

## GEOSECS Atlantic and Pacific $^{14}\text{C}$ Distribution

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Future progress in carbon reservoir modeling depends very much on the incorporation of a more detailed carbon transport model for the oceans. To facilitate the development of such a model, we present here the main features of the  $^{14}\text{C}$  distribution in the Atlantic and Pacific ocean for the years 1972 to 1974.

Average profiles of  $\Delta^{14}\text{C}$  and total  $^{14}\text{C}$  were constructed for polar, midlatitude gyre, and equatorial regions of the Pacific and Atlantic oceans. The differences in oceanographic circulation characteristics between these regions produce corresponding differences in the vertical distribution of bomb  $^{14}\text{C}$  and inventories of  $^{14}\text{C}$ . The regions were chosen as Polar (latitude  $>50^\circ\text{S}$ ), Gyre (latitude  $10^\circ$  to  $50^\circ$ , both S and N) and Equatorial (latitude  $10^\circ\text{N} - 10^\circ\text{S}$ ). The boundaries for these regions were chosen somewhat arbitrarily. The polar boundary corresponds roughly to the convergence zones, where dense waters sink to abyssal depths, and vertical mixing is rapid. The equatorial boundary coincides roughly with the surfacing of the regions of upward bending of isopycnals, and enhanced upwelling. These boundaries define the region of increased ocean surface water  $\text{pCO}_2$  levels, and net  $\text{CO}_2$  flux to the atmosphere (Broecker *et al.*, 1979).

The average  $\Delta^{14}\text{C}$  profiles (given as the per mil deviation from the oxalic acid standard after correction for isotope fractionation) given here provide a basis for general comparisons between these three oceanic regions (Figures 1–4), as well as for the examination of large scale oceanographic processes. However, for examining smaller scale processes the stations and depth should be much more carefully selected.

During the years of sampling (1972–1974) the thermocline and surface waters contained  $^{14}\text{C}$  derived from both natural (cosmic ray-produced) and anthropogenic (nuclear bomb-produced) sources. A limited amount of bomb produced  $^{14}\text{C}$  was, in 1972, advected by sinking waters in the deep waters of the North Atlantic Ocean. In the other regions of the world oceans, however, the waters below 1500 meters should reflect approximate pre-bomb  $^{14}\text{C}$  levels.

The contribution of nuclear bomb  $^{14}\text{C}$  is derived by deducting estimated pre-bomb  $\Delta^{14}\text{C}$  values from the measured values listed in the tables. From the few direct measurements of pre-bomb  $^{14}\text{C}$  in the ocean the pre-bomb mixed layer  $\Delta^{14}\text{C}$  levels in the Atlantic can be estimated at  $-55$  per mil for both gyre reservoirs ( $50^\circ\text{S} - 10^\circ\text{S}$ ,

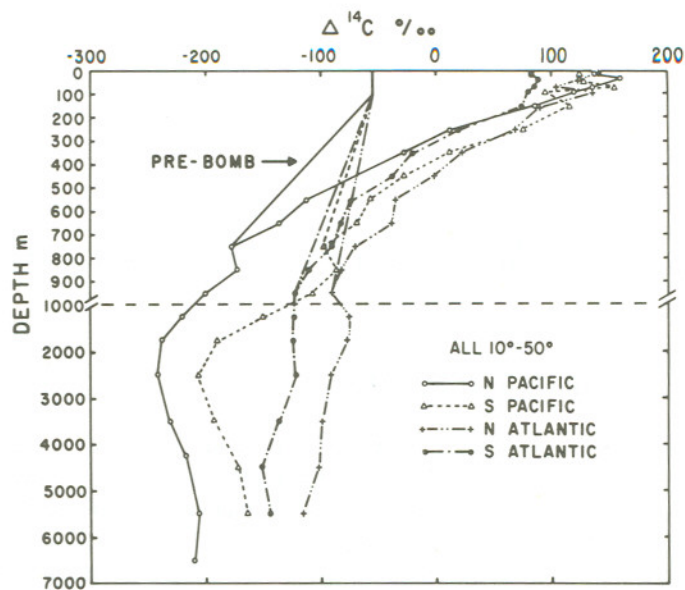


Figure 1:  $\Delta^{14}\text{C}$ -depth profiles for the Atlantic and Pacific Ocean gyre reservoirs ( $10^\circ$ – $50^\circ$  latitude). The assumed pre-bomb  $\Delta^{14}\text{C}$ -depth profiles all extend to  $\Delta^{14}\text{C} = -55$  per mil at the surface.

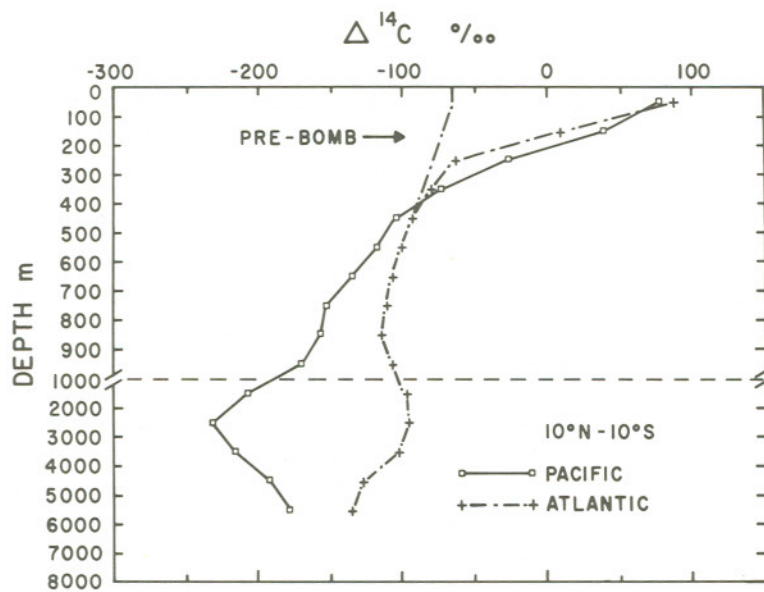


Figure 2:  $\Delta^{14}\text{C}$ -depth profiles for the equatorial ( $10^\circ\text{N}$ – $10^\circ\text{S}$ ) regions of the Atlantic and Pacific Ocean. The assumed pre-bomb depth profile extends to a  $\Delta^{14}\text{C}$  surface value of  $-65$  per mil.

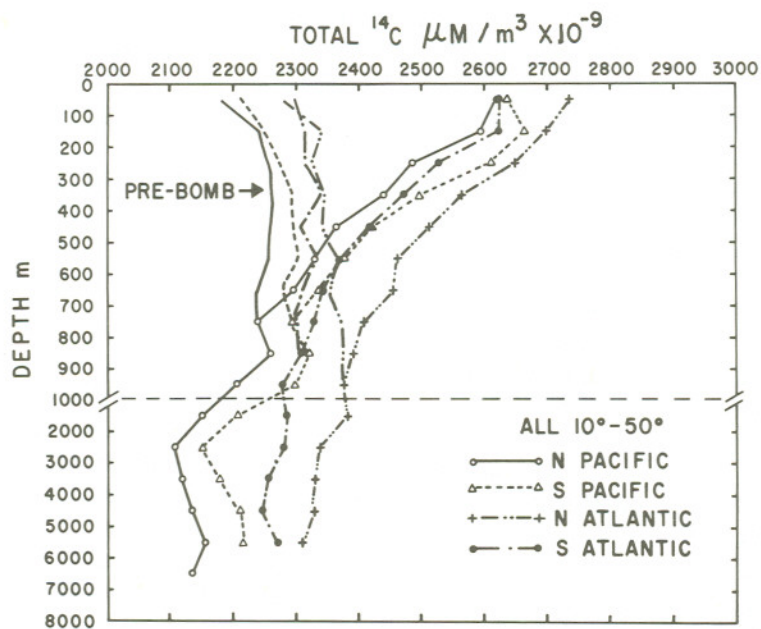


Figure 3: Dissolved inorganic  $^{14}\text{C}$  versus depth for the  $10^{\circ}$ – $50^{\circ}$  gyre reservoirs in the Atlantic and Pacific Ocean. Prebomb total levels were calculated by using the curves given in Figure 1.

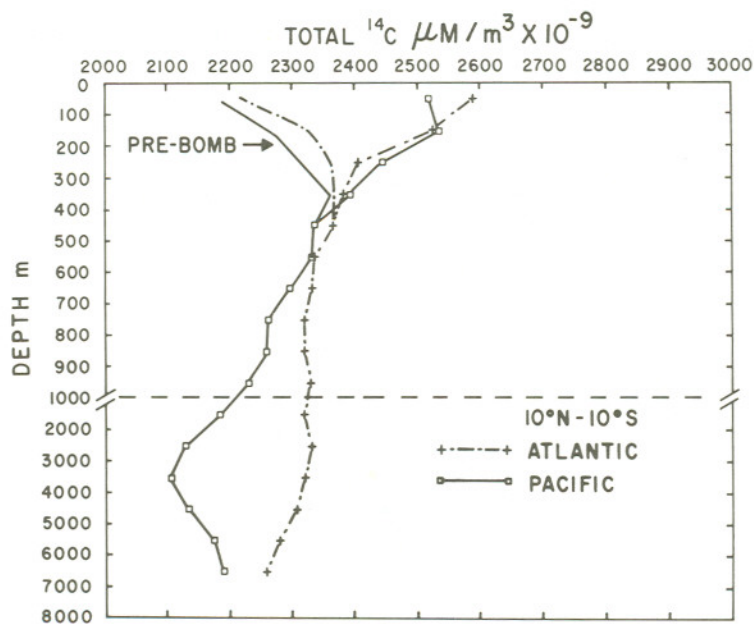


Figure 4: Dissolved inorganic  $^{14}\text{C}$  versus depth for the  $10^{\circ}\text{N}$ – $10^{\circ}\text{S}$  regions of the Pacific and Atlantic ocean. The prebomb levels were calculated by using the curve given in Figure 2.

and 10°N–50°N), and at about –65 per mil for the tropical reservoir (10°S–10°N) (Broecker *et al.*, 1960). These pre-bomb values are approximate *only because they* are the average  $\Delta^{14}\text{C}$  level of water samples collected between 1955 and 1958. Minor amounts of bomb radiocarbon could have been present in the samples because hydrogen bomb testing started already in 1952.

The pre-bomb baseline is more difficult to determine for the Pacific Ocean where sampling started later. Samples collected between 1957 and 1960 (Linick, 1978) yield an upper limit of –30 per mil for the mixed layer  $\Delta^{14}\text{C}$  values. Because this is an upper limit only, we have assumed that the pre-bomb Pacific mixed layer values were similar to the pre-bomb Atlantic values listed above.

The depth to which bomb  $^{14}\text{C}$  has penetrated can be estimated from the GEOSECS tritium measurements (Östlund *et al.*, 1976, 1979). For the North Atlantic gyre reservoir measurable amounts of tritium penetrated down to 1500 meters. For the other gyre reservoirs tritium is detectable to about 600 meters, whereas the tritium penetration in the tropics is only 300 meters. The depth to which nuclear bomb  $^{14}\text{C}$  has penetrated is assumed to be at least equal to the tritium penetration depths.

Our estimated pre-bomb  $\Delta^{14}\text{C}$  distribution (Figures 1–4) is based on a linear extrapolation of mixed-layer  $\Delta^{14}\text{C}$  values at depths of estimated maximum tritium penetration. The amounts of oceanic  $^{14}\text{C}$  of nuclear bomb origin per unit area are estimated from the differences between the pre-bomb, and measured  $\Delta^{14}\text{C}$  values. For the gyre reservoirs these amounts are  $1.47 \times 10^{-4}$ ,  $1.66 \times 10^{-4}$ ,  $1.20 \times 10^{-4}$  and  $1.82 \times 10^{-4}$   $\mu\text{mole } ^{14}\text{C}/\text{m}^2$  for respectively the North Pacific, South Pacific, South Atlantic and North Atlantic. For the Atlantic and Pacific tropical reservoirs these values are respectively 0.70 and  $0.80 \times 10^{-4}$   $\mu\text{mole } ^{14}\text{C}/\text{m}^2$ .

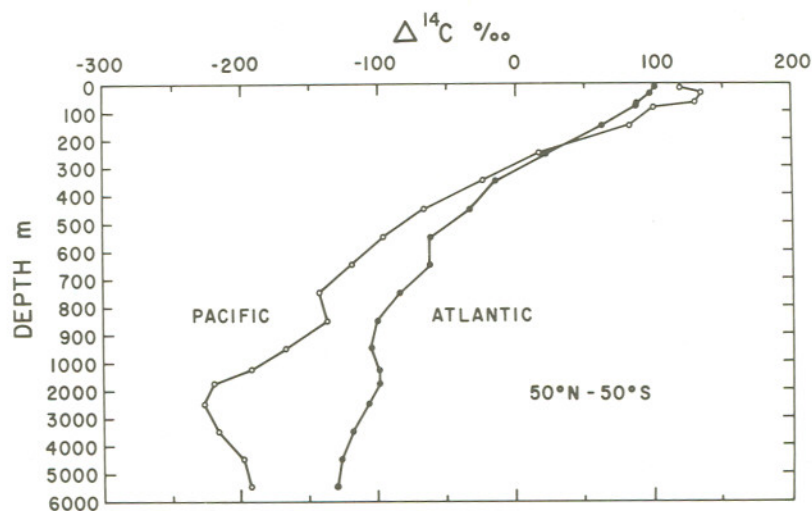


Figure 5:  $\Delta^{14}\text{C}$  versus depth for the Atlantic and Pacific Ocean (50°N–50°S latitude).

Average  $\Delta^{14}\text{C}$  and dissolved inorganic  $^{14}\text{C}$  profiles for the Atlantic and Pacific oceans (both between  $50^\circ\text{N}$  and  $50^\circ\text{S}$ ) are given in Figures 5 and 6.

The basic data from which these compilations have been made were published in Radiocarbon (Östlund and Stuiver, 1980; Stuiver and Östlund, 1980).

#### Appendix: Preliminary conclusions based on the GEOSECS $^{14}\text{C}$ -data

The flux of carbon dioxide per unit area between the atmosphere and the oceans,  $F_{\text{am}}$ , can be derived from the flux of nuclear bomb  $^{14}\text{C}$  transferred to the oceans and an integration of the  $\Delta^{14}\text{C}$  difference between the atmosphere and the mixed-layer of the ocean with proper consideration of fractionation (see Stuiver, 1980, for details). Such exchange rate calculations assume that the  $\Delta^{14}\text{C}$  vertical profile in a region or "box" is the result of vertical transport only. The calculated exchange rates are 27.2, 11.1 and 20.2 mole/( $\text{m}^2\text{yr}$ ) for the Atlantic ( $50^\circ\text{N}-10^\circ\text{N}$ ,  $10^\circ\text{N}-10^\circ\text{S}$ ,  $10^\circ\text{S}-50^\circ\text{S}$ ) and 21.0, 12.1 and 26.5 mole/( $\text{m}^2\text{yr}$ ) for the corresponding Pacific reservoirs. The average value (weighted for ocean surface area) for the Pacific between  $50^\circ\text{N}$  and  $50^\circ\text{S}$  is 20.8 mole/( $\text{m}^2\text{yr}$ ), and 21.4 mole/( $\text{m}^2\text{yr}$ ) for the Atlantic. The magnitude of the carbon exchange rates agrees with the values derived previously for the Atlantic Ocean (Stuiver, 1980).

The average  $\Delta^{14}\text{C}$  levels of the waters below 1500 meter are plotted in Figure 7 versus latitude for the Pacific and Atlantic equatorial, gyre and polar regions. Latitudes were obtained by averaging the latitudes of the stations for which the  $\Delta^{14}\text{C}$  values in the tables were calculated. The overall trend of the specific  $^{14}\text{C}$  content agrees with the concept of gradual "aging" of the deep waters that move southward in the Atlantic Ocean, enter the Antarctic Circumpolar current, and then move northward into the Pacific Ocean. The similar  $\Delta^{14}\text{C}$  gradients in Figure 7 for the Atlantic

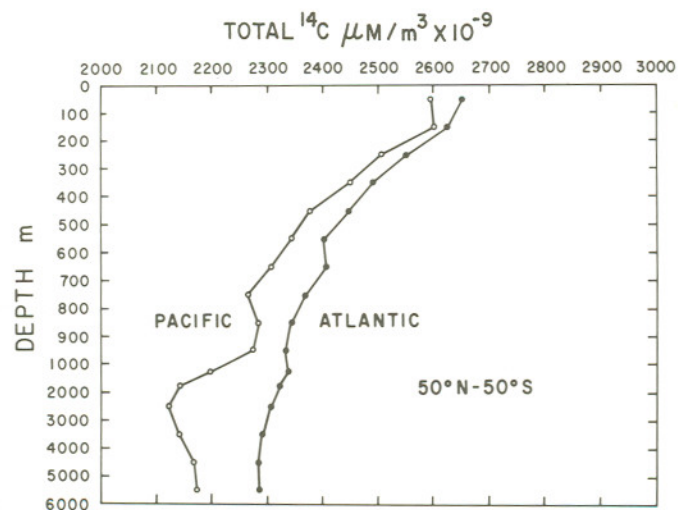


Figure 6: Dissolved inorganic  $^{14}\text{C}$  versus depth for the Atlantic and Pacific Ocean ( $50^\circ\text{N}-50^\circ\text{S}$  latitude).

and Pacific Oceans do not necessarily imply identical rates of aging because part of the "apparent" aging of the Atlantic deep water is due to mixing of water masses. The northward flowing water of Antarctic origin tends to increase the Atlantic  $\Delta^{14}\text{C}$  gradient. When correcting for this effect shorter ventilation times than otherwise indicated by the  $\Delta^{14}\text{C}$  trend in Figure 3 are obtained for the Atlantic (Broecker, 1979; Stuiver, 1976).

Weiss *et al.* (1979) calculate a  $\Delta^{14}\text{C}$  value of approximately  $-150$  per mil for newly formed Weddell Sea Bottom Water and Antarctic Bottom Water. This value is close to the actual  $\Delta^{14}\text{C}$  level of Antarctic deep water (Figure 7), and thus water exchange in the Antarctic can be neglected as a first approximation.

The dissolved inorganic carbon (DIC) content of a parcel of the water below 1500 m increases from about  $2200 \mu\text{mole/kg}$  to  $2330 \mu\text{mole/kg}$  when moving from the northern Atlantic to the northern Pacific (Figure 8). The assumption is made here that this increase in DIC is caused by  $\text{CaCO}_3$  dissolution and oxidation of sinking biological organisms. For instance, Chen (1978) estimates from alkalinity changes that  $\text{CaCO}_3$  dissolution and organic carbon oxidation contribute, respectively, 20 and 80 percent of the total vertical carbon flux.

If we assume that the  $\Delta^{14}\text{C}$  level of this carbon is equal to the preindustrial surface water  $\Delta^{14}\text{C}$  level of approximately  $-40$  per mil, we can calculate the amount of  $^{14}\text{C}$  added to this closed "parcel" of water by dissolution and oxidation. By subtracting away this additional  $^{14}\text{C}$  (Figure 7), and making the deep water closed to any atmospheric input of  $^{14}\text{C}$  we can calculate the age of the deep water.

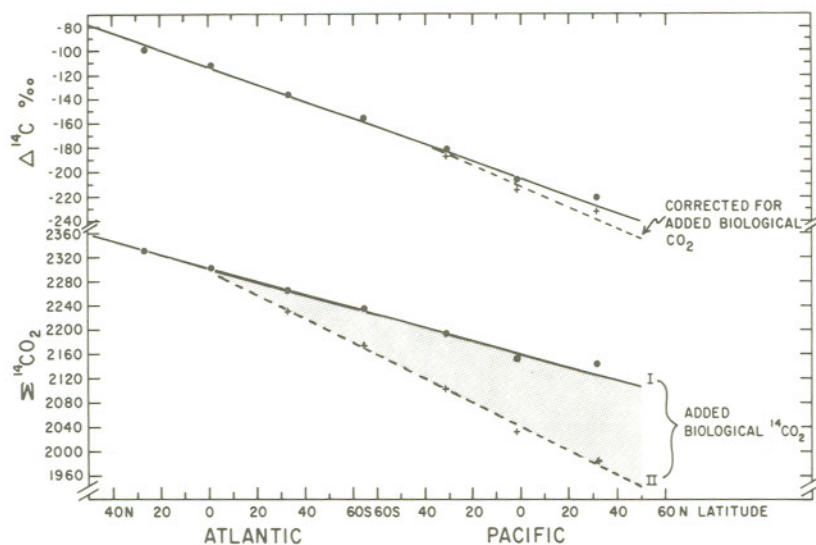


Figure 7: The change in  $\Delta^{14}\text{C}$  and dissolved inorganic  $^{14}\text{C}$  of waters below 1500 meters. The southern-most boundary of the circumpolar current was taken at  $65^\circ\text{S}$ . The solid points indicate measured values. Correcting for carbon of biological origin yields the dashed lines (see text).

The correction for this added  $^{14}\text{C}$  influences the  $\Delta^{14}\text{C}$  of the deep water to a minor degree only (upper dashed line in Figure 7). The total  $\Delta^{14}\text{C}$  change, after correction for the  $^{14}\text{CO}_2$  added from above, is 175 per mil between  $50^\circ\text{N}$  in the Atlantic and  $50^\circ\text{N}$  in the Pacific. This change in  $\Delta^{14}\text{C}$  corresponds with 1590 years of aging.

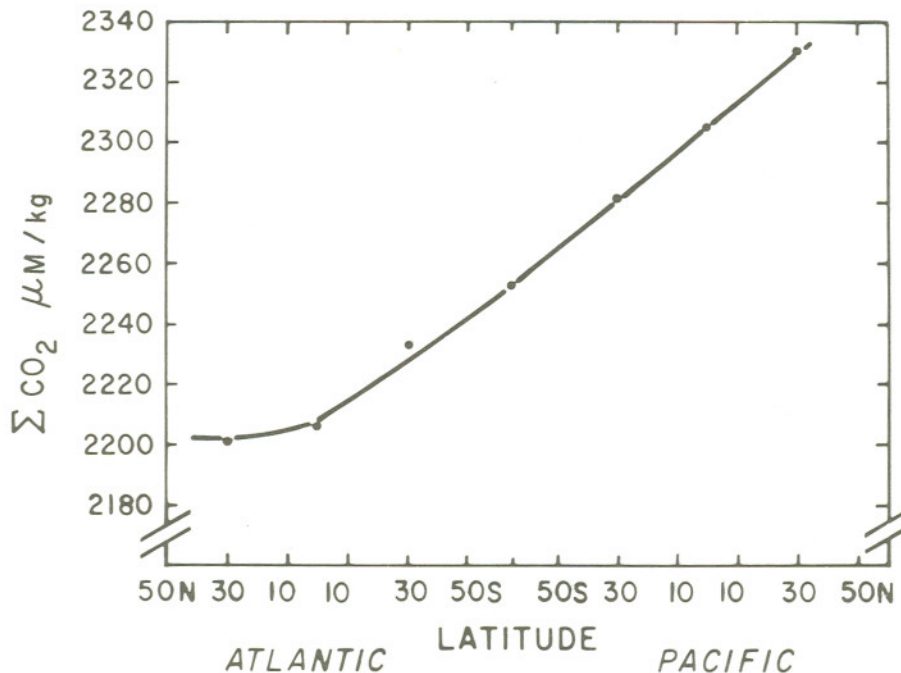


Figure 8: The increase in dissolved inorganic carbon of waters below 1500 meter when moving from the North Atlantic to the North Pacific.

#### EXPLANATION OF THE TABLES

Listed in the tables are average  $\Delta^{14}\text{C}$  values (in per mil), obtained by averaging all available  $\Delta^{14}\text{C}$  measurements between fixed depth brackets. For instance in Table 1, the  $-138.0$  per mil  $\Delta^{14}\text{C}$  value was obtained by averaging  $\Delta^{14}\text{C}$  of the 8 available measured samples collected between 0 and 25 m.

All data on position, depths, sigma theta and total  $\text{CO}_2$  were furnished by the GEOSECS Operations Group (now Physical and Chemical Ocean Data facility) at Scripps Institution of Oceanography. The operations Group handled the logistics and operations on board the ship and also served as a temporary repository for all GEOSECS data.

The positions, given in degrees and minutes, are no better defined than  $\pm$  a few minutes. Sigma theta is the deviation from unity, in per mill, of the relative density in g/ml where ml has the old value of  $1.000027 \text{ cm}^3$ .

The dissolved inorganic carbon, DIC, is given as  $\mu\text{moles per kg}$  of seawater. A final re-evaluation, to be made for all GEOSECS data, will most likely result in some minor adjustments of the numbers given here. Pacific data tabulated here have been adjusted by  $-20 \mu\text{mole/kg}$ .

$\Delta^{14}\text{C}$  is derived from a comparison between the measured sample activity and .95 times the NBS oxalic acid activity. The  $^{14}\text{C}$  activities of the sample and oxalic acid activities are normalized to  $\delta^{13}\text{C}$  values of respectively  $-25$  and  $-19$  per mil (with regard to P.D.B.). The delta values are given as the per mil difference from the age corrected and  $^{13}\text{C}$  normalized NBS oxalic acid standard. The details of the calculations were given previously (Stuiver and Polach, 1977; Stuiver and Robinson, 1974).

Karlén *et al.* (1968) determined the specific activity of oxalic acid (in 1950 A.D.,  $\delta^{13}\text{C} = -19$  per mil) at  $14.27 \pm 0.07$  disintegrations/minute gram C. Sample activities are compared with 95% of the oxalic acid activity, or 13.56 disintegrations/minute gram C. The  $^{14}\text{C}/\text{C}$  atom ratio of the standard is  $(1.176 \pm 0.010)10^{-12}$ .

$\text{DI}^{14}\text{C}$ , in  $10^{-9} \mu\text{mole/m}^3$ , was calculated according to:

$$\text{DI}^{14}\text{C} = 1.176 \cdot 10^{-12} \left[ 1 + \frac{\Delta^{14}\text{C}}{1000} \right] \cdot \left[ 1 + \frac{\sigma_{\theta}}{1000} \right] \text{DIC}$$

#### ACKNOWLEDGEMENTS

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GEOSECS Atlantic Ocean, 50°N–10°N.

Collection dates: 12 september 1972–27 March 1973

Average of 9 stations:

Station	Latitude	Longitude	Station	Latitude	Longitude
27	42.0°N	42.0°W	113	11.0°N	20.5°W
29	36.0°N	47.0°W	115	28.0°N	26.0°W
31	27.0°N	53.5°W	117	30.7°N	39.0°W
33	21.0°N	54.0°W	120	33.3°N	56.5°W
37	12.0°N	51.0°W			

DEPTH m	$\delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	8	138.0	5	2758	5	2039	6	24.355
25–50	1	123.5	1	2767	1	2095	1	26.532
50–75	4	103.2	4	2698	4	2080	4	25.338
75–100	1	136.6	1	2739	1	2050	1	24.723
100–200	14	87.5	14	2698	14	2112	14	26.301
200–300	10	68.5	10	2643	10	2109	10	26.630
300–400	9	21.6	9	2565	9	2138	9	26.804
400–500	7	-1.8	7	2513	7	2144	7	26.875
500–600	7	-36.6	7	2462	7	2175	7	27.077
600–700	8	-38.8	8	2455	8	2173	8	27.137
700–800	9	-70.5	9	2407	9	2203	9	27.302
800–900	5	-82.0	5	2391	5	2215	5	27.453
900–1000	5	-91.0	5	2376	5	2224	5	27.493
1000–1500	24	-74.4	24	2388	24	2195	24	27.730
1500–2000	13	-76.6	13	2371	13	2183	13	27.855
2000–3000	17	-91.9	17	2337	17	2189	17	27.891
3000–4000	18	-98.5	18	2328	18	2196	18	27.915
4000–5000	17	-101.6	16	2327	16	2209	17	27.924
5000–6000	6	-115.0	5	2308	5	2219	6	27.918

GEOSecs Atlantic Ocean, 10°N–10°S.

Collection dates: 19 October, 1972–5 March, 1973

Average of 4 stations:

Station	Latitude	Longitude	Station	Latitude	Longitude
40	3.9°N	38.5°W	49	7.9°S	28.2°W
48	4.0°S	39.0°W	111	2.0°N	14.0°W

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	4	93.0	2	2610	2	2016	3	23.705
25–50	0		0		0		0	
50–75	3	74.6	3	2569	3	2034	3	23.945
75–100	1	105.6	1	2614	1	2011	1	23.375
100–200	10	8.9	10	2526	10	2132	10	26.000
200–300	5	-63.4	5	2406	5	2185	5	26.844
300–400	4	-80.7	4	2383	4	2205	4	27.046
400–500	3	-93.5	3	2366	3	2220	3	27.180
500–600	2	-100.7	2	2336	2	2209	2	27.225
600–700	2	-107.9	2	2333	2	2224	2	27.319
700–800	3	-111.0	3	2320	3	2220	3	27.345
800–900	3	-114.4	3	2320	3	2228	3	27.401
900–1000	3	-106.9	3	2332	3	2221	3	27.467
1000–1500	9	-103.8	9	2319	9	2202	9	27.644
1500–2000	5	-85.5	5	2332	5	2169	5	27.830
2000–3000	9	-96.0	9	2322	9	2185	9	27.882
3000–4000	9	-103.4	9	2307	9	2188	9	27.911
4000–5000	10	-127.9	10	2279	10	2224	10	27.906
5000–6000	2	-135.5	1	2258	1	2273	1	27.881

GEOSecs Atlantic Ocean, 10°S–50°S.

Collection dates: 8 November, 1972–22 February 1973

Average of 13 Stations:

Station	Latitude	Longitude	Station	Latitude	Longitude
54	15.1°S	29.5°W	91	49.6°S	11.5°E
56	21.0°S	33.0°W	92	46.2°S	14.6°E
58	27.0°S	37.0°W	93	41.8°S	18.5°E
60	33.0°S	42.5°W	94	38.3°S	19.4°E
64	39.1°S	48.5°W	103	24.0°S	8.5°E
67	45.0°S	18.5°W	107	12.0°S	2.0°E
68	48.6°S	46.0°W			

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	14	82.4	7	2621	7	2059	11	25.752
25–50	3	89.3	3	2623	3	2048	3	25.961
50–75	6	85.2	5	2624	5	2075	6	26.285
75–100	8	79.5	8	2633	8	2076	8	26.153
100–200	16	73.1	14	2623	14	2094	16	26.328
200–300	11	19.0	11	2527	11	2111	11	26.595
300–400	12	-21.3	12	2471	12	2150	12	26.929
400–500	7	-39.2	7	2414	7	2138	7	26.880
500–600	9	-74.9	9	2369	9	2197	9	27.194
600–700	4	-83.5	4	2344	4	2176	4	27.176
700–800	6	-90.7	6	2329	6	2180	6	27.309
800–900	5	-111.1	5	2309	5	2210	5	27.357
900–1000	4	-123.0	4	2278	4	2210	4	27.462
1000–1500	25	-122.5	25	2289	25	2219	25	27.577
1500–2000	15	-124.2	15	2278	15	2213	15	27.768
2000–3000	25	-121.0	25	2279	25	2205	25	27.858
3000–4000	27	-137.5	27	2259	27	2228	27	27.875
4000–5000	18	-152.3	17	2244	17	2251	17	27.884
5000–6000	6	-144.2	6	2271	6	2258	6	27.890

GEOSECS, Atlantic plus Pacific Ocean, South of 50°S.

Collection dates for the Atlantic: 17 December 1972–26 January 1973.

Collection dates for the Pacific: 10 February 1974–1 March 1974.

Average of 11 stations:

Station	Latitude	Longitude	Station	Latitude	Longitude
73	53.0°S	49.5°W	90	56.4°S	4.5°E
74	55.0°S	50.1°W	282	57.6°S	169.6°E
76	57.7°S	66.1°W	287	69.1°S	173.5°W
78	61.1°S	63.0°W	290	58.0°S	174.0°W
82	56.3°S	24.9°W	293	52.7°S	175.1°W
89	60.0°S	0.0°			

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	10	-13.2	7	2434	7	2112	9	26.938
25–50	0		0		0		0	
50–75	6	-13.1	6	2469	6	2130	6	27.125
75–100	2	-42.5	2	2434	2	2162	2	27.347
100–200	16	-58.5	16	2409	16	2179	16	27.412
200–300	9	-32.4	8	2437	8	2165	9	27.273
300–400	8	-86.0	8	2353	8	2194	8	27.425
400–500	9	-92.5	8	2341	8	2203	9	27.424
500–600	7	-105.3	7	2310	7	2200	7	27.460
600–700	7	-121.2	6	2292	6	2225	7	27.551
700–800	6	-138.8	6	2260	6	2234	6	27.648
800–900	3	-138.1	3	2279	3	2249	3	27.624
900–1000	5	-138.2	5	2259	5	2230	5	27.592
1000–1500	12	-152.6	12	2246	12	2254	12	27.750
1500–2000	13	-159.3	13	2230	13	2256	13	27.804
2000–3000	19	-159.8	19	2229	19	2256	19	27.851
3000–4000	25	-157.3	25	2239	25	2259	25	27.880
4000–5000	19	-160.0	18	2226	18	2254	17	27.872
5000–6000	5	-157.0	4	2230	4	2246	4	27.881
6000–7000	2	-153.9	1	2259	1	2249	1	27.885

GEOSecs Pacific Ocean, 10°N–50°N.

Collection dates: 25 August 1973–8 June 1974.

Average of 20 stations:

Station	Latitude	Longitude	Station	Latitude	Longitude
201	34.2°N	127.9°W	223	35.0°N	151.0°E
202	33.1°N	139.6°W	224	34.2°N	142.0°E
204	31.4°N	150.0°W	225	32.6°N	161.9°E
212	30.0°N	159.8°W	226	30.6°N	170.6°E
213	31.0°N	168.5°W	227	25.0°N	170.1°E
214	32.0°N	177.0°W	229	12.9°N	173.5°E
217	44.7°N	177.0°W	231	14.1°N	178.6°W
218	53.1°N	177.3°W	235	16.7°N	161.4°W
219	50.4°N	176.6°W	343	16.5°N	123.0°W
222	40.2°N	160.5°E	347	28.5°N	121.5°W

DEPTH m	$\delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	19	136.2	11	2628	11	1958	18	23.888
25–50	2	158.8	2	2621	2	1924	2	23.060
50–75	13	135.2	13	2616	13	1961	13	23.935
75–100	8	118.8	8	2606	8	1983	8	24.661
100–200	22	84.2	22	2595	22	2040	22	25.595
200–300	19	11.4	19	2486	19	2096	19	26.138
300–400	18	-28.5	18	2440	18	2144	18	26.324
400–500	15	-77.3	15	2364	15	2186	15	26.655
500–600	13	-110.3	13	2329	13	2233	13	26.835
600–700	11	-135.9	11	2296	11	2262	11	27.003
700–800	8	-178.0	8	2237	8	2314	8	27.228
800–900	10	-173.4	10	2259	10	2325	10	27.199
900–1000	9	-200.6	9	2204	9	2346	9	27.357
1000–1500	35	-220.0	35	2173	35	2370	35	27.497
1500–2000	31	-239.7	31	2121	31	2373	31	27.655
2000–3000	49	-241.7	49	2105	49	2361	49	27.747
3000–4000	44	-231.9	44	2117	44	2345	44	27.798
4000–5000	37	-218.0	36	2134	36	2321	37	27.818
5000–6000	24	-205.9	20	2154	20	2305	21	27.830
6000–7000	2	-210.0	2	2134	2	2297	2	27.824

GEOSECS Pacific Ocean,  $10^{\circ}\text{N}$ – $10^{\circ}\text{S}$ .

Collection dates: 12 December 1973–29 May 1974.

Average of 9 stations:

Station	Latitude	Longitude	Station	Latitude	Longitude
239	$5.9^{\circ}\text{N}$	$172.0^{\circ}\text{W}$	328	$9.3^{\circ}\text{S}$	$125.5^{\circ}\text{W}$
241	$4.6^{\circ}\text{N}$	$179.0^{\circ}\text{E}$	331	$4.6^{\circ}\text{S}$	$125.1^{\circ}\text{W}$
246	$0.0^{\circ}$	$179.0^{\circ}\text{E}$	334	$0.0^{\circ}$	$124.6^{\circ}\text{W}$
251	$4.0^{\circ}\text{S}$	$179.0^{\circ}\text{E}$	337	$4.8^{\circ}\text{N}$	$124.1^{\circ}\text{W}$
257	$10.0^{\circ}\text{S}$	$170.0^{\circ}\text{W}$			

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	8	75.6	7	2486	7	1968	7	22.947
25–50	1	93.0	1	2466	1	1919	1	22.802
50–75	3	84.6	3	2527	3	1981	3	23.022
75–100	5	73.5	5	2566	5	2033	5	24.064
100–200	14	39.1	14	2536	14	2079	14	24.690
200–300	11	-27.5	11	2444	11	2141	11	26.148
300–400	6	-74.7	6	2394	6	2202	6	26.650
400–500	5	-104.9	5	2334	5	2218	5	26.965
500–600	6	-118.1	6	2331	6	2248	6	27.079
600–700	8	-135.2	8	2297	8	2259	8	27.198
700–800	4	-152.5	4	2261	4	2269	4	27.319
800–900	2	-156.9	2	2260	2	2280	2	27.361
900–1000	2	-170.0	2	2231	2	2286	2	27.407
1000–1500	11	-193.7	11	2183	11	2304	11	27.520
1500–2000	10	-222.8	10	2129	10	2330	10	27.660
2000–3000	23	-231.8	23	2105	23	2331	23	27.753
3000–4000	22	-216.5	22	2135	22	2318	22	27.806
4000–5000	14	-192.5	13	2174	13	2287	13	27.838
5000–6000	7	-178.6	6	2189	6	2270	7	27.849

GEOSECS Pacific Ocean, 10°S–50°S.

Collection dates: 10 January 1974–20 May 1974.

Average of 11 stations:

Station	Latitude	Longitude	Station	Latitude	Longitude
263	16.7°S	167.1°W	317	23.6°S	127.2°W
269	24.0°S	174.5°W	320	33.3°S	128.6°W
296	45.0°S	166.7°W	322	43.0°S	129.9°W
303	38.4°S	170.1°W	324	23.0°S	146.1°W
306	32.8°S	163.6°W	326	14.1°S	126.3°W
310	27.0°S	157.1°W			

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	10	123.1	7	2623	7	1989	8	24.267
25–50	1	126.5	1	2522	1	1904	1	22.276
50–75	3	154.1	3	2715	3	2001	3	24.290
75–100	2	93.7	2	2628	2	2045	2	25.753
100–200	17	115.0	17	2664	17	2033	17	25.439
200–300	10	74.3	10	2610	10	2067	10	26.120
300–400	11	11.1	11	2497	11	2102	11	26.429
400–500	9	-28.0	9	2421	9	2119	9	26.747
500–600	8	-57.6	8	2377	8	2146	8	26.954
600–700	6	-69.6	6	2336	6	2136	6	27.005
700–800	7	-99.2	7	2294	7	2167	7	27.121
800–900	8	-86.9	8	2322	8	2163	8	27.116
900–1000	5	-107.8	5	2297	5	2191	5	27.242
1000–1500	23	-150.4	23	2236	23	2240	23	27.422
1500–2000	22	-190.5	22	2177	22	2288	22	27.637
2000–3000	41	-207.0	41	2150	41	2306	41	27.749
3000–4000	28	-193.4	27	2176	27	2293	28	27.814
4000–5000	25	-172.0	24	2209	24	2270	25	27.854
5000–6000	7	-164.0	6	2213	6	2251	6	27.865



GEOSECS, Atlantic plus Pacific Ocean, 50°N–10°N.

Collection dates and stations are given separately in the corresponding tables for each ocean.

Average of 29 stations:

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	27	136.7	16	2668	16	1984	24	24.005
25–50	3	147.0	3	2670	3	1981	3	24.217
50–75	17	127.7	17	2635	17	1989	17	24.265
75–100	9	120.8	9	2621	9	1991	9	24.668
100–200	36	85.5	36	2635	36	2068	36	25.870
200–300	29	31.1	29	2542	29	2100	29	26.308
300–400	27	-11.8	27	2482	27	2142	27	26.484
400–500	22	-53.3	22	2411	22	2173	22	26.725
500–600	20	-84.5	20	2376	20	2213	20	26.920
600–700	19	-95.1	19	2363	19	2225	19	27.059
700–800	17	-121.1	17	2327	17	2255	17	27.267
800–900	15	-142.9	15	2303	15	2289	15	27.283
900–1000	14	-161.5	14	2265	14	2302	14	27.406
1000–1500	59	-160.8	59	2260	59	2298	59	27.592
1500–2000	44	-191.5	44	2195	44	2317	44	27.714
2000–3000	66	-203.1	66	2164	66	2316	66	27.784
3000–4000	62	-193.2	62	2178	62	2302	62	27.832
4000–5000	54	-181.4	52	2193	52	2286	54	27.852
5000–6000	30	-187.8	25	2185	25	2288	27	27.849
6000–7000	2	-210.0	2	2134	2	2297	2	27.824

GEOSSECS, Atlantic plus Pacific Ocean, 10°N–10°S.

Collection dates and stations are given separately in the corresponding tables for each ocean.

Average of 15 stations:

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$			DIC		SIGMA THETA
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	12	81.4	9	2513	9	1979	10	23.175
25–50	1	93.0	1	2466	1	1919	1	22.802
50–75	6	79.6	6	2548	6	2007	6	23.484
75–100	6	78.9	6	2574	6	2029	6	23.949
100–200	24	26.5	24	2532	24	2101	24	25.236
200–300	16	-38.8	16	2432	16	2155	16	26.366
300–400	10	-77.1	10	2390	10	2203	10	26.808
400–500	8	-100.6	8	2346	8	2219	8	27.046
500–600	8	-113.8	8	2332	8	2239	8	27.115
600–700	10	-129.7	10	2304	10	2252	10	27.222
700–800	7	-134.7	7	2286	7	2248	7	27.330
800–900	5	-131.4	5	2296	5	2249	5	27.385
900–1000	5	-132.1	5	2292	5	2247	5	27.443
1000–1500	20	-153.3	20	2245	20	2258	20	27.576
1500–2000	15	-177.0	15	2197	15	2276	15	27.717
2000–3000	32	-193.6	32	2166	32	2290	32	27.789
3000–4000	31	-183.7	31	2185	31	2281	31	27.837
4000–5000	24	-165.6	23	2220	23	2259	23	27.868
5000–6000	9	-169.0	7	2199	7	2271	8	27.853

GEOSECS, Atlantic plus Pacific Ocean,  $10^{\circ}\text{S}$ – $50^{\circ}\text{S}$ .

Collection dates and stations are given separately in the corresponding tables for each ocean.

Average of 24 stations:

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	24	99.4	14	2622	14	2024	19	25.127
25–50	4	98.6	4	2597	4	2012	4	24.837
50–75	9	108.1	8	2658	8	2047	9	25.620
100–100	10	82.3	10	2632	10	2070	10	26.073
100–200	33	94.7	31	2645	31	2061	33	25.870
200–300	21	45.3	21	2567	21	2090	21	26.369
300–400	23	-5.8	23	2483	23	2127	23	26.690
400–500	16	-32.9	16	2418	16	2127	16	26.805
500–600	17	-66.7	17	2373	17	2164	17	27.081
600–700	10	-75.1	10	2339	10	2152	10	27.074
700–800	13	-95.3	13	2310	13	2173	13	27.208
800–900	13	-96.2	13	2317	13	2182	13	27.208
900–1000	9	-114.6	9	2289	9	2199	9	27.339
1000–1500	48	-135.9	48	2264	48	2229	48	27.503
1500–2000	37	-163.6	37	2218	37	2257	37	27.690
2000–3000	66	-174.4	66	2199	66	2268	66	27.790
3000–4000	55	-166.0	54	2217	54	2261	55	27.844
4000–5000	43	-163.8	41	2223	41	2262	42	27.866
5000–6000	13	-154.9	12	2242	12	2254	12	27.877

GEOSecs Pacific Ocean, 50°N–50°S.

Average of 40 stations. The stations, collection dates, and locations are given in the 50°N–10°N, 10°N–10°S and 10°S–50°S Pacific tables.

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	37	119.6	25	2587	25	1970	33	23.780
25–50	4	134.3	4	2558	4	1918	4	22.799
50–75	19	130.2	19	2617	19	1971	19	23.847
75–100	15	100.4	15	2596	15	2008	15	24.608
100–200	53	82.2	53	2602	53	2048	53	25.306
200–300	40	16.4	40	2505	40	2101	40	26.136
300–400	35	-24.0	35	2450	35	2141	35	26.413
400–500	29	-66.7	29	2376	29	2171	29	26.737
500–600	27	-96.4	27	2344	27	2211	27	26.924
600–700	25	-119.8	25	2306	25	2231	25	27.066
700–800	19	-143.6	19	2263	19	2251	19	27.208
800–900	20	-137.1	20	2284	20	2256	20	27.182
900–1000	16	-167.8	16	2237	16	2290	16	27.327
1000–1500	69	-192.6	69	2196	69	2316	69	27.476
1500–2000	63	-219.8	63	2142	63	2337	63	27.649
2000–3000	113	-227.1	113	2121	113	2335	113	27.749
3000–4000	94	-216.8	93	2139	93	2324	94	27.805
4000–5000	76	-198.2	73	2166	73	2298	75	27.833
5000–6000	38	-193.2	32	2172	32	2289	34	27.840
6000–7000	2	-210.0	2	2134	2	2298	2	27.824
7000–8000	1	-212.3	0		0		0	

GEOSECS Atlantic Ocean, 50°N–50°S.

Average of 26 stations. The stations, collection dates and locations, are given in the 50°N–10°N, 10°N–10°S and 10°S–50°S Atlantic tables.

DEPTH m	$\Delta^{14}\text{C}$		$\text{DI}^{14}\text{C}$		DIC		SIGMA THETA	
	OBS	MEAN	OBS	MEAN	OBS	MEAN	OBS	MEAN
0–25	26	101.1	14	2668	14	2046	20	25.026
25–50	4	97.9	4	2659	4	2060	4	25.901
50–75	13	88.3	12	2635	12	2067	13	25.453
75–100	10	87.8	10	2642	10	2067	10	25.732
100–200	40	62.1	38	2625	38	2111	40	26.237
200–300	26	22.2	26	2550	26	2125	26	26.656
300–400	25	-15.4	25	2491	25	2154	25	26.903
300–400	25	-15.4	25	2491	25	2154	25	26.903
400–500	17	-33.4	17	2446	17	2155	17	26.931
500–600	18	-62.9	18	2401	18	2181	18	27.152
600–700	14	-61.5	14	2406	14	2181	14	27.174
700–800	18	-84.0	18	2367	18	2198	18	27.312
800–900	13	-100.7	13	2343	13	2216	13	27.404
900–1000	12	-105.7	12	2332	12	2218	12	27.476
1000–1500	58	-99.7	58	2335	58	2206	58	27.651
1500–2000	33	-99.5	33	2322	33	2194	33	27.812
2000–3000	51	-106.9	51	2306	51	2196	51	27.873
3000–4000	54	-118.8	54	2290	54	2211	54	27.895
4000–5000	45	-127.8	43	2283	43	2229	44	27.905
5000–6000	14	-130.5	12	2285	12	2243	13	27.902

