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ON THE ESTIMATION OF THE APPARENT UTILIZATION AND OVER SATURATION OF OXYGEN IN THE S.E. MEDITERRANEAN COASTAL WATERS.

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ABSTRACT

The hydrological characteristics of the S.E. Mediterranean during 1964-1971 is described. The apparent utilization and the over saturation of oxygen is determined in the surface and subsurface water layers. The over saturation values are recently indicated within 0.90-0.05 ml/l. The gross weights of both oxygen fractions are calculated. Monthly standing gross value of OSO ranges in between 15.0 and 341.5 thousand tons in the continental shelf waters north to the Nile delta. Clear regional and seasonal variations are detected.

INTRODUCTION

During the year 1965, the Nile water discharge was restricted due to its reservation beyond the recently constructed Aswan High Dam. A sharp decline of faunal and floral components of the coastal regions was observed. Naturally, the changes in the concentrations of nutrients were effective upon the phytoplankton abundance. Little is known about the decline of the biomass and abundance of the phytoplankton after 1966. Evaluation of the change in the fertility is suggested in this work, by using the apparent utilization and over saturation values of oxygen in the surface S.E. Mediterranean waters. This attempt is based upon the survey of the R/V "Ichthyology" 1964-1971 in these regions.

MATERIAL AND METHODS

The water samples were collected by means of reversible Nansen bottles. The temperature of sea water in situ, was measured using protected reversible thermometers accurate to $\pm$ 0.05°C. The salinity was determined titrimetrically according to Mohr method as modified by Oxner and Knudsen (1920), using a Knudsen burette and pipette. Oxygen was determined according to Winkler method as described by Strickland and Parsons (1968). Green and Carritt tables (1967) were used for the computation of oxygen saturation.

General Hydrology and Chemistry of the Coastal Waters

The hydrological features and pattern of distribution of water masses in the S.E. Mediterranean regions were discussed in details by Al-Kholy

and El-Wakeel (1975), El-Hehyawi and El-Tabbakh (1976), Ledovskoy (1970), Halim et al (1967) and Rzhonsnitsky (1970). The sea water of these regions is influenced by the interaction of evaporation, influx of waters from the outlets of the Nile mouth and lakes. In addition, it is also highly affected by the south eastwardly flowing surface water current of Atlantic origin along the coastal line. The flow path of the current is characterised by lower salinity and higher nutrient concentrations than the surrounding waters. The average oxygen values reaches 5.5, 5.1, 4.8 and 4.6 ml/l in February, May, September and August, respectively.

The presence of a subsurface layer of maximum oxygen content (5.2-5.6 ml/l) at depths from 30-50 meters is also distinguished during autumn.

In the winter season, there is comparatively uniform oxygen concentrations, due to the convection mixing in the upper 200 meters layer. Some slight increase of the oxygen from 5.5 to 5.6 ml/l is observed in the layers from 30-50 meters.

Definition and Applicability of the Apparant Utilization and Over Saturation of Oxygen

The sea water in the S.E. Mediterranean indicates a poor content of nutrient salts, which are frequently recorded beyond the analytical zero.

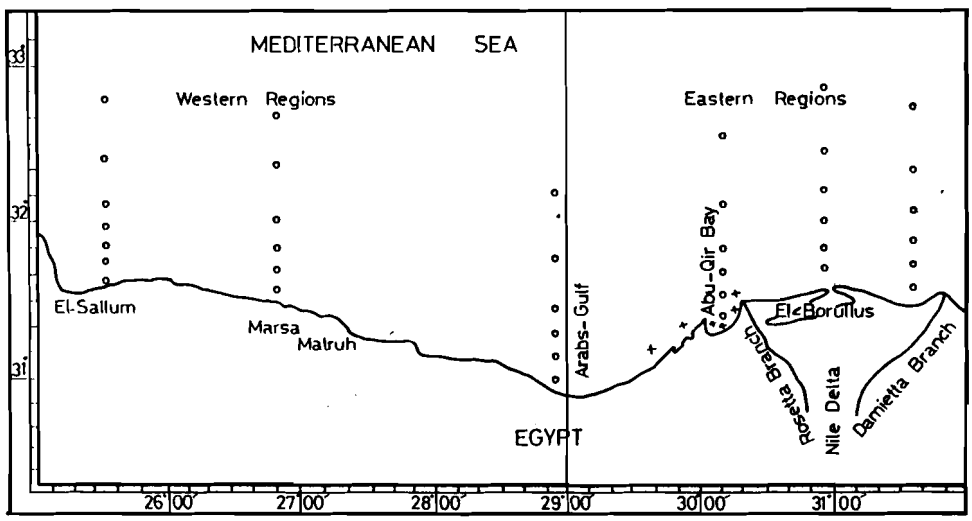

Fig. 1. The locations of sampling stations in the S.E. Mediterranean during 1970-1978.

Ryther and Gullard (1959) stated for the warm waters of the Sargasso Sea that the instantaneous concentration of nutrients is not as important in affecting productivity as the rate with which these elements are regenerated and absorbed in forms other than inorganic salts. These facts suggest the use of the apparent oxygen utilization (AOU) and the over saturation of oxygen (OSO) as indicators of the consumption and the production of photosynthetic oxygen successively in the sea water. The maximum oxygen consumption by the dissolved organic matter was recorded within 0.6-1.4 ml O_2/1 in the S.E. Mediterranean.

Significant seasonal and local variations of oxygen were found in association with the productivity of sea water (Ledovskoy 1970, Redfield 1942 and Stefansson 1968). Other advantage of the use of these values is that they facilitate the determination of their standing gross weight in the investigated water masses.

Utilization and Over Saturation Changes of Oxygen During 1964 - 66.

The investigations during 1964 were restricted to the autumn season. The northern waters to Abu-Qir Bay, Rosetta and Damietta mouths of the Nile were found during October 1964 to attain oxygen percent saturation range from 105 to 121%. The discharge of about 32 Km^3 flood waters into the sea was recorded during August and September. A low value of about 90% was detected in the water layer (20-50 m) adjacent to Rosetta mouth of the Nile. This was explained by the intense oxidation of organic matter. Other intensive phytoplankton blooms were recorded in the continental shelf waters within the range 2400 x 10^6-500 x 10^6 counts/m^3 in autumn. Positive over saturation oxygen values dominated the surface 0-10 m water layer in these regions. They ranged from about 1.60 ml/l in the nearshore waters to about 0.25 ml/l beyond the continental shelf waters (Fig.2).

A sharp decrease in the oxygen content was observed during the following years. The Nile discharge dcereased to about 2.0 Km^3 during August and September 1966. Ledovskoy (1970) detected the oxygen percent saturation in the coastal water to drop from 115 to 105%. Obvious variations in the over saturation oxygen could be noticed between 0.54 and 0.23 ml/l during November 1966. Average 0.42 ml/l covered about 2/3 of the total area. The sea water in the western regions acquired poor concentrations of average 0.36-0.26 ml/l OSO. With the fall of the spring the homogenity of the over saturation oxygen observed in the different regions during the winter was interrupted in a patch wise pattern of distribution with wide range of 0.59-0.09 ml/l. The surface water during the summer season in 1966 was characterized by an increase in the over saturtaion oxygen to about 0.45-0.20 ml/l. The majority of the investigated localities were occupied with waters attaining about 0.35 ml/l. The sea water in the northern regions along Lat. 32°10' attained about 0.45 ml/l OSO.

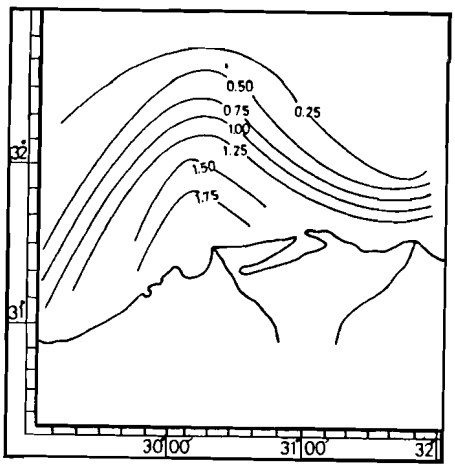

Fig. 2. The distribution of the maximum over saturation oxygen (+ml/l) in the surface 0-10 m. water layers in the eastern part of the S.E. Mediterranean during October 1964.

Recent Variations in the Utilization and Over Saturation of Oxygen

Oxygen Utilization During Autumn

The western surface 0-10 m water layer north to El-Sallum / Arabs Gulf regions shows oxygen utilization between -0.05 and -0.28 ml/l (Fig.3 A). Flow of the transformed water mass of Atlantic origin (Nilson 1912) dominates in the surface water and may explain the tongue-like extension of the negative core 0.20-0.28 ml/l AOU.

The pattern of distribution of the Nile Delta nearshore water mass is clear in the area enveloped by positive over saturation oxygen isolines (0.05-0.35 ml/l). A surface counter current which converges in these localities could be identified forming a cyclonic anticlockwise vortex. Some waters of the countercurrent become deflected sharply in a S.S.E. direction while the other part of the countercurrent proceeds in its main W.S.W direction. This latter part appears to explain the tongue of positive OSO isolines at lat.32°50' (Fig. 3 A). Other waters of apparent oxygen utilization are noticed to have an extension along Lat. 32°30' with values of about -0.07 ml/l. They interrupt the continuity of the positive characteristics in the waters north to the Nile Delta. Drobisheva (1970) found the maximum annual abundance 2287-3645 counts/m^3 of zooplankton during autumn. This high abundance may explain the apparent oxygen utilization in the S.E. Mediterranean during this season. At the same time, the phytoplankton abundance was indicated also by the relatively low average of 39 x 10^6 counts/m^3 (Savich 1970).

In the sea water layers from 10 to 50 m depths, it is possible to notice

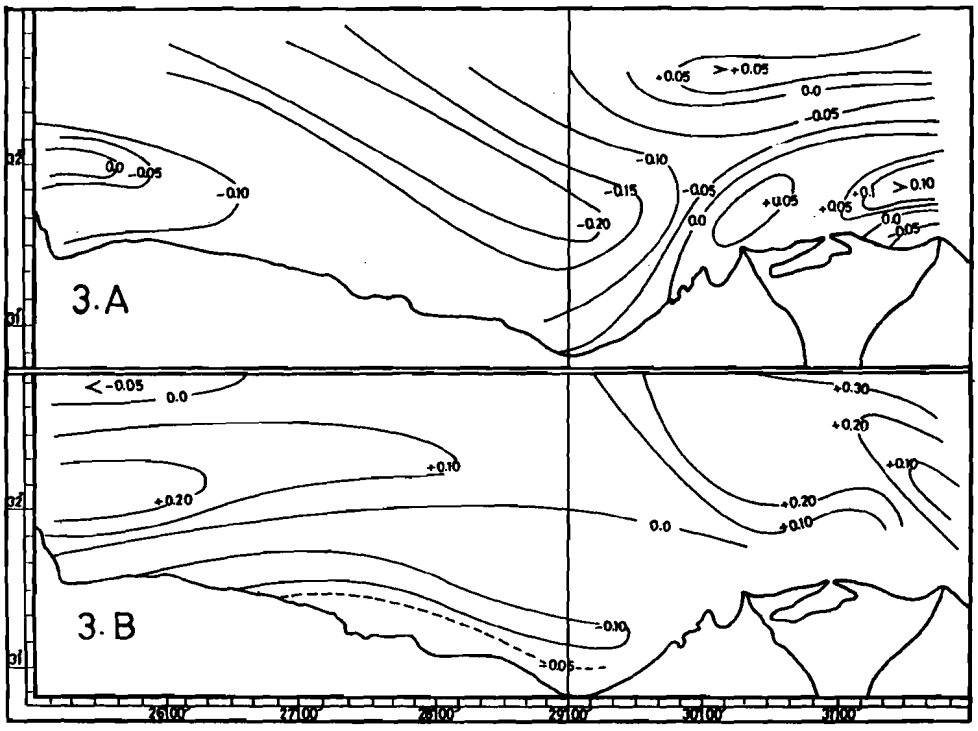

Fig. 3. The distribution of the maximum apparent oxygen utilization (- ml/l) and the over saturation oxygen (+ ml/l) in the water layers (0-10 m.),A and (10-50), B during Sept. 1970.

nearly the same pattern of distribution of the apparent oxygen utilization as in the surface waters. An exception is the discontinuity of the surface values north to Lat. 32°00' with the positive over saturation oxygen in the lower 10-50 m layers (Fig.3 B).

El-Sayed El-Hehyawi (1976) shows that these localities are dominated by transformed current waters of Atlantic origin with relatively high nutrients content and hence of considerable productivity.

Over Saturation of Oxygen During Winter

Relatively high over saturation of oxygen was found in the surface 0-10 m layer of the northern regions to El-Sallum Bay. The nearshore waters from El-Sallum show the same characteristic high values. They decrease eastwardly till they reach the minima in the Arabs Gulf. About two-thirds of the total area between Long. 25°10'E and 29°30'E indicate low values within the range from 0.05 to 0.10 ml/l (Fig.4 A).

The regions north to the Nile Delta are apparently dominated with values

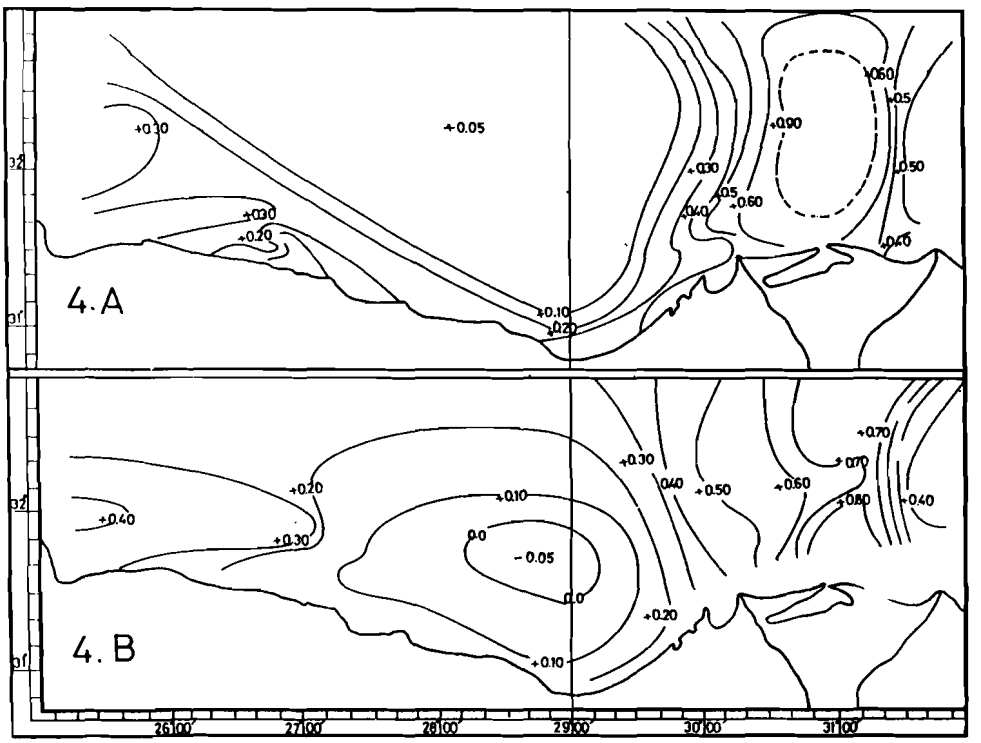

Fig. 4. The distribution of the maximum apparent oxygen utilization (- ml/l) and the over saturation oxygen (+ ml/l) in the water layers (0-10 m.):A and (10-50 m.):B during February 1971.

from 0.95 to 0.50 ml/l. The maximum values were centralized in the locations north to El-Borullus lake outlet. Savich (1970) found that maximum phytoplankton blooming is reached during the winter, with an average abundance of 179.2 x 10^6 count/m^3. The over saturation oxygen isolines pattern of distribution is in good agreement with the Nile Delta nearshore water mass.

A much more clear relation to the surface water masses pattern of distribution and productivity was noticed during winter in the 10-50 m water layer (Fig. 4 B).

Over Saturation of Oxygen During Spring

No spatial indication could be deduced from the OSO values in the 0-10 m water layer of the deep S.E. Mediterranean regions. Exceptionally high values were identified in the north western waters to El-Sallum and reaching 0.85 ml/l (Fig. 5 A).

The contrary is found in the 10-50 m water layers. Specific pattern

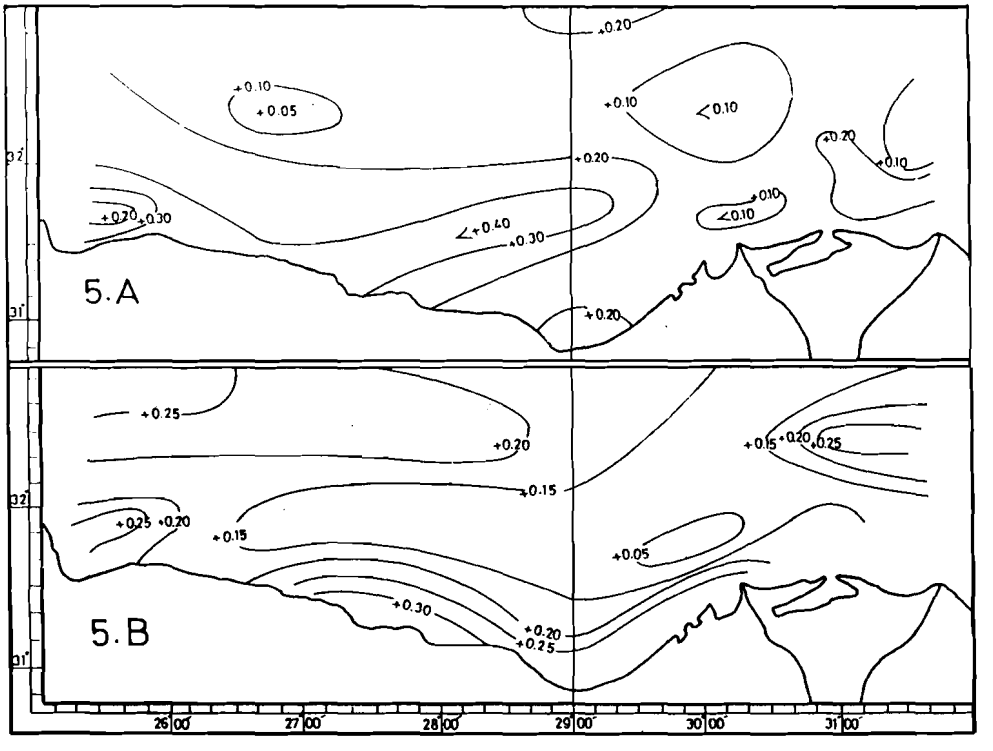

Fig. 5. The distribution of maximum over saturation oxygen (+ ml/l) in the water layers (0-10 m.):A and (10-50 m.):B during May 1971.

of distribution of OSO indicates a well developed core of maxima 0.20-0.30 ml/l in the northern regions to El-Sallum / Arabs Gulf along Lat. 32°50'N. This distribution suggests some modification of the flow path of the current waters during spring (Fig. 5 B).

Over Saturation of Oxygen During Summer

The general distribution of the values from 0.15-0.25 ml/l appears to dominate in all the surface 0-10 m water layer of the S.E. Mediterranean (Fig.6 A). This indicates the relatively poor photosynthesis oxygen production during this season, compared with winter. The nearshore waters from El-Sallum Bay to the Arabs Gulf show high OSO values. Comparatively low values were indicated in the offshore regions north to the Arabs Gulf. A dominating feature of the core isolines of maximum OSO is its tendency to be directed from east to west or south west. Other marked characteristic of the water layers at 10-50 m depths is its rich content of over saturation oxygen during summer. This could be noticed especially in the regions north to Lat. 31°50'N. The current system in both the eastern and western regions influences, through its flow path and nutritive elements, the productivity and the corresponding over saturation oxygen (Fig.6 B).

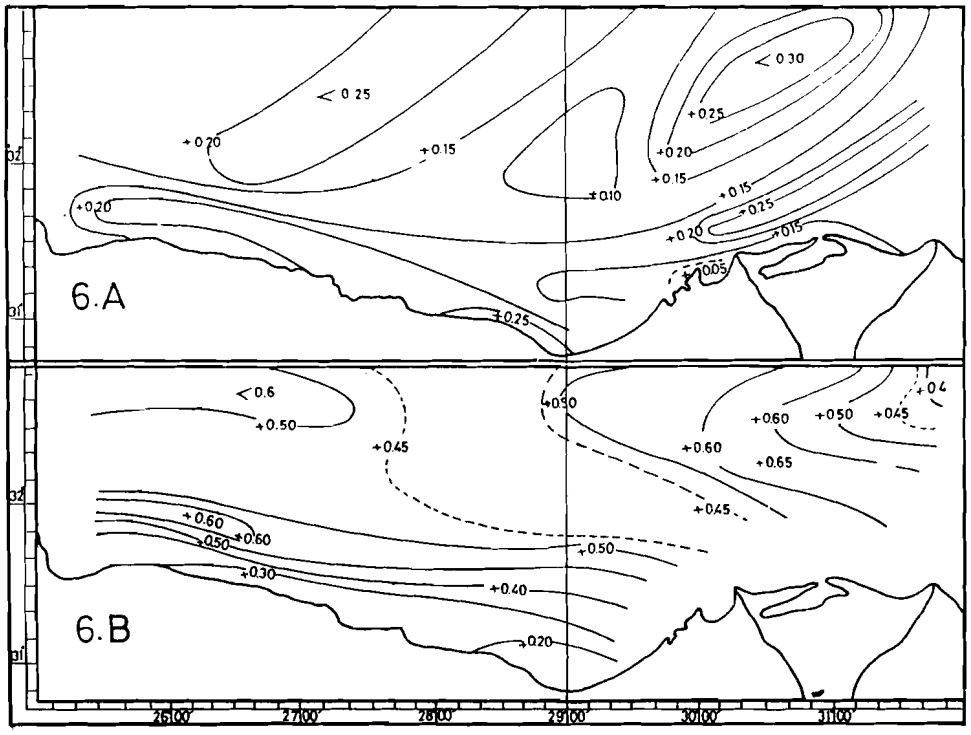

Fig. 6. The distribution of the maximum over saturation oxygen (+ ml/l) in the water layers (0-10 m.):A and (10-50 m.):B during August 1971.

Gross Weight of Utilization and Over Saturation of Oxygen

The standing gross weight of the apparently utilized and the over saturated oxygen is determined in the waters of the regions bordered by the southern coastal line and the northern Lat.33°00'N. Its eastern part is located between Long.29°00' and Long.31°15'E with a total area of about 61900 Km^2 of the surface layer. The western part is located between Long 25°00'E and 29°00'E. Therefore, the western area is estimated to reach about 79300 Km^2. A useful attempt is also made to determine the gross weight of both oxygen fractions resulting from the Nile flood in the eastern part during October 1964. This gives a record for the influence of the last outburst of phytoplankton blooming and surplus organic matter upon the oxygen content in these regions. It represents the conditions of maximum fertility of sea water, ever recorded in the S.E. Mediterranean.

The estimated weight of the over saturation oxygen in the surface 0-10 m layer during October 1964 was about 28 times that found during September 1971, while the apparent oxygen utilization is about 0.08 times that found during 1971.

During September 1971, the negative 0.15 ml/l AOU was distributed in these region and constituted about 25 x 10^3 tons of the gross weight. This indicates the poor phytoplankton production during autumn 1971 which through the photosynthesis could not compensate the oxygen utilization in these regions. The consumption of oxygen in the western part is 3 times higher than that in the eastern part of the S.E. mediterranean (Table 1). The content of over saturation oxygen during February 1971 appears to reach about 2.5 times its weight during both May and August. This suggests a considerable productivity in the eastern coastal waters during winter.

The over saturation oxygen in the deep 10-50 m layer of the eastern region is estimated to reach significant weight during February and August, respectively.

CONCLUSION

The use of apparent oxygen utilization and over satuartion oxygen to identify the characteristics of the water masses provides a simple index to evaluate the equilibrium between the consumed oxygen, through the oxidation of organic matter plus the respiration of organisms, and the oxygen production through the photosynthesis in the surface water layers. The distribution and magnitude of the over satuartion of oxygen during October 1964 is impressive in identifying the highly productive localities. The decline in the productivity was sharply indicated, during September 1970, by the drop of the values.

The gross weight of apparent oxygen utilization in the eastern regions, suggest that the consumption of oxygen during autumn in the surface water masses of the mentioned regions, is 3.2 times more than the production.

There are clear seasonal fluctuations in the over saturation oxygen. Oxygen utilization values appeared in the subsurface waters during the autumn and winter seasons. The gross weight of AOU constituted about one-tenth and 0.002 of the estimated weight of OSO during September and February 1970-1971 successively in the mentioned layers of the eastern regions.

A marked difference exists between the gross weights of OSO in the investigated western and eastern waters. During the autumn, winter and spring seasons, the western regions contained 2-20 times less weight of OSO than the eastern regions. This fact was noticed inspite of the larger western area. However, during August, the subsurface water in the western regions attained high OSO values and gave nearly an equal estimate of gross weight to that in the eastern regions. The weight of AOU in the western waters was higher by about four times than that in the eastern waters during September and February. It disappeared in the spring and summer seasons.

TABLE 1

Standing gross weight of apparent utilization and over saturation of oxygen in the regions south to Lat. 33°00'N during 1964 and 1970-71.

Date	Depth (m)	East to Long. 29°06'E		West to Long. 29°00'E	
		+ ΔSO (Ton x 10^3)	- AOU (Ton x 10^3)	+ ΔSO (Ton x 10^3)	- AOU (Ton x 10^3)
x 1964	0-10	390.463	3.503	-	-
IX 1970	0-10	14.712	45.864	0.735	172.061
	10-50	384.791	33.313	238.181	111.406
II 1971	0-10	341.452	0.0	162.435	0.0
	10-50	1325.441	2.950	894.230	10.289
V 1971	0-10	140.602	0.0	220.243	0.0
	10-50	492.864	0.0	809.259	0.0
VIII 1971	0-10	137.606	0.0	178.282	0.0
	10-50	1487-585	0.0	1909.354	0.0

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