Operation of the

Norwegian National Seismic Network

2007

Supported by

University of Bergen, Faculty of Mathematics and Natural Sciences

and

Norwegian Oil Industry Association

Prepared by

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1. Introduction

This annual report describes the operation of the Norwegian National Seismic Network (NNSN) for the year 2007. It covers operational aspects as well as a financial report for all seismic stations operated by the Department of Earth Science at the University of Bergen (UiB), which has the responsibility of the NNSN.

The network is supported by the oil industry through the Norwegian Oil Industry Association ("Oljeindustriens Landsforening" (OLF)) and the Faculty of Mathematics and Natural Sciences, University of Bergen (UiB).

The seismicity of Norway and surrounding areas is presented in Appendix 1. The seismic arrays operated by NORSAR are covered in Appendix 2 of this report. NORSAR is subcontracted to deliver data of interest to NNSN.

2. Operation

The operational stability for each station is shown in Table 1. The average downtime for all stations during this reporting period is 1.8 % compared to 1.5 % for 2006. It should however be noted that for the stations KTK and FOO have had periods where they were not operating optimal. During these time periods there have not been any significant earthquakes so no data has been lost. The goal of average downtime is below 2%.

Table 1. Downtime in % for the period 2007 for the NNSN stations.

Station	Downtime in %
Askøy (ASK)	0
Bergen (BER)	0
Bjørnøya (BJO)	2
Blåsjø (BLS)	0
Dombås (DOMB)	0
Espegrend (EGD)	0
Florø (FOO)	0
Flostrand (FLOS)	2
Hopen (HOPEN)	17
Høyanger (HYA)	0
Jan Mayen BB (JMI)	0
Jan Mayen SP (JMI)	0
Jan Mayen (JNE)	0
Jan Mayen (JNW)	0
Karmøy (KMY)	0
Kautokeino (KTK)	0
Kings Bay (KBS)	0
Kongsberg (KONO)	3
Konsvik (KONS)	8
Lofoten (LOF)	1
Mo i Rana (MOR8)	0
Molde (MOL)	0
Namsos (NSS)	0
Odda (ODD1)	0
Oslo (OSL)	22
Rundemanen (RUND)	0
Snartemo (SNART)	0
Stavanger (STAV)	0
Steigen (STEI)	0
Stokkvågen (STOK)	0
Sulen (SUE)	7
Tromsø (TRO)	1
Average	**2,0**

3. Field stations and technical service

The technical changes for each seismic station are listed below. It is noted if these changes are not related to a visit from the technical staff at the University of Bergen. When a station stops working, tests are made to locate the problem. Sometimes the reason cannot be found and the cause of the problem will be marked as unknown.

Bjørnøya (BJO1)

30.09. – 01.10.07. Visit.
Inspected the aluminium box – ok. Recording equipment is working well.
02.11.07. Station down for 3 days. Reason unknown.
11.10.07. Due to a software problem data lost for 6 days.

Blåsjø (BLS)

No visit or technical changes.

Florø (FOO)

21-22.06.07. Visit. A damping resistance was installed.
12.07.07. A new ADSL connection was installed. It was not possible to identify the local communication problem by the staff in Bergen. No data has been lost, since the local PC was running.
18.10.07. New temporary PC (laptop) and digitizer (ED-2400) were installed by local operator.

Flostrand (FLOS)

11.06.07. Visit. The station was upgraded with GSM communication. The station code was changed from STOK2 to FLOS.
27.09.07. A new and better GSM (EDGE) antenna was installed by the local operator.

Høyanger (HYA)

No visit or technical changes.

Karmøy (KMY)

No visit or technical changes.

Konsvik (KONS)

11.06.07. Visit. Station upgraded eith new equipment. Changed station Code from STOK1 to KONS. Equipment: SARA SR04/53 (digitizer/geophone). One new GPS antenna, Dell PC
01.11.07. Due to lightning no connection with station.
17.11.07. A new GPS router was installed, still not able to login
29.11.07. A new SARA SRD/S3 (24 bit) was installed, still no login. Local operator moved input signal from COM1 to COM2 on PC. Station now ok.

Lofoten (LOF)

23-30.03.07. Power failure. Station was down for 7 days.
15.05.07. Visit. Replaced accelerometer.
27.11.07. Station down for 1 day. Reason unknown
11.12.07. Station down for 1 day. Reason unknown
17.12.07. Station down for 2 days. Reason unknown
27.12.07. Station down for 1 day. Reason unknown

Mo i Rana (MOR8)

No visit or technical changes.

Molde (MOL)

16.01-22.02.07. Bad timing
05-12.04.07. Communication problems.
17.03.07. Communication problems. No data lost.

Namsos (NSS)

No visit or technical changes.

Odda (ODD1)

No visit or technical changes.

Tromsø (TRO)

14.05.07. Visit. Installed Linux system.
15.10.07. Station down for 2 days. Reason unknown

Sulen (SUE)

1-12.02.07. data lost due to no free space on disk.
29.07.07. Station down for 1 day. Reason unknown
02.08.07. Due to a software problem the ringbufferfiles shut down, new ringbufferfiles generated using re_initi. Data lost for 1 days.
12.08.07. Due to a software problem the ringbufferfiles shut down, new ringbufferfiles generated using re_initi. Data lost for 8 days.
27.08.07. Due to a software problem the ringbufferfiles shut down, new ringbufferfiles generated using re_initi. Data lost for 10 days.
19.10.07. Due to a software problem the ringbufferfiles shut down, new ringbufferfiles generated using re_initi. Data lost for 6 days.

Steigen (STEI)

17.07.07. Station installed. Equipment: Sprtngnether S-6000 sensor, 1 SARA SR04 digitizer, Dell PC with Seislog for Windows, 15" LSD screen

Kautokeino (KTK)

23.09.07. Visit: A new Guralp CMG 40T BB sensor, Earth Data Digitizer (ED 2400), Dell PC Seislog for Linux, was installed. During the installation of the sensor, it turned out that the EW component was unable to centre, several efforts were made to correct it. The installation of The BB sensor is temporary. The measurement will be a part of the POLENET/LAPNET temporary research during the International Polar Year 2007-2009. Installation was done in cooperation with University of Oulu Finland.
17.10.07. Due to various technical problems it was decided not to extract trigger data from KTK until a new sensor and digitizer was installed.
01.11.07. Visit: A new Guralp CMG 40T BB sensor, belonging to NNSN, was installed by people from University of Oulu Finland. The signal was checked ok.

02.11.07. Z component hanging (out of range) and NS and EW noisy due a malfunction digitizer.
08.11.07. New digitizer (ED-2400) installed by the local operator. NS and EW are working properly.

Stavanger (STAV)

No visit or technical changes.

WNN network: Bergen (BER), Espegrend (EGD), Ask (ASK)

No visit or technical changes.

Rundemanen (RUND)

23.07.07. Station down for 1 day. Reason unknown

Trondheim (TRON)

04.05.06. Station was closed due to constructions at NGU. The station will be reinstalled.
An additional location at Blussvoll skole is also being prepared in parallel. Expected start time for new station is spring 2008.

Oslo (OSL)

31.07.07. Station down for 9 days. Reason unknown
05.11.07. Due to a broken Digitizer and PC, station down for 72 days. New Nanometrics Digitizer (RD3) and Dell PC vers. Seislog for windows was installed by the local operator.

Dombås (DOMB)

No visit or technical changes.

Jan Mayen (JMI)

No visit or technical changes.

Kongsberg (KONO)

23.05.07. Replaced the CPU Board s/n 1220164.
05.06.07. Replaced new tape drives.MT0 s/n AA160452, MT1 s/n AA105018.

Kings Bay (KBS)

No visit or technical changes.

Stokkvågen (STOK)

12.06.07. Visit
New Sara digitizer (SR04 s/n 041) installed.

Snartemo (SNART)

No visit or technical changes.

Hopen (HOPEN)

07.03.07. Local operator installed new digitizer (SRO 4). After installation the PC was not restarted locally. Data lost between 07.03-10.05.07.
02.-04.10.07. Visit.
1 new Streckeisen STS-2 BB sensor, 1 ED 2400 Digitizer, 1 Dell Pc Seislog for windows, was installed.
29.11.07. 1 ED 2400 Digitizer, 1 Dell Pc Seislog for windows, was sent for spare.

4. Technical changes and plans

The network now has 10 broadband stations where continuous data is collected. The move to get more continuous data on line is progressing and different systems for real time monitoring are being tested. By the end of 2007, 12 stations are operating in real time mode enabling the network to make faster earthquake locations and a better real time operational monitoring.

APPENDIX 1

Seismicity of Norway and surrounding areas in 2007.

Seismicity of Norway and surrounding areas

for

2007

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1. Introduction

This annual report on the seismicity of Norway and adjacent areas encompasses the time period January 1st - December 31st, 2007. The earthquake locations have been compiled from all available seismic stations operating on the Norwegian territory including the Arctic islands of Spitsbergen, Bjørnøya, Hopen and Jan Mayen. In addition, stations from neighbouring countries have been included for large or well-recorded events.

In Norway, the University of Bergen (UiB) operates the Norwegian National Seismic Network (NNSN) consisting of 31 seismic stations where 10 have broad band sensors. NORSAR operates 3 seismic arrays and one seismic station (Figure 1). Data from temporarily installed local networks are also included whenever data are made available. In 2006 two temporary stations (STOK1 and STOK2) were installed in northern Norway in the Stokvågen area. These stations changed station code to KONS and FLOS and are still in operation.

The Steigen area in Troms is a location where a significant number of small earthquakes have been registered previously (Atakan et al., 1994). A seismic station, STEI, was in June 2007 located in the area to monitor the seismic activity. Since an increase in the seismic activity was observed late autumn, a temporary station (LEINS) was installed.

Phase data from arrays in Russia (Apatity), Finland (Finess), Sweden (Hagfors) and from stations operated by the British Geological Survey (BGS) are also included when available. All phase data are collected by UiB, and a monthly bulletin is prepared and distributed. All earthquakes with magnitude ≥ 2.0 on mainland Norway and $M \geq 3.0$ around Jan Mayen and the midatlantic-ridge, are presented on the web pages and also e-mailed to European-Mediterranean Seismological Centre (EMSC). A brief overview of the events published in the monthly bulletins is given in this annual report. Macroseismic data for the largest felt earthquakes in Norway are collected, and macroseismic maps are presented.

Local, regional and teleseismic events that are detected by the UiB network are included. The merging of data between NORSAR and UiB is based on the following principles:

i) All local and regional events recorded by NORSAR that are also detected by the NNSN network are included.

ii) All local and regional events with local magnitude larger than 2.0 detected by NORSAR and not recorded by the NNSN are included.

iii) All teleseismic events recorded by NORSAR and also detected by the NNSN are included.

iv) All teleseismic events with NORSAR magnitude $M_b \geq 5.0$ are included.

Data from British Geological Survey (BGS) are included in the database in Bergen following similar criteria as mentioned above, however only events located in the prime area of interest, shown in Figure 1, are included.

Data availability to the public

All the data stored in the NNSN database is also available to the public via Internet, e-mail or manual request. The main web-portal for earthquake information is www.skjelv.no. It is possible to search interactively for specific data, display the data locally (waveforms and hypocenters) and then download the data. Data are processed daily and updated lists of events recorded by Norwegian stations are available soon after recording. All events with an estimated local magnitude ≥ 2.0 are plotted on individual maps shown on the web pages.

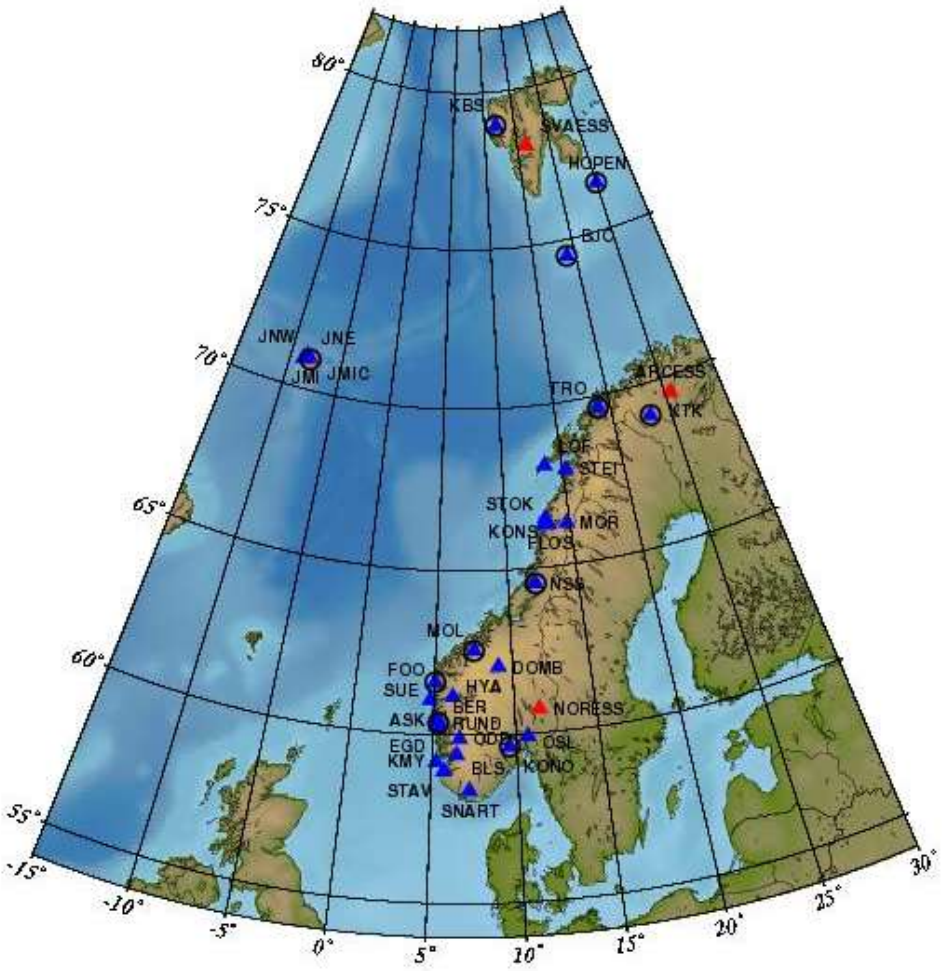

Figure 1: Norwegian seismic stations. UiB operates the 31 stations (blue triangles) in the National Seismic Network (NNSN) and NORSAR operates the 3 arrays and the station JMIC (red triangles). Circles identify broad band stations.

2. Velocity models and magnitude relations

The velocity model used for locating all local and regional events, except for the local Jan Mayen events, is shown in Table 1 (Havskov and Bungum, 1987). Event locations are performed using the HYPOCENTER program (Lienert and Havskov, 1995) and all processing is performed using the SEISAN data analysis software (Havskov and Ottemöller, 1999).

Table 1: Velocity model used for locating all local and regional events, except for the local Jan Mayen events, (from Havskov and Bungum, 1987).

P-wave velocity (km/sec)	Depth to layer interface (km)
6.2	0.0
6.6	12.0
7.1	23.0
8.05	31.0
8.25	50.0
8.5	80.0

Magnitudes are calculated from coda duration, amplitudes or seismic spectra. The coda magnitude relation was revised in 2006 (Havskov & Sørensen 2006). The coda wave magnitude scale (M_C) is estimated through the relation

$$M_C = -4.28 + 3.16 \cdot \log10(T) + 0.0003 \cdot D$$

where T is the coda length in seconds and D is the epicentral distance in km. The new scale made M_C more consistent with M_L since M_C in general is reduced. For this report all data are updated using the new magnitude scale. When instrument corrected ground amplitudes A (nm) are available, local magnitude M_L is calculated using the equation given by Alsaker et al. (1991):

$$M_L = 1.0 \cdot \log(A) + 0.91 \cdot \log(D) + 0.00087 \cdot D - 1.67$$

where D is the hypocentral distance in km.

The moment magnitude M_w is calculated from the seismic moment M_0 using the relation (Kanamori, 1977)

$$M_w = 0.67 \cdot \log(M_0) - 6.06$$

The unit of M_0 is Nm. The seismic moment is calculated from standard spectral analysis assuming the Brune model (Brune, 1970) and using the following parameters:

Density: 3.0 g/cm^2
$Q = 440 \cdot f^{0.7}$
P-velocity = 6.2 km/s
S velocity = 3.6 km/s

For more computational details, see Havskov and Ottemöller, (2003).

For the Jan Mayen area, a local velocity model (see Table 2) and coda magnitude scale is used (Sørnes and Navrestad, 1975).

Table 2: Velocity model used for locating local Jan Mayen events.

P-wave velocity (km/sec)	Depth to layer interface (km)
3.14	0
6.33	3
8.27	18

The coda magnitude scale for Jan Mayen which is used in this report is given by Havskov & Sørensen (2006). This scale was implemented in 2006 but all events used in this report are updated during April/May 2006.

$$M_C = 3.27 \cdot \log(T)\ 2.74 + 0.001 \cdot D$$

where T is the coda duration and D is the epicentral distance in km.

The regional and teleseismic events recorded by the network are located using the global velocity model IASPEI91 (Kennett and Engdahl, 1991).

Body wave magnitude is calculated using the equation by Veith and Clawson (1972):

$$Mb = \log(A/T) + Q(D,h)$$

Here h is the hypocentre depth (km), A is the amplitude (microns), T is period in seconds and Q(D,h) is a correction for distance and depth.

Surface wave magnitude Ms is calculated using the equation (Karnik et al., 1962):

$$Ms = \log(A/T) + 1.66 \cdot \log(D) + 3.3$$

where A is the amplitude (microns), T is period in seconds and D is the hypocentral distance in degrees.

Starting from January 2001, the European Macroseismic Scale, EMS98, (Grünthal, 1998) has been used. All macroseismic intensities mentioned in the text will refer to the EMS98 instead of the previously used Modified Mercalli Intensity scale. The two scales are very similar at the lower end of the scale for intensities less than VII.

3. Events recorded by the Norwegian stations

Based on the criteria mentioned in section 1 and above, a total of 3630 local and regional events, were detected by the Norwegian seismic stations during 2007. Of these local and regional events analysed, 54% were large enough to be recorded by several stations and hence could be located reliably. The number of local/regional and teleseismic events, recorded per month in 2007 is shown in Figure 2. The average number of local and regional events recorded per month is 302.

A total of 918 teleseismic events were recorded between January and December 2007, of which 96% were located. In addition to the locations determined at UiB, also preliminary locations published by the USGS (United States Geological Survey) based on the worldwide network are included in the UiB database whenever the earthquake is recorded with Norwegian stations. The monthly average of teleseismic earthquakes recorded by NNSN is 77.

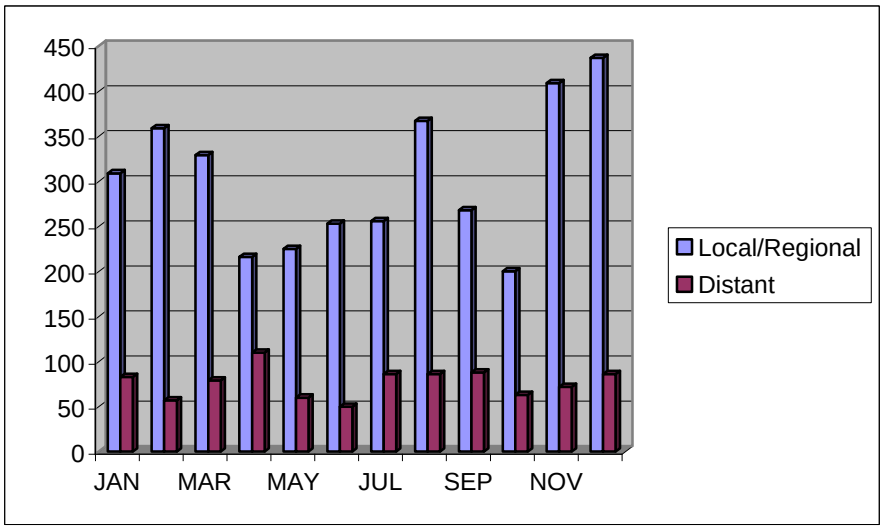

Figure 2: Monthly distribution of local/regional and distant events, recorded during 2007.

UiB, as an observatory in the global net of seismological observatories, reports as many secondary phases as possible from the teleseismic recordings. All events (teleseismic, regional and local) recorded from January to December 2007 with M ≥ 3 are plotted on Figure 3.

Monthly station recording statistics from January to December 2007 are given in Table 3. This table shows, for each station, the number of local events that were recorded only at one station, local events recorded on more than one station and recorded teleseismic events. It must be observed that Table 3 shows both earthquakes and explosions, and that the large number of detections at KTK mainly is due to explosions at the Kirruna/Malmberget mines in Sweden. The MOR station also records the Kirruna/Malmberget explosions but in addition the station also records a large number of local earthquakes. Since 2003 a new seismic station, STOK, was located close to the existing MOR station and in 2006 this is further extended by two more stations (FLOS and KONS). Therefore the number of recorded local earthquakes increased.

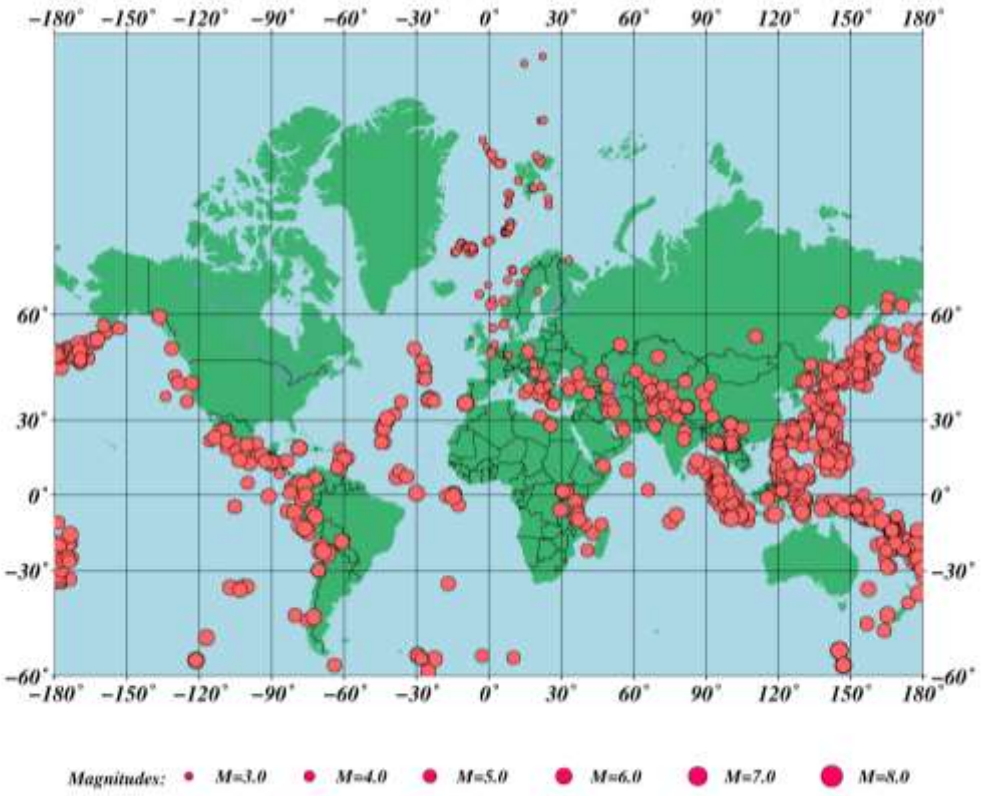

Figure 3: Epicentre distribution of earthquakes with M≥3.0, located by the Norwegian Seismic Network from January to December 2007. Teleseismic events recorded only by NORSAR have M≥5.0.

4. The seismicity of Norway and adjacent areas

A total of 1934 of the recorded events are located inside the NNSN prime area, 54°N-82°N and 15°W-32°E. During analysis and using the explosion filter (Ottemöller, 1995), 34% of these events were identified as probable explosions. Figure 4 shows all local/regional events in the prime area, analyzed and located during 2007.

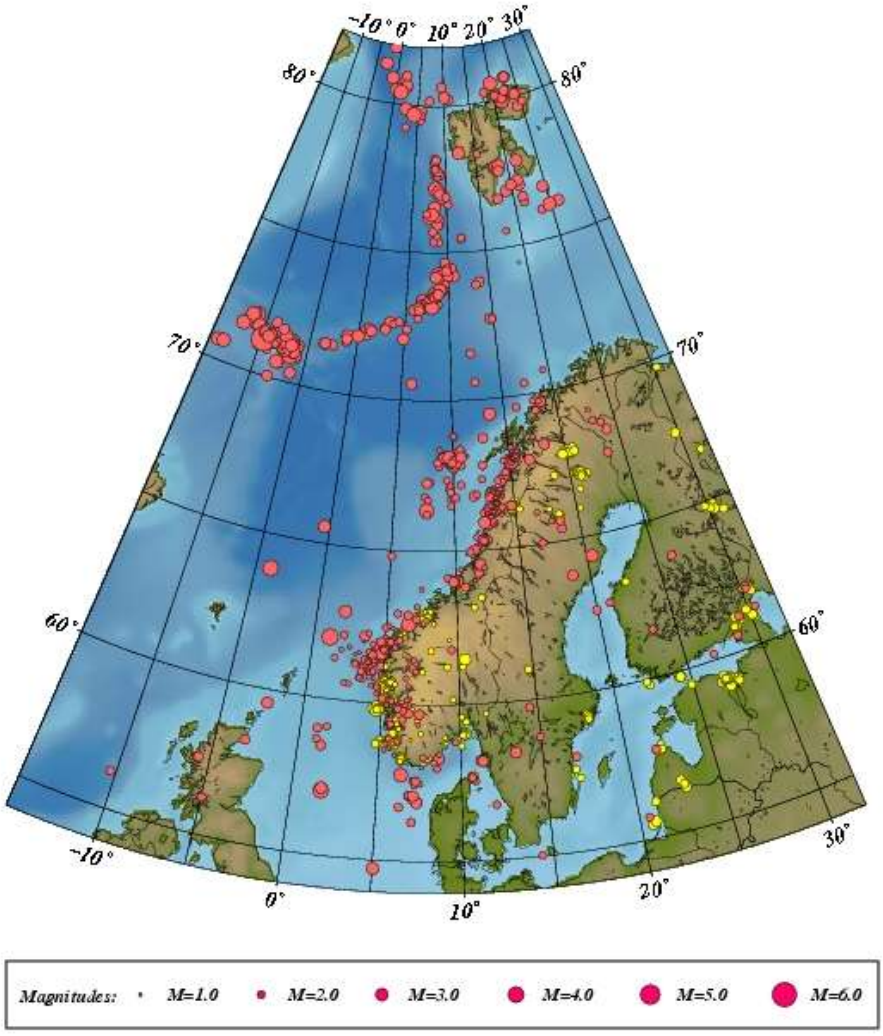

Figure 4: Epicentre distribution of events analyzed and located from January through December 2007. Earthquakes are plotted in red and probable and known explosions in yellow. For station locations, see Figure 1.

Table 3a: Monthly statistics of events recorded at each station for January-June 2007. Abbreviations are: **LM** = Number of local events recorded at more than one station, **LS** = Number of local events recorded at only one station and **D** = Number of teleseismic events. The station STEI was installed during June and then also the STOK1 and STOK2 seismic stations changed station code to KONS and FLOS respectively.

	JANUARY			**FEBRUARY**			**MARCH**			**APRIL**			**MAY**			**JUNE**		
STATION	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**
ASK	39	0	10	40	0	1	58	0	13	24	0	8	46	0	10	35	0	3
BER	13	2	17	8	0	8	10	2	25	7	0	38	12	0	23	11	0	23
BJO1	4	0	13	15	0	7	7	1	18	8	8	21	5	1	6	4	0	11
BLS5	31	0	15	39	0	10	48	0	19	28	0	15	39	0	12	34	0	4
DOMB	9	0	16	13	0	9	13	0	15	8	0	19	11	0	9	8	0	3
EGD	29	0	8	25	0	1	34	0	12	15	0	5	36	0	9	28	0	1
STOK2/FLOS	26	0	0	4	0	0	24	0	0	10	0	0	18	0	0	5	0	0
FOO	20	0	4	31	0	0	21	0	3	13	0	1	34	0	1	17	0	0
HOPEN	1	0	0	5	4	0	0	0	0	0	0	0	1	0	0	0	0	0
HYA	35	1	10	45	0	0	48	0	15	29	0	7	46	0	10	32	0	3
JMI	19	0	0	20	0	0	14	0	0	11	0	0	28	0	0	26	0	0
JMIC	1	0	14	3	0	8	5	0	12	0	0	29	1	0	18	3	0	20
JNE	21	0	0	18	0	0	16	0	0	11	0	0	28	0	0	26	0	0
JNW	21	0	0	20	0	0	18	0	0	11	0	1	28	0	1	28	1	0
KBS	11	0	22	28	0	9	26	3	22	11	2	41	18	1	24	17	6	24
KMY	30	0	3	48	0	0	55	0	11	29	0	1	43	0	7	44	1	3
KONO	12	0	19	6	0	7	2	1	23	3	0	39	6	0	20	5	0	21
STOK1/KONS	39	0	0	9	0	0	30	0	0	15	0	0	23	0	0	7	0	0
KTK1	25	1	26	36	3	20	24	3	23	16	0	10	12	0	11	26	0	7
LOF	16	1	15	35	3	7	21	0	9	16	2	8	25	3	12	27	1	6
MOL	9	0	9	6	0	4	15	0	11	9	0	18	16	0	11	8	0	10
MOR8	49	0	26	47	2	17	52	3	25	35	1	29	41	4	16	33	0	9
NSS	21	4	16	33	6	16	38	2	28	16	2	26	3	0	1	5	0	9
ODD1	35	0	13	47	0	4	57	0	17	30	0	6	30	0	10	19	0	2
OSL	3	0	6	0	0	2	0	0	3	0	0	8	0	0	5	1	0	3
RUND	18	0	8	30	0	5	22	0	10	20	0	10	29	0	9	21	0	3
SNART	25	0	8	29	1	2	39	0	9	27	1	8	34	0	6	27	1	2
STAV	11	0	3	6	0	2	24	0	5	14	0	6	11	0	4	7	0	1
STEI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	0	2
STOK	59	2	10	39	0	3	50	0	11	32	2	10	40	3	9	35	0	3
SUE	16	0	3	33	0	0	24	0	4	19	0	2	26	0	0	22	0	0
TRO	14	0	31	30	0	23	20	0	32	13	0	49	14	2	27	16	0	23
NORSAR	19	0	78	26	0	56	21	0	74	18	0	106	25	0	55	27	0	48
ARCES	32	0	0	61	0	0	52	0	0	41	0	0	43	0	0	45	0	0
SPITS	17	0	0	36	0	0	29	0	0	25	0	0	25	0	0	21	0	0

Table 3b: Monthly statistics of events recorded at each station for July-December 2007. Abbreviations are: **LM** = Number of local events recorded at more than one station, **LS** = Number of local events recorded at only one station and **D** = Number of teleseismic events.

	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
STATION	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**
ASK	23	0	4	30	0	4	34	0	5	49	0	7	43	0	8	23	0	2
BER	5	0	33	3	0	31	3	0	29	4	0	21	14	0	15	5	0	13
BJO1	4	0	18	2	0	20	4	0	22	0	0	13	2	0	11	5	0	10
BLS5	20	0	12	34	0	11	32	0	15	48	0	13	42	0	14	26	0	10
DOMB	11	0	15	2	0	13	10	0	10	11	0	12	11	0	12	9	0	13
EGD	20	0	4	20	0	4	22	0	4	36	0	7	27	0	5	16	0	2
FOO	3	1	0	0	0	0	1	0	0	2	0	0	0	0	2	0	0	0
FLOS	31	0	3	57	0	6	44	1	8	32	0	3	74	0	3	79	0	1
HOPEN	2	1	0	1	0	0	4	0	0	5	2	0	0	0	0	13	5	0
HYA	20	0	7	18	0	6	29	0	8	42	0	7	46	2	8	30	3	2
JMI	37	0	0	26	0	0	21	0	0	13	0	0	18	0	0	21	0	0
JMIC	2	0	26	15	0	27	5	0	21	0	0	10	1	0	11	2	0	4
JNE	34	0	0	42	0	0	21	0	0	12	0	0	21	0	0	20	0	0
JNW	36	0	1	43	0	1	22	0	6	13	0	0	21	0	0	22	1	1
KBS	25	9	46	13	4	35	17	4	29	11	0	22	9	0	13	31	2	20
KMY	23	0	5	34	0	1	31	0	3	52	0	7	40	0	5	25	0	1
KONO	7	0	38	4	0	30	5	0	33	8	0	22	10	0	15	5	0	18
KONS	34	4	3	65	1	5	50	0	8	31	0	2	12	0	0	102	0	3
KTK1	20	1	33	22	5	23	20	2	23	0	0	3	21	3	20	25	7	18
LOF	18	1	19	28	2	14	27	2	21	17	3	4	43	1	7	80	2	3
MOL	12	0	26	2	0	29	13	0	29	15	1	17	10	0	15	10	0	11
MOR8	31	0	33	52	2	30	48	1	30	44	4	13	89	1	18	116	5	21
NSS	21	2	33	15	0	31	14	0	36	15	1	21	41	15	20	21	4	20
ODD1	11	0	5	26	0	2	24	0	9	43	0	8	38	0	15	25	0	9
OSL	0	0	6	0	0	4	0	0	0	0	0	0	0	0	8	0	0	3
RUND	18	0	7	12	0	6	24	0	4	26	0	6	26	0	4	13	0	4
SNART	16	0	8	26	1	10	21	0	4	32	2	9	25	0	3	12	0	4
STAV	7	0	6	8	0	6	8	0	3	5	0	3	4	0	4	1	0	2
STEI	13	0	24	13	0	11	11	0	7	4	0	1	41	2	4	93	6	8
STOK	40	0	26	64	0	17	53	0	20	34	0	9	88	0	10	98	2	10
SUE	16	0	5	7	0	2	7	0	2	20	0	1	24	0	4	13	0	2
TRO	14	0	49	14	0	47	13	0	42	6	0	19	14	0	22	16	0	27
NORSAR	24	0	82	15	0	79	32	0	80	21	0	61	27	0	68	32	0	79
ARCES	42	0	0	27	0	0	55	0	0	42	1	0	43	0	0	56	0	0
SPITS	18	0	0	9	0	0	11	0	0	15	0	0	15	0	0	29	0	0

Figure 5 and Table 4 show the 95 local and regional events, located in the prime area, with one of the calculated magnitudes greater than or equal to 3.0. Among these, 42 are located in the vicinity of the Jan Mayen Island. Depth is checked for the earthquakes with magnitude equal or above 3.5.

It should be emphasized that it is often difficult to get a good magnitude estimate for the earthquakes located on the oceanic ridge in the Norwegian sea, since distances are too large to compute a proper M_L, too short for M_b and coda magnitudes for these locations are often unreliable. Most of the recorded earthquakes in this area have magnitudes above 3.0 if they are recorded on Norwegian mainland stations.

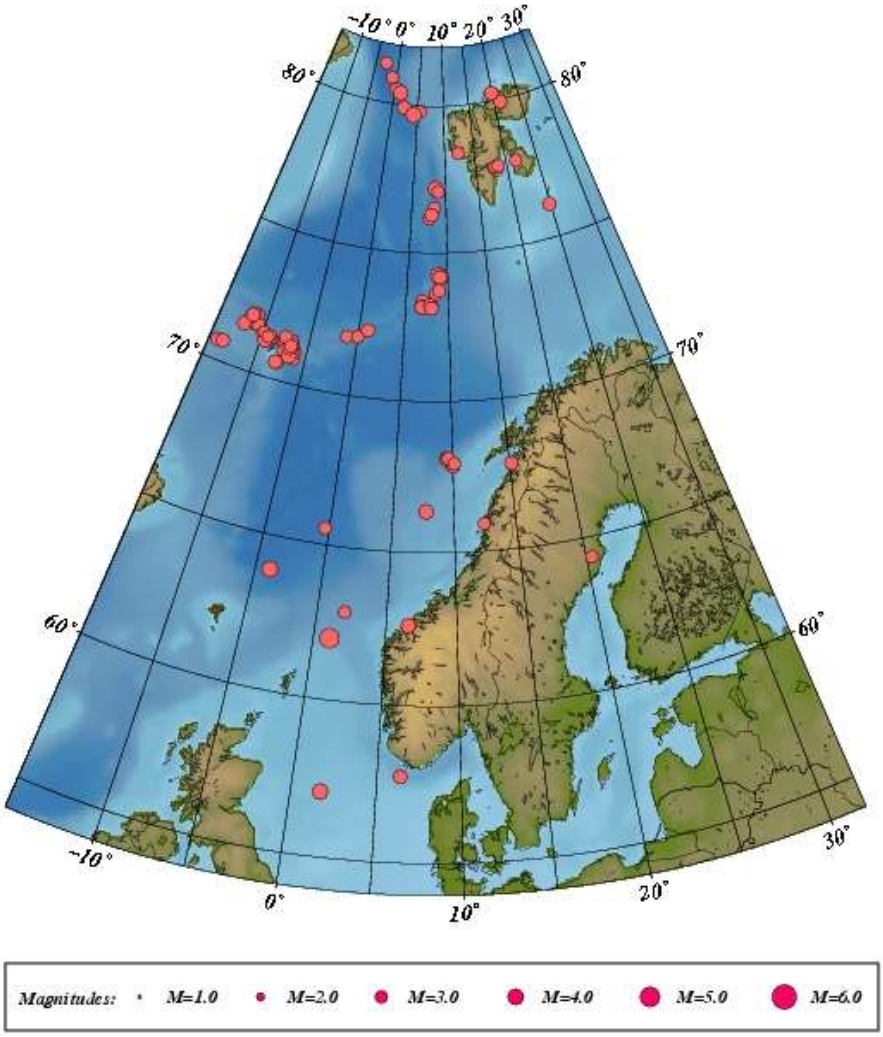

Figure 5: Epicentre distribution of located events with one of the calculated magnitudes above or equal to 3.0. All earthquakes are listed in Table 2. For station location, see Figure 1.

The largest local or regional earthquake in 2007, recorded on Norwegian stations and within the prime area, occurred on January 7th at 01:50 (UTC) west of Florø. The earthquake had a magnitude of M_L=4.2 (BER) and M_L=4.9 (BGS). The difference in estimated magnitude between BER and BGS is caused by the wave path toward East pass through geological structures causing damping of the amplitudes of the seismic

signals. The earthquake was felt on the Statfjord oil platforms, on the Shetland island and also on mainland Norway.

Table 4: Local and regional events in prime area with any magnitude above or equal to 3.0 for the time period January through December 2007. Only magnitudes reported by the University of Bergen are included. In cases where all BER magnitudes are below 3 but the event still is included in the list, NORSAR has reported a magnitude of 3.0 or larger.
Abbreviations are: **HR** = hour (UTC), **MM** = minutes, **Sec** = seconds, **L** = distance identification (L=local, R=regional, D=teleseismic), **Latitud** = latitude, **Longitud** = longitude, **Depth** = focal depth (km), **F** = fixed depth, **AGA** = agency (BER=Bergen), **NST** = number of stations, **RMS** = root mean square of the travel-time residuals, **Mc** = coda magnitude, **Ml** = local magnitude and **Mw** = moment magnitude.

Year	Date	HRMM	Sec	L	Latitud	Longitud	Depth	FF	AGA	NST	RMS	Mc	Ml	Mb	Ms	Mw
2007	1 4	0851	12.3	L	71.312	-9.171	16.3		BER	3	0.1	3.0	2.6			2.5
2007	1 7	0150	55.0	L	61.999	1.126	10.0	F	BER	57	2.0	3.9	4.2			4.8
2007	1 9	1956	11.6	L	71.050	-6.952	12.8	F	BER	3	0.1	3.3	3.6			2.9
2007	121	1345	23.1	L	62.611	6.560	10.0	F	BER	34	1.2	3.5	3.6			3.3
2007	122	0356	17.9	L	77.845	21.584	15.0	F	BER	5	1.5	3.1	2.9			3.2
2007	123	1302	49.2	L	71.175	-9.189	23.4	F	BER	3	0.1	3.3	3.0			2.7
2007	126	0305	40.6	L	71.579	-10.959	10.0	F	BER	3	0.1	3.0	2.7			2.5
2007	128	1030	54.8	L	57.736	6.377	20.0	F	BER	50	1.3	3.2	3.6			3.1
2007	212	0646	39.0	L	71.234	-6.548	11.0	F	BER	3	0.1	3.2	2.8			2.8
2007	216	0752	56.1	L	71.456	-9.984	15.0	F	BER	3	0.0	3.2				3.0
2007	217	2226	45.7	L	70.848	-6.277	6.0	F	BER	9	0.9	3.3	3.1			3.2
2007	220	0834	10.9	L	77.199	8.423	7.0	F	BER	5	0.4	2.9	3.7			2.5
2007	221	0005	51.4	L	63.877	-3.928	10.0	F	BER	44	1.5	3.2	3.2			3.4
2007	224	0346	34.8	L	79.907	2.322	10.0	F	BER	7	2.2		3.1			3.3
2007	224	0718	12.9	L	77.665	18.291	13.0	F	BER	6	1.0		3.1			3.0
2007	225	0913	56.7	L	73.258	7.772	10.0	F	BER	17	1.5	3.1	3.1			3.2
2007	225	0921	54.6	L	73.264	8.003	10.0	F	BER	13	1.6	2.4	3.0			3.1
2007	225	2013	41.9	L	73.380	6.938	10.0	F	BER	22	1.6		3.3	4.8	4.4	3.5
2007	225	2153	14.6	L	73.197	6.903	22.0	F	BER	27	0.9	3.1	3.8	5.3	5.1	3.7
2007	225	2312	26.8	L	73.181	6.880	10.0	F	BER	18	1.5	3.2	3.0	4.8		3.3
2007	225	2330	16.6	L	73.273	7.785	10.0	F	BER	16	1.8		3.2	4.7		3.0
2007	3 6	1445	26.3	L	65.546	-0.343	4.7		BER	20	1.2	3.0	2.6			2.6
2007	3 9	2213	31.0	L	78.390	12.248	15.0		BER	3	0.4	3.0	2.9			
2007	310	1703	37.9	L	74.235	8.915	10.0	F	BER	21	1.4		3.7		4.4	4.3
2007	310	1818	56.2	L	74.231	9.215	15.0		BER	11	1.5		2.7			
2007	310	2148	53.6	L	74.188	9.021	10.0	F	BER	15	1.8		2.9			
2007	314	1605	6.6	L	76.545	8.308	10.0	F	BER	6	1.4	3.1	2.2			
2007	320	1703	39.4	L	72.259	1.004	10.0	F	BER	17	1.6		3.1			
2007	323	0749	57.8	L	79.944	21.222	23.0	F	BER	3	0.6	2.5	3.5			3.4
2007	324	1505	52.0	L	67.925	9.816	0.1		BER	9	1.2	3.0	1.9			
2007	327	1334	59.3	L	77.096	8.867	12.9		BER	3	0.5	3.0	1.9			
2007	4 9	1516	12.0	L	76.185	7.567	10.0	F	BER	3	1.1	3.0	2.3			
2007	422	1136	40.7	L	71.079	-7.167	13.8		BER	3	0.0	3.4	2.9			
2007	5 8	0716	20.9	L	71.893	-11.057	10.0	F	BER	3	0.2	3.6	2.8			2.7
2007	5 8	0725	7.3	L	71.723	-11.759	15.5		BER	3	0.2	3.0	2.5			
2007	510	0457	7.8	L	71.148	-6.697	12.7		BER	4	0.1	2.8	3.4			
2007	520	1019	15.1	L	70.578	-7.755	15.0	F	BER	3	0.5	3.3	2.4			2.8
2007	520	1113	15.6	L	77.762	17.876	18.7		BER	8	1.3	2.8	3.1			
2007	521	0658	8.6	L	77.789	18.046	13.6		BER	6	1.0	2.6	2.9			
2007	522	0636	14.5	L	64.356	20.398	0.0		BER	11	1.5	3.0	2.6			
2007	522	1554	4.8	L	67.850	10.068	1.2		BER	17	1.3	3.0	2.9			
2007	6 4	1734	46.4	L	57.069	1.728	5.0	F	BER	75	0.9	3.5	3.3			3.1
2007	6 7	0553	21.4	L	66.357	7.721	8.0	F	BER	21	1.4	3.7	3.1			3.3
2007	610	1627	21.6	L	71.593	-10.711	14.9		BER	3	0.1	3.4	2.4			
2007	626	1102	44.0	L	70.657	-14.124	3.9		BER	20	1.5		3.4	4.7		
2007	627	0248	44.2	L	76.133	24.772	15.0		BER	11	1.8	3.4	3.0			
2007	627	1410	29.2	L	70.685	-13.611	10.0	F	BER	10	1.5		3.4	4.7	4.3	
2007	7 4	0208	22.2	L	71.376	-9.975	12.1		BER	3	0.6	3.0	1.8			
2007	7 9	0002	2.0	L	80.502	0.331	10.0	F	BER	4	1.4	3.3	2.9			
2007	711	0729	28.3	L	71.328	-9.369	15.4		BER	3	0.1	3.1	2.1			
2007	713	0908	29.7	L	76.300	7.890	10.0	F	BER	3	0.9	3.3	2.2			
2007	716	1322	11.9	L	80.878	-0.836	10.0	F	BER	8	1.3	3.0	2.5			
2007	723	1526	21.1	L	77.798	18.591	15.0		BER	4	1.3		3.0			
2007	728	1213	48.7	L	71.740	-11.774	15.0		BER	3	0.1	3.0	2.3			
2007	730	0033	58.2	L	80.403	1.251	10.0	F	BER	16	1.5	3.1	3.5	4.3		3.5
2007	731	0911	44.0	L	71.118	-7.471	16.5		BER	3	0.0	3.0	2.4			
2007	8 2	2246	55.1	L	71.946	-1.177	10.0	F	BER	17	1.7	2.9	3.0			

2007	820	1434	18.0	L	71.321	-9.129	10.0	F	BER	3	0.4	3.2	2.5				
2007	830	1656	54.5	L	71.276	-8.973	10.0	F	BER	3	0.1	3.5	2.8				3.2
2007	9	1	0056	2.5	L	71.308	-9.136	16.7		BER	3	0.1	3.1	2.4			
2007	9	1	0123	9.2	L	71.320	-8.992	10.0	F	BER	3	0.4	3.4	2.9			
2007	9	2	0207	7.8	L	71.065	-6.151	8.1		BER	3	0.1	3.1	2.7			
2007	9	3	2116	40.0	L	80.269	19.741	10.0	F	BER	7	1.4		3.4			
2007	9	7	1809	32.3	L	68.141	9.412	7.6		BER	15	1.2	3.1	2.7			
2007	9	7	2030	35.3	L	68.101	9.425	2.1		BER	16	1.1	3.1	2.5			
2007	910	1459	24.3	L	71.099	-6.355	14.8		BER	3	0.0	3.0					
2007	913	0013	43.7	L	68.125	9.648	10.0	F	BER	21	1.2	3.2	3.0				
2007	918	1142	18.7	L	71.024	-7.423	16.4		BER	3	0.1	3.0	2.6				
2007	918	2223	19.7	L	70.591	-7.889	10.0	F	BER	3	0.5	3.6					3.1
2007	927	0700	18.6	L	73.154	8.028	10.0	F	BER	17	1.2	2.9	2.7				
2007	928	2334	50.6	L	71.418	-6.737	13.3		BER	7	0.4	3.2	2.7				
2007	10	5	1434	18.5	L	81.341	-2.683	15.0		BER	4	0.9	3.0	2.8			
2007	10	6	1057	22.2	L	71.916	-11.445	15.0		BER	3	0.1	3.4	2.9			
2007	10	6	1251	31.4	L	71.479	-12.184	10.0	F	BER	3	0.4	3.6	3.0			3.0
2007	1011	1250	27.7	L	71.347	-9.572	15.0	F	BER	3	0.1	3.4	2.8				2.9
2007	1012	1217	58.0	L	71.851	-11.570	10.0	F	BER	3	0.0	3.6	2.6				3.0
2007	1027	0630	57.3	L	62.901	1.973	10.0	F	BER	21	1.8	3.0	2.7				
2007	11	4	1358	15.7	L	79.804	5.409	10.0	F	BER	8	1.1		3.2	4.4		
2007	1119	1137	54.3	L	71.332	-6.729	18.1		BER	3	0.1	3.1	2.9				
2007	1119	1211	30.7	L	71.161	-6.732	12.0	F	BER	3	0.1	3.3	3.6				3.2
2007	1121	0526	9.3	L	70.907	-6.738	10.0	F	BER	14	1.3	3.8	3.9				3.3
2007	1121	1909	32.7	L	67.943	10.131	10.0	F	BER	16	1.3	3.0	2.6				
2007	1124	2031	37.3	L	71.186	-6.810	11.0	F	BER	3	0.1	3.3	3.9				3.4
2007	12	1	1458	56.2	L	73.633	8.480	10.0	F	BER	17	1.4	2.8	2.9			
2007	12	1	2245	10.2	L	73.744	8.889	12.0		BER	12	1.9	3.3	2.9			
2007	12	6	1052	33.3	L	71.176	-9.560	20.0	F	BER	26	2.2	3.7	3.7	5.2	4.7	3.7
2007	12	7	1035	17.1	L	71.426	-9.848	15.0		BER	3	0.1	3.1	2.4			
2007	12	9	1541	2.6	L	65.921	12.439	10.0	F	BER	16	1.8	3.2	2.6			
2007	1210	1358	17.4	L	71.393	-9.128	10.0	F	BER	3	0.3	3.2	2.7				
2007	1212	1319	59.8	L	71.473	-7.519	15.0		BER	4	0.3		3.3				
2007	1216	1005	5.9	L	72.008	-0.053	10.0	F	BER	14	1.2		2.9	4.0			
2007	1220	1118	59.2	L	67.837	15.151	7.0	F	BER	14	1.4	2.8	2.9				
2007	1222	2025	51.1	L	79.695	4.312	10.0	F	BER	12	1.9	3.0	3.3				3.9
2007	1227	1904	29.6	L	71.239	-6.769	15.0		BER	3	0.2	2.8	3.1				
2007	1230	1517	45.2	L	71.318	-9.357	17.2		BER	3	0.1	3.0	2.1				

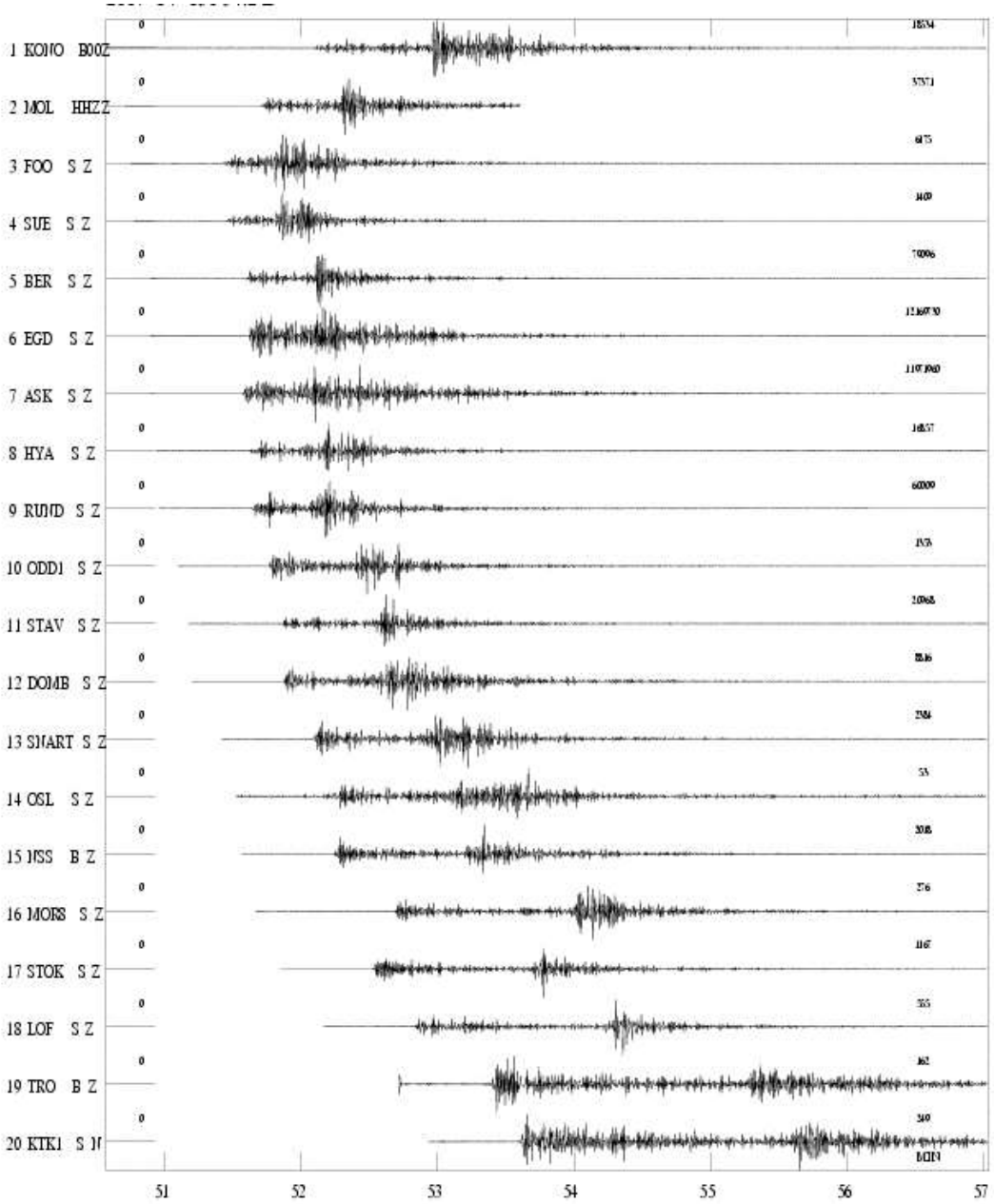

Figure 6: Seismograms for the earthquake on January 1st 2007 at 01:50(UTC). This earthquake is located northwest of Florø, at 61.99N and 1.13E. The seismograms are filtered between 5-10 Hz. The horizontal time scale is minutes, first marking at 01:51 (UTC). The station abbreviations are: KONO: Kongsberg, MOL: Molde, FOO: Florø, SUE: Sulen, BER: Bergen, EGD: Espegrend, ASK: Askøy, HYA: Høyanger, RUND: Rundemannen, ODD: Odda, STAV: Stavanger, DOMB: Dombås, SNART: Snartemo, OSL: Oslo, NSS: Namsos, MOR8: Mo i Rana, STOK: Stokkvågen, LOF: Lofoten, TRO: Tromsø , KTK1: Kautokeino.

Earthquake recordings in the Stokkvågen area

The temporary network around Stokkvågen had continued operation in most of 2007. The seismic activity is reduced compared to 2006. During 2007, 203 seismic events were located in the area shown on Figure 8. There is a renewed research interest in the area and independent funding might be needed for additional monitoring of seismicity and crustal motions.

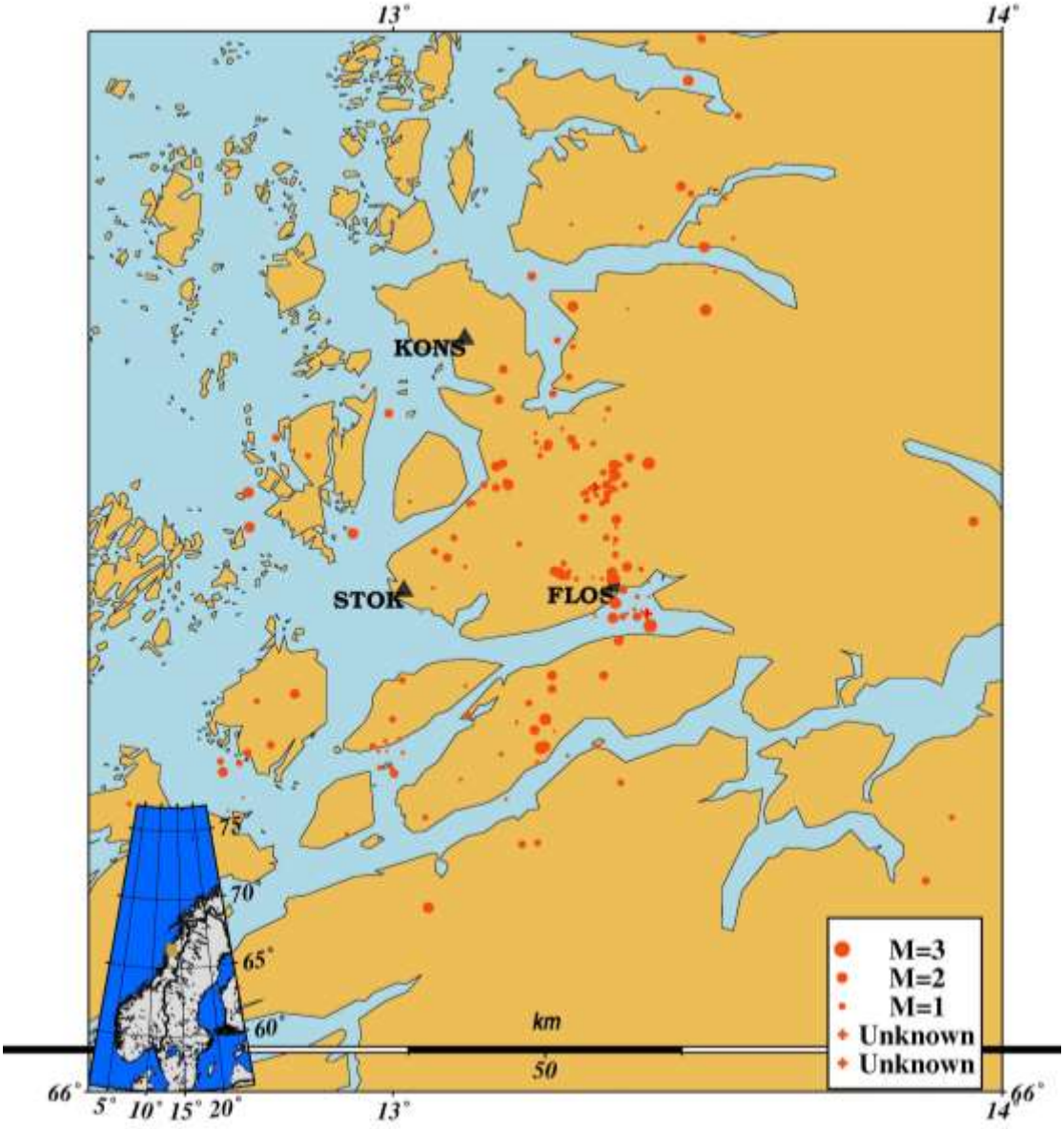

Figure 8: Events located in the Stokkvågen area during 2007.

Earthquake recordings in the Steigen area

A new seismic station (STEI) was in June 2007, installed in the Steigen area in Nordland. This seismic station is recording small local earthquakes and also the larger earthquakes occurring offshore Lofoten. During 2007 a total of 156 events is recorded by STEI and located to the area shown in Figure 9. During 2007 the seismic activity

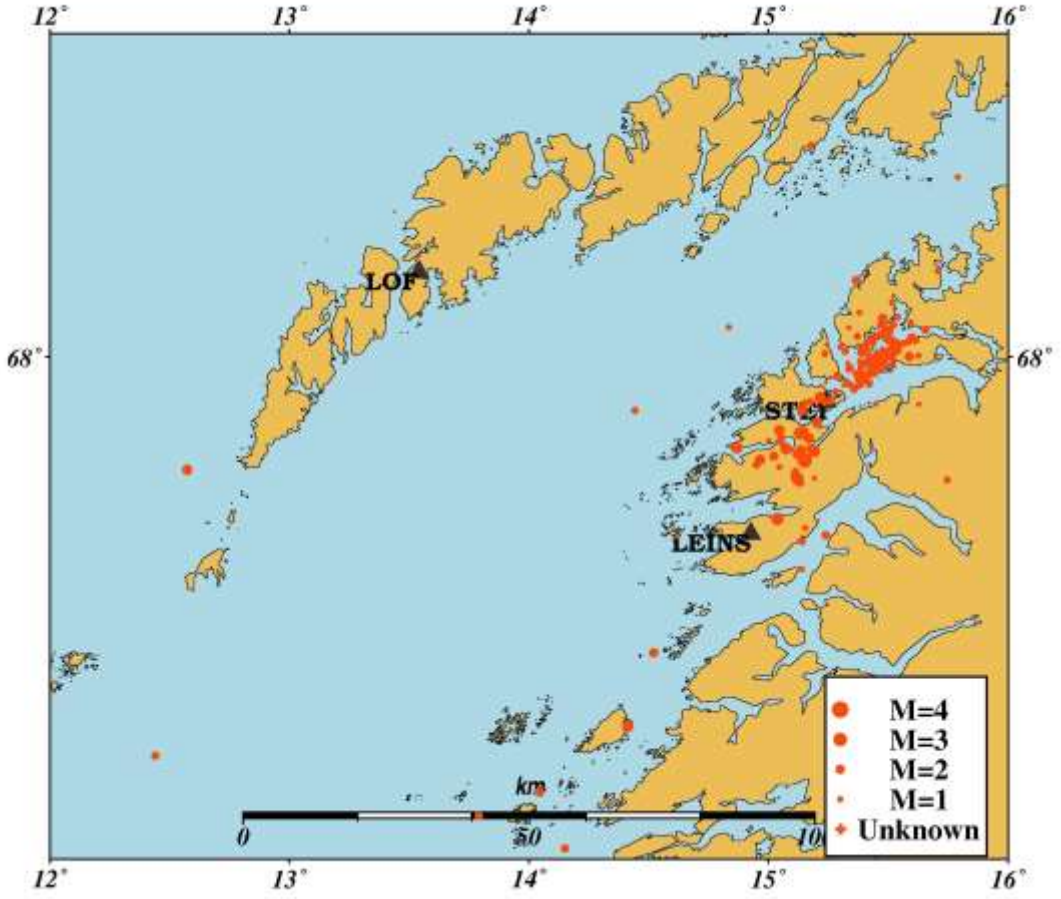

Figure 9. Events located in the Steigen area during 2007.

in the area intensified in the late Autumn, and it was decided to install an additional temporary station in Leines, south of STEI. This choice of location was based on the previous earthquake swarm. The data from this station is received on memory sticks and have not yet been included in the regular processing. These are therefore not shown in Figure 9. It is evident that the distribution of epicentres follows a NE-trend, which is known to coincide with a previously known zone of weakness (Atakan et. al. 1994). However, the activity now seems to be more concentrated in the NE when compared to the 1993 earthquake swarm.

The earthquake January 7th 2007

On 7th January 2007, an earthquake occurred in the northern North Sea. The earthquake was located to 61.99 N, 1.13 E at 01:50 (UTC) and with magnitude 4.8 (BGS). This earthquake was reported felt by people on the Shetland island. In addition, one phone call was received from western Norway. The earthquake was also felt at the Statfjord oil platform. Reported description of the earthquake corresponds to EM98 (European Macroseismic Scale (Grünthal, 1998)) intensity of IV of this location. The preliminary regional moment tensor inversion shows a NE trending reverse faulting which is in line with the general stress tensor in the region (pers. comm., L. Ottemöller).

Jan Mayen

The Jan Mayen Island is located in an active tectonic area with two major structures, the Mid Atlantic ridge and the Jan Mayen fracture zone, interacting in the vicinity of the island. Due to both tectonic and magmatic activity in the area, the number of recorded earthquakes is higher than in other areas covered by Norwegian seismic stations. During 2007 a total of 255 earthquakes were located as seen on Figure 8 and of these, 42 were calculated to have a magnitude equal to or above 3.0.
The largest earthquake in the Jan Mayen region occurred November 21st at 05:26 (UTC). This earthquake was located to 70.88N and 6.69W with magnitude 3.8.

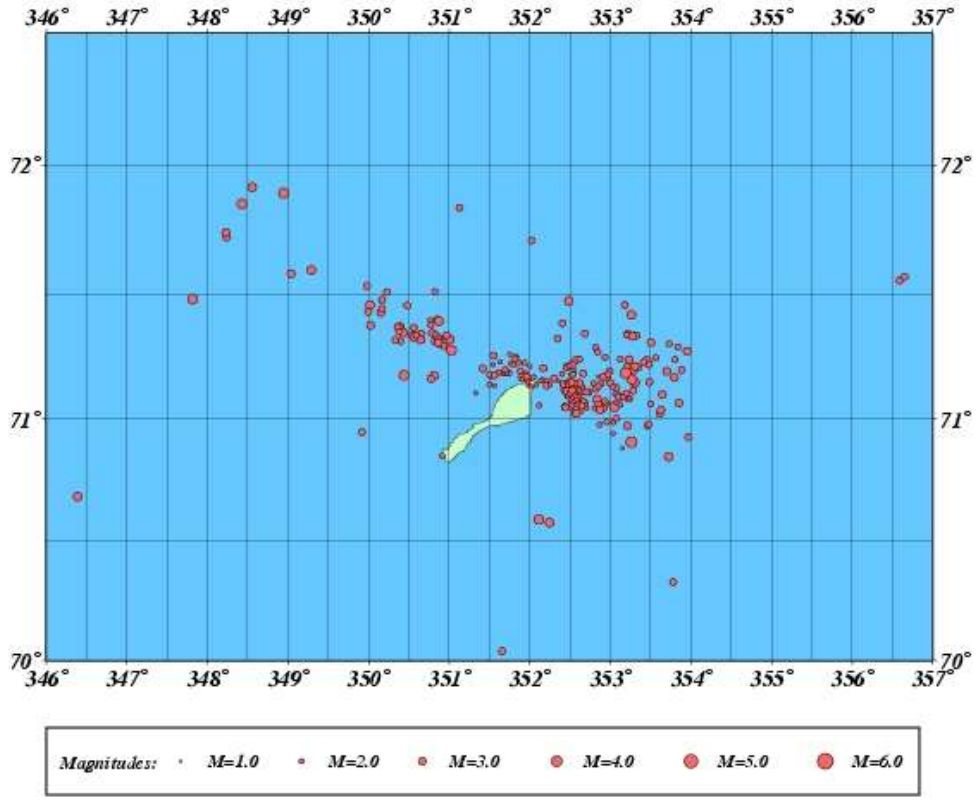

Figure 8: Earthquakes located in the vicinity of the Jan Mayen Island during 2007

The number of recorded earthquakes in the Jan Mayen area has varied over the last years, see Figure 9. The number of relative strong earthquakes show smaller time variation than smaller earthquakes. The apparent increase in 2004 and 2005 is due to the M=6.0 earthquake in 2004 and its aftershocks (Sørensen et al., 2007).

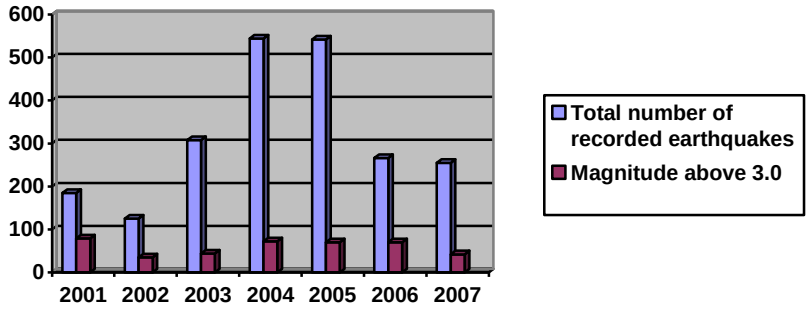

Figure 9: Yearly distribution of earthquakes located in the Jan Mayen area.

5. Felt earthquakes

From 2006 it is possible to report felt earthquakes using the internet. On the site www.skjelv.no., questionnaires are available for the public. In total, 18 earthquakes were reported felt during 2007 (see Table 5 and Figure 12).

Table 5: Earthquakes reported felt in the BER database in 2007. Abbreviations are: $\mathbf{M_c}$ = coda magnitude, $\mathbf{M_L}$ = local magnitude and $\mathbf{M_w}$ = moment magnitude, Q: questionnaires sent (Y/N), W: questionnaires received on web.

Nr	Date	Time (UTC)	Max. Intensity (MMI)	Magnitude (BER)	Instrumental epicentre location	Q	W
1	07.01.07	01:50	IV	M_c=3.9, M_L=4.2 Mw=4.8 (BGS)	61.99N / 01.13E	Y	Y
2	21.01.07	13:45	VI	M_c=3.6, M_L=3.6, MW=3.5	62.61N / 06.57E	N	Y
3	28.01.07	10:30	V	M_c=3.2, M_L=3.6	57.74N / 06.37E	N	Y
4	22.02.07	07:22	III	M_c=1.8, M_L=2.0	62.78N / 07.12E	N	Y
5	23.04.07	20:10	III	M_c=1.8, M_L=1.7	62.01N / 05.12E	N	N
6	10.05.07	04:57	III	M_c=2.8, M_L=3.4	71.15N / 06.70W	N	N
7	19.05.07	10:02	III	M_c=2.5, M_L=2.7	67.81N / 15.12E	N	N
8	21.05.07	20:22	III	M_c=2.1, M_L=2.3	61.66N / 04.65E	N	N
9	04.06.07	17:34	III	M_c=3.5, M_L=3.3, M_L=3.9 (BGS)	57.06N / 01.73E	N	N
10	18.07.07	17:29	III	M_c=2.6, M_L=2.2	68.30N / 18.26E	N	N
11	12.09.07	22:56	III	M_c=2.7, M_L=2.8	61.60N / 04.76E	N	Y
12	03.10.07	21:28	III	M_c=1.6, M_L=2.1	60.18N / 04.98E	N	Y
13	06.11.07	09:07	III	M_c=2.5, M_L=2.5	59.69N / 07.43E	N	Y
14	07.11.07	05:16	III	M_c=2.2, M_L=2.1	66.31N / 13.42E	N	Y
15	22.11.07	21:00	III	M_c=2.4, M_L=2.5	67.85N / 15.19E	N	N
16	24.11.07	15:47	III	M_c=2.7, M_L=2.4	67.88N / 15.13E	N	N
17	09.12.07	15:41	III	M_c=3.2, M_L=2.6	65.92N / 12.44E	N	N
18	20.12.07	11:18	III	M_c=2.8, M_L=2.9	67.84N / 15.15E	N	Y

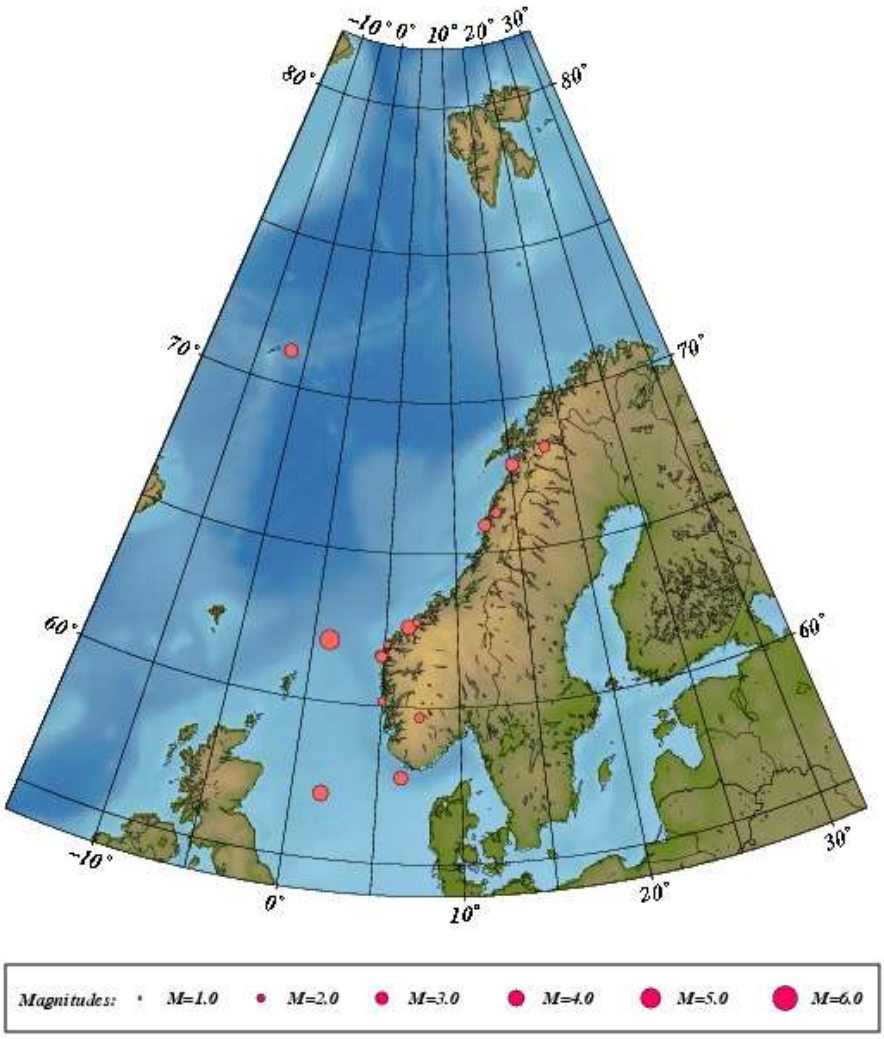

Figure 12: Location of the 18 earthquakes reported felt during 2007.

6. Use of NNSN data during 2007

Data collected by Norwegian seismic stations are made available through the Internet and are provided on request to interested parties. The use and publication of this data is beyond our control.

Publications and reports

Bungum, H. & C. Lindholm (2007): Tsunamigenic Seismic Sources in the North Sea, the Norwegian Continental Margin and the Norwegian-Greenland Sea. Report for NGI within the EU Transfer project, 18 pp.

Chabassier, J. & J. Schweitzer (2007): Single small array regional localization using PMCC (ELOSV2). In: Semiannual Technical Summary, 1 January - 30 June 2007, NORSAR Sci. Rep. 2-2007, Kjeller.

Chatelain, J-L., Guillier, B., Cara, F., Duval, A-M., Atakan, K., Bard, P-Y., and the WP02 SESAME Team. 2007. Evaluation of the influence of experimental

conditions on H/V results from ambient noise recordings. *Bulletin of Earthquake Engineering*, doi: 10.1007/s10518-007-9040-7. 42p.

Gibbons, S.J., M. Bøttger Sørensen, D.B. Harris & F. Ringdal (2007): The detection and location of low magnitude earthquakes in northern Finland using multi-channel waveform correlation at regional distances. Phys. Earth Planet. Inter., 160, 285-309.

Guillier, B., Atakan, K., Chatelain, J-L., Havskov, J., Ohrnberger, M., Cara, F., Duval, A-M., Zacharapoulos, S., Teves-Costa, P., and the SESAME Team. 2007. Influence of instruments on H/V spectral ratios of ambient vibrations. *Bulletin of Earthquake Engineering*, doi: 10.1007/s10518-007-9039-0. 29p.

Kværna, T, F. Ringdal & U. Baadshaug (2007): North Korea's nuclear test: the capability for seismic monitoring of the North Korean test site. Seism. Res. Lett., 78/5, 487-496.

NORSAR (2007): Seismic Hazard Assessment for the Fredrikstad (Øra) LNG Project, Norway. Report for Statoil ASA, 36 pp.

Schweitzer, J. & B.L.N. Kennett (2007): Comparison of location procedures – The Kara Sea event of 16 August 1997
Bulletin Seismological Society America, **97**, 2, 389-400, 2007, doi: 10.1785/0120040017

Svenningsen, L., N. Balling, B.H. Jacobsen, R. Kind, J. Schweitzer and K. Wylegalla (2007): Crustal thickness beneath the highlands of southern Norway from teleseismic receiver functions. Geophys. J. Int., **170**, 1129-1138, 2007, doi: 10.1111/j.1365-246X.2007.03402.x

Svenningsen, L., N. Balling, B.H. Jacobsen, R. Kind, K. Wylegalla & J. Schweitzer (2007): Accurate depth to Moho beneath the highlands of southern Norway resolved by teleseismic receiver functions.Geophys. Res. Abs., **9**, 02719 (abstract)
SRef-ID: 1607-7962/gra/EGU2007-A-02719

Sørensen, M.B., Ottemöller, L., Havskov, J., and Atakan, K., Hellevang, B., Pedersen, R.B. 2007. Tectonic processes in the Jan Mayen Fracture Zone based on earthquake occurrence and bathymetry. *Bulletin of the Seismological Society of America*, Vol.**97** No.3, 772-779, doi: 10.1785/0120060025.

Weidle, Ch., V. Maupin, J. Ritter, T. Kværna, J. Schweitzer, N. Balling, H. Thybo and J.I. Faleide (2007): MAantle investiGations of Norwegian Uplift Structure (MAGNUS) - a flying start into Topo Europe. Geophys. Res. Abs., **9**, 03820 (abstract)
SRef-ID: 1607-7962/gra/EGU2007-A-03820

7. References

Alsaker A., Kvamme, L.B., Hansen, R.A., Dahle, A. and Bungum, H. (1991): The ML scale in Norway. *Bull. Seism. Soc. Am*., Vol. **81**, No. 2, pp.379-398.

Atakan,K., Lindholm,C.D., and Havskov,J. 1994. Earthquake swarm in Steigen, northern Norway: An unusual example of intraplate seismicity. *Terra Nova* **6**, 180-194.

Brune J.N. (1970): Tectonic stress and spectra of seismic shear waves. *Journal of Geophysical Research*, **75**, 4997-5009.

Grünthal, G. (1998): "European Macroseismic Scale 1998". Cahiers du Centre Européen de Géodynamique et de Séismologie Volume 15, Luxembourg.

Havskov J., and Bungum, H. (1987): Source parameters for earthquakes in the northern North Sea. *Norsk Geologisk Tidskrift*,Vol.**67**, pp 51-58.

Havskov, J. and Ottemöller, L. (1999): SEISAN earthquake analysis software. *Seism. Res. Letters*, Vol. 70, pp. 532-534.

Havskov, J. and Ottemöller, L. (2001): SEISAN: The earthquake analysis software. Manual for SEISAN v. 8.0, Department of Earth Science, University of Bergen, Norway.

Havskov, J. and Sørensen, M.B. (2006): New coda magnitude scales for mainland Norway and the Jan mayen region. *NNSN Technical report no. 19.*

Kanamori, H. (1977): The energy release in great earthquakes. *Journal of Geophysicsl Research* 82; 20, pp. 2981-2987.

Karnik, V., Kondorskaya, N.V., Riznichenko, Y. V., Savarensky, Y. F., Solovev, S.L., Shebalin, N.V., Vanek, J. and Zatopek, A. (1962): Standardisation of the earthquake magnitude scales. *Studia Geophys. et Geod*., Vol. **6**, pp. 41-48.

Kennett, B.L.N. and Engdahl, E.R. (1991): Traveltimes for global earthquake location and phase identification. *Geophys. J. Int*., Vol. **105**, pp. 429-465.

Kradolfer, U. (1996): AuroDRM – The First Five Years. *Seismological Research Letters*, vol. 67, no. 4, 30-33.

Lienert, B.R. and Havskov, J. (1995): HYPOCENTER 3.2 A computer program for locating earthquakes locally, regionally and globally. *Seismological Research Letters*, Vol. **66**, 26-36.

Moreno, B, Ottemöller, L., Havskov, J. and Olesen, K.A. (2002): Seisweb: A Client-Server-Architecture-Based Interactive Processing Tool for Earthquake Analysis. *Seism. Res. Letters.* Vol.73, No.1.

Ottemöller, L. (1995): Explosion filtering for Scandinavia. *Technical Report* No. **2**, Institute of Solid Earth Physics, University of Bergen, Norway.

Sørensen, M.B., Ottemöller, L., Havskov, J., and Atakan, K., Hellevang, B., Pedersen, R.B. 2007. Tectonic processes in the Jan Mayen Fracture Zone based on earthquake occurrence and bathymetry. *Bulletin of the Seismological Society of America*, Vol.**97** No.3, 772-779, doi: 10.1785/0120060025.

Sørnes A. and Navrestad, T. (1975): Seismic survey of Jan Mayen. *Norsk Polarinstitutt*, Årbok 37-52.

Veith K.F., and Clawson, G.E. (1972): Magnitude from short-period P-wave data. *Bull. Seism. Soc. Am.*, Vol. **62**, pp.435-452.

Westre S. (1975): Richter's lokale magnitude og total signal varighet for lokale jordskjelv på Jan Mayen. *Cand. real thesis*., Seismological Observatory, University of Bergen, Norway.

APPENDIX 2

The NORSAR Regional Arrays

The NORSAR Regional Arrays

NORSAR operates the two regional seismic arrays, ARCES (near Karasjok, Finnmark) and SPITS (on Svalbard). In addition, data from NORSAR (the original large aperture array in southern Norway), FINES (in Finland), HAGFORS (southern Sweden), KBS (Kings Bay on Svalbard), KONO (Kongsberg, southern Norway) and JMIC (Jan Mayen) are collected and analyzed. All data are openly available and the interested layman can see daily data on www.norsar.no/NDC/data.

The NORES array, which was damaged by lightening in 2002, represents a significant loss in the regional monitoring capability. Alternative processing algorithms for the NORSAR array have been developed, and the reconstruction of the NORES array as a broader research facility is now in progress.

Fig. 1. Seismic arrays (and a planned infrasound station) currently operated by NORSAR.

1 Systems Recording Performance

The arrays have continuous data recording. In 2007 the average recording time for the SPITS array was 91.89%, for the ARCES array 98.13%, and for the NORSAR array 99.24%.

The recording performance in terms of monthly uptime statistics is shown in Table 1.

	ARCES	SPITS	NORSAR
January	96.259%	99.679%	99.480%
February	88.839%	99.994%	99.998%
March	98.050%	99.992%	99.999%
April	99.994%	99.994%	99.999%
May	100%	99.991%	99.991%
June	99.365%	99.996%	97.966%
July	99.702%	97.633%	99.455%
August	97.014%	95.238%	99.862%
September	98.474%	53.101%	99.208%
October	100%	99.999%	98.298%
November	99.923%	83.338%	98.251%
December	99.982%	73.768%	98.405%

Table 1. Systems recording performance (uptime in % of theoretical) for three arrays operated by NORSAR in 2007.

1 Detections

The NORSAR analysis results are based on automatic phase detection and automatic phase associations which produce the automatic bulletin. Based on the automatic bulletin a manual analysis of the data is done, resulting in the reviewed bulletin (which is available under the NORSAR web pages). This procedure is often referred to as the Regional Monitoring System (RMS), and has been in operation since 1989. To reduce the work load on the analyst, the Generalized Beam Forming (GBF) is used as a pre-processor to RMS, so that only phases associated with selected events in northern Europe are considered in the automatic RMS phase association. However, all detections are available for analyst screening and review.

Table 2 gives a summary of the phase detections and events declared by the RMS.

	Jan.	Feb.	March	April	May	June
Phase detections	156259	125636	130577	142538	147430	142146
Associated phases	4550	4369	4737	4181	4345	4547

Un-associated phases	151709	121267	125840	138357	143085	137599
Events automatically declared by RMS	927	798	870	780	824	813
No. of events defined by the analyst	39	72	60	47	60	56
	July	Aug.	Sep.	October	Nov.	Dec.
Phase detections	156264	203836	157498	154224	133318	165404
Associated phases	5036	8349	5814	6421	5196	5458
Un-associated phases	151228	195487	151684	147803	128122	159946
Events automatically declared by RMS	1031	1952	1288	1456	1079	1129
No. of events defined by the analyst	48	39	60	53	57	62

Table 2. RMS phase detections and event summary.

The phase arrival time data from the arrays processed by NORSAR is provided to the UiB processing centre and merged with UiB readings, and a location based on all data is computed and published in the monthly bulletins.

1 The use of Norwegian data

Data collected on Norwegian seismic stations is made available through the Internet and is provided on request to interested parties. The use and publication of this data is beyond our control.

Several investigations make use of the data from the Norwegian National Seismic Network. Only one investigation is described in the Appendix which deals with the rather rare analysis of a meteorite. This analysis is based on data from ARCES and in particular from the the seismic station in Tromsø.

A particular use of the NNSN data is for the Åknes slide monitoring project in which local seismicity is associated with data from NNSN. For details see:
http://www.norsar.no/seismology/research/aaknes/ and
http://www.aknes-tafjord.no/artikkel.aspx?AId=182&back=1&MId1=568