

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

CATALOG OF EARTHQUAKE HYPOCENTERS AT REDOUBT VOLCANO  
AND MT. SPURR, ALASKA: OCTOBER 12, 1989 - DECEMBER 31, 1990

by

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Open-File Report 93 - 685-A

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## INTRODUCTION

The Alaska Volcano Observatory (AVO), a cooperative program of the U.S. Geological Survey, the Geophysical Institute of the University of Alaska, Fairbanks, and the Alaska Division of Geological and Geophysical Surveys, began a program of seismic monitoring at potentially active volcanoes in the Cook Inlet region in 1988. Seismic monitoring of this area was previously accomplished by two independent seismic networks operated by the U.S. Geological Survey (Northern Cook Inlet) and the Geophysical Institute (Southern Cook Inlet). In 1989 the AVO seismic program consisted of three small-aperture networks of six, five, and six stations on Mt. Spurr, Redoubt Volcano, and Augustine Volcano respectively. Thirty-five other stations were operated in the Cook Inlet region as part of the AVO program. During 1990 six additional stations were added to the Redoubt network in response to eruptive activity, and three stations were installed at Iliamna Volcano. The principal objectives of the AVO program have been the seismic surveillance of the Cook Inlet volcanoes and the investigation of seismic processes associated with active volcanism.

The locations of seismograph stations operated by AVO between 1988 and 1990 are shown in Figure 1. Geographic coordinates, elevations, and the installation date of each of the stations are contained in Appendix A. Signals from each of the stations are telemetered to Fairbanks, where recording and analysis take place. Data is recorded digitally in event-detection mode on a PC/AT system and continuously and in event-detection mode on a Masscomp system (Alaska Volcano Observatory Staff, 1990). The two event-detection systems employ different triggering parameters, with the PC/AT system having greater sensitivity for events in close proximity to the volcanoes. Data is also recorded on Helicorders, a Real-time Seismic Amplitude Measurement (RSAM) system (Murray and Endo, 1989; Endo and Murray, 1991), and a Seismic Spectral Amplitude Measurement (SSAM) system (Stephens and others, in press). A description of the various components of the computer systems, their networking, and associated software is given by March and Power (1990).

Following a 23 year period of quiescence, Redoubt Volcano erupted between December 14, 1989 and April 21, 1990. The eruption was accompanied by thousands of earthquakes (Alaska Volcano Observatory Staff, 1990). Throughout the eruption sequence, data from the PC/AT system provided the primary means of determining earthquake hypocenters. This report catalogs the earthquake hypocenters and magnitudes calculated from data collected between October 12, 1989 and December 31, 1990 on the PC/AT acquisition system, provides station locations, statistics, and calibrations, and outlines which stations were recorded and used in triggering the PC/AT system.

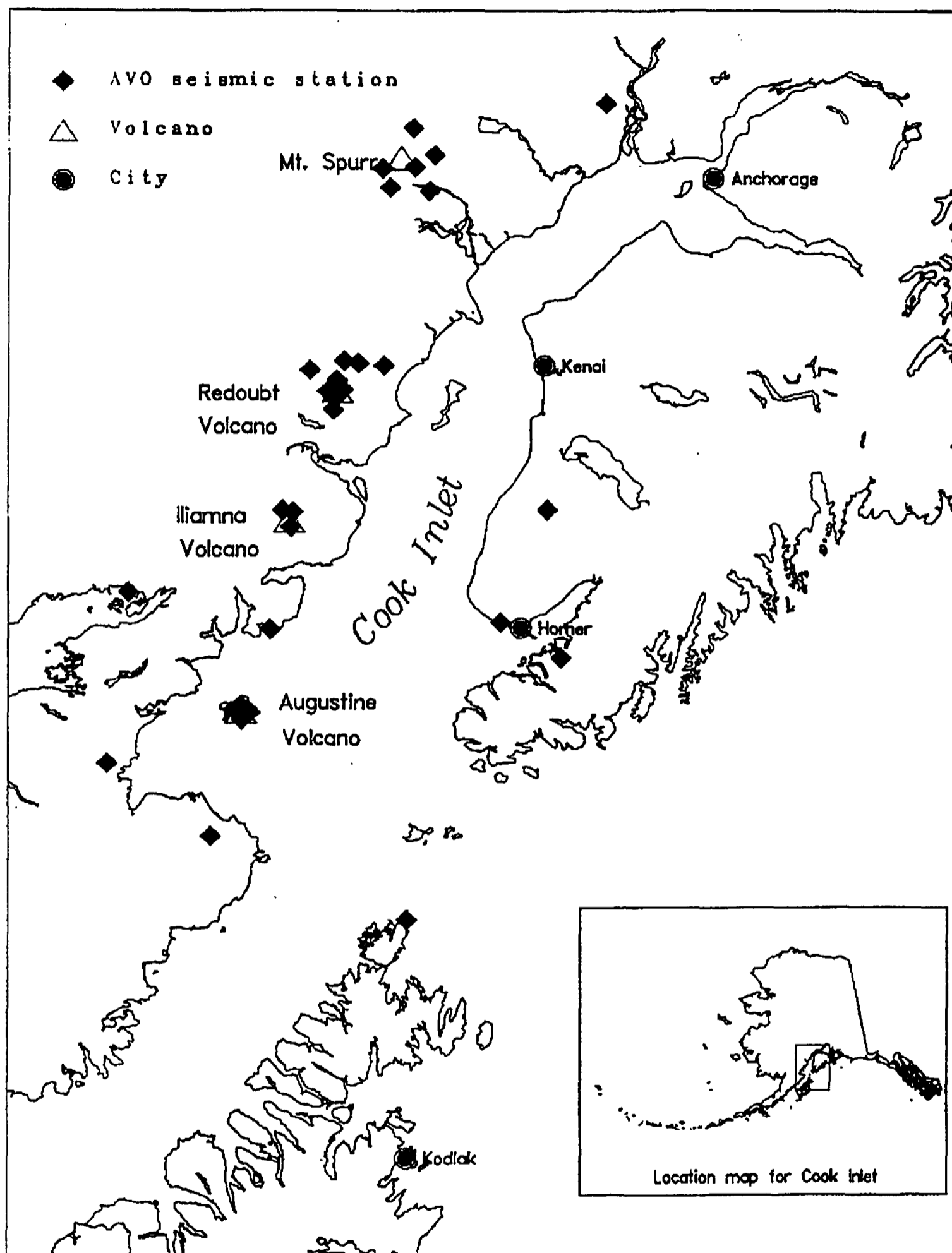


Figure 1. Location of seismic stations operated by the Alaska Volcano Observatory between 1988 and 1990.

## INSTRUMENTATION

In October 1989 six seismic stations, SPU, CRP, CGL, NCG, BGL, and CKL, were in operation around Mt. Spurr (Figure 2). Between October 1989 and February 1990 the Redoubt network consisted of 5 stations; RED, RDN, NCT, DFR, and RDT. RDT was a three-component station with north-south and east-west oriented horizontal instruments. On February 2, 1990 station DRE was installed both to augment monitoring capability at Redoubt Volcano and to aid in monitoring for eruption-related floods in the Drift River valley. In March stations RSO, REF, and RWS were installed on the Redoubt cone to augment the existing network (Figure 3). Station RWS was replaced by station RDW on September 9. On September 10 and 24 two additional stations, RS1 and RS2, were added to form a tripartite array with station RSO. The horizontal instruments at station RDT were moved to station RED on August 30, 1990. Station RDN was disabled as a result of eruptive activity between January 2 - 9, 1990 and February 11 - November 9, 1990. Eruptive activity on December 14, 1989 apparently damaged the RDN seismometer, altering the frequency response. This problem was corrected on November 9, 1990 when the seismometer was replaced. Other stations experienced minor technical trouble and short interruptions in telemetry during the report period. Information on which stations were recorded and used in triggering on the PC/AT system is contained in Appendix B.

AVO seismic stations in the northern portion of Cook Inlet are maintained by the U. S. Geological Survey, and in southern Cook Inlet by the Geophysical Institute (Figure 1). Each institution uses slightly different field equipment. As this report catalogs only hypocenters at Mt. Spurr and Redoubt Volcano, just equipment at and operation of stations at these volcanoes is covered.

## SPURR SEISMIC STATIONS 1989 - 1990

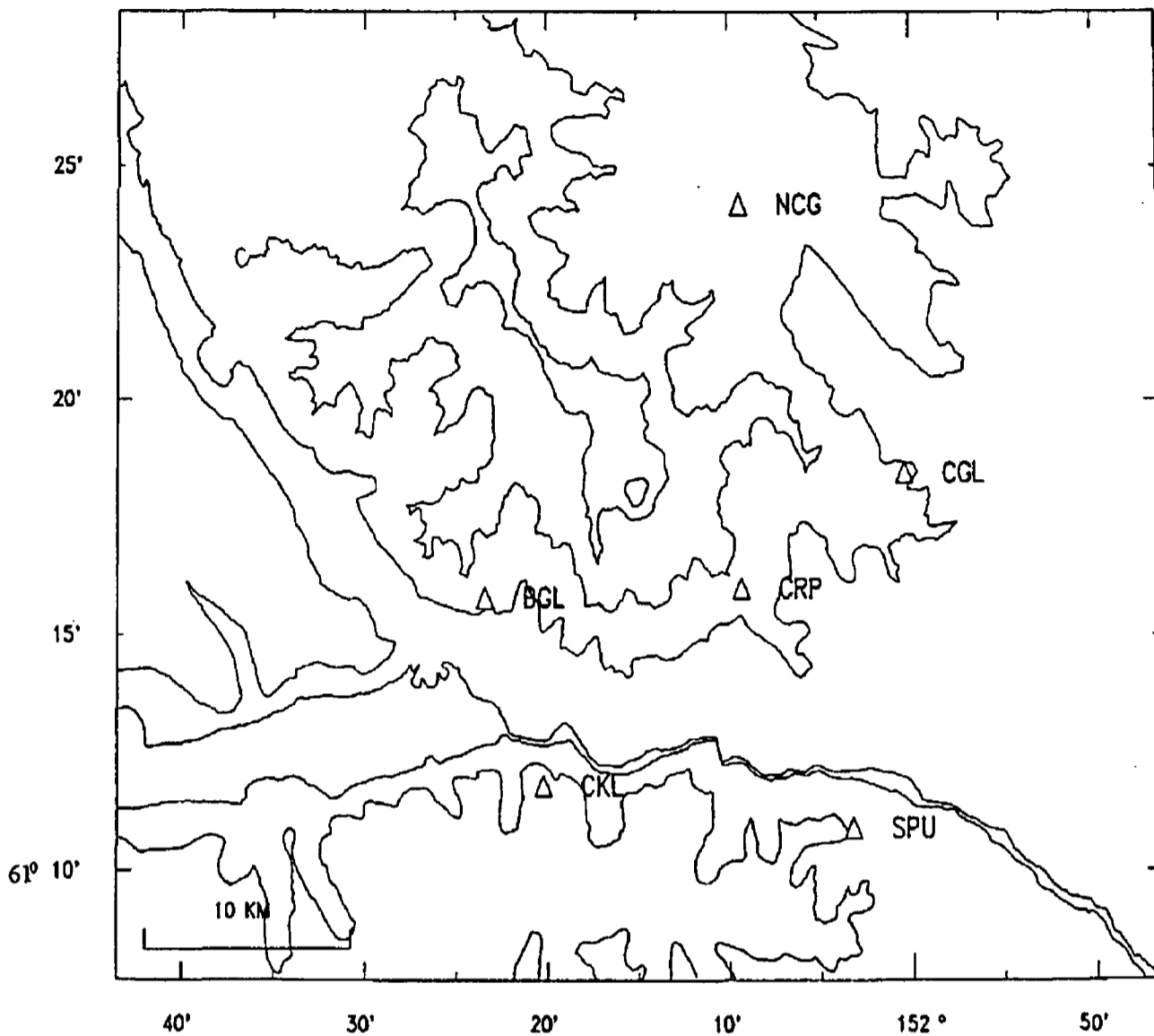


Figure 2. Seismic stations in vicinity of Mt. Spurr.

Stations at Mt. Spurr and Redoubt Volcano consist of a vertical component seismometer with a frequency of 1 HZ (Mark Products L-4C), an A1VCO (Rogers and others, 1980), radio transmitter, antenna, and batteries (which in some cases are float-charged by a solar panel). The two exceptions to this are stations RED and DRE, which differ only in the use of a monitron VCO. Signals from each station are relayed to radio receivers and telemetered via frequency-multiplexed phone lines to the AVO offices in Fairbanks. Appendix C illustrates the response characteristics of the entire system from the seismometer to the computer screen for the various stations.

## REDOUBT SEISMIC STATIONS 1989 – 1990

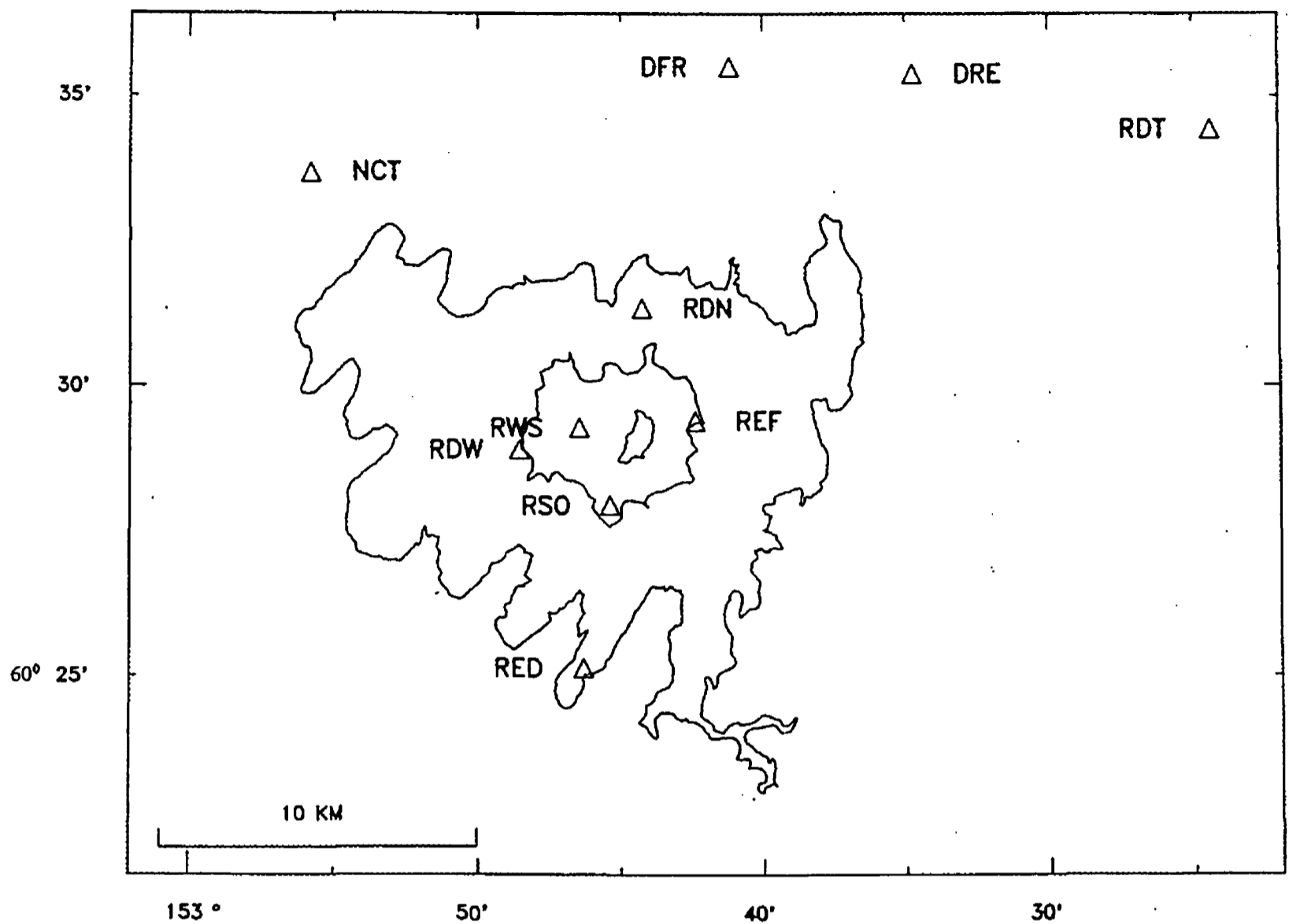


Figure 3. Seismic stations in vicinity of Redoubt Volcano. Stations RS1 and RS2 are not shown.

### DATA ACQUISITION AND REDUCTION

On October 12, 1989 event-triggered recording began on a PC/AT-based seismic data acquisition system (Lee and others, 1989). This system uses the program MDETECT (Lee and others, 1988) to digitize, detect, and record sixteen channels of data. Between October 12, 1989 and December 31, 1990 the system triggered over 12,000 times.

When the PC/AT system was first installed in Fairbanks, the sixteen input channels were distributed evenly among stations on Mt. Spurr, Redoubt Volcano,

and Augustine Volcano. Through the course of the 1989-90 eruption of Redoubt Volcano, input channels were shifted from stations at Augustine and then Mt. Spurr to stations closer to Redoubt Volcano and to new stations added to the Redoubt network. After January 5, 1990, Augustine stations were not recorded on the PC/AT system and after March 10, 1990, stations near Mt. Spurr were not used to trigger event recording.

Recorded events were visually inspected on a computer screen and classified as either a volcano-tectonic earthquake, a long-period event, an explosion event, a regional tectonic earthquake, a teleseismic event, or a non-seismic event. After additional spectral analysis (Lahr, and others, in press), some events at Redoubt Volcano were reclassified as hybrid events (see Power and others, in press, for a description of the various event types). Events were only analyzed for reclassification as hybrids between December 13, 1989 and January 2, 1990. If an event was classified as either a volcano-tectonic or long-period event and had four or more distinct phases at three or more stations, it was selected for location. No attempt was made to locate long-period events with emergent arrivals or low-frequency events in the Spurr area. The initial examination on the computer screen, event classification, the determination of P and S arrival times, direction of first motion, and the period and amplitude of the maximum recorded signal were determined using the program XPICK (Robinson, 1990). Earthquake hypocenters and magnitudes were calculated using the program HYPOELLIPSE (Lahr, 1989). Computed magnitudes approximate the Richter local magnitude as outlined by Eaton and others, (1970). Earthquake depths are computed with respect to sea level, with the negative values reflecting height above sea level.

HYPOELLIPSE expresses the quality of earthquake solutions using a number of parameters which include: RMS (the root mean square residual); SEH (the 68 percent confidence limit in the least well-constrained direction); SEZ (the 68 percent confidence limit in depth); GAP (the largest azimuthal separation between stations measured from the epicenter); NP, the number of P arrivals used in the solution; and NS, the number of S arrivals used in the solution. More detailed information on these parameters is given by Lahr (1989). A complete discussion of the earthquake location process is given by Lee and Stewart (1981).

Earthquake hypocenter determinations contain both systematic and random errors. Systematic errors can result from errors in the velocity model, misidentification of phases, or systematic timing errors. Systematic errors affect the accuracy of the hypocenter determination and can be evaluated through controlled experiments such as locating man-made explosions. Random errors result from timing errors and are estimated for each earthquake through the use of standard

statistical techniques. Random errors affect the precision with which hypocenters can be calculated.

The quality of each solution was checked using a computer algorithm which identifies those events without magnitude, fewer than three P phases, fewer than one S phase, or SEH or SEZ greater than 15.0 km. Additionally all events at Redoubt Volcano with depths greater than 10 km and volcano-tectonic events with depths less than 4 km were reinspected. Corrections were made as required.

## VELOCITY MODELS

For earthquakes which occur at Mt. Spurr, the velocity model used to calculate hypocenters is:

LAYER	DEPTH (TO TOP OF LAYER)	P VELOCITY (km/s)	VP/VS (km/s)
1	-3.2	5.1	1.81
2	-2.2	5.5	1.81
3	-5.05	6.3	1.74

Depths are referenced to sea level, with negative values reflecting height above sea level. Below 27.05 km depth this model is underlain by a uniform halfspace with P-wave velocity of 7.2 km/s and VP/VS of 1.78 km/s. Station corrections for use with this model are shown below:

STATION	P-DELAY (Seconds)	S-DELAY (Seconds)
BGL	-0.12	0.00
BRLK	-0.62	-1.20
CGL	0.04	-0.11
CKL	0.07	0.00
CNP	-0.44	0.00
CRP	0.11	0.00
CUT	0.41	0.00
DFR	-0.37	-0.77
GHO	0.36	0.00
ILM	-0.63	-1.40
KNK	-0.85	-0.54
NCT	-0.24	-0.66
NKA	2.18	0.00
NNL	1.21	0.00
PME	0.18	0.00
RDN	-0.42	-0.69
RDT	-0.49	-0.88
RED	-0.43	-1.00
SKL	-0.20	-0.80
SLV	-1.10	0.00
SPU	0.04	-0.06
SVW	0.00	-0.65

The Spurr model was derived by minimizing the average root-mean-square (rms) residual of observed versus computed travel times (Jolly and others,1991).

At Redoubt Volcano the velocity model used is:

LAYER	DEPTH (TO TOP OF LAYER)	P VELOCITY (km/s)	VP/VS(km/s)
1	-3.00	2.9	1.80
2	-1.70	5.1	1.80
3	1.50	6.4	1.72

In this model depths are referenced to sea level; negative values reflect height above sea level. Below 17 km depth this model is underlain by a uniform halfspace with P-wave velocity of 7.0 km/s and a VP/VS ratio of 1.780. Station corrections for use with this model are shown below:

STATION	P-DELAY (Seconds)	S-DELAY (SECONDS)
DFR	0.00	-0.10
DRE	0.00	0.00
NCT	0.00	0.06
RDN	-0.01	-0.04
RDT	0.00	-0.02
RDTE	0.00	-0.02
RDTN	0.00	-0.02
RDW	0.02	-0.12
REF	0.01	0.00
RED	-0.02	-0.05
REDE	-0.02	-0.05
REDN	-0.02	-0.05
RSO	0.00	0.00
RS1	0.00	0.00
RS2	0.00	0.00

S phases at DFR, RDN, REF, RS1, RS2, and RSO are not used. S phases at the remaining stations are used with reading errors set to 0.14 seconds. This model was derived by Lahr and others, (in press) by minimizing the average root-mean-square (rms) residual of observed versus computed travel times and developing station corrections based on explosion data collected during the summer of 1991.

## DISCUSSION

Origin times, focal coordinates, magnitudes, and related parameters for 9877 earthquakes from October 12, 1989 through December 31, 1990 are contained in a file on the accompanying floppy disk. Epicenters of 144 of these events occur within 20 km of the summit of Mt. Spurr (Figure 4). The remaining 9733 earthquakes occur in the vicinity of Redoubt Volcano and are associated with the 1989-90 eruption (Power and others, in press).

# MT SPURR SEISMICITY OCTOBER 12, 1989 - DECEMBER 31, 1990

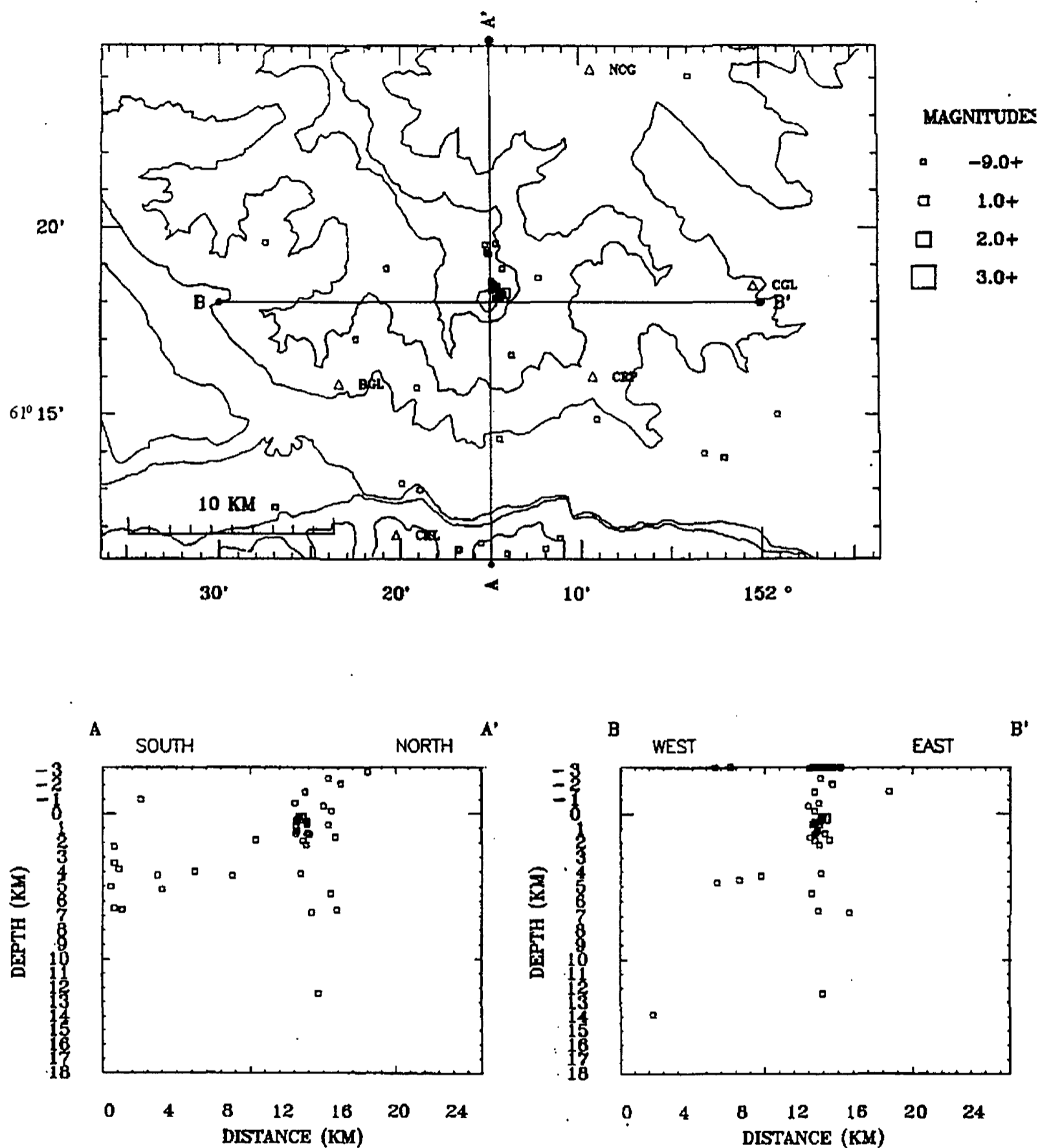


Figure 4. Epicenter map and cross sections for Mt. Spurr from October 12, 1989 through March 10, 1990.

Earthquakes located at Mt. Spurr by the PC/AT system form a dominant cluster beneath the summit of Mt. Spurr. Events in this cluster are shallow and range from -3.0 to 1.0 km depth. This cluster of events is a long-standing feature of seismic activity at Mt. Spurr (Jolly, and others, 1991). Magnitudes of located events at Mt Spurr ranged from -0.6 to 2.7 during the report period. In March 1990 stations on the PC/AT system were shifted from stations in the Mt. Spurr network to new stations at Redoubt Volcano. The PC/AT system did not trigger on stations in the Mt. Spurr network for the remainder of the report period.

At Redoubt Volcano a few small earthquakes were located during October and November 1989. A vigorous swarm of long-period earthquakes occurred in the 23-hour period prior to the onset of the 1989-90 eruption on December 14, 1989. Shallow swarms (-3 to 1 km depth) of volcano-tectonic earthquakes followed explosive events on December 15 and 19. A deeper swarm of volcano-tectonic earthquakes was initiated by explosive events on December 15. This deeper swarm increased in intensity in late December and declined gradually through the remainder of the eruption. Additional swarms of long-period events are described by Stephens and others, (in press). Generally only those long-period events which occurred during swarms on December 13 - 14 and December 26, 1989 - January 2, 1990 were large enough to locate. A map of earthquake epicenters for Redoubt Volcano is shown in Figure 5. A plot of focal depth versus time of all located events in the Redoubt network between October 12, 1989 and December 31, 1990 is shown in Figure 6. For more detailed descriptions and analysis of the seismicity accompanying the 1989-90 eruption of Redoubt Volcano see Chouet and others, (in press), Lahr and others, (in press), Power and others, (in press), and Stephens and others, (in press).

# REDOUBT SEISMICITY OCTOBER 12, 1989 - DECEMBER 31, 1990

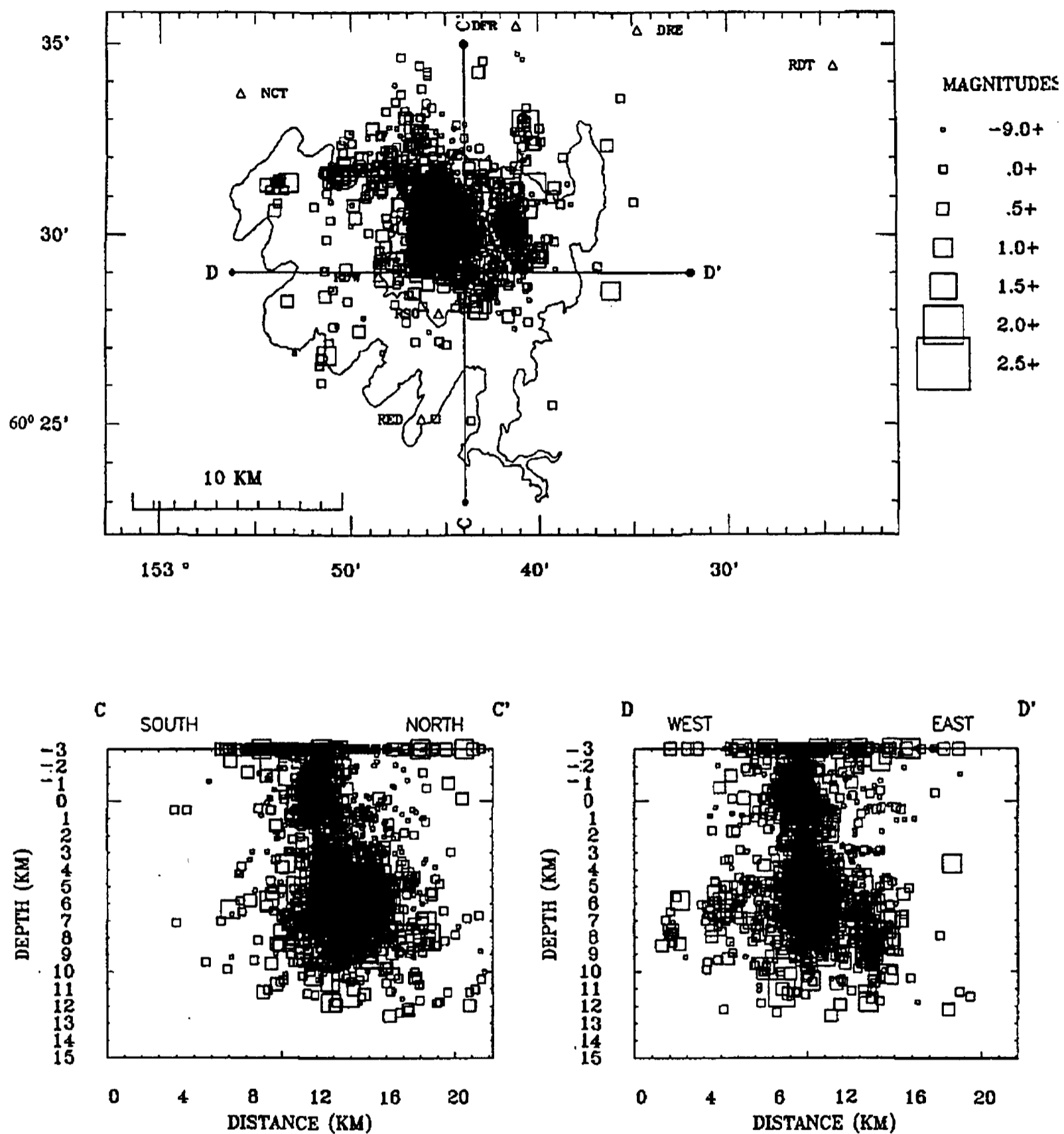


Figure 5. Epicenters map and cross sections for Redoubt Volcano from October 12, 1989 through December 31, 1990.

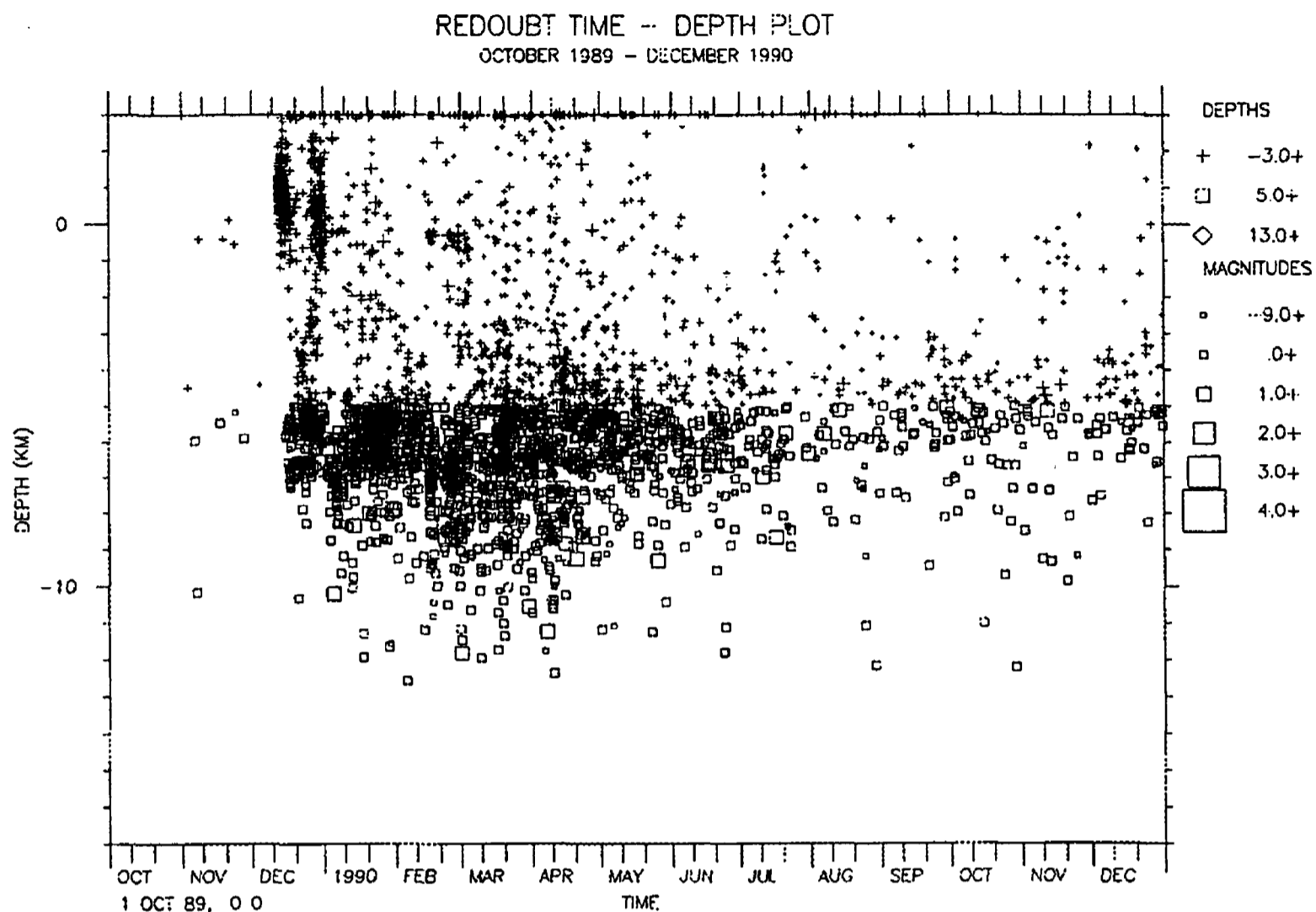


Figure 6. Focal depth versus time for all located events in the Redoubt network between October 12, 1989 and December 31, 1990.

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## APPENDIX A

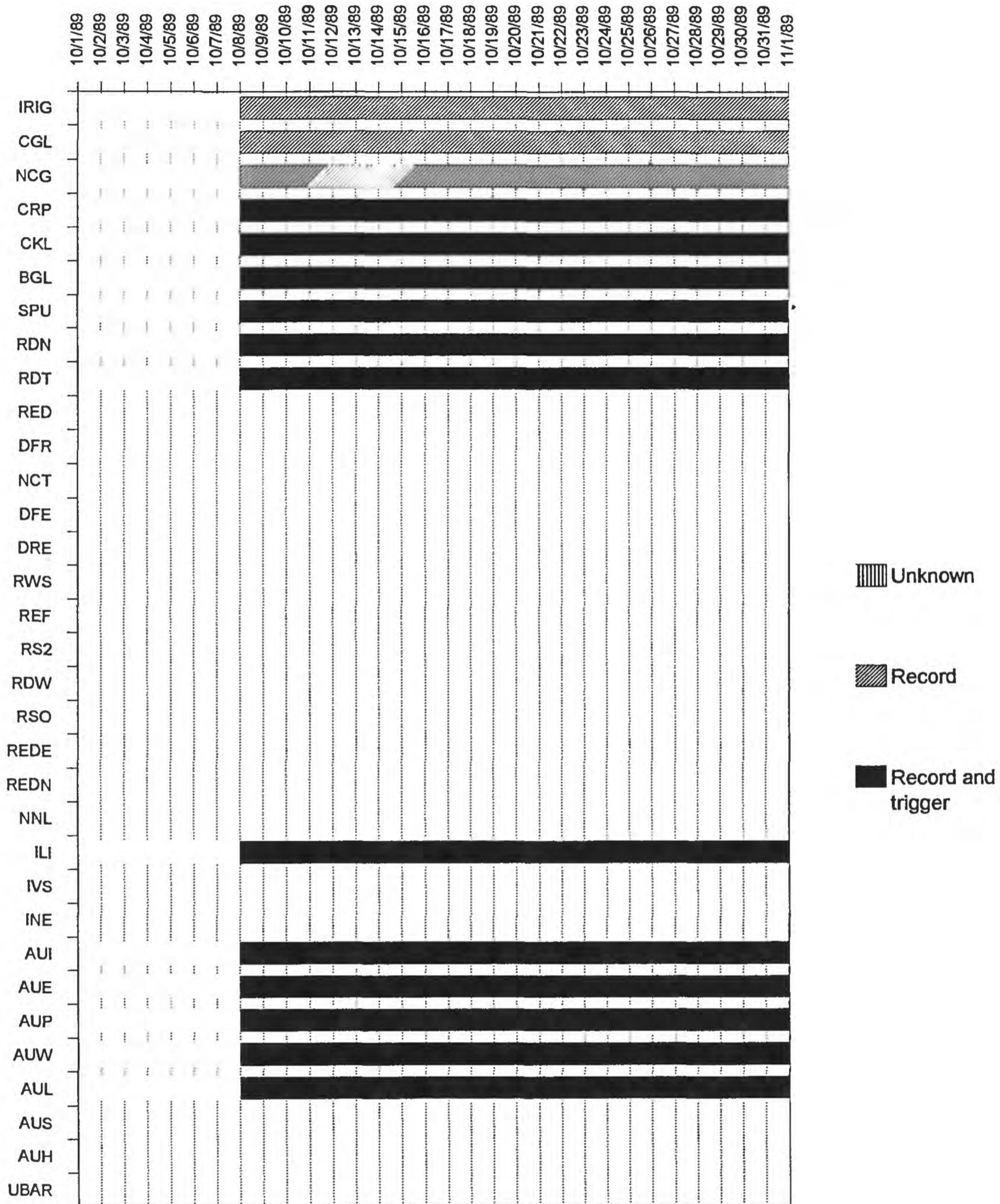
Appendix A lists stations operated by the Alaska Volcano Observatory in the Cook Inlet region between October, 1989 and December, 1990. The list includes geographic coordinates, elevation, installation date, and organization responsible for maintenance for each station.

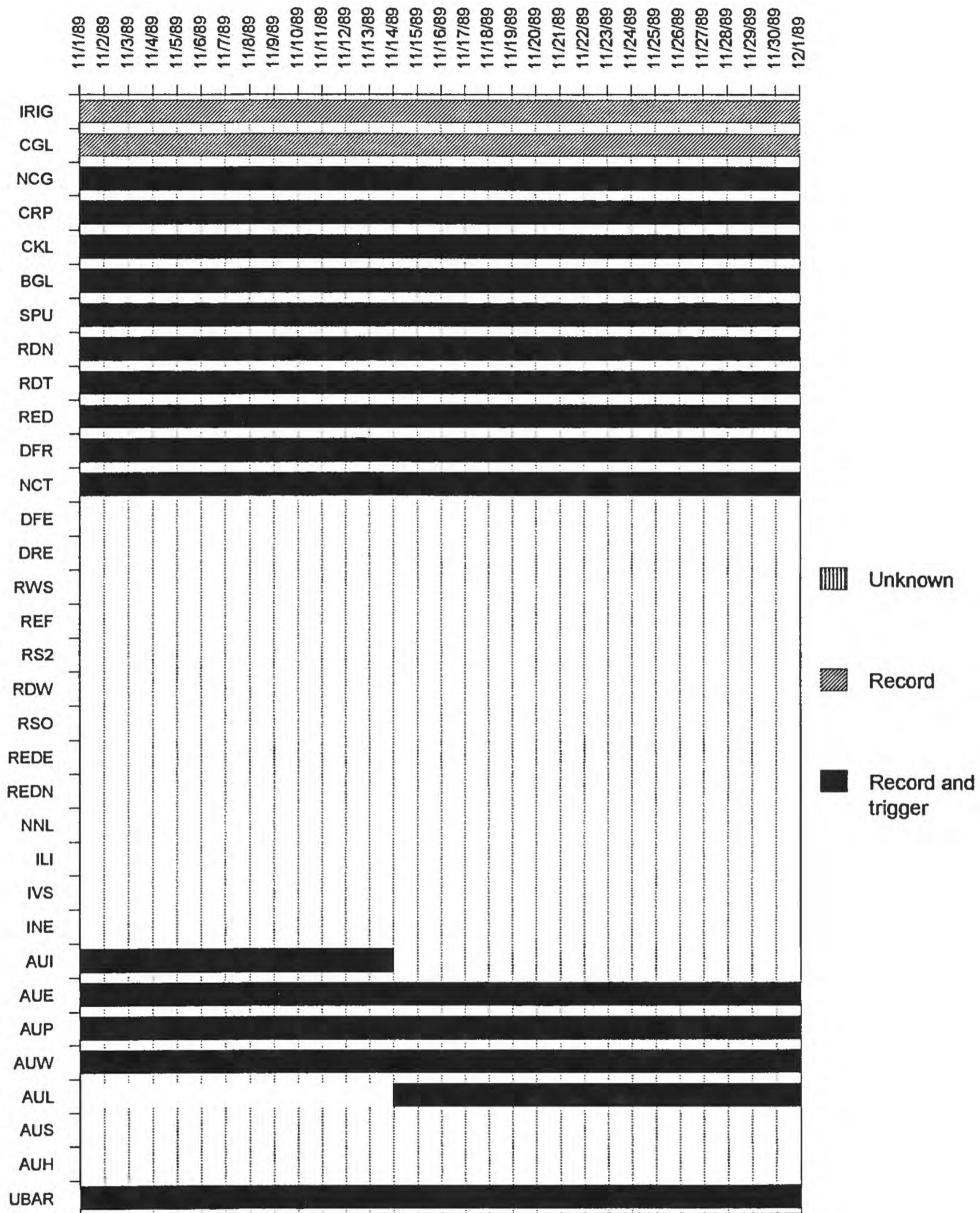
Station	Latitude	Longitude	Elevation (m)	Installation date	Maintainer
BGL	61.2635	-152.3905	1173	890813	USGS
CGL	61.3077	-152.0067	1082	810922	USGS
CKL	61.1965	-152.3378	1265	890805	USGS
CKN	61.2073	-152.1815	735	910819	USGS
CRP	61.2670	-152.1555	1622	810826	USGS
NCG	61.4037	-152.1567	1244	890806	USGS
SPU	61.1817	-152.0543	800	710810	USGS
REF	60.4892	-152.7017	1801	900314	USGS
RDN	60.5230	-152.7385	1372	880813	USGS
RDW	60.4827	-152.8095	1813	900907	USGS
RS1	60.4602	-152.7580	1864	900910	USGS
RS2	60.4630	-152.7573	1953	900910	USGS
RSO	60.4622	-152.7538	1921	900301	USGS
RED	60.4190	-152.7720	1067	740000	USGS
REDE	60.4190	-152.7720	1067	900830	USGS
REDN	60.4190	-152.7720	1067	900830	USGS
REDL	60.1490	-152.7720	1067	900830	USGS
RWS	60.4880	-152.7745	2713	900315	USGS
DFR	60.5920	-152.6862	1097	880815	USGS
DRE	60.5832	-152.5868	489	900201	USGS
NCT	60.5617	-152.9297	1166	880814	USGS
RDT	60.5738	-152.4062	930	710809	USGS
RDTN	60.5738	-152.4062	930	710809	USGS
RDTE	60.5738	-152.4062	930	710809	USGS
INE	60.0608	-153.6250	1585	900829	UAGI
INW	60.0677	-153.1325	1219	900829	UAGI
IVS	60.0092	-153.0808	2332	900829	UAGI
AUH	59.3638	-153.4435	900	781201	UAGI
AUI	59.3352	-153.4277	293	780406	UAGI
AUIE	59.3352	-153.4277	293	860600	UAGI
AUIN	59.3352	-153.4277	293	860600	UAGI
AUP	59.3623	-153.4205	1033	870922	UAGI
AUS	59.3600	-153.4307	1226	900901	UAGI
AUW	59.3670	-153.4708	320	860700	UAGI
AUE	59.3590	-153.3722	172	870830	UAGI
AUL	59.3822	-153.4345	360	801029	UAGI
CDD	58.9298	-153.6430	622	810817	UAGI
SKN	61.9803	-151.5297	564	720808	USGS
NNL	60.0443	-151.2893	381	720824	USGS
CNP	59.5258	-151.2360	564	830701	USGS

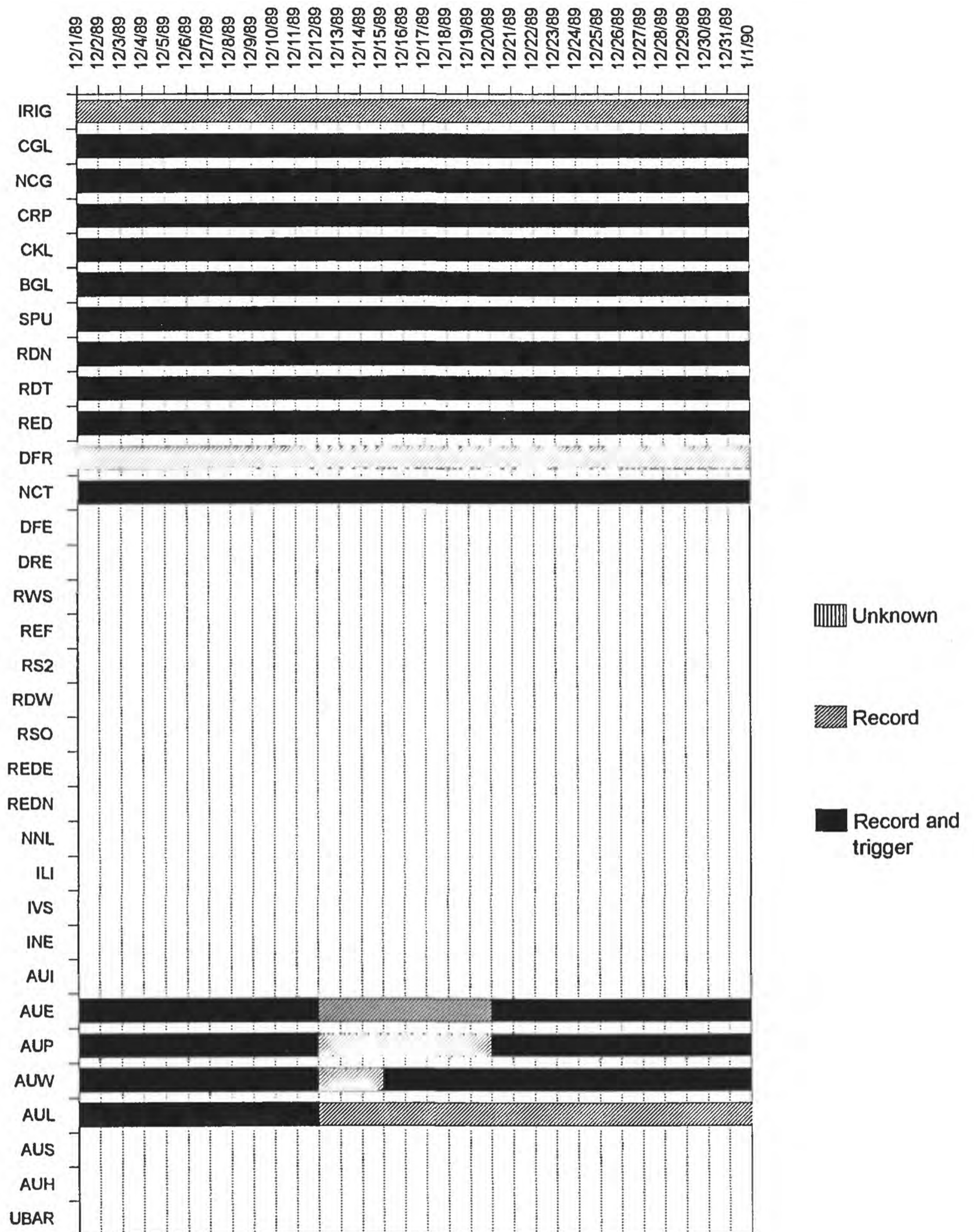
Station	Latitude	Longitude	Elevation (m)	Installation date	Maintainer
HOM	59.6583	-151.6433	198	760800	UAGI
PDB	59.7878	-154.1925	305	780909	UAGI
OPT	59.6527	-153.2297	450	740000	UAGI
PDB	59.7878	-154.1925	305	780909	UAGI
MMN	59.1852	-154.3367	442	810822	UAGI
BGM	59.3927	-155.2293	625	780908	UAGI
SHU	58.6280	-152.3488	34	740000	UAGI
XLV	59.4547	-151.6717	320	870916	UAGI

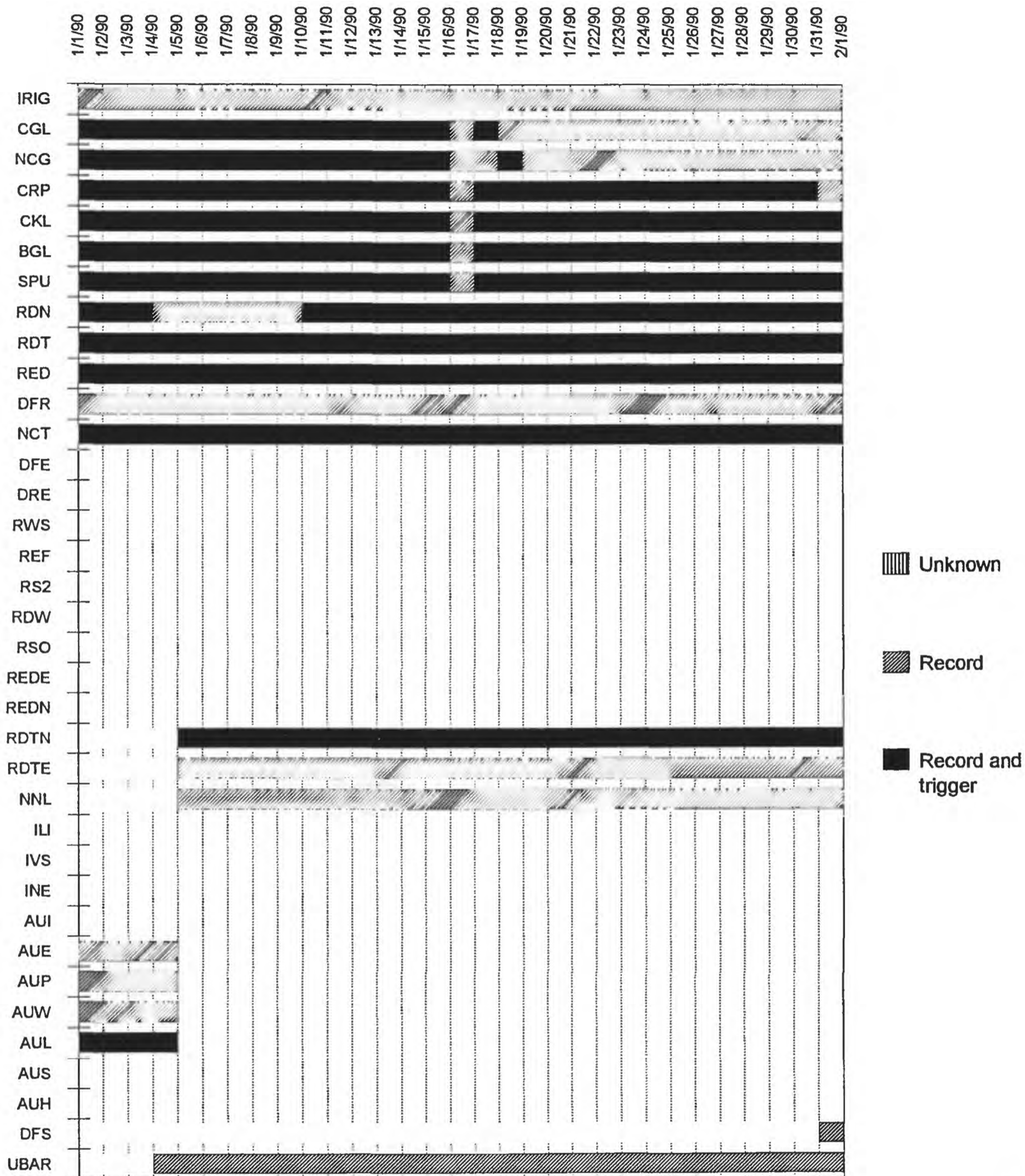
## APPENDIX B

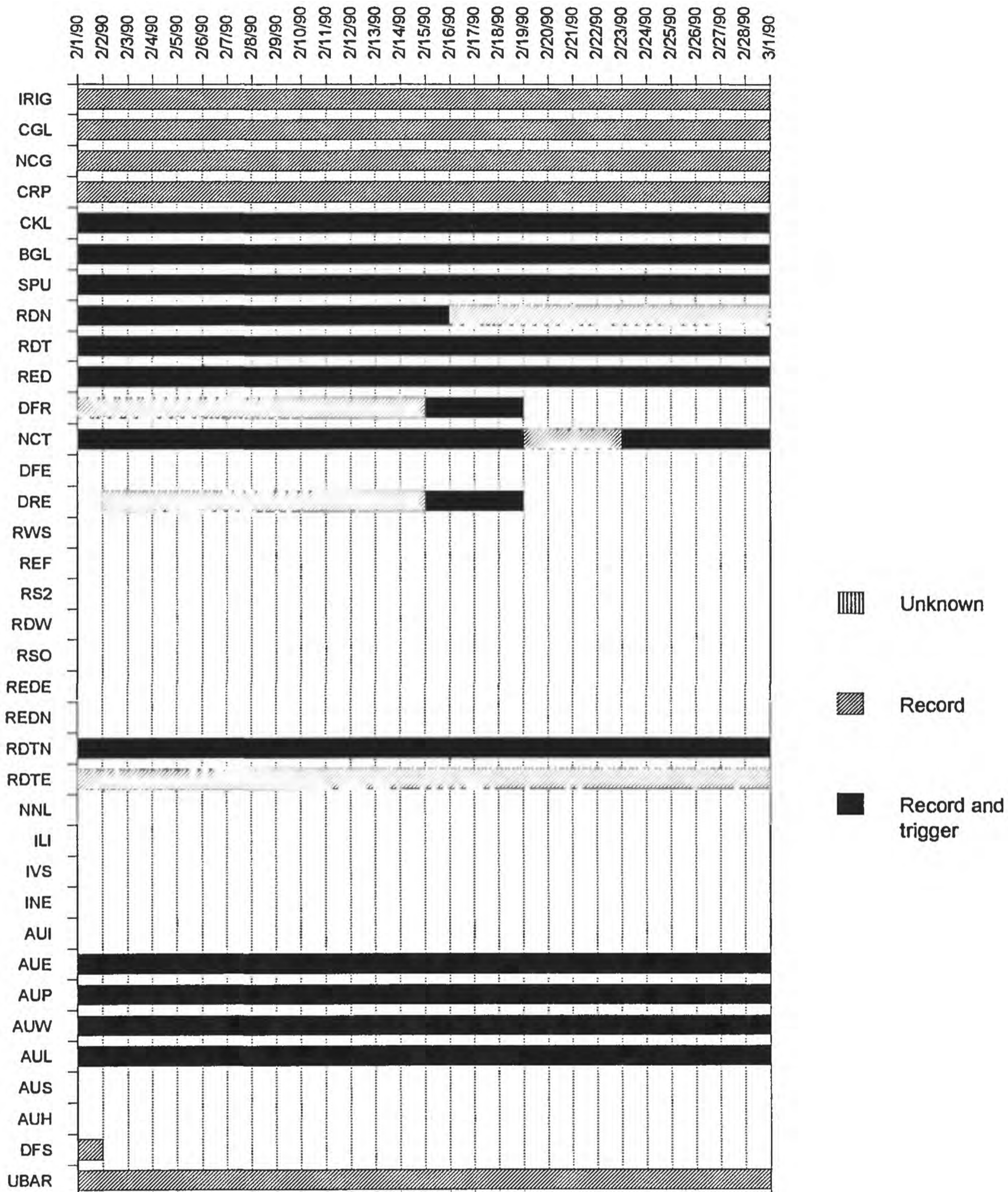
Appendix B shows stations being recorded on the PC/AT acquisition system on a daily scale for the period October 8, 1989 through December 31, 1990. The period from October 8, 1989 through December 11, 1989 is not well documented, as few events were recorded during this period. The period from December 12, 1989 through December 31, 1990 is well documented. Different patterns are used to distinguish whether stations were used in event triggering or were only recorded.

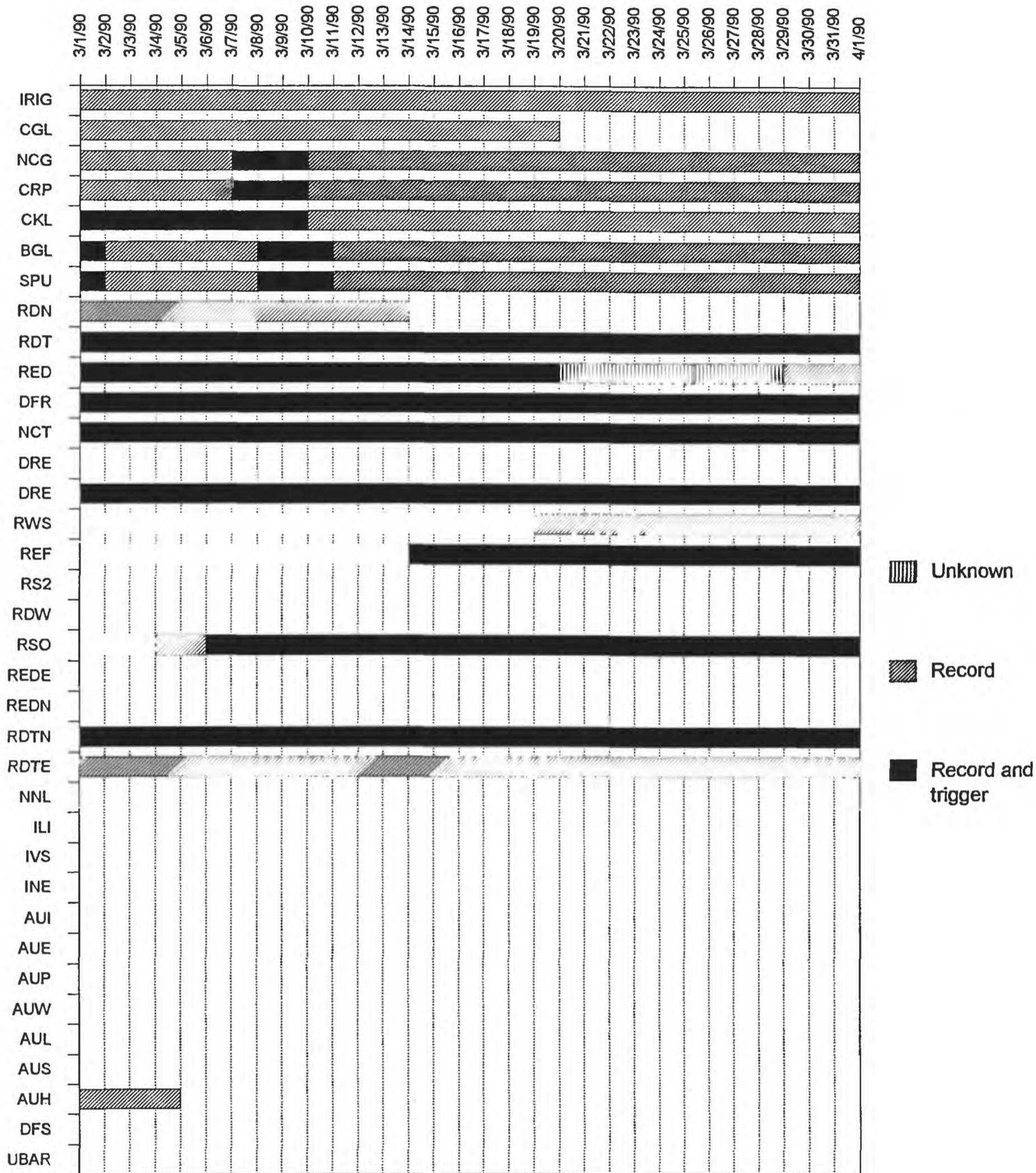


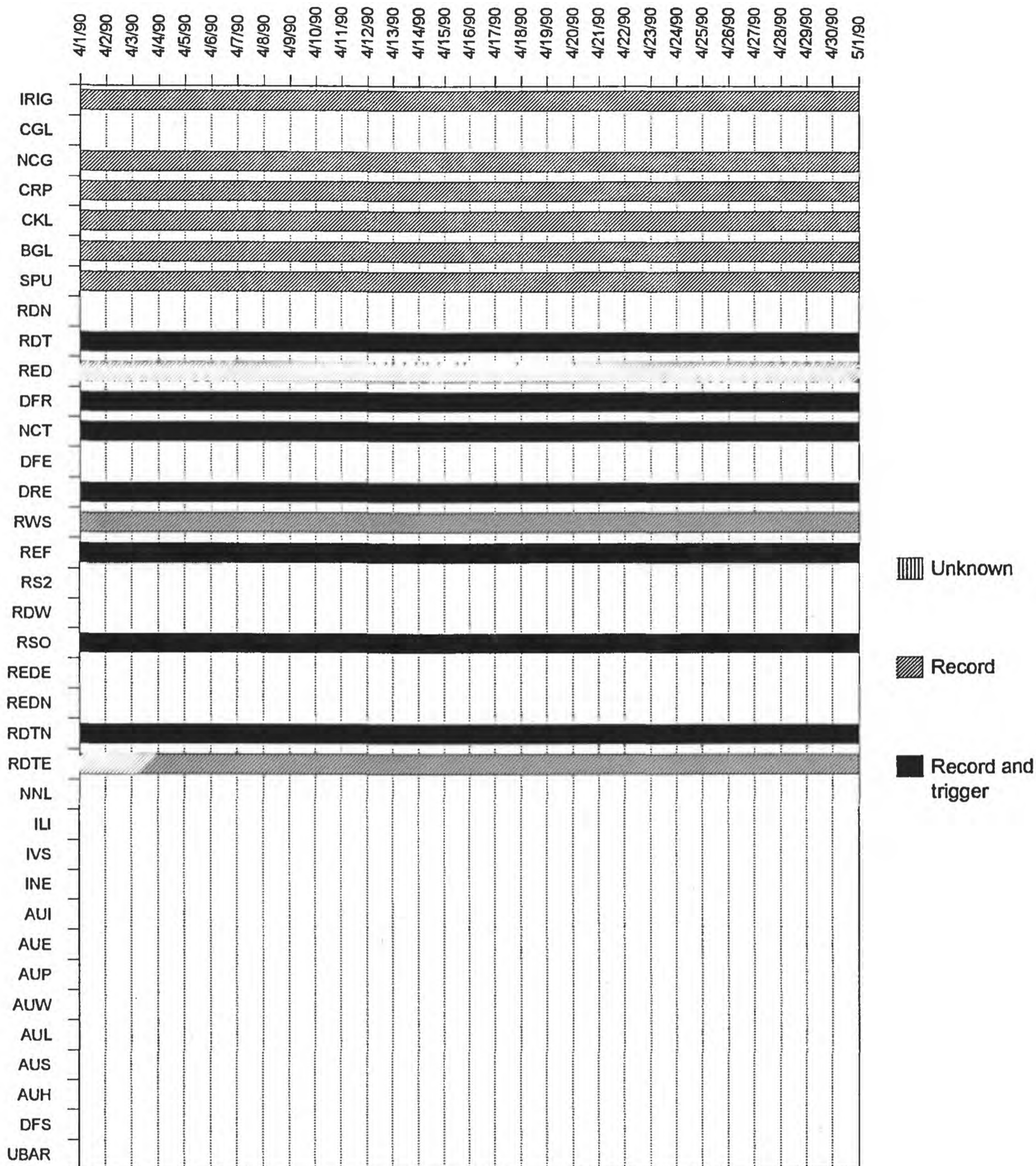


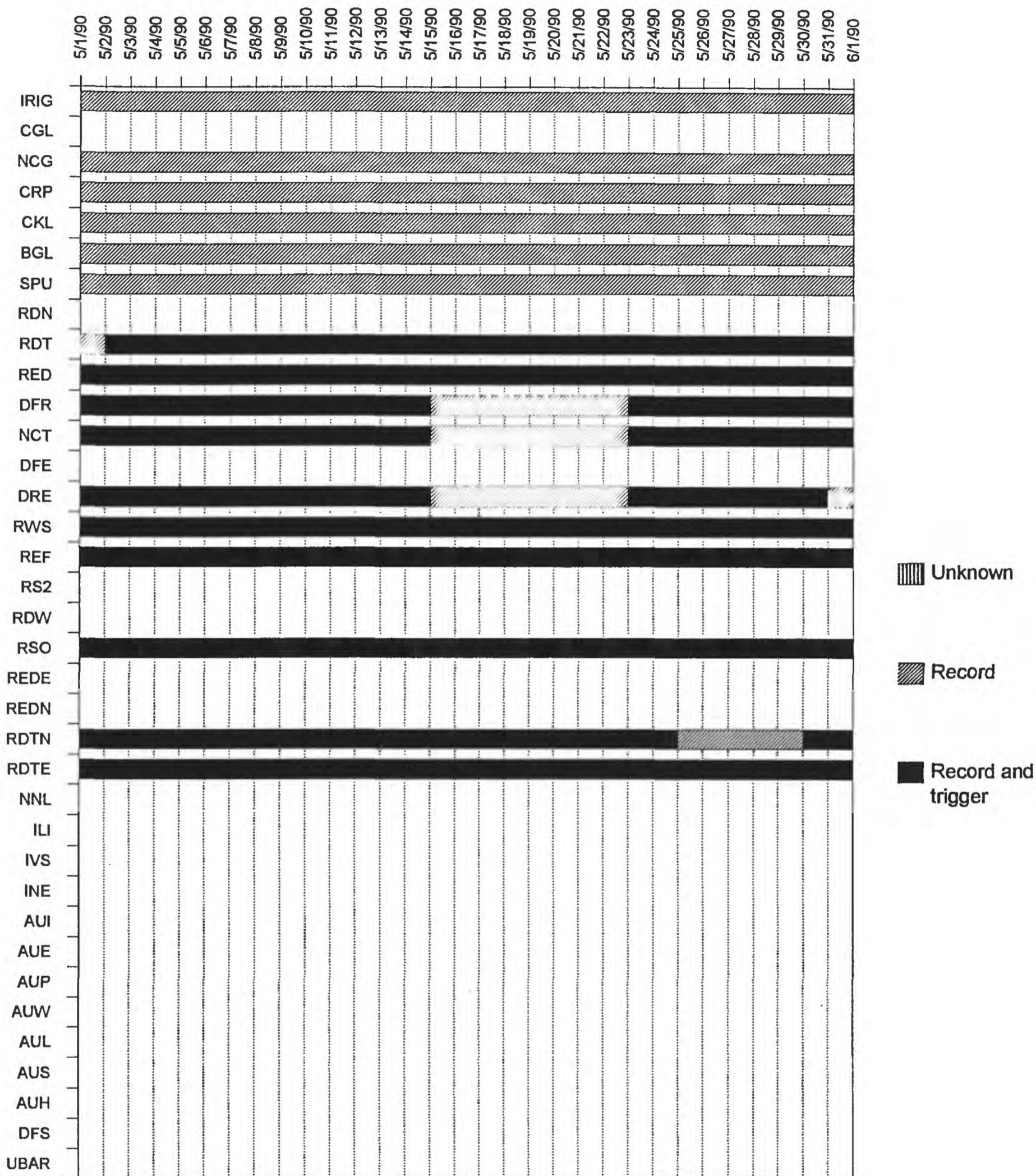


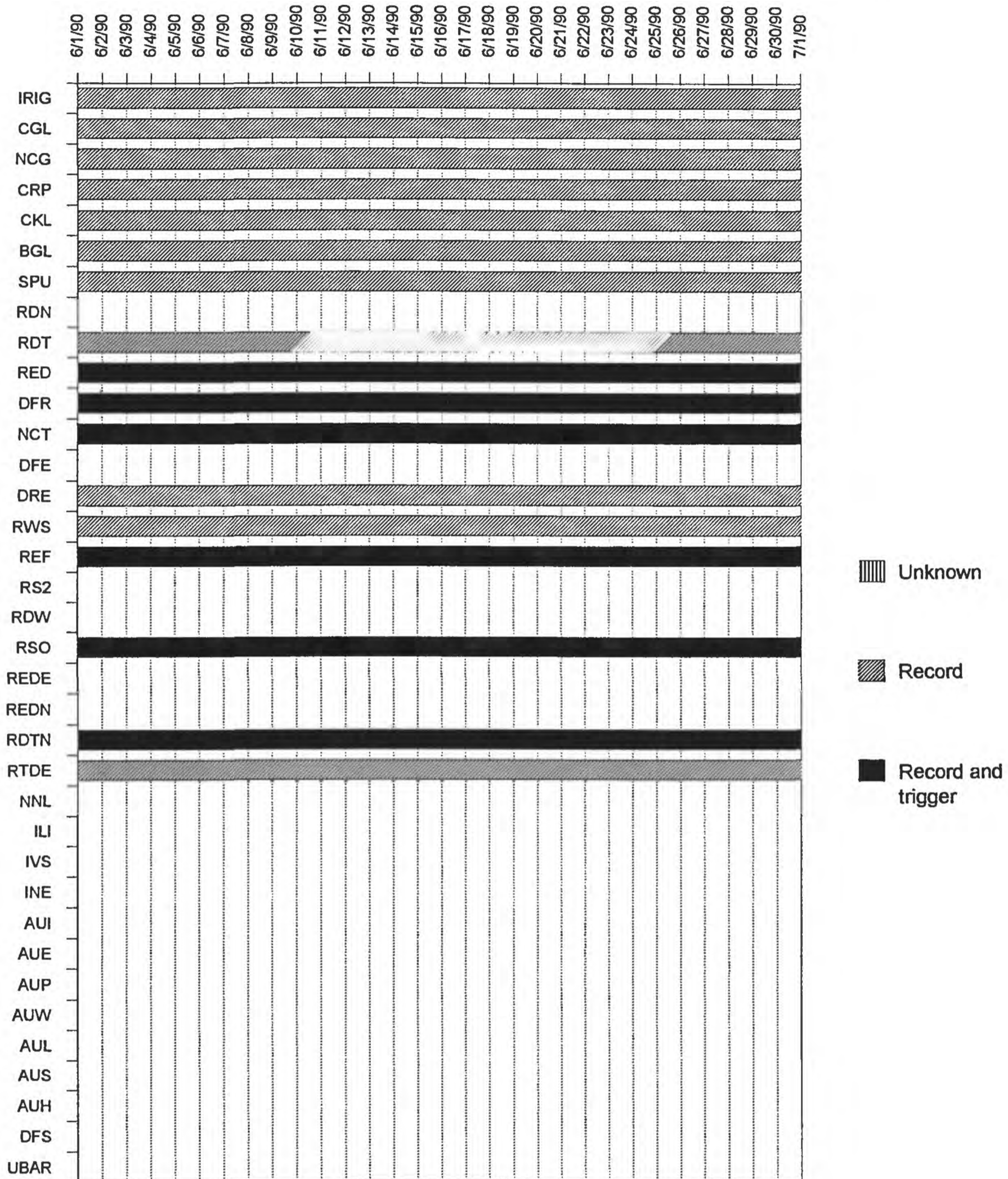


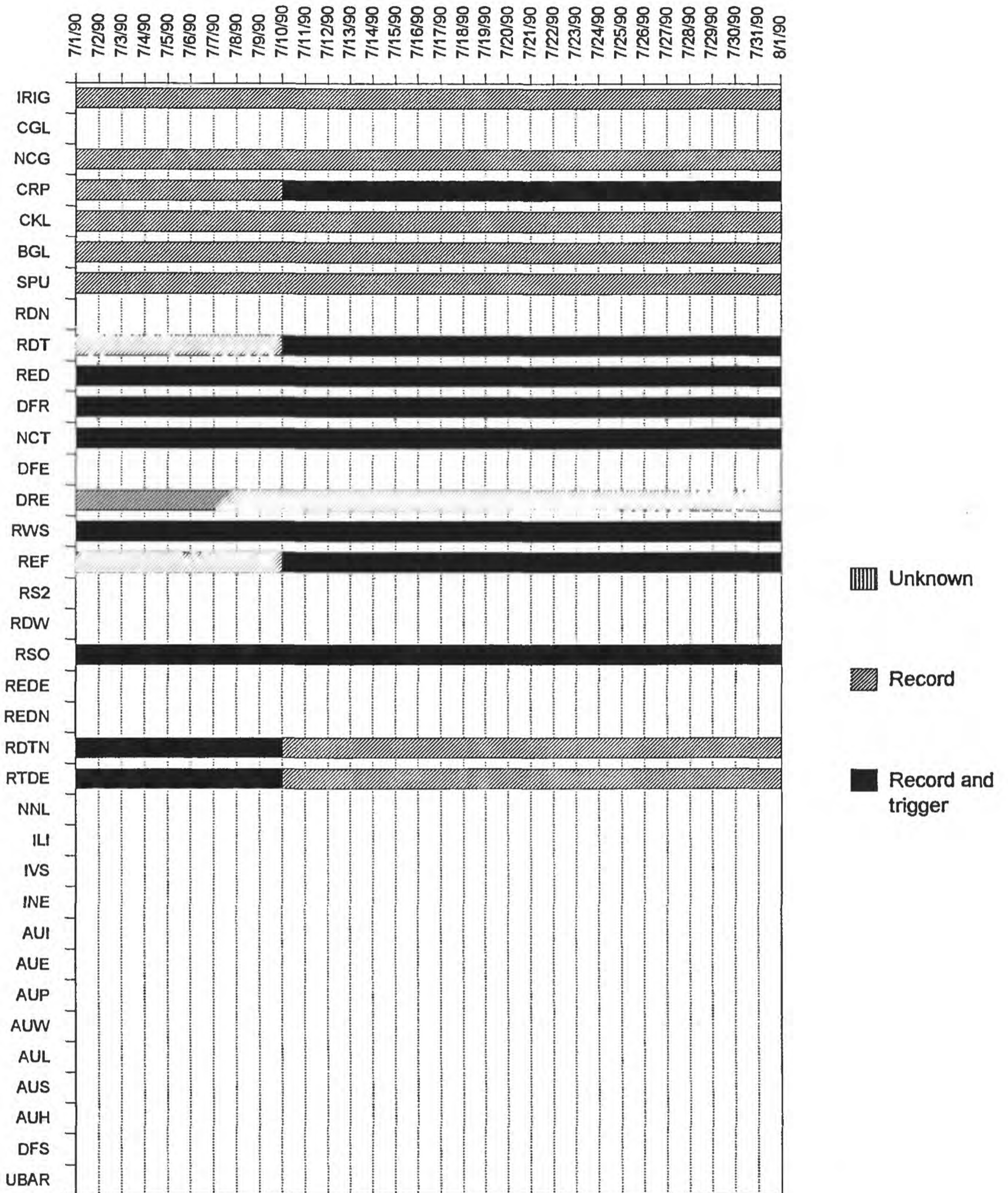


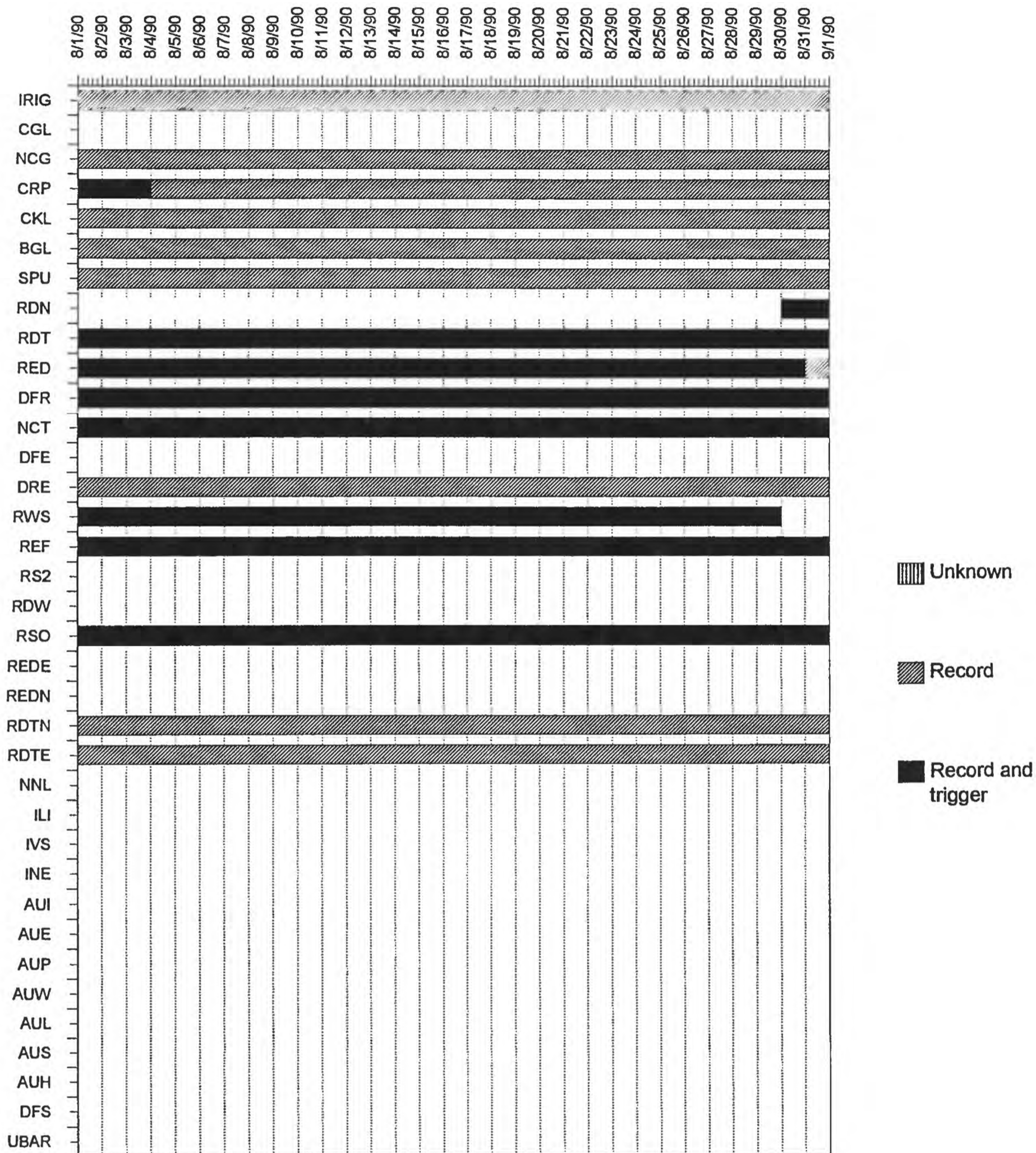


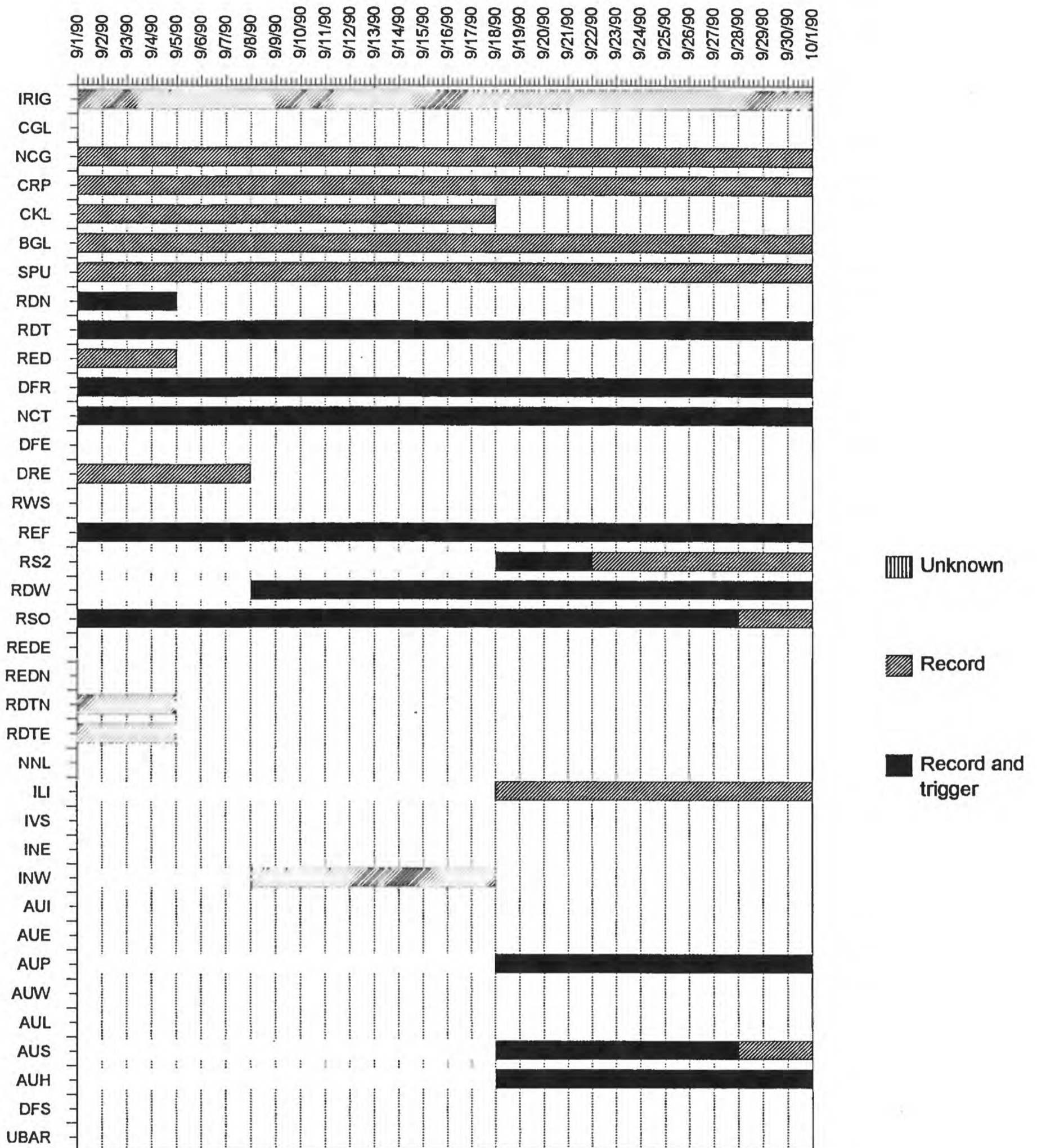


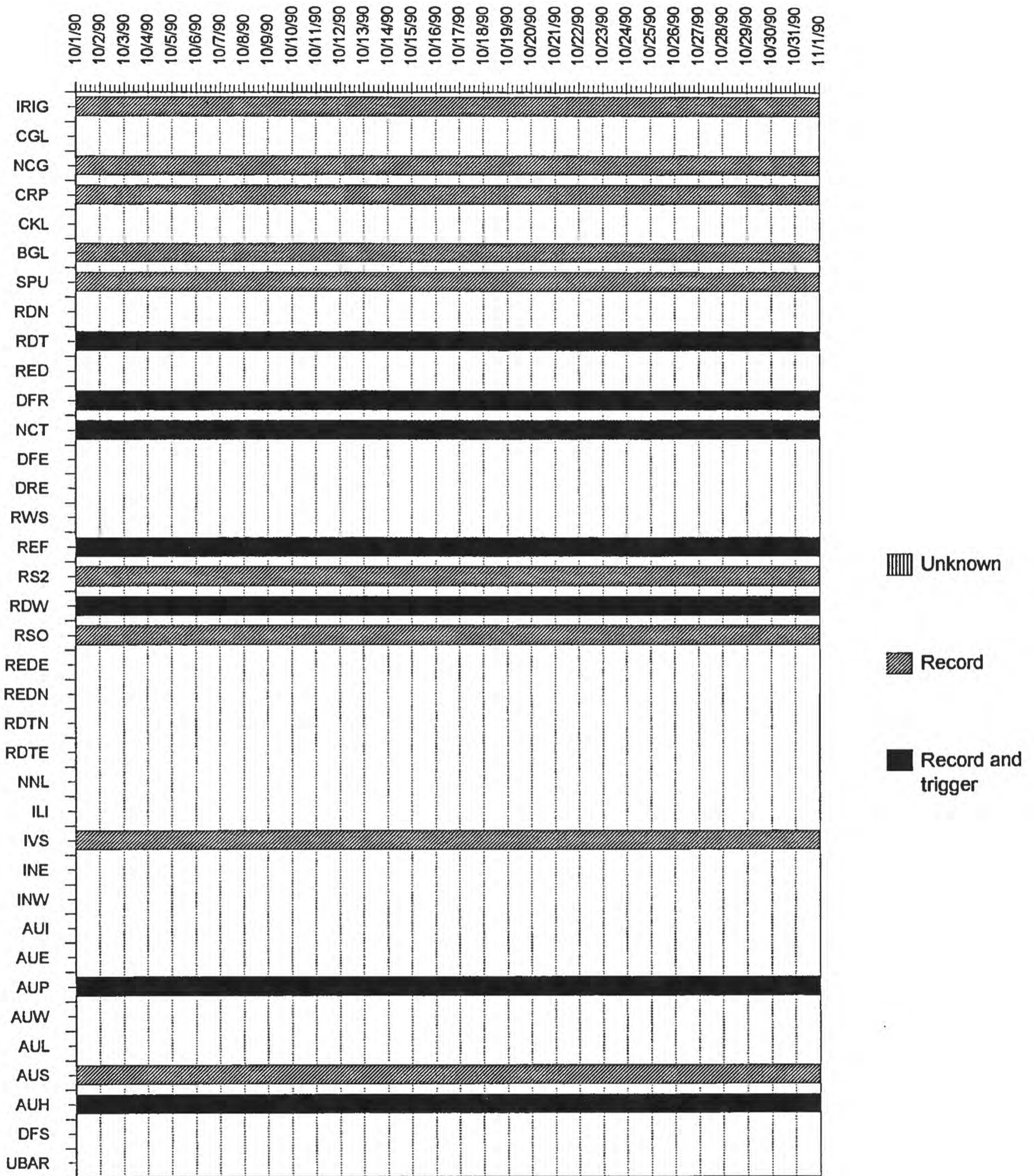


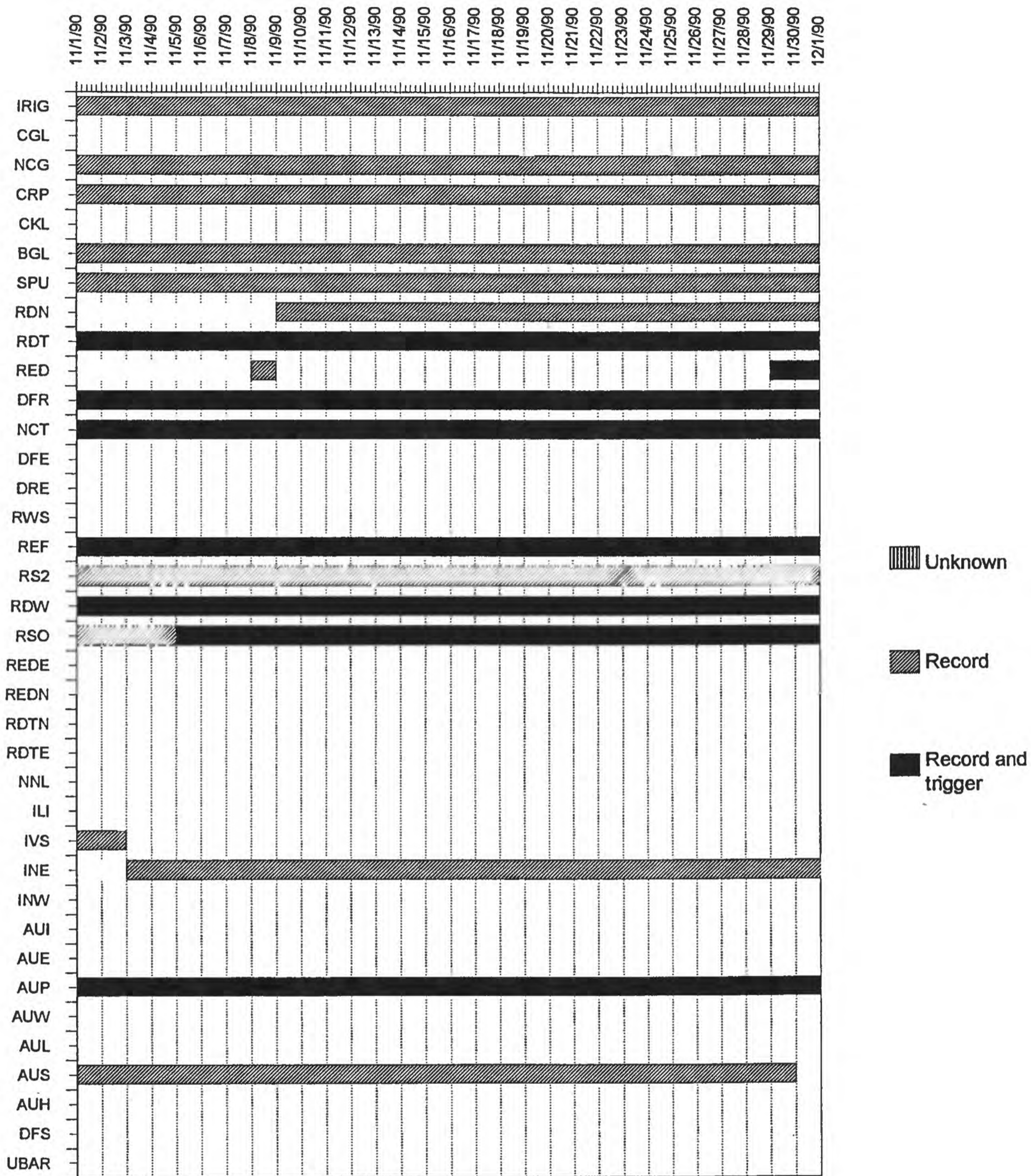


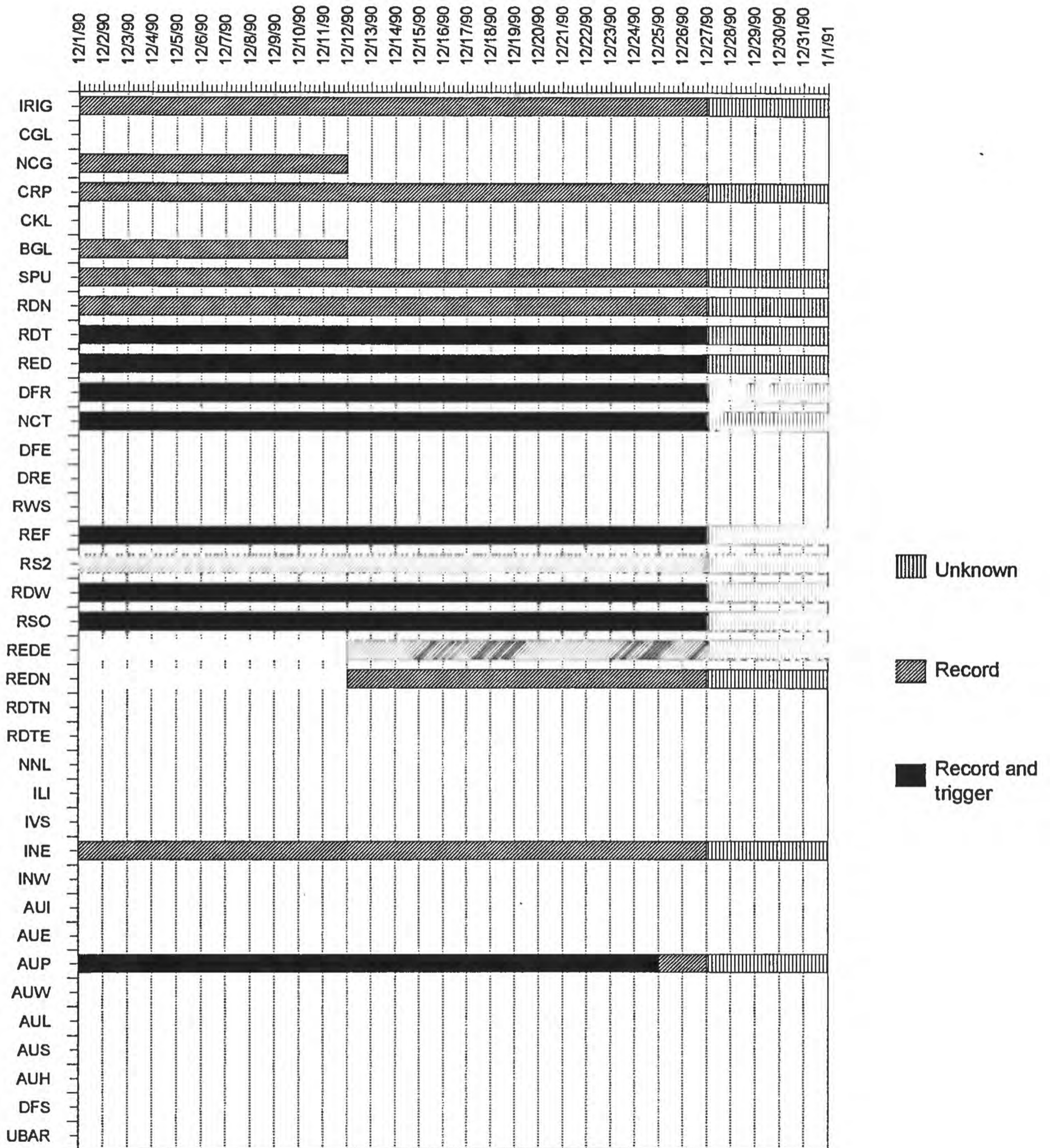












## APPENDIX C

Response curves for stations monitored by the PC/AT seismic acquisition system from December, 1989 through December, 1990. Calibration data is not available for stations CGL, REDN, REDE, and NNL during the report period. No calibration data is available for station RED between August 30 and December 21, 1990. Prior to August 30, 1990, station RED used a monitron VCO, so calculation of its response curve uses separate parameters. All other stations use the A1VCO (Rogers and others, 1980).

### Station Response Curves

Frequency	CRP	NCG	CGL	SPU	BGL	CKL	RDT	DFR
0.012589	4.655144	9.879016	no	20.453144	5.266	5.560896	7.983256	9.078584
0.015849	12.384398	26.281822	calibration	54.412898	14.0095	14.794032	21.238402	24.152378
0.019953	29.40626	62.40514	available	129.20126	33.265	35.12784	50.42974	57.34886
0.025119	98.60799	209.26311		433.25049	111.5475	117.79416	169.10601	192.30789
0.031623	344.318	730.702		1512.818	389.5	411.312	590.482	671.498
0.039811	761.632322	1616.31475		3346.3574	861.575025	909.823226	1306.14774	1485.35534
0.050119	1837.04042	3898.51565		8071.3405	2078.10003	2194.47363	3150.39964	3582.64444
0.063096	5322.7848	11295.8646		23386.5341	6021.24978	6358.43976	9128.21466	10380.6346
0.079433	13071.0453	27739.0056		57429.7962	14786.2503	15614.2803	22415.9555	25491.4955
0.100000	31720.1311	67315.5723		139367.635	35882.5012	37891.9213	54397.8719	61861.4321
0.125893	72633.8622	154141.545		319128.87	82165.0025	86766.2426	124562.144	141652.464
0.158489	155046.974	329036.339		681224.489	175392.505	185214.485	265895.037	302376.678
0.199526	329621.5	699513.5		1448246.5	372875	393756	565278.5	642836.5
0.251189	698558.9	1482462.1		3069233.9	790225	834477.6	1197981.1	1362347.9
0.316228	1418157	3009573		6230907	1604250	1694088	2432043	2765727
0.398107	2905045	6165005		12763795	3286250	3470280	4981955	5665495
0.501187	5874843	12467427		25812093	6645750	7017912	10074957	11457273
0.630957	11652004	24727556		51195004	13181000	13919136	19982396	22724044
0.794328	21345948	45299772		93786948	24147000	25499232	36606852	41629428
1.000000	35751170	75870130		157078670	40442500	42707280	61310830	69722870
1.258925	53619020	113788780		235584020	60655000	64051680	91952980	104569220
1.584893	73480290	155937810		322847790	83122500	87777360	126013710	143303190
1.995262	95757090	203213010		420724590	108322500	114388560	164216910	186747990
2.511886	121987580	258878620		535972580	137995000	145722720	209200420	237903380
3.162278	154065730	326953970		676913230	174282500	184042320	264212270	300463030
3.981072	193993800	411688200		852343800	219450000	231739200	332686200	378331800
5.011872	231453300	491183700		1016928300	261825000	276487200	396926700	451386300
6.309573	284979500	604775500		1252104500	322375000	340428000	488720500	555774500
7.943282	347787700	738065300		1528062700	393425000	415456800	596432300	678264700
10.000000	414419200	879468800		1820819200	468800000	495052800	710700800	808211200
12.589254	475127900	1008303100		2087552900	537475000	567573600	814812100	926606900
15.848932	548455700	1163917300		2409730700	620425000	655168800	940564300	1069612700
19.952623	535372500	1136152500		2352247500	605625000	639540000	918127500	1044097500
25.118864	551881200	1171186800		2424781200	624300000	659260800	946438800	1076293200
31.622777	422994000	897666000		1858494000	478500000	505296000	725406000	824934000
39.810717	386860500	820984500		1699735500	437625000	462132000	663439500	754465500
50.118723	305201000	647689000		1340951000	345250000	364584000	523399000	595211000
63.095734	230790300	489776700		1014015300	261075000	275695200	395789700	450093300
79.432823	97295250	206477250		427482750	110062500	116226000	166854750	189747750
100.000000	74017320	157077480		325207320	83730000	88418880	126934680	144350520

# Station Response Curves

NCT	RDN *	RDN +	REF	RSO	RWS	RDW	RS2	RDTN
4.865784	4.52876	5.076424	4.613016	5.16068	3.854712	4.697272	4.549824	2.295976
12.944778	12.04817	13.505158	12.272322	13.72931	10.254954	12.496474	12.104208	6.108142
30.73686	28.6079	32.06746	29.14014	32.5997	24.34998	29.67238	28.74096	14.50354
103.06989	95.93085	107.53179	97.71561	109.31655	81.65277	99.50037	96.37704	48.63471
359.898	334.97	375.478	341.202	381.71	285.114	347.434	336.528	169.822
796.095323	740.954522	830.558324	754.739722	844.343525	630.672918	768.524922	744.400822	375.646711
1920.16442	1787.16602	2003.28842	1820.41562	2036.53802	1521.16922	1853.66522	1795.47842	906.051611
5563.63479	5178.27481	5804.48478	5274.6148	5900.82478	4407.55484	5370.9548	5202.35981	2625.2649
13662.4953	12716.1753	14253.9453	12952.7553	14490.5253	10823.5352	13189.3353	12775.3203	6446.80513
33155.4311	30858.9511	34590.7312	31433.0711	35164.8512	26265.9909	32007.1911	31002.4811	15644.7705
75920.4623	70661.9021	79207.0624	71976.5421	80521.7024	60144.7818	73291.1822	70990.5621	35823.9411
162062.675	150837.554	169078.375	153643.834	171884.655	128387.314	156450.114	151539.124	76471.1321
344536.5	320672.5	359451.5	326638.5	365417.5	272944.5	332604.5	322164	162573.5
730167.9	679593.5	761776.9	692237.1	774420.5	578444.7	704880.7	682754.4	344538.1
1482327	1379655	1546497	1405323	1572165	1174311	1430991	1386072	699453
3036495	2826175	3167945	2878755	3220525	2405535	2931335	2839320	1432805
6140673	5715345	6406503	5821677	6512835	4864689	5928009	5741928	2897547
12179244	11335660	12706484	11546556	12917380	9648492	11757452	11388384	5746916
22311828	20766420	23277708	21152772	23664060	17675604	21539124	20863008	10528092
37368870	34780550	38986570	35427630	39633650	29603910	36074710	34942320	17632930
56045220	52163300	58471420	53133780	59441900	44399460	54104260	52405920	26445580
76805190	71485350	80130090	72815310	81460050	60845670	74145270	71817840	36241410
100089990	93157350	104422890	94890510	106156050	79292070	96623670	93590640	47228610
127507380	118675700	133027180	120883620	135235100	101012340	123091540	119227680	60165820
161037030	149882950	168008330	152671470	170796850	127574790	155459990	150580080	75987170
202771800	188727000	211549800	192238200	215061000	160637400	195749400	189604800	95680200
241926300	225169500	252399300	229358700	256588500	191655900	233547900	226216800	114155700
297874500	277242500	310769500	282400500	315927500	235978500	287558500	278532000	140555500
363524700	338345500	379261700	344640300	385556500	287987100	350935100	339919200	171533300
433171200	403168000	451923200	410668800	459424000	343161600	418169600	405043200	204396800
496626900	462228500	518125900	470828100	526725500	393431700	479427700	464378400	234339100
573272700	533565500	598089700	543492300	608016500	454151100	553419100	536047200	270505300
559597500	520837500	583822500	530527500	593512500	443317500	540217500	523260000	264052500
576853200	536898000	601825200	546886800	611814000	456987600	556875600	539395200	272194800
442134000	411510000	461274000	419166000	468930000	350262000	426822000	413424000	208626000
404365500	376357500	421870500	383359500	428872500	320341500	390361500	378108000	190804500
319011000	296915000	332821000	302439000	338345000	252723000	307963000	298296000	150529000
241233300	224524500	251676300	228701700	255853500	191106900	232878900	225568800	113828700
101697750	94653750	106100250	96414750	107861250	80565750	98175750	95094000	47987250
77366520	72007800	80715720	73347480	82055400	61290360	74687160	72342720	36506280

\* Before 2/15/90

+ After 8/30/90

## Station Response Curves

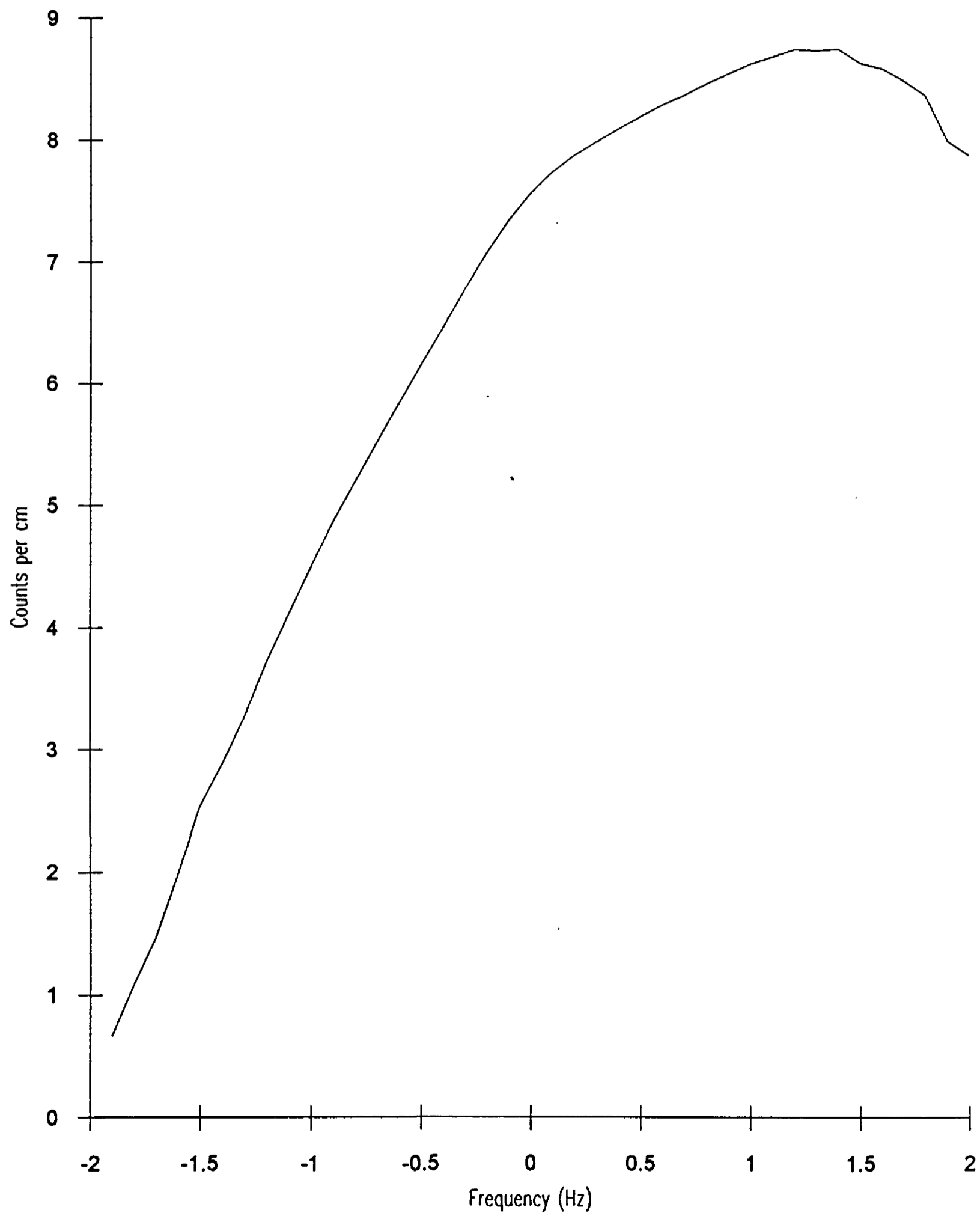
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14.37048	available	available	available	available
48.18852				
168.264				
372.200411				
897.739211				
2601.1799				
6387.66013				
15501.2405				
35495.2811				
75769.5621				
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232189200				
268023600				
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## Monitron VCO

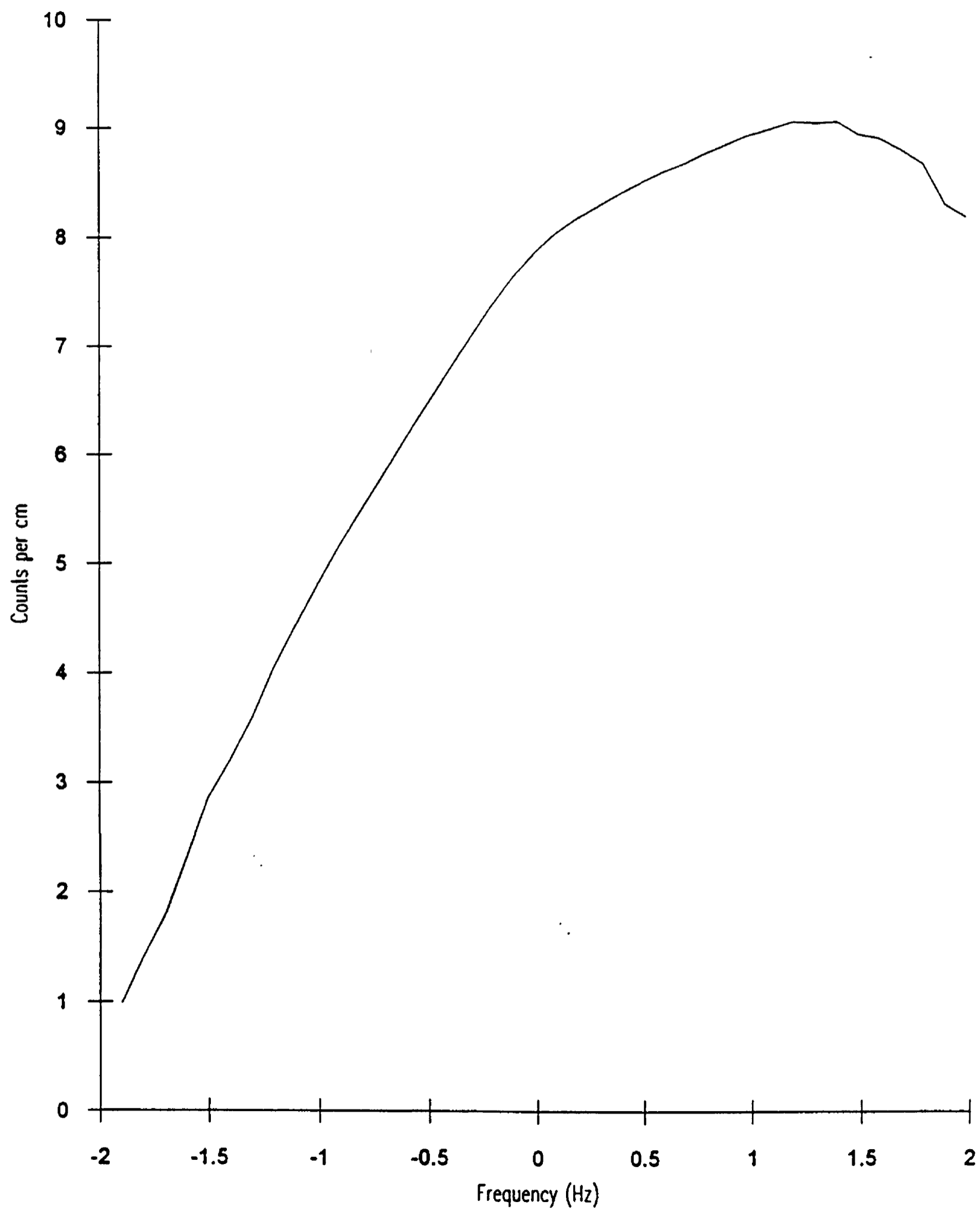
[illegible]

# After 8/30/90, maintained by U.S. Geological Survey  
## Before 8/30/90, maintained by University of Alaska

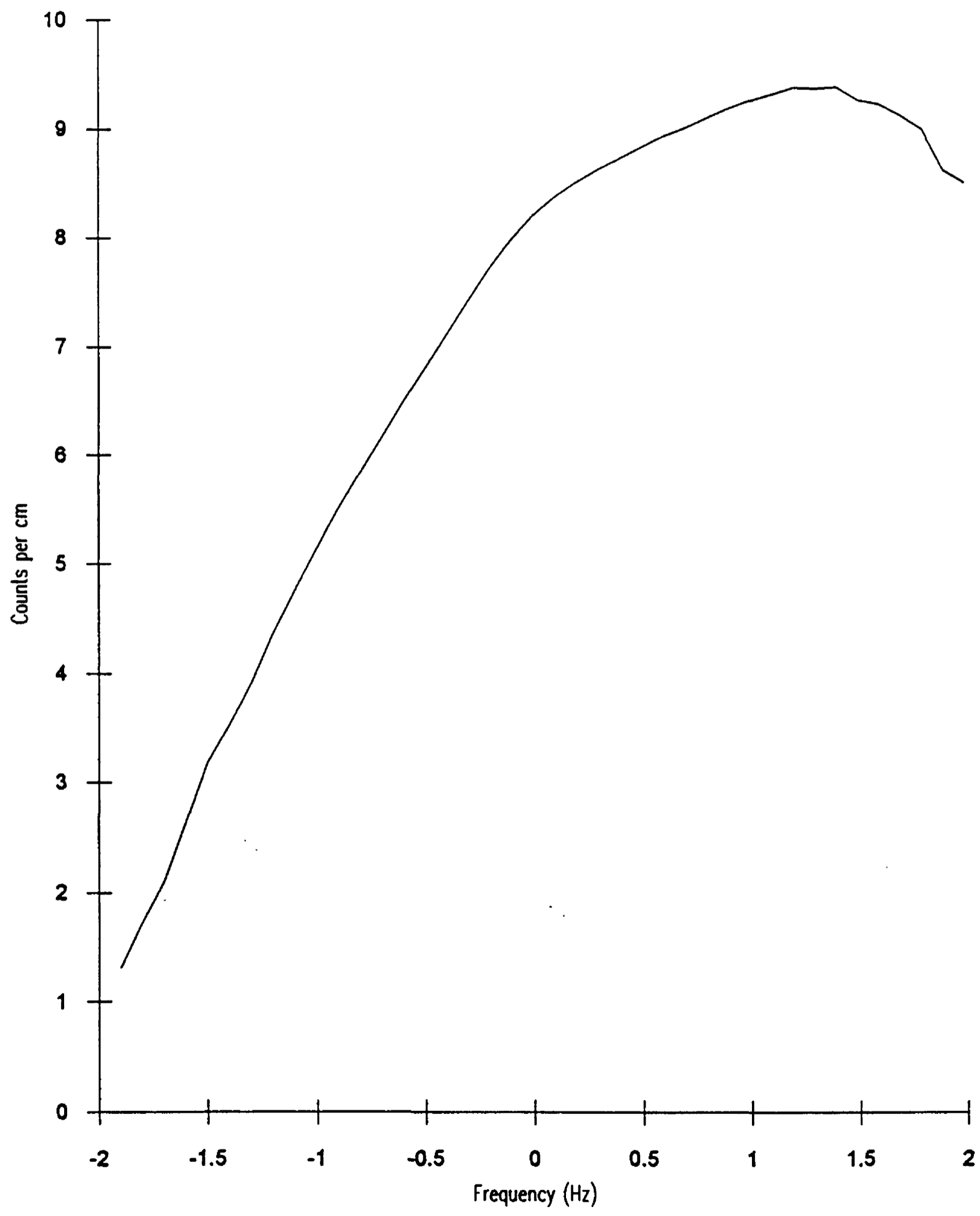
# CRP



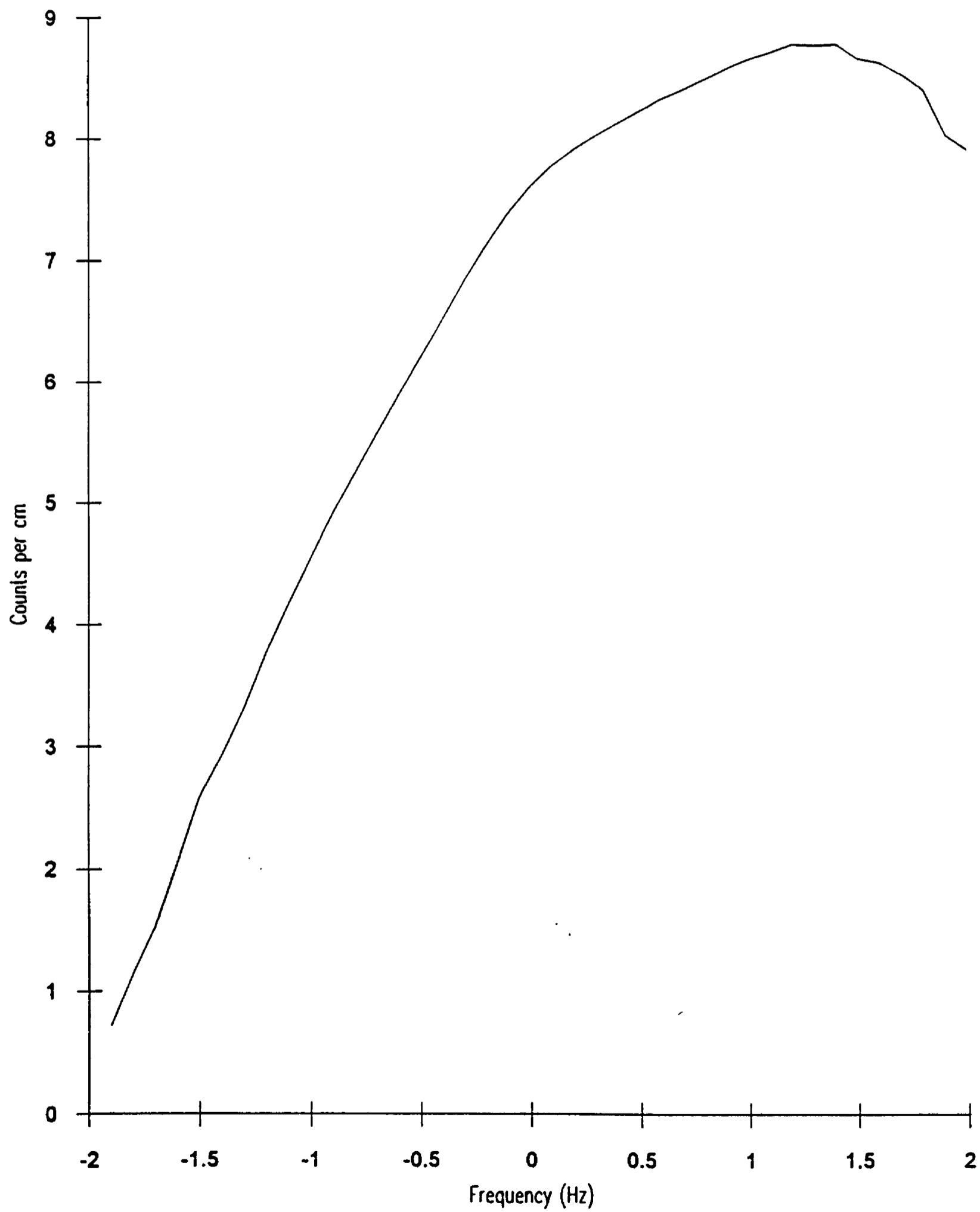
# NCG



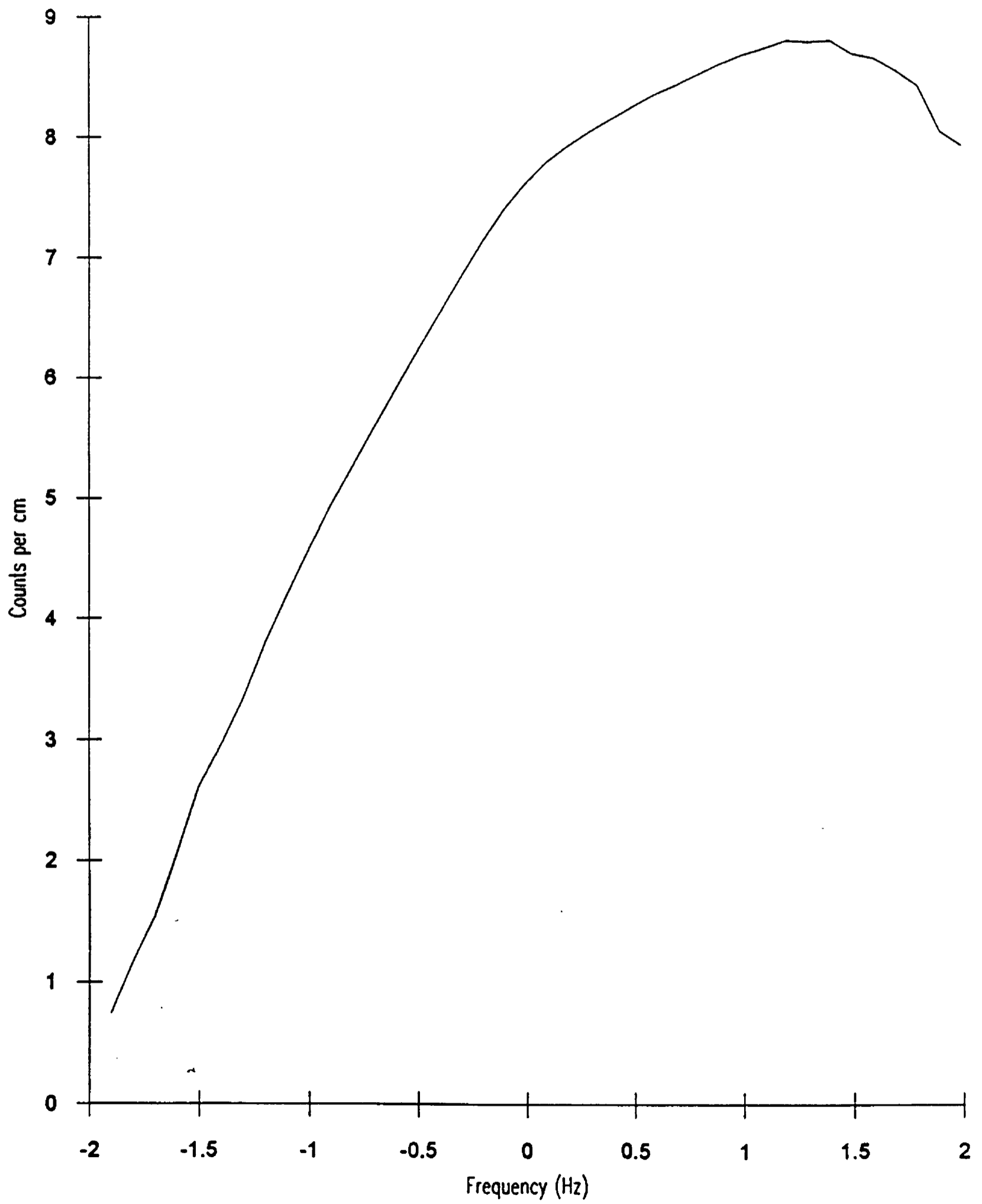
SPU



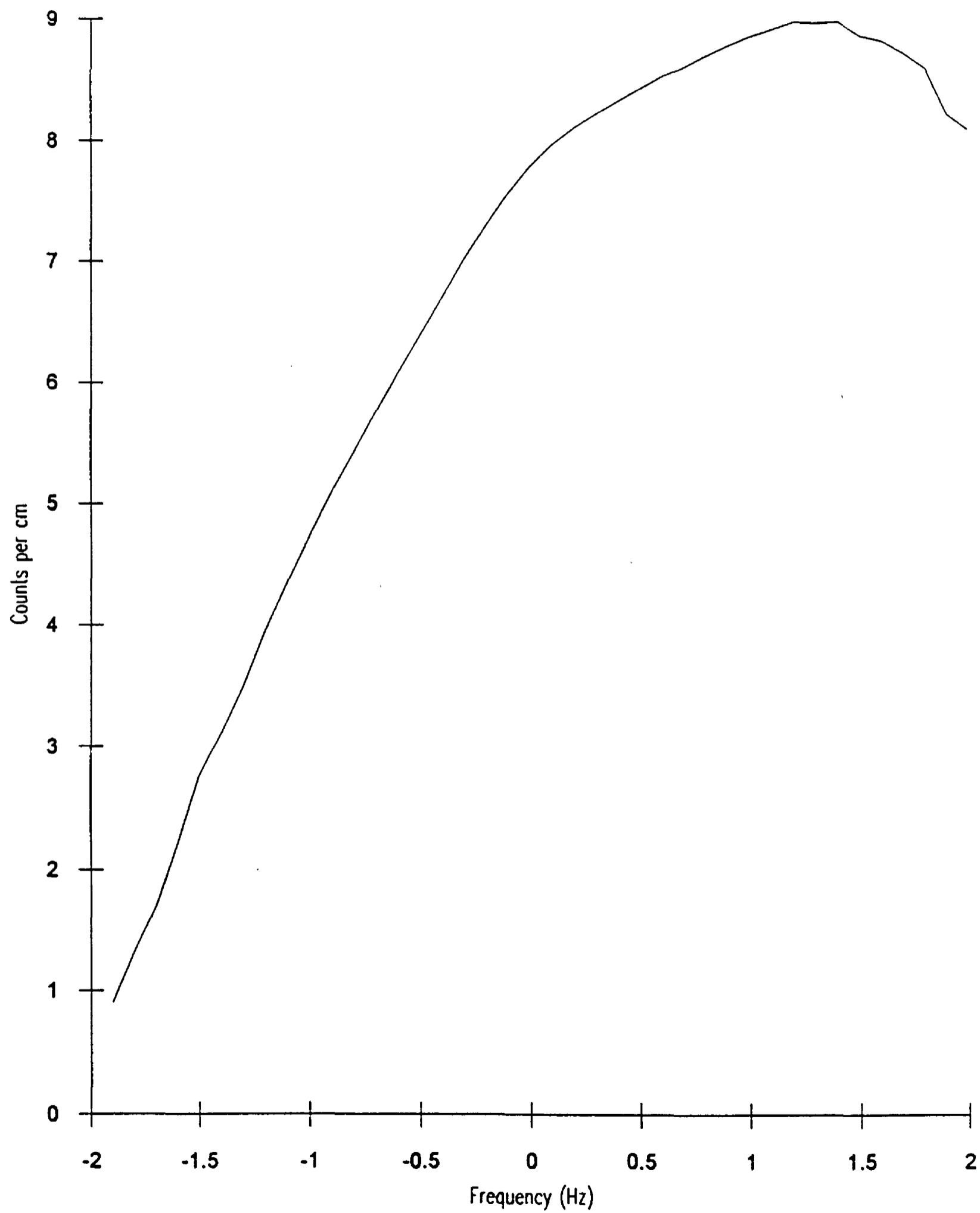
# BGL



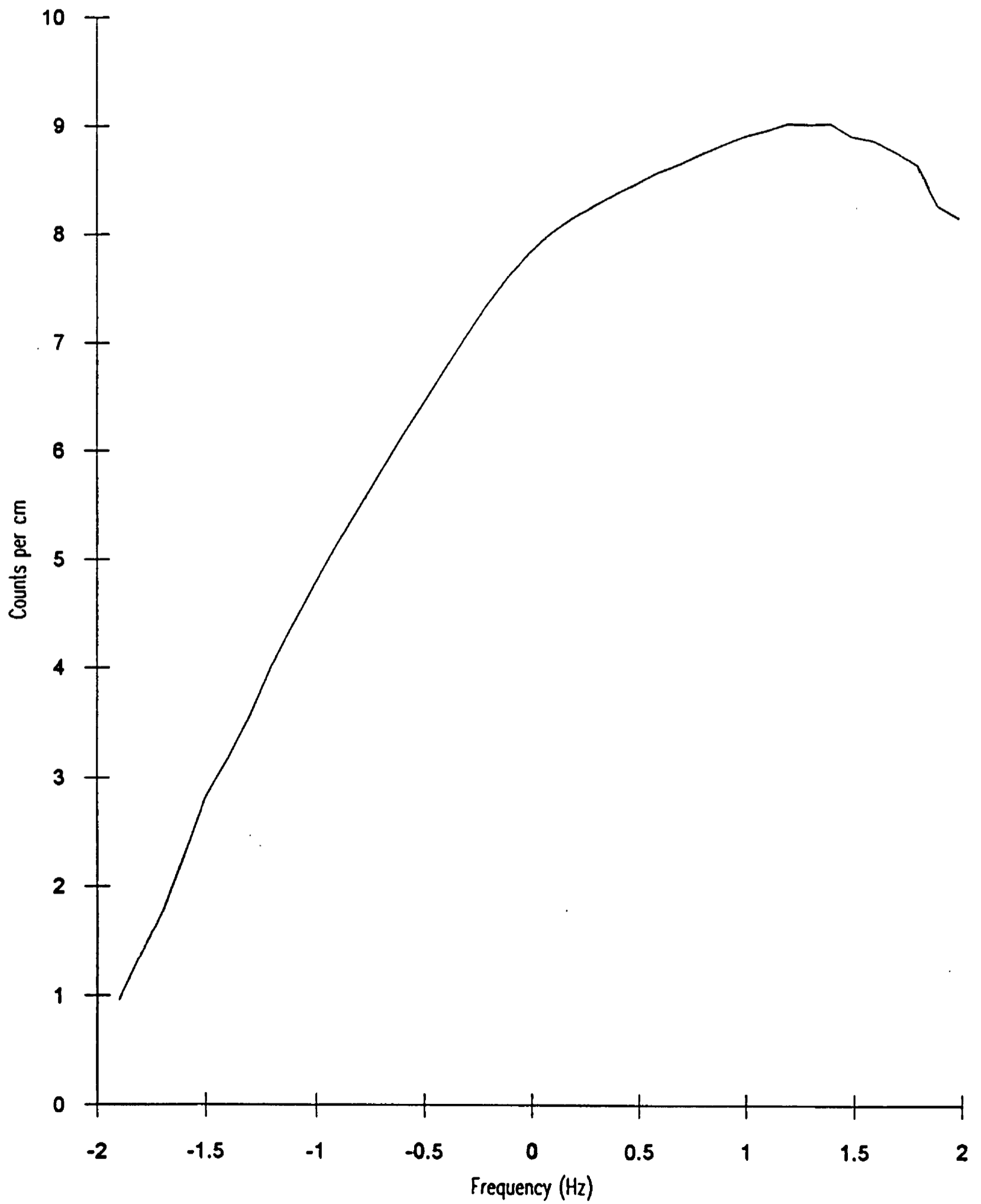
CKL



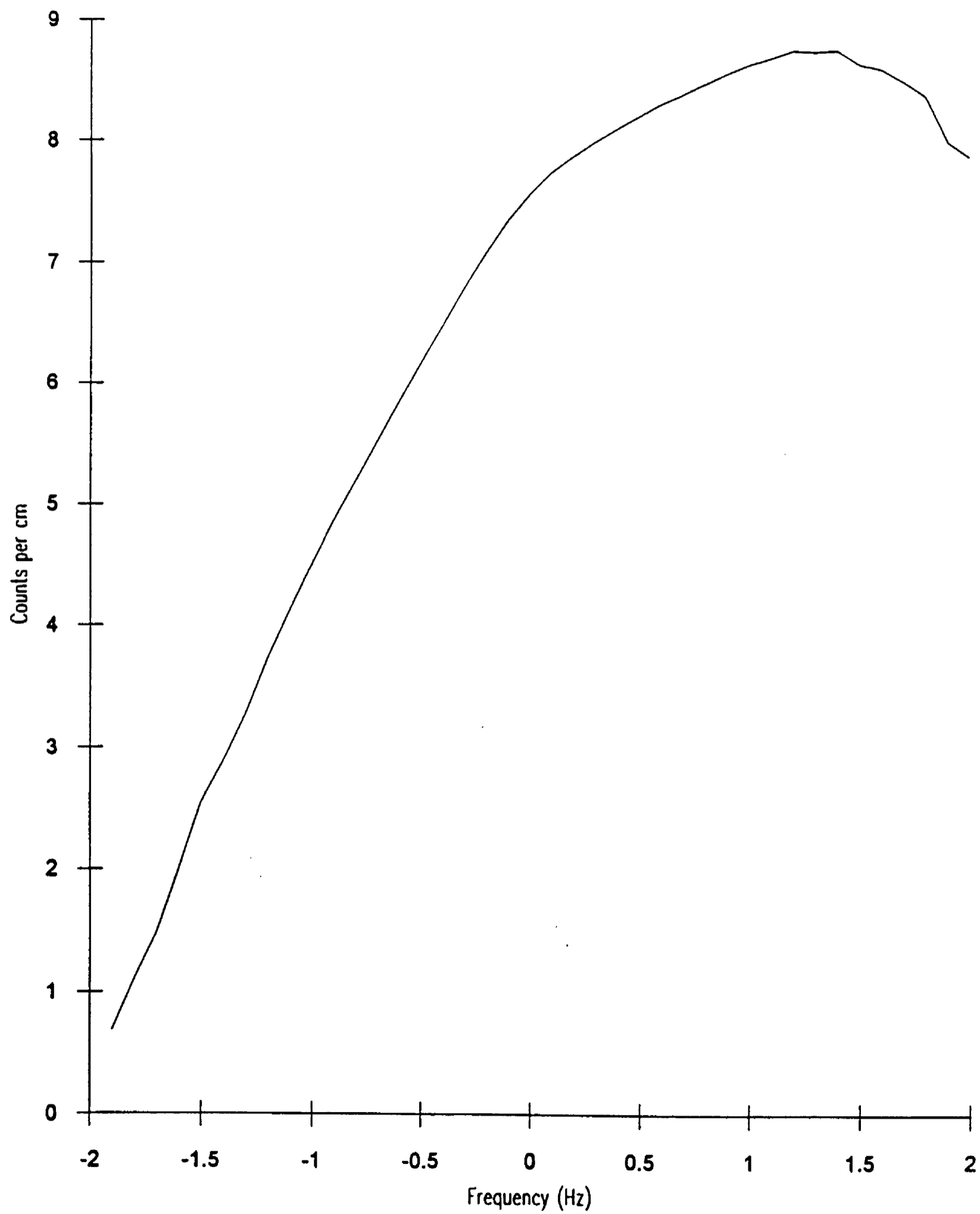
# RDT



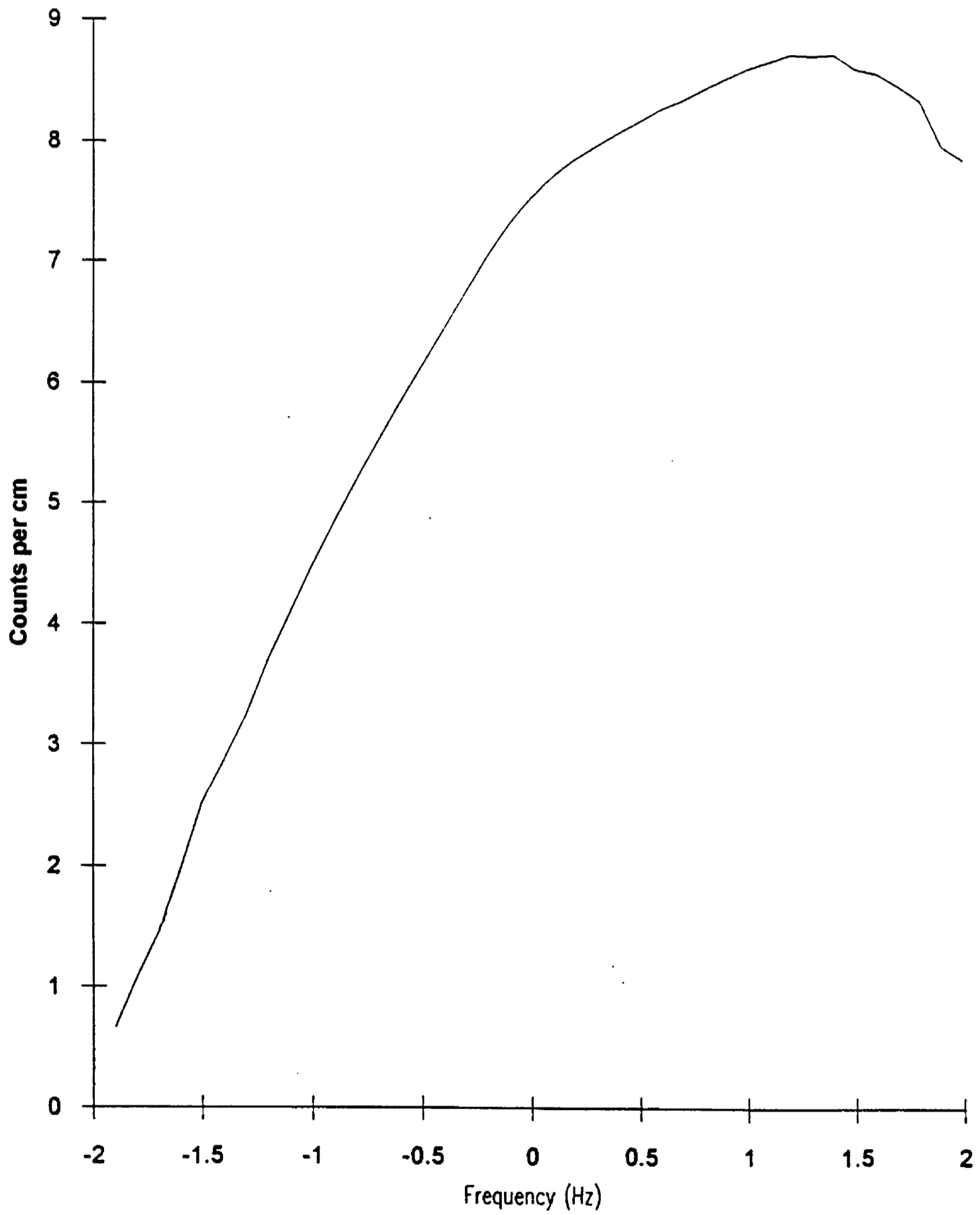
# DFR



NCT

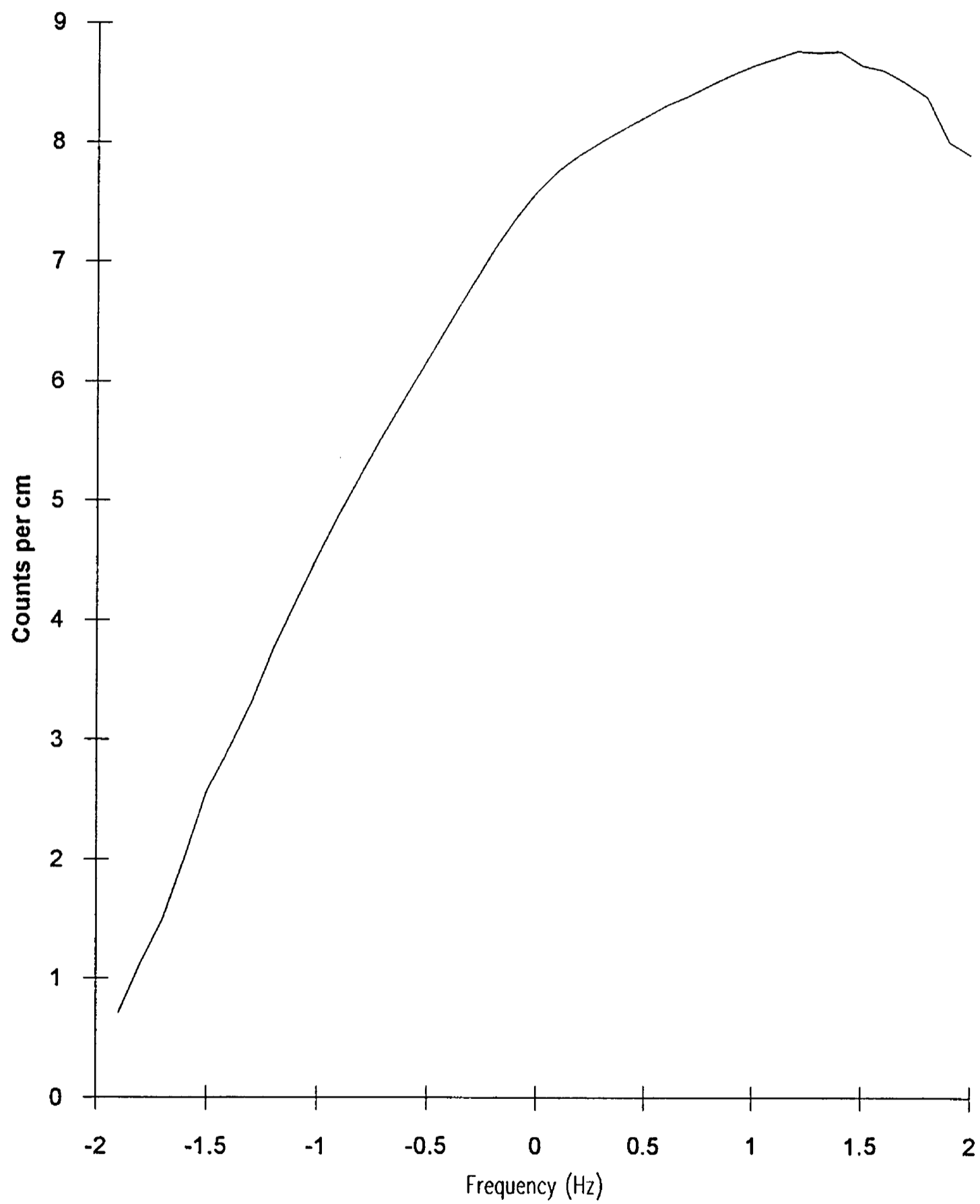


RDN



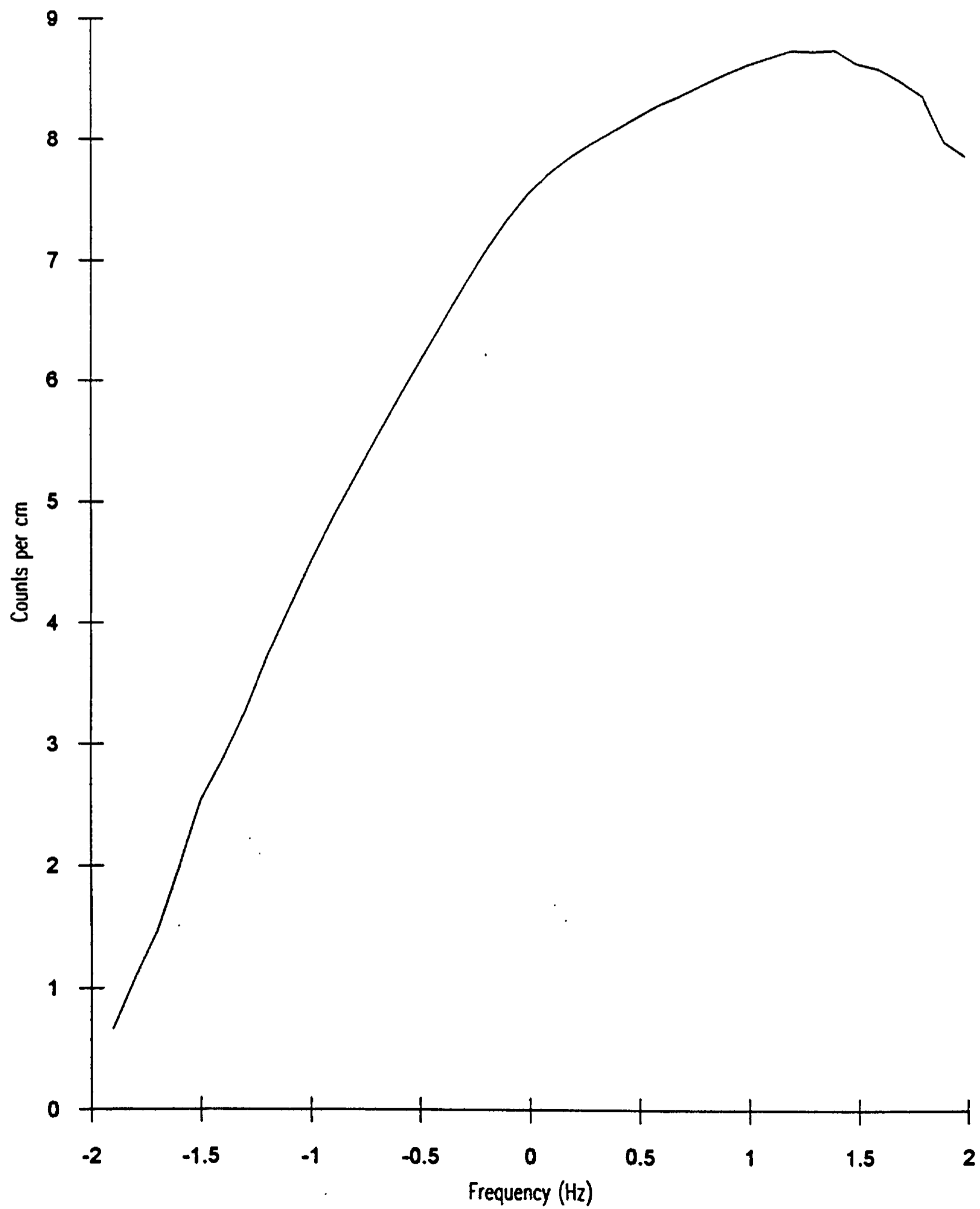
Before February 15, 1990

RDN

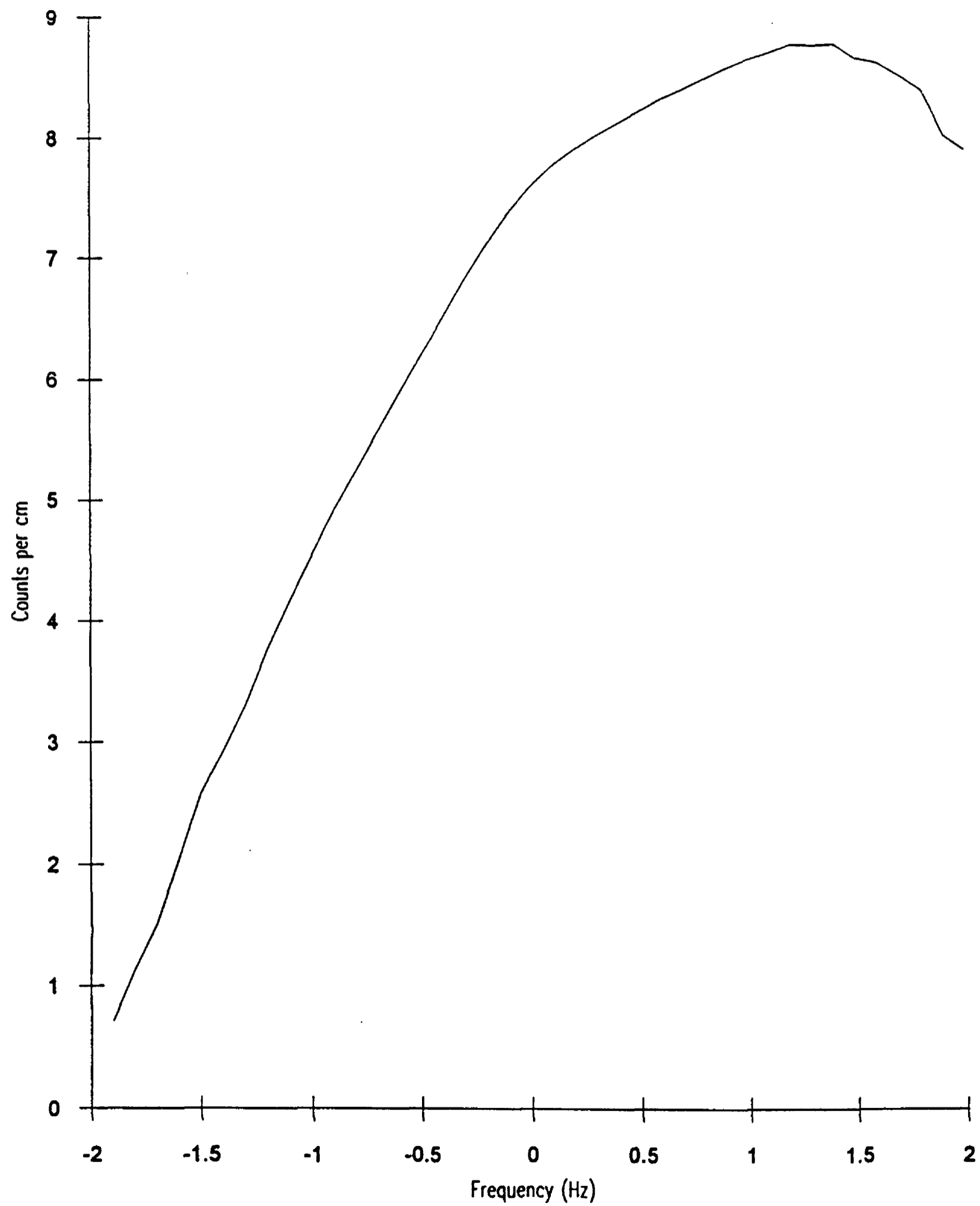


After August 30, 1990

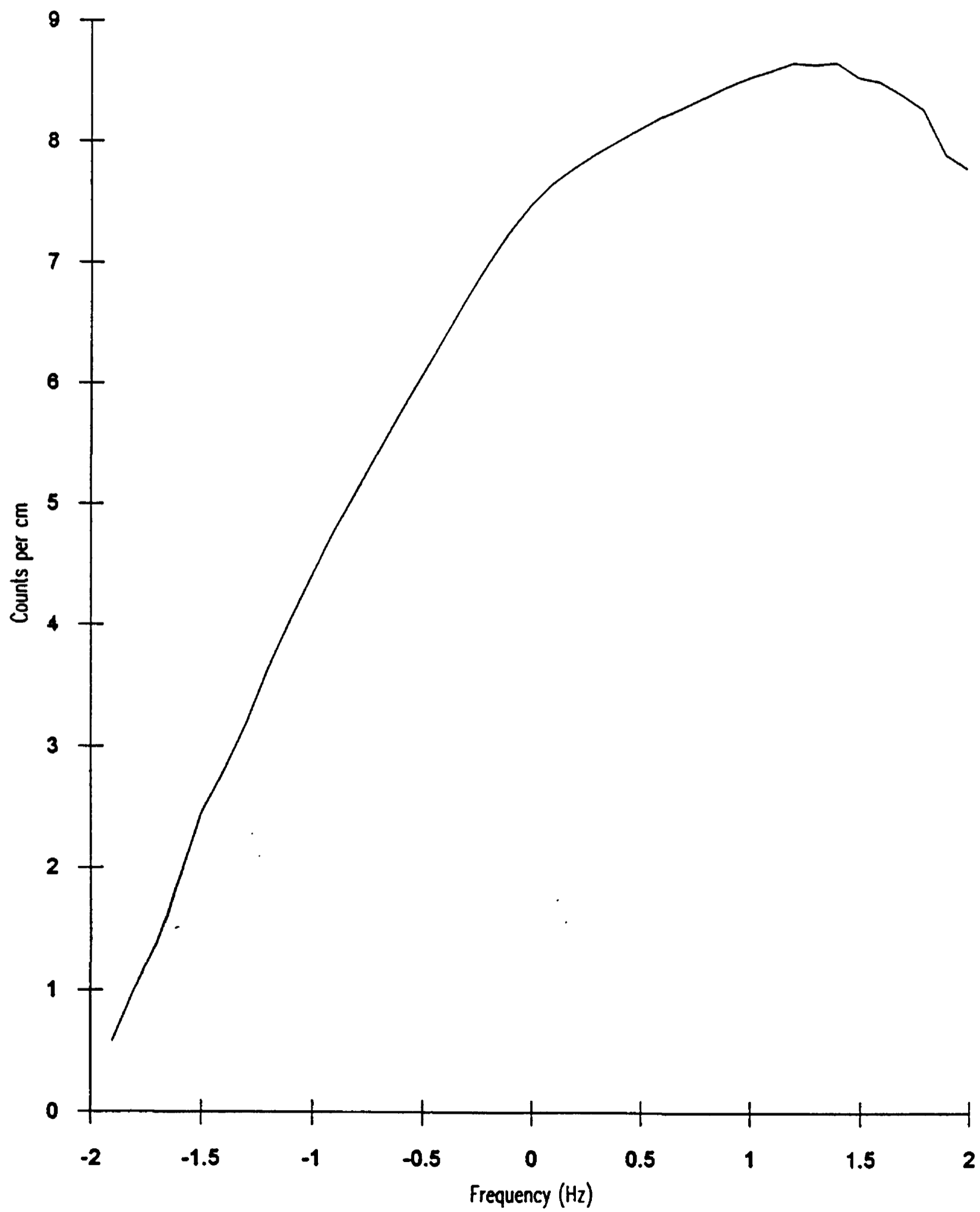
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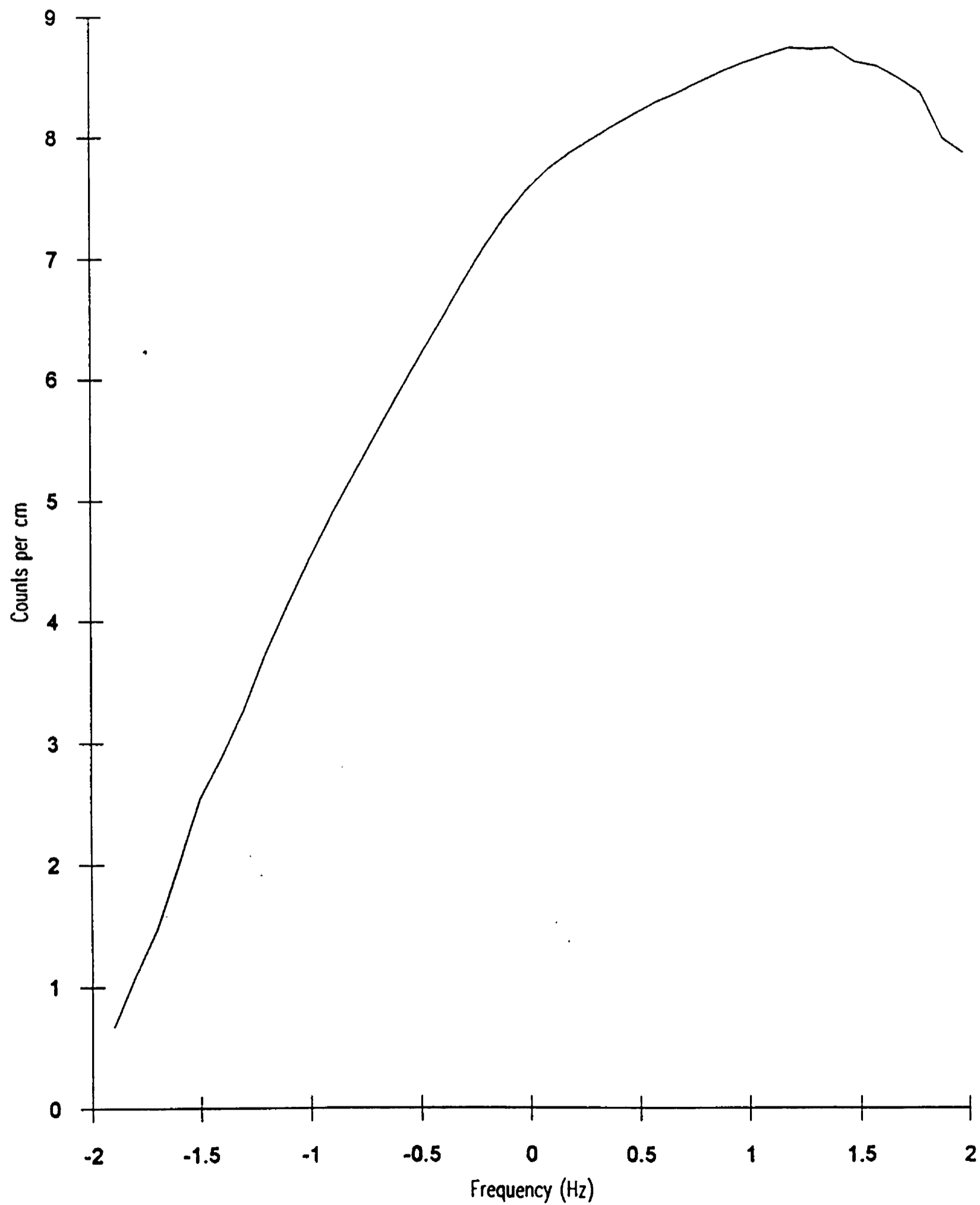
RSO



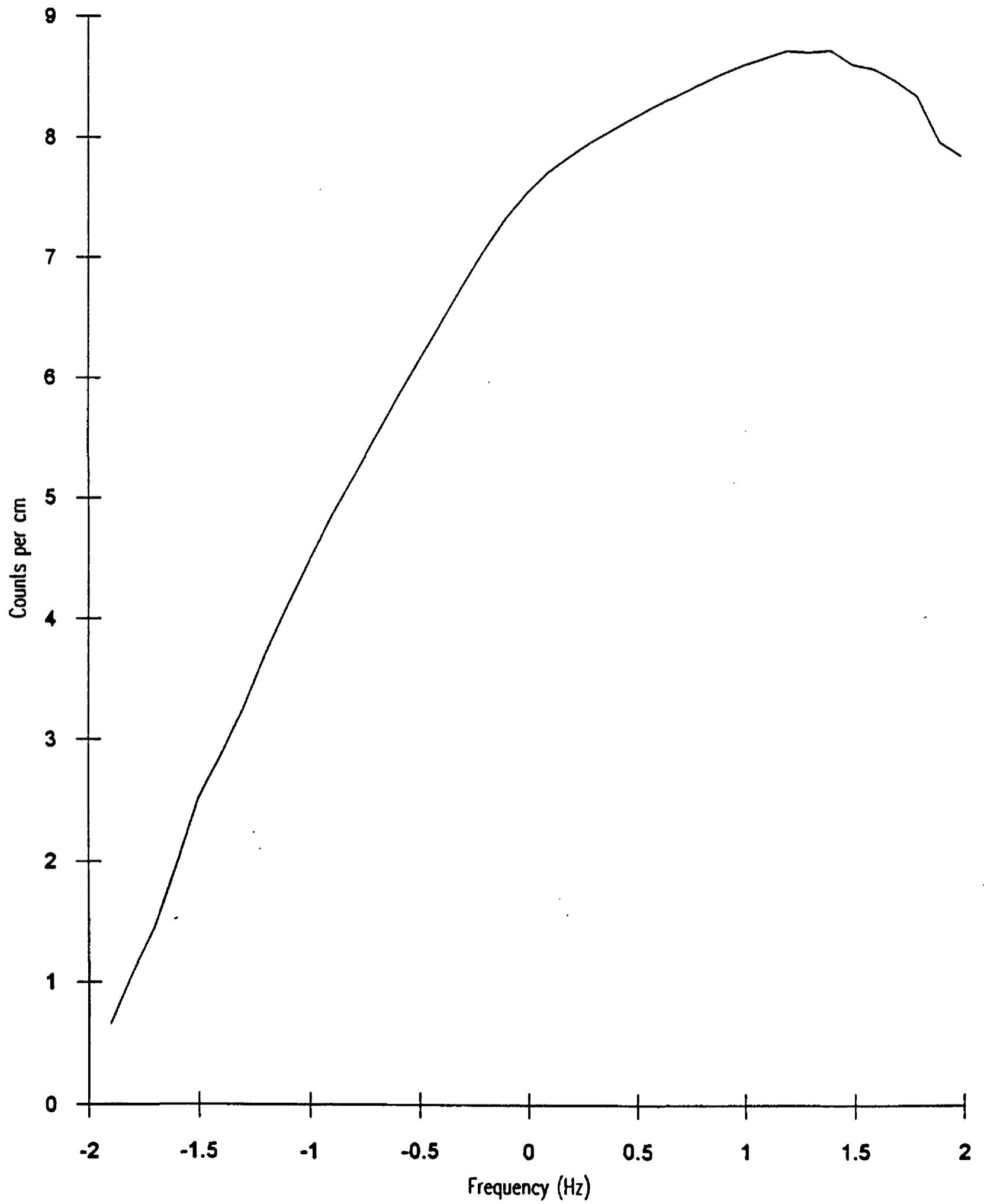
RWS



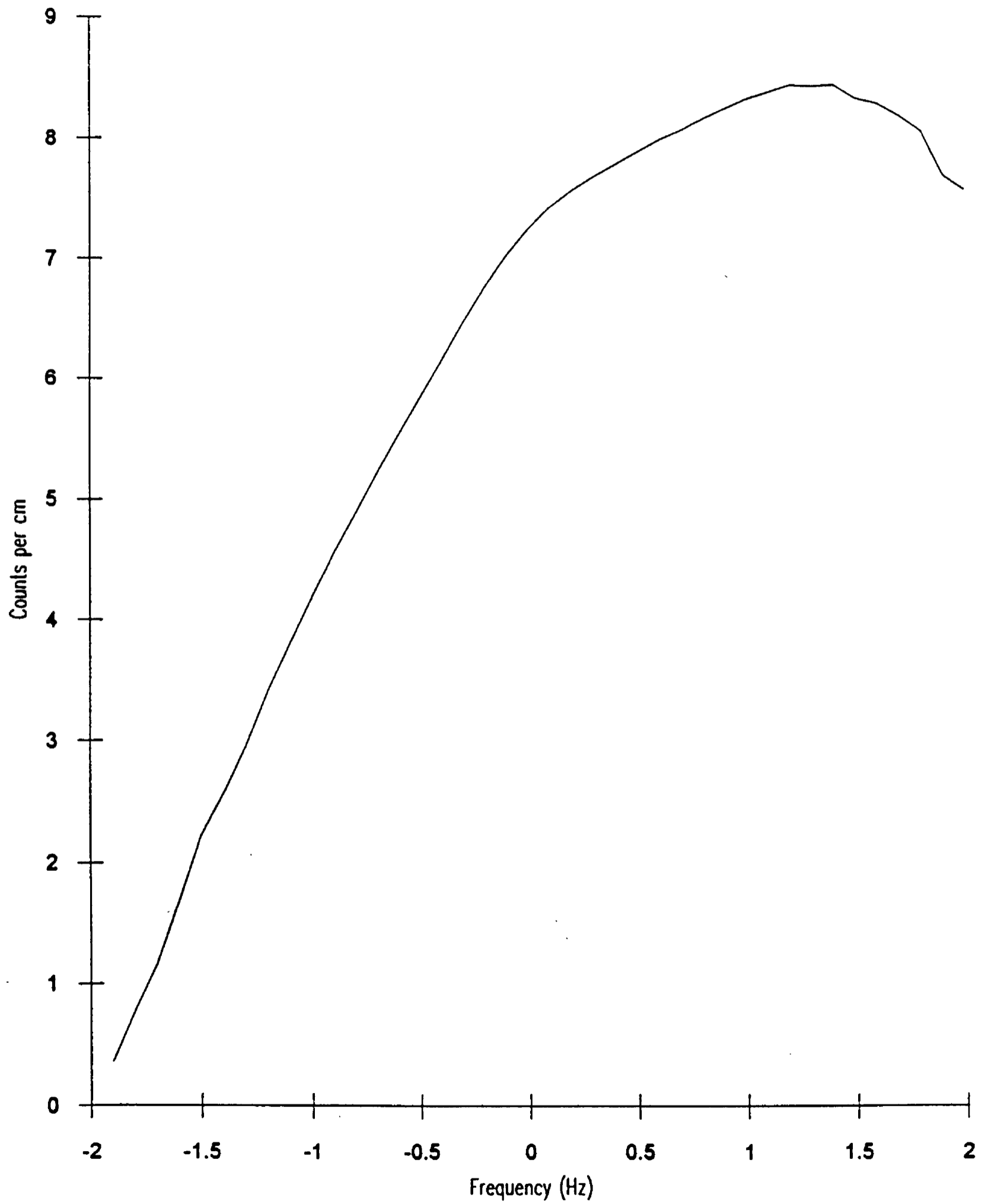
# RDW



RS2



# RDTN



# RDTE

