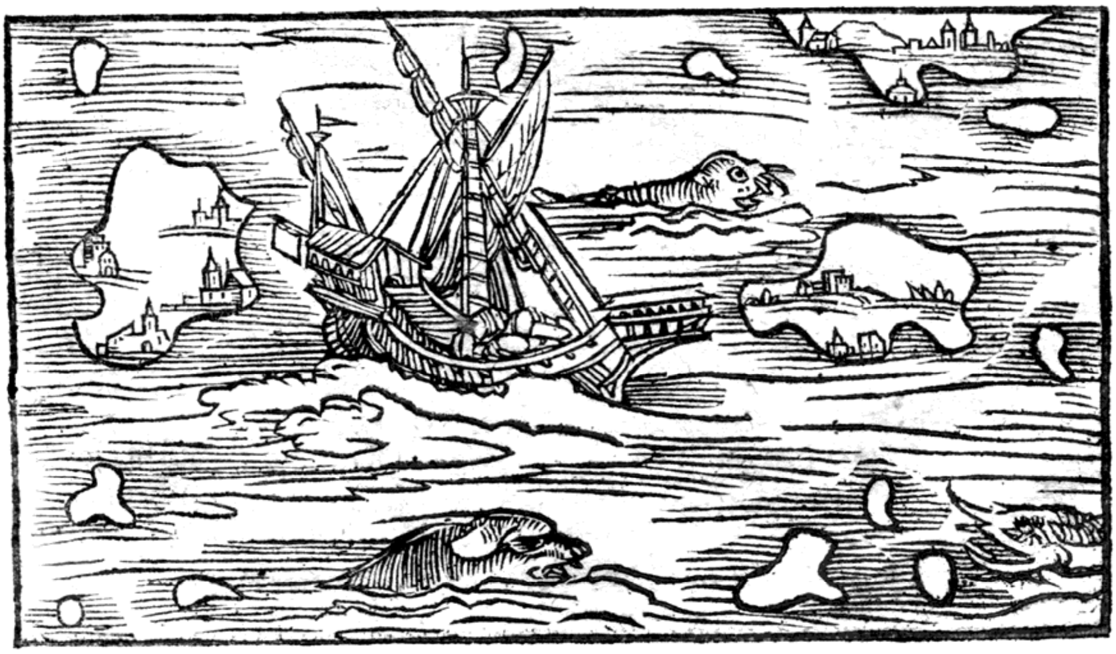
GEF 2610
ON R/V TRYGVE BRAARUD – PART III
16.04.2015

(Program, presentation of results)
Deadline Wednesday 29. April



Stations

Measurements will be taken at two locations: the first in Bekkelagsbassenget - Malmøykalven, the second in the mouth of Lysakerfjorden - Geitholmen ("Geita"). The students will be divided into two or three groups, depending on the number of students. The groups will do the CTD, measure hydrography by the ST instrument, read meteorological quantities and measure the Secchi disk depth and the incident shortwave irradiance (PAR) at different depths.

Hydrography

One group will measure salinity *S* and temperature *T* with the CTD as a function of depth (pressure).

Another group will record the same quantities with a salinoterm or ST instrument.

Meteorological Variables, Shortwave Radiation, Secchi Disk Depth

The air and sea temperatures, air humidity, incident irradiance (use the reference instrument mounted for this day at the bridge), wind speed and direction, Beaufort wind force, wave height, cloudiness and weather will be noted. Some of these quantities are displayed on the bridge and on the screen in the laboratory. The Secchi disk depth shall be observed and noted.

The downward irradiance (flux of light quanta) in the sea will also be measured with a quanta irradiance meter. Simultaneous irradiance measurements on deck (an irradiance meter mounted above the bridge) are used as a reference. The applied depths will be: air, 1 m, 2 m, 5 m, 10 m, 15 m, and 20 m.

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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. What is the depth range of the transition layer (thermocline, halocline)? Is there an upper layer that can be distinguished from the transition layer? How has the depth of the transition layer changed through February-March-April?

Calculate from the CTD recordings the hydrostatic pressure at 30 m depth at *both* of the stations Malmøykalven and Geitholmen. Estimate the total density as 1000 + *sigma-t* [kg m^{-3}], where *sigma-t* is taken from the CTD data. Use $g = 9.82$ m s^{-2}. What is the pressure difference at 30 m depth? If the surface is completely horizontal, which way will the current flow? In order to compensate for the pressure difference at 30 m depth, what must the sea level difference be between the two stations?

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).

All irradiance readings shall be normalized to the same deck value. This value should be representative for the whole recording. If the recording Q_q in water was obtained with a deck value of Q_{deck}, and if $Q_{deck,ref}$ has been chosen as the reference deck value, then the normalized irradiance value in water becomes $Q_{q,norm}=Q_q \cdot Q_{deck,ref}/Q_{deck}$. The surface 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 April 16th in Oslo (summer time):

Local time	9	11	13	15
Solar altitude	21°	34°	40°	37°

The irradiance Q_s transmitted to the water is 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

The quanta irradiance should be presented in a semilogarithmic graph as a function of depth (irradiance along the logarithmic axis and depth along the linear axis), and the depth *Z(1%)* should be determined.

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%).

It is easier to measure the Secchi disk depth *D* than *Z(1%)*, 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? How does it fit with your irradiance measurements?

How have the Secchi disk depths changed in the period from February to April?

Shortwave radiation from sun and sky

In our study here we shall analyze the contributions from shortwave and longwave radiation separately,

The quanta irradiance (PAR) is measured as the number of light quanta per area unit, and for our instrument the irradiance unit is [μmol m^{-2} s^{-1}]. 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 just beneath the surface can be obtained from the PAR value Q_q by multiplying it with the empirical factor

$$0.5 \text{ (W m}^{-2}\text{)/(μmol m}^{-2}\text{ s}^{-1}\text{)}.$$

What is Q_s at this depth (0 m) expressed in W m^{-2}?

This radiation will not continue diurnally, but around April 16 the diurnal integral may correspond to approximately 4 hours of the energy flux close to noon. What will be the diurnal contribution from the shortwave radiation Q_s to the upper layer in a horizontal square meter, expressed in Joule per square meters?

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?

How many Joules are lost diurnally from one square meter of water surface, based on the sea surface temperature, the relative air humidity and the cloudiness, provided these quantities remain constant?

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?

How large will the heat gain or loss due to conduction be per m^2, integrated over 24 hrs, if the wind velocity and the air and sea temperatures remain constant?

Total heat budget of the upper two meters

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

We shall further assume for simplicity that Q_{tot} is in total consumed by the upper two meters, and that this layer at all times is well mixed, so that there are no significant spatial temperature gradients. Calculate how much the temperature of the upper two meters will have changed after 24 hrs. For simplicity we assume in this case that the specific heat capacity of seawater is 4200 J kg^{-1} deg^{-1} and that the mass of one cubic meter of seawater is 1000 kg.

Transfer of kinetic energy to the sea

What is the transfer of kinetic energy by 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}?

What is the diurnal integral of this transfer in J m^{-2} if the wind remains constant?

Instruments

-The CTD is manufactured by Sea-Bird Electronics and the model is SBE911*plus*.
-The quanta irradiance meter is LI-COR quantum (PAR) sensor model LI-185B for the underwater measurements, and model LI-189 for the recordings in air.
-The salinoterm instrument is a Salinity Temperature Bridge Type M.C.5 produced by Kent Eil 5005.
-The Secchi disk is a standard disk of unknown origin.