



California Regional Water Quality Control Board North Coast Region

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TO: File: Laguna de Santa Rosa; TMDL Development and Planning

FROM: Steve Butkus

DATE: December 9, 2011

SUBJECT: Descriptive Statistics of Diel Water Quality collected within the Laguna de Santa Rosa Watershed during the years 1995 through 2011

The water quality of the Laguna de Santa Rosa (Laguna) has been studied for decades. The State Water Board adopted the Section 303(d) listings of the Laguna in 1976 for high nutrients and low dissolved oxygen (DO) concentrations. Dissolved oxygen concentrations can vary considerably over a 24-hour period (i.e., diel cycle) driven by changes in temperature and photosynthesis. Understanding the dynamics of diel DO requires deployment of continuous monitoring equipment (i.e., DataSondes). These instruments concurrently measure continuous DO, temperature and pH.

Since the Section 303(d) listing, North Coast Regional Water Quality Control Board (Water Board) staff and others have intermittently monitored diel water quality in the Laguna watershed (Table 1 and Figure 1). These data have been presented in several monitoring reports and staff memorandums to the Laguna TMDL administrative file:

- *Water Quality Dynamics within the Laguna de Santa Rosa Watershed*, the memorandum to the file dated March 25, 2010 (Butkus 2010), describes
- *Diel Water Quality within the Laguna de Santa Rosa Watershed during 2001-2002*, the memorandum to the file dated October 25, 2011 (Butkus 2011), describes collection of diel DO concentration, pH and temperature data during 2001-2002 at four mainstem Laguna locations to assess the effectiveness of the original TMDL (Morris, 1995)..
- *Laguna de Santa Rosa TMDL – Diel Water Quality Monitoring Report 2011* (NCRWQCB, 2011) describes the monitoring of diel water quality in Laguna tributaries. Earlier diel monitoring efforts were primarily focused only on the lentic areas of the mainstem Laguna.

The diel DO concentration, pH and temperature data from these monitoring efforts were combined to conduct a statistical assessment for use the Laguna TMDL staff report.

Several statistical metrics (i.e., daily mean, daily maximum, daily minimum, and diel range) were presented that represent the median value of each survey period. Descriptive statistics were derived for dissolved oxygen concentration and percent saturation, pH and water temperature diel data. These statistics were not presented in Butkus (2010) but appear below (Tables 2 – 5).

Results

The seasonal distribution of each of the descriptive statistics derived from the Laguna diel water quality measurements are shown in Figures 2 - 81. The median value of each survey period was presented as a point on the middle date of the survey period. Box plots were also prepared to compare data between locations in the watershed where diel measurement have been collected (Figures 82 – 97). The following observations were made from visual observation of these figures.

Laguna de Santa Rosa at Stony Point Road (Figures 2 - 17)

Dissolved oxygen concentrations are very low and show no apparent seasonal pattern. Water temperatures show the expected annual seasonal pattern of higher overall temperatures in the summer and lower temperatures in the Spring and Fall. That same seasonal pattern is not apparent in the dissolved oxygen saturation values. The values and diel range of pH show little productivity. A larger diel range of pH was expected due to the infestations of *Ludwigia* at the measurement location. However, a seasonal pattern is apparent in the pH diel range with larger productivity shown in the late summer period.

Laguna de Santa Rosa at Highway 12 (Figures 18 – 33)

Diel measurements have been collected in only two years: 1998 and 2009. Both years showed large differences in dissolved oxygen concentrations, water temperature and pH. The year 1998 was much more productive than 2009 with very high dissolved oxygen saturation (i.e., supersaturation) and elevated pH. The year 1998 also showed higher water temperatures with a larger diel range in daily temperature. The higher water temperatures may be the result of the higher productivity in 1998 as compared to 2009. The higher productivity is inferred from the DO supersaturation and elevated pH values observed in 1998.

Laguna de Santa Rosa at Occidental Road (Figures 34 – 49)

Dissolved oxygen concentration and saturation show a definitive seasonal pattern, with lowest values during the summer and highest values in spring and fall. The large diel range of dissolved oxygen does not show the same seasonal pattern. Supersaturation of dissolved oxygen is common throughout the year. Water temperatures show the expected annual seasonal pattern, but the diel temperature range remains the same throughout the year. Values of pH are high indicating high productivity. The diel range of pH is higher in the spring and fall, following the pattern observed with dissolved oxygen concentration and saturation. This observation suggests that the dissolved oxygen concentration is responding to high productivity.

Laguna de Santa Rosa near Guerneville Road (Figures 50 – 65)

Dissolved oxygen concentration and saturation does not show any apparent seasonality. Water temperatures show the expected annual seasonal pattern, with the diel temperature range highest during the middle summer. Values of pH are elevated indicating high productivity.

Laguna de Santa Rosa at Trenton-Healdsburg Road (Figures 66 – 81)

Dissolved oxygen concentration does not show any apparent seasonality. Water temperatures show the expected annual seasonal pattern, with the diel temperature range highest during the middle summer. Dissolved oxygen saturation follows the same seasonal pattern as water temperature. Values of pH are elevated indicating high productivity.

Watershed Comparisons (Figures 82 – 97)

Comparison of locations in the Laguna mainstem show increasing dissolved oxygen concentrations and saturation as water flows downstream towards the Russian River. Minimum dissolved oxygen is very low at Stony Point Road at levels that do not support aquatic life uses. Dissolved oxygen levels increase downstream, but most measurements still do not meet the water quality objective of 7.0 mg/L specified in the Basin Plan (NCRWQCB, 2007). Santa Rosa Creek and other Laguna watershed tributaries have similar dissolved oxygen levels, but many of these levels are also below the water quality objective of 7.0 mg/L.

Productivity in the Laguna appears the greatest at Occidental Road. The maximum and diel ranges of dissolved oxygen concentrations and pH are largest at this location. This

area of the Laguna is largely lentic (i.e., lake-like). Due to the larger areas of open water, productivity in this area is driven primarily by phytoplankton, and not submerged macrophytes. Water temperatures are also higher in this location due to less shading from riparian or surface macrophytes.

Citations

Butkus, S. 2010. Water Quality Dynamics within the Laguna de Santa Rosa Watershed. Memorandum to the File: Laguna de Santa Rosa: TMDL Development and Planning dated March 25, 2010. North Coast Regional Water Quality Control Board, Santa Rosa, CA.

Butkus, S. 2011. Diel Water Quality within the Laguna de Santa Rosa Watershed during 2001-2002. Memorandum to the File: Laguna de Santa Rosa: TMDL Development and Planning dated October 25, 2011. North Coast Regional Water Quality Control Board, Santa Rosa, CA.

Morris, C.N. 1995. Final Report- Waster Reduction Startegy for the Laguna de Santa Rosa. North Coast Regional Water Quality Control Board, Santa Rosa, CA.

NCRWQCB, 2011. Laguna de Santa Rosa TMDL – Diel Water Quality Monitoring Report 2011. North Coast Regional Water Quality Control Board, Santa Rosa, CA.

NCRWQCB, 2011. Water Quality Control Plan for the North Coast Region. Adopted May 2011. North Coast Regional Water Quality Control Board, Santa Rosa CA.

Tables

Table 1. Diel Water Quality Surveys conducted in the Laguna Watershed

Waterbody	Location	Survey Years	Total Diel Days Monitored
Laguna	Stony Point Road	1995, 2001, 2002, 2007	98
Laguna	Highway 12	1998, 2009	13
Laguna	Occidental Road	1995, 1998, 2001, 2002, 2008, 2009	121
Laguna	Guerneville Road	2001, 2002, 2007, 2009	109
Laguna	Trenton-Healdsburg Road	1995, 1996, 1997, 2001, 2002, 2009	113
Santa Rosa Creek, S.F.	Upstream of Azalea Creek	2011	11
Santa Rosa Creek	Brookwood Ave	2009, 2011	18
Santa Rosa Creek	Upstream of Laguna confluence	2009	13
Blucher Creek	Lone Pine Road	2011	4
Copeland Creek	Lichau Road	2011	4
Paulin Creek	Marlow Road	2011	4
Mark West Creek	Erland Road	2011	5
Windsor Creek	Mark West Station Road	2011	4

Table 2. Dissolved Oxygen Concentration Statistics from Butkus (2010)
 Values represent the median value of each survey period.

Location	Monitoring Dates	Dissolved Oxygen (mg/L)			
		Daily Mean	Daily Maximum	Daily Minimum	Diel Range
Laguna at Stony Point Road	8/22/1995 - 8/27/1995	5.8	7.6	4.0	3.6
	6/14/2007 - 6/20/2007	6.8	12.2	2.8	8.2
Laguna at Hwy 12	7/22/1998 - 7/26/1998	7.5	16.8	3.3	12.3
	8/5/2009 - 8/10/2009	5.2	5.9	4.2	1.9
Laguna at Occidental Road	8/24/1995 - 8/27/1995	4.5	6.9	2.7	4.2
	7/22/1998 - 7/26/1998	5.8	9.0	2.9	5.4
	6/8/2007 - 6/12/1998	6.6	9.1	4.1	4.2
	9/28/2008 - 10/2/2008	11.8	21.2	5.4	16.4
	7/22/2009 - 7/26/2009	5.9	7.7	4.3	3.4
	9/3/2009 - 9/7/2009	4.6	10.7	1.6	9.1
Laguna upstream of Santa Rosa Creek confluence	6/30/2007 - 7/10/2007	3.3	6.6	1.1	5.2
	7/29/2009 - 8/3/2009	6.3	7.3	5.6	1.6
	8/25/2009 - 8/31/2009	2.3	3.1	1.7	1.5
Laguna at Trenton-Healdsburg Road	9/27/1995 - 10/2/1995	6.8	7.5	6.6	1.0
	8/9/1996 - 8/14/1996	3.8	4.8	3.3	1.5
	8/7/1997 - 8/15/1997	4.5	5.0	4.0	0.9
	8/25/2009 - 8/30/2009	4.5	4.7	4.1	0.6
Santa Rosa Creek upstream of Laguna confluence	7/29/2009 - 8/2/2009	5.0	5.5	4.8	0.7
	8/25/2009 - 8/30/2009	6.0	6.6	5.2	1.5
Santa Rosa Creek at Brookwood Ave	8/13/2009 - 8/18/2009	5.2	6.8	3.8	3.1
	9/22/2009 - 9/27/2009	1.5	1.9	1.2	0.8

Table 3. Dissolved Oxygen Saturation Statistics from Butkus (2010)
 Values represent the median value of each survey period.

Location	Monitoring Dates	Dissolved Oxygen Saturation (%)			
		Daily Mean	Daily Maximum	Daily Minimum	Diel Range
Laguna at Stony Point Road	8/22/1995 - 8/27/1995	63	86	43	42
	6/14/2007 - 6/20/2007	83	146	32	106
Laguna at Hwy 12	7/22/1998 - 7/26/1998	87	198	36	149
	8/5/2009 - 8/10/2009	59	68	47	23
Laguna at Occidental Road	8/24/1995 - 8/27/1995	53	87	30	57
	7/22/1998 - 7/26/1998	68	105	34	64
	6/8/2007 - 6/12/1998	79	109	47	56
	9/28/2008 - 10/2/2008	133	253	59	202
	7/22/2009 - 7/26/2009	71	94	50	44
	9/3/2009 - 9/7/2009	55	131	18	113
Laguna upstream of Santa Rosa Creek confluence	6/30/2007 - 7/10/2007	38	76	12	61
	7/29/2009 - 8/3/2009	69	81	60	21
	8/25/2009 - 8/31/2009	24	33	18	17
Laguna at Trenton-Healdsburg Road	9/27/1995 - 10/2/1995	72	82	67	15
	8/9/1996 - 8/14/1996	45	60	37	22
	8/7/1997 - 8/15/1997	50	58	44	15
	8/25/2009 - 8/30/2009	47	49	43	7
Santa Rosa Creek upstream of Laguna confluence	7/29/2009 - 8/2/2009	54	61	51	8
	8/25/2009 - 8/30/2009	63	71	55	16
Santa Rosa Creek at Brookwood Ave	8/13/2009 - 8/18/2009	56	75	39	35
	9/22/2009 - 9/27/2009	16	20	12	8

Table 4. Water Temperature Statistics from Butkus (2010)
 Values represent the median value of each survey period.

Location	Monitoring Dates	Water Temperature (°C)			
		Daily Mean	Daily Maximum	Daily Minimum	Diel Range
Laguna at Stony Point Road	8/22/1995 - 8/27/1995	19.8	21.5	18.3	3.5
	6/14/2007 - 6/20/2007	23.6	26.2	21.2	5.2
Laguna at Hwy 12	7/22/1998 - 7/26/1998	21.5	24.3	20.0	3.8
	8/5/2009 - 8/10/2009	21.2	22.0	20.5	1.6
Laguna at Occidental Road	8/24/1995 - 8/27/1995	23.2	27.7	19.9	8.2
	7/22/1998 - 7/26/1998	23.1	24.2	22.2	1.4
	6/8/2007 - 6/12/1998	23.0	24.8	21.6	3.2
	9/28/2008 - 10/2/2008	20.6	22.7	18.9	3.8
	7/22/2009 - 7/26/2009	23.9	25.5	22.6	2.7
	9/3/2009 - 9/7/2009	23.2	25.0	21.7	3.6
Laguna upstream of Santa Rosa Creek confluence	6/30/2007 - 7/10/2007	22.1	23.4	20.9	2.5
	7/29/2009 - 8/3/2009	19.6	21.1	18.0	3.3
	8/25/2009 - 8/31/2009	18.6	19.2	18.1	1.2
Laguna at Trenton-Healdsburg Road	9/27/1995 - 10/2/1995	17.7	19.1	16.3	3.2
	8/9/1996 - 8/14/1996	23.3	26.0	20.9	5.8
	8/7/1997 - 8/15/1997	21.1	23.4	20.2	3.8
	8/25/2009 - 8/30/2009	17.8	18.0	17.5	0.6
Santa Rosa Creek upstream of Laguna confluence	7/29/2009 - 8/2/2009	19.4	20.1	18.8	1.3
	8/25/2009 - 8/30/2009	18.3	19.4	17.3	2.2
Santa Rosa Creek at Brookwood Ave	8/13/2009 - 8/18/2009	18.7	20.4	17.3	3.0
	9/22/2009 - 9/27/2009	16.7	17.6	16.0	1.7

Table 5. pH Statistics from Butkus (2010)
Values represent the median value of each survey period.

Location	Monitoring Dates	pH (s.u.)			
		Daily Mean	Daily Maximum	Daily Minimum	Diel Range
Laguna at Stony Point Road	8/22/1995 - 8/27/1995	7.8	7.9	7.7	0.16
	6/14/2007 - 6/20/2007	8.0	8.3	7.8	0.46
Laguna at Hwy 12	7/22/1998 - 7/26/1998	8.0	8.7	7.8	0.86
	8/5/2009 - 8/10/2009	7.9	8.0	7.9	0.16
Laguna at Occidental Road	8/24/1995 - 8/27/1995	8.4	8.7	8.1	0.52
	7/22/1998 - 7/26/1998	7.9	8.2	7.7	0.40
	6/8/2007 - 6/12/1998	8.0	8.2	7.8	0.37
	9/28/2008 - 10/2/2008	8.8	9.0	8.6	0.47
	7/22/2009 - 7/26/2009	7.8	7.9	7.7	0.27
	9/3/2009 - 9/7/2009	8.2	8.7	7.9	0.66
Laguna upstream of Santa Rosa Creek confluence	6/30/2007 - 7/10/2007	7.4	7.6	7.2	0.39
	7/29/2009 - 8/3/2009	7.8	7.9	7.8	0.11
	8/25/2009 - 8/31/2009	7.6	7.7	7.5	0.14
Laguna at Trenton-Healdsburg Road	9/27/1995 - 10/2/1995	7.7	7.8	7.7	0.13
	8/9/1996 - 8/14/1996	7.7	7.8	7.6	0.23
	8/7/1997 - 8/15/1997	7.6	7.7	7.6	0.12
	8/25/2009 - 8/30/2009	7.6	7.7	7.6	0.04
Santa Rosa Creek upstream of Laguna confluence	7/29/2009 - 8/2/2009	7.7	7.8	7.7	0.04
	8/25/2009 - 8/30/2009	7.7	7.8	7.7	0.10
Santa Rosa Creek at Brookwood Ave	8/13/2009 - 8/18/2009	7.4	7.4	7.3	0.08
	9/22/2009 - 9/27/2009	7.1	7.1	7.1	0.05

Table 6. Monthly Distribution of Diel Measurements in the Laguna Watershed

Month	Diel Days Measured
April	6
May	9
June	28
July	57
August	81
September	28
October	16
November	15
December - March	0

Figures

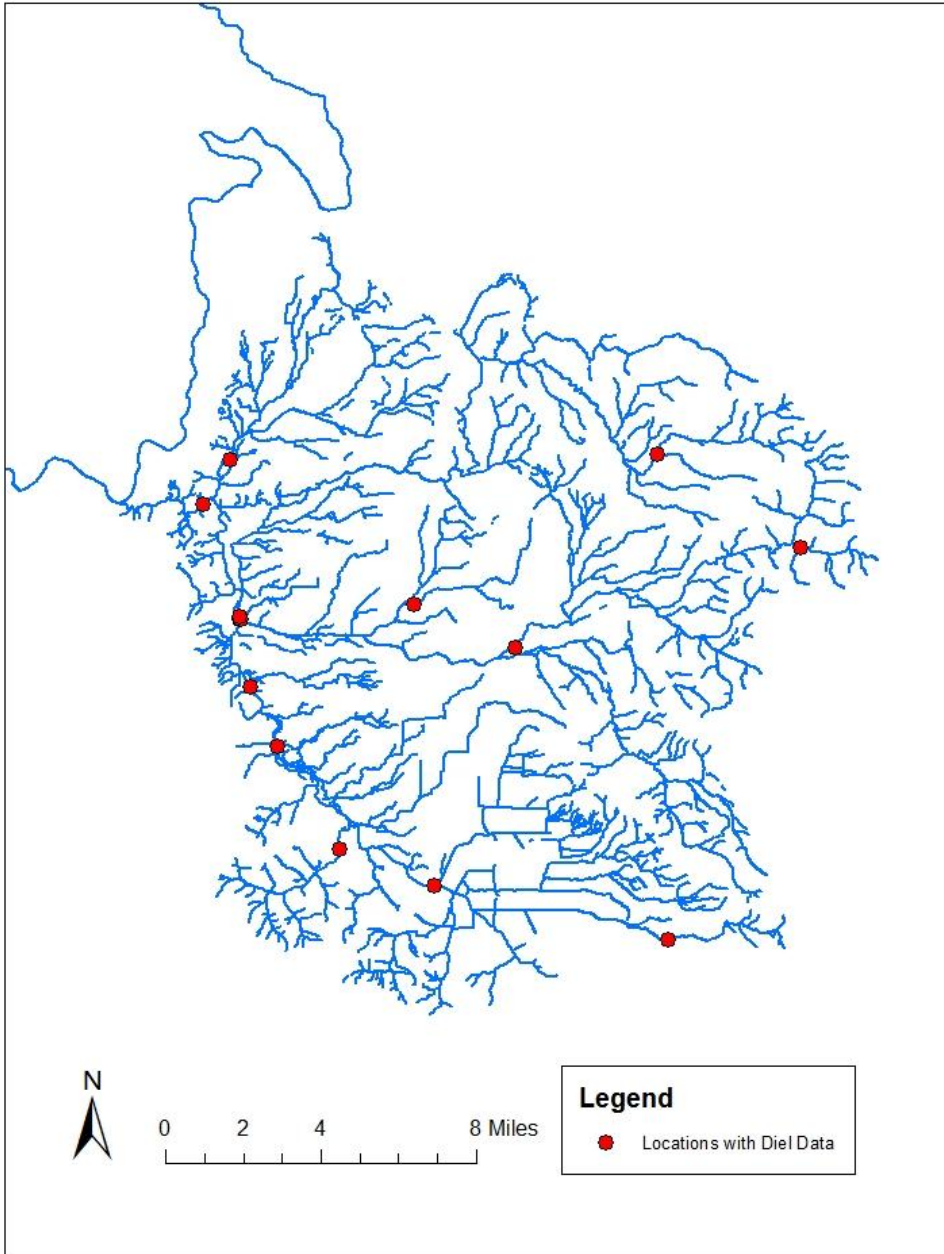


Figure 1. Laguna Watershed Locations with Diel Water Quality Monitoring Data

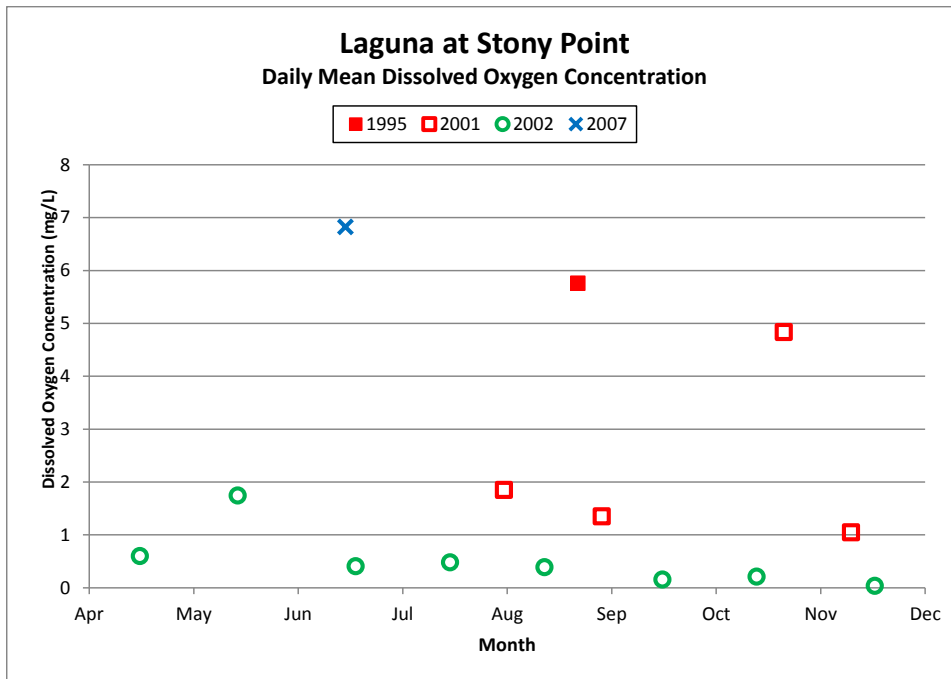


Figure 2. Seasonal Distribution of Daily Mean Dissolved Oxygen Concentrations measured in the Laguna at Stony Point Road

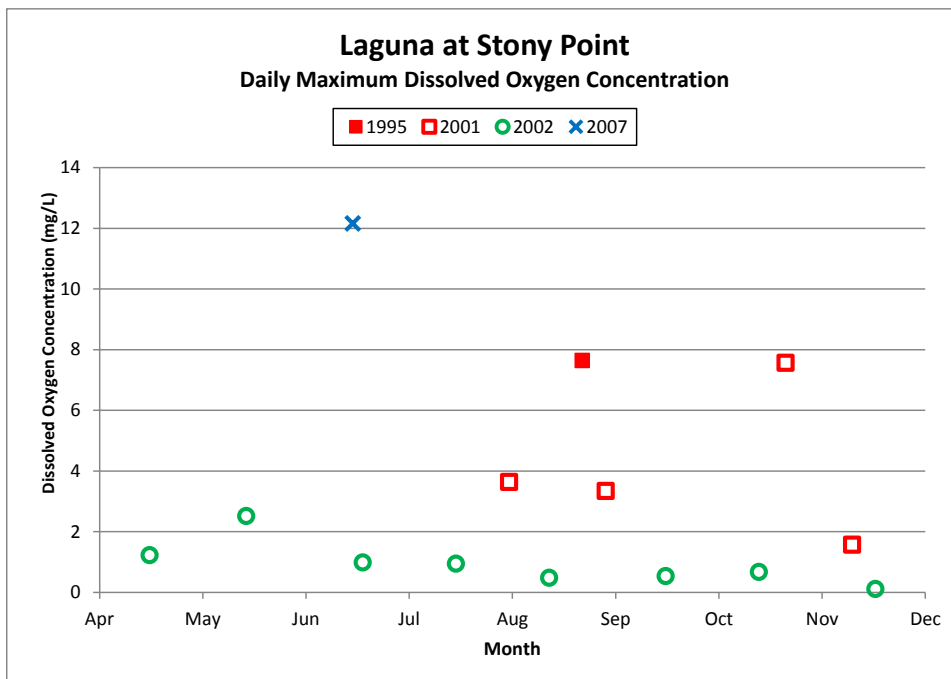


Figure 3. Seasonal Distribution of Daily Maximum Dissolved Oxygen Concentrations measured in the Laguna at Stony Point Road

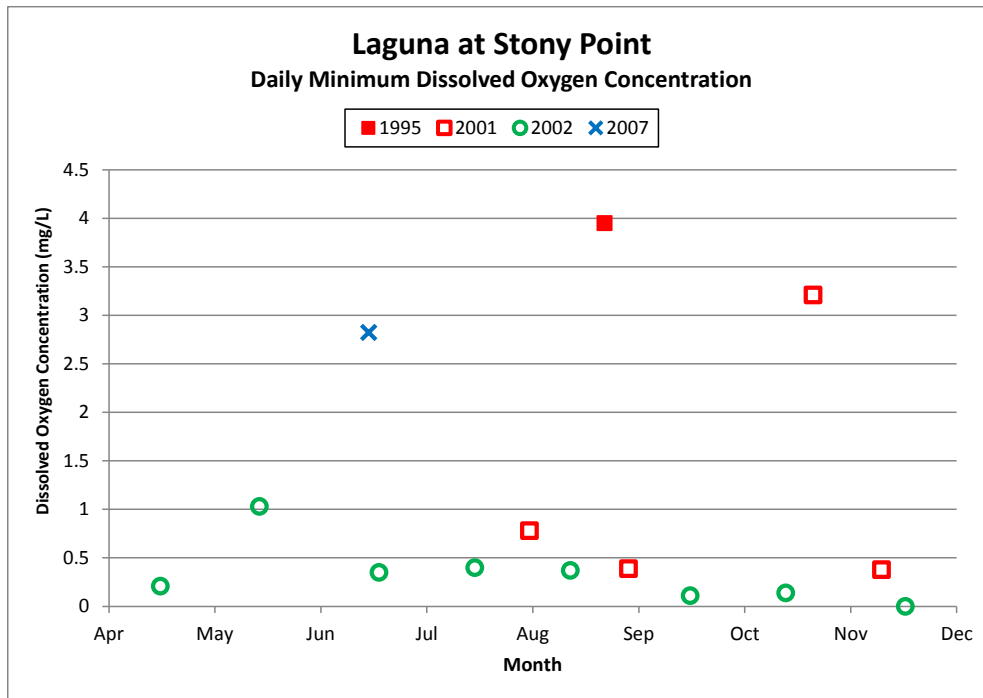


Figure 4. Seasonal Distribution of Daily Minimum Dissolved Oxygen Concentrations measured in the Laguna at Stony Point Road

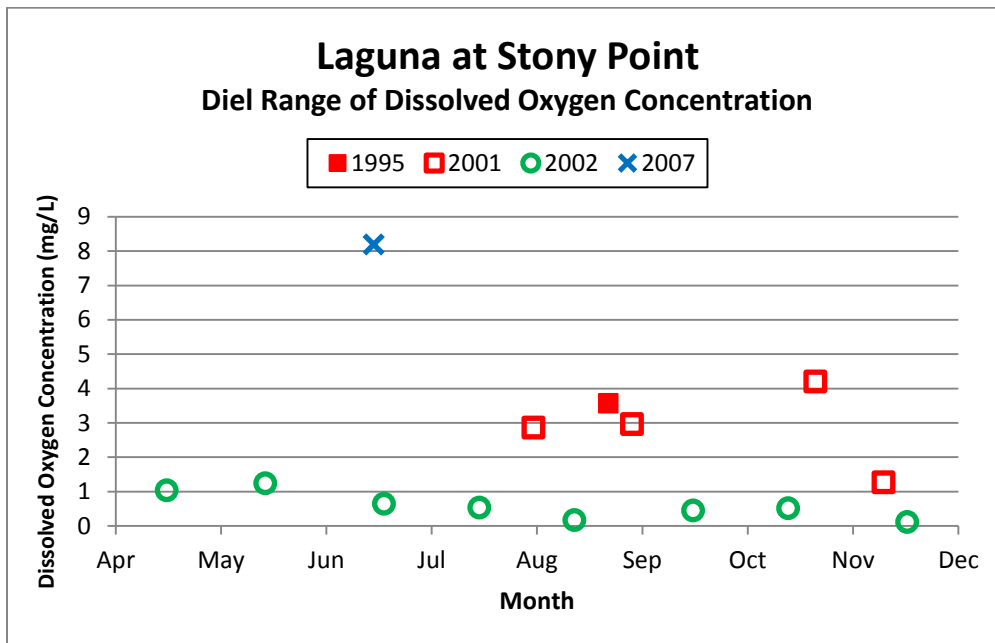


Figure 5. Seasonal Distribution of the Diel Range of Dissolved Oxygen Concentrations measured in the Laguna at Stony Point Road

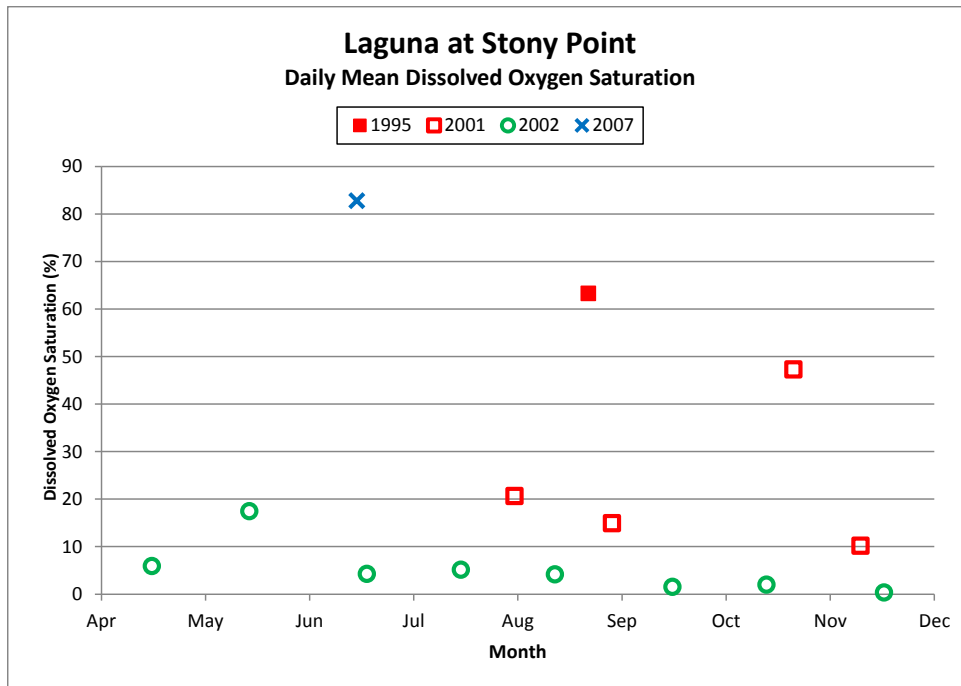


Figure 6. Seasonal Distribution of Daily Mean Dissolved Oxygen Saturation measured in the Laguna at Stony Point Road

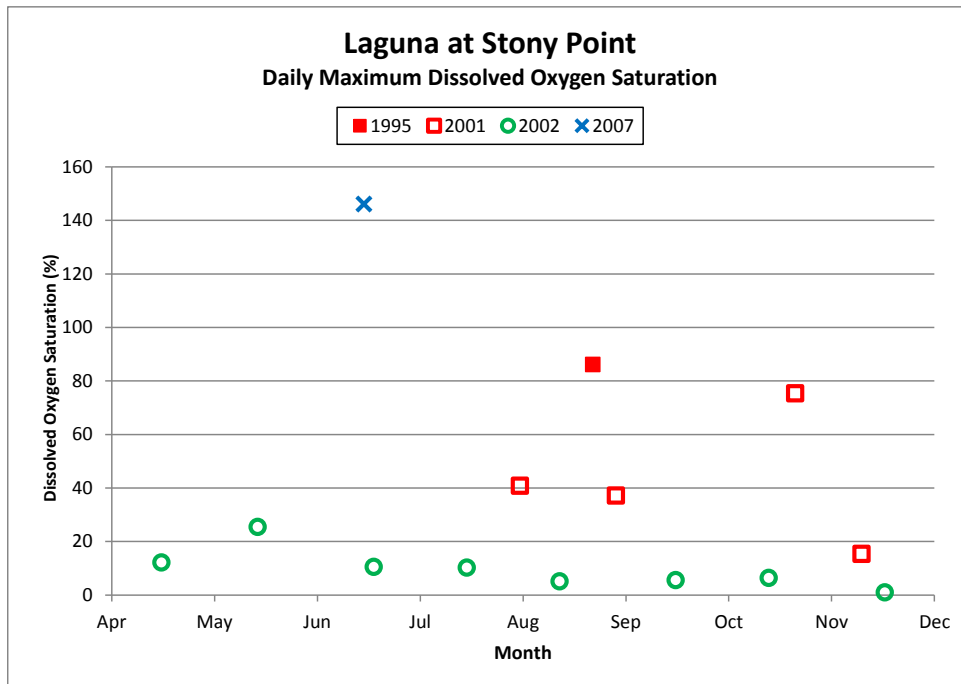


Figure 7. Seasonal Distribution of Daily Maximum Dissolved Oxygen Saturation measured in the Laguna at Stony Point Road

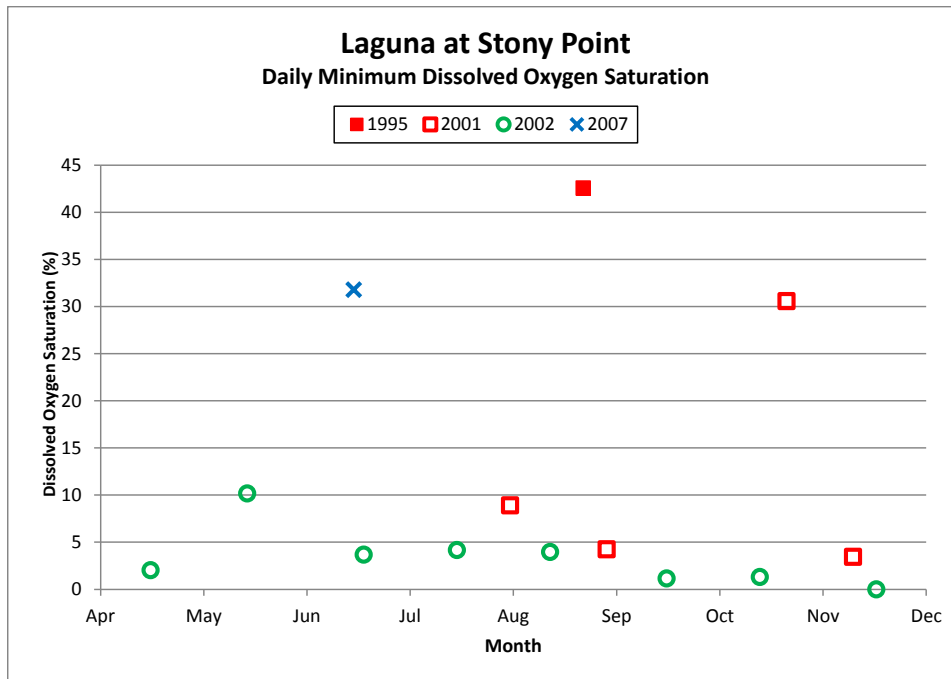


Figure 8. Seasonal Distribution of Daily Minimum Dissolved Oxygen Saturation measured in the Laguna at Stony Point Road

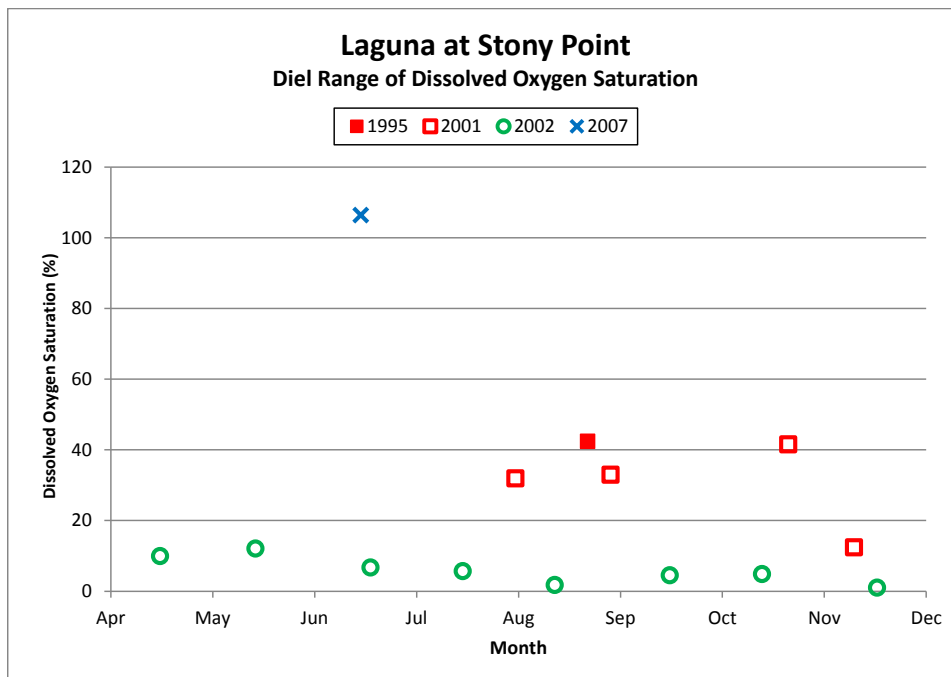


Figure 9. Seasonal Distribution of the Diel Range of Dissolved Oxygen Saturation measured in the Laguna at Stony Point Road

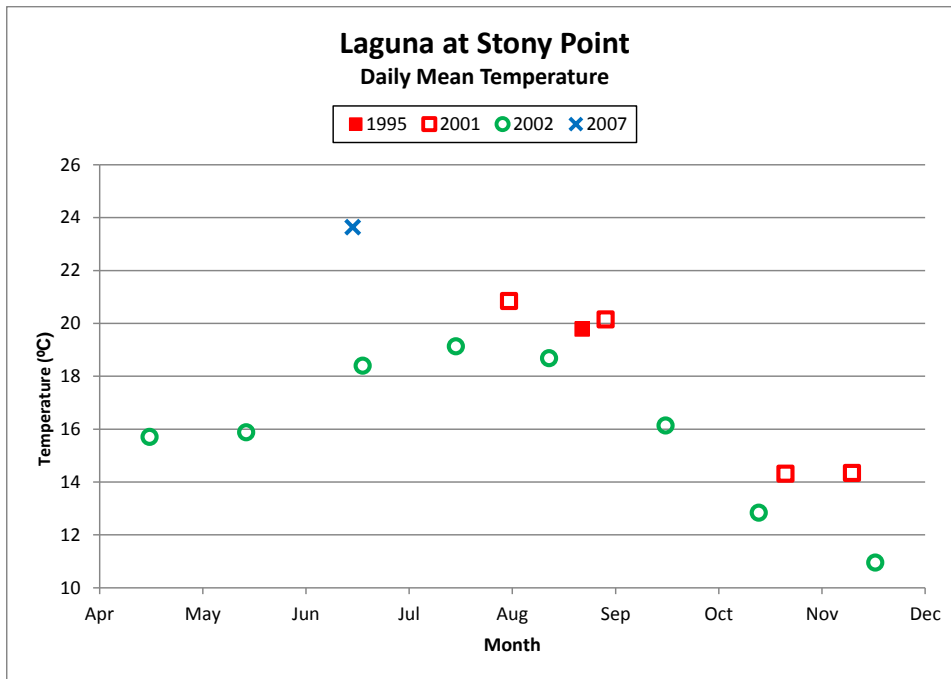


Figure 10. Seasonal Distribution of Daily Mean Water Temperature measured in the Laguna at Stony Point Road

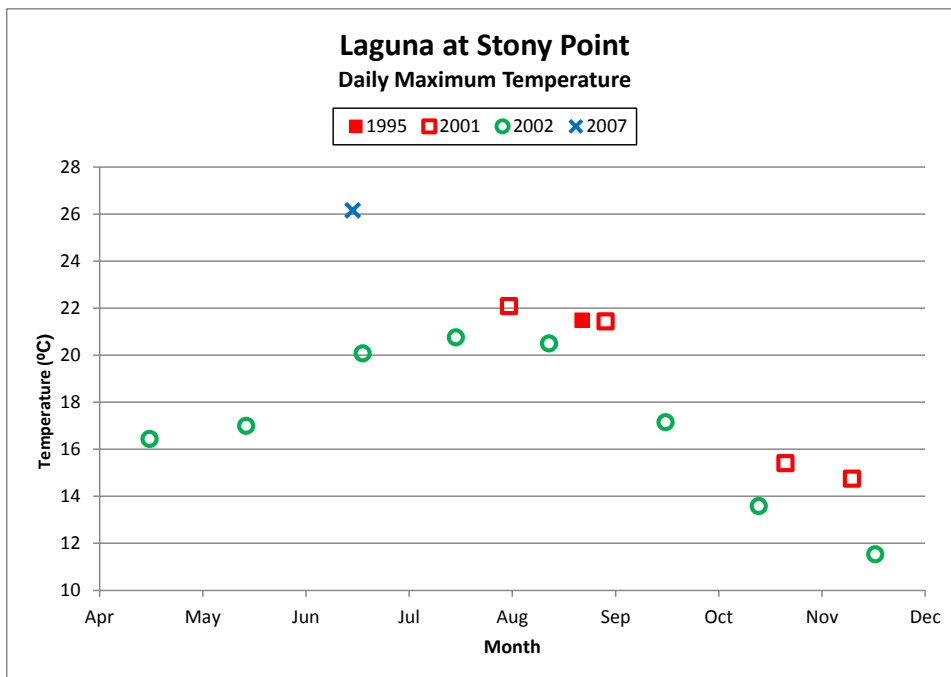


Figure 11. Seasonal Distribution of Daily Maximum Water Temperature measured in the Laguna at Stony Point Road

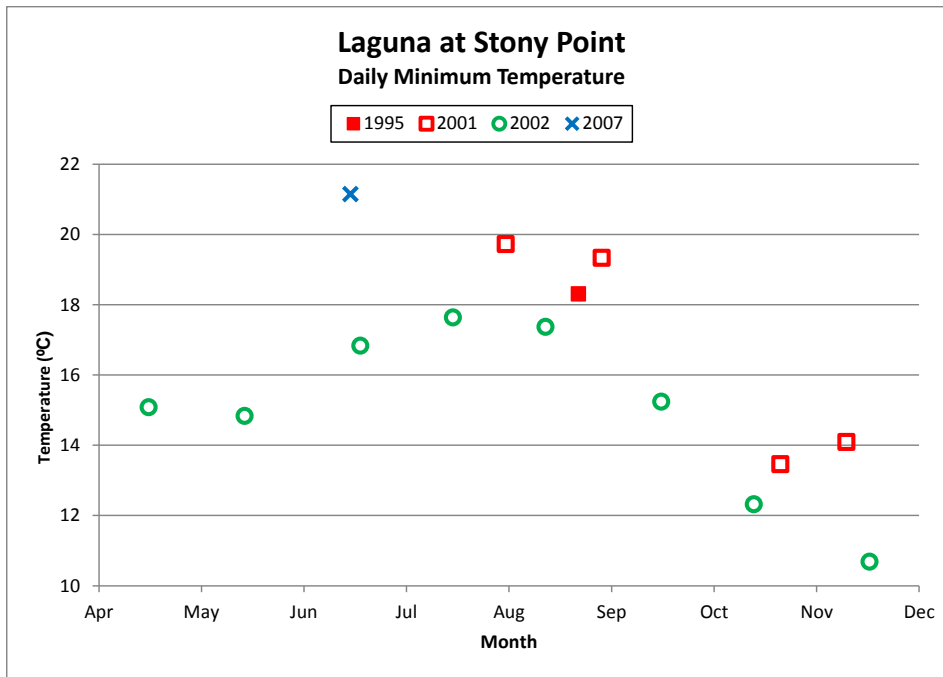


Figure 12. Seasonal Distribution of Daily Minimum Water Temperature measured in the Laguna at Stony Point Road

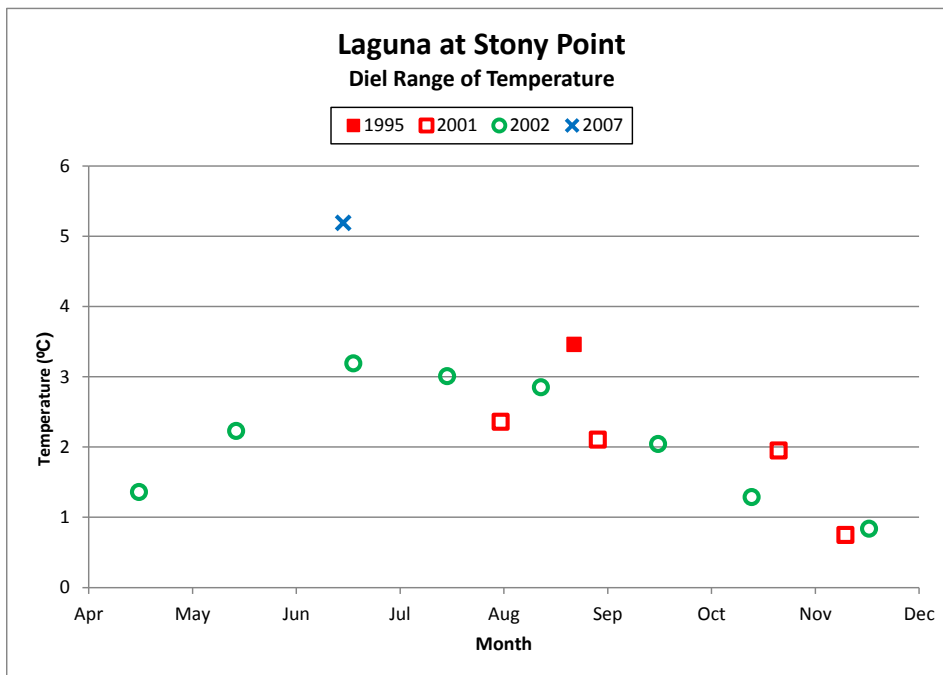


Figure 13. Seasonal Distribution of the Diel Range of Water Temperature measured in the Laguna at Stony Point Road

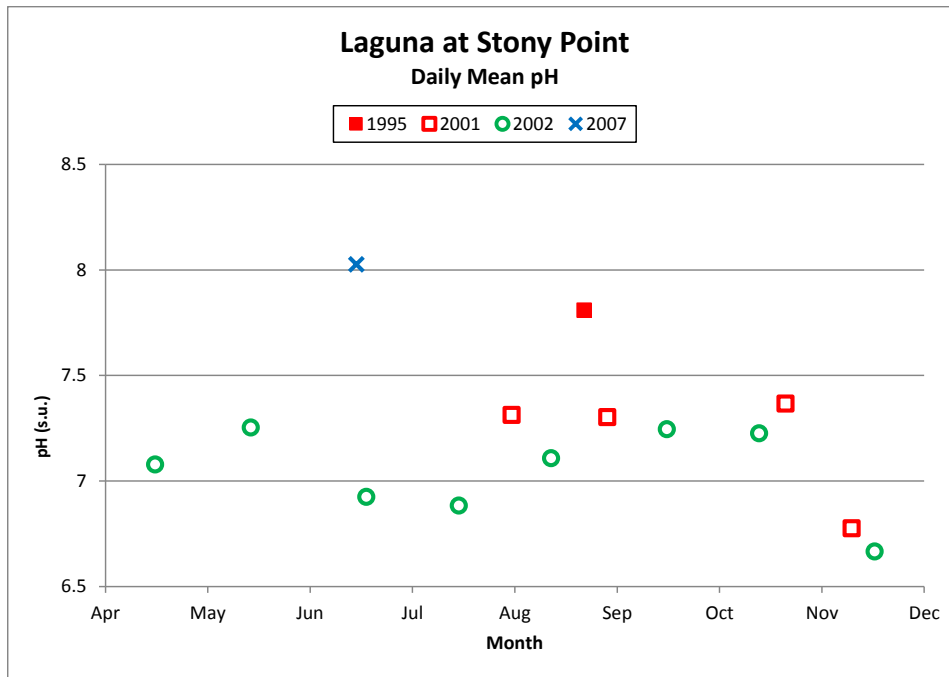


Figure 14. Seasonal Distribution of Daily Mean pH measured in the Laguna at Stony Point Road

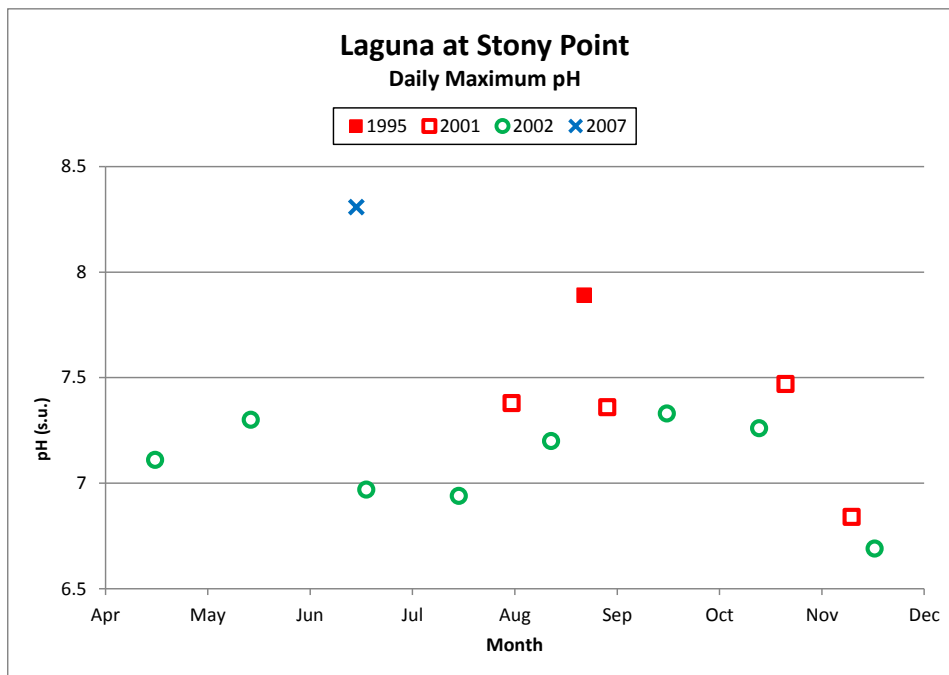


Figure 15. Seasonal Distribution of Daily Maximum pH measured in the Laguna at Stony Point Road

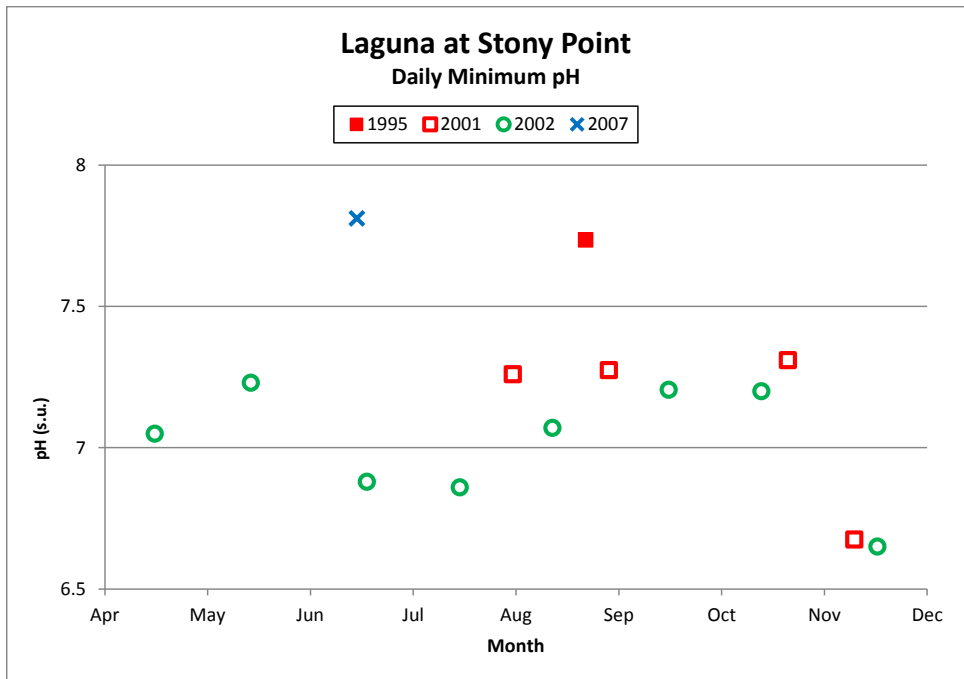


Figure 16. Seasonal Distribution of Daily Minimum pH measured in the Laguna at Stony Point Road

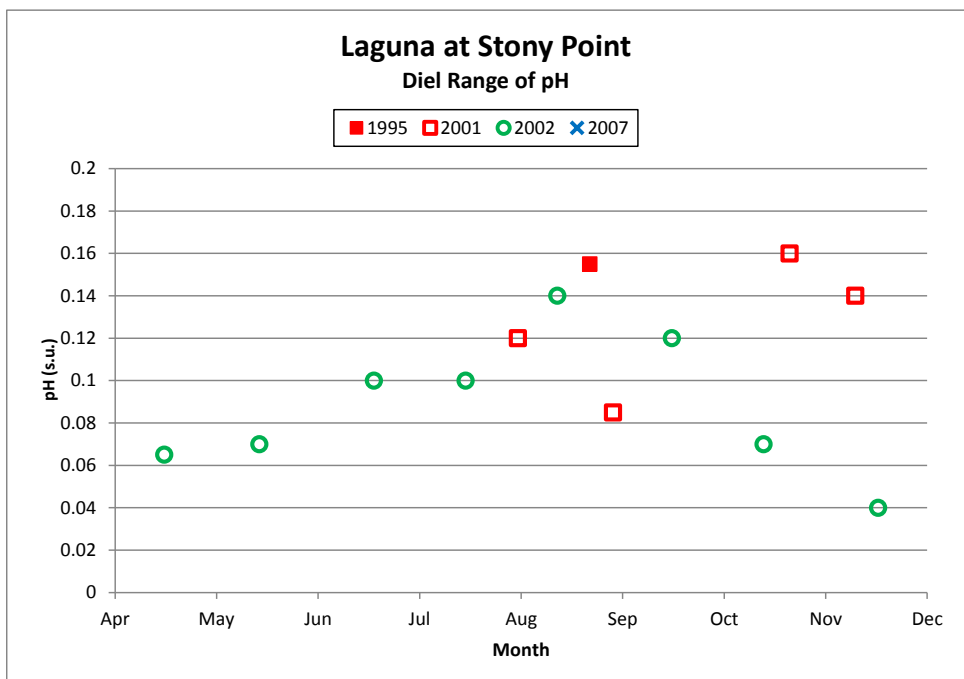


Figure 17. Seasonal Distribution of the Diel Range of pH measured in the Laguna at Stony Point Road

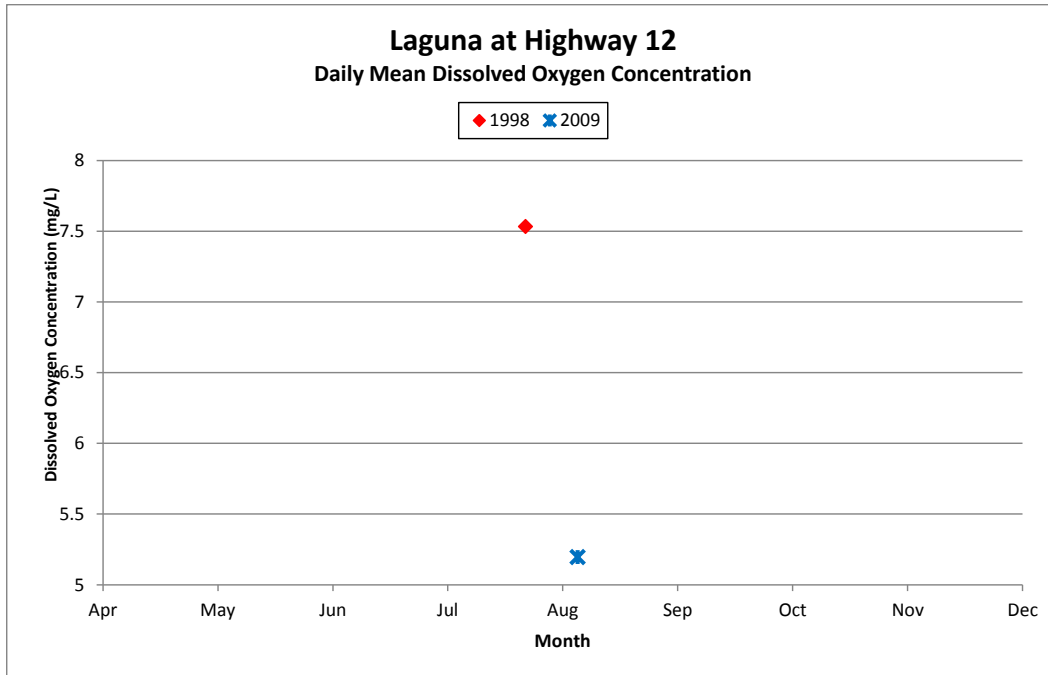


Figure 18. Seasonal Distribution of Daily Mean Dissolved Oxygen Concentrations measured in the Laguna at Highway 12

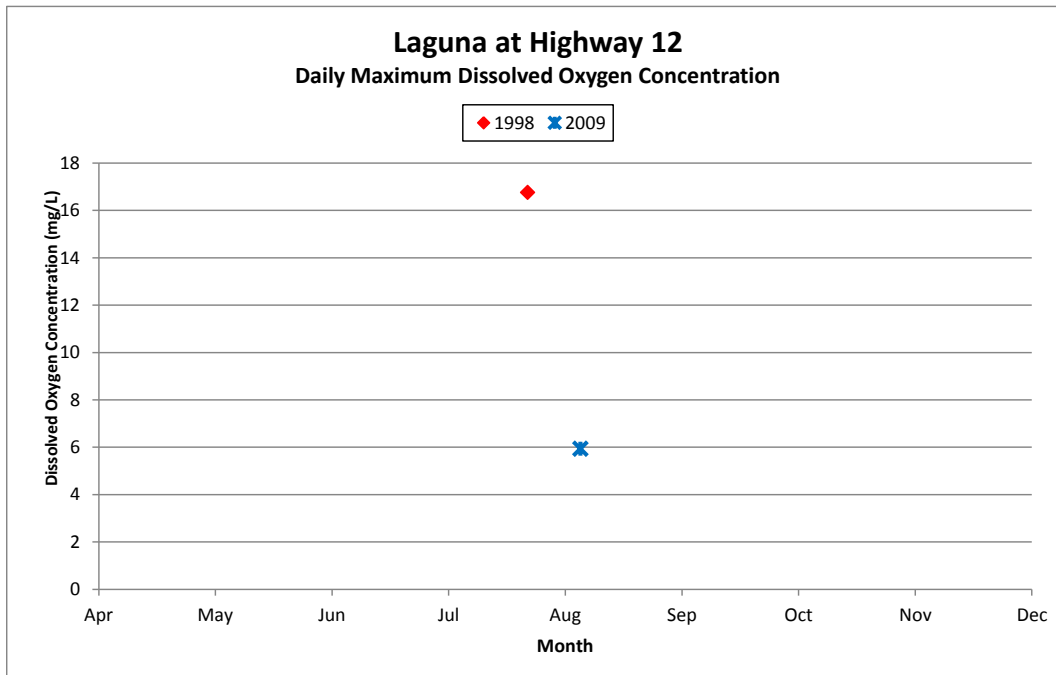


Figure 19. Seasonal Distribution of Daily Maximum Dissolved Oxygen Concentrations measured in the Laguna at Highway 12

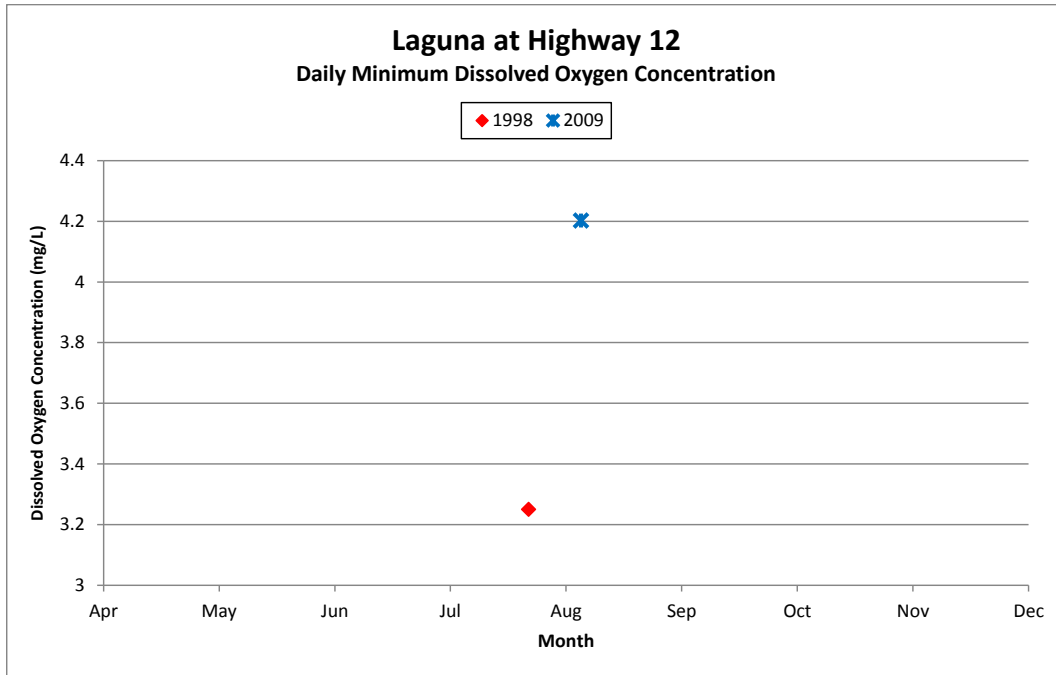


Figure 20. Seasonal Distribution of Daily Minimum Dissolved Oxygen Concentrations measured in the Laguna at Highway 12

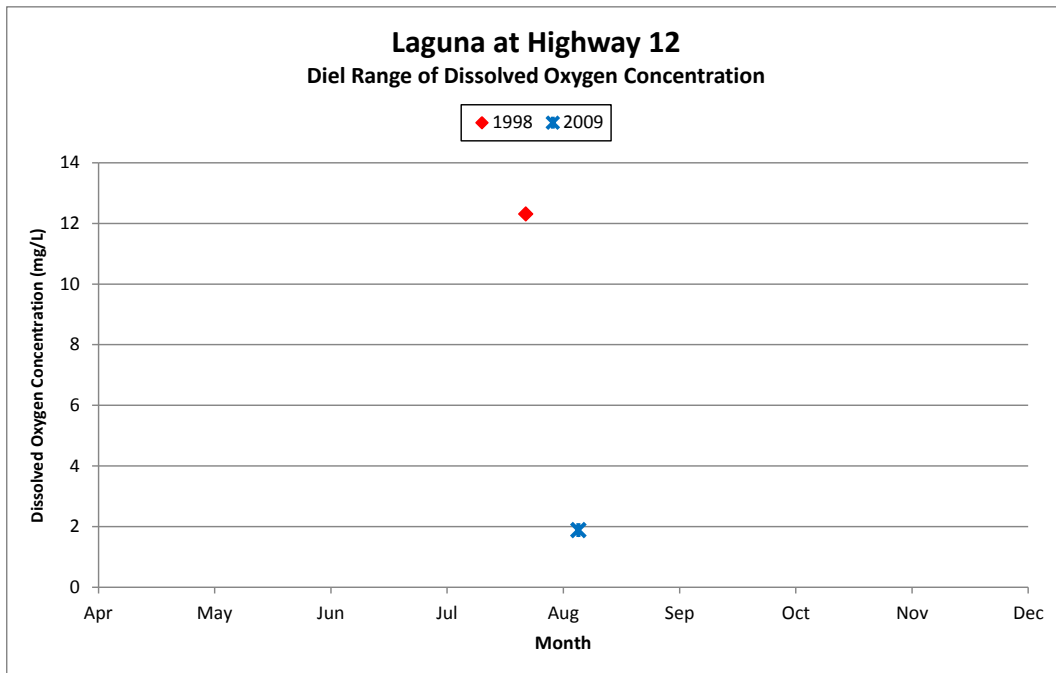


Figure 21. Seasonal Distribution of the Diel Range of Dissolved Oxygen Concentrations measured in the Laguna at Highway 12

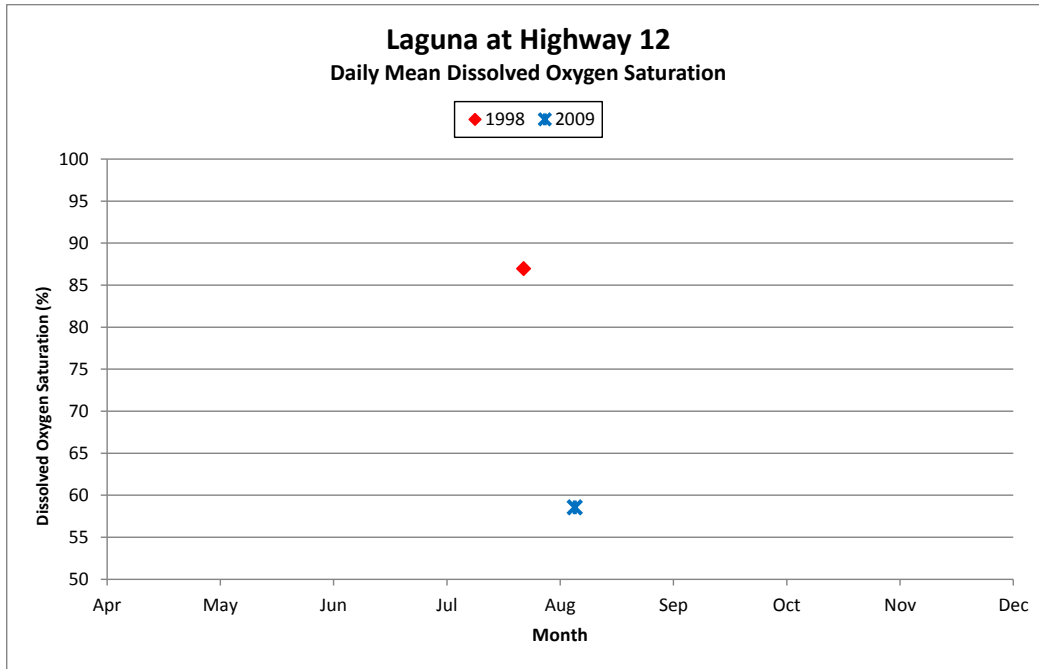


Figure 22. Seasonal Distribution of Daily Mean Dissolved Oxygen Saturation measured in the Laguna at Highway 12

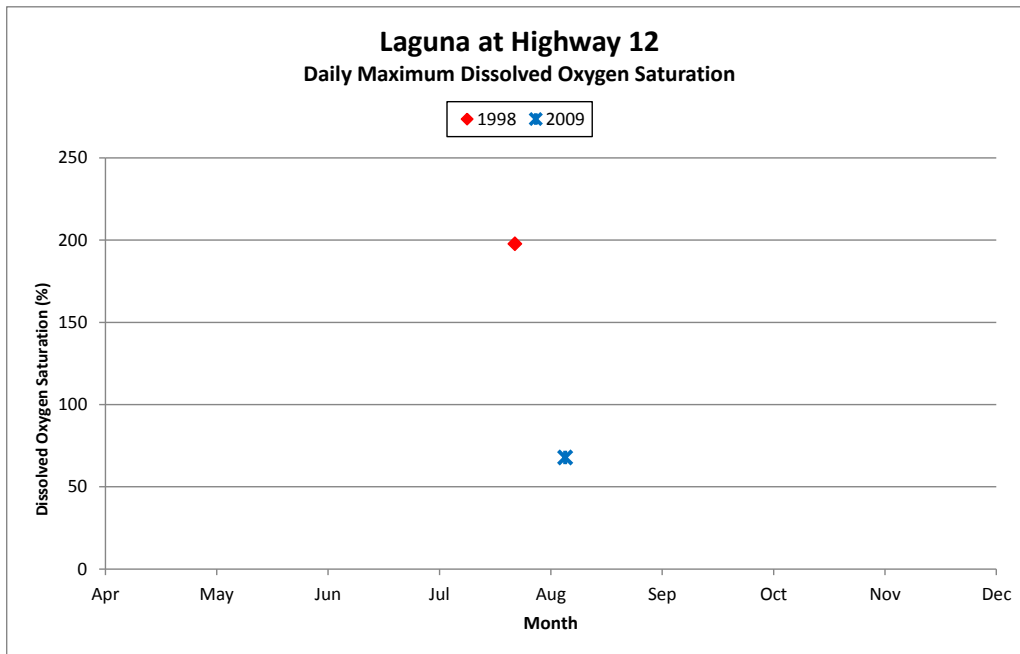


Figure 23. Seasonal Distribution of Daily Maximum Dissolved Oxygen Saturation measured in the Laguna at Highway 12

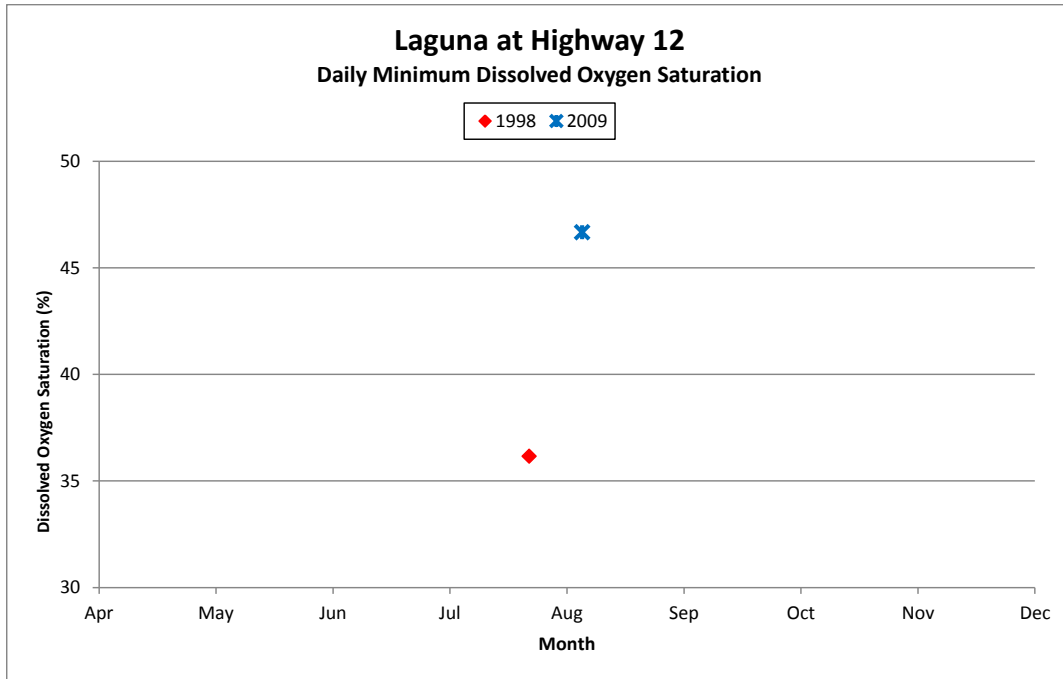


Figure 24. Seasonal Distribution of Daily Minimum Dissolved Oxygen Saturation measured in the Laguna at Highway 12

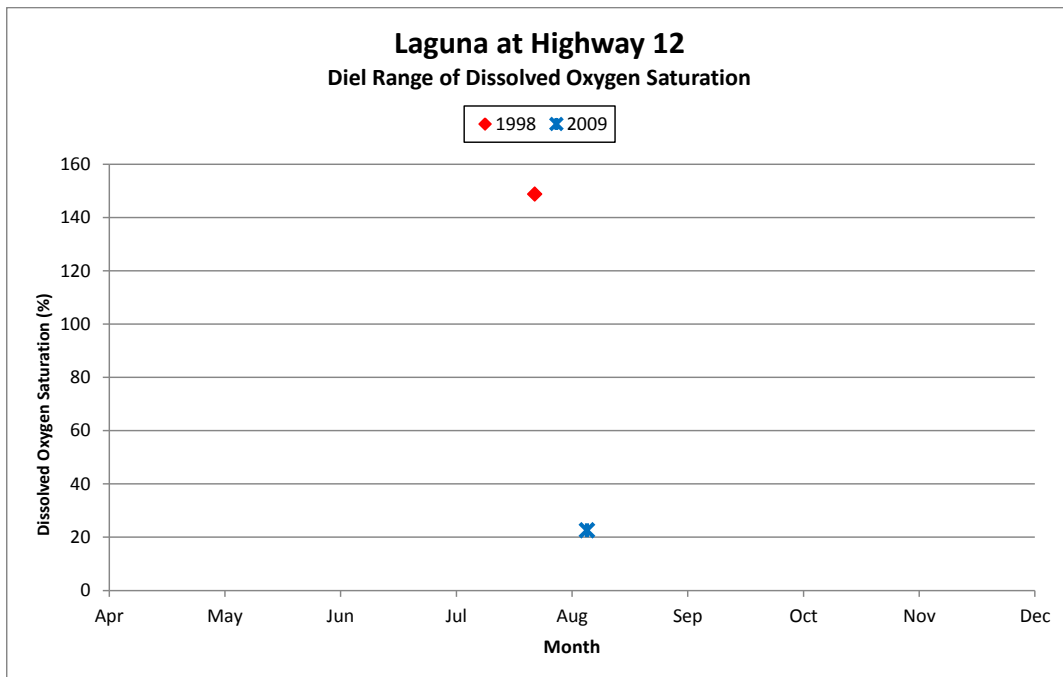


Figure 25. Seasonal Distribution of the Diel Range of Dissolved Oxygen Saturation measured in the Laguna at Highway 12

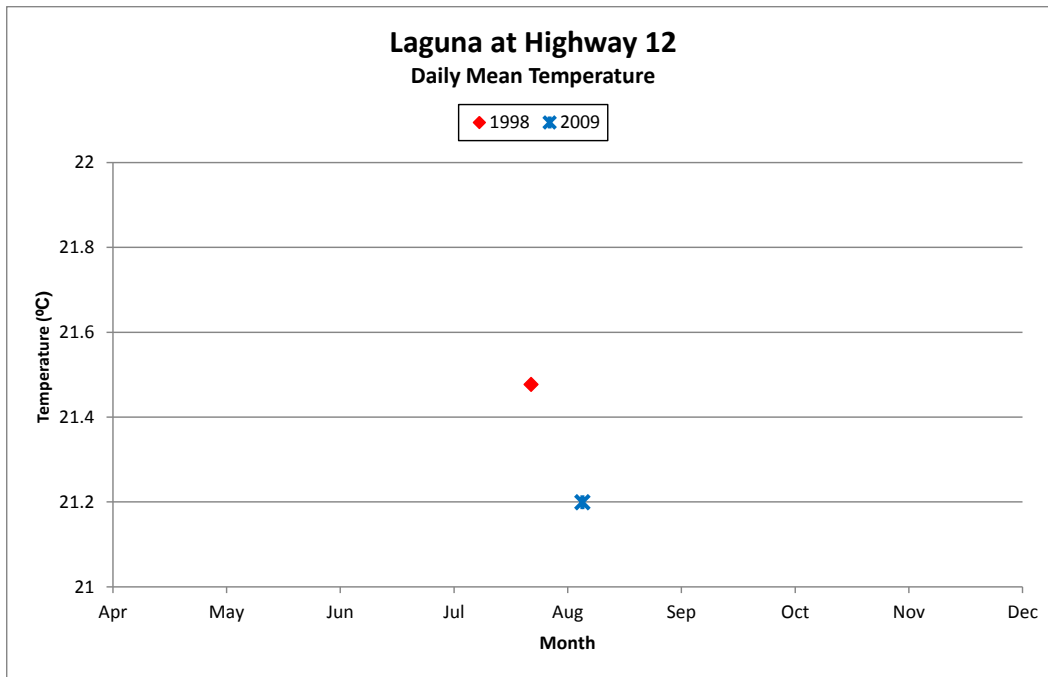


Figure 26. Seasonal Distribution of Daily Mean Water Temperatures measured in the Laguna at Highway 12

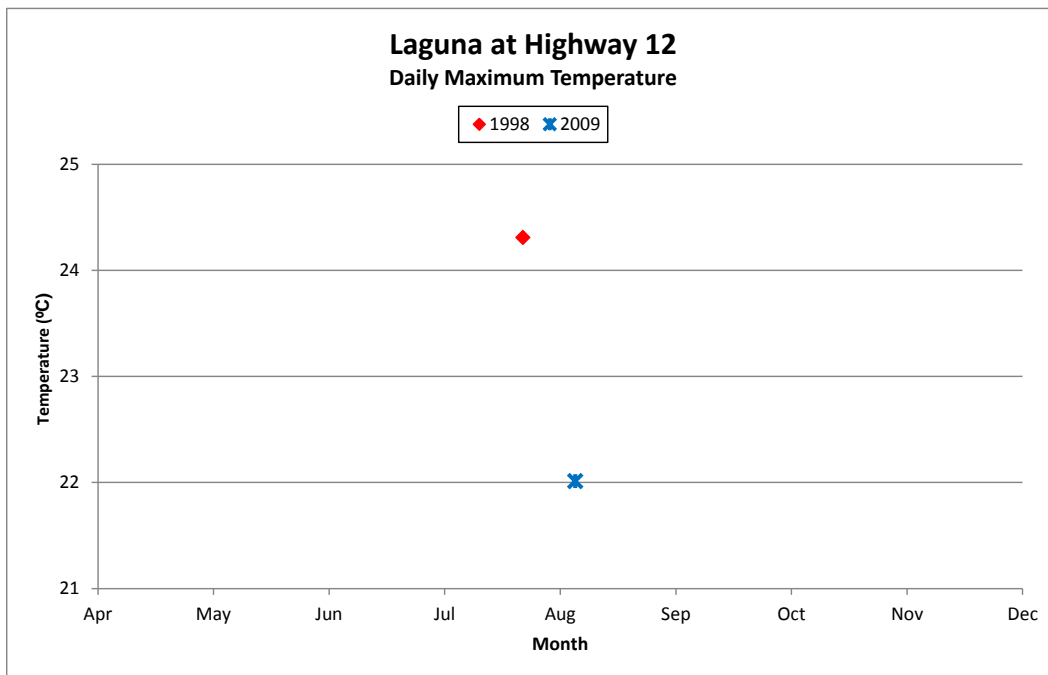


Figure 27. Seasonal Distribution of Daily Maximum Water Temperatures measured in the Laguna at Highway 12

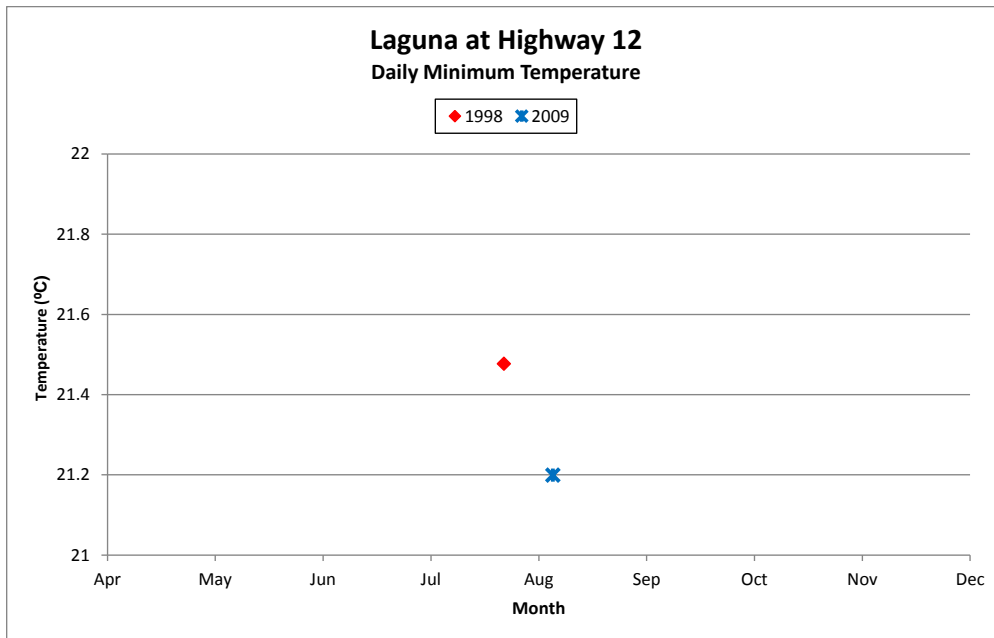


Figure 28. Seasonal Distribution of Daily Minimum Water Temperatures measured in the Laguna at Highway 12

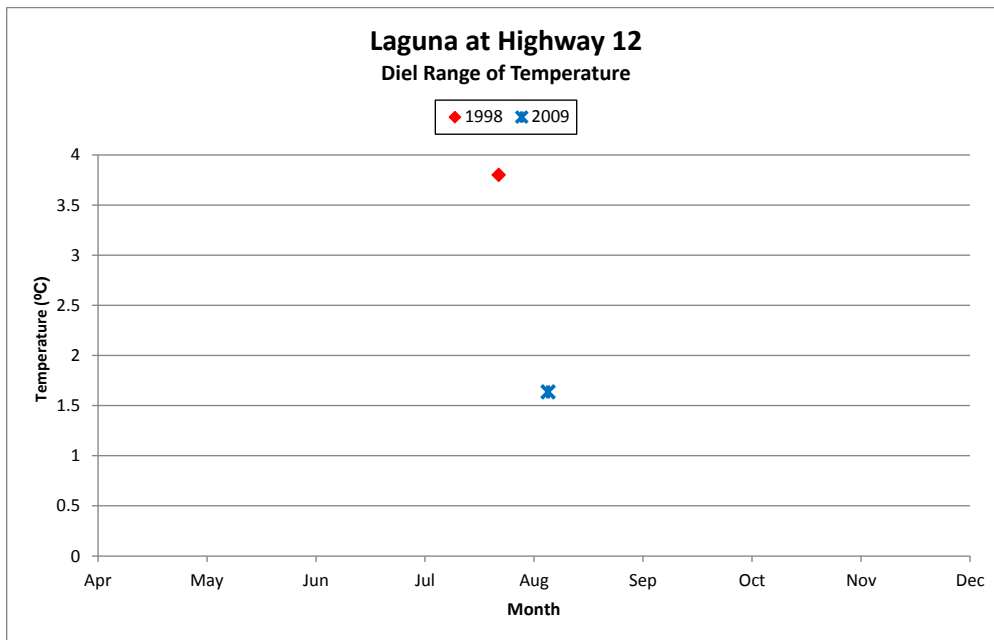


Figure 29. Seasonal Distribution of the Diel Range of Water Temperatures measured in the Laguna at Highway 12

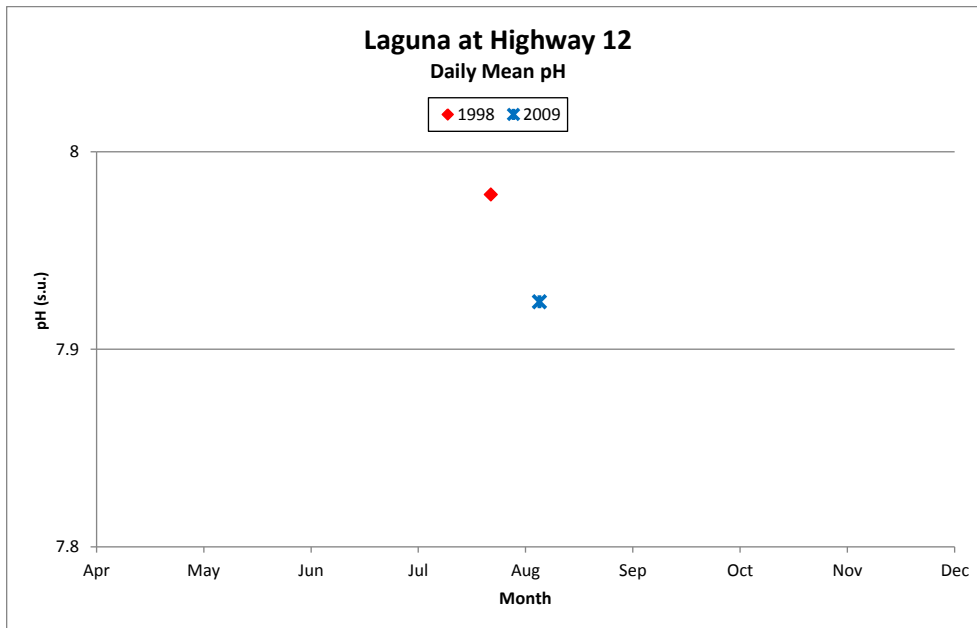


Figure 30. Seasonal Distribution of Daily Mean pH measured in the Laguna at Highway 12

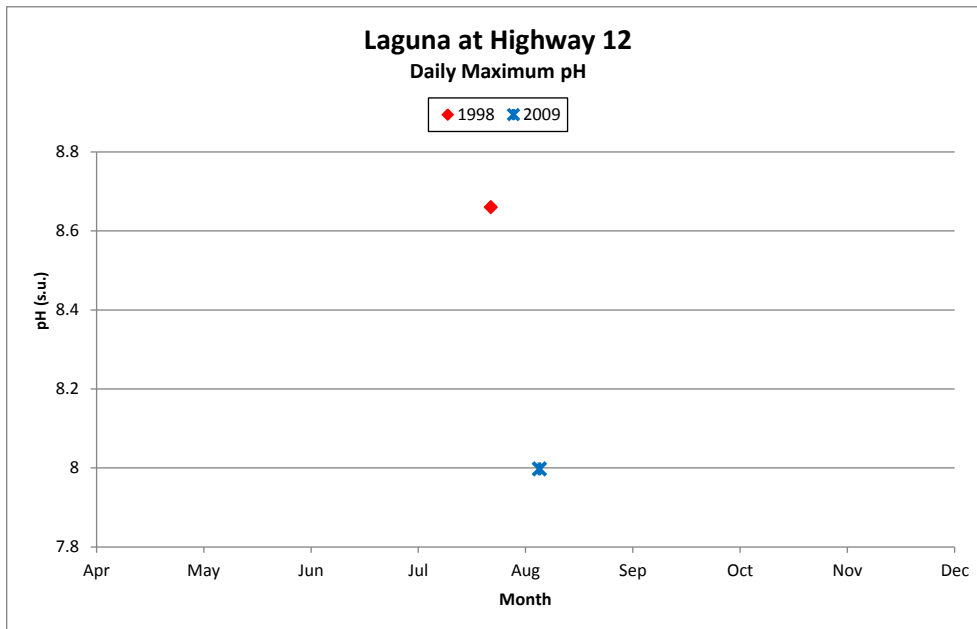


Figure 31. Seasonal Distribution of Daily Maximum pH measured in the Laguna at Highway 12

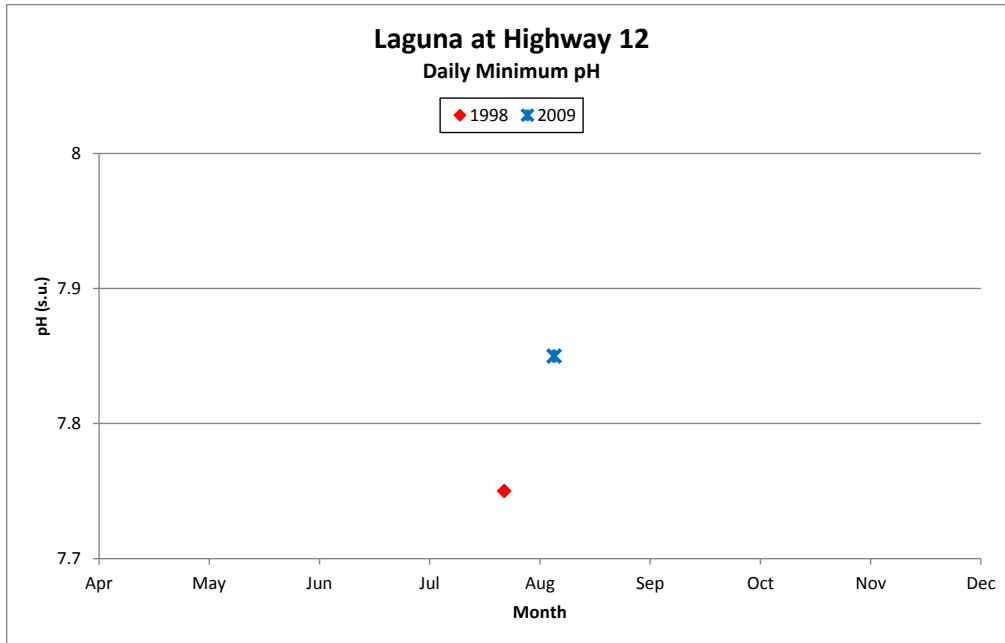


Figure 32. Seasonal Distribution of Daily Minimum pH measured in the Laguna at Highway 12

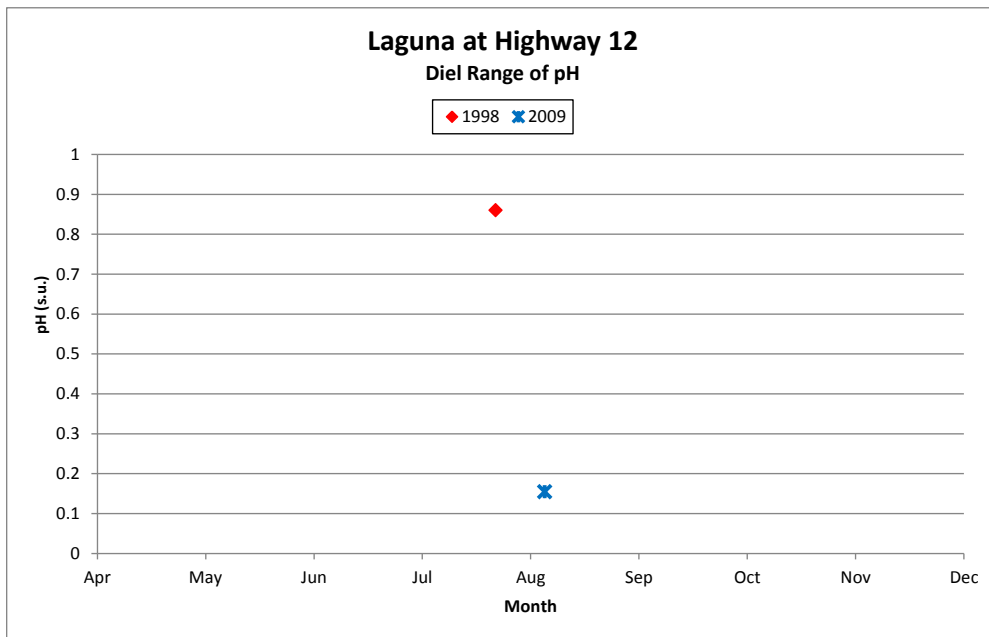


Figure 33. Seasonal Distribution of the Diel Range of pH measured in the Laguna at Highway 12

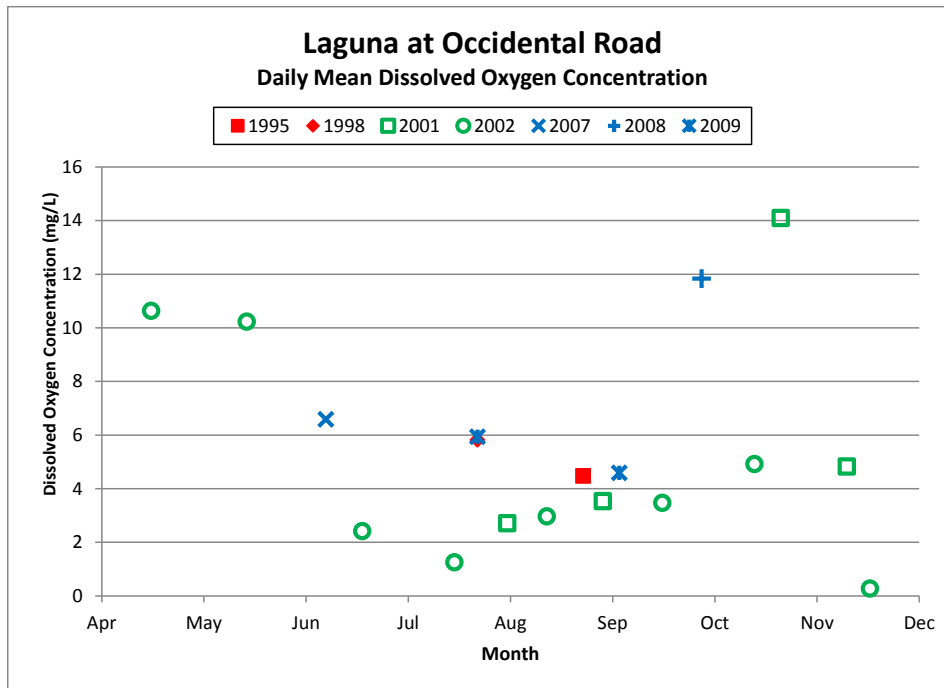


Figure 34. Seasonal Distribution of Daily Mean Dissolved Oxygen Concentrations measured in the Laguna at Occidental Road

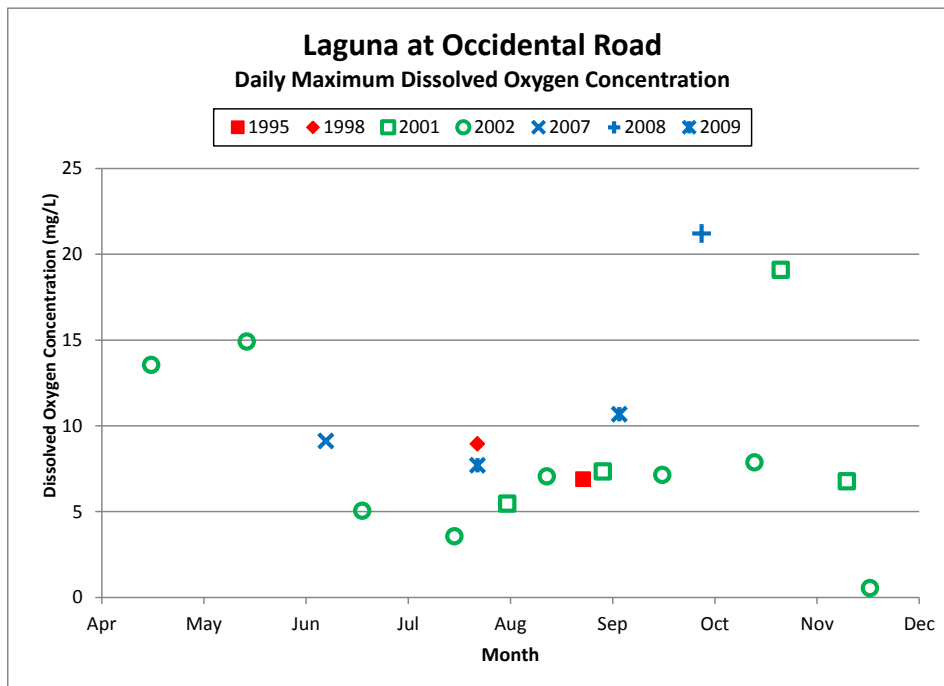


Figure 35. Seasonal Distribution of Daily Maximum Dissolved Oxygen Concentrations measured in the Laguna at Occidental Road

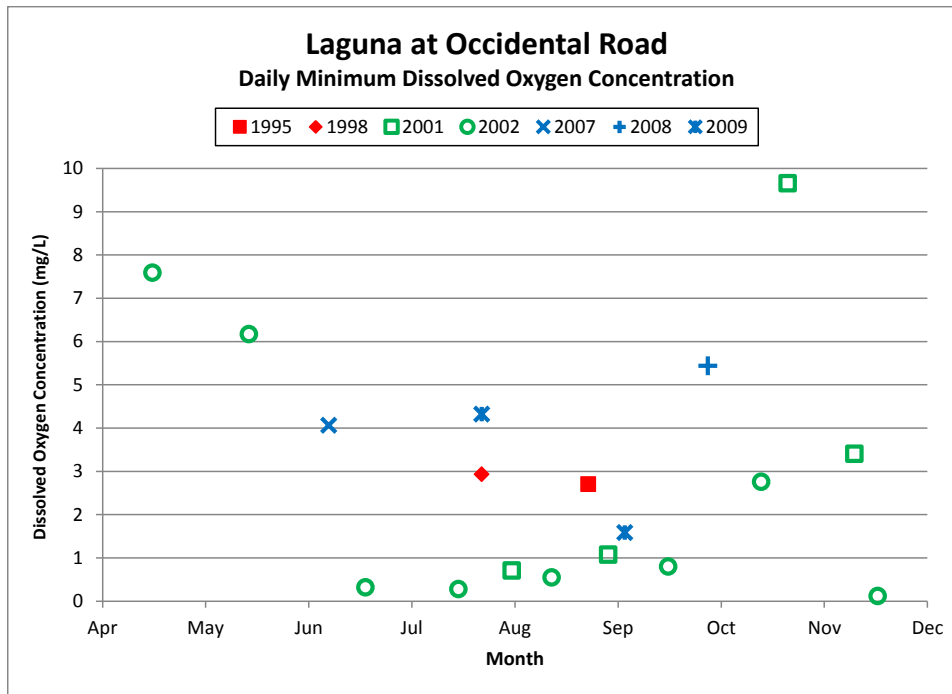


Figure 36. Seasonal Distribution of Daily Minimum Dissolved Oxygen Concentrations measured in the Laguna at Occidental Road

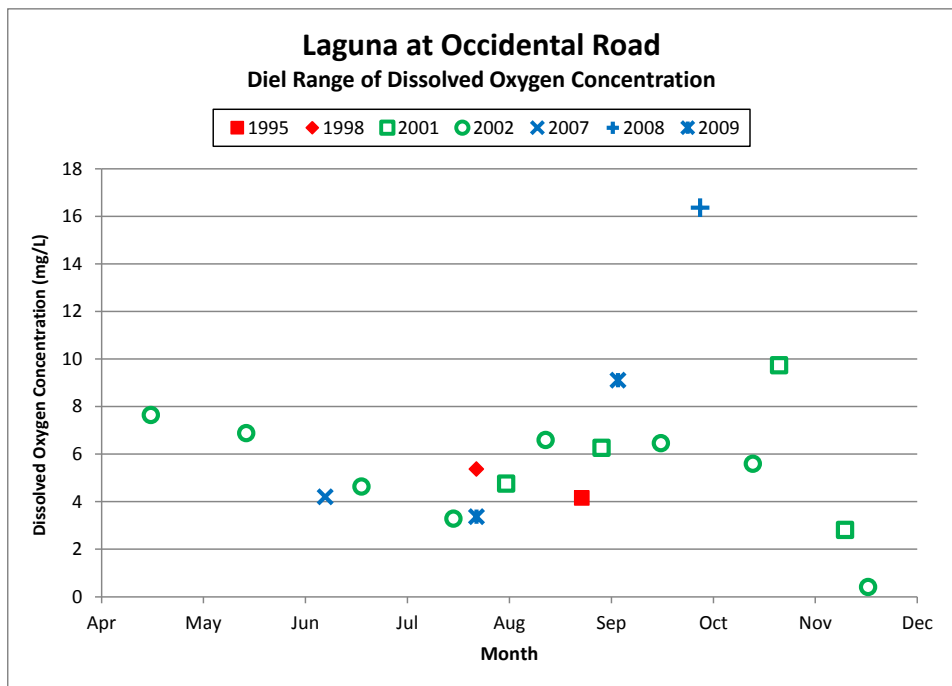


Figure 37. Seasonal Distribution of the Diel Range of Dissolved Oxygen Concentrations measured in the Laguna at Occidental Road

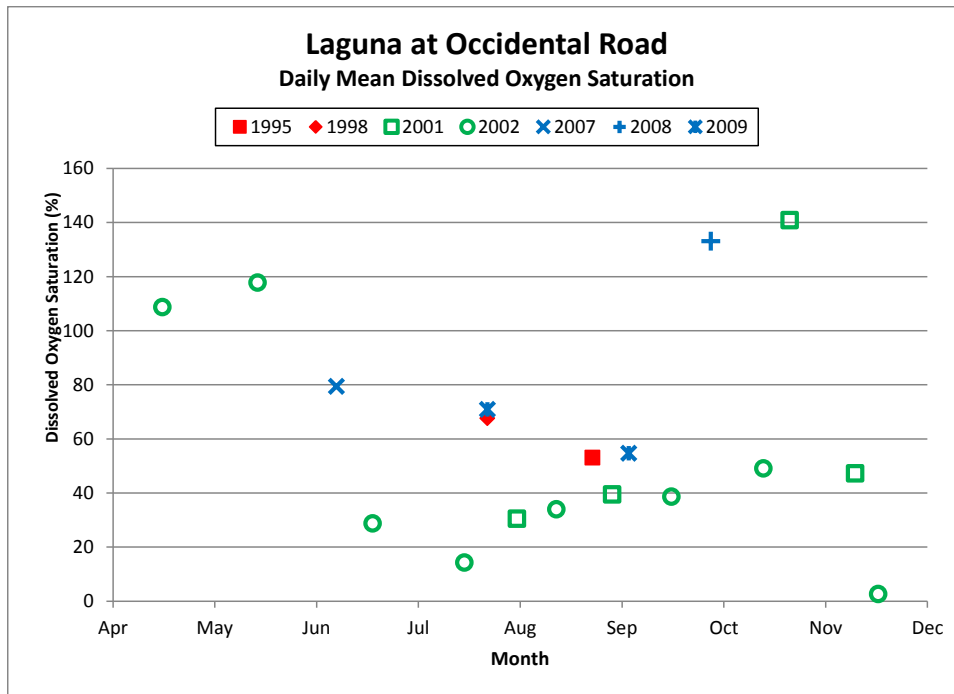


Figure 38. Seasonal Distribution of Daily Mean Dissolved Oxygen Saturation measured in the Laguna at Occidental Road

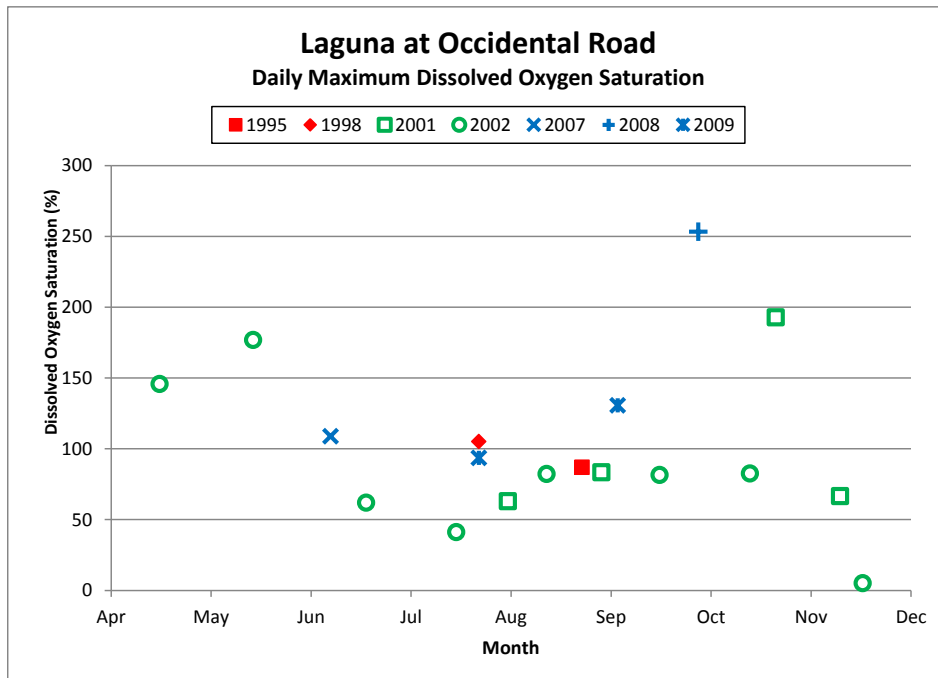


Figure 39. Seasonal Distribution of Daily Maximum Dissolved Oxygen Saturation measured in the Laguna at Occidental Road

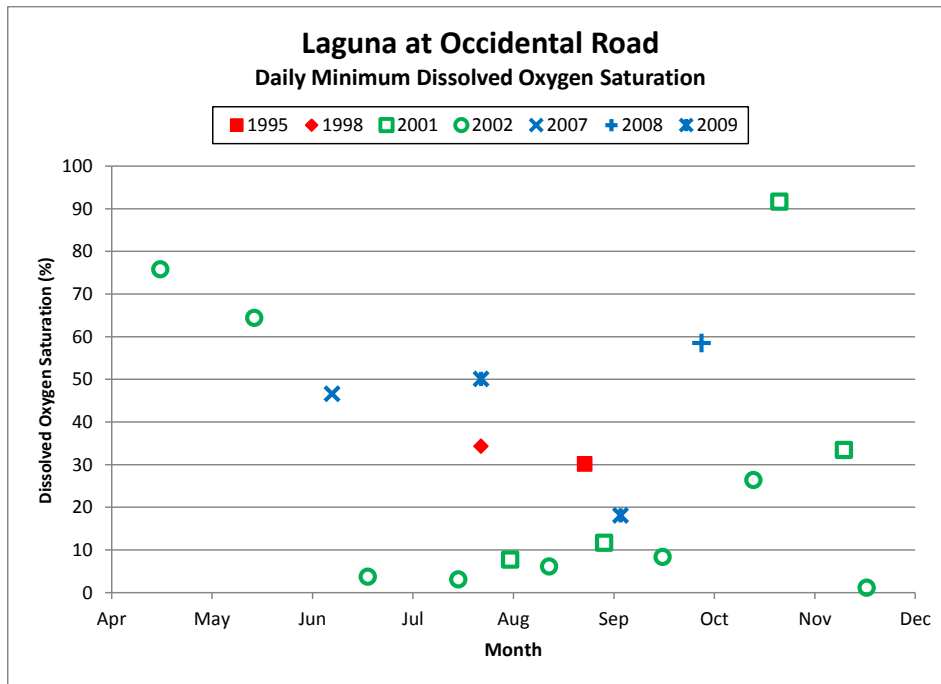


Figure 40. Seasonal Distribution of Daily Minimum Dissolved Oxygen Concentrations measured in the Laguna at Stony Point Road

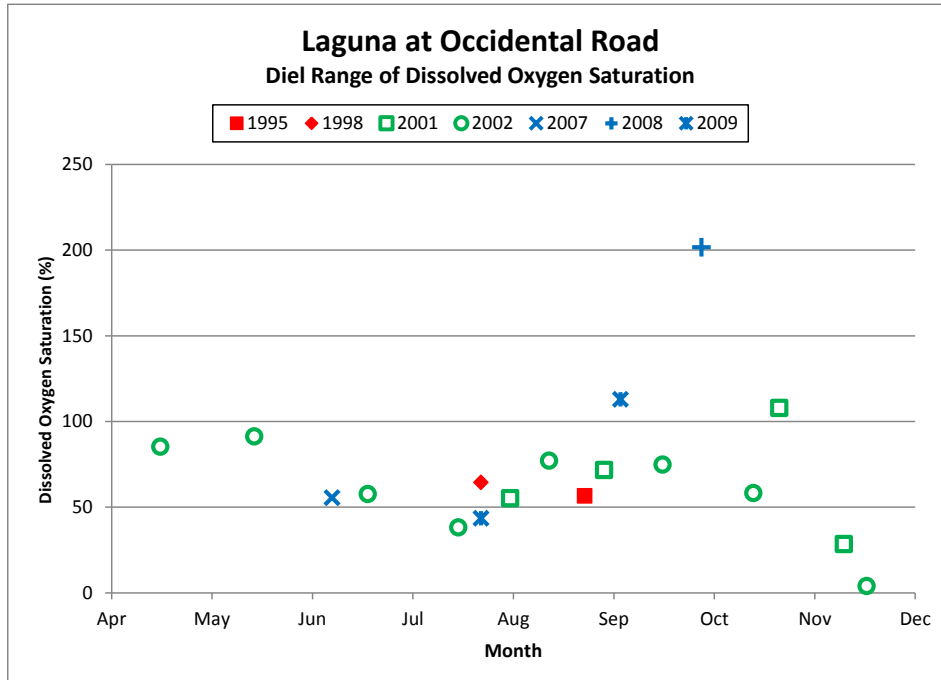


Figure 41. Seasonal Distribution of the Diel Range of Dissolved Oxygen Saturation measured in the Laguna at Occidental Road

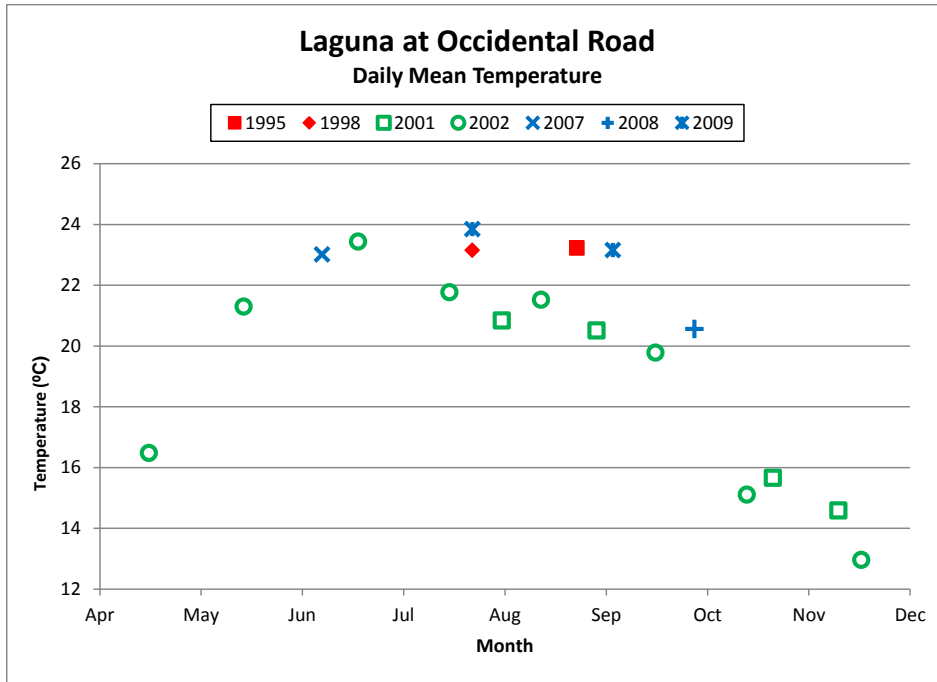


Figure 42. Seasonal Distribution of Daily Mean Water Temperature measured in the Laguna at Occidental Road

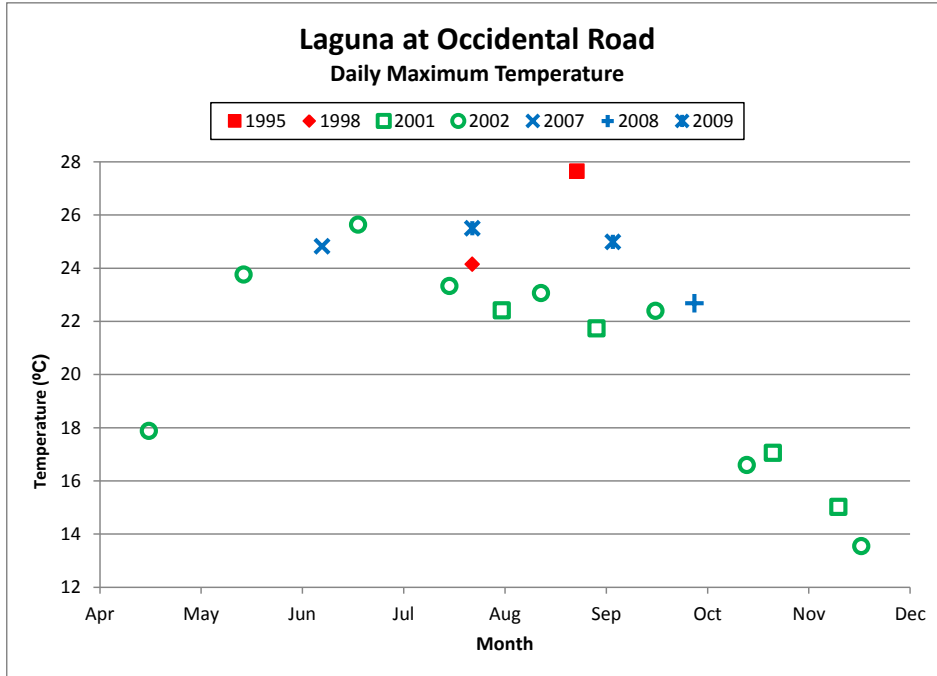


Figure 43. Seasonal Distribution of Daily Maximum Water Temperature measured in the Laguna at Occidental Road

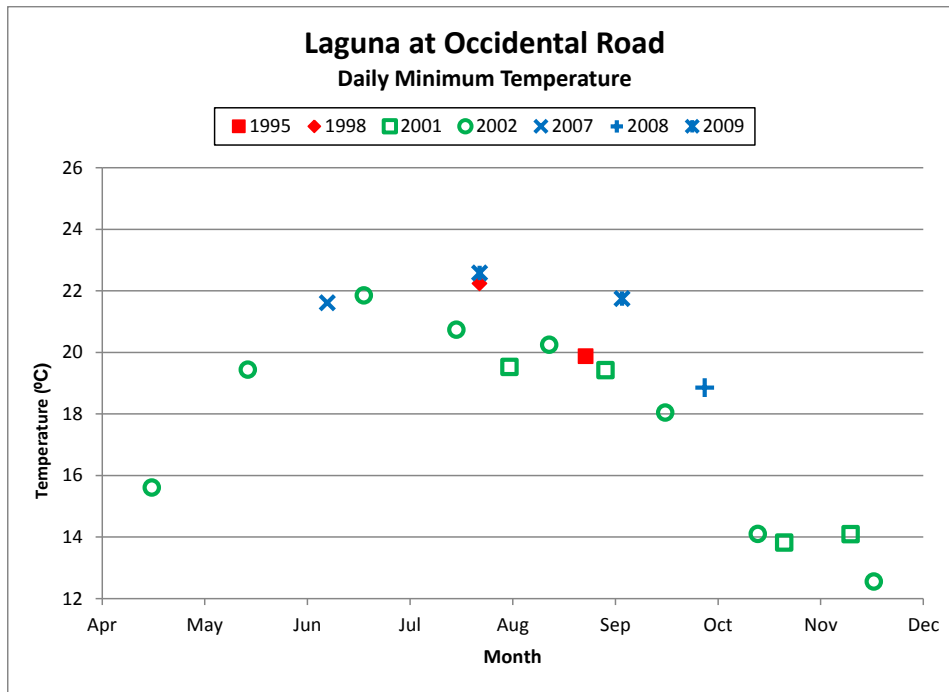


Figure 44. Seasonal Distribution of Daily Minimum Water Temperature measured in the Laguna at Occidental Road

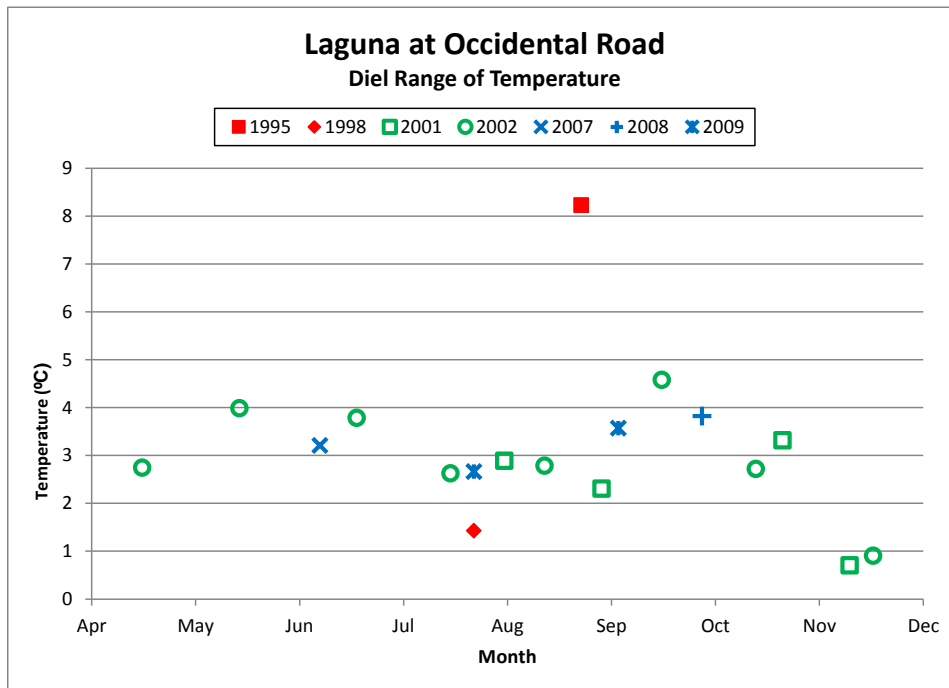


Figure 45. Seasonal Distribution of the Diel Range of Water Temperature measured in the Laguna at Occidental Road

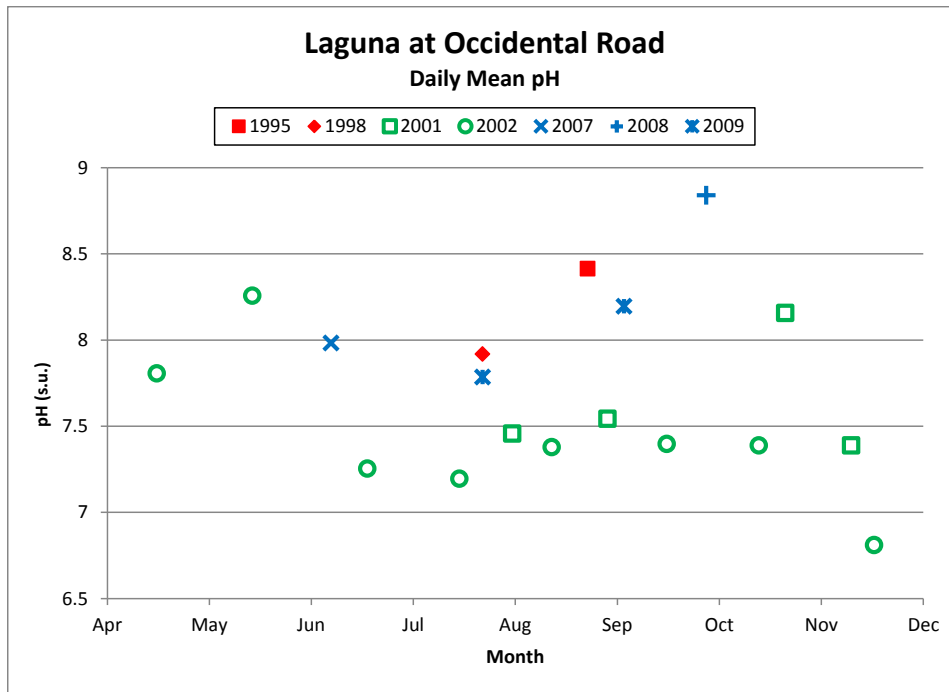


Figure 46. Seasonal Distribution of Daily Mean pH measured in the Laguna at Occidental Road

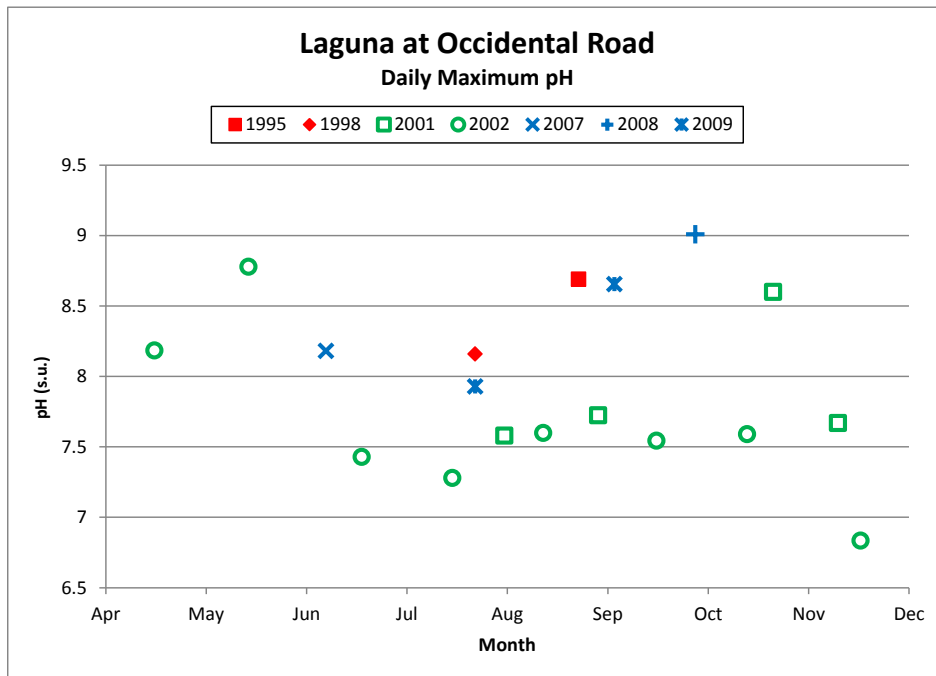


Figure 47. Seasonal Distribution of Daily Maximum pH measured in the Laguna at Occidental Road

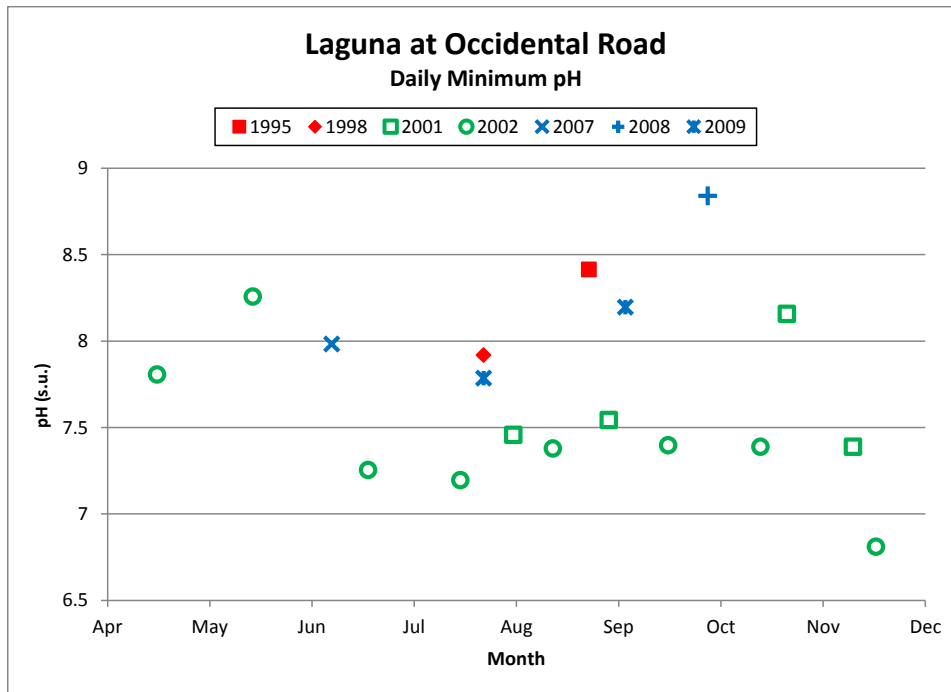


Figure 48. Seasonal Distribution of Daily Minimum pH measured in the Laguna at Occidental Road

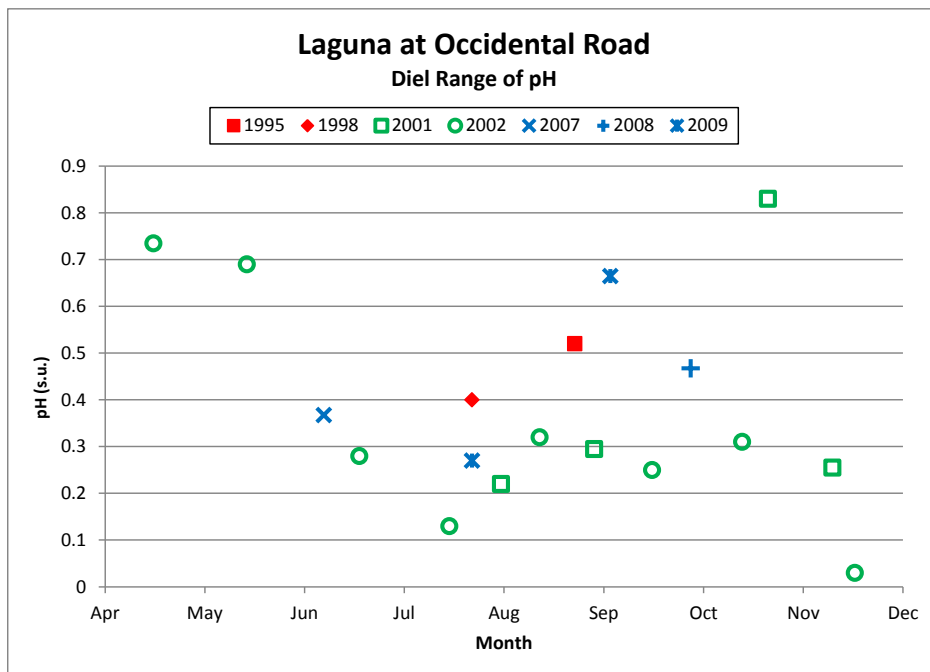


Figure 49. Seasonal Distribution of the Diel Range of pH measured in the Laguna at Occidental Road

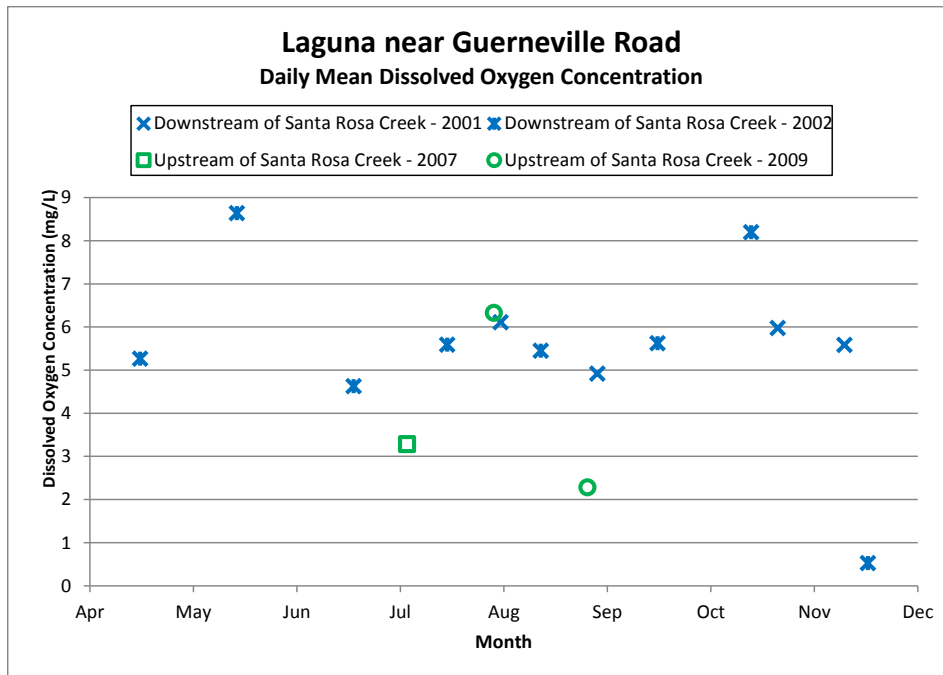


Figure 50. Seasonal Distribution of Daily Mean Dissolved Oxygen Concentrations measured in the Laguna near Guerneville Road

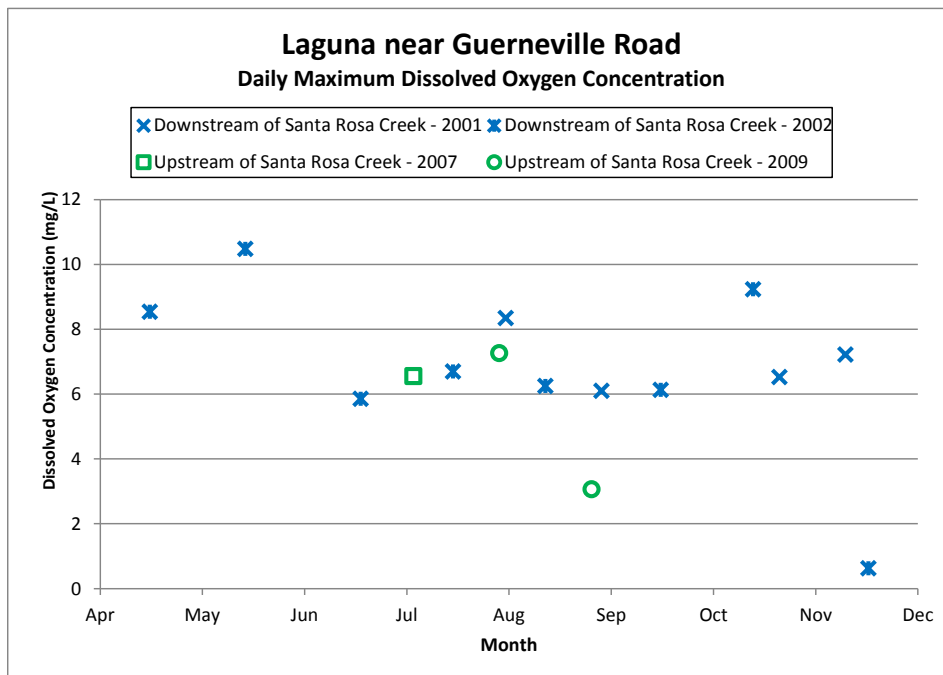


Figure 51. Seasonal Distribution of Daily Maximum Dissolved Oxygen Concentrations measured in the Laguna near Guerneville Road

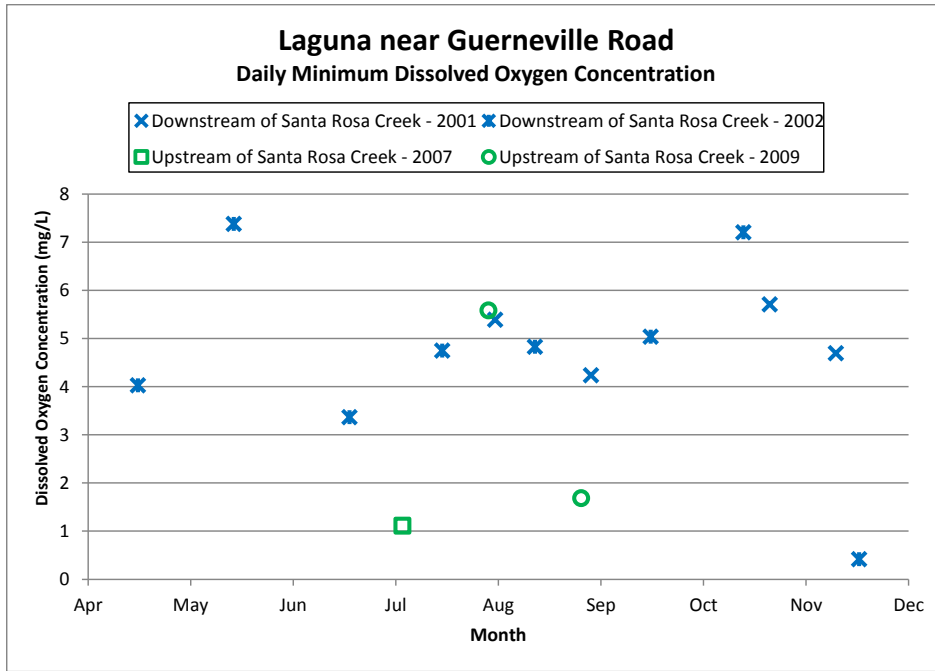


Figure 52. Seasonal Distribution of Daily Minimum Dissolved Oxygen Concentrations measured in the Laguna near Guerneville Road

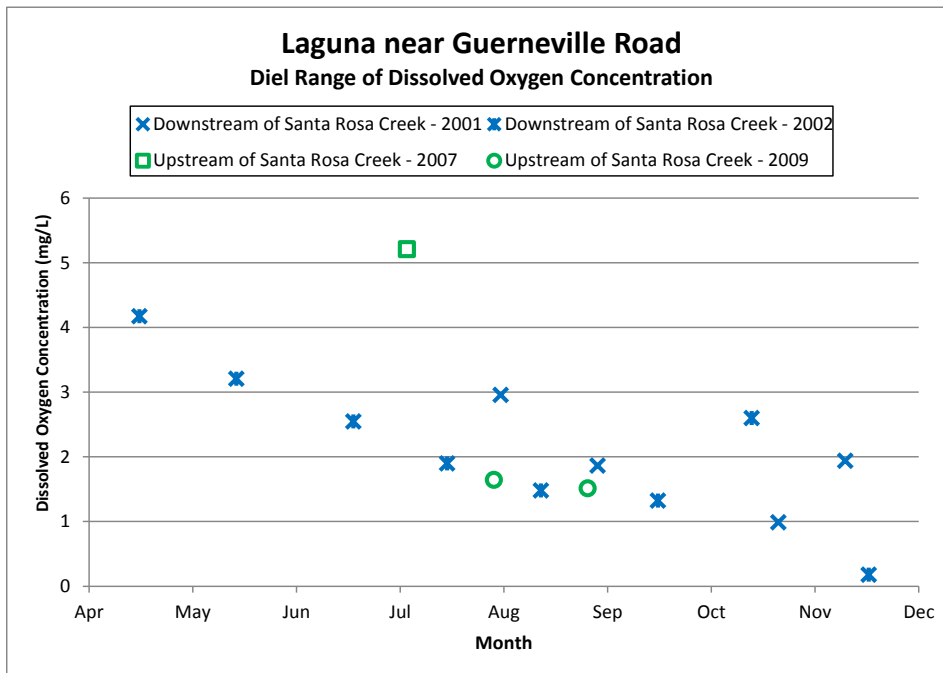


Figure 53. Seasonal Distribution of the Diel Range of Dissolved Oxygen Concentrations measured in the Laguna near Guerneville Road

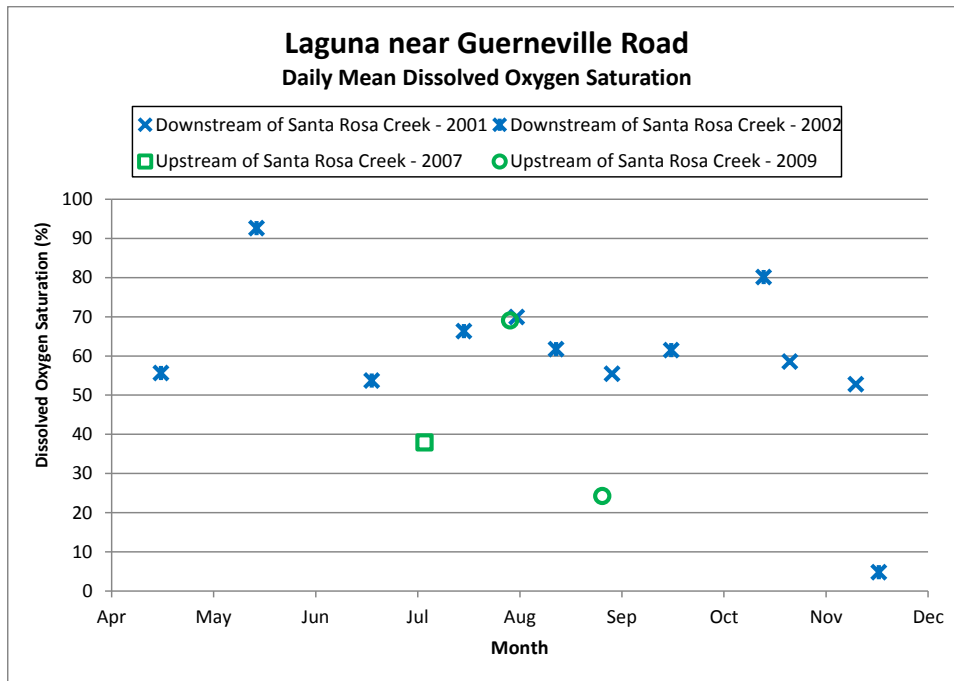


Figure 54. Seasonal Distribution of Daily Mean Dissolved Oxygen Saturation measured in the Laguna near Guerneville Road

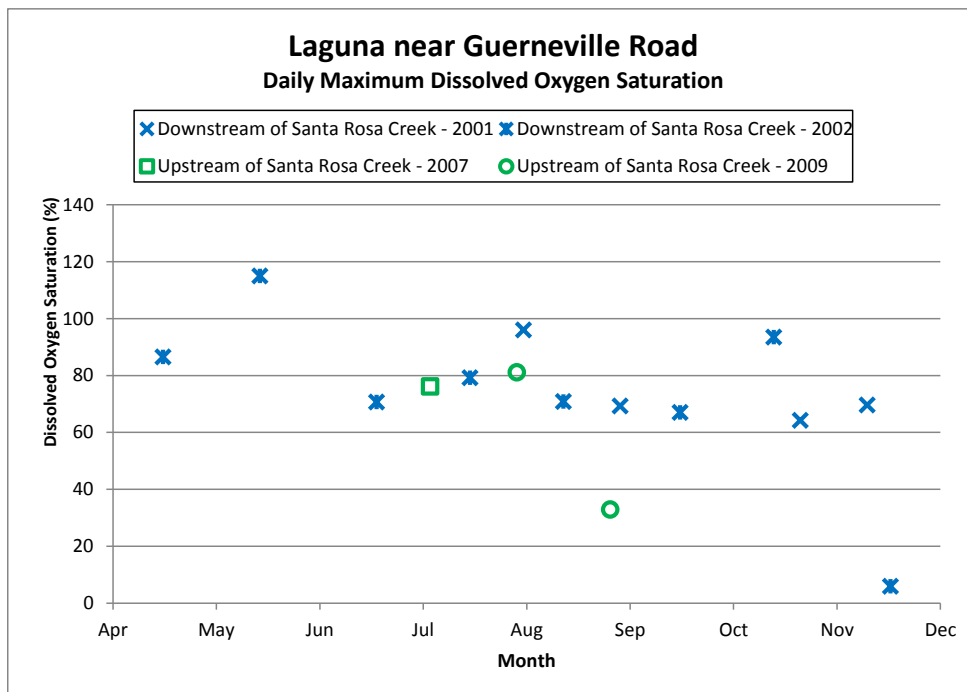


Figure 55. Seasonal Distribution of Daily Maximum Dissolved Oxygen Saturation measured in the Laguna near Guerneville Road

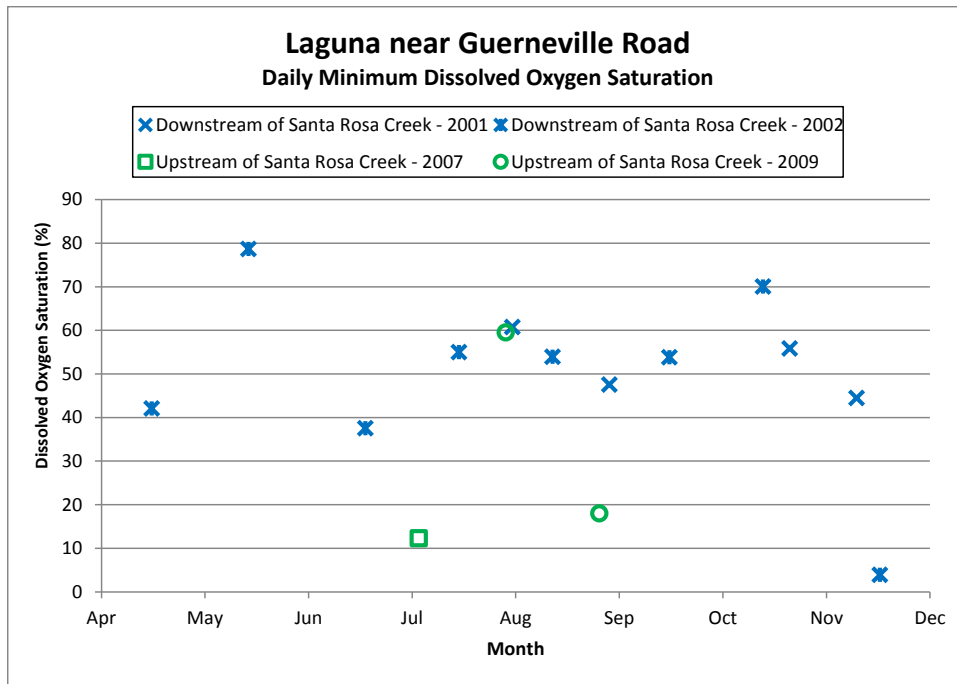


Figure 56. Seasonal Distribution of Daily Minimum Dissolved Oxygen Saturation measured in the Laguna near Guerneville Road

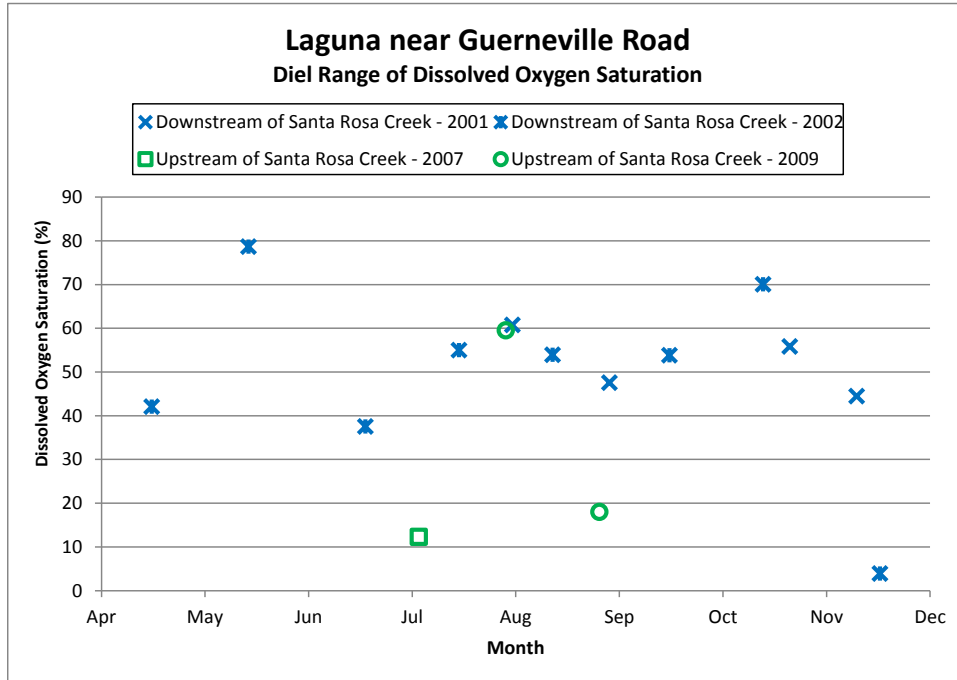


Figure 57. Seasonal Distribution of the Diel Range of Dissolved Oxygen Saturation measured in the Laguna near Guerneville Road

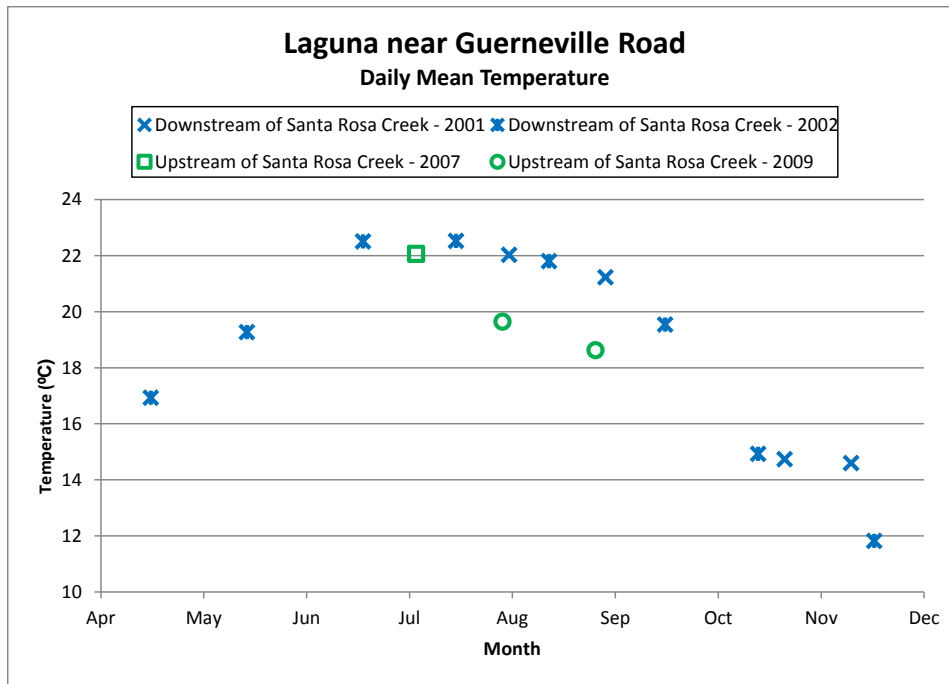


Figure 58. Seasonal Distribution of Daily Mean Water Temperature measured in the Laguna near Guerneville Road

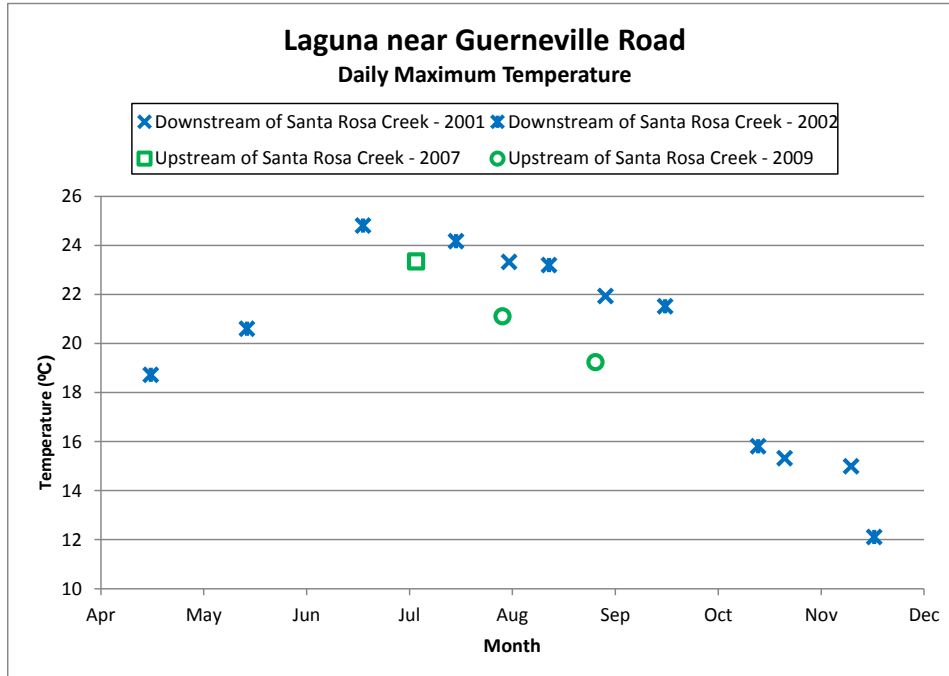


Figure 59. Seasonal Distribution of Daily Maximum Water Temperature measured in the Laguna near Guerneville Road

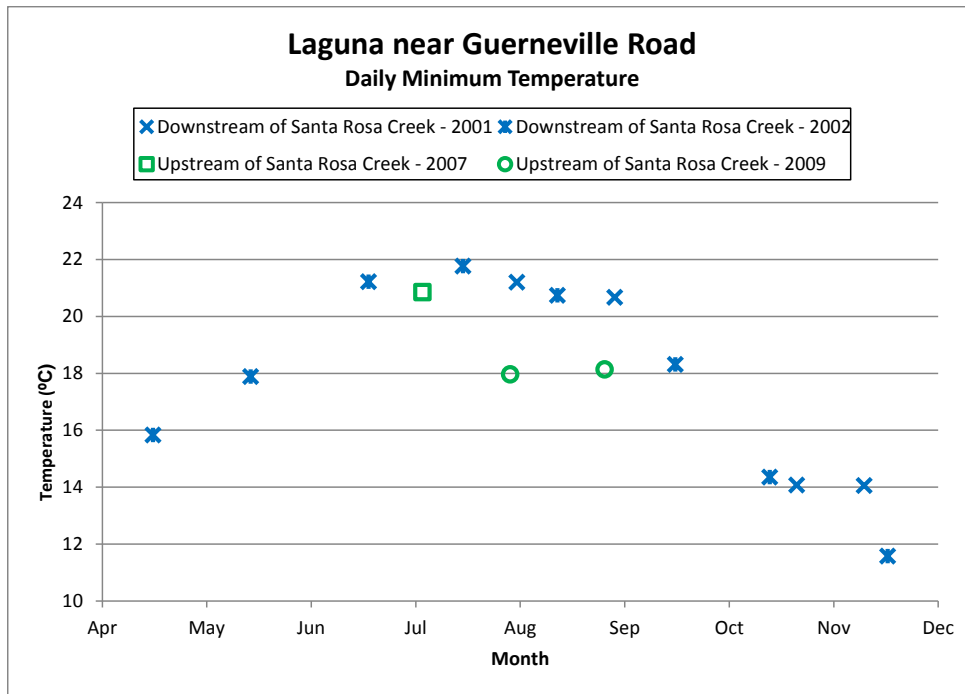


Figure 60. Seasonal Distribution of Daily Minimum Water Temperature measured in the Laguna near Guerneville Road

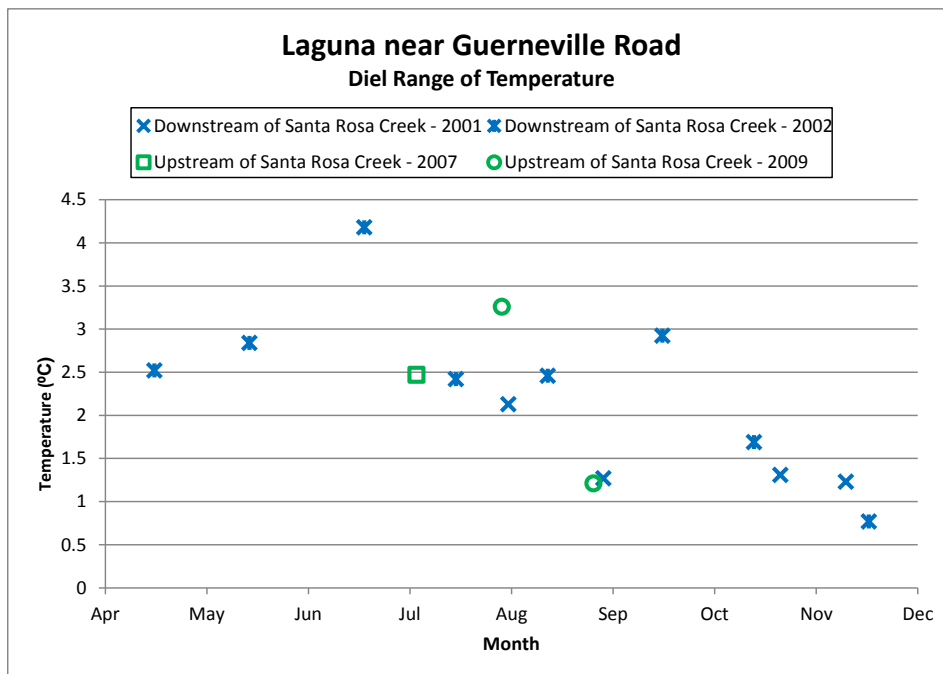


Figure 61. Seasonal Distribution of the Diel Range of Water Temperatures measured in the Laguna at near Guerneville Road

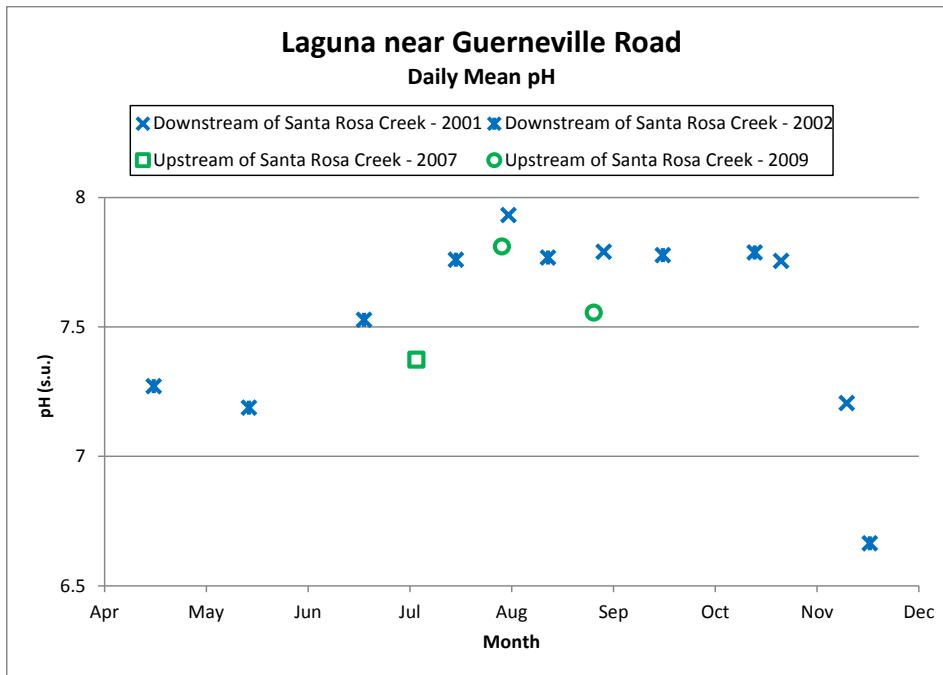


Figure 62. Seasonal Distribution of Daily Mean pH measured in the Laguna near Guerneville Road

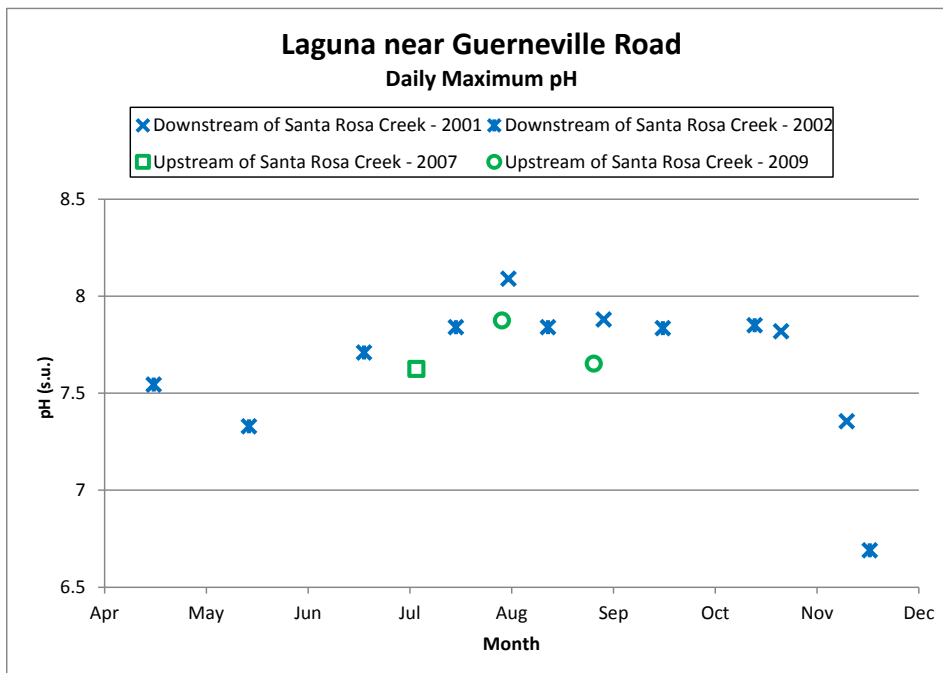


Figure 63. Seasonal Distribution of Daily Maximum pH measured in the Laguna near Guerneville Road

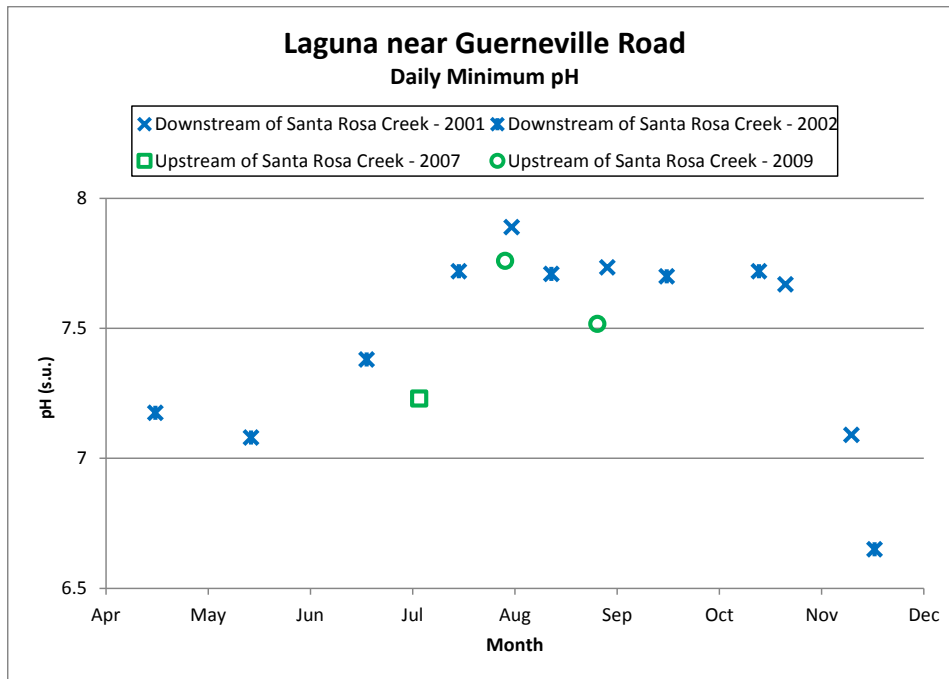


Figure 64. Seasonal Distribution of Daily Minimum pH measured in the Laguna near Guerneville Road

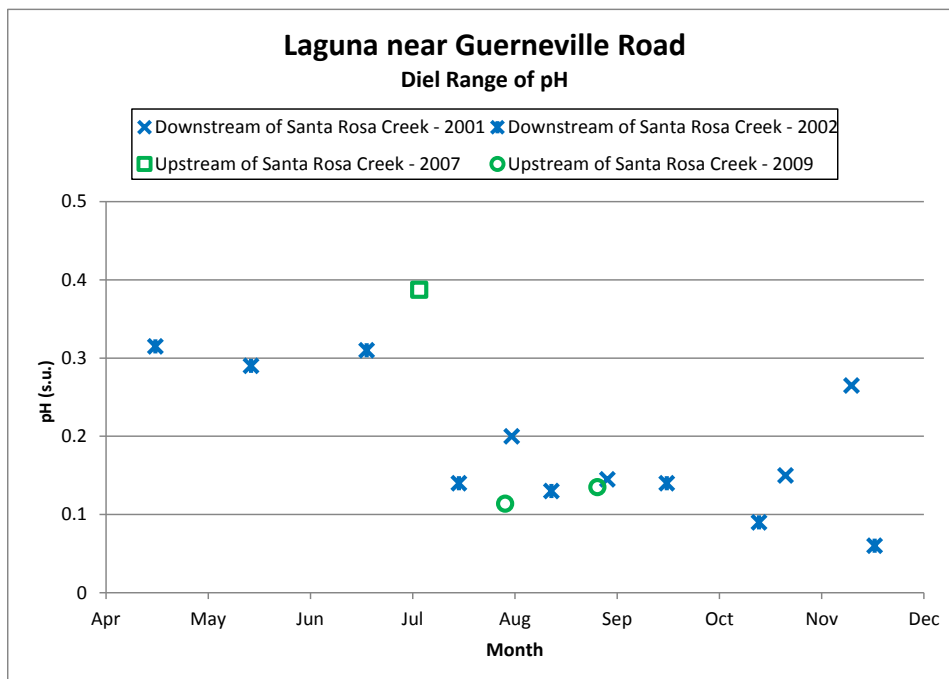


Figure 65. Seasonal Distribution of the Diel Range of pH measured in the Laguna near Guerneville Road

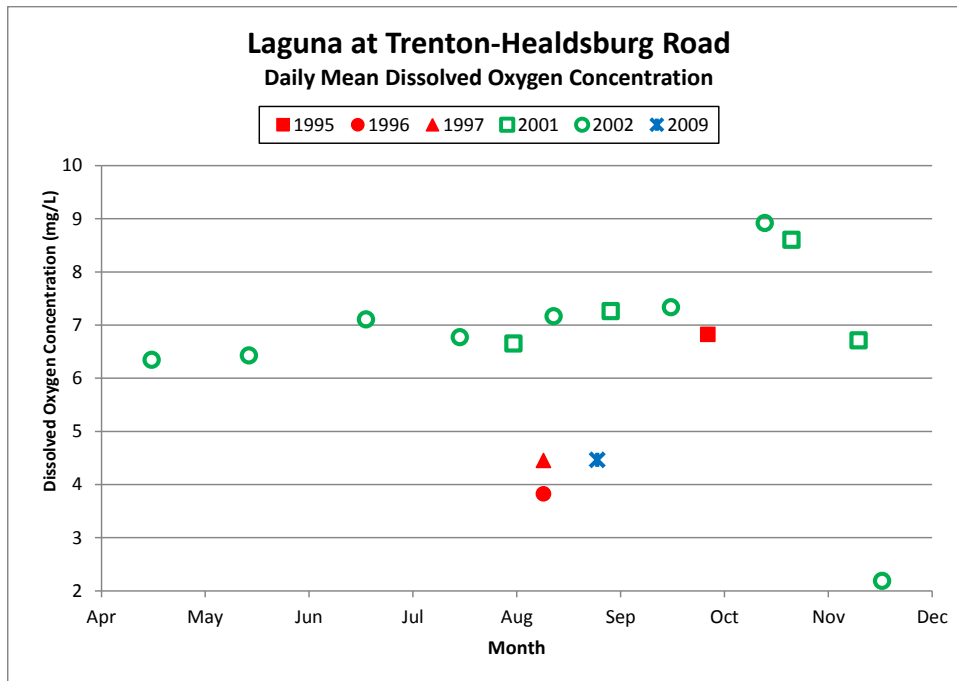


Figure 66. Seasonal Distribution of Daily Mean Dissolved Oxygen Concentrations measured in the Laguna at Trenton-Healdsburg Road

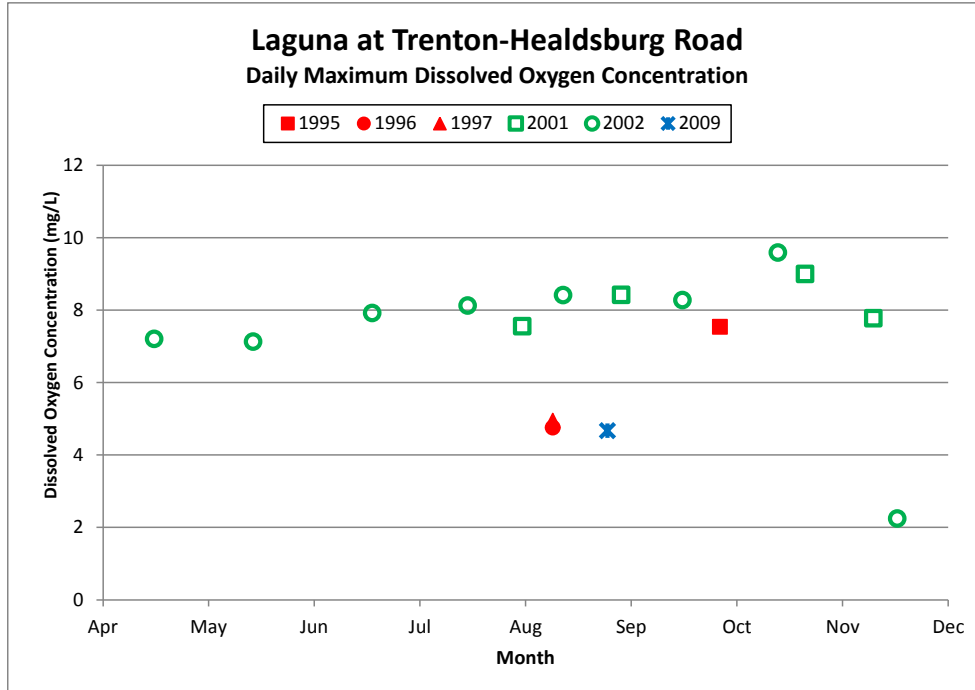


Figure 67. Seasonal Distribution of Daily Maximum Dissolved Oxygen Concentrations measured in the Laguna at Trenton-Healdsburg Road

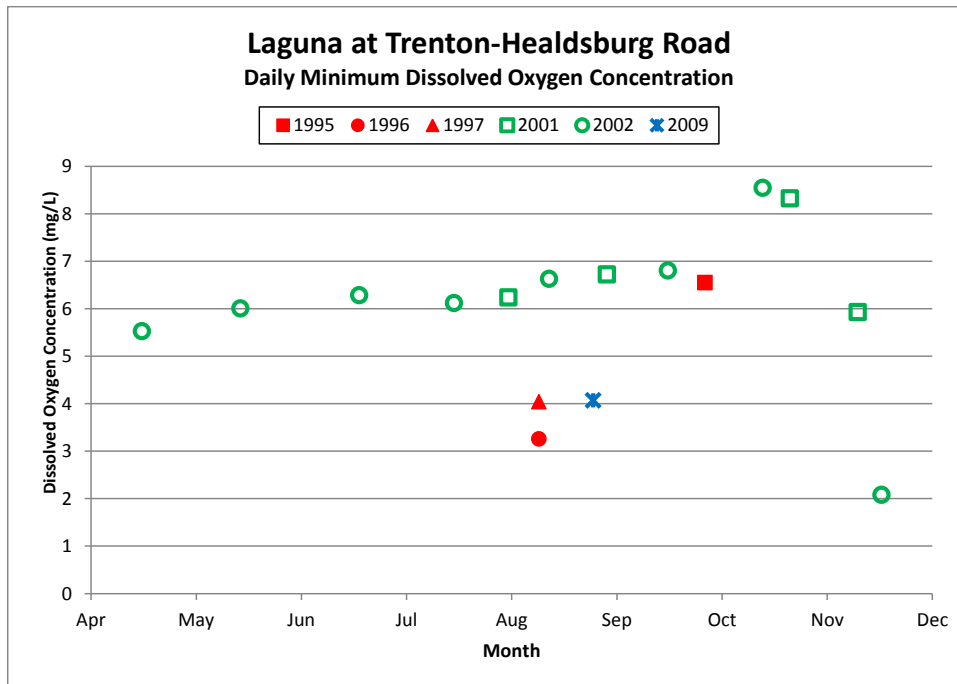


Figure 68. Seasonal Distribution of Daily Minimum Dissolved Oxygen Concentrations measured in the Laguna at Trenton-Healdsburg Road

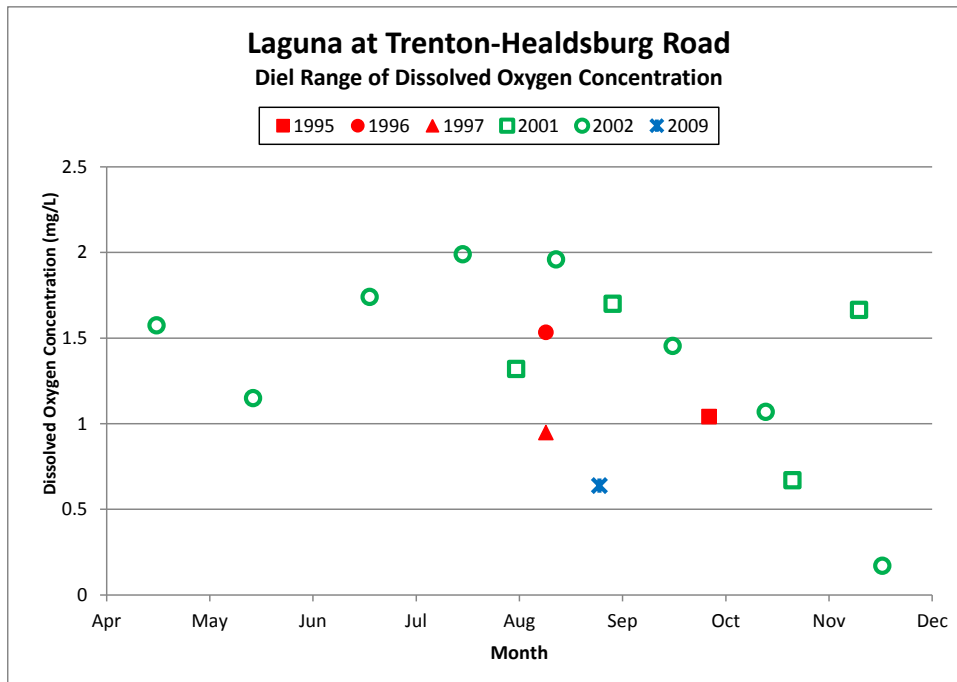


Figure 69. Seasonal Distribution of the Diel Range of Dissolved Oxygen Concentrations measured in the Laguna at Trenton-Healdsburg Road

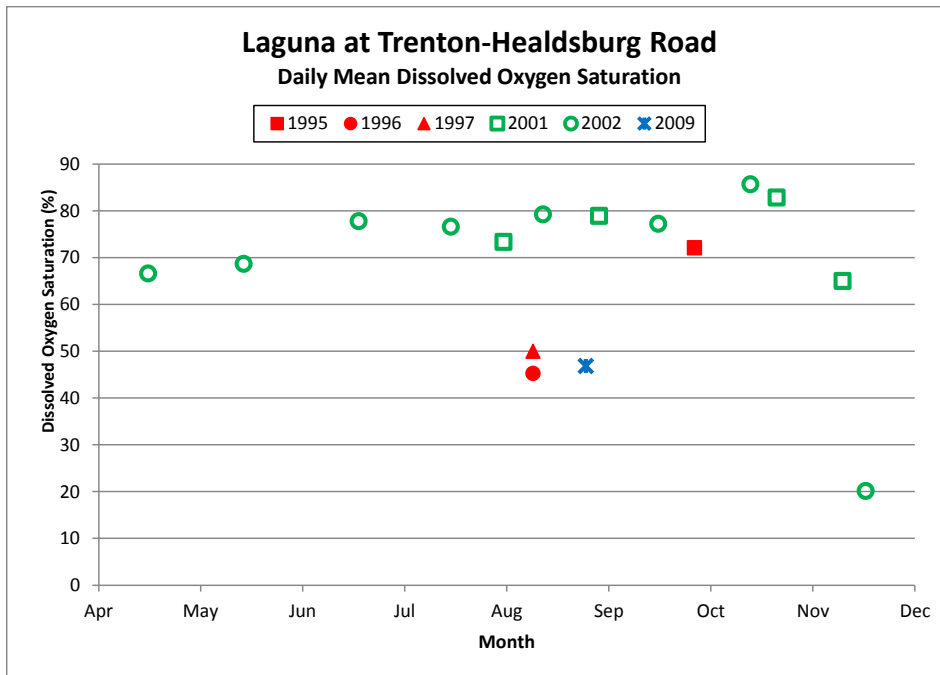


Figure 70. Seasonal Distribution of Daily Mean Dissolved Oxygen Saturation measured in the Laguna at Trenton-Healdsburg Road

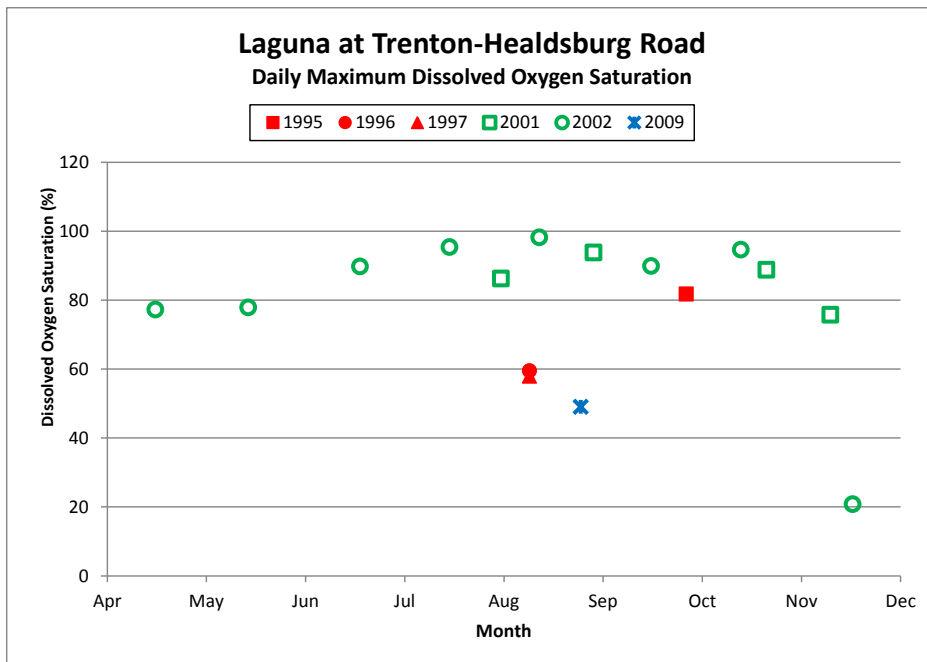


Figure 71. Seasonal Distribution of Daily Maximum Dissolved Oxygen Saturation measured in the Laguna at Trenton-Healdsburg Road

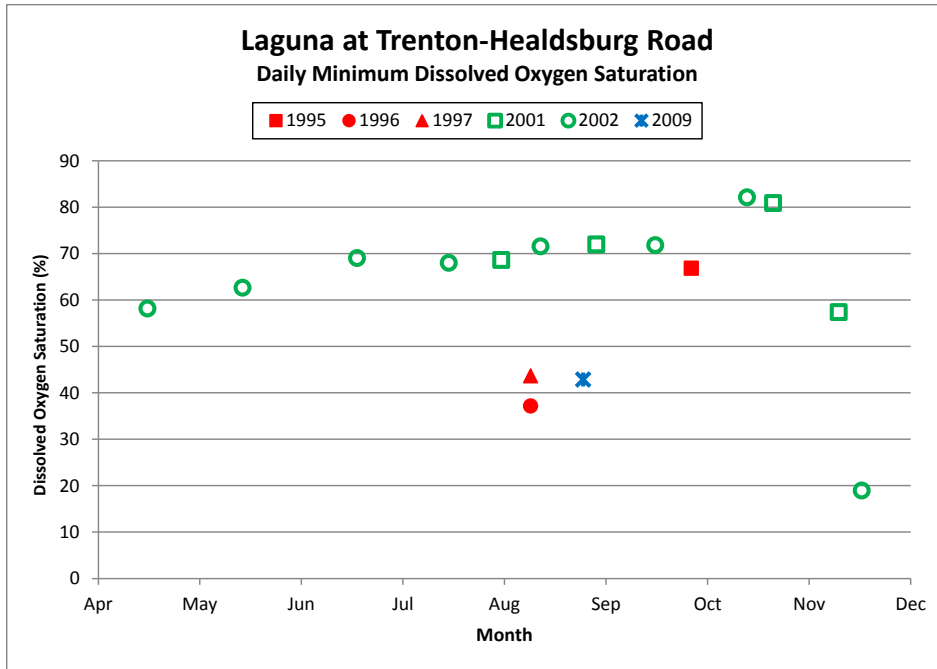


Figure 72. Seasonal Distribution of Daily Minimum Dissolved Oxygen Saturation measured in the Laguna at Trenton-Healdsburg Road

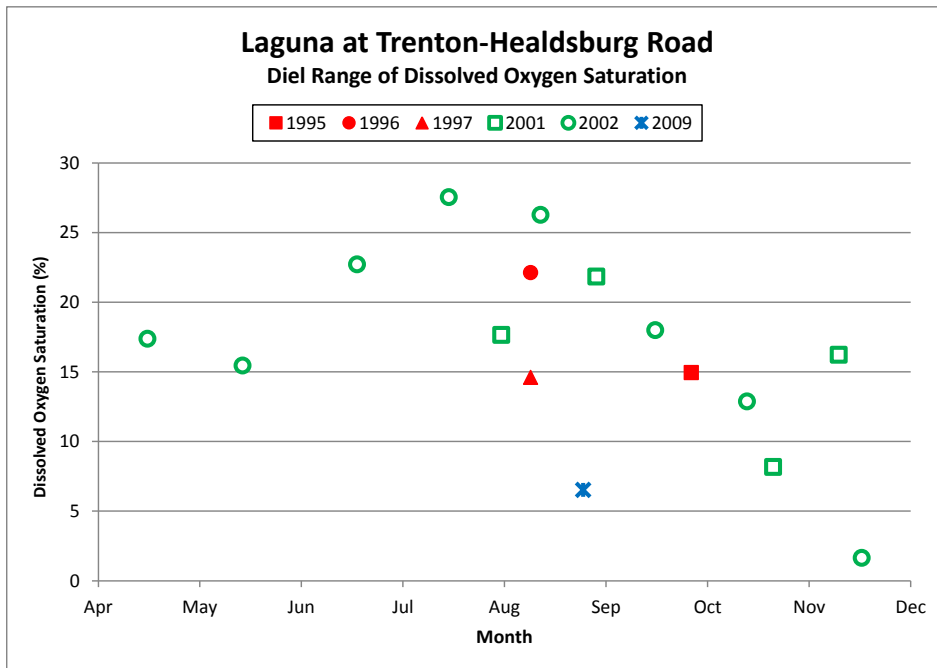


Figure 73. Seasonal Distribution of the Diel Range of Dissolved Oxygen Saturation measured in the Laguna at Trenton-Healdsburg Road

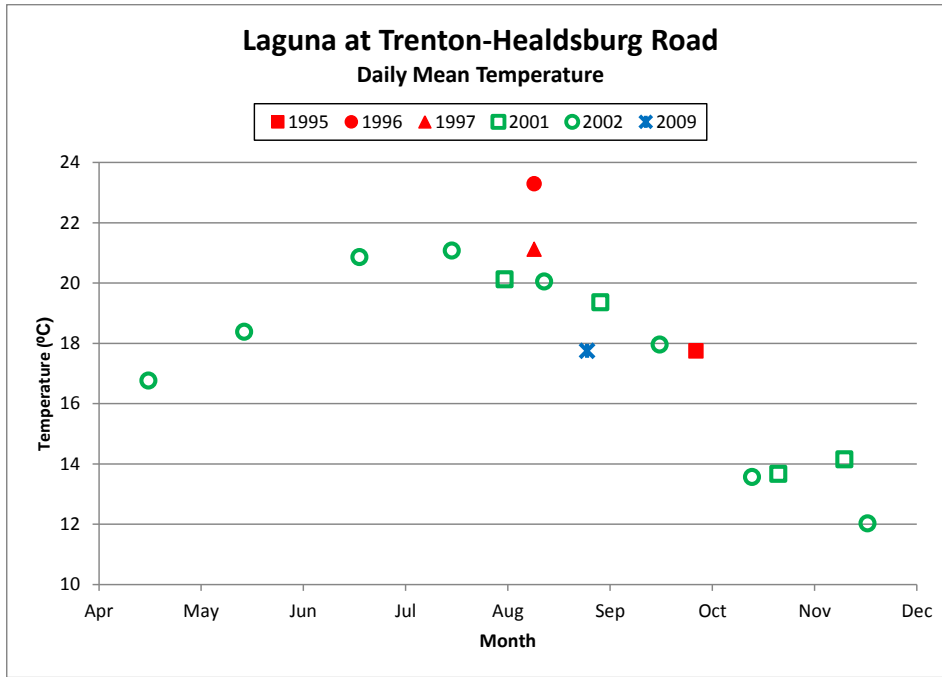


Figure 74. Seasonal Distribution of Daily Mean Water Temperatures measured in the Laguna at Trenton-Healdsburg Road

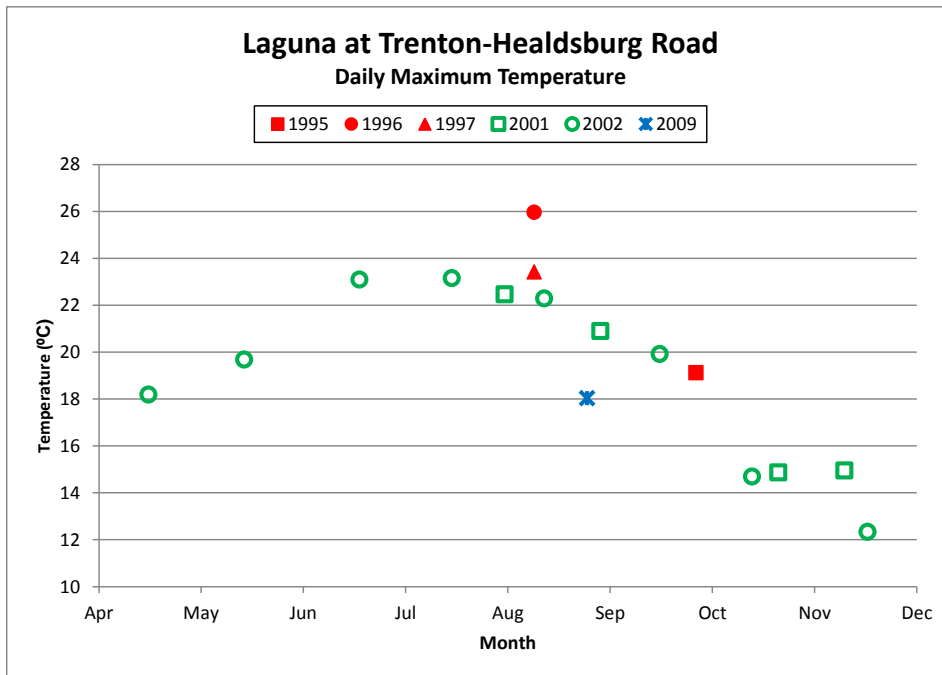


Figure 75. Seasonal Distribution of Daily Maximum Water Temperatures measured in the Laguna at Trenton-Healdsburg Road

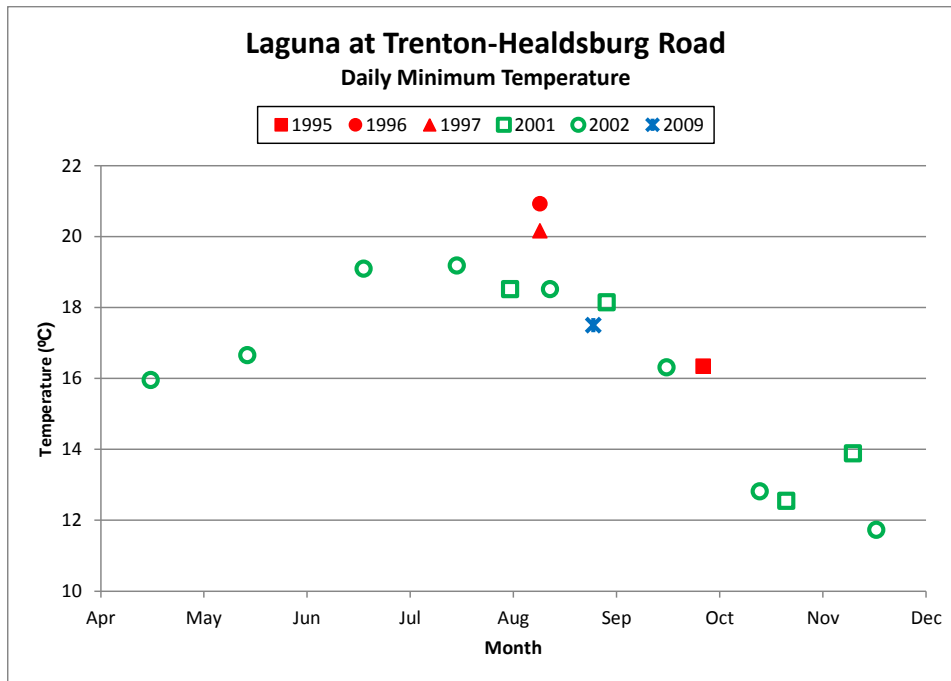


Figure 76. Seasonal Distribution of Daily Minimum Water Temperatures measured in the Laguna at Trenton-Healdsburg Road

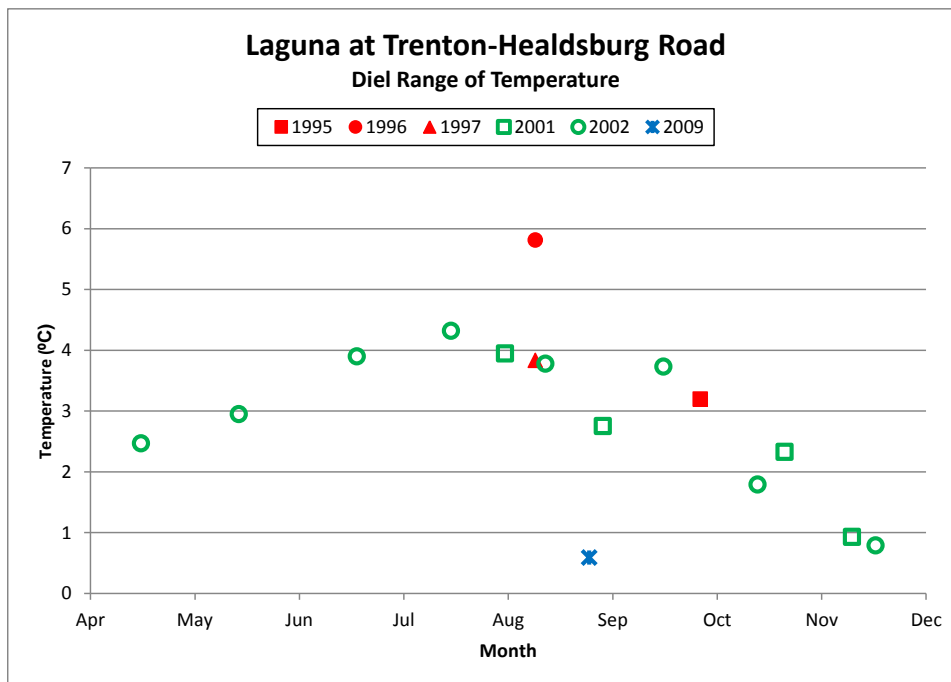


Figure 77. Seasonal Distribution of the Diel Range of Water Temperatures measured in the Laguna at Trenton-Healdsburg Road

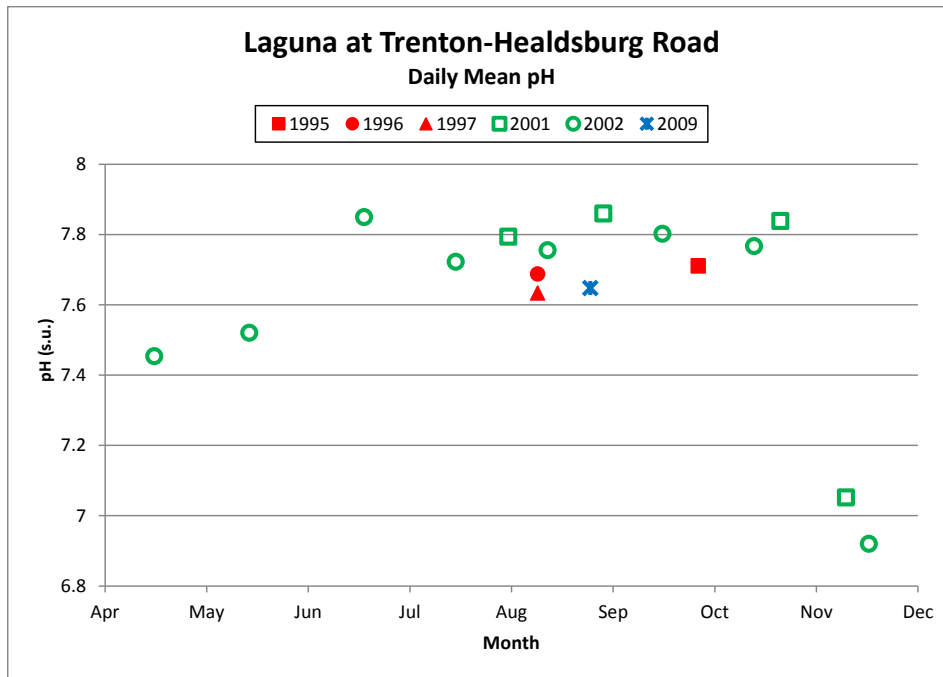


Figure 78. Seasonal Distribution of Daily Mean pH measured in the Laguna at Trenton-Healdsburg Road

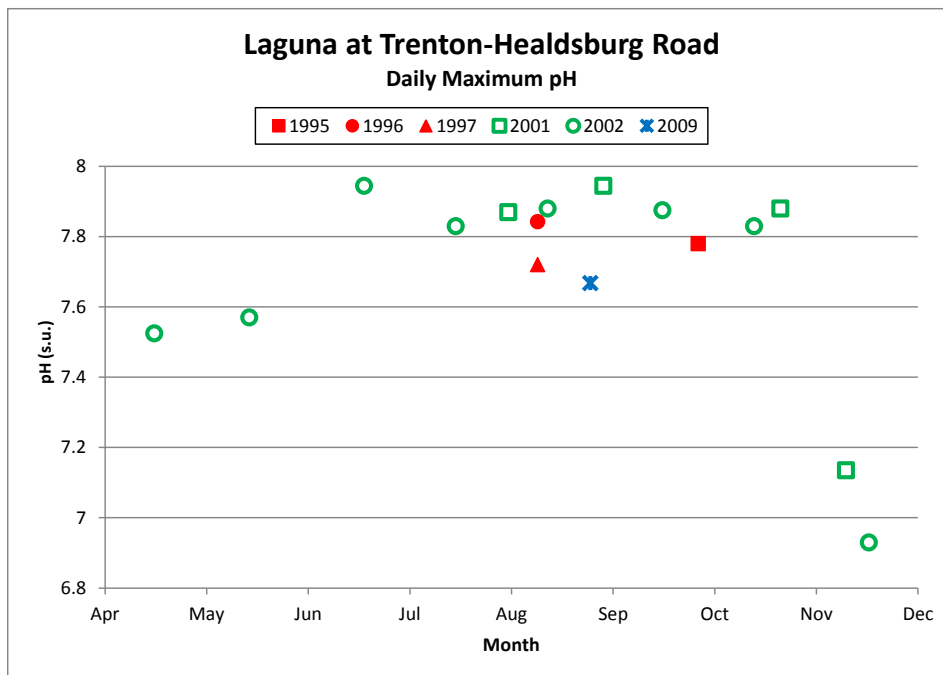


Figure 79. Seasonal Distribution of Daily Maximum pH measured in the Laguna at Trenton-Healdsburg Road

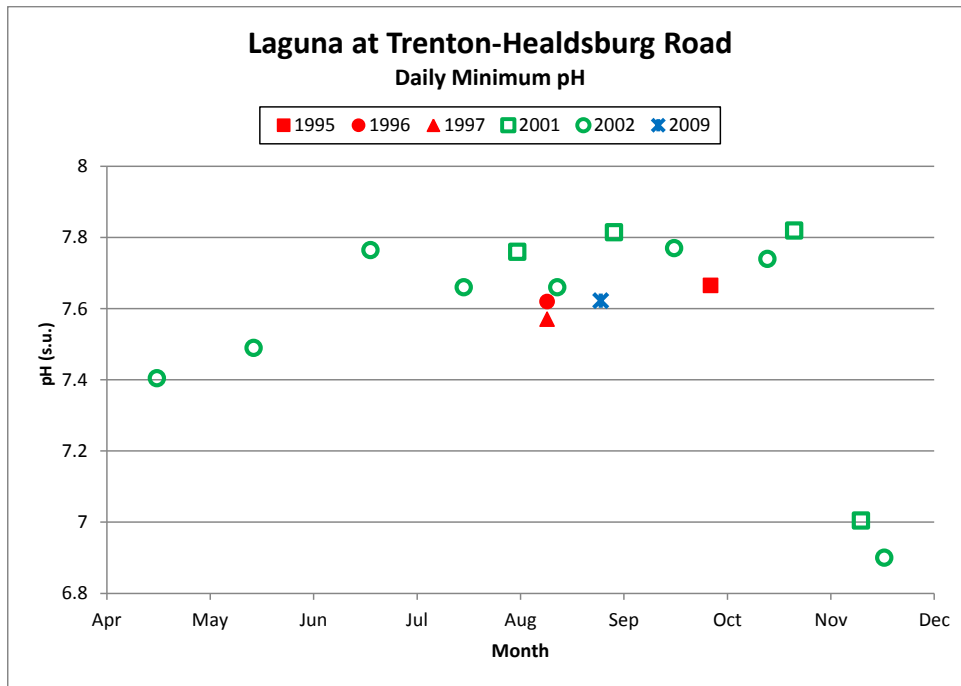


Figure 80. Seasonal Distribution of Daily Minimum pH measured in the Laguna at Trenton-Healdsburg Road

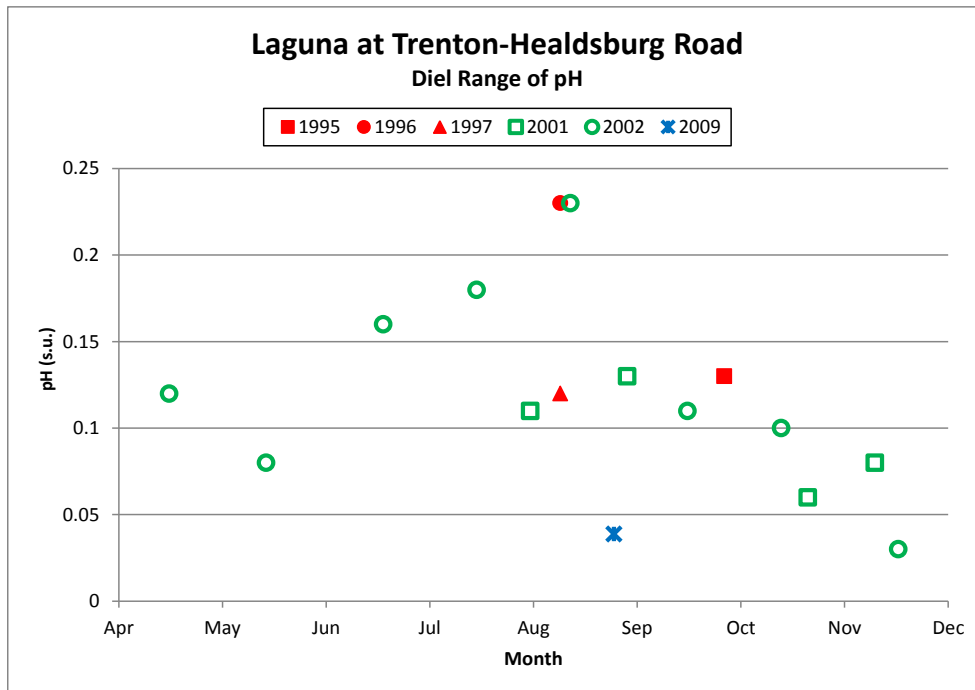


Figure 81. Seasonal Distribution of the Diel Range of pH measured in the Laguna at Trenton-Healdsburg Road

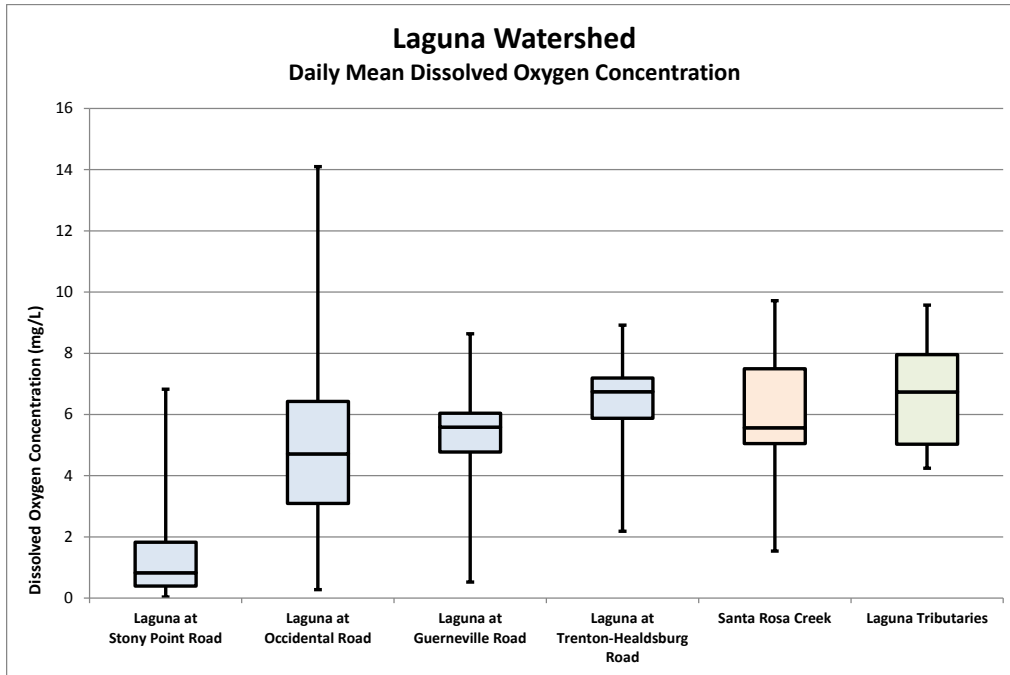


Figure 82. Distribution of Daily Mean Dissolved Oxygen Concentrations measured in the Laguna Watershed

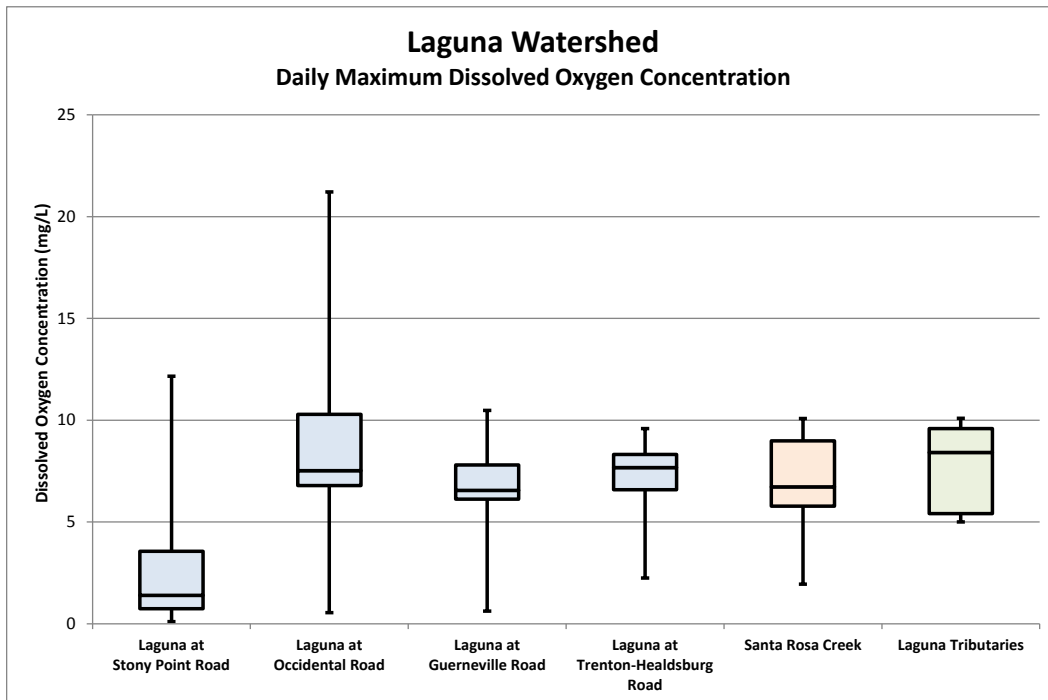


Figure 83. Distribution of Daily Maximum Dissolved Oxygen Concentrations measured in the Laguna Watershed

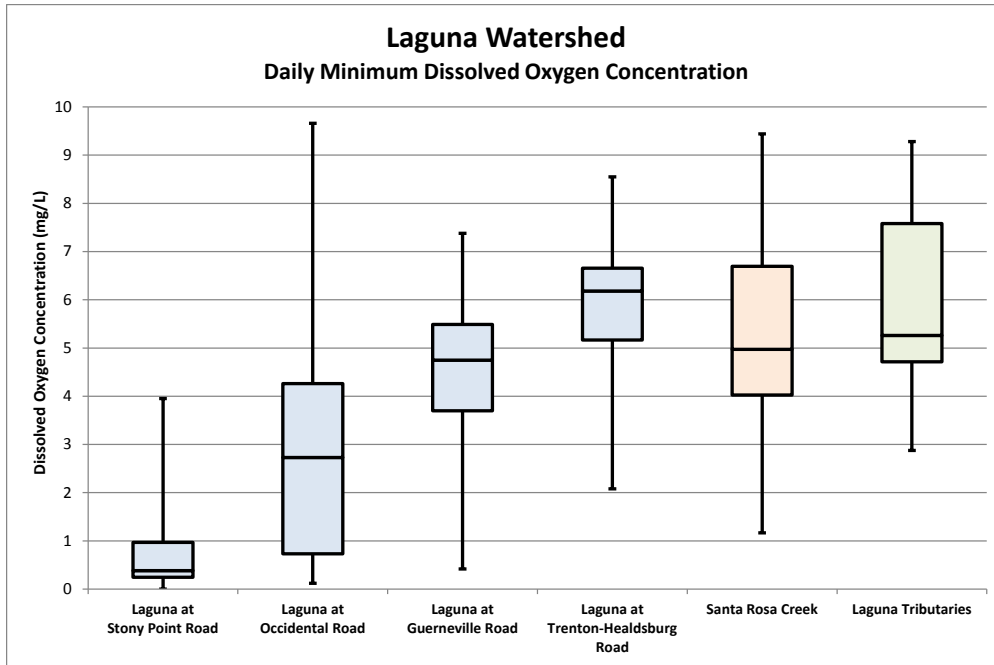


Figure 84. Distribution of Daily Minimum Dissolved Oxygen Concentrations measured in the Laguna Watershed

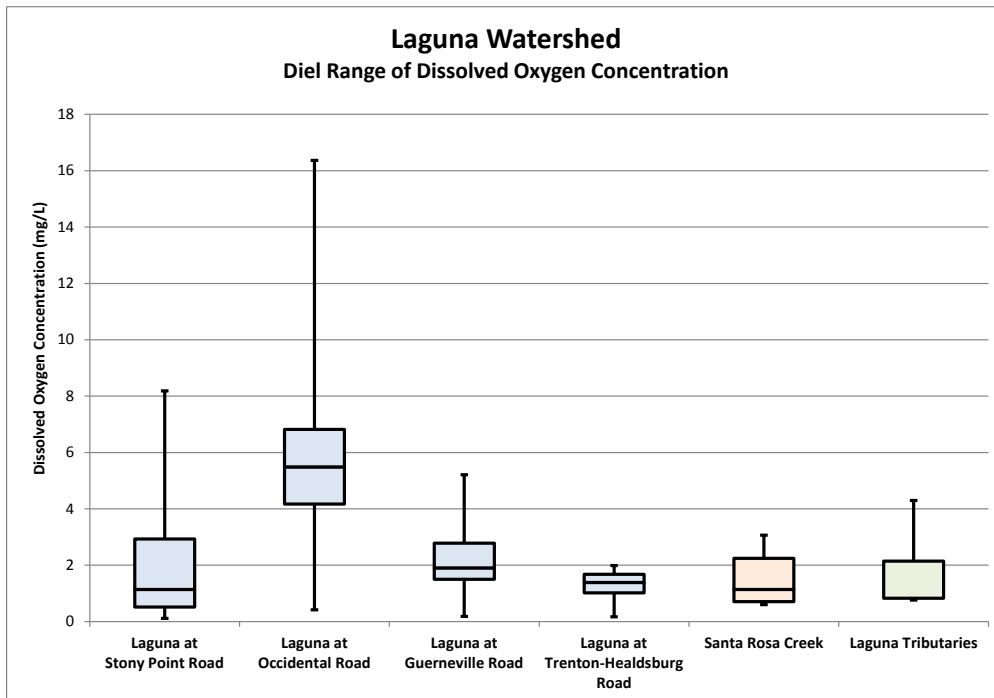


Figure 85. Distribution of the Diel Range of Dissolved Oxygen Concentrations measured in the Laguna Watershed

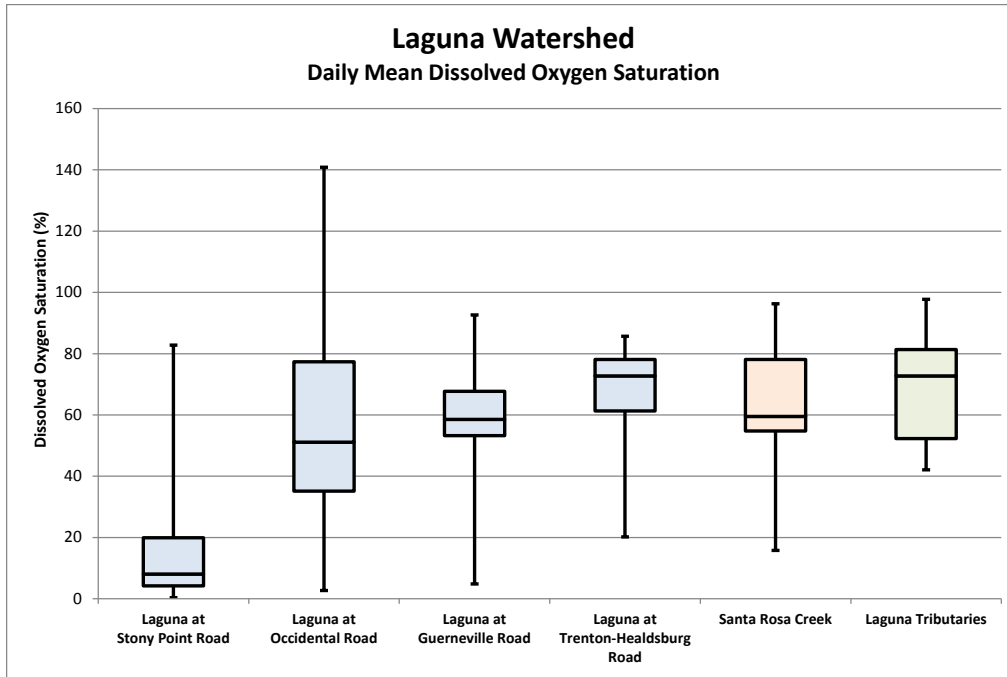


Figure 86. Distribution of Daily Mean Dissolved Oxygen Saturation measured in the Laguna Watershed

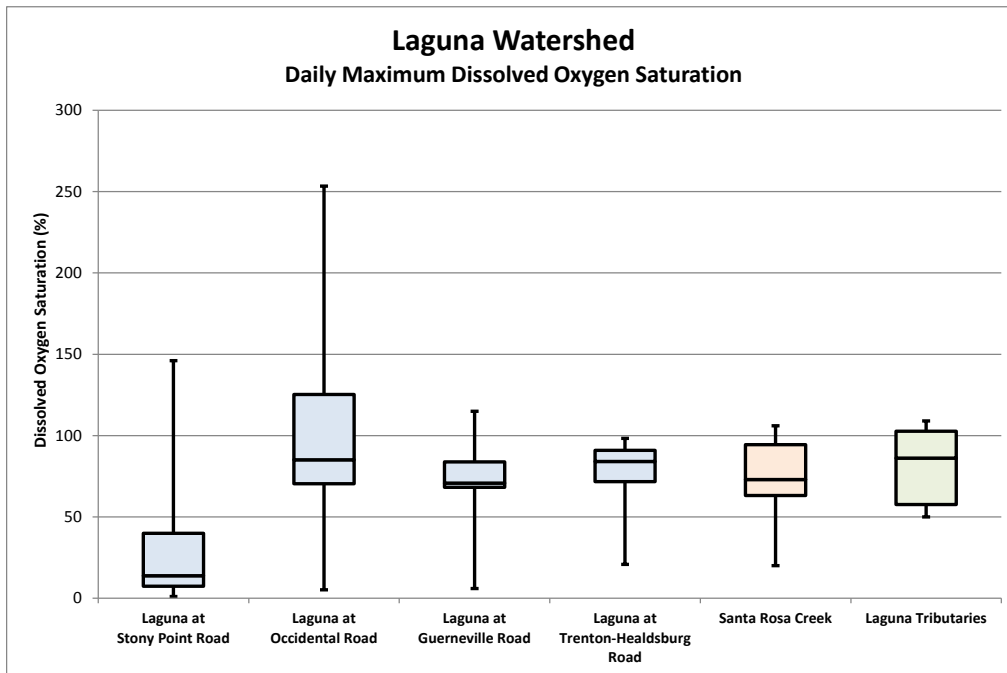


Figure 87. Distribution of Daily Maximum Dissolved Oxygen Saturation measured in the Laguna Watershed

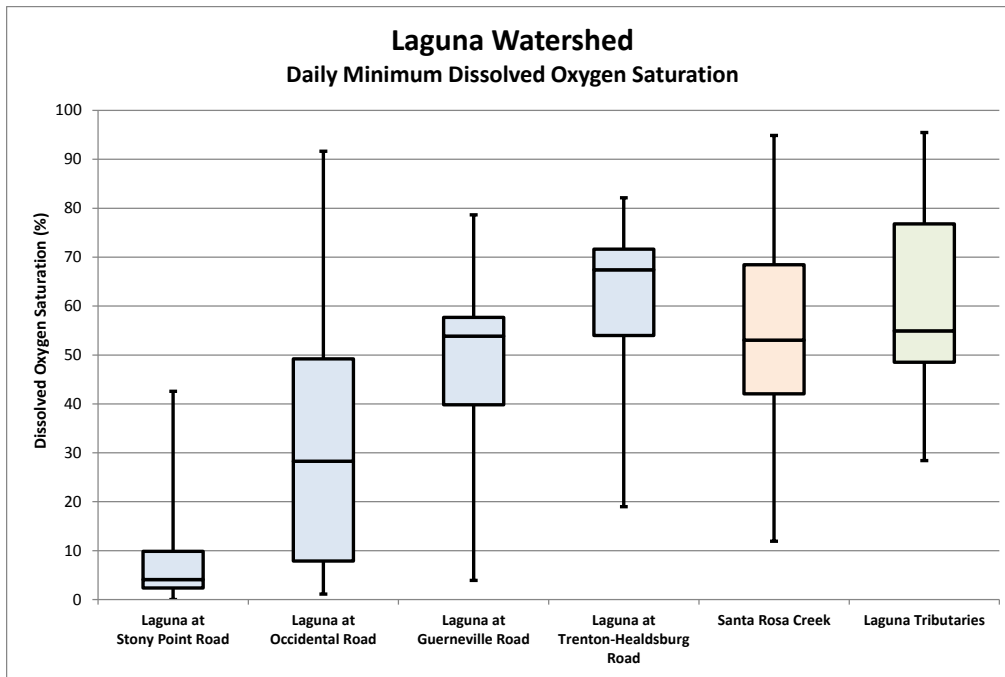


Figure 88. Distribution of Daily Minimum Dissolved Oxygen Saturation measured in the Laguna Watershed

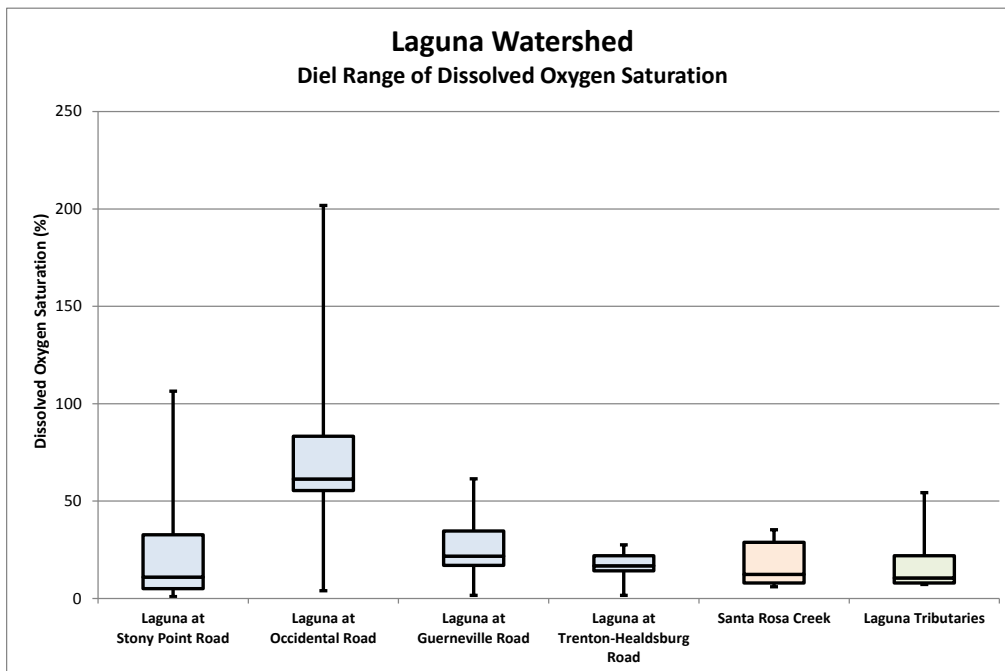


Figure 89. Distribution of the Diel Range of Mean Dissolved Oxygen Saturation measured in the Laguna Watershed

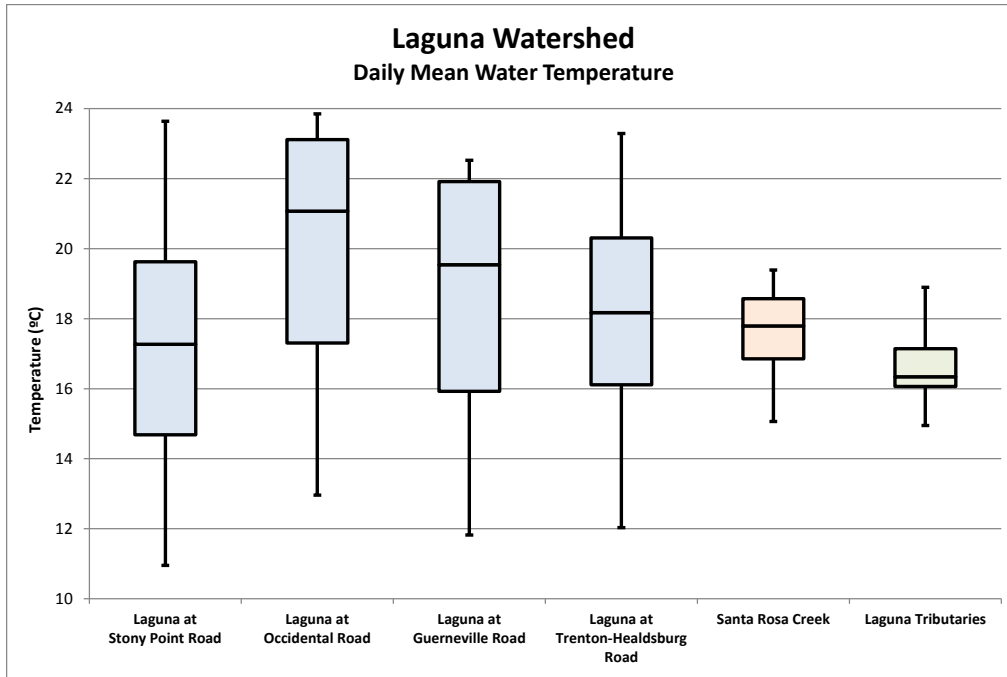


Figure 90. Distribution of Daily Mean Water Temperatures measured in the Laguna Watershed

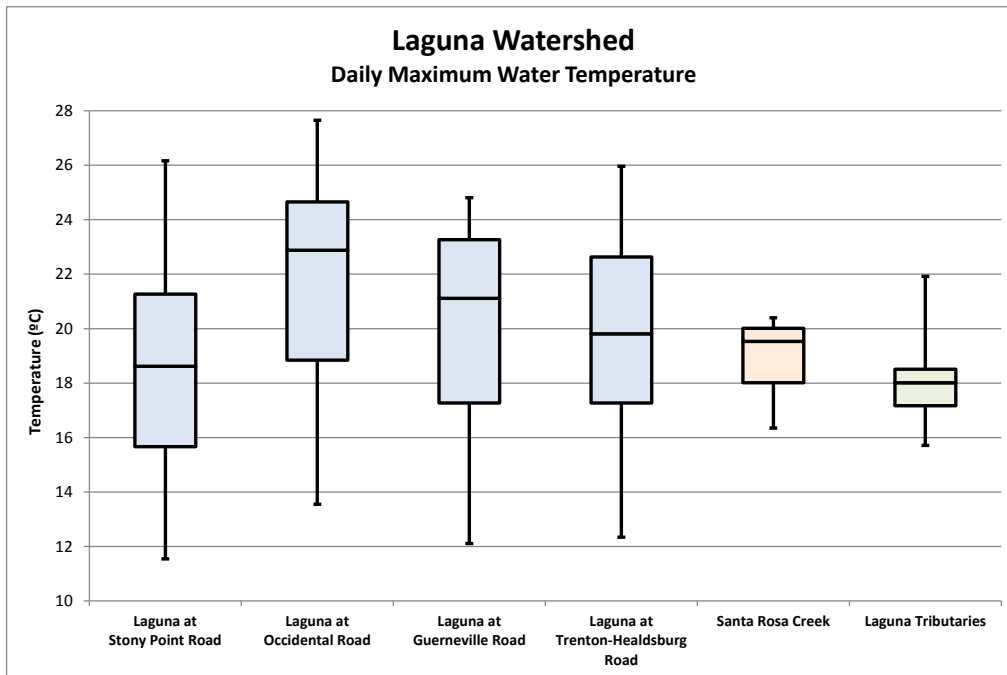


Figure 91. Distribution of Daily Maximum Water Temperatures measured in the Laguna Watershed

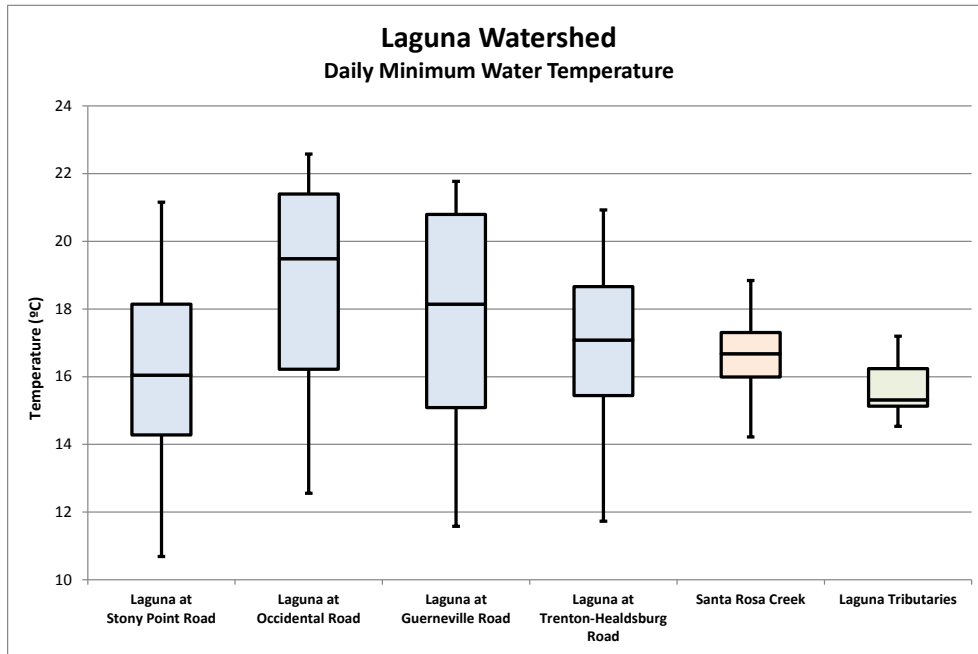


Figure 92. Distribution of Daily Minimum Water Temperatures measured in the Laguna Watershed

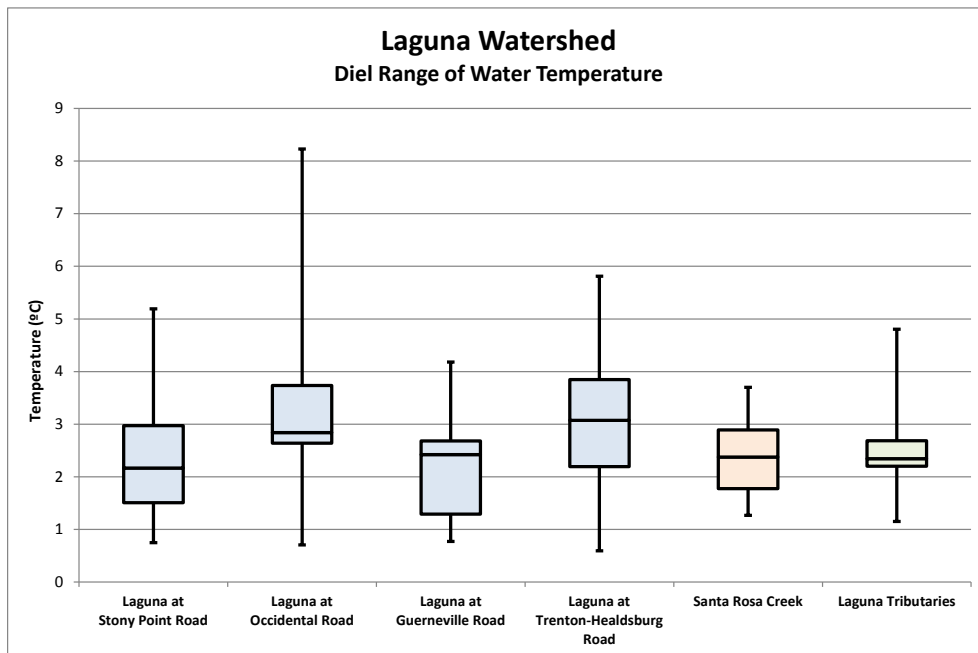


Figure 93. Distribution of the Diel Range of Water Temperatures measured in the Laguna Watershed

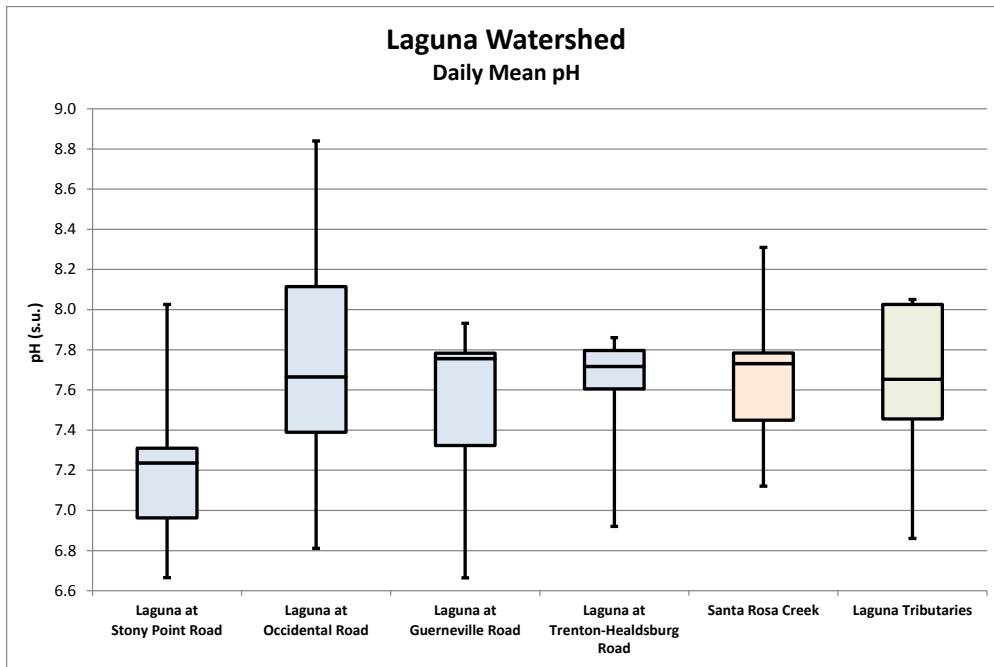


Figure 94. Distribution of Daily Mean pH measured in the Laguna Watershed

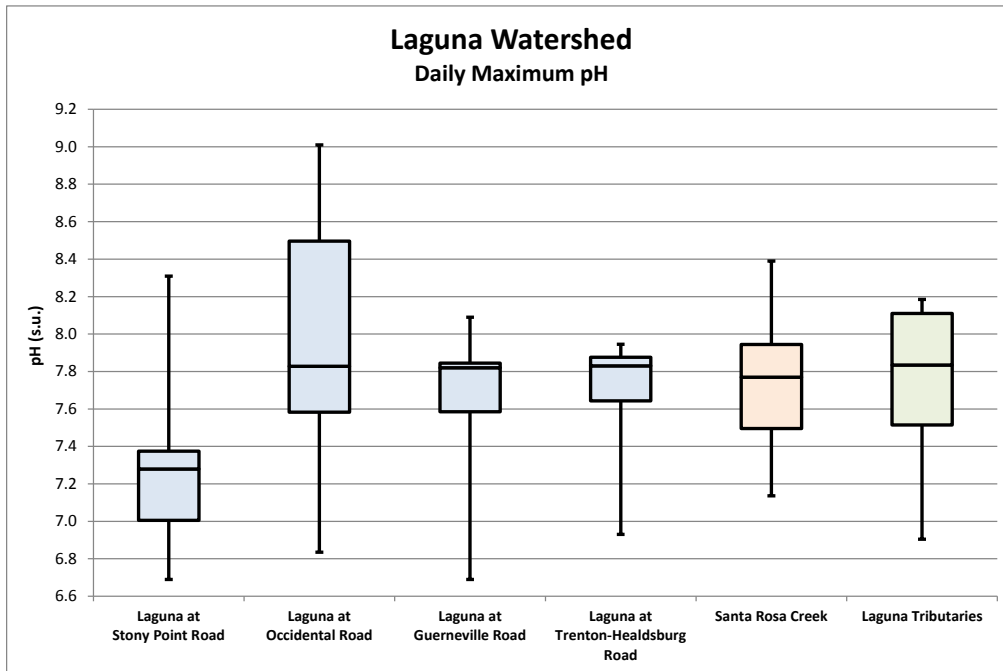


Figure 95. Distribution of Daily Maximum pH measured in the Laguna Watershed

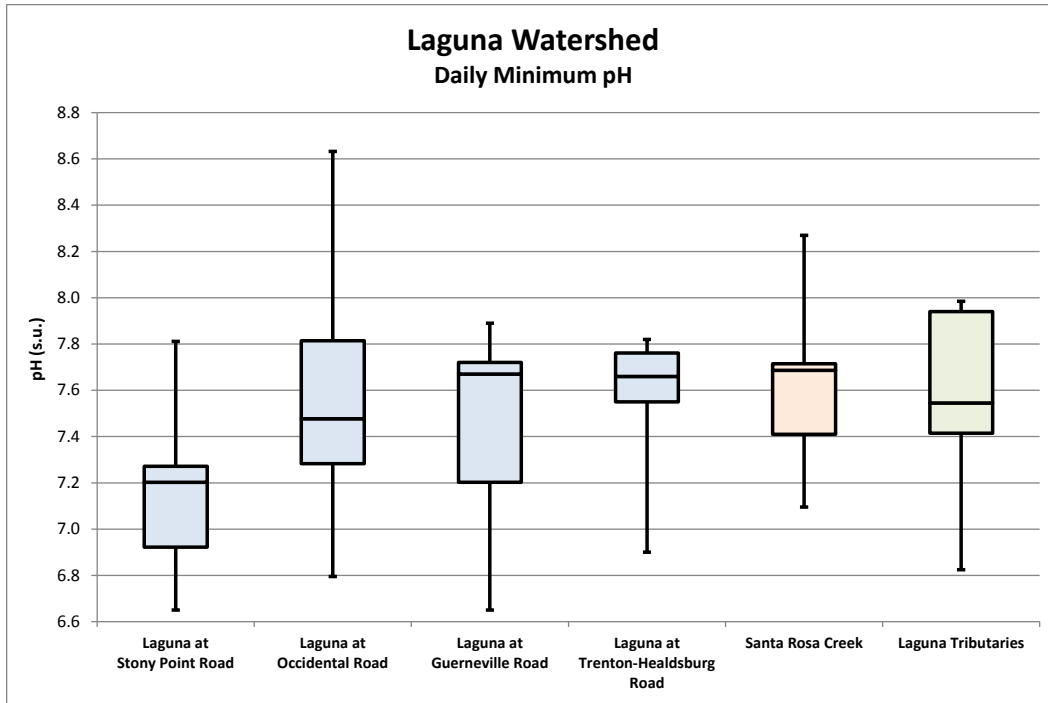


Figure 96. Distribution of Daily Minimum pH measured in the Laguna Watershed

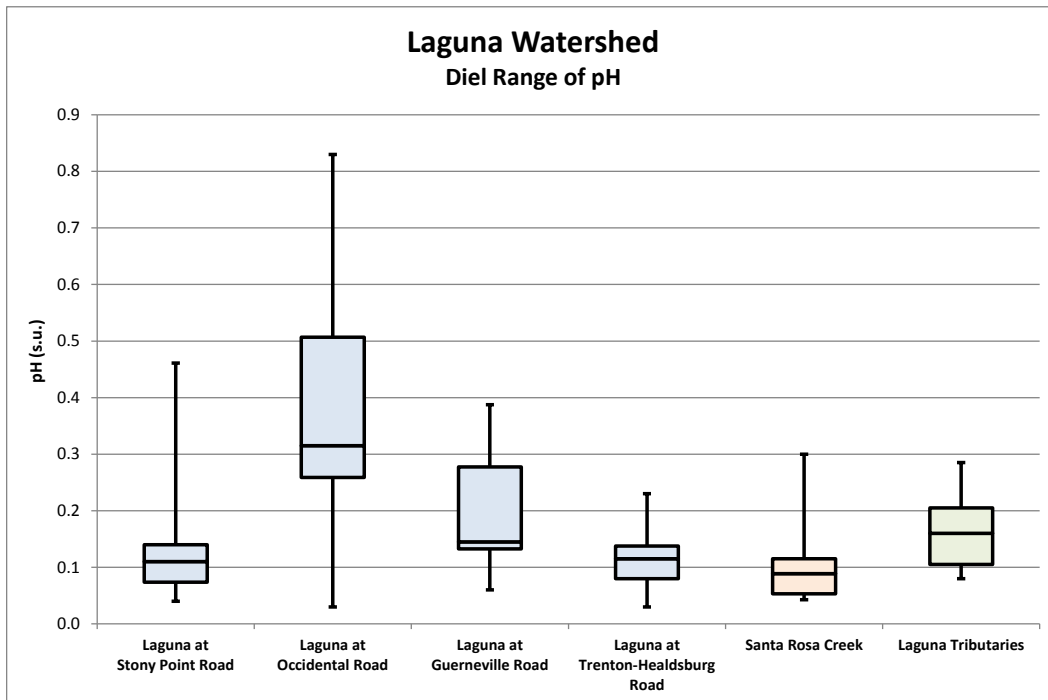


Figure 97. Distribution of the Diel Range of pH measured in the Laguna Watershed