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Seasonal Fluctuations in the Surface Salinity off the North Coast of Java

by

RD. E. SOERIAATMADJA

The Subtropical Lower Water between the Philippines and Irian (New Guinea)

by

KLAUS WYRTKI

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SEASONAL FLUCTUATIONS IN THE SURFACE SALINITY OFF THE NORTH COAST OF JAVA

by

Rd. E. SOERIAATMADJA

SUMMARY

The division of the region investigated according to P. CH. VEEN is redescribed.

The micro salinity titration by means of the method described by G. H. ARNOLD with an accuracy of 0.1 °/00 was used for this investigation. This technique was adopted because of the large number of observations, and was sufficiently accurate since salinity in these waters varies widely.

The annual range in salinity is large, caused by a considerable discharge of fresh water from the many big and small rivers, especially in the rainy-season as well as by the inequality of salinity of the ocean-waters coming from the East, and the South China Sea water coming from the West, during the dry and wet-sason respectively.

In the east-monsoon, the eastern section is covered with ocean water over 34.0 °/oo and the western section with mixed waters ranging between 31.5 °/oo and 34.0 °/oo, while in the west-monsoon, the area is covered with mixed water less than 32.5 °/oo.

ZUSAMMENFASSUNG

Die Einteilung des untersuchten Gebietes nach P. CH. VEEN wird beschrieben. Die von G. H. ARNOLD beschriebene Mikro-Methode zur Bestimmung des Salzgehaltes mit einer Genauigkeit von 0,l‰ wurde fur die Untersuchungen benutzt. Dies war notig wegen der grossen Zahl der untersuchten Proben und genugend genau wegen der grossen Schwankungen des Salzgehaltes.

Die Jahresschwankung des Salzgehaltes ist gross wegen des erheblichen Abflusses von Frischwasser aus den zahlreichen grosseren und kleineren Flussen, besonders wahrend der Regenzeit, als auch wegen des Unterschiedes im Salzgehalt zwischen den ozeanischen Wassermassen, die

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wahrend der Trockenzeit vom Osten vordringen, und den Wassermassen der Siid-China-See, die wahrend der Regenzeit von Westen kommen. Wahrend des Ost-Monsuns sind die ostlichen Teile mit ozeanischem Wasser von iiber 34‰ bedeckt, und die westlichen Teile mit Mischwasser zwischen 31,5‰ und 34‰, wahrend zur Zeit des West-Monsuns das gesanimte Gebiet von Mischwasser mit weniger als 32,5‰ angefullt 1st.

ICHTISAR

Pembagian daerah jang diselidiki menurut P. CH. VEEN telah diuraikan lagi.

Tritasi micro dari kadar garam dengan tjara jang diuraikan oleh G. H. ARNOLD dengan ketelitian 0.1‰ telah dipergunakan dalam penjelidikan ini. Teknik ini dipakai, berhubung dengan banjaknja pemeriksaan dan teknik mana tjukup teliti, oleh karena kadar garam diperairan ini mempunjai perobahan jang agak besar.

Pergojangan kadar garam tiap tahun adalah besar, disebabkan sangat banjaknja pemasukan air tawar dari sungai-sungai besar dan ketjil, teristimewa dalam musim hudj an dan ketidak samaan kadar garam air lautan jang berasal dari Timur dan air Laut Tiongkok Selatan jang berasal dari Barat, masing-masing selama musim kemarau dan musim hud Jan.

Dalam musim Timur, bagian sebelah timur diliputi oleh air lautan lebih dari 34.O‰ dan bagian sebelah barat oleh tjampuran air antara 31.5°/oo dan 34.0‰, sedangkan dalam musim barat, seluruh daerah diliputi oleh tjampuran air kurang dari 32.‰.

In 1949 P. CH. VEEN, oceanographer of the Lembaga Penjelidikan Laut (Institute of Marine Research) Djakarta, started with an extensive survey of surface salinities over the whole area of the Indonesian Archipelago. This survey was made possible through the courtesy and voluntary cooperation of all Captains and Officers of the private navigation companies and the government Navigation Service and lighthousekeepers, who participate, in the collection of the thousands of watersamples.

As a result of this work P. CH. VEEN published, in 1951, charts for the mean surface-salinities for the 12 months March 1949 — February 1950, whereas J. D. F. HARDENBERG and the author, in 1955, made a continuation of the same charts for the months March 1950 — February 1953. In 1953 P. CH. VEEN gave a summary of all oceanographic data collected by our laboratory and the previous research workers, by drawing monthly charts of the mean salinity. Since January 1955 monthly charts of surface salinities in Indonesian and surrounding waters were made regularly by K. WYRTKI, who became oceanographer of the Lembaga Penjelidikan Laut in October 1954. The same author published, in 1956, an introduction to the regular monthly charts of surface salinity in Indonesian and adjacent waters.

For those who are not in possession of the above mentioned papers a brief review on the methodology is considered to be necessary here.

The whole area of the survey is divided in twenty-minute (20') squares, which means that every square degree (1°) on the chart is subdivided into nine squares of twenty-minutes each. These twenty-minute squares are numbered from 1 to 9 running from West to East and from the Equator toward the Poles.

Each of these squares is numbered so that the actual position of the square on the chart can easily be read from the number. These numbers consist of five figures preceded by a prefix N or S standing for North or South latitude. The first two figures indicate the degree latitude of the square. If the degree is less than 10° it is preceded by a zero. The following two figures indicate the degree of longitude of the square. If the degree is 100° or over, the initial "one" is omitted. The last figure indicates the subdivision of the square-

For example (fig. 1 and 2).

N. 01976 means the square limited by N. latitude 1°—20' and 1°—40' and E. longitude 97°—40' and 98°— 00', whereas N. 0197 means the square bounded by N. latitude 1°—2° and E. longitude 97° and 98°.

S. 07158 means the square limited by S. latitude 7°—40' and 8°—00' and E. longitude 115°— 20' and 115°—40', whereas S. 0715 means the square bounded by S. latitude 7° and 8° and E. longitude 115° and 116°.

All data from the observations are recorded in a card index. A separate card bearing the number of the square is taken for each square. All data pertaining to the same square are entered on the same card. A separate card is used for each month's observations. As soon as all samples of a certain month are complete, averages are calculated. The results are plotted on the charts and isohalines can be drawn.

The salinities are determined by the Knudsen method, modified by G. H. ARNOLD (1951), which only needs 1 ml. of sample and which has an accuracy of 0.1 ‰. Titrations are made against standard seawater from Copenhague. The speed of this method is necessary, because of the large number of observations. The accuracy is just sufficient for the purpose of this investigation.

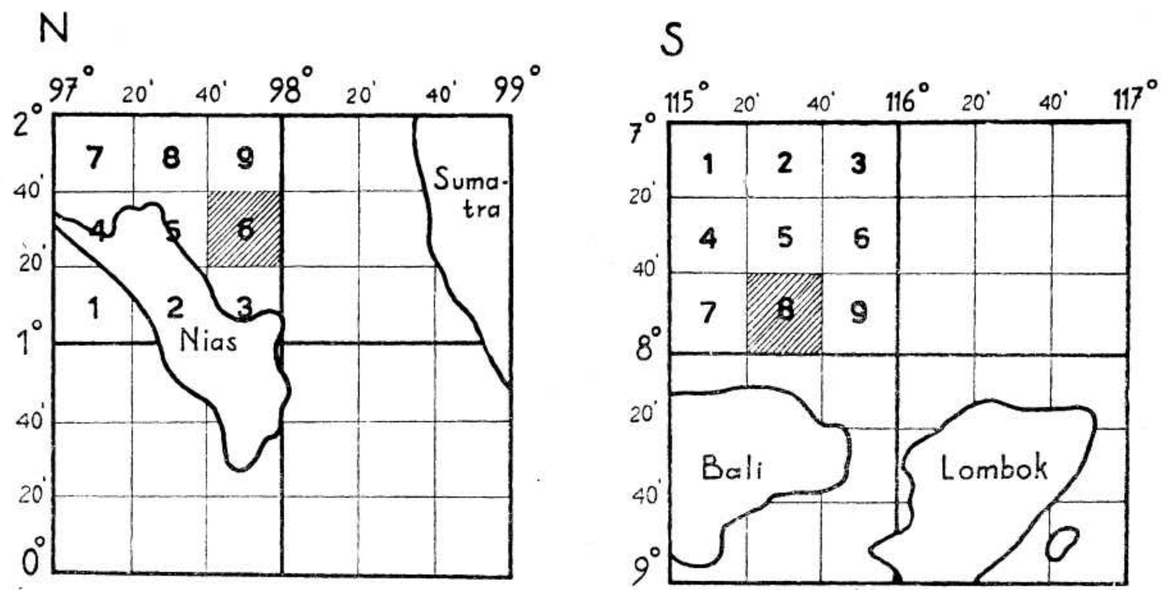

FIG. 1 and 2 : **Sample for the division of the 1°**— squares and 20′— squares.

The present paper is based on the data 1949—1955 consisting of 30,739 observations divided in 18 squares each of one degree, which were collected by our Institute (table 1). The area surveyed includes the region between S- latitude 5° and 7°, and extending from the Sunda Strait to E. longitude 115°, occupying the whole southern part of the Java Sea (fig. 3).

The Java Sea has a rectangular shape and is bordered on the West by South Sumatra and Sunda Strait, on the North by South China Sea and Kalimantan (Borneo), on the East by Flores Sea and on the South by Java. It is a shallow sea and the bottom shows a slight gradual slope from the coast to the centre and from West to East, so that in general the western section shows the lowest and the eastern section the highest depths with an average of about 50 meters in the middle.

Compared with the range in surface salinity of the occeans, which is subject to only small annual variation, the mean range in salinity of the surface waters of the Java Sea in the centre is large, from 30.8 ‰ to 34.3 ‰ in the eastern section, and from 30.6 ‰ to 32.6‰ in the western section or a mean annual range of 3.5 ‰ and 2.0 ‰, respectively. This is namely caused by a considerable discharge of fresh water from the many big and small rivers of Kalimantan, South Sumatra and Java, and by the changes of the current systems due to the monsoons-

The yearly variation of the surface salinity of the whole Java Sea would be the same, if the waterbody coming from the shallow South China Sea in the west-monsoon and the waterbody coming from the Flores Sea and Macassar Strait in the east-monsoon, were equal in salinity. This asymetry in salinities results in the yearly variation in the eastern part of the Java Sea being much greater than that of the western part.

Fig. 4 and 5 represent isopleths of the surface salinities of the region investigated. As in the previous papers the author begins with his diagrams in March, in accordence with the changing windstrength and wind-directions occuring in Indonesia.

March, April and May is the time wherein the west-monsoon gradually decreases in strength and is by and by replaced by the counteracting east-monsoon. At the end of this period, ocean water from the East approaches the Java Sea, pushing the less saline water in a westward and landward direction.

During the period of the full east-monsoon, June, July and August, the time of the strongest wind coming from the East, a westgoing current prevails, adducing Indian Ocean water over 34.0 ‰ from the Flores Sea. At the same time, Pacific Ocean water penetrates the Sulawesi Sea

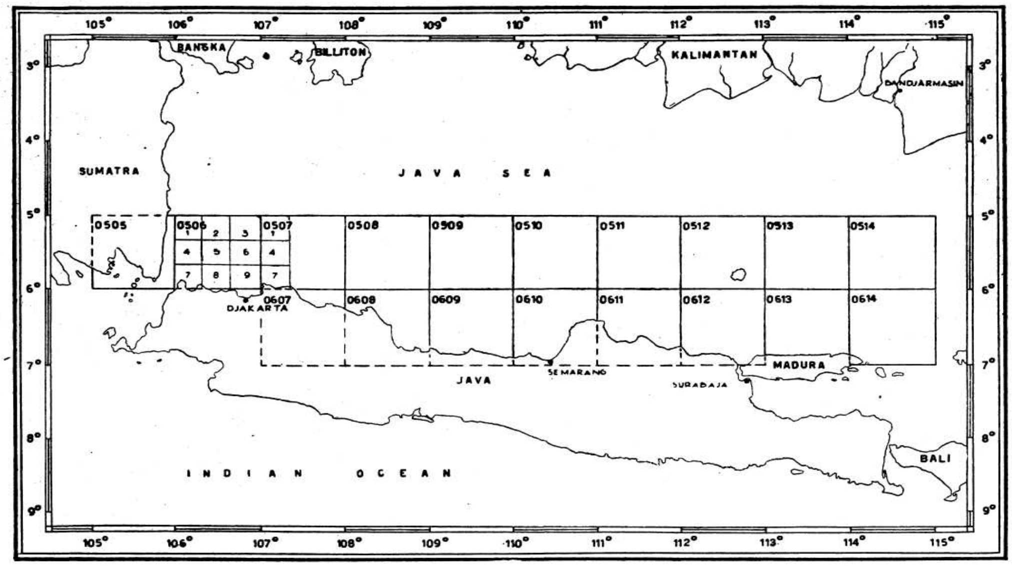

FIG. 3 : Area under investigation with 1°— squares used.

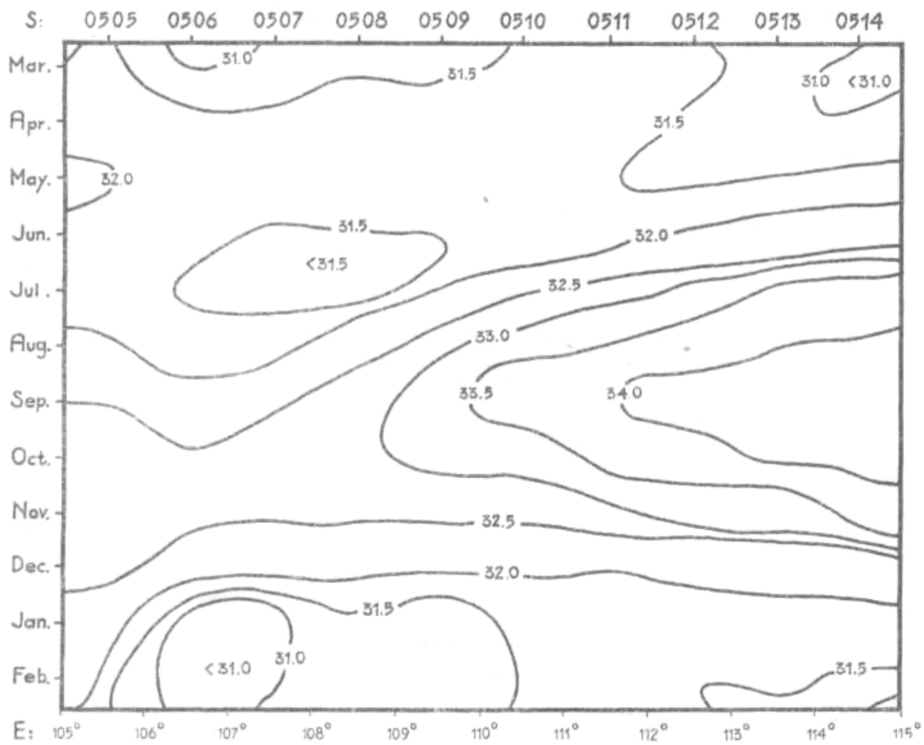

FIG. 4 : Isopleths of surface salinity along the north-coast of Java.

and Macassar Strait and meets the Indian Ocean water in August. The waterbody with high salinity thus formed reaches its maximal westward movement in the central part of the Java Sea off Semarang in September. At the same time and in October, the more saline water, gradually mixed with less saline water moves landward and westward, so that the salinity gradually decreases as it approaches the western part of the Java Sea and the coasts of Kalimantan and Java.

During September, October and November the situation is opposite to that occuring in March, April and May.

The succeeding period December, January and February, is the time of the full west-monsoon, wherein a strong rain-laden wind blows from the West. An east-going current prevails, adducing water from the South China Sea and pushing the oceanic water far eastward. As already mentioned, the waterbody coming from the shallow southern part of the South China Sea is less saline. Besides, as a result of the rainy-season, a considerable discharge of fresh water from all the rivers takes place, the

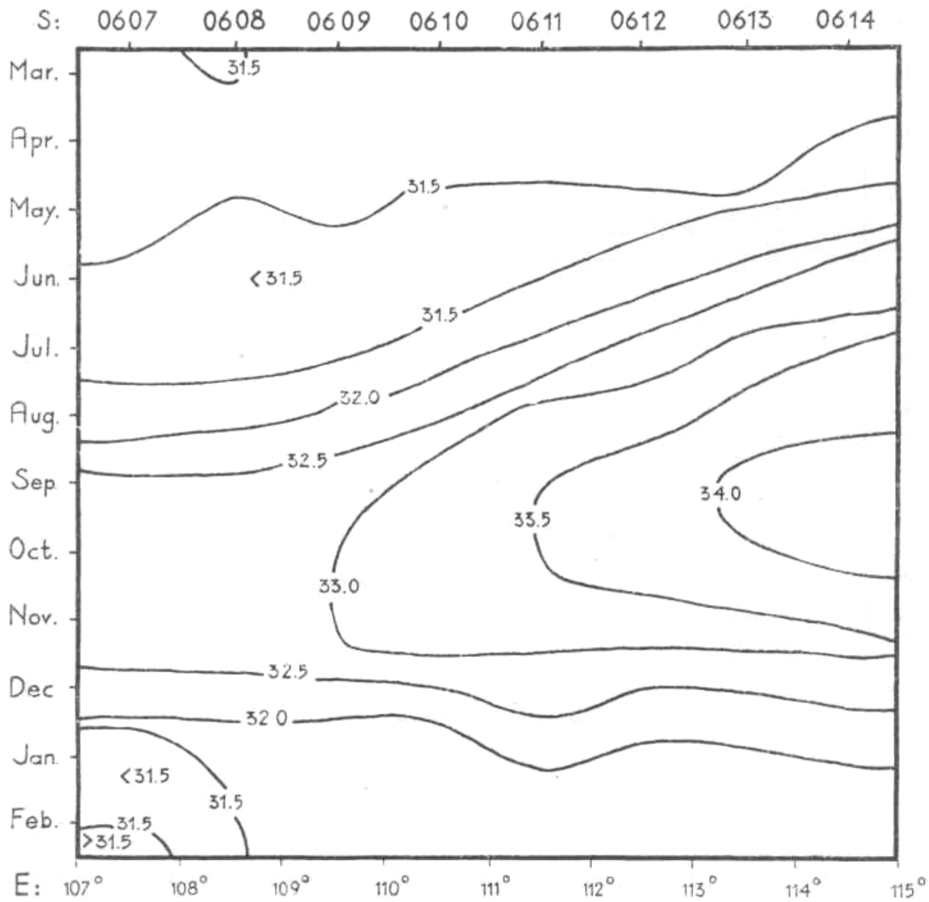

FIG. 5 : Isopleths of surface salinity along the north-coast of Java.

discharge from the rivers of Kalimantan being more than that from the rivers of Java. This fresh water spreads over the more saline water in the middle and gradually mixes with the latter. As a result of these two circumstances, a sudden drop in salinity is found in this period. The salinity in the region investigated varies between31-0‰ and 32.5 ‰except in the bay of Djakarta (S. 0506) and off Bandjarmasin (S. 0514) where, because of heavy river discharges, water less than 31.0 ‰ can be found, compared to 31.5 ‰ to over 34.0 ‰ during the east-monsoon. Despite its proximity to the Indian Ocean, no salinities over 33.0 ‰ were observed in the Sunda Strait. This can be attributed, according to the Eastern Archipelago Pilot Vol. II Chap. III, to a constant south-west current from* the Java Sea to the Indian Ocean which takes place during all months but November, SQ that virtually no influence of the Indian Ocean is noted in the strait.

In summary, as a result of the east-monsoon or dry-season, the region investigated is partly filled with high saline ocean-water (over 34.0‰) and with mixed waters ranging between 31.5 ‰ and 34.0‰, while as a result of the west-monsoon or rainy-season, the region is only covered with mixed waters ranging between 31.0 ‰ and 32.5 ‰ except in some squares under the coasts of Kalimantan and Java, where the salinity distributions show less than 31.0 ‰

Compared with the previous charts of VAN WEEL (1930), G. SCHOTT (1937) and P. CH. VEEN (1953) for the same region, a certain principal pattern of the isohalines is maintained, although here and there one will find differences.

Fig. 6 and 7 illustrate the annual variation in the salinity of every square, while the dotted lines show the annual mean.

With exception of S. 0505, which represent the Sunda Strait and a small part of the Indian Ocean, the annual mean of salinity shows a slight gradual increase, running from West to East- This phenemenon is, again, caused by the inequality of salinity of the watermass emanating from the South China Sea in the west-monsoon, and the watermass emanating from the Indian and Pacific Ocean in the east-monsoon into the Java Sea, as stated above.

An increase in salinity in the eastern section starts in the period March — May, when the east-going current gradually decreases and finally is replaced by an inverse current, which means an invasion of the ocean-water into the Java Sea. This waterbody with high salinity over 34.0 ‰ reaches its maximum advance at the end of the succeeding full east-monsoon (June — August) at longitude 110° E. between latitude 5°—6° S., and at longitude 113° E. between latitude 6°—7° S. This ocean-water advances further westward and landward, mixing with less saline water. As may be expected, one sees the gradual displacement of the highest salinity of every square from September in the eastern section to November in the western section, the time wherein the opposite of the happening is found in the period March-May.

The first outburst of rain in December, being the beginning of the full west-monsoon, causes the sudden drop of salinity in the western section.

In general, the difference between the annual mean and the highest salinity is much greater than that between the annual mean and the

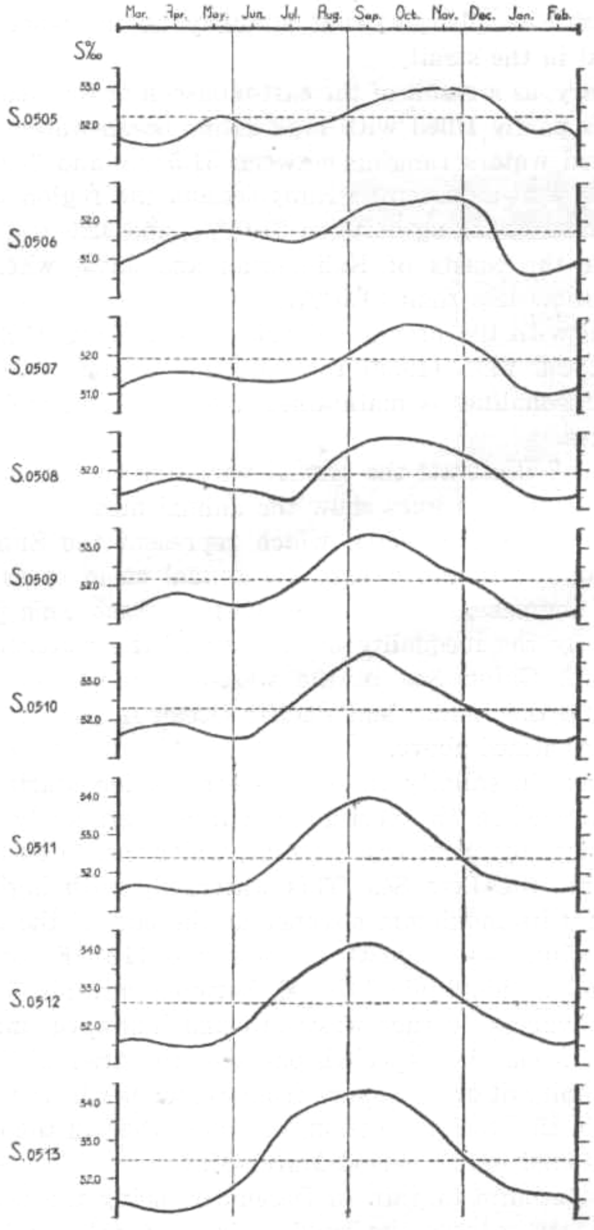

FIG. 6: The annual variation and the annual mean of salinity for every 1°— square.

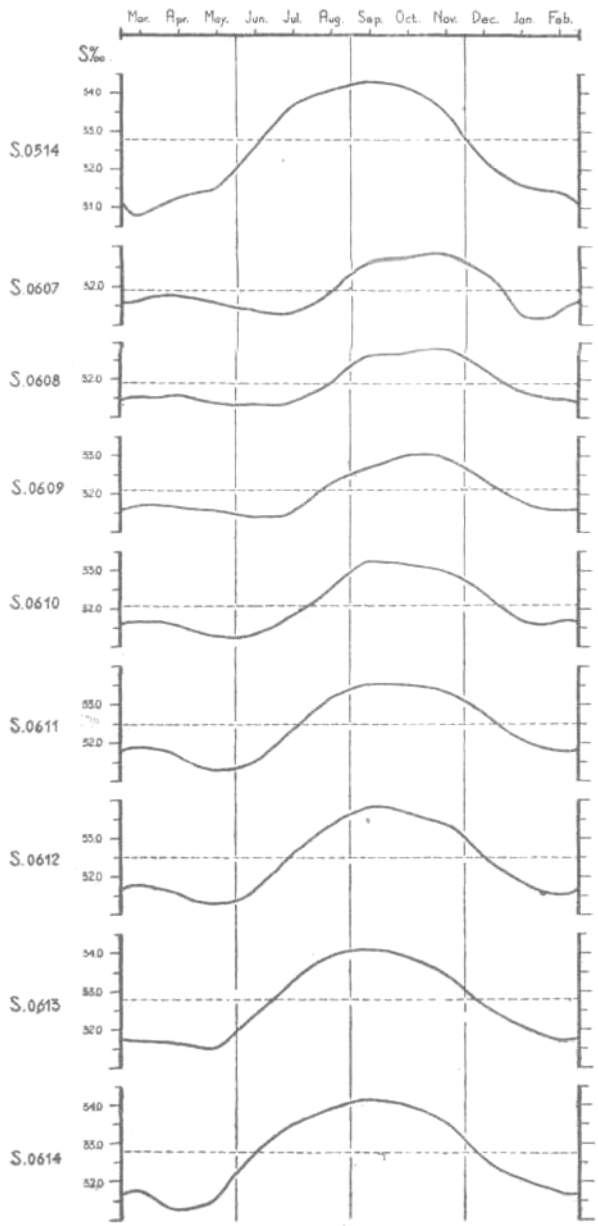

FIG. 7: The annual variation and the annual mean of salinity for every 1°— square.

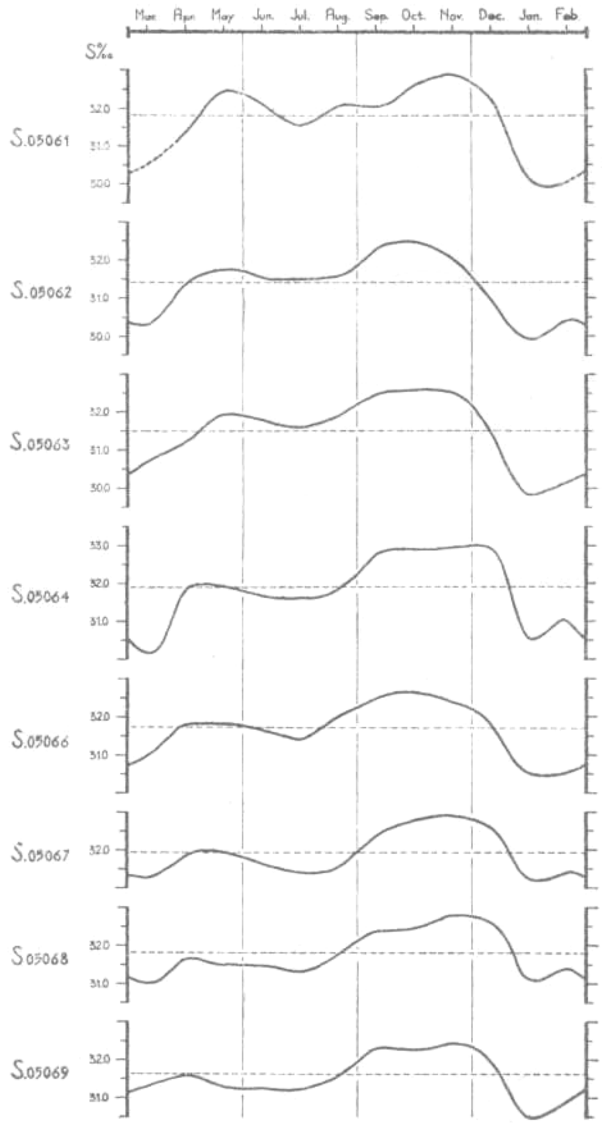

FIG. 8: The annual variation and the annual mean of salinity for every 20′— square off the bay of Djakarta.

lowest salinity, as is seen in the diagrams. So the salinity of the region is above annual mean only during 5 months of the year.

To gain an insight into the fluctuations of the surface salinities in every twenty-minute square off the bay of Djakarta, fig. 8 and 9 were prepared. Because of the few observations, no diagram is made for the square S. 05065. Although the diagrams show irregularities, a principal

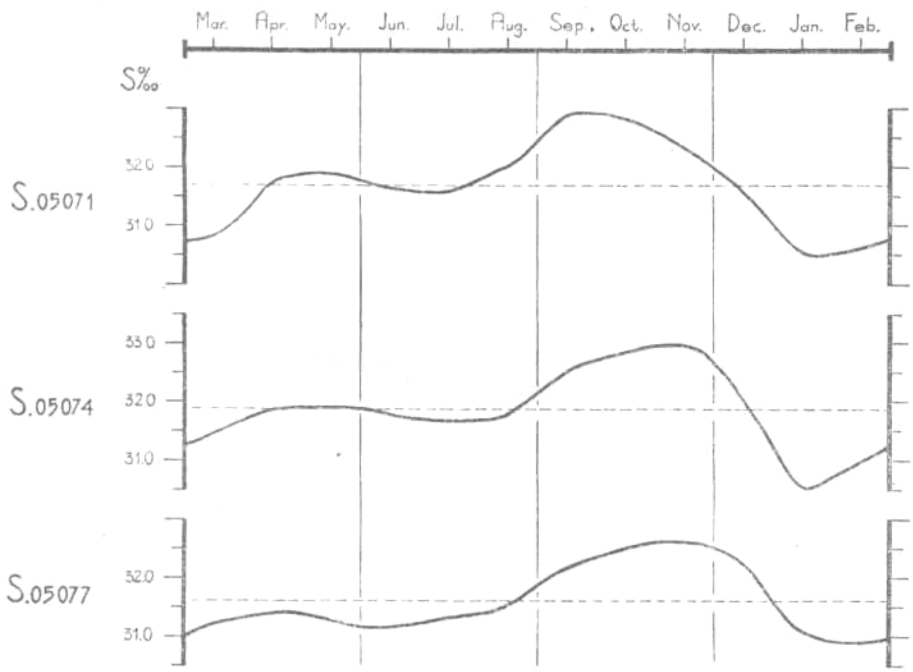

FIG. 9: The annual variation and the annual mean of salinity for every 20′— square off the bay of Djakarta.

pattern is maintained. The highest salinity is found in the months of October — November and the lowest in the period January — March. An extreme drop in salinity as is seen in the coastal squares (05061 and 05064) in these months could be attributed to a considerable discharge of fresh water and probably to the continue strong south-west current in this section, as stated above. Irregular fluctuations due to the influence of the rainy-season are found in the advancing months.

ACKNOWLEDGMENTS

Great acknowledgment goes to Mr. P. CH. VEEN, former oceanographer of the Lembaga Penjelidikan Laut at Djakarta, for his initiative in developing the Marine Research in Indonesia and his invention of the easy methodology.

Sincerest thanks are due to all Captains and Officers of the private navigation companies K. P. M. (N. V. Koninklijke Paketvaart My). K. J. C. P. L. (Koninklijke Java China Paketvaart Lijnen), S. M. N. (Stoomvaart Maatschappij Nederland), Danish Maerskline and government Navigation Service (Djawatan Pelajaran) including lighthouse-keepers for their voluntary co-operation and keen interest in collecting of watersamples.

Finally to Dr. K. WYRTKI, present oceanographer of Lembaga Penjelidikan Laut at Djakarta, for his kind critical advices in preparing this paper.

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TABLE 1. NUMBER OF OBSERVATIONS PER SQUARE DEGREE FOR EACH MONTH 1949-1955

Latitude-South.

Month	0505	0506	0507	0508	0509	0510	0511	0512	0513	0514	0607	0608	0609	0610	0611	0612	0613	0614
March	79	366	275	127	74	75	82	54	77	70	16	164	212	244	255	260	129	55
April	102	338	285	132	73	55	47	36	73	56	5	154	207	245	242	224	138	63
May	101	403	285	122	70	68	65	42	98	67	15	195	200	217	222	215	139	79
June	128	309	238	108	66	50	63	49	65	73	5	162	181	210	216	213	155	69
July	158	355	280	136	88	65	53	61	78	85	12	217	227	269	241	275	157	69
August	116	344	328	141	94	73	63	43	53	96	9	218	253	260	267	267	187	87
September	97	289	276	111	75	45	53	34	61	77	9	192	201	182	229	234	152	64
October	116	390	305	120	103	75	73	34	49	82	10	226	230	246	268	263	144	59
November	103	379	280	111	75	50	50	46	78	72	3	203	232	248	271	268	150	68
December	89	314	278	127	70	63	51	36	53	77	10	187	224	238	257	169	123	55
January	111	358	255	121	61	49	49	29	49	48	8	208	203	240	221	239	113	47
February	106	379	233	94	63	49	41	26	55	37	5	185	189	214	226	218	97	54
TOTAL	1306	4224	3318	1450	912	717	690	490	789	840	107	2311	2559	2813	2915	2845	1684	769

TABLE 2. MEAN SURFACE SALINITY AND NUMBER OF OBSERVATIONS PER SQUARE DEGREE FOR EACH MONTH

Latitude-South.

Year	Square degree	March		April		May		June		July		August		Sept.		October		Nov.		Dec.		January		Febr.	
		S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No
1949	0505	—	—	32,8	1	32,3	6	31,0	7	32,3	3	32,5	11	33,1	9	33,1	11	32,8	9	32,6	19	—	—	—	—
,,	0506	30,8	27	31,7	33	31,5	13	31,4	28	31,5	19	31,8	25	32,8	26	33,0	22	32,9	31	32,4	50	30,2	5	31,5	5
,,	0507	30,8	4	31,9	10	32,2	10	31,4	18	31,2	40	32,9	45	32,8	40	33,2	59	32,8	50	32,7	58	—	—	—	—
,,	0508	31,5	11	31,7	8	31,8	9	31,3	7	31.5	7	32,5	14	33,0	16	33,2	22	32,8	21	32,4	21	31,1	5	31,1	4
,,	0509	31,9	4	32,1	5	32,3	5	31,2	6	32,3	8	33,4	14	33,2	9	33,4	17	32,7	23	32,1	13	—	—	—	—
,,	0510	31,7	2	32,1	2	31,5	2	31,5	1	32,7	5	33,3	3	33,6	7	33,2	14	32,8	11	32,4	11	—	—	—	—
,,	0511	—	—	—	—	—	—	31,9	1	32,8	1	33,9	1	—	—	—	—	32,9	2	32,2	3	—	—	—	—
,,	0512	—	—	—	—	30,0	1	32,6	1	33,4	1	—	—	—	—	—	—	—	—	31,8	3	—	—	—	—
,,	0513	31,4	4	30,4	8	30,5	10	31,7	20	33,5	6	34,0	6	34,0	8	34,1	8	33,2	10	—	—	—	—	—	—
,,	0514	—	—	—	—	—	—	32,6	3	33,7	5	34,0	5	34,2	6	34,4	4	34,2	3	32,6	1	—	—	—	—
,,	0607	—	—	—	—	—	—	—	—	30,7	1	31,2	1	32,6	2	32,9	1	—	—	—	—	—	—	—	—
,,	0608	—	—	—	—	—	—	30,8	7	31,2	31	31,8	34	32,6	29	33,3	35	33,1	31	32,7	33	—	—	—	—
,,	0609	—	—	—	—	—	—	31,0	2	31,4	29	32,1	29	33,0	25	33,3	33	32,9	68	32,7	39	—	—	—	—
,,	0610	—	—	—	—	—	—	30,9	3	31,7	28	32,6	31	33,1	30	33,3	34	33,3	30	33,1	35	—	—	—	—
,,	0611	32,0	1	32,3	1	31,7	2	31,7	3	32,3	36	33,1	40	33,6	40	33,5	49	33,3	37	33,2	43	—	—	—	—
,,	0612	31,8	3	32,0	3	31,1	8	31,7	9	32,2	32	33,3	34	33,8	30	33,8	48	33,1	42	—	—	—	—	—	—
,,	0613	31,9	3	31,4	8	31,1	6	32,3	9	32,9	16	33,9	14	33,9	14	34,0	15	33,2	8	33,2	8	—	—	—	—
,,	0614	31,5	2	—	—	32,0	2	32,5	5	32,9	6	33,7	2	33,8	3	34,0	2	33,8	1	32,9	5	—	—	—	—
1950	0505	31.9	38	31,6	15	31,7	32	32,0	40	31,7	37	31,7	28	32,3	15	32,3	22	32,8	9	33,0	27	32,7	27	31,9	32
,,	0506	31,0	61	31,4	40	31,4	49	31,7	70	31,3	84	31,6	74	32,0	50	32,0	58	32,7	51	32,6	58	31,2	56	30,6	59
,,	0507	31,3	53	31,5	51	31,6	42	31,4	37	31,2	56	31,5	74	32,0	43	32,4	49	32,3	42	32,3	60	31,6	45	31,2	43
,,	0508	31,4	23	31,7	18	31,8	19	31,5	15	31,4	39	31,9	42	32,5	20	32,7	19	32,4	21	32,0	33	31,7	30	31,5	25
,,	0509	31,3	10	31,5	7	31,4	17	31,4	8	31,4	21	32,8	14	33,0	15	32,9	16	32,2	13	31,5	22	31,2	14	31,5	13
,,	0510	31,6	9	31,5	10	31,1	15	31,3	9	31,9	7	32,9	18	33,7	6	33,0	13	32,4	7	31,6	13	31,7	10	31,9	6
,,	0511	31,8	9	31,7	9	30,9	3	31,5	7	32,0	5	33,2	13	33,9	5	33,4	11	32,5	6	31,6	11	31,7	2	32,0	4
,,	0512	31,5	13	31,6	8	31,1	5	32,0	8	32,3	7	33,6	6	34,0	6	33,7	6	32,9	17	32,2	12	31,9	5	31,3	7
,,	0513	31,1	16	31,4	21	31,7	5	—	—	33,0	14	33,7	3	34,0	10	33,7	5	32,8	18	32,0	21	32,0	6	31,6	11
,,	0514	31,2	10	31,4	8	31,5	8	32,1	8	33,5	7	34,0	16	34,3	16	34,1	14	33,4	9	32,2	21	31,4	2	31,5	5
,,	0607	31,8	2	—	—	31,7	2	31,5	2	31,2	2	31,6	2	31,9	1	32,0	1	—	—	31,9	3	—	—	—	—

,,	0608	31,2	4	31,8	34	31,6	33	31,4	25	31,2	34	31,7	46	32,4	26	32,4	35	32,3	28	32,3	34	32,4	26	31,5	30
,,	0609	31,4	39	31,7	47	31,6	33	31,3	38	31,3	50	32,3	52	32,3	41	32,4	38	—	—	32,2	50	32,0	37	32,0	43
,,	0610	31,5	43	31,7	50	31,2	27	30,9	37	31,6	62	32,1	41	32,8	39	32,6	33	32,5	49	31,9	40	31,8	33	31,8	37
,,	0611	31,9	43	31,5	46	31,0	40	31,1	42	32,3	45	32,8	63	33,5	49	33,5	41	32,9	36	32,2	46	32,1	40	32,0	44
,,	0612	31,4	45	31,5	43	31,1	25	31,4	39	32,4	47	32,9	61	33,3	46	33,6	37	33,0	35	32.3	38	32.2	45	31,8	45
,,	0613	31,8	22	31,8	16	31,4	16	31,8	18	32,9	18	33,7	27	34,0	26	33,8	19	33,4	30	32,4	24	32,5	12	31.8	10
,,	0614	31,7	3	31,7	6	31,1	9	32,3	7	33,0	7	33,8	18	34,0	8	34,0	12	33,4	13	32,7	9	32,8	3	—	—
1951	0505	—	—	31,9	19	31,7	10	31,7	13	31,5	18	31,2	14	32,0	8	32,6	20	32,2	23	32,1	10	31,3	30	32,4	23
,,	0506	31,2	60	32,0	70	31,6	78	31,1	55	30,9	76	31,0	71	32,0	64	31,6	123	32,1	92	31,8	69	30,0	60	30,7	75
,,	0507	31,5	46	31,8	42	31,3	46	30,9	52	30,9	39	31,1	52	31,8	54	32,1	54	32,3	47	32,2	37	30,7	59	30,7	51
,,	0508	31,3	20	31,7	21	31,2	26	31,1	25	30,7	30	32,0	18	32,4	15	32,3	28	32,4	13	32,3	26	31,0	27	31,0	21
,,	0509	31,3	12	31,0	10	31,3	12	31,3	11	31,5	9	32,3	14	33,1	9	32,4	25	32,2	8	32,3	11	31,1	9	30,9	19
,,	0510	31,6	9	30,8	7	31,2	13	31,3	10	31,8	5	32,8	6	33,7	6	32,9	15	32,3	6	32,3	13	31,4	5	31,2	8
,,	0511	31,2	12	30,8	10	31,0	18	31,5	20	32,2	5	33,2	10	34,0	18	33,7	15	32,9	5	32,3	10	31,5	10	31,5	4
,,	0512	31,3	3	30,8	6	31,3	8	31,9	14	33,1	4	33,7	6	33,9	5	33,8	12	32,6	6	32,2	8	31,4	4	31,6	2
,,	0513	31,0	9	30,9	15	31,7	17	32,0	15	33,3	6	33,8	11	34,2	14	34,0	13	33,4	18	31,9	5	31,4	14	31,1	13
,,	0514	30,8	14	31,5	13	32,1	13	32,5	23	33,3	21	33,9	14	34,2	14	34,2	24	34,1	11	32,3	22	31,5	13	31,2	12
,,	0607	31,4	1	31,6	1	—	—	—	—	31,0	3	31,4	1	31,9	2	32,4	1	—	—	32.3	2	31,1	1	30,5	1
,,	0608	31,4	29	31,5	31	31,0	37	31,1	33	30,8	34	31,3	37	32,2	44	32,5	35	32,5	42	32,4	34	31,2	30	31,1	34
,,	0609	31,7	40	31,4	40	31,1	43	30,8	35	30,8	37	31,7	48	32,5	51	32,9	40	32,6	46	32,3	43	31,5	35	31,3	38
,,	0610	31,6	37	31,2	51	30,7	50	30,7	43	31,3	47	32,3	44	32,6	5	32,9	51	32,5	34	32,1	53	31,6	58	31,4	44
,,	0611	31,6	46	30,9	45	31,0	54	31,3	41	32,0	44	33,0	51	33,6	49	33,3	56	33,1	47	32,6	44	31,8	35	31,5	44
,,	0612	31,5	48	30,9	40	31,0	54	31,5	56	32,4	47	33,3	53	33,9	63	33,5	46	33,2	43	32,3	49	31,4	63	31,4	38
,,	0613	31,4	23	31,0	26	31,7	27	32,3	38	33,0	34	33,7	37	34,1	33	33,9	39	33,0	23	32,4	37	31,6	29	31,6	24
,,	0614	31,7	6	31,1	8	31,9	13	32,7	18	33,2	9	33,7	15	34,1	14	34,0	11	33,4	10	32,1	9	31,5	8	31,4	10
1952	0505	30,7	7	31,7	18	31,4	7	31,7	18	31,7	37	31,7	33	32,5	29	33,0	20	33,3	31	32,7	21	32,5	20	30,8	8
,,	0506	30,4	69	31,3	74	31,8	85	31,4	59	31,3	68	31,8	79	32,7	75	33,2	95	32,9	109	32,1	73	31,0	73	30,2	72
,,	0507	31,1	64	31,4	48	31,4	59	31,2	64	31,3	54	31,9	57	32,8	71	33,2	68	33,0	67	31,8	53	31,5	39	30,9	50
,,	0508	31,4	32	31,5	23	31,3	19	31,2	25	31,5	22	32,4	22	33,0	30	33,0	21	32,9	23	31,7	22	31,8	21	31,4	22
,,	0509	31,3	26	31,7	11	31,1	12	31,3	23	32,4	21	33,4	16	33,9	27	33,7	19	32,5	14	31,8	10	31,7	7	31,2	13
,,	0510	31,7	27	31,8	10	31,3	7	31,5	17	32,9	10	34,0	10	34,2	20	33,7	13	32,7	17	32,2	17	31,9	13	31,4	20
,,	0511	31,7	16	31,6	13	31,3	20	32,0	18	33,5	9	34,3	11	34,3	16	34,0	19	33,1	12	32,1	13	31,9	13	31,4	15
,,	0512	31,7	17	31,4	9	31,2	9	32,2	16	33,6	9	34,2	8	34,3	16	33,5	8	33,6	9	32,5	6	32,0	8	31,5	9
,,	0513	31,2	22	31,0	5	31,5	18	32,5	14	34,1	29	34,4	15	34,5	21	34,2	9	33,4	19	32,5	20	31,6	6	31,6	10
,,	0514	31,2	12	31,0	13	31,9	14	32,4	18	34,2	24	34,3	22	34,4	26	34,4	12	33,8	21	32,5	26	31,6	12	31,5	8
,,	0607	31,0	4	31,8	1	31,4	7	31,0	2	31,3	4	32,0	2	33,3	1	32,9	5	—	—	32,8	2	31,6	1	—	—

MEAN SURFACE SALINITY AND NUMBER OF OBSERVATIONS PER SQUARE DEGREE FOR EACH MONTH

Latitude-South.

Year	Square degree	March		April		May		June		July		August		Sept.		October		Nov.		Dec.		January		Febr.	
		S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No	S°/∞	No
1952	0608	31,3	43	31,4	35	31,4	49	31,2	40	31,4	56	32,2	36	32,9	28	33,4	46	33,0	49	32,3	35	31,7	33	31,5	39
„	0609	31,3	47	31,6	36	31,5	42	31,2	45	31,5	47	32,6	45	33,0	31	33,7	40	33,2	49	32,2	36	31,9	33	31,5	36
„	0610	31,5	58	31,8	39	31,2	43	31,2	50	32,1	54	32,9	44	33,4	39	33,7	49	33,6	57	32,6	47	31,5	46	31,5	50
„	0611	31,9	53	31,7	43	31,1	37	31,4	56	32,6	50	33,9	52	33,9	43	34,0	56	33,9	58	33,0	59	32,1	44	32,0	51
„	0612	31,8	47	31,7	31	31,3	47	31,5	50	33,3	64	34,2	49	34,2	40	34,1	52	33,7	70	32,6	36	32,0	43	31,8	41
„	0613	31,7	23	31,7	21	31,3	31	32,6	39	33,9	36	34,2	43	34,3	37	34,4	29	33,9	42	33,0	32	32,1	19	31,5	19
„	0614	31,7	12	31,0	20	31,7	22	33,0	16	34,1	14	34,1	22	34,5	16	34,4	12	33,8	19	33,3	12	32,4	8	31,6	17
1953	0505	31,7	28	32,1	36	32,2	34	32,1	40	32,3	36	33,7	25	32,5	29	33,5	37	33,3	28	33,2	8	31,5	25	32,2	39
„	0506	31,1	96	31,4	85	31,7	114	31,9	54	31,9	57	32,4	58	33,1	55	33,4	55	32,8	59	32,5	32	30,1	104	31,4	114
„	0507	31,5	68	31,7	87	31,4	68	31,8	51	32,0	54	32,3	52	33,1	36	33,4	34	32,7	44	32,5	43	30,8	75	31,2	56
„	0508	31,6	28	31,7	35	31,8	36	31,9	22	31,0	23	32,7	30	33,4	15	33,6	19	32,5	19	32,7	13	31,2	17	31,4	11
„	0509	31,5	18	31,9	28	31,9	18	31,9	10	32,1	21	33,0	22	33,7	9	33,8	13	32,8	7	32,6	10	31,2	11	31,4	8
„	0510	31,9	24	32,2	17	31,9	24	32,1	9	32,5	31	33,4	24	34,1	4	33,7	14	33,4	7	32,9	5	31,4	10	31,9	5
„	0511	32,1	24	32,2	9	32,1	18	32,0	14	32,9	24	33,6	17	34,1	6	34,1	17	33,6	15	32,4	2	31,7	10	31,9	10
„	0512	31,8	17	32,1	8	31,8	14	32,4	8	33,3	35	33,8	18	34,5	3	34,4	7	33,8	8	33,1	4	32,0	7	31,8	7
„	0513	31,7	23	31,4	19	31,6	43	32,5	14	33,3	21	34,0	15	34,4	6	33,9	12	33,8	7	32,5	5	31,7	16	31,7	15
„	0514	30,5	33	31,3	16	31,5	18	32,5	16	33,6	24	34,4	28	34,2	9	34,2	20	34,1	16	33,9	1	31,7	15	31,4	11
„	0607	31,6	5	31,5	2	31,7	4	31,8	1	32,5	1	32,4	2	32,7	2	33,5	1	33,3	2	33,0	2	31,3	4	31,6	2
„	0608	31,4	49	31,3	25	31,2	36	32,0	36	32,1	32	32,6	35	33,2	36	33,5	34	33,1	33	32,6	30	31,3	56	31,5	42
„	0609	31,8	48	31,8	51	31,7	43	31,9	38	32,2	39	32,7	38	33,4	31	33,7	31	33,3	41	33,0	44	31,6	43	31,8	35
„	0610	31,7	61	31,6	67	31,6	58	31,9	47	32,1	44	32,8	56	33,5	44	33,7	38	33,6	49	33,2	45	31,7	49	31,9	47
„	0611	32,2	57	32,3	71	31,6	57	32,0	41	32,5	37	33,4	23	33,7	20	33,7	38	33,8	48	33,6	46	32,0	40	32,3	50
„	0612	31,9	64	31,9	62	31,8	46	31,9	40	32,8	58	33,5	39	33,9	29	33,9	37	33,8	48	33,3	27	31,7	45	32,0	53
„	0613	32,0	37	31,9	46	31,8	33	32,5	30	33,4	39	34,0	43	34,3	22	34,0	15	33,7	28	33,3	9	31,8	38	32,0	31
„	0614	31,7	15	31,3	19	31,9	15	32,8	11	33,5	25	34,1	19	34,2	12	34,1	11	33,8	15	33,1	8	32,0	20	31,9	18
1954	0505	32,2	3	32,4	10	32,3	7	32,3	10	32,1	21	32,0	5	32,6	4	32,9	4	33,2	2	33,1	2	32,8	5	30,3	2
„	0506	31,6	26	32,7	19	32,1	30	32,0	24	31,7	32	31,9	23	32,6	6	32,6	24	32,5	29	32,0	17	31,4	32	30,8	26
„	0507	31,7	24	31,9	34	32,0	41	32,0	16	31,9	18	31,9	29	32,2	20	32,8	20	33,1	12	30,2	11	31,6	23	31,8	17

											[illegible]	[illegible]	[illegible]	[illegible]	20	32,8	20	33,1	12	30,2	11	31,6	23	31,8	17
,,	0508	31,9	9	32,2	16	32,4	7	32,2	5	31,7	5	32,2	9	32,5	8	33,0	4	33,0	8	31,6	7	32,1	11	31,2	8
,,	0509	31,8	3	32,2	5	32,4	5	32,0	3	31,8	3	32,8	6	33,3	4	32,4	4	32,3	6	—	—	32,1	8	31,2	5
,,	0510	31,9	2	32,3	7	32,3	4	—	—	33,4	2	33,4	6	—	—	31,9	3	32,2	1	31,9	2	32,0	4	31,5	8
,,	0511	31,1	9	31,9	1	31,6	4	31,6	1	32,7	2	33,5	8	33,6	5	33,0	3	32,4	3	32,1	10	32,1	4	31,6	6
,,	0512	32,0	2	31,6	4	31,2	2	—	—	33,6	1	33,5	3	34,5	3	—	—	32,7	3	32,2	2	31,8	4	—	—
,,	0513	31,1	3	31,8	4	31,0	4	32,4	1	33,6	2	34,0	2	34,0	1	34,3	2	32,3	5	32,1	1	32,2	7	32,0	6
,,	0514	31,4	1	31,5	6	31,3	10	32,5	3	33,4	3	33,8	7	34,4	5	34,3	6	32,7	7	32,1	4	32,0	6	31,9	1
,,	0607	32,4	3	32,2	1	32,1	2	—	—	32,5	1	—	—	33,5	1	31,6	1	—	—	—	—	30,9	1	32,1	1
,,	0608	32,1	23	32,1	15	32,1	27	31,8	13	31,9	14	31,8	16	32,4	19	32,9	20	33.1	11	32,0	10	32,2	52	31,6	29
,,	0609	32,2	22	31,9	21	32,1	27	31,9	16	31,8	14	32,0	22	32,3	11	33,2	16	33,9	14	32,5	6	32,3	39	31,4	27
,,	0610	32,1	29	32,2	20	32,0	29	31,5	21	31,8	21	32,6	25	32,9	14	32,9	21	32,8	16	32,3	9	32,4	37	31,3	27
,,	0611	32,5	35	32,4	22	31,7	23	31,6	20	32,3	16	33,2	19	33,5	15	33.0	11	33,3	28	32,7	9	32,7	45	31,8	31
,,	0612	32,3	29	32,1	28	31,6	22	31,2	12	32,1	16	33,2	20	33,8	14	33,6	24	33,2	19	32,4	13	32,6	26	31,8	33
,,	0613	32,3	12	32,1	16	31,5	16	32,8	10	33,1	9	33,7	16	34,2	10	33,8	15	33,5	6	32,5	7	32,7	11	32,2	7
,,	0614	32,2	9	31,8	6	31,1	12	33,1	7	33,4	3	34,1	7	34,3	2	33,9	3	33,7	5	32,4	7	32,4	7	32,2	4
1955	0505	30,6	3	31,8	3	32,7	5	—	—	31,9	6	—	—	31,6	3	31,9	2	33,2	1	32,3	2	31,0	4	31,0	2
,,	0506	31,0	27	31,7	17	32,1	34	33,4	19	31,7	19	31,2	14	31,5	13	31,9	13	32,6	8	31,1	15	30,7	28	30,6	28
,,	0507	31,1	16	31,4	13	31,5	19	31,7	10	31,7	19	31,3	19	31,7	12	31,7	21	31,6	18	31,5	16	31,1	14	30,7	16
,,	0508	31,9	4	32,2	11	31,7	6	31,9	9	31,5	10	31,5	6	31,8	7	31,9	7	32,3	6	32,4	5	31,3	10	30,8	3
,,	0509	31,4	1	32,3	7	31,3	1	32,5	5	31,2	5	31,7	8	32,5	2	32,3	9	31,7	4	32,3	4	31,1	12	31,4	5
,,	0510	31,8	2	32,5	2	32,1	3	32,2	4	31,2	5	32,3	6	31,4	2	32,5	3	31,7	1	31,8	2	31,7	7	31,7	2
,,	0511	32,1	12	32,3	5	32,5	2	32,2	2	31,6	7	32,2	3	32,5	3	32,6	8	31,6	7	31,9	2	31,8	10	31,5	2
,,	0512	32,2	2	31,3	1	31,9	3	32,0	2	31,8	4	32,4	2	33,2	1	33,1	1	31,6	3	32,1	1	32,0	1	31,7	1
,,	0513	—	—	31,6	1	30,3	1	31,1	1	—	—	32,6	1	33,4	1	—	—	31,9	1	31,8	1	—	—	—	—
,,	0514	—	—	—	—	30,4	4	31,5	2	32,6	1	32,7	4	33,6	1	33,9	2	31,5	5	32,6	2	—	—	—	—
,,	0607	32,6	1	—	—	—	—	—	—	—	—	31,8	1	—	—	—	—	32,6	1	32,2	1	31,2	1	31,8	1
,,	0608	32,2	16	31,4	14	31,3	13	31,9	8	31,8	16	31,5	14	31,7	10	31,6	21	31,6	9	31,8	11	31,6	11	31,7	11
,,	0609	32,2	16	31,7	12	31,8	12	31,8	7	31,7	11	31,8	19	31,8	11	31,9	32	31,9	14	32,1	6	31,6	16	31,9	10
,,	0610	32,0	16	31,8	18	31,6	10	32,0	9	31,7	13	31,9	19	31,8	11	32,0	20	31,6	13	32,1	9	30,8	17	31,2	9
,,	0611	32,3	20	31,8	14	31,1	9	31,7	13	31,7	13	32,1	19	32,4	13	32,9	17	32,5	17	31,9	10	31,6	17	32,3	6
,,	0612	31,7	24	31,4	17	31,4	13	31,7	7	31,8	11	32,1	11	33,3	12	33,0	19	32,3	11	32,0	6	31,4	17	32,0	8
,,	0613	32,0	9	31,4	5	31,4	10	31,9	11	31,8	5	33,0	7	33,6	10	33,1	12	32,4	13	32,0	6	32,5	4	32,2	6
,,	0614	32,0	8	31,3	4	31,4	6	31,8	5	33,1	5	32,9	4	33,8	9	33,5	8	32,3	5	31,9	5	31,9	1	32,2	5