

SAN DIEGO STATE UNIVERSITY

Abstract

Water quality in San Diego drinking water reservoirs is compromised by seasonal algal production, which may lead to significant economic costs for municipalities that draw water from them. This study looks at temporal trends (1990-2011) in and controlling factors of thermal stability and anoxia in reservoirs whose watersheds are currently in varying degrees of agricultural and urban development. It compares how land use, particularly urbanization, compares with other controls, such as climate and lake water fluctuations, on water quality. Lake volume is a significant control of thermal processes. An increase in anoxia in Lakes Barrett and Hodges is most strongly correlated with land use.

Study Site



- Barrett, Hodges, Morena and Sutherland are drinking water reservoirs that receive only surface runoff and no imported water
- warm monomictic lakes (stratify once in the summer)
- anoxic hypolimnia in the summer, though oxygen is depleted at varying rates



- nitrogen (N) and phosphorus (P) are the primary catalysts for algae growth
- different amounts of land use in their watersheds
- urbanization is expected to increase¹ across the county until 2050

Thermal and Oxygen Dynamics in Four Drinking Water Reservoirs Raymond Lee and Dr. Trent Biggs Department of Geography, San Diego State University





 lake volume is a major control of thermal processes:

- temperature
- thermocline depth
- Schmidt stability²
- stratification

 lake volumes fluctuate often

• few trends in lake thermal behavior were observed from 1990-2011



(Above) Linear regression lines show significant ($\alpha <$ 0.05) relationships. Points are annual means.

Characteristics of study reservoirs: Elevation; V—lake volume*; A40 —lake surface area*; z4max maximum depth; z — mean depth; S Jmax — mean maximum annual Stability; S — mean annual Stability; Stratified season — mean length of stratified season; AF — mean annual Anoxic Factor.

ervoir	Elevation (m)	V (10 ⁶ m ³)	A↓0 (km²)	z√max (m)	z (m)	z/A↓0 <i>î</i> 0.5 (m km <i>î</i> −1)	S √max (J m↑ −2)	S (J m <i>î</i> −2)	Stratified season (days)	Ŋ
rett	490	48.0	3.5	41.9	13.8	7.4	944.5	411.0	266	
lges	67	51.2	6.0	29.1	8.45	3.5	326.8	149.6	220	
ena	926	64.1	6.4	32.2	10.0	4.0	242.8	85.8	146	
herland	627	36.6	2.3	40.6	16.3	10.9	715.3	300.0	229	
gest value observed from 1990-2011.										

Results



At Barrett, the Anoxic Factor is correlated with:

- minimum air temperature
- (r = -0.44; p-value < 0.05)
- transparency
- (r = -0.62; p-value < 0.001)
- urban land use
- (r = 0.87; p-value < 0.001)
- rural residential land use
- (r = 0.80; p-value < 0.001)

At Hodges, the Anoxic Factor is correlated with:

- urban land use
- (r = 0.63; pvalue < 0.01)







(Left, below) Linear regression lines show significant (α < 0.05) relationships. For Hodges, data points were excluded for years when the lake did not stratify. Points are annual means.





(Above, below) Timeseries of independent variables.



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Conclusions

 This study looked at temperature and oxygen profile data at 4 reservoirs from 1990 – 2011. The reservoirs receive only surface runoff and no imported water. Water quality in the lakes reflects the water quality of runoff, which is related to human activity in the watershed.

• Lake volume has a large influence on lake temperature, stability and stratification in all of the study lakes. This has implications for reservoir management.

 Water temperature is not warming and is not significantly correlated with the Anoxic Factor at any of the study lakes.

 There are no trends in mean annual stability or the duration of stratification at Barrett, Hodges and Sutherland. The length of summer stratification is decreasing at Morena, due to a significant drop in lake volume. There is no trend, after controlling for lake volume.

 The Anoxic Factor increased at Barrett (3.7) days year⁻¹) and Hodges (2.0 days year⁻¹).

Factors contributing to increased anoxia include air temperature, transparency and land use.

 Land use (urbanization) shows the strongest statistical relationship to the increase in the Anoxic Factor.

References

. San Diego Association of Governments (SANDAG) Land <u>http://www.sandag.org/index.asp?</u> subclassid=100&fuseaction=home.subclasshome>. Accessed 20 Apr. 2012.

2. Hutchinson, G E. (1957) A treatise on limnology. Volume 1. Geography, physics and chemistry. 1015 PP. Wiley, New York. 3. Nurnberg, G. K. (1995) Quantifying anoxia in lakes. Limnology and Oceanography, 40, 1100-1111.