International Council for the
Exploration of the Sea

CM 1999/CM Z:6

Operational data acquisition and Internet presentation of marine environmental data from ships of opportunity and fixed monitoring stations

by

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Abstract:
Since 1935 Institute of Marine Research (IMR) in Bergen has run an operational system for acquisition of temperature and salinity data from passenger and cargo lines operating in the North Sea and on the Norwegian coast and from fixed hydrographic monitoring stations on the Norwegian coast. Presently temperature and salinity data from three ships of opportunity and temperature / salinity profiles from eight hydrographic stations are regulary collected and transmitted to IMR for quality check, processing,automatic loading into a database and immediate presentation on Internet.

The acquired information is used for climatic references, short and long term climatic forecasting, location planning,remote sensor calibration and general information to the public.

The paper describes history, instrumentation strategy ,IMR`s data quality procedures for operational data and how the data are presented on Internet. Plans for future development based on more sensors and two way satellite communication are also described.

Key words: data acquisition, internet, monitoring,, salinity, satellite communication, ship of opportunity, temperature

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Introduction

The Norwegian society and Norwegian economy has always been highly dependent on a continuous exploitation of the fish resources that are produced in the marine ecosystems in the Barents sea, the Norwegian Sea, the North Sea and Skagerrak/ Kattegat.

About 100 years ago Norwegian scientists realised that there excists a connection between the ocean climate and the output of fisheries in an ecosystem. Pelagic fish tend to follow water masses with favorable environmental properties, and changes in the oceanic climate could be a major cause for variations and long term changes in the fisheries yield .

The Norwegian Institute of Marine Research was initiated in 1900 basically to explain the cause for the experienced large varations in the output of seasonal fisheries.

One important task for the young institute was to correlate variations in the outcome of seasonal fisheries with changes in the coastal hydrography. To define hydrographic baselines and variabilities, series with environmental data from both the sea and the coast were needed.

Scattered temperature data series from lighthouses on the Norwegian coast had been available since the 1880s, but systematic operational data could not be achieved until end of 1930.

In 1935 the IMR scientist Jens Eggvin started regular acquisition of sea temperature and salinity from coastal steamers and from fixed hydrographic stations on the Norwegian coast.

The mission: Get operational hydrographic data from important fishing aeras.

In as speech to ICES in 1959 Dr Eggvin looked back to the 1930s and gave the following rationale for his pioneering work within operational oceanography:

"We know that certain hydrographic situations influence the fisheries in various ways. If we can predict such special situations, we can expect to be able to assist the fisheries with valuable information , knowing in advance that certain oceanographic situations affect the fish in such and such manner that we shall know how the fishery will turn out."

"If knowing the basic laws for the energy and the temperature exchange between sea and air space, the transfer of energy to sea by windstress, the turbulence in the sea, the evaporation, heat conduction and some other factors : and if we could arrange all these factors in a computing machine for mathematically calculation of the state of the sea in advance, it should be very valuable for the fisheries"

Making observations from ships of convenience proved to be a cost efficient way to acquire data. During the spring 1935 Eggvin installed pen recording mercury thermometers on two vessels which together covered the 2726 km stretch from Oslo to Kirkenes.

Fig. 1 shows the historical first continuous trace of surface temperature (at 4 m depth) along the Norwegian coast between the Oslofjord and the Varangerfjord (close to the Russian border).

To determine salinity, samples of sea water from fixed positions along the route were collected by the ship`s crew and returned to IMR for salinity analysis.

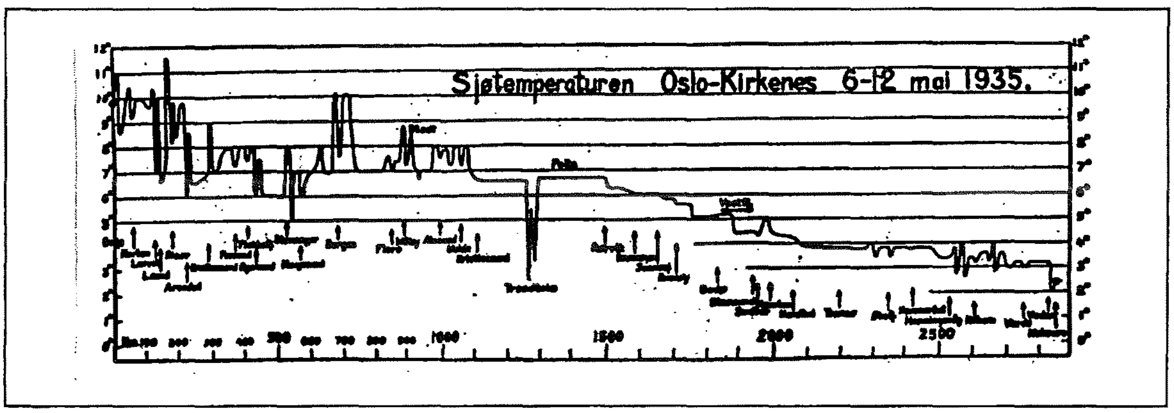

Fig. 1 Historical first continuous trace of surface temperature (at 4 m depth) along the Norwegian coast between Oslofjord and Varangerfjord 6. - 12. May 1935

In 1935 also the first fixed coastal hydrographic monitoring stations were established. Each coastal monitoring stations is operated by a locally resident observer- often a retired fisherman. Equipped with instruments from IMR, the observer takes his own small boat to a fixed position within a few hours from his home, measures a STD profile, returns home and sends the acquired data to IMR in Bergen. During the first years measurements were made with Nansen bottles, and the collected material was sent to Bergen by boat.
The first generation of equipment used by ships of convenience and IMR`s local observers involved demanding physical work and lots of cumbersome processing.
Fig 2 shows an original thermogram from 1936 showing the temperature-time trace with hand written comments on it.

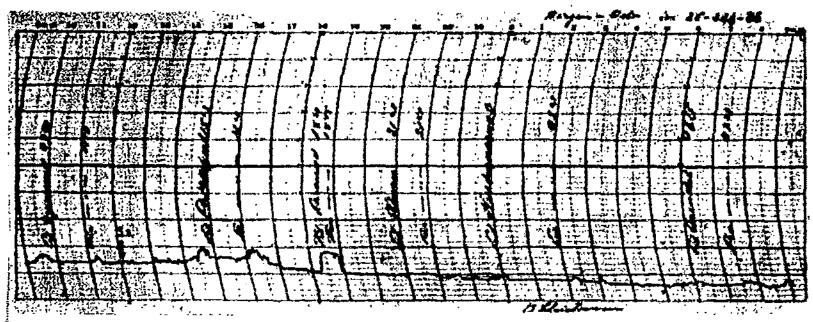

Fig. 2: Original thermogram from 1936.
The crew noted time, ship position and other comments directly on the thermogram.

Except for the war years 1940-1945 IMR has continued to make regular records from ships of opportunity and from coastal stations. Till now a more than 60 year old time series for temperature and salinity in theNorth Sea and along the Norwegian coast has been acquired. A typical data set showing variations in the Atlantic water temperature from 1935 to 1998 - is shown on fig. 3.

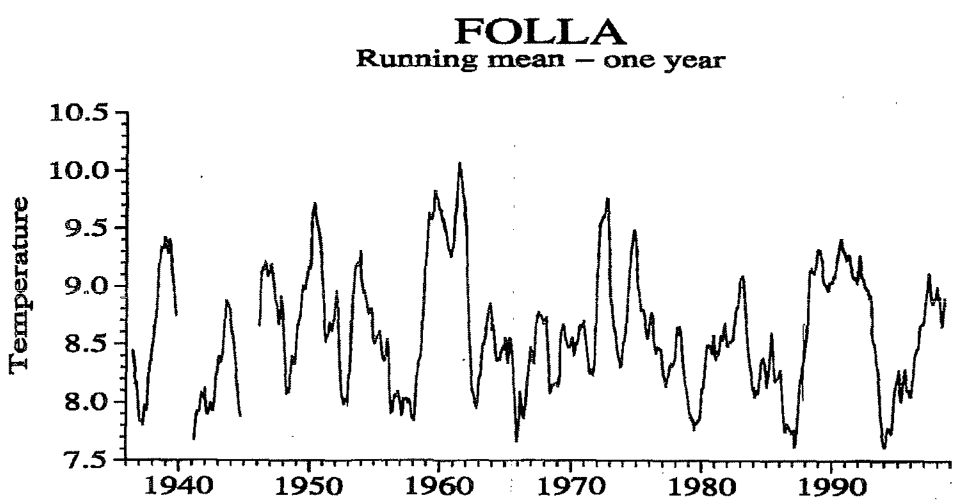

Fig. 3
One year running mean Atlantic water temperature from 1935- 1998 measured at Folla on the mid- Norwegian coast

During the years since1935 the operational network has been gradually modified and modernized. Fig. 4 shows IMRs present network. The ships of opportunity are now two Coastal Express ships that trafficate the 11 day long Bergen- Kirkenes - Bergen route and one cargo ship which transects Bergen - Aberdeen - Bergen once per week. The network was originally intended for national use,but it is now being gradually integrated in the strategy of EuroGoos and Seanet. Since1998 data from the operational network has been available on Internet.

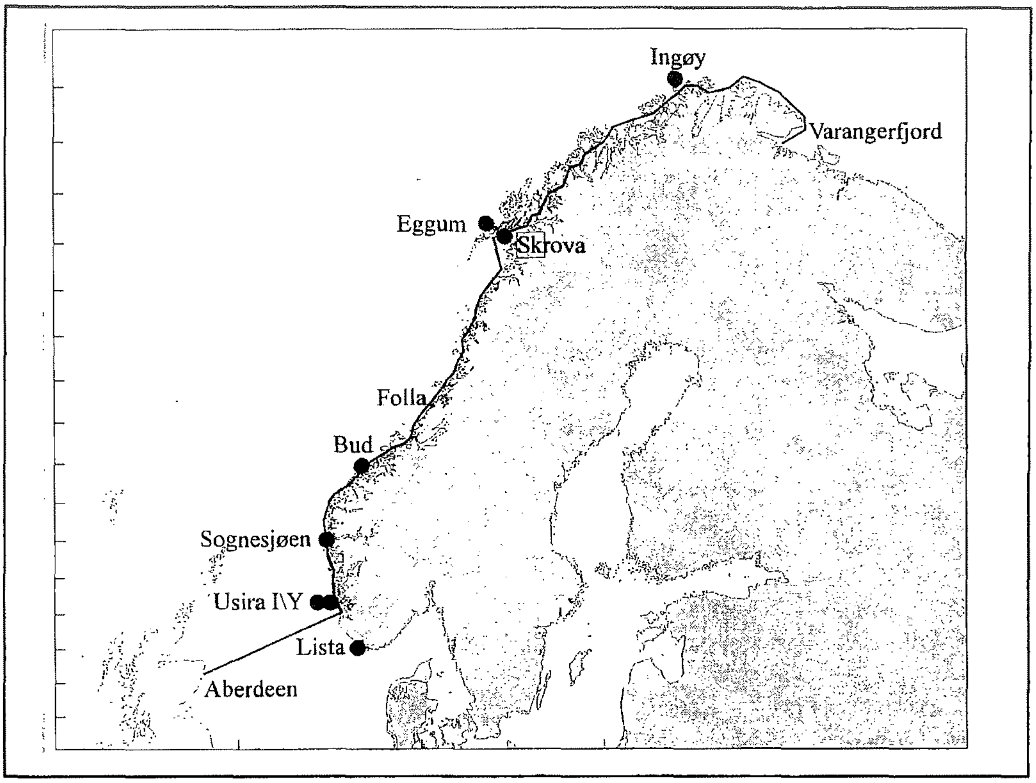

Fig. 4
IMR`s Internet based operational network consisting of two ship of opportunity - routes and 8 fixed hydrographical stations

Products

Data from IMRs ships of opportunity and fixed hydrographic stations make basis for both scientific and operational products. Typical excamples are climatic references, short term forecasting, long term forecasting, planning of locations, remote sensor calibration and general information to the public.

- Influx of warm Atlantic water is a major ecological factor for the life in the Norwegian waters, and changes in the heat flux must be continuously monitored. Fig 3 represents a typical climatic product.

- On the Norwegian coast a given mass of water will propagate towards North appr. 20 km per day. Pulses of cold water or water containing poisonous algae may threaten fish farms on the coast. Based on information from the operational network IMR can advice fish farmers along the coastline about approaching threaths.

- Even small changes in the mean influx atlantic water temperature will sooner or later influence on the biological production and hence on the fish stocks in the Northern waters. Information from IMR`s operational services is used as an input to fish population prognosis models for important fishing areas. Climatic prognoses for more than one year are now given.

-Successful location of a fish farm on the coast is highly dependent on the water quality. Processed data showing typical temperature and salinity through the year for a planned location can be used to estimate maximum possible production.

- The ships of opportunity trafficate regions of the sea which are also remotely measured from observational satellites. Surface observations from a ship in a given position at a given time can be calibrated against corresponding data from a satellite.

- Sea temperature and salinity information as presented on internet (fig8 and 9) is higly interesting information for fishermen and the coastal population in Norway.

System description

- IMR`s operational environmental monitoring system involves:
- On line instrumentation
- Data quality assurance
- Recording in database
- Presentation of data to the public

Instrumentation for ships of opportunity

Instrumentation for ships of opportunity must in general be be reliable and simple to install and use. The operation of the instruments must not interfere with running ship functions.
Fig. 5 shows typical components in IMR`s operational data acquisition system for ships of opportunity which has been designed to measure, record and present time, ship position and selected sea data.

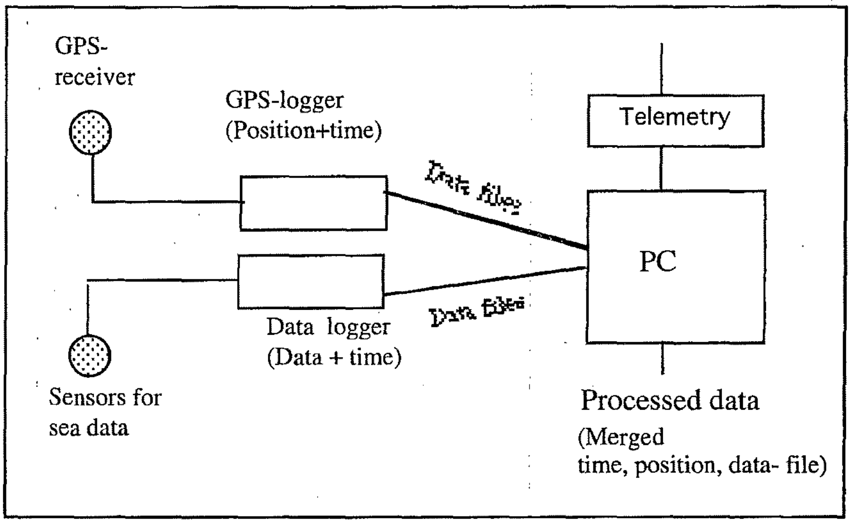

Fig.5: Components in a ship mounted data acquisition system for ships of opportunity

Precise time measurements are now a basic function in most modern instruments, and measurement of time is not a general problem.

A ship`s position can be easily measured by a GPS system provided that the GPS antenna has free access to the sky.

Representative data from the sea are best obtained from the engine cooling water system. Access to the cooling water needs a certified installation which may be a problem in some ships.
The most challenging practical problem is to neutralize effects of foam,bubbles and biofouling on the sensors. Special mechanical / electronic designs may be needed.
If data from the sea are needed fast, batches of recorded information should be transferred to land via a convenient communication system. If time is not critical,data can be recorded on board and downloaded to a computer system when convenient.

In the system presently used by IMR,the water temperature is measured continuously by a thermistor inside the cooling water system. The temperature sensor is connected to a time / temperature logger mounted in the engine room.
Due to problems with bubble formation in the cooling water, salinity is still measured discontinuously. The crew takes water samples on bottles in fixed geographic positions along the shipping route, and the botles are analyzed when the ships arrive Bergen

In a ship there may be a considerable distance between the engine cooling water system and a sky accessable place where the GPS antenna can be succcessfully mounted. To avoid installation of connecting wires through the ship, separate autonomous loggers are used for recording of position and sea data. A GPS logger on deck records position and time. The GPS logger is time syncronized with the corresponding sea data logger in the engine room.
Each time the ships arrive in Bergen the loggers are unplugged from their sensors and brought to IMR for data download, time syncronization, quality control, processing and internet presentation.

Instrumentation for fixed hydrographic stations

In general instrumentation for non - professional observers must be compact and easy to operate, and the end user must be able to control and correct the data in a simple way.
The instrumentation which has been designed for the IMR observers involves a portable, recording CTD instrument and a home installed modem terminal. Fig. 6 illustrates the system.
The observer instrument ("MINI STD") weighs appr. 2 kg in air. It can be programmed to measure and record temperature, conductivity, depth and (if wanted) a limited number of optional parameters at a wanted repetition interval- f. inst. each 5 sec.
The observer starts a STD-cast by holding a magnet outside a START position on the instrument surface. Then he lowers the instrument to the actual station depth, pulls it back to surface and terminates measurements by holding the magnet outside a stop position. The data is recorded in the instrument memory. For quality check a Nansen bottle with reversing thermometer mounted close to the instrument is released in a depth with stable hydrography.
Upon returning to his home the observer connects the STD to a modem based data terminal. From this terminal data is automatically downloaded to a dedicated PC at IMR. The data terminal works in both directions. If the quality control discovers changes in the instrument calibration, new calibration coefficients will be calculated at IMR and loaded into the instrument memory via modem.

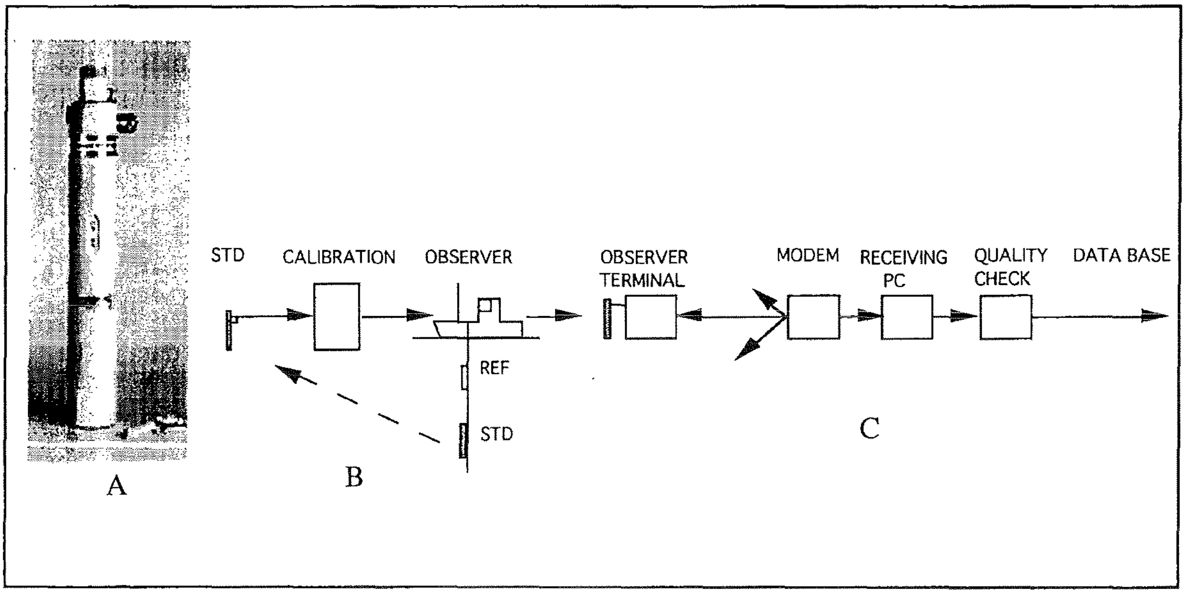

Fig. 6 Instrumentation for fixed observers.
A: Magnet operated MINI STD instrument which can record up to 58.000 data set and transmit data to IMR via modem
B: Calibration control system. STD- data from a stable hydrographic layer is compared with corresponding data from a reference Nansen bottle with reversing thermometer If deviations are observed, STD calibration coefficients will be recalculated and loaded into the instrument via modem.
C: Receiving terminal at IMR. The terminal can adress all observer terminals and download data from their connected instrument.

Data quality control

The temperature loggers used for temperature measurements in ships of convenience and the STD - instruments used by the hydrographic observers calculate their output data in calibrated physical units by entering the raw sensor data into a polynominal with specific sensor calibration coefficients.

If data differ from control references,the sensor coefficients will be adjusted.

In the ships of convenience the recorded temperature is compared with a reference thermometer.

The salinity samples are analyzed in the IMR salinity laboratory with an accuracy of +/- 0.001 ppt.

Temperature and salinity data from the fixed hydrographicstations are compared with reference data from a Nansen bottle in each cast.

After each data submission data from selected positions at the ship of opportunity routes and from standard depths at the fixed stations are automatically calculated and entered into the IMR scientific data base. In the same process data are organized for successive presentation on the web

Data flow from instrument to web

IMR has developed an operator controlled automatic system for the data flow from instrument to web.

The software is mainly written in C++ and the system is heavily based on HTML, Java Script,,perl and FoxPro. X/Motif has been used for general data exchange and UNIRAS was selected for plotted graphics.

The procedures for handling data from ships of opportunity and from coastal stations are quite similar.

Fig.7 illustrates the information flow from a coastal monitoring station to the web.

The process starts in the field as the observer activates his STD instrument and takes a vertical STD- profile. He collects a water sample by releasing a Nansen bottle. He brings the instrument to his home terminal and ships the reference water sample to IMR via postal mail.

The home terminal data are transferred to a local server at IMR and displayed on a screen.

Noisy or possible erroneous observations in the data sets are tagged, and a human operator decides wether the tagged data can be accepted or not. Non accepted data will be removed.

Accepted data are formatted and entered into a local data base under specified file names.

After the water samples have been analyzed, data in the database may be modified via a manually operated spreadsheet routine.

Files in the database can be transferred to IMR`s web server net at any time by selecting the actual file and clicking a button. Within a few seconds the operational data can be viewed on the net.

Fig. 8 shows a typical web presentation showing temperature and salinity profiles from a coastal station.

The green zone cover the mean value +/- one standard deviation of all corresponding data in the database.

Fig. 9 shows web presented surface temperatures in North Norway measured from Coastal Express ship M/S Vesteraalen.

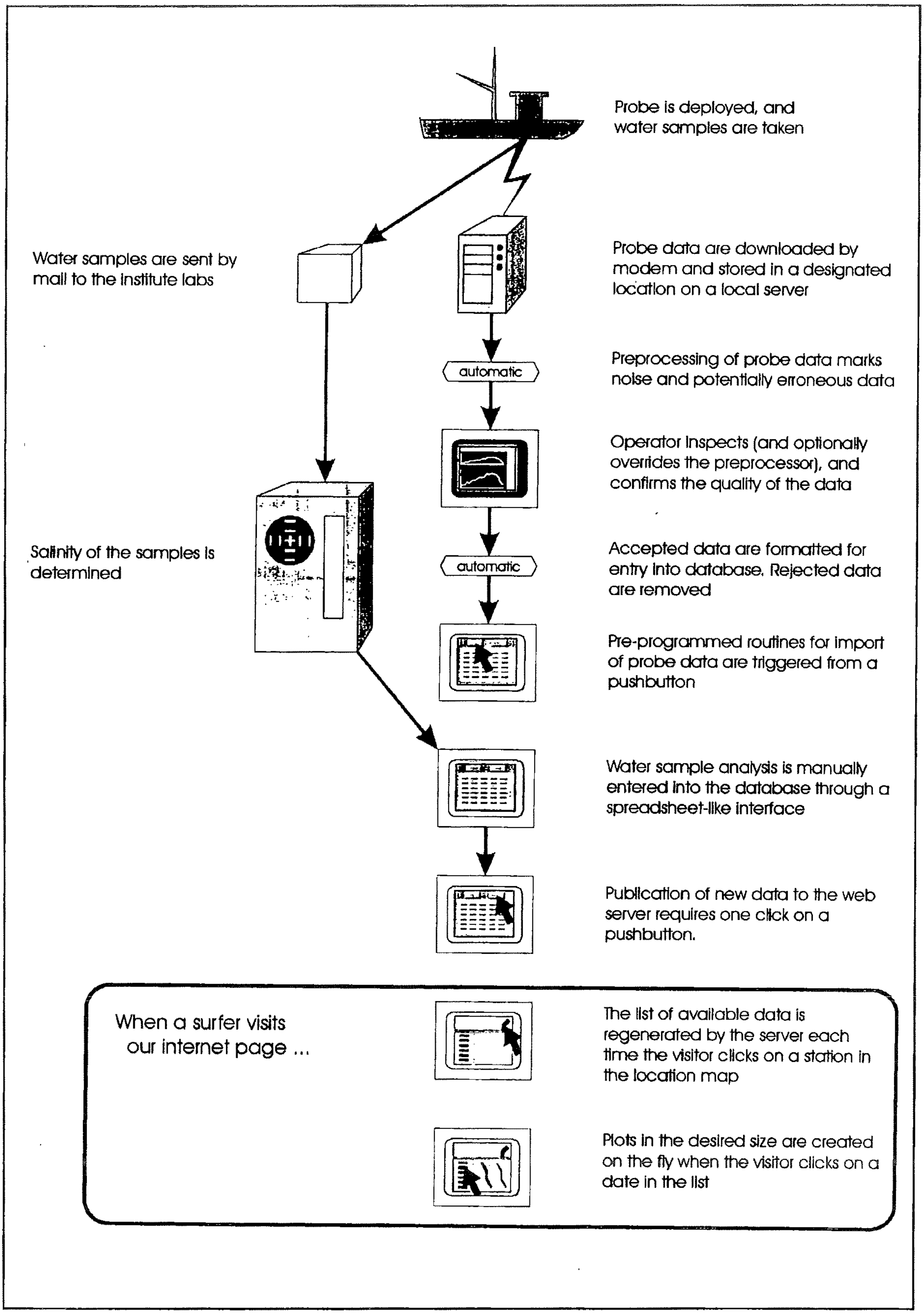

Fig. 7 Information flow from from a fixed hydrographic station to web presentation

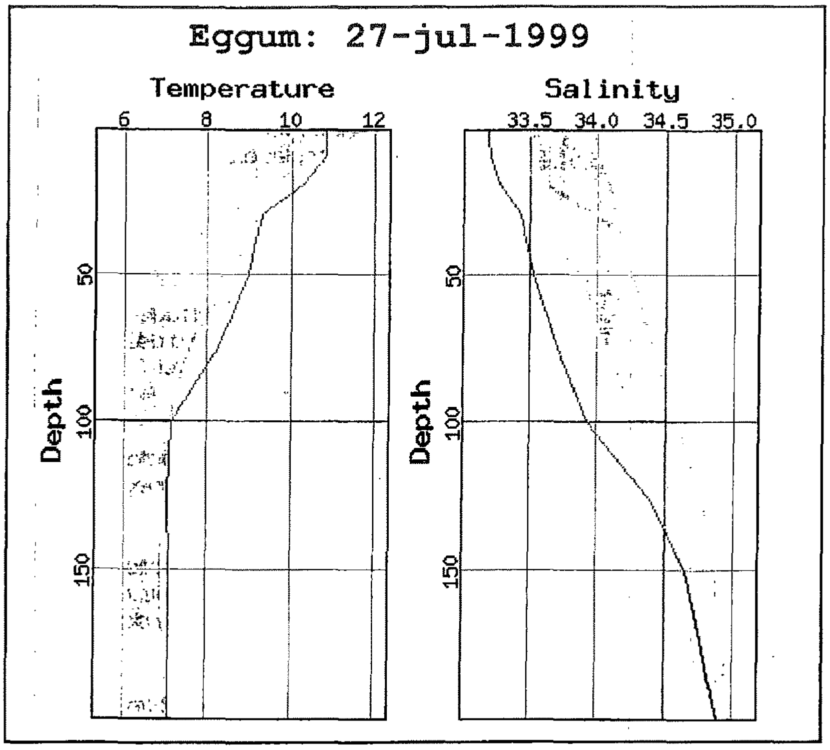

Fig.8 Web presentation of a temperature / salinity profile from a fixed hydrographic monitoring station.
Green aera shows mean value +/- 1 standard deviation of all corresponding data sets in the database. (www.imr.no)

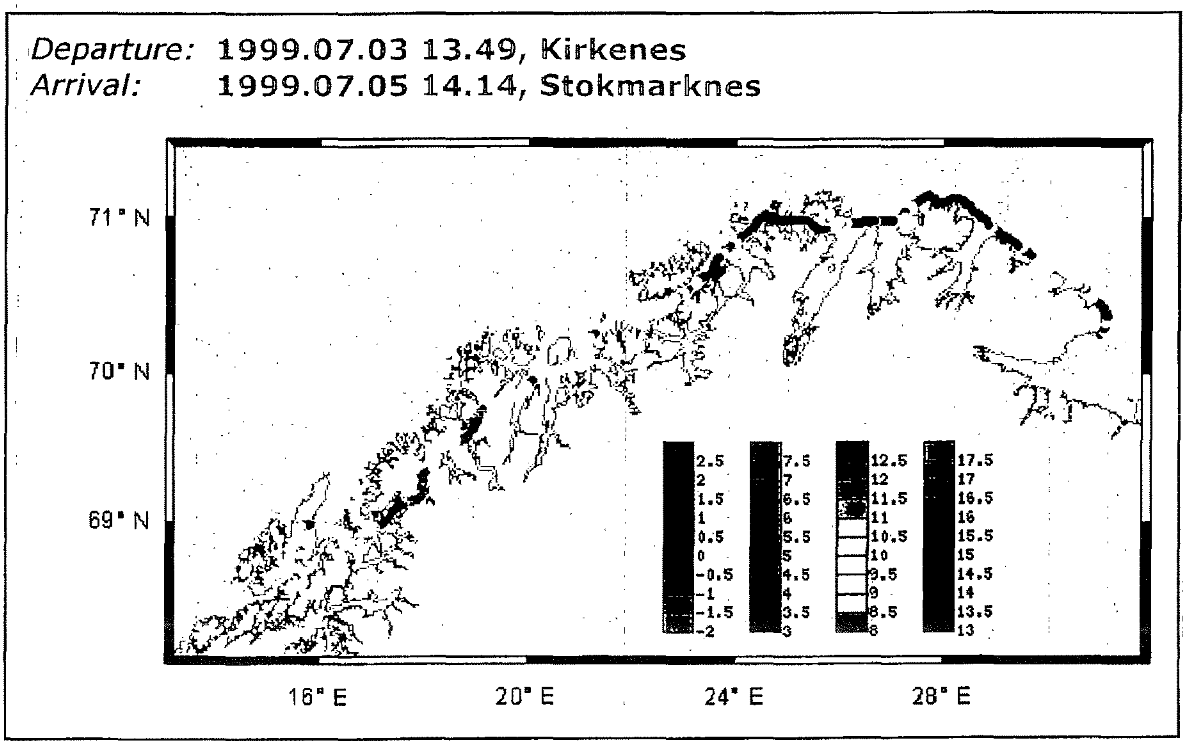

Fig.9: Temperature/ position plot from North Norway measured from Coastal Express ship M/S Lofoten and presented on Internet (wwwimr.no)

The future

The basic strategy for IMRs operational use of ships of opportunity and fixed hydrographic stations is to continue the long term series and to improve their performance. Immediate plans for ships of opportunity include automatic measurement of salinity, turbidity and fluorescence. After this continuous monitoring of nutrients, pollutants and plankton is planned.
The fixed hydrographic stations will be expanded to measure fluorescence in addition to salinity and temperature.
New satellite based communication systems will soon make it easy to communicate with instruments on board a ship. IMR has started a data communication experiment using the ORBCOMM two way satellite communication system. The OBBCOMM system uses 28 low orbit (LEO) satellites which cover most of the world. Data from a ship of opportunity can be loaded into a ORBCOMM compatible terminal which will transfer data to a satellite. The satellite relays data back to a ground station, and the ground station immediately sends the received message to the user`s email address.
When needed the user may return emails the instrument containing f. inst. new calibration coefficients, instructions to a connected device to clean the sensor surface or to change the sampling rate. Fig 10 shows the principle.

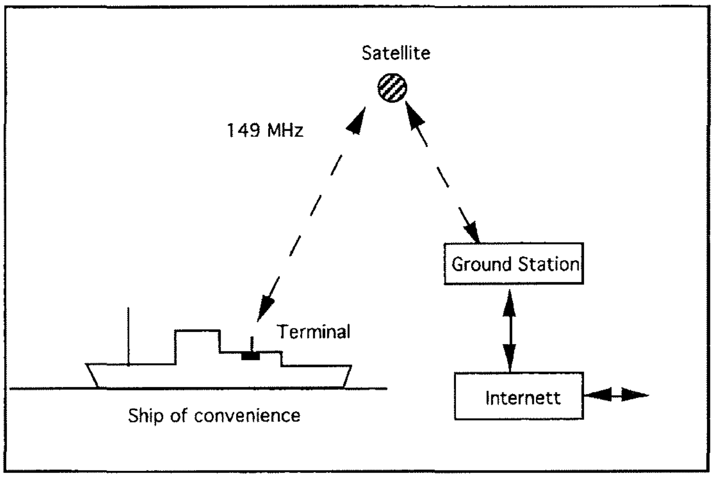

Fig.10 Satellite based communication via internet.
Data from recording instruments are formatted and sent to the system owner via satellite. The system owner will eceive the information as an email message.
Instructions to the instruments concerning calibration, cleaning, sampling rate etc. can be rrteturned via email.

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