Upper ocean profiles in the Beaufort Sea using the SBE 19+

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1 Motivations

During the 2007 *Louis S. St-Laurent* cruise in the Canada Basin, Sarah Zimmermann brought a little SBE19+ CTD along, so that we would be able to make short casts by hand on the ice and whenever the opportunity would present itself. In particular, we are curious to see how different the upper few meters are if you take a profile right next the the ship (like the CTD rosette), or further away from ship's hull. Similarly, is the profile under the ice any different than in an open lead? All the data recorded in 2007 were taken where and when we had an opportunity. The zodiac trip from Aug 21 is a slightly more systematic study - just over an hour of doing profiles of the upper 40 meters at estimated distances from the ship, and from the ice edge.

2 Overview of data collected in 2007

05 August 2007: Vertical profiles in a small lead from the zodiac, at the station CB-3. Profiles near the ice (1 cast), right next to 2-m thick ice (4 casts), in the middle of the lake (1 cast), and next to the ship (2 casts). 73° 59.07' N 149° 58.56' W.

07 August 2007: Vertical profiles in a small lead from the zodiac, at the station RS-02. Profiles right next to 0.3-m thick ice (4 casts), in the middle of the lake (3 cast), in the middle of the lake next to a small ice floe (6 casts) and next to the ship (2 casts). A couple of horizontal tows. Look at the impact of the bubbler. 75° 39.56' N, 156° 18.3' W.

11 August 2007, 20:27: One vertical profile from the middle of a 3.49 m ice floe, at the location of the first ITP deployment (ITP-8) deployment. 79° N, 152° W.

13 August 2007, 18:45: Profile from the ship during deployment of WHOI mooring B.

13 August 2007, 20:59 and 23:30: 2 profiles from the middle of a 3.10 m thick ice floe where the first Ice Based Observatory was deployed. 78° 01' N, 149° 12' W.

16 August 2007, 17:07: 2 profiles from the middle of a 3.05 m thick ice floe at 78° 56' N, 139° 58' W. where the second Ice Based Observatory was deployed

18 August 2007, 17:39: Profile from the ship during deployment of WHOI mooring C.

20 August 2007, 15:18, 15:34: Vertical profiles near ice floes in a lead from the zodiac. Quite a bit of ice - some floes with dirty ice (we went out to collect samples).

21 August 2007, 09:19: SBE19+ mounted on the rosette for a 300-m cast for Jen Jackson (CB-17).

21 August 2007: A series of 17 profiles to 40-m from the zodiac during station CB-18. Near the ship (with and without bubbler), near the ice, and away from both.

26 August 2007: A series of 7 profiles to 40-m from the zodiac during station A. Start near the ship and progressively gets further. A couple of casts near large old ice floes.

Note: times are in UTC, from the SBE19 itself (cast data).

3 05 August 2007, from the zodiac

These casts were taken during the deployment of a XCP during station CB-3 by Luc. Four files:

- **2007_08_05 cast 1.hex** 19:02. One profile to 35 m, about 20 meters from the ice edge.
- **2007_08_05 cast 2.hex** 19:09. A series of 4 profiles (2 to 20 m, 2 to 7 m), within 0.5 meters from the ice edge (about 2-m thick ice).
- **2007_08_05 cast 3.hex** 19:19. One profile to 35 m, one to 8 m, in the middle of the lake, about 50 meters from the nearest ice.
- **2007_08_05 cast 4.hex** 19:24. One profile to 40 m, one to 15 m, within 0.5 meters from the ship's hull.

See Figure 1.

4 07 August 2007, from the zodiac

These casts were taken during the deployment of a XCP at RS-02 (Northwind Ridge South line) by Luc and Jen. It was a summy day, no wind, and warm. Eleven files:

- **2007_08_07 cast 01.hex** 07 Aug 23:47. 2 casts (30m, 18m) about 20 meters from the ice edge, after the deployment of the XCP.
- **2007_08_07 cast 02.hex** 07 Aug 23:51. 4 casts (30m, 30m, 10m, 10m) about 20 cm from the ice edge. The ice was very thin: no more than 0.5 m. 75° 39.56' N, 156° 18.3' W.
- **2007_08_07 cast 03.hex** 07 Aug 23:58. 1 profile (20m) away from the ice.
- **2007_08_07 cast 04.hex** 08 Aug 00:03. Dragged along the surface just below a very thin (0.5 cm) layer of new ice. Ouch. Never really got close to the ice, but went towards it.
- **2007_08_07 cast 05.hex** 08 Aug 00:04. Similar to previous file, but 1m below the surface.

  These two casts seemed to work (there is both horizontal and spatial variability), but we would need to record GPS and do straight line to see if there is something that makes sense - warming towards the ship, or cooling towards the ice. These two casts are not plotted here, as the route was quite random.
- **2007_08_07 cast 06.hex** 08 Aug 00:24. 2 casts (40m, 20m) right next to the ship, where the CTD rosette goes in the water, about 2 m from the hull. 75° 39.960' N, 156° 18.1034' W.
- **2007_08_07 cast 07.hex** 08 Aug 00:34. 2 casts (30m, 20m) right next to a little ice flow (1-m thick) in the middle of the lake. Waiting for the bubbler.
- **2007_08_07 cast 08.hex** 08 Aug 00:42. Yoyo casts (30m, 5×20m), right next to a little ice flow (1-m thick) in the middle of the lake. Waiting for the bubbler.
- **2007_08_07 cast 09.hex** 08 Aug 00:45. Casts (40m, 10m) on the edge of the white water while the bubbler is going on.

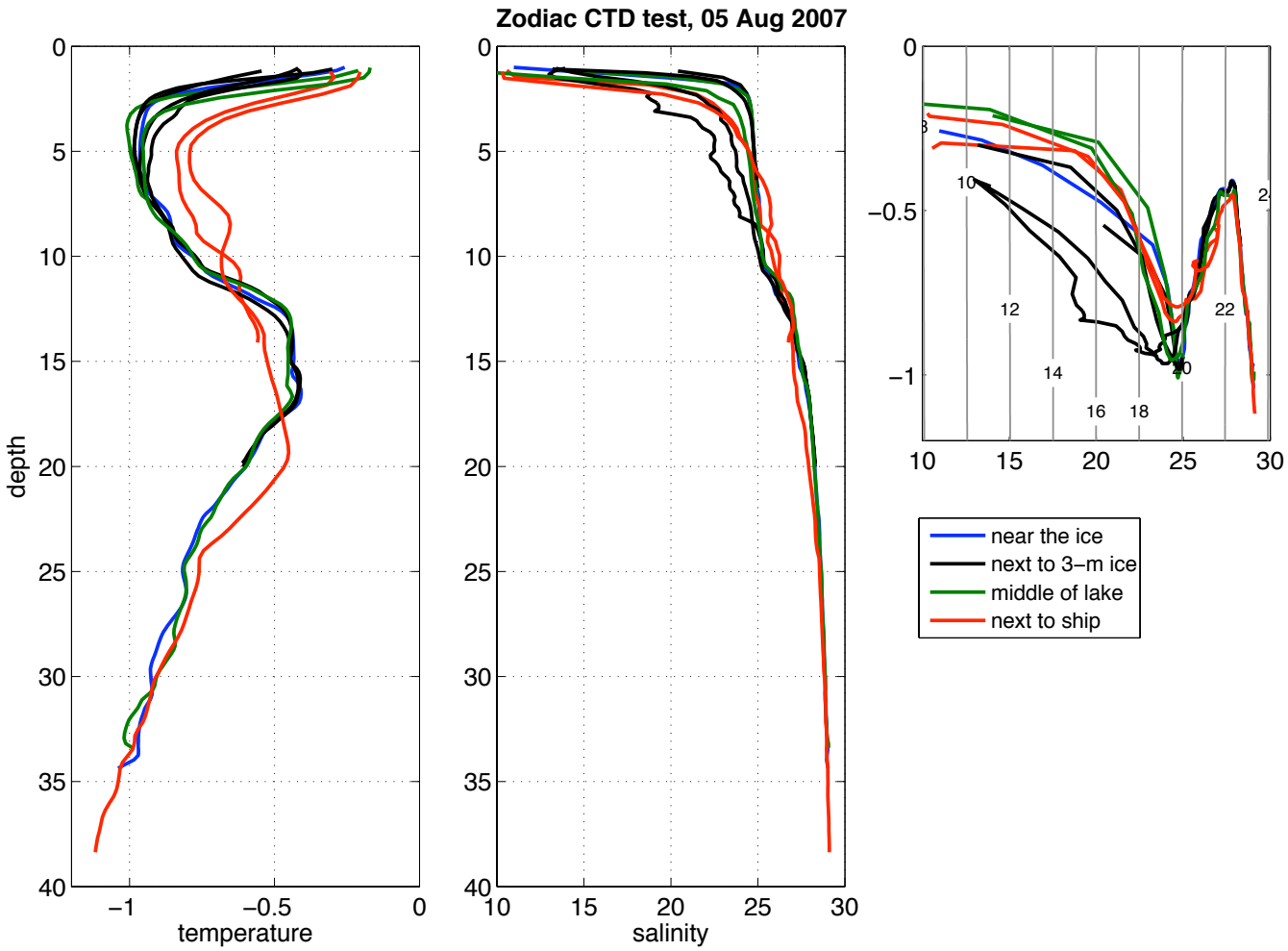

Figure 1: Profiles from Aug 05. Temperature maximum between 10 and 15 meters very obvious. The profiles around the little lake are similar, for the upper 25 m except near the ship. Interestingly, the TS diagrams are all similar. The profile near the ship could be consistent with some amount of vertical mixing. Away from the ship, the profiles get a little cooler as you get closer to the ice edge - more pronounced temperature minimum and the top few meters are slightly cooler too. Potential density is contoured (σ_θ) in the TS diagram.

- **BUBBLER WAS ON FOR 3min 45sec**
- **2007_08_07 cast 10.hex** 08 Aug 00:48. Bubbler off, cast (40m) where the CTD goes in the water.
- **2007_08_07 cast 11.hex** 08 Aug 00:50. Bubbler off, cast (40m) where the bubbles were maximum.

See Figures 2 and 3.

5 Under ice profiles

- **ITP_deployment1.hex**: 11 August 2007, 20:27. One vertical profile by Rick Krisfield at the location of the first ITP deployment (ITP-8), on a 3.49 m icefloe at 79° N, 152° W. *The data don't look very good. Maybe the pump had ice in it.*
- **ITP_deployment2_[1-3].hex**: 13 August 2007, 20:59, 21:39, and 23:30. Profiles by Luc from a 3.10 m thick ice floe where the first Ice Based Observatory was deployed. Two good profiles: one from the hole for the

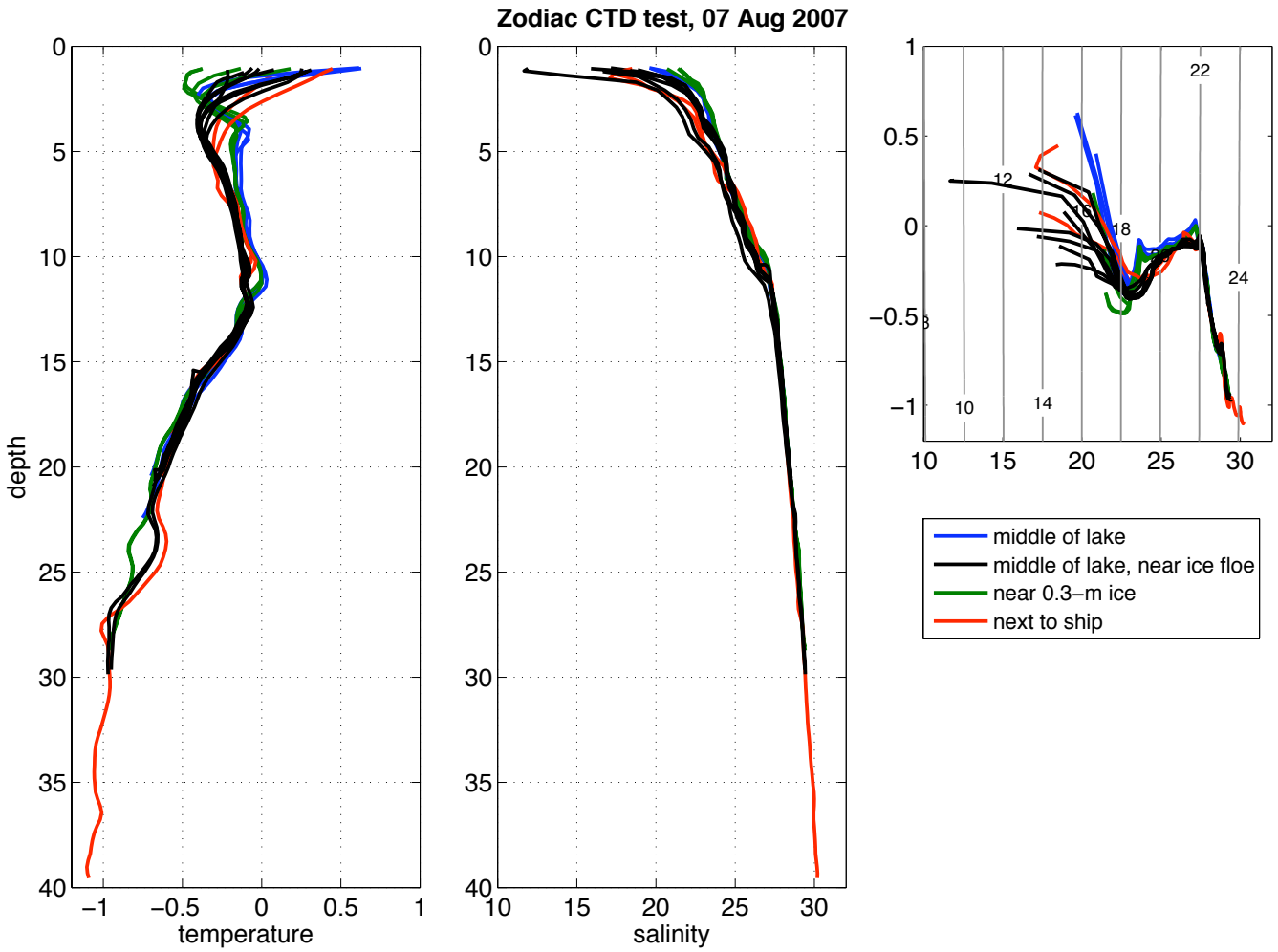

Figure 2: Profiles from August 07. There seems to be more variability here, but it's similar to the previous casts. The profiles right next to the ship are a little smoother in the TS space. Profiles next or close to the ice are a little fresher and cooler. Temperature maximum between 10 and 15 meters is obvious, but less so than on Aug 05.

ocean flux buoy, and the other from the ITP (ITP-13) hole. 78° 01' N, 149° 12' W. The ice thickness at the AOFB was 3.20 m. There are 3 files from this day: 2 have good profiles (20:59 - AOFB hole - and 23:30 - ITP hole) and the other one is a very short cast through the first hole we drilled for the ITP, which happened to have an ice ledge a couple of meters below the bottom of the hole.

- **ITP_deployment3.hex**: 16 August 2007, 17:07. Two sequential profiles by Luc from a 3.05 m thick ice floe at 78° 56' N, 139° 58' W. where the second Ice Based Observatory was deployed (and ITP-18). The ice thickness at the AOFB site was 2.78 m.

See Figures 4 and 5.

6 Profiles from the ship

This is a series of profiles that we should use to compare what the CTD rosette measures to what we did from the small SBE 19+. Note that the most of the zodiac tests also contain profiles that were taken right next to the ship - they are not repeated here.

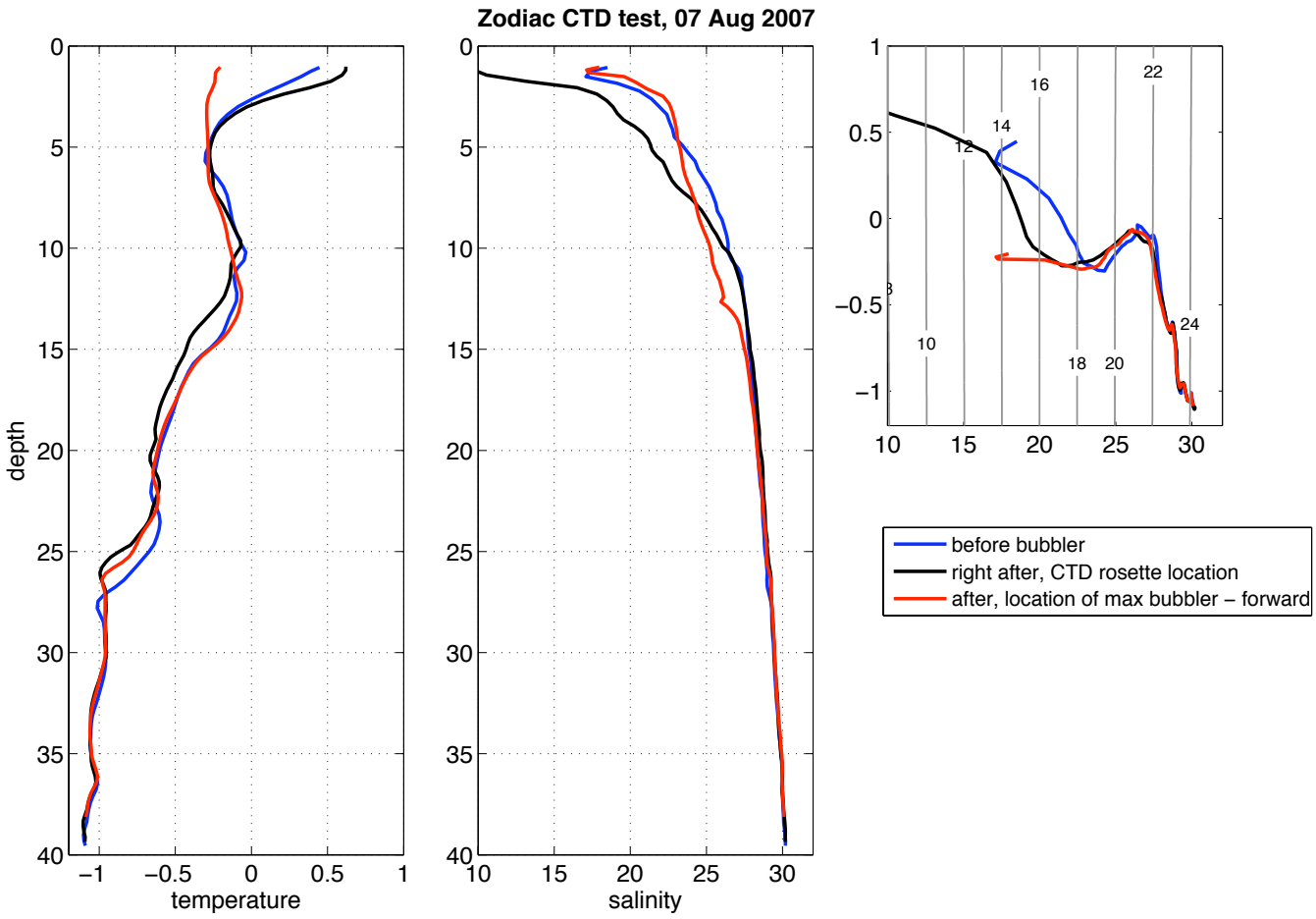

Figure 3: Bubbler test on Aug. 07. This is a little strange, but I guess it makes some sense: here I don't show the first meter (data not great quality), which is very fresh. It seems that very fresh water is mixed by the bubbler, freshening the water column to 10 meters where the CTD is, and up to 15 meters at the location of the maximum bubble action. Temperature is strongly mixed in the upper 15 meters for that last profile.

I haven't looked at the rosette casts yet.

- **Aug13_MooringB.hex**: 13 August 2007, 18:45. Profile from the ship during deployment of WHOI mooring B. Done by Sarah and Motoyo.
- **Aug18_MooringC.hex**: 18 August 2007, 17:39. Profile from the ship during deployment of WHOI mooring C. Done by Sarah and Motoyo.
- **Aug21_rosette.hex**: 21 August 2007, 09:19. SBE19+ mounted on the rosette for a 300-m cast for Jen Jackson (station CB-17). Setup by Mike.

7 20 August 2007, from the zodiac

These casts were taken during short trip to go collect dirty ice with Jenny Hutchings. Cloudy and humid (fog). General position is 75° 45' N, 129° 51' W.

- **Aug20_1.hex**: 20 August 2007. 1 cast to 60 meters, about 100 m from the bow, near a old dirty floe, about 4 meter thick.

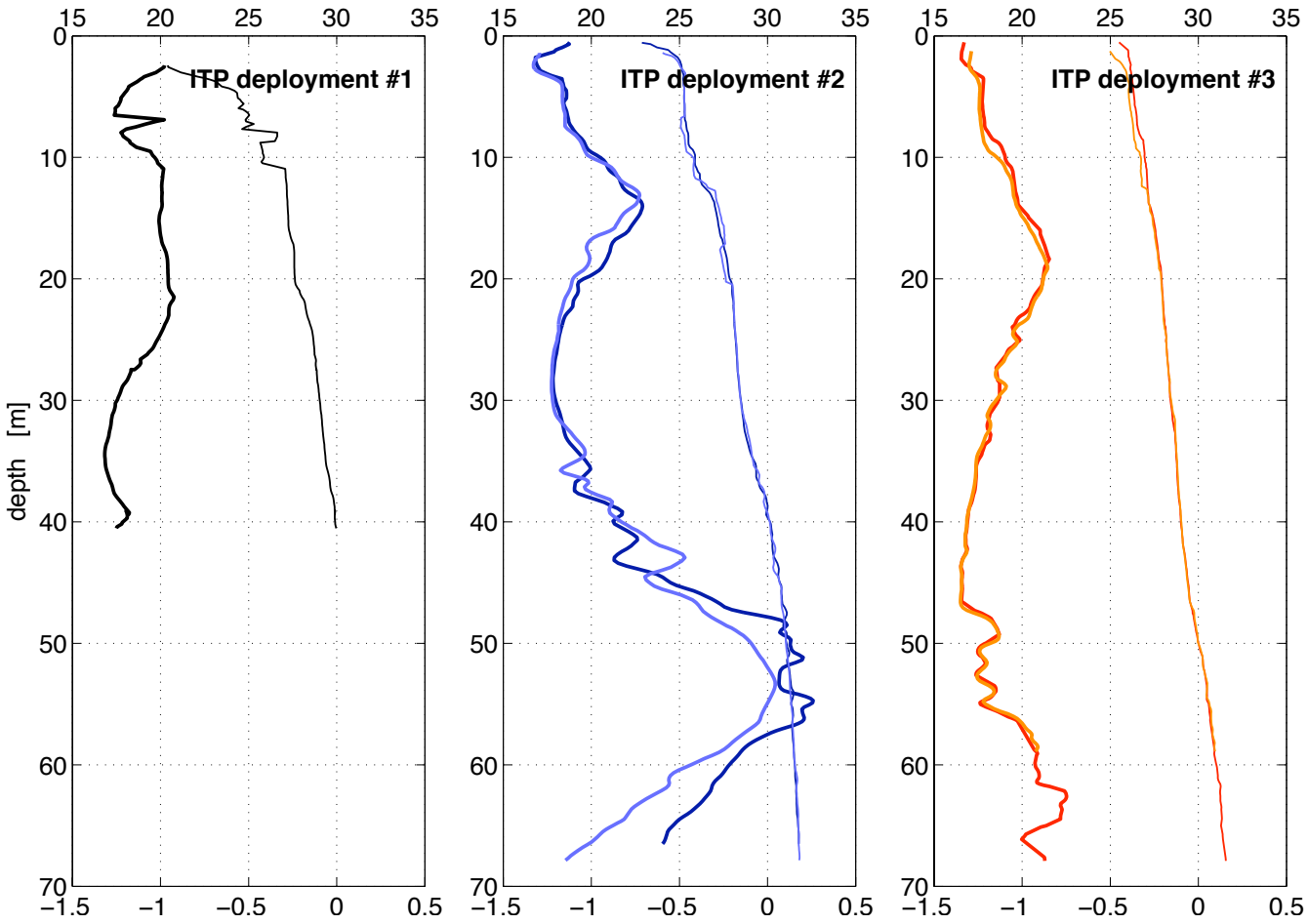

Figure 4: Profiles under the ice from (a) 11 August 2007 at the location of the first ITP deployment (ITP-8), on a 3.49 m icefloe at 79° N, 152° W. *The pump might have been clogged!* (b). 13 August at 78° 01' N, 149° 12' W through a 3.20 m hole (dark blue, AOFB) and 3.10 m thick hole (light blue, ITP-13). (c) 16 August at 78° 56' N, 139° 58' W through a 2.78 m hole (red, AOFB) and a 3.05 m hole (orange, ITP-18).

- **Aug20_1.hex**: 20 August 2007. 1 cast to 50 meters about 3 m from 5m+ thick floe with a freeboard of about 1 meter. Second (30 m) and third casts (25 m) are right next to the ice.

See Figure 6.

8 21 August 2007, from the zodiac

These casts were taken during a dedicated zodiac expedition near station CB-18 (Canada Basin) by Jen, Luc, and Kristina Brown. It was a sunny day, a little wind, warm, blue sky with some high clouds and 15% cloud on the horizon. 6/10 ice cover, mixed 1st year and new ice, some multi-year pans. We did 17 casts, which I downloaded in a single file named **Aug21_zodiac.hex**.

The profiles are (times are from the SBE19+, lat and lon from a handheld GPS):

- **Profile 1**: 20:28. 75° 00.114' N, 140° 00.810' W. Near the location of the rosette cast (starboard side), 5-10 meters from the rosette. Open water, no ice.

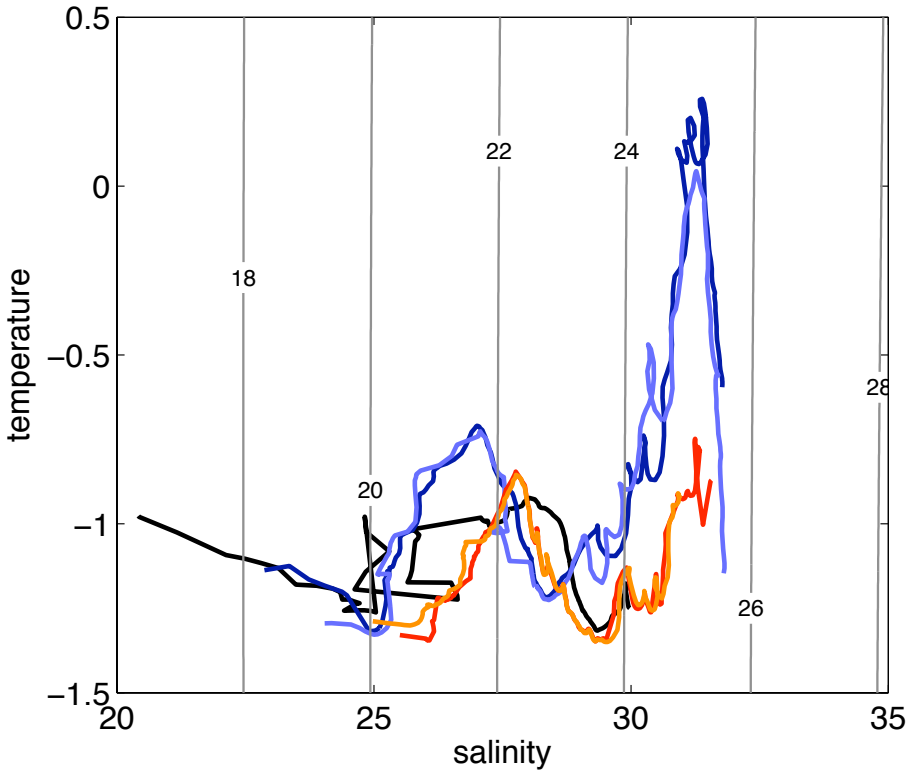

Figure 5: Temperature - Salinity diagram of the under ice casts. See Figure 4 to know which color corresponds to which cast. Potential density is contoured (σ_θ)

- **Profile 2**: 20:32. 75° 00.152' N, 140° 00.816' W. About 30 meters from the ship (starboard side). Open water, no ice.
- **Profile 3**: 20:36. 75° 00.170' N, 140° 00.876' W. In new ice. The bubbler was on for about one minute. About 40 meters from the ship (starboard side).
- **Profile 4**: 20:39. 75° 00.208' N, 140° 01.003' W. About 100 m from the ship (starboard side). On the opposite side of the zodiac, there was new ice and older pans of ice.
- **Profile 5**: 20:45. 75° 00.251' N, 140° 01.012' W. Open water, about 250 m from the ship. Pretty open, but surrounded by pans but in a big (30m+) open spot.
- **Profile 6**: 20:48. 75° 00.294' N, 140° 01.003' W. Open water, about 300 m from the ship. Middle of a pond.
- **Profile 7**: 20:52. 75° 00.352' N, 140° 00.818' W. Open water, about 500 m from the ship, at the 'narrow' entrance of a big lake, older ice on either side at about 30 meters.
- **Profile 8**: 20:55. 75° 00.364' N, 140° 00.799' W. Halfway between cast #7 and the ice, about 10 m from the ice edge (open water).
- **Profile 9**: 20:58. 75° 00.370' N, 140° 00.734' W. Ice edge. Profile in a little cove of new ice a the edge of a multiyear pan.
- **Profile 10**: 21:01. 75° 00.378' N, 140° 00.766' W. About 3-4 meter from the ice edge, started near the back of the zodiac while nose was touching the ice, and slowly drifted away from the ice.
- **Profile 11**: 21:05. 75° 00.439' N, 140° 00.806' W. Middle of the little lake.

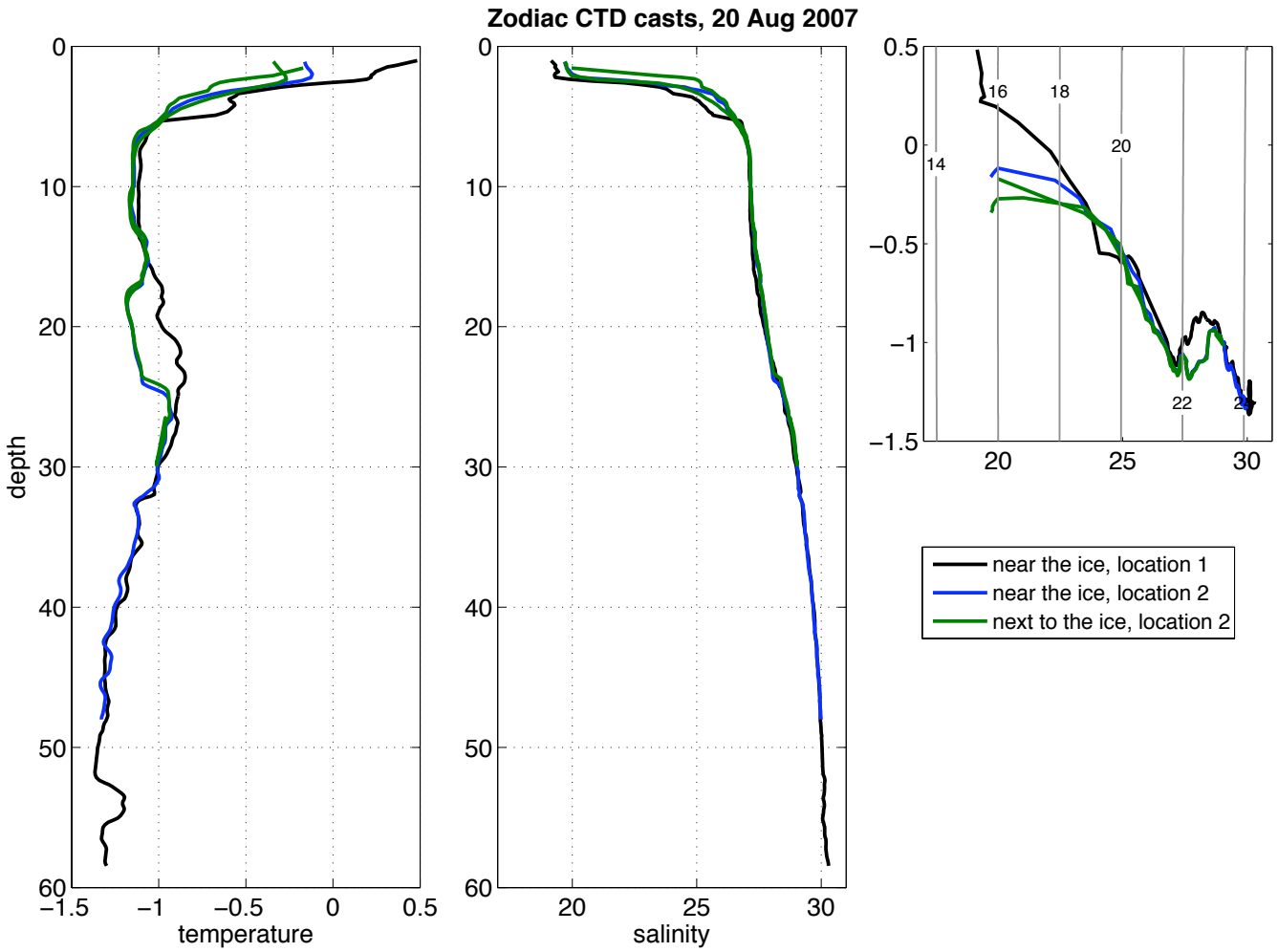

Figure 6: Profiles from August 20. We sampled two locations, both near old thick floes. At the second location we did profiles away (blue) and very near the ice (green). The profiles next to the ice (10 cm) are cooler. Note the difference near 20 meters between the two locations.

- **Profile 12**: 21:14. 75° 00.345' N, 140° 01.373' W. Just soaked it, no profile.
- **Profile 13**: 21:16. 75° 00.338' N, 140° 01.422' W. Open water, about 10 meters from the nearest ice. Bunch of little ice floes, about 100 m from the stern of the ship, stbd side. BUBBLER ON, pushing the ship forward.
- **Profile 14**: 21:20. 75° 00.318' N, 140° 01.646' W. Open water, about 10 meters from the nearest ice. No ice between the ship and us. BUBBLER ON, we start about 60-75 meters from the ship (aft, stbd). The bubbler disturbance (slick water) at the surface seems to be about 20 meters away.
- **Profile 15**: 21:23. 75° 00.295' N, 140° 01.911' W. 30-40 meters from the ship, in the water that has obviously been disturbed. Directly aft of the ship. BUBBLER ON.
- **Profile 16**: 21:27. 75° 00.215' N, 140° 02.018' W. Next to the ship where the rosette goes in. BUBBLER ON.
- **Profile 17**: 21:31. Beside bubbler, next to the bow of the ship. Bubbler off during down cast, turned on during up cast.

9 26 August 2007, from the zodiac

These casts were collected during zodiac trip at Station A (after refueling). Jen, Alice Orlich, and Luc went out to do another series of measurements starting close to the ship and progressively going away. The ice was very melted here. Ice concentration is between 1 and 2/10. Cold (freezing temperature) and windy day. Foggy. Sea state is choppy, $<$ 0.5 m. General position: 73° 00' N, 145°22' W.

All profiles are to a 40-meter depth .

- **Aug26_zodiac01.hex**: 26 August 2007, 16:57. Profile right where the rosette goes in, about 1 meter from the hull. No ice within 50 meters. 73° 00.529' N, 145°21.935' W.
- **Aug26_zodiac02.hex**: 26 August 2007, 17:00. Profile about 50 meters from the ship, off the starboard side. No ice within 50 meters. 73° 00.548' N, 145°21.907' W.
- **Aug26_zodiac03.hex**: 26 August 2007, 17:03. Profile about 100 meters from the ship, off the starboard side. No ice within 50 meters. 73° 00.563' N, 145°21.834' W.
- **Aug26_zodiac04.hex**: 26 August 2007, 17:06. Profile about 200 meters from the ship, off the starboard side. No ice within 50 meters. 73° 00.584' N, 145°21.709' W.
- **Aug26_zodiac05.hex**: 26 August 2007, 17:10. Profile about 500 meters from the ship, off the starboard side. No ice within 50 meters. 73° 00.634' N, 145°21.410' W.
- **Aug26_zodiac06.hex**: 26 August 2007, 17:17. Profile right next to a multi-year ice floe, 6-8 meter thick. 73° 00.569' N, 145°21.517' W.
- **Aug26_zodiac07.hex**: 26 August 2007, 17:47. Profile right next to a multi-year ice floe, near a 2-m tall ridge. CTD goes down along the face of the ice for at least 5 meters (ice keel $>$ 10m). 73° 00.807' N, 145°21.407' W.