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Innovated Management Design of Lake Kinnere (Israel) and its Drainage Basin

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Abstract

During the last 80 years, the Lake Kinneret and its Drainage Basin ecosystems have undergone significant anthropogenic and natural modifications. Man made operations in the drainage basin and in the lake, accompanied by natural climatic conditions, resulted in modifications of the ecosystem structure. Old lake Hula and swamps were dredged and were being converted for agricultural development. Years later, the partial land utilization was modified, in an operation, referred to as the Hula Project operation. Twenty years later, several improvements for the Hula Project structure are suggested. Regimes of nutrient inputs into Lake Kinneret were changed by a decline in Nitrogen influx. Air and epilimnetic water temperature increase, as well as change of the nutrients composition. The lake ecosystem was shifted from P to N limitation. The phytoplankton and fish communities in the lake, were respectively modified. There were enhancements in N_2-Fixing Cyano-bacteria and Bleak fishes beside the partial decline of tilapias. The impact of Albedo and ENSO (EL-NIÑO/SOUTHERN OSCILLATION) factors is indicated. A combined impact of the natural and anthropogenic parameters are involved. An innovation in the management design within the lake, and the drainage basin ecosystems are suggested: 1: Cutoff of beach vegetation along 20% of the shoreline length enabling public recreation; 2: Intensification of Bleak and improvement of Tilapias fisheries aimed at both, the fishers' income and the water quality improvement; 3) Slight changes in the Hula Project structure.

Keywords: Lake Kinneret, Hula Valley, Management

1. Introduction

1.1 Background

Lake Kinneret, is the major source of water for drinking in Israel. Over the last 80 years, the Kinneret ecosystem has undergone man-made and natural modifications: dam construction, salty water diversion, salinity fluctuations, National Water Carrier construction, fish stocking and fisheries management, long term decline and increase in water level, droughts and floods, plankton biomass and species composition, as well as beach vegetation. Nitrogen decline and a slight increase in Phosphorus in the lake epilimnion, and the lowering of nitrogen loads in the Jordan River. The significant relationship between Nitrogen availability and *Peridinium* biomass in the lake, was previously documented. Therefore, a *Peridinium* biomass decline accompanied by an enhancement of nano-phytoplankton (mostly *Cyanobacteria*), was developed. The decline in a N/P mass ratio, which enhances the biomass of N_2-fixing Cyano-Bacteria are widely known. The outcome of those changes within the Kinneret ecosystem was a shift from P to N limitation. Since the early 1970s, a general trend of Lake Water Level (WL) decline, was documented. A decline in the total phytoplankton biomass, under the regime of water level decline was also indicated. Long term decline in water level is due to both natural droughts and surplus pumping. The decline in nitrogen in the Kinneret epilimnion was probably due to both the reduction in river discharges (droughts) and a lower N contribution from the drainage basin, as a result of anthropogenic activities. Before the Hula Drainage operation (1950-1957), Nitrogen was fluxed from the catchment to the lake, mostly as highly bio-available Ammonia. After the Hula drainage implementation, the dominant N form originated from the catchment, and was modified to Nitrate which is less available than Ammonia. After the Hula drainage and before the mid-1990s, the lake also collected a daily volume of 25 X 10^3 m^3 of raw sewage and Fishponds (1700 ha) effluents, rich with ammonia. From the early 1990s, the areas meant for fishpond were dramatically reduced (450 ha), as well as their effluents, and the raw sewage was stored in reservoirs and reused. Conclusively, the change in the Kinneret ecosystem structure by shifting from P to N limitation was affected by both the anthropogenic and natural processes. The shift from P to N limitation was probably not directly affected by the water Level decline, or global warming and temperature increase, or by beach vegetation, and probably not directly by fishery management. Whereas, the dominant factor which directly enhanced this change, was the decline in the bio-available N.

1.2 History

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. Three rivers, Hatzbani, Banyas and Dan, flow southern down from Mount Hermon, together with several other streams, forming the Jordan River. The Jordan River contributes about 63% of the downstream 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 both sides (East and West).

During the 1950s, 6,500 ha of natural wetland and old Lake Hula were drained, and converted for agricultural use, which serve as an income source for the local residents. During the following 40 years, the drained area was successfully cultivated, agricultural products were economically produced, 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. It was accompanied by heavy dust storms, subsidence of soil surface, blocking of drainage canals, enhancement of underground fires, and outbreaks of rodent populations. These deteriorated processes caused severe damage to agricultural crops. Therefore, in 500 ha of the deteriorated land, the income for agriculture purposes lost its economic viability, and therefore, resulted in ignorance of cultivation and increased threats to water quality in Lake Kinneret by the already exceeded nutrient fluxes. A reclamation project (Hula Reclamation Project, HRP) was consequently implemented and its aimed at reducing nutrient fluxes, and combined with a land economical benefit, through a shift of 500 ha land from agriculture to eco-tourism usage. The innovated concept is based on anthropogenic changes in the environment, combined with the introduction of natural plants and the reconstruction of the hydrological – drainage structure of the entire valley.

1.3 Desertification

The Hula drainage agricultural development was operated, afterwards, the desertification processes as well. Desertification does not necessarily overlap with dryness. Desertification is a process of soil fertility decline. Most of the world's population is located in deserts, where water resources are very limited. The population in these dry lands does their best to enhance food production under water limitation, investing much efforts to save and /or transport water, and therefore, soil fertility becomes the limiting factor. Agricultural development is highly related to soil fertility (desertification) even if the water supply is sufficient (no dryness), as is relevant to the Hula Valley. The decline in soil fertility after the Hula Swamp drainage, was accompanied by a decline in crops, and the low harvest was followed by the other economical difficulties detailed above. The HRP was an attempt aimed at overcoming those obstacles. The design and implementation of the HRP were done with preclusion to avoid conflict between agriculture, Kinneret water quality protection and nature conservation. The outcome of the HRP was the renewal of an ecosystem, which has become a tourist attraction, including a rich biological diversity with approximately, 300 species of birds (30-40000 Cranes, annually), 40 species of water plants, and 12 fish species. However, it turned out that the amount of nitrogen and phosphorus is not significant as measured in the load removal, through the newly created shallow lake Agmon. Only in the summer, occasionally, has it become meaningful in terms of phosphorus.

2. Material and Methods

The_Long-Term Data record of Lake Kinneret Fishery was taken from the Annual Reports, KLL-IOLR-LKDB (1970-2014), and from the Fishery Department Agriculture Ministry (1960-2014). The information on Kinneret Phytoplankton composition and the Temperature, is given in the Annual (1969-2014) Reports from the Kinneret Limnological Laboratory, IOLR (KLL-LKDB-IOLR 1970-2014). The Climatological data (rain gauge and air temperature data) are given in the annual reports of the Israeli Meteorological Service. Three statistical analyses were used: ANOVA Test ($p<0.05$); Value Prediction by Polynomial Fractional; and LOWESS (0.8), for trend indication. Long term Data information on Lake Kinneret limnology (Temperature, plankton, nutrients and fishery) is given in KLL-LKDB-IOLR (1970-2014), Fishery Department (1960-2014), and on the Hula Valley in Gophen (1994-2006), and Barnea (2006-2015).

3. Results and Discussion

3.1 Climatological Fluctuations

Results shown in Figure 1 indicates an increase of about 1.0 ^{0}C of air temperature in the Hula Peatland region (Figure 1), during the last 10 years, and in the entire valley since the 1980s (Figure 2). Moreover, a decline in precipitation regime since the 1980s in the Hula region was also documented (Figure 3) (Gophen, 2015a, b). As obviously predicted, the Temperature increase and precipitation decline were accompanied by the elevation of the relative (%) humidity during the last 10 years (Figure 4). The climatological extremism trend was consequently expressed by the lowering of the Kinneret rivers inflow discharges, and it results in the lake Water Level (WL) decline (Figure 5). Conclusively, the epilimnetic (surface-thermocline water column depth) temperatures increased as well (Figure 6). The increase in the epilimnion temperature was caused by both climatological change and a higher capacity of heat in the upper layer of the water column in the thinner epilimnioin.

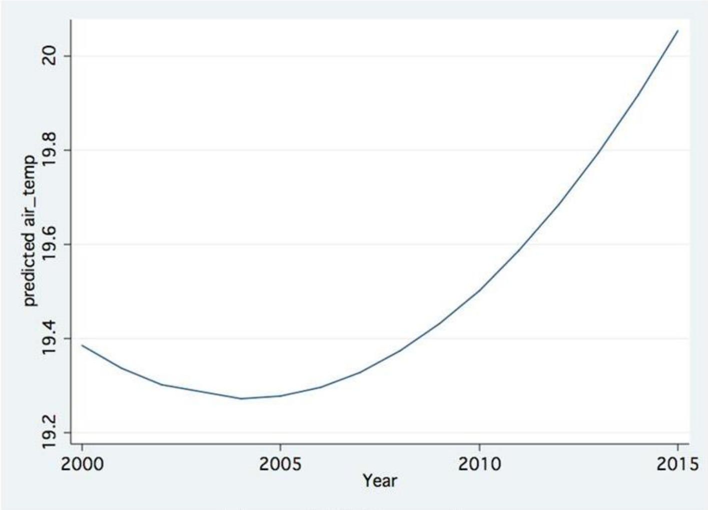

Figure 1: Air Temperature Hula Peat Land 2000-2015 (Fractional Polynomial)

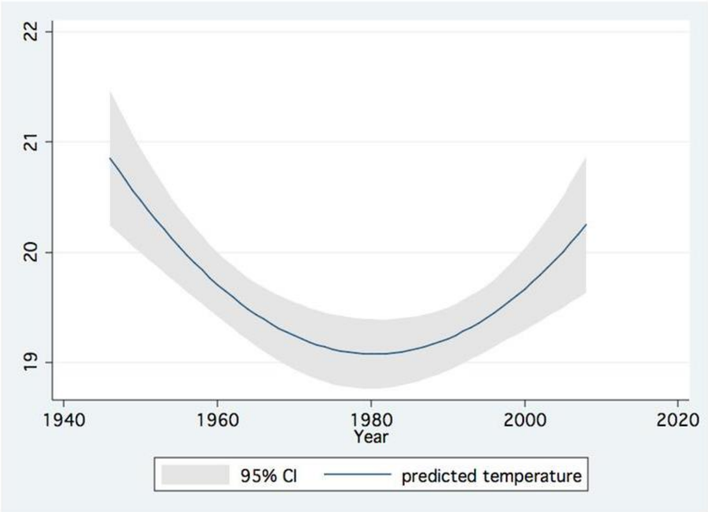

Figure 2: Air Temperature (^{0}C) Drainage Basin (Dafna) (1940-2014) (Fractional Polynomial).

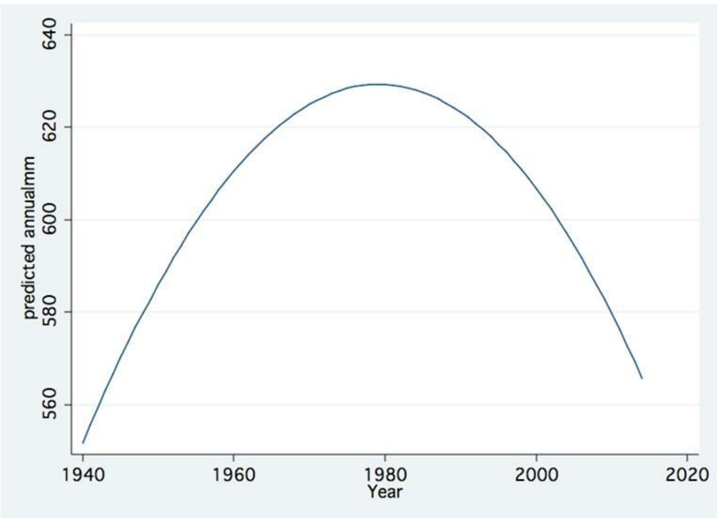

Figure 3: Precipitations (mm/y) in the Drainage Basin (Dafna) Fractional Polynomial (1940-2014)

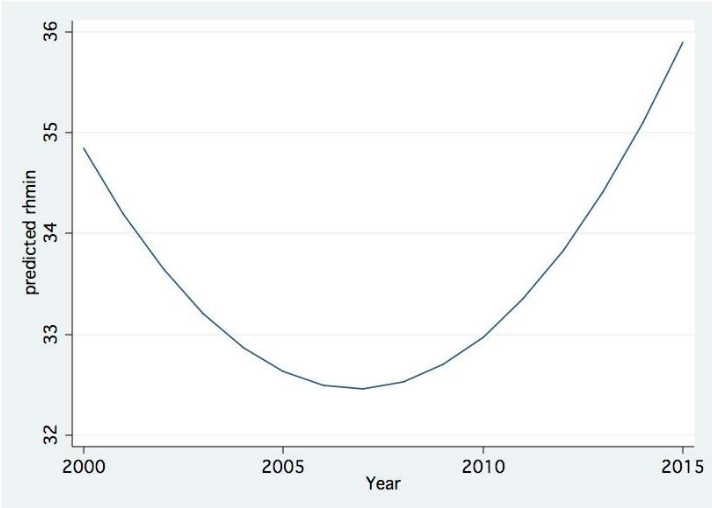

Figure 4: Relative Humidity (%) Hula Peat Land 2000-2015 (Fractional Polynomial).

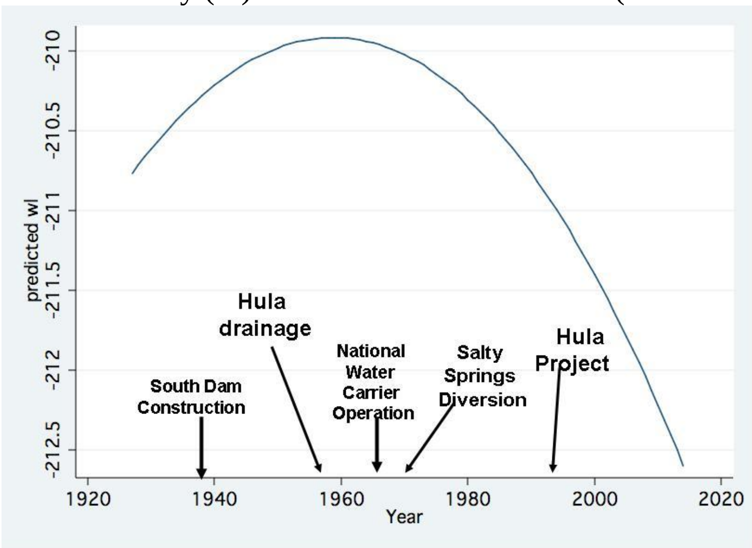

Figure 5: Annual Fluctuations of Lake Kinneret Water Level (MBSL) Monthly averages(1926-2014) (Fractional Polynomial).

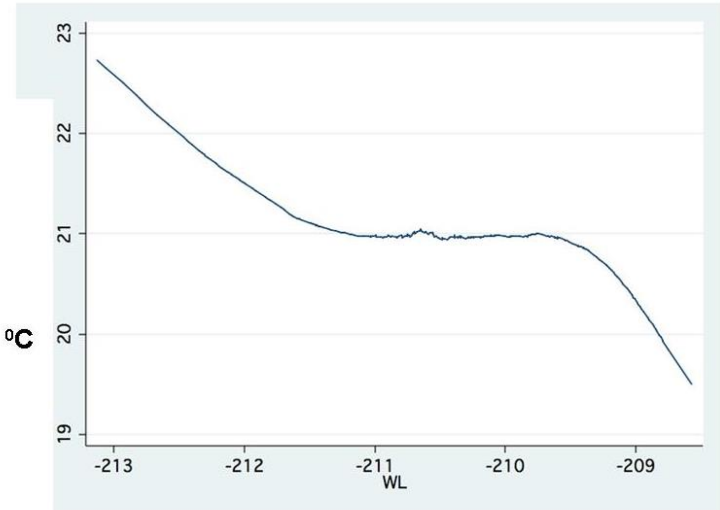

Figure 6: Trend of changes (LOWESS; 0.8) Averaged Epilimnion Temperature Vs. Kinneret WL (monthly means).

3.2 Nutrient Inputs and WL fluctuations

The decline in river inflow discharges (mostly Jordan, contributing 65% of the lake budget) was followed by a reduction in the nutrient inputs, especially those, like Nitrogen, which is mostly supplied externally (Figures 7, 8, 9). Polynomial Regression Tests indicated a significant (r^2=0.079-0.339; $p<0.0001$) direct relationship between monthly means of epilimnetic nutrient concentration (ppm) (including TDP) andPeridinium Biomass (g/m^2) Vs Jordan River discharges (m^3/s). The proportional decline in the monthly means of the epilimnetic TP concentration with Jordan discharge and the multi-annual load increase, probably confirm the internal location of P major source (Figure 10). The final result was a decline in the N/P mass - ratio in the epilimnion (Figure 11). A global and well known follow-up response to that kind of change is the enhancement of N_2- Fixers Cyano-bacterial organisms (Figure 12). This was developed in Lake Kinneret since mid-1990s (Figure 12). The indirect relationship between climatological conditions and the Cyano-bacteria are presented in Figure 13 as an inverse relation between WL (Decline) and algal biomass (elevated) (Gophen 2014b). The decline in available N (TIN-Total Inorganic N) in the epilimnion, is shown in Figure 14. This insufficiency of N for algal physiology is covered by N_2 fixation capabilities of the Cyano-bacteria. An increase in the epilimnetic TP load is presented in Figure10, but led to a decline in the bio-available P (TDP-Total Dissolved P), when WL decrease is indicated from the results in Figure 15. Polynomial Regression Tests between monthly averages of Water Level and epilimnetic concentration (ppm) of nutrients (Particulate Organic Nitrogen, Total Kieldhal, Total Dissolved Nitrogen, Total Nitrogen) and Peridinium Biomass (g/m^2), indicated a significant (r^2 = 0.085-0.187; $p \leq 0.0001$) decline with lowered WL. The decline in N was as a result of the climatic conditions and decline in N inputs. The slight increase in TP originated from internal sources, and partly from dust deposition. The biomass enhancement of Cyano-bacteria is probably due to their N fixation usage, and it was accompanied by an accelerated bio-available P uptake, causing TP elevation, including intra-cell nutrients. The N deficiency and P sufficiency conditions suppressed the N consumer Pyrrhophyte large cell Peridinium (Figure 16) and the niche replacement was by Cyano-bacteria, and other nano-planktonic algae. The zooplankton response to dominancy of no edible Cyano-bacteria was a decline in the total zooplankton biomass, especially herbivores (Figures 17, 18).

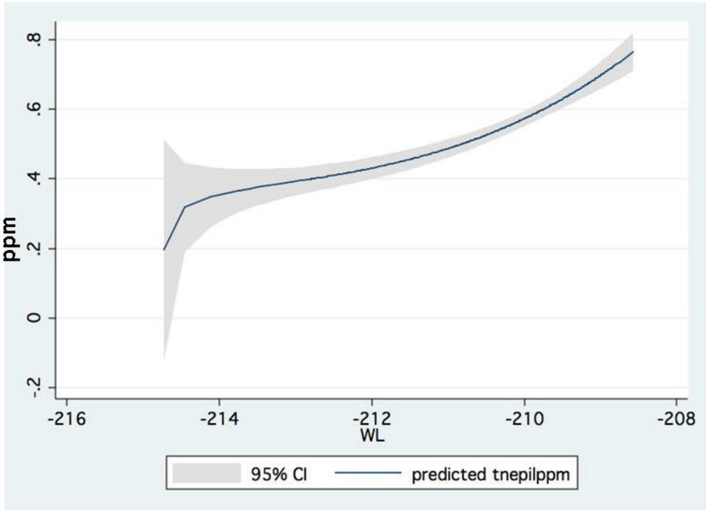

Figure 7: Fractional Polynomial Prediction of Epilimnetic TN concentration (ppm) Vs. Kinneret WL (monthly means)

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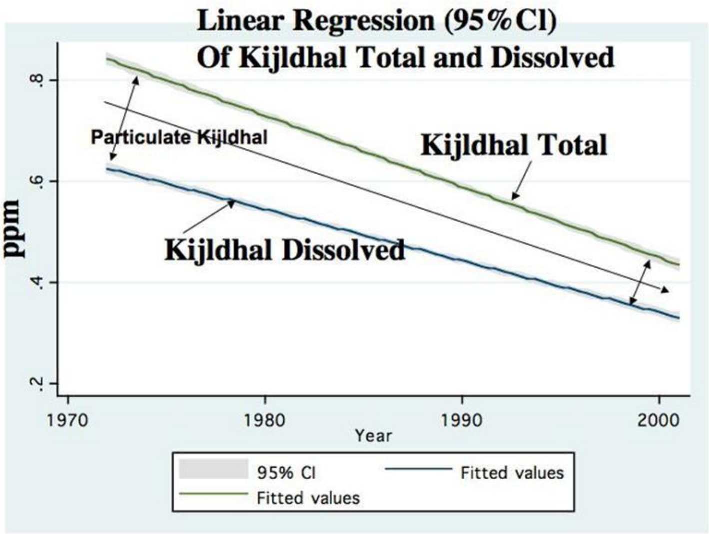

Figure 8: Annual fluctuations of Nitrogen Forms concentrations (ppm) In the Kinneret Epilimnion during 1970-2005

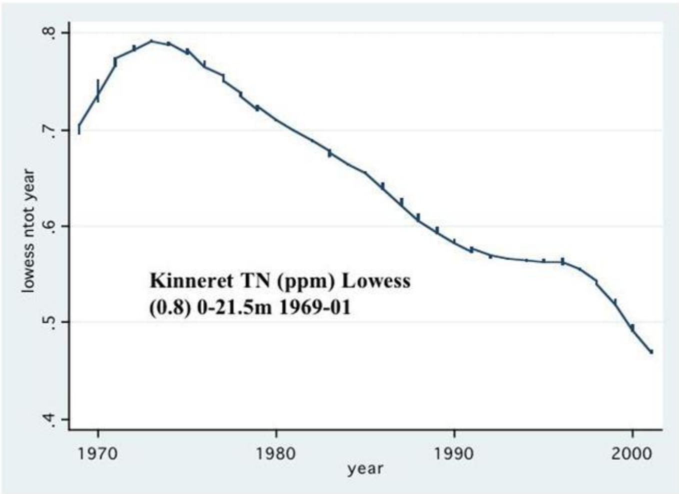

Figure 9: TN decline in the Epilimnion from 0.80 to 0.48 ppm (LOWESS; 0.8)

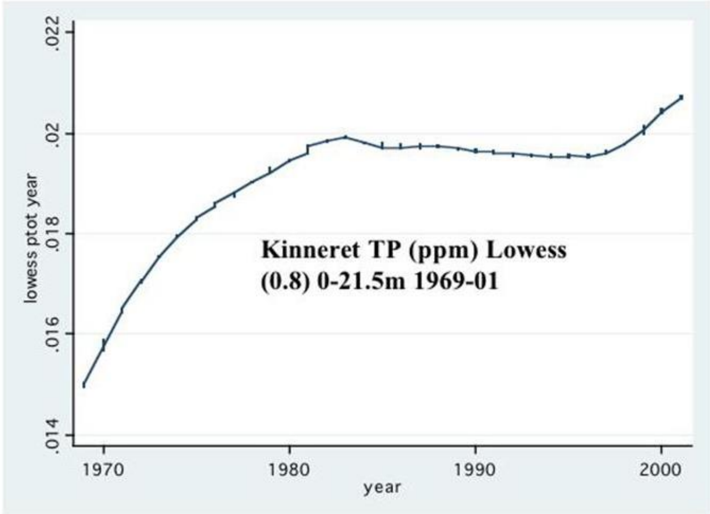

Figure 10: TP increase in the Epilimnion from 0.015 to 0.21 ppm (LOWESS; 0.8)

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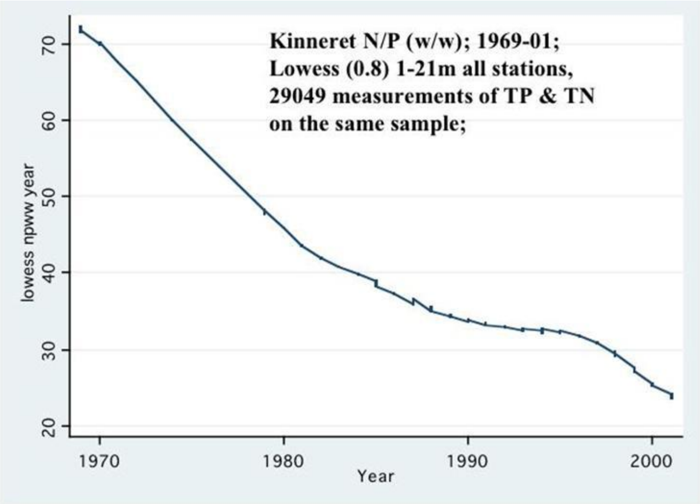
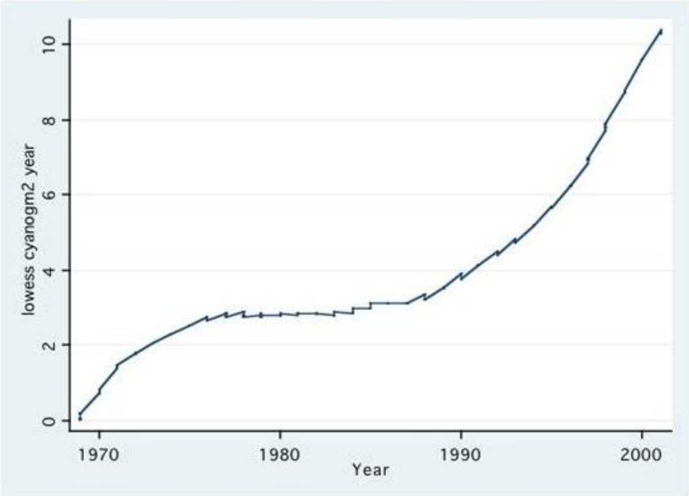


Figure 11: TN/TP in the Epilimnion decreased from 71 to 22 (LOWESS; 0.8)



Kinneret Cyanophyta (g/m²) 1969-02;
all dates, all depths, all stations Lowess (0.8);

Figure 12: Increase of Cyanobacteria from 0.1 to 10.2 g/m2 (LOWESS; 0.8)

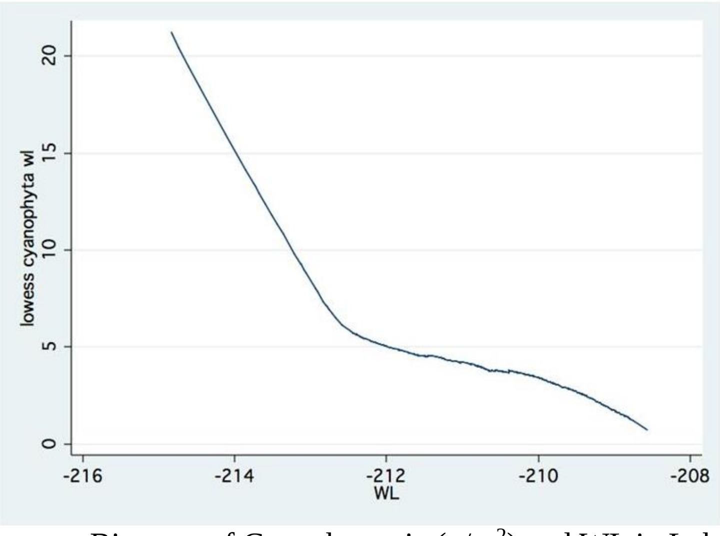


Figure 13: Relation Between Biomass of Cyanobacteria (g/m^2) and WL in Lake Kinneret (LOWESS; 0.8)

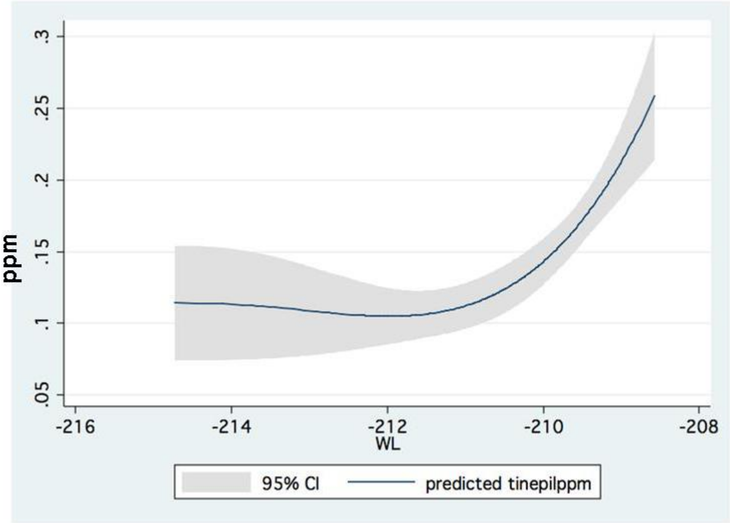


Figure 14: Fractional Polynomial Prediction of Epilimnetic TIN concentration (ppm) Vs. Kinneret WL (monthly means)

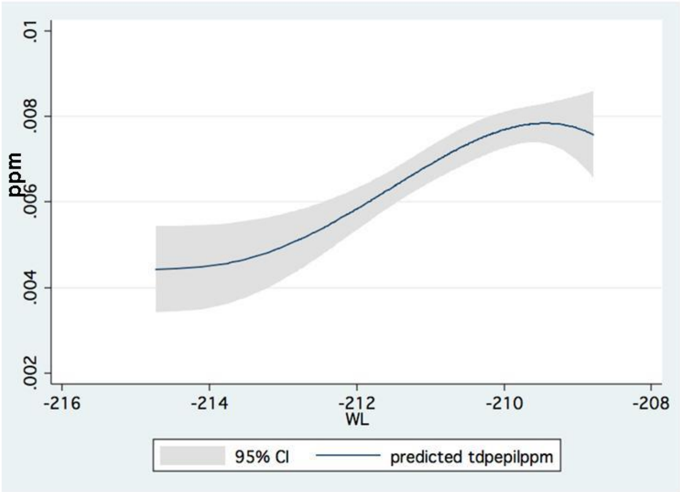


Figure 15: Fractional Polynomial Prediction of Epilimnetic TDP concentration (ppm) Vs.Kinneret WL (monthly means)

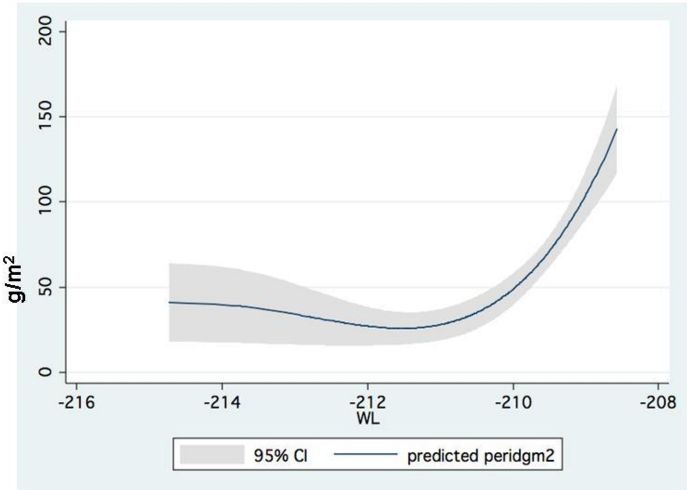


Figure 16: Fractional Polynomial Prediction (95%CI) of Pyrrhophyta (g/m2) Vs. Kinneret WL (monthly means)

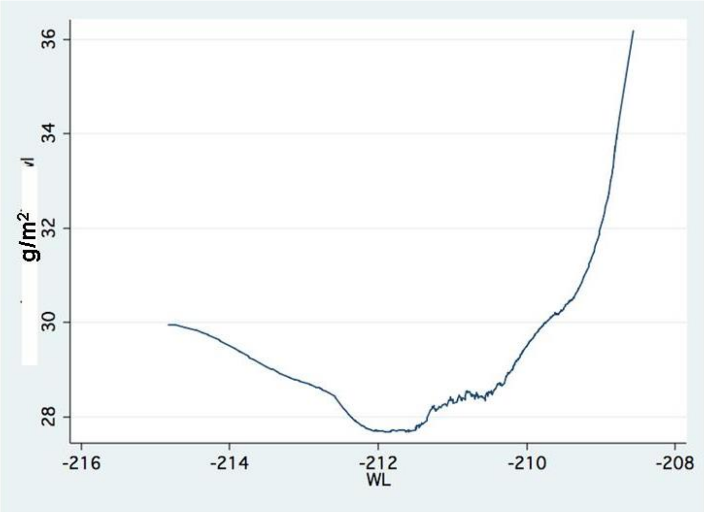


Figure 17: Trend of Changes (LOWESS; 0.8) of Total Zooplankton Biomass (g/m2) Vs. Kinneret WL (monthly means)

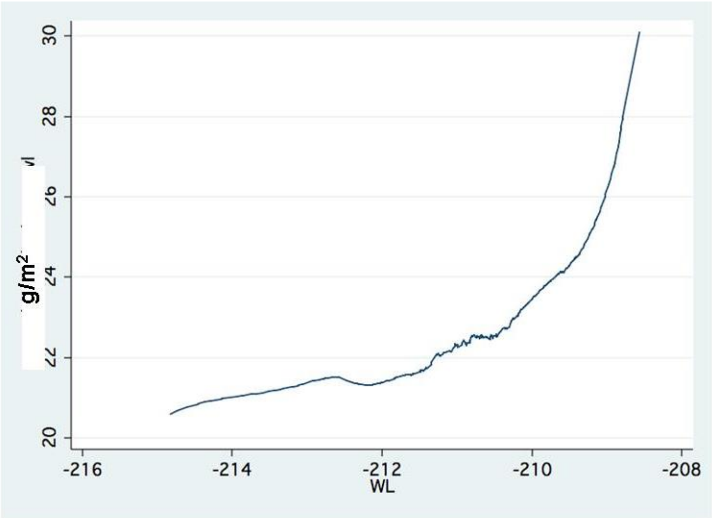


Figure 18: Trend of changes (LOWESS; 0.8) of Herbivorous Zooplankton Biomass (g/m2) Vs. Kinneret WL (monthly means)

3.3 Temperature Impact on Zooplankton

The temperature increase in the epilimnion of Lake Kinneret also affected the Zooplankton Metabolic trait Metabolism (Edmondson & Winberg, 1971; Winberg, 1971; Gophen, 2013). The physiological features of zooplankton (specific increment in mgC/Body mgC/Day), was measured experimentally and a decline in food utilization efficiency (%) with Temperature elevation, was documented (Table 1).

Table 1: Temperature (15, 20, 27 ^{0}C) impact on the efficiency (%) of Food utilization: % of assimilated from ingested energy in mgC/Body mgC/Day, by Lake Kinneret zooplankton: Herbivore and Predator Copepods, Cladocerans and Rotifers (Edmondson and Winberg 1971; Gophen 2013; Winberg 1971).

Zoplankton / Temperature	15^{0}C	20^{0}C	27^{0}C
Herbivore Copepods	45	24	39
Predator Copepods	45	18	26
Cladocerans	24	18	18
Rotifers	27		11

3.4 The ENSO Factor

A correlation between fishery and extreme winter conditions in Lake Kinneret was indicated: Populations of Bleak fishes were enhanced and those of *Sarotherodon galilaeus* (SG) declined. The impact of ENSO events on fishery in Kinneret was confirmed. The study included a long term data records of the Kinneret Epilimnetic temperatures, water level increase, precipitation and air temperatures in the drainage basin, together with a record of the ENSO events. Results suggest an impact of ENSO events, on the lake population size of Bleaks and SG. It is very likely that the influence of ENSO on the two key fish species in the Lake is contradictory: Reproduction enhancement of the winter spawner Bleaks and a reduction in the population recruitment of the early summer spawner, SG. It is likely that the winter extreme in the Kinneret region is a consequence of the ENSO event and therefore, it negatively affects the water quality in Kinneret (Alpert & Reisin, 1986; Price et al., 1998; Gophen et al., 2015).

3.5 The ALBEDO Factor

Long-Term (1946-2008) record of the daily mean air temperatures in the Hula Valley (Dan, Dafna, Kfar Blum stations) was statistically evaluated. Temperature decline after the drainage of the old Lake Hula and adjacent wetlands (1958), and an increase from the mid 1980s, after the implementation of the Hula Project aimed at permanent land green cover. Those regional climate changes are probably due to the changes in the Albedo level. The changes in the Albedo value by the Lake Hula and swamps drainage (1950-1957), caused a decline in the air temperature and later on, it resulted in an agricultural enhanced increase in the air temperature. Prior to the Lake Hula and Swamps dredging (1957), 100% of the valley surface was covered with water and aquatic plants covered approximately 50% of it. When the lake and the Hula swamps drainage was completed (1958), the surface covered with water shrunk to 15%, while the rest of it was covered seasonally by field crops. During the year 1959-1986, before the implementation of the Hula Project, only 6% of the surface was covered with water and the rest of it by field crops, although, 50% of the time, this agricultural land was uncovered. After the accomplishment of the Hula Project, only 11% of the surface is covered with water and the rest of it by field crops and they are later improved upon. Albedo reflection from the water surface is lower than that from the exposed soil surface, and higher than that from the plant covered land. The Hula drainage operation elevated Albedo reflection,which is accompanied by the air temperature decline (Gophen, 2014a; Gophen et al., 2014). The temporal continuity of the soil green cover that was implemented by the Hula Project lowered the Albedo reflection, followed by air temperature increase. Albedo is the measure of the reflection of the earth`s surface. Water is a higher absorbent and it is less reflective than soil, and bare soil is more reflective and less absorbent than the grass covered land. When the Albedo of certain substrate is increasing, the heat balance becomes warmer and vice versa. If Albedo is increasing, the air temperature above declines. The decline in Kinneret water level was followed by the diminishing of the water surface area which lowered the total capacity of evaporation induced cooling process, by so doing, the heat capacity was enhanced. The linkage between Lake Kinneret Water Level (WL) decline and their temperature, go partly through the local decline in the Albedo level. WL decline led to the reduction in the total capacities of absorbance and reflectance of solar radiation. Those changes were only due to capacities fluctuations because the Albedo factor was not modified. The lower reflectance and the smaller volume of the epilimnion induced temperature increase. WL decline accompanied by surface reduction has created two factors of heat enhancement: 1) The reduction of cooling effect by smaller capacity of evaporation; and 2) Lower impact of the Albedo level on the smaller surface area. Those two factors probably enhanced the local air and consequently, the epilimnetic temperatures.

3.6 Lake Kinneret Fishery (Gophen et al., 2015)

External, natural and anthropogenic constraints, mounted pressure on the Kinneret fishery: 1) Population increase in the migratory fish predator, Great Cormorant (*Phalacrocorax carbo*) in the lake, reduction in stocked fingerlings of the cichlid, *Sarotherodon galilaeus*, (SG); 2) The use of illegal small mesh sized fishing nets; 3) A sharp decline in the market demands for Bleaks, caused the elimination of fishing and the lake population enhancement of Bleaks; 4) An outburst of Virus disease, which infected mostly Tilapias. Climatic conditions initiated fluctuations in the population size of SG and Bleaks. SG is a species of fish on top priority in the fishery management design, due to its contribution to water quality protection and to fisher's income. During the year 2007-2008, landings of SG sharply declined from an earlier annual crop of 200-400 tons, to less than 10 tons in the year 2008. Among several other potential reasons for the decline in SG landings, the relevance of climatic conditions periodicity was also considered.

3.7 Beach Vegetation Gophen et al., 2013)

3.7.1 Ecosystem Services

Development and management of public beaches aimed at appropriately facilitating recreationists, require the regularization of inundated belt, which occur due to Water Level (WL) fluctuations. This belt is the contact zone between the terrestrial and aquatic ecosystems. The width and the total area of these sections are changed according to the WL fluctuations. When inundated beach zone is exposed as a result of the WL decline, it is immediately covered by the terrestrial plants. These plants create a plant "wall" which is difficult to penetrate by the swimmers and recreationists. It is suspected that the beach vegetation removal might deteriorate the Lake water quality, and interfere, with the reproduction of Tilapia fishes. On the other hand, if these plants will not be removed, they create optimal habitat initiating sever nuisance to the public: mosquitoes and other aquatic insects outbreaks, refuge for dangerous animals (Hogs, Mangus, Koyots, Foxes, and Venomous snakes). The Kinneretr ecosystem services require, among others, public beach development and for the sake of human convenience plants, removal is obvious.

The Lake Kinneret management design is now facing the dilemma of deciding whether lake utilization for human society is possible without compromising the ecosystem structure and function or whether the ecosystem services should be reserved solely for the lake ecosystem, while ignoring human benefits partially or totally. A wide belt of dense *Phragmites australis australis* and *Tamarix jordanis* has become established along the shore of Kinneret as the lake level dropped progressively during the last 10 years. Heavy rainfall in the year 2012 led to an exceptional water level increase, and the vegetation was partly covered with water, decomposed and accompanied by an outbreak of mosquitoes (including common Malaria and the Western Nile Malaria vectors which its virus was found and documented), and unpleasant odors from sulfide and ammonia smell. In addition, public access to the lake has diminished since the initial expansion of the plants and has been further hindered recently, by decomposing plant matter. The improvement in those unpleasant nuisances is included in the management design.

3.7.2 Fish Habitat

Vegetation removal could have some implications on *SG* recruitment. Nesting within dense emergent vegetation in Lake Kinneret are mostly due to *Tilapia zillii*. The mouth breeding cichlids, SG,and OA *(Oreochromis aureus)* construct their nests on bare lake bottoms near the shore (0.5-2.0 m depth), and the fingerlings, after being released from the parent's mouth, find refuge among the submerged macrophytes, such as *Potamogeton spp. Myriophyllum sp. Ceratophyllum sp.* and *Najas spp*. Removal of *Phragmites* sp. and *Tamarix* sp. along 12.6 Km of public beaches (Kinneret shoreline length-55 Km) will probably have no impact on the nesting behavior and fingerling survival of SG (Gophen et al., 2012). About 80% of the total "beach belt" area, including the declared Nature Reservation Site located in the East-Northern lake side will be untouched. The proposed management of the terrestrial vegetation management is aimed not only to mitigate recreation activities, but also to alleviate living standard for citizens in the vicinity.

4. Practical Management recommendations

4.1 Beach Vegetation (Gophen et al., 2012):

Beach vegetation removal (cutoff, mowing) from 23% of beach shoreline area along the shore line during fall-early winter when the water level is at an annual low, aimed at eliminating smell and mosquito problems for both recreationists and the nearby population, and improve public access to the lake in order to enhance the potential of the long designated recreation sites. Mean width of the vegetation belt along the 55 Km shoreline of Kinneret is approximately, 100 m which is used to occupy approximately 127 ha. To facilitate the recreational use of the lake, plant removal is proposed for only 17 sections of beach front totaling 12.6 km (23% of total shoreline) (Gophen et al., 2012).

4.2 Fishery Management

3-5 millions Fingerlings production per annum raised to the weight of >5 g/ind. for stocking during the month of September-November; Enforcement of the use of legal fishing net and the size of cropped Tilapias ; Aggressive Deportation of Cormorant from Lake Kinneret (Gophen et al., 2013); Renewal of intensive Bleak fishery (Serruya et al., 1979; 1980; Gophen et al., 2015).

4.3 Drainage Basin

After the successful implementation of the Hula Project, the following is suggested for innovation of the present status: Enhance Nitrogen supply and reduce Phosphorus flux to Lake Kinneret (Gophen et al., 2014; Gophen, 2015c); Continuation of the "Green cover" policy of agricultural development throughout the whole year round to ensure reasonable crops, slow down soil surface subsidence and dust storms, and rodents elimination; The lake Agmon structure change (Gophen, 2014c; 2015c) might improve birds diversity and nesting activity for the benefit of touristic objectives; Continuation usage of portable irrigation technology accompanied by high level of underground water table (0.5-1.0 m below surface);

4.4 Water Level Fluctuations (WLF) Policy in Lake Kinneret

WLF per se is a natural event. Nevertheless, the fluctuations amplitude might be artificially affected. WLF was controlled by natural conditions in Lake Kinneret until the year 1932, when the south dam was constructed. Later on, the seasonal fluctuations and its altitude became a man made control. Moreover, the construction and operation of the National Water Carrier (1964) (NWC) made the anthropogenic impact to be more pronounced. Until early 2010s, Lake Kinneret supplied >50% of the national domestic demands. Presently, most of the domestic supply is the desalinization product. Therefore, the consideration and discussion of the amplitude regime of WLF is extremely relevant.

The predicted outcome of high amplitude is the formation of beach vegetation belt under inundation accompanied nuisance factors, such as unwanted vertebrate and invertebrate animals and organic matter drift. On the contrary, high WL stability and low amplitude of WLF might produce longer retention time and lower water exchange, which is known as an eutrophication factor. No clear evidence were observed in Lake Kinneret to confirm littoral cascading to the pelagic system (Sukenik and Parparov, 2003 Interim Report), with impacts on the entire food web and on water quality. Consequently, it is likely that a decline in native species and a decline in diversity and ecosystem services are not predicted. Internal processes and littoral loading partly compensate for the decline in external nutrients input during drought and during the WL decline. Conclusively, it is recommended to return to the natural amplitude changes of WLF regime by enhancing Kinneret water utilization (pumping). Potential water consumption are: regional (lake vicinity and drainage basin population) consumption for agricultural irrigation and domestic requirements; national aquifers recharging; slow down of the WL decline in the Dead Sea through Kinneret open Dam and others. The WL altitude might be manipulated between 208.80 MBSL (formal upper line legislation) and flexible lower limit.

5. Summary

The air Temperature in the Hula Valley and Lake Kinneret region was increased, precipitation declined and relative Humidity increased. Those climatological changes were affected by three factors: Global Warming, Albedo and ESNO (EL-NINO/Southern Oscillation). Due to reduction in precipitation, river discharges declined and the external nutrient inputs into Lake Kinneret were reduced. As a result of those changes, the Kinneret ecosystem was modified from N to P limited food web relations.

Phytoplankton assemblage composition was changed by Peridinium decline and cyanobacteria enhancement. Bleaks fishery was dramatically reduced as a result of lower market demands. The Tilapia fish population encountered intensive Cormorant predation, illegal use of inappropriate fishing net, viral disease and smaller stocks of raised fingerlings. El-Niño enhanced Bleaks increment and decline in Tilapias. Management recommendations are submitted.

Reference

Alpert, P., & Reisin, T. (1986). An early winter polar air mass penetration to the eastern Mediterranean. *Monthly weather review*, *114*(7), 1411-1418.

Barnea, I. (2007-2013). Hula Project Annual Reports. Migal, Water Authority, and Jewish National Fund (KKL).

Edmondson, W. T., & Vinberg, G. G. (1971). Manual on methods for the assessment of secondary productivity in fresh waters.

Fishery Department Agriculture Ministry. (1960-2014). Annual Reports. (in Hebrew)

Gophen, M. (1995-2006). *Hula Project annual reports*. Migal, Water Authority, and Jewish National Fund (KKL) (in Hebrew).

Gophen, M. (2013). The Impact of Temperature Elevation on the Decline of Cyclopoid Population in Lake Kinneret (Israel). *The Journal of Ecology, Photon*, *107*, 233-239.

Gophen, M. (2014). The Impact of Water Level Decline on Water Quality in the Epilimnion of Lake Kinneret (Israel): Perennial Perspectives. *Open Journal of Ecology*, *4*(14), 892.

Gophen, M. (2014a). Land-Use, Albedo and Air Temperature Changes in the Hula Valley (Israel) during 1946-2008. *Open Journal of Modern Hydrology*, *4*(04), 101.

Gophen, M. (2015a). The Impact of Available Nitrogen Deficiency on Long-Term Changes in the Lake Kinneret Ecosystem. *Open Journal of Ecology*, *5*(04), 147. http://dx/doi.org./10.4236/oje.2015.54013

Gophen, M. (2015b). Experimental Study of the Aphanizomenon ovalisporum Response to Nitrogen Fertilization in the Sub-Tropical Eu-Meso-Trophic Lake Kinneret (Israel). *Open Journal of Ecology*, *5*(06), 259. http://dx.doi.org/10.4236/oje.2015.56020

Gophen, M. (2015c). The Impact of Available Nitrogen Deficiency on Long-Term Changes in the Lake Kinneret Ecosystem. *Open Journal of Ecology*, *5*(04), 147. http://dx.doi.org./10.4236/ojmh.2015.51001

Gophen, M., Crisman, T., & Zalidis, G. (2012).Charting a course for ecosystem services in Lake Kinneret, (Israel). *SIL News Letter, 61*, 13-16.

Gophen, M., Meron, M., Orlov-Levin, V., & Tsipris, Y. (2014). Seasonal and Spatial Distribution of N & P Substances in the Hula Valley (Israel) Subterranean. *Open Journal of Modern Hydrology*, *4*(04), 121. http://dx.doi.org./10.4236/ojmh.2014.44012

Gophen, M., Sonin, O., & Golani, D. (2013). How Cormorant Impact The Kinneret Ecosystem (Israel)? *SIL newsletter, December 2013, pp. 20-21*.

Gophen, M., Sonin, O., Lev, M., & Snovsky, G. (2015). Regulated Fishery Is Beneficial for the Sustainability of Fish Population in Lake Kinneret (Israel). *Open Journal of Ecology*, *5*(10), 513. http://dx.doi.org/10.4236/oje.2015.510042

KLL-LKDB-IOLR. (1970-2014). Annual Reports (in Hebrew).

Price, C., Stone, L., Huppert, A., Rajagopalan, B., & Alpert, P. (1998). A possible link between El Nino and precipitation in Israel. *Geophysical Research Letters*, *25*(21), 3963-3966.

Serruya, C., Gophen, M., & Pollingher, U. (1980). Lake Kinneret: carbon flow patterns and ecosystem management. *Archiv fur Hydrobiologie*, *88*(3). 265-302.

Serruya, C., Pollingher, U., Cavari, B. Z., Gophen, M., Landau, R., & Serruya, S. (1979). Lake Kinneret: management options. *Archiv fur Hydrobiologie Beiheft Ergebnisse der Limnologie*, *13*, 306-316.

Winberg, G. D., & Duncan, A. (1971). *Methods for the estimation of production of aquatic animals*. London, New York, Academic Press. Translated by A. Duncan.