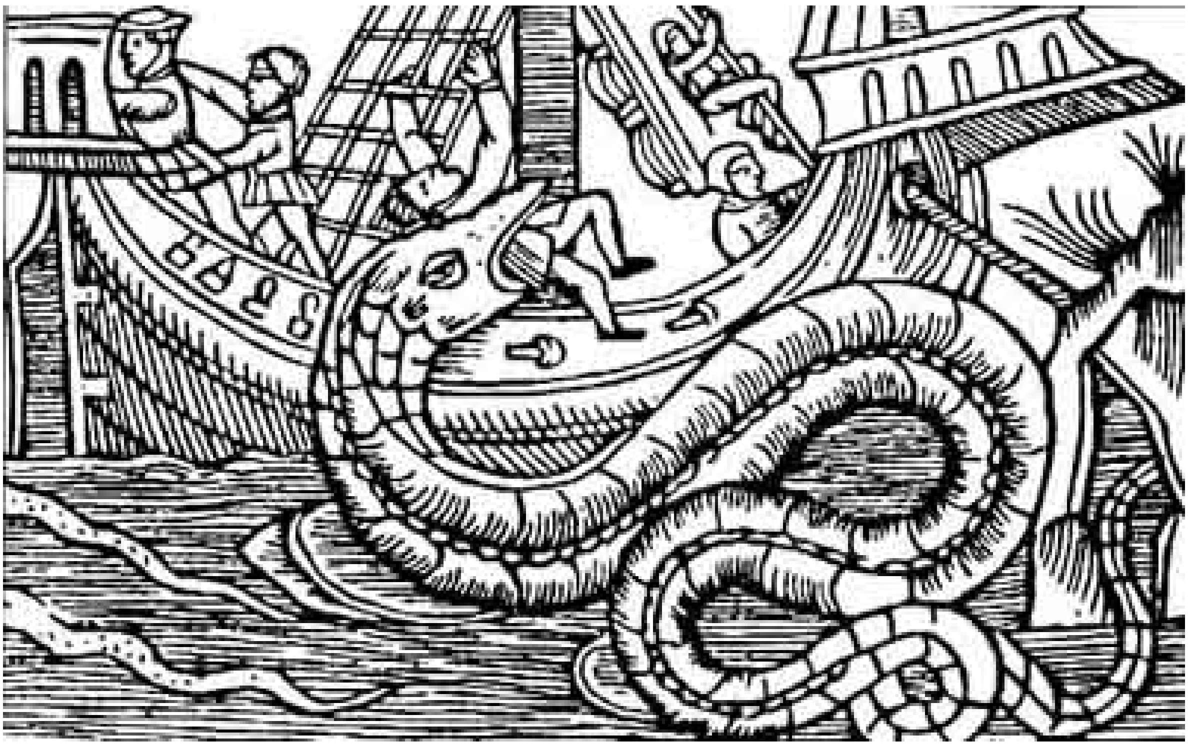
GEF 2610
ON R/V TRYGVE BRAARUD – PART II
19.03.2015

Program, presentation of results
Deadline Thursday 9. April



(From Olaus Magnus, History of the Nordic People, 1555)

Stations

Measurements will be taken at 1-3 stations: their locations will be chosen based on the the number of students. The students will be divided into groups and perform different activities. These activities are (1) to measure hydrography with the CTD instrument, (2) record the Secchi disk depth, incoming shortwave radiation and meteorological quantities, and (3) measure hydrography with the ST instrument (the "salinoterm"). The measurements will be repeated at the different stations, and the groups will then change instruments.

Hydrography

Salinity and temperature will be measured with the ST and CTD as a function of depth. Recordings with the ST are made at 0-1-2-3 m and so on down to 20 m.

Radiation, Secchi Disk Depth, Meteorological Variables

Downward irradiance (radiative energy flux) is measured by an irradiance meter mounted above the bridge.

The Secchi disk depth is the depth where a white disk disappears from sight. At the stations air and sea temperatures, air humidity, wind speed and direction (all recorded on the bridge), wave height, cloudiness and weather shall also be noted.

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NB!
All recordings will be left onboard. After the cruise the web page for the course will provide a link to the data.

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PROCESSING OF THE MEASUREMENTS AFTER THE CRUISE AND DESCRIPTION OF THE REPORT

The cruise report shall start with a description of the date and time for the whole cruise and for the stations with name of the areas of investigations. The stations shall be marked on a map. The report shall also contain the names of the research vessel, the crew, the teachers/instructors and the students.

Presentation and analysis of hydrographic measurements

The salinoterm (ST) measurements of the group shall be presented in a table, and shown in graphs as vertical profiles. Is there an upper mixed layer? If yes, how deep is it? What is the depth range of the transition layer (thermocline, halocline)?

What is the average difference between temperature recorded by the ST and CTD instruments within the upper 20 m? What is the same average difference for salinity?

Calculate from the CTD recordings the hydrostatic pressure at 30 m depth (or at another depth, chosen after the cruise). Estimate the total density as 1000 + sigma-t [kg m^{-3}], where sigma-t (=σ_t) is taken from the CTD data. Use $g = 9.82$ m s^{-2}. One station only.

Plot sigma-t as a function of S for the CTD data (one station only) from the upper 20 m. Try to express the average relationship by a linear expression.

Analysis of optical and meteorological measurements

Euphotic zone

A rather crude rule of thumb states that net photosynthesis/primary production will exist down to the depth *Z(1%)* where the quanta irradiance is reduced to 1% of its surface value (just beneath the surface). The quanta irradiance is often termed PAR (Photosynthetically Available Radiation), and it is usually assumed that the spectral range 400-700 nm contributes to the photosynthesis. The layer where a net photosynthesis occurs is termed *the euphotic zone* (the zone with good light).

It is easier to measure the Secchi disk depth D than to determine *Z(1%)* directly, and a statistical analysis of earlier results from the inner Oslofjord has shown that

$$Z(1\%) \approx 2.0\ D$$

$$\Delta Z \approx 0.7\ D$$

where ΔZ is the average error of Z(1%) estimated from D. How deep is Z(1%) according to your Secchi disk depth?

(The total irradiance incident at the surface of the sea has a spectrum from about 300 to 3000 nm. The shortwave part of this may be wavelengths less than 750 nm, and the longwave or infrared part wavelengths above 750 nm. The energy within the spectral range of the quanta irradiance (400-700 nm) will practically correspond to the energy of the shortwave spectrum. In air and just beneath the surface the shortwave radiation will contain about half of the energy of the total irradiance, implying that when we are at the 1% depth of the quanta irradiance we are also at the 0.5% depth of the total irradiance. This means that practically all incident radiation is absorbed in the layer above Z(1%).)

Shortwave radiation from sun and sky

The quanta irradiance Q_q (or PAR) is measured as the number of light quanta per area unit, and for our instrument the quanta irradiance unit is [µmol m^{-2} s^{-1}]. The ship sensor recording quanta irradiance has weakened through the years, and the reading should be multiplied by 1.13 to compensate for this.

When we want to calculate the heat effect of the irradiance, it is better to express it in physical units, as [W m^{-2}]. The incident shortwave irradiance Q_s in physical units can be obtained from the PAR value by multiplying it with the empirical factor

$$0.5\ (\mathrm{W\ m^{-2}})/(\mu\mathrm{mol\ m^{-2}\ s^{-1}}).$$

Altogether the value of Q_s in air is then related to the ship-sensor reading of Q_q by

$$Q_s = 1.13 \cdot 0.5\ Q_q\ \ (\mathrm{W\ m^{-2}})/(\mu\mathrm{mol\ m^{-2}\ s^{-1}}).$$

The value of the irradiance just beneath the surface is obtained from the value in air by multiplying it with a transmittance value for the air-water interface, corresponding to the solar altitude. The table below is valid for March 19th in Oslo:

Local time	8	10	12	14
Solar altitude	11°	23°	29°	26°

The irradiance Q_s transmitted to the water is then obtained from the value in air by multiplying it by a transmittance value interpolated from the table below:

Solar altitude (°)	5	10	20	30	40
Clear sky transmittance	0.60	0.73	0.88	0.94	0.96
Overcast sky transmittance	0.90	0.90	0.90	0.90	0.90

What is the value of Q_s just beneath the surface (0 m) expressed in W m^{-2}?

Longwave radiation

A practical formula for the *net received* longwave (infrared) radiation at the surface of the sea is

$$Q_b \approx -(143 - 0.9t_w - 0.46e_a)(1 - 0.1C)\left[W\,m^{-2}\right]$$

where t_w is the sea surface temperature measured in ºC, e_a is the relative humidity of the air measured in %, and C is the cloudiness measured in oktas. Usually Q_b will be negative and thus represent a *loss*. What is Q_b at the time of observation?

Heat conduction

The heat gain of the sea due to heat conduction can be approximated by

$$Q_h \approx -1.88\,V\left(t_w - t_a\right)\left[W\,m^{-2}\right]$$

where V is wind velocity in m s^{-1}, t_w is again the sea surface temperature in ºC, and t_a is the air temperature in ºC. If $t_w > t_a$, Q_h will be negative and represent a loss. What is Q_h at the time of observation?

Total heat budget of the upper layer

We assume that heat losses or gains due to evaporation, advection and vertical diffusion can be neglected, implying that the sum of $Q_s + Q_b + Q_h$ corresponds to the total heat budget Q_{tot} for the upper layer. What is Q_{tot}?

Transfer of kinetic energy to the sea

What is the energy transfer of the wind, expressed as

$$Q_{wind} = \rho_{air} c\, V^3$$

where $\rho_{air} \approx 1.3$ kg m^{-3}, $c \approx 1 \cdot 10^{-3}$ and V is the wind speed, expressed in units of W m^{-2}?