II. RECALCULATION OF POSITIONS BY NNSS

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Introduction

NNSS was only applied for positioning and navigational purposes in the survey area. Some technical problems concerning NNSS have already been discussed by CHUJO and MURAKAMI (1975), and here we will be concerned with the recalculation procedure of ship's positions by NNSS and the results of recalculation. The particular purpose of the recalculation was to obtain the ship's positions with an accuracy as exact as possible particularly at the sites where various samplings and observations were made within a very small extent.

There was a satellite fix every one or two hours. After each satellite fix, the ship's position was dead reckoned using an EM log as the speed sensor. During sampling operations, speed values were sometimes put manually into the computer of NNSS, because the speed input from the EM log is always positive even if the ship is moving aft. The EM log measures the ship's speed with respect to the water mass. The speed in relation to the sea bottom is calculated by adding an assumed water current to the ship's speed measured by the EM log. The accuracy of satellite fixes is of the order of 0.2 km, but the error of dead reckoning often reaches to 2 km or more. Therefore some recalculation needs to be done to get more accurate dead reckoning positions.

Recalculation procedure

Recalculation of ship's positions was carried out using an off-line computer on board the Hakurei-maru, YHP 2100A.

At each satellite fix, there are latitudinal and longitudinal differences between the dead reckoned position and the satellite fix. We recalculate the water current so as to match the recalculated dead reckoning position to the satellite fix. We assume that the northern and eastern component of water current, respectively, varies in a quadratic manner of time from one satellite fix to the next, and that they are continuous at each satellite fix. Though it is not only water current that causes the differences between dead reckoned positions and satellite fixes, the recalculated positions would be considerably accurate, unless other effects change rapidly compared with frequency of satellite fixes.

Results of water current computation

The water current vectors obtained while the ship was sailing from one sampling station to another, from the above-mentioned procedure, are shown in Fig. II-1. There seemed to be other effects other than that of the true water current. There is a tendency that water current vectors depend on the ship's heading, even if in the same area. This is probably caused from the reason that there was no sensor measuring ship's speed cross course, and also other effects such as wind force acted in a different way when the ship's heading was different. However, these effects would not seriously impair the accuracy of the ship's position, unless the ship's course changes frequently.

Though these vectors do not show true water current, the general trend of water current in the survey area can be obtained from Fig. II-1. In the northern part, north of about 7°N, the water current is in a W to NW direction. This is called the North Equatorial Current (SVERDRUP *et al.*, 1942). In the southwestern part, south of 7°N and west of 173°W, the water current is in a E to NE direction, while in the southeastern part it was almost in a N direction. This would reflect the Equatorial Counter-Current, although the water current has a significant northern component. Generally speaking, the water speed ranged from 0.5 to 1 knots.

Results of recalculation

Recalculations were carried out on the ship's positions throughout the cruise. However, we present here only the results of recalculation concerning sampling and observation positions. All the positions before and after recalculation are summarized in Table II-1. As discussed in detail later, there is a tendency that the difference of a position before and after recalculation increases with the time from the last satellite fix.

At first, two examples are shown concerning the problem.

Ship's positions before and after recalculation at stations 408A and 408A-1 are shown in Fig. II-2. In this case, there were six satellite fixes over some nine hours duration of the sampling operation, and the ship's positions are relatively accurate. Differences of positions before and after recalculations are generally within 2 km. Errors of re-

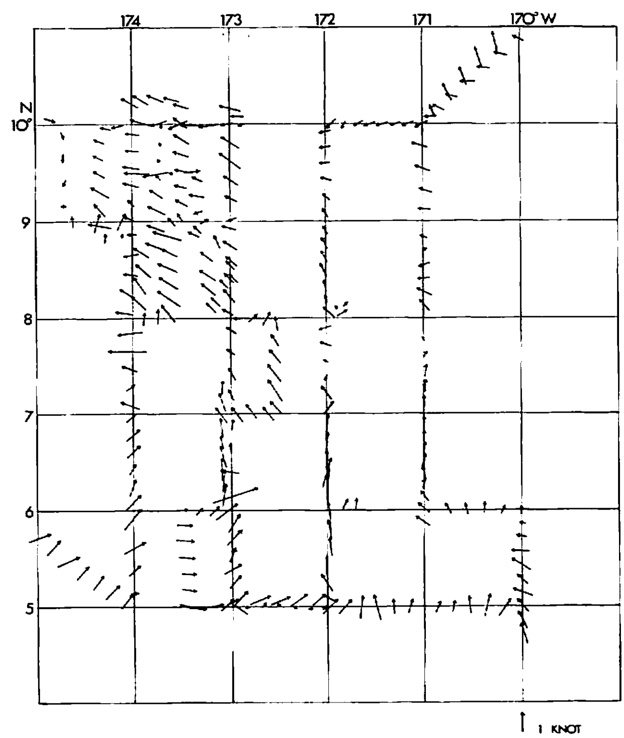

Fig. II-1 Water current vectors in the survey area.

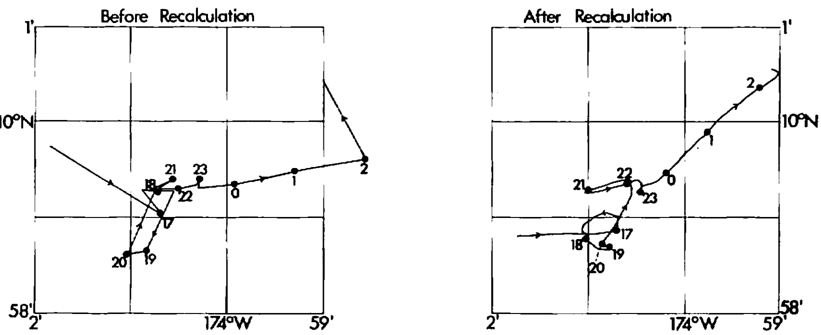

Fig. II-2 Ship's positions at the station 408A and 408A-1. Positions before recalculation (on the left side) are compared with the positions after recalculation (on the right side).

calculated results should be within some 0.5 km in this case, and this provides a rather preferable example.

As an unfavorable example, ship's positions at station 410 are shown in Fig. II-3. In this case, there was no satellite fix during some three hours of sampling. Differences of positions before and after recalculation are usually greater than 2 km. Errors of recalculated positions might be nearly 1 km.

For the estimation of errors of recalculated positions, we will introduce here a simple estimate of the errors which is dependent only on the time from the closest good satellite fix. As shown in Table II-1, the root mean square of radial differences of all the sampling positions is 1.03 n.m. (=1.91 km).

Roughly speaking, a difference of position before and after recalculation indicates the dead reckoning error of real time position because the recalculated position is generally more accurate. As shown in Fig. II-4, a radial difference of a position before and after recalculation generally increases with the time from the last good satellite fix. Therefore, we have assumed a linear relation,

$$\Delta R = \alpha \Delta T, \qquad (1)$$

where ΔR is the radial difference and ΔT is the time from the last good satellite fix. We obtain the value of the coefficient α from the least square fit of all the sampling positions:

$$\alpha = 0.80 \text{ km/hr}. \qquad (2)$$

The recalculated positions are in a double sense more accurate than the real time ones.

1. The water current can be estimated more accurately than before recalculation. This corresponds to a decrease of the coefficient α in (1).
2. In about half of all the cases other satellite fixes are closer to the sampling times than the last ones. This corresponds to the decrease of the time ΔT in (1).

We have estimated the error of a recalculated position by a simple equation:

$$\Delta R' = 0.2 \text{ km} + (\alpha/2)\Delta T', \qquad (3)$$

where $\Delta R'$ is the estimated error and $\Delta T'$ is the time from the closest good satellite fix. The first term of the right-hand side of (3) indicates the error of the closest satellite fix. The second term is the dead reckoning error of the recalculated position. Taking account of the above discussion, we have assumed the coefficient in (3) as a half of the coefficient in (1).

Table II-1 Results of recalculation of stationary positions.

St. no.	Observ. no.	Day[1]	Time (GMT)	Real time position Lat. (N)		Real time position Long. (W)		Recalculated position Lat. (N)		Recalculated position Long. (W)		Difference[2] (n.m.) Lat.	Difference[2] (n.m.) Long.	Difference[2] (n.m.) ΔR	Satellite fix time[3]		Error[4] ΔR′
403	G167, S1, W2	24	2055	04	58.26	173	56.39	04	57.89	173	56.28	+0.37	−0.11	0.39	2024	2048	0.12
	FG1-1	24	1908	04	57.83	173	56.82	04	57.72	173	57.07	+0.11	+0.25	0.27	1812		0.30
	FG1-2	24	1914	04	57.77	173	56.63	04	57.64	173	56.90	+0.13	+0.27	0.30	1812		0.32
404	G168, S2, W3	25	0511	06	01.56	173	58.09	06	01.57	173	58.32	−0.01	+0.23	0.23	0402	0548	0.23
	FG2-1	25	0348	06	01.06	173	59.99	06	01.15	173	58.79	−0.09	−1.19	1.19	0156	0402	0.15
	FG2-2	25	0352	06	01.22	173	59.97	06	01.29	173	58.74	−0.07	−1.22	1.22	0156	0402	0.14
405	G169, S3, W4	25	1927	07	00.60	173	58.27	06	58.22	174	00.78	+2.38	+2.49	3.44	1716	1936	0.13
	FG3-1	25	1724	07	00.03	173	59.88	06	58.72	174	00.73	+1.31	+0.84	1.56	1532	1716	0.13
406	G170, S4, W5	26	0453	08	01.66	173	57.06	08	00.01	174	02.06	+1.65	+4.95	5.22	0104	0706	0.57
	FG4-1	26	0301	08	00.90	173	59.84	07	59.89	174	01.96	+1.01	+2.10	2.33	0104		0.52
	FG4-2, FC1	26	0306	08	01.18	173	59.76	08	00.03	174	02.04	+1.15	+2.26	2.54	0104		0.53
406A	G194	54	1901	08	00.52	173	58.65	08	00.04	173	58.95	+0.48	+0.30	0.57	1728	1916	0.15
407	G171, S5	26	1852	09	00.40	174	00.50	09	00.36	174	00.68	+0.04	+0.18	0.18	1808	1850	0.11
	FG5-1	26	1711	09	00.45	173	59.75	09	00.32	174	00.32	+0.13	+0.56	0.57	1620		0.28
	FG5-2	26	1715	09	00.58	173	59.68	09	00.42	174	00.27	+0.16	+0.58	0.60	1620	1808	0.30
407A	D173, C8	56	2131	08	58.75	174	00.21	08	59.31	174	00.02	−0.56	−0.19	0.59	2004	2140	0.13
		56	2242	08	58.89	174	00.74	08	59.04	174	00.93	−0.15	+0.19	0.24	2140	2320	0.24
407A-1	C9, W8	57	0305	08	58.58	173	58.98	08	58.75	174	00.08	−0.17	+1.09	1.10	2320	0300	0.12
		57	0401	08	58.63	173	59.93	08	59.07	174	00.16	−0.44	+0.23	0.50	0300		0.32
407A-2	FG32-1	59	0151	09	00.06	173	57.97	09	00.27	173	57.72	−0.21	−0.25	0.33	2324	0256	0.33
	FG32-2	59	0209	09	00.01	173	56.01	09	00.23	173	55.59	−0.22	−0.41	0.47	2324	0256	0.27
	FG32-3	59	0228	09	00.00	173	54.00	09	00.26	173	53.32	−0.26	−0.67	0.72	2324	0256	0.20
	FG32-4	59	0245	09	00.01	173	51.98	09	00.28	173	51.27	−0.27	−0.70	0.75	2324	0256	0.14
	FG32-5	59	0305	09	01.96	173	53.15	09	02.30	173	53.15	−0.34	−0.86	0.92	2324	0256	0.13
	FG32-6	59	0318	09	02.01	173	56.01	09	02.37	173	55.00	−0.36	−1.00	1.06	2324	0256	0.18
	FG32-7	59	0331	09	02.02	173	58.01	09	02.40	173	56.80	−0.38	−1.20	1.26	2324	0256	0.22
	FG32-8	59	0344	09	01.99	174	00.01	09	02.41	173	58.57	−0.42	−1.42	1.48	2324	0256	0.27
408	G172	27	0421	10	00.77	173	59.90	10	00.70	173	59.67	+0.07	−0.23	0.24	0358		0.18
	FG6-1	27	0244	10	00.56	173	59.79	10	00.65	173	59.68	−0.09	−0.11	0.14	0200		0.26
	FG6-2	27	0247	10	00.64	173	59.84	10	00.79	173	59.70	−0.15	−0.14	0.21	0200		0.27
408A	P73	55	1840	09	59.70	174	00.91	09	58.68	174	00.91	+1.02	+0.00	1.02	1642	1826	0.15

408A–1	TV5, C7	55	2256	09	59.40	174	00.31	09	59.27	174	00.46	+0.13	+0.15	0.20	2224	2256	0.10
		56	0015	09	59.38	173	59.78	09	59.57	174	00.09	−0.19	+0.31	0.36	2256		0.38
409	G173	27	1838	10	00.35	173	02.14	10	00.03	173	01.25	+0.32	−0.88	0.94	1710	1946	0.34
	FG7–1	27	1703	09	59.97	173	00.03	10	00.33	173	00.67	−0.36	+0.63	0.73	1526	1710	0.12
	FG7–2	27	1707	09	59.77	173	00.04	10	00.17	173	00.74	−0.40	+0.69	0.11	1526	1710	0.11
410	G174	28	0357	09	00.55	173	00.81	08	58.86	173	00.07	+1.69	−0.73	1.84	0108	0448	0.28
	FG8–1	28	0226	08	59.83	172	59.99	08	59.12	172	59.67	+0.71	−0.32	0.78	0108		0.38
	FG8–2	28	0231	08	59.83	172	59.90	08	59.08	172	59.58	+0.75	−0.32	0.82	0108		0.40
410A	P71	54	0404	08	59.81	173	00.29	08	59.18	173	00.97	+0.63	+0.67	0.92	0212	0400	0.11
411	G175	28	1856	07	58.19	172	59.80	07	58.20	172	59.79	−0.01	−0.01	0.01	1804	1858	0.11
	FG9–1	28	1729	07	58.69	172	59.94	07	58.56	172	59.68	+0.13	−0.26	0.29	1616	1804	0.22
	FG9–2	28	1732	07	58.58	172	59.96	07	58.45	172	59.69	+0.13	−0.27	0.30	1616	1804	0.21
411A	P70	53	1906	07	59.59	173	00.50	07	59.43	173	01.03	+0.16	+0.52	0.54	1816		0.28
412	G176	29	0334	06	59.81	173	00.43	06	59.66	172	59.77	+0.15	−0.66	0.68	0122	0354	0.17
	FG10–1	29	0203	06	59.89	172	59.80	06	59.69	172	59.58	+0.20	−0.22	0.30	0122		0.25
	FG10–2	29	0205	06	59.80	172	59.80	06	59.61	172	59.58	+0.19	−0.22	0.29	0122		0.25
412A	P69	53	0412	06	59.48	172	58.41	06	59.75	172	59.00	−0.27	+0.59	0.65	0306	0452	0.24
413	G177	29	1858	06	00.50	173	00.23	06	00.09	172	59.49	+0.41	−0.74	0.85	1708	1954	0.30
	FG11–1	29	1731	06	00.17	172	59.81	05	59.94	172	59.71	+0.23	−0.10	0.25	1708		0.18
	FG11–2	29	1734	06	00.06	172	59.74	05	59.83	172	59.64	+0.23	−0.10	0.25	1708		0.19
413A	P68	52	2051	06	01.83	172	58.83	06	01.56	172	59.29	+0.27	+0.46	0.53	1906	2104	0.15
414	G178, FC2	30	0457	04	59.78	173	00.05	04	59.07	173	00.17	+0.71	+0.12	0.72	0300	0444	0.15
	FG12–1	30	0334	04	59.73	172	59.98	04	59.63	173	00.11	+0.10	+0.13	0.16	0300		0.22
	FG12–2	30	0338	04	59.57	172	59.97	04	59.41	173	00.12	+0.16	+0.15	0.22	0300		0.24
414A	G193, W7	51	1925	05	00.26	173	00.13	05	00.11	173	00.73	+0.15	+0.60	0.62	1806	2024	0.31
414A–1	P67	51	2309	04	59.40	172	58.33	04	59.37	172	58.28	+0.03	−0.05	0.06	2238		0.21
414A–2	FG25–1	52	0034	04	59.42	172	57.64	04	59.35	172	58.26	+0.07	+0.62	0.62	0004		0.21
	FG25–2	52	0031	04	59.53	172	57.84	04	59.43	172	58.34	+0.10	+0.50	0.51	0004		0.20
414A–3	C6, FG26	52	0229	04	59.07	172	57.81	04	59.06	172	58.96	+0.01	+1.15	1.15	0004	0216	0.15
		52	0300	04	59.33	172	59.13	04	59.38	172	58.37	−0.05	−0.76	0.76	0216		0.26
415	G179	30	1854	05	00.31	171	59.31	05	00.02	171	58.72	+0.29	−0.59	0.66	1614	1906	0.66
	FG13–1	30	1729	05	00.02	171	59.47	04	59.73	171	58.99	+0.29	−0.48	0.56	1614		0.37
	FG13–2	30	1732	05	00.04	171	59.29	04	59.76	171	58.86	+0.28	−0.43	0.51	1614		0.38

Table II-1 (continued)

St. no.	Observ. no.	Day[1]	Time (GMT)	Real time position Lat. (N)		Long. (W)		Recalculated position Lat. (N)		Long. (W)		Difference[2] (n.m.) Lat.	Long.	ΔR	Satellite fix time[3]		Error[4] ΔR′
416	G180	31	0414	06	01.48	171	59.74	06	01.51	171	59.52	−0.03	−0.22	0.22	0348		0.19
	FG14–1	31	0213	06	00.04	171	59.99	06	00.33	171	59.40	−0.29	−0.59	0.66	2344	0348	0.44
	FG14–2	31	0215	06	00.54	172	00.00	06	00.45	171	59.40	+0.09	−0.60	0.61	2344	0348	0.43
417	G181	31	1904	07	01.62	171	59.67	07	01.43	171	59.65	+0.19	−0.02	0.19	1820		0.26
	FG15–1	31	1736	07	01.80	171	59.62	07	01.56	171	59.60	+0.24	−0.02	0.24	1704		0.21
	FG15–2	31	1740	07	01.74	171	59.63	07	01.39	171	59.65	+0.35	+0.02	0.35	1704		0.23
418	G182	32	0359	07	59.53	172	00.59	07	59.62	172	00.25	−0.09	−0.34	0.35	0256	0440	0.25
	FG16–1	32	0236	07	59.82	172	00.12	07	59.48	172	00.08	+0.34	−0.04	0.34	0116	0256	0.17
	FG16–2	32	0240	08	00.04	172	00.12	07	59.68	172	00.06	+0.36	−0.06	0.36	0116	0256	0.16
419	G183	32	1831	09	00.70	172	00.89	09	00.68	172	00.61	+0.02	−0.28	0.28	1608	1916	0.26
	FG17–1	32	1658	08	59.29	172	00.31	09	00.27	172	00.25	−0.98	−0.06	0.98	1608		0.28
	FG17–2	32	1701	09	00.46	172	00.27	09	00.39	172	00.23	+0.07	−0.04	0.08	1608		0.29
420	G184	33	0354	09	59.62	172	00.36	09	59.10	172	00.94	+0.52	+0.57	0.77	0024	0346	0.13
	FG18–1	33	0229	09	59.47	172	00.01	09	59.10	172	00.24	+0.37	+0.23	0.44	0024	0346	0.37
	FG18–2	33	0233	09	59.66	172	00.01	09	59.27	172	00.28	+0.39	+0.27	0.47	0024	0346	0.36
421	G185–1	48	0046	09	59.08	171	00.24	09	59.28	171	01.01	−0.20	+0.76	0.79	2358		0.27
422	G186	48	0816	08	56.20	170	59.33	08	55.26	170	59.67	+0.94	+0.34	1.00	0706	0850	0.22
423	G187	48	1901	07	59.21	170	59.82	07	59.08	170	59.89	+0.13	+0.07	0.15	1846		0.15
	FG19–1	48	1737	08	00.19	171	00.03	07	59.93	170	59.96	+0.26	−0.07	0.27	1702		0.22
	FG19–2	48	1746	08	00.12	170	59.45	07	59.79	170	59.58	+0.33	+0.13	0.35	1702		0.26
424	G188	49	0425	07	01.00	171	00.04	07	01.11	171	00.11	−0.11	+0.07	0.13	0314		0.35
	FG20–1	49	0248	07	00.35	170	59.86	07	00.88	170	59.97	−0.53	+0.11	0.54	2304	0314	0.19
	FG20–2	49	0251	07	00.22	170	59.84	07	00.73	170	59.96	−0.51	+0.12	0.52	2304	0314	0.18
425	G189	49	1900	06	00.93	171	00.92	06	01.07	171	01.07	−0.14	+0.15	0.21	1756	1946	0.26
	FG21–1	49	1733	06	00.53	171	00.62	06	00.37	171	00.27	+0.16	−0.35	0.38	1630	1756	0.18
	FG21–2	49	1738	06	00.71	171	00.64	06	00.63	171	00.25	+0.08	−0.39	0.40	1630	1756	0.16

426	G190	50	0336	06	00.29	169	59.03	06	00.17	169	59.59	+0.12	+0.56	0.57	0220	0406	0.21
	FG22-1	50	0219	06	00.00	170	00.14	05	59.95	169	59.24	+0.05	−0.90	0.90	0000	0220	0.10
	FG22-2	50	0222	06	00.03	169	59.93	05	59.96	169	59.14	+0.07	−0.79	0.79	0000	0220	0.11
427	G191	50	1909	04	59.20	170	01.16	04	59.09	170	01.85	+0.11	+0.69	0.70	1710	1856	0.15
	FG23-1	50	1733	04	59.58	170	00.84	04	59.39	170	00.98	+0.19	+0.14	0.24	1710		0.18
	FG23-2	50	1737	04	59.44	170	00.86	04	59.22	170	01.05	+0.22	+0.19	0.29	1710		0.20
428	G192	51	0409	04	59.57	171	00.53	04	59.24	171	00.95	+0.33	+0.42	0.53	0310	0444	0.22
	FG24-1	51	0248	05	00.13	170	59.43	04	59.28	171	00.38	+0.85	+0.95	1.27	2328	0310	0.18
	FG24-2	51	0251	05	00.14	170	59.55	04	59.25	171	00.53	+0.89	+0.98	1.32	2328	0310	0.17
429	P72	55	0423	08	51.56	174	00.31	08	51.39	174	00.41	+0.17	+0.10	0.20	0304	0502	0.24
	FG27-1	55	0233	08	50.65	174	00.12	08	50.85	173	59.72	−0.20	−0.40	0.45	2316	0304	0.21
	FG27-2	55	0239	08	50.96	174	00.20	08	51.16	173	59.78	−0.20	−0.41	0.46	2316	0304	0.19
430	G195	57	1900	09	59.52	173	30.04	09	59.55	173	29.92	−0.03	−0.12	0.12	1836		0.19
	FG28-1	57	1735	09	59.90	173	29.78	09	59.79	173	29.90	+0.11	+0.12	0.16	1652		0.25
	FG28-2	57	1738	09	59.89	173	30.02	09	59.78	173	30.04	+0.11	+0.02	0.11	1652		0.26
431	G196	58	0017	09	30.63	173	30.11	09	28.81	173	29.90	+1.82	−0.21	1.83	2120	0210	0.50
	FG29-1	57	2255	09	30.25	173	30.02	09	29.17	173	29.81	+1.08	−0.21	1.10	2120		0.44
	FG29-2	57	2258	09	30.17	173	30.04	09	29.04	173	29.89	+1.13	−0.15	1.14	2120		0.45
432	FG30-1	58	0424	09	00.03	173	30.02	09	00.42	173	30.37	−0.39	+0.35	0.52	0352		0.21
	FG30-2	58	0427	08	59.85	173	30.03	09	00.27	173	30.42	−0.42	+0.39	0.57	0352		0.22
	FC3	58	0500	08	59.90	173	30.05	09	00.60	173	30.92	−0.70	+0.86	1.11	0352	0608	0.34
433	D138	58	1944	09	29.21	174	03.55	09	30.30	174	02.28	−1.09	−1.25	1.66	1748	2032	0.27
		58	2046	09	29.04	174	04.68	09	30.86	174	02.78	−1.82	−1.87	2.61	1748	2032	0.15
	FG31-1	58	2006	09	29.12	174	03.93	09	30.48	174	02.26	−1.36	−1.65	2.14	1748	2032	0.19
	FG31-2	58	2009	09	29.11	174	03.98	09	30.51	174	02.28	−1.40	−1.68	2.19	1748	2032	0.18
		Root mean square										0.61	0.84	1.03			0.26

[1]Julian day.
[2]A latitudinal difference is positive, when a real time position is north of the recalculated position which corresponds to it. A longitudinal difference is positive, when a real time position is on the eastern side. A radial difference ΔR is the root mean square of a latitudinal and a longitudinal ones.
[3]The time of the last good satellite fix, the calculation of which had already finished by the time of sampling operation, is in the first column. The time of the closest good satellite fix is in the second column. The second column is blank, when the last good satellite fix is the closest.
[4]An estimated error of a recalculated position obtained by (3).

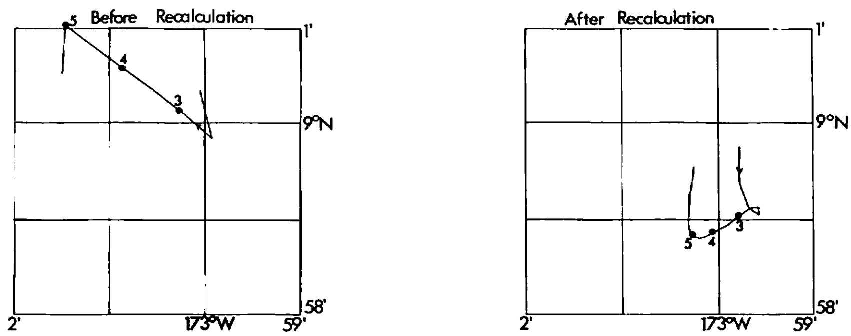

Fig. II-3 Ship's positions at the station 410. Positions before recalculation (on the left side), are considerably different from positions after recalculation (on the right side).

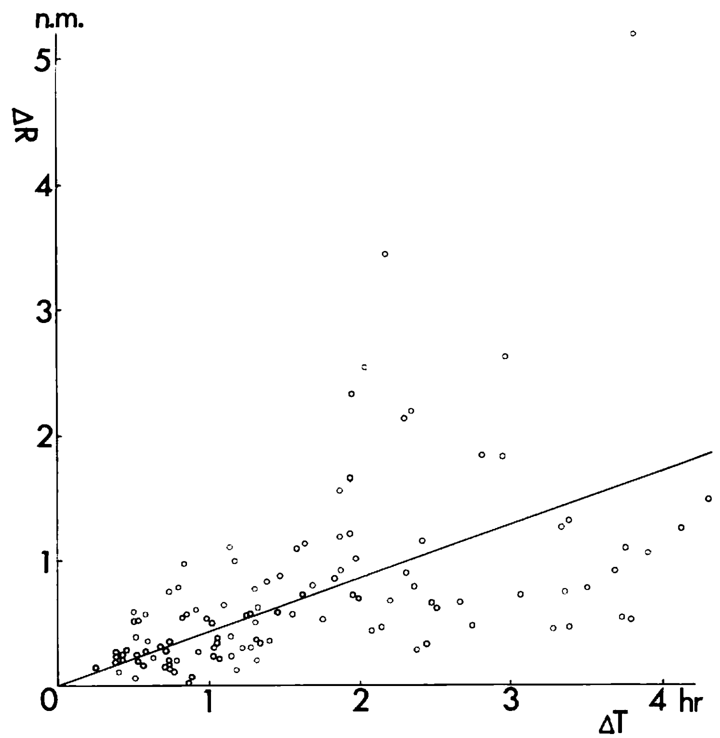

Fig. II-4 Difference of sampling position before and after recalculation, ΔR, as a function of time from the last satellite fix, ΔT. The oblique line indicates the relation $\Delta R = \chi \Delta T$, where $\chi = 0.80$ km/hr ($=0.43$ n.m./hr).

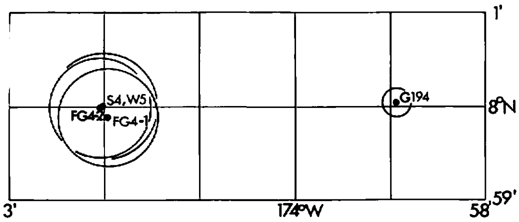

Fig. II-5 Recalculated sampling positions at stations 406 and 406A.

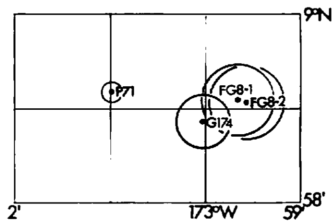

Fig. II-8 Recalculated sampling positions at stations 410 and 410A.

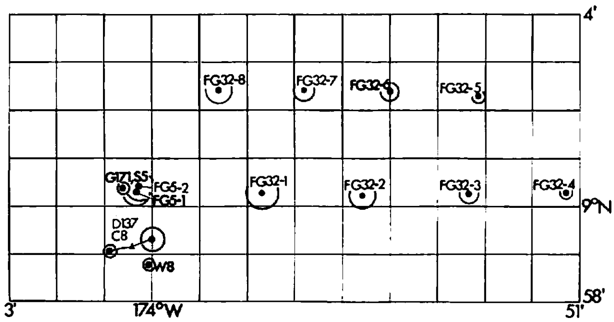

Fig. II-6 Recalculated sampling positions at stations 407, 407A, 407A-1 and 407A-2.

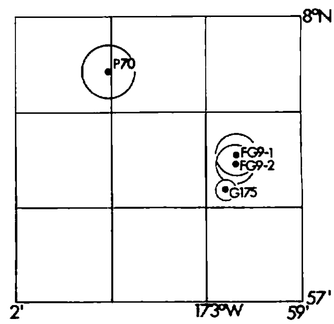

Fig. II-9 Recalculated sampling positions at stations 411 and 411A.

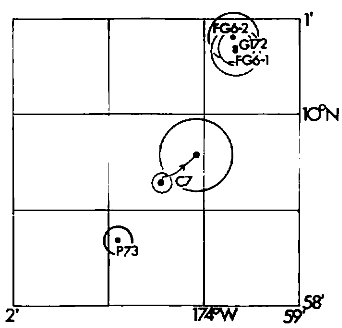

Fig. II-7 Recalculated sampling positions at stations 408, 408A and 408A-1.

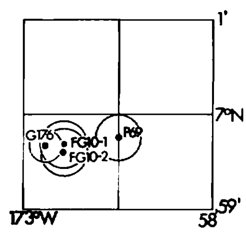

Fig. II-10 Recalculated sampling positions at stations 412 and 412A.

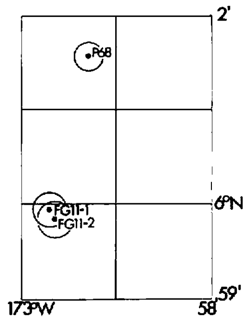

Fig. II-11 Recalculated sampling positions at stations 413 and 413A.

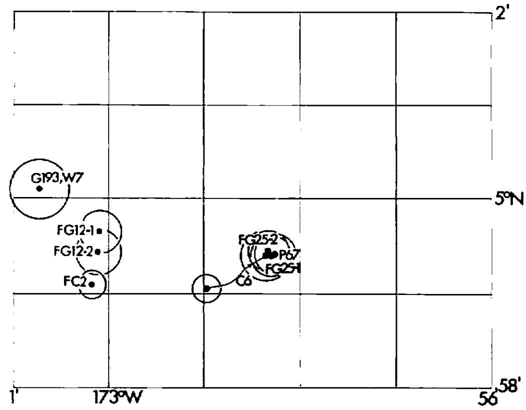

Fig. II-12 Recalculated sampling positions at stations 414, 414A, 414A-1, 414A-2 and 414A-3.

(3) indicates the estimated error is 0.6 km and 1.0 km, when the time from the closest satellite fix is one hour and two hours, respectively. The closest satellite fix is usually within one hour. And therefore, as shown in Table II-1, the root mean square of the estimated errors of all the recalculated positions is only 0.26 n.m. (=0.48 km). Some of the recalculated positions are shown in Figs. II-5—12 with circles, having the radii of estimated errors. Camera observation at station 408A-1 (c7) indicates that the ship was going to the northeast (KINOSHITA, in this report). This is consistent with the result of recalculation shown in Fig. II-7. However, camera observation at station 414A-3 (c6) shows that the ship was moving to the northwest. This shows a discrepancy with the result of recalculation shown in Fig. II-12. The camera observation may tell accurately how the ship was moving with respect to the sea bottom. Therefore, it might be probable that the recalculated water current is not so accurate as the error estimate (3) holds good, and we might be better to assume the coefficient in (3) greater than a half of the coefficient in (1), although we cannot exactly fix the coefficient in this moment, because we do not have any other information about the errors of sampling positions. In this case, the radii of estimated errors are greater.

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