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The Impact of Climate Change on Zooplankton Biodiversity Index (ZBDI) in Lake Kinneret, Israel

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Abstract

Climate change conditions were indicated in the watershed of Lake Kinneret: air and consequently water temperature increase, decline in rainfall, and diminish river discharges accompanied by a reduction in Epilimnetic nitrogen and a slight increase in phosphorus. It is suggested that warming trend of the Kinneret Epilimnion enhanced decline of Zooplankton Biodiversity Index (ZBDI).

Keywords

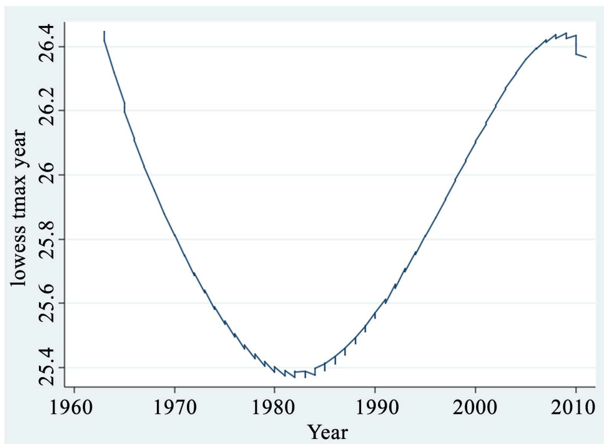
Climate Change, Kinneret, Zooplankton, Biodiversity

1. Prefaced Background

Evaluation of pollution processes in lakes are commonly, indicates changes of nutrients dynamics, phytoplankton biomass (density and composition) and physical properties such as water temperature, water level fluctuations and hydrological conditions. During the last 30 - 40 years, the involvement of fish community structure and feeding habits respectively were also included as factors of lakes pollution significances. The study of thermal pollution became recently an intensive research topic due to climate change, mostly global warming. A world-wide development of awareness to concern about water quality is indicated by major parameters such as biodiversity and biomass density of plankton organisms.

The Shannon-Wiener Biodiversity Index was implemented for the study of Zooplankton Bio-Diversity Index (BDI) in Lake Kinneret. Four, five and nine species of Copepoda, Cladocera and Rotifera, respectively, were included. Direct relations between Epilimnetic temperatures [1] and Zooplankton Bio-Diversity

Indexes (BDI) were indicated: Matching was found between low BDI and the high summer temperature and between higher BDI and the low winter temperature. Lake Kinneret is a warm Monomictic body of freshwater located in the sub-tropical geographic zone which represents short, wet and cold winter whilst the summer is long, dry and warm [2]. Consequently, high degrees of seasonal temperature changes induce significantly seasonal BDI fluctuations. Since mid-1980's Regional Climate change of, among others, temperature elevation was documented in the Lake Kinneret (**Figure 1** and **Figure 2**) drainage basin and consequently in the Kinneret Epilimnion (**Figure 3**) [1]. It is suggested that temperature increase probably enhanced the seasonal changes of BDI values. Moreover, progressive dryness conditions (**Figure 4**) induced Peridinium disappearance and promoted domination of Cyanobacteria in Lake Kinneret (**Figure 5**). The proliferation of Harmful Cyanobacteria (HFCB) is presently a global concern and the impact of temperature elevation is emphasized. Lake Kinneret is a prominent example of those global climate changes. The decline of precipitation, reduction of river discharges and temperature elevation were enhanced during the recent 25 Years.



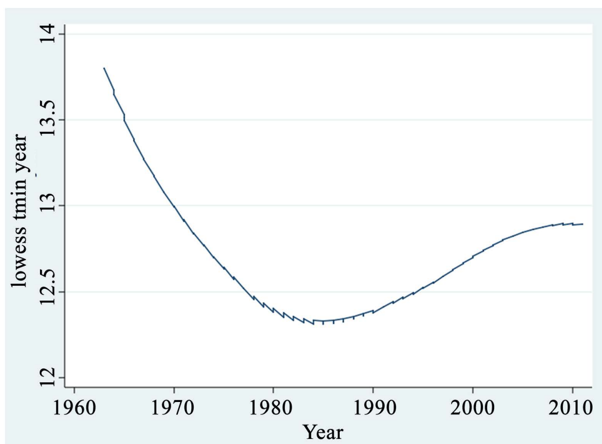


Figure 1. Trend of temporal (1963-2011) changes (LOWESS; 0.8) of annual averages of daily maxima (upper) and minima (lower) of air Temperatures in Dafna meteorological station In the Kinneret Watershed.

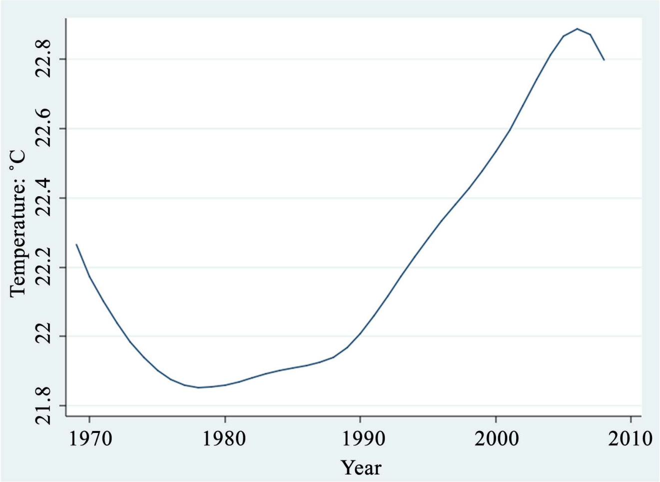


Figure 2. Trend of changes (LOWESS; 0.8) of annual means of whole water column averaged temperature in Lake Kinneret during 1969-2008.

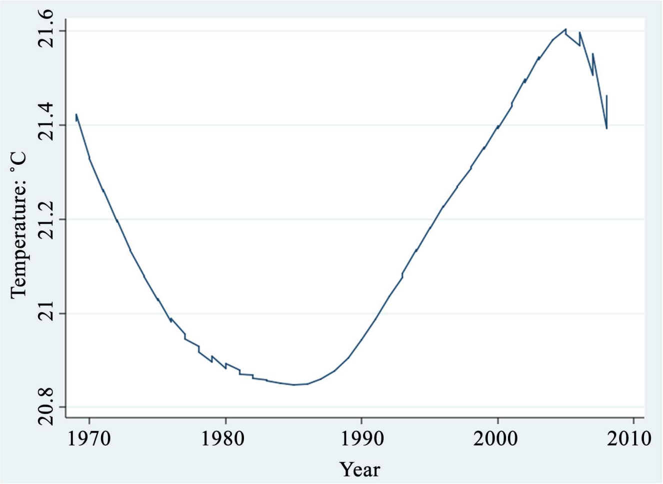


Figure 3. Trend of changes (LOWESS; 0.8) of annual means of the Epilimnioin layer averaged temperature in Lake Kinneret during 1969-2008.

Consequently, the influence of resulted Nitrogen input decline and water temperature increase enhanced the disappearance of the Peridinium phytoplankter domination which was replaced by toxic Cyanobacteria (HFCB) algal composition (**Figure 5**) [3].

2. Results and Discussion

2.1. Climate Change Implication

Heat capacity or thermal capacity, defined as the amount of heat energy that must be provided to an object (water mass) in order to raise its temperature by one unit. Heat capacity is proportional to the water mass volume. Heat capacity of a certain mass is divided by the weight or volume of the mass, yielding the specific heat capacity (or "specific heat"). The volumetric heat capacity indicates the heat capacity per volume.

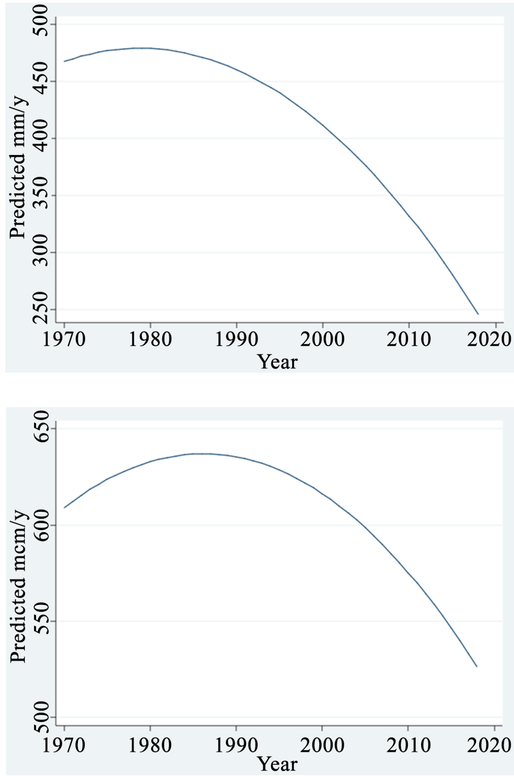


Figure 4. FP Regressions between annual rain (mm) (upper) and annual Jordan discharge (mcm/y) (lower) and Years (1970-2010).

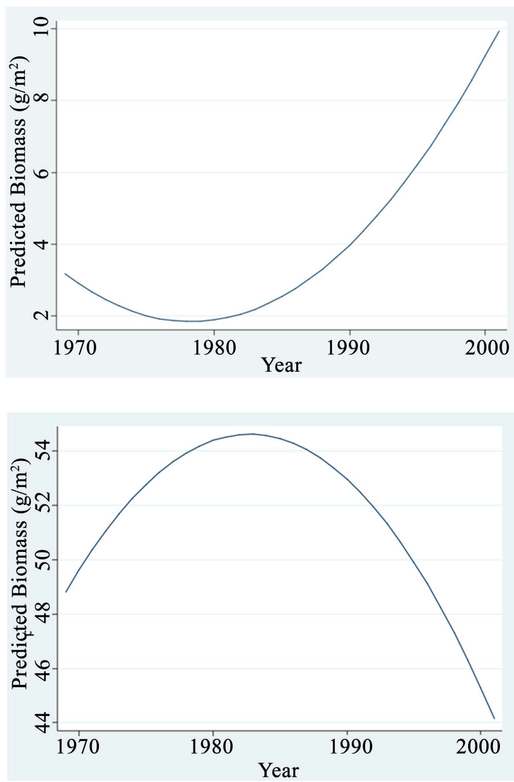


Figure 5. FP regressions between annual averages of phytoplankton biomass (g/m^2): Peridinium (upper) and Cyanobacteria (lower), and years (1970-2001).

Data given in Table 1 indicates a typical reduction of Bathymetric layer volumes (Serruya 1978), and the increase of layer temperatures (ΔT) by 0.2˚C - 0.4˚C between 1969-2001.

The data given in Table 2 indicates the closely related changes of rain decline and air temperature increase.

2.2. Climate Change and BDI Interrelationships

There are many documentations about temperature causation for modification of the BDI's aimed at undermining ecosystems' stability. It was indicated that Climate change potentially drives Biodiversity patterns. The great level of dependence between Biodiversity and Temperature at the extreme nutrient level, confirmed the direct impact of Temperature and nutrients on Biodiversity. Consequently, future climate scenarios such as global warming could alter Biodiversity. The positive relations between temperature and species richness (Biodiversity) was widely documented.

Results in Table 3 indicate linear temporal significant relations between BDI and Years, and Temperature and Years; and also Significant relations between

Table 1. Bathymetrical depth layer volumes (10^6 m^3) and respective mean temperatures during two periods in Lake Kinneret: 1969-1980 (mean Water level 210.09 mbsl; mean lake volume 3834 × 10^6 m^3) and 1991-2002 (mean Water Level 211.42 mbsl; mean lake volume 2863 × 10^6 m^3) and periodical ΔT (˚C).

Depth Layer (m)	Volume (10^6 m^3) 1969-1980	Volume (10^6 m^3) 1991-2002	Mean Temp. (˚C) (1969-1980)	Mean Temp. (˚C) (1991-2002)	ΔT (˚C)
0 - 10	1573	1279	21.9	22.3	0.4
11 - 20	1215	992	20.2	20.4	0.2
21 - 30	729	506	16.3	16.7	0.4
31 - 40	309	85	15.3	15.5	0.2

Table 2. Periodical means of annual precipitations (mm), daily maximal and minimal air temperatures (Dafna station).

Period	Annual Precipitation (mm)	Daily Minimal air temperature (˚C)	Daily Mximal air temperature (˚C)
1969-1980	657	12.6	25.6
1981-1990	617	11.8	25.0
1991-2001	604	12.8	26.0

Table 3. Linear regression parameters (r^2, p) between epilimnetic Temperature (annual mean) (Tem.), Time (year), Annual mean Index of Diversity (Index), annual mean of Total zooplankton densities (No/L) (Total) during 1970-2001, S = Significant ($p < 0.1$).

Regression	r^2	p
Tem Vs Year	0.307	0.001 (S)
Index Vs Year	0.525	<0.0001 (S)
Index Vs Tem	0.180	0.015 (S)
Total Vs Year	0.141	0.034 (S)
Total Vs Index	0.272	0.002 (S)

BDI and Temperature, and Total zoolnkton [4]. The BDI is a measure of biological diversity which is an indicator of species richness in a habitat diverted. It was fairly accepted that the dominant parameter effect on the BDI changes is temperature. Global Biodiversity expressed as the richness of families, genera, species and sub-species is significantly affected by temperature. The decline of BDI in response to warm "greenhouse" phases which may have implications for biological extinctions and Biodiversity changes under future global warming events is also known. An important conclusion documented in a UN report on loss of Biodiversity and extinctions is that the severe threat to species richness and elimination is significantly affected by climate change and the decline of the index is clearly related to temperature elevation. BDI is affected by temperature but the significance of this impact depends on the time span continuation and/or the thermal range of the modification. If high and low thermal conditions alternate, BDI fluctuates intermittently as well. It was indicated that seasonal fluctuations of epilimnetic temperature are consequently accompanied by a significant change of BDI level. Therefore, it is suggested that BDI monitoring in the Kinneret Epilimnion supports an indication of Global Warming effect in this part of the planet.

Air temperature elevation causes warmer lake surface waters which in turn increase stratification stability due to increase water density gradient profoundly. Reduction in bottom-up fluxed nutrient migration is possibly enhanced. Decline of rainfall could be the reason for longer residence time following by nutrients accumulation a well known cause of pollution and water quality deterioration. Moreover, bloom forming Cyanobacteria are likely to be favored in a warming climate [5] [6] [7]. It was reported that in the last century temperature increased by approximately 0.7˚C and continuation is likely to be elevated by 1˚C - 6˚C by the end of the 21st century.

3. Summary

The climate change (rainfall decline) induced lowering of external nutrient inputs (mostly Nitrogen) whilst internal factors of volume shrinkage and possibly internal conditions enhanced Phosphorus release from the sediments. Consequently, the thermal pollution (Temperature increase) driven eco-forces enforced a combined effect between the external (climate condition) and internal conditions (enhanced P release from the sediments) and resulted in a water quality deterioration. Moreover, global warming caused an increase of extinction risk, *i.e.* BDI decline [8]. Climate change acts as addittional pressure compromising Biodiversity and freshwater ecosystem function and potentially disturbing the ecological services they provide [9]. Increase of diversity in response to minor decline of temperature in a warm deep sea was documented by [10].

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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