The 1998 Southern California Seismic Network Bulletin

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INTRODUCTION

The Pasadena Office of the U.S. Geological Survey (USGS), together with the Caltech Seismological Laboratory, operates a network of more than 350 remote seismometers in southern California called the Southern California Seismic Network (SCSN). SCSN is part of TriNet, a cooperative project between the USGS, Caltech, and the California Division of Mines and Geology (CDMG). TriNet will upgrade the existing network to digital, add new stations, and develop real-time and early-warning capabilities. Signals from the SCSN sites are telemetered to a central processing location at the Caltech Seismological Lab in Pasadena. These signals are continuously monitored by computers that detect and record thousands of earthquakes each year. Phase arrival times for these events are picked by analysts and archived along with digital seismograms. Data acquisition, processing, and archiving are achieved using the Caltech/USGS Seismic Processing (CUSP) system (Dollar, 1989). These data have been compiled into the SCSN Catalog of Earthquakes, a list beginning in 1932 that currently contains more than 344,000 events. Waveform, phase, and catalog data are archived by the Southern California Earthquake Center Data Center (SCEC_DC). This data set is critical to the evaluation of earthquake hazards in California and to the advancement of geoscience as a whole.

This and previous SCSN Bulletins are intended to serve several purposes, the most important of which is to make Network data more accessible to current and potential users. The Bulletins also document important details of Network operation so that researchers can use the data with a full understanding of the process by which they are collected.

NEW STATIONS

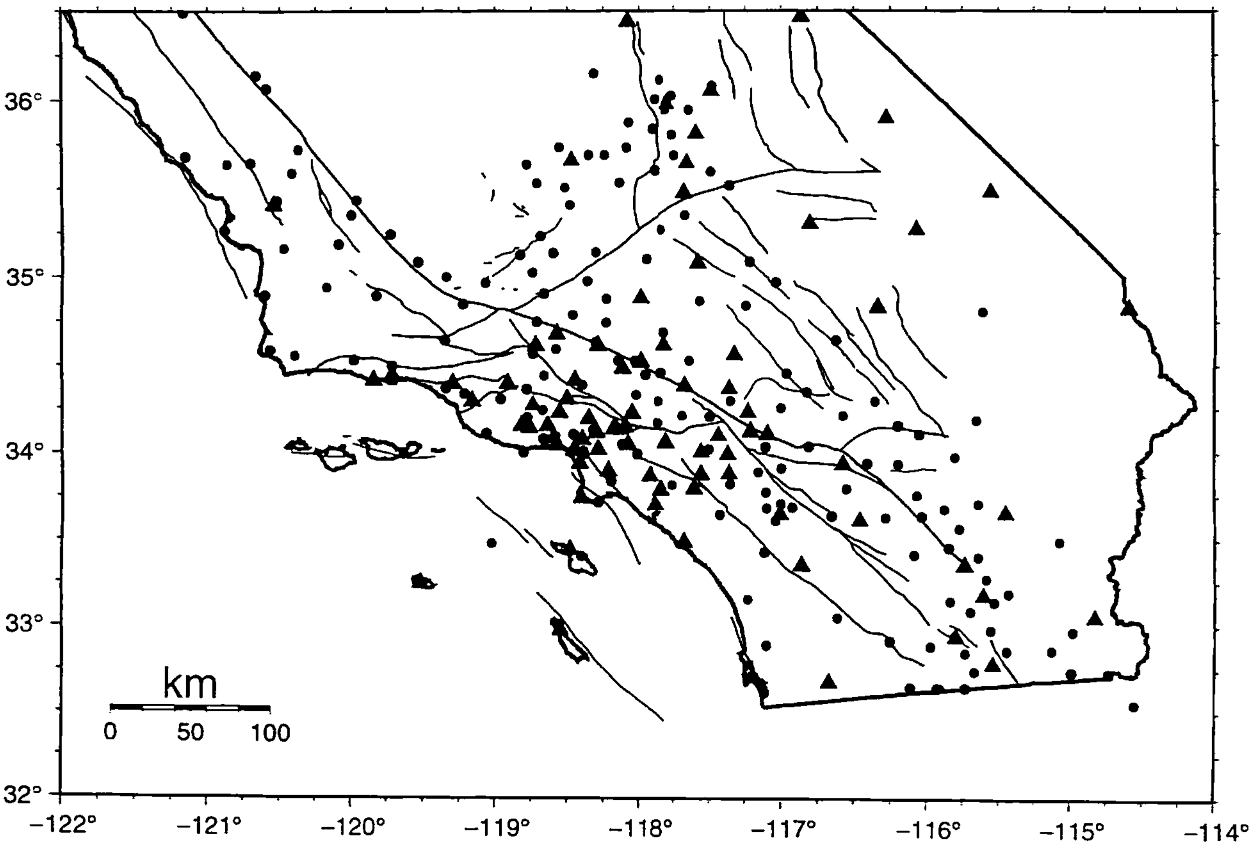
All but one of the new seismic stations added to the Network in 1998 are digital. The list of sixteen new digital and analog stations added through December 31, 1998 is in Table 1. A

TABLE 1
New Stations Added to SCSN in 1998

Code	Site Name	Lat (North)	Lon (East)	Elev (m)	Install Date	Instr
CIA	Catalina Island Airport	33.40200°	–118.41520°	398	09/10/98	ST2
CLC	China Lake	35.81574°	–117.59751°	705	01/09/98	SQU
DAN	Danby	34.63710°	–115.38050°	368	09/22/98	ST2
DEV	Devers	33.93500°	–116.57700°	302	02/27/98	SQU
DJJ	Donna J. Jenkins	34.10580°	–118.45380°	215	11/09/98	ST2
DRC	Desert Research Center	32.80540°	–115.44654°	–15	10/02/98	SQU
GR2	Griffith Park 2	34.11830°	–118.29940°	316	03/31/98	SQU
HOL*	Holcomb Ridge	34.45825°	–117.84505°	1160	03/02/98	STA
JCS	Julian Camp Stevens	33.08590°	–116.59590°	1228	09/17/98	ST2
LRL	Laurel Mountain	35.47940°	–117.68210°	1285	06/18/98	SQU
LUG	Lugo	34.36610°	–117.36580°	1110	02/19/98	SQU
MLS	Mira Loma Substation	34.00460°	–117.56090°	199	03/05/98	SQU
MPM	Manuel Prospect Mine	36.05799°	–117.48901°	1823	06/25/98	SQU
RSB	Riverside Borehole	33.97310°	–117.32720°	306	09/09/98	ST2
RUS	Rush	34.05050°	–118.07990°	37	05/29/98	SQU
SSW	Salton Sea Wildlife	33.17660°	–115.60240°	–60	04/24/98	SQU

Notes: An * next to a station code indicates an analog site.

TABLE 2 Discontinued Stations in the SCSN in 1998			
Code	**Site Name**	**Date Terminated**	**Comments**
CIW	Catalina Island West	01/14/98	replaced by CIA
GRH	Granada Hills	04/08/98	temporary Northridge
LJB	Lovejoy Butte	02/04/98	replaced by HOL
SYL	Sylmar	04/08/98	temporary Northridge
TWL	Twin Lakes	04/08/98	lost telemetry, plan to reloc.
VRD	Verdugo Hills	04/08/98	temporary Northridge



▲ **Figure 1.** Southern California Seismographic Network, January 1999. Triangles represent digital stations. Circles are analog stations.

list of all currently operating stations may be found at http://www.trinet.org/stalist.web. Figure 1 shows the locations of all the current SCSN analog and digital stations. The "ST2" type instruments are Streckheisen STS-2 broadband seismometers with an FBA-23 in addition, and the "SQU" type instruments are Guralp CMG-40T instruments with an FBA-23.

DISCONTINUED STATIONS

Six stations were discontinued in 1998. The removal dates are shown in Table 2. Most were removed because they were replaced with digital instruments at a nearby site.

PROCESSING STATUS OF NETWORK DATA

The processing status for each month of the catalog since the advent of digital recording is described in Table 3. Events for months marked **P** (preliminary) have been located but have not yet run the gauntlet of quality checking, adjustment and checking of magnitudes, and rearchiving necessary to become final (**F** with shading). For months marked **PNK** (pinked), large events (~*M*3.0) have been crudely timed on only a few stations, while smaller events are absent. The event information was recorded on pink index cards, thus they are called "pinked" until the data have been located completely and checked for quality. The 1977 and 1979 events occurred before the current seismic processing system

TABLE 3.
Processing Status of Network Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1932–1974	PREDIGITAL RECORDING—COMPLETE FOR **M** ≥ 3.0											
1975	F	F	F	F	F	F	F	F	F	F	F	F
1976	F	F	F	F	F	F	F	F	F	F	F	F
1977	P	P	P	P	P	P	P	P	P	P	P	P
1978	F	F	F	F	F	F	F	F	F	F	F	F
1979	P	P	P	P	P	P	P	P	P	P	P	P
1980	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK	PNK
1981	PNK	PNK	P	P	P	P	F	F	F	F	F	F
1982	F	F	F	F	F	F	F	F	F	F	F	F
1983	P	P	P	PNK	PNK	PNK	PNK	F	F	F	F	F
1984	F	F	F	F	F	F	F	F	F	F	F	F
1985	F	F	F	F	F	F	F	F	F	F	F	F
1986	F	F	F	F	F	F	F	F	F	F	F	F
1987	F	F	F	F	F	F	F	F	F	F	F	F
1988	F	F	F	F	F	F	F	F	F	F	F	F
1989	F	F	F	F	F	F	F	F	F	F	F	F
1990	F	F	F	F	F	F	F	F	F	F	F	F
1991	F	F	F	F	F	F	F	F	F	F	F	F
1992	F	F	F	P	P	P	P	P	P	P	P	P
1993	F	F	F	F	F	F	P	P	P	P	P	P
1994	P	P	P	F	F	F	F	F	F	F	F	F
1995	F	F	F	F	F	F	F	F	F	F	F	F
1996	F	F	F	F	F	F	P	P	P	P	P	P
1997	F	F	F	F	F	F	F	F	F	F	F	F
1998	F	F	F	F	F	F	F	F	F	F	F	F
1999	P	P	P	P	P							

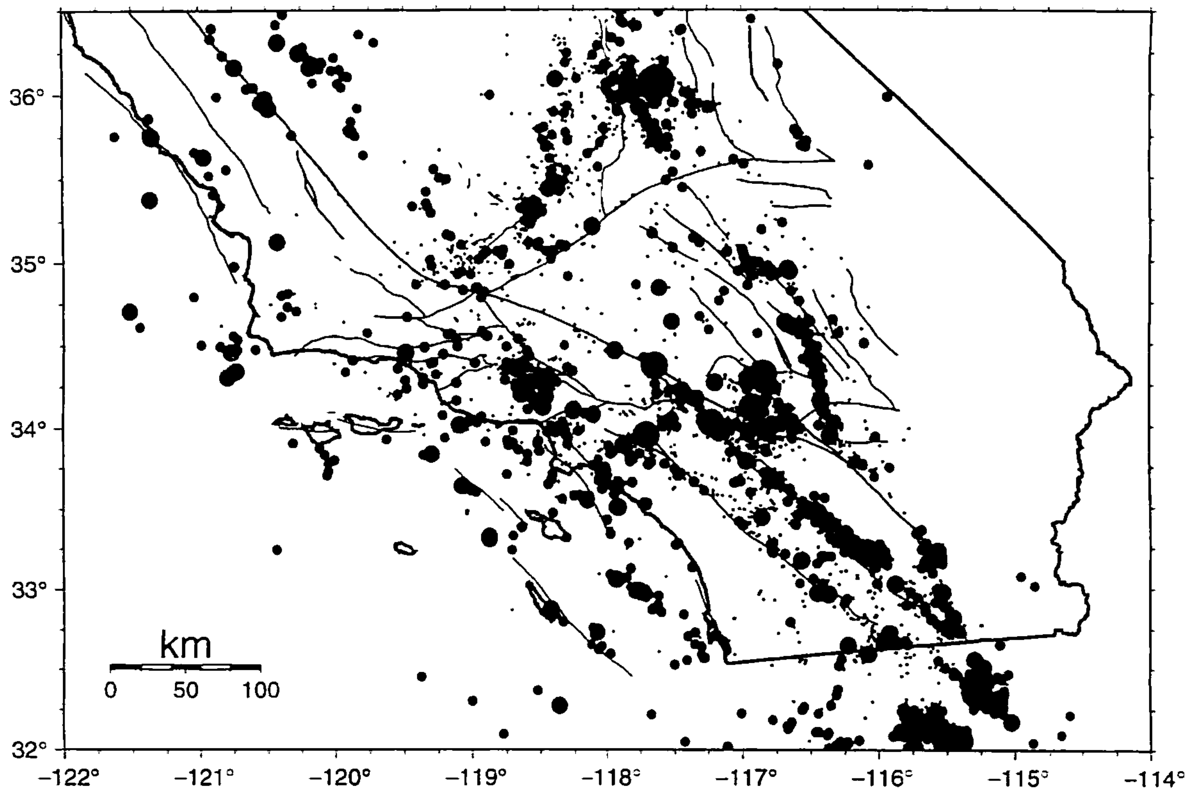
F Final; P Preliminary; PNK Pinked

was in place, and these data are still in the process of being hand-entered into the computer. The early-1980's gaps exist because of the abundant Mammoth events during that time. When a large number of events occur in a short period of time, the seismic analysts cannot keep up with the processing, and often the event files have to be loaded onto a backup system to make room for more events to be filed on the online system. Reloading those files back onto the online system at a later time is then required for the analysis and processing. A period in 1980–1981 has actually been timed and digital seismograms are available, but the "pinked" version is still used for research requiring the best magnitudes or completeness estimates for large events. Several months in 1992–1994 (from the Joshua Tree/Landers sequence) and 1996 (from the Northridge sequence) (marked P) are nearly finalized and need only magnitude calibrations. 1983 data are presently being processed.

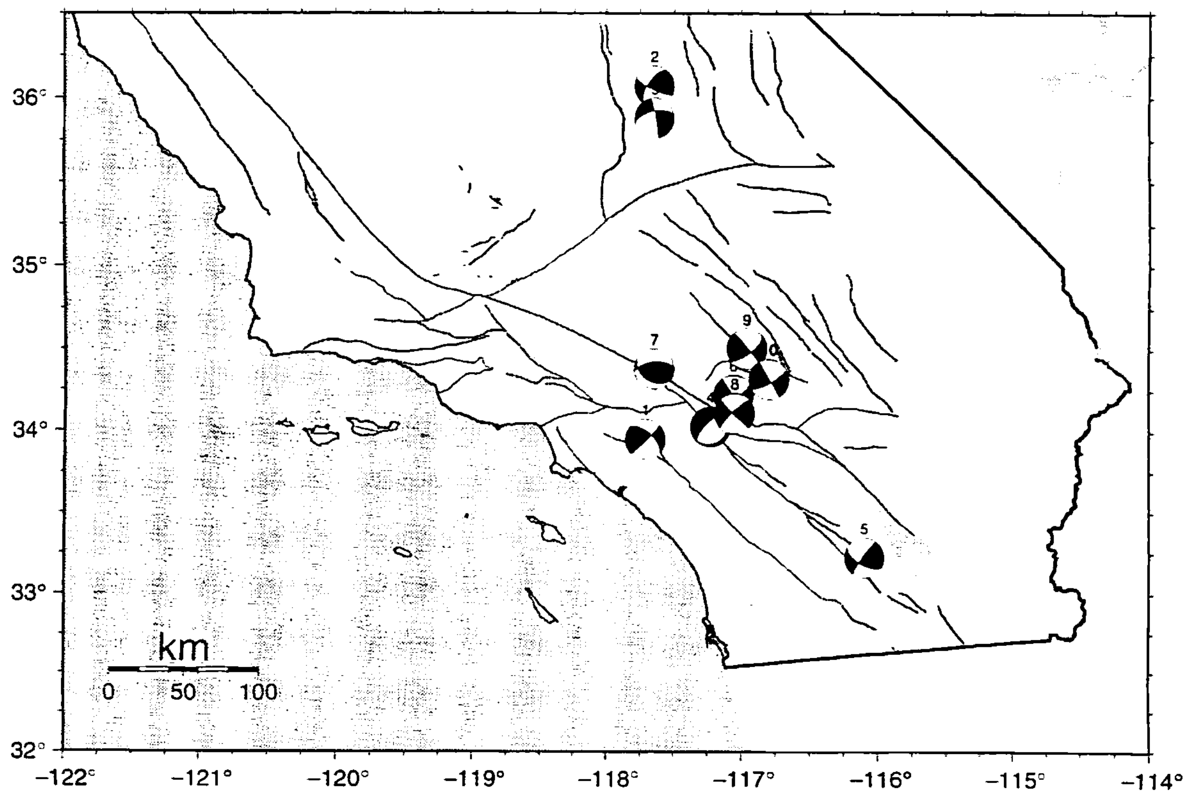
1998 SEISMICITY HIGHLIGHTS

A total of 11,781 earthquakes and 1,642 blasts were catalogued for 1998 (Figure 2). Of the catalogued events, 166 were greater than or equal to M_L3.0 (Appendix A). The largest earthquake within the SCSN network in 1998 had a magnitude of 5.2 and is called the Coso earthquake. Focal mechanisms for ten selected events ($M_L \geq 4.0$) are shown in Figure 3.

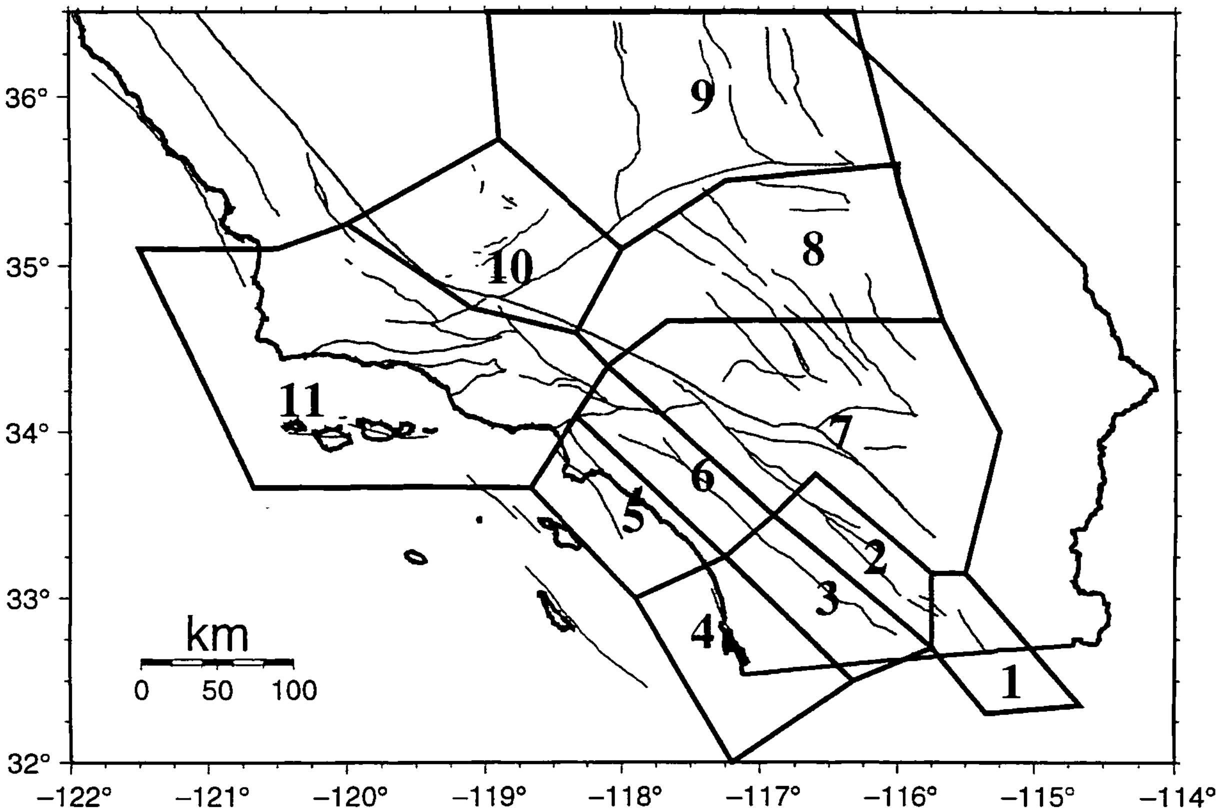
For the following discussion, southern California has been divided into eleven subregions (Figure 4). These regions are arbitrary but useful for discussing the characteristics of the seismicity in a manageable context. Figure 5 sum-



▲ **Figure 2.** All located earthquakes in southern California for the period of January–December 1998.



▲ **Figure 3.** Lower hemisphere focal mechanisms for selected *M*4.0+ events for the period January–December 1998. Event numbers correspond to numbers in F column of Appendix A. Some focal mechanism locations have been adjusted slightly in order for each one to be seen.



▲ **Figure 4.** Boundaries of subregions used in summary of seismicity. 1 = Imperial Valley, 2 = South San Jacinto, 3 = South Elsinore, 4 = San Diego, 5 = Los Angeles, 6 = North Elsinore, 7 = San Bernardino/South Mojave, 8 = North Mojave, 9 = South Sierra Nevada, 10 = Kern County, 11 = San Fernando/Santa Barbara.

marizes the activity of each subregion over the past ten years. A separate discussion section follows for those regions with notable activity. The earthquakes included in the discussion are shown on Figure 6. Earthquakes of *M*3.5 or greater, or those of any size that were felt, are discussed. The discussions include all earthquakes recorded by the SCSN that occur between latitudes 32.0°N and 36.5°N and longitudes 114°W and 122°W. We also mention some interesting and/or large events near but outside this region; these are typically events in the Owens Valley (north of Coso) or to the south in Mexico. The dates are all based on Greenwich Mean Time (GMT).

Imperial Valley—Region 1.

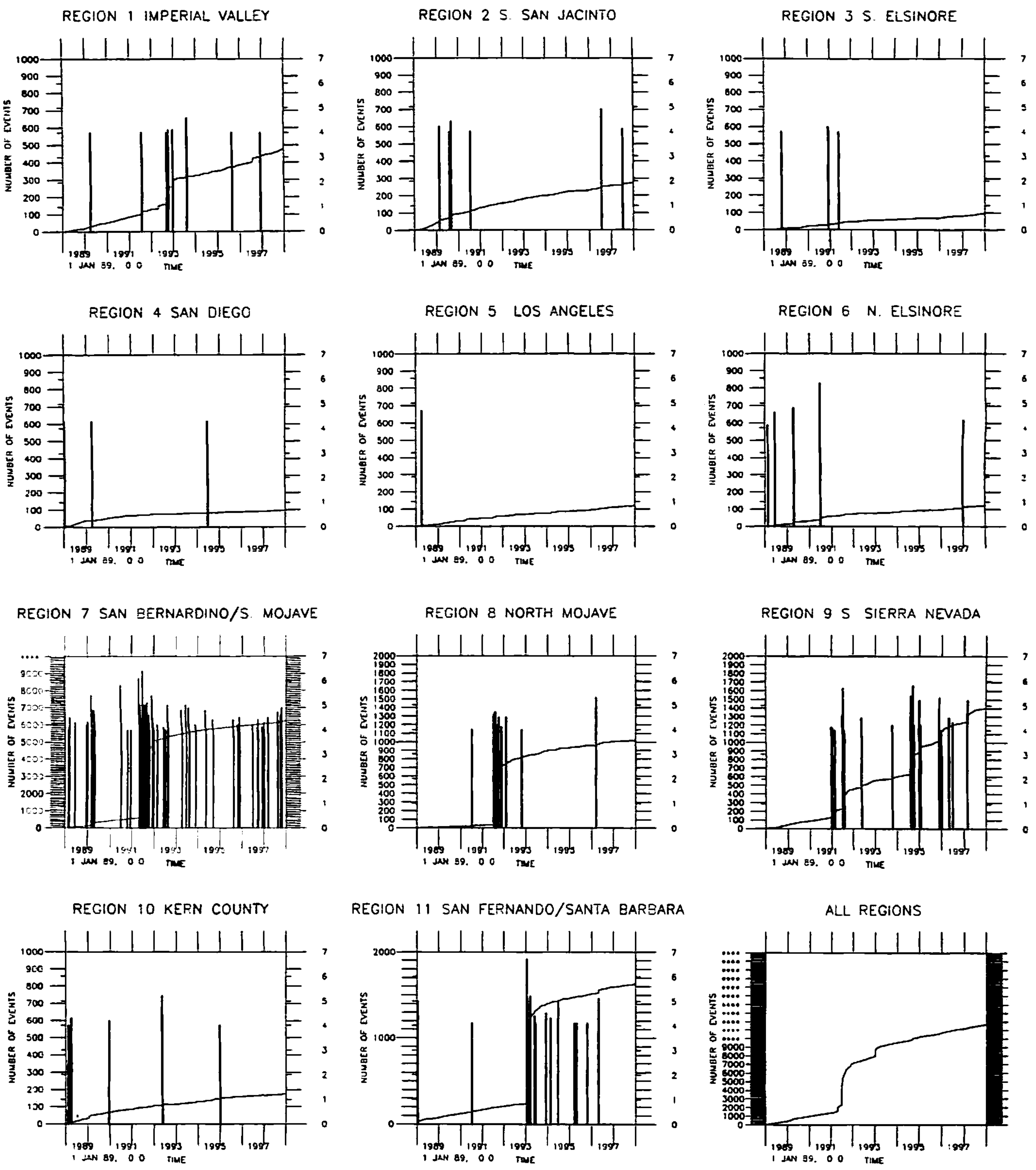
This region of frequent swarms stayed true to form in 1998. A swarm began on December 1, 1997 with an *M*4.1 near Obsidian Butte in the Brawley Seismic Zone and continued throughout most of January. An *M*3.8 on January 12 was the second largest event of the swarm. The Obsidian Butte area then stayed relatively quiet until an *M*3.8 occurred on November 2. Near Ocotillo, at the U.S./Mexico border, there was an *M*3.5 on January 26 and an *M*3.7 on December 12. Another small swarm occurred near El Centro in October. The rest of the seismic activity down south actually occurred in Mexico but may have been felt by residents along the border. On August 2, there were an *M*3.3 and an *M*3.7 44 miles south of the border town of Calexico. Then an *M*3.8 in the Cerro Prieto Seismic Zone shook the area 26 miles south-southeast of Calexico on October 14. A few days later a swarm began 50 miles south of Calexico that included two *M*3.7's, an *M*3.6, an *M*4.2, an *M*3.9, and an *M*3.8 within three days. This was followed two weeks later by an *M*4.0 40 km to the south.

South San Jacinto—Region 2.

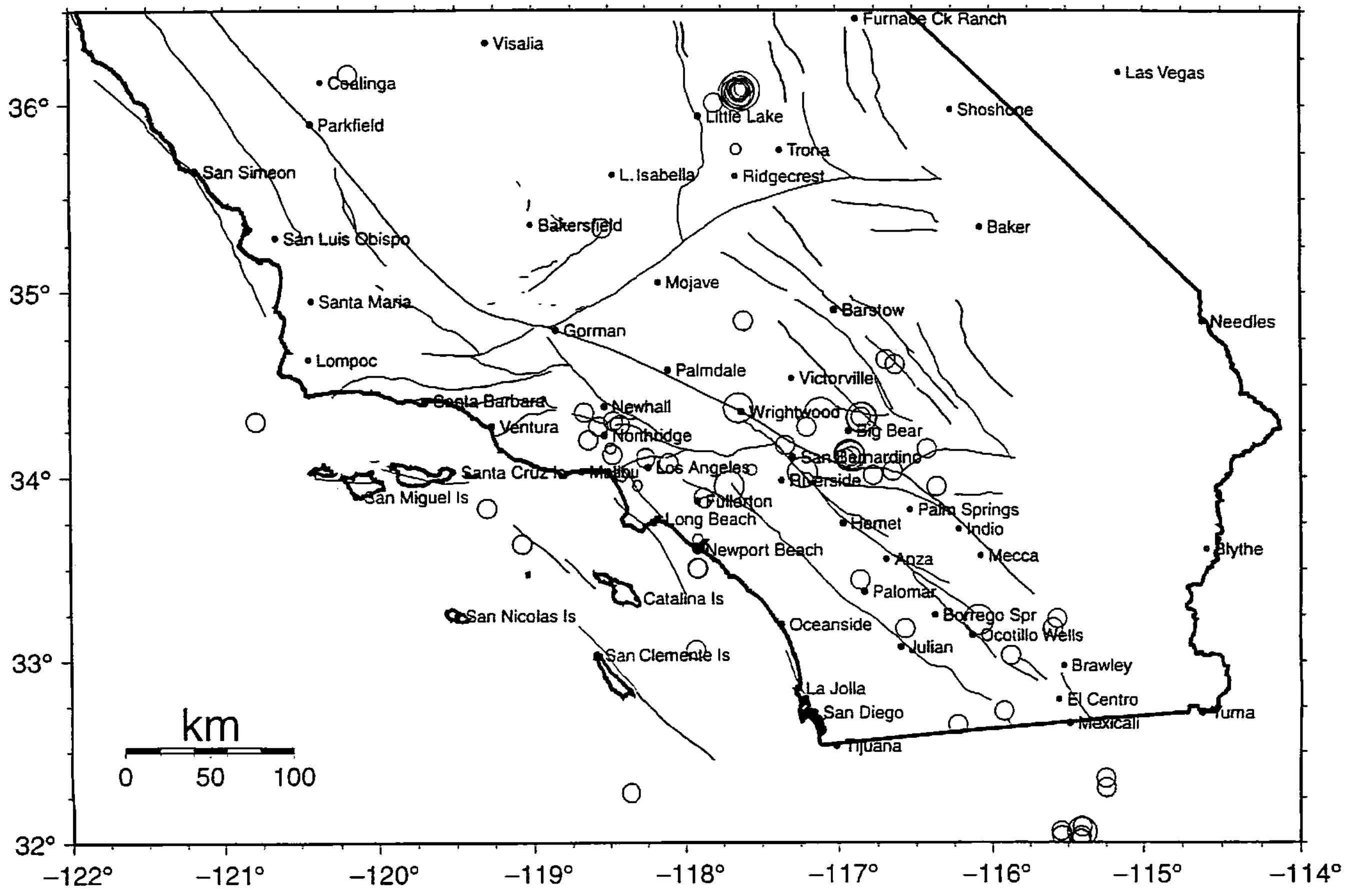
The only events of interest in this area were an *M*3.9 near Salton City on June 26 in the aftershock zone of the Superstition Hills earthquake, although after this long it is no longer considered an aftershock, and an *M*4.1 (Figure 3, #5) on July 10 in the Anza-Borrego desert 6 miles from Ocotillo Wells. The latter event was in the San Jacinto Fault system and was felt as far as San Diego and Palm Springs.

South Elsinore—Region 3.

It was relatively quiet in this area except for an *M*3.7 on June 4 just north of Mt. Palomar Observatory, which was felt in Temecula and Pauna Valley, and an M3.9 on July 24 near Julian, close to the Elsinore Fault Zone.



▲ **Figure 5.** Cumulative number of events ($M_L \geq 2.5$) in all subregions over the ten-year period ending December 1998. The boundaries of the subregions are shown in Figure 4. Vertical bars represent time and magnitude (scale on right) of large events ($M_L \geq 4.0$). Note that the vertical scales of the plots may not be the same.



▲ **Figure 6.** 1998 earthquake highlights. Earthquakes discussed in the "Earthquake Highlights" section and labeled towns for reference.

San Diego—Region 4.

An $M4.8$ 180 miles offshore southwest of San Diego on July 9 was recorded just outside this region.

Los Angeles—Region 5.

The largest event in the Los Angeles area in 1998 was an $M3.8$ on April 25 north of downtown in Alhambra that was widely felt throughout Los Angeles. Ten days before that, an $M3.2$ just slightly to the south but north of downtown in Silver Lake was also widely felt. Since the Los Angeles metropolitan area is so densely populated, even small earthquakes are often felt. On June 14 an $M2.7$ and on July 20 an $M2.5$ were both felt in Newport Beach; these occurred in the Newport-Inglewood Fault Zone. On the northern section of the Newport-Inglewood Fault Zone, an $M2.5$ was felt under Inglewood on December 13. The Santa Monica Beach area felt an $M2.8$ under Culver City on August 26, and an $M2.5$ under Encino shook residents on November 11. This one fell just outside the Northridge (January 17, 1994) aftershock zone. Offshore events included an $M3.7$ 30 miles south-southwest of Dana Point on June 14, and further to the north an $M3.6$ 38 miles south of San Clemente Island on November 10.

North Elsinore—Region 6.

An $M4.3$ (Figure 3, #1) on January 5 in Chino was widely felt from Santa Monica to San Bernardino. This event had a strike-slip mechanism and a location consistent with the Whittier Fault. Aftershocks continued for about one week. Two days later on the other side of the Chino Hills in Brea an $M3.1$ was felt. Later in the year on June 5 Orange County felt an $M2.7$ near Fullerton.

San Bernardino/South Mojave—Region 7.

Landers aftershocks (June 28, 1992) continued sporadically throughout the year, including an $M3.6$ near Lucerne Valley on April 17, an $M3.6$ nearby on July 4, an $M3.6$ on July 27 near Desert Hot Springs in the Joshua Tree aftershock zone, and an M3.5 near Yucca Valley on November 10. The Big Bear area had a little excitement with an $M4.7$ (Figure 3, #6) on August 16 near Mt. San Gorgonio. The earthquake had a strike-slip mechanism, and the aftershock pattern defined a northwest-trending fault. Another event of $M4.7$ (Figure 3, #8) occurred here on October 1. Then in a different location 4 miles north of Big Bear City an $M4.9$ (Figure 3, #9) strike-slip event surprised everyone just twenty-six days later. It was named the Whiskey Springs earthquake, and it had a healthy aftershock sequence, including the largest aftershock of *M*4.1 (Figure 3, #10) on the same day. Continuing to the east, the Morongo Valley area had an *M*3.7 event on June 21 near the intersection of the Morongo Valley Fault and the Mission Creek branch of the San Andreas. The mechanism was oblique strike-slip, consistent with the Mission Creek Fault. In Yucaipa an *M*3.4 was felt on August 23. An *M*4.5 (Figure 3, #4) in the Crafton Hills near Redlands on March 11 shook people in the Inland Empire and as far away as Thousand Oaks and Palm Springs. This location is near the intersection of the San Jacinto Fault and the Crafton Hills Fault, and the normal faulting mechanism indicates it was on the Crafton Hills Fault. Lake Arrowhead experienced an *M*3.5 with a normal mechanism on August 17. An *M*4.4 (Figure 3, #7) shook the Wrightwood area on August 20 and was widely felt in the Inland Empire. Although it was close to the San Andreas Fault, it had a thrust mechanism.

The San Bernardino area had its share of seismicity, too. February 3 saw an *M*3.5 in the San Bernardino Mountains, and another *M*3.5 occurred much later in the year on December 12 near Cabazon in the foothills. Closer to the more highly populated area, an *M*3.0 was felt near Rialto on May 22, and an *M*2.7 was felt by a few near Rancho Cucamonga on September 30.

Farther south a small swarm buzzed on December 18 at Bombay Beach on the northeast shore of the Salton Sea.

North Mojave—Region 8.

There was a lone *M*3.6 thrust event 11 miles south of Boron on August 12.

South Sierra Nevada—Region 9.

The largest earthquake in southern California occurred in this region on March 6. It was an *M*5.2 (Figure 3, #2) and was called the Coso earthquake, since it was located near the Coso geothermal area, 2 km east of an *M*5.3 that occurred on Thanksgiving of 1996. An *M*5.0 (Figure 3, #3) followed the next day, and an *M*3.8 occurred later on March 18. Even though this is an extensional regime, these events were strike-slip. They were felt in China Lake and Ridgecrest. On May 10 an *M*3.5 occurred in the Coso Range near Coso Junction, 10 miles from the March activity. An *M*3.9 initiated a small swarm just east of Coso Junction on June 8.

Kern County—Region 10.

There was an *M*3.6 in the mountains 16 miles north-northwest of Tehachapi on December 11.

San Fernando/Santa Barbara—Region 11.

Offshore there were an *M*3.5 on July 17, 18 miles southeast of Santa Cruz Island, and an *M*3.7 21 miles south-southwest of Pt. Arguello (63 miles west of Santa Barbara) on December 11. An *M*3.9 occurred on December 18 offshore north of Santa Barbara Island, and two days later an *M*3.7, preceded two minutes earlier by an *M*3.2, shook the offshore area southwest of Laguna Beach. On January 11, an *M*3.3 under Van Nuys was widely felt in the San Fernando Valley and the Hollywood area. June 3 brought an *M*3.0 near Encino in the southern San Fernando Valley, just outside of the Northridge aftershock zone, that was felt in the epicentral area. Northridge aftershocks were felt occasionally throughout the year. On January 4, an *M*3.3 was felt as part of a cluster of aftershocks near Canoga Park in the western San Fernando Valley. Later in the month on January 30 an *M*3.0 was felt in the Granada Hills area. An *M*3.7 was felt in Simi Valley and the western San Fernando Valley on May 1. An *M*3.9 near Chatsworth was widely felt on June 17, and an *M*3.3 occurred under San Fernando on August 26.

WEB NOTES

Did You Feel It?

Did you feel it? If you did, or even if you didn't, you can report what you felt on the Southern California Community Internet Intensity Map Web page. Automatic, rapid generation of seismic intensity maps is accomplished by collecting shaking and damage reports from Internet users immediately following felt earthquakes in southern California (Quitoriano *et al.*, 1998). Intensity survey questionnaires are made available through the World Wide Web within minutes after the detection of a significant event by the TriNet real-time system. Responses to the questionnaire are automatically converted to Community Decimal Intensities (CDI) using a modification of the algorithm from Dengler and Dewey (1998). Distinct areas are defined by the geographic boundaries of 5-digit ZIP codes. As questionnaires are contributed, the associated ZIP code is color-coded based on the calculated intensity, and a regional map of the seismic intensity distribution is created and displayed a few minutes after each response. Combining felt reports with automated processing and intensity assignment allows for much more rapid generation of preliminary intensity maps than the standard practice of mailing intensity surveys and manually processing them. In the absence of automatic monitoring, the process can be initiated by a certain number of felt reports. The URL for the Community Internet Intensity Maps is http://www-socal.wr.usgs.gov/ciim.html.

Northridge Earthquake Online

A collection of work done by the U.S. Geological Survey following the Northridge earthquake is now online at http://www-socal.wr.usgs.gov/north. Users can download data and maps showing many aspects of the earthquake, such as mainshock rupture, damage patterns, local site response effects, and landslide effects. Also available are various supporting data sets including a fault database, digital geologic maps, topographic data, and reference lists to Northridge publications with links to those that are online. The site also has photos from the earthquake and animations of the earthquake rupture and aftershock sequence.

FOR FURTHER INFORMATION

To order back issues of the Southern California Seismic Network Bulletins for 1985–1996, contact the USGS at Books and Open-File Reports Section, Branch of Distribution, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado, 80225 or call (303) 236–7476. Network Bulletins are published only in *Seismological Research Letters* starting with the 1997 Bulletin. Network Bulletins for 1990 through the present can also be seen at http://www-socal.wr.usgs.gov/lisa/NETBULLS. Archived SCSN data and information about getting an account on the SCEC Data Center can be obtained at http://www.scecdc.scec.org.

ACKNOWLEDGMENTS

The Summary of Seismicity section was written using information in the Weekly Seismicity Reports and TriNet Earthquake Commentary (online at http://www.trinet.org/eqreports/eqreports.html). Thanks to Nancy King and Peg Johnson for internal reviews.

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Appendix A

Significant Southern California Earthquakes

All events of $M \geq 3.0$ for the period January to December 1998. Times are GMT, Q is the overall quality of the location, M is the magnitude, Z is the depth in km, PH is the number of phases picked, RMS is the root mean square of the arrival times (in seconds), ID is the unique number assigned to the event by the CUSP system, and F denotes the number of the accompanying focal mechanism in Figure 3. Note that these events have not been finalized, and therefore their magnitudes may not be of the highest accuracy. In most cases, if the magnitude is incorrect, it is larger than indicated.