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Predictability of Ecological Changes in Lake Kinneret

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Abstract

Several ecological key factors were indicated in the Lake Kinneret ecosystem during 1969-2000: Elevation of the biomass of non-pyrrhophyte-phytoplankton, chlorophyta, cyanobacteria, and diatoms; decline of Peridinium maximal from 215 - 240 to 175 - 200 ranges (g/m^2); decline of zooplankton (herbivore and predator) relative to phytoplankton biomass (g/m^2); lower loads of Nitrogen and slightly also phosphorus in the river Jordan discharge; decline of precipitations and lake water level; significant decline of epilimnetic nitrogen and minor changes of phosphorus concentrations initiated decline of N/P mass ratio to the establishment of a significant change of the ecosystem to be modified from P to N limitation. What could be other than essential outcome of future prediction that results of 20 years (1969-2000) of routine and comprehensive monitor carried out in Lake Kinneret initiated? The Lake Kinneret ecosystem dynamics after 2000 justified retroactive post-factum earlier conclusion of appropriate predictability.

Keywords

Kinneret, Nitrogen, Phosphorus, Cyanobacteria, Ecosystem Structure

1. Introduction

During the last 80 years the Lake Kinneret and its drainage basin have undergone significant changes. Some of those changes are natural and others are anthropogenic. The present ecosystem structure is not similar to that one that was investigated and practically operated during 20 years earlier. Ecological modifications did not come abruptly but gradually instead. It is the natural characterization of ecological systems to be changed gradually and therefore their recognition is not commonly strictly defined. The rational of this paper is making a renovated insight into an earlier (1969-2000) recognized trait of Lake Kinneret ecosystem structure as background for the consideration of the up-to-date (>2000's) alterations. Gradual ecosystem changes do not always appear abruptly and therefore the recognition of a change as a long-term modification requires longer duration. A critical question is therefore: would it be possible to recognize earlier ecosystem significant alteration as a start of a long-term case. The usage of old (1969-2000) data through re-evaluation access was considered here to justify an outcome of predicted conclusion about on-going trends of ecological changes.

As of 2010, when desalinization program was implemented (650 10^6 m^3/y; mcm/y), Lake Kinneret, was the national major source for domestic water supply. The Kinneret ecosystem has undergone man-made and natural modifications: dam construction (1933), salty water diversion (1967), salinity fluctuations, National Water Carrier construction (1957), fish stocking and fisheries management, long term decline and increase of water level, droughts and floods, modification of phytoplankton biomass and species composition, beach vegetation; nitrogen decline and a slight increase of phosphorus in the lake epilimnion; decline of nitrogen loads in the Jordan River; decline of the epilimnetic N/P mass ratio, followed by enhancement of cyanobacteria. The Kinneret ecosystem shifted from P to N limitation. The decline of water level is due to both natural droughts and surplus pumping. Decline in nitrogen in the Kinneret epilimnion was probably due to both the reduction of river discharges (droughts) and a lower N contribution from the drainage basin, as a result of anthropogenic activities. The Hula old Lake and swamps in the vicinity were drained and land was converted to agricultural development; most of the sewage (human and fishpond effluents) was eliminated from the lake; conclusively, the change in the Kinneret ecosystem structure by shifting from P to N limitation was affected by both the anthropogenic and natural processes. Those changes implemented from 1933 and onwards [1].

2. Historical Developments within the Hula Valley

Prior to the 1950s, the Hula Valley was mostly (6500 ha) covered with old Lake Hula (1300 ha), and swampy wetlands. This area was not cultivated, malaria was common, and water loss by Evapo-Transpiration was significant. The Jordan River contributes about 63% of the Lake Kinneret's water budget, but 70% of the total nutrient inputs, of which, over 50% originate in the Hula Valley region, with the valley and slopes on its both sides (East and West).

During the 1950s, 6500 ha of natural wetland and old Lake Hula were drained, and converted to agricultural use. During the following 40 years, the drained area was successfully cultivated, and the nutrient flux into Lake Kinneret did not threaten its water quality. Nevertheless, as a result of inappropriate irrigation and agricultural methods and the desertification processes, the peat soil quality was deteriorated by consolidation and destruction. A reclamation project was consequently implemented aimed at reducing nutrient fluxes, and combined with a land economical benefit.

3. Material and Methods

The chemical data of nutrient concentrations in the Jordan River, the computed Jordan River loads, and Discharges, as well, as the Epilimnetic nutrient concentrations during 1969-2000 was supported by the Kinneret Limnological Laboratory Data Base and Mekorot Water Supply Co. [2] [3] [4] The precipitations data and air temperature (1940-2018) was taken from the Dafna Meteorological Station (located in the northern region of the Kinneret basin) (M. Peres, The Hydrological and Meteorological Services, Water Authority).

Different parameters were assembled into implicated figures aimed at clear imaginary presentation. Several parameters together indicate the major issue of the paper: The awareness to potential initiation by comprehensive analysis of routinely monitoring of known and accepted parameters.

Four statistical methods were in use for the data analysis: Linear Regression, Fractional Polynomial Regression, LOWESS—Smoother Trend of Changes analysis (Strength 0.8), ANOVA ($p < 0.05$ or <0.01) STATA 9 and Statview).

4. Results

Jordan Discharge and Lake Epilimnion (1969-2000)

In order to indicate temporal changes of nutrient concentrations (ppm) the period of 1970-2000 was divided into two periodical groups (Table 1): 1970-1984 and 1985-2000. The two periods were comparatively (ANOVA Test) ($p < 0.05$) analyzed against each other. In Table 2 the total period of 1970-2000 was comparatively tested (ANOVA Test) ($p < 0.05$) against the Period of 2001-2018.

Table 1. Results of ANOVA Test ($p < 0.05$) comparatively evaluation of (p = probability values are given) annual averages (SD) of monthly means of chemical parameters (ppm) measured in the Jordan River at the Gesher Huri (Gesher Ha'Pkak) sampling Station during two periods, 1970-1984 and 1985-2000; Data Source: Mekorot Water Supply Co. Jordan Region Monitoring Unit; Kinneret Limnological Laboratory, IOLR (1970-2018) [2] [3] [4].

Parameter	1970-1984	1985-2000	p:S = Significant; NS = Not Significant
Kjeldhal Dissolved	0.583 (0.157)	0.342 (0.076)	<0.0001 S
Kjeldhal Total	1.197 (0.341)	0.645 (0.092)	<0.0001 S
NH_4	0.129 (0.068)	0.100 (0.054)	0.1915 NS
NO_3	1.621 (0.363)	1.911 (0.348)	0.0308 S
N-Organic	1.068 (0.353)	0.545 (0.077)	<0.0001 S
TN	2.804 (0.451)	2.550 (0.370)	0.0965 NS
SRP	0.027 (0.008)	0.033 (0.005)	0.0143 S
TDP	0.044 (0.013)	0.040 (0.004)	0.2485 NS
TP	0.239 (0.083)	0.176 (0.078)	0.0381 S

Table 2. Results of ANOVA Test ($p < 0.05$) comparatively evaluation of (p = probability values are given) annual averages (SD) of monthly means of chemical parameters (ppm) measured in the Jordan River at the Gesher Huri (Gesher Ha'Pkak) sampling Station during two periods, 1970-2000 and 2001-2018; Data Source: Mekorot Water Supply Co. Jordan Region Monitoring Unit; Kinneret Limnological Laboratory, IOLR (1970-2018) [2] [3] [4].

Parameter	1970-2000	2001-2018	p:S = Significant; NS = Not Significant
Kjeldhal Dissolved	0.459 (0.171)	0.230 (0.038)	<0.0001 S
Kjeldhal Total	0.912 (0.370)	0.434 (0.069)	<0.0001 S
NH_4	0.114 (0.062)	0.058 (0.013)	0.0004 S
NO_3	1.771 (0.379)	2.021 (0.229)	0.0144 S
N-Organic	0.789 (0.363)	0.381 (0.063)	<0.0001 S
TN	2.673 (0.425)	2.440 (0.228)	0.0367 S
SRP	0.030 (0.007)	0.026 (0.005)	0.0755 NS
TDP	0.042 (0.010)	0.033 (0.006)	0.0004 S
TP	0.207 (0.085)	0.117 (0.030)	<0.0001 S

Results in Table 1 indicate significant lower concentrations of nutrients, excluding Ammonium, Total Nitrogen and Total Dissolved Phosphorus during 1985-2000 period, *i.e.* temporal decline. Similar ANOVA Test ($p < 0.05$) was done for Jordan River Annual Discharge (mcm/y): the two averages were 479 (SD = 116) and 418 (SD = 187) for the two periods respectively and p value = 0.2875, *i.e.* the difference is not significant.

Results in Table 2 indicate recent (2001-2018) long-term decline of nutrient concentrations, except Soluble Reactive Phosphorus in Jordan waters. Similar ANOVA Test ($p < 0.05$) was done for Jordan River Annual Discharge (mcm/y) the two averages were 448 (SD = 157) and 355 (SD = 181) for the two periods respectively and p value = 0.0669, *i.e.* the Jordan discharge was significantly lower during 2001-2018 than during 1970-2000.

Rain Gauge

In Table 3, the annual rain gauges of 1940-2018 were grouped in 4 periods.

Results in Table 3 indicate precipitation decline since 1970. The obvious outcome of the precipitation decline is the annual Jordan River discharge (10^6 m^3/y; mcm/y) also decreased (see above) and consequently the Lake Kinneret Water Level (WL) as presented in Table 4.

Results in Table 4 indicate 21% decline of water input through the Jordan River into Lake Kinneret and mean WL decline of 0.96 m during 1985-2000. Averaged Daily changes of WL (ups and downs in cm) were about the same in both periods.

The change of Lake Kinneret ecosystem structure during 1969-2000 is presented in the following three tables: Table 5—Zooplankton; Table 6—Phytoplankton; and Table 7—Chemistry.

Tables 5-7 represent the temporal changes of zooplankton (Copepoda, Cladocera, Rotifera) wet biomass (g/m^2) (Table 5) and Numerical densities (No./L) (Table 7) and Phytoplankton (Chlorophyta, Cyanobacteria, Diatoms, Peridinium.

Non-Pyrrhophytes (g/m^2), Chlorophyll (mg/m^2), Primary Production (gC/m^2/day) in Lake Kinneret comparatively (ANOVA; $p < 0.05$) in two periods: 1970-1984 and 1985-2000.

Results in Table 5 indicate sharp decline of the biomass of Copepoda, herbivores and predators later than 1984 whilst the decline of Cladocera was moderate and no significant change of the Rotifer's biomass.

Results in Table 6 indicate significant increase of the biomass of Cyanophyta, Diatoms and Chlorophyta. The periodical averages of the biomass of Peridinium was not significantly changed between the two periods whilst Maximal measures were varied between 215 - 240 and 175 - 200 g(ww)/m^2 during the earlier and later periods respectively. Taking into account that algal Primary Production is dominantly affecting DO concentration (upper 10 meters), the influence of increased biomass of Non-Pyrrhophyta is pronounced.

The Epilimnetic loads (tons/Epilimnion) were comparatively tested (ANOVA; $p < 0.05$) in two periods: 1969-1984 and 1985-2000 (Table 8).

Table 3. Rain data (mm/year) summary: periodical averages (SD), Max. - Min ranges, as measured in Dafna Station in the northern Hula Valley Region.

Period	Max-Min (mm/y)	Average (mm/y) (SD)
1940-1970	377 - 1038	594 (136)
1971-1984	358 - 843	637 (159)
1985-2000	348 - 1057	606 (189)
2001-2018	352 - 964	590 (152)
2014-2018	352 - 607	475 (90)

Table 4. Results of ANOVA Test ($p < 0.05$; S = Significant) comparatively evaluation of the annual averages (SD) of monthly means of Jordan River Discharge (mcm/y) measured at the Gesher Huri (Gesher Ha'Pkak) sampling station, and the WL (Meter Below Sea Level: MBSL) monitoring during two periods, 1970-2000 and 2001-2018; Data Source: Mekorot Water Supply Co. Jordan Region Monitoring Unit; Kinneret Limnological Laboratory, IOLR (1970-2018) [2] [3] [4].

Period	Mean WL (SD) (MBSL)	Mean (SD) Discharge (mcm/y)
1970-1984	210.02 (0.79)	448 (157)
1985-2000	211.06 (1.42)	355 (181)

Table 5. Results of ANOVA Test ($p < 0.05$) comparatively evaluated (p = probability values are given) annual averages (SD) of monthly means of Zooplankton Biomass parameters (g(ww)/m^2) measured in the Lake sampling stations during two periods, 1969-2000 and 2001-2018; Data Source: Kinneret Limnological Laboratory, IOLR (1970-2018) [2].

Parameter	1969-1984 (Mean (SD)	1985-2000 (mean (SD)	p value (S = Significant; NS = Not Significant
Copepoda (g(ww)/m^2)	12.2 (6.2)	7.3 (4.6)	<0.0001 S
Cladocera (g(ww)/m^2)	19.4 (11.6)	15.2 (9.7)	0.0001 S
Rotifera (g(ww)/m^2)	2.3 (2.9)	2.0 (3.0)	0.2135 NS
Total Zooplankton (g(ww)/m^2)	33.9 (14.5)	24.5 (12.5)	<0.0001 S
Total Phytoplankton/Total Zooplankton (biomass, w/w)	2.1 (2.1)	4.1 (4.1)	<0.0001 S
Herbivore Copepods	4.5 (2.3)	2.7 (1.7)	<0.0001 S
Predator Copepods	7.7 (3.9)	4.6 (2.9)	<0.0001 S

Table 6. Results of ANOVA Test ($p < 0.05$) comparatively evaluated (p = probability values are given) annual averages (SD) of monthly means of Phytoplankton Biomass (g(ww)/m^2) measured in the Lake sampling stations during two periods, 1969-2000 and 2001-2018; Data Source: Kinneret Limnological Laboratory, IOLR (1970-2018) [2].

Parameter	1969-1984 (Mean (SD)	1985-2000 (mean (SD)	p value (S = Significant; NS = Not Significant
Cyanophyta (g(ww)/m^2)	3.0 (4.4)	4.3 (8.0)	0.0387 S
Diatoms (g(ww)/m^2)	4.4 (12.0)	12.8 (32.3)	0.0007 S
Chlorophyta (g(ww)/m^2)	8.0 (6.3)	14.1 (14.0)	<0.0001 S
Peridinium (g(ww)/m^2)	49.2 (70)	55.7 (79)	0.3888 NS
Total Phytoplankton (g(ww)/m^2)	65.7 (68.1)	87.2 (79.0)	0.0044 S
Non-Pyrrhophyta (g(ww)/m^2)	15.3 (16.9)	31.5 (38.9)	<0.0001 S
Secchi Depth (m)	3.04 (0.88)	3.36 (0.74)	0.0005 S
Chlorophyll (mg/m^2)	202.2 (151.4)	207.1 (198.5)	0.8146 NS
PP (gC/m^2/month)	49.7 (21.5)	53.4 (24.0)	0.1603 NS
DO (0 - 10 m) ppm	8.5 (1.9)	9.4 (2.1)	0.0003 S

Table 7. Results of ANOVA Test ($p < 0.05$) comparatively evaluated (p = probability values are given) annual averages (SD) of monthly means of Zooplankton Density (No/L) measured in the Lake sampling stations during two periods: 1969-2000 and 2001-2018; Data Source: Kinneret Limnological Laboratory, IOLR (1970-2018) [2].

Parameter	1969-1984 (Mean (SD)	1985-2000 (mean (SD)	p value (S = Significant; NS = Not Significant
Rotifera	93 (34)	80 (51)	0.4080 NS
Ceriodaphnia spp.	30 (13)	22 (8)	0.0552 NS
Bosmina spp.	29 (10)	22 (8)	0.0419 S
Diaphanosoma sp.	17 (8)	8 (5)	0.0008 S
Cyclopoid Eggs	12 (5)	8 (7)	0.1147 NS
Adult Cyclopoida	47 (24)	19 (13)	0.0003 S
Cyclopoid Copepodite (1-4)	80 (29)	50 (21)	0.0024 S
Cyclopoid Nauplii	89 (19)	58 (32)	0.0027 S
Predator Cyclopoida Vs Herbivore Zooplankton (g(ww)/m^2)	0.34 (0.06)	0.29 (0.11)	0.1124 NS

Table 8. Results of ANOVA Test ($p < 0.05$) comparatively evaluated (p = probability values are given) annual averages (SD) of monthly means of Epilimnetic Chemical Parameters (Tons/Epilimnion) measured in the Lake sampling during two periods: 1969-2000 and 2001-2018; Data Source: Kinneret Limnological Laboratory, IOLR (1970-2018) [2].

Chemical Parameter (Tons/Epilimnion)	1969-1984 (Mean (SD)	1985-2000 (mean (SD)	p value (S = Significant; NS = Not Significant
TP	32 (11)	31 (12)	0.4016 NS
TDP	17 (5.)	11 (5)	<0.0001 S
SRP	4 (2)	2 (2)	<0.0001 S
NH4	103 (121)	97 (1124)	0.5927 NS
NO3	126 (155)	148 216)	0.2852 NS
Kjidhal. Total	1069 (361)	680 (201)	<0.0001 S
Kjldhal. Dissolved	756 (237)	457 (130)	<0.0001 S
TN	1195 (418)	848 (357)	<0.0001 S
TIN	268 (214)	266 (250)	0.9234 NS
NORG	927 (350)	582 (195)	<0.0001 S

Results in **Table 8** indicate significant decline of the loads of TDP, SRP, Nitrogen forms except TIN. The general trend of the nutrient content in the Epilimnion of Lake Kinneret was decline of Nitrogen and Bioavailable Phosphorus but no significant change of Total Phosphorus.

The dynamical trend of changes either in the Jordan River or in the Kinneret Epilimnion was evaluated graphically by regressions (Fractional Polynomial and LOWESS Smoother, 0.8) and the results are presented in Figures 1-11.

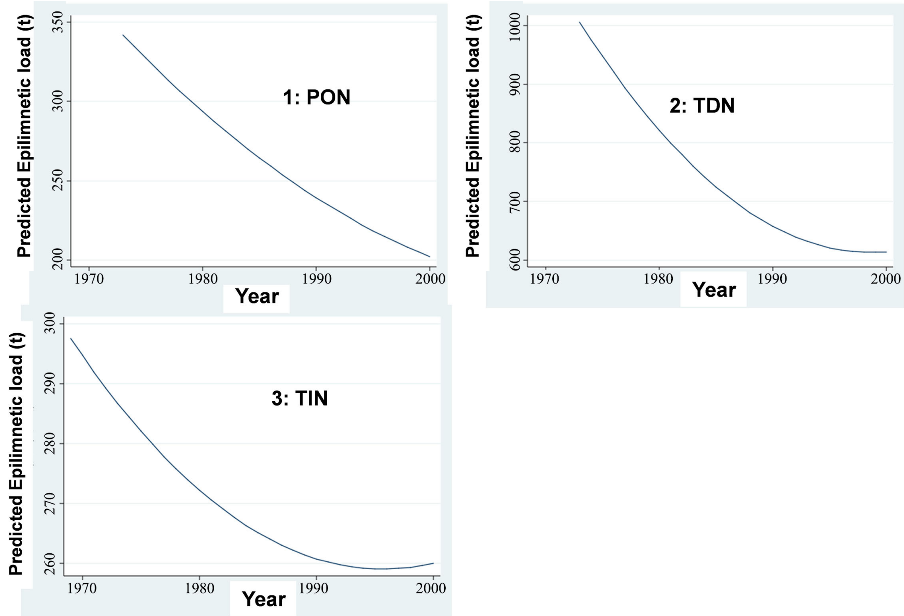

Figure 1. Fractional polynomial regressions between monthly averages of epilimnetic loads (ton) of particulate organic nitrogen (1: PON), total dissolved nitrogen (2: TDN) and Total inorganic nitrogen (3: TIN) and years (1969-2000).

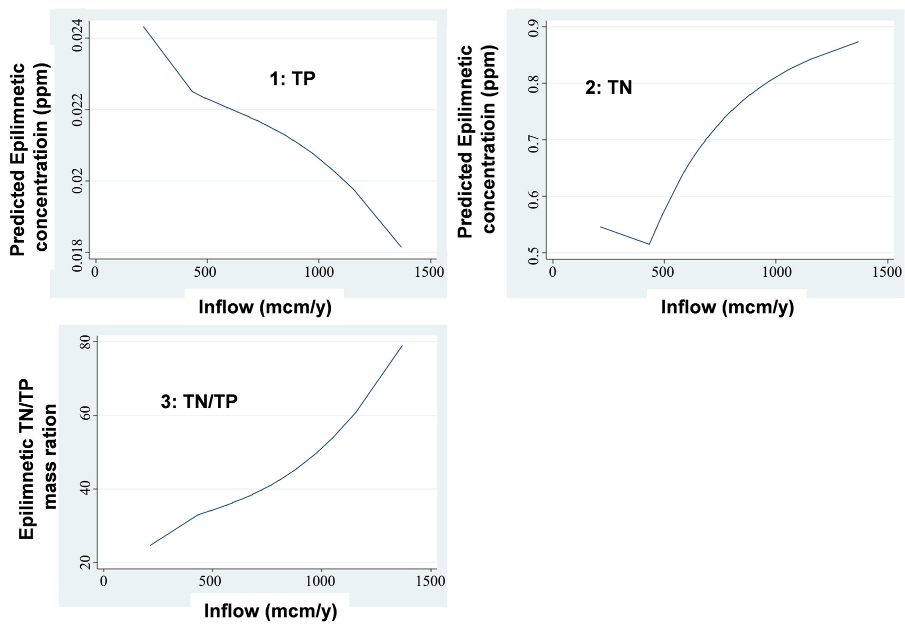

Figure 2. Fractional polynomial regressions between monthly averages of epilimnetic TP (1), TN (2) concentrations (ppm) and TN/TP mass ratio (3) and total water inputs (mcm/y) during 1969-2000.

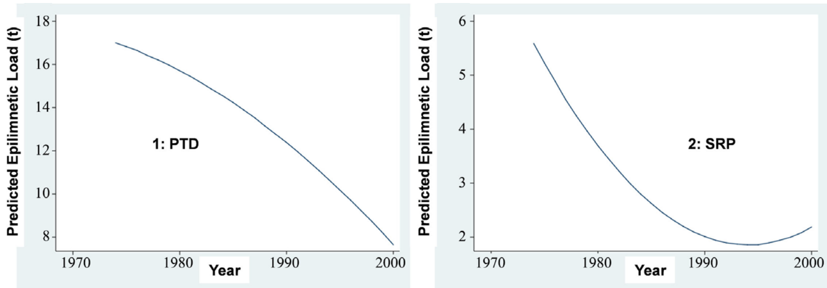

Figure 3. Fractional polynomial regressions between monthly averages of epilimnetic loads (tons) of phosphorus total dissolved (PTD) (1) and soluble reactive phosphorus (SRP) (2) and years (1969-2000).

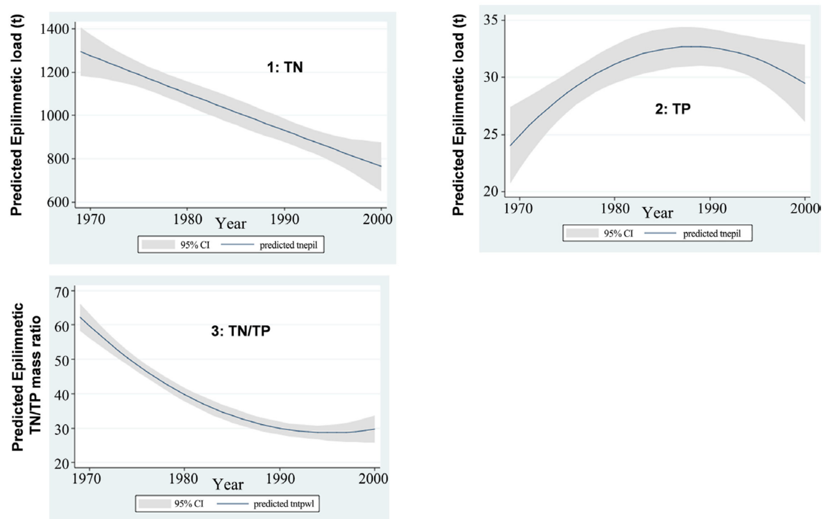

Figure 4. Fractional polynomial regressions (95% confidence interval) between monthly averages of epilimnetic loads (tons) of TN (1), TP (2) and TN/Tp mass ratio (3) vs years (1969-2000).

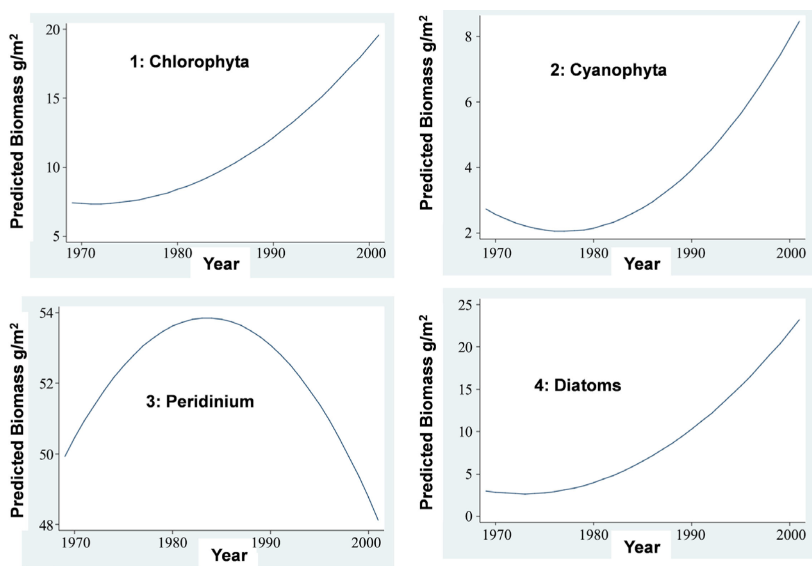

Figure 5. Fractional polynomial regressions between monthly means of phytoplankton biomass (g/m^2): chlorophyta (1), cyanophytes (2), peridinium (3), diatoms (4) and years.

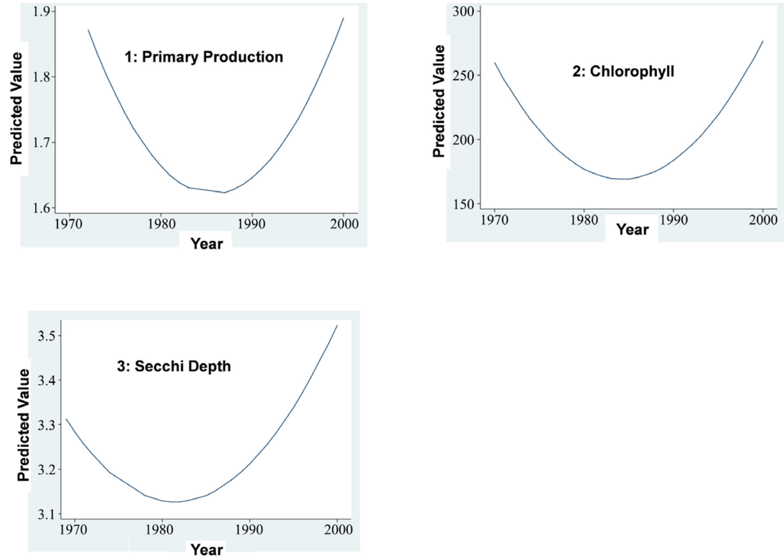

Figure 6. Fractional polynomial regressions of monthly averages of primary production ($gC/m^2/day$) (1), chlorophyll (mg/m^2) (2), and secchi depth (m) (3) vs years (1969-2000).

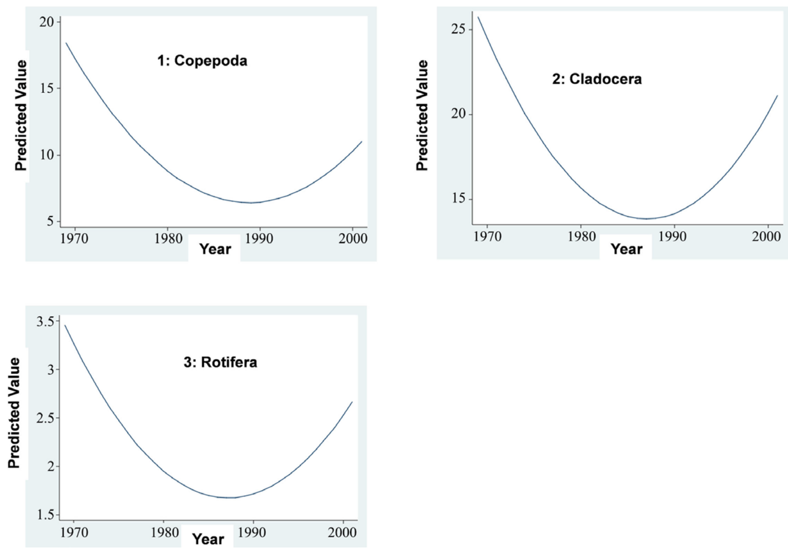

Figure 7. Fractional polynomial regression between monthly averages of the biomass (g/m^2) of zooplankton: 1: copepoda, 2: cladocera 3: rotifers and years (1969-2000).

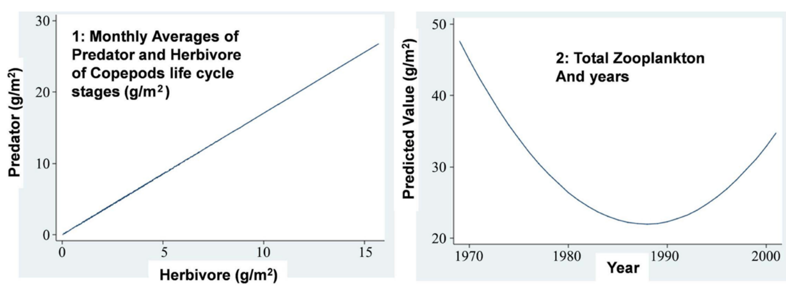

Figure 8. Fractional polynomial regression between monthly averages of predator and herbivore life cycle stages of copepoda (g/m^2) (1) and total zooplankton biomass (g/m^2) (2) and years (1969-2000).

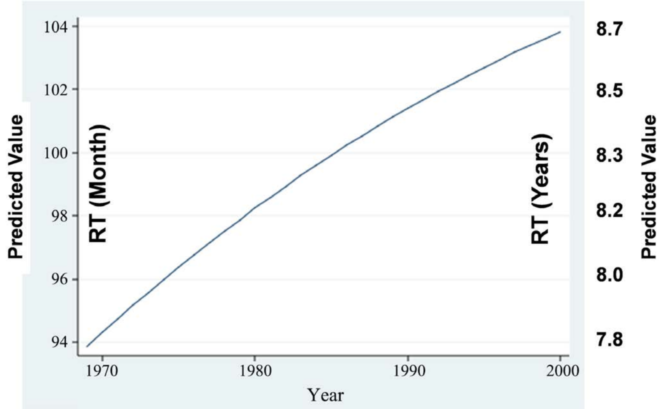

Figure 9. Fractional polynomial regression between monthly values of residence time (RT) in month (left) or year (right) (see text) during 1969-2000.

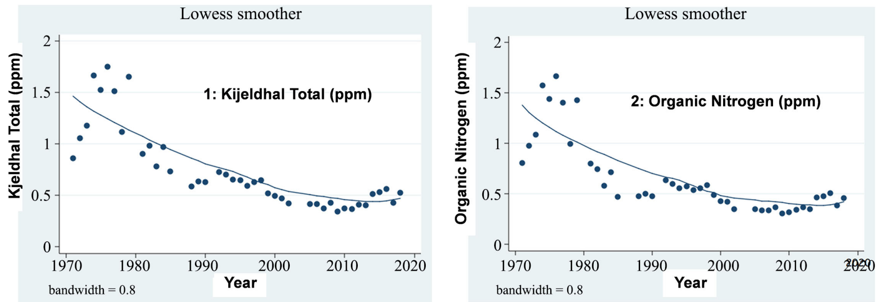

Figure 10. LOWESS smoother plot (band width = 0.8) of the relations between monthly averages of total Kjeldhal (1) and organic nitrogen (2) concentrations (ppm) in Jordan waters and years (1970-2018).

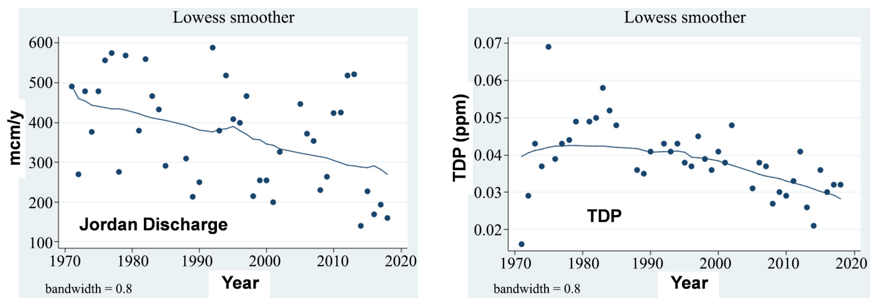

Figure 11. LOWESS smoother plot (bandwidth = 0.8) of the relations between monthly averages (1969-2018) of Jordan discharge (mcm/y) (1) and TDP concentrations (ppm). In Jordan water (2) and years.

The significant decline of the loads of PON, TDN and TIN in the Epilimnion of Lake Kinneret is shown in Figure 1. The decrease of TP concentration (ppm) in the Kinneret Epilimnion as related to enhancement of water inflow and inversely with TN concentration, is presented in Figure 2, *i.e.* the higher is the water input the higher is the Epilimnetic TN concentration and the lower is the TP concentration. Moreover, the higher is the inflow the higher is the TN/TP mass ratio. Figure 3 represents the decline of Epilimnetic loads of PTD and SRP during 1974-2000. The long-term decline of TN and increase epilimnetic loads of

TP and consequently decrease of TN/TP mass ratio is shown in Figure 4.

The long-term (1969-2000) elevation of Phytoplankton groups (Chlorophyta, Cyanophyta, Diatoms Peridinium) wet biomass (g/m^2) is presented in Figure 5 as well as increase of Peridinium between 1970-Mid 1980's and decline later. The decline of Secchi depth (turbidity enhancement) Primary Production and Chlorophyll content, are closely related to the enhancement of Peridinium Biomass whilst their increase is correlated with enhancement of non-phyrrhophyte algae (Figure 6). The fluctuations of Zooplankton Biomass (Figure 7 and Figure 8) are minor and probably mostly affected by fish predation pressure but insignificantly by predator zooplankters (Figure 8).

The record of Residence Time (RT) in Lake Kinneret during 1969-2000 was computed as follows:

Monthly total inflow = A

Monthly mean of Lake Volume = B

RT = B/A, expressed in months or years.

The results for the period of 1969-2000 are presented in Figure 9 indicates mostly decline of inputs from 1969 to 2000.

Figure 10 and Figure 11 present long term decline of Organic Nitrogen, Total Kjeldhal and Total Dissolved Phosphorus concentrations (ppm) as well as the total discharge in the Jordan River from 1969 to 2000.

5. Discussion

The management and design of Lake Kinneret, deserves a wide range of acceptance willing and agreement, between the public's ambition and formal authorized managers, legislators, and scientists within a formulated scope of a "golden pass" aimed at bridging between public demands and ecological rules. If scientific information is insufficient, a worldwide replacement principle known as "Carefulness Prevention" (CP) is implemented. The publicized separation between CP and scientific prediction is quite often not clearly obscured. Ecological rules are not always accepted as a preconditioned precedent. Compromise and compensations are significant contributions to a required "golden pass" solution. Nevertheless, cases of late recognition of scientific results and conclusions are well known worldwide. The specific case of the abrupt blooming by *Aphanizomenon ovalisporum* during the summer of 1994 as well as gradual changes within the ecosystem structure of Lake Kinneret exemplified an unpredictable phenomenon. The focus of this paper is an attempt at tentative definition: are those alterations are predictable or unpredictable? In the summer (September-October) of 1994, a heavy bloom of the N_2 Fixer-filamentous-heterocystous cyanobacterium, *Aphanizomenon ovalisporum* (*Forti*), was recorded for the first time in Lake Kinneret [5] [6] [7]. Earlier studies predicted cyanobacterial outbreak option as a result of epilimnetic N loads decline and a slight increase of the P load causing decline of N/P mass ratio. The ecosystem modification as a result of N decline but not that of P was recorded but the consequence of long term cyanobacterial dominance unfortunately was not predicted. On the contrary, the scientific response was even a negative objection. Cyanobacterial burst was denied accompanied by false alarm blame but in summer 1994 the N_2 fixers bloomed [5]-[15]. Zofia *et al.* [16] concluded that the best explanation for variations among lakes in the rate of cyanobacteria enhancement was due to nutrient (P, N) concentrations [14] [15] [16] [17] [18]. The Kinneret case represents how evaluated prediction of scientific data might prevent the replacement of "Carefulness Prevention" principle by submission of solid scientific conclusion for managers implementation [19].

The construction of the National Water Carrier (NWC) (1950's) gave Lake Kinneret the status of the major national resource for domestic supply. Recently (2010), seawater desalinization was almost exclusively designated for domestic supply, and the role of the Kinneret component was dramatically reduced to be functioned as an emergent storage. During 60 years (1950-2010) Lake Kinneret was stated as a public dependant and the population—as lake dependent. Therefore, the Hula Valley drainage implementation (1957) enhanced national concern of potential threat on the Kinneret water quality but unfortunately a modern routine limnological research of Lake Kinneret was not yet established. Two major governmental decisions were therefore concluded (1967): 1) To establish a modern—routine limnological research to be carried out by local team in the newly established Kinneret Limnological Laboratory (1968); 2) An invitation of external expert for professional opinion about the impact of the Hula Valley drainage on the quality of Kinneret waters (1973). The available record routinely collected by different institutions/organizations in Lake Kinneret that was opened to the external expert covered only 4 years. A professional opinion document was composed and submitted [19]. The document initiated a public "noise" due to predicted an abrupt development of Eutrophication in Lake Kinneret with enhanced conditions of anoxia within 3 - 4 years. A thorough evaluation of the available data record classified these predictions as wrong and the publicized outcry deceased. This is an example of a case where unpredictable conclusion was wrongly predicted as a result of lack of information.

Accelerated rates of qualitative and quantitative degradation of fresh waters are a global case. Nevertheless the level of success of potential cope capability of pollution reduction is highly dependent on data quality and temporal cover [20] [21] [22] [23] which require appropriate economic and social background. Reasonable certainty of prediction depends much on functional properties of lakes in general and especially Kinneret, the only natural body of freshwater in Israel. Considering Kinneret water quality degradation the most common contaminants are organic and inorganic pollutants. Commonly, if loading of pollutants has been reduced appreciably renewal rate relies upon dilution effect of the contaminants. Nevertheless significant trait is due not only to quantity aspect but also to the compositional level. Reduction of Nitrogen without relatively P decline might be a case of quality degradation, as in the Kinneret case. The anthropogenic intervention in the Kinneret ecosystem management reflects its inability to be operated in self-sustaining ways due to damage that is above the self-repair capacity of it. It is commonly indicated that the cause of enhanced lakes productivity is enhanced Phosphorus availability and to a lesser extent Nitrogen. The Kinneret Case is exceptional by being altered from P to N limitation. The prominent modification within the ecosystem structure was Phytoplankton species composition as affected by nutrient availabilities. Therefore, renewal of water quality is mostly due to nutrients supply and to a lesser extent to hydrological properties such as residence time and salts budget (salinity). Diversion of major external nutrient loadings was found to be adequate to restore the Eutrophic Lake Washington in Seattle [23] [24]. The optimal implementation aimed at reduction of nutrient availability is known [22] as Nutrient removal by land management. Such a management policy prominently exemplified the history of the Kinneret and the Hula Valley ecosystems.

What could be other than the essential concluded prediction from the results of 20 years (1969-2000) of routine and comprehensive monitor carried out in Lake Kinneret? Several key factors were clearly indicated: Elevation of the biomass of non-pyrrhophyte-phytoplankton, chlorophyta, cyanobacteria, and diatoms; decline of peridinium maximal blooms from 215 - 240 to 175 - 200 ranges (g/m^2); decline of Zooplankton (herbivore and predator) relative to phytoplankton biomass (g/m^2); lower loads of Nitrogen and slightly also Phosphorus in the river Jordan discharge; decline of regional precipitations and consequently lake water level; significant decline of Epilimnetic Nitrogen and minor changes of Phosphorus concentrations initiated decline of N/P mass ratio suitable for the establishment of a significant change of the ecosystem to be modified from P to N limitation and outbreaks of Cyanobacteria. Retroactive post-factum data evaluation (this paper) of the Lake Kinneret ecosystem dynamics justified earlier predictive conclusion.

Istvanovics [25] discussed the importance of P cycle and the role of limitation in shallow lake. Nitrogen plentiful conditions during 1970-1990 in lake Kinneret created limitation status of P. Nevertheless decline of Nitrogen resources accompanied by slight elevation of Phosphorus resources during late 1980's and the 1990's formed the decline of Peridinium and the enhancement of Cyanobacteria. Nitrogen limitation is vital to a lesser extent to Cyanobacteri as a result of their capability of Nitrogen fixation. For Peridinium Nitrogen is a significant demand *i.e.* limiting factor. The term "Nutrient Limitation" in nature include more than one consumer and several game players (organisms) [25]. The present paper is focused at the Kinneret ecosystem which includes the following "game players": N and P nutrients, and three algal groups: Pridinium, Non-Pyrrhophyes (Chlorophyta, Diatoms), and Cyanobacteria. The Nitrogen sources for the Peridinium, Chlorophytes and Diatoms are external (drainage basin) and for the Cyanobacteria—also Nitrogen fixation. The Phosphorus origin for the Peridinium growth and reproduction is in the bottom sediments and is therefore not limited. This P is transferred into the Epilimnion through Peridinium Cysts mediation and later, from the Peridinium vegetative bloom crash, together with deposited dust storm as bio-available substrate for Non-Phrrhophyte algal growth and reproduction. As soon as the external Nitrogen supply was sufficient (1969-mid 1980's and occasionally later as a result of heavy floods) Peridinium was dominant and the limiting nutrient was Phosphorus. From late 1980's and onwards external supply on Nitrogen declined and a sequence of changes started: Cyanobacteria enhancement, Peridinium decline and nanno-phytoplankton (Chlorophyta, Diatoms) enrichment: The Nitrogen became the nutritional limiting factor. The essence of this paper is: Does those ecosystem changes were possible to be predicted 20 year earlier, at the beginning of the 2000's? Conclusively the answer is YES! So what? What could be beneficial for Lake Kinneret if kind of approach would come earlier by 20 years. Ivanovitcs [25] demonstrate the case of Lake Balaton where surplus of external P loads during 10 years created Eutrophication in the lake, followed by 10 years of external P loads reduction which initiated 10 years of recovered Lake Balaton. The limnological literature includes numerous of cases of ecological deterioration, pollution or even Eutrophication case evaluations. Those evaluated cases were resulted by various conditions such as nutrient/pollutant surplus inputs, over-fishing, invasion or introduction of exotic species, industrialization, de-forestation, air pollution anthropogenic intervention or inappropriate hydrological lake managements and others. But preconditioned prediction cases are rare. Appropriate evaluation of the Lake Kinneret ecosystem 20 years ago could probably prevent later complete or partial water quality deterioration.

Conflicts of Interest

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

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