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Phytoplankton and Zooplankton development in a lowland temperate river

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Abstract-

The longitudinal and seasonal patterns Of Plankton development were examined over 2 years in a lowland, temperate river: the Rideau river (ontario, Canada).

Following an initial decrease in phytoplankton and Zooplankton biomass as water flowed from the headwaters into the Rideau River Proper, there was an increase in chhorophyu a (Chl a) and Zooplankton biomass with downstream travel. At Approximately river km 60, Both Phytoplankton and Zooplankton reached their Maximum biomass of both planktonic comimunitiesdeclmed significantly despite increasing nutrient concentrations and for our able light conditions. These downstream declines may be due to the feeding activity of the exotic zebra mussel (DreisinaPolymorpha) Which was at high density in downstream reaches (<1000 Individuals m^{-2}). There was no evidence for longitudinal phasing of phytoplankton and zooplankton as increases and decreases m chla and zooplankton biomass appeared to coincide. Overall chla was best predicted by total phosphorus (R^2=0.20). There was no evidence for significant graving effects of zooplankton on phytoplankton biomass.

Introduction:-

Planktonic organisms can attain significant densities in large lowland rivers where residence times and low flow rates allow sufficient time for growth and reproduction (Margalef,1960, de Ruytervansteveninck et al, 1990 a). However, little research has focused on the regulation of phytoplankton and zooplankton development and the interactions between these two communities in rivers (Reynolds 1988; Kohler, 1993; Thorp et al. 1994).

The factors regulating river plankton abundance may be hydrological (Discharge, water, residence, time, chemical) (nutrient concentration), Physical (light conditions) and biotic (grazing, competition) (Reynolds, 1988; Mass et al. 1989) An ined inverse correlation between phytoplankton biomass and river discharge has been demonstrated (Jones, 1984; Tones and Barrington,1985; Reynolds, 1988). Others Researchers have concluded that river phytoplankton is more strongly regulated by nutrient concentrations. A significant positive relationship between river phytoplankton abundance and total phosphorus concentration has been observed (Soballe and Kimma, 1987; Mass et al. 1989; Basu and pick, 1996; Van Nleuwanhuyse and Jones, (1996). Owing to the turbulent and often turbid conditions found in many rivers, light conditions may regulate river phytoplankton development (krogstad and lovstad, 1989; gole et al. 1992). In deep sections of rivers, When the depth of mixing is greater than the depth of the phatic zone. It is possible that algal ceus are exposed to light levels below the threshold for net growth (Lewis, 1988; case et al. 1992).

In comparison to phytoplankton, there has been less attention devoted to the Zooplankton of rivers. Pace et al. 1992) and Thorpe et al. 1994) Observed zooplankton abundance to be negatively correlated with river discharge in the Hudson and olio rivers (USA), respectively, similarly, Basu and Pick (1996) Observed that across a range of 31 rivers in on torpo, Canada. Zooplankton biomass was positively related to water residence time. In addition, to what extent zooplankton impact algal communities in rivers remains little explored. The present study examines the development of phytoplankton and zooplankton longitudin ally and seasmally within a temperature lowland river (Rideau River Ontario, Canada). Our previous work on the RideawlBasu and pick, 1995) indicated extensive longitudinal changes in phytoplankton biomass. The objectives ettries. Study were: (I) To describe the longitudinal and seasonal pattern of both phytoplankton and zooplankton development (II) To determine the factors most strongly related to zooplankton biomass (III) To determine the factors most strongly related to phytoplankton biomass. Variable measured included chlorophyll a (chla), crustoneon zooplankton biomass, rotifer biomass, nutrient concentrations River discharge, light attenuation, depth and temperature. Invasim of the Rideau River by the exotic zebra mussel (dreissenapolymorphy) Ocurea in 1990 and densities have increased since (1990-1995) (Martel, 1995). Therefore, we also evaluated the potential effect that this benthic suspension feeder could have on plankton biomass.

Method

Study Area

The Rideau River is located in southeastern Ontario and flows northeast for 110 km from flits. Headwaters in lower Rideau lake before discharging into the Ottawa river at Ottawa ($45^o27^,$ N, 75^0 $42^,$W). The average annual discharge of the Rideau is 38.9 m^3/s and the watershed area at Ottawa is 3830 km^2 (water survey of canada 1990).

Being lake fed, discharge does not change appreciably along the Rideau's length and there are only a few small tributaries. In summer when river discharge is 10 m^3s^{-1}, It takes 15 days for water to trace from lower Rideau lake to the mouth of the Rideau lake to the mouth of the Rideau (B. K. Basu, Unpublished data). Approximately 70% of the water shed area is Agricultural land, the remainder is either forested or urban (Davidson, 1990). The primary user of the river are for recreation and water supply, and there are no major Industries located along the Rideau's course.

One month, from May to October 1994 and May to September 1995, the Rideau was sampled at 15 sites. Site 1 was located In the headwaters while sites the 2-15 were located within the river proper upstream from the city of Ottawa. The sites were evenly spaced 7 km a part.

Field Sampling

Water samples were taken Mid-channel using a 4 km vertically integrated tube and it was assumed that the water column was vertically homogeneous (Basu and pick, 1995). Five 21 samples were taken for algal chla and three 300ml samples were taken for measurement of total phosphorus (TP), soluble reactive phosphorus (SRP) and total nitrogen (TN) Concentrations. For chl a water sampels were filtered through whatman GFIF filters. Chl a was extracted using DMSO and acetone (Burnison , 1980), and concentrations were calculated using the equations of Jeffrey and Humphrey (1975). Chempcal analysis to determine TP, SRP and TN concentrations was performed at the regional municipality of Ottawa-cerleton, water quality laboratories by standard methods (Basu and pick 1995). Zooplankton were sampled mid-channel at site 1, 3, 5 7, 9, 12 and 14 following methods described in (Basu and pick 1996). Tripicate macro zooplankton (rotifess) samples were collected by filtering 41 through a 35 km. Nitex mesh screen. Samples were preserved with 4% formalin-sucrose (Haney and Hall, 1975).

Zooplankton abundance was determined by enumerating either whole simples or counting at least 120 individuals in sub simples to each replicate. Cladocerans and copepeds were counted under a dissecting microscope (50x), and rotifers under and inverted microscope (80x). crustaceans and rotifers were identified to genus level following. Thorp and couich (1991) and stemberger (1979). Biomass estimates for crustaceans and rotifers were determined using methods described, in Basu and pick (1996). Total Zooplankton biomass (dry mass) was the sum of crustacean and rotifer biomass.

Depth was measured with and LCR 400ID depth sounder (Marine Information, USA) and temperature was measured with a mercury thermo light attention coeffictents were calculated using irradiance measurements Obtained with a Li-cor 185B 4π under water photometer (Li-cor USA).

Euphatic depth (1% light level) to mixing depth ratios were calculated using attention coefficient and assuming that mixing depth was equivalent to the total depth the shallow depth of the Rideau (usually 3-5 km) Justified this assumption.

Discharge values were Obtained from the water survey to Canada. Which maintains a continuous gauging site a Ottawa. Discharge was calculated as the average of the daily discharges for the period 7 days prior to and including the sampling date (Pace et al. 1992; Basu and pick, 1995).

Statistical Analysis

Statistical analysis was performed using systat 5.03 (systatinc; USA, 1993) software polynomial regression was used to quantity longitualtral pattern of variables. The inclusion of site 1 (Lower Rideau lake km 0) during polynomial regresoion analysis created significance at third-and forth-order levels. Therefore because site 1 was not located in the Rideau river proper and the most parsimonious regression models were desired we did not include site 1 during the deriuation of equations. Linear regresstion and correlation were used identify relationships between variables.

All Parametric test performed satisfied the assumptions of normality and homoscedasticity following any required logarithmic transformation of the data.

Results.

Longitudinal and seasonal development of chlorophyll a The longitudinal patterns in chl a for the sampling months of 1994 and 1995. In all months for both1994 and 1995 there was decrease in chl a as the water flowed from site1 (lower Rideau lake, km 0) into the Rideau River proper at site 2 (km 7). With the exception of may 1994, October 1994 and July 1995, the subsequent development of chla along the river proper could be describe using a second-order polynomial including km and km^2 terms as significant independent variables. Chila increased with downstream longvel peaked, and then decreased. The longitudinal kilometerat which the peak in chla occurred ranged from km 54 to km 76 and was most often located near km 60. To obtain the most general second-order polynomical describing the longitudinal development of cha in the Rideau, the data from all the months (Of second order) were combined and an over all second orver equation deriver (chl a $=1.29+0.47\text{km}-0.004\text{km}^2$, $p=0.001$, $R^2=0.35$).

Using this equation, we estimated that peak chla occurred at km 59.3.

The longitudinal pattern of chla in May 1994 and October 1994 was best described using a first-order (simple linear) regression. In these months chl a continued to increase with downstream travel. The longitudinal pattern of chla for July 1995 was not predictable even upon trial of a tenth-order polynomial longitudinal and deasonal development of Zooplankton biomass.

The longitudinal development of zooplankton biomass in the Rideau River could not be described using polynomial regressions (p)0.05 for all months up to fifth orders. However several patterns were repeated from month to month and across years. For all months to both 1994 and 1995, there was a decrease in total Zooplankton biomass from site 1 (lower Rideau lake, km 0) to the first river line Zooplankton sampling site (site3,km 14). This decrease in Zooplankton biomass was often very large (e.g. August 1994, June 1995).

Following this initial decrease Zooplankton biomass tended to increase downstream. After peaking at site 9 (km 56) or site 12 (km 27) Zooplankton biomass usually fell, often with very low levels recorded at site 14 (km 91) Longitudinal and seasonal trends in nectrient concentrations.

The longitudinal pattern in TP for the sampling months of 1994 and 1995 is shown. In contrast to the second-order pattern exhibited by chla the longitudinal trend in TP for most months was a simple linear increase in TP with downstream travel. Seasonally, TP tended to be higher in the summer months (June, July and August).

In comparison to TP longitudinal and seasonal patterns in SRP were less evident. SRP was low (<10 ug I^{-1}) along most of the Rideau, but increased at sites 13 (km 84), 14 (km 91) and 15 (km 98). At these downstream sites, SRP was often >20mgi^{-1}. As with SRP Indentifi able longitudinal or seasonal patterns in TN were difficult to establish Gradual increases in TN were sometimes. Observed, as wedre high concentrations at sites 13 (km 84), 14 (km 91) and 15 (km 98) for several months (>1000 ligin).

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