

FREAK WAVE EVENT AT DRAUPNER JACKET JANUAR 1 1995

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Introductory remarks

As a response to a request for some info on this subject during the summer 2003, a brief description of the wave event and the conditions January 1 1995 at the Draupner field is given below. The description has been updated and modified several times during the last year.

The platform in the front (the platform with living quarter) is Draupner S, which was installed in the mid-eighties, while the aft platform, Draupner E, was installed during the summer 1994. Draupner E is the first platform build with a bucket foundation and in order to verify the bucket loading and bucket behaviour, the platform was instrumented for that purpose during the first winter. The instrumentation involved a down looking laserbased wave sensor. The wave sensor is said to be located at a platform corner, Haver and Karunakaran (1998). Presently I do not remember which corner, but it is most likely the northern platform corner. The well-known Draupner wave was measured at the wave sensor on the Draupner E platform, i.e. the unmanned platform. It is seen that the platform is rather transparent, i.e. wave measurements are not likely to be much disturbed by the platform legs.



Fig. 0 The Draupner S and Draupner E platforms in the North Sea,
Photo: Øyvind Hagen, Statoil.

The Weather Situation January 1

The weather situation in the North Sea January 1 at 12UTC is indicated in Fig 1. The weather pattern is dominated by a major low with center in Southern Sweden causing a strong northerly wind field over the whole North Sea and Norwegian Sea. In addition to the major low, a smaller low has been moving southwards in the North Sea during the morning hours and in Fig. 1 it is indicated to be located close to Skagerak. The effect of this smaller low is to strengthen the wind field in the western North Sea. As the smaller low moved southwards, the area with the strongest wind field moved southwards as indicated in Fig. 2. The wind conditions seemed to peak at hurricane level wind between 12UTC and 18UTC. The Draupner platform is located more or less straight west of the southern tip of Norway midway between Norway and Scotland. This means that the platform was outside the area where the wind conditions seem to have been most extreme.

The England – Norway ferry “Color Viking” was hit by this storm event on its way over the North Sea. In an interview the ship master told he had never experienced such a weather during his years as a ship master of Color Line ferries. The bridge of this ferry is about 30m above sea level when floating on even keel. In the same interview the ship master said that in connection with the highest waves, those on the bridge looked upwards on the wave crests approaching the vessel. Although it may be somewhat difficult relate observations to a horizontal base line in this sort of weather conditions due to ship pitching and rolling, the statement clearly suggests that a number of rather extreme wave crests seem to have occurred in a certain area of the storm event.

One interesting aspect of the overall situation is the local enhancement of an underlying strong wind field by the secondary low moving southwards. It may well be that this will result a significant increase of sea state steepness over certain areas. In turn this may represent conditions being favourable regarding non-linear wave phenomena.

A more detailed discussion of the weather pattern that particular day can be obtained by contacting e.g. The Norwegian Meteorological Institute in Bergen.

Wave Conditions at Draupner

At Draupner the wave conditions started increasing late in morning. The significant wave height reached 11 –12 m just after noon and stayed at that level until early evening, Haver and Andersen (2000). For a significant wave height we will expect the maximum wave height (height from trough to crest) to be about 20, but occasionally it may well be 10-15% higher. The maximum crest height (height from still water level until wave crest) would be expected to be about 15m. We have a number of 20-minute observations of the wave condition during peak level of the storm. Most of these show nothing particular, see e.g. Fig. 3, which is rather representative for most of the 20-min. time histories. (It should be noted that we merely have one 20-min record every hour, i.e. no measurements are made for 2/3 of the time.)

The 20-min. wave history collected at about 15:20, however, did include a very extreme wave event bearing in mind the sea state conditions. The time history is shown in Fig 4, and a closer look at the extreme wave is given in Fig. 5. The maximum wave height is close to 26m. For the actual area, the wave with an annual probability of 10^{-2} (i.e. the so-called 100-year wave height) was estimated to be around 27m. This means that the wave height in itself is not that extreme, but we did not expect the wave height to be realized in a sea with a 12m significant wave height. It is more likely to be experienced in a sea state with 13-14m significant wave height.

The wave spectrum for the time history shown in Fig. 4 is shown in Fig.6. Although the estimated spectral ordinates are associated with a considerable statistical uncertainty, the estimated spectrum clearly suggests the existence of two sea systems. This is in agreement with the previous description of the weather scenario January 1 1995.

The extreme pattern of this wave event is its asymmetry about the still water level. The crest height reaches about 18.5m above still water level. For the actual area, the crest height occurring with an annual probability of 10^{-4} (i.e. 10000-year crest height) was at that time estimated to be 19.5m. This means that the crest event was not beyond design parameters, but we did not expect such a wave to occur for a significant wave height of 12m. None of our basic engineering approaches suggest the possibility of such a crest height for a 12m sea state. We think the measured event is of good quality. Of course some uncertainties may be associated with the crest height, but the uncertainties or possible biases cannot bring the wave event into the class of typical (slightly non-Gaussian) wave events. The measured structural loads do also suggest that a big wave hit the structure, but the loads is relatively speaking not as bad as the observed crest height. Although the crest height is well beyond the 10^{-2} probability crest height, the maximum platform loads do not exceed that level. This suggests that the shape of the wave do differ from our typical design waves. As the wave passed the structure, it was rather close to a temporary deck and as I remember being told some minor damage was reported to equipment located on that deck.

To my knowledge, people onboard the platform did not particularly note the wave event as it happened. But of course during those weather conditions nobody will be out on the open deck area. It is said in the platform daily journal that all work on deck was stopped at 15:00 due to very strong wind.

Freak waves

A number of people and institutions have been given access to the Draupner time history. I think there is a general agreement that the wave event can be referred to as a freak event, i.e. an event that would not be expected under our typical engineering models for extreme wave predictions. I think there is competing ideas regarding explaining the event and not least regarding modelling it mathematically, but my favourite theory involves self-focusing of energy of a wave group into one majestic wave event, i.e. the big event steal energy from its neighbours. The major challenge from my point of view is to understand when and why this strongly non-linear self-focusing process is turned on.

References:

Sunde, Alv (1995): "Kjempebølger i Nordsjøen" (Extreme Waves in the North Sea), Paper is written in Norwegian, Vær & Klima, Nr.1, 1995.

Haver, S. and Andersen, O. J. (2000): "Freak waves – Rare Realizations of a Typical Population or Typical Realizations of a Rare Population?", ISOPE'2000, Seattle.

Haver, S. and Karunakaran, D. (1998): "Probabilistic description of crest heights of ocean waves", Proceedings 5th International Workshop of Wave Hindcasting and Forecasting, Melbourne, Florida, January 1998.

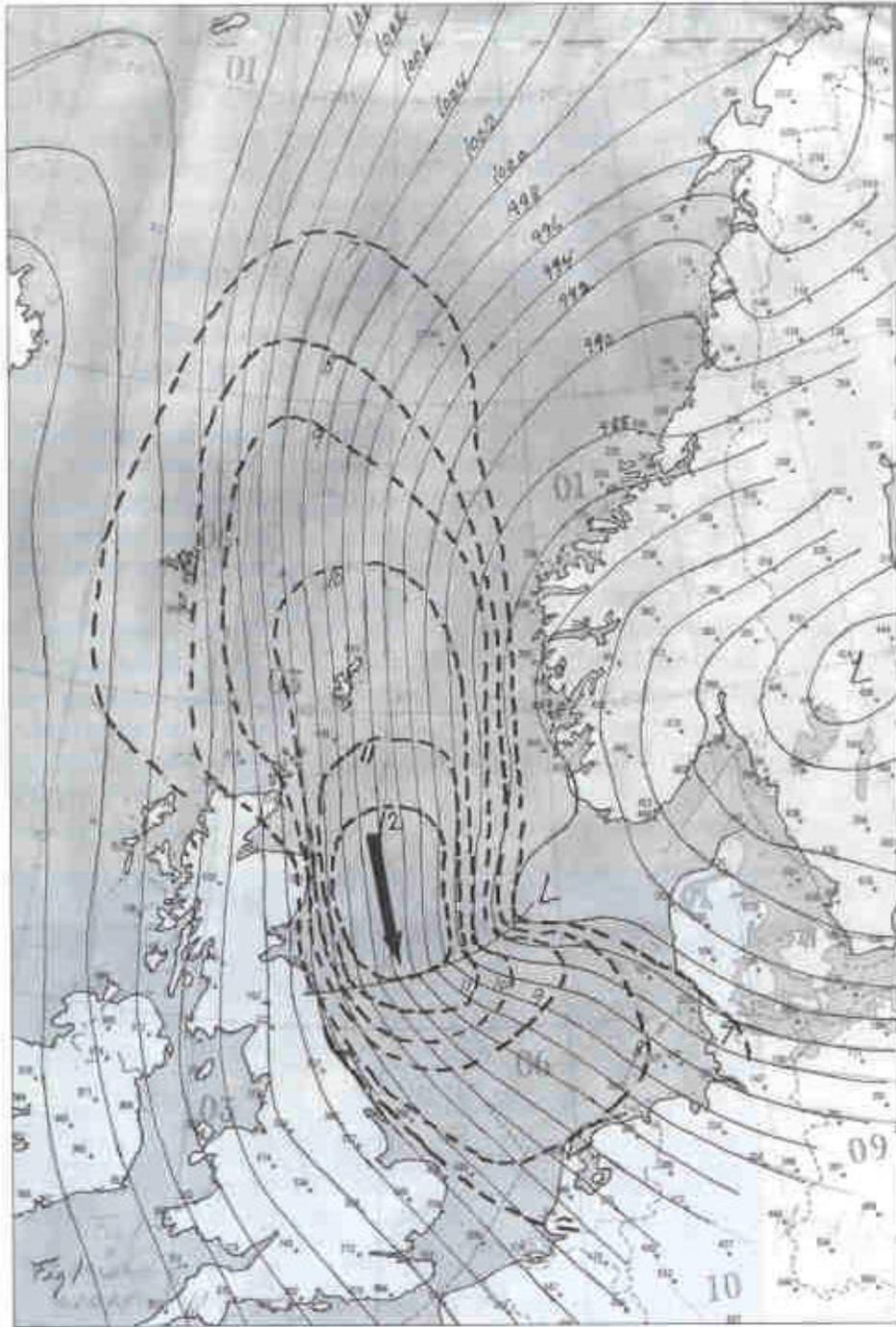


Fig. 1 Weather situation in the North Sea, Januar 1 at 12 UTC, Sunde (1995)

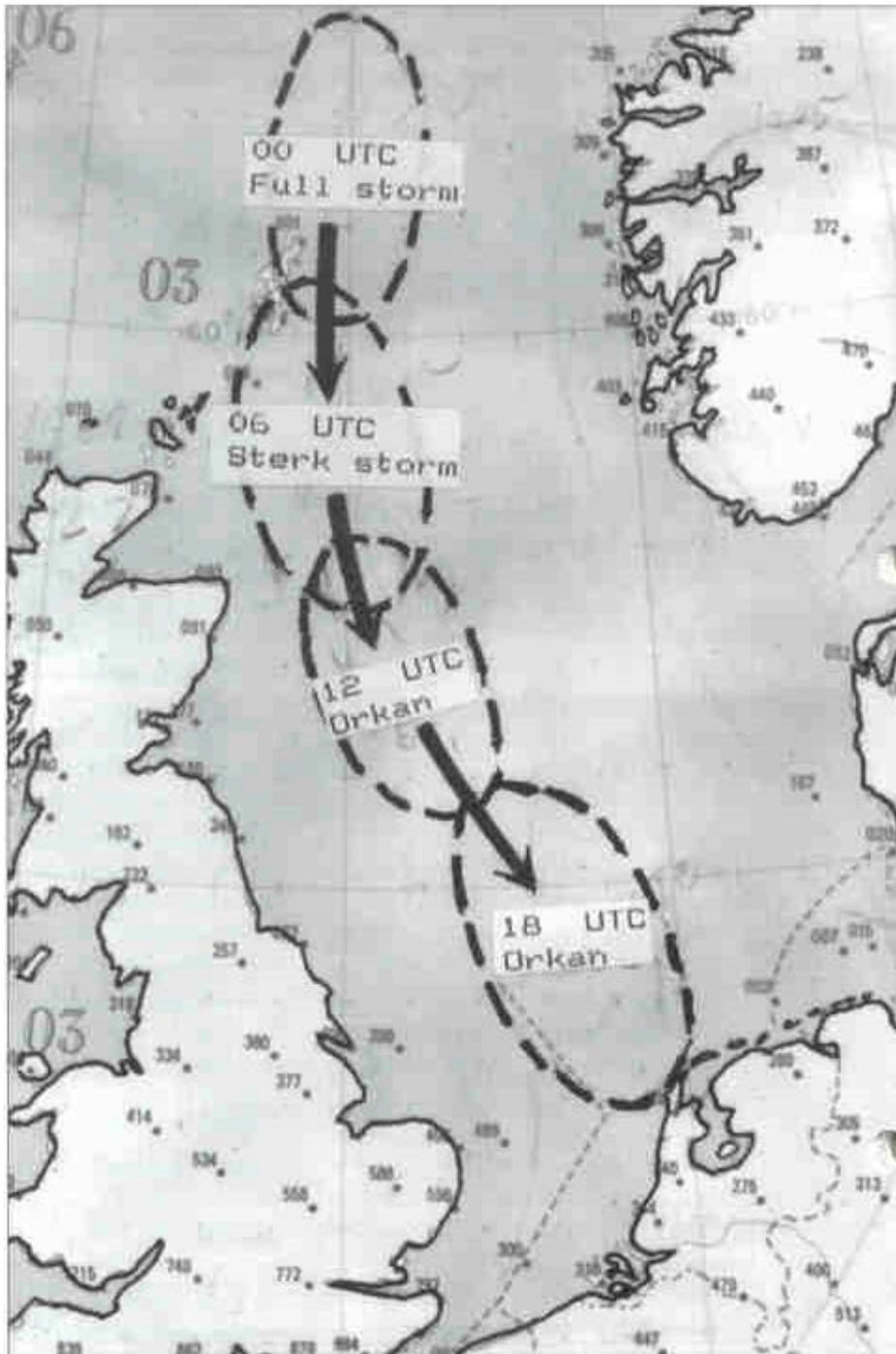


Fig 2 Area with most severe wind during January 1, Sunde (1995).

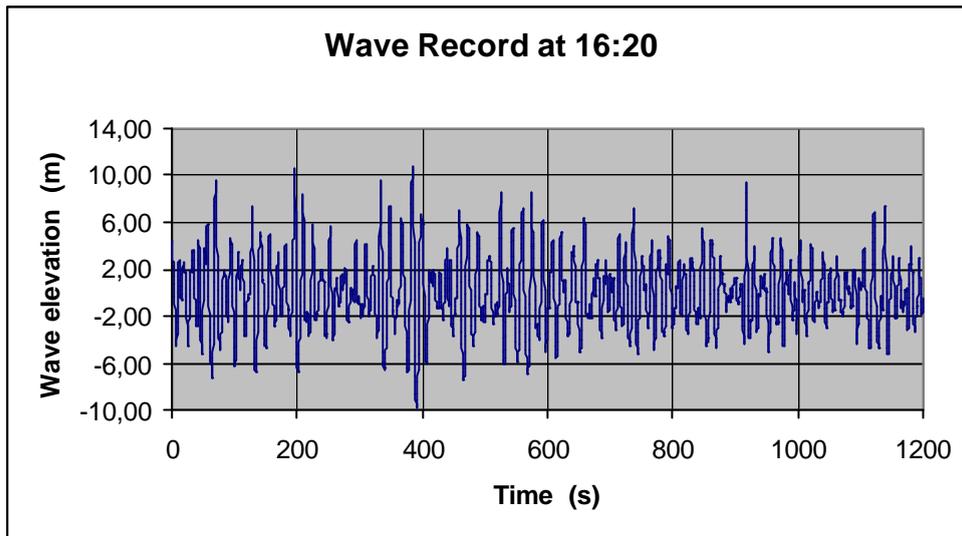


Fig. 3 A typical 20-min. time history of surface elevation during the storm.

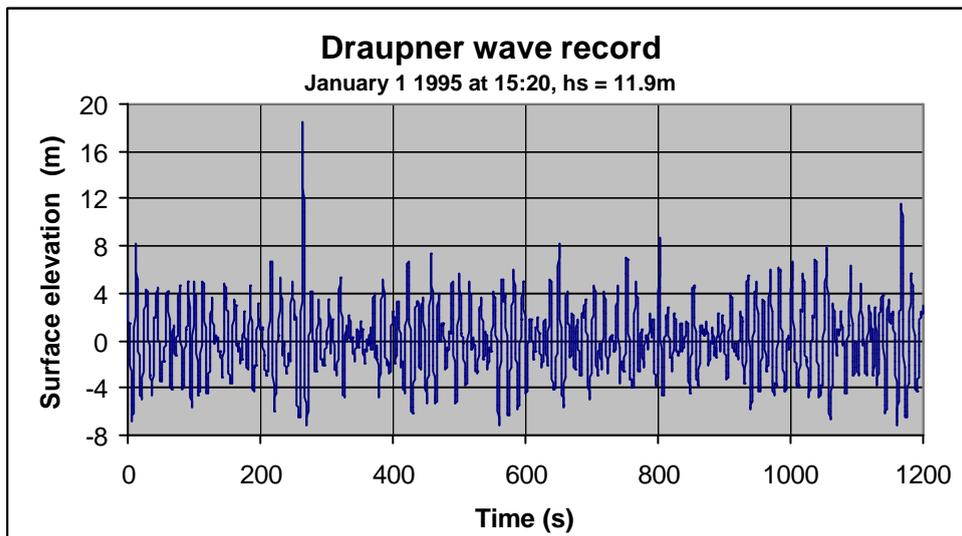


Fig. 4 Time history including an possible freak wave event

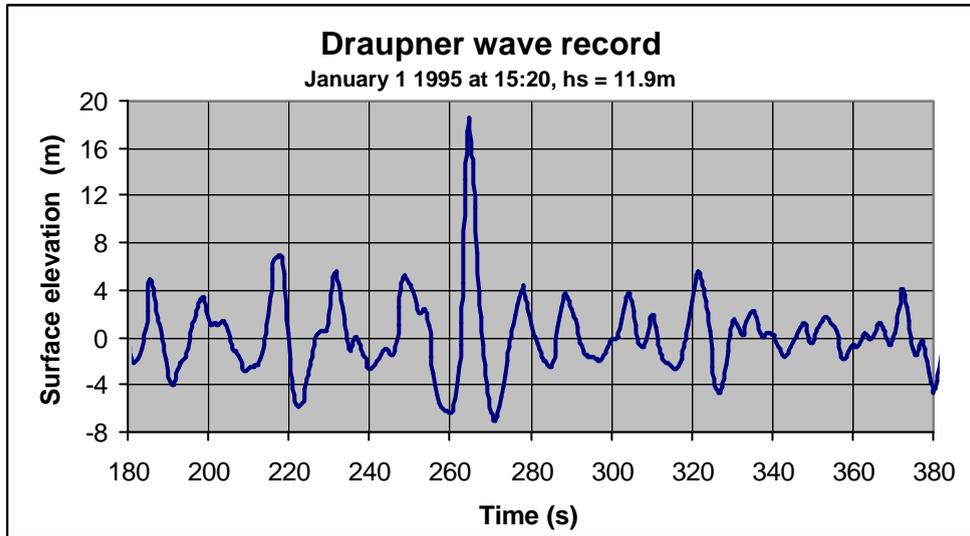


Fig. 5 A closer look at the possible freak wave event.

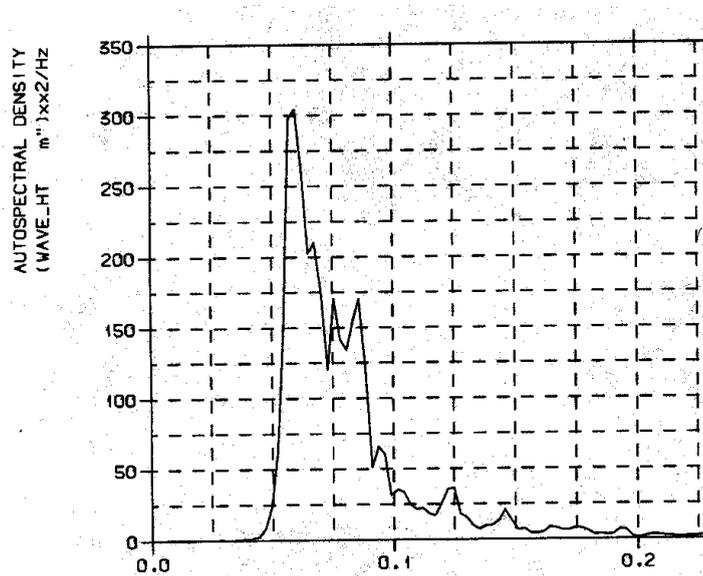


Fig. 15 Wave spectrum for the time history in Fig. 13.

Fig. 6 Estimated wave spectrum for the 15:20 wave time history, Haver and Karunakaran (1998)