Indicator: Dissolved oxygen in the Great Bay Estuary

Question

How often does dissolved oxygen (DO) in the estuary fall below 5 mg/L?

Short Answer

Datasondes, an automated water quality sensor or probe, in the bays and open waters located at the center of the Great Bay and in Portsmouth Harbor at the Coastal Marine Laboratory indicate dissolved oxygen levels well above 5 mg/L. Low dissolved oxygen events occur in all the tidal rivers. In August 2015–the most recent year we have data–most low dissolved oxygen events in the tidal rivers lasted between two and six hours.

PREP Goal
Reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur (from the PREP Comprehensive Conservation and Management Plan, PREP 2010).

Why This Matters

Fish and many other organisms need dissolved oxygen in the water to survive. Dissolved oxygen levels can decrease due to various factors, including rapid changes in temperature and salinity, as well as respiration of organic matter. Dissolved oxygen levels can also decrease as a reaction to nutrient inputs. When nutrient loading is too high, phytoplankton and/or seaweed can bloom and then die. Bacteria and other decomposer organisms then use oxygen to break down the organic matter.

Explanation (from 2018 State of Our Estuaries Report)

National ecosystem health thresholds for dissolved oxygen (DO) concentrations range from 2 mg/L to 5 mg/L, depending on the region or state (US EPA 2012). The threshold of 5 mg/L is considered protective of all organisms (Bierman et al. 2014). Dissolved oxygen levels in Great Bay at the central datasonde and in Portsmouth Harbor at the Coastal Marine Laboratory (Table DO-1; Figure DO-6) remain consistently above 5 mg/L. The most recently collected data from 2015 show that DO concentrations never fell below 6 mg/L at these two sites.

The tidal portions of the major tributary rivers continue to experience many days when the minimum DO concentration value is below 5 mg/L. No long-term trends are notable at any stations, as exemplified by the data from the Squamscott River and Salmon Falls River datasondes (Figures DO-1 and DO-2). These datasondes were used in this long-term trend analysis because they had complete datasets going back as far as 2004, and because they represent different parts of the estuary.

It is important to note not only the number of low DO events but also the duration of those events because there are implications for organisms (such as small invertebrates in the sediment) that cannot move quickly to areas with higher DO levels. In 2015, the Lamprey and Squamscott Rivers had the highest number of low DO events, the majority of which took place in August and September. Figure DO-3 shows data taken every 15 minutes throughout August 2015 for the Squamscott River; this figure indicates that DO concentrations fell below 5 mg/L most days during the month, and that there was less than 5 mg/L for 12% of the month. These low DO events lasted anywhere from one to four hours.

In August 2015, 73% of the time Lamprey River DO levels were below 5 mg/L and stayed below the threshold for more than 24 hours on two occasions (Figure DO-4) with the second occasion

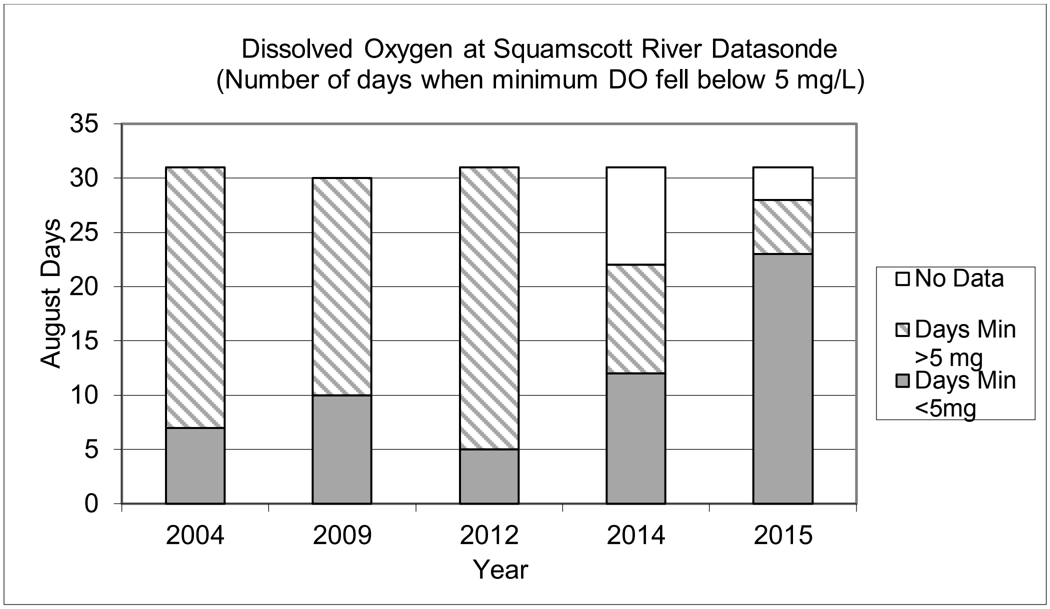

Figure DO-1. Number of days in August when minimum DO fell below 5 mg/L at the Squamscott River datasonde. Particular years shown have the most complete datasets.

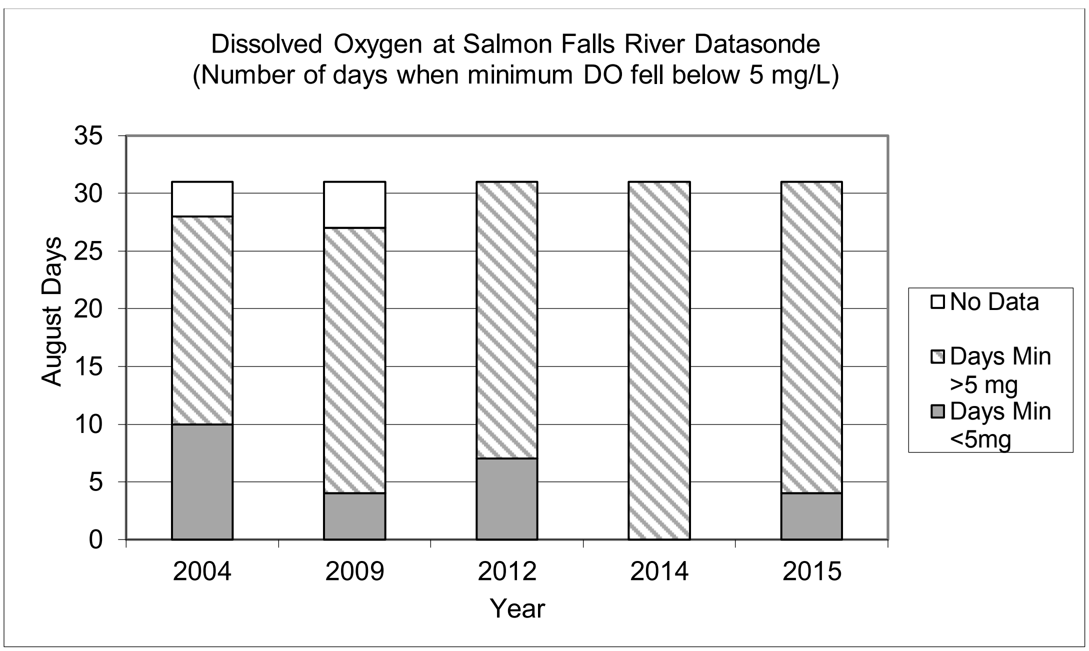

Figure DO-2. Number of August days when minimum DO fell below 5 mg/L at the Salmon Falls River datasonde. Particular years shown have the most complete datasets.

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lasting almost 168 hours (7 days). A 2005 study (Pennock 2005) of the Lamprey River concluded that the datasonde readings were reflective of river conditions, but that density stratification—when salt water and fresh water stack in layers without mixing—was a significant factor in the low DO conditions in the Lamprey River.

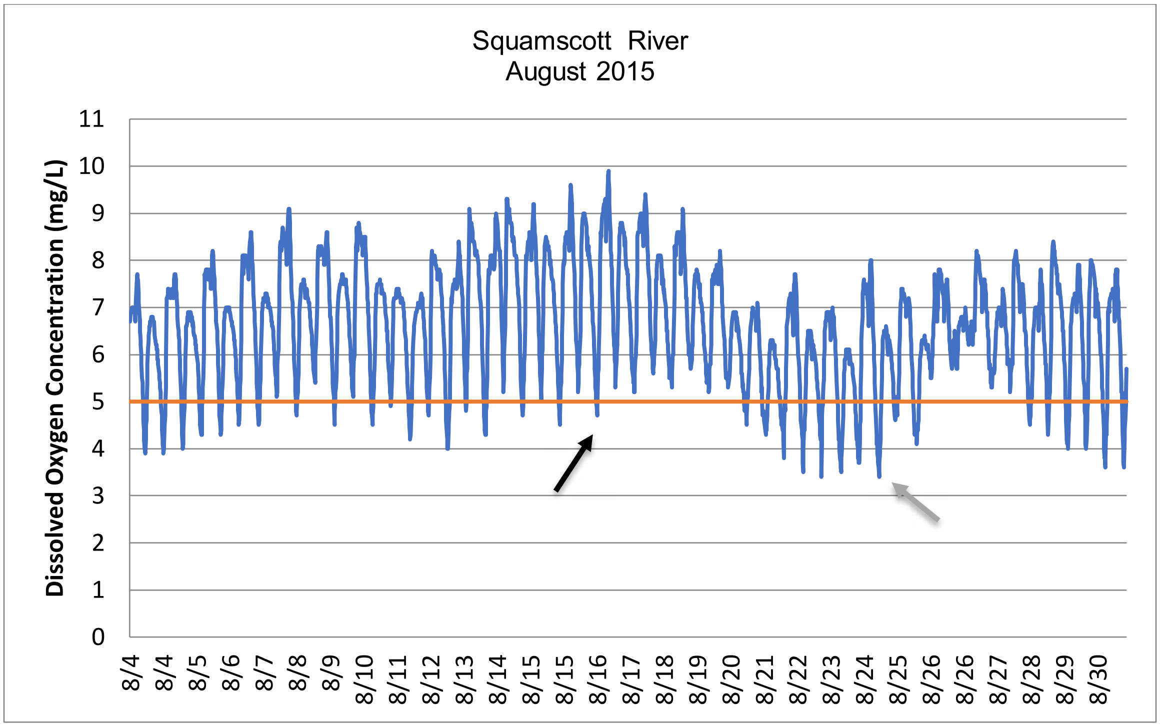

Figure DO-3. Dissolved oxygen concentration measurements at the Squamscott River datasonde, taken every 15 minutes during the month of August 2015. The red line marks the 5 mg/L value; levels below this line may present a danger to fish and benthic invertebrates. The black arrow points to an event that represents approximately 1 hour below 5 mg/L. The gray arrow indicates an event that represents approximately 4 hours below 5 mg/L.

In August 2015, the Oyster River experienced four low DO events, lasting between two and six hours each. The Salmon Falls River experienced two low DO events, each lasting approximately three hours. In the Cocheco River, data was only available for the month of September 2015. In that month, the datasonde indicates 12 low DO events, all lasting approximately two hours. More data and analysis is required to understand the relative importance of temperature, tidal stage, time of day, freshwater inputs, organic matter loading and nutrient loading as contributing factors to these low DO events.

Finally, this analysis does not include all DO data collected in the Great Bay Estuary. For information on other data, please see the 2017 Technical Support Document for Aquatic Life Use Support (NH DES 2017).

<u>Methods and Data Sources</u>
In a system as well mixed as the Great Bay Estuary, low DO events may occur rapidly. Therefore, DO measurements taken at a high frequency by in-situ datasondes deployed 1-2 meters above the sediments were used for this indicator.

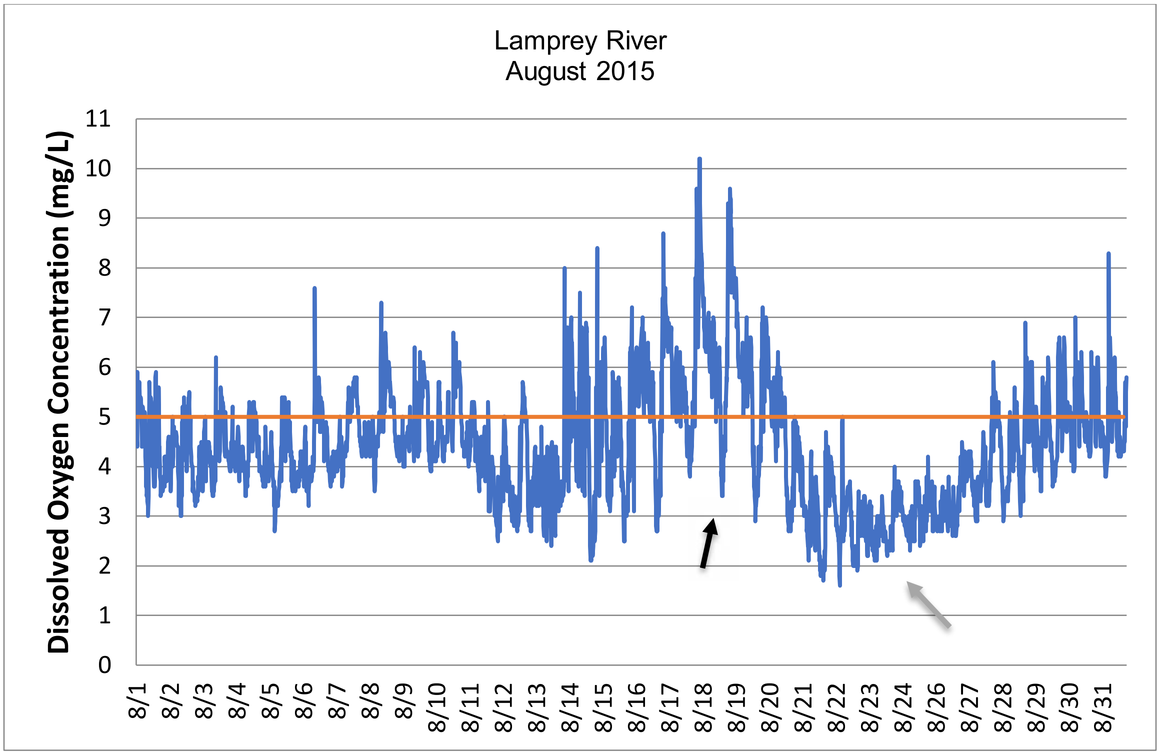

Figure DO-4. Dissolved oxygen concentration measurements at the Lamprey River datasonde, taken every 15 minutes during the month of August. The red line marks the 5 mg/L value; levels below this line may present a danger to fish and benthic invertebrates. The black arrow points to one event (August 18) that represents approximately 3 hours below 5 mg/L. The gray arrow represents a longer event of below 5 mg/L conditions, lasting approximately 7 days.

The daily minimum dissolved oxygen concentration were calculated at each station in the Great Bay Estuary (Figure DO-5). The number of days per year that the daily minimum DO fell below 5 mg/L was tabulated and is reported in Table DO-1. Inter-annual comparisons of that data are shown in Figure DO-6.

The Great Bay National Estuarine Research Reserve Datasonde Program and the UNH Datasonde Program provided data for this indicator. The data used for this indicator were quality assured by staff from the UNH Jackson Estuarine Lab and NHDES. For data from 2004 and later, the dissolved oxygen measurements were validated by pre- and post-deployment checks with an independently calibrated dissolved oxygen sensor or post-deployment calibration checks in the laboratory. For earlier years, for which quality control data were not available, only measurements from the first 96 hours of the sonde deployment were used. This is due to the fact that the older type of DO membrane-style probes had a tendency to drift over time.

Technical Advisory Committee (TAC) Discussion Highlights

For more information on the PREP TAC, please see:

http://prepestuaries.org/prep-technical-advisory-committee/

With regard to the low DO events in the tributaries, the committee was divided in terms of how to interpret the dissolved oxygen data. Some TAC members see the occurrence of low DO events as indicators of high productivity and potential water quality problems related to excess nutrients and point to supersaturation events as an indication of this. Others feel more caution is required in the interpretation of the data, noting that low DO events can relate to stratification, rainfall/runoff conditions, diurnal conditions, and changes in wind patterns. However, there is wider agreement that regardless of the cause of the low DO, these events are of concern to the resiliency of the system and may be of detriment to the organisms that live within it.

With regard to comparing DO conditions between different stations, most of the TAC members urged caution, noting that the locations of the datasondes are not consistent in terms of distance from the mouths of the river (Figure DO-5). For example, the Oyster and Lamprey River stations are located fairly far up river, while the Squamscott River station is located at the mouth of the river.

References Cited

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Pennock J. 2005. Lamprey River Dissolved Oxygen Study: A final report to the NH Estuaries Project. University of New Hampshire, Durham, NH. http://scholars.unh.edu/cgi/viewcontent.cgi?article=1185&context=prep

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Table DO-1: Measurements of dissolved oxygen concentrations less than 5 mg/L at datasondes in the Great Bay Estuary.

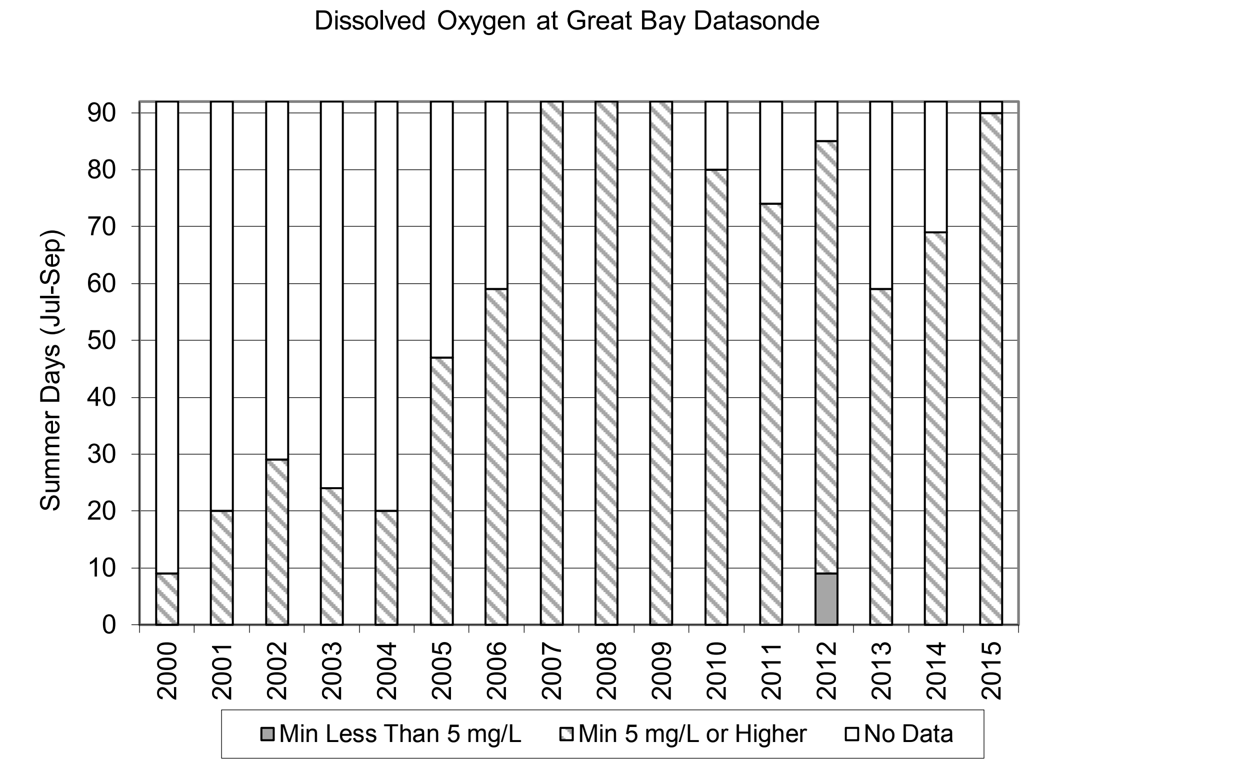
Station	Year	Number of Summer Days with Valid DO Data (Max of 92)	Number of Summer Days with Minimum DO <5 mg/L
Portsmouth Harbor	2002	16	0 (of 16)
Portsmouth Harbor	2003	20	0 (of 20)
Portsmouth Harbor	2004	21	0 (of 21)
Portsmouth Harbor	2005	49	0 (of 49)
Portsmouth Harbor	2006	51	0 (of 51)
Portsmouth Harbor	2007	15	0 (of 15)
Portsmouth Harbor	2008	92	0 (of 92)
Portsmouth Harbor	2009	92	0 (of 92)
Portsmouth Harbor	2010	88	1 (of 88)
Portsmouth Harbor	2011	92	0 (of 92)
Portsmouth Harbor	2012	92	0 (of 92)
Portsmouth Harbor	2013	27	0 (of 27)
Portsmouth Harbor	2014	81	0 (of 81)
Portsmouth Harbor	2015	92	0 (of 92)
Great Bay	2000	9	0 (of 9)
Great Bay	2001	20	0 (of 20)
Great Bay	2002	29	0 (of 29)
Great Bay	2003	24	0 (of 24)
Great Bay	2004	20	0 (of 20)
Great Bay	2005	47	0 (of 47)
Great Bay	2006	59	0 (of 59)
Great Bay	2007	92	0 (of 92)
Great Bay	2008	92	0 (of 92)
Great Bay	2009	92	0 (of 92)
Great Bay	2010	80	0 (of 80)
Great Bay	2011	74	0 (of 74)
Great Bay	2012	85	9 (of 85)
Great Bay	2013	59	0 (of 59)
Great Bay	2014	69	0 (of 69)
Great Bay	2015	90	0 (of 90)
Lamprey River	2000	7	0 (of 7)
Lamprey River	2001	20	3 (of 20)
Lamprey River	2002	25	21 (of 25)
Lamprey River	2003	15	9 (of 15)
Lamprey River	2004	52	33 (of 52)
Lamprey River	2005	44	10 (of 44)
Lamprey River	2006	55	1 (of 55)
Lamprey River	2007	92	49 (of 92)
Lamprey River	2008	92	12 (of 92)
Lamprey River	2009	77	1 (of 77)
Lamprey River	2010	92	87 (of 92)
Lamprey River	2011	92	51 (of 92)
Lamprey River	2012	92	55 (of 92)
Lamprey River	2013	92	20 (of 92)

Station	Year	Number of Summer Days with Valid DO Data (Max of 92)	Number of Summer Days with Minimum DO <5 mg/L
Lamprey River	2014	87	23 (of 87)
Lamprey River	2015	92	62 (of 92)
Oyster River	2002	25	9 (of 25)
Oyster River	2003	19	1 (of 19)
Oyster River	2004	52	21 (of 52)
Oyster River	2005	35	2 (of 35)
Oyster River	2006	30	1 (of 30)
Oyster River	2007	92	4 (of 92)
Oyster River	2008	53	7 (of 53)
Oyster River	2009	92	3 (of 92)
Oyster River	2010	12	2 (of 12)
Oyster River	2011	92	31 (of 92)
Oyster River	2012	86	9 (of 86)
Oyster River	2013	91	34 (of 91)
Oyster River	2014	91	10 (of 91)
Oyster River	2015	92	8 (of 92)
Salmon Falls River	2002	10	0 (of 10)
Salmon Falls River	2003	17	6 (of 17)
Salmon Falls River	2004	60	12 (of 60)
Salmon Falls River	2005	10	1 (of 10)
Salmon Falls River	2006	28	0 (of 28)
Salmon Falls River	2007	15	1 (of 15)
Salmon Falls River	2008	41	2 (of 41)
Salmon Falls River	2009	78	4 (of 78)
Salmon Falls River	2010	25	7 (of 25)
Salmon Falls River	2011	45	8 (of 45)
Salmon Falls River	2012	77	31 (of 77)
Salmon Falls River	2013	79	2 (of 79)
Salmon Falls River	2014	83	0 (of 83)
Salmon Falls River	2015	62	4 (of 62)
Squamscott River	2000	15	4 (of 15)
Squamscott River	2001	20	0 (of 20)
Squamscott River	2002	20	8 (of 20)
Squamscott River	2003	18	8 (of 18)
Squamscott River	2004	92	19 (of 92)
Squamscott River	2005	37	4 (of 37)
Squamscott River	2006	73	12 (of 73)
Squamscott River	2007	92	7 (of 92)
Squamscott River	2008	88	14 (of 88)
Squamscott River	2009	92	10 (of 92)
Squamscott River	2010	80	36 (of 80)
Squamscott River	2011	92	25 (of 92)
Squamscott River	2012	92	25 (of 92)
Squamscott River	2013	92	28 (of 92)
Squamscott River	2014	83	27 (of 83)
Squamscott River	2015	87	51 (of 87)

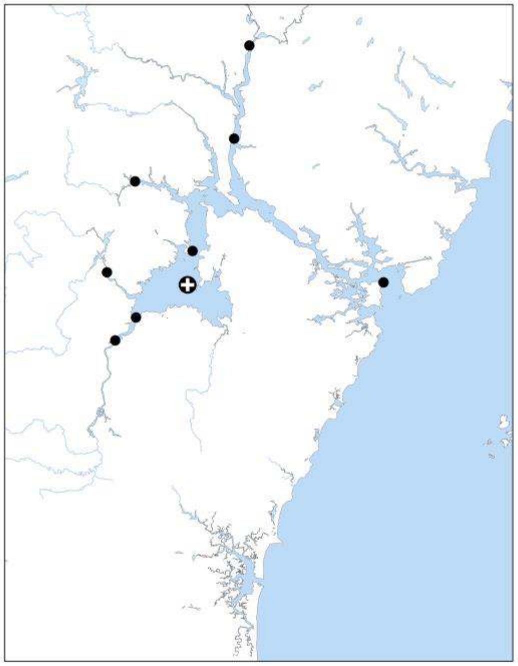
Note: Summer days are defined as days in the months of July, August, and September. Maximum is 92.

Figure DO-5: Map of datasonde station locations.

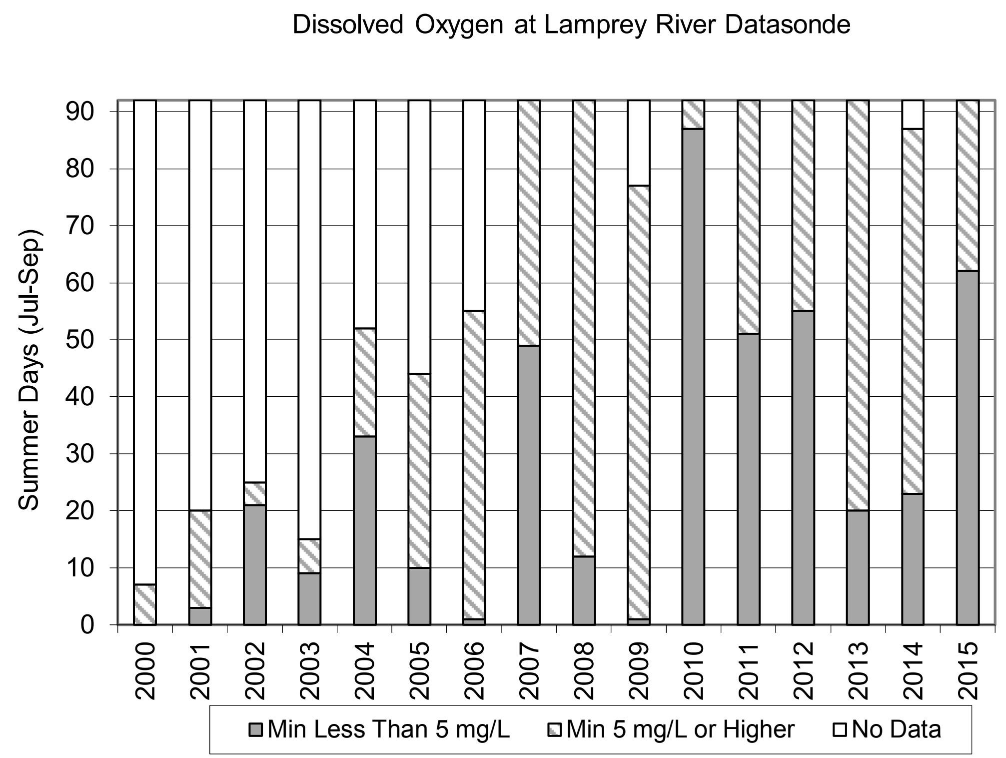
Figure DO-6: DO concentrations. Number of days in July, August, and September relative to 5 mg/L threshold.



Monitoring Location (GRBGB)
(black circle with white plus sign)



Station: GRBGB (Great Bay). Maximum number of days is 92.



Monitoring Location (GRBLR)
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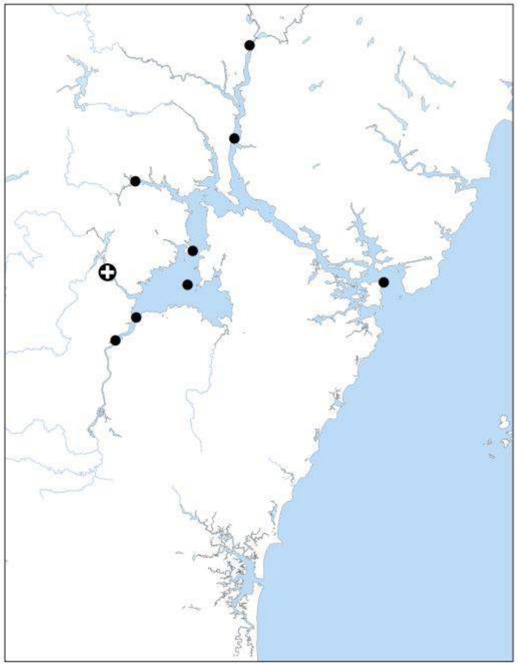
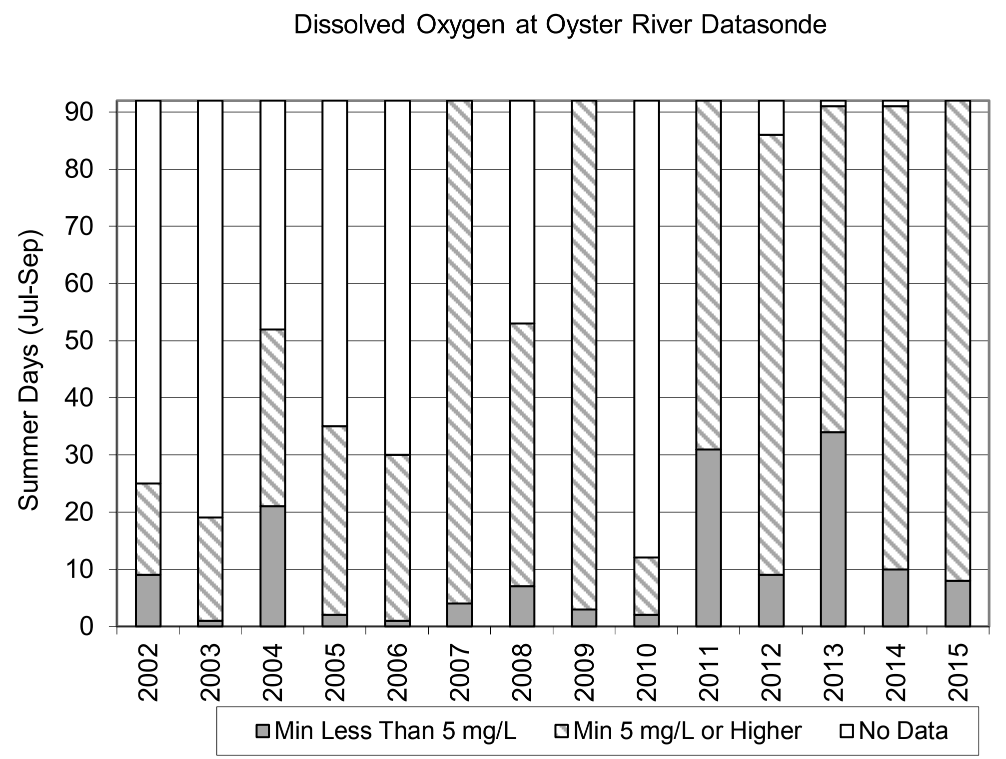


Station: GRBLR (Lamprey River). Maximum number of days is 92.



Monitoring Location (GRBOR)
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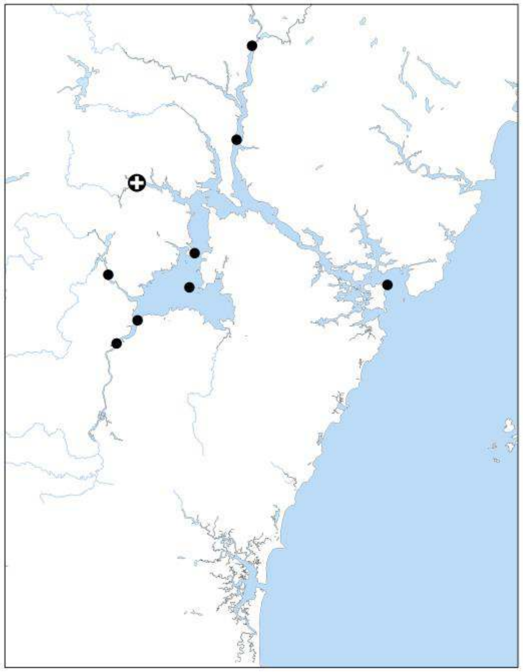
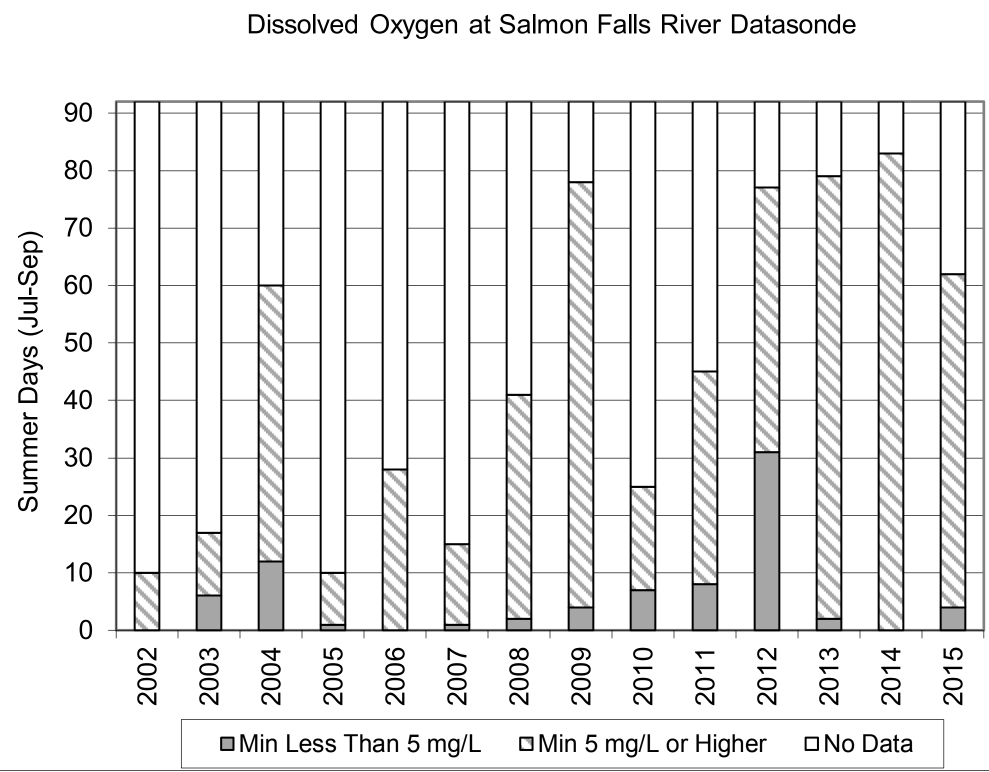


Station: GRBOR (Oyster River). Maximum number of days is 92.



Monitoring Location (GRBSF)
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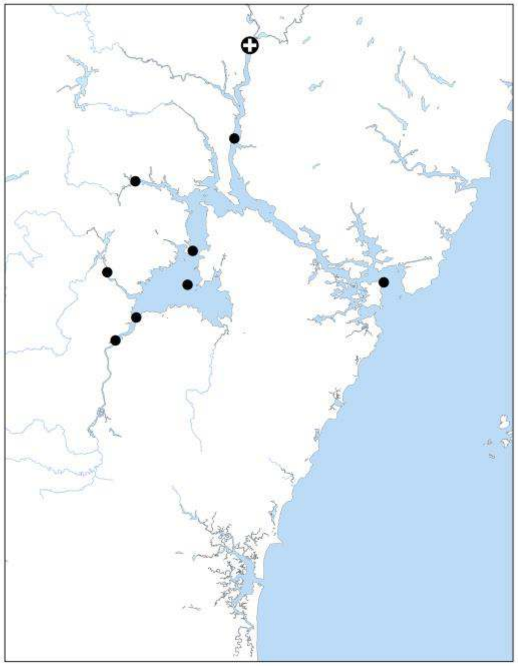
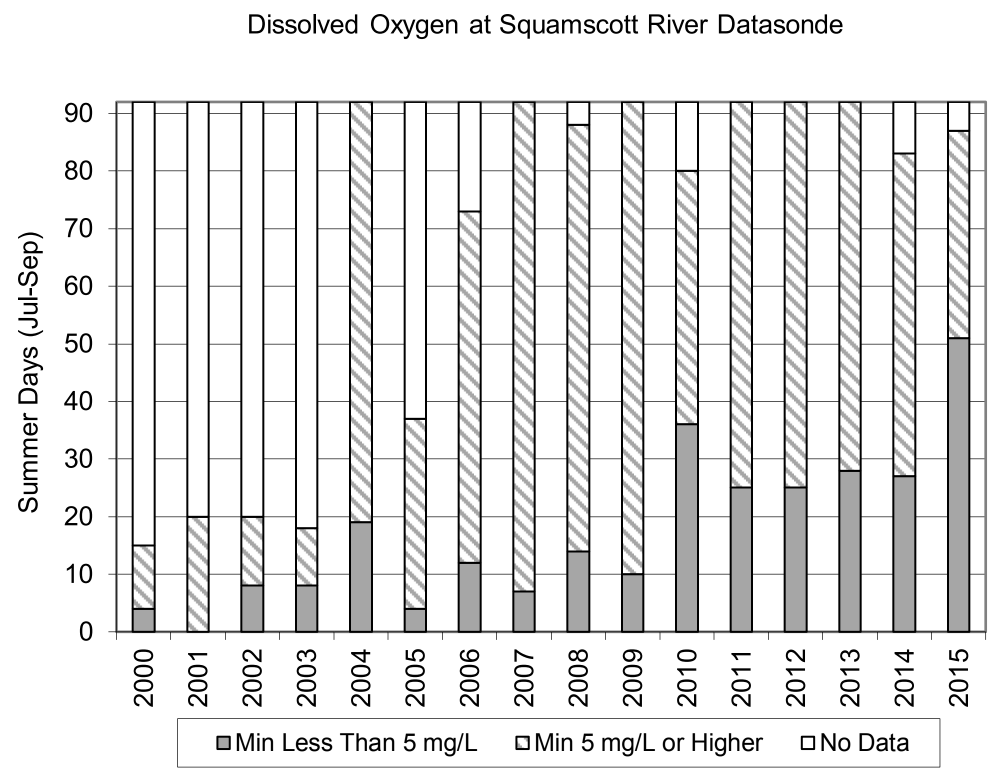


Station: GRBSF (Salmon Falls River). Maximum number of days is 92.



Monitoring Location (GRBSQ)
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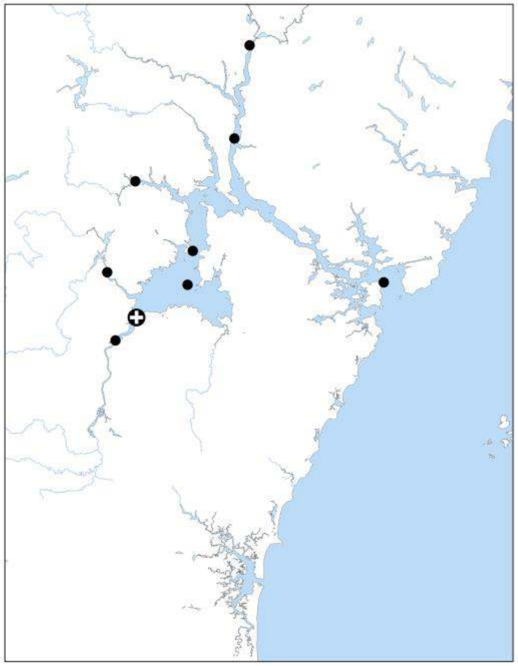
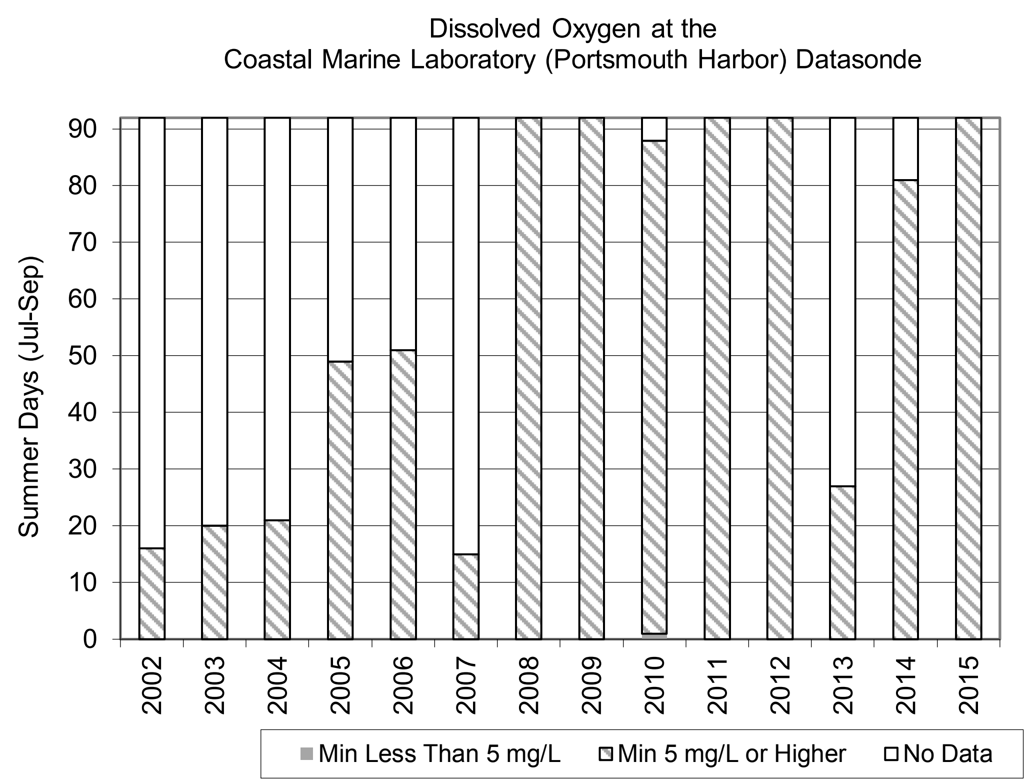


Station: GRBSQ (Squamscott River at the railroad trestle). Maximum number of days is 92.



Monitoring Location (GRBCML)
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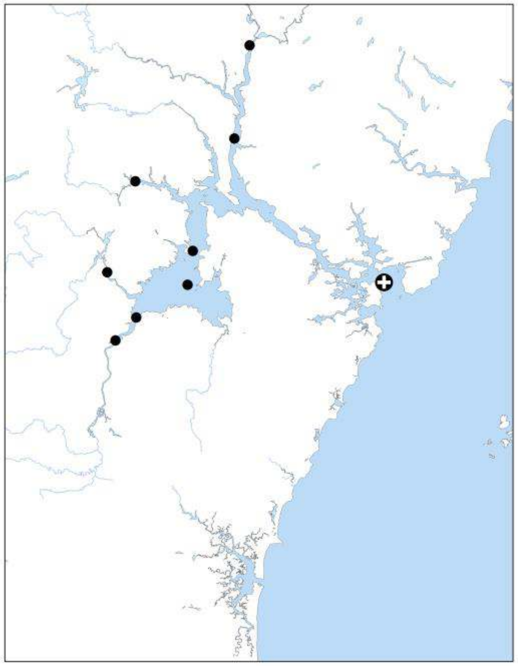

Station: GRBCML (Portsmouth Harbor at the Coastal Marine Laboratory). Maximum number of days is 92.