TO: Elizabeth Krafft/MCWRA

FROM: FISHBIO

DATE: November 2, 2018

SUBJECT: Summary of Salinas River Lagoon water quality and fish population monitoring data 2010–2016

This memo summarizes six years of water quality and fish monitoring data from the Salinas River Lagoon and discusses trends in these data with respect to lagoon management, flow conditions, and fish habitat suitability. Continuous water quality measurements, including temperature, dissolved oxygen, and conductivity were collected during the Salinas River Diversion Facility (SRDF) operational period from April to October, beginning in 2010. The SRDF was operated from 2010-2013, but not from 2014-2016, however, water quality data was still collected during 2015-2016. Water quality data was collected from two locations in the Salinas River Lagoon (located near the mouth of the lagoon and near Highway 1 Bridge) and shows distinct patterns depending on whether or not the lagoon was open to the ocean. Water quality in the lagoon was influenced by multiple factors, including lagoon breaching, freshwater inflow, and biological processes (photosynthesis and respiration). Despite water temperatures exceeding 25°C at times, water quality conditions in the lagoon were often within acceptable limits for steelhead migration and rearing. In addition, tidewater goby was present in fish surveys in 2013 and 2014, and likely represents a natural recolonization event for the species. A technical analysis of the data is presented in this memo with several key points detailed below. Following the discussion, we provide recommendations for enhancing the Salinas River Lagoon monitoring program.

Key points

- Lagoon breaching influences water temperature. In the three years that the lagoon was open, daily temperatures ranges (between daily minimum and maximum) were greater when open than when closed.
- Conductivity of the lagoon was high and tidally influenced when the sand bar was breached. Freshwater inflow reduced conductivity in the upstream portion of the lagoon when breached, but only when significant freshwater flows occurred (either reservoir releases or natural flows from the upper watershed).
- Dissolved oxygen concentration appeared to be driven primarily by primary production within the lagoon.
- Stratification occurs when the lagoon is closed and resulted in a saline, anoxic layer in the lower portion of the water column. More monitoring may be needed to determine the frequency and extent of stratification and assess its influence on fish habitat.
- Despite habitat conditions that prevented fish monitoring surveys in later years, the water quality conditions were on par with water conditions when fish monitoring was performed.

Background

The Lagoon Monitoring Program, which has been conducted by the Monterey County Water Resource Agency (MCWRA) since 2002, was modified in 2010 according to the draft[1] Biological Opinion (BO) issued by the National Marine Fisheries Service (NMFS) for sandbar management at the mouth of the Salinas River (NMFS 2009). The draft BO addresses effects on the South Central California Coast steelhead (*Oncorhynchus mykiss*) designated population segment (DPS) inhabiting the Salinas River and lagoon, and calls for sampling for fish and habitat conditions (i.e., water quality) during the SRDF operational period in the spring, summer, and fall. The SRDF was operated from 2010-2013, but not from 2014-2016. An emergency repair of the hydroelectric plant at Nacimiento in 2013 resulted in an imbalance of releases that brought San Antonio reservoir to minimum pool in September 2013. Subsequent drought conditions resulted in three years of storage imbalance between the reservoirs. The lack of sufficient low level outlet capacity at Nacimiento Reservoir and a lack of storage at San Antonio Reservoir, coupled with drought conditions, prevented conservation releases during the 2014, 2015 and 2016 SRDF operations seasons.

The Salinas River is typical of many streams draining the California Central Coast in that, during summer when flow in the river is low, a sandbar typically builds at the river mouth and a closed lagoon is formed. With the onset of the first precipitation events during late fall or winter, rapidly raising water levels in the lagoon increase the potential for flooding of surrounding agricultural areas. Infrequently, the lagoon will naturally breach during the winter as it overtops the sandbar due to increased river flows and wave action that erodes the beach. However, Central California lagoons vary widely in seasonal cycles of filling and breaching, and in water quality conditions.

In the Salinas River lagoon, flooding of agricultural (and residential) lands bordering the lagoon can precede natural breaching, prompting MCWRA to manually breach the sandbar at the mouth of the Salinas River as required as part of its flood control activity. Under the terms and conditions of the draft BO (NMFS 2009), the MCWRA is required to monitor changes in the estuary environment associated with the sandbar management activities and to operate the slide gate at the outlet to the Old Salinas River (OSR) channel in a manner that facilitates filling of the lagoon between December 1 and March 31. NMFS anticipated that incidental take of steelhead will occur as a result of the management activities and provided an incidental take statement with the BO with non-discretionary terms and conditions and conservation recommendations.

To meet these terms and conditions, NMFS determined that a Lagoon Monitoring Plan shall be implemented and include sampling of water quality and fish species composition during the spring, summer, and fall months. The goal of the water quality monitoring is to assess the habitat parameters that affect steelhead use of the lagoon, specifically temperature, dissolved oxygen, and conductivity (a proxy for salinity). Using continuously recorded water quality data collected by MCWRA since 2010, we examined how trends in water quality parameters changed within and among seasons and examined the amount of time that each of the water quality parameters was above recommended thresholds for steelhead migration and rearing.

[1] No Army Corps of Engineers permit was issued along with this BO and therefore the terms are not legally binding

Methods

Continuous Water Quality

Temperature (°C), dissolved oxygen (DO; mg/L), and specific conductivity (μS/cm) were continuously measured at two stations during the SRDF diversion period from April through October. Water quality meters (Hydrolab MS5 Multiparameter Sondes) were deployed in a PVC housing that positioned the instruments within the water column (HES 2014). They were anchored to the substrate using cinder blocks and raised for calibration by a rope and float. This deployment method allowed for continuous data collection and maintenance regardless of water level fluctuations, which can be extreme when the lagoon is open to the ocean. The first monitoring station, Site 1, was located near the mouth of the lagoon. The average depth at Site 1 was approximately 1.83 m (6.0 ft) but varied depending on the lagoon stage height. The data sonde at Site 1 was placed approximately 0.3 m (1.0 ft) above the substrate. The second monitoring station, Site 5, was located near the Highway 1 and Monte Road bridge crossing. The water depth at Site 5 was deeper, approximately 2.74 m (9.0 ft). In 2010, the water quality sonde was placed near the bottom of the river but stratification of the lagoon lead to monitoring of the anoxic lower stratum (see Discussion). In later years, the sonde was positioned approximately 1.0 m (3.0 ft) below the water's surface to more accurately represent conditions suitable for fish.

Water quality measurements were logged at hourly intervals and data was downloaded monthly. After each download, the sondes were recalibrated before being redeployed. Calibration was conducted using a two-point calibration method with known standard solutions and verified using another known standard solution of a mid-range value for conductivity and a one point DO calibration using 100% water saturated air (HES 2014). Temperature was recorded using a thermistor on the data sonde but cannot be calibrated in the field. Reference data were also collected at each site with a separate calibrated instrument to check for variation among instruments and to serve as a quality control for temperature.

Battery voltage was logged along with water quality parameters in attempt to explain any lapses in data collection or out of range readings. The Luminescent Dissolved Oxygen (LDO) probe used on the Hydrolab MS5 requires more battery voltage than the conductivity and temperature sensors and can become inaccurate during periods of a battery voltage reduction. As such, DO measurements collected during periods of voltage reduction were omitted from the dataset.

For the analyses, DO and conductivity data were averaged into 6-hour interval blocks (i.e. 0:00–05:59, 06:00–11:59, 13:00–18:59, and 19:00–23:59) as required by the BO. If data gaps were present due to calibrations or meter malfunction, 6-hour interval averages were created using the available data for a given block (i.e., if data was unavailable for 1 hour, the average was calculated from the remaining 5 hours in the block). For temperature analyses, daily mean, maximum, and minimum values were calculated from the hourly data. Seven-day averages of the daily maximum temperatures (7DADM) were also calculated. When missing daily temperatures occurred, averages were only calculated across 4 or more consecutive days.

All data were analyzed by examining the number of days each year when water quality conditions were above accepted habitat thresholds for salmonids in order to get a sense of how the lagoon may, or may not, have provided suitable conditions for steelhead. Temperature criteria of 18°C and 20°C are recommended by the United States Environmental Protection Agency as suitable temperature standards for adult salmonid migration and juvenile rearing, respectively (USEPA 2003). Dissolved oxygen criteria of 4.0 mg/L and 6.5 mg/L were chosen based on recommended thresholds for protecting salmonids in California estuaries (Sutula et al. 2012). These thresholds are based on acute and chronic exposure, respectively. These thresholds are also supported by additional research showing avoidance behavior, inhibited growth rates, and slight production impairment when DO was below 6 mg/L and inhibited adult migration below 4.2 mg/L (Hallock et al. 1970, USEPA 1986).

Lagoon Fish Monitoring

Fish population sampling in the Salinas River Lagoon occurs during spring (April/May), summer (June-August), and fall (October or early November) as required in the draft BO (NMFS 2009). The objective of the sampling is to determine whether steelhead are present, and evaluate steelhead distribution, relative abundance (catch per unit effort), and condition. Sampling is conducted at stations from the mouth of the lagoon upstream past Highway 1 to approximately river mile 3. Sample stations were chosen for accessibility and habitat characteristics for beach seining.

Large beach seines (150-ft X 8-ft) were used to sample fish in areas with deeper water or along obstructed banks. In these locations, the seine was set from a small boat and hauled across the channel to the opposite bank. Where the water is shallow enough to maneuver the seine or where there are few underwater obstructions, a smaller bag seine (100-ft X 6-ft) is used for sampling and the seine hauled fully onto the open sand borders of the lagoon. This method is effective for capturing multiple size classes of bottom-oriented, mid-water, and near-shore species (HES 2004). Captured fish were identified by species, enumerated, measured or estimated for fork length, and external condition were noted.

Any juvenile steelhead that are captured are measured and condition is described relative to advancement of smoltification (parr marks, scales, coloration) and incidence of external parasites or abnormalities. Fish are released at the site of capture following each seine haul (replacement method). The number of seine hauls performed at each site varied depending on habitat appropriateness to steelhead, as well as amount of area that could reasonably be sampled. In addition, number of seine hauls varied across seasons and years as environmental and extraneous habitat conditions changed.

Sampling effort was not meant to be consistent between stations (although it was as consistent as possible), between the different sampling events, or from one year to the next for the lagoon as a whole. While some idea of the distribution of steelhead within the lagoon is possible with this sampling plan, rigorous comparison of catch between stations was not an objective of the study (HES 2010; 2011; 2012; 2013; 2014). However, to facilitate comparisons of the total number of individuals sampled across seasons and years, catch per unit effort (CPUE) was used to standardize catch for the varying level of effort across samples.

Results

Continuous Water Quality

Water quality data from the Salinas River lagoon showed several distinct patterns based on sampling location, lagoon connectivity with the ocean, season, and incoming flow of freshwater. Water quality parameters showed greater variability when the lagoon was connected with the ocean. Conductivity fluctuated wildly and was high when the lagoon was open, and conversely, was low and relatively stable during closed periods (Figures 1 and 2). When the lagoon was open in 2011, conductivity at Site 1 was high, but high natural flows during that year appeared to lower conductivity at Site 5 until flows decreased beginning around July (Figures 1 and 2). Breaching did not occur at all from 2013 through 2016. Temperatures, showed a similar pattern, with high variability (among daily minimum, mean, and maximum) during periods when the lagoon was open. Dissolved oxygen concentrations varied over space and time, however, DO did not appear to respond to times when the lagoon was open (Figures 5 and 6). Six-hour average DO at Site 1 frequently hovered around 10 mg/L and the greatest range of DO values was observed in 2016 (0 - 18.8 mg/L). Average DO readings at Site 5 were more variable than Site 1 and peaked at 24.6 mg/L in 2012 and was nearly 0.0 for the latter part of 2010.

At Site 1 (closest to the ocean), temperature 7DADM criteria were exceeded between 59 (2011) and 81 (2013) percent of the time for 18°C (adult migration), and between 22 (2011) and 49 (2015) percent of the time for 20°C (juvenile rearing; Table 1; Figure 3). Dissolved oxygen criteria were exceeded between 0 and 17 percent of the time for the acute DO threshold (4 mg/L), and between 0 and 28% of the time for the chronic threshold (6.5 mg/L; Table 1; Figure 5). Conductivity was high and variable during periods when the lagoon was open to the ocean, reflecting the marine influence at this location (Figure 1). During periods when the lagoon was closed, conductivity remained low and relatively stable.

Table 1. The number of days exceeding temperature (7DADM) and DO criteria at Site 1 in the Salinas River lagoon. Percentage of total monitoring days exceeding criteria in parenthesis.

Year	Total Days of Monitoring	Number of Days Above 18°C	Number of Days Above 20°C	Number of Days with DO <4 mg/L	Number of Days with DO <6.5 mg/L
2010	225	173 (77%)	89 (40%)	11 (5%)	63(28%)
2011	170	101 (59%)	38 (22%)	0 (0%)	13 (8%)
2012	180	135 (75%)	66 (37%)	30 (17%)	50 (28%)
2013	220	179 (81%)	100 (45%)	0 (0%)	1 (0%)
2015	122	97 (80%)	60 (49%)	5 (4%)	19 (16%)
2016	144	114 (79%)	66 (46%)	6 (4%)	13 (9%)
Total	**1,061**	**799 (75%)**	**419 (39%)**	**52 (5%)**	**159 (15%)**

At Site 5(closest to the inlet), temperature criteria were exceeded between 69 and 97 percent of the time for 18°C (adult migration), with four of the six years exceeding the criteria more than 85 percent of the time (Table 2; Figure 5). Temperature criteria for juvenile rearing (20°C), were exceeded between 0 and 73 percent of the time, with five of the six years exceeding the criteria more than half the time. Dissolved oxygen criteria were exceeded between 0 and 83 percent of the time for the acute DO threshold (4 mg/L), and between 6 and 94% of the time for the chronic threshold (6.5 mg/L; Table 2; Figure 6). Conductivity was high and variable during periods when the lagoon was open to the ocean and relatively low and stable during periods when the lagoon was closed (Figure 4), with the exception of 2010 when conductivity remained high for the latter part of the monitoring period.

Table 2. The number of days exceeding temperature (7DADM) and DO criteria at Site 5 in the Salinas River lagoon. Percentage of total monitoring days exceeding criteria in parenthesis.

Year	Total Days of Monitoring	Number of Days Above 18°C	Number of Days Above 20°C	Number of Days with DO <4 mg/L	Number of Days with DO <6.5 mg/L
2010	188	130 (69%)	0 (0%)	156 (83%)	176 (94%)
2011	164	129 (79%)	99 (60%)	39 (24%)	54 (33%)
2012	201	171 (85%)	132 (66%)	4 (2%)	19 (9%)
2013	214	182 (85%)	156 (73%)	0 (0%)	13 (6%)
2015	120	115 (96%)	74 (62%)	9 (8%)	12 (10%)
2016	188	183 (97%)	106 (56%)	4 (2%)	42 (22%)
Total	**1,075**	**910 (85%)**	**567 (53%)**	**212 (20%)**	**316 (29%)**

Lagoon Fish Monitoring

The greatest diversity of species (i.e., number of species) was 19 during summer monitoring in 2010 (Table 3). Since then, the number species detected has peaked at 14 species in 2012 (Spring) and 2013 (Summer and Fall). The lowest diversity of fish detected occurred during the 2014 samples. Sampling efforts in 2014 were hindered by extraneous habitat conditions (see Discussion). Catch of all species, corrected for effort (CPUE), varied across seasons and years. The greatest CPUE was observed in Summer 2010 and was lowest in summer 2011. Low CPUE was also observed in Fall 2012 and Summer 2014, but these values are not as readily comparable to CPUE from other years because of incomplete sampling or incomplete enumeration of fish. Five individual steelhead were observed in 5 out of 13 sampling events (Table 4). Over 60 tidewater goby were observed in three sampling events in 2013 and 2014.

Table 3. Summary of seasonal fish monitoring in the Salinas River Lagoon from 2010 through 2014. Data reproduced from reports by Hagar Environmental Sciences (HES 2013; 2014)

Year	Season	Number of Species	CPUE[1]	Effort (number of seine hauls)	Number of Steelhead	Number of Tidewater Goby
2010	Spring[B]					
2010	Summer	19	6,669	7	0	0
2010	Fall	11	1,290	N/A	0	0
2011	Spring	10	170	16	1	0
2011	Summer	7	92	9	1	0
2011	Fall	11	826	16	1	0
2012	Spring	14	282	17	1	0
2012	Summer	9	309	13	0	0
2012	Fall	5	46*	17	0	0

2013	Spring	7	1,174	14	0	0
2013	Summer	14	426	13	0	0
2013	Fall	14	460	12	1	2
2014	Spring	3	189	8	0	58
2014	Summer[A]	3[A]	32[A]	1[A]	0	2
2014	Fall[B]					

[1] Data is presented as catch per unit effort (CPUE) to provide a better comparison between years because the number of seine hauls (i.e., effort) varied across sites, seasons, and years. As reported in HES 2013 and 2014, CPUE is the effort from 10 seine hauls.

* Estimated count of individuals. Only presence/absence of mosquitofish and threespine stickleback was reported.

[A] Sampling was aborted after 1 haul due to extensive algae growth was affecting sample efficiency and fish health. Reported values not corrected for effort.

[B] Fish sampling not performed.

Table 4. Sample details pertaining to the five steelhead observed in the Salinas River Lagoon from 2010 to 2014. Fish monitoring was not performed in Fall 2014 or during 2015 and 2016 monitoring seasons.

Date	Station/Location	Fork Length (mm)	Life stage	Ad-clip
5/10/11	5	152	smolt	no
8/23/11	6	336	Adult	no
10/25/11	1	421	Adult	no
4/24/12	1.5	182	Adult	no
10/14/13	OSR outlet	333	smolt	no

Discussion

Water quality parameters in the lagoon showed several distinct patterns that varied according to sampling location. At site 1, the data sonde was deployed in a shallow and tidally influenced section of lagoon near the river mouth. As a result, water quality conditions were less influenced by freshwater inputs and show more variability due to the marine influence than conditions further upstream in the lagoon. Water quality parameters showed distinct patterns during periods when the lagoon was open to the ocean, which occurred at various times throughout 2010-2012 including nearly the majority of the 2011 monitoring period.

Lower water temperatures, higher DO concentrations, and higher conductivity were all observed at Site 1 when compared to the upstream location. Temperature criteria were exceeded 75 and 39 percent of the total monitoring days for adult migration and juvenile rearing, respectively. Dissolved oxygen criteria were exceeded 15 and 5 percent of the time for the chronic and acute thresholds, respectively. Specific conductivity approached 50,000 µS during periods when the lagoon was open to the ocean, but was highly variable, and dropped to below 5,000 µS during periods when the lagoon was closed.

At Site 5, the data sonde was placed near the bottom of the water column for the 2010 monitoring period. Dissolved oxygen at this site was well below thresholds for the majority of the year due to a strong seasonal stratification of the water column. In 2011, the sonde was moved from the bottom of the water column to the upper 3 feet of the water column which is likely just above a solute-rich and oxygen-depleted stratum of water on the bottom of the channel. Variation observed during 2011 for all continuously measured water quality parameters was likely due to a shifting of the halocline relative to the sonde. During the block flows, the amount of freshwater entering the lagoon was sufficient to displace the more saline water at Site 5 but not enough to influence conductivity at site 1. Notably, once the block flows were finished, conductivity increased and remained elevated until the lagoon closed.

Temperature criteria were frequently exceeded at Site 5, with 85 and 53 percent of the monitoring days exceeding criteria for adult migration and juvenile rearing, respectively. Dissolved oxygen criteria were exceeded 20 and 29 percent of the time for the chronic and acute thresholds, respectively. However, in 2010, when the sonde was located in the halocline, chronic and acute thresholds were exceeded 83 and 94 percent of the time, respectively. Dissolved oxygen concentrations also appeared to fluctuate diurnally. During daylight, photosynthesis by aquatic plants results in production of oxygen, and the lagoon is productive enough that this can lead to greater than 100% saturation of oxygen in the water column, especially the upper water column where light levels and photosynthesis are high. During the night, photosynthesis is replaced by respiration, which consumes oxygen and can lead to depression of DO levels. Dense algal mats and rooted aquatic vegetation were more common beginning in 2014 and persisted in through 2016.

Monitoring of the water quality conditions in the Salinas River Lagoon indicates that, although water temperatures can reach 23–25°C in July, conditions in the lagoon remained adequate for rearing juvenile steelhead and migrating adult steelhead throughout the majority of the monitoring period. While temperatures did exceed recommended criteria for these two life stages, there were only a few relatively brief periods when temperatures reached stressful or lethal limits (>25.0°C; Myrick and Cech 2000), although they remained well below critical thermal maxima for stream rearing fish acclimated to warm temperatures (30.0-32.0°C; Myrick and Cech 2000, Sloat and Osterback 2013). Dissolved oxygen concentrations generally remained above recommended criteria at both sampling locations, with exceedance occurring primarily at Site 5 when the water quality meter was positioned near the bottom of the river channel.

Monitoring of the lagoon fish community using beach seines has been conducted in the fall since 2002 and was altered in 2010 by adding spring and summer samples to be consistent with the BO. This memo only discusses lagoon fish monitoring since 2010. Prior to the change in sampling periodicity, steelhead had not been detected in lagoon surveys dating back to 1990 (J. Gilchrist and Associates 1997; Hagar Environmental Science [HES] 2001; HES 2003; HES 2004; HES 2005; HES 2006; HES 2007; HES 2008; HES 2009; HES 2010; HES 2011). In 2011, juvenile steelhead were detected in the lagoon throughout the sampling period. Steelhead were detected in April and October sampling during 2012, and again in October of 2013. No steelhead have been detected since 2013, but excessive aquatic vegetation and algal growth have precluded the ability to effectively sample the lagoon in 2014, and extreme drought conditions 2015 and 2016 and no flow in the Salinas River meant that SRDF was not operated in those years. Furthermore, lack of flow in the Salinas River prevented monitoring of upstream or downstream migration of steelhead in 2015 and 2016. Although steelhead have not been detected recently, conditions in the lagoon may have allowed them to persist despite not being open since 2012

Notably in 2013, tidewater goby (*Eucyclogobius newberryi*, listed as endangered), were detected again for the first time since 1951 (HES 2013). Surveys for tidewater goby by USFWS (2013) in 1991, 1992, and 2004 also failed to detect them in the lagoon. Presumably, tidewater goby were extirpated from the lagoon due to levee construction and channelization (USFWS 2013). The tidewater goby Recovery Plan has identified the Salinas River Lagoon as a potential reintroduction site, but no reintroduction efforts are currently underway. The individuals recently captured likely dispersed from nearby Bennett Slough or Moro Cojo Slough (approximately 11.3 km). In 2014, tidewater goby were the second most abundant species (only 3 species were detected) sampled in the lagoon (HES 2014). Again, no sampling was performed in 2015 or 2016. Salinity measured at sites where tidewater goby were found was < 2.5 ppt.

During most years, the lagoon environment is characterized by a salinity gradient that provides habitat for a broad range of fish species. In total, 21 unique species have been observed in the lagoon since 2002 (HES 2014). Typical estuarine species, such as starry flounder (*Platichthys stellatus*), staghorn sculpin (*Leptocottus armatus*) and topsmelt (*Atherinops affinis*) can be found in areas closer to the mouth of the lagoon. Striped bass (*Morone saxatilis*) and prickly sculpin (*Cottus asper*) are found throughout the lagoon. Freshwater species, such as hitch (*Lavinia exilicauda*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (Catostomus occidentalis) and threespine stickleback (*Gasterosteus aculeatus*) typically are present in the upper parts of the lagoon.

In general, the number of species found, and their relative abundances are highly variable from year to year and between sampling events. There are two factors contributing to this variability; 1) changes in freshwater inflow and the status of the sandbar (open/closed) influence the distribution of various species depending on their specific salinity tolerances, and 2) extraneous environmental conditions such as extreme algal and macrophyte growth that substantially decreased capture efficiency of the beach seines.

Recommendations

1. As required by the BO, monitoring of the Salinas River Lagoon water quality will continue. To ensure that the highest quality of data is being collected, more routine maintenance of the water quality meters is needed to ensure continuous data collection. Water chemistry in the Salinas River can create fouling conditions on the meters that need to be checked and cleaned at a more frequent interval.
2. Low detection of listed species can obfuscate abundance trends. A better understanding of detection probabilities is needed to monitor abundance trends of listed species. Occupancy models are a way to quantify species detection probabilities and only require a modest increase in sampling effort.
3. The Salinas River Lagoon is a dynamic system where salinity levels can vary longitudinally (from mouth to inlet), by depth, and by hydrologic conditions. The accepted salinity preference of tidewater goby is 8 – 12 ppt but they will occur in salinities outside this range (see above). Potentially, tidewater goby could move within

the lagoon to stay in the salinity range or remain sessile and acclimate to changing salinity levels, but this is not known. Another unknown is the source population of the individuals who recolonized the lagoon and their dispersal pathway. Although research into these aspects of tidewater goby biology are not part of the monitoring program, studies like these have the potential to better inform monitoring protocols and locations.

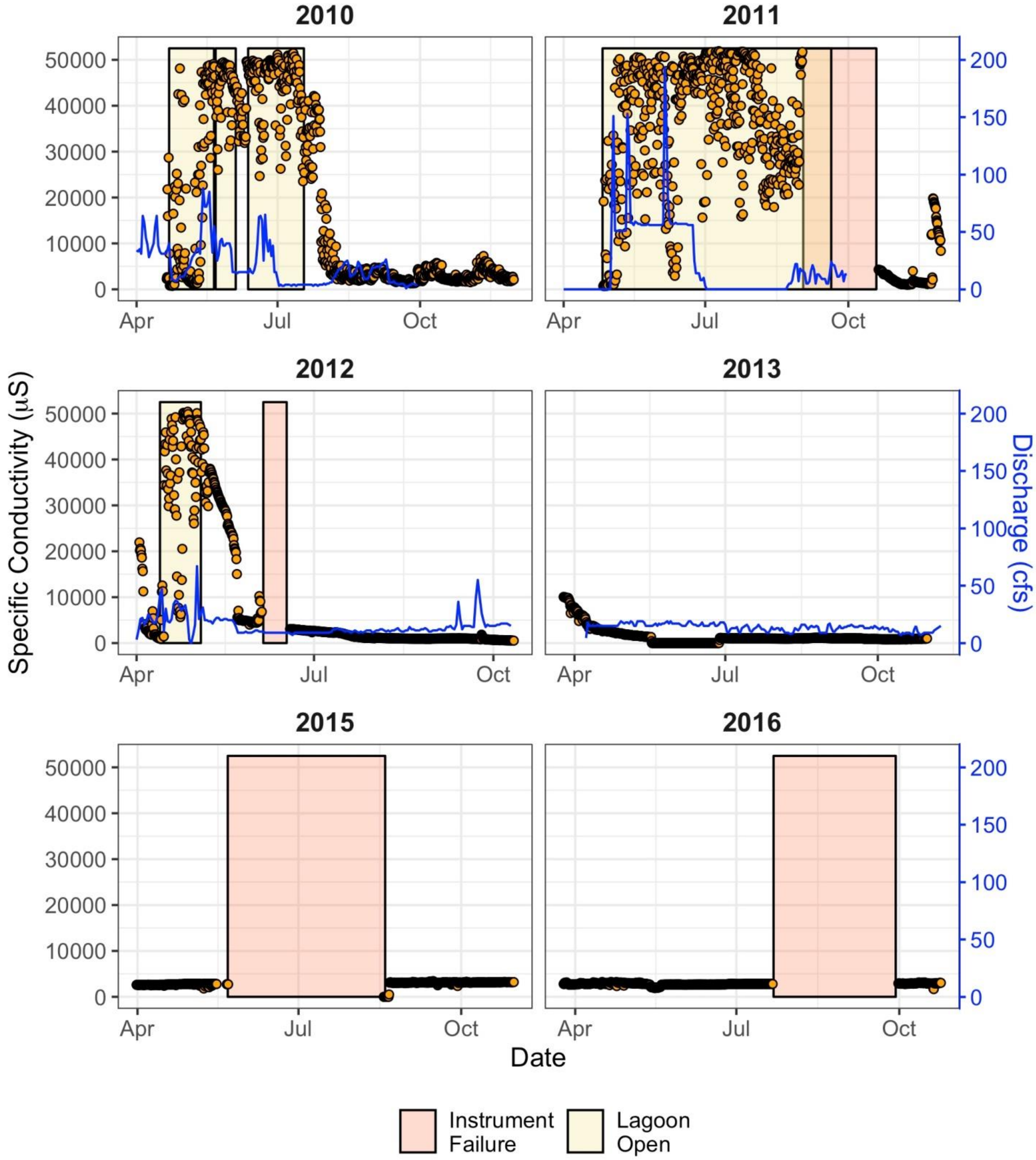

Figure 1. Conductivity (averaged over 6 hr intervals) observed from April-October at Site 1, located near the mouth of the Salinas River lagoon. Discharge (thin blue line) is total bypass discharge at SRDF, which was not operating in 2015 and 2016.

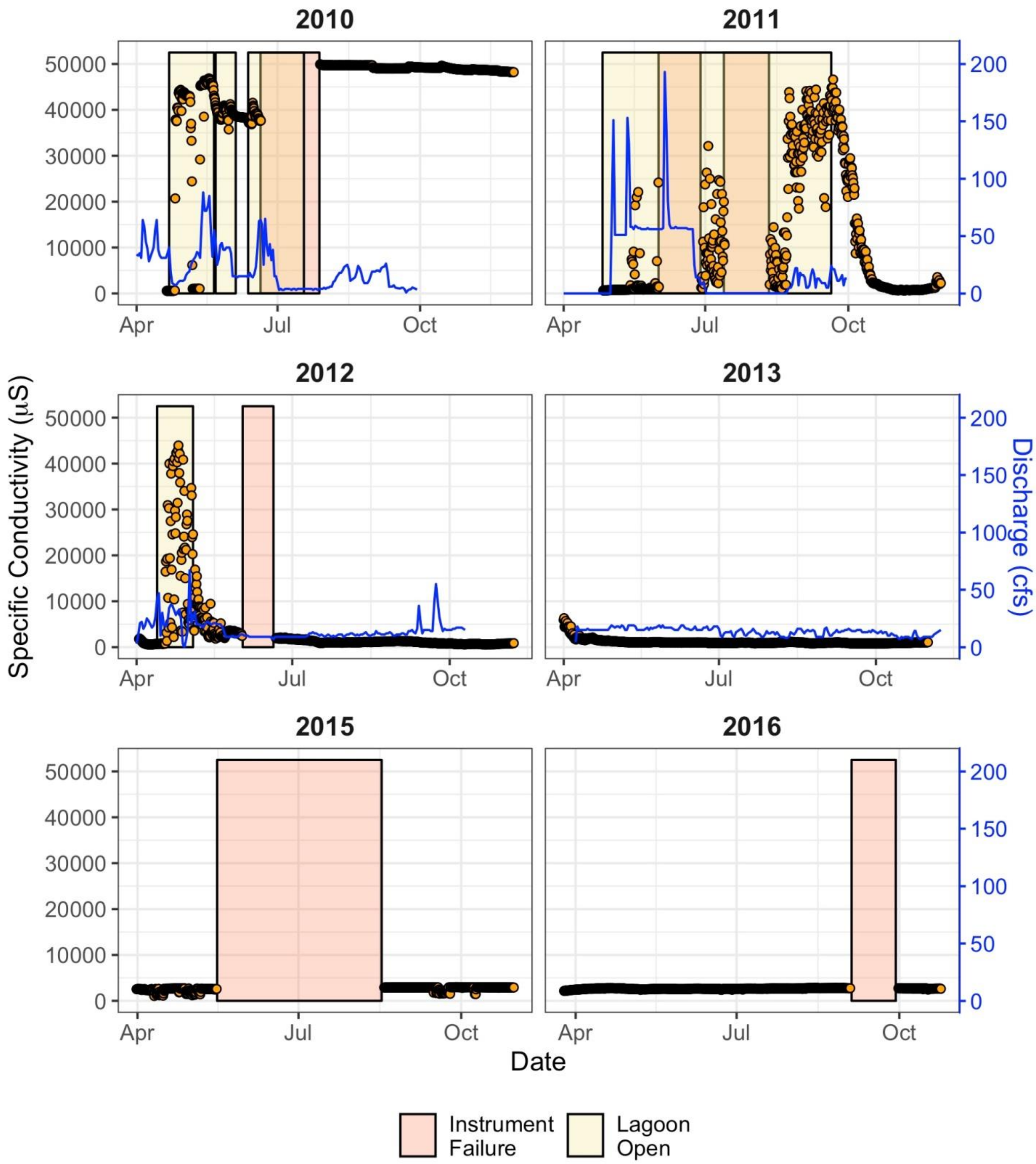

Figure 2. Conductivity (averaged over 6 hr intervals) observed from April-October at Site 5, located near the Highway 1 Bridge. Discharge (thin blue line) is total bypass discharge at SRDF, which was not operating in 2015 and 2016.

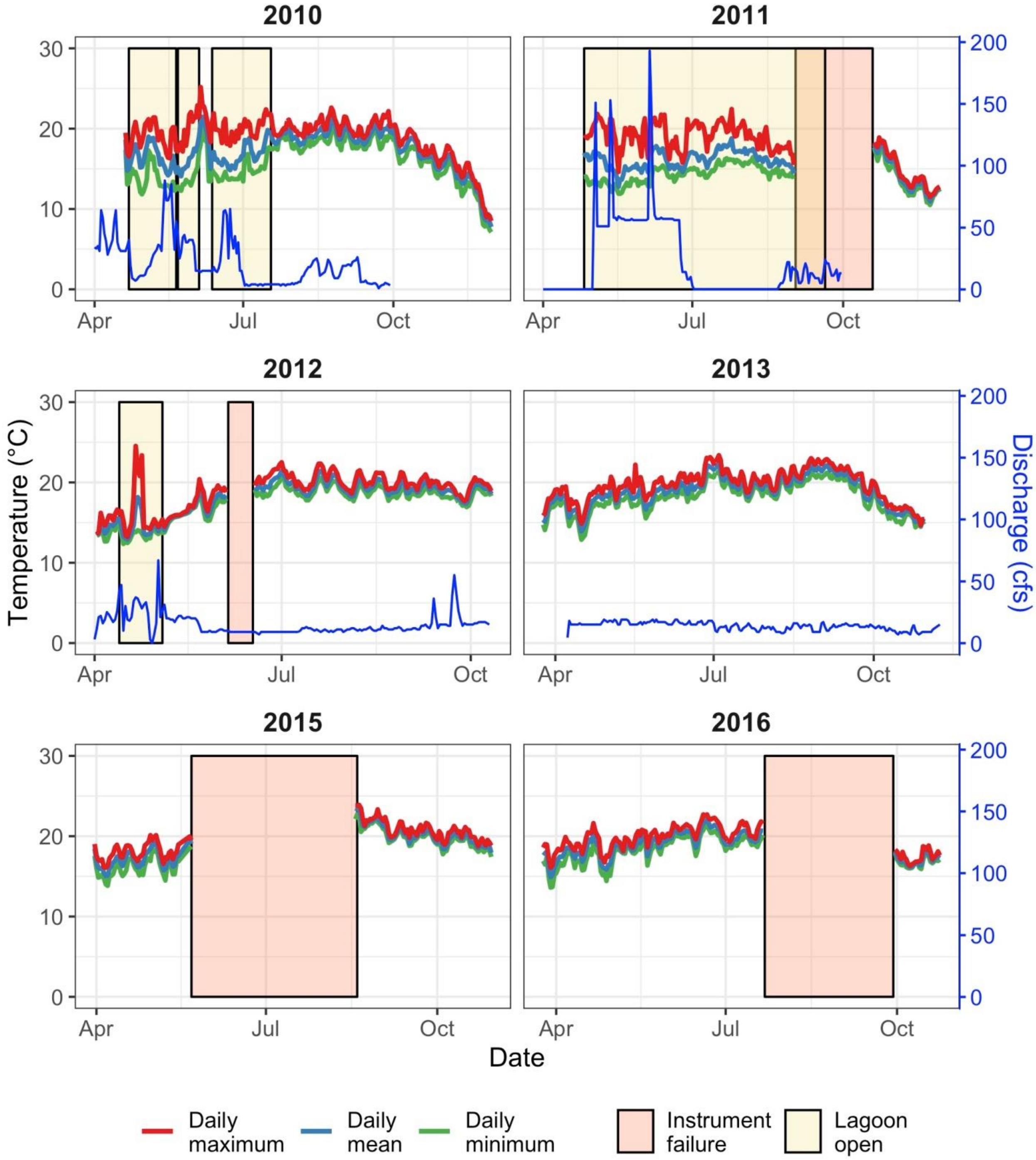

Figure 3. Daily maximum, mean, and minimum temperatures observed at Site 1, located near the mouth of the Salinas River lagoon. Discharge (thin blue line) is total bypass discharge at SRDF, which was not operating in 2015 and 2016.

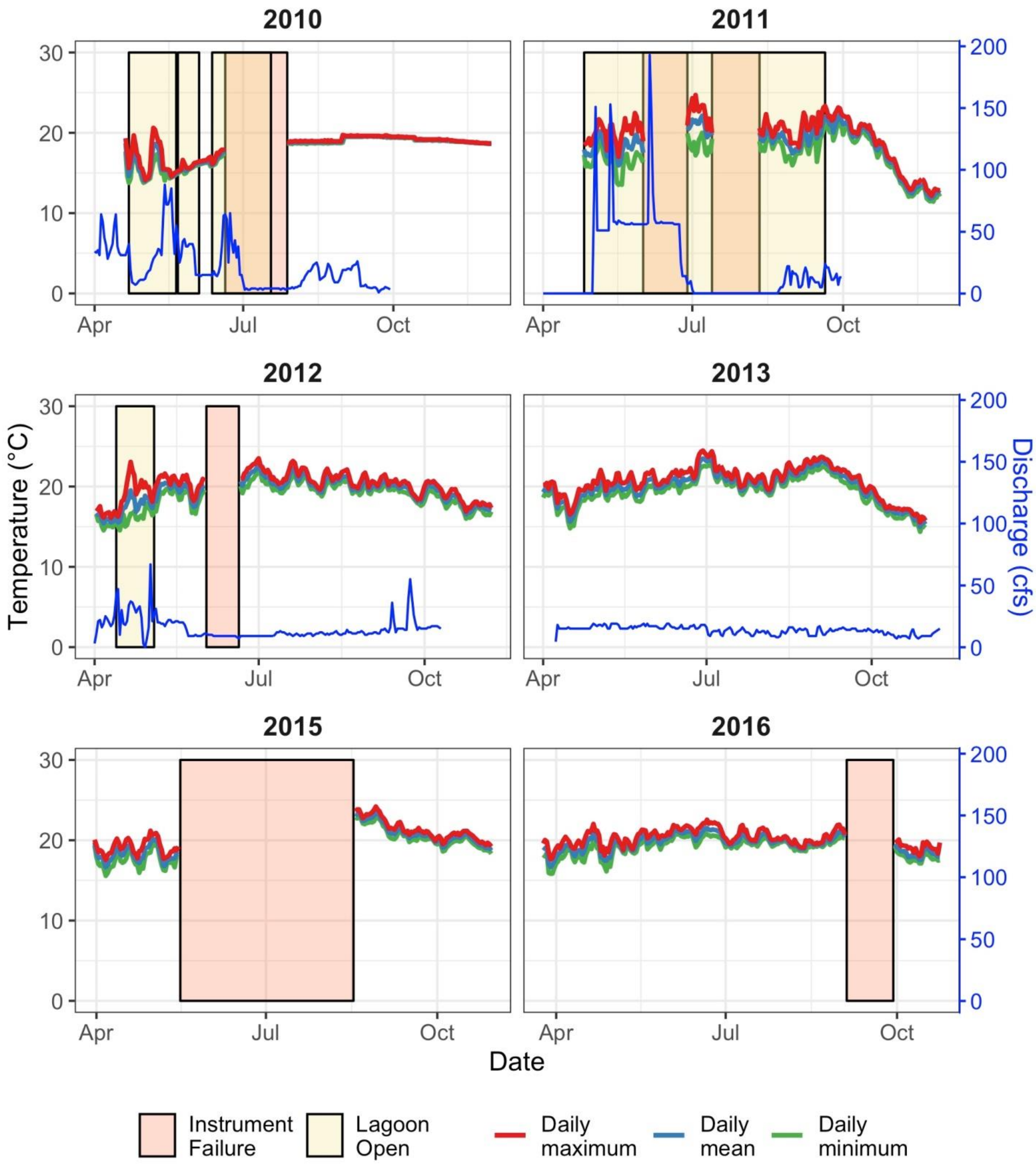

Figure 4. Daily maximum, mean, and minimum temperatures observed between April and October at Site 5, located near the Highway 1 Bridge. Discharge (thin blue line) is total bypass discharge at SRDF, which was not operating in 2015 and 2016.

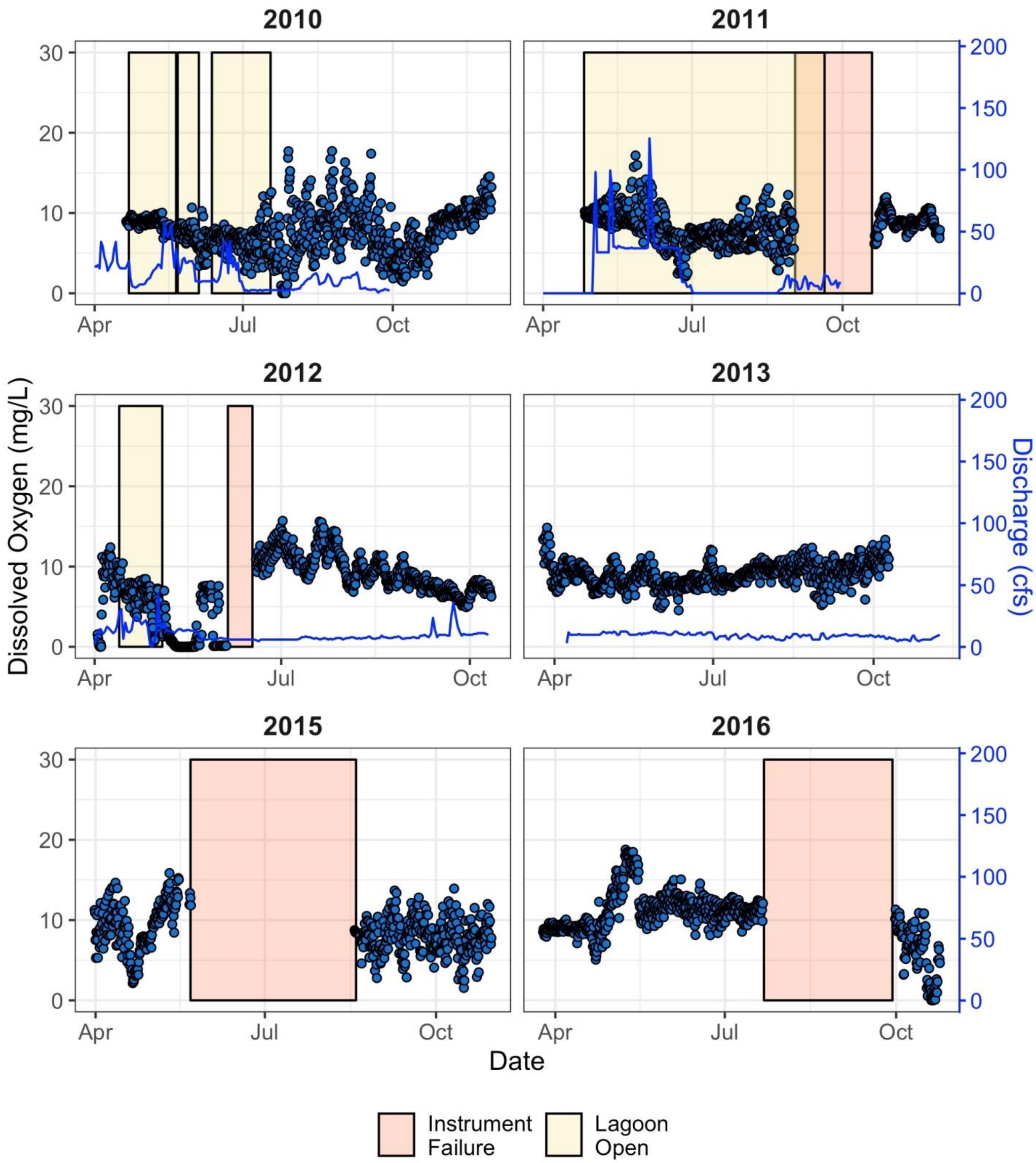

Figure 5. Dissolved oxygen (averaged over 6 hr intervals) observed from April-October at Site 1, located near the mouth of the Salinas River lagoon. Discharge (thin blue line) is total bypass discharge at SRDF, which was not operating in 2015 and 2016.

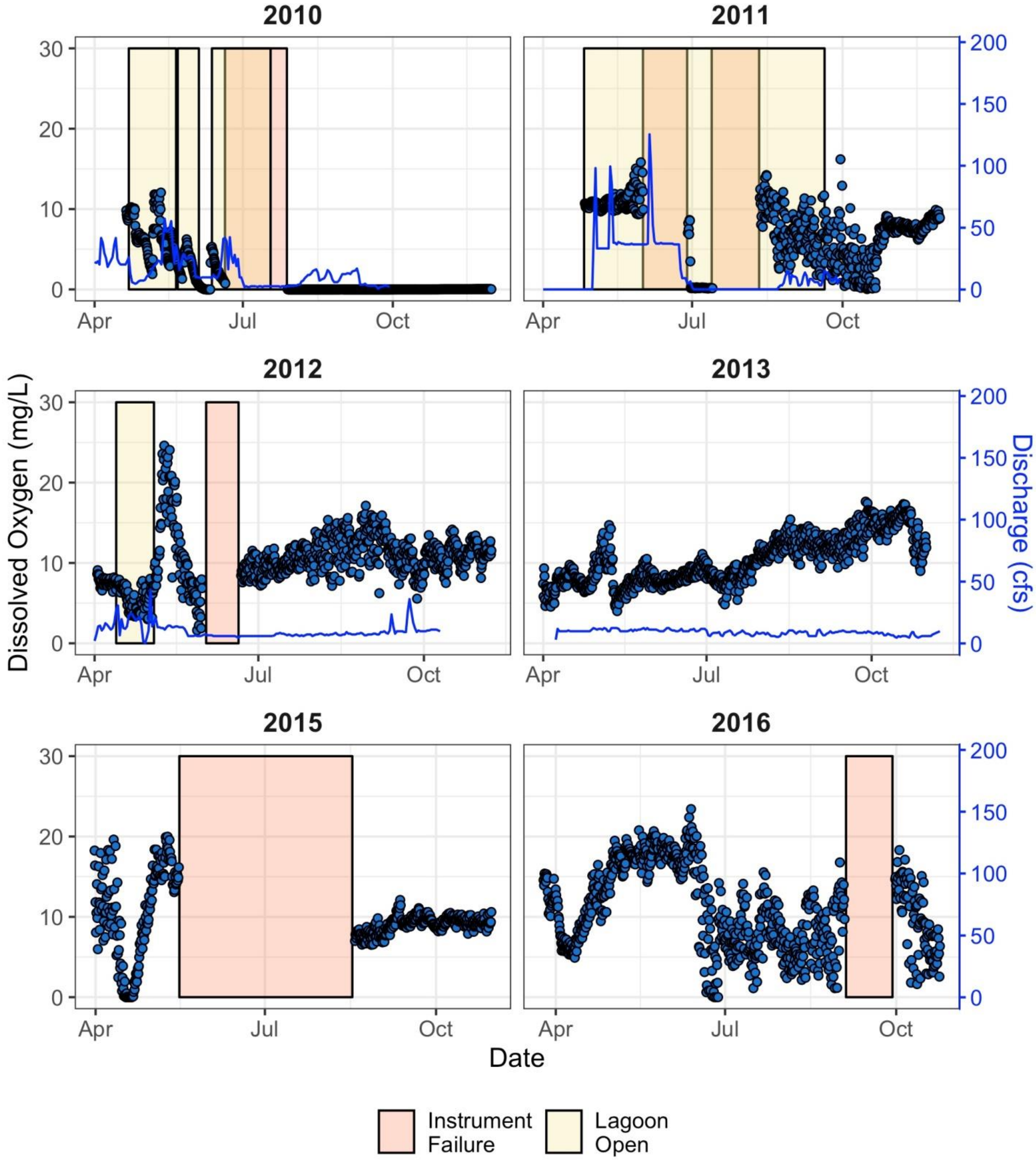

Figure 6. Dissolved oxygen (averaged over 6 hr intervals) observed from April-October at Site 5, located near the Highway 1 Bridge. Discharge (thin blue line) is total bypass discharge at SRDF, which was not operating in 2015 and 2016.

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