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CDOM-HEAT - Source and transformations of Chromophoric Dissolved Organic Matter and its role in surface ocean heating and carbon cycling in Nordic Seas and European Arctic.

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Fram Strait Cruise Report

11th August – 12th September 2013

FS2013

CDOM-Heat Related Work

(supported by NPI monitoring, and Centre of Ice, Climate and Ecosystems (ICE))

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Physical and chemical oceanography

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Sea ice

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Helicopter team

20. Pilot, Airlift **(first leg only)**
21. Technician, Airlift **(first leg only)**

Cruise Outline

Since 1997 NPI has maintained an array of oceanographic moorings in the East Greenland Current at Fram Strait. This array has provided a long time series of observations with which to monitor the outflow from the Arctic Ocean. The main purpose of the 2013 Fram Strait cruise was to recover and redeploy the mooring array. All six moorings were recovered and redeployed as planned.

NPI has completed annual sections of CTD and conservative tracer measurements along 78°50'N since 1997. The zonal extent of sections varies from year to year, but the region between the 0 and W 010° (which includes the main outflow from the Arctic Ocean) has been sampled in every year. During the 2013 Fram Strait cruise a CTD section was completed between W 013° to E 008°. Samples were collected for analysis of $\delta^{18}\text{O}$, nutrient, coloured dissolved organic matter (CDOM), dissolved organic carbon-13 (DO^{13}C), dissolved inorganic carbon (DIC), total alkalinity (A_T), Iodide, Iodate and ^{129}I samples at most stations along the section.

A second CTD and tracer section was completed across the Norske Trough between N 77° 48', W 017° 30' and N78° 24', W 014 on the East Greenland Shelf. The primary purpose of this section was to study the circulation of warm Atlantic water within the Belgica - Norske - Westwind trough system. Atlantic water in the trough system is thought to cross the shelf before reaching the Greenland coast, where it interacts with the floating glacier tongues through basal melting.

Ice conditions were favourable along the 78°50'N section and the Norske trough section; wide leads, generally open drift ice and a predominance of small ice floes allowed the moored array to be recovered in good time and mostly during daylight hours. However this predominance of small ice floes (few exceeding 25 m in diameter) impeded the sea ice work requiring large ice floes.

Three days into the cruise on 13 August 2013, R/V Lance experienced a serious problem with the clutch between the engine and propeller shaft, which necessitated an immediate return to port in order to undertake repairs. All scientific personnel were put ashore in Longyearbyen on 14 August and R/V Lance returned to Tromsø for repair. Ten of the original scientific personnel were able to rejoin R/V Lance in Longyearbyen on 29 August 2013 and participated in the complete cruise. Nine of the original 19 participants were unable to rejoin the cruise (which was extended at short notice following the clutch failure) and did not have the opportunity to complete any scientific work. No helicopter was available to join the second leg of the cruise.

The locations of moorings deployed during FS2013 as well as the CTD and sea ice stations are shown in figure 1.

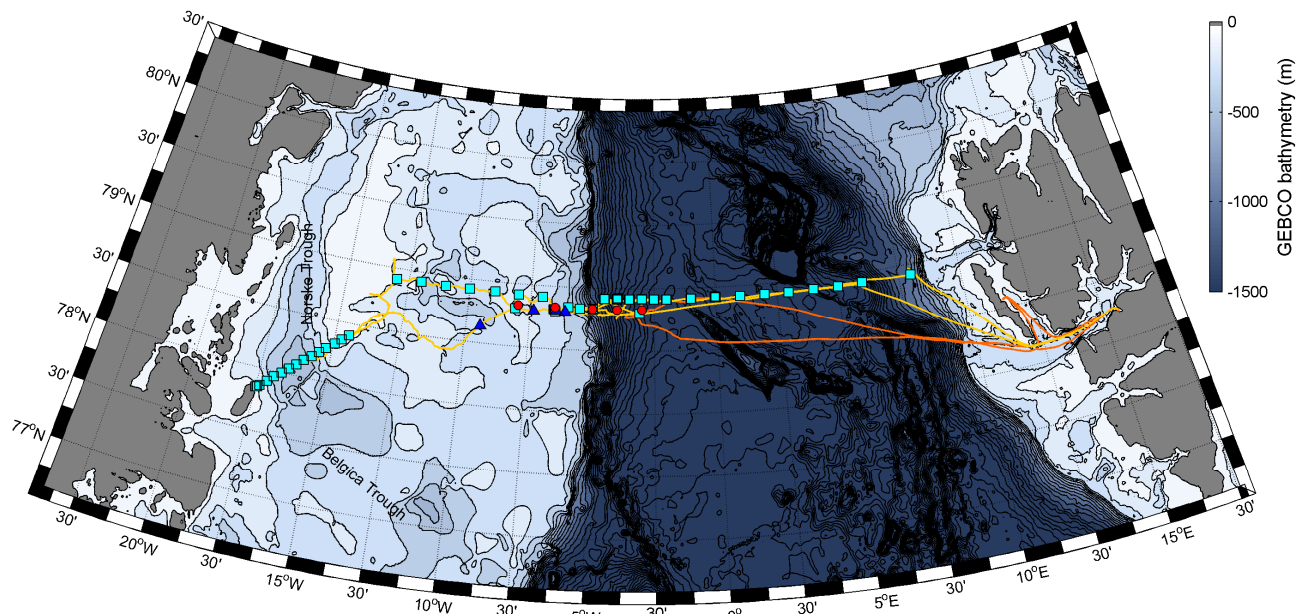


Figure 1. Chart showing the locations of major activities during the FS2013. Red circles indicate mooring positions; cyan squares indicate CTD, LADCP and tracer stations (including CDOM); blue triangles indicate sea ice stations. Bathymetric contours are drawn at 100m intervals. The ship track for the first leg of the cruise (up until the clutch failure) is shown in light orange. The ship track for the second part of the cruise is shown in yellowish.

Sailing Log

Date	Activity (all times UTC)
Saturday 10 August 2013	15:00 First meeting on board Lance CTD installed and made ready
Sunday 11 August 2013	15:15 Departed Longyearbyen (Bykaia) <i>Sailing towards geology camp on Prins Karls Foreland</i> 22:00 In place ready for helicopter operation. Bad weather. 23:30 Helicopter operation started after waiting 1.5 hours for visibility, but helicopter could not drop gear because of poor visibility
Monday 12 August 2013	03:00 Re-attempted helicopter operation. Success this time 05:00 Steaming at normal speed towards mooring array 19:25 CTD station 001 (W 00°02', N 78°56') 22:24 CTD station 002 (W 00°02', N 78°55')
Tuesday 13 August 2013	00:14 CTD station 003 (W 01°01', N 78°55') 03:18 CTD station 004 (W 01°59', N 78°55') 09:28 Begin searching for F11 on echo sounder 11:36 F11 released 12:30 Clutch failure. A temporary repair is made but Lance is forced to return to Tromsø via Longyearbyen. 14:00 (ca.) Helicopter pilot is airlifted to Longyearbyen with suspected

	<p>appendicitis. <i>Sailing to Longyearbyen</i></p>
<p>Wednesday 14 August 2013</p>	<p>17:00 (ca.) Arrived Longyeabyen (Bykaia) Scientific personnel put ashore 19:00 (ca.) Departed Longyeabyen (Bykaia). <i>Sailing to Tromsø</i></p>
<p>Thursday 15 August 2013</p>	<p><i>Sailing to Tromsø</i></p>
<p>Friday 16 August 2013</p>	<p><i>Sailing to Tromsø</i></p>
<p>Saturday 17 August 2013</p> <p>to</p> <p>Sunday 25 August 2013</p>	<p><i>Repair work in Tromsø</i></p>
<p>Monday 26 August 2013</p>	<p><i>Depart Tromsø (Eidkjosen)</i> <i>Sailing to Longyearbyen</i></p>
<p>Tuesday 27 August 2013</p>	<p><i>Sailing to Longyearbyen</i></p>
<p>Wednesday 28 August 2013</p>	<p><i>Sailing to Longyearbyen</i></p>
<p>Thursday 29 August 2013</p>	<p>10:25 Arrived Longyearbyen <i>Loading personnel and equipment</i> 15:00 Departed Longyearbyen <i>Sailing towards BPR at E 001° 12 ' , N 78° 55'</i></p>
<p>Friday 30 August 2013</p>	<p>03:40 Receiving data from BPR at E 001° 12 ' , N 78° 55' 16:36 CTD station 005 (W 03°05', N 78°48') 22:22 CTD station 006 (W 03°00', N 78°55')</p>
<p>Saturday 31 August 2013</p>	<p>01:05 CTD station 007 (W 02°30', N 78°55') 03:51 CTD station 008 (W 03°30', N 78°55') 06:17 CTD station 009 (W 03°60', N 78°55') 09:09 CTD station 010 (W 04°01', N 78°55') 11:16 CTD station 011 (W 04°30', N 78°55') 14:20 Began F11 deployment. Kevlar snapped during deployment. Lower portion of F11 recovered immediately.</p>
<p>Sunday 01 September 2013</p>	<p>01:15 F11 Deployed (correctly) 17:06 CTD station 012 (W 04°59', N 78°50') 19:18 CTD station 013 (W 04°59', N 78°50')</p>
<p>Monday 02 September 2013</p>	<p>00:06 CTD station 014 (W 05°30', N 78°50') 01:56 CTD station 015 (W 05°58', N 78°50') 08:25 CTD station 016 (W 06°33', N 78°49') 09:47 F14 Released 16:49 CTD station 017 (W 07°01', N 78°55') 23:26 CTD station 018 (W 08°01', N 78°55')</p>
<p>Tuesday 03 September 2013</p>	<p>06:21 F17 Released 09:15 F18 Released 09:46 CTD station 019 (W 08°06', N 78°48')</p>

	13:01 CTD station 020 (W 08°58', N 78°55') 15:31 CTD station 021 (W 10°00', N 78°55') 18:33 CTD station 022 (W 10°60', N 78°55') 21:02 CTD station 023 (W 11°60', N 78°55') 23:18 CTD station 024 (W 12°60', N 78°55') <i>Sailing to Norske Trough section</i>
Wednesday 04 September 2013	<i>Sailing to Norske Trough section</i>
Thursday 05 September 2013	<i>Sailing to Norske Trough section</i> 00:13 CTD station 025 (W 17°30', N 77°51') 00:55 CTD station 026 (W 17°30', N 77°51') 01:16 CTD station 027 (W 17°29', N 77°51') 01:38 CTD station 028 (W 17°27', N 77°51') 02:09 CTD station 029 (W 17°22', N 77°52') 03:09 CTD station 030 (W 17°08', N 77°55') 04:27 CTD station 031 (W 16°56', N 77°57') 05:58 CTD station 032 (W 16°40', N 78°00') 07:01 CTD station 033 (W 16°26', N 78°03') 07:58 CTD station 034 (W 16°12', N 78°05') 09:09 CTD station 035 (W 15°58', N 78°08') 10:32 CTD station 036 (W 15°42', N 78°11') 11:59 CTD station 037 (W 15°27', N 78°14') 12:56 CTD station 038 (W 15°13', N 78°16') 14:16 CTD station 039 (W 14°56', N 78°19') 15:17 CTD station 040 (W 14°43', N 78°22') 16:38 CTD station 041 (W 14°28', N 78°24') 21:30 Moored to large piece of glacial ice shelf to attempt ADCP calibration. 22:45 Calibration exercise terminated
Friday 06 September 2013	12:06 Ice station 1 (4 pax) 12:25 GPS buoy deployed 12:50 Ice station 1 completed 15:26 F14 Deployed 21:28 F17 Deployed
Saturday 07 September 2013	00:31 F18 Deployed 07:36 Ice station 2 (4 pax) 08:50 Ice station 2 completed 13:16 CTD station 042 (W 06°31', N 78°49') 15:26 F14 Deployed 17:15 ice station 3 (9 pax) 19:10 Ice station 3 completed 19:37 CTD station 043 (W 06°29', N 78°48')
Sunday 08 September 2013	07:35 CTD station 044 (W 04°59', N 78°50') 09:22 CTD station 045 (W 04°31', N 78°55') 11:18 CTD station 046 (W 03°59', N 78°56') 15:21 F13 Deployed
Monday 09 September 2013	06:35 Ice station 4 (7 pax) 10:40 Ice station 4 completed 12:40 Began deployment of F12 14:35 Deployed F12 at incorrect depth
Tuesday 10 September 2013	13:20 Recovered F12 21:36 F12 deployed correctly 16:58 CTD station 047 (W 03°31', N 78°55') 20:50 CTD station 048 (W 03°00', N 78°55')

Wednesday 11 September 2013	00:07 CTD station 049 (W 02°30', N 78°55') 02:44 CTD station 050 (W 02°00', N 78°55') 06:08 CTD station 051 (W 00°60', N 78°55') 09:22 CTD station 052 (E 00°00', N 78°55') 12:12 CTD station 053 (E 01°00', N 78°55') 14:59 CTD station 054 (E 01°60', N 78°55') 17:56 CTD station 055 (E 02°59', N 78°55') 20:48 CTD station 056 (E 04°01', N 78°55') 23:44 CTD station 057 (E 05°00', N 78°55')
Thursday 12 September 2013	02:31 CTD station 058 (E 06°00', N 78°55') 06:56 CTD station 059 (E 08°00', N 78°55') Sailing to Longyearbyen 18:00 (ca.) Arrived Longyearbyen

Tracer Sampling

Overview: Water samples were collected at standard pressures of 5, 15, 25, 50, 75, 100, 150, 200, 250, 400 decibar (approximately the same in meters) and at the bottom of each cast. Samples were collected in the following order:

1. Dissolved inorganic carbon (DIC) & Total alkalinity (TA)
2. CDOM (Filtered)
3. DOC (Filtered)
4. Nutrients
5. $\delta^{18}\text{O}$
6. Iodide / Iodate
7. Salinity
8. ^{129}I

Laboratory salinity analysis: Samples for laboratory salinity analysis were collected from all Niskin bottles. When the surface of the water column is strongly stratified, the salinity of water trapped in Niskin bottles can be significantly different from that measured by the conductivity sensor at the bottom of the CTD package, which is approximately 1 meter deeper than the top of the Niskin bottles. Independent laboratory salinity measurements give salinity measurements which correspond exactly to the other tracer measurements made from Niskin bottles. Laboratory measurements were made with a Guildline Portasal 8400b salinometer, which was standardized every 24 samples using P-series seawater supplied by OSIL.

Oxygen isotope ratio analysis and dissolved nutrient analysis: Samples for $\delta^{18}\text{O}$ isotope ratio analysis and dissolved nutrient analysis were collected at the locations listed in appendices 1 and 2. Note that samples for $\delta^{18}\text{O}$ and dissolved nutrients were always collected concurrently.

Coloured dissolved organic matter (CDOM): Samples for CDOM analysis were collected using a 0.2 micron Millipore cartridge filter through gravity filtration directly from the Niskin to sample vials (pre-combusted amber glass). Samples for $\delta^{18}\text{O}$ isotope ratio analysis and dissolved nutrient analysis were always collected when CDOM samples were collected. Samples were stored at +4C in dark, and shipped for analysis after the cruise.

Total alkalinity and dissolved inorganic carbon (A_T & DIC): Samples total alkalinity and dissolved inorganic carbon analysis were collected and kept at +4C in dark. Samples for $\delta^{18}\text{O}$ isotope ratio analysis and dissolved nutrient analysis were always collected when Total Alkalinity and Dissolved Inorganic Carbon samples were collected.

Iodide / Iodate: Samples for Iodide / Iodate were collected at a limited number of stations chosen so as to sample inflowing Atlantic water entering the Arctic Ocean as well as recirculating and return Atlantic water passing out of the Arctic Ocean.

^{129}I : Samples for ^{129}I were collected at a limited number of stations chosen so as to sample inflowing Atlantic water entering the Arctic Ocean as well as recirculating and return Atlantic water passing out of the Arctic Ocean. Due to the high cost of ^{129}I analyses, samples for ^{129}I were only collected at selected depths.

Niskin bottle operations: The rubber bands which hold the Niskin bottles closed were in good condition at the beginning on the cruise and did not require any attention during the cruise. All taps, valves and rubber seals on Niskin bottles remained in good working order throughout the cruise.

Mooring deployments

During the FS2013 a number of moorings were deployed. One of these moorings on the western side of Fram Strait, in the East Greenland Current, was equipped with CDOM-Heat CTD sensor with a CDOM fluorometer, this was deployed on mooring F17-10 at about 8 degrees West, which is the westernmost mooring location on the map in Figure 1..

Table 1: Moorings deployed during FS2013

Moorin g	Position	Depth (m)	Date and time (UTC)	Instrument	Serial #	Instrument depth (m)
F11-15	N 78° 48.4100', W 002° 58.0500'	2470	Deployed: 01 September 2013 01:15			

F12-15	N 78° 47.6720' W 003° 57.8600'	1873	Deployed: 10 September 2013 21:36			
F13-15	N 78° 50.0378', W 004° 59.5912'	1012	Deployed: 08 September 2013 15:21			
F14-15	N 78° 49.0115', W 006° 31.0877'	266	Deployed: 07 September 2013 15:26			
F17-10	N 78° 50.6103', W 008° 08.4930'	225	Deployed: 06 September 2013 21:28			
F18-9	N 78° 48.3092', 008° 04.6912'	217	Deployed: 07 September 2013 00:31			