>%   
 filter(Taxa %in% c("Spirinchus thaleichthys"))  
  
  
# do a join and collect the resulting data frame  
# collect executes the sql query and gives you a table  
data\_longfinsmelt<-left\_join(surv, fish\_longfinsmelt) %>%   
 collect()   
  
  
#Create time series summary  
data\_longfinsmelt\_time\_summary<-data\_longfinsmelt %>% group\_by(Source) %>% summarise(StartDate=min(Date),EndDate=max(Date))  
data\_longfinsmelt\_time\_summary

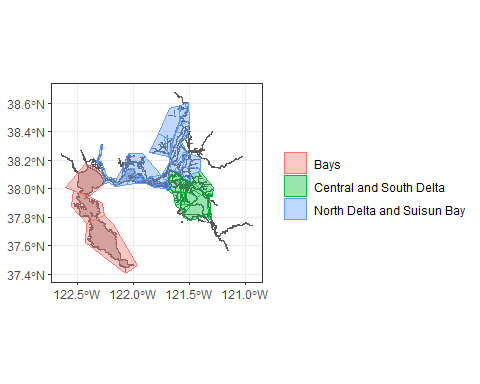
## # A tibble: 9 x 3  
## Source StartDate EndDate   
## <chr> <date> <date>   
## 1 20mm 1995-04-24 2021-07-16  
## 2 Bay Study 1980-01-23 2020-12-01  
## 3 DJFMP 1976-03-08 2020-12-31  
## 4 EDSM 2016-12-15 2021-03-25  
## 5 FMWT 1967-09-13 2020-12-15  
## 6 SKT 2002-01-07 2021-04-29  
## 7 SLS 2009-01-05 2021-03-17  
## 8 STN 1959-06-14 2021-08-19  
## 9 Suisun 1979-05-16 2021-09-23

#Remove 0 counts, only use years 1994 and after, only ones with non-zero lengths  
data\_longfinsmelt <- data\_longfinsmelt %>%   
 filter(Count>0) %>% filter(year(Date)>=1994) %>% filter(!is.na(Length))  
  
#Change count to integer  
data\_longfinsmelt$Count<-as.integer(data\_longfinsmelt$Count)  
#Remove zero catch data  
data\_longfinsmelt<- data\_longfinsmelt%>% filter(Count>0)  
  
#Create long form, remove data prior to 1994  
data\_longfinsmelt\_long <-data\_longfinsmelt[rep(1:nrow(data\_longfinsmelt), data\_longfinsmelt$Count),] %>% mutate(Count=1)

## Regions used to understand spatial distribution

Shown below are the regional cutoffs used to better understand when fish are found in a particular area within the estuary

## # A tibble: 13 x 1  
## SubRegion   
## <chr>   
## 1 San Joaquin River at Twitchell Island  
## 2 San Joaquin River at Prisoners Pt   
## 3 Franks Tract   
## 4 Holland Cut   
## 5 Middle River   
## 6 Upper San Joaquin River   
## 7 Victoria Canal   
## 8 Grant Line Canal and Old River   
## 9 San Joaquin River near Stockton   
## 10 Old River   
## 11 Disappointment Slough   
## 12 Rock Slough and Discovery Bay   
## 13 Mildred Island



## Create spatial data frame, categorizing fish catch into regions

## Size cutoffs used for Longfin Smelt

Larvae: (<20mm FL)

Juvenile: (20-84mm FL)

Adult: (>84mm FL)

### Brood year cutoff for the life stages

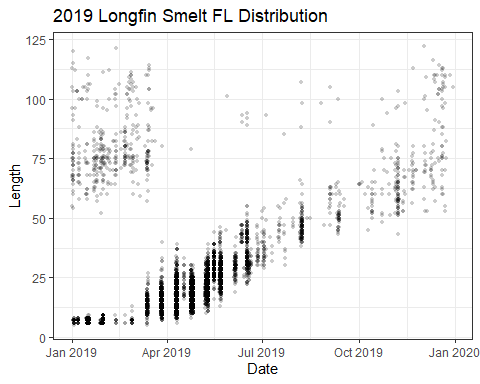
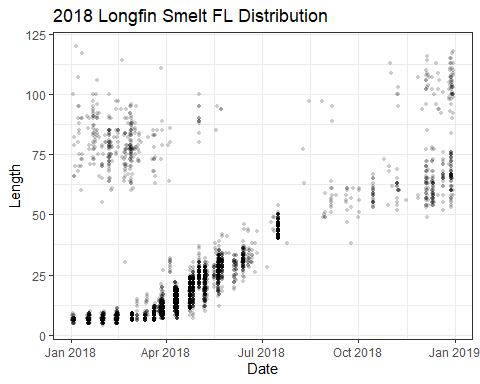
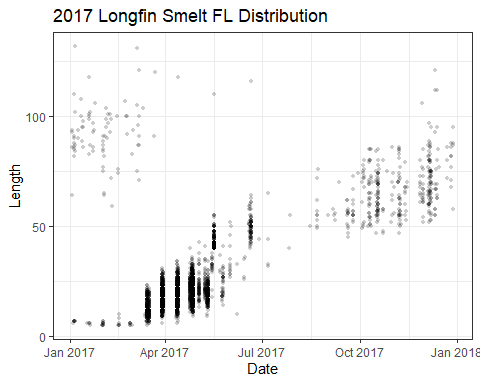
Larvae: brood year = calendar year

Juvenile: brood year = calendar year

Adult: brood year starts in July 1st of current year to June 30th of the following year

# Overview of size distribution

Subadult and adult Longfin Smelt typically are present and caught from January to July, and then again starting October to November.



## Adult Longfin Smelt

(mature and immature adults of >84 mm FL, cohort year set to July 1st - June 30th)

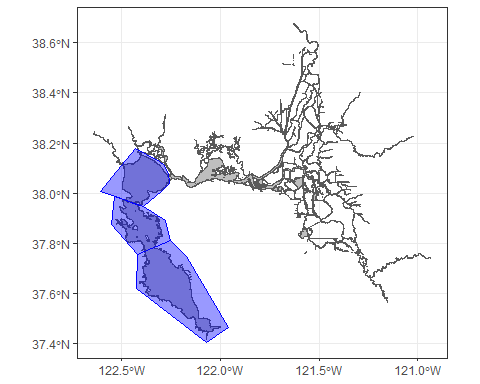
## Juvenile Longfin Smelt

(20-84 mm FL, cohort year set to January 1st - December 31st; same as calendar year)

## Larval Longfin Smelt

(<20 mm FL, cohort year set to just calendar year)

## Bay Region

 ### Adults

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1994 | 07-06-1994 | 09-12-1994 | 11-07-1994 | 05-03-1995 | 05-04-1995 | 05-09-1995 | 80 |
| 1995 | 07-10-1995 | 07-10-1995 | 01-08-1996 | 06-06-1996 | 06-10-1996 | 06-10-1996 | 203 |
| 1996 | 07-03-1996 | 08-12-1996 | 11-06-1996 | 04-14-1997 | 05-12-1997 | 06-10-1997 | 439 |
| 1997 | 07-09-1997 | 09-08-1997 | 11-05-1997 | 05-11-1998 | 05-11-1998 | 06-08-1998 | 181 |
| 1998 | 11-02-1998 | 12-03-1998 | 12-07-1998 | 05-27-1999 | 06-09-1999 | 06-15-1999 | 173 |
| 1999 | 07-08-1999 | 07-12-1999 | 07-12-1999 | 04-05-2000 | 05-10-2000 | 06-13-2000 | 119 |
| 2000 | 07-07-2000 | 08-24-2000 | 12-12-2000 | 04-16-2001 | 05-10-2001 | 06-07-2001 | 196 |
| 2001 | 07-17-2001 | 10-25-2001 | 11-14-2001 | 04-04-2002 | 04-04-2002 | 05-14-2002 | 154 |
| 2002 | 09-09-2002 | 12-04-2002 | 01-08-2003 | 06-02-2003 | 06-25-2003 | 06-25-2003 | 114 |
| 2003 | 07-17-2003 | 08-07-2003 | 10-14-2003 | 04-15-2004 | 05-05-2004 | 05-11-2004 | 67 |
| 2004 | 09-09-2004 | 09-09-2004 | 12-06-2004 | 06-09-2005 | 06-09-2005 | 06-13-2005 | 62 |
| 2005 | 07-11-2005 | 10-05-2005 | 11-08-2005 | 05-06-2006 | 05-18-2006 | 06-14-2006 | 95 |
| 2006 | 07-19-2006 | 09-07-2006 | 11-08-2006 | 05-14-2007 | 05-14-2007 | 06-05-2007 | 65 |
| 2007 | 07-11-2007 | 07-11-2007 | 08-08-2007 | 03-05-2008 | 06-05-2008 | 06-05-2008 | 15 |
| 2008 | 08-07-2008 | 11-05-2008 | 12-02-2008 | 04-13-2009 | 05-06-2009 | 06-03-2009 | 62 |
| 2009 | 07-13-2009 | 07-13-2009 | 07-13-2009 | 03-08-2010 | 03-10-2010 | 05-12-2010 | 41 |
| 2010 | 07-08-2010 | 12-06-2010 | 01-13-2011 | 05-04-2011 | 05-04-2011 | 06-08-2011 | 39 |
| 2011 | 07-07-2011 | 10-10-2011 | 12-07-2011 | 04-09-2012 | 05-10-2012 | 06-07-2012 | 77 |
| 2012 | 07-05-2012 | 07-10-2012 | 09-06-2012 | 03-11-2013 | 06-11-2013 | 06-11-2013 | 46 |
| 2013 | 07-03-2013 | 07-03-2013 | 07-09-2013 | 02-11-2014 | 05-19-2014 | 05-19-2014 | 19 |
| 2014 | 12-03-2014 | 12-03-2014 | 12-03-2014 | 05-12-2015 | 05-12-2015 | 05-12-2015 | 7 |
| 2016 | 12-12-2016 | 12-12-2016 | 12-12-2016 | 06-21-2017 | 06-21-2017 | 06-21-2017 | 8 |
| 2017 | 10-31-2017 | 10-31-2017 | 11-29-2017 | 02-27-2018 | 02-28-2018 | 02-28-2018 | 16 |
| 2018 | 12-06-2018 | 12-06-2018 | 12-06-2018 | 06-12-2019 | 06-17-2019 | 06-17-2019 | 10 |
| 2019 | 07-22-2019 | 07-22-2019 | 08-07-2019 | 02-03-2020 | 02-03-2020 | 02-03-2020 | 17 |
| 2020 | 09-23-2020 | 09-23-2020 | 09-23-2020 | 11-12-2020 | 11-12-2020 | 11-12-2020 | 5 |

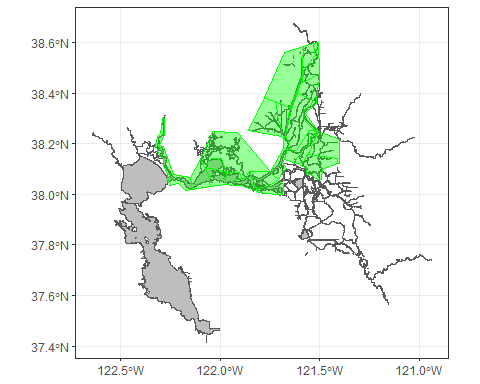
### Juveniles

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1994 | 02-04-1994 | 02-04-1994 | 02-04-1994 | 12-05-1994 | 12-05-1994 | 12-05-1994 | 288 |
| 1995 | 01-05-1995 | 05-04-1995 | 05-09-1995 | 09-11-1995 | 11-14-1995 | 12-13-1995 | 14009 |
| 1996 | 01-08-1996 | 01-08-1996 | 02-14-1996 | 12-09-1996 | 12-11-1996 | 12-12-1996 | 1390 |
| 1997 | 01-07-1997 | 02-04-1997 | 03-04-1997 | 12-01-1997 | 12-01-1997 | 12-09-1997 | 969 |
| 1998 | 01-06-1998 | 02-11-1998 | 05-08-1998 | 11-02-1998 | 12-02-1998 | 12-08-1998 | 3927 |
| 1999 | 01-13-1999 | 02-08-1999 | 04-21-1999 | 09-07-1999 | 09-30-1999 | 11-29-1999 | 6184 |
| 2000 | 01-24-2000 | 02-09-2000 | 03-24-2000 | 11-17-2000 | 12-12-2000 | 12-15-2000 | 2352 |
| 2001 | 01-10-2001 | 01-10-2001 | 01-10-2001 | 09-10-2001 | 10-31-2001 | 12-11-2001 | 425 |
| 2002 | 02-14-2002 | 03-14-2002 | 04-06-2002 | 11-06-2002 | 12-04-2002 | 12-09-2002 | 638 |
| 2003 | 01-08-2003 | 01-09-2003 | 01-09-2003 | 12-01-2003 | 12-03-2003 | 12-18-2003 | 428 |
| 2004 | 01-07-2004 | 01-07-2004 | 01-13-2004 | 12-06-2004 | 12-07-2004 | 12-14-2004 | 432 |
| 2005 | 01-05-2005 | 01-05-2005 | 01-11-2005 | 10-11-2005 | 12-13-2005 | 12-20-2005 | 402 |
| 2006 | 01-09-2006 | 04-22-2006 | 04-22-2006 | 09-05-2006 | 10-04-2006 | 12-11-2006 | 7929 |
| 2007 | 01-08-2007 | 01-08-2007 | 01-08-2007 | 09-13-2007 | 10-10-2007 | 12-05-2007 | 308 |
| 2008 | 01-28-2008 | 06-05-2008 | 06-10-2008 | 12-02-2008 | 12-04-2008 | 12-04-2008 | 237 |
| 2009 | 01-07-2009 | 01-12-2009 | 01-13-2009 | 07-13-2009 | 10-12-2009 | 12-09-2009 | 243 |
| 2010 | 01-06-2010 | 01-19-2010 | 02-09-2010 | 12-06-2010 | 12-06-2010 | 12-09-2010 | 151 |
| 2011 | 01-12-2011 | 02-10-2011 | 03-14-2011 | 12-05-2011 | 12-07-2011 | 12-12-2011 | 1386 |
| 2012 | 01-05-2012 | 01-05-2012 | 01-05-2012 | 11-06-2012 | 11-06-2012 | 12-10-2012 | 328 |
| 2013 | 01-09-2013 | 01-09-2013 | 02-06-2013 | 12-04-2013 | 12-09-2013 | 12-10-2013 | 334 |
| 2014 | 01-13-2014 | 01-13-2014 | 01-13-2014 | 11-12-2014 | 12-04-2014 | 12-09-2014 | 66 |
| 2015 | 01-07-2015 | 01-07-2015 | 01-07-2015 | 06-09-2015 | 10-12-2015 | 10-12-2015 | 31 |
| 2016 | 05-04-2016 | 05-04-2016 | 05-04-2016 | 09-07-2016 | 11-29-2016 | 12-13-2016 | 32 |
| 2017 | 02-09-2017 | 03-29-2017 | 03-29-2017 | 07-07-2017 | 10-17-2017 | 12-13-2017 | 1083 |
| 2018 | 02-26-2018 | 02-27-2018 | 05-29-2018 | 12-10-2018 | 12-11-2018 | 12-11-2018 | 406 |
| 2019 | 01-14-2019 | 03-13-2019 | 03-27-2019 | 09-12-2019 | 11-07-2019 | 12-11-2019 | 945 |
| 2020 | 01-28-2020 | 06-23-2020 | 07-27-2020 | 11-05-2020 | 11-05-2020 | 12-01-2020 | 321 |
| 2021 | 02-22-2021 | 02-22-2021 | 02-22-2021 | 02-22-2021 | 02-22-2021 | 02-22-2021 | 1 |

### Larvae

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1995 | 04-28-1995 | 04-28-1995 | 04-28-1995 | 05-26-1995 | 05-26-1995 | 06-09-1995 | 146 |
| 1996 | 04-14-1996 | 04-14-1996 | 04-14-1996 | 04-17-1996 | 04-17-1996 | 05-29-1996 | 2759 |
| 1997 | 04-18-1997 | 04-18-1997 | 04-18-1997 | 04-18-1997 | 04-18-1997 | 04-18-1997 | 14 |
| 1998 | 04-10-1998 | 04-10-1998 | 04-10-1998 | 05-08-1998 | 05-08-1998 | 06-05-1998 | 398 |
| 1999 | 04-15-1999 | 04-15-1999 | 04-15-1999 | 05-13-1999 | 05-13-1999 | 06-25-1999 | 43 |
| 2000 | 03-24-2000 | 03-24-2000 | 03-24-2000 | 05-04-2000 | 05-04-2000 | 09-11-2000 | 298 |
| 2001 | 03-23-2001 | 03-23-2001 | 03-23-2001 | 04-06-2001 | 04-06-2001 | 04-20-2001 | 26 |
| 2002 | 03-22-2002 | 03-22-2002 | 03-22-2002 | 03-22-2002 | 06-01-2002 | 06-01-2002 | 13 |
| 2004 | 04-15-2004 | 04-15-2004 | 04-15-2004 | 04-15-2004 | 04-15-2004 | 04-15-2004 | 1 |
| 2005 | 04-02-2005 | 04-02-2005 | 04-02-2005 | 04-29-2005 | 04-29-2005 | 04-29-2005 | 8 |
| 2006 | 03-24-2006 | 04-22-2006 | 04-22-2006 | 05-06-2006 | 05-19-2006 | 05-19-2006 | 7006 |
| 2007 | 03-30-2007 | 03-30-2007 | 03-30-2007 | 04-13-2007 | 04-13-2007 | 04-13-2007 | 6 |
| 2008 | 03-20-2008 | 03-20-2008 | 03-20-2008 | 03-20-2008 | 03-20-2008 | 03-20-2008 | 3 |
| 2009 | 03-13-2009 | 03-13-2009 | 03-13-2009 | 03-26-2009 | 04-24-2009 | 05-08-2009 | 31 |
| 2010 | 03-17-2010 | 03-17-2010 | 03-17-2010 | 04-14-2010 | 04-14-2010 | 05-26-2010 | 37 |
| 2011 | 03-17-2011 | 04-25-2011 | 04-25-2011 | 04-25-2011 | 04-25-2011 | 05-10-2011 | 2972 |
| 2012 | 03-14-2012 | 03-14-2012 | 03-14-2012 | 05-23-2012 | 05-23-2012 | 05-23-2012 | 7 |
| 2013 | 04-10-2013 | 04-10-2013 | 04-10-2013 | 04-24-2013 | 04-24-2013 | 04-24-2013 | 8 |
| 2017 | 03-15-2017 | 03-15-2017 | 03-15-2017 | 04-26-2017 | 04-26-2017 | 05-10-2017 | 1530 |
| 2018 | 03-28-2018 | 03-28-2018 | 03-28-2018 | 03-28-2018 | 03-28-2018 | 03-28-2018 | 1 |
| 2019 | 03-13-2019 | 03-13-2019 | 03-27-2019 | 04-24-2019 | 04-24-2019 | 05-22-2019 | 1784 |

## North Delta and Suisun Bay Region



### Adults

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1994 | 07-03-1994 | 11-28-1994 | 12-07-1994 | 02-10-1995 | 03-06-1995 | 06-12-1995 | 1981 |
| 1995 | 08-09-1995 | 01-03-1996 | 01-03-1996 | 05-13-1996 | 05-13-1996 | 06-27-1996 | 2025 |
| 1996 | 07-10-1996 | 12-08-1996 | 12-17-1996 | 01-23-1997 | 03-03-1997 | 06-30-1997 | 11754 |
| 1997 | 07-15-1997 | 12-05-1997 | 12-09-1997 | 01-12-1998 | 01-27-1998 | 06-03-1998 | 1904 |
| 1998 | 09-16-1998 | 12-07-1998 | 12-09-1998 | 05-19-1999 | 06-08-1999 | 06-16-1999 | 1431 |
| 1999 | 07-07-1999 | 12-02-1999 | 12-16-1999 | 03-06-2000 | 05-09-2000 | 06-14-2000 | 2847 |
| 2000 | 07-11-2000 | 12-06-2000 | 12-15-2000 | 03-19-2001 | 04-02-2001 | 06-13-2001 | 1897 |
| 2001 | 07-03-2001 | 12-12-2001 | 12-19-2001 | 01-22-2002 | 03-04-2002 | 06-18-2002 | 6764 |
| 2002 | 07-10-2002 | 12-19-2002 | 12-24-2002 | 01-22-2003 | 01-31-2003 | 06-24-2003 | 1900 |
| 2003 | 07-14-2003 | 12-13-2003 | 12-17-2003 | 01-12-2004 | 03-02-2004 | 06-30-2004 | 4968 |
| 2004 | 07-07-2004 | 12-07-2004 | 12-16-2004 | 01-26-2005 | 02-14-2005 | 06-23-2005 | 1447 |
| 2005 | 07-25-2005 | 12-07-2005 | 12-09-2005 | 02-09-2006 | 02-22-2006 | 04-21-2006 | 732 |
| 2006 | 07-17-2006 | 11-11-2006 | 12-12-2006 | 04-20-2007 | 05-06-2007 | 06-13-2007 | 216 |
| 2007 | 08-13-2007 | 12-01-2007 | 12-11-2007 | 02-12-2008 | 03-03-2008 | 04-02-2008 | 744 |
| 2008 | 10-16-2008 | 12-08-2008 | 12-09-2008 | 03-18-2009 | 04-09-2009 | 06-25-2009 | 389 |
| 2009 | 07-07-2009 | 12-09-2009 | 12-16-2009 | 03-10-2010 | 03-15-2010 | 05-27-2010 | 593 |
| 2010 | 10-07-2010 | 12-17-2010 | 12-17-2010 | 01-12-2011 | 02-09-2011 | 06-07-2011 | 251 |
| 2011 | 08-02-2011 | 11-01-2011 | 12-05-2011 | 03-06-2012 | 03-13-2012 | 06-05-2012 | 252 |
| 2012 | 09-10-2012 | 12-12-2012 | 12-17-2012 | 01-11-2013 | 02-19-2013 | 05-13-2013 | 1089 |
| 2013 | 09-09-2013 | 11-12-2013 | 11-13-2013 | 02-26-2014 | 03-13-2014 | 05-15-2014 | 126 |
| 2014 | 09-03-2014 | 12-10-2014 | 12-19-2014 | 03-03-2015 | 04-07-2015 | 06-08-2015 | 121 |
| 2015 | 07-10-2015 | 07-10-2015 | 09-17-2015 | 02-12-2016 | 02-22-2016 | 02-24-2016 | 20 |
| 2016 | 11-08-2016 | 12-07-2016 | 12-19-2016 | 03-01-2017 | 03-06-2017 | 03-22-2017 | 82 |
| 2017 | 10-10-2017 | 11-07-2017 | 12-06-2017 | 05-03-2018 | 05-03-2018 | 05-23-2018 | 113 |
| 2018 | 08-15-2018 | 11-08-2018 | 12-04-2018 | 03-05-2019 | 03-15-2019 | 06-17-2019 | 181 |
| 2019 | 07-05-2019 | 10-28-2019 | 12-04-2019 | 03-02-2020 | 03-12-2020 | 06-11-2020 | 103 |
| 2020 | 07-07-2020 | 09-15-2020 | 10-15-2020 | 02-12-2021 | 03-03-2021 | 04-29-2021 | 38 |
| 2021 | 09-23-2021 | 09-23-2021 | 09-23-2021 | 09-23-2021 | 09-23-2021 | 09-23-2021 | 1 |

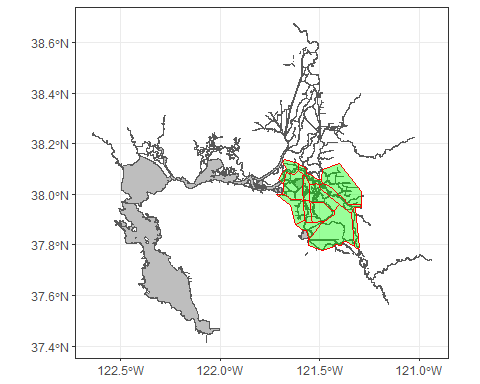
### Juveniles

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1994 | 01-03-1994 | 01-11-1994 | 03-08-1994 | 06-14-1994 | 06-17-1994 | 12-31-1994 | 10263 |
| 1995 | 01-03-1995 | 04-28-1995 | 05-12-1995 | 12-06-1995 | 12-20-1995 | 12-28-1995 | 9228 |
| 1996 | 01-03-1996 | 01-04-1996 | 01-11-1996 | 06-29-1996 | 07-29-1996 | 12-30-1996 | 15906 |
| 1997 | 01-17-1997 | 04-04-1997 | 04-05-1997 | 12-06-1997 | 12-20-1997 | 12-31-1997 | 11208 |
| 1998 | 01-03-1998 | 04-10-1998 | 04-10-1998 | 11-24-1998 | 12-15-1998 | 12-31-1998 | 24423 |
| 1999 | 01-01-1999 | 04-15-1999 | 04-16-1999 | 08-16-1999 | 10-05-1999 | 12-31-1999 | 41724 |
| 2000 | 01-02-2000 | 04-06-2000 | 04-07-2000 | 06-21-2000 | 09-13-2000 | 12-20-2000 | 64002 |
| 2001 | 01-03-2001 | 02-06-2001 | 03-24-2001 | 05-30-2001 | 06-03-2001 | 12-31-2001 | 25079 |
| 2002 | 01-02-2002 | 03-22-2002 | 03-22-2002 | 06-15-2002 | 10-20-2002 | 12-31-2002 | 20473 |
| 2003 | 01-02-2003 | 03-26-2003 | 03-28-2003 | 05-22-2003 | 10-13-2003 | 12-31-2003 | 8436 |
| 2004 | 01-02-2004 | 01-27-2004 | 02-11-2004 | 08-03-2004 | 12-09-2004 | 12-31-2004 | 4440 |
| 2005 | 01-02-2005 | 01-05-2005 | 01-24-2005 | 06-09-2005 | 10-07-2005 | 12-28-2005 | 2407 |
| 2006 | 01-10-2006 | 03-24-2006 | 03-24-2006 | 10-11-2006 | 11-15-2006 | 12-31-2006 | 1364 |
| 2007 | 01-03-2007 | 01-09-2007 | 01-22-2007 | 05-26-2007 | 06-07-2007 | 12-30-2007 | 1162 |
| 2008 | 01-02-2008 | 03-19-2008 | 03-19-2008 | 06-04-2008 | 06-18-2008 | 12-24-2008 | 11480 |
| 2009 | 01-02-2009 | 03-12-2009 | 03-26-2009 | 06-11-2009 | 06-16-2009 | 12-23-2009 | 2672 |
| 2010 | 01-05-2010 | 03-16-2010 | 03-17-2010 | 05-13-2010 | 05-25-2010 | 12-06-2010 | 4972 |
| 2011 | 01-05-2011 | 03-16-2011 | 04-14-2011 | 06-30-2011 | 12-05-2011 | 12-30-2011 | 4531 |
| 2012 | 01-03-2012 | 02-07-2012 | 03-27-2012 | 06-13-2012 | 06-27-2012 | 12-21-2012 | 1589 |
| 2013 | 01-04-2013 | 04-09-2013 | 04-09-2013 | 06-04-2013 | 06-11-2013 | 12-11-2013 | 20106 |
| 2014 | 01-06-2014 | 03-19-2014 | 03-20-2014 | 05-15-2014 | 06-18-2014 | 12-31-2014 | 1315 |
| 2015 | 01-02-2015 | 01-06-2015 | 01-07-2015 | 05-12-2015 | 05-26-2015 | 06-09-2015 | 434 |
| 2016 | 02-03-2016 | 03-10-2016 | 03-30-2016 | 05-11-2016 | 05-24-2016 | 12-27-2016 | 760 |
| 2017 | 01-03-2017 | 03-30-2017 | 03-30-2017 | 10-18-2017 | 12-05-2017 | 12-28-2017 | 1283 |
| 2018 | 01-04-2018 | 02-07-2018 | 03-22-2018 | 08-09-2018 | 12-20-2018 | 12-30-2018 | 1676 |
| 2019 | 01-01-2019 | 03-28-2019 | 04-11-2019 | 06-06-2019 | 06-26-2019 | 12-23-2019 | 4328 |
| 2020 | 01-03-2020 | 04-06-2020 | 04-23-2020 | 06-17-2020 | 06-22-2020 | 12-28-2020 | 1667 |
| 2021 | 01-04-2021 | 04-07-2021 | 04-07-2021 | 05-19-2021 | 05-19-2021 | 08-11-2021 | 5990 |

### Larvae

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1994 | 03-18-1994 | 03-18-1994 | 03-18-1994 | 04-24-1994 | 04-24-1994 | 04-24-1994 | 4 |
| 1995 | 04-27-1995 | 04-27-1995 | 04-27-1995 | 05-12-1995 | 05-25-1995 | 06-27-1995 | 386 |
| 1996 | 04-12-1996 | 04-13-1996 | 04-16-1996 | 05-13-1996 | 05-14-1996 | 06-29-1996 | 9816 |
| 1997 | 04-03-1997 | 04-04-1997 | 04-04-1997 | 04-30-1997 | 04-30-1997 | 06-01-1997 | 8349 |
| 1998 | 04-10-1998 | 04-10-1998 | 04-10-1998 | 04-10-1998 | 04-10-1998 | 06-19-1998 | 10706 |
| 1999 | 04-14-1999 | 04-15-1999 | 04-15-1999 | 04-30-1999 | 05-14-1999 | 07-23-1999 | 28318 |
| 2000 | 03-22-2000 | 03-24-2000 | 04-06-2000 | 04-21-2000 | 04-22-2000 | 06-17-2000 | 101153 |
| 2001 | 03-20-2001 | 03-22-2001 | 03-23-2001 | 04-20-2001 | 04-20-2001 | 07-12-2001 | 50238 |
| 2002 | 03-19-2002 | 03-20-2002 | 03-21-2002 | 04-17-2002 | 04-18-2002 | 07-31-2002 | 26821 |
| 2003 | 03-25-2003 | 03-26-2003 | 03-26-2003 | 04-11-2003 | 04-25-2003 | 06-07-2003 | 13420 |
| 2004 | 03-30-2004 | 04-01-2004 | 04-01-2004 | 04-16-2004 | 04-28-2004 | 06-10-2004 | 7478 |
| 2005 | 03-15-2005 | 03-17-2005 | 03-18-2005 | 04-27-2005 | 04-29-2005 | 06-15-2005 | 5600 |
| 2006 | 03-23-2006 | 03-24-2006 | 03-24-2006 | 06-02-2006 | 06-03-2006 | 08-16-2006 | 711 |
| 2007 | 03-14-2007 | 03-17-2007 | 03-17-2007 | 04-25-2007 | 04-25-2007 | 05-12-2007 | 2156 |
| 2008 | 03-05-2008 | 03-18-2008 | 03-19-2008 | 04-30-2008 | 04-30-2008 | 06-12-2008 | 12284 |
| 2009 | 01-06-2009 | 01-22-2009 | 02-03-2009 | 04-08-2009 | 04-21-2009 | 06-11-2009 | 19047 |
| 2010 | 01-04-2010 | 01-19-2010 | 01-21-2010 | 04-14-2010 | 04-14-2010 | 05-26-2010 | 26944 |
| 2011 | 01-18-2011 | 01-31-2011 | 02-01-2011 | 05-09-2011 | 05-11-2011 | 06-30-2011 | 17932 |
| 2012 | 01-09-2012 | 01-10-2012 | 01-23-2012 | 03-28-2012 | 05-08-2012 | 06-06-2012 | 16715 |
| 2013 | 01-02-2013 | 01-29-2013 | 02-11-2013 | 04-23-2013 | 04-24-2013 | 07-03-2013 | 47892 |
| 2014 | 01-06-2014 | 01-21-2014 | 01-22-2014 | 03-21-2014 | 04-03-2014 | 05-13-2014 | 5867 |
| 2015 | 01-07-2015 | 01-08-2015 | 01-22-2015 | 04-01-2015 | 04-08-2015 | 05-11-2015 | 1098 |
| 2016 | 01-04-2016 | 01-20-2016 | 02-02-2016 | 04-26-2016 | 04-26-2016 | 05-23-2016 | 1266 |
| 2017 | 01-04-2017 | 03-16-2017 | 03-16-2017 | 05-10-2017 | 05-11-2017 | 06-07-2017 | 1308 |
| 2018 | 01-03-2018 | 01-18-2018 | 01-31-2018 | 04-24-2018 | 04-24-2018 | 06-05-2018 | 4432 |
| 2019 | 01-03-2019 | 01-17-2019 | 01-30-2019 | 05-10-2019 | 05-10-2019 | 06-05-2019 | 4253 |
| 2020 | 01-08-2020 | 01-21-2020 | 01-21-2020 | 04-22-2020 | 04-23-2020 | 05-20-2020 | 3545 |
| 2021 | 01-12-2021 | 01-26-2021 | 02-10-2021 | 04-21-2021 | 05-05-2021 | 06-03-2021 | 5079 |

## Central and South Delta



### Adults

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1999 | 01-07-2000 | 01-07-2000 | 01-07-2000 | 01-07-2000 | 01-07-2000 | 01-07-2000 | 4 |
| 2000 | 12-06-2000 | 12-06-2000 | 12-06-2000 | 01-03-2001 | 01-03-2001 | 01-03-2001 | 5 |
| 2001 | 12-07-2001 | 12-07-2001 | 12-07-2001 | 04-15-2002 | 04-15-2002 | 04-15-2002 | 4 |
| 2003 | 01-05-2004 | 01-05-2004 | 01-05-2004 | 01-05-2004 | 01-05-2004 | 01-05-2004 | 2 |
| 2008 | 01-05-2009 | 01-05-2009 | 01-05-2009 | 01-05-2009 | 01-05-2009 | 01-05-2009 | 1 |
| 2009 | 12-15-2009 | 12-15-2009 | 12-15-2009 | 01-04-2010 | 01-04-2010 | 01-04-2010 | 3 |
| 2011 | 01-03-2012 | 01-03-2012 | 01-03-2012 | 01-03-2012 | 01-03-2012 | 01-03-2012 | 1 |
| 2012 | 01-07-2013 | 01-07-2013 | 01-07-2013 | 01-07-2013 | 01-07-2013 | 01-07-2013 | 2 |
| 2016 | 01-24-2017 | 01-24-2017 | 01-24-2017 | 01-24-2017 | 01-24-2017 | 01-24-2017 | 1 |
| 2019 | 12-02-2019 | 12-02-2019 | 12-02-2019 | 12-02-2019 | 12-02-2019 | 12-02-2019 | 1 |

### Juveniles

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1994 | 06-15-1994 | 06-15-1994 | 06-15-1994 | 06-15-1994 | 06-15-1994 | 06-15-1994 | 1 |
| 1995 | 12-04-1995 | 12-04-1995 | 12-04-1995 | 12-04-1995 | 12-04-1995 | 12-04-1995 | 1 |
| 1996 | 04-25-1996 | 04-25-1996 | 04-25-1996 | 04-30-1996 | 04-30-1996 | 04-30-1996 | 5 |
| 1997 | 04-14-1997 | 04-14-1997 | 04-14-1997 | 05-12-1997 | 05-12-1997 | 05-12-1997 | 8 |
| 1999 | 04-12-1999 | 04-12-1999 | 04-12-1999 | 05-11-1999 | 05-11-1999 | 05-11-1999 | 4 |
| 2000 | 05-01-2000 | 05-01-2000 | 05-01-2000 | 12-06-2000 | 12-06-2000 | 12-06-2000 | 3 |
| 2001 | 04-16-2001 | 04-16-2001 | 04-16-2001 | 06-11-2001 | 06-11-2001 | 06-11-2001 | 6 |
| 2002 | 03-18-2002 | 04-15-2002 | 04-15-2002 | 04-29-2002 | 05-13-2002 | 05-28-2002 | 779 |
| 2003 | 03-24-2003 | 04-07-2003 | 04-07-2003 | 04-21-2003 | 04-22-2003 | 04-22-2003 | 23 |
| 2004 | 04-12-2004 | 04-12-2004 | 04-12-2004 | 06-07-2004 | 06-07-2004 | 06-07-2004 | 5 |
| 2005 | 03-14-2005 | 03-14-2005 | 03-14-2005 | 03-14-2005 | 03-14-2005 | 03-14-2005 | 14 |
| 2006 | 05-01-2006 | 05-01-2006 | 05-01-2006 | 05-01-2006 | 05-01-2006 | 05-01-2006 | 1 |
| 2007 | 06-04-2007 | 06-04-2007 | 06-04-2007 | 06-04-2007 | 06-04-2007 | 06-04-2007 | 1 |
| 2008 | 04-14-2008 | 04-14-2008 | 04-14-2008 | 06-30-2008 | 06-30-2008 | 06-30-2008 | 4 |
| 2010 | 03-29-2010 | 03-29-2010 | 03-29-2010 | 05-10-2010 | 05-10-2010 | 05-10-2010 | 2 |
| 2012 | 03-12-2012 | 03-12-2012 | 03-12-2012 | 04-23-2012 | 04-23-2012 | 04-23-2012 | 6 |
| 2013 | 03-25-2013 | 04-08-2013 | 04-22-2013 | 06-10-2013 | 06-17-2013 | 06-26-2013 | 44 |
| 2014 | 03-18-2014 | 03-18-2014 | 03-18-2014 | 04-28-2014 | 04-28-2014 | 04-28-2014 | 24 |
| 2015 | 04-06-2015 | 04-06-2015 | 04-06-2015 | 04-27-2015 | 04-27-2015 | 04-27-2015 | 9 |
| 2017 | 02-10-2017 | 02-10-2017 | 02-10-2017 | 03-07-2017 | 03-07-2017 | 03-07-2017 | 3 |
| 2019 | 02-19-2019 | 02-19-2019 | 02-19-2019 | 12-04-2019 | 12-04-2019 | 12-04-2019 | 3 |
| 2020 | 04-27-2020 | 04-27-2020 | 04-27-2020 | 04-27-2020 | 04-27-2020 | 04-27-2020 | 1 |
| 2021 | 04-05-2021 | 04-05-2021 | 04-05-2021 | 05-18-2021 | 05-18-2021 | 05-18-2021 | 9 |

### Larvae

| Cohort Year | 0.0% | 5.0% | 10.0% | 90.0% | 95.0% | 100.0% | Sample size |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1996 | 04-24-1996 | 04-30-1996 | 04-30-1996 | 04-30-1996 | 04-30-1996 | 04-30-1996 | 69 |
| 1997 | 03-31-1997 | 04-14-1997 | 04-14-1997 | 04-28-1997 | 04-28-1997 | 05-12-1997 | 91 |
| 1999 | 04-12-1999 | 04-12-1999 | 04-12-1999 | 04-26-1999 | 04-26-1999 | 04-26-1999 | 6 |
| 2000 | 04-03-2000 | 04-03-2000 | 04-03-2000 | 05-22-2000 | 06-12-2000 | 06-12-2000 | 85 |
| 2001 | 03-19-2001 | 03-19-2001 | 03-19-2001 | 04-30-2001 | 05-01-2001 | 05-29-2001 | 143 |
| 2002 | 03-18-2002 | 03-18-2002 | 04-02-2002 | 04-29-2002 | 04-29-2002 | 05-28-2002 | 1292 |
| 2003 | 03-24-2003 | 03-24-2003 | 03-24-2003 | 04-21-2003 | 04-21-2003 | 05-05-2003 | 135 |
| 2004 | 03-29-2004 | 03-29-2004 | 03-29-2004 | 04-13-2004 | 04-26-2004 | 04-26-2004 | 14 |
| 2005 | 03-14-2005 | 03-14-2005 | 03-14-2005 | 03-14-2005 | 03-28-2005 | 06-21-2005 | 106 |
| 2006 | 04-18-2006 | 04-18-2006 | 04-18-2006 | 05-01-2006 | 05-01-2006 | 05-01-2006 | 9 |
| 2007 | 03-26-2007 | 03-26-2007 | 03-26-2007 | 04-23-2007 | 04-23-2007 | 04-23-2007 | 12 |
| 2008 | 03-17-2008 | 04-01-2008 | 04-01-2008 | 04-28-2008 | 04-29-2008 | 05-27-2008 | 121 |
| 2009 | 01-05-2009 | 01-20-2009 | 01-20-2009 | 03-02-2009 | 04-06-2009 | 04-21-2009 | 437 |
| 2010 | 01-04-2010 | 01-04-2010 | 01-04-2010 | 03-01-2010 | 03-23-2010 | 05-10-2010 | 605 |
| 2011 | 01-18-2011 | 01-31-2011 | 01-31-2011 | 02-14-2011 | 02-28-2011 | 03-22-2011 | 297 |
| 2012 | 01-09-2012 | 01-09-2012 | 01-09-2012 | 03-12-2012 | 03-19-2012 | 05-07-2012 | 705 |
| 2013 | 01-02-2013 | 01-28-2013 | 01-28-2013 | 04-08-2013 | 04-09-2013 | 06-03-2013 | 1130 |
| 2014 | 01-06-2014 | 01-21-2014 | 01-21-2014 | 03-18-2014 | 04-01-2014 | 04-29-2014 | 632 |
| 2015 | 01-05-2015 | 02-02-2015 | 02-02-2015 | 04-27-2015 | 04-27-2015 | 04-27-2015 | 110 |
| 2016 | 01-04-2016 | 01-04-2016 | 01-04-2016 | 02-16-2016 | 03-14-2016 | 03-29-2016 | 49 |
| 2017 | 01-17-2017 | 01-17-2017 | 01-17-2017 | 03-13-2017 | 03-13-2017 | 03-13-2017 | 2 |
| 2018 | 01-02-2018 | 01-02-2018 | 01-02-2018 | 02-12-2018 | 02-12-2018 | 02-12-2018 | 16 |
| 2019 | 01-02-2019 | 01-02-2019 | 01-02-2019 | 01-28-2019 | 02-11-2019 | 02-11-2019 | 11 |
| 2020 | 01-06-2020 | 01-06-2020 | 01-21-2020 | 03-17-2020 | 03-31-2020 | 12-28-2020 | 108 |
| 2021 | 01-11-2021 | 01-25-2021 | 01-25-2021 | 04-05-2021 | 04-20-2021 | 05-18-2021 | 218 |