Measurement of Wintertime Primary Production in the Lower Severn River

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Abstract

Primary production drives biological activity in aquatic systems. In this study, primary production was measured and the standing stock and biomass of secondary producers was estimated to establish baseline wintertime productivity values for follow-on studies of biological productivity in the lower Severn River.

Study Area and Methods

Figure 1. Map of study area of lower Severn River, MD in the vicinity of the U.S. Naval Academy (USNA) and Hendrix Oceanography Laboratory (HOL). The red circle represents the location of the light and dark bottle rig deployment on 04-05 March 2019. The red box is where plankton net tows were conducted to estimate zooplankton standing stock and biomass.

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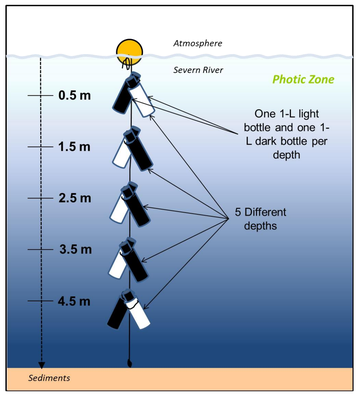


Figure 2. Conceptual diagram of light/dark bottle rig used to measure primary production . One light and dark bottle pair was present at each of the 5 depths..

Primary productivity was measured in the lower Severn River from 04-05 March 2019 using a modified version of the "Light and Dark Bottle" (L/D Bottle) Method (*Gran, 1918*). A L/D Bottle rig of 5 sets of bottles was constructed in Hendrix Oceanography Lab (HOL) and deployed on 04 March 2019 near the Naval Academy Bridge and recovered ~ 24 hours later (**Fig. 1**). Bottles were deployed at 0.5, 1.5, 2.5, 3.5, and 4.5 meters (**Fig. 2**). A YSI EXO2 water quality monitoring sonde was used to measure water column temperature, salinity, dissolved oxygen (DO), conductivity, Chl-a, pH, turbidity, and blue green algae at the time of L/D Bottle rig deployment. A Secchi Disk and Profiling Natural Fluorometer (PNF) were used to estimate the depth of the base of the photic zone (**Fig. 3a**). AYSI PRO+ was used to measure DO concentrations in bottles after recovery in order to estimate Net Primary Production (NPP), Respiration (R), Gross Primary Production (GPP). A net 1:1 stoichiometry of O_2 to CO_2 during photosynthesis and/or respiration was used to covert measured DO concentrations changes in the L/D Bottles to units of g-C/m^2-d.

Water samples were collected at each of the 5 L/D Bottle depths and from each light and dark bottle and syringe filtered through 0.7 µm GFF filters for nutrient analysis (NO_3^-, PO_4^{3-}). Nutrient analysis was performed at the University of Maryland Center for Environmental Science. A 5-minute tow of a 0.3 m^2, 50 µm mesh plankton net was conducted with L/D Bottle deployment and recovery. Plankton samples were filtered through a 250 µm stainless steel sieve and preserved with ethanol for subsequent counting in HOL using a dissecting microscope (**Fig. 3b**).

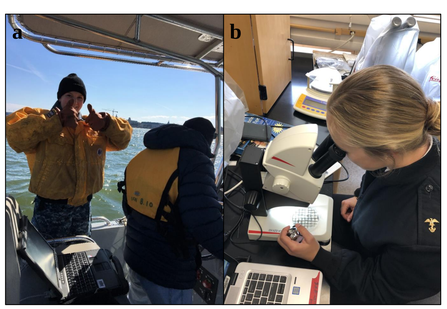


Figure 3. (**a**) MIDN 1/C Lucia Donnelly working with Mr. Andrew Keppel and Mr. Luis Rodriguez deploying a PNF and (**b**) MIDN 1/C Paige Brigham counting zooplankton captured in plankton net tows.

Results and Discussion

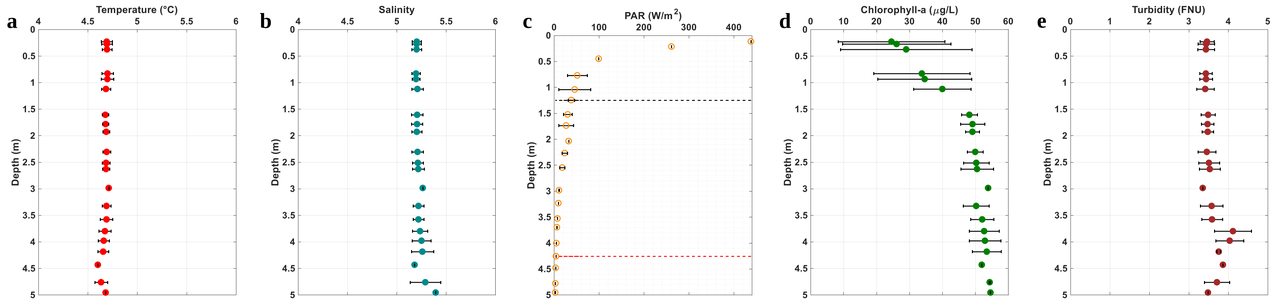


Figure 4. Water column profile plots vs. depth (m) for: (**a**) Temperature (°C); (**b**) Salinity; (**c**) Photosynthetically-Active Radiation (PAR, W/m^2); (**d**) Chlorophyll-a concentration (Chl-a, µg/L), and (**e**) Turbidity (FNU) from 04-05 March 2019 in the lower Severn River at the L/D Bottle deployment location (**Fig. 1**). Water quality parameters were measured using a YSI EXO2 water quality monitoring sonde and PAR was measured using a PNF. Data from 04 & 05 March 2019 was averaged over a +/- 0.25 m moving depth interval.

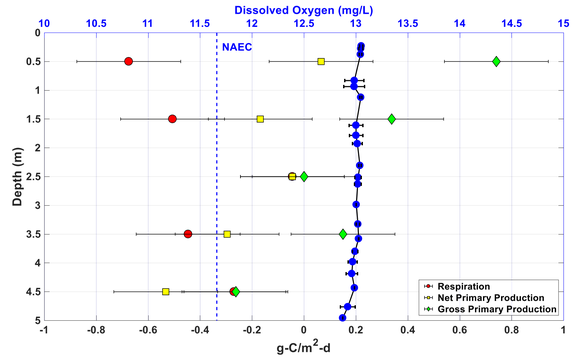


Figure 5. Plot of Gross Primary Production (GPP), Net Primary Production (NPP) and respiration (R) (g-C/m^2-d) as measured using the L/D Bottle Method and measured Dissolved Oxygen (DO) concentrations (mg/L) vs. depth (m) from 04-05 March 2019. Note: The 0.5 m depth light bottle opened on recovery so GPP, NPP, and R values for the 0.5 m depth were estimated using a light bottle deployed near HOL from 05-06 March 2019. The dashed blue line indicates the Normal Atmospheric Equilibrium Concentration (NAEC) for oxygen for 04-05 March 2019.

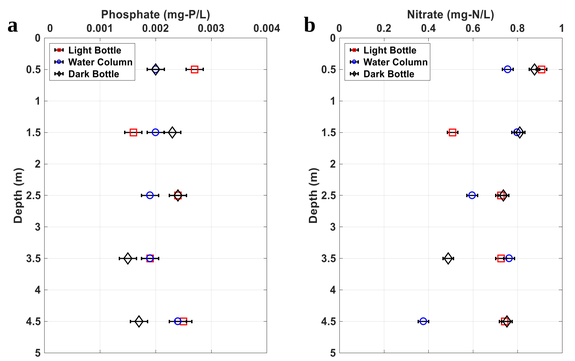


Figure 6. Water column (**a**) Phosphate (PO_4^{3-}) and (**b**) Nitrate (NO_3^-) concentrations vs. depth (m) in the lower Severn River water column on 04 March 2019 and in light and dark bottles after recovery on 05 March 2019. Note: light bottle concentrations 0.5 m were measured in bottle deployed near HOL from 05-06 March 2019

Conclusions

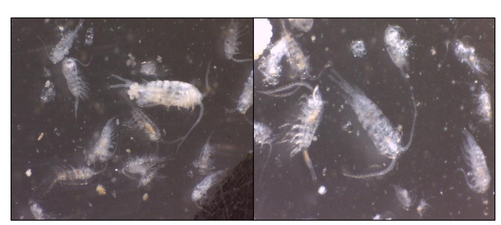
- ***Results show limited primary production in the wintertime water column of the lower Severn River but active organic matter cycling***
- ***Similar studies should be conducted to quantify seasonal and annual biological production and organic matter cycling in the lower Severn River and similar estuarine systems***

Water column profiles at the L/D Bottle deployment site in the lower Severn River were consistent with wintertime condition (**Fig. 4**). Temperature (**Fig. 4a**) and salinity (**Fig. 4b**) profiles indicated a well-mixed water column that was abnormally fresh for wintertime before the spring freshet. Chlorophyll-a concentration (**Fig. 4d**) and turbidity (**Fig. 4e**) profiles suggested low phytoplankton biomass, even though the base of the photic zone was deeper that 4 m (**Fig. 4c**). The well-mixed water column was supersaturated with respect to dissolved oxygen (**Fig. 5**) down to 5 m. Results from the L/D Bottle Method showed limited Gross Primary Production (GPP) in the water column with GPP decreasing from ~ 0.8 g-C/m^2-d at the surface (0.5 m) to ~ 0 g-C/m^2-d below 3.5 m. Respiration (R) was also highest at the surface (~ - 0.7 g-C/m^2-d) decreasing to ~ -0.3 g-C/m^2-d at 4.5 m. Only the surface waters (0.5) showed positive Net Primary Production (NPP). Total integrated water column GPP (GPP_{TOT}) was only 0.73 g-C/m^2-d and was exceeded by a R_{TOT} of -1.47 g-C/m^2-d yielding a NPP_{TOT} was -0.74 g-C/m^2-d indicative of net heterotrophic conditions (**Fig. 5**). A comparison of nutrient concentrations (PO_4^{3-} (**Fig. 6a**) and NO_3^- (**Fig. 6b**)) in the water column at the L/D Bottle deployment site in the lower Severn River on 04 March 2019 to those measured in light and dark bottles on 05 March 2019 shows some uptake of nutrients during photosynthesis and remineralization of nutrients by respiration consistent with the low rates of GPP and R. The standing stock and biomass of large (meso-) zooplankton (> 250 µm) in the lower Severn River over the course of the study was fairly high, ~ 3000 – 5000 individuals/m^3 and 0.003-0.005 g-C/m^3, respectively. This suggests active cycling of organic matter in the lower Severn River even at the low wintertime primary productivity levels measured in this study.

Table 1. Mean zooplankton (> 250 µm) standing stock (# individuals/m^3) and biomass (g-C/m^3) from plankton net tows of the lower Severn River on 04 and 05 March 2019. The mean and standard deviation was based on n = 10 counts. Zooplankton biomass was estimated using a carbon content for adult *Acartia* spp. and *Eurytemora affinis* following methods modified from *Reaugh et al.(2007)*.

Date	Standing Stock (# Individuals/m^3)		Biomass (g-C/m^3)	
	Mean	***Std. Dev. (n=10)***	***Mean***	***Std. Dev. (n=10)***
04 March 2019	3199	+/- 524	0.003	+/- 0.0005
05 March 2019	5036	+/- 2253	0.005	+/- 0.002

Figure 7. Pictures of zooplankton (> 250 µm) collected from the lower Severn River (Fig. 1) in plankton net tows on 04 and 05 March 2019. Pictures are magnified digital microscope images.



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