

Gulf Research Reports

Volume 7 | Issue 4

January 1984

Comments on Density Inversions in Marine Shallow Waters and Beyond

Gordon Gunter

Gulf Coast Research Laboratory

Forrest V. Durand

Bureau of Outdoor Recreation, Atlanta

DOI: 10.18785/grr.0704.12

Follow this and additional works at: <http://aquila.usm.edu/gcr>

 Part of the [Marine Biology Commons](#)

Recommended Citation

Gunter, G. and F. V. Durand. 1984. Comments on Density Inversions in Marine Shallow Waters and Beyond. *Gulf Research Reports* 7 (4): 383-384.

Retrieved from <http://aquila.usm.edu/gcr/vol7/iss4/12>

This Short Communication is brought to you for free and open access by The Aquila Digital Community. It has been accepted for inclusion in *Gulf and Caribbean Research* by an authorized editor of The Aquila Digital Community. For more information, please contact Joshua.Cromwell@usm.edu.

COMMENTS ON DENSITY INVERSIONS IN MARINE SHALLOW WATERS AND BEYOND

GORDON GUNTER, DIRECTOR EMERITUS
AND FORREST V. DURAND¹, RETIRED

*Gulf Coast Research Laboratory, Ocean Springs, Mississippi 39564,
and Bureau of Outdoor Recreation, Atlanta, Georgia*

It has been shown within the past 70 years that salinity and thus density inversions are often detectible in shallow bays and estuaries. This terminology means that surface salinities are sometimes higher than those at lower depths. The first such discoveries in this country were made by Sumner, Louderback, Schmitt and Johnston (1914) in San Francisco Bay. They used Negretti-Zambra reversing thermometers for temperature and silver nitrate titration for salinity determination. These were by then considered to be classical methods and had been worked out in northern Europe, mostly in Scandinavia. They were introduced to the United States Gulf Coast and the authors in 1931 by Frank W. Weymouth, of Stanford University, who headed the Shrimp Investigations of the U.S. Bureau of Fisheries from 1930, which were later taken over by Milton J. Lindner.

Forrest V. Durand, as a cooperative agent of the Louisiana Department of Conservation, carried on the hydrographic work in Louisiana, mostly in Barataria Bay and adjacent offshore waters. The first author, as biologist for the Bureau, was a close observer, but of not much hydrographic assistance. Durand was under J. Nelson Gowanloch. After Durand left Louisiana the data were unfortunately misplaced.

Thirty-one years after Sumner et al. (1914), Gunter (1945) reported 5.5 percent inversions in 109 readings taken during a biological study of Copano and Aransas bays in Texas in the years 1941 and 1942.

Albert Collier, first marine biologist of the Texas Game, Fish, and Oyster Commission, had conducted a hydrographic survey in the same area in 1936 and 1937. During these years he took 385 salinity readings in Copano Bay and 874 in Aransas Bay at 47 station locations. He found 20.9 percent salinity inversions, 101 in Copano Bay and 144 in Aransas Bay, the higher salinity bay next to the sea.

There were 197 top and bottom equalities of salinity in Copano Bay and 85 in Aransas Bay. Copano is about 7 feet deep as compared to 11 feet for Aransas, the outer bay. In Copano Bay there were 14 readings of only 0.1 per mil difference in inversions, that is with the surface 0.1 parts per thousand higher in salinity. In Aransas Bay there were 17 such readings.

The data used here were taken from Tables 5 and 6, pages 186-192 (Collier and Hedgpeth 1950). Collier's data had been transported around to various places between 1936 and 1949 and moved hurriedly three times in front of hurricanes. Finally they aroused the interest of Joel W. Hedgpeth who resurrected them and completed the writing of the Collier, Hedgpeth paper with the addition of the Laguna Madre data which Hedgpeth had collated and in part gathered himself. In the meantime various parts of Collier's data were lost or displaced but we have held to Tables 5 and 6 as stated above. These comprised 1,169 salinity readings.

Strangely enough, Collier and Hedgpeth did not mention salinity inversions, which they so carefully recorded in their data, nor did they refer to similar data collected by Sumner et al. (1914) or the previously published reference of Gunter (1945) in their own region. However, their work has been referred to as the seminal paper in shallow-water hydrography on the United States Gulf coast and the authors had many subjects to address.

In Copano Bay the inversions ranged from 0.1 parts to 2.9 parts per thousand difference. There were only two of the larger size with many more at lower ranges. In Aransas Bay there were much wider variations, 2 up to 12 per mil, which could be doubted except for other high readings at nearby stations. These high readings at the surface in Aransas Bay may have been due to overriding of Gulf water or current aberrations in turbulent waters. In any case it is not thought to be worthwhile to try to analyze these data further in view of the impossibility of determining what caused the high figure inversions.

In Aransas Bay there were 399 more salinity samplings than in Copano Bay. In Copano Bay 101 density inversions were found among 385 readings. In Aransas Bay there were 144 inversions at 785 stations. Thus in the lower bay there was a decrease in density inversions per number of stations. This is apparently a real difference with a confidence limit of $p = 0.95$. Aransas Bay is about 4 feet deeper than Copano and this may be an important fact but we cannot be sure that wind velocity and some other factor made a difference nearer the sea. In any case, if this inversion trend were to continue on into saltier water of the open sea, density inversions at the surface would decrease in number. These matters need to be studied with sensitive instruments near the surface of the ocean. However, we cannot expect that any effect of physical factors will change merely because

¹ Present address: 105 Pine Street Drive, Jackson, TN 38301.
Manuscript received June 22, 1984; accepted June 25, 1984.

they are farther offshore. Thus it is to be assumed that winds and atmospheric conditions will affect the waters of the open sea in the same manner as they do in the bays. Thus it is expected that density inversions in surface waters will be found offshore, although the depth to which they extend is unknown. This should be a field for inquiry in the future because the situation remains very much as it was when Sverdrup stated, "... but nothing is known as to the annual variation of salinity at subsurface depths,..." (Sverdrup, Johnson and Fleming 1946, p. 146). In the past when salinity and temperature data were collected only at finite depths, oceanographers increased vertical spacing by wide intervals at sea when depth permitted, with some skipping of intervening phenomena.

Jacobs (1942) has given information on the evaporation rates in the Gulf of Mexico, the presumed basic cause of density inversions. In the open ocean, turbulence would not play such a strong part as we have implied above in the bays, channels, and confined waters.

Density inversions have been noted many times in Mississippi waters but the tables showing inversions are rather scarce and the matter is nowhere clearly discussed.

Charles Eleuterius (1973) in a processed report says of salinity on page 106, "During periods of high evaporation, the measurements in the surface layer of water were higher than those immediately beneath; however, the temperature

differential substantiated the stability of this structure."

This is not the clearest possible language but it does mention the essential conditions for density inversions. They occur first at the surface due to evaporation, then sink to their own level of specific gravity, where essentially they disappear. The lighter, displaced water then rises to the surface where it is subjected to evaporation. Thus the process is cyclical and continuous at all water surfaces, varying with temperatures of the water and air, the water salinity, the percentage of water vapor in the air and the wind speed. It causes an exchange of various surface layers of water and deeper layers, varying with the numerous conditions listed above. It has not been studied thoroughly and carefully anywhere.

In the above discussion we have spoken of salinity inversions although the temperature readings at the same stations have substantiated the reality of density inversions based on both factors, salinity and temperature.

It seems to be of some importance to consider that the sinking of high-salinity water to its equilibrium level, and a compensating rise of water from a greater depth, is somewhat analogous to a breathing process at the surface of the sea modified by various climatic and atmospheric conditions, and results in modified exchange of water and atmospheric components. This process is continually carried on or "powered" so to speak by evaporation at the sea surface.

REFERENCES CITED

- Collier, Albert & Joel W. Hedgpeth. 1950. An introduction to the hydrography of tidal waters of Texas. *Publ. Inst. Mar. Sci. Univ. Tex.* 1(2):121-194.
- Eleuterius, Charles K. (1973). Biloxi Bay Hydrography Final Report. NASA Contract NAS9-12965. 112 pp., (unpublished report).
- Gunter, Gordon. 1945. Studies on marine fishes of Texas. *Publ. Inst. Mar. Sci. Univ. Tex.* 1(1):1-190.
- Jacobs, W. C. 1942. On the energy exchange between sea and atmosphere. *J. Mar. Res.* 5:37-66.
- Sumner, Francis B., George D. Louderback, Waldo L. Schmitt & Edward C. Johnston. 1914. A report upon the physical conditions in San Francisco Bay, based upon the operations of the United States Fisheries Steamer "Albatross" during the years 1912 and 1913. *Univ. Calif. Publ. Zool.* 14(1):1-198.
- Sverdrup, H. U., M. W. Johnson & R. H. Fleming. 1942. *The Oceans, their Physics, Chemistry, and General Biology*. Prentice Hall, Inc., New York.