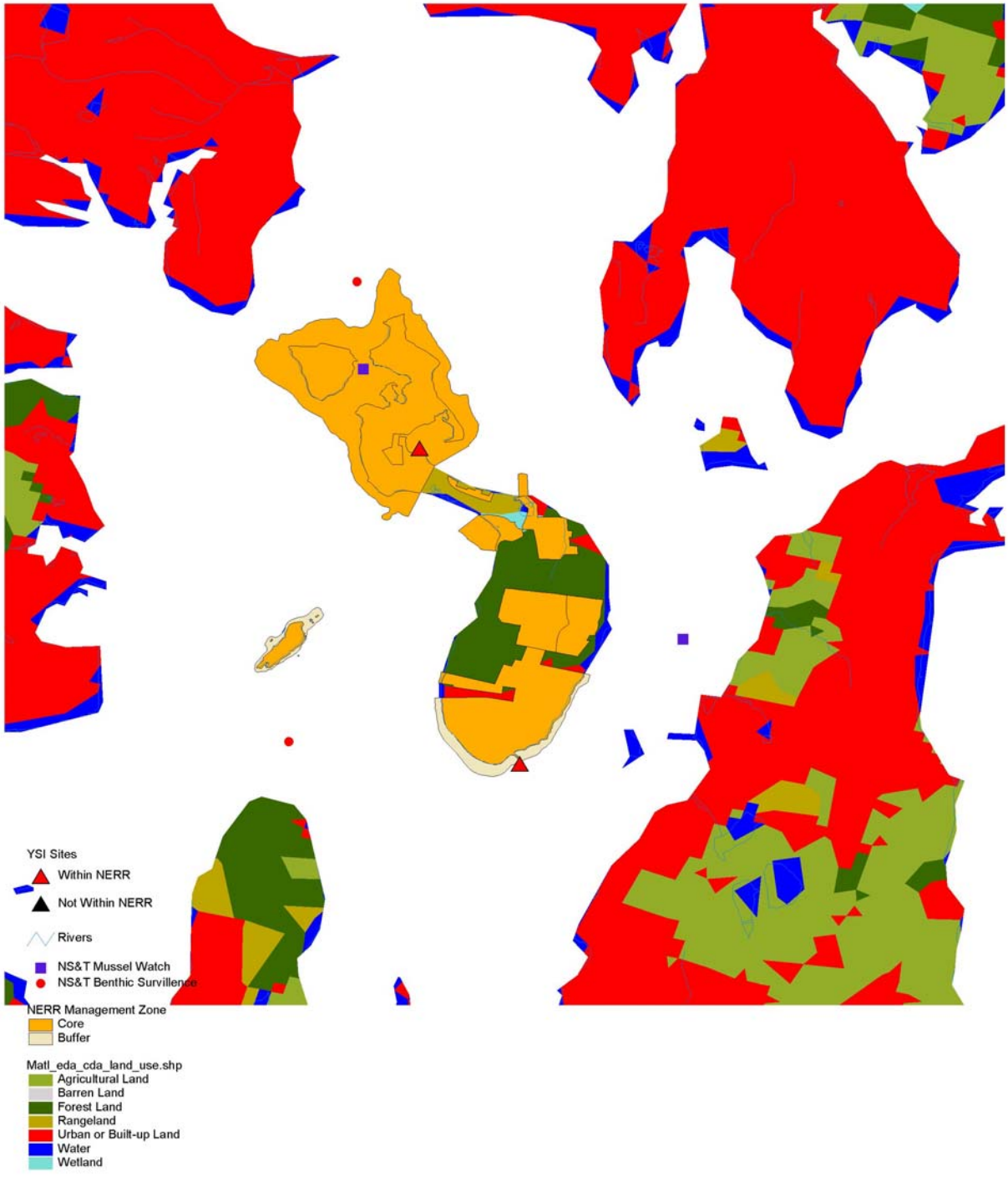
Narragansett Bay



Narragansett Bay, Potters Cove (NARPC)

Characterization (Latitude = 41° 38' 25"N; Longitude = 71° 20' 28"W)
Tides at Potters Cove are semidiurnal and range from –0.2 m to 1.7 m (average 1.1 m). The main estuary (Narragansett Bay) is 40 km long (mainstream linear dimension), has an average depth of 8.3 m MHW, and an average width of ~10-12 km. At the sampling site, the depth is ~3.5 - 4 m MHW and the width of the cove is 0.9 km, while the width of the East Passage here to the opposite shore (Bristol) is ~ 2.7 km. This site is located at a point approximately one-third of the way down the estuary. Bottom habitats are predominantly silt and sand, with some organic mud, and support communities of *Ulva* sp. and other macroalgal bottom vegetation. The dominant marsh vegetation near the sampling site is a degraded *Phragmites* sp./ *Spartina alterniflora* marsh. The dominant upland vegetation includes scrub/shrub. Upland land use near the sampling site includes a restricted flow saltmarsh and a small number of very low-density dwellings. Activities that potentially impact the site include illegally discharged boater waste and pollutants from the upper urbanized Bay which is a source of nutrients, bacteria, and very low level toxics. Potters Cove received wastes from boaters until a federal no-discharge zone was declared for all Rhode Island State waters in late spring 1998. Potters Cove is considered impacted from possible continuing boater discharges (now illegal, but relying on voluntary compliance) and upper Bay pollution sources including sewage treatment effluents, urbanized runoff, and Combined Sewer Overflows (CSO's) which combine industrial, commercial, domestic, and storm-water waste into a single, often untreated, discharge.

Descriptive Statistics
Forty-six deployments were made at this site between Jan 1996 and Dec 1998, with equal coverage during all seasons (Figure 57). Mean deployment duration was 30 days and two deployments (Apr 1996 and Aug 1998) were less than 10 days.

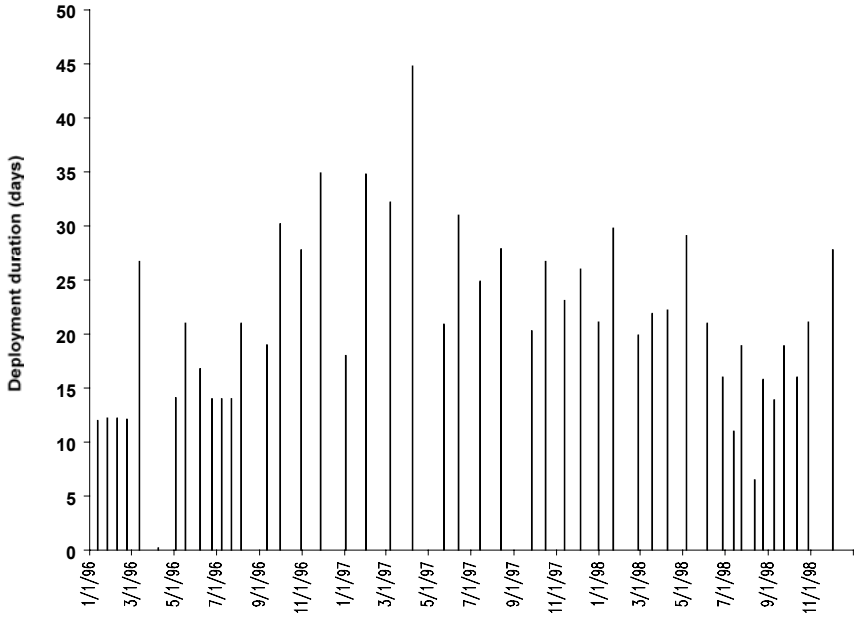


Figure 57. Narragansett Bay, Potters Cove deployments (1996-1998).

Eighty-seven percent of annual depth data were included in analyses (83% in 1996, 88% in 1997, and 89% in 1998). Sensors were typically deployed at a depth of 2.5 m below the water surface (range = 1.7-3.2 m) and 1 m above the bottom sediment. Strong fluctuations (2-3 m) in daily and bi-weekly water depth were evident from scatter plots, with consistent amplitude throughout the data set. Harmonic regression analysis attributed 92% of depth variance to 12.42 hour cycles, 6% of variance to 24 hour cycles, and 2% of variance to interaction between 12.42 hour and 24 hour cycles.

Eighty-seven percent of annual water temperature data were included in analyses (83% in 1996, 88% in 1997, and 89% in 1998). Water temperature followed a seasonal cycle, with mean water temperature 3-5°C in winter (1997, 1998) and 20-22°C in summer (Figure 58). Mean water temperature between Jan-Mar 1996 was slightly lower (1-3°C) than mean water temperature in Jan-Mar 1997 and 1998. Minimum and maximum water temperatures between 1996-1998 were –1.3°C (Feb 1996) and 25.8 (Jul 1997), respectively. Scatter plots suggest strong fluctuations (1-2°C) in daily water temperature and stronger fluctuations (3-8°C) in bi-weekly water temperature in summer, fall, and winter. Harmonic regression analysis attributed 44% of temperature variance to both 24 hour cycles and interaction between 12.42 hour cycles and 24 hour cycles, and 12% of temperature variance to 12.42 hour cycles.

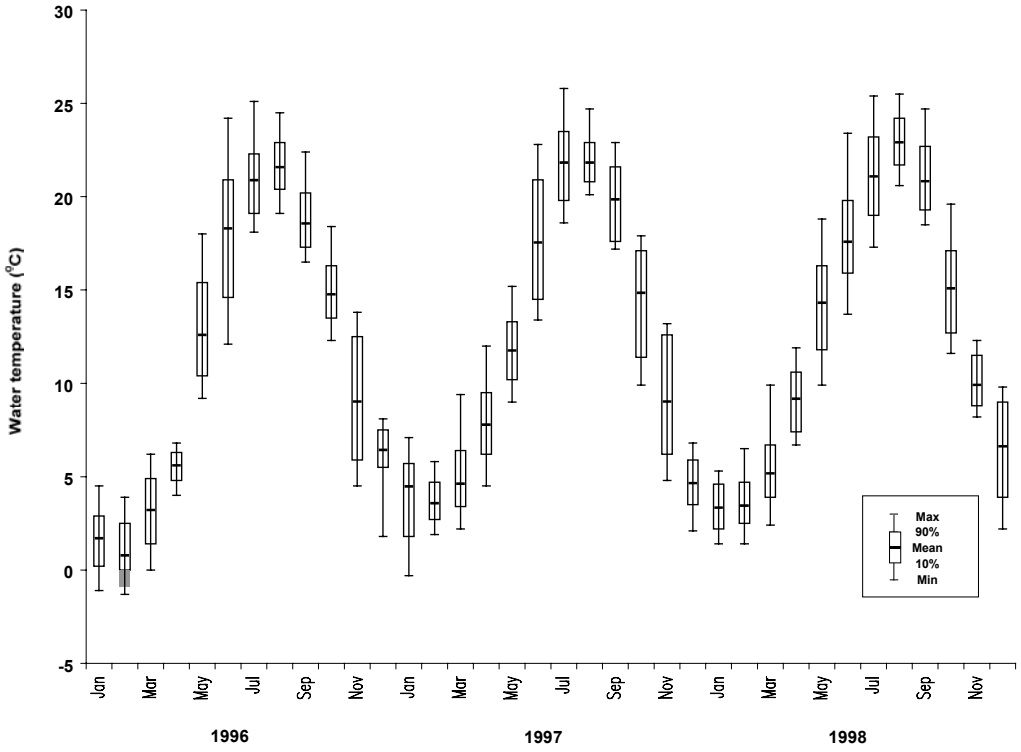


Figure 58. Water temperature statistics for Potters Cove, 1996-1998.

Eighty-six percent of annual salinity data were included in analyses (80% in 1996, 88% in 1997, and 89% in 1998). Mean salinity was typically 25-30 ppt between 1996-1998. Mean salinity was greatest between Jul-Oct and least between Dec-Mar; however, large variances were often associated with mean salinity values (Figure 59). Minimum and maximum salinity between 1996-1998 was 13.6 ppt (Jun 1998) and 32.1 ppt (Sep 1997), respectively. Scatter plots suggest daily and bi-weekly

fluctuations in salinity equivalent to annual variation in mean salinity throughout the data set. Fluctuations in salinity >10 ppt were observed during episodic events in Jan 1996 and Jun 1998. Harmonic regression analysis attributed 51% of salinity variance to interaction between 12.42 hour and 24 hour cycles, 29% of variance to 24 hour cycles, and 20% of variance to 12.42 hour cycles.

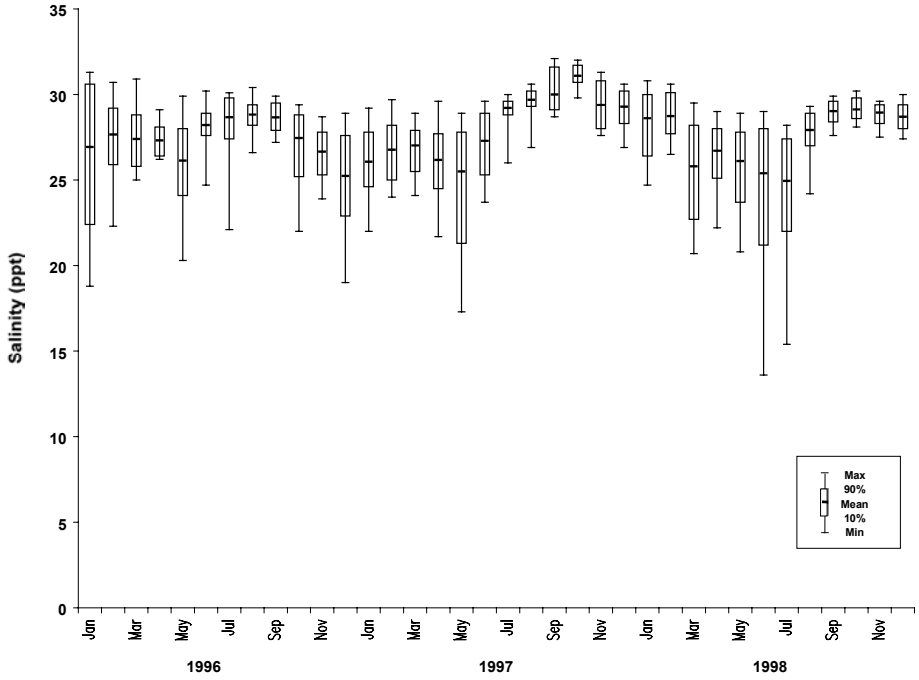


Figure 59. Salinity statistics at Potters Cove, 1996-1998.

Sixty-seven percent of annual dissolved oxygen (% saturation) data were included in analyses (60% in 1996, 71% in 1997 and 1998). Mean DO was typically 50-110% saturation and followed a seasonal cycle, with greatest DO in spring, fall and winter. Mean DO below 50% saturation and mean DO above 120% saturation was never observed. Minimum and maximum DO between 1996-1998 was 3.6% saturation (Aug 1998) and 204.4% saturation (May 1998), respectively. Hypoxia was observed in one month (Jul 1998) and persisted for 4% of the first 48 hours post-deployment (Figure 60). Supersaturation was observed in eight months between 1996-1998 and, when present, supersaturation persisted for 24% of the first 48 hours post-deployment on average. Scatter plots suggest minor fluctuations (20-40%) in percent saturation in winter and fall (1996, 1997). Strong fluctuations (60-100%) in percent saturation were regularly observed in spring and summer. Harmonic regression analysis attributed 62% of DO variance to 24 hour cycles, 27% of DO variance to interaction between 12.42 hour and 24 hour cycles, and 11% of DO variance to 12.42 hour cycles.

Photosynthesis/Respiration

Nearly three quarters (74%) of the data used to calculate the metabolic rates fit the basic assumption of the method (heterogeneity of water masses moving past the sensor) and were used to estimate net production, gross production, total respiration and net ecosystem metabolism (Table 19). Instrument drift during the duration of the deployments was not a significant problem at this site. Total respiration exceeded gross production at Potters Cove; thus, the net ecosystem metabolism and P/R ratio indicated that this is a heterotrophic site (Figure 61). Temperature was significantly ($p<0.05$) correlated with gross production, total respiration and net ecosystem metabolism. Gross production

and respiration increased as temperature increased, while net ecosystem metabolism became more heterotrophic as temperature increased. Salinity was not significantly ($p<0.05$) correlated with any metabolic measurement.

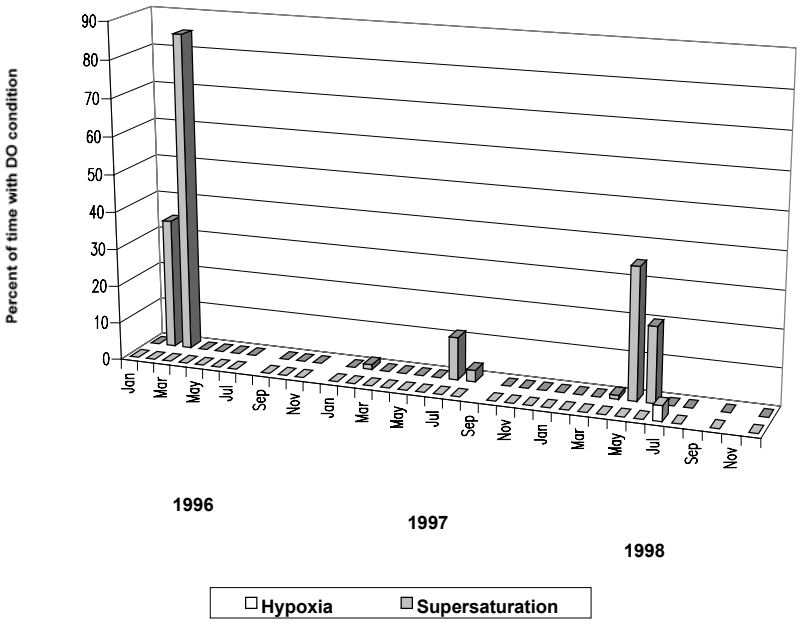


Figure 60. Dissolved oxygen extremes at Potters Cove, 1996-1998.

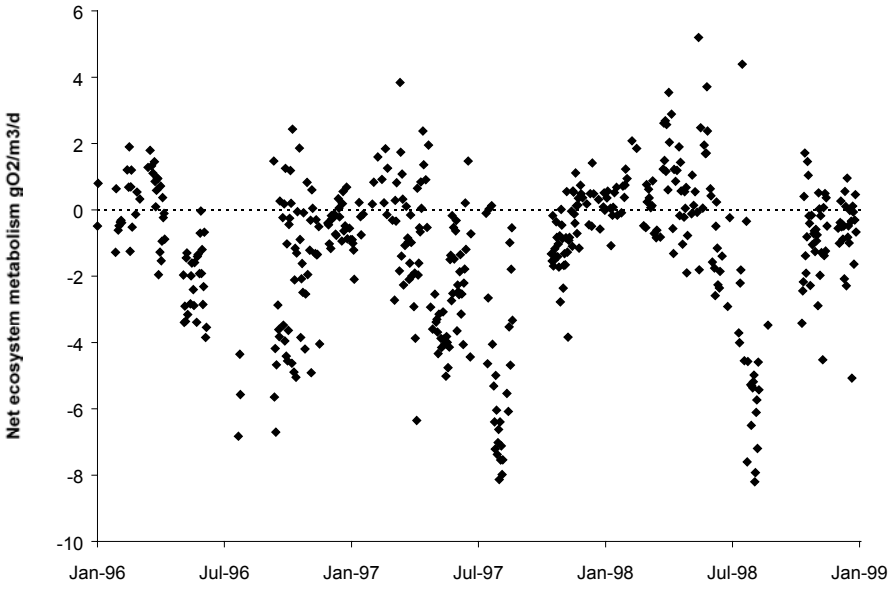


Figure 61. Net metabolism at Potter's Cove, 1996-1998.

Table 19. Summary of metabolism data and statistics at Potter's Cove, 1996-1998.

Potters Cove	mean	s.e.
Water depth (m)	8.3	
Net production $gO_2/m3/d$	0.90	0.05
Gross production $gO_2/m3/d$	2.35	0.09
Total respiration $gO_2/m3/d$	2.67	0.11
Net ecosystem metabolism g $O_2/m3/d$	-0.32	0.05
Net ecosystem metabolism g C/m2/y	127	
P/R	0.88	
Statistical results		
Drift – paired t-test		
Gross production	ns	
Total respiration	ns	
Net ecosystem metabolism	ns	
Percent useable observations	74%	
Paired t-test on gross production and total respiration	$p < 0.001$	
Correlation coefficient	Temperature	Salinity
Gross production	0.47	ns
Total respiration	0.55	ns
Net ecosystem metabolism	-0.33	ns

Narragansett Bay, T-wharf (NARTW)

Characterization (Latitude = 41° 34'53"N; Longitude = 71° 19'18"W)
Tides at T-wharf are semidiurnal and range from –0.2 m to 1.7 m (average 1.1 m). The Narragansett Bay estuary is 40 km long (mainstream linear dimension), has an average depth of 8.3 m MHW, and an average width of ~10-12 km. At the sampling site, the width from the T Wharf to Carr Point in Portsmouth on the eastern shore of the Bay is 2.44 km, and the mean depth is ~5 m MHW, with depth rapidly dropping off to >10 m within 100 m of this site. The T-wharf is located in fairly open water roughly mid-way between the head and the mouth of the estuary. Bottom habitats are mostly sand and some silt, with low-density macroalgae (*Fucus* sp. and *Codium* sp.) and a small eelgrass bed nearby. The dominant marsh vegetation near the sampling site is *Spartina alterniflora*. The dominant upland vegetation includes scrub/shrub. Activities that potentially impact the site include pollution sources to the Bay, primarily nutrients coming from both upper Bay and offshore deep waters (this area is a possible upwelling/mixing zone for deep waters coming into Narragansett Bay from offshore). The T-wharf site is at the southern tip of an island and is considered a relatively non-impacted site.

Descriptive Statistics
Fifteen deployments were made at this site between Sep 1996 and Dec 1997, with equal coverage during all months (Figure 62). Mean deployment duration was 27 days. Only two deployments (Sep, Dec 1997) were less than 15 days.

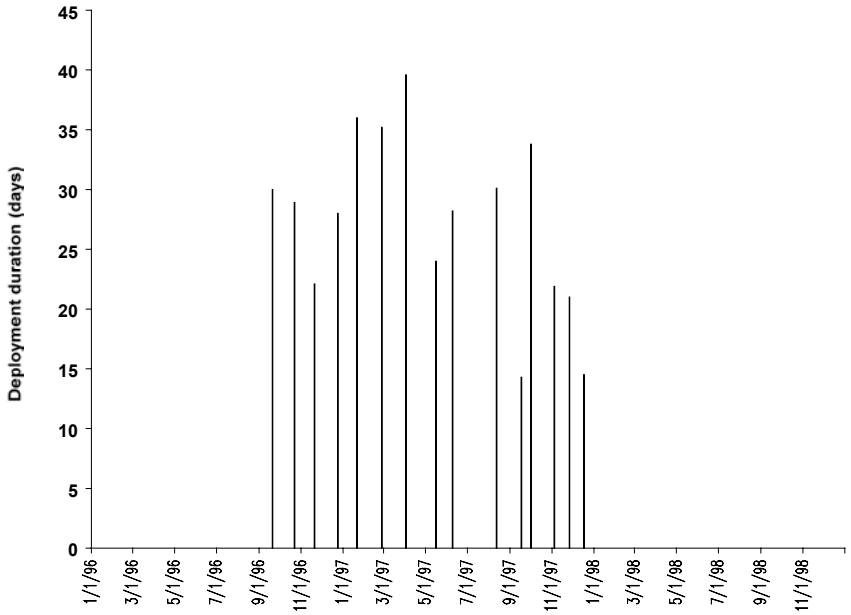


Figure 62. Narragansett Bay, T-wharf deployments (1996-1998).

Twenty-four percent of annual depth data in 1996 and 87% of annual depth data in 1997 were included in analyses. Sensors were deployed at a mean depth of 3.8 m below the water surface (range = 2.7-4 m) and 1 m above bottom sediment. Scatter plots suggest strong fluctuation (2 m) in daily and bi-weekly depth readings, with consistent amplitude throughout the data set (except for Dec 1997 when fluctuations exceeded 3 m). Harmonic regression analysis attributed 93% of depth variance to 12.42 hour cycles, 5% of depth variance to 24 hour cycles, and 2% of depth variance to interaction between 12.42 hour and 24 hour cycles.

Twenty-four percent of annual water temperature data in 1996 and 87% of annual water temperature data in 1997 were included in analyses. Water temperature followed a seasonal cycle from Sep 1996 to Dec 1997, with mean water temperatures 3-5°C in winter and 19-21°C in summer (Figure 63). Minimum and maximum water temperatures were 0.7°C (Jan 1997) and 23.8 (Aug 1997), respectively. Moderate fluctuations (1-3°C) were observed for daily and bi-weekly water temperatures in all seasons except for Oct-Nov, when strong (≥ 5°C) fluctuations were observed for bi-weekly water temperatures. Harmonic regression analysis attributed 54% of temperature variance to 12.42 hour cycles, 26% of temperature variance to 24 hour cycles, and 20% of temperature variance to interaction between 12.42 hour and 24 hour cycles.

Twenty-four percent of annual salinity data in 1996 and 87% of annual salinity data in 1997 were included in analyses. Mean salinity between Sep 1996 and Dec 1997 was 28-31 ppt (Figure 64). Minimum and maximum salinity was 23.7 ppt (Dec 1996) and 32.1 ppt (Nov 1997), respectively. Scatter plots suggest fluctuations in daily and bi-weekly salinity equivalent to or in excess of variance in annual mean salinity. Harmonic regression analysis attributed 65% of salinity variance to 12.42 hour cycles, 21% of salinity variance to interaction between 12.42 hour and 24 hour cycles, and 14% of salinity variance to 24 hour cycles.

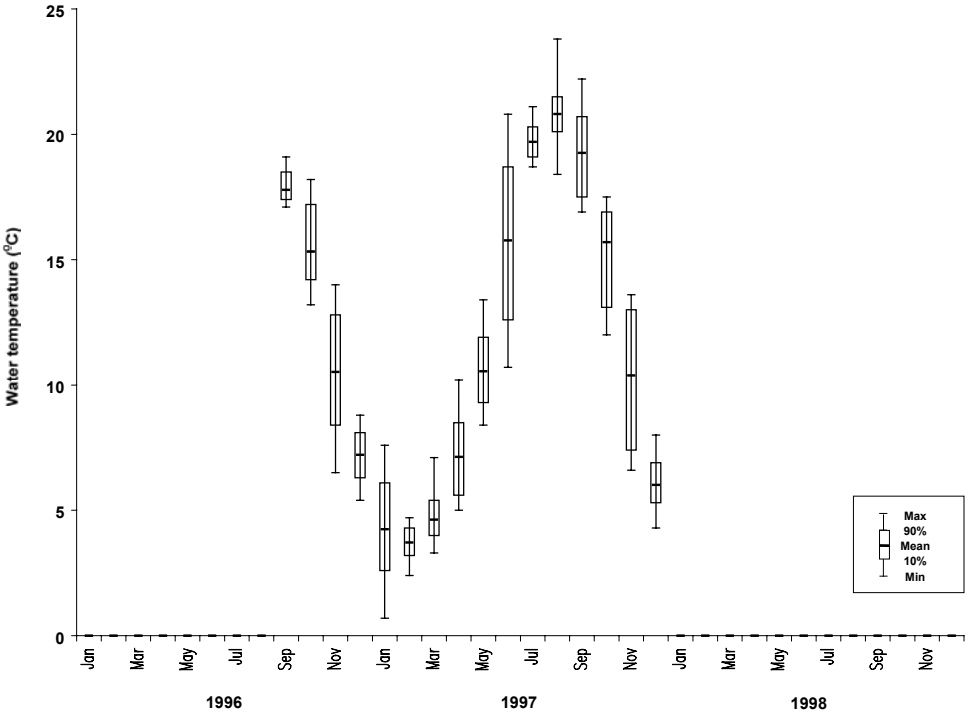


Figure 63. Water temperature statistics for T-wharf, 1996-1998.

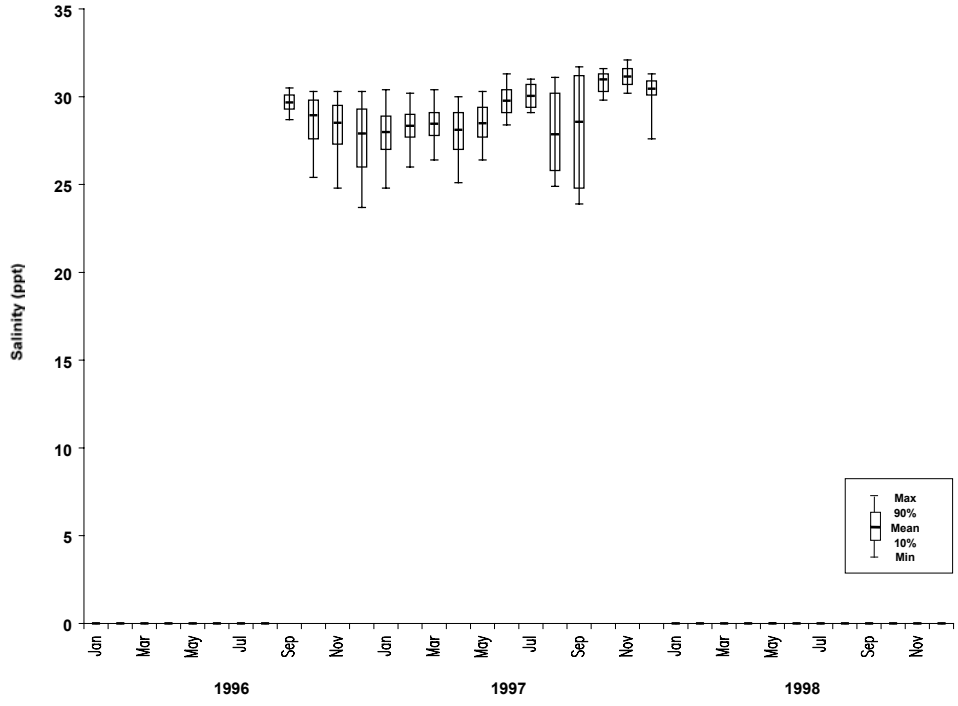


Figure 64. Salinity statistics at T-wharf, 1996-1998.

Twenty-one percent of annual dissolved oxygen (% saturation) data in 1996 and 69% of annual dissolved oxygen (% saturation) data in 1997 were included in analyses. Mean DO was typically 75-110% saturation. Minimum and maximum DO was 0.2% saturation (Aug 1997) and 138.4% saturation (Feb 1997), respectively. Hypoxia was observed in one month (Aug 1997) and persisted for 2% of the first 48 hours post-deployment (Figure 65). Supersaturation was observed in one month (Nov 1997) and persisted for 5.4% of the first 48 hours post-deployment. Scatter plots suggest moderate fluctuation (20-60%) in percent saturation at daily and bi-weekly intervals throughout the data set, except for Mar-Apr and Sep-Oct 1997 when DO fluctuations ≥ 90% were observed. Harmonic regression analysis attributed 39% of DO variance to 12.42 hour cycles, 36% of variance to interaction between 12.42 hour and 24 hour cycles, and 25% of variance to 24 hour cycles.

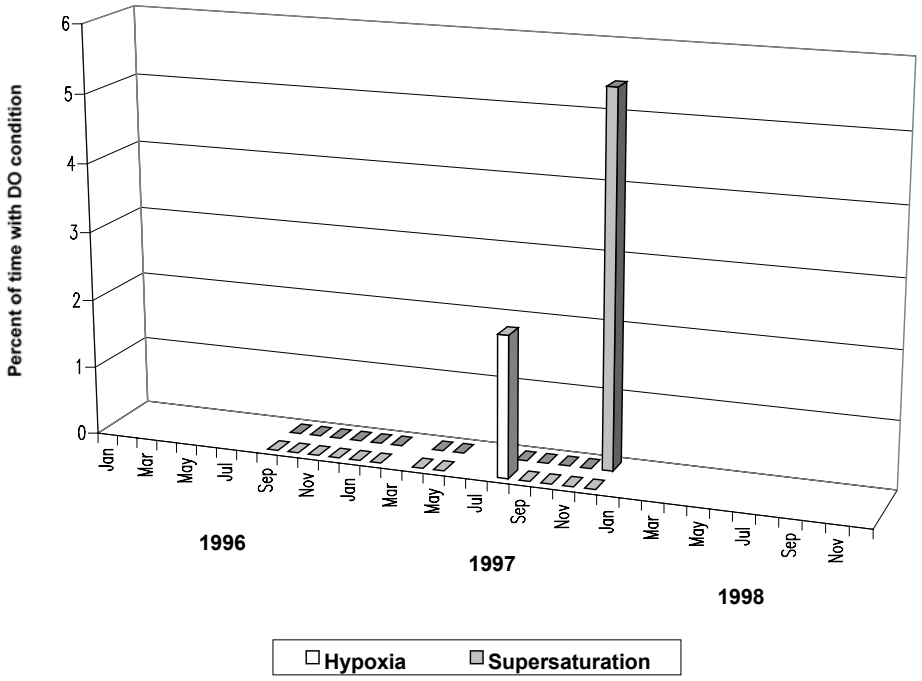


Figure 65. Dissolved oxygen extremes at T-wharf, 1996-1998.

Production/Respiration

Nearly two thirds (62%) of the data used to calculate the metabolic rates fit the basic assumption of the method (heterogeneity of water masses moving past the sensor) and were used to estimate net production, gross production, total respiration and net ecosystem metabolism (Table 20). Instrument drift during the duration of the deployments was not a significant problem at this site. Total respiration greatly exceeded gross production at T-wharf; thus, the net ecosystem metabolism and P/R ratio indicated that this is a heterotrophic site (Figure 66). Temperature was significantly ($p<0.05$) correlated with gross production and respiration. Gross production and respiration increased as temperature increased. Salinity was significantly ($p<0.05$) correlated with gross production and total respiration. Gross production and respiration decreased as salinity increased.

Table 20. Summary of metabolism data and statistics at T-wharf, 1996-1998.

T-wharf	mean	s.e.
Water depth (m)	4.83	
Net production $gO_2/m3/d$	0.51	0.06
Gross production $gO_2/m3/d$	1.23	0.12
Total respiration $gO_2/m3/d$	1.45	0.15
Net ecosystem metabolism g $O_2/m3/d$	-0.22	0.07
Net ecosystem metabolism g C/m2/y	61	
P/R	0.85	
Statistical results		
Drift – paired t-test		
Gross production	ns	
Total respiration	ns	
Net ecosystem metabolism	ns	
Percent useable observations	62 %	
Paired t-test on gross production and total respiration	$p < 0.002$	
Correlation coefficient	Temperature	Salinity
Gross production	0.19	-0.18
Total respiration	0.19	-0.21
Net ecosystem metabolism	ns	ns

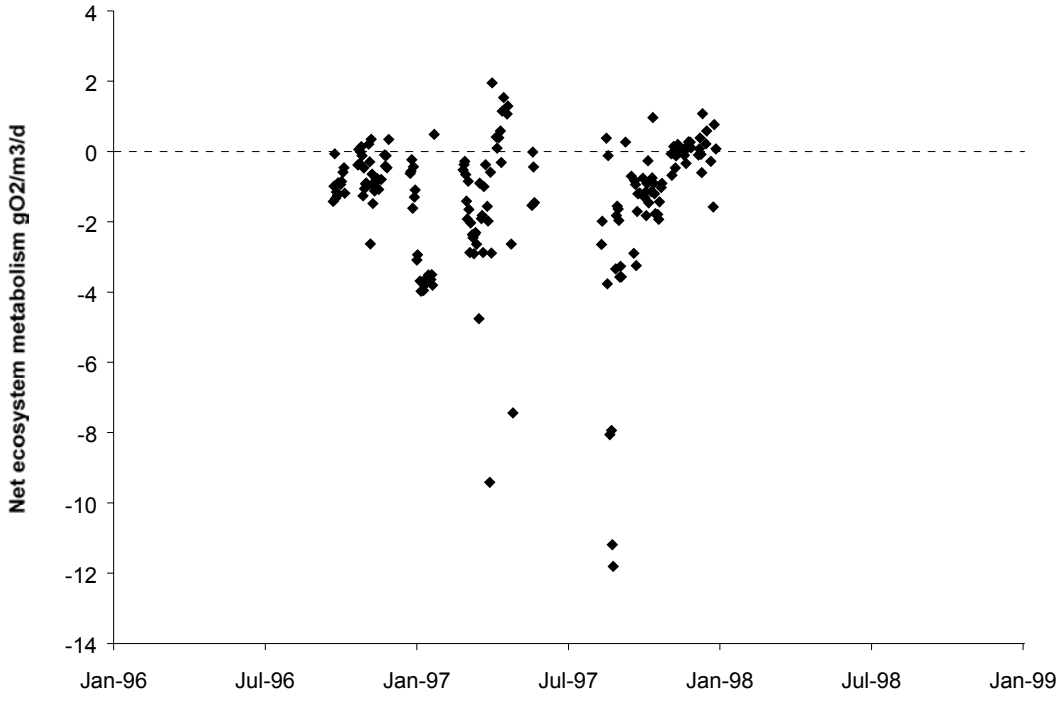


Figure 66. Net metabolism at T-wharf, 1996-1998.