Managing Salinity Levels in the Salton Sea
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Abstract

In 1905, a conveyance system that delivered water from the Colorado River to the Imperial Valley failed, creating what is now called the Salton Sea (Ponce 2005). The original average salinity of the Sea was about 3,500 parts per million, but since Congress deemed the Sea an area for the Imperial Valley to dump their agricultural water waste, the salinity of the sea has risen to about 52,000 parts per million- 50 percent more saline than the ocean (Ponce 2005). Due to this rising salinity, the Sea's fisheries and the wildlife that depend on it for livelihood are at risk of collapsing (University of Redlands n.d.). As such, there is a pressing need for policymakers and stakeholders to take action to prevent this. Although many factors influence the salinity levels of the Salton Sea, our project attempts to synthesize the Salton Sea water budget and project when the salinity level will reach a point at which the fisheries can no longer survive- the year 2020. All this information can be used to give insight to policymakers on how to manage the rising salinity levels, and provide them with a timeline with which they can follow.

Introduction

The Salton Sea is now the host of one of the most diverse bird populations in the United States, in addition to being a major drainage basin for excess nutrients and salts (McClurg 1994). Over the years many fish species have been introduced to the inland sea, the most successful of which is the tilapia (University of Redlands, n.d.). Now many migratory birds use the Salton Sea as a resting area during migrations to South America (University of Redlands, n.d.). Because the fish in the Salton Sea form an important economic and biological role, it is important to maintain healthy fish populations, or risk the destabilization of the local biodiversity of the Salton Sea and Imperial Valley. To maintain healthy populations, it is imperative that salinity levels do not exceed maximum limits deemed unhealthy for fish. If salinity reaches too high of a concentration, large die-off events will ensue, and eventual collapse of the fish populations will soon follow.

Objective

The main objective of this project is to determine the critical year, before which action must be taken, in order to avoid the Salton Sea fish population collapse. It is imperative that the Imperial Irrigation District sets up plans to ensure Salton Sea salinity levels do not exceed 60,000 ppm, or risk large fish die-offs (University of Redlands, n.d.). Many Southern California water agencies will look to secure inflows for future water demands that historically flow into the Salton Sea, which will pose a threat to these plans. To determine a year in which salinity levels exceed the 60,000 ppm, our group will apply a power regression line to data collected on total dissolved solids, from 2004 to 2014, by the Department of the Interior. A regression line will then be used to project concentrations into the future, to determine the year where levels reach 60,000 ppm. A secondary objective of our project is the creation of a model depicting the water budget system, to better understand the processes leading to the issues at hand. This model can act as a visual aid for residents and local leaders in better understanding the Salton Sea's limitations and constraints on salinity levels.

Hypothesis

Salinity levels of the Salton Sea will exceed 60,000 mg/L (ppm) within the next few decades, leading to the collapse of the fish populations, unless measures are taken to curb escalating salinity levels.

Data Sources

The data utilized in our study was obtained from the U.S. Department of the Interior, Bureau of Reclamation’s Lower Colorado Region website (U.S. Department of the Interior n.d.). Since the 1960’s, the Bureau of Reclamation has been conducting studies on the Salton Sea’s water quality and salinity, and offers access to related data on its webpage titled “Salton Sea.” An Excel spreadsheet is found on this page, in which quarterly water samples at the Sea and at influent rivers from 2004-2014 are recorded. While multiple water quality parameters and various locations are included in the spreadsheet, we utilized the data for Total Dissolved Solids (TDS) to represent salinity, measured in mg/L, and the location of “Whole Sea Average.”

Methods and Assumption

The methods utilized while obtaining salinity levels was obtained from data from the U.S. Department of the Interior, Bureau of Reclamation. While reviewing the data set, it was discovered that the units were in terms of total dissolved solids (TDS). An assumption made while determining salinity values was that TDS serves as a proxy for salinity. Methods in which the TDS was obtained include the collection of the top 10 cm of surface water, freezing the water, and then sampling the water for its composition (Miles et. al 2009). Given the TDS values for the years 2004-2014 were provided, a linear regression model was used to project future values.

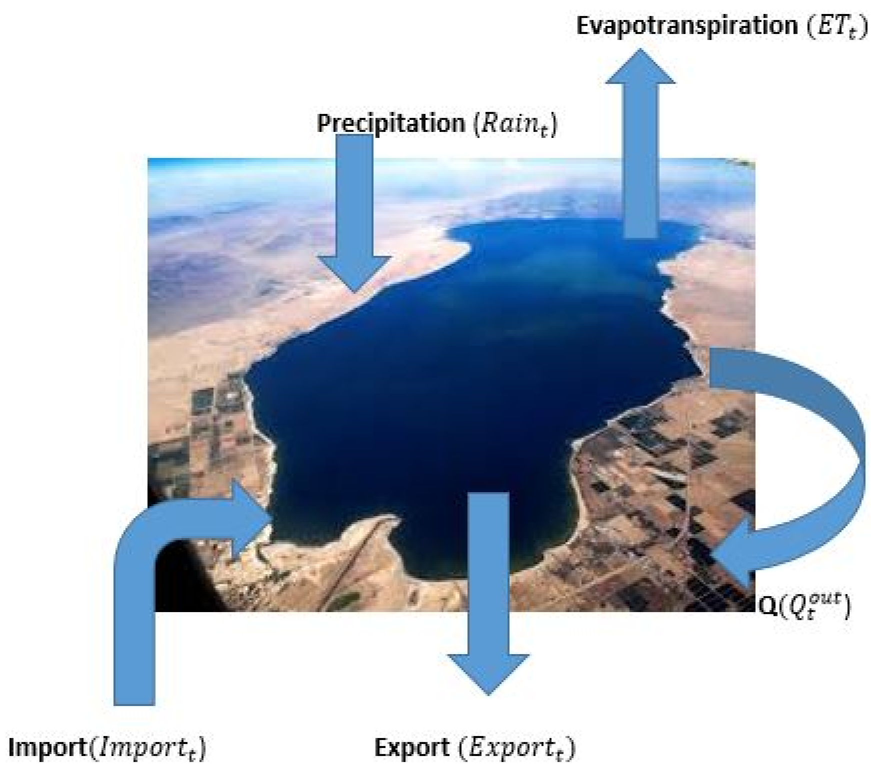
<u>Obtaining TDS values</u>:

1. Obtaining 10 cm of surficial water from the Salton Sea 3 times at 4 points (20-30 m apart).

2. Collected water samples were then each frozen and sent to UC Davis Agricultural and Natural Resources Laboratory for nutrient analysis.
3. Data analysis of each sample consisted of nitrate, ammonium, and phosphorus readings. Then TDS was determined by oven drying and gravimetric analysis. The following data has been recorded and graphed.

*TDS methods were formulated by Miles et. al as part of the Salton Sea Ecosystem Monitoring Program (2009).

Water Budget for the Salton Sea:



$$\Delta S_t = [Rain_t + Import_{t]} - [ET_t + Export_t + Q_t^{out}]$$

The Salton Sea is a natural system water budget, having influxes of inputs and outputs that affect the Sea itself. The inputs into the Sea consist of precipitation, and agricultural waste (Miles et. al 2009). Furthermore, exports of the Salton Sea include: diversions, exports, and evapotranspiration.

Calculation/Results

Using the data for total dissolved solid levels for years 2004-2014 (found on the U.S. Department of the Interior, Bureau of Reclamation, Lower Colorado Region website), both Linear and Power Regression curves were made.

Year	TDS
2004	45804
2005	46308
2006	46992
2007	48067
2008	49117
2009	50554
2010	51179
2011	52525
2012	53229
2013	54117
2014	55783

Table 1. Original total dissolved solids data taken from the Department of the Interior, Bureau of Reclamation, Lower Colorado Region (n.d.).

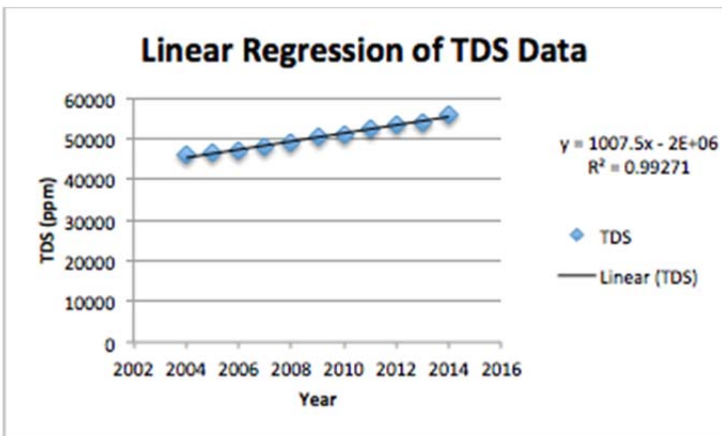


Figure 1. A linear regression analysis of the original total dissolved solids level with the equation R^2 value.

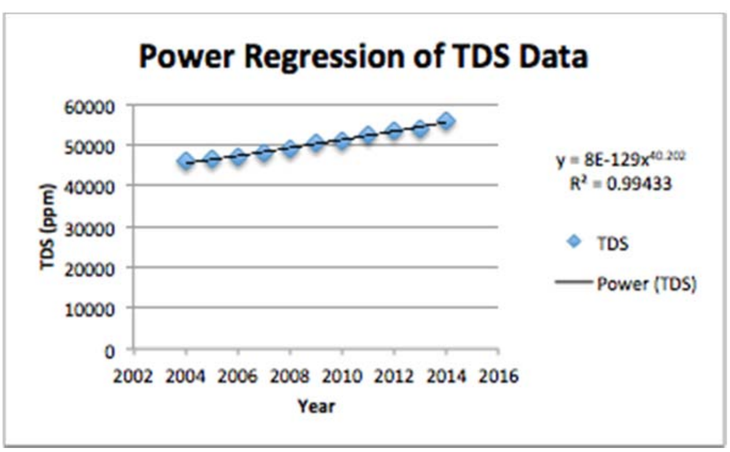


Figure 2. A power regression analysis of the original total dissolved solids level with the equation and R^2 value.

When comparing Figure 1 and Figure 2 the R^2 value for the power regression equation was closer to 1, and therefore it was used to project future (2015-2029) TDS levels:

y = 8E-129x^40.202
For year 2015:
y = 8E-129(2015)^40.202 = *55151.2762*
*same procedure was followed for the following years

2015	55151.27618
2016	56262.391
2017	57395.32335
2018	58550.49051
2019	59728.3175
2020	60929.23726
2021	62153.6908
2022	63402.12729
2023	64675.00428
2024	65972.7878
2025	67295.95252
2026	68644.98193
2027	70020.36849
2028	71422.61376
2029	72852.22863

Table 2. Projected total dissolved solid levels for years 2015-2029 based off the power regression curve.

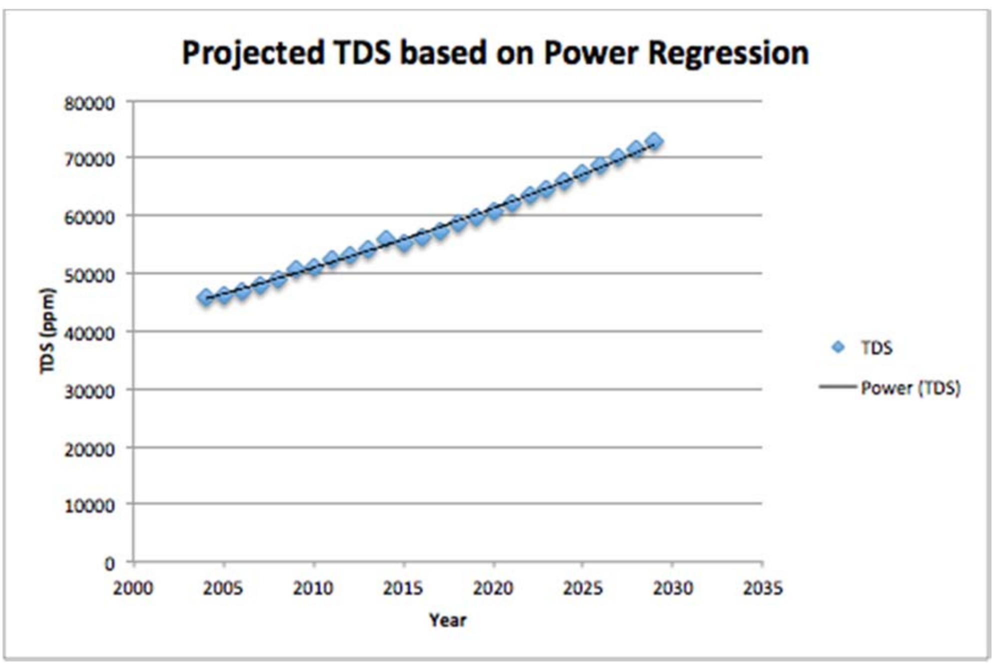


Figure 3. Combined original data from the Department of the Interior, Bureau of Reclamation, Lower Colorado Region (n.d.) and projected data.

Conclusion

Currently, millions of migratory birds use the fish in the Salton Sea as food every year. At a salinity level of 60,000 ppm, it is predicted that both the fisheries and the migratory bird populations dependent upon the fish populations will collapse (University of Redlands, n.d.). Using the power regression equation, we were able to reach the overall objective of our project by predicting the year in which the critical level of TDS occurs (if all other conditions, such as imports and exports, are held constant).

By identifying the year in which the Salton Sea salinity level reaches its threshold, we are able to provide policymakers with a deadline by which to implement new management efforts. Also, by explaining the water budget model of the Salton Sea, policymakers and stakeholders alike will be able to see how different imports and exports interact, and how they can best prioritize management efforts.

Recommendation/Limitations

Because our model predicts that the Sea's salinity level will exceed the tolerable limit for fisheries (and the connected food chain) by 2020, we strongly recommend that appropriate management actions be taken in order to slow this trend and preserve the Sea's ecological health as long as possible. According to the water budget model, the only two factors that humans can feasibly change are imports and exports. Although the Sea has no natural outlets and therefore exports are negligible (McClurg 1994), imports are essentially the major factor we must regulate in order to preserve the Sea. Reduction in imports can lead to less overall water and a greater proportion of salts; therefore any potential projects that plan to divert water from the region (and prevent maintenance of the current elevation level) should be curtailed. Instead, current inflow levels should be preserved to the greatest extent possible. A potential limitation to our recommendation is the fact that, according to the water budget model, the water level and salinity is affected by factors other than inflows, such as yearly precipitation and evaporation. Thus, altering inflows in certain years may make a larger impact in some years, but less of an impact in other years. Nevertheless, altering inflow levels is the only feasible management strategy that humans may utilize at this time.

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