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SOME NOTES ON THE USE OF THE TERM „THERMOCLINA"

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SOME NOTES ON THE USE OF THE TERM "THERMOCLINA"

By

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Is there any justification for the use, in the oceanographic literature, of the term »Thermoclina«, meaning »discontinuity layer«, as often found in that literature?

»Thermoclina« is a term which, originating from the limnobiologic literature (see Boguslawski-Krümmel 1907), denotes the depth of the layer with the maximal gradient of the decrease of temperature. That layer coincides with the maximal gradient of the increase of water density.

The conclusion on the condition of the density of layers on the basis of the data on temperature is made possible by that coincidence, because the quantities of dissolved salts in fresh waters are so small that they practically do not influence the density of water. There are cases, however, of freshwater lakes the lower layers of which stagnate, where considerable amounts of salts are added to their deep water not without influencing their density (see K. M. Strom 1945, Strom K. M. & H. Ostveit 1948).

What are the conditions prevailing with salt waters in this respect?

Besides the factor of temperature of salt waters, there is another, equally important factor, i. e. the salinity which affects the specific weight of a certain layer of sea water.

There is little difference in the salinity of the surface and bottom layers in the open sea region. Where such conditions prevail, making it practically possible to consider the water as a homogeneous one, it is here as in the case of fresh waters, that the region of thermoclina is identical with the maximal gradient of σt, when the appearance of thermoclina is caused by warming up of water. The term thermoclina is then equally suitable as e. g. »discontinuity layer« or »Sprungschicht«.

In those regions, however, where fresh water and ocean water or open sea water come into contact and mutually influence each other the conditions are somewhat different.

In these conditions the salinity factor may oscillate indipendently within single layers during different seasons of the year, without having any connection with the oscillation of temperature within single layers during different seasons. Similar oscillations of salinity are so significant that the temperature factor is often outweighted by them so that σt of such waters is predominantly influenced by salinity. That results very often in the phenomenon of disagreement between the layer with the thermoclina and the layer with the maximal gradient of sigma t, each of them belonging to different depths of the station.

The thermoclina might misguide us in the above case because it does not agree with the place of the border of layers differing in their density, as during the investigations into the stability of layers and into the vertical transport of salts or gases, an important part is played by the border of layers differing in density but not by the border of layers differing in temperature. In such cases, than, the region of the thermoclina differs from the region showing the maximal gradient of density, for which the term »pycnoclina« is suggested. The examples underlying this consideration, are given in adjoining tables.

When compiling the tables I applied the mathematical method of determination of average slopes of single curves for single intervals of depth $\frac{\Delta x}{\Delta z}$; ($x = t^0$ or Sal ‰ or σt, z = depth and Δz = thickness of layer in metres).

The maximal value $\frac{\Delta x}{\Delta z}$ in single columns of the table denotes the place of the maximal gradient of that factor, namely the place where there is the slightest inclination of the »clina« to the x axis, in other words where it is best developed, as e. g. in the usual graphs with coordinates x, z, (z is the ordinate).

The layer where $\frac{\Delta x}{\Delta z}$ of the highest value is placed can normally be taken as the layer where the border between two waters runs with regard to some factor, e. g. of the density of water. By using this method the necessity of drawing graphs is greatly reduced.

Four different cases of mutual placing of the maximal gradient of the three investigated factors are possible in all:

1st case: T-S pycnoclina, where the thermoclina and the haloclina belong to the same layer as the pycnoclina (table 1 and 2).

2nd case: T-pycnoclina, where the position of the pycnoclina agrees with that of the thermoclina, whilst the haloclina lies in another, upper or lower, water layer. (Tables 3, 4 and 5.)

3rd case: S-pycnoclina, where the position of the pycnoclina agrees with that of the haloclina, whilst the thermoclina shifts upwards or downwards (Tables 6—13.), and

4th case: where all the three clinas lie in different layers of the station, with the pycnoclina placed between the other two. This case is a very rare one, when during the analysis of material the differences of position of single »clinas« are neglected, differences which are smaller than the those relative to the depth of layers when samples are taken and the temperature is measured at some station. In other words, the case would be more frequent if a smaller difference of depth of single levels was taken. One example belonging to the »fourth« case has been found and given in Table 14.

T-S pycnoclina is characteristic for the open sea, but it is very frequent along the seashore too.

T-pycnoclina is characteristic for fresh waters and ocean water alike.

S-pycnoclina is characteristic for inshore regions where fresh water comes together with sea water, as it happens in the bays with river estuaries, e. g. Gulf of Trst (Trieste), Kaštela, in some fiords, such as Oslo Fiord, and in the straits, such as Bosphorus and Gibraltar. From the data we obtained by investigating the sea inlet called Mljet Lakes (Mljet Island), it has been found the T- and S-pycnoclina (2nd and 3rd case) are a very frequent phenomenon with sea water pools having a dichotomic arrangement of temperature.

To be able to draw a picture showing how the three types of these »clinas« are represented in the coastal region in the course of a year, I give the folloving data obtained by elaborating the paper by A. Ercegović (1934). At the A station

(Kaštela Bay near Split) 32 measurements of temperature and salinity were carried out in total, covering six levels. Thirty metres was the depth at that station. Out of those measurements, eleven of them showed a pycnoclina of the type T-S, whilst there were seven instances of S-pycnoclina and four instances of T-pycnoclina. Ten measurements were not considered, as they were taken mostly in winter-time, when the layers were labile, with the highest values of difference σt, of the lower and upper layers for each measuring being less than 2,50 of the walue of σt, so that we suppose that the »clinas«, were not clearly developed.

The occurrence of different types of »clinas« in the inshore waters with fresh water influx may be considered, then, as quite a normal appearance and this fact should be kept in mind.

CONCLUSION

We see from what has been said above that the temperature is an important factor valid for both the open sea and the inshore regions as well as for fresh waters, which determines, by its maximal gradient (thermoclina), the position of the maximal gradient σt in the layers (pycnoclina). These two data should, however, not be confounded or even identified, as it happens when using the terms thermoclina, Sprungschicht, discontinuity layer, and others to mark one and the same phenomenon. That cannot be admitted owing to the fact that the influence or the maximal gradient of salinity (haloclina) in the inshore regions, where the influx of fresh waters is more felt, may overweigh the value of thermoclina and cause the thermoclina layer and the pycnoclina layer to be separated at the same station for tens of metres in some instances. It happens analogously in straits where there is a simultaneous flow of deep water in one direction and a flow of surface water of different salinity in the opposite direction, as it had been found in the straits of Gibraltar and Bosphorus.

Owing to these facts, and in order to avoid any confusion, the use of the following terms is suggested for maximal gradients of density, temperature, and salinity, respectively:

»pycnoclina« — for the layer of water with the maximally developed gradient of specific gravity,

»haloclina« — analogously — for the layer with the maximally developed gradient of salinity,

»thermoclina« — for the layer with the maximal gradient of temperature.

The term »clina« has been used in this paper as a common term for the above three notions.

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APPENDIX

Table 1

A station 20 Nm SSE from Vis Island, Mid-Adriatic, 6. VI. 1949.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^{0}}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—20	0.047	0.163	0.007	
20—30	**0.071**	**0.261**	**0.013**	
30—50	0.006	0.024	0.001	
50—70	0.002	0.009	0.000	
70—100	0.005	0.034	0.003	(Buljan M.,
100—150	0.006	0.033	0.001	unpublished data)

Table 2

Station J1 — 16. V. 1911. Gulf of Trst (Trieste), North Adriatic

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^{0}}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—5	0.312	0.476	0.282	
5—10	**0.352**	**0.560**	**0.300**	
10—20	0.061	0.299	0.003	
20—30	0.021	0.020	0.024	
30—40	0.000	0.005	0.000	(»Najade« 1912)

Table 3

Station A — Kaštela Bay, Mid-Adriatic, 10. IX. 1932.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^{0}}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—5	0.240	0.572	**0.086**	
5—10	0.202	0.556	0.060	
10—15	**0.280**	**0.774**	0.040	
15—20	0.036	0.100	0.016	(A. Ercegović
20—30	0.040	0.104	0.022	op. cit.)

Table 4

Station D. Maslinica, Mid-Adriatic, 30. VI. 1932.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—10	**0.116**	**0.293**	0.047	
10—20	0.083	0.109	**0.072**	
20—30	0.058	0.235	0.012	
30—40	0.041	0.071	0.018	
40—50	0.014	0.052	0.006	
50—60	0.009	0.021	0.005	
60—70	0.001	0.002	0.000	
70—80	0.008	0.011	0.008	(A. Ercegović
80—90	0.002	0.028	0.010	op. cit.)

Table 5

Station 80 — Bay of Biscay 13. VI. 1910.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{z \nabla}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—50	**0.013**	**0.064**	<0.001	
50—100	0.004	0.024	<0.001	
100—200	0.001	0.003	<0.001	
200—400	<0.001	0.001	<0.001	
400—800	<0.001	0.001	<0.001	
800—1000	<0.001	0.003	<0.001	
1000—1200	<0.001	0.004	<0.001	
1200—1500	<0.001	0.009	<0.001	(Reports Dan. Oc.
1500—2000	<0.001	0.004	<0.001	Exp. »Thor« 1912)

Table 6
Station A — Kaštela Bay, Mid-Adriatic,
21. VI. 1933.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—5	0.114	**0.368**	0.040	
5—10	**0.126**	0.082	**0.160**	
10—15	0.094	0.040	0.112	
15—20	0.020	0.060	0.010	(A. Ercegović
20—30	0.040	0.067	0.031	op. cit.)

Table 7
Station 171 — Bosphorus, 10. VIII. 1910.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—10	0.050	0.170	0.007	
10—20	0.110	0.405	0.022	
20—25	0.170	**0.676**	0.046	
25—40	0.526	0.010	0.682	
40—45	**0.938**	0.246	**1.078**	
45—50	0.004	0.070	0.014	(Reports Dan. Oc.
50—58	0.121	0.020	0.182	Exp. »Thor« op. cit.)

Table 8
Station 98 — Strait of Gibraltar,
23. VI. 1910.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—25	**0.019**	**0.068**	0.003	
25—50	0.003	0.018	0.001	
50—100	0.012	0.033	0.005	
100—150	**0.019**	0.006	**0.023**	
150—200	0.004	0.001	0.002	
200—250	0.009	0.012	0.009	
250—300	0.005	0.005	0.005	
300—500	0.000	0.000	0.000	(Reports Dan. Oc.
500—700	—	0.000	—	Exp. »Thor« op. cit.)

Table 9

Station 99 — Strait of Gibraltar, 23. VI. 1910.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—25	0.002	0.013	0.000	
25—50	**0.023**	0.019	**0.012**	
50—100	0.019	0.005	0.003	
100—125	0.016	**0.049**	0.006	
125—150	0.010	0.016	0.009	
150—200	0.004	0.004	0.004	
200—250	0.001	0.001	0.001	
250—300	0.000	0.000	0.000	
300—400	0.000	0.000	0.000	
400—500	0.000	0.000	0.000	
500—600	0.000	0.000	0.000	
600—900	0.000	0.000	0.000	(Reports Dan. Oc.
900—1000	0.000	0.000	0.000	Exp. »Thor« op. cit.)

Table 10

Station 177 — Sea of Marmora, 12. VIII. 1910.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—10	—0.001	0.005	—0.002	
10—15	0.104	0.090	0.102	
15—20	0.946	**1.620**	0.714	
20—25	**1.110**	0.074	**1.430**	
25—30	0.646	—0.110	0.878	(Reports Dan. Oc.
30—50	0.041	0.006	0.051	Exp. »Thor« op. cit.)

Table 11

Station A 1 — 17. V. 1911., Northern Adriatic

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—5	**0.712**	0.316	**0.842**	
5—10	0.132	**0.530**	0.014	
10—20	0.492	0.447	0.524	
20—22	0.040	0.025	0.050	(»Najade« op. cit.)

Table 12

Station a 2 — Northern Adriatic, 18. V. 1912.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—5	0.002	0.036	0.016	
5—10	**0.290**	0.194	**0.320**	
10—20	0.131	**0.216**	0.110	
20—30	0.008	0.004	0.011	(»Najade« op. cit.)

Table 13

Station 20 — Drobak Sound, Oslo Fjord, 18. VII. 1933.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
1—10	**0.704**	0.327	**0.831**	
10—25	0.080	0.026	0.092	
25—40	0.208	**0.508**	0.149	
40—75	0.057	0.042	0.060	
75—150	0.005	0.004	0.005	(T. Braarud & J. T.
150—200	0.000	0.000	0.000	Ruud 1937)

Table 14
Station A — Kaštela Bay, Mid-Adriatic,
20. IX. 1932.

Thickness of water layer in metres	$\frac{\Delta \sigma t}{\Delta z}$	$\frac{\Delta t^0}{\Delta z}$	$\frac{\Delta Sal‰}{\Delta z}$	Reference
0—5	0.102	0.110	**0.090**	
5—10	0.028	0.020	0.038	
10—15	**0.122**	0.342	0.018	
15—20	0.078	0.240	0.020	(A. Ercegović
20—30	0.108	**0.361**	0.018	op. cit.)

REMARK CONCERNING ALL TABLES

Items in bold characters are maximal values of each of the vertical columns. In the first column can be seen the mutual vertical shifting of the maxima of clinas at each station.

BILJEŠKA O UPOTREBI IZRAZA TERMOKLINA

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KRATAK SADRŽAJ

U radu je kritički tretiran dosadašnji način uporabe izraza »termoklina« u oceanografskoj literaturi.

Iz gornjega izlazi, da je normalno na otvorenim područjima, u priobalnim morskim područjima, te također i u slatkim vodama, temperatura znatan faktor, koji određuje svojim maksimumom gradienta (termoklinom) i smještaj maksimuma gradienta σt u slojevima (piknoklinu). Međutim se ne smiju ova dva podatka pomiješati ili čak identificirati, kao što se to čini kad se upotrebljavaju izrazi termoklina, Sprungschicht, discontinuity layer i sl. za oznaku jedne pojave. To nije dopušteno stoga, što se u priobalnim područjima, gdje postoji jači donos slatkih voda, upliv maksimalnog gradienta slanosti (haloklina) može svojom vrijednošću superponirati vrijednosti termokline i tada uzrokuje, da su sloj termokline i sloj piknokline međusobno odijeljeni na istoj postaji i za nekoliko desetaka metara. Ovo je također slučaj u tjesnacima, gdje istodobno postoji tok dubinske vode u jednom pravcu, a tok površinske vode druge slanosti u suprotnom pravcu, kao što je to slučaj u Gibraltarskom tjesnacu i Bosporu.

Zbog toga, da bi se izbjeglo eventualno unošenje zabune, predlaže se upotreba termina za maksimume gradienta posebno gustoće, posebno temperature i posebno slanosti kako slijedi:

»piknoklina« je sloj vode, gdje je postignut maksimalni gradient specifične gustoće,

»haloklina« je, analogno gornjem, područje sloja maksimalno razvijenog gradienta saliniteta,

»termoklina« je sloj sa maksimalnim gradientom temperature.

Nađeno je da postoje tri tipa piknoklina: T-, S- i T-S-piknoklina, već prema tome da li iz temperaturnog, salinitetnog ili

iz oba gradienta rezultira najviši gradient specifične težine slojeva neke postaje.

U ovom članku je upotrebljen izraz klina kao opći (generički) termin za sva tri gornja izraza.

Priložene su table sa podacima koji podupiru iznesene prijedloge.

Tisak: Novinsko izdavačko poduzeće „Slobodna Dalmacija" - Split