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Yingping Li
(SUNY at Stony Brook)
Clifford Thurber
(University of Wisconsin-Madison)
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Project ALOHA - a PASSCAL field experiment

A mixed mode PASSCAL/GSN field experiment - Project ALOHA (Arrays for Lithosphere Observations in HAwaii) was carried out in Hawaii, beginning July 19, 1990, to collect digital seismic waveform data from local and teleseismic events. The experiment was supported by NSF. The "local" portion of the experiment using PASSCAL instruments ended December 11, 1990. The main goal of the project is to use converted and reflected seismic waves to map major discontinuities in structure beneath Mauna Loa's southeast flank. During the experiment, we used 16 sets of PASSCAL RefTek instruments, included Data Acquisition Subsystem (DAS), Disk Record Subsystem (DRS), Omega clock, Exabyte Tape Record Subsystem (TRS), and EPSON set up terminal, with 10 sets of 3-component S-13 sensors, four L4-3D seismometers, two CMG3-ESP (Guralp) broadband sensors, and several L4 sensors borrowed from HVO (Hawaiian Volcano Observatory). Two sets of GPS (Global Positioning System) Pathfinder were also used to determine the coordinates for the stations of the ALOHA arrays.

Locations of ALOHA Arrays

We set up four seismic arrays (26 stations) on the Southeast flank of Mauna Loa and one array (5 stations) on the south flank of Kilauea. Our PASSCAL arrays were set up with 4 to 6 three-component digital instruments separated 1 to 2 km in each array. In order to carry out a survey of the broadband ambient seismic noise, we also set up 5 stations equipped with broadband sensor CMG3-ESP on several sites in the center of Island of Hawaii and at the basement of HVO. The coordinates of stations are listed in Table 1 in terms of latitude, longitude, elevation and error. We used GSP Pathfinder to obtain 3–D fix for most of stations so long as signals from four healthy satellites are available. However, we have only 2-D fix for a few stations since sometimes there are not enough satellites available. We checked the GPS readings at HVO's 113 Benchmark, the coordinate of which was determined from a USGS 7.5' topographic map, and found that there was a systematic shift. The systematic differences for latitude and longitude are 11.94" and 9.60" , respectively. That is, LAT (USGS map) = LAT(GPS) + 11.94", and LON (USGS map) = LON (GPS) + 9.60". We also checked several stations whose locations are known and obtained the same result. This difference may due to the use of different geodetic reference surfaces for satellites and USGS maps. In order to make coordinates of the ALOHA arrays compatible with those of stations of HVO seismic network, we give coordinates of our stations (Table 1) after correcting for the systematic difference.

Collected Data

The stations of our arrays equipped with only short-period three-component sensors were set up with two data streams: (1) "microearthquake" triggered data stream with 100 sps and 60 second record (10 second record before trigger mark) and (2) "teleseismic" triggered data stream with 10 sps and 900 second record (30 second record before trigger mark). The lengths of LTA and STA are 1 and 60 seconds for both data streams; while trigger ratio STA/LTA are 4 for the data stream 1 and 3 for the data stream 2, respectively. For the stations equipped with broadband sensors, additional data stream of continuous record with 10 (BP6, BP7, BP7a, and PG6) or 20 (HV1, MK1, MK2, ML1, HV2) sps was set up. The lengths of STA and LTA of "teleseismic" triggered data stream for broadband instrument are 5 and 120 seconds, while trigger ratio STA/LTA is 2.5. We refer continuous, "microearthquake", and "teleseismic" data streams as stream 1, 2 and 3. As of December 11, 1990, we have recorded thousands of locatable local earthquakes and moderate numbers of teleseismic events with the instruments. The HVO magnitudes of local earthquakes range from 0.5 to 4.8. Most of local earthquakes were recorded on the data steam 2, with some of them on both data streams 2 and 3. Many long-period volcanic events were recorded on data stream 3. The teleseismic events with magnitude (Ms) $\geq$ 6.0 generally recorded on both triggered data streams. In most cases, Vertical (Z), north-south (N), and east-west (E) component sensors were generally connected with channels 1, 2, and 3; but sometimes, two additional vertical sensors (Z1 and Z2) were connected with channels 4 and 5. In order to compare the performance of the short-period sensor with broadband instrument, a broadband sensor (Guralp) was connected with channel 1, 2, and 3, while a L4-3D seismometer was connected with channels 4, 5, and 6.

Data Arrangement

The data provided to PASSCAL are the result of runs of the program "cluster" on triggered data from individual arrays (with a 2 second window). Thus the data are contained in directories of array name (AN, BP, PG, SF, WG) with "-cluster" suffix, with subdirectories of /year.day, trigger time (/year.day.hour.minute.second), and data stream number (/02 or /03). The data are in the RefTek SEGY format, though some data converted to SAC format may also be present. Preliminary HVO CUSP locations of local earthquakes are provided with the data; note however that HVO times are all in local Hawaii time (GMT minus 10 hours).

Types of Instruments and Other Pertinent Information

The types of instruments at each stations of our PASSCASL-ALOHA arrays are listed in Table 2. This table consists of types of instruments (sensor, DAS, and DRS) and operation period. Other information, such as preamp-gain, Omega clock health condition, trigger ratio, and site condition for each station are summarized in Table 3.

Table 1. Station Locations of ALOHA Arrays

Station	Latitude	Longitude	Elevation(m)	3-D fix error
AN1	19° 22.278'	155° 24.655'	1286	2.8
AN1a	19° 22.457'	155° 26.754'	1440	3.2
AN2	19° 22.302'	155° 25.905'	1280	3.1
AN3	19° 22.705'	155° 24.950'	1505	3.0
AN4	19° 23.137'	155° 24.502'	1482	2.5
AN5	19° 22.647'	155° 27.328'	1516	3.0
BP1	19° 26.208'	155° 18.637'	1210	3.3
BP2	19° 26.667'	155° 18.667'	1270	4.6
BP3	19° 26.758'	155° 19.775'	1370	3.5
BP4	19° 25.298'	155° 20.068'	1120	3.5
BP5	19° 25.147'	155° 18.977'	1082	2.9
BP5a	19° 25.035'	155° 18.997'	1123	4.0
BP6	19° 27.577'	155° 20.397'	1560	3.5
BP7	19° 26.418'	155° 20.777'	1425	2.6
BP7a	19° 24.625'	155° 20.010'	1085	3.5
PG1	19° 11.845'	155° 33.082'	703	2.2*
PG2	19° 10.192'	155° 32.505'	400	2.2*
PG3	19° 11.588'	155° 30.957'	446	3.0
PG4	19° 10.757'	155° 33.783'	640	3.3*
PG5	19° 11.738'	155° 32.500'	679	3.8
PG6	19° 11.933'	155° 31.925'	607	2.7
SF1	19° 19.587'	155° 13.393'	700	2.3*
SF2	19° 20.427'	155° 13.508'	904	2.6
SF3	19° 20.818'	155° 12.957'	899	2.7
SF4	19° 19.840'	155° 11.177'	722	4.0
SF5	19° 19.115'	155° 07.845'	411	2.3*
WG2	19° 16.100'	155° 27.825'	601	4.2
WG3	19° 17.730'	155° 27.458'	869	3.5
WG4	19° 16.995'	155° 27.340'	731	3.1
WG4a	19° 18.513'	155° 28.077'	996	4.6
WG5	19° 17.292'	155° 28.342'	893	3.6
HV1	19° 25.400	155° 17.600'	1240	**
HV2	19° 25.400	155° 17.600'	1240	**
MK1	19° 46.950	155° 27.500'	3396	**
MK2	19° 45.290	155° 31.650'	1982	**
ML1	19° 36.310	155° 29.130'	2445	**

* 2-D fix only and elevation is based on USGS 7.5' topographic map.
** Digitized from USGS 7.5' topographic map.

Table 2. Types of Instrument and Operation Period

Station	Operation Period	Equipment	
AN1	07/27 (209) - 08/23 (236)	Sensor:	L4-3D #582
		DAS:	#231
		DRS:	#5051
AN1a	08/23 (236) - 09/13 (256)	Sensor:	L4-3D #582
		DAS:	#363
		DRS:	#5070
AN2	07/27 (209) - 09/13 (256)	Sensor:	L4-3D #581
		DAS:	#393
		DRS:	#5071
AN3	07/27 (209) - 09/13 (256)	Sensor:	L4-3D #579
		DAS:	#078
		DRS:	#5050
AN4	07/27/ (209) - 08/07 (219)	Sensor:	L4-3D #578
		DAS:	#358
		DRS:	#5087
	08/07 (219) - 09/13 (256)	Sensor:	L4-3D #578
		DAS:	#358
		DRS:	#5079
AN5	08/23 (236) - 09/13 (256)	Sensor:	S-13
		Z:	#2989
		N:	#2967
		E:	#2956
		DAS:	#358
		DRS:	#5079
BP1	07/18 (199) - 07/19 (200)	Sensor:	S-13
		Z:	#2986
		N:	#2956
		E:	#2995
		DAS:	#363
		DRS:	#5048
	07/19 (200) - 08/10 (223)	DRS:	#5043
	08/10 (223) - 08/22 (234)	DRS:	#5070
BP2	07/19 (200) - 08/22 (234)	Sensor:	S-13
		Z:	#2966
		N:	#2952
		E:	#2955
		DAS:	#371
		DRS:	#5053
BP3	07/19 (201) - 08/21(233)	Sensor:	S-13
		Z:	#2964
		N:	#2997
		E:	#2965

		DAS:	#341
		DRS:	#5072
BP4	07/20 (202) - 07/30 (211)	Sensor:	S-13
		Z:	#2989
		N:	#2969
		E:	#2983
		DAS:	#348
		DRS:	#5044
	07/30 (211) - 08/03 (215)	Z:	#2300
	08/03 (215) - 08/22 (234)	Z:	#2984
BP5	07/20 (202) - 08/01 (214)	Sensor:	S-13
		Z:	#2984
		N:	#2967
		E:	#2301
		DAS:	#101
		DRS:	#5074
BP5a	08/01 (214) - 08/22 (235)	Sensor:	S-13
		Z:	#2989
		N:	#2967
		E:	#2301
		DAS:	#101
		DRS:	#5074
BP6	07/26 (208) - 08/21 (233)	Sensor:	CMG3 #T316
		DAS:	#153
		DRS:	#5042
BP7	07/28 (210) - 08/03 (216)	Sensor:	CMG3 #T319
		DAS:	#369
		DRS:	#5079
BP7a	08/05 (218) - 08/10 (222)	Sensor:	CMG3 #T319
		DAS:	#369
		DRS:	#5087
	08/16 (228) - 08/22 (235)	DAS:	#147
	08/22 (235) - 10/01 (275)	DAS:	#101
		DRS:	#5074
	10/01 (275) - 10/14 (288)	Sensor:	CMG3 #T319 (ch. 1, 2, 3)
		Sensor:	L4-3D #581 (ch. 4, 5, 6)
		DAS:	#393
		DRS:	#5071
PG1	10/05 (279) - 11/13 (317)	Sensor:	S-13
		Z:	#2954
		N:	#2994
		E:	#2953
		Sensor:	L4
		Z1:	#4115 (ch. 4)
		Z2:	#4217 (ch. 5)
		DAS:	#193
		DRS:	# 5084

	11/13 (317) - 12/10 (344)	Sensor:	S-13
		Z:	#2954
		N:	#2994
		E:	#2953
PG2	10/05 (280) - 11/08 (313)	Sensor:	S-13
		Z:	#2996
		N:	#2971
		E:	#2999
		DAS:	#078
		DRS:	#5050
PG3	10/06 (281) - 11/08 (313)	Sensor:	S-13
		Z:	#2951
		N:	#2998
		E:	#2977
		DAS:	#235
		DRS:	#5034
PG4	10/06 (281) - 12/10 (344)	Sensor:	S-13
		Z:	#2992
		N:	#2990
		E:	#2957
		DAS:	#239
		DRS:	#5041
PG5	10/15 (289) - 12/10 (344)	Sensor:	S-13
		Z:	#2989
		N:	#2967
		E:	#2956
		DAS:	#371
		DRS:	#5053
PG6	10/16 (290) - 11/13 (317)	Sensor:	CMG3 #T319 (ch. 1, 2, 3)
		Sensor:	L4-3D #581 (ch. 4, 5, 6)
		DAS:	#393
		DRS:	#5071
SF1	09/15 (259) - 09/30 (273)	Sensor:	S-13
		Z:	#2989
		N:	#2967
		E:	#2956
		DAS:	#153
		DRS:	#5042
SF2	09/15 (259) - 09/26 (270)	Sensor:	L4-3D #578
		DAS:	#393
		DRS:	#5071
	09/26 (270) - 09/30 (273)	Sensor:	L4-3D #578
		Sensor:	L4
		Z1:	#4115 (ch. 4)
		Z2:	#4127 (ch. 5)
	11/09 (314) - 12/09 (343)	Sensor:	S-13
		Z:	#2996

		N:	#2971
		E:	#2999
		Sensor:	L4
		Z1:	#2822 (ch. 4)
		Z2:	#7513 (ch. 5)
		DAS:	#078
		DRS:	#5050
SF3	09/16 (260) - 09/26 (270)	Sensor:	L4-3D #579
		DAS:	#371
		DRS:	#5053
	09/26 (270) - 09/30 (273)	Sensor:	L4-3D #579
		Sensor:	L4
		Z1:	#4120 (ch. 4)
		Z2:	#7513 (ch. 5)
	11/09 (313) - 12/09 (343)	Sensor:	S-13
		Z:	#2951
		N:	#2998
		E:	#2977
		DAS:	#235
		DRS:	#5034
SF4	09/16 (260) - 09/26 (270)	Sensor:	L4-3D #581
		DAS:	#363
		DRS:	#5070
	09/26 (270) - 10/01 (274)	Sensor:	L4-3D #581
		Sensor:	L4
		Z1:	#2822 (ch. 4)
		Z2:	#2357 (ch. 5)
	10/01 (274) - 10/14 (288)	Sensor:	S-13
		Z:	#2989
		N:	#2956
		E:	#2967
	10/14 (288) - 12/09 (344)	Sensor:	L4
		Z:	#4120
		N:	#1433
		E:	#1532
SF5	09/16 (260) - 09/30 (273)	Sensor:	L4-3D #582
		DAS:	#078
		DRS:	#5050
WG2	07/23 (204) - 08/13 (225)	Sensor:	S-13
		Z:	#2996
		N:	#2990
		E:	#2953
		DAS:	#339
		DRS:	#5048
	08/13 (225) - 10/03 (277)	Sensor:	S-13
		N:	#2971
		DAS:	#195
		DRS:	#5084
WG3	07/23 (205) - 10/03 (277)	Sensor:	S-13

		Z:	#2954
		N:	#2999
		E:	#2994
		DAS:	#392
		DRS:	#5082
WG4	07/23 (205) - 07/31 (212)	Sensor:	S-13
		Z:	#2951
		N:	#2977
		E:	#2998
		DAS:	#195
		DRS:	#5041
	07/31 (212) - 08/15 (227)	DAS:	#239
WG4a	08/15 (227) - 09/04 (248)	Sensor:	S-13
		Z:	#2951
		N:	#2977
		E:	#2998
		DAS:	#239
		DRS:	#5041
	09/04 (248) - 09/11 (254)	DAS:	#371
		DRS:	#5053
	09/11 (254) - 10/06 (280)	DAS:	#239
		DRS:	#5041
WG5	07/25 (206) - 07/30 (213)	Sensor:	S-13
		Z:	#2992
		N:	#2957
		E:	#2987
		DAS:	#147
		DRS:	#5084
	07/30 (213) - 08/15 (228)	DAS:	#235
	08/15 (228) - 10/06 (280)	E:	#2990
HV1	11/25 (330) - 11/27 (331)	Sensor:	CMG3 #T319
		DAS:	#393
		DRS:	#5071
MK1	11/27 (332) - 12/05 (340)	Sensor:	CMG3 #T319
		DAS:	#393
		DRS:	#5071
MK2	12/05 (340) - 12/11 (346)	Sensor:	CMG3 #T319
		DAS:	#393
		DRS:	#5071
ML1	12/11 (346) -12/11 (346)	Sensor:	CMG3 #T319
		DAS:	#393
		DRS:	#5071
HV2	12/11 (346) - 12/12 (347)	Sensor:	CMG3 #T319
		DAS:	#393
		DRS:	#5071

Table 3 . Instrument and site conditions of ALOHA arrays

Station	Date (day)	Pre-gain	clock healthy	STA/LTA Stream 02	STA/LTA Stream 03	Site Condition & Sensor
AN1	209	32	5	4	4	buried (L4-3D)
	219	32	HAW	4	4	
AN1a	236	32	500	4	3	buried (L4-3D)
	256	32	5	4	3	
AN2	209	32	JAP	4	4	on rock (L4-3D)
	220	32	HAW	4	4	
	235	32	HAW	4	3	
	256	32	50	4	3	
AN3	209	32	JAP	4	3	on rock (L4-3D)
	219	32	HAW	4	3	
	235	32	HAW	4	3	
	256	32	500	4	3	
AN4	208	32	500	4	4	on rock (L4-3D)
	219	32	JAP	4	4	
	235	32	JAP	4	3	
	256	32	500	4	3	
AN5	236	8	HAW	4	3	on rock (S-13)
	256	8	HAW	4	3	
BP1	199	32	JAP	4		on rock (S-13)
	201	8	500	4	4	
	203	8	JAP	4	4	
	206	8	JAP	4	4	
	212	8	JAP	4	4	
	215	8	HAW	4	4	
	223	8	HAW	4	4	
	229	8	JAP	4	3	
	234	8	HAW	4	3	
BP2	200	8	HAW	4	4	buried (S-13)
	206	8	JAP	4	4	
	212	8	JAP	4	4	
	215	8	HAW	4	4	
	222	8	HAW	4	4	
	224	8	500	4	4	
	229	8	JAP	4	3	
	233	8	HAW	4	3	
BP3	201	8	500	4	4	buried (S-13)
	203	8	HAW	4	4	
	206	8	HAW	4	4	
	212	8	HAW	4	4	
	215	8	HAW	4	4	

	223	8	HAW	4	4	
	229	8	HAW	4	3	
	233	8	HAW	4	3	
BP4	202	8	HAW	4	4	buried (S-13)
	205	8	HAW	4	4	
	207	8	HAW	4	4	
	211	8	HAW	4	4	
	215	8	HAW	4	4	
	222	8	HAW	4	4	
	228	8	HAW	4	3	
	234	8	HAW	4	3	
BP5	202	8	1	4	4	on rock (S-13)
	207	8	HAW	4	4	(Close to Highway)
	211	8	HAW	4	4	
BP5a	214	8	HAW	4	4	on rock (S-13)
	216	8	HAW	4	4	
	220	8	HAW	4	4	
	222	8	HAW	4	4	
	228	8	HAW	4	4	
	235	8	HAW	4	4	
BP6	207	8	HAW	4	3	buried (CMG-3)
	210	8	HAW	4	3	
	216	8	500	4	3	
	217	8	HAW	4	3	
	218	8	HAW	4	3	
	223	8	HAW	4	3	
	229	8	HAW	4	2.5	
	233	8	HAW	4	2.5	
BP7	210	8	HAW	4	3	buried (CMG-3)
	216	8	No clock	4	3	
BP7a	218	8	HAW	4	3	buried (CMG-3)
	221	8	HAW	4	3	
	222	8	HAW	4	3	
	228	8	HAW	4	2.5	
	235	8	HAW	4	2.5	
	243	8	HAW	4	2.5	
	249	8	HAW	4	2.5	
	255	8	HAW	4	2.5	
	256	8	HAW	4	2.5	
	258	8	JAP	4	2.5	
	261	8	HAW	4	2.5	
	271	8	500	4	2.5	
	275	8 (32)	HAW	4	2.5 (3)	buried
	280	8 (32)	HAW	4	2.5 (3)	(CMG-3, L4-3D)
	288	8 (32)	HAW	4	2.5 (3)	

PG1	279	8	5	4	3	on rock (S-13, L4)
	288	8	HAW	4	3	
	299	8	HAW	4	3	
	303	8	HAW	4	3	
	312	8	HAW	4	3	
	317	8	HAW	4	3	on rock (S-13)
	324	8	HAW	4	3	
	337	8	500	4	3	
	344	8	HAW	4	3	
PG2	280	8	HAW	4	3	on rock (S-13)
	289	8	1	4	3	
	299	8	JAP	4	3	
	303	8	HAW	4	3	
	313	8	HAW	4	3	
PG3	281	8	HAW	4	3	on rock (S-13)
	289	8	HAW	4	3	
	298	8	HAW	4	3	
	302	8	HAW	4	3	
	313	8	5	4	3	
PG4	282	8	500	4	3	on rock (S-13)
	289	8	5	4	3	
	299	8	HAW	4	3	
	303	8	5	4	3	
	313	8	HAW	4	3	
	324	8	HAW	4	3	
	338	8	5	4	3	
	344	8	HAW	4	3	
PG5	289	8	5	4	3	on rock (S-13)
	298	8	HAW	4	3	
	302	8	HAW	4	3	
	312	8	HAW	4	3	
	323	8	JAP	4	3	
	337	8	JAP	4	3	
	344	8	HAW	4	3	
PG6	290	8 (32)	HAW	4	2.5 (3)	buried
	298	8 (32)	HAW	4	2.5 (3)	(CMG-3, L4-3D)
	302	8 (32)	HAW	4	2.5 (3)	
	312	8 (32)	HAW	4	2.5 (3)	
	317	8 (32)	HAW	4	2.5 (3)	
SF1	259	8	HAW	4	3	on rock (S-13)
	261	8	HAW	4	3	
	270	8	HAW	4	3	
	273	8	HAW	4	3	
SF2	259	32	500	4	3	on rock (L4-3D)
	262	32	HAW	4	3	

	270	32	HAW	4	3	on rock (L4-3D, L4)
	273	32	HAW	4	3	
	314	8 (32)	1	4	3	on rock, (S-13, L4)
	326	8 (32)	HAW	4	3	
	336	8 (32)	HAW	4	3	
	339	8 (32)	HAW	4	3	
	343	8 (32)	HAW	4	3	
SF3	260	32	HAW	4	3	on rock (L4-3D)
	261	32	JAP	4	3	
	269	32	HAW	4	3	on rock (L4-3D, L4)
	273	32	HAW	4	3	
	313	8	HAW	4	3	on rock (S-13)
	325	8	HAW	4	3	
	337	8	HAW	4	3	
	339	8	HAW	4	3	
	344	8	HAW	4	3	
SF4	260	32	5	4	3	on rock (L4-3D)
	261	32	HAW	4	3	
	269	32	HAW	4	3	on rock (L4-3D, L4)
	274	8	HAW	4	3	on rock (S-13, L4)
	281	8	HAW	4	3	
	288	8	HAW	4	3	on rock (L4)
	297	8	50	4	3	
	311	8	500	4	3	
	325	8	50	4	3	
	337	8	50	4	3	
	339	8	5	4	3	
	344	8	500	4	3	
SF5	260	32	JAP	4	3	on rock (L4-3D)
	261	32	5	4	3	
	269	32	500	4	3	
	274	32	No clock	4	3	
WG2	204	8	500	4	4	on rock (S-13)
	212	8	500	4	4	
	218	8	500	4	4	
	225	8	500	4	4	
	227	8	HAW	4	3	
	232	8	HAW	4	4	
	239	8	HAW	4	3	
	247	8	HAW	4	3	
	254	8	HAW	4	3	
	262	8	500	4	3	
	270	8	HAW	4	3	
	277	8	HAW	4	3	
WG3	205	8	HAW	4	4	buried (S-13)
	213	8	HAW	4	4	

	218	8	HAW	4	4	
	225	8	HAW	4	4	
	228	8	HAW	4	3	
	232	8	HAW	4	4	
	239	8	HAW	4	3	
	247	8	HAW	4	3	
	254	8	HAW	4	3	
	262	8	HAW	4	3	
	270	8	HAW	4	3	
	277	8	HAW	4	3	
WG4	205	8	HAW	4	4	on rock (S-13)
	212	8	No clock	4	4	
	218	8	HAW	4	4	
	225	8	HAW	4	4	
WG4a	227	8	HAW	4	3	on rock (S-13)
	232	8	HAW	4	4	
	239	8	HAW	4	3	
	248	8	1	4	3	
	254	8	HAW	4	3	
	262	8	HAW	4	3	
	270	8	HAW	4	3	
	280	8	5	4	3	
WG5	206	8	AUS	4	4	on rock (S-13)
	213	8	ND	4	4	
	218	8	HAW	4	4	
	225	8	HAW	4	4	
	228	8	HAW	4	3	
	232	8	HAW	4	4	
	240	8	HAW	4	3	
	248	8	HAW	4	3	
	255	8	HAW	4	3	
	263	8	HAW	4	3	
	270	8	HAW	4	3	
	280	8	HAW	4	3	