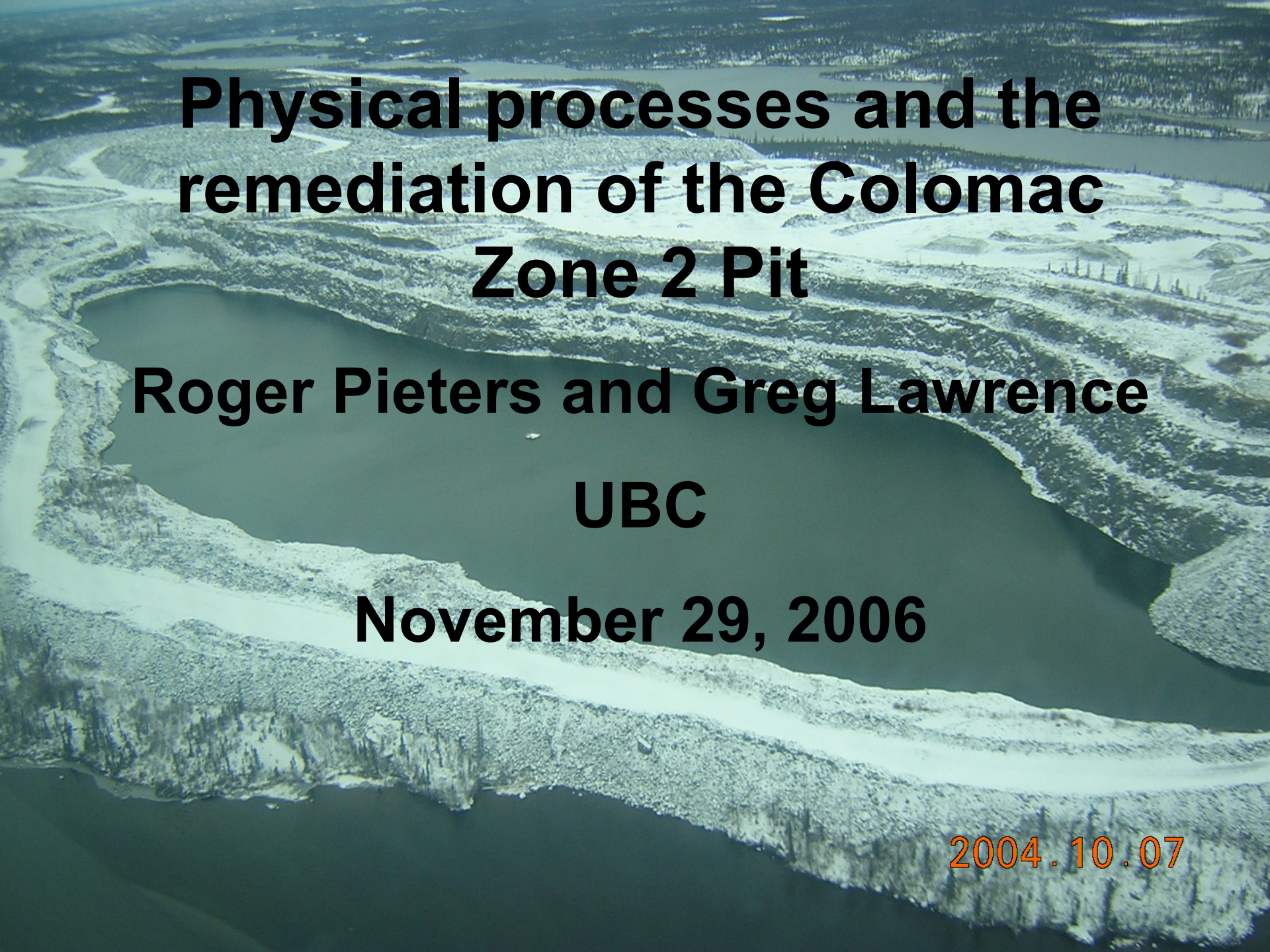


Physical processes and the remediation of the Colomac Zone 2 Pit

Roger Pieters and Greg Lawrence

UBC

November 29, 2006

Acknowledgements

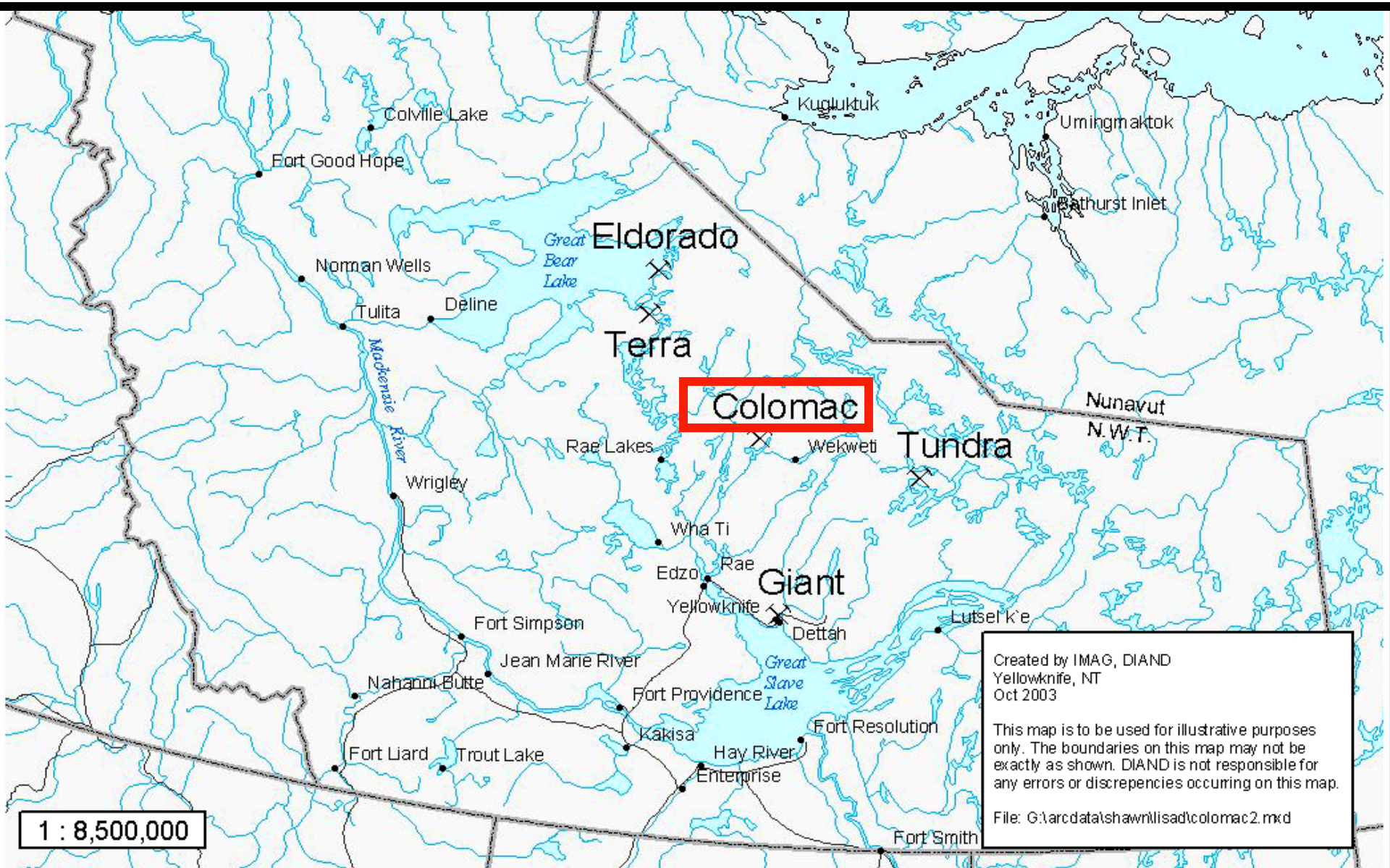
- Gratefully acknowledge funding by DIAND
- Bill Coedy, Octavio Melo DIAND
- John Chapman and Stephen Shultz, SRK (Vancouver)
- Ken Ashley, aeration system design
- Ken Hall, sediment traps
- Susan Watson, Hedy Kling phytoplankton
- Regan Fielding, Dean Holman, technical assistance
- James Edwards (INAC) and Dave Bynski (PWGSC), mgmt
- Tli Cho Logistics
- Dillon Consultants (Yellowknife)

Outline

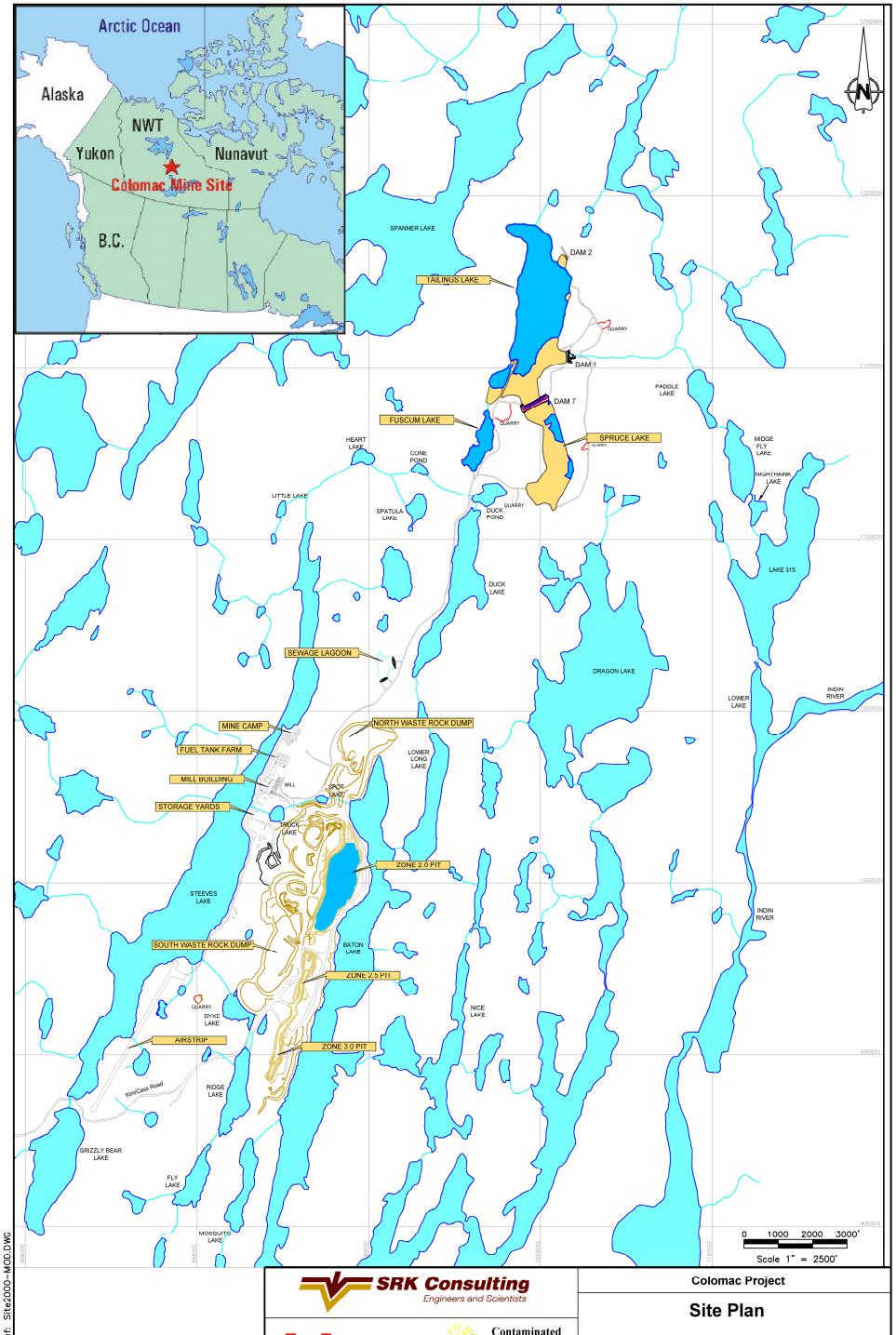
- Site description

1. Enhanced Natural Removal
2. Circulation of the pit
3. Aeration

Site Location



Site Map


Arctic Ocean
Alaska
NWT
Yukon
Nunavut
Colomac Mine Site
B.C.
SPANNER LAKE
DAM 2
TAILINGS LAKE
QUARRY
DAM 1
PADDLE LAKE
DAM 7
FUSCUM LAKE
QUARRY
SPRUCE LAKE
QUARRY
MIDGE FLY LAKE
NIGHTHAWK LAKE
HEART LAKE
CONE POND
LITTLE LAKE
SPATULA LAKE
QUARRY
DUCK POND
LAKE 315
DUCK LAKE
SEWAGE LAGOON
DRAGON LAKE
LOWER LAKE
INDIN RIVER
MINE CAMP
NORTH WASTE ROCK DUMP
FUEL TANK FARM
LOWER LONG LAKE
MILL BUILDING
MILL
STORAGE YARDS
ROCK LAKE
ZONE 2.0 PIT
STEEVES LAKE
INDIN RIVER
SOUTH WASTE ROCK DUMP
BATON LAKE
ZONE 2.5 PIT
QUARRY
DYKE LAKE
NICE LAKE
AIRSTRIP
ZONE 3.0 PIT
RidgeCast Road
RIDGE LAKE
GRIZZLY BEAR LAKE
FLY LAKE
MOSQUITO LAKE
N
0 1000 2000 3000'
Scale 1" = 2500'
SRK Consulting
Engineers and Scientists
Colomac Project
Site Plan
Contaminated

Water transfer from Tailing Lake

3.4 Mm3 from Tailings Lake to Zone 2 Pit 1999-2002

~50% of Zone 2 Pit volume

PART I Enhanced Natural Removal

Enhanced Natural Removal

Addition of mono-ammonium phosphate

June 2002: 22 tonnes of MAP (35 g/m2)

May 2003: 9 tonnes of MAP (13 g/m2)

Thiocyanate

$$SCN^- + 2H_2O + {}^5/_2\, O_2 \rightarrow SO_4^{-2} + HCO_3^- + NH_3$$

Biological oxidation

Produces ammonia

Ammonia

1) DIRECT UPTAKE BY ALGAE

2) MICROBIOLOGICAL NITRIFICATION

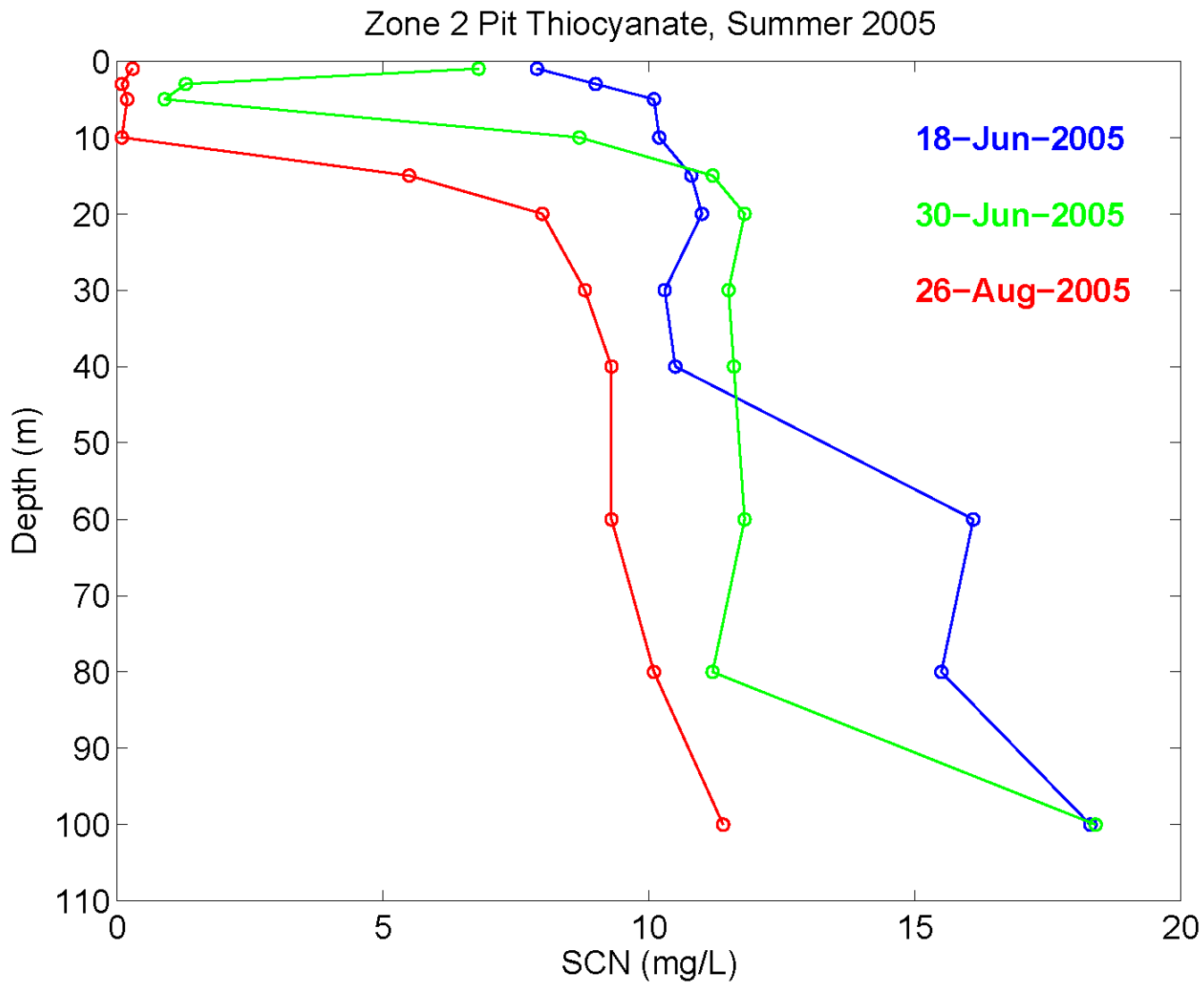
$NH_4^+ + {}^3/_2\ O_2 \rightarrow 2H^+ + H_2O + NO_2^-$

$NO_2^- + ½\ O_2 \rightarrow NO_3^-$

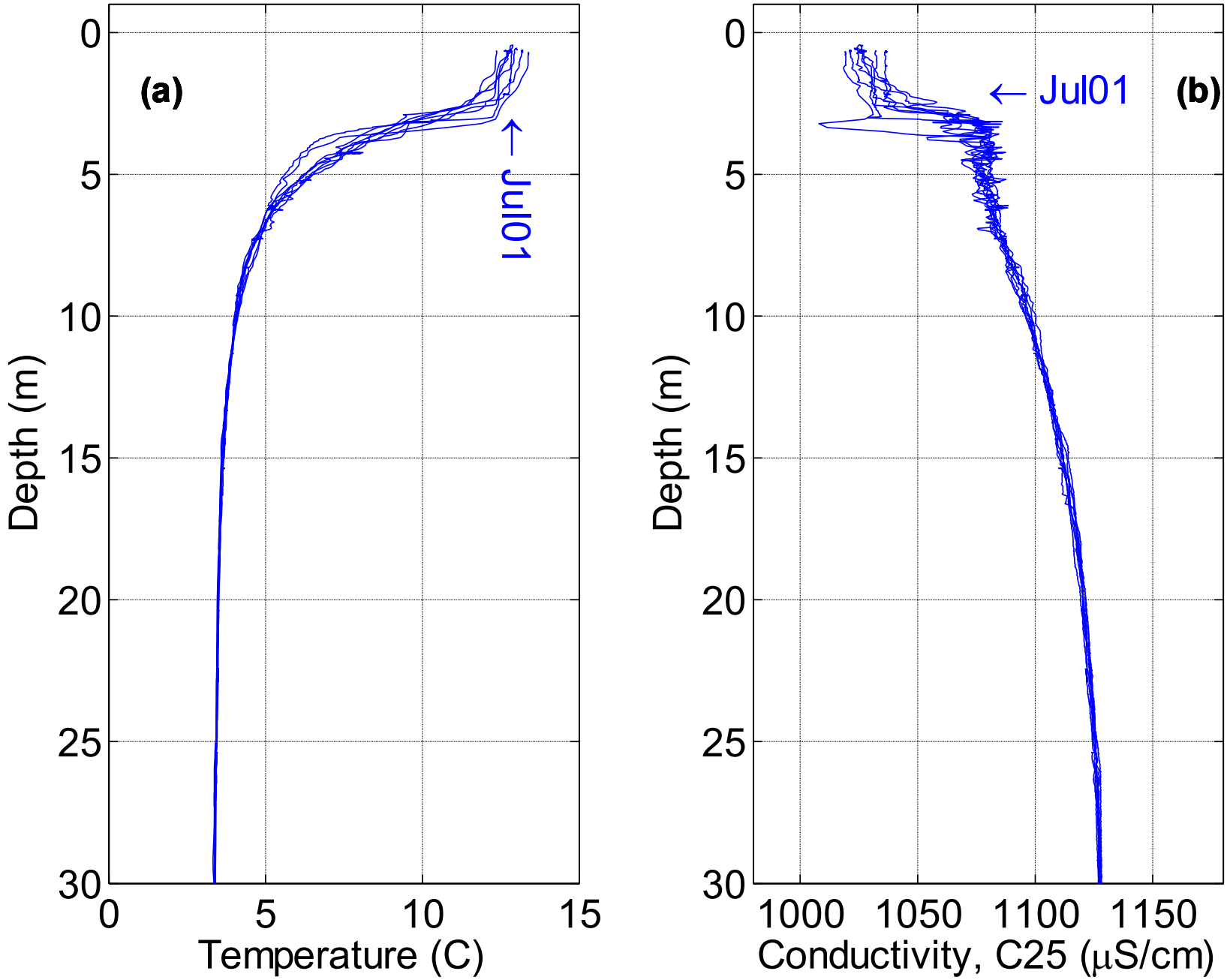
3) MICROBIOLICAL DENITRIFICATION (anoxic)
Nitrate to nitrogen gas

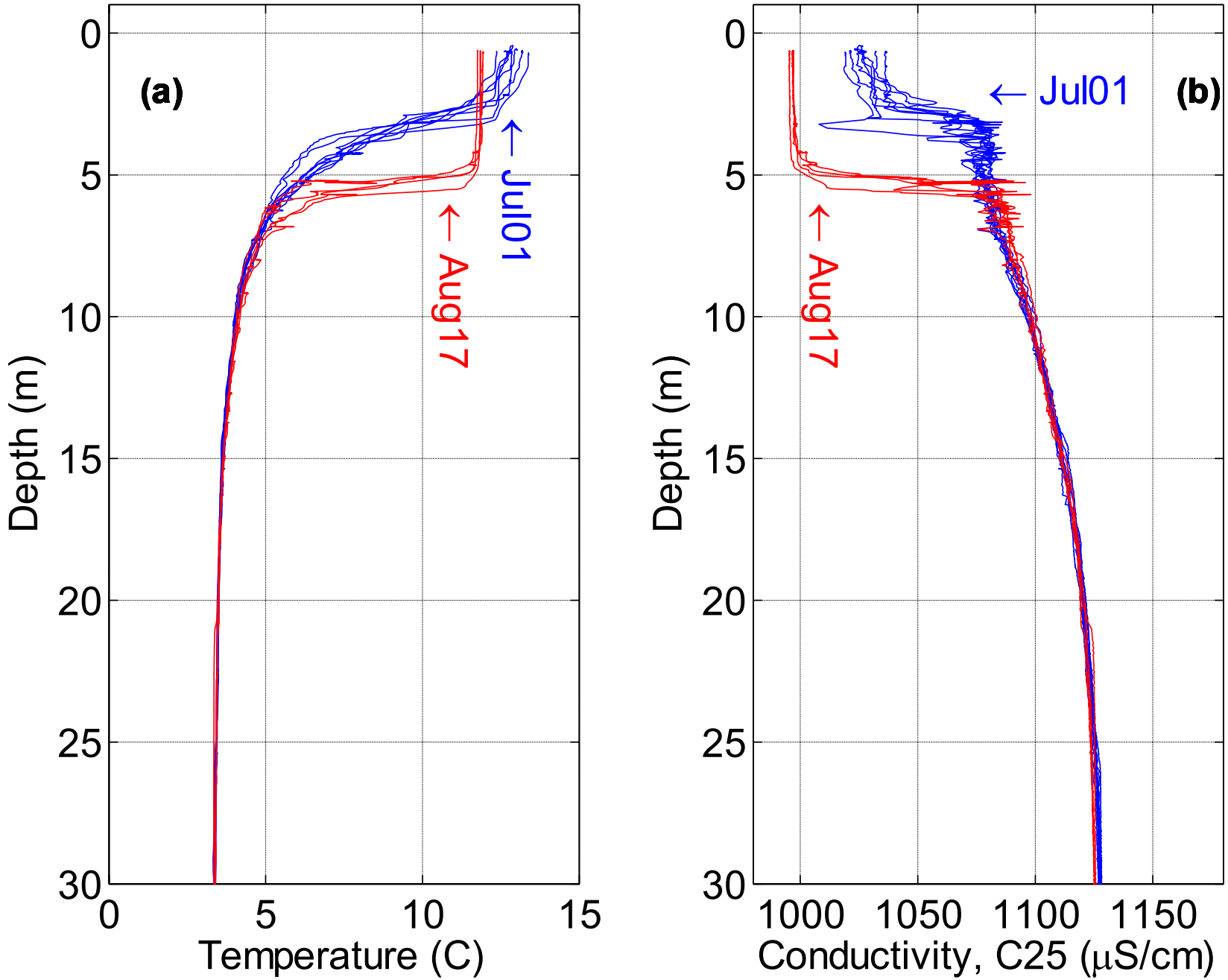
Response

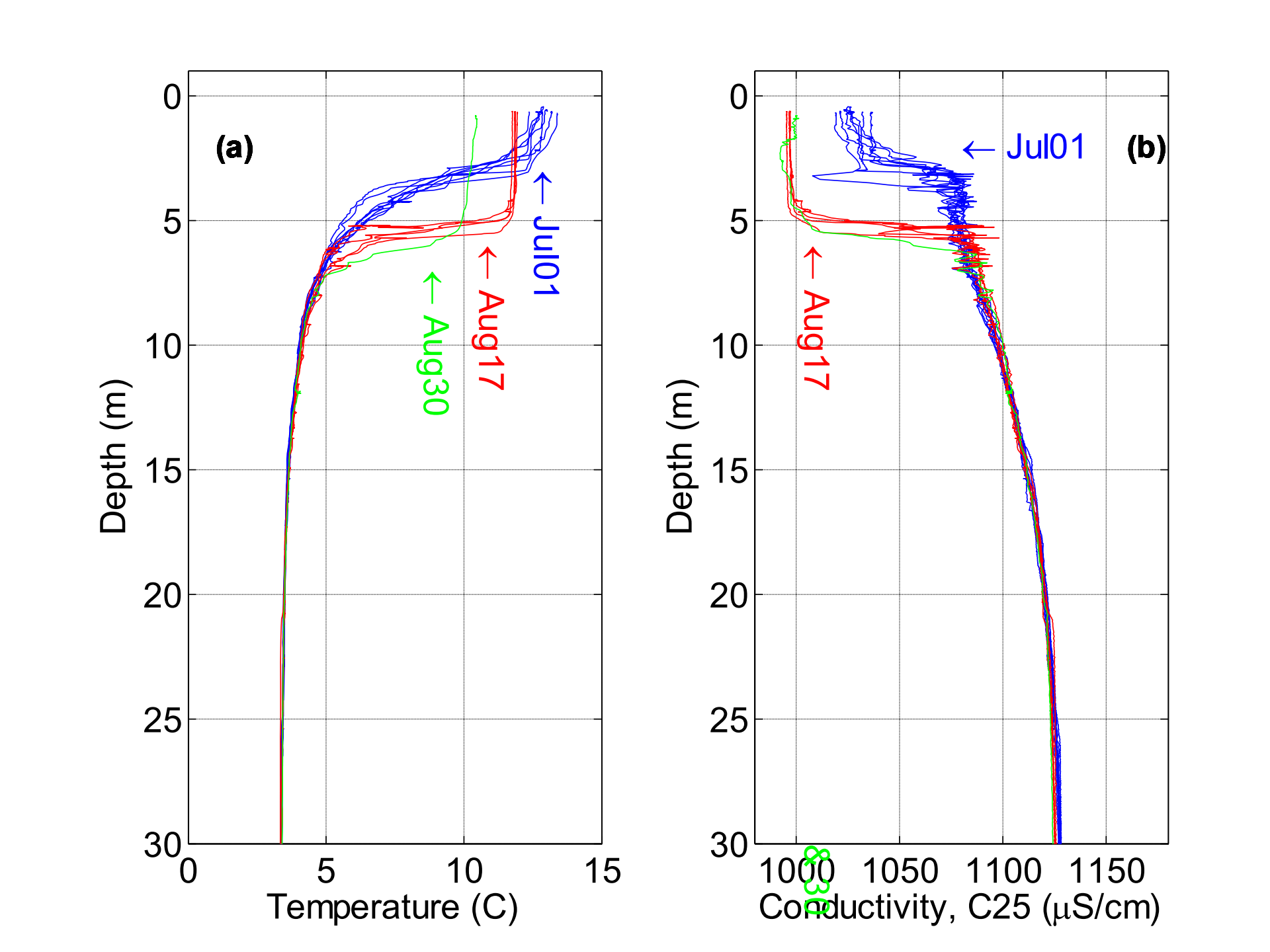
Thiocyanate

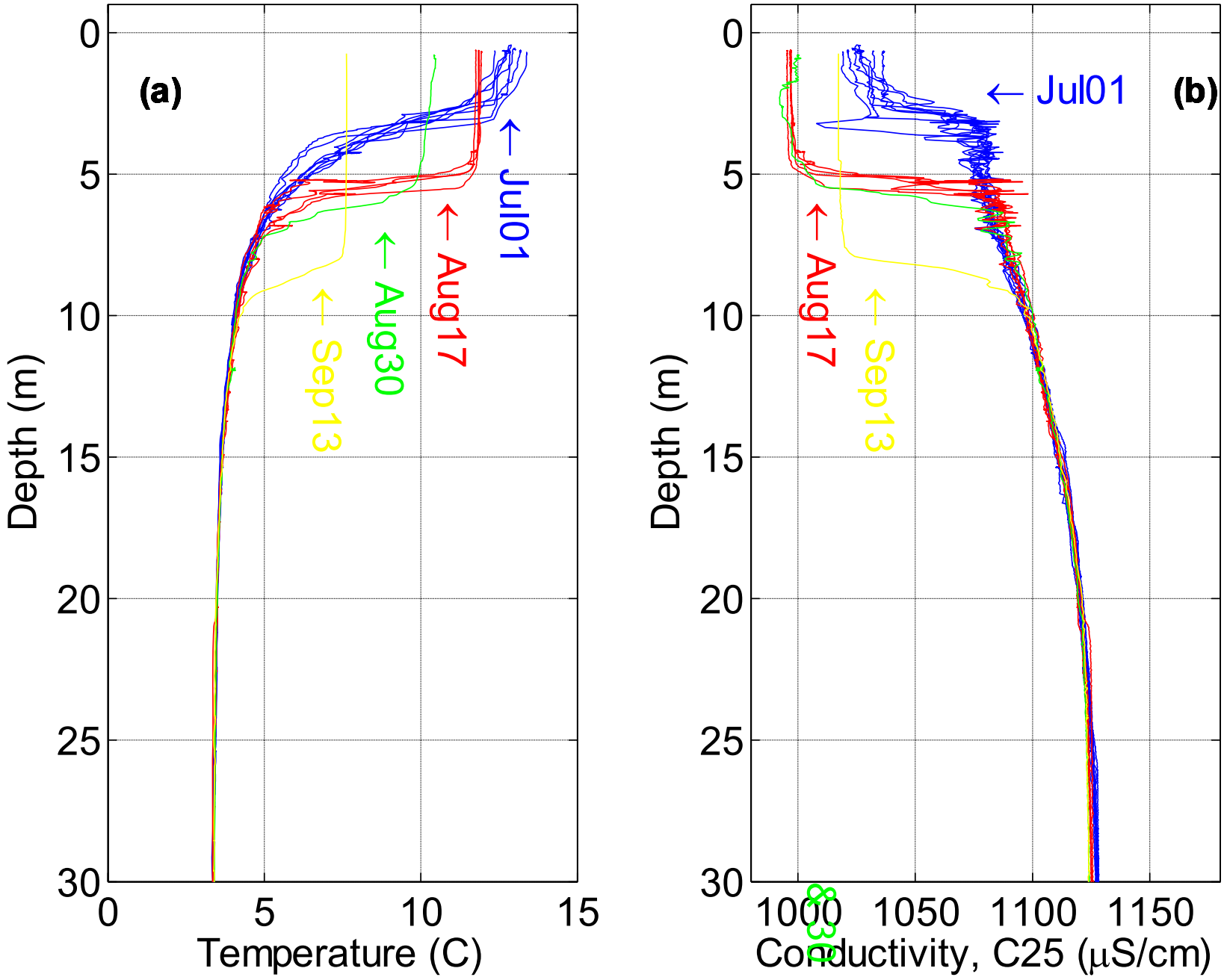


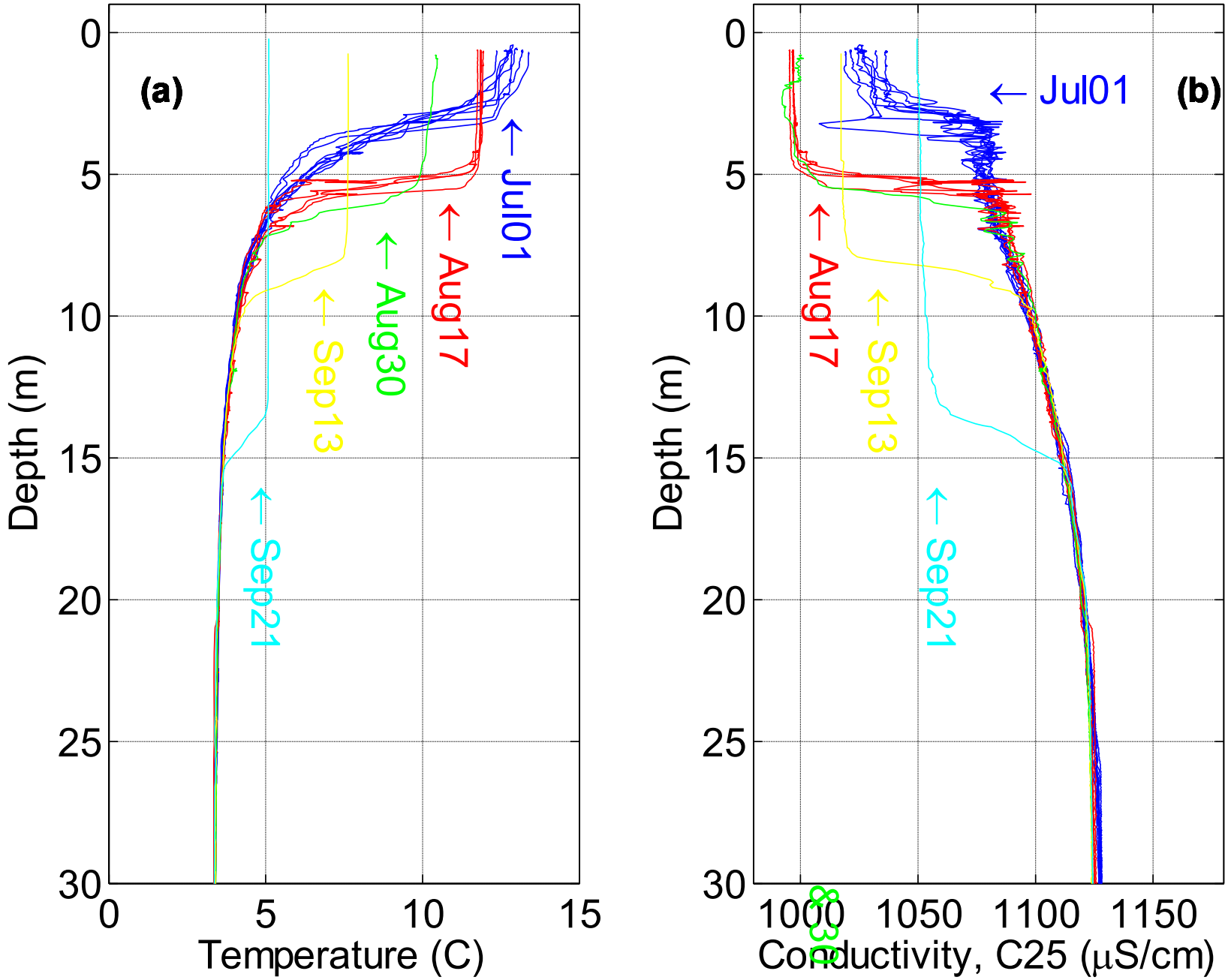
PART 2 Circulation

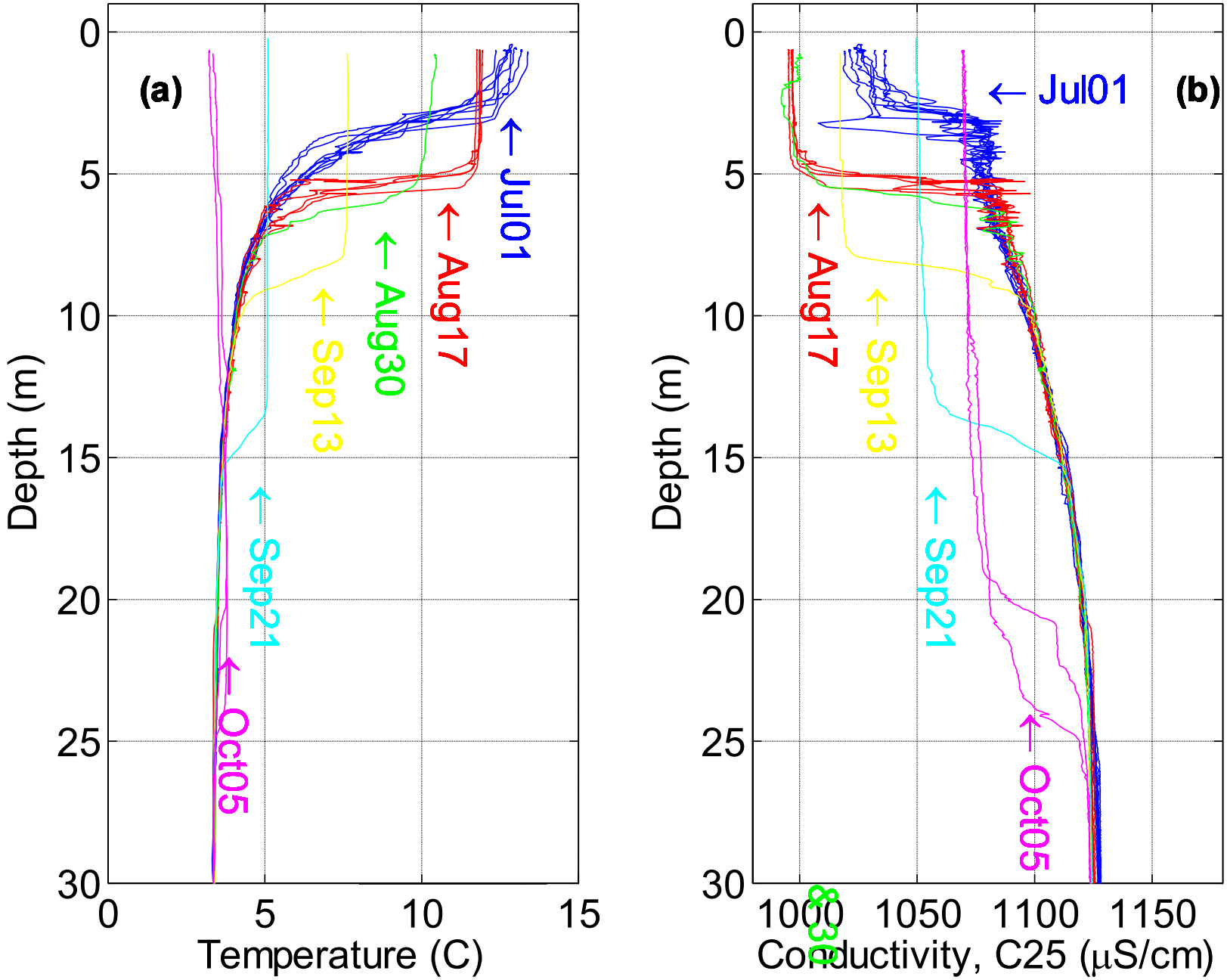

(a)
Jul01
Depth (m)
0
5
10
15
20
25
30
0
5
10
15
Temperature (C)
(b)
Jul01
1000
1050
1100
1150
Conductivity, C25 (μS/cm)

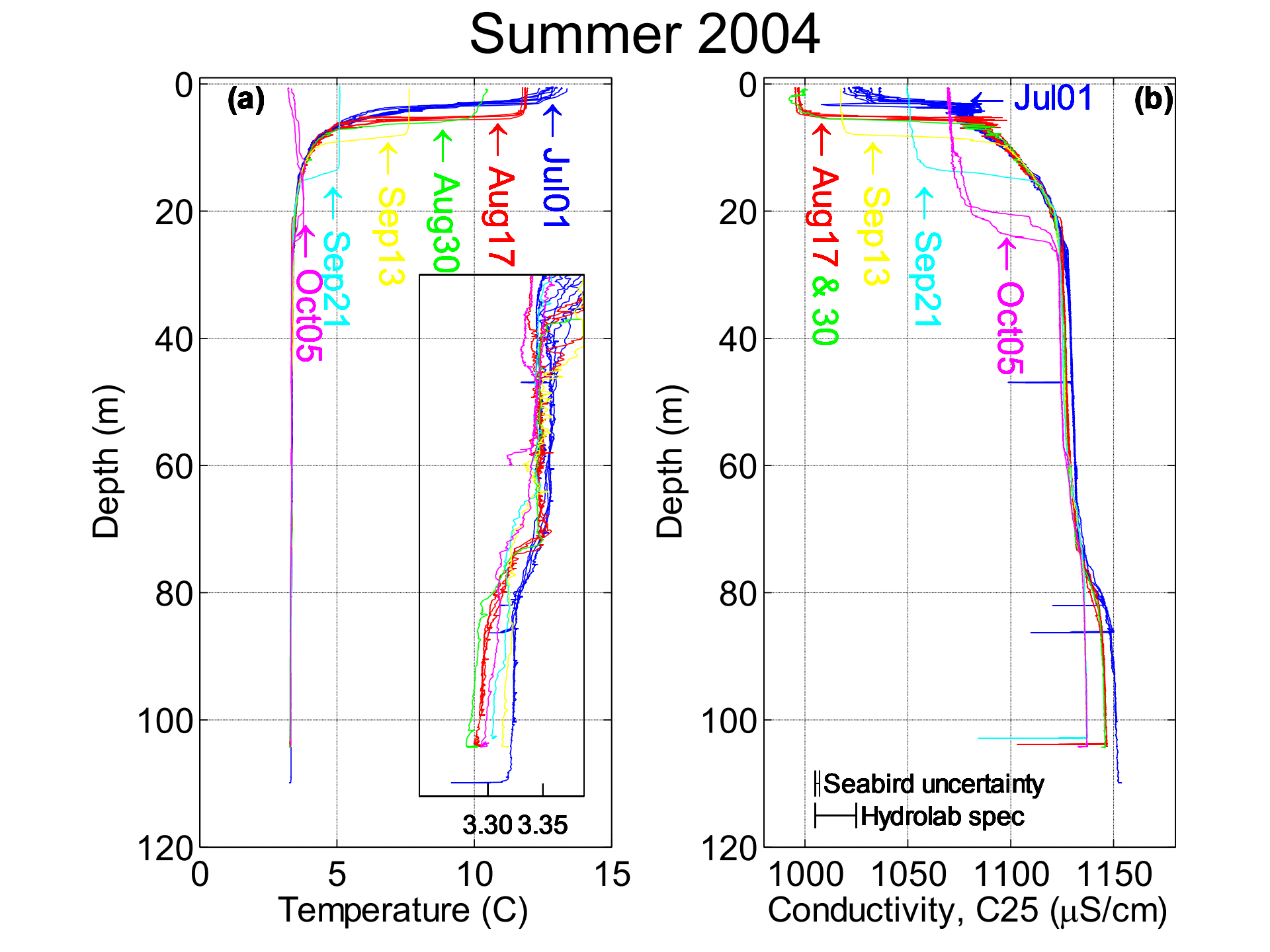

(a)
(b)
Depth (m)
Temperature (C)
Conductivity, C25 (µS/cm)
Jul01
Aug17
0
5
10
15
20
25
30
1000
1050
1100
1150


(a)
(b)
Depth (m)
Temperature (C)
Conductivity, C25 (µS/cm)
Jul01
Aug17
Aug30
0
5
10
15
20
25
30
1000
1050
1100
1150

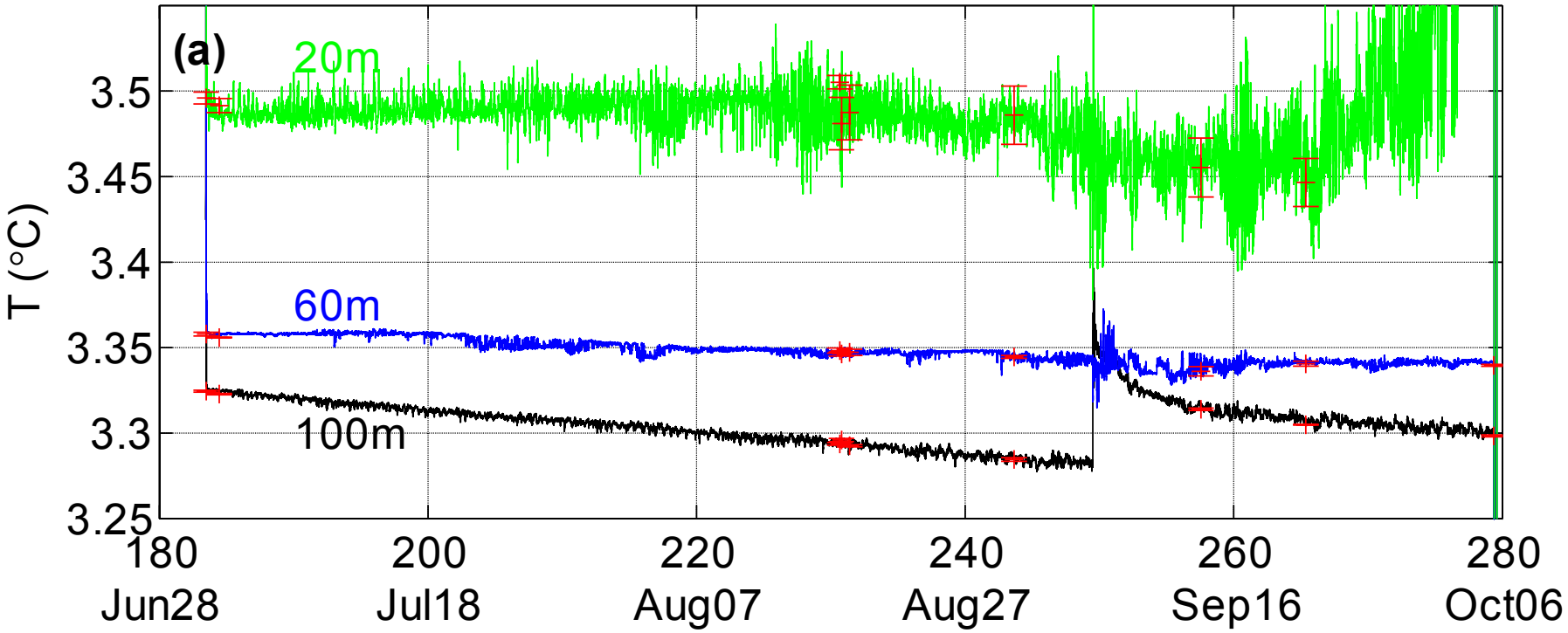

(a)
(b)
Depth (m)
Temperature (C)
Conductivity, C25 (µS/cm)
Jul01
Aug17
Aug30
Sep13
0
5
10
15
20
25
30
1000
1050
1100
1150

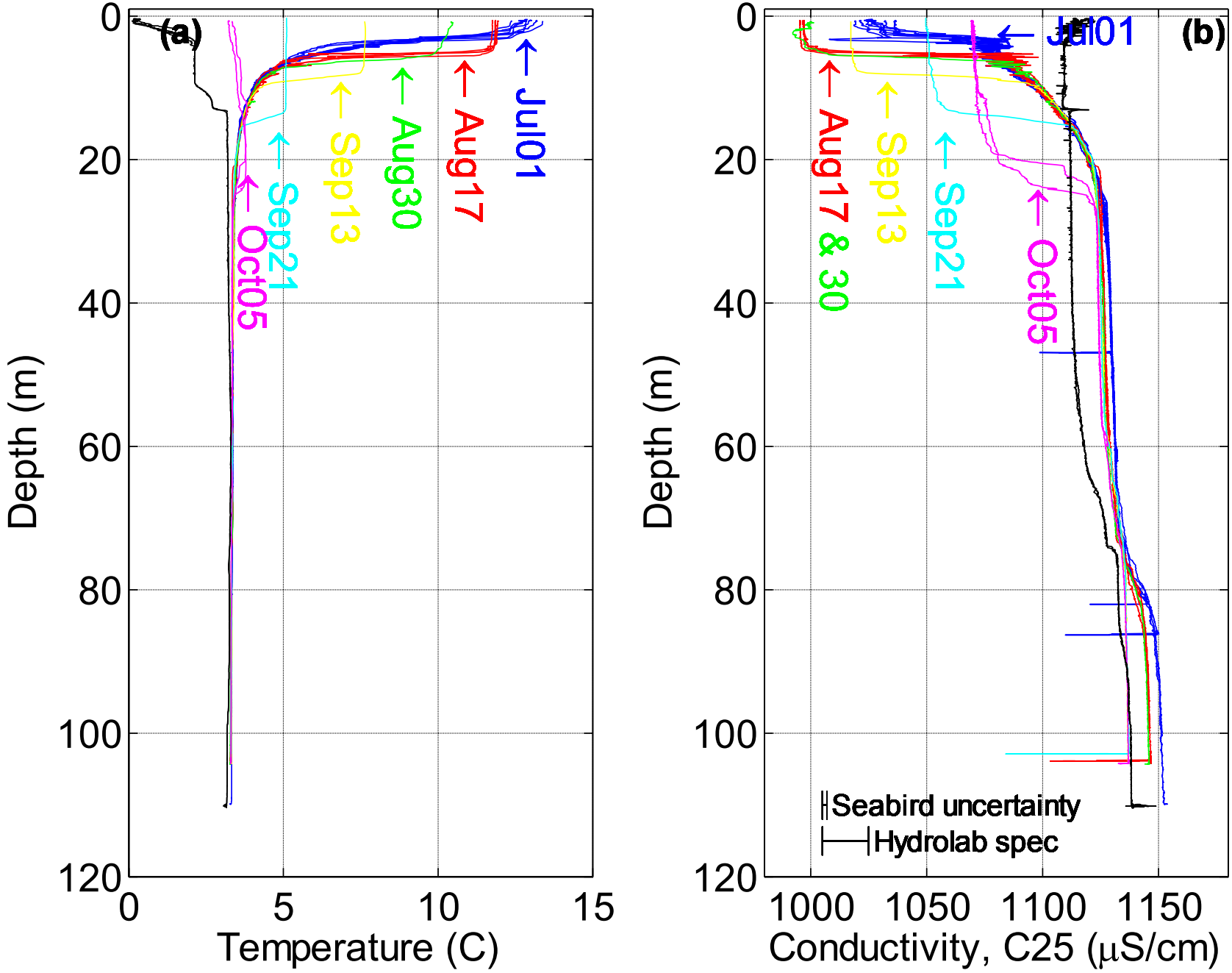

(a)
(b)
Depth (m)
Temperature (C)
Conductivity, C25 (µS/cm)
Jul01
Aug17
Aug30
Sep13
Sep21
&30
0
5
10
15
20
25
30
1000
1050
1100
1150

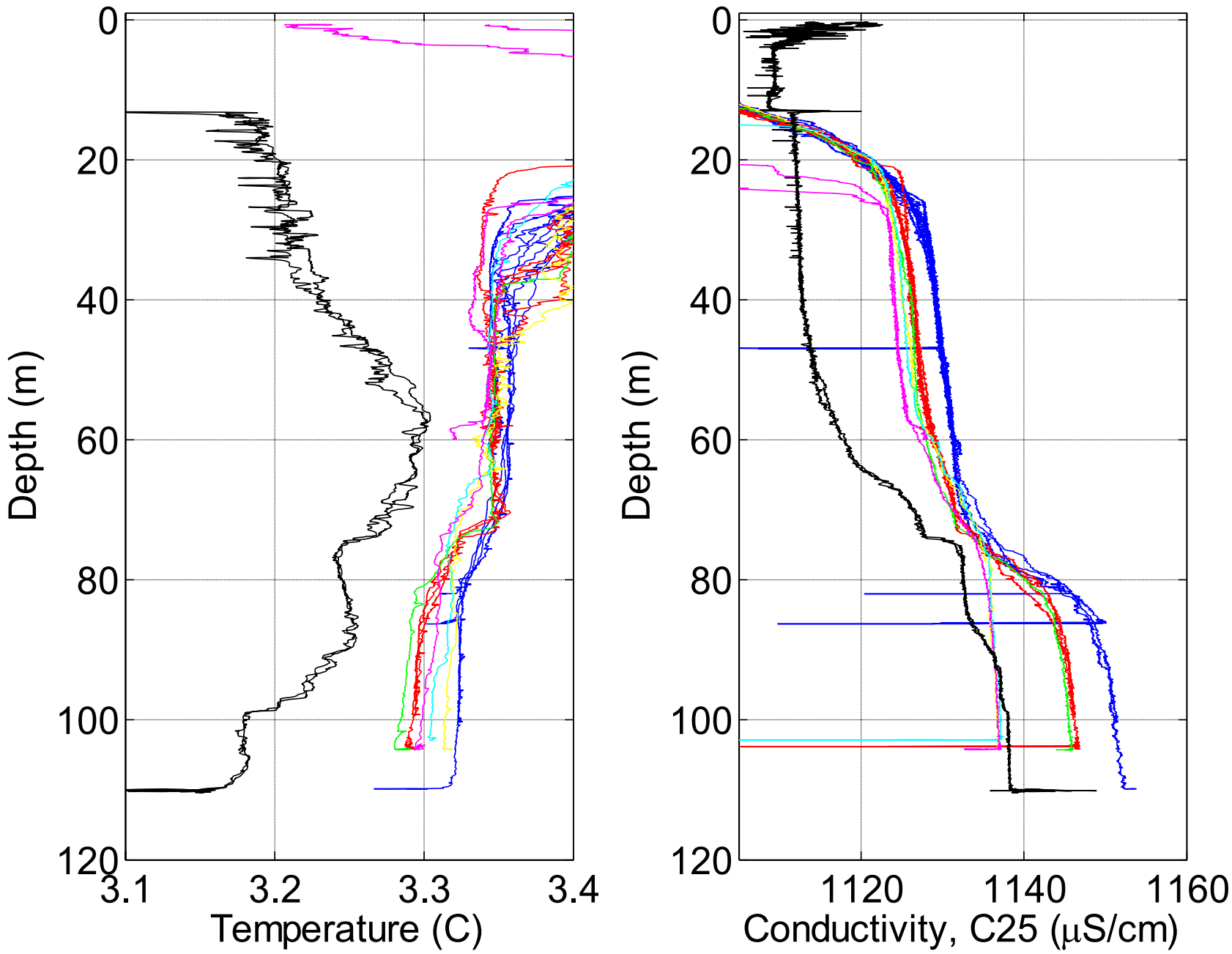

(a)
(b)
Depth (m)
Temperature (C)
Conductivity, C25 (µS/cm)
Jul01
Aug17
Aug30
Sep13
Sep21
Oct05
0
5
10
15
20
25
30
1000
1050
1100
1150


Summer 2004
(a)
(b)
Jul01
Aug30
Aug17
Sep13
Sep21
Oct05
Aug17 & 30
3.30 3.35
Seabird uncertainty
Hydrolab spec
Depth (m)
Temperature (C)
Conductivity, C25 (μS/cm)
0
20
40
60
80
100
120
0
5
10
15
1000
1050
1100
1150

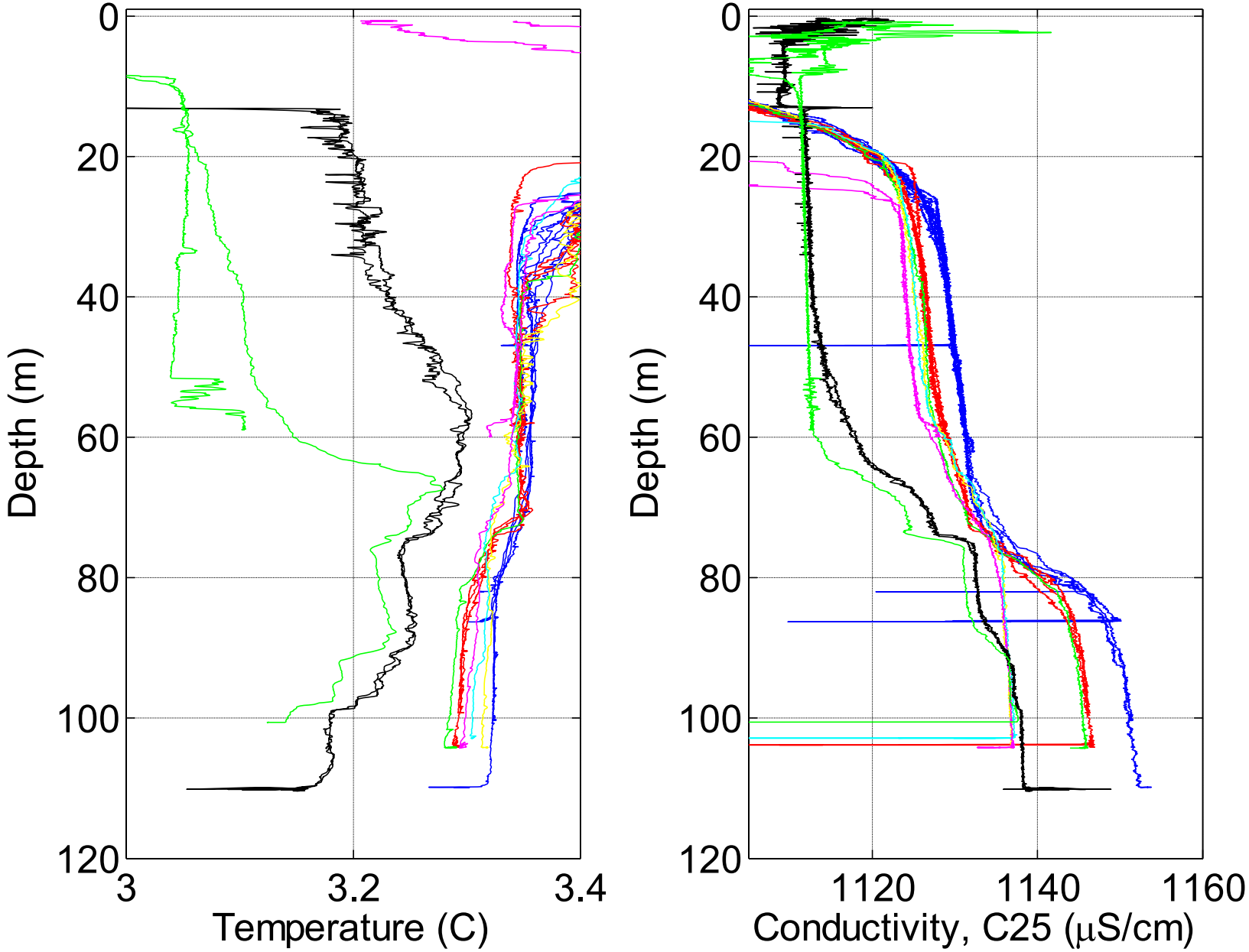
Rock Fall or Slump



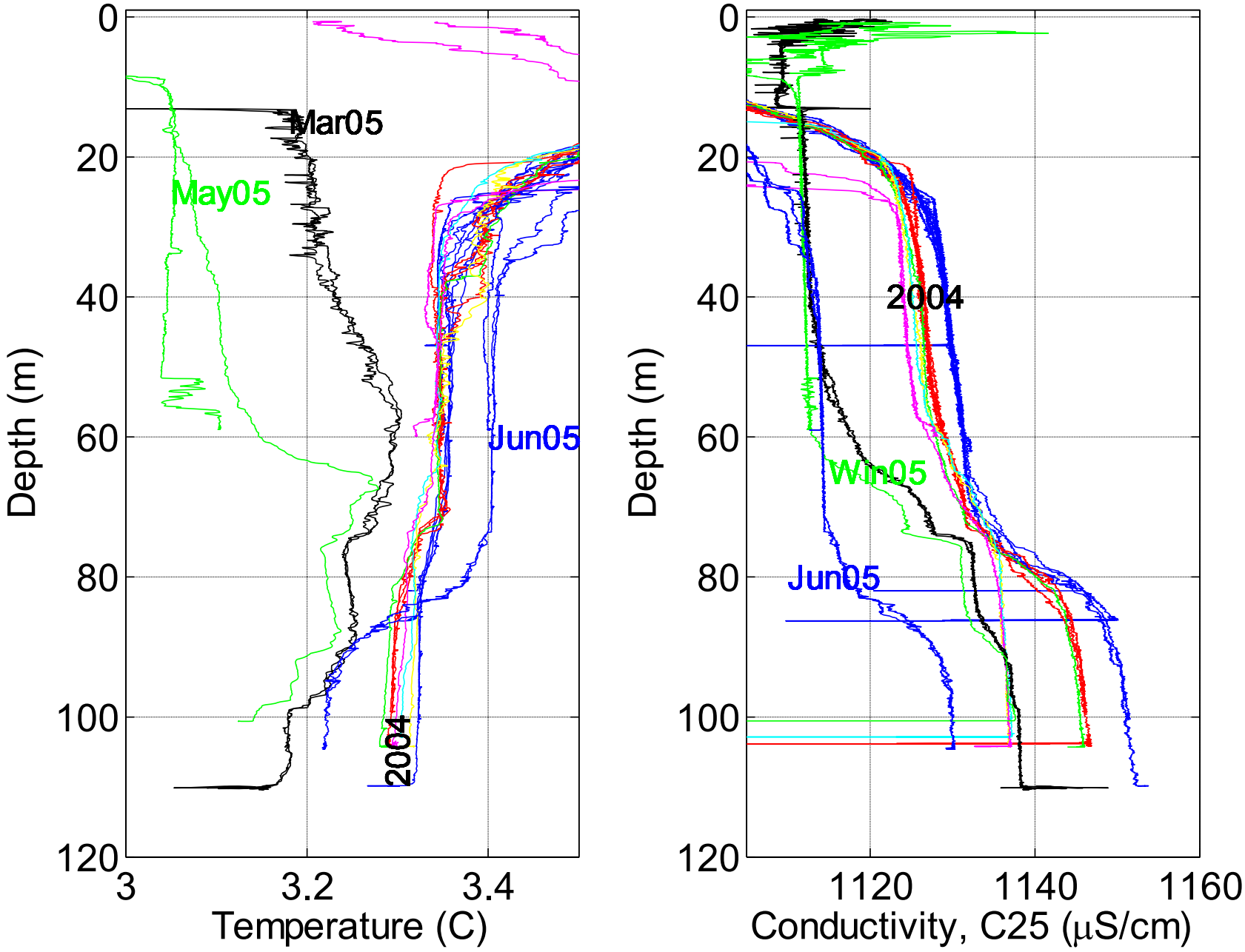

March 2005
(a)
(b)
Depth (m)
Temperature (C)
Conductivity, C25 (µS/cm)
Jul01
Aug30
Aug17
Sep13
Sep21
Oct05
Aug17 & 30
Seabird uncertainty
Hydrolab spec
0
20
40
60
80
100
120
0
5
10
15
1000
1050
1100
1150


March (blk) 2005 Deep water
Depth (m)
0
20
40
60
80
100
120
3.1
3.2
3.3
3.4
Temperature (C)
Depth (m)
0
20
40
60
80
100
120
1120
1140
1160
Conductivity, C25 (µS/cm)

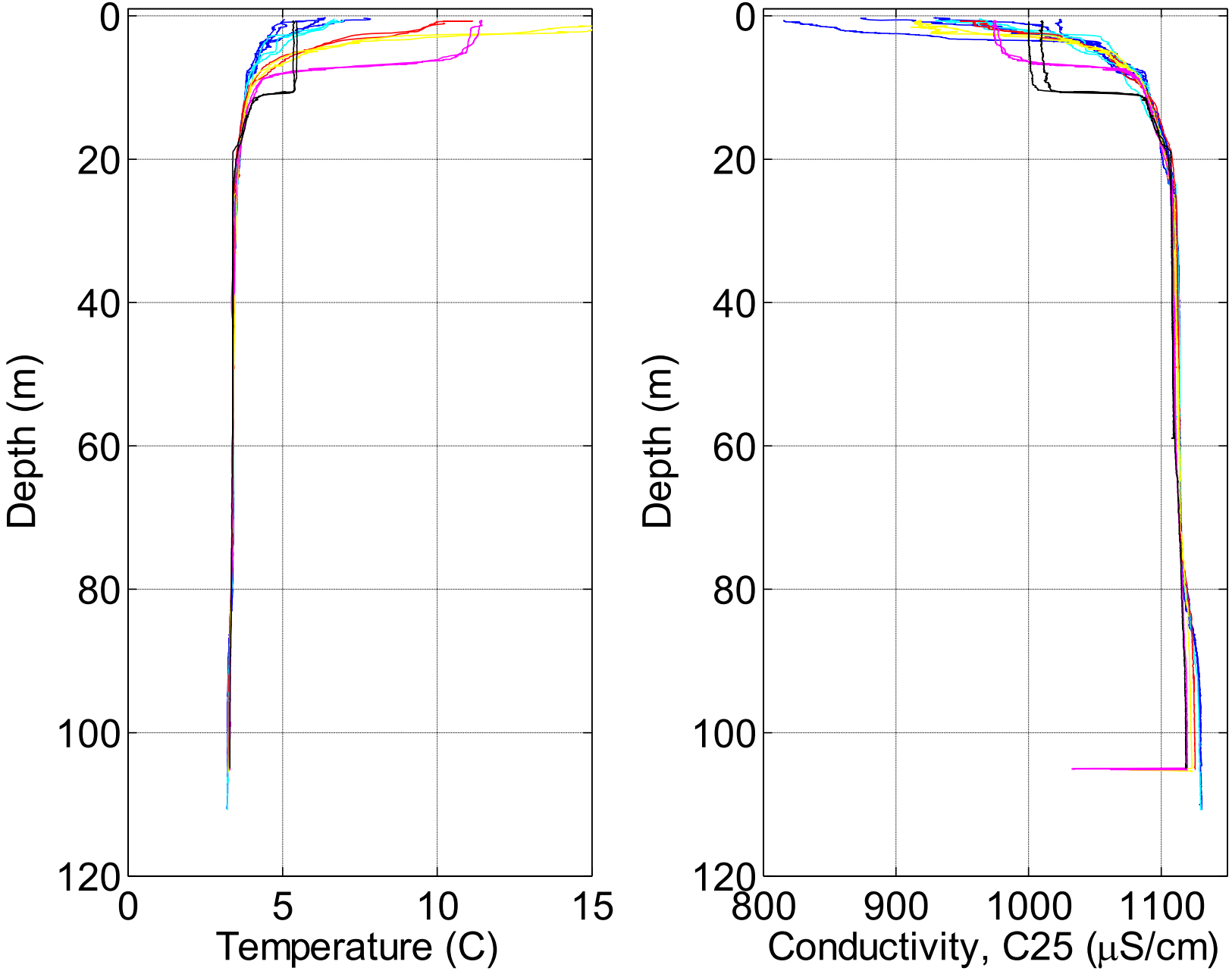
…with May 2005



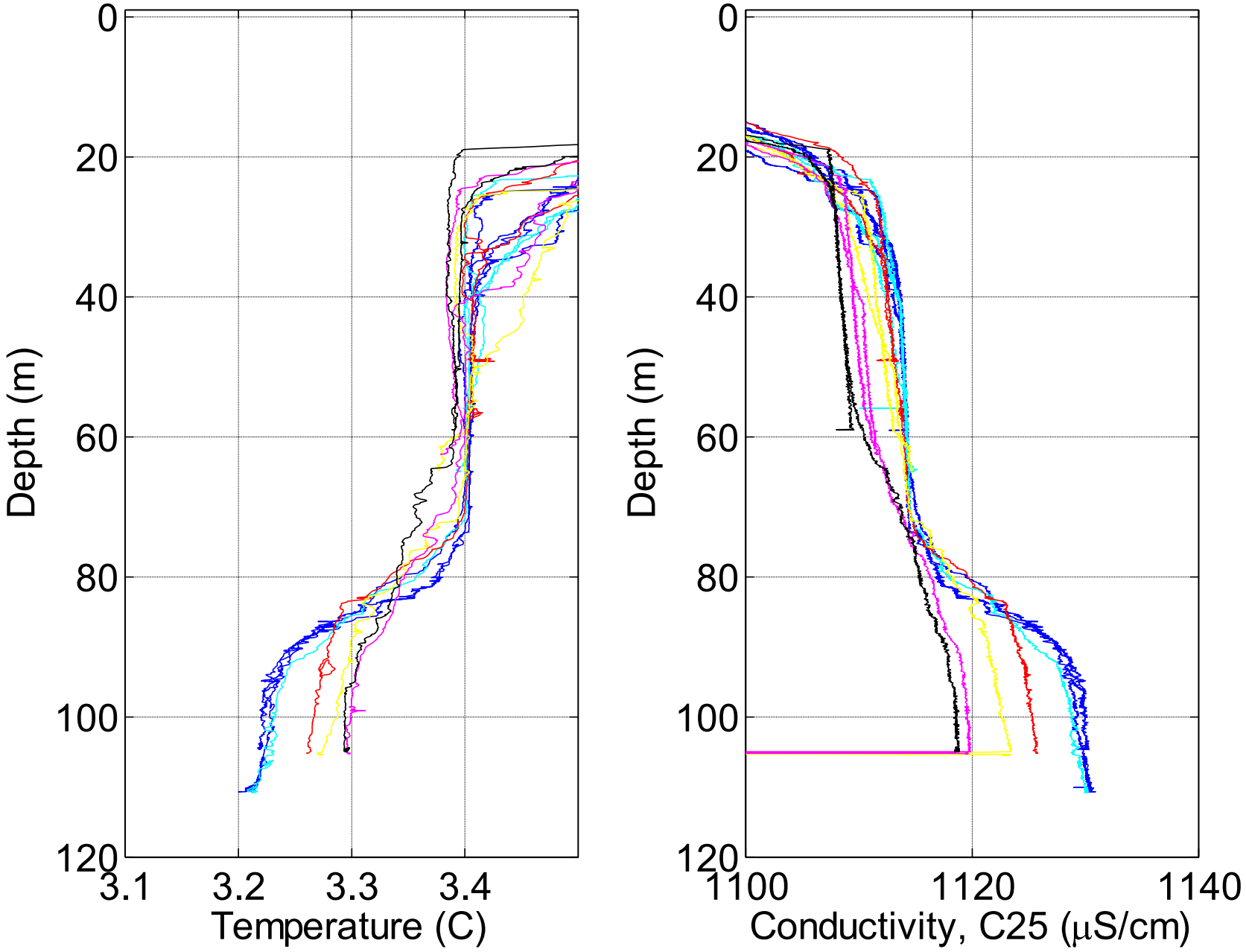
…with Jun 2005

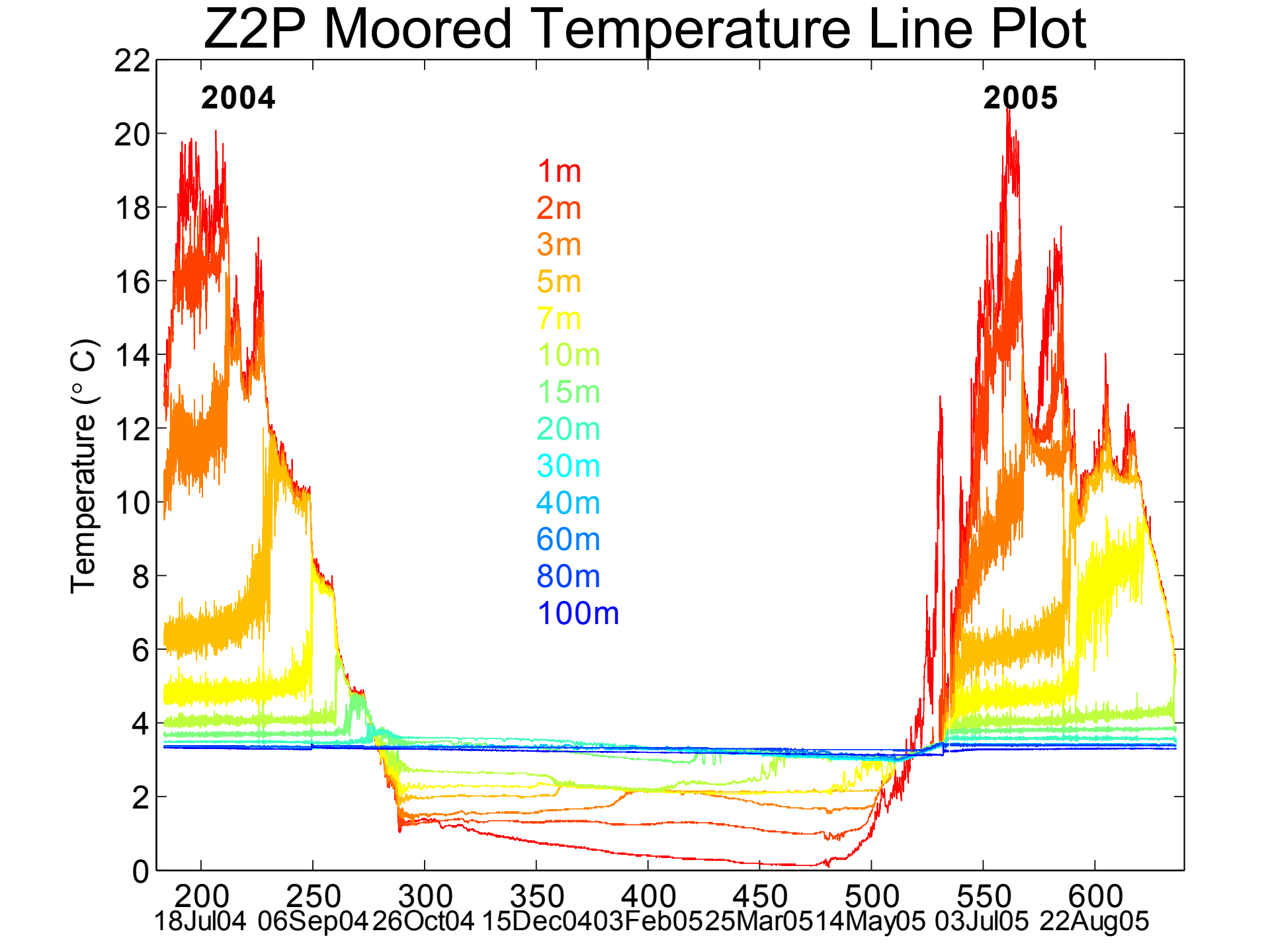


Summer 2005


0
20
40
60
80
100
120
Depth (m)
0
5
10
15
Temperature (C)
800
900
1000
1100
Conductivity, C25 (μS/cm)

Summer 2005: Deep Water




Z2P Moored Temperature Line Plot
2004
2005
1m
2m
3m
5m
7m
10m
15m
20m
30m
40m
60m
80m
100m
Temperature (° C)
0
2
4
6
8
10
12
14
16
18
20
22
200
250
300
350
400
450
500
550
600
18Jul04
06Sep04
26Oct04
15Dec04
03Feb05
25Mar05
14May05
03Jul05
22Aug05

Z2P Spring 2005

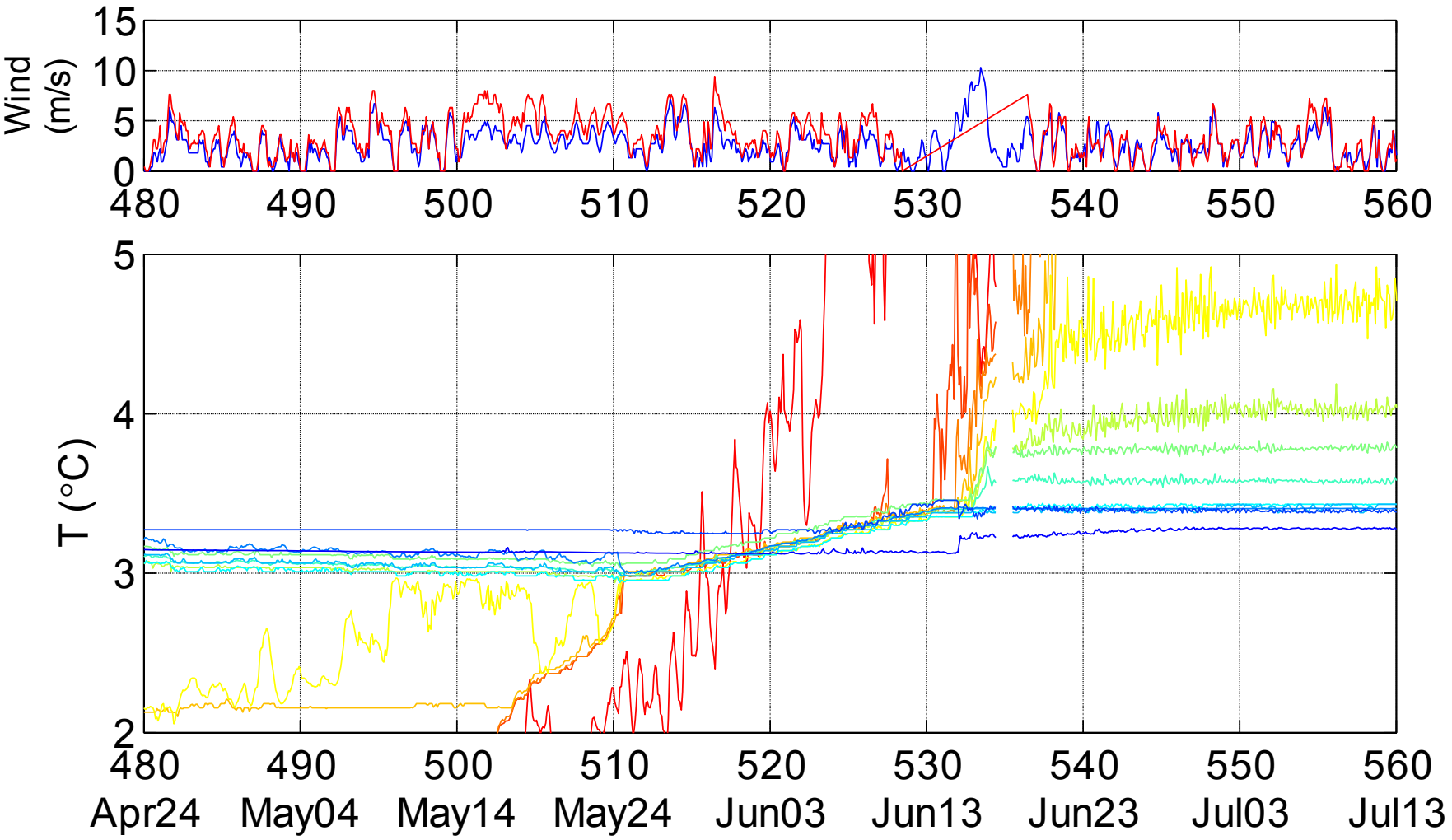


FIGURE 3b. COLOMAC Zone 2 Pit – Moored Data, 2005

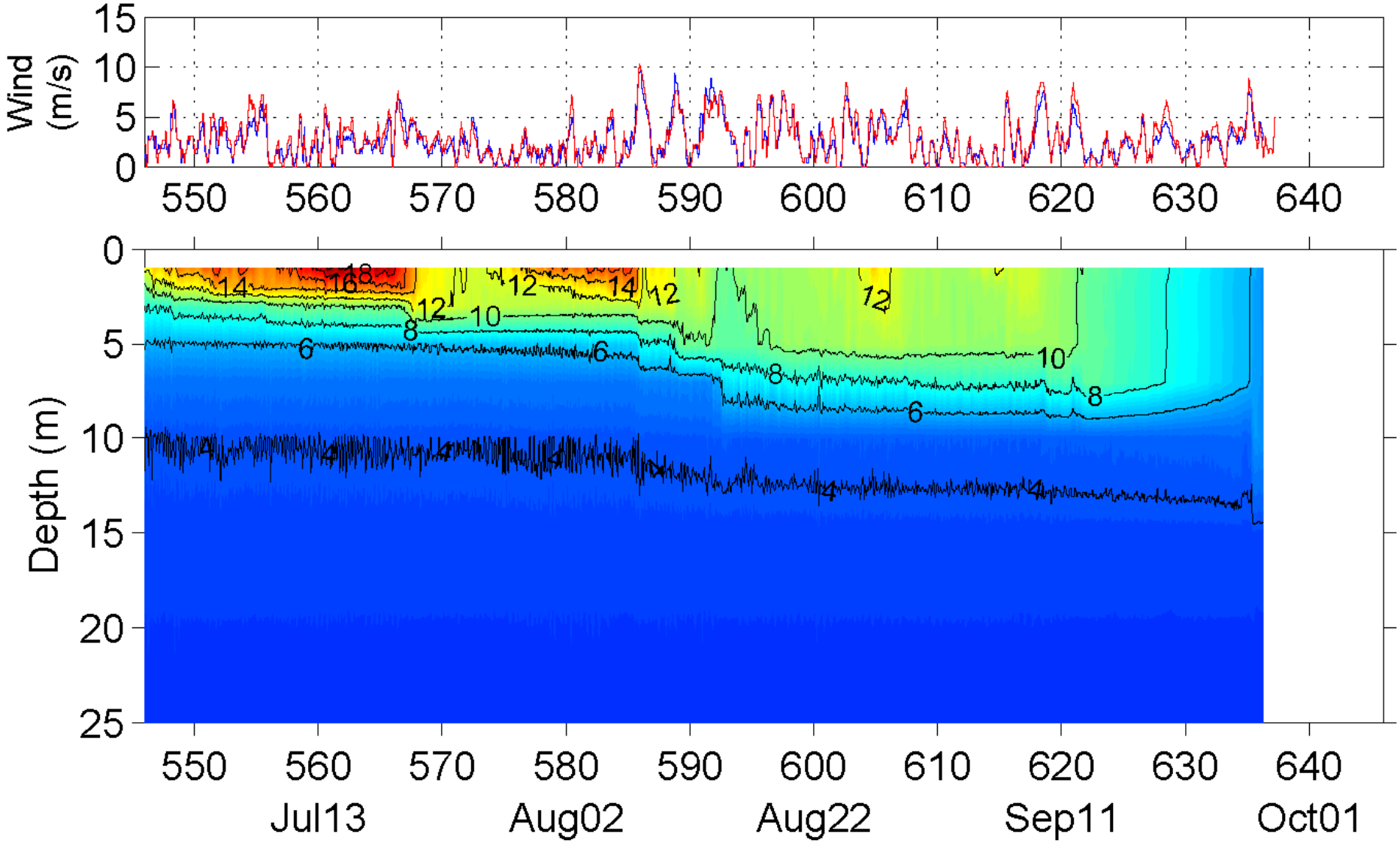
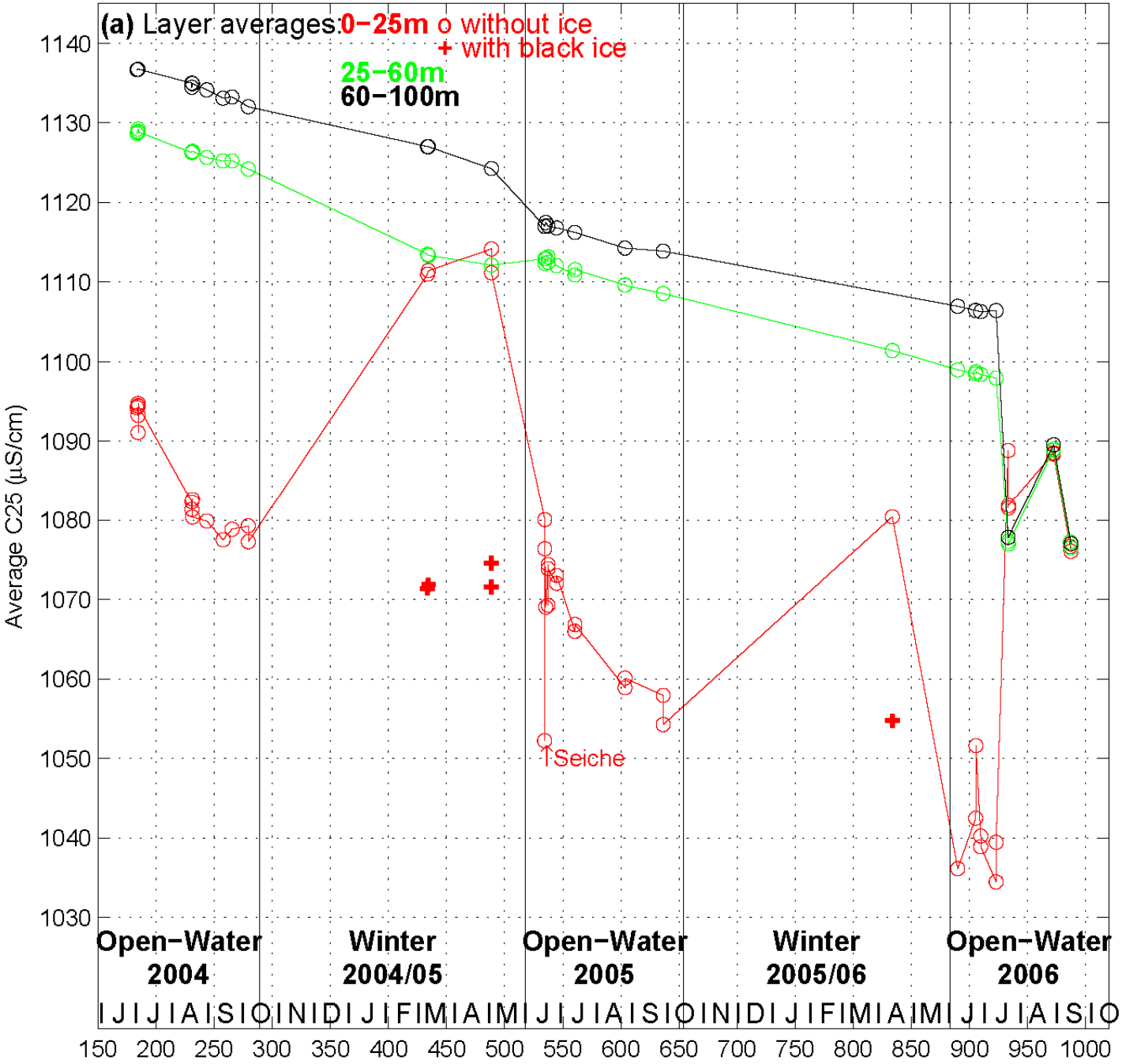


Figure 17 Average conductivity in Zone 2 Pit from all Seabird casts



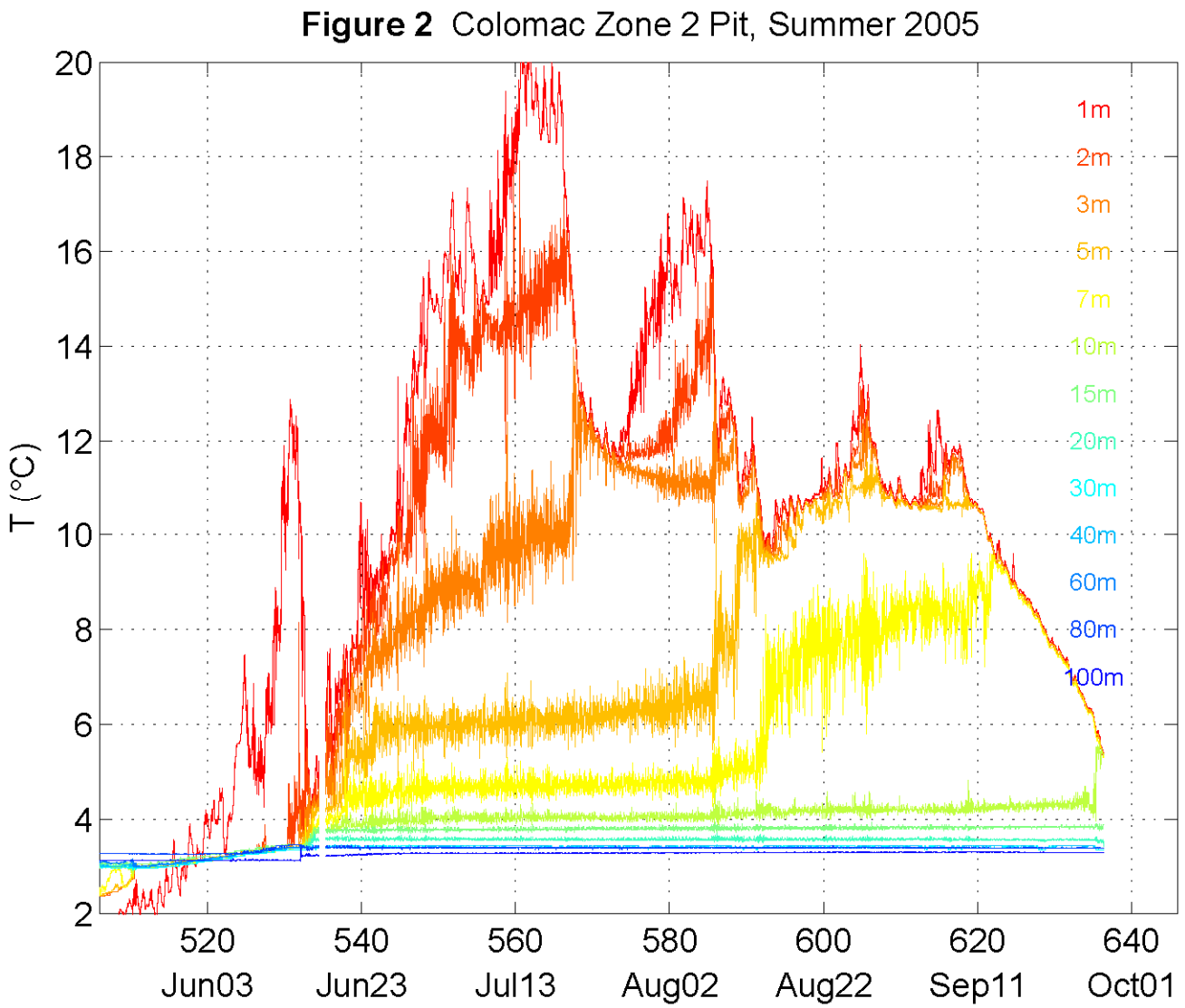
Part 3 Aeration

Stainless steel diffuser

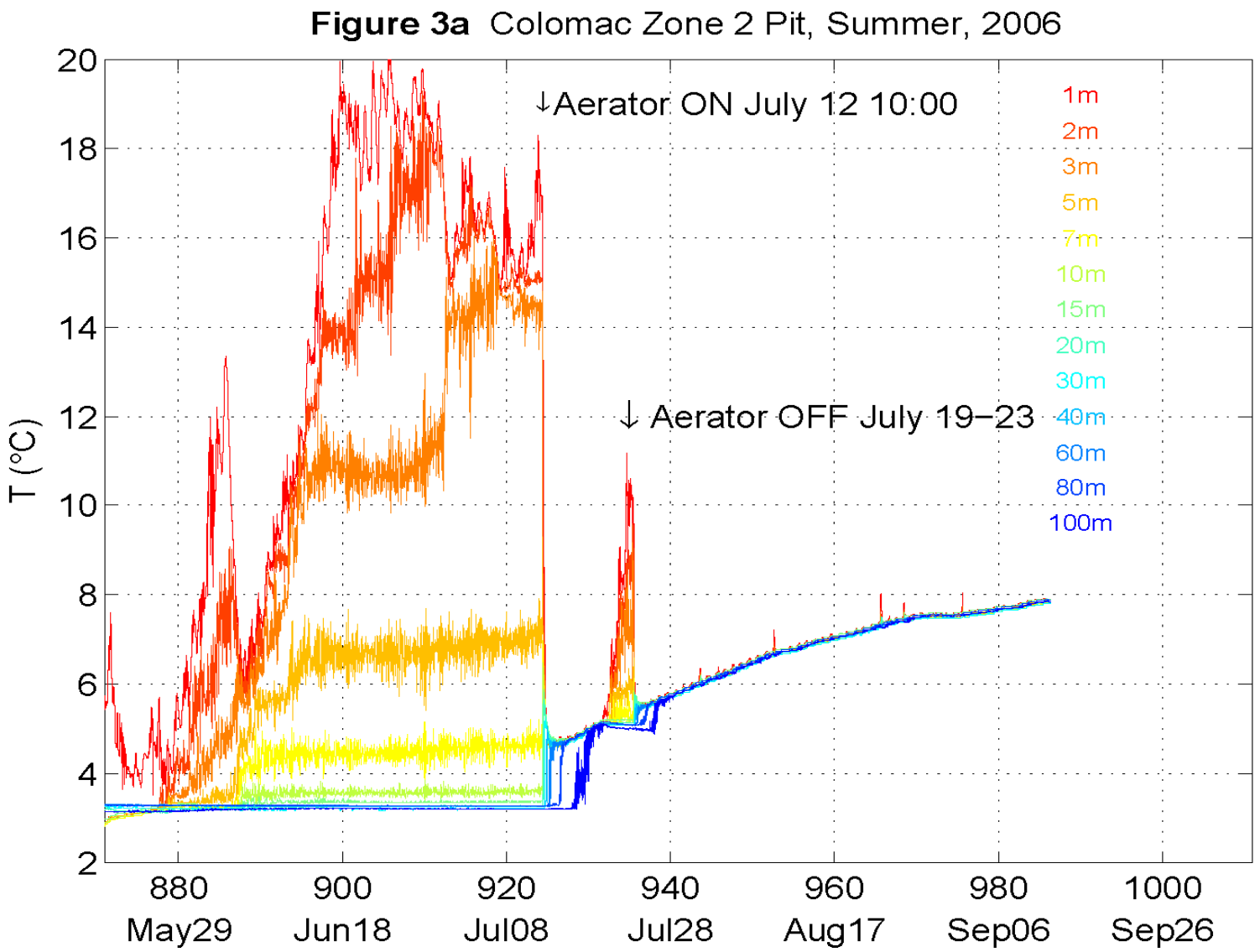
Aerator and monitoring rafts

July 22, 2006 startup

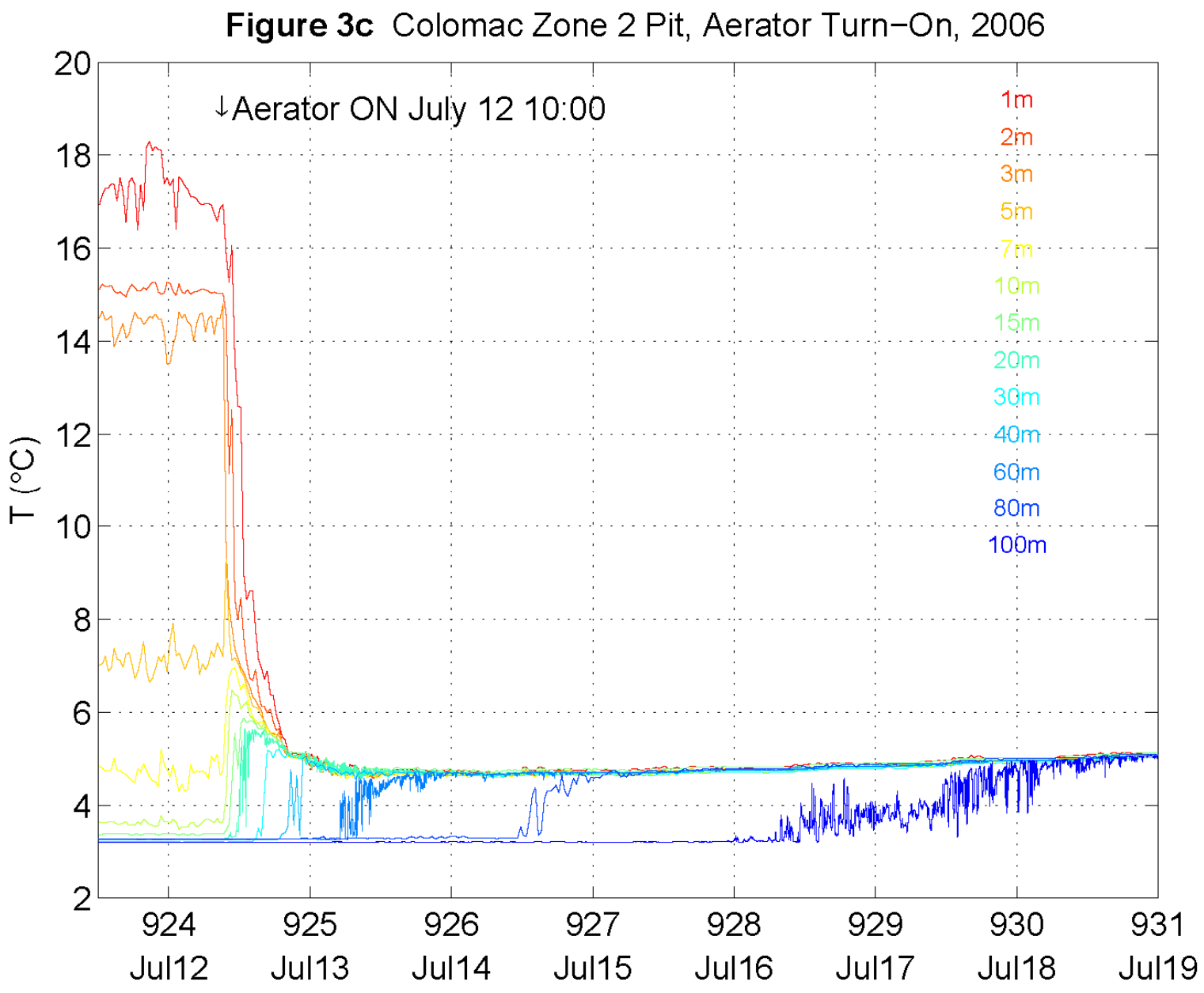
For comparison: summer 2005



Summer 2006 with aeration:

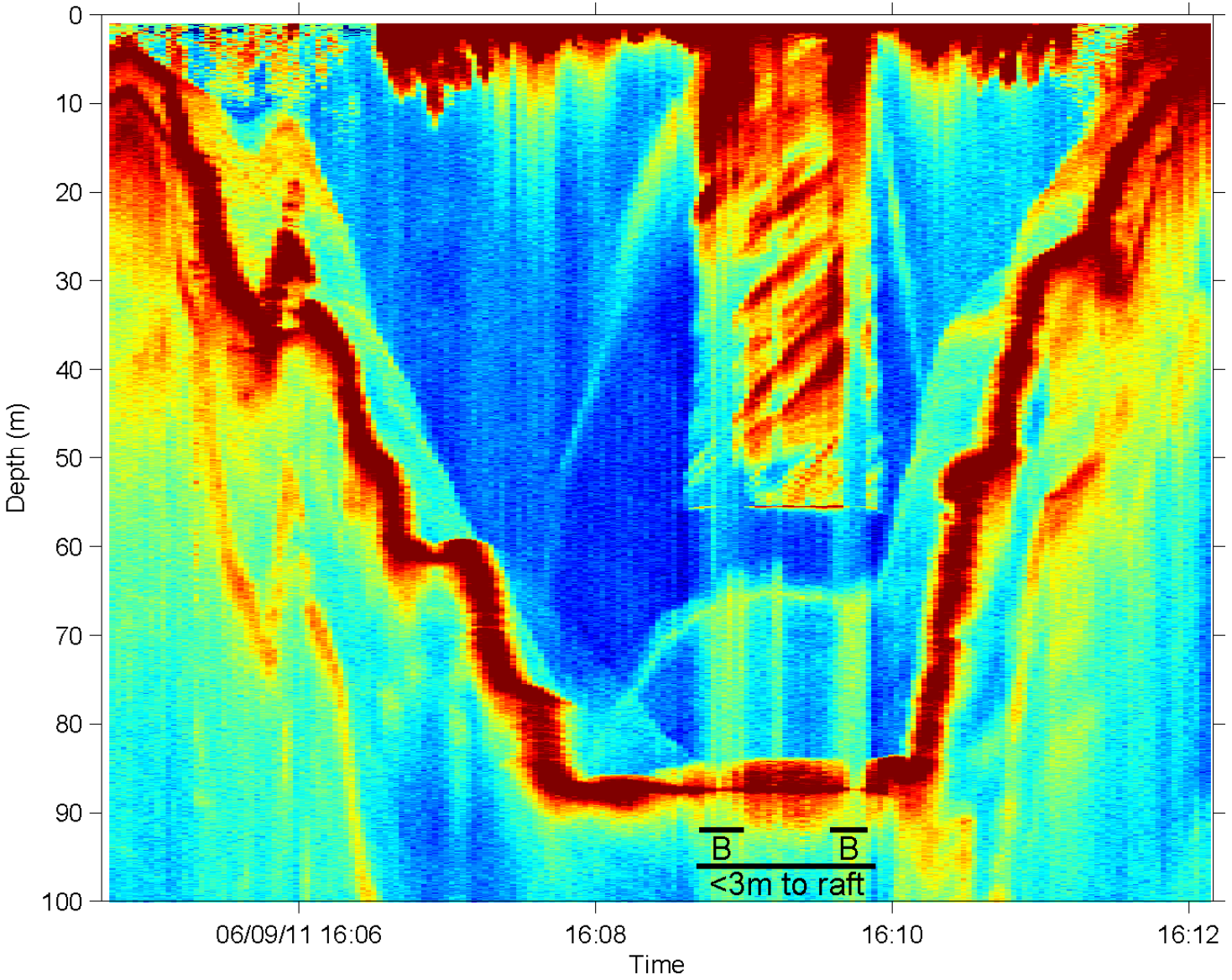


Initial Response



Sounder

Figure 6 Raw sounder transect east to west past south diffuser raft



Zone 2 Pit Conclusions

- Pit lake weakly meromictic
- Meromixis is affected by
  - Rockfall
  - Ground water inflow (even small amounts)
  - Year with thick ice cover
  - Spring upwelling
- Enhanced Natural Removal, in conjunction with aeration removed all thiocyanate (within detection)