Physical Oceanography Program

Jane Eert, DFO, Institute of Ocean Sciences, Sidney, BC

During the Frosti/BREA cruise, the physical oceanography programme was carried out in support of the fishing effort: to characterise water masses and oceanographic conditions such as upwelling or currents that might affect the habitat which the biota experience.

The 2012 program sampled on the shelf, over the shelf break and down to 1000m on the slope at the foot of the shelf break on two shelves: the wide Canadian Beaufort Shelf in the eastern part of the area and the Alaska Beaufort Shelf in the west. The two shelves are separated by the Mackenzie Trough, which is an area on intensified currents.

Upwelling along these shelves is of great interest both from a physical/chemical oceanography standpoint, looking at the flux of heat, salt and chemical components of the seawater in order to analyse circulation and water mass origin, but also from a biological standpoint since upwelling brings warmer, nutrient rich water up to the shelf where it can be more easily accessed by biota which prefer shallower water.

While in the previous studies carried out on the Nahidik, the Mackenzie River plume was a strong influence, we did not encounter the extreme brackish water (5psu salinity) that was seen during some of the Nahidik work. Minimum salinity seen was in the 18-20psu range. Typical on shelf profiles showed a mixed low salinity warm (8-11C) layer about 10m deep with an extremely sharp gradient leading to T,S values of 0C, 30psu only 10m deeper. Below this, profiles showed typical characteristics of Pacific winter water, Pacific summer water (often showing decreased beam transmission indicating particle in the watermass, and underneath, the relatively warm (0.5C) salty (>34PSU) Atlantic layer. The transition from Pacific to Atlantic layers was seen between 200 and 250m in most cases, with the exception of the 200m and 350m casts on the second section where there was a thick well mixed layer between 50 and 200m and the Atlantic layer was depressed.

Mackenzie Trough is a site of large amplitude upwelling that occurs when the alongshelf component of either the wind or the ice motion is towards the west. Although upwelling within the Trough is well documented, the location and flux of upwelled water onto the shelf is not. From numerical modeling of cross-shelf canyons, we expect that upwelling water crosses the shelf break either at the head of Mackenzie Trough or on its western side. Also on the western side is Herschel Island and a constriction in the bathymetry of Mackenzie Trough at this location causes the along-isobath flow to be much faster, possibly causing additional upwelling there and to the northwest.

Two high resolution sections using the underway CTD were carried out, the first across the shelf break on the Canadian Beaufort Shelf from 650m to 75m depth during a period following strong easterly winds which favour upwelling and the second across the Mackenzie Trough from east to west to a maximum depth of 345m. Both sections need to be analysed more carefully to draw any conclusions.

Regular CTD/rosette work was carried out at the main sampling stations: 7 on each of the 4 sections. When it was too rough to deploy the full rosette, a simple CTD was done using either the underway CTD or the backup Seabird SBE-19. When the rosette wqas used, water samples were collected to be analysed for salinity, barium, delO18 and DIC/alkalinity. See the report section covering primary production seawater sampling for more detail on these and the other water samples collected from the rosette.

CTDs:

Three CTD systems were used during 2012-44:

Primary CTD, installed in 24-bottle rosette: Seabird SBE-25, serial number 415
Backup CTD, deployed standalone: Seabird SBE-19plusV2, serial number 6009
Underway CTD: OceanScience UCTD, probe serials 0014 and 0108.

Primary CTD:

The CTD was mounted in a 24-bottle rosette, within a stainless steel frame with most external sensors also mounted in this frame. Exceptions were the Benthos altimeter and the Biosphericl/Licor underwater PAR sensors which were mounted to the rosette frame. A PDIM which was not used, was also mounted with the CTD in case it needed to be used without the rosette. Controlling the Niskins was a SBE-32 carousel water sampler. 24-10L Ocean Test Niskins (or equivalent) were mounted on the rosette, although 3 of these were removed to allow space to mount an ISUS nitrate sensor

Data signals from the SBE-25 ran through the carousel, through the conducting cable and slip rings at the winch and then through the seacable to the SBE-33 deck unit and an Acer laptop located in the bridge. The seacable was split at the bridge to provide connectors to both the deck unit for the CTD/rosette and for a Hydro-Bios MultiNet system which was also deployed using the conducting cable. Between their respective casts the CTD/rosette and MultiNet were disconnected from the conducting cable. An Evergrip electro-mechanical termination was used to support the CTD/rosette and MultiNet as well as connect to these instruments for real-time telemetry and data acquisition. The conducting cable was 1300m of Rochester .322 3-conductor armoured electro-mechanical cable. All 3 conductors were connected to the single wire needed by the two instruments.

Sensors:

- Temperature 4444
- Conductivity 3209
- Pressure (strain gauge) 0603
- Seabird SBE-43 Dissolved Oxygen 1202
- Seapoint Fluorometer
- Wetlab CSTAR transmissometer CST-1047DR
- Seapoint turbidity meter (OBS) 11074
- Biospherical/Licor PAR 20280
- Benthos Altimeter 41098

Standard deployment was to start acquisition of real-time data while to rosette was on deck to record the in-air pressure. Once in the water, the rosette was lowered to about 2m and soaked for 2 minutes. Decent to about 10m off the bottom was at approximately 0.8m/s. Since the ship did not keep station during casts, but rather drifted downwind, there were several casts with outboard wire angles of 10-15 degrees. Under these conditions, the rosette was stopped more than 10m off the bottom to avoid touching once recovery started. Niskins were closed on the upcast without stopping. Once on board, the Conductivity cell and DO sensor were rinsed with ship's reverse-osmosis water and the cell left full. Every 3 or 4 casts, the conductivity cell was also rinsed with dilute Triton-X to remove any film of oil. Samples for DIC, nutrients, bacteria, salinity, barium and delO18 were drawn directly from the Niskins. The remaining properties sampled for primary productivity were drawn in the lab below after the remaining water in the Niskins had been drained into carboys.

Sampling the rosette as the box core gets ready to go over.

We did 32 rosette casts, and took 384 Niskins.

Backup CTD:

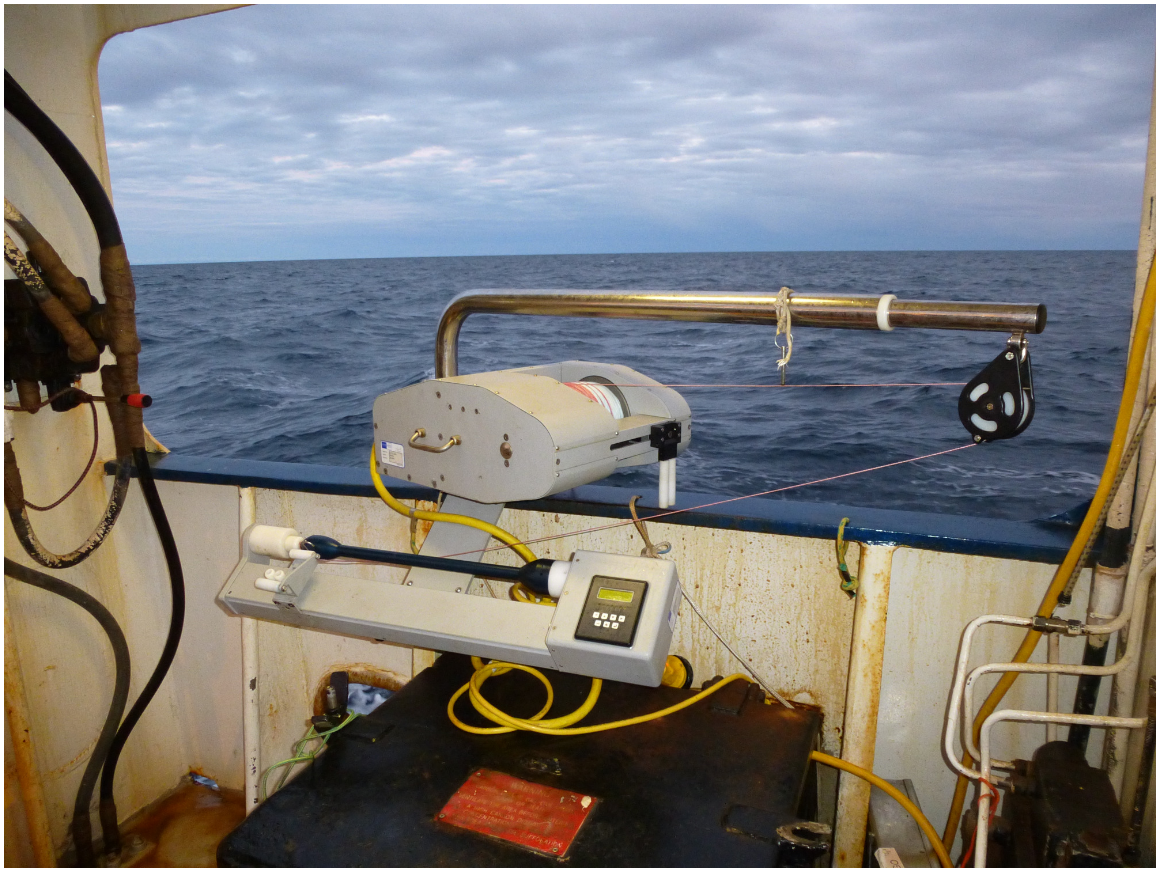
Sensors:

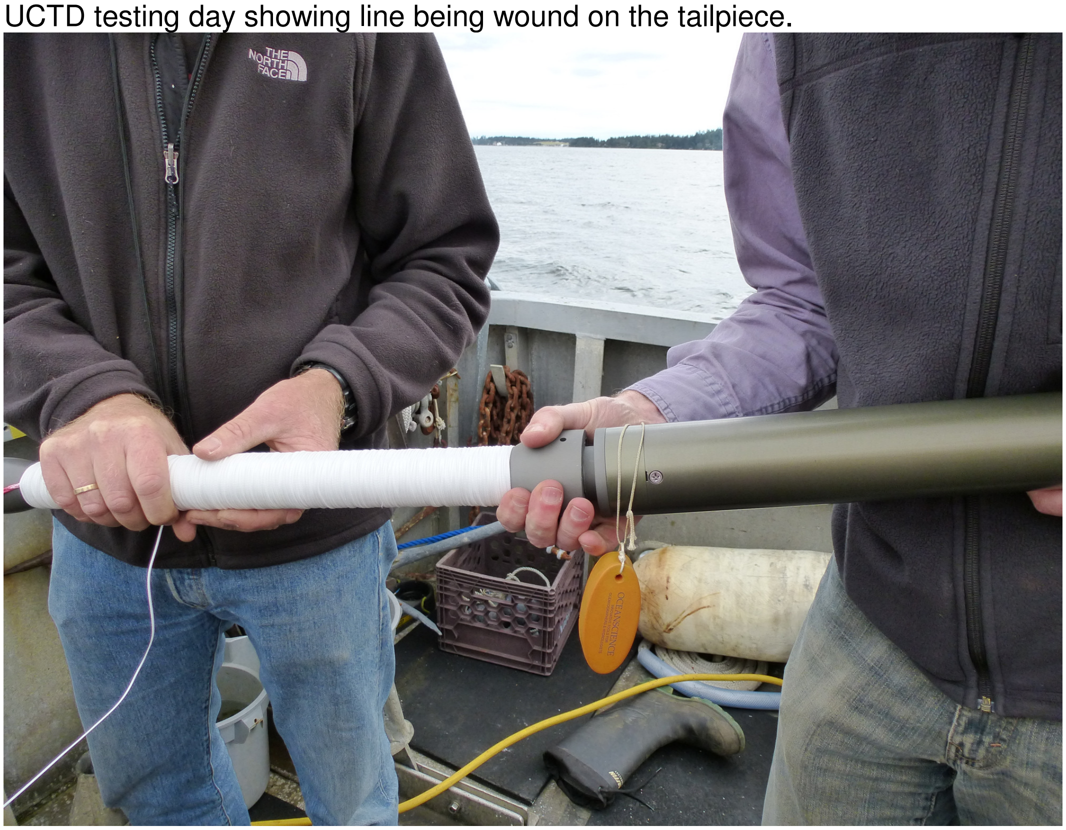
- Temperature 6009
- Conductivity 6009
- Pressure (strain gauge) 3646386

This CTD was deployed from the dead wire, weighted below by a large shackle. The CTD was turned on once it left the deck and soaked just below the surface for 2 minutes. Descent was at the same speed as the primary rosette, but without live data on how far off bottom it was, conservative wire out values were used. As a result, several of these casts stop more than 30m off bottom, particularly when there were significant outboard wire angles. This CTD was used for the last few casts where it was too rough to deploy the primary CTD/rosette, replacing the underway CTD after its power supply got wet.

We did 7 casts with the backup CTD

Underway CTD:


UCTD installed on the port side of the Frosti with tailpiece installed in the rewinder, ready to wind line.

UCTD testing day showing line being wound on the tailpiece.


Connecting the tailpiece, wound with line, to the CTD probe.

This CTD/winch system, made by OceanScience in Oceanside, CA consists of a Seabird FastCat CTD (sampling rate 16Hz) installed in a torpedo-like shell, and attached to 500lb test Spectra line by way of a .75m long tailpiece. In normal use, the UCTD is deployed while the ship is moving, anywhere up to 13kts, although the faster the ship moves, the less depth can be reached by the CTD. Before deployment, a target depth is chosen, and this amount of spectra line is wound on the tailpiece. Once the probe is in the water, line unwinds from the tail, letting the probe fall vertically from its point of entry. Line also spools out freely from the winch on board; this line stays near the surface until recovery starts. Depths reached are determined by the time of fall – the probe descends at 3.5-4m/s in free fall. We used 2 probes during the cruise, serial numbers 0014 and 0108. Early deployments were done with the ship stopped (drifting downwind) but after several instances of the probe reaching depths that were greater than intended (in an unpredictable fashion), we changed to deploying the probes only when under way except for very deep casts where the probe would not get near the bottom. Deployment in less than 50m depth was also uncertain and deployments were restricted to greater than this depth.

We collected 54 UCTD casts

Issues in 2012:

- Items damaged:
    1. The connector on the Seapoint Optical BackScatter turbidity meter (OBS) leaked during the first 8 casts and when examined, the power pin had corroded off.
    2. The power supply for the UCTD was submerged on August 21 when several waves came on board over the stern and shorted out at least one component on its circuit board. Despite an appearance of waterproofness, the Pelican case for the supply is not and should be installed in a place where it will get no more than spray.
    3. UCTD probe 0014 had not been updated to the latest firmware and still had a bug in its calculation of temperature that had been noticed as early as 2009. Temperatures below -1C were reported as 63C or higher; fortunately there is a post-processing formula available to correct these miscalculated values. Once probe 108, with up-to-date firmware, was in use, there was no need for this corrective stop.
    4. UCTD probe 0014 hit mud 3 times and then stopped giving realistic conductivity readings. It needs to be returned to OceanScience/Seabird for repair.
    5. The bulkhead connector on the altimeter was damaged during disassembly of the rosette – the Seacon connector was extremely difficult to remove and the pins got bent and a chip taken out of the base in the process.
    6. Niskin bottle 5 was gouged – probably by chafing against a line. Not sure if it needs repair. The top cap on Niskin 4 (finally installed at position 24) was gouged by chafing against one of the sheaves on the northbound transit. Several other Niskin bottles on this little-used rosette came with loose spigots that could not be made watertight by replacing the O-rings.

- The OceanScience underway CTD specifies that it uses a 30A 120V AC supply; this was not available on the Frosti. However the system was powered successfully off a 15A 120V circuit without blowing any fuses until the power supply was damaged.

- A Biospherical/Licor Surface PAR sensor was installed above the bridge and the cable run down through a bridge window to the back of the SBE-33 deck unit. This cable was the source of noise in the CTD records until August 18 when it was unplugged.
- Running the CTD serial feed from the deck unit to the PC via a Keyspan/Tripplite 4-port USB-serial converter resulted in blue screens every time. This may have been the cause of the blue screens seen on the Acer laptop during the sea trial. The solution was to run the CTD serial feed in through an IOGear single-port USB-serial converter. The carousel feed remained on the Keyspan and caused no problems. NMEA was fed into the PC via another IOGear converter.
- Seasave did not correctly interpret the NMEA sentences after August 18 when deck units were swapped and the NMEA feed was routed through GPSGate so that it could supply both Seasave and OziExplorer. This remains a mystery, worth looking at when setting up in 2013.
- The SBE-25 CTD had ongoing issues with data errors. Three main causes were: the above-mentioned noise on the SPAR feed, low batteries in the CTD, and poor signal along the conducting cable when it was stressed. Batteries were replaced three times during the cruise, on August 11, August 18 and September 1. The winch cable was reterminated three times, on August 6, August 12 and August 22.
- One consequence of the data errors is that the paper and electronic records of bottle closings differ significantly for the 6 casts 48-143 and the first half of cast 149. The electronic record shows bottles closing as much as 30s after the intended depth/time. This will have to be sorted out from the bottle salinity analyses. The electronic record shows as many as 4 of the last bottles closing after the rosette was out of the water, but we sampled these Niskins normally, so I suspect the electronic record is incorrect.
- Nine of the Niskins had round-ended top caps instead of the more commonly seen flat-bottomed caps. These caps seal well when closed, but were difficult to cock – it took 2 people for some of the tighter bottles, especially when the rosette was being prepared in the tight quarters of the catwalk. Also due the tight quarters, it was difficult to keep the spigots pulled out when crew had to work right next to the rosette during deployment.
- The ISUS nitrate meter was never used. The battery case was mounted after the second rosette cast, but ongoing difficulties with the CTD/rosette system interfered with inventing a way to safely mount the instrument in the rosette when the expected mounting location turned out to be infeasible. Given the history of temperament of the ISUS it would have been one more thing to try and get going when the core equipment was already giving trouble.

For 2013:

The physical oceanography programme was well supplied with equipment for 2012, with backups for most of the primary systems. One notable exception was an Auto-fire module (AFM) for the rosette; if we had lost real-time telemetry via the seacable-slipring-conducting winch cable system then we would have been unable to take water samples. Having an AFM on board would give the ability to close Niskins even using a dead wire. Another item that would complement this is a 38KHz acoustic pinger which could be attached to the rosette or CTD so that distance off bottom could be accurately gauged using the ship's sounder. Given the tough environment for the conducting cable (sharp bends, no heave compensation, no station keeping, occasional sharp yanks, less than perfect spooling) it would be a good idea to be prepared to carry out water sampling on a dead wire.

Spare sensors should be sent where possible; it would have been useful to have a spare OBS to replace the one that failed and an extra fluorometer to check unusual readings. The same applies to the other sensors that did not fail in 2012 but might well in another year.

Thorough maintenance is needed on the conducting cable and its winch. The cable should be lubed in consultation with the IOS winch shop. The spooling gear should be serviced as there are crossovers in the cable as currently spooled and it was not possible to remove these during regular casts.

Items to be added to the packing inventory:

- Dummy connectors for all CTD auxiliary sensors in case they need to be removed.
- Extra spare USB-serial converters (2 is not enough)
- Calibration coefficients for all instruments, not just those supplied by IOS (the Wetlabs fluorometer that came with the FWI CTD had none)
- Mounting bracket for PAR sensor on rosette
- Mount for ISUS

The 24 bottle rosette is very large for the space available for storage and sampling. If the water chemistry programme could be designed to efficiently use a 12 bottle rosette, the equipment would be less subject to damage and the samples easier to take without risk of contamination from nearby objects. Whatever rosette is used, the Niskins should all have the type of spigots with a metal pin which can be locked from accidental opening.

It would be really useful to have a dedicated dry piece of work bench with stowage for tools and parts nearby so that repairs and maintenance can be done while other activities are occurring on deck. This may well be an impossible ideal on the Frosti.