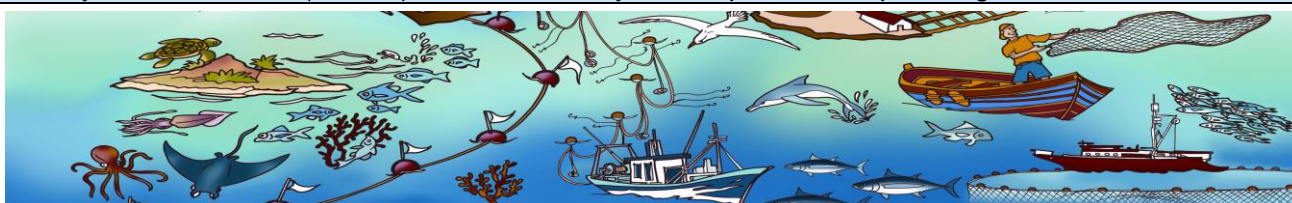
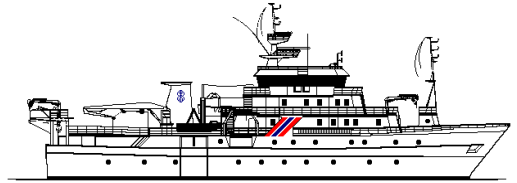


<b>Countries:</b> São Tomé and Príncipe and Nigeria				
<b>Research vessel:</b> R/V DR. FRIDTJOF NANSEN				
<b>Survey number:</b> 2011405				
<b>Number of days:</b> 19				
<b>General objectives:</b> Marine Environmental Survey of bottom fauna, selected physical and chemical compounds and fisheries survey in the Joint Development Zone between Nigeria and Sao Tome & Principe.				
	<b>Port</b>	<b>Date</b>	<b>Coverage</b>	<b>Specific objectives</b>
<b>Departure</b>	Tema, Ghana	9 May	São Tomé and Príncipe, Nigeria	<ul style="list-style-type: none"> <li>Establish what fisheries and sediment resources exist in the JDZ and their commercial value</li> <li>Perform environmental monitoring of the areas of the JDZ where petroleum activities have occurred with incidences recorded</li> <li>Conduct an assessment of fish, zooplankton and phytoplankton biodiversity in the JDZ</li> <li>Carry out an oceanographic and bathymetric mapping to improve knowledge and achieve date for map production: as well as an assessment of fish biodiversity in the JDZ</li> </ul>
<b>Arrival</b>	Tema, Ghana	27 May		
<b>Cruise leader:</b> Bjørn Serigstad				
<b>Participants:</b>				
<p><u>From JDA Sao Tomé &amp; Nigeria:</u> Louiz Gamboa, Akanbi Williams, Virginia Godinho, Samuel Iwu Jose Lopes, Ibrahim Buba, Eugenio Nascimento, Chindo Uche-Okeke, Ndubuisi Ajuonu</p> <p><u>From IMR :</u> Bjørn Serigstad, Magne Olsen, Tore Mørk, Jarle Kristiansen, Marek Ostrowski</p> <p><u>Uni Research AS, Norway:</u> Tor Magne Ensrud</p> <p><u>University of Bergen:</u> Frøydis Lygre</p>				
<b>Summary of the results:</b>				
<p><b>Oceanography:</b></p> <p>During the survey, a total of 17 hydrographic stations were occupied. At the 9 stations, CTD casts were extended to the bottom while at the remaining stations only the upper portion of the water column was covered, down to the 500 m depth. The bulk hydrographic stations were arranged along a straight-line section running along the eastern edge of the survey grid from northeast towards southwest. A typical distance between the stations along that section was 35 nautical miles. In the upper 150 m of the water column the T-S relationship varied strongly between the stations, resulting in the strong scatter in the upper part of the diagram. This area of the diagram, corresponding to the top layer of the water column, was dominated by Low Salinity Surface Water (LSSW), originated from the river runoff and local excess of precipitation over evaporation in the Gulf of Guinea. Although the temperature and salinity increased gradually with depth, this water mass maintained almost fixed spiciness signature of 5 kg m<sup>-3</sup>. The salinity maximum occurred in the depth range 50- 60 m. Its emergence marked a transition from LSSW to underlying it High Salinity Central Water (HSCW). The HSCW layer occupied the depth range of 60 – 800 m. This</p>				





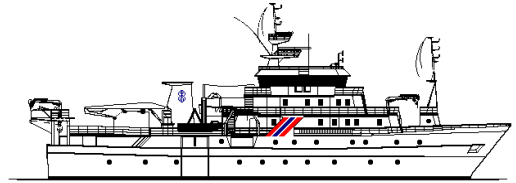
water mass is a major source of nutrients in the Gulf of Guinea. It originates at the sea surface in the subtropics and on its way towards the equator it subducts below the lighter tropical water. Between 800 and 1700 m, the T-S curve orientation changed to manifest a distinct layer, characterized by a constant temperature and varying salinity, associated to Antarctic Intermediate Water Mass (AAIW). This water mass originates to the south of the Southern Polar Front and propagates towards the equator below HSCW.

The hydrographic section extended over the distance of 230 nautical miles. All CTD casts below resulted in practically the same profiles in the depth range below 200 m. Above the 200 m; there was a gradual warming and freshening of the water column from the open towards coastal ocean. The change on the temperature and salinity distributions was not uniform. The warming trend occurred mainly in the upper part of the HSCW layer located just below the thermocline in the depth range of 35-100 m. In the top layer, the temperature oscillated between 28.3 and 29.3°C, but was relatively uniformly distributed across the section. The top 25 m of the water column on the salinity distribution were dominated by low salinity water originated within the Gulf of Guinea basin and along its lateral boundaries due to copious tropical precipitation and river runoff. There is a clear trend of a decreasing salinity in this layer from 34.2 at the oceanic boundary to less than 32.2 towards the Bay of Biafra. A very sharp halocline separates this low-salinity water from the salinity maximum,  $S > 36.2$ , associated to HSCW. This layer thickens from the open ocean towards the center of the section, suggesting that the inner Gulf of Guinea is likely to be the region of the highest sub-thermocline salinities in the Tropical Eastern Atlantic. The warming and freshening of the water column towards the inner Gulf of Guinea towards its continental boundaries, as indicated by data collected along the JDZ section, results in formation of the coastal ocean area that is lighter from the surrounding ocean. The potential density distribution illustrates this. The lowest density characterizes the water column at the north-eastern extremity of the section, located nearest to the Nigerian coast. The pool of the lighter is not confined to the surface layer, since as the north-eastward depression of isopycnals still observed at about 120 m. This isopycnal pattern would be favorable to cyclonic circulation, thus to north-westward ('into the page') flows across the JDZ section. The ADCP-derived currents were recorded continuously underway during this survey. From data collected along the survey tracks a continuous distribution has been obtained using statistical interpolation. Fig. 6 demonstrates the current distribution across the JDC Polygon at the depth of 60 m overlaying the salinity map at 5 m depth, derived from the thermosalinograph recorded concurrently to the ADCP. A weak southerly flow ( $V < 10 \text{ cm sec}^{-1}$ ) dominates the north-eastern sector of the survey polygon. Further south the flow is strong,  $40 \text{ cm sec}^{-1}$ , and its direction changes direction to westward. This results in the emergence of the flow component perpendicular to the JDZ hydrographic section, in agreement with the direction of the geostrophy-induced flows suggested by the density distribution.

### **Acoustics**

Multi-frequency acoustics at 18, 38, 120 and 200 kHz in conjunction with net sampling was used to study the composition and migratory behavior of mesopelagic fauna. While the results of net-samples are still under processing, the acoustic imagery has already provided some clues partitions on the main biota groups with respect to their diurnal behavior. As evidenced by the position of the scattering layers there are four major migratory behaviors: (a) animals staying in the top 50-70 m of the water column during day and night, (b) diel vertical migrants (DVM), consisting of animals that stay in the depth range of 250-350 during daytime and migrate to feed in the top layer during nighttime, (c) non-migratory animals that maintain the same depth range within the 200 m depth, both during the day and night, and (d) non-migratory fauna located below 400 meters. Interestingly, these partitions of migratory behaviors were coupled to the hydrographic





structure in the water column. The non-migratory biota (a) was found exclusively in the relatively warm and fresh tropical surface water (TSW) above the thermocline. The diel vertical migrants (b) resided below the oxygen minimum layer zone (OMZ) during nighttime, crossed the OMZ rapidly on their upward migration at dusk (16:00-17:00 UTC), remained in the top TSW layer during nighttime and descended to the depths below 350 m at dawn (04:00-05:20 UTC). The non-migratory scattering layers (c) and (d) kept their position within their respective depth ranges both during day and night. Note that the position of layer (c) was closely maintained immediately above the OMZ.

***Towards understanding the major environmental gradients and their consequences to oil spill disaster mitigation.***

The JDZ lies in the region of the equatorial current system. Those currents, unlike the current system at higher latitudes, have a persistent strong on- or offshore component. Having the future oil exploration in perspective, it is important to avoid locations of the oil platforms within regions of prevailing onshore flows. Such a location would have resulted with a major disaster to the coastal zone, had an oil spill occurred. In an attempt to avoid such miscalculated decisions at the prospection design stage it is therefore necessary to understand the major current patterns in the region. Although, some general knowledge on the flow patterns in the Gulf of Guinea may be learned from historical references, these old investigations are lacking both the spatial and timescale resolution necessary to support the engineering decisions. During the 2011 survey, no major eastward currents were observed within the pre-allocated JDZ polygon. The dominant flow was everywhere within this region oriented westward. However, additional underway data recorded during the vessel's transit to Sao Tome, indicated clearly that the region of a strong eastward current was located uncomfortably close to the JDZ. Note the eastward flow acceleration in the Principe – Sao Tome Channel. It manifests the core of Equatorial Undercurrent, which in the observed instance was found deflected just north of Sao Tome. The flow is subsurface intensified with the maximum speed at the 70 m depth. The core of this flow is relatively narrow – between 30 and 40 km. The observed position of this core is, however, not fixed. From historical observations the core of the Equatorial Undercurrent has been found at various positions within a 1-degree of latitude on both sides of the Equator, but the available data are scarce. The departures of this core into the zone defined as the JDZ cannot be fully ruled out on the basis of the available data. An emergence of this current within this zone, once the oil prospection has been established would have inherently increased the risk of shoreward transport of an oil spill.

While this may seem as the speculation at the present state of our knowledge, we propose that it should be one of the main roles of the future surveys with the RV Dr. F. Nansen to obtain sufficient data to understand the variability of the core of meandering Equatorial Current and to establish if this variability can increase the risk of shoreward transport of an oil spill.

**Report: status: final References:**

NORAD - FAO PROJECT GCP/INT/003/NOR. CRUISE REPORTS "DR. FRIDTJOF NANSEN" EAF – N/2011/5. Cruise Report "Dr. Fridtjof Nansen". **MARINE ENVIRONMENTAL SURVEY of bottom fauna, selected physical and chemical compounds and fisheries survey in the Joint Development Zone between Nigeria and Sao Tome & Principe. May 2011.** Bergen, November 2011

**Constraints/Comments:**



