NEC

NE Caribbean 1979-1982

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RECOVERY OF DIGITAL WAVEFORM DATA FOR EASTERN PUERTO RICO AND THE VIRGIN ISLANDS

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Abstract

Puerto Rico and the U. S. Virgin Islands have a high level of seismic activity, resulting from their location along the boundary between the North America and Caribbean tectonic plates. A felt seismic event occurs about once per month, with several large and damaging earthquakes having occurred during the last 500 years. The region has a 20-year history of digital recordings of local and regional earthquakes from two local networks. Thousands of records exist from small to moderate events, at small-to-regional distances. Many digital waveforms from 1979-1983 recorded by an LDEO-run seismic network in eastern Puerto Rico and east in to the Virgin Islands exist and are stored at LDEO. Data come from 17 well-calibrated stations, 11 of which were in eastern Puerto Rico and the Virgin Islands, 6 were 3-component station, one was broadband and one had a displacement response.

In this project, we recovered seismic station digital waveforms for the time period 1979 - 1983, and permanently archived the recovered data on modem media (CD, DLT tape) at UPR-Mayagüez and Lamont as well as submission of that data, reformatted to AH format, to the IRIS DMC. The recovery will allow incorporation of these data into the current NEHRP ground motion relations development, and will allow many other analyses. In particular, the recovered data can be used to address topics of current interest concerning calibration of a moment magnitude scale, and improvement of earthquake locations, velocity models and focal mechanisms by use of waveforms to determine P/SV ratios. With termination of this project, a major portion of the effort needed to rescue the catalog/bulletin and waveforms data from the seismic network that have monitored seismic activity for the US Territories in the Caribbean will be complete.

Introduction

Puerto Rico's 4 million inhabitants are exposed to a significant earthquake hazard. At least four destructive earthquakes have been experienced in populated areas in historic times. Earthquakes of magnitude 7 or greater are highly probable within the lifetime of the present generation. Despite the substantial seismic hazard, quantitative earthquake-hazard analysis is lacking for Puerto Rico. There is an urgent need for the further analyses. Many of the types of analyses needed, including the development of ground motion relations, require digital waveforms from past-recorded events, Digital data can be processed to extract information concerning source, site, and propagation effects in Puerto Rico and the US Virgin Islands. Unfortunately, many of the digital data recorded in Puerto Rico and the US Virgin Islands are not currently accessible due to their storage on archaic media, for which reading facilities are not easily available. Without speedy intervention, these data will be lost forever.

In this effort, we recovered valuable digital data recorded by the closed LDEO network and permanently archived these data on modem media. Recovered waveform data could be incorporated into a current NEFW project on ground motion relations for Puerto Rico, That project lacks important information in the distance range precisely recorded by this existing, but previously difficult to use data set.

Puerto Rico and the Virgin Islands lie on the boundary between the North American and the Caribbean plates. They are surrounded and crossed by active seismic faults and are a focus of brisk seismic activity. The islands have a significant seismic hazard, as evidenced by the hundreds of moderate (M4 to 5) events recorded in the last two decades. Since Spanish settlement in the early 1500's, there have been at least four destructive earthquakes, with intensities greater than VII on the Modified Mercalli Intensity Scale, causing loss of life and substantial property damage. Two major (M>7) events occurred in this century (1918 and 1943). Historical data show that Puerto Rico has been subjected to a strong earthquake about every 75 years. A possible great earthquake in 1787 (M 8 to 8.2) appears to have occurred along the main seismic zone near the Puerto Rico Trench to the north of the island (McCann, 1985).

Despite its high seismic risk, Puerto Rico lags behind other seismically active regions of the United States in terms of research to adequately assess and mitigate earthquake hazard. This knowledge gap is a subject of major concern within the Puerto Rican scientific and engineering community. Addressing this knowledge gap requires earthquake data, as seismology is largely an empirical science. A large body of data has been recorded, but unfortunately many of these data are archived on outdated media that are no longer generally accessible. Without speedy intervention, these valuable data will be lost forever.

Seismic Monitoring in the Northeastern Caribbean

Puerto Rico and the U. S. Virgin Islands have already benefited from the installation and operation of local seismic stations designed to monitor microearthquake activity. Information collected over the last 20 years has added the definition of local seismic hazard and helped to control the growth of seismic risk. Ongoing revisions of the building code in Puerto Rico are partly a result of investigations using data collected by the local seismic network. The locations of microearthquakes have played an important role in the decision of whether or not to construct important facilities at a given site, and to guide the use of appropriate seismo-resistant design parameters after a site decision has been made. Also, the local seismic network has been able to provide prompt information to the communications media when strong earthquakes have occurred, aiding the education of the general public in earthquake hazards. Unfortunately, because of a complicated history of seismic recording, and a general lack of funding, the existing 20-year database has not yet been fully utilized and part of it is in jeopardy of being lost. Herein we report on the rescue of part of those data.

In 1975 several seismic stations were installed in the Puerto Rico-Virgin Islands region by two organizations, the U. S. Geological Survey (USGS) and Lamont-Doherty Earth Observatory (LDEO). In the period 1982-84 those networks were combined to form the Puerto Rico Seismic Network operated by the University of Puerto Rico. The data collected from 1975-1983 from those separate networks were integrated to form a common catalog and bulletin, under a separate NEFW project to Earth Scientific Consultants. That program added about 9,000 microearthquake locations to the existing local catalog, more than doubling its size.

Brief History of the LDEO Seismic Network

The northeastern Caribbean Network was installed in early 1975 starting in the easternmost part of the Island of Puerto Rico and offshore islands to the east, as well as the U. S. Virgin Islands. Each station consisted of an HS-10 2 Hz geophone, Interproduccts VCO, and information was relayed by FM radio to a central recording site. Later many stations were increased to two components each and finally three. In the last few years a broadband station was added at VST and a displacement response at SJV. At the central recording station, data were first recorded on heliocorders and on l6mm film by use of a develocorder, and in 1979 by a digital recording system of LDEO design. Events were located using at first using *Hypoellipse* then later *Hypoinverse*. Bulletins reporting phase information and locations were published for data from at least 1977 until the end of 1982. Digital data for events in the last six months of network operation (1983) were neither interpreted nor locations determined. All events were located using the one velocity model though later a model was determined through inversion of event arrival times and multi-ton calibration shots (Fischer and McCann, 1984).

Formation of the Puerto Rico Seismic Network

Starting in the end of June 1982, operational responsibility of the USGS seismic network was transferred to the Center for Energy and Environmental Research (CEER) of the University of Puerto Rico. From that time through June 1987, network support included basic collection, interpretation and processing of seismic data. The antiquated develocorder style recording was replaced by an event triggered digital recording system of LDEO design. Continuous heliocorder recording was also added.

Both LDEO and USGS provided he1p in setting up the data processing system, with the LDEO crustal model (used by LDEO in the Virgin Islands) used in HYPOINVERSE to locate events. About June 1983 the LDEO network in the Virgin Islands was dismantled with some equipment shipped to the Dominican Republic. As part of a USGS funded program, six 3~component stations of the closing LDEO network in the Virgin Islands were transferred to the existing stations on the Island of Puerto Rico to form a 2 1 -station Puerto Rico Seismic Network.

Operation of the network was transferred to the Geology Department, University of Puerto Rico, Mayagüez on June 22, 1987. Since that time the recording system has been upgraded to use the PC based IASEPI data collection in conjunction with a system developed by the University of the West Indies. Earthquakes are still located using *Hypoinverse*, but a new crustal model has been introduced. A new magnitude scale has also been introduced, based on a desired equivalence to teleseismic m_b, but there remain unresolved questions concerning the calibration of this regional magnitude scale.

The net result of the above history is that catalogs of events near Puerto Rico and the Virgin Islands contain events located by two separate networks, using at least two different computer programs, with at least two different crustal models. Event magnitudes are calculated based on at least two different scales of uncertain equivalence.

A recent **NEHRP** effort merged phase arrival times, amplitudes and codas times for events from the period of common USGS~LDEO network operation and data reduction (1975-1978). That data, and the data from the LDEO network alone (1979-1982) were located using the same location program, velocity model, and magnitude parameters to form a uniform event catalog and bulletin covering the period 1975-1982. Nearly 9,000 events were recovered by that effort (McCann, 2001).

Efforts Undertaken

The goal of this project was to rescue the data available on magnetic tape from the former LDEO network, covering the time period from 1979-1983, and archive all of these data on modern media. This information includes digital records from a total of 17 stations; one is a broadband station, one with a displacement response, and 6 3-component stations. It includes records of at least 2300 local earthquakes, and 3 multi-ton calibration shots in 1976 and 1979. Calibration shots from the 1982 campaign are also included in the normal network digital data set.

The tasks required for this project involved substantial, but simple, data recovery efforts. At LDEO there are 239 digital tapes covering the period from April, 1979 through May, 1983. These l/2" 800bpi tapes contain event triggered multiplexed digital records of earthquakes waveforms recorded by the 17-station LDEO seismic network in the NE Caribbean. They contain information for at least 2,315 local and regional earthquakes. Waveform data were recorded by a digital recording system of LDEO design in a proprietary format. Approximately 50 of these tapes have their information already copied in demultiplexed format. So about 189 tapes were read and data demultiplexed. After being demultiplexed the time series were reformatted into a non-orphaned format thereby making it usable by the general scientific community. Auxiliary files with station gain/polarity information are already available having been recovered and copied as part of a previous NEHRP grant to Earth Scientific Consultants. The archived waveform database will be available through IRIS-DMC and a copy of the data will also be held at the offices of the seismic network of Puerto Rico. It is expected that this data will be a valuable resource in ground motion studies.

Summary of Data Rescue Efforts

Tapes were read on a 800bpi _" track tape reader (Kennedy 9300). Reader would not recognize tape EOF, so copies, that is images of a whole tapes, were made by the command tcopy /dev/rmt0m > tape#

Images have been saved in the event that someone needs to examine in an attempt to retrieve information of a particular event that was not successfully retrieved during the normal processing. All tapes (numbers 1-252) were read successfully. Of those tapes, #s1-240 are from the LDEO NE Caribbean network and #s 241-252 are from the Puerto Rico network. A mystery tape, contained the ring label duplicate to another LDEO network tape, but had no information on it. An image index of all tapes was produced and is given in Appendix A. That appendix includes tape number date on and off information, any special notes, and what channels were recorded etc.

LDEO programer David Lentrichia wrote a program, CARICLEAN, to break up a tape image into its component files and to clean up problems associated with minor losses of information that would damage the demultiplexing process. CARICLEAN generated raw carib network files that were further processed by the command "Tdmux –yr –f ", This program demultiplexed the data and wrote it in AH format. Data were checked by use of PQL (passcal quick look) to make sure that the demultiplexing process was successful. The vast majority of the raw data were demultiplexed and converted to AH format with out problems. It is self-evident in the data which files are good.

A problem was encountered during the 79/80 year transition. As the digital recording system did not record the years, only sequential day of year and smaller time units, one had to provide the year in the demultiplex process. At the end of 1979 the station attendants did not change the clock to day 001 on January 1, 1980, so it indicated day 366 for that day. Events at the end of 1979 were processed using the year 1979 and were processed correctly. However when the 1980 events on the same tape were processed using the year 1980, tdmux interpreted the day 366 as December 31, 1980 as 1980 is a leap year, thus assigning an incorrect date for those events on January 1, 1980. As we have no solution for the problem, any users encountering data on tape #60 must realize that the data have a problem with the data information, but that the waveform data are good.

Station lists providing equipment inventories were developed. That file provides several unique response types for the various digital stations. A history of each station and its components includes gain and response type.

In order to provide a patch for the data not successfully processed using the program tdmux, we used the information copied onto a DLT tape about 5 years ago in a predecessor to this project. That data consisted of 9 archived tapes of demultiplexed data. We processed that information using the program ping2ah to make one file in AH format. A C-shell script then called the program uncatah, broke the large file into individual components which were in turn renamed according to a list produced when the original archive tapes were dmultiplexed in 1983. In some cases the number of files retrieved from the DLT for a given archive tape did not correspond to the number of files originally placed on the tape. Those datasets were left unprocessed; while the data could be retrieved reading the header files, the process was deemed to be too time consuming and beyond the scope of this present program. If an event of particular interest was not successfully processed by tdmux, and is found to be on one of the problematic tapes, a search through the unprocessed archive data tape might be worthwhile. More detailed information about what was processed is to be found in Appendix A.

Digital Waveform Products

Four institutions hold the final digital waveform products of this effort. They are LDEO Seismology Group, Seismic Network of Puerto Rico, IRIS DMC, and Earth Scientific Consultants. LDEO hold the original DLT tapes containing the tape images and AH format data, and files containing station parameters including location, calibration and response information. The other institutions were provided a set of CDs with tape images and AH format data, and station parameter files. Copies of this final report, without the CD dataset, were distributed to researchers working on various aspects of the seismic hazards and neotectonics of the U.S. Caribbean Territories.

Appendix A.

This appendix contains details of tape files created during copying and processing. All original data are stored on a DLT tape at LDEO (Seismology Building, Room 106D, red filing cabinet). A copy of the Tape Images and AH- format data were also copied to CD-ROM and are held at the Seismic Network in Puerto Rico and at the offices of ESC. AH format data are also held in the IRIS DMC.

Step I-- Produce Tape Image: 252 files named Tape1 through Tape252 are located in the directory "images" on the DLT tape. Below is an index of the 252 magnetic tape images (9-track, 800 bpi, _") read by *tcopy*. The index provides the relation between tape number (1-252) and date of information contained therein. List also notes channels file to use in demultiplexing process and notes year-year changes as well as notes that were hand written onto tapes.

Index of _" Magnetic Tape Images Read by *tcopy*

```
FILE     --DATEON--- --DATEOFF-- NOTES
tape1    032979 1200 040879 1415 start with channels0 file
tape2    040879 1425 042079 0200
tape3    042079 0210 042779 1356
tape4    042779 1402 050279 1203
tape5    050279 1210 050879 2315
tape6    050879 2323 051379 1435
tape7    051379 1444 051879 2106
tape8    051879 2115 052279
tape9    052279 2327 052879 2120
tape10   052879 2127 060579 1518
tape11   060579 1522 060579 2317
tape12   060579 2323 061179 1052
tape13   061179 1058 061679 2226
tape14   061679 2234 062379 1031
tape15   062379 1040 063079 2258
tape16   063079 2308 070779 0826
tape17   070779 0831 071079 2345
tape18   071079 2353 071479 1517
tape19   071479 1529 072079 0254
tape20   072079 0259 072179 1430
tape21   072179 1437 072179
tape22   072179 2148 072279
tape23   072279 1053 072379
tape24   072379 1034 072879
tape25   072879 0145 073179 0141
tape26   073179 0230 073179 0300 note 1
tape27   073179 0300 080479 1336 note 2
tape28   080479 1343 080779 2220 note 3
tape29   080779 2230 081079 1813 note 4
tape30   081079 1818 081779 2300
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tape31  081779 2302 082279 1307
tape32  082279 1312 082479 1700 note 5
tape33  082479 1700 082679 1531 note 6
FILE    --DATEON--- --DATEOFF-- NOTES
tape34  082679 1536 082879 1500 note 7
tape35  082879 1510 082979 2323 note 8
tape36  090179 1230 091079 2000 note 9
tape37  091079 2030 091279 2254 note 10
tape38  091279 2259 091479 1610 note 11
tape39  091479 1615 091879 0125
tape40  091879 0128 092379
tape41  092379 1442 092579
tape42  092579 2316 100679 2124
tape43  100679 2130 101179 2257
tape44  101179 2303 101779 2333
tape45  101779 2345 102279 1612
tape46  102279 1619 102879 2307
tape47  102879 2325 110279 2355
tape48  110379 0000 111479 1719
tape49  110579 1723 110979 2235
tape50  110979 2240 111579 2250
tape51  111579 2256 111979 2331
tape52  111979 2337 112479 2307
tape53  112479 2312 120179 0942 Note 12 channels0/1 at 11/30/79 0000
tape54  120179 0947 120779 0053
tape55  120779 0100 121179 2250 end channel1
tape56  121179 2300 121279 2255 Note 13 start channels2 at 11/11/79 2300
tape57  121279 2303 121579 2245
tape58  121579 2253 122179 2251
tape59  122179 2302 122879 2257
tape60  122879 2305 010280 0353 change year 79/80
tape61  010280 1048 010580 2355
tape62  010580 2357 010780 1055
tape63  010780 1100 011080 1222
tape64  011080 1227 011580
tape65  011580 0321
tape66  011680 1133 011680
tape67  011680 2222 011780 0305
tape68  011780 0309 011780 1129
tape69  011780 1133 111880 1107
tape70  011880 1112 012080 0343
tape71  012080 0348 012380 1124
tape72  012380 1128 012580 1130
tape73  012580 1134 012880 2328
tape74  012880 2334 020380 1114
tape75  020380 1118 020880 2342
```

tape76	020880	2347	021480	1110	
tape77	021480	0114	021680	0103	
tape78	021680	0106	022280	2249	
tape79	022280	2253	022780	2353	
tape80	022780	2358	030380		
tape81	030380	1504	030880	0005	
tape82	030880	0006	031480	2229	
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tape84	031680	2155	032280	0210	
tape85	032280	0214	032680	1033	
tape86	032680	1038	040280		
tape87	040280		040680	1452	
tape88	040680	1457	041380	2342	
tape89	041380	2346			
tape90	042280	1022	050280	1130	
tape91	050280	1135	051180	2330	
tape92	051180	2340	051980	1230	Note14 channels2/3 5/16/80 0000
tape93	051980	1240	052580	1359	
tape94	052580	1405	052780	1630	
tape95	052780	1638	053180	2216	
tape96	053180	2223	060580	1238	
tape97	060580	1243	061080	1154	
tape98	061080	1159	061780	1543	
tape99	061780	1548	062380	2231	
tape100	062380	2237	063080		
tape101	062980	1342	070880	1702	
tape102	070880	1706	072080	2159	
tape103	072080	2203	080480	1807	
tape104	080480	1812	081380	0646	
tape105	081380	0653	082080	2211	
tape106	082080	2215	090180	2154	
tape107	090190	2159			
tape108	090480	0954	090680	1226	
tape109	090680	1231	090780	2255	
tape110	090780	2259	091780	2245	
tape111	091780	2251	092780	1331	
tape112	092880	1337	101380	2205	
tape113	101380	2210	103180	0949	
tape114	103180	1010	110880	1156	
tape115	110880	1201	111180	2037	
tape116	111180	2041	111380	2043	
tape117	111380	2047	111780	1048	
tape118	111780	1052	112080	2006	
tape119	112080	2010	112580	0111	
tape120	112580	0115	112880	2247	

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tape121 112880 2252 120280 0749
tape122 120280 1016 120380 2335
tape123 120380 2338 120780 2259
tape124 120780 2304 121180 2207
tape125 121180 2212 121680 0204
tape126 121680 0226 122080 1843
tape127 122080 1849 122780 1034
tape128 122780 1038 123180 1853
tape129 123180 1858 010481 0845 change year 80/81
tape130 010481 0852 010881 1449
tape131 010881 1449 011181 2346
FILE    --DATEON--- --DATEOFF-- NOTES
tape132 011181 2354 011681 1602
tape133 011681 1608 012181 1102
tape134 012181 1109 012381 2254
tape135 012381 2259 012981
tape136 012981 1049 021181 2245
tape137 021181 2313 022281
tape138 022281 2234 030181 1245
tape139 030181 1250 030681 2328
tape140 031681 2332 032181 1206
tape141 032181 1210 040381 0023
tape142 040381 0029 042181 2245
tape143 042181 2250 050381 2228
tape144 050381 2230 051781 0009
tape145 051781 0013 052781 2302
tape146 052781 2307
tape147 061281 1026 062781 1443
tape148 062781 1447 070781 1241
tape149 070781 1247 071581 2022
tape150 071581 2026 072281 2244
tape151 072281 2249 072781 2340
tape152 072781 2340 073081 0100
tape153 073081 0102 080181 2050
tape154 080181 2053 081481 0152
tape155 081481 0152 082181 2038
tape156 082181 2046 082781 0038
tape157 082781 0043
tape158 082881 1140 090381 2315
tape159 090381 2320 092181 2218
tape160 092181 2222 100481 1813
tape161 100481 1815 101381 2151
tape162 101381 0255 101581 2204
tape163 101581 2205 101681 2222
tape164 101681 2224 102281 2142
tape165 102281 2257 110381 2133
```

tape166 110381 2139 110581 2253
tape167 110581 2255 111281 2322
tape168 111281 23   112581 2138
tape169 112581 2143 112981 2200
tape170 112981 2204 120281 2146
tape171 120281 2150 120781 2153
tape172 120781 2157 121581 1230
tape173 121581 1235 121981 2257
tape174 121981 2259 122581 1915
tape175 122581 1920 010982 2055 change year 81/82
tape176 010982 2100 012282 2100
tape177 012282 2106 020182 2132
tape178 020182 2136 021582 2107
tape179 021582 2112 021882 2104
tape180 021882 2108 022582 2112
FILE --DATEON--- --DATEOFF-- NOTES
tape181 022582 2116 022882 2152
tape182 022882 2155 030282 2134
tape183 030282 2139 030582 2140
tape184 030582 2145 031282 2166
tape185 031282 2122 031482 2116
tape186 031482 2120 032082 1404
tape187 032082 1408
tape188 040182 2124 040582 2119
tape189 040582 2124 042682 2059
tape190 042682 2103 050382 2109
tape191 050382 2115 052382 1653
tape192 052382 1658 061382 1633
tape193 061382 1642 062382 1627
tape194 062382 1633 070482 1651
tape195 070482 1655 071782 1632
tape196 071782 1641
tape197 072982 2059 080182 2120
tape198 080182 2125 081482 1301
tape199 081482 1305
tape200 082082 2326 083182 1609
tape201 083182 1615 091182 1538
tape202 091182 1543 091482 1700
tape203 091482 1704 092182 1552
tape204 092182 1558 100982 1549
tape205 100982 1550 102782 1444
tape206 102782 1449 111982 1504
tape207 111982 1510 112482 1514
tape208 112482 1517 120582 1722
tape209 120582 1728 121582 1432
tape210 121682 1442

tape211	121782	1500	122582	1536	
tape212	122582	1541	122882	1430	
tape213	122882	1426	010383	1610	change year 82/83
tape214	010383	1617	011383	1544	
tape215	011383	1549	012483	1651	
tape216	012483	1706	020283	1546	
tape217	021683	1615	022083	1618	
tape218	021183	1606	021683	1610	
tape219	020283	1552	021183	1602	
tape220	022083	1624	030383	1608	
tape221	030383	1611	030983	1736	
tape222	030983	1741	031883	1630	
tape223	031883	1636	032283	1412	
tape224	032283	1417	032683	1647	
tape225	032683	1653	032983	1550	
tape226	032983	1604	040383	1653	
tape227	040383	1700	040783	1600	
tape228	040783	1605			
tape229	040883	1604	041183	1508	
FILE	**--DATEON---**		**--DATEOFF--**		**NOTES**
tape230	041183	1515	041383	1526	
tape231	041383	1534	041683	1600	
tape232	041683	1601			
tape233	042583	1710	050183	1619	
tape234	050183	1627	050583	1527	
tape235	050583	1534	051183	1646	
tape236	051183	1655	051583	1804	
tape237	051583	1810			
tape238	052783	1640	053183	1707	
teap239	053183	1710	061483	1742	
tape240	061683	1748	061783	1705	end of LDEO network tapes
tape241	011785	1906	012485	2413	change year 83/85 note 15
tape242	110985	1136	112985	1051	
tape243	112985	1101	010286	2300	change year 85/86
tape244	010286	2351	012886	1100	
tape245	012886	1111	022786	0317	
tape246	022786	0320	033186	1912	
tape247	033186	1917	042486	0040	
tape248	042486	0043	860505	0233	
tape249	050586	0236	051886	1658	
tape250	051886	1720	052986	0322	
tape251	052986	0327	060586	1823	
tape252	060586	1842	061786	1013	

General Note: Dateon and Dateoff give month, day, year in one column and hour, minute in next column. Blank entry means information not given. Use channels0 from start of digital data for channels assignments and demultiplexing raw data.

Note1: "Test" is marked on tape
Note2: offtime is approximate
Note3: VST calibration starts at 080779 014506
Note4: SJV calibration starts at 081089 133133
Note5: refraction profiles 1-6 and start of 7 on this tape.
Note6: End of refraction profile 7 on this tape.
Note7: Multiton calibration shot #1 (east of ABV) is on tape #34.
For this shot special channels assignments for the sonobouy signals are as follows: y1a=31, y2a=21,32, y3a=24, y4a=4.
Note8: tape35- Two multiton calibration shots are on tape #35. These are shots #2 (N of vst) and #3 (east of ABV again). For shot #2 special channel assignments for the sonobouy signals are as follows: y2b=24, y3b=4,31, y4b=21, y5b=32. Also, power out so no tape for 082979 2323 to 090179 1230.
Note 9: Refraction lines 9-11 on this tape.
Note 10: Refraction lines 12,13 on this tape.
Note 11: Refraction lines 14-16 on this tape.
Note12: Station STKP moved to SKBR, change in channels file 11/30/79 0000, use channels1 file.
Note13: Station SAB moved to SBN, change in channels file 12/11/79 2300, use channels2 file.
Note14: New station channel assignments start 05/16/80 0000, use channels3 file.
Note 15: Start of PR network tapes, use channels4; cannot read this tape so no image or follow up files, next tape really begins recording sequence for PR network.

STEP II-- Process 252 tape images through CARICLEAN to generate individual files containing RAW Caribbean network digital waveforms and header files.

These data are located in the directory “cleaned” on the DLT Tape. In “cleaned” there are subdirectories each having the name of a tape (i.e. tape104, etc.). Within each subdirectory are a series of files in the order in which they were found on the tape. So file.06 in directory tape213 is the 6th file found on tape #213, etc.

STEP III-- Process the files reformatting them from raw, multiplexed Caribbean network data format to AH format. These data are located in the directory “ahdata” on the DLT tape. In ‘ahdata’ there are subdirectories each having the name of a tape followed by ah (i.e. tape213.ah). Within each subdirectory are a series of directories named by the time of the event trigger and within those directories are the data in AH format. Each file is named after the channel whose data is contained therein. So data for channel ABVN for event triggered on 821229.102555 would be found in ahdata/tape213.ah/821229.102455/abvn.
Any station files with the names zzz, zzy, and zzx should be ignored, as they contain no data. **All raw data and data processed up to and including this step should have 0.5 seconds added to their times to obtain UCT.**

Files known or suspected to have suffered a problem during the *tcopy* or CARICLEAN step and may not contain reliable waveforms

Appendix B

Channels files

Channels0
1 csj 100
2 csje 100
3 rrd 100
4 rrde 100
5 mtp 100
6 mtpe 100
7 cup 100
8 cupe 100
9 cgv 100
10 cgve 100
11 scv 100
12 scve 100
13 sjv 100
14 sjve 100
15 cgp 100
16 cgpe 100
17 gpv 100
18 gpve 100
19 abv 100
20 abve 100
21 swi 100
22 sab 100
23 mrn 100
24 stk 100
25 awi 100
26 bwi 100
27 vst 100
28 vste 100
29 vstn 100
30 zzx 100
31 zzy 100
32 zzz 100

Channels1
1 csj 100
2 csje 100
3 rrd 100
4 rrde 100
5 mtp 100
6 mtpe 100
7 cup 100
8 cupe 100
9 cgv 100
10 cgve 100
11 scv 100
12 scve 100
13 sjv 100
14 sjve 100
15 cgp 100
16 cgpe 100
17 gpv 100
18 gpve 100
19 abv 100
20 abve 100
21 swi 100
22 sab 100
23 mrn 100
24 skb 100
25 awi 100
26 bwi 100
27 vst 100
28 vste 100
29 vstn 100
30 zzx 100
31 zzy 100
32 zzz 100

Channels2
1 csj 100
2 csje 100
3 rrd 100
4 rrde 100
5 mtp 100
6 mtpe 100
7 cup 100
8 cupe 100
9 cgv 100
10 cgve 100
11 scv 100
12 scve 100
13 sjv 100
14 sjve 100
15 cgp 100
16 cgpe 100
17 gpv 100
18 gpve 100
19 abv 100
20 abve 100
21 swi 100
22 sbn 100
23 mrn 100
24 skb 100
25 awi 100
26 bwi 100
27 vst 100
28 vste 100
29 vstn 100
30 zzx 100
31 zzy 100
32 zzz 100

Channels3
1 mtp 100
2 mtpn 100
3 mtpe 100
4 cup 100
5 cupn 100
6 cupe 100
7 sjv 100
8 sjvn 100
9 sjve 100
10 cgp 100
11 cgpn 100
12 cgpe 100
13 abv 100
14 abvn 100
15 abve 100
16 csj 100
17 rrd 100
18 cgv 100
19 scv 100
20 gpv 100
21 swi 100
22 sbn 100
23 mrn 100
24 skb 100
25 awi 100
26 bwi 100
27 vst 100
28 vstn 100
29 vste 100
30 bst 100
31 bstn 100
32 bste 100

Channelspr
1 lpr 100
2 cpd 100
3 cdp 100
4 cdpn 100
5 apr 100
6 pnp 100
7 mgp 100
8 mcp 100
9 imo 100
10 sjg 100
11 csb 100
12 mov 100
13 ide 100
14 lrs 100
15 100
16 100
17 sjv 100
18 sjvn 100
19 sjve 100
20 cgpv 100
21 cgpvn 100
22 cgpve 100
23 mtp 100
24 mtpn 100
25 mtpe 100
26 csj 100
27 abv 100

Appendix C

Station Information

Station coordinates, components, operating times and polarities in Hypoellipse format

```
abv18 43.92  64 20.22    3 1                              e
abv*     4          1 1       1983061823          R
abv18 43.92  64 20.22    3 1                              n
abv*     4          1 1       1983061823          R
abv18 43.92  64 20.22    3 1                              z
abv*     4          1 1       1977070123          ?
abv*     4          1 1       1977120923          N
abv*     4          1 1       1978082123          ?
abv*     4          1 1       1979032523          N
abv*     4          1 1       1981020823          R
abv*     4          1 1       1983061823          N
apr18 27.45  66 43.76   53 2                              z
apr*     4          1 1       1999123123          N
bwi17 39.90  61 47.40   36 1                              z
bwi*     4          1 1       1979082023          N
bwi*     4          1 1       1980051223          R
bwi*     4          1 1       1981021323          R
bwi*     4          1 1       1983061823          N
cag18 14.37  66 02.12  350 2                              z
cag*     4          1 1       1975071723
cca18 04.18  66 19.58  269 2                              z
cca*     4          1 1       1999123123          N
cdp18 10.50  66 35.50 1300 2                              z
cdp*     4          1 1       1999123123          N
cgv18  7.97  65 19.04  130 1                              z
cgv*     4          1 1       1979080323          R
cgv*     4          1 1       1981030223          N
cgv*     4          1 1       1983061823          N
cpd18 02.33  65 54.91  370 2                              z
cpd*     4          1 1       1999123123          N
csb18 17.35  66 09.35  480 2                              z
csb*     4          1 1       1999123123          N
csj18 22.98  65 37.08   66 1                              z
csj*     4          1 1       1977100123          ?
csj*     4          1 1       1978060623          ?
csj*     4          1 1       1978121223          N
csj*     4          1 1       1979080423          R
```

```
csj*     4            1 1          1980110723               R
csj*     4            1 1          1981020223               R
csj*     4            1 1          1979123123               N
csj*     4            1 1          1982111923               N
csj*     4            1 1          1983061823               N
cup18 20.10  65 18.54  120 1                                          e
cup*     4            1 1          1983061823               N
cup18 20.10  65 18.54  120 1                                          n
cup*     4            1 1          1983061823               N
cup18 20.00  65 19.83  120 1                                          z
cup*     4            1 1          1976101023               N
cup*     4            1 1          1977061623               ?                                20.1018.53 120
cup*     4            1 1          1979022823               N                                20.1018.53 120
cup*     4            1 1          1979041823               N                                20.1018.53 120
cup*     4            1 1          1979120823               N                                20.1018.53 120
cup*     4            1 1          1980042023               R                                20.1018.53 120
cup*     4            1 1          1981020623               R                                20.1018.53 120
cup*     4            1 1          1983061823               N                                20.1018.53 120
cyp18 06.70  66 09.00  457 2                                          z
cyp*     4            1 1          1999123123               N
dos18 19.77  66 40.73  400 2                                          z
dos*     4            1 1          1999071723               N
eyp18 18.75  65 47.50 1060 2                                          z
eyp*     4            1 1          1999123123               N
gpv18 29.52  64 24.24      1                                          z
gpv*     4            1 1          1979080123               N
gpv*     4            1 1          1981020123               R
gpv*     4            1 1          1983061823               N
ide18 23.19  67 29.77  218 2                                          z
ide*     4            1 1          1999123123               N
imo18 06.69  67 54.51   84 2                                          z
imo*     4            1 1          1999123123               N
imr18 05.30  67 50.83   55 2                                          z
imr*     4            1 1          1999123123               N
lpr18 18.52  65 52.16  580 2                                          z
lpr*     4            1 1          1999123123               N
lrs18 17.60  66 50.70  440 2                                          z
lrs*     4            1 1          1999123123               N
lsp18 10.65  67 05.16  390 2                                          z
lsp*     4            1 1          1999123123               N
mcp18 25.13  67 06.63  250 2                                          z
mcp*     4            1 1          1999123123               N
mgp18 00.45  67 05.35   60 2                                          z
```

mgp*   4   1 1   1999123123   N
mov18 16.92 66 22.00 485 2   z
mov*   4   1 1   1999123123   N
mpr18 12.76 67 08.35   20 2   z
mpr*   4   1 1   1999123123   N
mrn18 00.72 63 03.60   20 1   z
mrn*   4   1 1   1979081723   R
mrn*   4   1 1   1980110723   R
mrn*   4   1 1   1981022123   R
mrn*   4   1 1   1983061823   N
mtp18 5.64 65 33.42 175 1   e
mtp*   4   1 1   1999123123   N
mtp18 5.64 65 33.42 175 1   n
mtp*   4   1 1   1999123123   N
mtp18 5.64 65 33.42 175 1   z
mtp*   4   1 1   1977070123   ?
mtp*   4   1 1   1977101223   N
mtp*   4   1 1   1978031323   ?
mtp*   4   1 1   1978060923   N
mtp*   4   1 1   1978121323   N
mtp*   4   1 1   1979080223   R
mtp*   4   1 1   1980041723   R
mtp*   4   1 1   1980110723   R
mtp*   4   1 1   1981020723   N
mtp*   4   1 1   1983061823   N
pnp18 03.58 66 46.00 200 2   z
pnp*   4   1 1   1999123123   N
pon18 00.20 66 36.83   50 2   z
pon*   4   1 1   1999071723   N
pwp18 08.10 65 26.70   10 1   z
pwp*   4   1 1   1977073123   ?
pwp*   4   1 1   1977103123   R
pwp*   4   1 1   1978031323   R
rrd18 14.16 65 37.08   40 1   z
rrd*   4   1 1   1978120123   ?
rrd*   4   1 1   1979080923   ?
rrd*   4   1 1   1979081623   R
rrd*   4   1 1   1980110723   R
rrd*   4   1 1   1981020223   R
rrd*   4   1 1   1982111423   N
sbn17 38.22 63 14.10 870 1   z
sbn*   4   1 1   1977103123   R
sbn*   4   1 1   1979081823   R

sbn*	4	1 1	1979120223	R		
sbn*	4	1 1	1980110723	R		37.2313.60 470
sbn*	4	1 1	1981022323	R		
sbn*	4	1 1	1983061823	N		
scv17 46.90	64 47.34	12 1			z	
scv*	4	1 1	1976112123	?		
scv*	4	1 1	1977070123	?		
scv*	4	1 1	1977101023	?		
scv*	4	1 1	1977121023	R		
scv*	4	1 1	1979032823	R		
scv*	4	1 1	1980042623	N		
scv*	4	1 1	1980052623	N		
scv*	4	1 1	1980110723	R		
scv*	4	1 1	1981020523	R		
scv*	4	1 1	1982111623	N		
sjg18 06.70	66 09.00	457 2			z	
sjg*	4	1 1	1999123123	N		
sjv18 20.70	64 45.72	280 1			e	
sjv*	4	1 1	1999123123	N		
sjv18 20.70	64 45.72	280 1			n	
sjv*	4	1 1	1999123123	N		
sjv18 20.70	64 45.72	280 1			z	
sjv*	4	1 1	1977061423	?		
sjv*	4	1 1	1978061023	R		
sjv*	4	1 1	1978081823	N		
sjv*	4	1 1	1979080823	R		
sjv*	4	1 1	1980110723	R		
sjv*	4	1 1	1981013123	R		
sjv*	4	1 1	1983061823	N		
vst18 21.24	64 57.42	372 1			e	
vst*	4	1 1	1983061823	N		
vst18 21.24	64 57.42	372 1			n	
vst*	4	1 1	1983061823	N		
vst18 21.24	64 57.42	372 1			z	
vst*	4	1 1	1977070123	?		
vst*	4	1 1	1977081923	N		
vst*	4	1 1	1977103123	N		
vst*	4	1 1	1977123123	N		
vst*	4	1 1	1978033123	N		
vst*	4	1 1	1978063023	N		
vst*	4	1 1	1978083123	N		
vst*	4	1 1	1979013023	N		
vst*	4	1 1	1979041623	N		

vst* 4 1 1 1979051623 R
vst* 4 1 1 1979083123 R
vst* 4 1 1 1980110723 R
vst* 4 1 1 1981022623 R
vst* 4 1 1 1983061823 N
awin17 02.70 61 51.60 371 1 z
awin* 4 1 1 1978112723 ?
awin* 4 1 1 1979121823 R
awin* 4 1 1 1981022023 R
awin* 4 1 1 1982112523 N
awin* 4 1 1 1983061823 N
cagu18 14.37 66 02.12 350 1 z
cagu* 4 1 1 1999071723 N
cgpv17 45.81 64 35.02 40 1 e
cgpv* 4 1 1 1983061823 N
cgpv17 45.81 64 35.02 40 1 n
cgpv* 4 1 1 1983061823 N
cgpv17 45.81 64 35.02 40 1 z
cgpv* 4 1 1 1978121523 R
cgpv* 4 1 1 1979040123 N
cgpv* 4 1 1 1979083123 N
cgpv* 4 1 1 1979120923 N
cgpv* 4 1 1 1980041923 N
cgpv* 4 1 1 1980042423 R
cgpv* 4 1 1 1980110723 R
cgpv* 4 1 1 1981020423 R
cgpv* 4 1 1 1983061823 N
cllp18 04.23 66 34.53 195 2 z
cllp* 4 1 1 1999123123 N
porp18 03.23 66 38.22 165 2 z
porp* 4 1 1 1999123123 N
sjgc18 06.70 66 09.00 457 2 z
sjgc* 4 1 1 1999123123 N
skbr17 20.46 62 50.40 1 z
skbr* 4 1 1 1981021723 R
skbr* 4 1 1 1983061823 N
stkp17 22.80 62 49.62 366 1 z
stkp* 4 1 1 1978120123 N
stkp* 4 1 1 1979112823 R
swip18 35.88 63 25.56 15 1 z
swip* 4 1 1 1977101623 ?
swip* 4 1 1 1978090123 ?
swip* 4 1 1 1979081623 N

swip*	4	1 1	1979121623	R	
swip*	4	1 1	1980050423	R	
swip*	4	1 1	1980110723	R	
swip*	4	1 1	1981021523	R	
swip*	4	1 1	1983061823	N	
tcgo18 08.75	66 58.87	880 2			z
tcgo*	4	1 1	1999123123	N	
vstb18 21.24	64 57.42	372 1			e
vstb*	4	1 1	1983061823	N	
vstb18 21.24	64 57.42	372 1			n
vstb*	4	1 1	1983061823	N	
vstb18 21.24	64 57.42	372 1			z
vstb*	4	1 1	1983061823	N	

Appendix D

Calibration Information

Calibration of natural frequencies of 3 component Stations (component, date, natural frequency in Hz)

CGPVZ 04/29/80 2.1
CGPVZ 02/04/81 2.2
CGPVZ 02/04/81 1.05
CGPVZ 11/05/82 1.15

CGPVN 03/19/79 1.0
CGPVN 04/29/80 1.4
CGPVN 02/04/81 4.5
CGPVN 02/04/81 1.3
CGPVN 11/05/82 1.15

CGPVE 11/01/78 1.0
CGPVE 04/29/80 1.0
CGPVE 02/04/81 1.18
CGPVE 11/05/82 1.16

SJVZ 05/01/80 2.2
SJVZ 08/01/80 2.2
SJVZ 01/31/81 1.1
SJVZ 11/09/82 1.05

SJVN 05/01/80 1.0
SJVN 08/01/80 1.0
SJVN 01/31/81 1.1
SJVN 11/09/82 1.14

SJVE 05/01/80 1.1
SJVE 08/01/80 1.1
SJVE 01/31/81 1.1
SJVE 11/09/82 1.07

MTPZ 02/07/81 1.14
MTPZ 12/23/81 1.15
MTPZ 11/13/82 1.01

MTPN 12/23/81 1.16
MTPN 11/13/82 1.01

MTPE 12/23/81 1.09
MTPE 11/13/82 0.97

ABVZ 02/08/81 1.2
ABVZ 11/22/82 1.0

ABVN 02/08/81 1.14
ABVN 11/22/82 2.04

ABVE 02/08/81 1.18
ABVE 11/22/82 0.94

Appendix E

Station parameter Information

Station Component Information

Format is as follows:

Unique Station identifier, station code, latitude, longitude, elevation, number of components, start and end dates, station location

901 ABV 18.7320 -64.3370 3.0 2 EHZ EHE 90. 0. 0. 90. 1979,3,25-1980,05,15 Anegada, British Virgin Islands
901 ABV 18.7320 -64.3370 3.0 3 EHE EHN EHZ 0. 90. 0. 0. 90. 0. 1980,05,16-1981,2,07 Anegada, British Virgin Islands
901 ABV 18.7320 -64.3370 3.0 3 EHE EHN EHZ 0. 90. 0. 0. -90. 0. 1980,02,8-1983,6,01 Anegada, British Virgin Islands
902 AWIN 17.0450 -61.8600 371.0 1 EHZ 90. 0. 1979,1,1-1981,2,20 Boggy Peak, Antigua, Antigua and Barbuda, Lesser Antilles
902 AWIN 17.0450 -61.8600 371.0 1 EHZ -90. 0. 1981,2,21-1983,6,01 Boggy Peak, Antigua, Antigua and Barbuda, Lesser Antilles
903 BWI 17.6650 -61.7900 30.0 1 EHZ -90. 0. 1979,1,1-1979,08,19 Barbuda, Antigua and Barbuda, Lesser Antilles
903 BWI 17.6650 -61.7900 30.0 1 EHZ 90. 0. 1979,08,20-1981,02,12 Barbuda, Antigua and Barbuda, Lesser Antilles
903 BWI 17.6650 -61.7900 30.0 1 EHZ -90. 0. 1981,2,13-1983,06,01 Barbuda, Antigua and Barbuda, Lesser Antilles
904 CGPV 17.7635 -64.5837 40.0 2 EHZ EHE -90. 0. 0. 90. 1979,1,1-1979,12,09 Cotton Garden Point, Saint Croix, U.S. Virgin Islands
904 CGPV 17.7635 -64.5837 40.0 2 EHZ EHE 90. 0. 0. 90. 1979,12,10-1980,04,28 Cotton Garden Point, Saint Croix, U.S. Virgin Islands
904 CGPV 17.7635 -64.5837 40.0 3 EHE EHN EHZ 0. 90. 0. 0. 90. 0. 1980,04,29-1981,2,4 Cotton Garden Point, Saint Croix, U.S. Virgin Islands
904 CGPV 17.7635 -64.5837 40.0 3 EHE EHN EHZ 0. 90. 0. 0. -90. 0. 1980,2,5-1983,6,01 Cotton Garden Point, Saint Croix, U.S. Virgin Islands
905 CGV 18.1328 -65.3173 130.0 2 EHZ EHE 90. 0. 0. 90. 1979,1,1-1980,04,17 Camp Garcia, Vieques, Puerto Rico
905 CGV 18.1328 -65.3173 130.0 1 EHZ 90. 0. 1980,04,18-1981,3,2 Camp Garcia, Vieques, Puerto Rico
905 CGV 18.1328 -65.3173 130.0 1 EHZ -90. 0. 1981,3,3-1983,6,01 Camp Garcia, Vieques, Puerto Rico
906 CSJ 18.3830 -65.6180 66.0 2 EHZ EHE 90. 0. 0. 90. 1979,1,1-1980,04,15 Cape San Juan, Puerto Rico
906 CSJ 18.3830 -65.6180 66.0 1 EHZ 90. 0. 1980,04,16-1981,2,2 Cape San Juan, Puerto Rico
906 CSJ 18.3830 -65.6180 66.0 1 EHZ -90. 0. 1981,2,3-1983,6,01 Cape San Juan, Puerto Rico
907 CUP 18.3350 -65.3090 120.0 2 EHZ EHE 90. 0. 0. 90. 1979,1,1-1979,04,18 Culebra Island, Puerto Rico
907 CUP 18.3350 -65.3090 120.0 2 EHZ EHE -90. 0. 0. 90. 1979,4,19-1979,12,8 Culebra Island, Puerto Rico
907 CUP 18.3350 -65.3090 120.0 2 EHZ EHE 90. 0. 0. 90. 1979,12,9-1980,04,19 Culebra Island, Puerto Rico
907 CUP 18.3350 -65.3090 120.0 3 EHE EHN EHZ 0. 90. 0. 0. 90. 0. 1980,04,20-1981,2,05 Culebra Island, Puerto Rico
907 CUP 18.3350 -65.3090 120.0 3 EHE EHN EHZ 0. 90. 0. 0. -90. 0. 1981,02,06-1983,6,01 Culebra Island, Puerto Rico
908 GPV 18.4920 -64.4040 343.0 2 EHZ EHE 90. 0. 0. 90. 1979,1,1-1980,04,26 Gorda Peak, Virgin Gorda, British Virgin Islands
908 GPV 18.4920 -64.4040 343.0 2 EHZ 90. 0. 1980,04,27-1981,1,31 Gorda Peak, Virgin Gorda, British Virgin Islands
908 GPV 18.4920 -64.4040 343.0 1 EHZ -90. 0. 1981,02,1-1983,6,01 Gorda Peak, Virgin Gorda, British Virgin Islands
909 MRN 18.0120 -63.0600 20.0 1 EHZ 90. 0. 1979,1,1-1981,2,20 Saint Martin, Netherlands Antilles
909 MRN 18.0120 -63.0600 20.0 1 EHZ -90. 0. 1981,2,21-1983,6,01 Saint Martin, Netherlands Antilles
910 MTP 18.0940 -65.5570 175.0 2 EHZ EHE 90. 0. 0. 90. 1979,1,1-1980,04,16 Mount Pirata, Vieques, Puerto Rico
910 MTP 18.0940 -65.5570 175.0 3 EHE EHN EHZ 0. 90. 0. 0. 90. 0. 1980,04,17-1983,2,06 Mount Pirata, Vieques, Puerto Rico
910 MTP 18.0940 -65.5570 175.0 3 EHE EHN EHZ 0. 90. 0. 0. -90. 0. 1980,02,7-1983,6,01 Mount Pirata, Vieques, Puerto Rico
911 RRD 18.2360 -65.6180 40.0 2 EHZ EHE 90. 0. 0. 90. 1979,1,1-1980,04,15 Roosvelt Roads Naval Station, Puerto Rico
911 RRD 18.2360 -65.6180 40.0 1 EHZ 90. 0. 1980,4,16-1981,2,2 Roosvelt Roads Naval Station, Puerto Rico
911 RRD 18.2360 -65.6180 40.0 1 EHZ -90. 0. 1981,2,3-1983,6,01 Roosvelt Roads Naval Station, Puerto Rico
912 SBN2 17.6201 -63.2267 470.0 1 EHZ 90. 0. 1979,12,21-1981,2,22 Saba, Netherlands Antilles
912 SBN2 17.6201 -63.2267 470.0 1 EHZ -90. 0. 1981,2,23-1983,6,01 Saba, Netherlands Antilles
913 SBN 17.6370 -63.2350 870.0 1 EHZ 90. 0. 1979,1,1-1979,12,04 Saba Peak, Saba, Netherlands Antilles

914 SCV 17.7817 -64.7890 12.0 2 EHZ EHE -90. 0. 0. 90. 1979,1,1-1980,04,26 Saint Croix, U.S. Virgin Islands
914 SCV 17.7817 -64.7890 12.0 1 EHZ 90. 0. 1980,04,27-1981,2,4 Saint Croix, U.S. Virgin Islands
914 SCV 17.7817 -64.7890 12.0 1 EHZ -90. 0. 1981,2,5-1983,6,01 Saint Croix, U.S. Virgin Islands
915 SJV 18.3450 -64.7620 280.0 2 EHZ EHE 90. 0. 0. 90. 1979,1,1-1980,04,21 Saint John, U.S. Virgin Islands
915 SJV 18.3450 -64.7620 280.0 3 EHE EHN EHZ 0. 90. 0. 0. 90. 0. 1980,04,22-1981,1,30 Saint John, U.S. Virgin Islands
915 SJV 18.3450 -64.7620 280.0 3 EHE EHN EHZ 0. 90. 0. 0. -90. 0. 1981,1,31-1983,6,01 Saint John, U.S. Virgin Islands
916 STKP 17.3800 -62.8270 366.0 1 EHZ 90. 0. 1976,10,01-1979,11,28 Saint Kitts, Saint Kitts and Nevis, Leeward Islands
917 SKBR 17.3410 -62.8400 200.0 1 EHZ 90. 0. 1979,11,30-1981,2,16 Saint Kitts, Saint Kitts and Nevis, Leeward Islands
917 SKBR 17.3410 -62.8400 200.0 1 EHZ -90. 0. 1981,2,17-1983,6,01 Saint Kitts, Saint Kitts and Nevis, Leeward Islands
918 SWIP 18.5980 -63.4260 15.0 1 EHZ 90. 0. 1979,1,1-1981,2,14 Sombrero Island, Lesser Antilles
918 SWIP 18.5980 -63.4260 15.0 1 EHZ -90. 0. 1981,2,15-1983,6,01 Sombrero Island, Lesser Antilles
919 VST 18.3540 -64.9570 372.0 3 EHE EHN EHZ 0. 90. 0. 0. -90. 0. 1979,1,1-1979,04,15 Saint Thomas U.S. Virgin Islands
919 VST 18.3540 -64.9570 372.0 3 EHE EHN EHZ 0. 90. 0. 0. 90. 0. 1979,4,16-1981,02,25 Saint Thomas U.S. Virgin Islands
919 VST 18.3540 -64.9570 372.0 6 EHE EHN EHZ ELE ELN ELZ 0. 90. 0. 0. -90. 0. 0. 90. 0. 0. -90. 0. 1981,02,26-1983,6,01 Saint Thomas U.S. Virgin Islands

Station Response Type Information

Format is as follows:

Station Type, Discriminator, VCO, Amplifier Response, Frequency, Other, Remarks
1, interproducts, interproducts, velocity, 1.0, upisland
2, interproducts, interproducts, velocity, 2.0, upisland
3, teledyne, interproducts, velocity, 1.0, downisland
4, teledyne, interproducts, velocity, 2.0, downisland
5, none, none, velocity, 1.0, VST only
6, none, none, "broadband", 1.0, VST only
7, interproducts, interproducts, velocity, 1.0, notch filter, CGV only
8, interproducts, interproducts, velocity, 2.0, notch filter, CGV only
9, teledyne, interproducts, velocity, 2.0, SJV only
10, teledyne, interproducts, displacement, 1.0, SJV only
11, teledyne, interproducts, velocity, 1.0, SJV only

Station Response History Information

Format is as follows:

"station"
Unique station identifier, station code, component response
Start date, end date
"gain:",response in counts/cm, natural frequency,
component response type

station
901 ABV EHZ 001
1979,03,28-1979,12,11
gain: 7.5e7 1.0 1.0
TYPE 2
station
901 ABV EHZ 001
1979,12,12-1979,12,20
gain: 3.75e7 1.0 1.0
TYPE 2
station
901 ABV EHZ 001
1981,12,21-1983,02,07
gain: 3.75e7 1.0 1.0
TYPE 1
station
901 ABV EHZ 001
1981,2,08-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 1
station
901 ABV EHN 001
1980,05,09-1981,02,07
gain: 3.75e7 1.0 1.0
TYPE 1
station
901 ABV EHN 001
1981,02,08-1981,12,20
gain: 3.75e7 1.0 1.0
TYPE 1
station
901 ABV EHN 001
1981,12,21-1982,08,12
gain: 7.50e7 1.0 1.0
TYPE 1

station
901 ABV EHN 001
1982,08,13-1982,11,21
gain: 3.75e7 1.0 1.0
TYPE 1
station
901 ABV EHN 001
1982,11,22-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 2
station
901 ABV EHE 001
1979,03,28-1979,12,11
gain: 7.5e7 1.0 1.0
TYPE 1
station
901 ABV EHE 001
1979,12,12-1981,02,07
gain: 3.75e7 1.0 1.0
TYPE 1
station
901 ABV EHE 001
1981,02,08-1981,12,20
gain: 3.75e7 1.0 1.0
TYPE 1
station
901 ABV EHE 001
1981,12,21-1982,08,12
gain: 7.5e7 1.0 1.0
TYPE 1

station
901 ABV EHE 001
1982,08,13-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1

station
902 AWIN EHZ 001
1979,03,28-1979,08,07
gain: 7.5e7 1.0 1.0
TYPE 4
station
902 AWIN EHZ 001
1979,08,08-1979,12,17
gain: 7.5e7 1.0 1.0
TYPE 4
station
902 AWIN EHZ 001
1979,12,18-1982,03,14
gain: 3.75e7 1.0 1.0
TYPE 4
station
902 AWIN EHZ 001
1982,03,15-1982,11,24
gain: 3.75e7 1.0 1.0
TYPE 3
station
902 AWIN EHZ 001
1982,11,25-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 3
station
903 BWI EHZ001
1979,03,28-1979,08,19
gain: 1.5e8 1.0 1.0
TYPE 4
station
903 BWI EHZ001
1979,08,20-1980,05,11
gain: 7.5e7 1.0 1.0
TYPE 4
station
903 BWI EHZ001
1980,05,12-1981,02,12
gain: 7.5e7 1.0 1.0
TYPE 3
station
903 BWI EHZ001
1981,02,13-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 3
station
904 CGPV EHZ 001
1979,03,28-1979,12,08
gain: 1.5e8 1.0 1.0
TYPE 2
station
904 CGPV EHZ 001
1979,12,09-1981,02,03
gain: 7.5e7 1.0 1.0
TYPE 2
station
904 CGPV EHZ 001
1981,02,04-1981,12,14
gain: 3.75e7 1.0 1.0
TYPE 1
station
904 CGPV EHZ 001
1981,12,15-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 1
station
904 CGPV EHN 001
1980,04,29-1981,02,03
gain: 7.5e7 1.0 1.0
TYPE 1
station
904 CGPV EHN 001
1981,02,04-1981,12,14
gain: 9.35e6 1.0 1.0
TYPE 1
station
904 CGPV EHN 001
1981,12,15-1982,07,31
gain: 7.5e7 1.0 1.0
TYPE 1

station
904 CGPV EHN 001
1982,08,01-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
904 CGPV EHE 001
1979,03,28-1979,08,07
gain: 1.5e8 1.0 1.0
TYPE 1
station
904 CGPV EHE 001
1979,08,08-1979,12,08
gain: 1.5e8 1.0 1.0
TYPE 1
station
904 CGPV EHE 001
1979,12,09-1981,02,03
gain: 7.5e7 1.0 1.0
TYPE 1
station
904 CGPV EHE 001
1981,02,04-1981,12,15
gain: 9.35e6 1.0 1.0
TYPE 1
station
904 CGPV EHE 001
1981,12,15-1981,07,31
gain: 7.5e7 1.0 1.0
TYPE 1
station
904 CGPV EHE 001
1982,08,01-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
906 CSJ EHZ 001
1979,03,28 1980,04,14
gain: 7.5e7 1.0 1.0
TYPE 2
station
906 CSJ EHZ 001
1980,04,15-1981,02,01
gain: 7.5e7 1.0 1.0
TYPE 2
station
906 CSJ EHZ 001
1981,02,02-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 1
station
906 CSJ EHE 001
1979,03,28-1980,04,15
gain: 7.5e7 1.0 1.0
TYPE 1
station
905 CGV EHZ 001
1979,03,28-1980,4,17
gain: 1.5e8 1.0 1.0
TYPE 8
station
905 CGV EHZ 001
1980,04,18-1981,03,01
gain: 7.5e7 1.0 1.0
TYPE 8
station
905 CGV EHZ 001
1981,03,02-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 7
station
905 CGV EHE 001
1979,03,28-1980,04,18
gain: 7.5e7 1.0 1.0
TYPE 7
station
907 CUP EHZ 001
1979,03,28 -1979,12,07
gain: 1.5e8 1.0 1.0
TYPE 2
station
907 CUP EHZ 001
1979,12,08-1981,02,05
gain: 3.75e7 1.0 1.0
TYPE 2
station

907 CUP EHZ 001
1981,02,06-1981,12,16
gain: 3.75e7 1.0 1.0
TYPE 1
station
907 CUP EHZ 001
1981,12,17-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 1
station
907 CUP EHN 001
1980,04,20-1981,02,05
gain: 3.75e7 1.0 1.0
TYPE 1
station
907 CUP EHN 001
1981,02,06-1981,12,16
gain: 3.75e7 1.0 1.0
TYPE 1
station
907 CUP EHN 001
1981,12,17-1982,07,29
gain: 7.5e7 1.0 1.0
TYPE 1
station
907 CUP EHN 001
1982,07,30-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
907 CUP EHE 001
1979,03,28-1979,12,07
gain: 1.5e8 1.0 1.0
TYPE 2
station
907 CUP EHE 001
1979,12,08-1980,04,19
gain: 3.75e7 1.0 1.0
TYPE 2
station
907 CUP EHE 001
1980,04,20-1981,02,05
gain: 3.75e7 1.0 1.0
TYPE 1
station
907 CUP EHE 001
1981,02,06-1981,12,16
gain: 3.75e7 1.0 1.0
TYPE 1
station
907 CUP EHE 001
1981,12,17-1982,07,29
gain: 7.5e7 1.0 1.0
TYPE 1
station
907 CUP EHE 001
1982,07,30-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
908 GPV EHZ 001
1979,04,28-1981,01,31
gain: 7.5e7 1.0 1.0
TYPE 1
station
908 GPV EHZ 001
1981,02,01-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
908 GPV EHE 001
1979,04,28-1980,04,26
gain: 7.5e7 1.0 1.0
TYPE 1
station
909 MRN EHZ 001
1979,03,28-1979,08,15
gain: 7.5e7 1.0 1.0
TYPE 4
station
909 MRN EHZ 001
1979,08,16-1979,02,20
gain: 3.75e7 1.0 1.0
TYPE 4
station
909 MRN EHZ 001

1981,02,21-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 4
station
910 MTP EHZ 001
1979,03,29-1980,04,16
gain: 1.5e8 1.0 1.0
TYPE 2
station
910 MTP EHZ 001
1980,04,17-1981,02,06
gain: 3.75e7 1.0 1.0
TYPE 2
station
910 MTP EHZ 001
1981,02,07-1981,12,22
gain: 3.75e7 1.0 1.0
TYPE 1
station
910 MTP EHZ 001
1981,12,23-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 1
station
910 MTP EHN 001
1980,04,17-1980,02,06
gain: 3.75e7 1.0 1.0
TYPE 1
station
910 MTP EHN 001
1981,2,07-1981,12,22
gain: 3.75e7 1.0 1.0
TYPE 1
station
910 MTP EHN 001
1981,12,23-1982,08,02
gain: 7.5e7 1.0 1.0
TYPE 1
station
910 MTP EHN 001
1982,08,03-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
910 MTP EHE 001
1979,04,02-1980,04,16
gain: 7.5e7 1.0 1.0
TYPE 1
station
910 MTP EHE 001
1980,04,17-1981,02,06
gain: 3.75e7 1.0 1.0
TYPE 1
station
910 MTP EHE 001
1981,02,07-1981,12,22
gain: 3.75e7 1.0 1.0
TYPE 1
station
910 MTP EHE 001
1981,12,23-1982,08,02
gain: 7.5e7 1.0 1.0
TYPE 1
station
910 MTP EHE 001
1982,08,03-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
911 RRD EHZ 001
1979,03,28-1979,08,07
gain: 1.5e8 1.0 1.0
TYPE 2
station
911 RRD EHZ 001
1979,08,08-1979,04,14
gain: 1.5e8 1.0 1.0
TYPE 2
station
911 RRD EHZ 001
1980,04,15-1980,02,01
gain: 7.5e7 1.0 1.0
TYPE 2
station
911 RRD EHZ 001
1981,02,02-1983,06,01

gain: 1.5e8 1.0 1.0
TYPE 1
station
911 RRD EHE 001
1979,03,28-1980,04,15
gain: 7.5e7 1.0 1.0
TYPE 1
station
913 SBN EHZ 001
1979,03,28-1979,12,03
gain: 3.75e7 1.0 1.0
TYPE 4
station
912 SBN2 EHZ 001
1979,12,19-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 4
station
914 SCV EHZ 001
1979,03,28-1979,08,07
gain: 7.5e7 1.0 1.0
TYPE 2
station
914 SCV EHZ 001
1979,08,08-1981,02,04
gain: 7.5e7 1.0 1.0
TYPE 2
station
914 SCV EHZ 001
1981,02,05-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 1
station
914 SCV EHE 001
03,28,1979-1980,04,26
gain: 7.5e7 1.0 1.0
TYPE 1
station
915 SJV EHZ 001
1979,03,29-1979,08,07
gain: 1.5e8 1.0 1.0
TYPE 2
station
915 SJV EHZ 001
1979,08,08-1980,04,21
gain: 1.5e8 1.0 1.0
TYPE 2
station
915 SJV EHZ 001
1980,04,22-1981,01,30
gain: 7.5e7 1.0 1.0
TYPE 9
station
915 SJV EHZ 001
1981,01,31-1982,11,08
gain: 2.27e6 1.0 1.0
TYPE 10
station
915 SJV EHZ 001
1982,11,09-1983,06,01
gain: 1.5e8 1.0 1.0
TYPE 1
station
915 SJV EHN 001
1980,04,22-1981,01,30
gain: 7.5e7 1.0 1.0
TYPE 11
station
915 SJV EHN 001
1981,01,31-1982,11,09
gain: 1.68e6 1.0 1.0
TYPE 10
station
915 SJV EHN 001
1982,11,09-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
915 SJV EHE 001
1979,03,29-1979,08,07
gain: 1.5e8 1.0 1.0
TYPE 1
station
915 SJV EHE 001
1979,08,08-1980,04,21
gain: 1.5e8 1.0 1.0

TYPE 1
station
915 SJV EHE 001
1980,04,22-1980,01,30
gain: 7.5e7 1.0 1.0
TYPE 9
station
915 SJV EHE 001
1981,01,31-1982,11,08
gain: 1.68e6 1.0 1.0
TYPE 10
station
915 SJV EHE 001
1982,11,09-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 1
station
917 SKBR EHZ 001
1979,11,30-1981,02,16
gain: 3.75e7 1.0 1.0
TYPE 4
station
917 SKBR EHZ 001
1981,02,17-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 3
station
916 STKP EHZ 001
1979,03,29-1979,11,20
gain: 7.5e7 1.0 1.0
TYPE 4
station
918 SWIP EHZ 001
1979,03,28-1979,08,15
gain: 7.5e7 1.0 1.0
TYPE 4
station
918 SWIP EHZ 001
1979,08,16-1981,02,14
gain: 3.75e7 1.0 1.0
TYPE 4
station
918 SWIP EHZ 001
1981,02,15-1983,06,01
gain: 3.75e7 1.0 1.0
TYPE 3
station
919 VST EHZ 001
1979,03,29-1979,04,15
gain: 3.75e7 1.0 1.0
TYPE 1
station
919 VST EHZ 001
1979,04,16-1979,08,08
gain: 5.4e7 1.0 1.0
TYPE 5
station
919 VST EHZ 001
1979,08,08-1983,06,01,
gain: 5.4e7 1.0 1.0
TYPE 5
station
919 VST EHN 001
1979,03,29-1979,04,15
gain: 3.75e7 1.0 1.0
TYPE 1
station
919 VST EHN 001
1979,04,16-1979,08,07
gain: 5.4e7 1.0 1.0
TYPE 5
station
919 VST EHN 001
1979,08,08-1983,06,01
gain: 5.4e7 1.0 1.0
TYPE 5
station
919 VST EHE 001
1979,04,16-1979,08,07
gain: 5.4e7 1.0 1.0
TYPE 5
station
919 VST EHE 001
1979,08,08-1983,06,01
gain: 5.4e7 1.0 1.0
TYPE 5

station
919 VST ELZ 001
1981,02,26 1983,06,01
gain: 3.87e4 1.0 1.0 at 1hz
TYPE 6
station
919 VST ELN 001
1981,02,26 1983,06,01
gain: 4.25e4 1.0 1.0 at 1hz
TYPE 6
station
919 VST ELE 001
1981,02,26-1983,06,01
gain: 4.25e4 1.0 1.0 at 1hz
TYPE 6

Appendix F

Miscellaneous Comments

Ocean Bottom Seismometer data-

OBS data was also rescued. 15 OBS tapes were processed using “ping2ah –nys” to develop ah files that were checked by PQL. No time, however, was spent developing a modulated IRIG-C code reader to acquire the trigger time of each record. Besides the issue of the modulated IRIG time code, there is another issue that would need to be resolved if the data is to be used. That issue is that when the data were gathered the recording system used 2 read-write heads with a distinct time offset observed in recorded data. A channel common to each of the head allows the time offset to be removed.

Previous problem with tape OBS10 remains, and for OBS5 the second group of data, previously not captured, was recovered.

Data was generally taken from DLT tape image made in 1996. There were 15 OBS tapes written onto the DLT tape at that time. OBS tape 10 produced errors so none of its information was written. Data were extracted from the DLT tape and are given in this directory. DLT tape directories OBS5-15 are from the 1979 Conrad 22-12 cruise. The other directories are from the 1976 TIKI cruise.

The Channel OBS file used for demultiplexing is given below

Channels OBS
1 clk1 100
2 clk2 100
3 obsz 100
4 obsn 100
5 obse 100
6 hydr 100
7 unk1 100
8 unk2 100

1979 Conrad 22-12 Data

All processed with 7 channels as found in their header files. The 7 channels are: spzh, spzl, hydh, hydl, dm, time, and ref. When comparing the number of files created in 1996 and the number of file written onto the original tapes, we found significant discrepancies for OBS5, OBS8, OBS9, OBS10, OBS11, and OBS15.

OBS5 has 146 files and 78 recovered. The rest must still be on the tape after some EOF marks used to divide the tape into different OBS data units. The original tape would have to be reread to recover the data.

OBS8 has 341 files 226 are for OBSB6 and the rest are for OBSB5 (115). Originally we did not know how many data files were for OBSB5.

OBS9 we recovered 211 files with only 152 noted to OBSB7 on this tape. The other files appear to be for OBSO4 as per the file headers.

OBS10 produced errors in 1996. We tried again to read its 197 files, with no success

OBS11 has 221 of the files registered for OBSR4, the rest are on OBS15 tape. In total there are 334 files for OBSR4 some on this tape the rest on 15.

OBS15 the tape label says that there are 334 events for R4 but only 113 files are on this tape, the rest are on tape OBS11.

In summary, tapes for OBS5 and OBS10 need to be reread to get 100% data recovery.

1976 TIKI data

A readmeobs file found on the DLT tape indicated that there were 7 channels for the 1979 data (correct) and 8 channels for the 1976 data. Examining the headers we found 4 and 7 channels, but demutiplexing is still a problem to be solved. OBS1 data were demultiplexed with 8 channels successfully?. But the data don't all plot in pql with hz? complaints. OBS2 data were dmuxed with 4 channels, no complaints. OBS3 data the same. OBS4 contained some data from OBSR3, that was moved to OBS4b to be processed with 7 channels. The TIKI data herein was processed with 4 channels. The R3 data in OBS4b was processed with 5 channels.

List of OBS data rescued

1976

OBS	Number of Trigger Files
T1	159
T2	188
T3	48

1979

OBS	Number of Trigger Files
B1	79
B3	64
B4	253
B5	117
B6	224
B7	142
O1	66
O2	139
O3	21
O4	69
R2	371
R3	16
R4	334
R5	133

Final Report for USGS-HQ-1434-96-GR-02731

Development of a Unified Catalog of Locally Recorded Earthquakes for the Eastern Caribbean

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Earth Scientific Consultants
6860 West 99th Avenue, Westminster, CO 80021-5447

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TABLE OF CONTENTS

ABSTRACT

In 1975 local seismic monitoring in Puerto Rico and the Virgin Islands began. The monitoring was undertaken by two different entities, and the two seismic networks spatially and temporally overlapped. The Eastern Network, (herein call the LDEO or NE Caribbean network) operated by Lamont-Doherty Earth Observatory (LDEO), consisted of 17 stations reaching as far east and south as Antigua in the Lesser Antilles. Eleven of those stations were in the Virgin Islands- Puerto Rico region. The Western Network, (herein called the Puerto Rico Seismic Network, PRSN) operated by the U.S. Geological Survey, consisted of 15 stations on Puerto Rico and offshore islands to the West. The LDEO network operated continuously from 1975-June 1983; all of the data collected, except that of 1983, have been processed. The USGS Network has operated more or less continuously since 1975 to the present, but much of its data has not been processed, and the administrative responsibility of the network has changed several times.

In this program we rescued the earthquake phase data of the LDEO network and prepared it for combination with the phase data of the Puerto Rico Seismic Network. Phase arrival times, amplitudes and codas and other miscellaneous information from the LDEO network are stored on numerous 800bpi magnetic tapes, many of which had not been used in about 10 years. We successfully recovered that data and rewrote it onto high-density DAT tapes, and is also included herein on diskettes. Much to our surprise the time corrections necessary to correct the phase arrival times to UCT were either incomplete, improperly done, or non-existent. A significant portion of the recovery time at LDEO was therefore devoted to the reading of time corrections. Later, the time correction data was statistically analyzed to develop a series of equations to be used in the correction of the LDEO data to UCT. The final step, combining the data from the Puerto Rico and LDEO networks was not completed because of this time correction problem.

SEISMIC MONITORING IN THE NORTHEASTERN CARIBBEAN

Puerto Rico and the U.S. Virgin Islands have already benefited from the installation and operation of local seismic stations designed to monitor microearthquake activity. Information collected over the last 20 years has aided the definition of local seismic hazard and helped to control the growth of seismic risk. Ongoing revisions of the building code in Puerto Rico are partly a result of investigations using data collected by the local seismic network. The locations of microearthquakes have played an important role in the decision of whether or not to construct important facilities at a given site, and to guide the use of appropriate seismo-resistant design parameters after a siting decision has been made. Also, the local seismic network has also been able to provide prompt information to the communications media when strong earthquakes have occurred, aiding the education of the general public in earthquake hazards. Unfortunately, because of a complicated history of seismic recording, and lack of appropriate funding, the existing 20-year database has not yet been fully utilized and part of it may be in jeopardy of being lost. Herein we propose to take one important step toward the rescue and utilization of that data.

In 1975 several seismic stations were installed in the Puerto Rico-Virgin Islands region by two organizations, the U.S. Geological Survey (USGS) and Lamont-Doherty Earth Observatory (LDEO). In the period 1982-84 those networks were combined to form the Puerto Rico Seismic Network operated by the University of Puerto Rico. The data collected from 1975-1983 from those separate networks has not yet been integrated to form a common catalog and bulletin even though the networks overlapped spatially and temporally. This program rescued the data from LDEO and prepared it for integration with the data the adjoining Puerto Rico Seismic Network to form a single catalog of earthquakes. Final integration will need to await application of newly obtained clock corrections to the LDEO data. Clock corrections are now available as a result of this rescue program.

Brief History of the U. S. G. S. Seismic Network

The U. S. Geological Survey established a network of seismic stations in the Commonwealth of Puerto Rico in response to a lack of instrumentally recorded seismic data necessary to make earthquake hazards evaluations. The principal objective was to assess regional and local seismicity in relation to the construction by the Puerto Rico Electrical Power Authority (PREPA) of a nuclear power plant in Puerto Rico. The PREPA objectives were accomplished in 1979. Network stations were composed of Geotech S-13 seismometers, Emtel VCO/amplifiers and a RF transmitter. Data were transmitted to the San Juan Geophysical Observatory, operated by the USGS in Cayey, Puerto Rico where signals from the seismic stations were recorded on a 20-channel microfilm develocorder system. Although some temporary stations were in operation by August 16, 1974, the operation of a large number of stations sufficient to provide island-wide seismic monitoring (15 stations) began in July 30, 1975 (Carver et al., 1976; Tarr and King, 1976, Dart et al., 1979). From what we know, the network remained stable until February 1982 when recording on the develocorder was interrupted (Table 1.).

Data processing was described in detail by Tarr and Davids (1977) and events were located by the program HYPO71. A bulletin reporting reading and location of 20 events from

August 1974 through June 1975 was published in Carver et al., 1976). A catalog of later events from July 1,1975 through December 31, 1977 was published in Dart et al. (1979). They employed a different crustal structure than that used by Carver. The data were reprocessed again using the program HYPOELLIPSE and a catalog of those locations was published in Dart et al. (1980). Data from 1978, until the USGS relinquished control of the network in June 1982, were never published by them (Table 2.). Preliminary phase times of earthquakes for 1978, as read by USGS personnel, were later found and events for the first 6 months year were located, and published by the PRSN. Unanalyzed data tapes are held at the PRSN.

<u>Brief History of the LDEO Seismic Network</u>

The northeastern Caribbean Network was installed in early 1975 starting in the easternmost part of the Island of Puerto Rico and offshore islands to the east, as well as the U.. S. Virgin Islands. Each station consisted of an HS-10 2 Hz geophone, interproducts VCO, and information was relayed by FM radio to a central recording site. Later many stations were increase to two components each and finally three (Table 1.). At the central recording station, data were recorded on heliocorders and on 16mm film by use of a develocorder. Events were located using at first using Hypoellipse then later Hypoinverse. Bulletins reporting phase information and locations were published for data from at least 1977 until the end of 1982 (Table 2.) Data for events in the last six months of network operation were neither interpreted nor locations determined. All events were located using the one velocity model, though later a model was determined through inversion of event arrival times and multi-ton calibration shots (Fischer and McCann, 1984).

Table 1. Data Recording History for Eastern Caribbean Networks

U.S. Geol. Survey				Puerto Rico Network		Lamont-Doherty Earth Obs.		
Year	# Sta.	Recording		# Sta.	Recording		# Sta	Recording
1975	15	Develocorder					11	Devel/Helio
1976	15	Develocorder					11	Devel/Helio
1977	15	Develocorder					11	Devel/Helio
1978	15	Develocorder					17	Devel/Helio
1979	15	Develocorder					17	Mag Tape/Helio
1980	15	Develocorder					17	Mag Tape/Helio
1981	15	Develocorder					17	Mag Tape/Helio
1982	15	1-2 Develocorder		15	no recording 7-12		17	Mag Tape/Helio
1983				15	1-7 Devel, 5-12 Mag Tpe		17	1-6 Mag Tpe/Helio
1984				21	Mag Tape/Helio			
1985				21	Mag Tape/Helio			
1986				21	Mag Tape/Helio			
1987				21	Mag Tape/Helio			
1988				21	Mag Tape/Helio			

1989				21	Mag Tape/Helio			
1990				21	Mag Tape/Helio			
1991				21	1-6 Mag Tp/ Helio; 6-12 Comp/ Helio			
1992				21	Comp/Helio			
1993				15	Comp/Helio			
1994				15	Comp/Helio			
1995				15	Comp/Helio			

Notes: # Sta is number of stations in network; Recording is type of recording used to obtain waveforms; Devel is Develocorder; Mag Tpe or Tape is _" 8-track magnetic tape, digital-triggered recording system of LDEO design; Helio is continuous analog recording on Heliocorder; Comp is event triggered PC computer using IAPSEI or Soufriere software. Numbers in recording column gives months for which given system was used if operation was for part of one year. For the most reliable information about the existing network, please visit http://rmsismo.upr.clu.edu

Formation of the Puerto Rico Seismic Network

Starting in the end of June 1982, operational responsibility of the USGS seismic network was transferred to the Center for Energy and Environmental Research (CEER) of the University of Puerto Rico. From that time through June 1987, network support included basic collection, interpretation and processing of seismic data. The antiquated develocorder style recording was replaced by an event triggered digital recording system of LDEO design. Continuous heliocorder recording was also added.

Table 2. Status of Data Reduction for Northeastern Caribbean Seismic Networks

	US Geological Survey								Puerto Rico Network								Lamont-Doherty Earth Obs.							
	R	P	T	L	C	H	B		R	P	T	L	C	H	B		K	R	P	T	L	C	H	B
1975	X	X	X	X	X	X											X	X	X		X	X	X	X
1976	X	X	X	X	X	X											X	X	X		X	X	X	X
1977	X	X	X	X	X	X											X	X	X		X	X	X	X
1978	X	X	X									X	X	X	X		X	X	X		X	X	X	X
1979	X																X	X	X	X	X	X	X	X
1980	X																X	X	X	X	X	X	X	X
1981	X																X	X	X	X	X	X	X	X
1982									?								X	X	X	X	X	X	X	X
1983									X	X	X	X	X	X	X		X	X						
1984									X	X	X	X	X	X	X									
1985									X	X	X	X	X	X	X									
1986									X	X	X	X	X	X	X									
1987									X															
1988										X														
1989										X														
1990										X	X	X	X	X	X	X								
1991										X	X	X	X	X	X	X								

1992										X	X	X	X	X	X	X								
1993										X	X	X	X	X	X	X								
1994										X	X	X	X	X	X	X								
1995										X	X	X	X	X	X	X								

Notes: Column headings are as follows: R- data recorded; P- phase times picked; K- Clock correction made when possible; T- data time corrected to UCT; L- events located; C- catalog of events exists; H- phase data exists in machine readable format; B- Bulletin of events exists. X means work completed. For the most reliable information about the existing network, please visit http://rmsismo.upr.clu.edu

Both LDEO and USGS provided help in setting up the data processing system, with the LDEO crustal model (used by LDEO in the Virgin Islands) used in HYPOINVERSE to locate events. About June 1983 the LDEO network in the Virgin Islands was dismantled with some equipment shipped to the Dominican Republic. As part of a USGS funded program, Six 3-component stations of the closing LDEO network in the Virgin Islands were transferred to the existing stations on the Island of Puerto Rico to form a 21-station Puerto Rico Seismic Network (Figures 1, and 2).

Operation of the network was transferred to the Geology Department, University of Puerto Rico, Mayagüez on June 22, 1987. Since that time the recording system has been upgraded to use the PC based IASEPI data collection in conjunction with a system developed by the University of the West Indies. Earthquakes are still located using HYPOINVERSE and the same crustal model as before, however a new magnitude scale has been introduced. So the catalogs of events near Puerto Rico and the Virgin Islands contains events located by at least two different computer programs, and at least two different crustal models and events magnitudes are based off at least two different scales.
For the most reliable information about the existing network, please visit the web site at http://rmsismo.upr.clu.edu

Project Results

The project consisted of two parts. Part one was a visit to LDEO to rescue the network data available there. That process included the following activities:

1- Examination of written records/notes to develop time line for changes in collection/processing of network data (see Table 3.)

2- Locate all media containing original phase times and amplitudes, hypoellipse or hypoinverse related location files, bulletins or similar summaries of locations, along with location errors. (see Appendices C, D, E, and F as well as self executing zip files on the enclosed diskettes)

Table 3. Time Line for Collection/Processing of Northeast Caribbean Network Data

Time Period of Data	Computer for Processing	Program for Processing	Data Recording and Processing	Reading Precision
1975-1976	Local IBM or Columbia Univ. Mainframe	Hypoellipse	Develocorder and Reader	0.1 seconds
1977-1978	VAX	Hypoellipse	Develocorder and Reader	0.1 seconds
1979-1982	PDP 11/70	Hypoinverse	Digital Recording	.02 seconds

3- Locate listings of stations gains, polarities, and response curves, histories of time corrections See Appendix F for copy of Network Status Book containing this information. Original clock correction information is in Appendicies A, B, and E)

4- Copy machine readable information on to modern media especially all phase data, catalogs and bulletin data (see Appendix C and self executing zip files on the enclosed diskettes).

Data for 1983 has still yet to be analyzed. That data has been demultiplexed and should be copied onto modern media so that it can be analyzed using modern data analysis programs.

The second part of the project is composed of several tasks: 1- Prepare rescued data for combination with USGS network data 2- Relocate combined USGS and LDEO phase data to produce a new catalog of located microearthquakes for eastern Puerto Rico and the Virgin Islands. 3- Publish and distribute new catalog and datasets to LDEO/USGS/PRSN and Puerto Rican government agencies.

Task 1 was much more complicated than originally envisioned. The major set back was the lack of complete correct and consistent clock corrections for the period of interest (1975-1978). So much time was devoted to the collection and correction of the clock correction data, that none was left to correct the phase data and produce the final catalog.

However, as a result of this program the clock correction for the period 1975-1978 are complete, correct and consistent. In appendix E (and the enclosed diskettes- clockcor.xls an excel spreadsheet format) all the clock correction information is presented. The clock corrections were analyzed in segments of time. When a consistent drift rate, and without clock resets, was found, that segment was statistically analyzed to determine drift rate and intercept times. The information provided in appendix E can now be used to clock correct the data and merge with the USGS network data to produce the unified catalog. The stability in drift rates means that time corrections are available for the 95% of the time period from 6/8/75 through 9/30/78. Clock corrections after this time period are all 0.0 seconds as a satellite clock, not a ts-100 crystal clock, was used for timing.

Phase data for 1975 and 1976 were found in a file with no carriage returns at the end of the data records. The records were laboriously reformatted. Phase data for Mar-May 1975 was not to be found in electronic form. It exists only in the computer printouts at LDEO. During that time period only a few stations operated in both networks, so the amount of "lost" information is negligible. Even so the information could be recovered if someone wanted to reenter the phase and amplitude information.

In some of the files the formatting of the data was rather inconsistent with hypoellipse. That is, the columns for "P", i/e and u/d appeared to be inverted. This is not a significant problem for the data. In some files the three letter code of the station occurs after a space and in other files it is found before the space. This change in code position occurred with change of computers and with the introduction of 4 letter station codes. No data for October through December 1981. If memory serves me well, there was a problem with the digital recording system during that period and no data was recorded digitally or analyzed.

Table 4. Summary of LDEO Network Data Files

	Files Found or Constructed				**Bulletin Format**	**Bulletin Found**
Date	**File Type**				**Bulletin Information**	
	PREP	**PHA**	**HY**	**LOC**		
1975						
March					121 char/line computer output	yes
April					122 char/line computer output	yes
May					123 char/line computer output	yes
June		x			120 char/line computer output	yes
July		x			120 char/line computer output	yes
August		x			120 char/line computer output	yes
September		x			120 char/line computer output	yes
October		x			120 char/line computer output	yes
November		x			120 char/line computer output	yes
December		x			120 char/line computer output	yes
1976						
January		x			120 char/line computer output	yes
February		x			120 char/line computer output	yes
March		x			120 char/line computer output	yes
April		x			120 char/line computer output	yes
May		x			120 char/line computer output	yes
June		x			120 char/line computer output	yes
July		x			120 char/line computer output	yes
August		x			120 char/line computer output	yes
September		x			120 char/line computer output	yes
October		x			120 char/line computer output	yes
November		x			120 char/line computer output	yes
December		x			120 char/line computer output	yes
1977						

January	**x**	**x**	**x**		120 char/line computer output	yes
February	**x**	**x**	**x**		120 char/line computer output	yes
March	**x**	**x**	**x**		120 char/line computer output	yes
April	**x**	**x**	**x**	**x**	120 char/line computer output	yes
May	**x**	**x**	**x**		120 char/line computer output	yes
June	**x**	**x**	**x**	**x**	120 char/line computer output	yes
July	**x**	**x**	**x**	**x**	120 char/line computer output	no
August	**x**	**x**	**x**	**x**	120 char/line computer output	yes
September	**x**	**x**	**x**	**x**	120 char/line computer output	yes
October	**x**	**x**	**x**	**x**	120 char/line computer output	yes
November	**x**	**x**	**x**	**x**	120 char/line computer output	yes
December	**x**	**x**	**x**	**x**	120 char/line computer output	yes
1978						
January	**x**	**x**	**x**		120 char/line computer output	yes
February	**x**	**x**	**x**	**x**	120 char/line computer output	yes
March	**x**	**x**	**x**	**x**	120 char/line computer output	yes
April	**x**	**x**	**x**	**x**	120 char/line computer output	yes
May	**x**	**x**	**x**	**x**	120 char/line computer output	yes
June		**x**	**x**	**x**	120 char/line computer output	yes
July	**x**	**x**	**x**	**x**	120 char/line computer output	yes
August	**x**	**x**	**x**	**x**	120 char/line computer output	yes
September	**x**	**x**	**x**	**x**	120 char/line computer output	yes
October	**x**	**x**	**x**	**x**	120 char/line computer output	yes
November	**x**	**x**	**x**	**x**	120 char/line computer output	yes
December	**x**	**x**	**x**		120 char/line computer output	yes
1979						
January		**x**	**x**	**x**	fan fold versatec output	yes
February		**x**	**x**	**x**	fan fold versatec output	no
March		**x**	**x**	**x**	fan fold versatec output	yes
April		**x**	**x**	**x, roc**	fan fold versatec output	yes
May		**.hy**	**x**	**x**	fan fold versatec output	no
June		**x**	**x**	**x, roc**	fan fold versatec output	no
July		**x**	**x**		fan fold versatec output	yes
August		**x**	**x**	**x**	fan fold versatec output	yes
September		**x**	**x**	**x**	fan fold versatec output	yes
October		**x**	**x**	**x**	fan fold versatec output	yes
November		**x**	**x**	**x**	fan fold versatec output	yes
December		**x**	**x**	**x**	fan fold versatec output	yes
1980						
January		**x**	**x**		fan fold versatec output	yes
February		**x**	**x**		fan fold versatec output	yes
March			**x**		fan fold versatec output	yes
April			**x**		spiral bound quarterly	yes
May			**x**		spiral bound quarterly	yes

June			x		spiral bound quarterly	yes
July			x		spiral bound quarterly	yes
August			x		spiral bound quarterly	yes
September			x		spiral bound quarterly	yes
October			x		spiral bound quarterly	yes
November			x		spiral bound quarterly	yes
December			x		spiral bound quarterly	yes
1981						
January			x		spiral bound quarterly	yes
February			x		spiral bound quarterly	yes
March			x		spiral bound quarterly	yes
April			x	x	spiral bound quarterly	yes
May			x	x	spiral bound quarterly	yes
June			x	x	spiral bound quarterly	yes
July			x	x	spiral bound quarterly	yes
August			x	x	spiral bound quarterly	yes
September			x	x	spiral bound quarterly	yes
October						no
November						no
December						no
1982						
January			x	x	spiral bound annual	yes
February			x	x	spiral bound annual	yes
March			x	x	spiral bound annual	yes
April			x	x	spiral bound annual	yes
May			x	x	spiral bound annual	yes
June			x	x	spiral bound annual	yes
July			x	x	spiral bound annual	yes
August			x	x	spiral bound annual	yes
September			x	x	spiral bound annual	yes
October			x	x	spiral bound annual	yes
November			x	x	spiral bound annual	yes
December			x	x	spiral bound annual	yes

Bibliography of Older Seismic Bulletins and Catalogs (published 1975-1986)

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Dart R., A. Tarr, D. Carver, M. Wharton, 1980, Puerto Rico Seismic Network Data Report of Earthquakes Located by the Program Hypo71 and Hypoellipse July 1, 1975-December 31, 1977, U.S. Geol. Survey. Circular 821.

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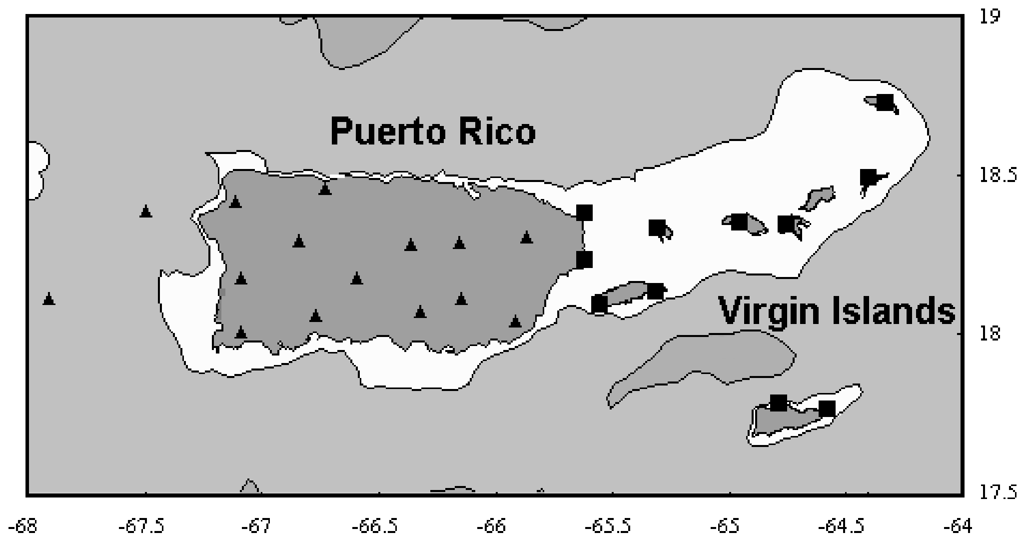

Figure 1. Distribution of seismic stations in the vicinity of Puerto Rico and the Virgin Islands in 1981. At that time, the U.S. Geological Survey operated stations on Puerto Rico and to the west (triangles), LDEO operated stations (squares) on easternmost Puerto Rico, the Virgin Islands and to the east into the Northern Lesser Antilles (not shown).

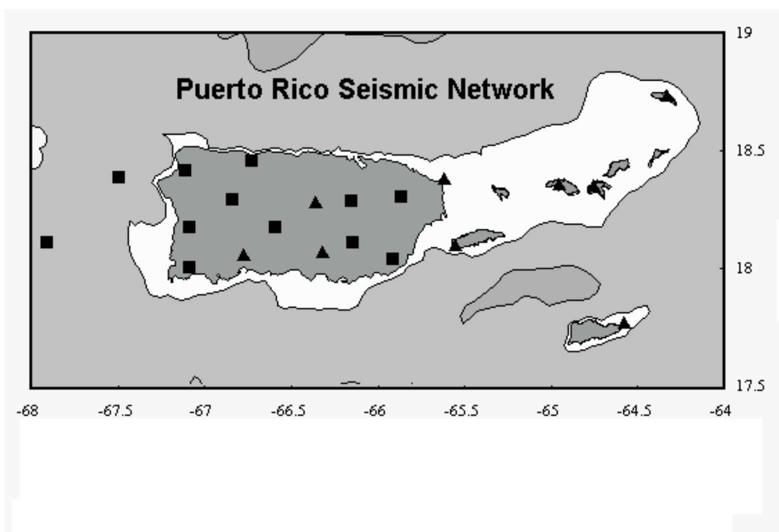

Figure 2. Location of stations of the Puerto Rico Seismic Network in 1993.

Appendix A.

Miscellaneous Comments and Information about Time Corrections for the Northeastern Caribbean Seismic Network

The information and comments presented here are taken from the various sources available to me during the execution of this USGS sponsored program to rescue information about the NE Caribbean Seismic Network. Text in italics are comments, remembrances or other non-observed information useful for the proper use of network data. All other text present information specifically observed during the visit to LDEO to rescue the network information. This information is designed to supplement the list of clock correction data presented in elsewhere in this report and is taken from Central Recording site (CRS) log books, notes on CRS or station repairs or from yellow boxes containing develocorder records.

Below is a chronological listing of information and comments on clock corrections.

Time correction information from 6/29/75 through 10/20/75 are written on the outside yellow box of the develocorder records. *If I remember correctly, this information was obtained by a oscilloscope line up of TS-100 or Station time with WWV signal.* That clock correction information included date, time for TS-100 clock and Universal Coordinated Time (UCT) as captured by WWV radio signal. Resulting clock corrections are: Station time - UCT = cc (or Station time + Clock Correction = UCT). Because the reading for station time were not read to any great precision at first, corrections were usually to the nearest second. Precision improved later in the year. *The station clock appears not to have been reset between 6/29/75 and 10/20/75.*

Below are information as taken from develocorder boxes. Clock corrections are given in Appendix E.

June, 1975
11 no clock correction
13 no signal

July, 1975
3, 4, 8, 12, 13, 17, 19, 20, 21, 24, 26, 27, 28, no clock correction written onto box
24 no radio signal

August, 1975
12, 13, 14, 15, 16, 22, 27 no clock correction written onto box

September, 1975
Correction only available for 1st of September

October, 1975
No information for October 1-5, 18, 21-23
Boxes with ending dates 10/24-11/3 have no time info on box or on film
The following time information was taken from the log book of the central recording site:

10/12/75	Station 11:42:45.1	Radio 11:43
10/14/75	10:40:44.8	10:41
10/15/75	12:15:44.5	12:16
10/16/75	13:06:44.3	13:07
10/17/75	10:26:44.2	10:27
10/18/75	13:16:44.0	13:17

November, 1975
1-26 no clock correction
Time corrected at some point between 11/20 and 11/27?
27 none
28-30 no clock correction

December, 1975
7 +2.0 to obtain correct *(no time indicated)*
11 corrected 1400 to 0.00 *(no correction prior to clock reset given)*
14 *Time of correction unknown*
16 *Time of correction unknown*
17 after 1940 hrs WWV starts *(WWV included as a separate channel on the develocorder)*
18 box says 0 as per WWV *(box correction not used)*
19 box says 0 as per WWV *(box correction not used)*

Clock corrections were done by William McCann in 1996 for the period 12/20/75 through 12/31/77

2 passes (pass 0 and pass 1) for the dates 12/20/75-1/4/76

Procedure: Use double pulse ion develocorder time line as marker for "1st" sec then subtract 1.0 sec to get position of "0th" in missed pulse region, read time on WWV (UCT) time channel.

January, 1976
1 -0.3 2329 (1 sec change occurs at beginning of day at 00hrs 1/1/-1/3 box says +-0.5 sec and 1/3 00:- to 1/3 23h says +-0.5 sec)
WWV with carrier starts on 1/5/76 @1217
Starting 1/8/76 clock corrections by WRM are generally taken from the end of a develocorder tape
10 box -1/2
11 box -1.5
13 box -1.5
14 box -1.5
15 Box 1/15/76 2350 to 1/17/76/ 0005 says was -2.0 reset to 0.0
17 box -0.5
18 box -1/2
22 wwv propagation poor- no usable signal on Drace *(Develocorder trace?)*
27 box says -1.2sec

28 (checked - OK The times on WWV channel are assumed to be the missing second- has long pulse "59", no pulse "00" then short pulse "01" cc is taken from short pulse -1.-sec and compared to devel min mark- that mark is taken to be 1st up pulse of 2 1/2 sec duration if starts on sec mark or preceding sec mark if not.)
28 box says -1.5sec until 1925 then 0.0 ; -1.3 to "00" and min-1
28 -1.3 "0" to min-1
power out 2350-1130 1/30/76
1/31/76 modify TS100 clock to provide motor stop sw for setting with out interrupting prec. 60 cycle & lite to synch minute pulse with wwv.

February, 1976
2/1/76 in view of power outage problems have rewired develocorder so ONLY clock motors run on prec. 60 cycle- drive motor on std ac. Also received overload on TS100 prec. 60 cycle circuit
2/1/76 quality estimates: TS 100 am running in and rating 2nd xtal clock which now has pulse synch lite & motor stop switch. Will transfer as soon as I've got rate adjusted then service original unit now on line.
WWV BCD from 100HZ sub carrier 10 and 15 MHZ please use this for corrections! (TS100 clock minute pulses not synched 100% with seconds hands)
2 box says slow 1/2sec 4 2217 -0.2 boxes of 4 and 5 say 1/2 sec slow
6 box says 1 sec slow
8 6-7th box says 1.2 sec slow
7 7-8 box tc +0.0
10 ok checked
14 1934 +/-0.5 no minute mark
16 Minutes printout intermittent- will wait for total failure before taking system down for maint WWV BCD provides redundancy

18 RE time corrections! I think that there may be a misunderstanding on the WWV signal-- WWV always usable at beginning and end of (unintel --film?) normally usable (unintel) film. Precision 60 cycle and seconds- dashes on develocorder CANNOT by synched to WWV on develocorder equipmwent. Clock hands (sweep seconds hand) synching is meaningless and imprecise. What we are doing is synching the switching contacts on the clock- which generate the minute marks on the develocorder and heliocorders with WWV. This is simple to check visually on develocorder thusly (diagram follows) Synch checked and corrected daily
y to +/- 1/10 sec normally This far more accurate and positive than watching seconds hand while listening to WWV

March , 1976
9 17xx -1.8

Note times on WWV channel are assumed to be the missing second- has long pulse "59", no pulse "00" then short pulse "01" cc is taken from short pulse -1.-sec and compared to devel min mark- that mark is taken to be 1st up pulse of 2 1/2 sec duration if starts on sec mark or preceding sec mark if not.

(last entry 3/20/76 from PWP (*Vieques*) central recording site)
(first entry 3/25/76 from VST (*St. Thomas*) central recording site)

April, 1976
6 21:10 set time clock

May, 1976

10 2153 +0.8? wrm in 1976
12 0109 +0.8 "
12 2318 +0.9 " box 5/12-5/13 cat cc+1.0 @22:17 and +0.9 @2233
13 2210 +0.9 "
14 2340 +0.9 (now I get +0.7)
16 21xx
17 21xx clock reset at some point
5/24 23:34 set develocorder clock

June
6/2 22:13 set develocorder clock
Note- WWV beginning of down pulse for "missing second" lines up exactly with beginning of develco minute pulse, sec marks indicate 0.5 sec lapse between full sec and beginning of min.. if true then TC is 0.0 and all times recorded here need to be corrected by -0.5 sec if read using the sec mark before develco minute mark as beginning of minute.

July, 1976

August, 1976
24 xxxx -0.5 xx
30 2122 -0.5 xx

September, 1976

October , 1976
15 1430 -0.8?

November , 1976

December, 1976

January, 1977

February, 1977

March, 1977

April ,1977

May, 1977

June, 1977

July, 1977

13 19:55 set develocorder time clock

August, 1977

5 20:17 set devel clock (after power failure)

September, 1977

10 21:45 set ts-100 radio clock (about 40 sec)
21 19:31 set devel. Time clock (power out)
27 02:28 set devel time clock (power out)
27 23:33 set devel time clock (power out)
28 05:10 set devel time clock (power out)

October, 1977

3 23:04 set devel time clock (power out)
6 02:25 set devel time clock (power out)
28 23:36 set ts-100

November, 1977

2 20:11 set devel time clock (power out)
4 19:48 set devel time clock (power out)
5 11:47 set devel time clock (power out)
6 18:58 set devel time clock (power out)
7 10:38 set devel time clock (power out)
7 22:00 set devel time clock (power out)
8 20:50 set devel time clock (power out)
8 21:04 set devel time clock (power out)
8 22:09 set ts-100 reading our clock 4 min ahead (not radio announcement)
12 17:49 set devel time clock (power out)
14 10:45 set devel time clock (power out)
17 20:35 set devel time clock (power out)
22 When talking to Larry *(Larry Shengold*) last night I explained to him that about two weeks or lets say the 11/8 I discovered that the TS-100 hourly reading is 4 minutes ahead and in the same time we're still loosing about 1 second a day. Sounds strange, but that where we at.
23 21:28 H-print* 18 minutes ahead! (*=hourly print on heli+devel are 18 min ahead of radio time!) please inform-should I changes TS-100 or ?)
23 21:37 set ts-100 sec

December, 1977

7	PM Larry arrives
15	Johnson + Larry leave *(Doug Johnson)*
29	Devel time 1 hour behind
30	11:00 clock time devel prints 10:00 -- set devel 1 hour up
30	13:50 clock time devel prints 14:50
30	23:05 clock time devel prints 00:05
31	00:08 set devel - 1 hour back
31	01:37 all times OK
31	22:40 radio clock 5 sec slow

January, 1978
8	12:12 set Develocorder time (power out)
8	23:22 set ts-100 sec sweep
13	21:52 set Develocorder time (power out)
15	00:04 develocorder +helios loosing time
15	13:33 set develocorder time (power out)
18	21:59 set devel time
18	Develocorder and Heliocorder loosing time
19	Develocorder and Heliocorder loosing time
20	Could be that new regulator is faulty?
20	devel +helio loosing time
21	21:01 sweep seconds ts-100
22	11:55 devel time 4 hours late--reset;
22	21:56 devel time 1 hour late
23	10:13 devel time 2 hours late
24	10:47 devel time 3 h late
24	19:40 devel time 8 hours late
27	21:51 set sweep seconds ts-100
28	20:00 ts-100 loosing time
29	11:40 ts-100 20 sec behind
29	21:31 ts-100 25 sec behind
29	20:59 reset ts-100
30	03:22 ts-100 behind by 3 sec
30	11:06 ts-100 behind by 6 sec
30	16:52 ts-100 behind by 8 sec
30	22:16 ts-100 behind by 11 sec
31	11:06 ts-100 behind by 12 sec
31	21:48 ts-100 behind by 12 sec

February, 1978
1	10:56 ts-100 behind by 12 sec
1	22:15 ts-100 behind by 13 sec
2	10:47 ts-100 behind by 14 sec
2	22:30 ts-100 behind by 15 sec
3	14:19 ts-100 behind by 15 sec
3	21:38 ts-100 behind by 16 sec

3	21:43 reset ts-100
4	13:59 exact time
4	21:50 exact time
5	14:59 exact time
5	22:11 exact time
5	As you can see the ts-100 was rather nervous but seems to be fine for the last two days
13	21:29 set devel time minute mark (power out earlier)
15	10:44 TS-100 now 5 sec off; it looses about 1/2 sec a day!
16	21:59 ts-100 5 sec off
19	22:03 set ts-100 (seconds sweep)
22	21:02 ts-100 2 sec off
23	03:07 ts-100 2 sec off
25	12:00 ts-100 3 sec off
26	10:32 ts-100 3 sec off
28	09:50 ts-100 4 sec off

April, 1978
6	15:00 reset clock (advance 100 msec)

May, 1978
5	21:30 digital clock 100msec advance

June, 1978
1	21:53 digital clock 10 msec advance
6	22:22 digital clock 10msec advance
25	03:07 noticed digital clock 6 seconds late
25	03:21 advanced 6 seconds
23	13:45 devel time 1 hour off--reset

July, 1978
5	digital timing clock seems to be loosing 1/2 sec per day or so
1	digital clock 3 sec behind
4	digital clock 4 sec behind
6	digital clock 5 sec behind
10	digital clock 6 sec off
13	07:05 7 sec off--reset
16	22:09 clock 2 sec off
18	22:16 clock 3 sec off
26	digital clock is still loosing about 1/2 sec a day

August, 1978
20	begin clock adjustment--clock reset to WWV
20	17:37 switch to ts-100 clock
20	18:25 return to ts-250 time- clock freq advanced 4 hz - LS (*Technician Larry Shengold*)
22	15:00 time to ts-100 clock adjustment cont.
23	21:53 time to ts-250 ""

24 Several fairly large earthquakes, careful time correction necessary because of clock adjustments and a power failure

September, 1978

October, 1978

November, 1978

December, 1978

3 Last entry in station log book with no mention of station clock since August

Appendix B.
Data on Clock Corrections of the Northeastern Caribbean Seismic Network

Time correction information from 6/29/75 through 10/20/75 are consistently written on the outside yellow box of the develocorder records. If I remember correctly, this information was obtained by a oscilloscope line up of develocorder (TS-100) clock time with WWV signal.

What follows is a list of clock information for that time period. Data given are: the date, seconds part of time for develocorder clock of preceding minute, and then radio time. e.g. on June 20th 1975 develocorder (TS-100) time is 20:34:58.5 and radio time is 20:35 GMT

1975
June
8 00.00 20:31
9 00.00 21:18
10 20:40:59 20:41
12 59 13:57
13 no signal
14 59 18:45
15 59 20:20
16 59 18:49
17 58.5 19:30
18 58.5 20:27
19 58.5 20:30
20 58.5 20:35
21 58 21:10
22 58 21:21
23 58 21:35
24 57.9 20:35
25 57.8 20:20
26 57.5 20:10
27 57.4 21:30
28 57 21:00
29 57 20:35
30 57 20:20

July
1 56.9 21:30
2 56.8 20:30
3
4
5 56 22:35
6 56 22:10
7 56 22:10
8
9 55.9 21:55
10 55.6 23:10

11 55.5 23:45
12
13
14 55.1 24:00
15 55 22:05
16 55 22:00
17
18 54.9 22:03
19
20
21
22 54.2 22:20
23
25 54.4 23:19
26
27
28
29 53.4 21:55
30 53.5 22:40
31 54.5 24:25

August
1 53.5 23:23
2 52.5 21:11
3 52.5 22:11
4 53.5 22:40
5 52.5 21:20
6 52.5 20:32
7 52.5 22:01
8 52.5 22:17
9 52.5 21:06
10 52.5 23:43
11 52.5 21:51
12
13
14
15
16
17 52.5 21:28
18 51.5 21:55
19 51.5 21:34
20 51.5 22:42
21 51.5 23:53
22
23 51.5 23:22
24 51.0 2339

25 51.0 0010
26 50.5 2309
27
28 50.5 2057
29 50.5 0904
30 50.3 0912
31 50.3 0912

September
1 50.0 0958

October
6 45.6 1058
7 45.5 1120
8 45.5 1154
9 45.4 1137
10 45.3 1253
11 45.2 1203
12 45.1 1143
13 44.8 0951
14 44.6 1041
18
19 44.2 1027
20 43.8 1016

boxes ending 10/24-11/3 have no time information on box or on film

November
time corrected at some point between 11/20 and 11/27? or 12/15
27 none

December
5 23:02? +2sec on box 7 +2.0 to obtain correct 11 corrected 1400 to 0.00
14 0
15 0
16 0
17 21:42 +0.4 after 1940 hrs WWV starts
18 box says 0 as per WWV 19 0001 -1.1 (even) box: 0 as per WWV
19 2330 +1.3 (even)

T*he following are clock corre*ctions done by WRM in july 1996. Data are date, correction of station clock to obtain GMT and time of correction.
19 +0.1? 0019
20 -0.7 2153
21 -0.4 2150
22 -0.3 2227

23 -0.65 2309
25 +0.1 2246even
26 -0.1 2300
28 +0.0 0013
28 +0.2 2337
30 +0.4 2235
31 +0.6 2146

1976
January
1 -0.3 (1 sec change occurs at beginning of data at 00hrs 1/1/-1/3 box says +-0.5 sec and 1/3 00:- to 1/3 23h says +-0.5 sec)
3 -0.2 0045
3 0.0 2323
4 +0.1 2347 WWV with carrier starts on 1/5/76 @1217 5 2316 +0.0 6 2254 +0.1 from here on readings are generally taken from the end of a tape
8 0115 +0.3
10 2350 +0.6
11 2250 +0.7
13 0119 +0.9
14 0020 +1.5 even
15 0059 +1.0
15 2346 +1.3 Box says was -2.0 reset to 0.0
16 2346 -0.6
17 2329 -0.4
18 2337 +0.2
19
20 2253 +0.5
21 0216 +0.7
22 1348 +0.6
22 1526 +0.6
22 1910 +0.6
22 1956 -0.1
22 2054 +0.1
23 0050 +0.2
23 2324 +0.2
24 2321 +0.3
25 2307 +0.6
26 2258 +0.7
27 2246 +0.7 box says -1.2sec
28 1836 +0.7
28 2309 -0.3 box says -1.5sec until 1925 then 0.0
28 2343 -0.3
29 2258 -0.3
31 2250 -0.5

February
2 2134 -0.4 box says slow 1/2sec
4 2217 -0.2 boxes of 4 and 5 say _ sec slow
6 2223 +0.3 box says 1 sec slow
8 2216 -0.8 6-7th box says 1.2 sec slow
7 2133 +0.3 7-8 box tc +0.0
10 2205 -0.7
12 2340 -1.0
14 2157 -0.5
16 2258 -0.8
17 2313 -1.0
18 2229 -0.5
20 2248 -0.6
22 2218 0.0
24 2235 0.0
26 2129 -0.2
28 2148 -0.3
29
March
1 2310 -0.4
3 2311 -0.3
5 2247 -0.1
7 2157 -0.2
9
11 2255 0.0
13 1926 -0.1 Note times on WWV channel are assumed to be the missing second- has long pulse "59", no pulse "00" then short pulse "01" cc is taken from short pulse -1.-sec and compared to develocorder minute mark- that mark is taken to be 1st up pulse of 2 _ sec duration if starts on sec mark or preceding sec mark if not.
15 2238 -0.3
17 2302 -0.2
19 2243 -0.5
21 2137 -0.4
23 2029 -0.4
25 2111 -0.3
27 2129 -0.5
29 2355 -0.5
31 2129 -0.6

April
3 0037 -0.6
4 2203 -0.5
6 2225 -0.5
9 2153 -0.3
20 2230 0?
26 0047 -0.3

29 2230 -0.1

May
4 2320 0.0
10 2153 +0.8? wrm in 1976
12 0109 +0.8 "
12 2318 +0.9 " box 5/12-5/13 cat cc+1.0 @22:17 and +0.9 @2233
13 2210 +0.9 "
13 2217 +1.0
14 2333 +0.9
14 2340 +0.9 (now I get +0.7)
16 0023 +1.0 16 21xx
17 21xx clock reset at some point
19 2337 -0.4
18
21 2130 -0.4
24 2018 -0.6
28 0132 -0.6
31 2157 -0.6

June
3 2110 -0.6
6 1040 -0.6 Note- WWV beginning of down pulse for "missing second" lines up exactly with beginning of develocorder minute pulse, sec marks indicate 0.5 sec lapse between full sec and beginning of min.. if true then Time correction is 0.0 and all times recorded here need to be corrected by -0.5 sec if read using the sec mark before develocorder minute mark as beginning of minute.
8 2133 -0.5
13 0006 -0.8
15 1225 -0.4
19 1533 -0.9
21 1935 -0.8
24 1403 -0.3
26 2259 -0.2
30 2130 -0.4

July
3 -0.5 1400
7 -0.5 1901
9 2023 -0.7
12 1917 -0.7
16 1518 -0.9
19 1529 -0.7
22 1711 -0.6
25 2059 -0.55
28 1348 -0.7

31 1316 -0.4

August
4 2022 -0.4
6 1225 -0.5
8 1044 -0.5
13 0914 -0.5
16 1240 -0.4
19 1346 -0.4
23 2245 -0.4
24 xxxx -0.5
25 2036 -0.3
28 2312 -0.3
30 2122 -0.5
31 1152 -0.4

September
3 2017 -0.4
6 2130 -0.5
10 0159 -.03
13 1439 -0.3
14 1929 -0.3
19 1417 -0.5
27 1937 -0.5
30 2329 -0.5

October
7 1439 -0.5
15 1441 -0.65
15 1430 -0.8?
26 2248 -0.3
31 2212 -0.4

November
6 2219 -0.7
9 2017 -0.8
11 2203 -0.7
14 1133 -0.8
18 1212 -0.9
23 1944 -0.6
27 1209 -0.6

December
3 0315 -0.5
4 1904 -0.4
7 1720 -0.5

10 2253 -0.5

1977
January
29 2146 -1.1
30 1333 -1.0
30 2049 -1.0
31 1757 -0.8

February
1 2145 -0.9
2 2227 -0.9
3 2049 -0.6
4 2110 -0.6
5 1838 -0.6
5 2115 -0.6
6 1837 -0.6
7 2100 -0.7
22 1926 -0.8
23 2333 -1.1
24 2037 -1.1
25 2152 -1.2
27 2101 -1.2

March
1 2053 -1.2
3 1950 -1.1
5 1924 -1.1
7 2020 -1.0
9 2057 -1.1
11 1914 -1.0
13 2049 -0.9
14 2045 -0.8
16 2128 -0.8
23 1635 -0.7
24 2055 -0.7
26 1952 -0.6

Appendix C.

Description of Magnetic Data Tapes for the Northeastern Caribbean Seismic Network Stored at Lamont-Doherty Earth Observatory

This note will hopefully guide the reader to a better understanding of the contents of the 1/2" magnetic tapes stored at Lamont-Doherty Earth Observatory (LDEO), and which contain information about the Northeastern Caribbean Seismic Network operated by LDEO from 1975 to 1983. All tapes found examined by the author during a visit in mid-late July 1996 are listed below. They were taken in a more or less random order and relabeled as given below.

Multiplexed Digital Network Data from Northeastern Caribbean Seismic Network and Puerto Rico Seismic Network

Several racks of _ " magnetic tapes from the Digital era of the Northeastern Caribbean Seismic Network are to be found in the Computer room of the Seismology Group. They are not inventoried here. Also, duplicate tapes from the Puerto Rico Seismic Network are found on the same tape rack. Their inventory follows:

1985	11/9-11/29
	11/29-1/2/86
1986	1 /2-1/28
	1/28-2/27
	2/27-3/31
	3/31-4/24
	4/24-5/5
	5/18-5/29
	5/29-6/5
	6/5-6/17

DEMULTIPLEXED DIGITAL NETWORK DATA

Nine "DMUX" tapes were found and examined. They contain demultiplexed digital data from the Northeastern Caribbean seismic network for the period 1981-1983 and were written onto tape using the UNIX dd command. Time series data are in D and d (header/data) ping format. The D files used bs=900, and d files used bs=2048. All nine tapes were copied onto a DLT cartridge using the UNIX program tapecopy. The tapes were originally labeled DMUX 1-9 and contain data from the following time intervals:

Tape Label	Time Period
dmux1	11/9/81-2/19/82
dmux2	2/19/82-5/21/82
dmux3	5/21/82-10/17/82
dmux4	10/17/82-12/5/82

dmux5 12/5/82-1/1/83
dmux6 1/1/83-1/22/82
dmux7 1/22/83-2/17/83
dmux8 2/17/83-3/17/83
dmux9 3/18/83-3/26/83

OBS EVENT-DETECTED DATA

OBS data tapes were also examined. Data were collected on the TIKI cruise in 1976 and the RV Conrad cruise 22-12 in 1979. Analog tapes were event detected on the PDP 11/34. That event detected data was found on 15 tapes labeled as follows (tape #, OBS number and number of events- if known):

Tape #	OBS #	Number of Events
obs1	TIKI101	160
obs2	TIKI102	80
obs3	TIKI102	109
Tape #	OBS #	Number of Events
obs4	TIKI003	33
obs5	B1	80
	O1	66
obs6	B3	31
	B4	253
obs7	R5	133
	B3	32
obs8	B5	?
	B6	226
obs9	B7	152
obs10	G7	197
obs11	O2	139
	R4	221
obs12	R3	3?
	O3	24
obs13	R2.1	307
obs14	R2.2	?
obs15	R4	334

MISCELANEOUS DATA TAPES

The accompanying list includes the original tape label as well as any other descriptive information that might be of use, following that is a commentary on the contents of the tape as seen by the author during the visit to LDEO. Tapes are labeled by a number indicating the order in which they were read starting with 100 and ending with 117. These tapes are all written using the TAR command.

CARIB100

"Carib Backup Tape 1" Contains digital tapes listings (trigger times for the digital recording system) for the network from 1979-1983

CARIB101

"Carib Backup Tape 2" Contains miscellaneous earthquake location programs and STD program files.

CARIB102

"SUN TAR McCANN MIGUEL 8/1/85" This tapes was found on a completely different tape rack than the rest of the tapes read. It was included only because the name McCann was on it and it might have contained information about the seismic network. The directories of MIGUEL were NOT copied off this TAR tape. Contains data and programs to determine velocity model of region (VELIN)—I am not sure how this data got not this tape.

CARIB103

"CARIB BACKUP TAPE 3" This tape appears to contain some updated location (bulletin info for 1981 as well as copies of bulletin data for 1980 and 1979, 78, 77 and swarm of May 1976, as well as west indes data.

CARIB104

"CARIB BACKUP TAPE 4" contains data from FRANKEL investigations

CARIB105

"CARIB BACKUP TAPE 5" Contains, among other things, phase and location matched data for 1977-1982 with 10-12 81 missing.

CARIB106

"TAR OF CARD CABINET- TAPE #4" (PHASES 76-79, P. R. DATA, May 76 swarm, Digitized Data, PHADIG, FAMG)" Tape containing a wealth of information had raw phase data for period 1/1/76 through 3/31/80 as well as pr phase data and locations

CARIB107

"TAR DISK 1-9 - TAPE #3 (HABERMAN, OBS, RYAN) Has bulletin data, Haberman data, second file has velin data etc, third has K. Fischer data and ryan files, 4th file has digital data and K. Newcomb as well as pingpong, fifth files has misc data, 6th has misc. data and codes, 7th has focal mech and master files, 8th has digital data for polarization project, 10th has more of the same, 11th has habermann codes, 12th has r4 obs data, 13 has picker program dr map and supermap program.

CARIB108

"CARIB BACKUP TAPE 6" Contains digital 3 comp data from selected events from 1981 and some repeats of bulletin data.

CARIB109

"Caribbean RL disks 1-9 (Tarred onto this tape 25 mar 88 1600bpi)" This is a catchall of many files .

CARIB110

"(no label on the outside only label is piece of paper inside that says 'small tape 1')" Tape supplied by WRM. sep87.pha only.

CARIB111

"OBS Line 10a (multiplexed, standard and other assorted data)" Tape supplied by WRM. Appears to contain wavform data for line refraction line 10a run in 1979.

CARIB112

"Art Frankel's Carib events" Tape found in completely separate tape rack than the rest. Has a few digital records.

CARIB113

"Tar Tape /g34 Carib Earthquakes Site B1" Contains digital data from OBS station B1 from 1979 experiment

CARIB114

"has no label on tape, but ring does say -5- " Contains hypoinverse source code, hplt code, pdeisc cose, relocate code, sunpick code.

CARIB115

"Witte tape1 " Has digital data for events from 79-81, by Dean Witte.

CARIB116

"has no label on tape, ring does say -6-" contains marine gravity data for the Puerto Rico region.

CARIB117

"has no label on tape, ring does say -2- " Contains "bin" files, dr/ryan files. 2nd file contains velin codes, planewave codes, Aol files from Taber, velin/veiques files, fischer files, 3rd file has reloc files, hplt files, dplt files, and pdeisc files,

OUTPUTS

All the above tapes were copied using the program TAR onto two _” archive tapes labeled

CARIB ARCHIVE 1 (tape1) and
CARIB ARCHIVE TAPE 2 (tape2)

Tape1 is a 10 file TAR tape with the data from tapes CARIB100 through CARIB109 as described above.

Tape2 is a 8 file TAR tape with the data from tapes CARIB110 through CARIB117 as described above.

DLT ARCHIVE TAPE

Data was also copied onto a DLT cartridge using the program TAR. There is one large file on the DLT tape. Data on that tape are in the following order:

DMUX1
DMUX2
DMUX9
DMUX8
DMUX7
DMUX6
DMUX5
DMUX4
obs1
obs2
obs3
obs4
obs5
obs6
obs7
obs8
obs9
obs11
obs12
obs13
obs14

obs15
TAPE1 (Tapes CARIB001-109)
TAPE2 (Tapes CARIB110-117)
DMUX3
obs10

Tapes DMUX3 and obs10 had numerous errors on read and are probably not complete copies of their originals.

Appendix D.

Inventory of Materials Related to the Northeastern Caribbean Seismic Network Housed in the Seismology Group Archive Center in the Shipping Building, Lamont-Doherty Earth Observatory

1st room contains miscellaneous magnetic tapes and reader for develocorder tapes
2 room is large and 1st rack on left after entering has 8 shelves labeled Caribbean seismic network tapes and bulletins

Top shelf has:

Develocorder Tapes
3-24-76 to 6-18-75 (*network starts recording in March 1976*)
6-18-75 to 10-8-75
10-8-75 to 1-4-76
1-4-76 to 3-9-76
3-10-76 to 5-26-76
5-27-76 to 7-29-76

2nd shelf down has:

Develocorder Tapes
7-29-76 to 9-29-76
10-2-76 to 11-19-76
11-19-76 to 12-15-76
3-13-77 to 4-27-77
4-27-77 to 6-11-77
1-28-77 to 3-13-77

3rd shelf down has:

Develocorder Tapes
9-30-77 to 12-2-77
6-12-77 to 8-1-77
8/77 to 9/77
12/2/77 to 1/31/78
1/31/78 to 3/31/78
3/31/78 to 5/31/78

4th shelf down has:

Develocorder Tapes
5/31/78 to 7/31/78
8/6/78 to 9/30/78

9/30/78 to 11/30/78
11/30/78 11/30/78
11/30/78 to 1/31/79
1/31/79 to 3/31/79
3/31/79 to 5/16/79

5th shelf down has:

Develocorder Tapes
5/14/79 to 6/29/79
6/29/79/ to 8/13/79
8/13/79 10/3/79
10/3/79 to 11/20/79
11/20/79 to 1/8/80
1/8/80 to 2/20/80
2/20/80 to 4/15/80

6th shelf down has:

Final Bulletin listing (*hypoellipse computer outputs*)

Box 1

1975 3-6 (*7-12 is in box 2*)
1976 1-12

Box 2

1975 7-12
1977 1-5
1977 6, 8-9 (*missing 7 1977*)
197710-12
1978 1-6

Box 3

1978 7-12 and 1/79
1979 3,4,7-10 *(missing 2,5, and 6)*

7th shelf down has:

1979 11-12
1980 1-3 1980

1975-77 phase and location data for Puerto Rico seismic network as supplied by USGS *(paper listing)*

LDEO digital system trigger times for digital tapes- listings
1979 (2)
1980
1981
1982
1983 Puerto Rico Digital recording system

UWI Bulletins
1959-1963
1964-1966
1966
1976 3
1977 1-6, 7-12
1978 1-6, 7-12
1979 1-3, 4-7, 8-10
1980 1-6, 7-12
1981 8-11

IPG Bulletins (French Caribbean Islands)
1979 10-12
1980 1-6, 7-12
1981 1-6, 7-12
1982
1983
1984
1985

8th shelf down (Bottom shelf) does not contain material related to the Northeastern Caribbean Seismic Network

Final Report for 99HQGR0067

CHARACTERIZATION OF ACTIVE SUBMARINE FAULTS NEAR U.S. CARIBBEAN TERRITORIES

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99HQGR0067: Characterization of Active Submarine Faults Near U.S. Caribbean Territories

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Abstract

The US territories in the Caribbean (Puerto Rico and the U.S. Virgin Islands) lie within an actively deforming plate boundary zone. Proper determination of earthquake hazard for these islands will be based on the identification and characterization of active faults and the determination of the microseismicity associated with them.

One task undertaken in this program was the development of unified catalog of microearthquakes for the region near the U.S. Territories in the Caribbean. By applying newly acquired clock corrections to LDEO network data (from a previous NEHRP proposal) and combining that data with USGS/PR network data, we were able to form the unified catalog. More than 9,000 events have been rescued from 1975-1982 by this effort, covering more than 700 km of the NE Caribbean seismic zone. That new catalog will greatly improve our understanding of the seismotectonics of the NE Caribbean.

Identification of microearthquakes related to specific submarine faults in the Anegada Passage region, and just off the coast, western Puerto Rico is another task. Microearthquakes in the newly formed catalog of the local seismic network have be used to determine the level and 3-D distribution of seismic activity on the most important faults in those areas. For the Anegada Passage region, the best station distribution (even better than today's) is the period from 1975-1978.

Finally, we have constructed 10 composite focal mechanisms by use of P-wave first motions for events in the Anegada Passage region. Those mechanisms have been compared with the 3-D geometry of the seismicity on the fault, as well as the mapped trace of the segments of the fault. Eight of the solutions are normal faulting and the other two are oblique strike-slip with a normal component. These events describe an extensional regime oriented essentially E-W. The data are consistent with regional stresses induced by arc-parallel extension

Development of a Unified Catalog of Microearthquakes

We have applied the clock corrections made available under a previous NEHRP program to the LDEO network data and merged with USGS/PR network data to form a unified catalog for the period 1975-1978. LDEO network data spans 1975-1982, the life of the network.. PR network data spans 1975-1978 (Table 1). Therefore, the merged dataset spans 1975-1978. When data from the PR network for the period 1979-1982 becomes available, it will be easily merged with the LDEO network data provided herein. More than 9,000 events have been rescued by this effort. Stations codes have been converted to the 4-letter code format and conflicting codes converted (Table 2). The final bulletin and final catalog were checked for order in time and duplicate events removed. In the pocket in the back of this report are several diskettes containing original network phase data, the clock corrected, as well as the merged data forming the new regional catalog. The readme file describes the contents of the files and the purpose of the FORTRAN programs used to develop the dataset.

Stations on Puerto Rico used the velocity model of Asencio (1980) for locating events. Stations of the NE Caribbean network (LDEO) used the average velocity model developed by Fischer and McCann (1984) to determine locations. Even though some station delays were calculated to the various models developed by them, we did not apply any of them during this phase of the relocation process. Our intent now is merely to develop a unified catalog with basic new, microearthquake locations. The Fischer and McCann model is a calibrated velocity model using multi-ton calibration shots. All events were located using the Y2K compliant version of Hypoellipse.

Coda magnitudes were calculated using the parameters of the NE Caribbean network developed by Frankel (unpubl. Data). Coda corrections developed for that network magnitude scale were not used.

Table 1. Status of US Caribbean seismic monitoring data

	US Geological Survey								Puerto Rico Network								Lamont-Doherty Earth Obs.							
	R	P	T	L	C	H	B		R	P	T	L	C	H	B		K	R	P	T	L	C	H	B
1975	X	X	**X**	**X**	**X**	**X**	**X**										X	X	X	**X**	**X**	**X**	**X**	**X**
1976	X	X	**X**	**X**	**X**	**X**	**X**										X	X	X	**X**	**X**	**X**	**X**	**X**
1977	X	X	**X**	**X**	**X**	**X**	**X**										X	X	X	**X**	**X**	**X**	**X**	**X**
1978	X	X	X									**X**	**X**	**X**	**X**		X	X	X	**X**	**X**	**X**	**X**	**X**
1979	X																X	X	X	**X**	**X**	**X**	**X**	**X**
1980	X																X	X	X	**X**	**X**	**X**	**X**	**X**
1981	X																X	X	X	**X**	**X**	**X**	**X**	**X**
1982																	X	X	X	**X**	**X**	**X**	**X**	**X**
1983									X	X	X	X	X	X	X		X	X						
1984									X	X	X	X	X	X	X									
1985									X	X	X	X	X	X	X									
1986									X	X	X	X	X	X	X									
1987									X															
1988										X														
1989										X														
1990										X	X	X	X	X	X	X								
1991										X	X	X	X	X	X	X								
1992										X	X	X	X	X	X	X								
1993										X	X	X	X	X	X	X								
1994										X	X	X	X	X	X	X								
1995										X	X	X	X	X	X	X								

Notes: Column headings are as follows: R- data recorded; P- phase times picked; K- Clock correction made when possible; T- data time corrected to UCT; L- events located; C- catalog of events exists; H- phase data exists in machine readable format; B- Bulletin of events exists. X means work completed. **X** means work done in this project to develop unified catalog. For the most reliable information about the existing network, please visit http://rmsismo.upr.clu.edu

Table 2. Conversion from internal to external station codes

Lamont-Doherty Earth Observatory Internally used Station Code	Corresponding Non-Conflicting International Station Code
ABV_	_ABV
AWI_	AWIN
BWI_	_BWI
CGP_	CGPV
CGV_	_CGV
CSJ_	_CSJ
CUL_	_CUP
CUP_	_CUP
GPV_	_GPV
MTP_	_MTP
PWP_	_PWP
RRD_	_RRD
SAB_	_SBN
SBN_	_SBN
SCV_	_SCV
SJV_	_SJV
SKB_	SKBR
STK_	STKP
STM_	_MRN
SWI_	SWIP
VST_	_VST

United States Geological Survey Internally used Station Code	Corresponding Non-Conflicting International Station Code
CAG_	CAGU
SAB_	_SBN
SLA_	SWIP
AIB_	_ABV
ISP_	_PWP

Note: Underscore indicates blank space

Seismotectonics of the Anegada Passage Region

Another task was the development of fault plane solutions using first motion data, and the identification of microearthquakes related to specific submarine faults in the Anegada Passage region and just off the coast, western Puerto Rico. Microearthquakes in the newly formed catalog of the local seismic network were used to determine the level distribution of seismic activity on the most important faults in the area. Events were chosen based on typical parameters such as gap, distance to closest station and vertical and horizontal errors. For the Anegada Passage region the best station distribution (even better than today's) is the period from 1975-1978. (That good distribution continued until 1982, but the data from the Puerto Rico network for the period 1979-1982 has yet to be analyzed). Of particular interest is the maximum extent of the depth of seismic faulting, and the segmentation of any fault. Knowledge of both of these parameters will have an important impact on the determination of the potential of the fault to generate damaging earthquakes.

First motion data for locally recorded microearthquakes was used to construct fault plane solutions of events in the Anegada Passage region. We defined the region by 17^{o}N-18.75^{o}N and 66.5^{o}W-63^{o}W. Events on or north of the PRVI platform were then excluded. The remaining events were then filtered to exclude those with no S arrival, any error greater then 10 km, a depth greater than 30 km, or less than 6 first motions. The remaining events were checked for to assure a high quality location. Fault plane solutions were then determined using FPFIT. Nearby events with 4 or more first motions, and high quality locations were then added if found to be compatible with the first fault plane solution. A total of 10 composite solutions were developed (Figure 1). Tables 3 and 4 contain the pertinent information about the events used, and the parameters determined for the fault plane solutions.

Eight of the solutions are normal faulting and the other two are oblique strike-slip with a normal component. These events describe an extensional regime oriented essentially E-W. The data are consistent with regional stresses induced by arc-parallel extension (McCann et al., 1996), but are not consistent with present-day counterclockwise rotation of the Puerto Rico microplate about a nearby pole of rotation, or just trench roll-back inducing N-S extension. We find no evidence in the present dataset in support of a N-NE oriented T-axis as suggested in other models based on seismic reflection data (Jany et al., 1987).

Table 3. Parameters for events used in composite fault plane solutions.

mech #	year	mo	da	hr	mi	lon	lat	dep	Npha	gap	rms	azim1	dip1	stderr1	azm2	dip2	stderr2	stderr3	ns
1	1975	12	9	23	5	-66.2680	18.2582	12	10	139	0.31	183	16	1.2	281	26	0.59	2.4	2
1	1976	5	14	22	14	-66.2807	18.1963	10	11	132	0.1	267	15	1.03	169	25	2.55	3.66	1
1	1977	7	21	20	46	-66.2513	18.2857	30	5	195	0.02	239	8	1.38	145	25	3.61	2.16	2
2	1976	12	31	14	1	-66.1913	18.1497	21	7	127	0.04	143	14	2.39	44	33	2.73	7.84	1
2	1977	8	27	0	23	-66.0402	18.2117	6	8	167	0.46	243	6	0.7	337	39	1.22	3.33	3
2	1985	3	22	22	6	-66.1763	18.1705	8	7	110	0.34	36	13	0.86	302	16	1.05	3.06	2
3	1975	12	17	11	8	-66.2668	17.9002	5	9	210	0.34	155	4	2.11	246	17	0.81	4.03	1
3	1976	9	2	11	48	-66.2738	17.9158	12	8	207	0.07	32	6	7.8	122	8	3.59	2.89	1
4	1975	12	19	21	14	-66.2098	18.0975	1	8	164	0.39	267	21	0.61	12	35	1.02	2.05	2
5	1977	7	15	6	6	-65.6212	18.0397	14	6	311	0.13	160	10	2.75	252	13	2.18	1.37	2
5	1977	8	14	16	14	-65.5505	18.0267	8	9	319	0.1	318	13	1.75	54	23	2.04	1.4	4
5	1981	7	27	18	7	-65.6678	17.9287	11	21	263	0.26	44	16	6.83	307	24	2.02	1.45	8
5	1982	1	25	7	9	-65.6812	17.8622	9	13	271	17	17	16	167	108	5	206	100	6

mech #	year	mo	da	hr	mi	lon	lat	dep	Npha	gap	rms	azim1	dip1	stderr1	azm2	dip2	stderr2	stderr3	ns
6	1975	12	24	17	25	-65.4367	18.0077	7	7	322	0.29	51	32	4.15	300	30	2.28	1.58	2
6	1982	1	26	11	49	-65.4060	17.9473	2	11	221	0.07	126	11	1.02	218	11	2.53	6.36	1
6	1980	11	16	9	12	-65.4022	18.0123	16	16	188	8	263	6	192	168	42	1104	720	7
6	1981	4	5	2	51	-65.3710	18.0040	5	11	185	10	249	16	211	344	17	1117	270	3
7	1980	3	8	1	29	-64.9445	18.1173	20	11	137	0.04	243	18	1.39	341	23	4.92	3.89	3
7	1981	3	20	14	4	-64.9562	18.1170	20	16	113	0.08	241	6	1.32	150	11	3.51	17.09	7
8	1980	1	29	3	26	-64.7720	18.1515	11	15	109	0.12	273	19	1.89	175	23	0.93	2.25	6
8	1982	4	13	15	58	-64.7983	18.0997	5	12	121	0.46	319	0	3.97	229	4	5.96	16.72	5
8	1982	5	31	18	55	-64.7395	18.1847	11	10	123	0.25	62	14	1.74	162	34	1.1	2.06	4
9	1982	1	2	2	27	-64.8057	17.9212	0	14	157	0.48	38	9	1.3	305	20	0.83	2.62	4
10	1980	4	2	22	13	-64.0455	18.5460	24	14	176	0.22	105	10	1.03	9	31	4.78	1.93	2
10	1982	8	25	16	47	-64.3270	18.4012	11	12	203	0.42	291	13	2.58	189	42	1.04	1.71	4
10	1982	9	27	17	28	-64.3390	18.3530	10	11	201	0.08	288	18	3.12	187	32	1.09	2.09	5

Note: parameters are standard output from hypoellipse. See documentation of hypoellipse for details.

Table 4. Parameters of composite fault plane solutions from FPFIT

mech #	dip	strike	rake	dip	strike	rake	Fj	nobs	avwt	stdr
1	90	165	-150	60	75	0	0.090	15	0.14	0.61
2	65	0	-80	27	157	-110	0.070	19	0.12	0.65
3	45	215	-150	69	103	-49	0.000	12	0.05	0.56
4	85	120	-160	70	28	-5	0.000	6	0.07	0.6
5	10	230	-70	81	30	-93	0.130	25	0.16	0.67
6	25	180	-100	65	11	-85	0.070	27	0.11	0.57
7	45	260	10	83	163	135	0.000	15	0.05	0.55
8	85	210	-160	70	118	-5	0.100	17	0.15	0.5
9	55	30	-40	58	146	-138	0.000	8	0.06	0.28
10	50	155	-140	61	37	-48	0.080	13	0.12	0.56

Note: Fj, avwt, and stdr are measures of goodness of the solution- see documentation of FPFIT for details; nobs is number of observations.

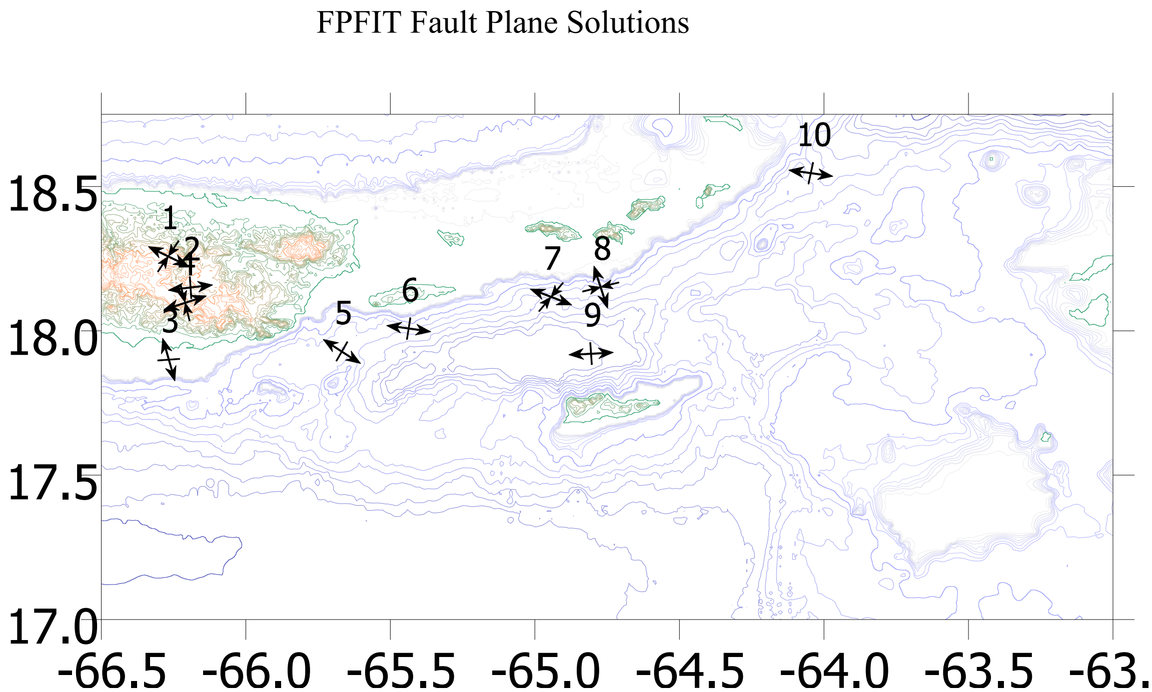

Figure 1. Orientation of two most horizontal stress axes for composite fault plane solutions.

Final report and Dissemination

Two abstracts and two articles are being submitted for publication (McCann, 2000a,b,c,d). One article is a note describing the newly rescued unified catalog, and another describes the results of the investigation of the Anegada Passage.

Copies of this report will be sent to: A. Frankel (USGS), the Seismic Network of Puerto Rico, Pamela Jasma (UPR Mayagüez, GPS studies), Tish Tuttle, Carol Prentice, Nancy Grindlay and Paul Mann (Marine and Land Geologic Studies), K. Scanlon (USGS, Woods Hole, Marine Geology of Puerto Rico) and W. Rodriguez (USGS, San Juan Office, Puerto Rico), PR civil Defense and VITEMA.

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McCann, W., 2000d, Microearthquake catalog elucidates details of Caribbean subduction zone, to be submitted to Bull. Seism Soc. Amer.