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The Icelandic Information System on Weather and Sea State for Seafarers

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ABSTRACT

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The Icelandic Maritime Administration (IMA) has recently employed an Information System on Weather and Sea-state for Seafarers. The system is developed by IMA in co-operation with Hugrun Scientific Instruments AS, an Icelandic manufacturer of meteorological and marine instruments, provides seafarers with real-time information on weather, tidal elevation and waves offshore, inshore and/or inside harbours. The concept behind this system is to provide seafarers with information when fishing offshore, sailing along the coast and entering harbour in the same way as air pilots receive similar information from ground control. Inside harbours information about the tide and waves and long period disturbance together with wind velocity and wind direction are of vital importance for operating vessels.

INTRODUCTION

The information system on weather and sea state for seafarers was developed to meet the demand for detailed environmental information. The system consists at present of 15 automatic weather stations in lighthouses, 7 Waverider buoys offshore and 15 weather, tidal and wave measurement stations in harbours. The system gives a clear picture of weather and sea-state at any given moment showing wind speed and gustiness, wind direction, wave height and long period waves inside and outside harbours, tide elevation, barometric pressure and a forecast for tide based on local tidal tables. Several other parameters can be measured using optional sensors. The system stores the information for future reference and scientific data processing.

Software modules of the system retrieve this information from the weather stations and formulate the data for distribution via on-line graphical presentation in harbours, on automatic voice machines and on the Internet where the information is upgrated every hour.

The system is ideal for providing information, to ships entering, on weather and sea-state outside and inside harbours for safety purposes. The system also provides information to seafarers on weather along coastlines. It basically is a cost effective alternative for monitoring weather and/or sea-state at offshore structures, individual piers inside ports or anywhere as needed by individual or a network of stations. In Iceland a network system is already in use on the Internet at http://www.sigling.is/uks/blika/isl100.html

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BACKGROUND

The system originates from Hofn, the town of Hornafjordur where skippers showed a keen interest in the wave measurements that were commenced outside the Hornafjordur tidal inlet in 1990. Soon, fishermen started to rely upon this information and boats and vessels would call the harbour office to inquire about conditions at the entrance before entering. As a result, a computer terminal was installed at the harbour office where information of wave heights were displayed. Later on, a weather station was installed at Sudurfjorutangi, near the rock headland Hvanney and instruments were installed to measure tide elevation in the entrance.

All the information was transmitted with a telephone line to the harbour office and displayed on the computer screen. The system has been refined to take advantage of graphically displaying the wave height, wind velocity, wind direction, etc. Automatic data collection and storage of data has also been made more accessible as the data is updated every ten minutes and the offshore wave buoy data every hour.

The limiting wave heights for vessels to sail out the tidal inlet at Hornafjordur vary according to size. Boats less than 10 m long will not leave the harbour when the significant wave height at the Waverider buoy outside the inlet exceeds 2.5–3.0 m. Boats from 25 m up to 40 m will not set to sea in wave heights exceeding 3.5 m and 5.5 m respectively. For larger vessels the conditions are more critical. Due to difficulties when maneuvering in the currents, coasters will only navigate the entrance at slack water. At spring tide, slack water lasts for 15 minutes on the flood tide but 30 minutes on the ebb tide but for some 60 minutes on both tides on a neap tide. As a rule, a coasters longer than 70 m will not enter if the significant wave height exceeds 3.5–3.8 m. The

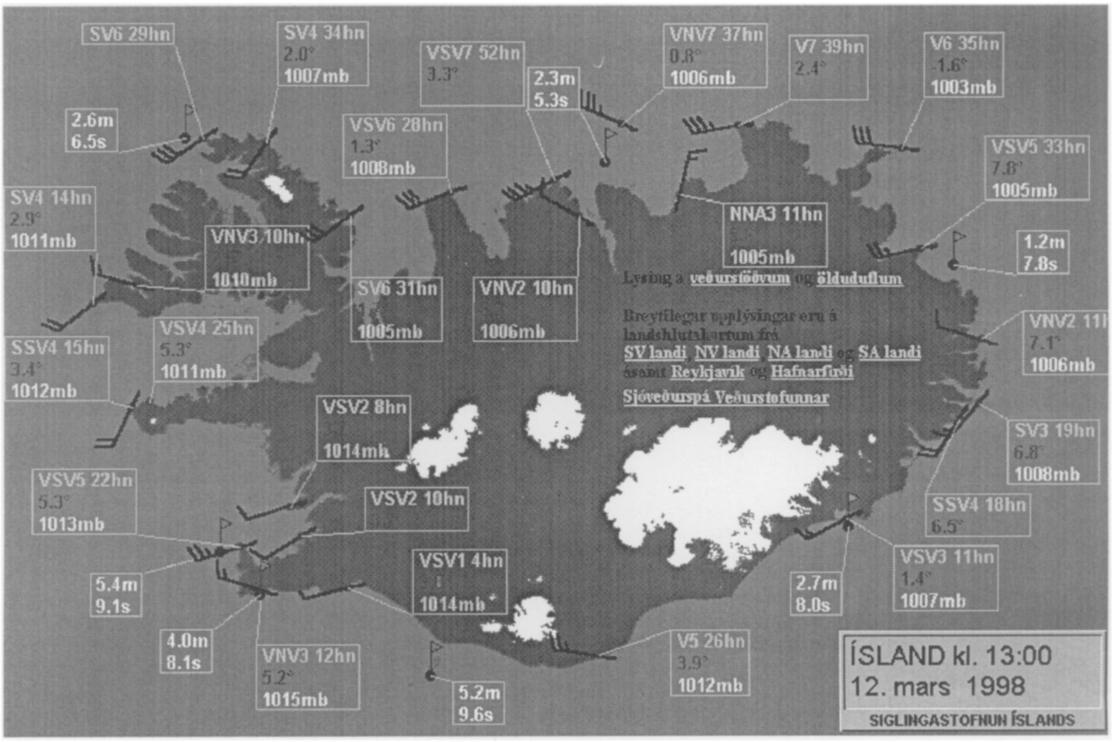

Figure 1. A layout of the Icelandic Information System on Weather and Sea-state for Seafarers.

above limits all refer to daylight and good visibility (VIGGOSSON *et al.*, 1994).

Both fishing vessels and coasters are becoming larger, increasing the demand for more maneuvering space and water depth at harbour entrances and inside harbours. In addition, the ships are more sensitive to drift as the wind area is increased due to containers on deck.

Another very important factor to be considered for the safety of harbours is whether it is possible for a vessel experiencing excessive movements to leave the port. In some ports the maneuvering conditions in the harbour entrance are so difficult, that ships can not enter or leave the port once a storm has reached the site. In such a port the aspect of safe mooring at berth becomes even more important as the vessels have no other choice but to stay in the port.

The data acquisition by the system enables analysis to determine downtime or non-availability of harbours, when limits for safe working conditions are exceeded and when ships are forced to leave harbours due to unsafe conditions. These factors are all very important with regard to operations of harbours and safety.

The number of small craft, both fishing and pleasure boats has increased significantly in the last few years. The operators of these vessels must rely upon information on waves and weather in the rough seas that characterize Icelandic waters. Figure 1 shows a lay-out of the Icelandic information system on weather and sea state for seafarers. As an example of how the information is used, we now look at the system operated at the harbour office of Hafnarfjordur. The pilots at Hafnarfjordur are responsible for berthing oil tankers in Hafnarfjordur and bulk carriers of up to 40.000–50.000 DWT into the Straumsvik harbour and ore bulk carriers of 20.000 DWT bound for the Grundartangi harbour. These vessels can only be docked when wind speed and wave heights are within certain limits and often large draught hinders berthing at low tide. The system will allow the pilots to have all the information available at their fingertips. When the master of the ship reports the estimated time of arrival to the harbour office the pilot will have direct access to real-time information on weather and waves, both offshore and at the harbour and can direct the captain accordingly.

DATA COLLECTION SYSTEM

The data collection system can be divided into two categories: A harbour system which provides information on weather, tidal information and wave measurements in harbour areas and a coastal system consisting of wave measurement buoys offshore and weather stations in exposed lighthouses, which provide seafarers with information on weather and sea-state in the coastal zone. The basic components of the harbour system are a measuring station with weather sensors and a pressure gauge(s) and a display station. The coastal system consists of Datawell Waverider bouys and weather stations in lighthouses (VIGGOSSON *et al.*, 1994, 1996).

The measuring stations are developed by IMA in co-operation with Hugrun Scientific Instruments AS, an Icelandic

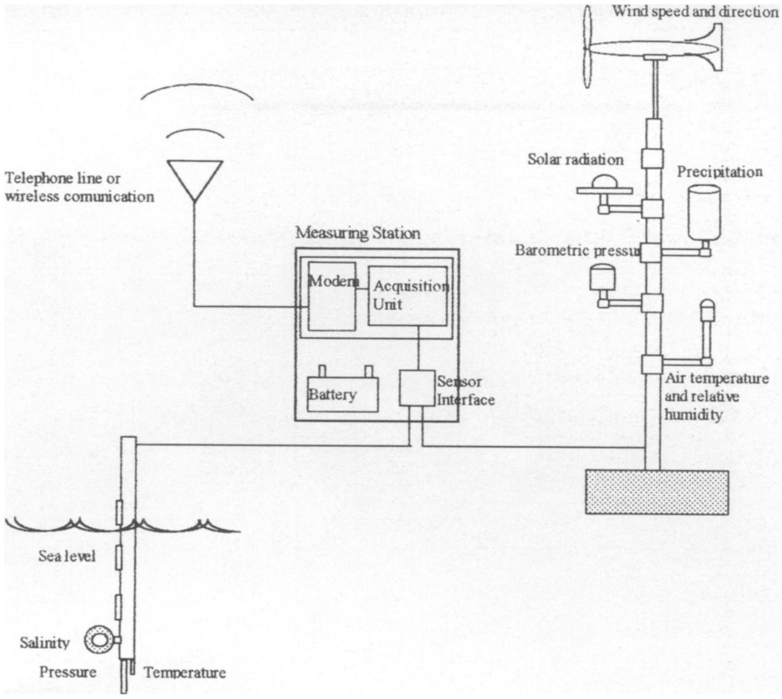

Figure 2. Schematic view of a measuring station.

manufacturer of meteorological and marine instruments. The weather stations and offshore wave receiver stations that collect the data are fully automated and are connected by the public telephone network to IMA. The software that controls the data collection and the system interface are developed as a joint effort of the IMA and Hugrun Scientific Instruments AS. In all respect, the weather stations conform to the standards set by the Icelandic Meteorological Office.

The network and the coastal system together with the offshore buoys are owned by IMA but the harbour system is owned by the respective harbours.

The following information can now be gathered through the system but, depending on the location of the weather stations, usually a part of this information is needed:

- Sea level observations
- Tide elevation
- Wind and ocean waves inside harbour
- Long period waves inside harbour
- Waves in entrances and outside harbours
- Offshore waves
- Wind speed and gusts
- Wind direction
- Barometric pressure
- Air temperature
- Relative humidity
- Precipitation
- Solar radiation
- Sea water temperature
- Sea water conductivity

Measuring Stations

The measuring station is housed in a stainless steel case and is located near the meteorological and marine sensors. It includes a battery backed-up multi channel measuring device and a data modem for a leased line or a telephone line. Radio modem or cellular telephone are optionally available. All 10-minute values are stored in the internal RAM buffer of the measuring device as back-up. Because of the battery, the measuring unit will continue to operate during electrical power breaks.

Figure 2 shows a schematic view of a measuring station. The system has proven reliable using solar panels in Iceland and can, therefore, be utilised in remote areas. The automated stations can facilitate phaseout of manual weather data collection with enormous cost effectiveness.

Offshore Wave Measurements

Wave climate around Iceland is severe with measured offshore significant wave heights over 16 m and wave peak periods up to 20 seconds. Cyclones from North America pass over Iceland from the southwest and generate high waves when reaching southwest Iceland. Deep cyclones may stagnate east or north of Iceland for several days generating high waves (VIGGOSSON, 1988).

Heavy storms in the past few winters have caused higher wave activity from the south and southwest than previously during the last 30 years at least. In January 1990 an extreme storm hit the south coast of Iceland. At its peak intensity,

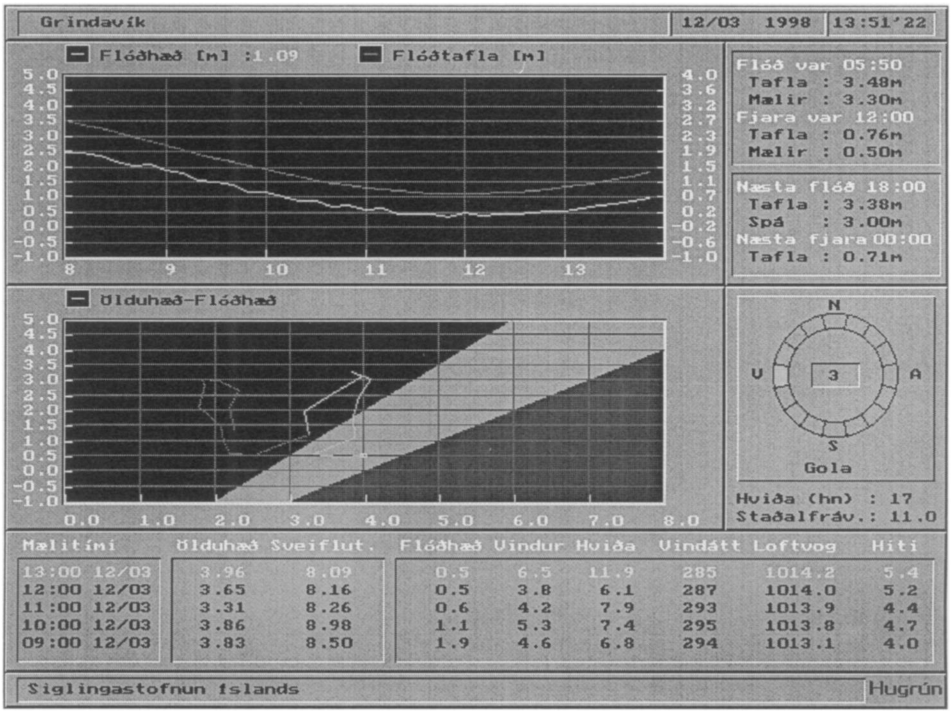

Figure 3. The real-time windows at the harbour office at Grindavik showing the most important parameters in an easily apprehended way and the navigational entrance entry.

atmospheric pressure plunged to 928 millibars at a location 200 km southwest of Iceland. The offshore Waverider buoys at Gardskagi and Surtsey recorded significant wave heights of 16.25 m and 16.68 m respectively with peak periods of 17.8 and 19.4 seconds (VIGGOSSON *et al.*, 1993).

Since 1988, four Waverider buoys have been in continuous operation, but from 1996 7 Waveriders have been in operation at the following locations:

Vestmannaeyjar:	63°17,14 N 20°20,70 W	130 m water depth
Grindavík:	63°48,80 N 22°27,63 W	67 m water depth
Garðskagi:	64°03,27 N 22°56,57 W	80 m water depth
Straumnes:	66°26,30 N 23°22,00 W	70 m water depth
Grímseyjarsund:	66°17,50 N 18°11,50 W	90 m water depth
Kögur:	65°38,89 N 13°37,59 W	100 m water depth
Hornafjordur:	64°11,81 N 15°11,31 W	32 m water depth

Weather Stations

The exposed lighthouses are the most suitable locations for automatic weather stations for collecting data on weather for seafarers. The choice of location has been done in cooperation with the Icelandic Meteorological Office and with captains and skippers of coasters and fishing vessels. The Icelandic Meteorological Office collects data from the weather stations in lighthouses and transmit them to IMA automatically through the Internet mail system.

The idea behind the system was to provide information on weather and sea state 24 hours a day. The experience shows that skippers of small fishing boats use information from the system primarily to decide whether to set to sea when the weather is critical. Coasters and larger fishing vessels use the information when entering harbours and to plan their voyage along the coast or fishing off the shore. Sudden increase in wave height is dangerous for fishing vessels as the crew is not always prepared for stormy weather. The information from the system is of most use when it is compared with the weather forecast for coastal areas and in that way each skipper finds the limits for this vessel in a critical situation.

Harbour Stations

The harbour system was developed to meet the demand for detailed environmental information. The system gives a clear picture of the situation at any given moment, showing 10 minute averages of wind speed and gustiness, wind direction, wave height and long period waves inside harbours, tide elevation, barometric pressure and a forecast for tide based on local tidal tables. Several other parameters can be measured using optional sensors. The system also stores the information for future reference and scientific data processing. To increase the service and safety, the system has been installed in 15 entrances and harbours.

Figure 3 shows the windows from the display station located at the harbour office at Grindavik where the weather and wave data are displayed simultaneously with an additional information on low and high tides. The navigational entrance display shows whether or not the entrance is open for fishing vessels due to low tide and/ or too high waves. The

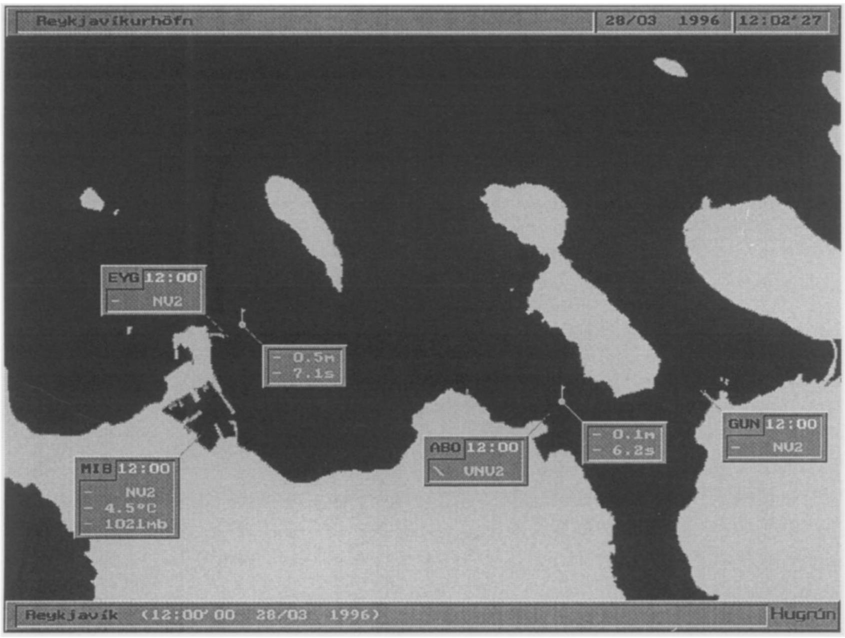

Figure 4. The display at the harbour office at Reykjavik showing weather, tide and waves from four locations.

entry criteria is based on hydraulic model study at IMA's hydraulic model hall and experiences from the Grindavik entrance.

The main criteria for a good harbour is whether the ship has sufficiently calm conditions when moored at berth. It is, therefore, important to establish a realistic criteria for acceptable movements of moored ships at the berth. The IMA commenced this work in 1977 and from 1980 to 1986 a joint Nordic research project made field measurements on moored fishing vessels and coasters at berth (VIGGOSSON *et al.*, 1986, 1987, 1990), (JENSEN *et al.*, 1995). Based on this work and others PIANC published in 1995 a "Practical guide on Criteria for Movements of Moored Ships in Harbours" where recommended motion of moored vessels for "Safe Working Condition" and "Safe Stay at Berth" are established for various categories of vessels.

In 1995, hydraulic model studies of moored oil tanker were carried out, for two locations in Reykjavik Harbour, at IMA's hydraulic model hall. Following the studies, three weather stations and two pressure gauges were installed at the two sites and at the proposed extension site of the Port of Reykjavik in Eidsvik. Figure 4 shows the data of weather, tide and waves at the Eyjagardur Oil Terminal, the old Port of Reykjavik, the Container Terminal at Sundahofn and the proposed extension site in Eidsvik.

Analysing the time series of the wave height, the spectrum of the wave energy gives the significant wave height and peak period, and the spectrum of the long periodic waves at berth. Figure 5 shows a graph from the display for the oil terminal at Reykjavik Harbour. The upper part shows the waves parameters and the lower part shows the long period parameters together with the tidal elevation during one storm.

Additional Features

All the existing sea level gauges are connected to the geodetic network in Iceland. Data from the gauges can thus be used in the future to determine long-term changes in sea level around the country. A rise in the global sea level is predicted for the next decades as a result of climate changes caused by the actions of man. Iceland is well located to monitor these changes, being an island in the open ocean. The geodetic network of the country, recently being established by GPS mesurements, provides good conditions to determine crustal movements in order to obtain absolute sea level. The project is developed by the University of Iceland, Sciences Institute and Hugrun in co-operation with the IMA.

INFORMATION SYSTEM AT IMA

At the IMA data from the measuring stations is collected and stored in a database for further processing. (Figure 6) One of the most important features of the system is a quality control of the data so that the database will be a platform for various predictions and simulations of environmental parameters.

The software development is a joint venture of VSG Engineering and IMA.

There are number of ways for seafarers to get information from the measuring stations and from the Information System.

Apart from calling the harbour pilots, it is also possible to call an automated call-up voice generators which updates the data every hour. The phone number of IMA call-up service is +354-902-1000, voice Icelandic.

An overview of weather and sea state around Iceland is

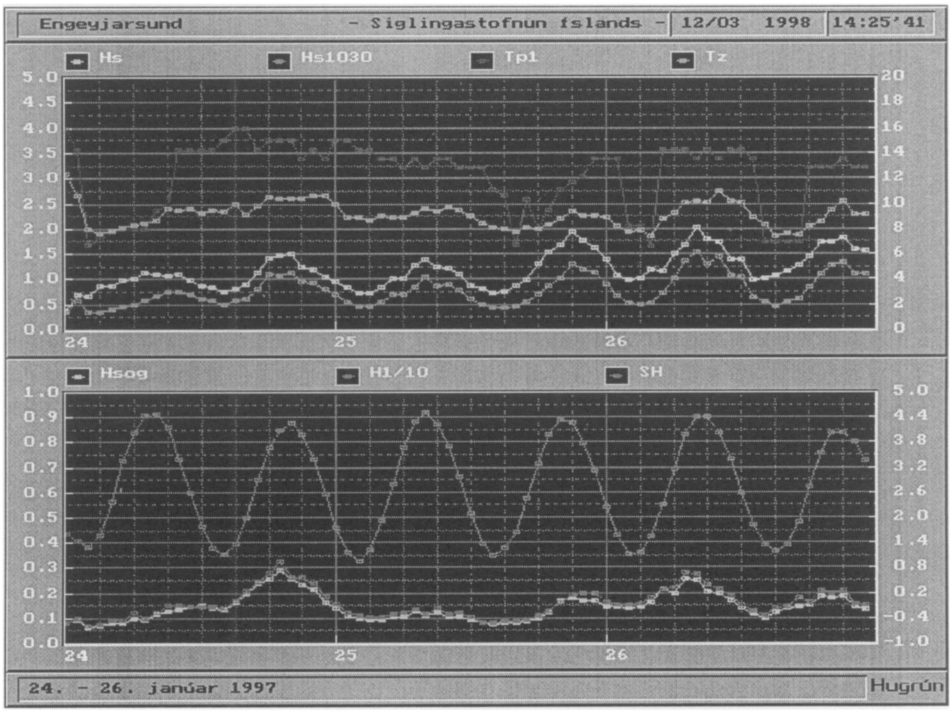

Figure 5. Waves, long period waves and tide elevation outside the oil terminal at Reykjavík harbour.

available on the Internet at http://www.sigling.is/uks/blika/isl100.html. This was the first step in IMA's plan in providing Icelandic seafarers with environmental information on the Internet.

At the IMA office the system collects the newest data from the database, generating "gif" pictures and updating them on the Internet Web server.

By means of the software, data can be transmitted between harbour stations. This also enables any harbour station to exchange data with other stations. This gives the possibility for ships to be equipped with a display station and receive data from shore stations.

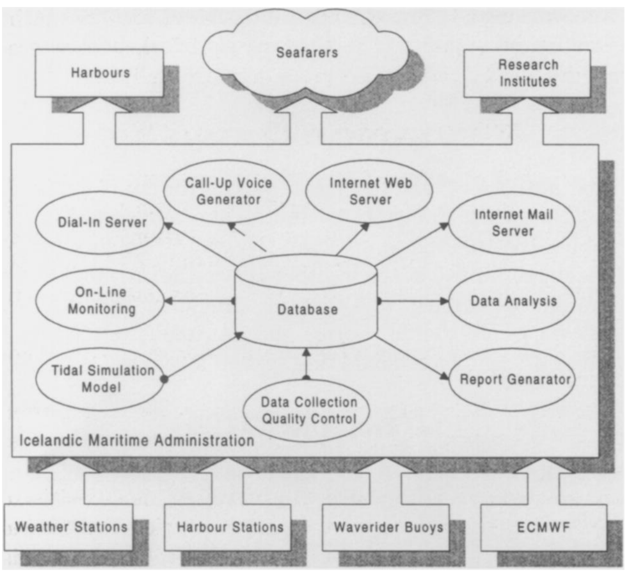

Figure 6. Schematic view of the Information System at IMA.

FURTHER DEVELOPMENT OF THE SYSTEM

Installing the information system on IMA's web page is the first step in providing Icelandic seafarers with environmental information on the Internet.

The second step will be the installment of Ocean Wave Forecast from the European Centre for Medium Range Weather Forecasts (ECMWF) in cooperation with the Icelandic Meteorological Office. At the European Centre, the WAM model has been implemented on the globe with resolution of 0.5° (Janssen *et al.*, 1996). (Figure 7) The wave spectrum has 25 frequencies and 12 directions at each gridpoint. The model allows for possibility of indicating a variable ice edge which is of particular importance north of Iceland. The wave forecasting will be updated at 6 hour interval up to 60 hour. The area which is covered on the Internet is from 0° W to 40° W and from 58° N to 70° N. The significant wave height and the mean period together with the mean wave direction will be displayed on the Internet.

The third step will be the installment of the existing tidal simulation model covering the area from 20° E to 55° W and 52° N to 72° N which has been extended to a storm surge

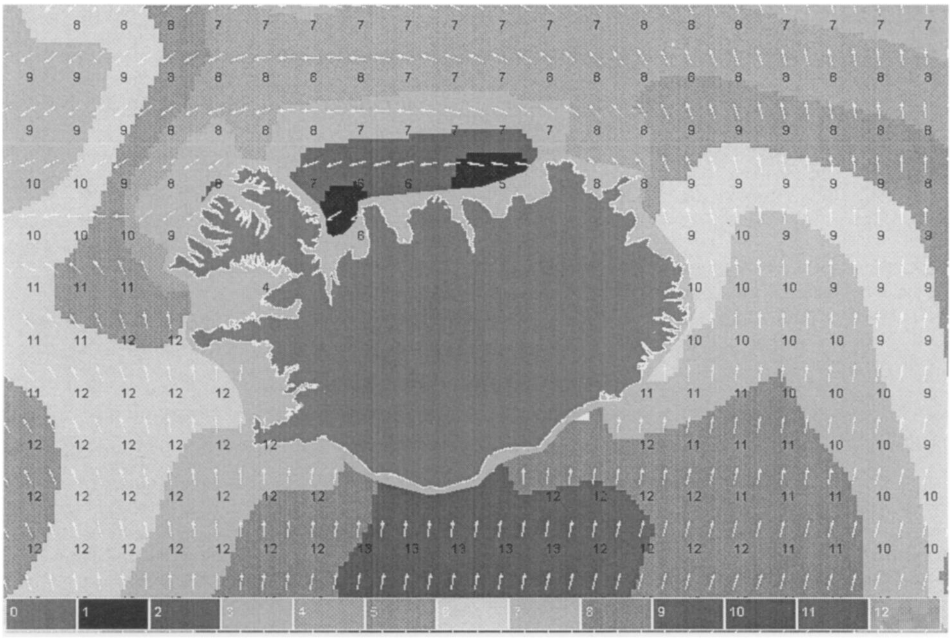

Figure 7. ECMWF Wave Forecasting in Icelandic waters.

model for the coast of Iceland. The tidal simulations are based on seven tidal components, M_2, S_2, N_2, K_2, K_1, O_1, and Q_1 with the 10 × 10 km finite difference method in the 2-D Princeton Ocean Model (TOMASSON *et al.,* 1997).

The ECMWF Weather Forecasting will be used for the storm surge model. The tide and the tidal current together with the storm surge will be displayed on the Internet.

The fourth step will be installment of an information system on waves and stability of small fishing vessels which will be based on the ECMWF Wave Forecasting (DAHLE *et al.,* 1997). The IMA has developed a method by which ship operators can receive information on the possibility of exposures to dangerous steep waves thereby reducing risks of capsizing. The method is based on knowledge of the number of dangerous, steep waves that will occur in a defined sea state. When the sea state is measured, as is the case in Iceland, it is possible to forcast the number of such waves within a given period of time.

The fifth step will be forecasting of marine ice accretion on vessels (VEFSNMO *et al.,* 1998).

Later this year, the continental shelf will be available digitized. Several new possibilities will be opened such as simulating tidal current in more detail nearshore and using the SWAN model, which is a numerical wave model to obtain a realistic estimate of wave parameters in coastal areas and estuaries from given wind, bottom, and current conditions (RIS *et al.,* 1996).

In connection with the growing concern of environmental problems an oil spill hydrodynamic simulation model is planned later this year.

CONCLUSIONS

Sailing in Icelandic waters can be difficult, especially during the winter. The purpose of the Icelandic Information system on weather and sea state for seafarers is to increase the safety by providing seafarers with the necessary information on weather and waves. The system has proved itself as a valuable tool for harbour pilots and seafarers. The positive reactions to this system has encourage further development which will take into account forecasts on waves and storm surge warnings, information on tidal current and later on information on stability of fishing vessels in relation to wave heights.

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