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Literature Study on the Chemical Composition of Sea Water.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
Washington, D.C.

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CONTENTS

CONTENTS (Cont'd.)

Reference No.	1	2	3	4	5	6	7	8
pH	8.5	8.6	8.6			7.7		
Sp.Gr.	1.0253	1.025	1.025	1.023	1.023	1.027	1.025	1.023
Conductivity referred to 1/50 normal KCl		15.06	15.18					
Total Solids	35.891	32.741	33.521	37.500	36.800	37.750	37.170	36.350
Non-Volatile Solids	34.018	27.688	27.902	34.550	34.950	34.580	32.500	32.540
Volatile Solids	1.873	5.053	5.619	2.950	1.850	3.170	4.670	3.810
SiO_2	0.01110	0.0060	0.0060	0.0060	0.0040	0.0098	0.00750	0.0090
Fe	0.00012	0.00014	0.00013	0.00550	0.00300	0.00150	0.00030	0.00030
Al		0.00025	0.00020	0.00520	0.00200	0.00240	0.00080	0.00080
Ca	0.42700	0.41000	0.41400	0.61400	0.46000	0.43500	0.39800	0.39300

1/50 normal KCl		15.06	15.18						
Total Solids	35.891	32.741	33.521	37.500	36.300	37.750	37.170	36.350	
Non-Volatile Solids	34.018	27.688	27.902	34.550	34.950	34.580	32.500	32.540	
Volatile Solids	1.873	5.053	5.619	2.950	1.850	3.170	4.670	3.810	
SiO_2	0.01110	0.0060	0.0060	0.0060	0.0040	0.0098	0.00750	0.0090	
Fe	0.00012	0.00014	0.00013	0.00550	0.00300	0.00150	0.00030	0.00030	
Al		0.00025	0.00020	0.00520	0.00200	0.00240	0.00080	0.00080	
Ca	0.42700	0.41000	0.41400	0.61400	0.46000	0.43500	0.39800	0.39300	
CaO									
Mg	1.31300	1.14100	1.15600	1.16000	0.98000	1.32500	1.26640	1.23700	
MgO									
K	0.40400	0.34300	0.34400	1.01000	0.94500	0.43500	0.38100	0.38100	
K_2O									
Na	11.05000	9.08900	9.15200	10.08300	10.47500	11.04000	10.85000	10.84500	
Na_2O									
SO_4	2.64900	2.36400	2.41800	2.60000	2.70000	2.71000	2.54500	2.50700	
SO_3									
PO_4	0.00480	0.00120	0.00093	0.00200	0.001300	0.001000	0.000200	0.00015	
CO_2									
CO_3	0.01170							0.00	
HCO_3	0.13700			0.12500	0.16000	0.15000	0.14000	0.14000	
Cl	19.69000	16.86900	17.17900	19.35000	19.60000	19.96000	18.75500	18.58000	
Br									
I									
F									
Total N	0.00200			0.003600	0.00315	0.00035			
NaCl	28.06000	21.79200	21.95900	27.65000	26.62500				
KCl	0.76800	1.30700	1.31000	1.92500	1.80000				
NaCl plus KCl	28.82500	24.36900	24.56900						
$CaCO_3$									
H_2SO_4									
Mineral Arsenic									
Organic Arsenic									
B									
Li									

\# Combined
& Free
* Lime not included in $CaCO_3$ below.

TABLE 1 - COMPOSITION OF SEA WATER, PARTS/1000

8	9	10	11	12	13	13A	14	15	16	17	18
									8.1		
023	1.023	1.0265	1.0275	1.02434					1.028		
350	34.965		36.31	36.3516	42.54926	35.55121					
540	31.490										

023	1.023	1.0265	1.0275	1.02434					8.1 1.028	
350	34.965		36.31	36.3516	42.54926	35.55121				
40	31.490									
10	3.475									
090	0.00193									
0030	0.00040									
0080	0.00040									
3300	0.43400			0.407137						
		0.578	0.6518		0.50439*	0.5063*				
3700	1.23100			1.30502						
		2.203	2.4270		2.3034	1.94439				
3100	0.41200			0.399867						
		0.472	0.049952		0.49751	0.40292				
500	10.18500			11.196289						
			1.5266		15.6263	13.08292				
700	2.47800			2.7409					2.972	
		2.214	2.4679							
015	0.00020									
			58.46# 5.11&							
	0.01305			0.12359						
000										
000	18.29500	19.320	20.6569	20.0806	20.854	17.395	17.926	19.020	23.609	
			0.0671	0.061797	0.0702	0.05857	0.0622	0.0646		
									0.04878	
		26.82								
		0.747								
		0.0200			0.123902	0.09853				
					2.4887	2.0682				
										0.0087
										0.0002

18	19	20A	20B	20C	20D	20E	21	22	23	24	25
								8.64	8.47	8.64	8.57
								16.32	16.32	16.26	16.39

				16.32	16.32	16.26	16.39
				0.00017	0.00017	0.00025	0.00017
	0.433	0.429	0.440	0.436	0.392
	1.353	1.301	1.313	1.323	0.177
	0.442	0.390	0.394	0.394	0.368
	11.049	10.968	11.022	11.036	9.771
	2.754	2.681	2.699	2.730	2.378
	0.132	0.129	0.129	0.129	0.129
	19.909	19.635	19.767	19.810	17.571

0.00878

0.00078

0.00450

0.000097

GENERAL COMPOSITION

(1-9) The Chemical Composition of Sea Water.
C.B. Lipman - Carnegie Institute of Washington,
Publication No. 391.

(10) Journal of the Chemical Society, 1881-A 81.

Results of the Norwegian North Sea Expedition.
Jr. P.R. Chem. (2), 22, (165 - 188) - 1.
L. Schmelck.
Solid Constitutents of Sea Water.

The Northern Arctic Ocean has a mean sp.gr. of 1.0265, and contains (per cent):

CaO	MgO	K_2O	Cl	SO_3
0.0578	0.2203	0.0472	1.9320	0.2214

The average amounts of salts occurring in the sea and the composition of the sea salt are:

	Sea Water - %	Sea Salt - %
Calcium carbonate	0.0020	0.057
Calcium sulphate	0.1395	4.00
Magnesium sulphate	0.2070	5.93
Magnesium chloride	0.3562	10.20
Potassium chloride	0.0747	2.14
Hydrogen sodium carbonate	0.0166	0.476
Sodium chloride	2.682	76.84

F.L.T.

(11) Journal of the Chemical Society, 1898 - A II - 441.

Sea Water from the Atlantic Ocean.
Composition of the Atlantic Ocean.
Charles J.S. Makin (Chem. News, 1898 77, 155 - 156) 171 - 172.

Samples of water from the Atlantic Ocean were taken at noon during a homeward voyage from the cape; there were twenty-two

samples in all. The total solids were determined in each sample, and varied from 34.51 per 1000 (taken during a continued heavy rain) to 37.39 per 1000 (taken at Tinereffe, 200 yards from shore, in about 11 fathoms). The samples were mixed and a full analysis made of the average samples so obtained; it had a sp.gr. equal to 1.0275 at 15.5 degrees and contained, in parts per 1000:

Total solids 36.31 -

Cl	20.6569
Br	0.0671
CO_2 (free)	5.11
CO_2 (combined)	58.46
SO_3	24.679
CaO	0.6518
MgO	2.4270
Na_2O	1.5266
K_2O	0.49952

Ammonia (milligrams per litre) - free, 0.192; and 11.00 milligrams of oxygen per litre. The various methods of analysis employed are recorded.

D.A.L.

(12) Chemical Abstracts, 5: 3214.5.

Note on the Composition of Sea Water.
F.W. Clarke and George Steiger. J. Wash. Acad. Sci., 1, 4 -

Although the water of the ocean varies widely in salinity from less than 1% in the Baltic to 5% in the Red Sea, the composition of its saline matter is curiously constant. Data are so far lacking, however, with regard to waters of American coasts, except

for a single group of analysis by A.S. Wheeler, of water near Beaufort, N.C. In order to remedy this deficiency, a sample of water from near Loggerhead Key in the Gulf of Mexico was analyzed. The sp.gr. was 1.02434 at 25 degrees and the total salinity was 3.63516%. This is slightly above the mean salinity of the ocean, 3.5%. The per cent composition of the saline matter is given below:

(Per Cent)

Cl	55.24
Br	.17
SO_4	7.54
CO_3	0.34
Na	30.80
K	1.10
Ca	1.12
Mg	3.59
	99.90

Sp.Gr.	1.02434
	3.63516
	parts/1000 parts
Cl	20.0806
Br	0 .061797
SO_4	2.7409
CO_3	0.123595
Na	11.196289
K	0.399867
Ca	0.407137
Mg	1.30502

Calculation:

1.02434 x 1000 = 1024.34 = Wt. 1 liter solution.

1024.34 x 3.63516 x 100 = 37.23639 gr. per liter (solid)

37.23639 ÷ 1024.34 = 36.35159 parts per 1000 parts

36.35159 x 55.24 = 20.0806 parts Cl/1000 parts

(13) and (13A). Journal of the Chemical Society, 1906 - A 176

Chemical Study of Sea Waters.
Theophite Schloesing (Compt. rend., 1906, 142, 320 - 324).

Analysis of the water of the Atlantic Ocean and of the Mediterranean show that the two waters differ only in degree of salinity, the composition of the mineral constituents being almost identical in the two cases; the analytical results are given in the following table;

1 litre of water at 20 degrees contains:

	(13) Mediterranean	(13A) Atlantic	Ratio
Calcium carbonate	0.127 grams	0.099	0.78
Sulphuric acid	2.551	2.120	0.831
Chlorine	21.376	17.830	0.834
Bromine	0.072	0.060	0.833
Lime (not incl.above)	0.599	0.519	0.866
Magnesia	2.361	1.993	0.844
Sodium oxide	16.017	13.410	0.837
Potassium oxide	0.510	0.413	0.810
	43.613	36.44	
Oxygen equivalent of chlorine & bromine	4.824	4.024	
	38.789	32.420	0.836

(14) Journal of the Chemical Society, 1916 A; ii 184.

Bromine Ion Content of Sea Water.
L. W. Winkler (Zeitsch. Angew. Chem., 1916 - 29, 68. Compare this volume, 109.)

Waters from the Adriatic were found to contain 63.81 mg. of bromine per liter; the chlorine amounted to .18375 mg. per litre.

Calculated using Sp.Gr. 1.025.

17.926 parts Cl/~~liter~~ 1000

0.0622 parts Br/~~liter~~ 1000

(15) Chemical Composition of the Water composing the Clyde Sea Area.
A. Dickie (Proc. Roy.Soc. Edin. 124, 422-427).

The Chemical Composition of the Water composing the Clyde Sea Area.
A. Dickie (Proc. Roy. Soc. Edin. 127, 283 - 286).

Journal of the Chem. Soc. 1886 - A; ii 134.
Proportion of Bromine in Sea Water.
E. Berglund (Ber., 18, 2888 - 2890).

340 mgrms. of Br. to 100 grams Cl, and 19.5 grams Cl/litre.
Calculated from .0663 grams Br. liter.
.0646 parts Br/1000 parts.
19.02 parts Cl/1000 parts.

(Calculations)

	(13) Mediterranean	(13A) Atlantic	Ratio
Calcium carbonate	0.123902	0.09853	(0.78)
Sulphuric acid	2.4887	2.0682	(0.831)
Chlorine	20.854	17.395	(0.834)
Bromine	0.0702	0.05857	(0.833)
Lime (not incl. above)	0.58439	0.5063	(0.866)
Magnesia	2.30342	1.94439	(0.844)
Sodium oxide	15.6263	13.08292	(0.837)
Potassium oxide	0.49751	0.40292	(0.810)
	42.54926	35.551219	0.836*

* Actual ratios.

(16) Journal of the Chemical Society, 1896 AII - 117.

Composition of Water of the Pacific.
Camille Chabrie (Bulletin Soc.Fran.Min., 1894, 17, 220 - 222).

A sample of water taken from the surface of the Pacific at latitude 12 hours north of Paris, contained in a litre, 24.27 (23.69 parts/1000) grams of chlorine and 3.056 (2.983 parts/1000) grams of SO_4. Bromine and iodine are absent or present only in traces. The water is neutral and has a sp.gr. of 1.028 at 26 degrees. The amount of chlorine in this water is greater than that in the water of other oceans. From Red Sea - Konrad Natterer, Monatsh 1899, 20, 1 - 263 - 1899, A, II, 501, 1901, A, II; 173.

pH - Sea water 8.1 to 8.22 average.

(17) Journal of the Chemical Society, 1916, AII 389.

Iodine content 0.05 mg. per litre.
0.04878 parts per 1000.

(18) Journal of the Chemical Society, 1903 A, II 593.

Mineral arsenic (0.00878 parts/1000
(0.009 milligrams per liter

Organic arsenic (0.00078 parts/1000
(0.0008 milligrams per litre

Atlantic Ocean (Azores) 0.01 to 0.08 milligrams per liter variation due to volcanic action.

(19) Chemical Abstracts, Vol. 27, 1934 - 4142.

The boron content of sea water.
E.G. Moberg and M.W. Harding, Science 77, 510 (1933).

Fifty samples of sea water from depths varying to 500 m. off La Jolla, to 3200 m. off Hawaii and from the surface near

North California and Florida averaged 4.50 mg. B. per Kg., about 0.013% of the total solids and nearly 20% of the equivalent concentration of all weak acid radicals present. The electrometric method of titration of Wilcox was used (cf. C.A. 26, 1214). Probably B. compounds play an important part in regulating H-ion concentration of sea water.

(20) Chemical Abstracts, 5 - 2614.

Analysis of Sea Water Taken from Beaufort Harbor.

Table 1 - parts per 1000 grams of sea water.

	A	B	C	D	E
Cl	19.909	19.635	19.767	19.810	17.571
So_4	2.754	2.681	2.699	2.730	2.378
CO_3	0.132	0.129	0.129	0.129	0.129
Na	11.049	10.968	11.022	11.036	9.771
K	0.442	0.390	0.394	0.394	0.368
Ca	0.433	0.429	0.440	0.436	0.392
Mg	1.353	1.301	1.313	1.323	0.177
Total	36.072	35.533	35.767	35.876	31.786

(21) Chemical Abstracts, Vol. 27, 1933 - 3862.

Li content of ordinary sea water is 0.1 mg per liter.

.00009756 parts/1000 parts.

Journal of the Chemical Society, 1893 - A; II 326.

Saline Constituents of Water from the Black Sea.
S. Kolotoff (J. Russ. Chem. Soc., 24, 77 - 89).

The following numbers were found on analysis of sea water from different depths at a station in the Black Sea 41°51' N. latitude and 9°20' E. longitude from Pulkova. The depth of water at this station is 976 Russian fathoms.

Depth	50 fathoms	100 fathoms	900 fathoms
Specific gravity 0°/4°	1.01471	1.01672	1.01746
Solids dried at 180°	1.8261	2.0726	2.1758
Na	0.5582	0.6254	0.6556
K	0.0202	0.0236	0.0298
MgO	0.1129	0.1278	0.1364
CaO	0.0345	0.0400	0.0428
Cl	1.1013	1.1365	1.1915
Br	0.0033	0.0037	0.0039
SO_3	0.1142	0.1297	0.1351
CO_2 in $M''CO_3$	0.0062	0.0072	0.0039
CO_2 in excess	0.0016	0.0010	0.0014
Equivalent Acid to 1 eq. base	0.9903	1.0006	0.9882

J.W.

Journal of the Chemical Society, Vol. 23 - 16 - (1870)

Results of the Analysis of Sea Water, performed on board H.M.S. PORCUPINE, July 1869. Read December 2, 1869.

Comparatively few researches have been carried on with the object of determining the precise amount and nature of the gases which are dissolved in sea water at any great depths below the surface. During the voyage of the BONITE in the years 1836 - 1837, samples of sea water were collected, carefully sealed up in flasks, and brought home to be analyzed in the College of France. M. Darondeau*(*Comptes Rendus, T. VI, p. 616) in a paper read April 30, 1838, gives the following table of the results of these analysis:

Date & Place	Latitude	Longitude	Depth in Fathoms	Density 8° to 10° - C.	Gas in 100 c.c. of Water	Composition of 100 vols. of gas: Carbonic Acid	Nitrogen	Oxygen
Aug.30,1836 Pacific Ocean	11° 8'N	108° 50'W	Surface	1025.94	2.09	10.51*	83.33	6.16
			70	1027.02	2.23	18.06	71.05	10.09
Mar.19,1837 Bay of Bengal	11 43 N	87 18 E	Surface	1025.45	1.98	13.97	80.50	5.53
			200	1026.63	3.04	58.15	38.50	3.29
May 10, 1837 Bay of Bengal	18 ON	85 32 E	Surface	1026.11	1.91	13.32	80.34	6.34
			300	1025.86	2.43	30.13	64.15	5.72
July 31, 1837 Indian Ocean	24 5 S	52 0 E	Surface	1025.77	1.85	13.46	77.70	9.84
			450	1027.39	2.75	34.92	55.23	9.85
Aug. 24, 1837 Atlantic South	30 40 S	11 47 E	400	1027.08	2.04	28.82	67.01	4.17

* This carbonic acid in this experiment is uncertain.

According to Bischof (Chemical and Physical Geology 1, 113) 10,000 parts by weight of water contain:

			Observer
Atlantic	1.1	by weight of carbonic acid	Vogel
English Channel	2.3	" " " " "	"
Same	2.3	" " " " "	"
	0.77	" " " " "	Bischof

Analysis made on board the PORCUPINE during the month of July 1869:

FIRST SERIES

Lat. 47° 39', Long. 11° 33' 0" July 23, 1869.

Depth in Fathoms	Temp. °F.	Sp.Gr. of Bottom and Intermediate Waters	Sp. Gr. of Surface Water	Grams of Oxygen for 250 c.c.	Total Gas in 100 c.c.	Composition of 100 vols. of gas		
						Carbonic Acid	Nitrogen	Oxygen
2090	36.4	1027.3	1027.5	0.0016	2.80	35.92	43.54	20.54
1750	36.8	1027.5	〃	0.0012	-	34.10	45.20	20.70
1500	37.2	1027.5	〃	0.0017	2.87	31.76	48.04	20.20
1250	37.7	1027.5	〃	0.0015	2.90	32.00	47.74	20.26
1000	37.8	1027.5	〃	0.0010	2.60	30.10	49.20	20.70
750	41.4	1027.3	〃	0.0006	2.20	28.62	49.44	21.94
500	47.8	1027.4	〃	0.0010	2.80	28.10	49.70	22.20
250	50.5	1027.4	〃	0.0014	2.70	25.12	52.42	22.46

SECOND SERIES

Lat. 49° 12' 0", Long. 12° 52' 0" July 27, 1869.

862	39.8	1027.5	1027.5	0.001	3.5	48.28	17.22	34.50
800	42.0	1027.7	〃	0.001	2.8	33.75	17.79	48.46
750	42.5	1027.5	〃	0.0012	2.8	31.92	18.76	49.32
700	43.7	1027.5	〃	0.0013	-	31.03	19.31	49.66
650	44.4	1027.5	〃	-	2.4	30.00	19.80	50.20
600	45.5	1027.5	〃	0.0005	2.4	28.34	20.14	51.52
550	46.4	1027.5	〃	0.0009	2.6	29.06	20.70	50.24
500	47.4	1027.5	〃	0.0014	2.2	27.26	-	-
450	47.6	1027.5	〃	0.0005	2.8	24.73	22.18	53.09
400	48.5	1027.5	〃	0.0014	2.5			
350	49.2	1027.3	〃	0.0015				
300	49.6	1027.3	〃	0.0018				
250	50.3	1027.3	〃	0.0019				
200	50.5	1027.3	〃	0.0017				
50	53.4	1027.3	〃	0.0014	2.2			

MISCELLANEOUS EXPERIMENTS

Temp. °F.	Lat.	Long.	Sp.Gr. Bottom Water	Sp.Gr. Surface Water	Grams of Oxygen for 250.c.c.	Total Gas in 100 c.c.	Composition of 100 vols. of gas			Date	Depth
							Carbonic Acid	Nitrogen	Oxygen		
49.5	50° 38'	9° 27'	1026.7	1026.7	0.001	-	37.88	45.63	16.49	July 20	74
-	48 50	10 57	1027.7	"	0.0002	-	3.27	59.63	37.10	21	Surface
44.2	"	"	1027.6	1027.7	0.0024	2.2	24.85	57.02	18.13	21	725
-	-	-	1027.6	-	0.0012	2.4	24.37	50.07	25.56	23	Surface

Journal of the Chemical Society, 36 (1879), page 1060.

Results of the Norwegian Expedition to the North Sea.
H. Tornöe (Jor. Chem. (2), 19, 401 - 433 and 20, 44-76) - 1
on the air contained in sea water.

From 78 observations of the amount of carbonic anhydride in sea water from every depth, and many different places, nothing can be inferred as to the laws of its distribution. All that can be done is to take the mean of all the determinations. One liter of sea water contains on the average 52.78 mgms. of carbonic anhydride in neutral, and 43.64 mgms. in an acid combination.

Proc. 5th Pacific Sci. Congress, Victoria and Vancouver, Can., 1933, 2101 - 7.

Sea Water of the Puget Sound Region.
Thomas G. Thompson and Rex J. Robinson.

At 200 miles off Juan de Fuca Strait the chlorinites of the sea water varied from 17.65‰ at the surface to 19.13‰ at 2500 m. Marked variations were observed as the waters passed over the continental shelf, indicating much upwelling. In Washington Sound the dilu. effect of the Fraser River was evident. In Hood Canal the chlorinity dropped to 12 - 16.5‰ because of the fresh water inflow. The surface water in the open ocean contained 8.5 mg. of dissolved oxygen per kg. At depths of 750 - 1000m. a minimum value of 0.34 mg. was found. Beyond this depth the dissolved oxygen again increased slightly to approximately 2.9 mg. In the Strait of Juan de Fuca the surface oxygen reached 13 mg., but was normally 8 - 10 mg. The bottom samples of all inside waters varied from 3 to 5 mg. per kg. The entire Puget Sound region was particularly abundant in silicates, phosphates and nitrates.

However, in the euphotic zone of the ocean there were no surface nitrates, 0.05 - 0.10 mg, Si and 0.006 mg.P. Gradual increases in these substances were noted to 2500 feet in depth. N in the form of NH_3 was not found except in brackish waters.

C.R. Fellers.

Chemical Abstracts, Vol. 28, 1934, page 1901.

Arsenic in Sea Water.
Morris W. Bakestraw and Frank B. Lutz.
Biol. Bull. 65, 397 - 401 (1933).

Detns. of total As by the Gutzeit method showed 6 - 28 mg. per cu. m. of sea water, the mean being about 15 mg. Although the As content increases at 10 - 50 m. below the surface, there is no general increase with depth; hence the distribution is quite unlike that of P. Most of the As is in other forms other than arsenate.

K.V. THimann.

Chemical Abstracts, Vol. 27 - 1933 - 1840.

The Copper Content of Sea Water.
W.R.G. Atkins.
J. Marine Biol. Assoc. United Kingdom 18, 193 - 7 (1932)

Cu was determined in sea water (10 mgms. per cubic meter) by the Na diethyldithiocarbomate method after electro deposition.

C.M. McCay.

Journal of the Chemical Society, 1916 - A; II, 389.

Iodide and Iodate Ion Content of Sea Water.
L.W. Winkler (Zeitsch. Angew. Chem.) 1916, 29, I 205 - 207.
Compare the vol., 11, 184).

Iodine in organic combination was not found to be present in water from the Adriatic. The total iodine content of the water was approximately 0.50 mg. per liter. Near the surface, where the water was exposed to air and sunlight, the iodate -ion content predominated; at a greater depth the relation between the iodate and iodide changed, the proportion of the latter increasing.

 W.P.S.

Chemical Abstracts, Vol. 21 - 1927 - 784.

Sr. in Sea Water (0.0135 gm. per liter
(0.01317 parts per 1000

Sr: Ca 1:47.

Chemical Abstracts, Vol. 29, 1935, p. 3863.

Determination and Quantity of Boron in Sea Water.
Maynard W. Harding and Erik G. Moberg.
Proc. 5th Pacific Sci. Congr. 3, 2005 - 5 (1934).

A method of titration of B in sea water in the presence of mannitol is given. The B content ranged from 4.3 to 4.8 mg. per kg. of sea water; as H_3BO_3 this corresponds to 0.4 millimol. per l. or to 18% of the equivalent concentration of all weak acid radicals in the water; the ratio of B and Cl averaged - 0.000239.

C.J. West.

Cl, Br and I ratio.
Proportion of Br, Cl and I in sea water:

Cl	Br	Io.
100 grams	0.368 grams	0.00020 grams
100 "	0.347 "	0.00023 "
100 "	0.340 "	

Cl and Fl ratio.
Chemical Abstracts, Vol. 27, 1933, 2072.

The Determination on Occurrence of Flourides in Sea Water.
Thomas G. Thompson and Howard J. Taylor.
Ind. Eng. Chem., Anal. Ed., 5, 87 - 9 (1933).

Flourides are titrated in sea water by the $Zr(NO_3)_2$ alizarin procedure. To offset the interference of chlorides and sulfates present in sea water, comparison standards containing the same amount of chloride and sulfate are employed.

The speed of the reaction between zralizarin and the flouride ion is increased by heating. For ocean waters the flouride ion is proportional to the chloride content, the ratio being $1:7.0 \times 10^{-5}$. Surface coatal waters and other waters that

are subjected to dilution appear to give a slightly higher flouride chloride ratio.

Na and K ratio.
Chemical Abstracts, 1933, 1555[3].

Analysis of the Water of the Baltic Sea.
H.V. Wortenberg, H. Werth and A. Zodrow.
Chem.Erde 7, 616 - 19 (1932).

Thirteen analyses from various points in the Baltic are given and also 11 analyses of fresh water near Danzig. The latter, as well as the sea water near the coast, has low Na:K ratio. Farther from the coast, the ratio averages 31, nearly the normal value.

Cl and Sulfate Ratio.
Chemical Abstracts, V 26 - 1932 - p. 2093.

Sulfate - Chloride Ratio in Ocean Waters.
Thomas G. Thompson, William R. Johnston and Henry E. Wirth.
J. Conseil Intern. Exploration Mer 6, 246 - 51 (1931).

Forty-five samples of sea water collected from all the oceans, Baltic, Mediterranean, and Red Seas gave a sulfate-chloride ratio of 0.1395:1 which was remarkably constant in the different samples. The samples from the Baltic Sea showed evidence of dilution from land drainage. These results confirm earlier work (C.A. 22, 745) where the ratio as determined on 551 samples was identical with the above figures.

Specific Gravity.
Chemical Abstracts, 1932 - 26, 635.

Specific Gravity of Sea Water at Zero Degrees in Relation to the Chlorinity.
Thomas G. Thompson and Henry E. Wirth.
J. Conseil Intern. Exploration Mer. 6, 232 - 40 (1931).

Very accurate determinations of specific gravity were made on water from several oceans. The agreement between the observed values and those calculated from the chloride content by the hydrographical tables were close. The relationship between chlorinity and specific gravity are, therefore, almost identical in the waters of all the oceans.

Chemical Abstracts.

4 : 2612
The Alkalinity of Sea Water.
1.7×10^{-6} OH ion concentration.

H Ion.
Chemical Abstracts, 6 - 522[3].

Measurement of the Magnitude of the Hydrogen Ion Concentration of Sea Water.
Iven Palitzsch. Carlsberg Lab., Copenhagen, Biochem. 2, 37 - 116 - 30.

Specimens of water from the Atlantic, the Mediterranean, the Black Sea, and the Baltic Sea were tested. The color reaction with phenolph and α-naphtholphthalein was used to determine the H ion concentration. Known solutions of borate and hydrochloric acid were used for comparison. The hydrogen ion (H^+) concentration was found to be quite constant, varying only $10^{-7.95}$ - 10 - 8.35.

D.D. Van Slyke.

pH.
Variations of the Hydrogen Ion Concentration of Sea Water.

Daphne Caulston - J. Proc. Roy. Soc.(N.S.Wales) 65, 43 - 50.

The alkalinity decreased from pH 8.4 in the open sea to about 7.4 in the mouth of rivers.

K.V. Thimiann.

pH.
Hydrogen Ion Concentrations of Sea Water in the Southern Portion of the North Pacific.

Koichi Ito. Ric. Oceanogr. Works in Japan 1, 90 - 4; Suiro Yoho (Hydrographic Bulletin) 7, 570 - 3 (1928); Japan J. Astrom. and Geophysics 7, No. 1 Abstracts 3 - 4.

(cont'd)

According to an examination of water samples taken at more than 200 stations from various depths in the southwestern portion of the North Pacific, the Hydrogen ion concentration ranges from 8.47 to a value much less than 8.08 in Palitzsch's series. Throughout the region just mentioned the water is altogether homogeneous from the surface down to 20 m. and also below 1000 m. giving pH 8.39 and < 8.08, respectively. Between these, some water layers of different pH values appeared, the arrangement of which varies in different regions and depths. At a depth of 400 m. there can be seen 4 zones of pH - 8.39, 8.30, 8.20, 8.08. The alkalinity, though at varying rates in different regions, falls gradually as the depth increases. Generally, the discontinuity layer can be met with at a depth far greater in the north than in the south.

pH Variation with Depth.

Atkins and Harvey.
Nature; Vol. 116 - 784.

The following determinations were made and are shown in the table along with the temperature records received from Dr. Kemp. Alkalinity of the water, expressed as $_{p}H$, namely, log 1/H, where H is the hydrogen ion concentration in grams per liter; phosphate, expressed as phosphorous pentoxide, nitrate as nitrogen, and silicate as silicon dioxide, all three in milligrams per cubic meter, namely, parts per thousand million of sea water. The

methods of analysis have already been described in the Journal of the Marine Biological Association, save that for nitrate, which forms the subject of a forthcoming paper by one of us.

Depth in Meters	T°C	pH	In mgm. per m^3. P_2O_5	Nitrate - N_2	SiO_2
0	21.10	8.35	0	15;11	
10	21.10	...	...	7	
20	21.00	...	...	6	
30	21.00	...	...	...	220
40	21.00	...	...	16	
50	20.01	8.35	0	Ca6	
75	17.31	8.31	5	6	
100	15.10	8.18	8	55	220
150	15.06	8.16	10	65	
200	13.86	8.11	22	100	250
300	12.25	8.12	44	178;158	
500	10.94	8.00	50	200	280
1000	9.55	8.03	74	264;262;274	450
2000	4.81	7.94	78	Ca 265	480
3000	3.10	7.87	88	Ca 265	1200

pH
Sea Water pH of, in relation to the tides 1933 17898.

pH and the Rhythm of the Tides.
Alphonse Labbe. Comp. rend. 195, 1297 - 9 (1932).

With ebbing tide the pH follows a descending curve and returns with a rising tide. Diurnal variations are greater than nocturnal. The effects caused by photosynthesis and marine animal life are considered factors.

* The relation between carbon dioxide content and hydrogen ion concentration of sea water of varying salt content.

E.M. Kreps, Internat. Rev. ges. Hydrobiol. Hydrogr. 15, 240 - 57 (1926); Ber. ges. Physiol. expll. Pharmakol. 38, 766.

The relation was determined within the relatively wide pH range of the water from the Barents Sea. Tables were compiled for the determination of total carbon dioxide for any given pH and salt content. The buffer action of sea water increases in proportion to the carbon dioxide concentration and the alkali reserve. Low alkalinity of sea water is less favorable for life than a high salt content.

Mary Jacobsen.

The Hydrogen Ion Concentration of Sea Water off the Coast of Southern California.

E.G. Moberg.
Proc. 3rd Pan-Pacific Sci. Congr. 1926, 1, 221 - 8 (Publ. 1928)

The pH of sea water depends upon the interrelation between alkaline salts and carbon dioxide. Since the amount of alkaline salts is relatively constant, changes in pH are due chiefly to fluctuations in amount of carbon dioxide, so that the pH of sea water may be used as an index of carbon dioxide present. These factors may be influenced by metabolic activity of organisms, by decay of ~~original~~ R & materials, by change in temperature of water or atmosphere and by changes in carbon dioxide content of the atmosphere.

Chemical Abstracts, Vol. 23 - 1929 - 1654.

Phosphate content and hydrogen ion concentration of the surface water of the English Channel and Southern North Sea.

English Channel av.	8.64 mg.	P_2O_5 per m^3 av.(cor.)	pH 8.03
So. North Sea	3.44 "	" " "	pH 8.11
Str. of Dover	3.65 "	" " "	pH 8.05

British Chemical Abstracts, 1926 - A42.

Increase in pH value (8.35 - 7.87) with depth) (0 - 3000) due mainly to removal of carbon dioxide by phytoplankton, but partly to the high surface temperature alternating the equilibrium between hydrogen carbonate and atmospheric carbon dioxide, phosphate first appears at a depth of 50 - 55 m. and increases to 88 milligrams per meter.

Nitrate nitrogen varies from 15 mg. per m. at the surface to 6 mg. at 75 m. and 265 mg. at 3000 m; silica varies from 220 mg. at the surface to 1200 mg. at 3000 m.

W.R.G. Atkins and H.V. Harvey
(Nature, 1925, 116, 784 - 785).

Investigations concerning the relations between hydrogen ion concentration, free carbon dioxide, and alkalinity in sea water.
R. Kandler.
Intern. Rev. ges. Hydrobiol. Hydrog. 24, 177 (1930);
Dept. Sci. Ind. Research.

Water Pollution Research, Summary of Current Lit. 5, 14.

No simple relationship could be deduced between the pH and changes in alkalinity. The addition of a strongly dissocd. acid to the sea water causes an increase in the concentration of free carbon dioxide from about the bicarbonate point, until in the case of complete neutralization, all the carbon dioxide

is present as dissolved gas. At atm. CO_2 tension, the hydrogen ion concentration increases with decrease of alkalinity, the relationship between the logs of both factors being linear. If the alkalinity is reduced by dilution with distilled water instead of additions of acid so that the salt content is so reduced, for equal alkalinities the pH of water with a low salt content is greater than that of water with a high salt content. If the hydrogen ion concentration is increased by the introduction of carbon dioxide, an increasingly greater increase in concentration of free carbon dioxide is necessary to produce an equal reduction of pH. For constant alkalinity, a linear relationship exists between the pH and the log of the concentration of free carbon dioxide. The relation between the hydrogen ion concentration, free carbon dioxide, and alkalinity is expressed by the equation -

$$(H^+) = \left(\frac{(K_1 \times (CO_2))}{(alky_c)} \right)^{0.92}$$

where K_1 equals the dissocn. const. of H_2CO_3 which, except for the exponent 0.92, is identical with the theoretical equation for a $NaHCO_3$ solution. The laws of electrolytic dissocn. valid for Na_2CO_3 cannot be used for sea water. Observations indicate that the dissocn. relationship detd. for the carbonates of sea water are characteristic of $CaCO_3$ and $MgCO_3$.

G.G.

Chemical Abstracts, 3 - 1900[5].

Concentration of Hydrogen Ion in Sea Water -
W.E. Ringer.
Chem. Weekblad - 6 - 113 - 23

Gas electrodes were used to determine the ionic concentration of the hydrogen. The influence of the carbon dioxide was determined by expt. With pressure of carbon dioxide varying from 53 to 0.0 mm the ionic concentration of the hydrogen ranged from 0.139×10^{-5} to 0.600×10^{-8}. For the North Sea, water H^+ was found to vary between 0.58 and 1.40×10^{-8}.

Chemical Abstracts, Volume 23 - 2230.

Determination of Organic Matter in Sea Waters.
Jose Giral. Pereira.
Inst. Espani. Oceanografia Notas. Resumenes 11, No. 4, 25 p.p.

The original matter may include living cells of the microplankton and bacteria, spores, dead matter, hydrosol micelles and chemically dissolved matter. Hence, albumins, fats, carbohydrates, carotinoids and anthocyanims may be present. From the dead detritus one may expect peptones, prosthetic groups, polypeptides, amino acids, amines, etc., and putrifactive products, zymases and diastases, mercaptans, and the like, cystine and the like. H_2SO_3 and H_2SO_4, glucosides, fats, lipoids and glycerides may be present. A separation according to chemical orders of the original matter is not possible, and analytical methods for these orders are very imperfect. The relation with oxygen, carbon dioxide and oxidants has been studied, particularly the action with permanganate. The Schulze Trommsdoff (alk. $KMnO_4$, acidulation, addition of oxalic and back titration) was used although recognized as defective. The Algeciras Bay has a factory discharging organic matter into the water. The results for June and July 1922 are given in a table.

S.L.B. Etherton

Chemical Abstracts, 1935 - Vol. 29 - 5706.

Organic Carbon in Sea Water.
L. Espil, Bull. Soc. Chem. (5), 2, 1007 - 12 (1935).

Carbon was determined by combustion or by alk. oxidation and measurement of the carbon dioxide evolved. Sea water from the Arcachon basin contained from 9 to 75 mg C per l. The C content was higher near the shore. Its origin lies in solution of marine algae.

P.S.R.

Journal of the Chem. Soc. 39 - (1881) T 320.

Organic Matter in Sea Water.
William Jago.

Tables showing amount of organic carbon, organic nitrogen, ratio nitrogen as ammonia, and nitrogen as albuminoid ammonia.

Chemical Abstracts, Vol. 7 - 5239.

Dissolved organic matter 1 gm. per liter.
Undissolved " " 1 - 2 gms. per liter.

Chemical Abstracts, Vol. 23 - 44874.

The use of $KMnO_4$ to determine the organic content of filtered and unfiltered sea water by oxidation was studied.

Chemical Abstracts, Vol. 23 - 41117.

Determination of the organic matter in sea water.
Olimpio G. Ibanez.
Inst. espanol oceanografia notas y resumenes, Ser. 11, No. 26, 10 pp. (1928).

(continued)

Tables give the following data for numerous samples of sea water: location, time, depth, temperature of the water and of the air, d_4 of the water, amount of oxygen per liter, amount of organic matter (in mg O.O per liter, as obtained by $KMnO_4$ titration) per cent Cl and ratio of organic matter to oxygen.

A.L.H.

Chemical Abstracts, Vol. 29 - 1935 - 1295.

Report on the free ammonia, albuminoid nitrogen and organic nitrogen in the waters of the Puget Sound area during the summers of 1931 and 1932.
Rex J. Robinson and Henry E. Wirth.
J. Conseil intern. exploration mer 9, No. 1, 15 - 27 (1934).

The NH_3 of sea water was determined by a modification of Wattenberg's method: - - - - -

In Puget Sound the free NH_3 content of the water in general is less than 0.02 mg. per liter, but in a few places values increasing with depth up to 0.4 mg. per liter at 400 m. was found. The albuminoid and organic N decrease with depth, reaching .0 at 400 m., but in East Sound they pass through a maximum (0.14 and 0.25 mg. per liter, respectively) at 5 m; the average values for the area are 0.10 and 0.21 mg. per liter, respectively) and the average ratio albuminoid organic N is about 4.7.

K.V. ~~Thiram~~ Kirsanow.

Chemical Abstracts, Vol. 29 (1935) 1295.

Free ammonia, albuminoid nitrogen and organic nitrogen in the waters of the Pacific Ocean off the coasts of Washington and Vancouver Island.
Rex J. Robinson and Henry E. Wirth
J. Conseil intern. exploration mer 9, No. 2, 187 - 95 (1934).

Cf. preceding abstr. - The free NH_3 found was below 0.02 mg. per liter and decreased with depth; the albuminoid and organic N passed through minima of 0.02 and 0.05 mg. per liter, respectively at about 800 m. and ~~increased~~ increased definitely again toward the bottom. The average ratio albuminoid org. N was 0.57 for samples above 800 m. and 0.40 for samples below this depth; hence, the nitrogenous material at great depths is of a

more stable type than usual. The nitrate increases regularly with depth.

K.V. Thi[illegible].

Chemical Abstracts, Vol. 29 - 1935 - 1295.

Determination of Ammonical Nitrogen in Sea Water.
O. Gomez Ibanez. Anales soc. espan. fis. quim. 32, 897 - 8 (1934).

Wattenberg (C.A. 26, 5873) described a method for determining NH_3 in sea water by direct nesslerization in the presence of a tartrate, which prevents pptn. of $Ca(OH)_2$ and $Mg(OH)_2$. This method is sensitive to about 5 mg. of ammonia N per cu.m. In the English Channel a maximum of about 30 mg/cu.m. was found.

Chemical Abstracts, 1931 - 25, 5062[9].

Ammonia Content of Sea Water.
H.R. Seiwell, Ecology 12, 485 - 8 (1931).

Sea water from vicinity of Mt. Desert Island, Me.

Surface water contained 0.48 mgms. NH_3 per cu.m. Samples from Penobscot Bay, taken at depth of 25 m., 350 mg. per cu.m.

Chemical Abstracts, Vol. 29 - 1935 - 3562.

The Distribution of Nitrogen Compounds in Sea Near Southern California.
Erik G. Moberg and Richard H. Fleming.
Proc. 5th Pacific Sci. Congr. 3, 2085 - 8 (1933).

In the surface layer of the sea there were 150 mg. org. N. and 30 mg. ammonia N per cu. meter, nitrite and nitrate being absent. At a depth of 20 - 60 m. the org. N averaged 150 mg. and at 70 m. 250 mg. Nitrate was found at 40 m. and below, while

nitrite appeared only in traces at 40 - 60 m. and not above or below this. The ammonia N was the same at all depths down to 70 m.

K.V.T.

Chemical Abstracts, Vol. 28 (1934) - page 1901.

The Buffer Capacity of Sea Water.
Philip H. Mitchell and Norris W. Rakestraw.
Biol. Bull. 65, 437-51 (1933).

By determining the change in pH of carbon dioxide-free sea water on adding a known quantity of acid, a correction chart is worked out for use with the Thompson and Bonnar method (C.A. 25, 5863) of determining buffer capacity. This correction covers the true non-carbonate buffering and also the effects of chloride on indicator, etc. While there was found in general an increase in buffer capacity with depth, this was sometimes absent. The ratio of buffer capacity/total chloride, the "specific buffer capacity," increased from Cape Cod southward toward the Caribbean and was somewhat higher in the Pacific than in the Atlantic. Its average was about 0.119.

K.V. Thi[illegible]

The Probable Role of Boron in the Buffer Mechanism of Sea Water.

Roger Revelle and Erik G. Moberg.
Proc. 5th Pacific Sci. Congr. 3, 2147-51 (1933).
Cf. Buch, C.A. 27, 4723.

The value of pK'_2 for the bicarbonate-carbonate system in sea water varies somewhat with the pH at which it is determined. The value of 8.78 of Buch, et al. (Conseil intern. exploration mer., Roy. Proces - Verbaux 79, 1 (1932)), holds for sea water brought to pH about 8.6 - 9.0 by removal of some of the carbon dioxide. At pH 7.8 the PK' approaches the constant figure and is therefore assumed to be correct, the deviations at more alkaline reactions being ascribed to the presence of borate, of which there is 0.4 mille quiv. per liter of normal sea water (Harding and Moberg). (Preceding abstract). This comparatively large amount of borate certainly modifies the buffer relations of sea water in the same pH region as the bicarbonate-carbonate system.

K.V.T.

Chemical Abstracts, 1935, Vol. 29, No. 5.

Acid Base Equilibrium in Sea Water.
Laurence Irving, Science 80, 587 - 8 (1934).

The presence of boric acid in sea water renders uncertain the value of K' for H_2CO_3. The value is significant only when the analytical procedures are sufficiently accurate.

W.D. Langley.

Cal[illegible]lation of Salinity from Ch[illegible]ride Content.

Journal of the Chemical Society, 1914 - A[illegible] 852.

Hydrographical Chem. Relation - Between the Different Salts in Sea Water.
A. Manvelli, Ann. Chim. Appliata, 1914, 2 - 132 - 153).

The author gives a summary of the literature dealing with saline composition of sea water and with the methods suggested for calculating the total salinity from the proportion of one constituent ion, for example, chlorine.

Journal of the Chemical Society, 1914 A[illegible] 852.

The Waters of the Atlantic Ocean on the Argentine Coasts. Hercules Cori and Hector H. Alvarez (Anal. Soc. Quim. Argentine, 1918, 6, 108 - 120).

A detailed study of samples of sea water taken under varying conditions at different places on the Argentine coast.

Extensive tabular statements are given of chemical composition and of general and physico-chemical properties. The method of analysis adopted are briefly indicated.

W - S.M.

Journal of the Chemical Society, 1900 - A[illegible] 23.

Formation of Oceanic Salt Deposits, Particularly of the Strassfurt Beds. XIII. Evaporation of Sea Water at 25°. Jacobus H. Varit Hoff and W. Meyerhoffer (Chem. Centr. 899 [illegible] 76 from Sitzuingsber. Akad. Wiss. Berlin 20, 372-383).

The most recent and trustworthy analysis of sea water shows that on an average 1000 parts contain:

NaCl	47.0
K Cl	1.03
MgCl	7.36
$MgSO_4$	5.57

S. (Cont'd.)

Strontium 15;

Sulphate 3; 5; 6; 17;

SO_3 - 1; 2; 37;

Sulphuric Acid 4; 4A; 26;