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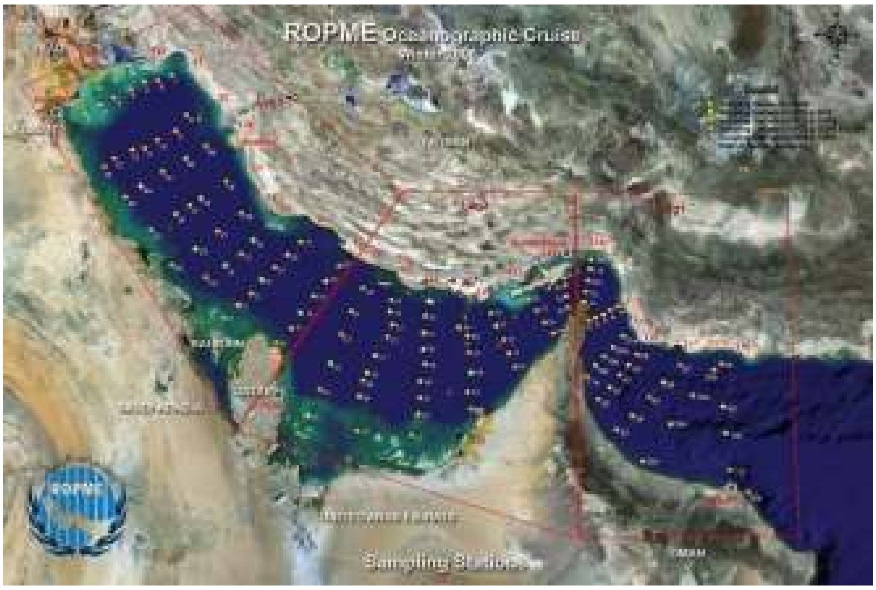
Regional Organization for the Protection of the Marine Environment

ROPME Oceanographic Cruise - Winter 2006



Technical Report Series

Technical Report : No. 1

Physical oceanography

December 2010

ROPME Oceanographic Cruise - Winter 2006
Technical Report Series:

1. Physical oceanography
2. Contaminants in Marine Sediments
3. Nutrients
4. Chlorophyll
5. Phytoplankton
6. Zooplankton
7. Ichthyoplankton
8. Meiobenthos
9. Macrobenthos

Disclaimer

This Report has been prepared Khorramshahr University of Marine Science and Technology (KUMST) and Iranian National Center for Oceanography (INCO), I. R. Iran, as the principal Investigator on 'Physical Oceanography ' under a contract with ROPME. The report is being separately subjected to peer review and linking with other relevant data and information, in order to develop an integrated understanding of the ROPME Sea Area. Meanwhile, in order to bestow the benefit of viewing the results in their preliminary form and promote a general level of understanding of the marine environment of the Region, notwithstanding the possible delay by peer review, this document is being brought out as part of a special Technical Report Series in the very form in which it was submitted by the Principal Investigator. Owing to this reason, ROPME shall not accept responsibility on the accuracy of data or interpretations contained in this Report.

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Preface:

In recognition of the importance of the oceanographic Cruises in ROPME Sea Area to understand the state of the marine environment, ROPME Council has assign high priority to the scientific Cruises. In pursuance of the Council Decision CM12/7, ROPME had the responsibility to coordinate a comprehensive oceanographic Cruise in winter 2006. The Cruise was planned in such a way that the results and reports of the studies can find their way into the synthesis of ROPME State of the Marine Environment Report.

As a result of sustained efforts, cooperation of Member States, guidance of the designated scientific committee for the Cruise, encouragements from the Excutive Committee of ROPME and the generous provision made by the Council, the historic Winter Cruise was carried out successfully on board of M/V Ghods of I. R.Iran during 1st February and 11 March 2006.

Totally, 115 stations covering the RSA have been surveyed and 97 experts from ROPME Member States participated in the Cruise. The survey covered most of the main oceanographic disciplines.

The collected samples during the Cruise were distributed on a competitive basis to the competent laboratories in the Region and elsewhere for detailed analyses while sub-sample sets were kept in ROPME Marine Sample Bank to enable repetitive analyses in future, when required.

To enhance benefits from the reproduced results from the Cruise among Regional scientific community towards a better understanding of the marine environment in the RSA and to enable higher marine research, ROPME Secretariat decided on the publication of the results in a series of Technical Reports as follows:

1. Physical oceanography
2. Contaminants in Marine Sediments
3. Nutrients
4. Chlorophyll
5. Phytoplankton
6. Zooplankton
7. Ichthyoplankton
8. Meiobenthos
9. Macrobenthos

The present Technical Report is prepared by Dr. M. Sardinasab of Khorramshahr University of Marine Science and Technology (KUMST) and Mr. M.S. Sanjani of Iranian National Center for Oceanography (INCO), I.R. Iran on 'Physical Oceanography' under a contract with ROPME.

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1. Introduction

The Regional Organization for the Protection of the Marine Environment (ROPME) organized its third oceanographic cruise in winter 2006. The goals of ROPME cruises are in line with current global thrusts and support compliance with international commitment on environmental conservation and development.

This cruise aimed to expand the scope of oceanographic observation in the ROPME Sea Area (RSA). The present report outlines the scientific endeavors undertaken aboard the M/V Ghods during the ROPME winter cruise 2006 which only describes the aims, objectives and results of physical oceanography of the mentioned cruise. The cruise information is shown in Table 1.

Table 1. Cruise information.

Leg No.	Start		End		Duration (days)	Number of transects	Number of stations	Distance traveled (nm)
	Port	Date	Port	Date				
1	Muscat	03/02/2006	Bandar Abbass	09/02/2006	7	8	48	613
2	Bandar Abbass	13/02/2006	Doha	23/02/2006	11	7	35	623
3	Doha	28/02/2006	Khuweikh	09/03/2006	10	7	32	928
Total					**28**	**22**	**115**	**2173**

Leg 1:

As shown in table 1, the first leg of the cruise starts from Muscat in Oman passing through the Strait of Hormuz and ended in Bandar-Abbass in I.R. of Iran. During this trip, our ship traveled over 613 nautical miles and was punctuated by 48 research stations with 8 transects (Figure 1). The weather was extremely fine and the sea was like mirror.

Leg 2:

The second leg of the cruise took us from Bandar-Abbass to Doha in Qatar. The first 11 days, the weather was also fine but in contrast to the previous leg the weather became worst near Iranian shore. Due to this bad weather the ship had to anchored and used Kish Island as shelter for 4 days. After this stoppage the sea was getting better and the ship proceeded to continue the cruise. During this trip, our ship traveled over 623 nautical miles and was punctuated by 35 research stations with 7 transects.

Leg 3:

The third leg of the cruise started from Doha and ended in Kuwait. Duration of this leg was 10 days and the weather was also fine. During these days our ship traveled over 928 nautical miles and was punctuated by 32 research stations with 7 transects.

To collect meteorological parameters (air temperature, atmospheric pressure, wind speed and direction, and relative humidity) an AANDERAA Automatic Weather Station has been used. Also to conduct in-situ physical oceanography measurement of the water masses an IDRONAUT type of CTD (Conductivity, Temperature and Depth) meter has been employed and additional sensors for other parameters (pH, Chlorophyll-*a* and turbidity) were attached. The CTD meter is attached to a Hydro Bios Rosette and Niskin water sampler with 12 bottles.

2. Participants

The List of physical oceanography participants in the winter cruise 2006 is shown in Table 2. Also the institutions participating in this cruise are presented in table 3 in abbreviate and complete form.

Table 2. List of physical oceanography participants in the cruise

NAME	FROM	ROLE
Dr. M. Sadrinasab	KUMST (Iran)	Principal Scientist & Team Leader for leg 2
Mr. M. S. Sanjani	INCO (Iran)	Consultant & Team Leader for leg 1 and leg3
Mr. P. Ghaffari	INCO (Iran)	Expert
Mr. S. Jamshidi	INCO (Iran)	Expert
Mr.M.A. Najarpoor	KUMST (Iran)	Expert
Mr. M. G. Ali	KUWAIT	Expert
Mr. M. H. Al-Harbi	ROPME	Expert
Ms. K. Rafietabar	DOE (Iran)	Expert

Table 3. Participating institutions

ROPME	Regional Organization for Protection of Marine Environment
DME	Deputy Of Marine Environment, I.R. Iran
KUMST	Khorramshahr University of Marine Science and Technology , I.R. Iran
INCO	Iranian National Centre for Oceanography

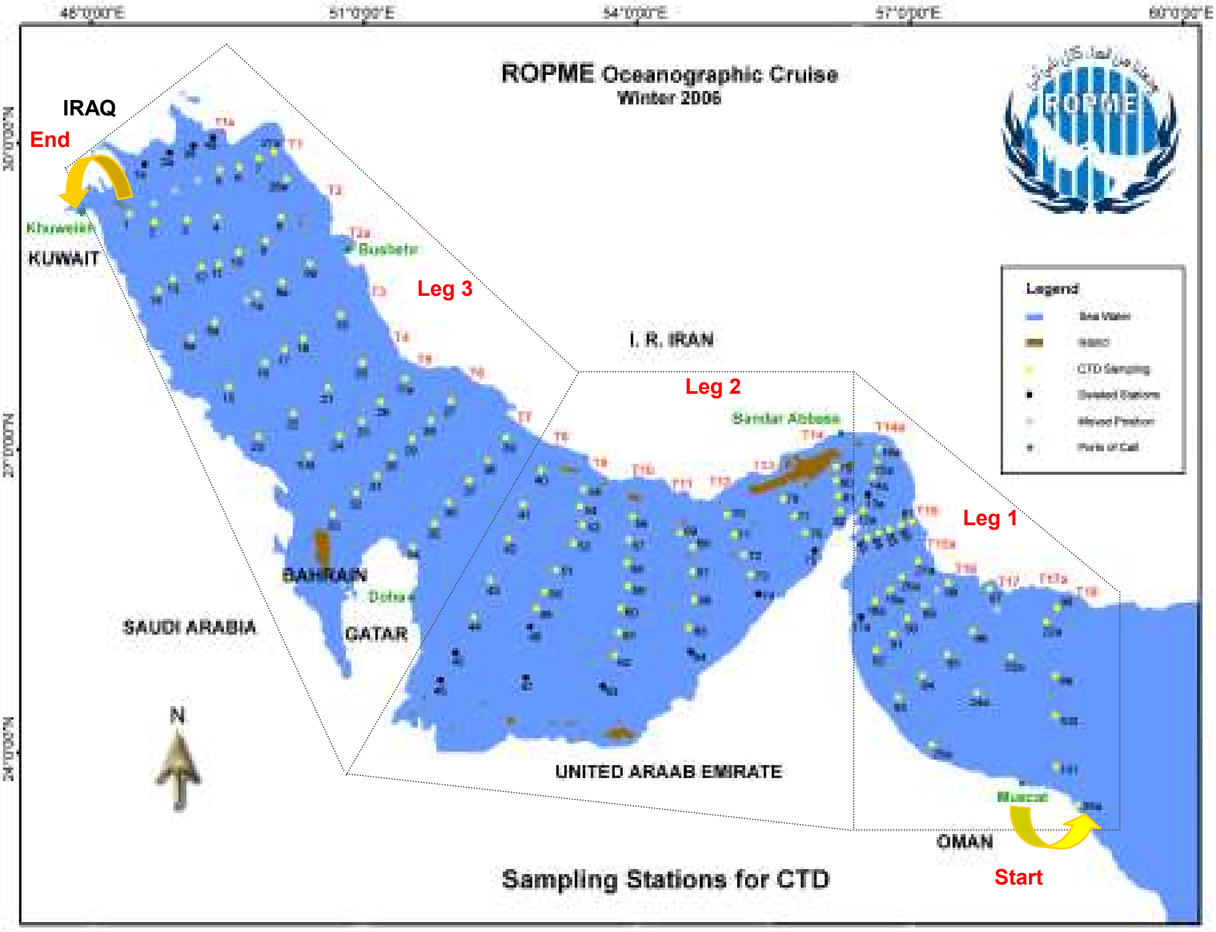
3. Acknowledgements

We would like to extend our sincere thanks to the Iranian Deputy of Maine Environment Organization and his colleagues for their best achievement during the cruise. Also it is a great pleasure to acknowledge the efficiency and profession of the Master, Officers and Crew of the M/V Ghods, who contributed enormously to the smooth-running of such a multi-disciplinary cruise with many disparate scientific aspects and objectives. The research reported here was funded by Regional Organization for Protection of Marine Environment (ROPME) and organized by its focal poin, i.e. Iranian Deputy of Maine Environment Organization.

4. Study Area and Cruise Track

Our study area was ROPME Sea Area bounded approximately between 24°N and 30°N in latitude and 48°E and 59°E in longitude. The cruise was carried out from Muscat in Oman to Kuwait. The complete cruise track is shown in figure 1. As shown in this figure the cruise has been divided into three legs namely Leg 1, leg 2 and leg 3 which are between Muscat to Bandar-Abbass, Bandar-Abbass to Doha and Doha to Kuwait respectively.

Figure 1. Cruise track of M/V Ghods ROPME Winter Cruise 2006



5. Equipment Onboard

For physical oceanography studies in this cruise, the physical parameters of sea water and atmosphere were measured by using:

- CTD probe
- Automatic weather station

5.1. CTD

4 CTDs were used in this cruise. The pressure range of two of them were 0 – 200 dbar, and the rest (the more two) were 0 – 1000 dbar. The latter were used in leg1 at Oman Sea. Other specifications of all CTDs are as follows:

Model : Ocean Seven 316 (IDRONAUT, Italy)
Number : 4 Probes
S/N : 0701202 & 0701203
Pressure Case : 1500 meter

5.1.1. Sensors Specifications

The specifications of sensors for CTDs used in cruise 2006 are as follows:

	Parameter	Range	Accuracy	Resolution
1	Pressure	0 … 200 dbar	0.05 % full scale	0.03 %
2	Temperature	-3 … +50 °C	0.003 °C	0.0005 °C
3	Conductivity	0 … 64 mS/cm	0.003 mS/cm	0.001 mS/cm
4	Oxygen	0 … 50 ppm	0.1 ppm	0.01 ppm
5	pH	0 … 14 pH	0.01 pH	0.001 pH
6	Redox	-1000 to +1000 mV	0.5 mV	0.076 mV
7	Chlorophyll a	5 … 150 μg/l		
8	Turbidity	25 … 750 FTU		

The calculated parameters are salinity, sound speed in seawater, density (Sigma T), pressure, conversion, & potential temperature (Theta).

As the CTD was attached with Rosette (Multi Water Sampler) for sampling in this cruise, following the specifications of this sampler are mentioned:

5.2. Rosette (Multi Water Sampler)

The specifications of sampler used in this cruise are as follows:

Model : MWS 12, Hydro Bios (Germany)
Number : two
Operation Depth: 3000 m Standard
Depth meter : 0 – 3000 m Standard
Resolution : 1 m
Accuracy (0 ... 50 ^{o}C): type. < 0.25 %

5. 3. AWS (Automatic Weather Station)

The specifications of Automatic Weather Station (AWS) are as follows:

Model : AWS 2700 (AANDERAA, Norway)
Number: One

5.3.1. Sensors Specifications:

The specifications of sensors used at AWS are as follows:

	Parameter	Range	Accuracy
1	Wind Speed	0 … 79 m/s	± 2 %
2	Wind Direction	0 … 360 degree	Better than ± 2^{o}
3	Air Temperature	-30 to +60 ^{o}C	± 0.1 % of rang
4	Net Radiation	± 2000 W/m^{2}	± 1 % of full scale
5	Air Pressure	920 – 1080 hpa	± 0.2 hpa
6	Relative Humidity	0 to 100 %	± 2 % RH
7	Mira Visibility	20 to 3000 m	
8	Sunshine Duration	Wave Length: 400 – 1100 nm	

5. 4. Secchi Disk

Secchi disk (Figure 2) is a device used to measure water transparency in open waters of lakes, bays, and the ocean. It is a circular plate divided into four equal parts which are painted alternately black and white. The disk which was employed in the cruise was 30cm in diameter and attached to a rope. One meter intervals were marked on the rope. The Secchi disk used to be lowered into the water off the shady side of the ship until it was no longer visible. The depth at which the pattern on the disk was no longer visible was taken as a measure of the transparency of the water. This measure is known as the Secchi depth and is related to water turbidity. Higher Secchi readings mean more rope was let out before the disk disappeared from sight and indicates more transparent water. Lower readings indicate turbid water.

To obtain a good measurement, the disk is lowered into the water while observing the depth at which it disappears. It is lowered some more and then raised while observing the depth at which it reappears. The Secchi disk measurement in this cruise was the average of the two observations. Unfortunately the Secchi disk wasn't available in the first few days of the cruise (Leg 1) and also due to its technical feature we couldn't use it from sunset to sunrise, as well as during the rough sea. Table 4, 5 and 6 show the Secchi disk depths recorded as well as amount of cloud coverage in leg 1, 2 and 3 respectively during the ROPME Winter Cruise 2006.

Figure 2. The employed Secchi Disk in the ROPME Winter cruise 2006.

Table 4- Secchi Disk readings (meters) taken in Leg 1

Tr No.	St No.	Date	Time		Depth (m)	Disappearance Depth (m)	Cloud Cover	Remarks
			Local	GMT				
18	**26a**	2/3/2006	7:50	4:20	53	**--**	--	Not sampling because Secchi disk was not ready
	101	2/3/2006	11:55	8:25	450	**--**	--	Not sampling because Secchi disk was not ready
	100	2/3/2006	16:07	12:37	2700	**--**	--	Not sampling because Secchi disk was not ready
	99	2/3/2006	18:45	15:15	1700	**--**	--	Not sampling because Secchi disk was not ready
	98	2/4/2006	7:30	4:00	50	**--**	--	No sampling due to high bloom
17a	**22a**	2/4/2006	9:10	5:40	200	**--**	--	No sampling due to high bloom
	23a	2/4/2006	11:54	8:24	1000	**--**	--	No sampling due to high bloom
	24a	2/4/2006	15:20	11:50	1600	**--**	--	No sampling due to high bloom
	25a	2/4/2006	19:15	15:45	55	**--**	--	No sampling due to high bloom
17	**93**	2/5/2006	7:00	3:30	67	**--**	--	No sampling due to high bloom
	94	2/5/2006	10:25	6:55	1000	**8**	0/10	
	95	2/5/2006	12:30	9:00	1039	**7**	2/10	
	96	2/5/2006	14:45	11:15	885	**6**	10/10	
	97	2/5/2006	17:50	14:20	54	**--**	--	Not Sampling Due to Sunset
16	**88**	2/6/2006	7:20	3:50	65	**--**	4/10	
	89	2/6/2006	9:25	5:55	313	**6**	4/10	
	90	2/6/2006	11:15	7:45	300	**6**	4/10	
	91	2/6/2006	12:45	9:15	236	**6.5**	2/10	
	92	2/6/2006	15:25	11:55	183	**7**	4/10	
15a	**18a**	2/6/2006	18:35	15:05	98	**--**	--	Not Sampling Due to Sunset
	19a	2/6/2006	20:00	16:30	110	**--**	--	Not Sampling Due to Sunset
	20a	2/6/2006	22:00	18:30	104	**--**	--	Not Sampling Due to Sunset
	21a	2/7/2006	7:25	3:55	57	**7**	0/10	
15	**87**	2/7/2006	12:00	8:30	26	**6**	0/10	
	86	2/7/2006	18:05	14:35	70	**5.5**	0/10	
	85	2/8/2006	8:15	4:45	104	**6**	0/10	
	84	2/8/2006	10:20	6:50	117	**5**	0/10	
	83	2/8/2006	13:30	10:00	65	**8**	0/10	
14a	**12a**	2/8/2006	19:20	15:50	137	**--**	--	Not Sampling Due to Sunset
	14a	2/9/2006	8:00	4:30	64	**--**	4/10	
	15a	2/9/2006	9:50	6:20	44	**5.5**	4/10	
	16a	2/9/2006	11:50	8:20	30	**5**	2/10	

Table 5- Secchi Disk readings (meters) taken in Leg 2

Tr No.	St No.	Date	Time		Depth (m)	Disappearance Depth (m)	Cloud Cover	Remarks
			Local	GMT				
14	**79**	2/13/2006	8:45	5:15	45	**7**	8/10	
	80	2/13/2006	11:30	8:00	68	**5**	1/10	
	81	2/13/2006	12:55	9:25	83	**6**	1/10	
	82	2/13/2006	14:50	11:20	88	**7**	0/10	
13	**76**	2/13/2006	18:00	14:30	87	**--**	--	Not sampling due to sunset
	77	2/14/2006	8:10	4:40	61	**8**	1/10	
	78	2/14/2006	11:00	7:30	45	**6**	0/10	
12	**70**	2/14/2006	14:35	11:05	45	**6**	3/10	
	71	2/14/2006	16:50	13:20	83	**5.5**	3/10	
	72	2/15/2006	8:40	5:10	72	**6**	2/10	
	73	2/15/2006	11:00	7:30	45	**6.5**	2/10	
11	**65**	2/15/2006	14:55	11:25	28	**7**	3/10	
	66	2/15/2006	16:30	13:00	41	**7**	4/10	
	67	2/15/2006	18:40	15:10	65	**--**	--	Not sampling due to sunset
	68	2/15/2006	20:30	17:00	88	**--**	--	Not sampling due to sunset
	69	2/15/2006	21:50	18:20	75	**--**	--	Not sampling due to sunset
10	**56**	2/21/2006	5:20	1:50	93	**--**	--	Not sampling due sea condition
	57	2/21/2006	9:25	5:55	83	**--**	--	Not sampling due sea condition
	58	2/21/2006	10:40	7:10	75	**--**	--	Not sampling due sea condition
	59	2/21/2006	12:40	9:10	42	**--**	--	Not sampling due sea condition
	60	2/21/2006	15:00	11:30	33	**--**	--	Not sampling due sea condition
	61	2/21/2006	16:20	12:50	35	**--**	--	Not sampling due sea condition
	62	2/21/2006	18:15	14:45	18	**--**	--	Not sampling due sea condition
09	**49**	2/22/2006	5:40	2:10	42	**--**	--	Not sampling due to sunset
	50	2/22/2006	7:30	4:00	39	**6**	8/10	
	51	2/22/2006	9:30	6:00	60	**8**	6/10	
	52	2/22/2006	11:25	7:55	72	**7**	8/10	
	53	2/22/2006	12:45	9:15	80	**9**	7/10	
	54	2/22/2006	14:55	11:25	83	**6.5**	8/10	
	55	2/22/2006	16:35	13:05	86	**5**	10/10	
08	**40**	2/22/2006	20:15	16:45	86	**--**	--	Not sampling due after sunset
	41	2/23/2006	9:10	5:40	80	**6**	10/10	
	42	2/23/2006	11:00	7:30	61	**5**	10/10	
	43	2/23/2006	14:45	11:15	33	**6**	10/10	
	44	2/23/2006	17:50	14:20	17	**--**	--	Not sampling due after sunset

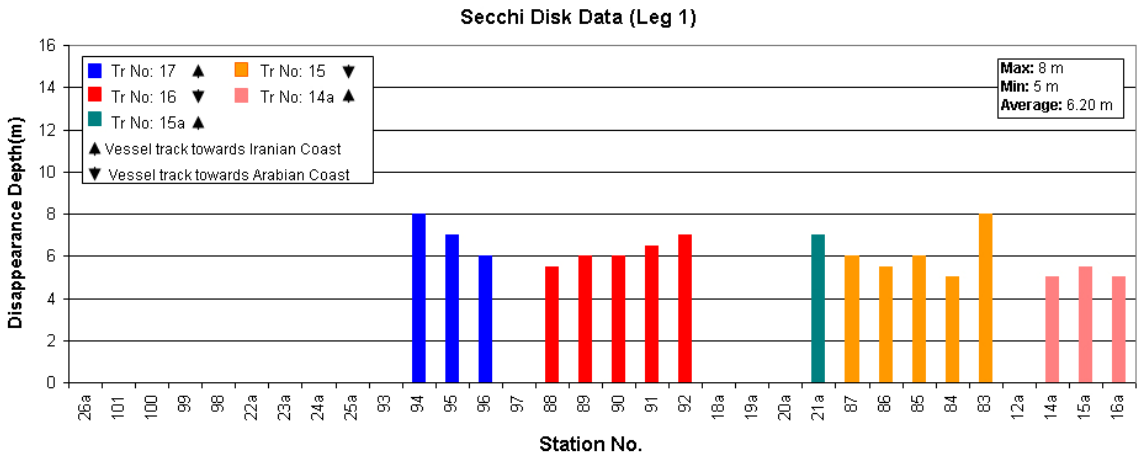
Table 6- Secchi Disk readings (meters) taken in Leg 3

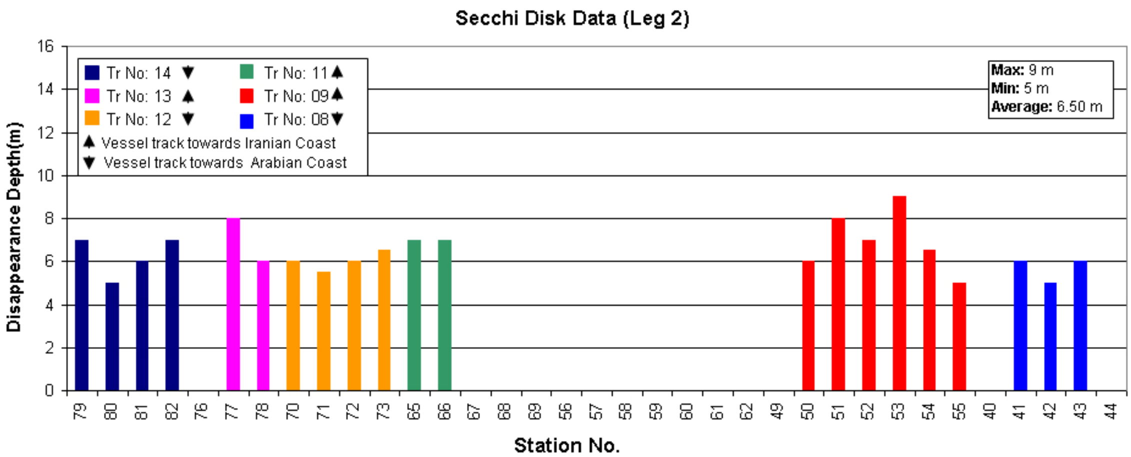
Tr No.	St No.	Date	Time		Depth (m)	Disappearance Depth (m)	Cloud Cover	Remarks
			Local	*GMT*				
07	**34**	2/28/2006	9:00	5:30	14	**6.4**	0/10	
	35	2/28/2006	12:10	8:40	31	**--**	--	Not sampling
	36	2/28/2006	14:10	10:40	52	**3.2**	0/10	
	37	2/28/2006	17:00	13:30	65	**3.3**	0/10	
	38	2/28/2006	19:10	15:40	73	**--**	--	Not sampling due after sunset
	39	3/1/2006	6:30	3:00	77	**5.4**	0/10	
06	**27**	3/1/2006	11:10	7:40	54	**5**	0/10	
	28	3/1/2006	11:45	8:15	43	**3**	0/10	
	29	3/1/2006	15:35	12:05	73	**4.5**	0/10	
	30	3/1/2006	17:30	14:00	71	**7**	0/10	
	31	3/1/2006	20:00	16:30	29	**--**	--	Not sampling due after sunset
	33	3/2/2006	6:45	3:15	14	**9**	0/10	
	32	3/2/2006	9:45	6:15	20	**9**	0/10	
05	**10a**	3/2/2006	17:00	13:30	26	**9**	0/10	
	24	3/3/2006	6:36	3:06	65	**7.8**	0/10	
	25	3/3/2006	9:00	5:30	67	**8.5**	0/10	
	26	3/3/2006	12:30	9:00	73	**8.8**	0/10	
	11a	3/3/2006	3:30	12:00	17	**--**	--	Not sampling
04	**20**	3/4/2006	6:45	3:15	63	**5.8**	3/10	
	21	3/4/2006	9:45	6:15	60	**9**	3/10	
	22	3/4/2006	12:35	9:05	57	**12.2**	4/10	
	23	3/4/2006	16:00	12:30	43	**10.5**	3/10	
03	**15**	3/5/2006	7:00	3:30	21	**5**	0/10	
	16	3/5/2006	10:15	6:45	53	**10**	0/10	
	17	3/5/2006	12:00	8:30	60	**9.5**	0/10	
	18	3/5/2006	15:00	11:30	58	**6.4**	0/10	
	19	3/5/2006	17:40	14:10	57	**4.8**	0/10	
2a	**9a**	3/6/2006	6:45	3:15	47	**7.1**	0/10	
	8a	3/6/2006	9:35	6:05	55	**7.5**	0/10	
	7a	3/6/2006	11:35	8:05	55	**15.5**	0/10	
	6a	3/6/2006	14:00	10:30	47	**5.8**	0/10	
	5a	3/6/2006	15:00	11:30	21	**6.6**	0/10	
02	**14**	3/7/2006	7:10	3:40	24	**7.5**	0/10	
	13	3/7/2006	8:15	4:45	41	**10**	0/10	
	12	3/7/2006	10:30	7:00	39	**7.2**	0/10	
	11	3/7/2006	12:20	8:50	44	**7.5**	0/10	
	10	3/7/2006	14:30	11:00	49	**6.3**	0/10	
	9	3/7/2006	17:00	13:30	50	**7.3**	0/10	
	8	3/8/2006	6:40	3:10	42	**6.1**	0/10	
	28a	3/8/2006	11:20	7:50	26	**7.1**	1/10	

Table 6. Continue

Tr No.	St No.	Date	Time		Depth (m)	Disappearance Depth (m)	Cloud Cover	Remarks
			Local	*GMT*				
01	**27a**	3/8/2006	12:45	9:15	15.5	**3.1**	3/10	
	7	3/8/2006	14:00	10:30	13.5	**4.3**	1/10	
	6	3/8/2006	17:40	14:10	20	**5.8**	3/10	
	5	3/9/2006	6:45	3:15	17.7	**4**	0/10	
	4	3/9/2006	10:10	6:40	41.5	**7.1**	0/10	
	3	3/9/2006	13:35	10:05	32	**12**	0/10	
	2	3/9/2006	16:30	13:00	15	**4.4**	3/10	
	1	3/9/2006	18:45	15:15	13	**2.6**	2/10	

Figure 3 shows the Secchi disk readings at sampling stations during legs 1, 2 and 3 at this cruise. As shown in this figure no measurements were taken at the beginning of the cruise because the Secchi disk was not ready for use. There is also a big gap in leg 2 due to rough sea. Due to technical problems the Secchi disk could not be used from sunset to sunrise.





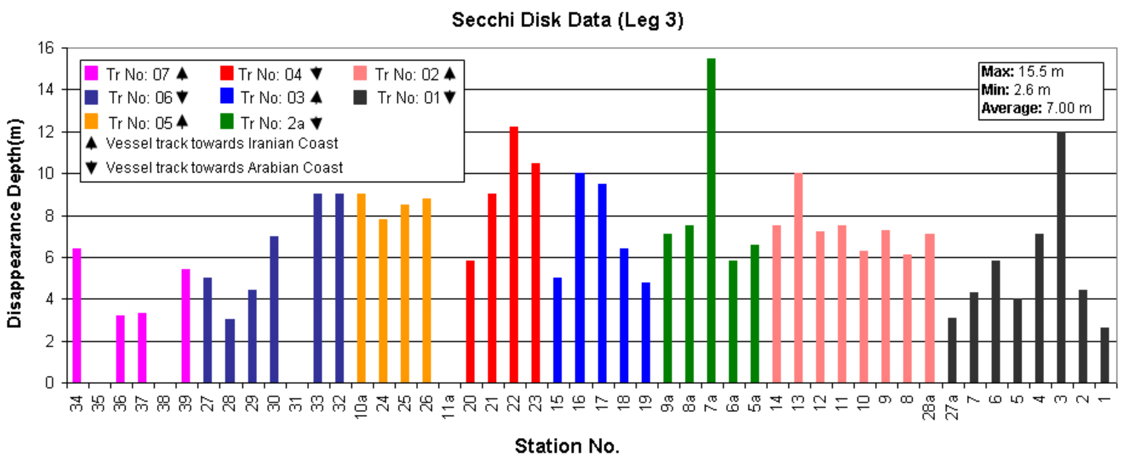


Figure 3. Secchi disk depth at sampling stations during legs 1, 2 and 3.

6. Cruise Objectives for Physical Oceanography Studies

The cruise supported several objectives under this program in physical oceanography point of view. The main objective of this cruise was to record the water circulation features in the RSA. Since Strait of Hormuz is a narrow passage and plays an important role in the circulation pattern of the study area, another objective was to study the circulation in this Strait. In order to reach the mentioned objectives, the following points had to be achieved during the cruise.

- The primary objective of the research in this cruise was an improved understanding of water characteristics in the RSA during winter.
- To carry out a survey of the temperature, Salinity and density structure in the RSA during winter.
- To collect meteorological data (air temperature, atmospheric pressure, wind speed and direction, and relative humidity).
- To carry out detailed oceanographic studies which are necessary for other disciplines such chemical and biological oceanography in the RSA.
- Determine thermohaline circulation of the inner RSA during winter.
- To improved understanding of RSA circulation.
- To investigate stratification at the Strait of Hormuz during winter.
- To conduct in situ physicochemical measurements of the water masses through the deployment of a CTD (conductivity, temperature, and depth) meter, to which other sensors for other parameters like pH, chlorophyll *a*, and turbidity were also attached.
- To understand the textural characteristics of the existing substratum in the study area.

7. Hydrographic Stations

A total of 127 stations were selected for measurement before the cruise started, but 14 of them deleted and 2 stations (27a and 28a) were added to T1 and T2 extended to Iranian coast during the cruise. Also, 115 stations were chosen to measure the physical properties of water at the study area. All stations were numbered sequentially as shown in figure 1. At all stations CTD casts were recorded along with the Rosette system. A description of each station is given by table 7 and includes date, time, sampling depth and positions.

Table 7. Stations information

St No.	Date	Time		Sampling Depth (m)	Probe No	File Name	Position		Remarks
		Local	*GMT*				*Lat. (N)*	*Long. (E)*	
1	09/03/2006	18:23	14:53	13.28	0701203	St 01-P2	29° 21.000′	048° 29.000′	Moved Position
2	09/03/2006	16:21	12:51	15.15	0701203	St 02-P2	29° 10.734′	048° 38.543′	Moved Position
3	09/03/2006	13:53	10:23	32.01	0701203	St 03-P2	29° 11.981′	049° 03.276′	Moved Position
4	09/03/2006	10:23	06:53	41.47	0701203	St 04-P2	29° 13.245′	049° 26.487′	Moved Position
5	09/03/2006	06:47	03:17	17.70	0701203	St 05-P2	29° 45.257′	049° 25.300′	
6	08/03/2006	17:39	14:09	19.72	0701203	St 06-P2	29° 47.662′	049° 37.608′	
7	08/03/2006	13:58	10:28	13.51	0701203	St 07-P2	29° 52.106′	049° 52.049′	
8	08/03/2006	07:01	03:31	41.00	0701203	St 08-P2	29° 17.580′	050° 05.490′	
9	07/03/2006	16:33	13:03	50.00	0701203	St 09-P2	29° 03.600′	049° 55.588′	
10	07/03/2006	14:28	10:58	48.90	0701203	St 10-P2	28° 56.224′	049° 37.640′	
11	07/03/2006	12:19	08:49	44.01	0701203	St 11-P2	28° 49.120′	049° 25.120′	
12	07/03/2006	10:18	06:48	38.66	0701203	St 12-P2	28° 48.321′	049° 13.328′	
13	07/03/2006	08:13	04:43	41.35	0701203	St 13-P2	28° 40.380′	048° 55.238′	
14	07/03/2006	06:44	03:14	23.80	0701203	St 14-P2	28° 33.885′	048° 45.702′	
15	05/03/2006	06:57	03:27	21.92	0701203	St 15-P2	27° 39.842′	049° 30.928′	
16	05/03/2006	10:16	06:46	53.30	0701203	St 16-P2	27° 53.699′	049° 55.120′	
17	05/03/2006	13:02	09:32	60.89	0701203	St 17-P2	28° 01.115′	050° 07.896′	
18	05/03/2006	15:07	11:37	58.22	0701203	St 18-P2	28° 07.033′	050° 19.954′	
19	05/03/2006	17:45	14:15	57.30	0701203	St 19-P2	28° 21.033′	050° 44.312′	
20	04/03/2006	06:34	03:04	62.80	0701203	St 20-P2	27° 54.410′	050° 59.518′	
20	04/03/2006	06:55	03:25	63.08	0701203	St 20R2-P2	27° 54.410′	050° 59.518′	
21	04/03/2006	09:56	06:26	59.94	0701203	St 21-P2	27° 39.417′	050° 36.294′	
22	04/03/2006	12:42	09:12	57.58	0701203	St 22-P2	27° 23.887′	050° 13.952′	
23	04/03/2006	16:03	12:33	43.06	0701203	St 23-P2	27° 09.561′	049° 52.363′	
24	03/03/2006	07:07	03:37	65.22	0701203	St 24-P2	27° 10.100′	050° 43.500′	
25	03/03/2006	09:31	06:01	67.33	0701203	St 25-P2	27° 18.290′	050° 58.400′	
26	03/03/2006	13:10	09:40	73.55	0701203	St 26-P2	27° 30.497′	051° 11.060′	
27	01/03/2006	11:17	07:47	54.64	0701203	St 27-P2	27° 29.200′	051° 57.000′	
28	01/03/2006	13:57	10:27	43.60	0701203	St 28-P2	27° 18.400′	051° 43.500′	
29	01/03/2006	15:57	12:27	73.32	0701203	St 29-P2	27° 07.120′	051° 31.400′	
30	01/03/2006	17:39	14:09	71.40	0701203	St 30-P2	26° 57.100′	051° 18.500′	
31	01/03/2006	20:20	16:50	29.03	0701203	St 31-P2	26° 45.000′	051° 08.600′	
31	02/03/2006	11:12	07:42	28.43	0701203	St 31R2-P2	26° 44.200′	051° 07.300′	
31	02/03/2006	11:43	08:13	26.86	0701203	St 31R3-P2	26° 44.200′	051° 07.300′	
31	02/03/2006	12:13	08:43	24.42	0701203	St 31R4-P2	26° 44.200′	051° 07.300′	
32	02/03/2006	09:43	06:13	20.20	0701203	St 32-P2	26° 35.200′	050° 54.700′	
33	02/03/2006	07:00	03:30	14.37	0701203	St 33R2-P2	26° 21.800′	050° 45.500′	
34	28/02/2006	07:51	04:21	14.42	0701203	St 34-P2	26° 02.500′	051° 31.200′	
34	28/02/2006	08:11	04:41	14.62	0701203	St 34R2-P2	26° 02.500′	051° 31.200′	

Table 7. Continue

St No.	Date	Time		Sampling Depth (m)	Probe No	File Name	Position		Remarks
		Local	*GMT*				*Lat. (N)*	*Long. (E)*	
35	28/02/2006	12:18	08:48	31.12	0701203	St 35-P2	26° 15.000′	051° 46.000′	
36	28/02/2006	13:56	10:26	52.61	0701203	St 36-P2	26° 28.190′	051° 54.900′	
37	28/02/2006	17:00	13:30	65.26	0701203	St 37-P2	26° 42.100′	052° 08.900′	
38	28/02/2006	19:10	15:40	73.96	0701203	St 38-P2	26° 54.600′	052° 21.200′	
39	01/03/2006	06:21	02:51	77.87	0701203	St 39-P2	27° 07.000′	052° 34.100′	
40	23/02/2006	06:34	03:04	86.15	0701203	St 40-P2	26° 47.800′	052° 57.400′	
41	23/02/2006	09:05	05:35	80.41	0701203	St 41-P2	26° 27.300′	052° 44.300′	
42	23/02/2006	11:03	07:33	61.58	0701203	St 42-P2	26° 07.645′	052° 34.495′	
43	23/02/2006	14:27	10:57	33.85	0701203	St 43-P2	25° 43.513′	052° 23.170′	
43	23/02/2006	14:46	11:16	33.59	0701203	St 43R2-P2	25° 43.513′	052° 23.170′	
44	23/02/2006	17:55	14:25	16.97	0701203	St 44-P2	25° 22.100′	052° 11.700′	
45									Deleted Station
46									Deleted Station
47									Deleted Station
48									Deleted Station
49	22/02/2006	05:39	02:09	42.92	0701203	St 49-P2	25° 26.090′	052° 54.000′	
50	22/02/2006	07:40	04:10	39.27	0701203	St 50-P2	25° 35.092′	052° 58.225′	
51	22/02/2006	09:28	05:58	60.10	0701203	St 51-P2	25° 48.625′	053° 05.650′	
52	22/02/2006	11:21	07:51	72.51	0701203	St 52-P2	26° 04.193′	053° 18.059′	
53	22/02/2006	12:45	09:15	79.65	0701203	St 53-P2	26° 14.632′	053° 23.531′	
54	22/02/2006	14:52	11:22	83.04	0701203	St 54-P2	26° 26.753′	053° 22.263′	
55	22/02/2006	16:26	12:56	86.15	0701203	St 55-P2	26° 36.057′	053° 24.057′	
56	21/02/2006	06:50	03:20	93.71	0701202	St 56-P3	26° 20.905′	053° 55.864′	
57	21/02/2006	09:29	05:59	83.65	0701202	St 57-P3	26° 04.691′	053° 53.920′	
58	21/02/2006	10:46	07:16	75.25	0701202	St 58-P3	25° 53.289′	053° 52.585′	
59	21/02/2006	12:42	09:12	42.59	0701202	St 59-P3	25° 39.885′	053° 53.944′	
60	21/02/2006	15:09	11:39	33.43	0701202	St 60-P3	25° 25.260′	053° 48.614′	
61	21/02/2006	16:34	13:04	35.02	0701202	St 61-P3	25° 12.347′	053° 47.509′	
61	21/02/2006	16:36	13:06	35.40	0701203	St 61-P2	25° 12.347′	053° 47.509′	
62	21/02/2006	18:23	14:53	18.82	0701203	St 69-P2	24° 59.300′	053° 45.100′	
63									Deleted Station
64									Deleted Station
65	15/02/2006	14:42	11:12	28.90	0701202	St 65-P3	25° 14.934′	054° 33.470′	
66	15/02/2006	16:22	12:52	42.35	0701202	St 66-P3	25° 31.090′	054° 37.156′	
67	15/02/2006	18:38	15:08	65.20	0701202	St 67-P3	25° 47.127′	054° 33.719′	
68	15/02/2006	20:30	17:00	88.50	0701202	St 68-P3	26° 02.716′	054° 35.755′	
69	15/02/2006	21:55	18:25	75.68	0701202	St 69-P3	26° 08.382′	054° 27.506′	
70	14/02/2006	14:11	10:41	44.46	0701202	St 70-P3	26° 21.104′	054° 57.957′	
71	14/02/2006	16:49	13:19	83.54	0701202	St 71-P3	26° 12.000′	055° 03.000′	

Table 7. Continue

St No.	Date	Time		Sampling Depth (m)	Probe No	File Name	Position		Remarks
		Local	*GMT*				*Lat. (N)*	*Long. (E)*	
72	14/2/2006	18:40	15:10	72.31	0701202	St 72-P3	25° 57.254′	055° 10.080′	
72	15/02/2006	08:21	04:51	81.01	0701202	St 72R2-P3	25° 57.254′	055° 10.080′	
73	15/02/2006	10:36	07:06	35.17	0701202	St 73-P3	25° 44.899′	055° 16.722′	
74									Deleted Station
75									Deleted Station
76	13/02/2006	17:51	14:21	85.99	0701202	St 76-P3	26° 10.200′	055° 50.510′	
77	13/02/2006	20:47	17:17	60.81	0701203	St 77-P3	26° 20.671′	055° 43.561′	
77	14/02/2006	07:44	04:14	59.63	0701202	St 77-P2	26° 20.671′	055° 43.561′	
77	14/02/2006	07:54	04:24	59.49	0701202	St 77R2-P3	26° 20.671′	055° 43.561′	
78	14/02/2006	10:27	06:57	44.20	0701202	St 78-P3	26° 28.769′	055° 36.474′	
79	13/02/2006	07:56	04:26	43.13	0701203	St 79-P2	26° 51.046′	056° 10.378′	
79	13/02/2006	08:04	04:34	42.13	0701202	St 79-P3	26° 51.046′	056° 10.378′	
79	13/02/2006	10:02	06:32	44.07	0701203	St 79R2-P2	26° 51.046′	056° 10.378′	
79	13/02/2006	10:02	06:32	44.10	0701202	St 79R2-P3	26° 51.046′	056° 10.378′	
80	13/02/2006	11:42	08:12	66.73	0701202	St 80-P3	26° 42.265′	056° 11.241′	
81	13/02/2006	12:42	09:12	82.02	0701203	St 81-P2	26° 34.533′	056° 12.241′	
81	13/02/2006	12:42	09:12	82.20	0701202	St 81-P3	26° 34.533′	056° 12.241′	
82	13/02/2006	14:12	10:42	89.98	0701202	St 82-P3	26° 23.771′	056° 13.583′	
82	13/02/2006	14:12	10:42	90.17	0701203	St 82-P2	26° 23.771′	056° 13.583′	
83	08/02/2006	12:51	09:21	95.00	0702267	St 083-P1	26° 08.763′	056° 31.767′	
84	08/02/2006	09:59	06:29	117.29	0702267	St 084-P1	26° 10.500′	056° 39.500′	
85	08/02/2006	07:39	04:09	103.11	0702267	St 085-P1	26° 13.000′	056° 46.000′	
86	07/02/2006	17:54	14:24	70.60	0702267	St 086-P1	26° 15.000′	056° 54.000′	
87	07/02/2006	11:47	08:17	25.64	0702267	St 087-P1	26° 18.900′	057° 01.800′	Moved Position
88	06/02/2006	07:07	03:37	63.37	0702267	St 088-P1	25° 40.043′	057° 24.048′	Moved Position
88	06/02/2006	07:08	03:38	62.76	0701203	St 088-P2	25° 40.043′	057° 24.048′	Moved Position
89	06/02/2006	09:20	05:50	179.46	0702267	St 089-P1	25° 28.557′	057° 08.500′	
90	06/02/2006	10:57	07:27	175.50	0702267	St 090-P1	25° 20.310′	056° 58.530′	
91	06/02/2006	12.39	05:51	179.43	0702267	St 091-P1	25° 11.176′	056° 48.496′	
92	06/02/2006	15:20	11:50	169.87	0702267	St 092-P1	25° 01.340′	056° 37.800′	
93	05/02/2006	07:09	03:39	66.59	0702267	St 093-P1	24° 33.147′	056° 50.739′	
94	05/02/2006	10:06	06:36	163.27	0702267	St 094-P1	24° 45.000′	057° 07.200′	
95	05/02/2006	12:22	08:52	174.71	0702267	St 095-P1	24° 59.595′	057° 24.758′	
96	05/02/2006	14:40	11:10	170.76	0702267	St 096-P1	25° 11.666′	057° 40.968′	
97	05/02/2006	18:00	14:30	54.08	0702267	St 097-P1	25° 38.200′	057° 54.000′	Moved Position
98	04/02/2006	07:10	03:40	47.80	0702267	St 098-P1	25° 26.801′	058° 36.914′	Moved Position
99	03/02/2006	18:51	15:21	174.78	0702267	St 099-P1	24° 46.136′	058° 35.100′	
100	03/02/2006	16:11	12:41	173.52	0702267	St 100-P1	24° 23.404′	058° 35.244′	
101	03/02/2006	12:15	08:45	111.96	0702267	St 101-P1	23° 52.420′	058° 36.791′	

Table 7. Continue

St No.	Date	Time		Sampling Depth (m)	Probe No	File Name	Position		Remarks
		Local	*GMT*				*Lat. (N)*	*Long. (E)*	
1a									Deleted Station
2a									Deleted Station
3a									Deleted Station
4a									Deleted Station
5a	06/03/2006	17:34	14:04	21.34	0701203	St 5a-P2	28° 08.501′	049° 05.508′	
6a	06/03/2006	15:28	11:58	47.61	0701203	St 6a-P2	28° 17.620′	049° 21.701′	
7a	06/03/2006	12:17	08:47	54.95	0701203	St 7a-P2	28° 31.145′	049° 49.321′	Moved Position
8a	06/03/2006	10:24	06:54	55.15	0701203	St 8a-P2	28° 41.450′	050° 05.321′	
9a	06/03/2006	07:32	04:02	47.71	0701203	St 9a-P2	28° 51.200′	050° 24.200′	
10a	02/03/2006	16:59	13:29	26.64	0701203	St 10a-P2	26° 59.800′	050° 23.700′	
11a	03/03/2006	15:35	12:05	17.23	0701203	St 11a-P2	27° 43.179′	051° 27.088′	
12a	08/02/2006	18:32	15:02	92.53	0702267	St 12a-P1	26° 25.302′	056° 28.770′	
12a	08/02/2006	18:32	15:02	92.53	0701203	St 12a-P2	26° 25.302′	056° 28.770′	
13a									Deleted Station
14a	08/02/2006	21:40	18:10	63.01	0702267	St 14a-P1	26° 43.200′	056° 34.900′	
14a	09/02/2006	07:20	03:50	60.17	0701203	St 14a-P2	26° 43.200′	056° 34.900′	
15a	09/02/2006	10:05	06:35	44.77	0702267	St 15a-P1	26° 53.600′	056° 37.000′	
16a	09/02/2006	11:12	07:42	30.39	0702267	St 16a-P1	27° 01.400′	056° 39.300′	
17a									Deleted Station
18a	06/02/2006	18.36	05:08	98.15	0702267	St 18a-P1	25° 30.653′	056° 36.224′	
19a	06/02/2006	20:20	16:50	109.57	0702267	St 19a-P1	25° 37.386′	056° 45.487′	
20a	06/02/2006	22:14	18:44	104.92	0702267	St 20a-P1	25° 44.557′	056° 54.721′	
21a	07/02/2006	07:19	03:49	54.94	0702267	St 21a-P1	25° 53.400′	057° 11.300′	
22a	04/02/2006	09:19	05:49	116.08	0702267	St 22a-P1	25° 18.070′	058° 28.909′	
23a	04/02/2006	12:04	08:34	170.30	0702267	St 23a-P1	24° 58.210′	058° 06.300′	
24a	04/02/2006	15:26	11:56	173.41	0702267	St 24a-P1	24° 36.260′	057° 43.425′	
25a	04/02/2006	19:20	15:50	56.02	0702267	St 25a-P1	24° 05.505′	057° 13.813′	
26a	03/02/2006	07:52	04:22	53.62	0702267	St 26a-P1	23° 31.000′	058° 46.100′	Moved Position
27a	08/03/2006	12:21	08:51	15.48	0701203	St 27a-P2	29° 56.006′	050° 03.006′	
28a	08/03/2006	10:10	06:40	26.05	0701203	St 28a-P2	29° 38.011′	050° 11.008′	

8. Hydrographic Measurements Descriptions, Techniques & Calibrations

At the hydrographic stations the CTD was attached to the rosette and deployed with a speed of about 1 m/s. During the up-cast of CTD/Rosette up to 12 samples were taken at regular depth intervals in each station (Figure 4). Due to the use of the ship's echo sounder, we were able to sample within quite a short distance from the bottom. The multi-valve system allowed closing the sampler bottles by computer command from the rosette operator at each selected depth. For calibration purposes CTD was used to be checked with another CTD for any error on daily bases. Also in order to make sure about the accurate functioning of the CTD, the vertical profile of each parameter used to be plotted at each station and the plot was conformed by other scientific teams. Due to the limited wire of the crane, maximum sampling depth was limited to 180 meters. The general behaviors of the samplers were good and no errors in the functioning of the rosette sampler itself were detected.

Figure 4. Rosette system used during the ROPME winter cruise 2006.

9. Data Collection and Processing

The Ocean Seven 316 CTD was fitted with additional sensors (pH, Oxygen, Chlorophyll-*a* and Turbidity) and attached to the rosette system. For set up and retrieval CTD data Hyper Terminal software was used. After each CTD cast the data were copied to a hard disk of the ship's computer network and a daily back-up copy was made on external hard disk.

At the same time, in each station Secchi Disk was used to determine the water transparency and in order to determine cloud coverage and sea surface condition, pictures of the sky and sea surface have been recorded.

10. Results

10.1. Meteorological Results

Meteorological data collected in this cruise are air temperature, wind speed, wind direction, net radiation, air pressure, relative humidity, visibility and sunshine Duration. The collected Meteorological data for all stations are shown in table 8. Note that given meteorological data to authors excludes data between the legs as well as period of bad weather in leg 2 (17 to 21 February 2006) in which the ship had to anchor near the Kish Island.

Table 8. Meteorological data collected for all stations

St No.	Date	Time		WS (m/s)	WD (Deg.)	A.Temp (ºC)	A. Press (hpa)	RH (%)	Visb. (m)	S.Dur (min)	NR (w/m^2)
		Local	*GMT*								
1	09/03/2006	18:23	14:53	7.61	67.86	19.65	1031.31	103.8	1705.26	0	-26.14
2	09/03/2006	16:21	12:51	10.18	286.55	20.3	1030.64	103.8	1708.2	10	131.76
3	09/03/2006	13:53	10:23	7.61	285.5	20.21	1031.31	103.8	1758.11	10	482.64
4	09/03/2006	10:23	06:53	6.14	64.69	20.3	1039.28	103.8	1810.96	10	425.62
5	09/03/2006	06:47	03:17	5.98	356.52	18.63	1047.59	103.8	1781.6	0	-56.84
6	08/03/2006	17:39	14:09	2.72	47.47	19.93	1043.27	103.8	1740.5	10	-144.56
7	08/03/2006	13:58	10:28	2.8	71.02	19.93	1042.28	103.8	1740.5	10	583.51
8	08/03/2006	07:01	03:31	3.73	28.13	18.53	1039.95	103.8	1769.86	7	-52.46
9	07/03/2006	16:33	13:03	4.51	304.49	19.56	1035.96	103.8	1722.88	10	39.65
10	07/03/2006	14:28	10:58	6.53	293.23	19.74	1024.99	103.8	1725.82	10	530.88
11	07/03/2006	12:19	08:49	8.08	290.07	19.56	1023.33	103.8	1743.43	10	561.58
12	07/03/2006	10:18	06:48	8.16	285.15	19.18	1027.15	103.8	1752.24	10	447.55
13	07/03/2006	08:13	04:43	10.64	313.98	18.72	1029.31	103.8	1749.3	10	65.97
14	07/03/2006	06:44	03:14	4.35	5.98	18.53	1035.96	103.8	1737.56	0	-56.84
15	05/03/2006	06:57	03:27	5.75	310.81	18.44	1044.6	103.8	1766.92	7	-43.68
16	05/03/2006	10:16	06:46	9.48	309.06	20.21	1022	103.8	1766.92	10	522.11
17	05/03/2006	13:02	09:32	8.08	6.68	20.39	1020.01	102.77	1752.24	10	535.27
18	05/03/2006	15:07	11:37	10.1	308.35	20.21	1025.99	103.8	1728.75	10	315.97
19	05/03/2006	17:45	14:15	5.98	345.97	19.93	1034.63	103.8	1728.75	9	-122.63
20	04/03/2006	06:34	03:04	5.21	8.44	18.44	1029.98	103.8	1717.01	0	-52.46
20	04/03/2006	06:55	03:25	4.97	1.76	18.44	1035.96	103.8	1722.88	0	-17.37
21	04/03/2006	09:56	06:26	4.27	21.45	19.65	1022.66	103.8	1743.43	9	482.64
22	04/03/2006	12:42	09:12	2.25	42.19	20.3	1010.7	103.8	1725.82	0	412.46
23	04/03/2006	16:03	12:33	2.95	317.49	20.39	1016.68	103.8	1699.39	10	237.02
24	03/03/2006	07:07	03:37	8.78	273.9	20.39	1021.33	103.8	1737.56	10	-48.07
25	03/03/2006	09:31	06:01	10.88	309.41	20.49	1019.34	103.8	1749.3	10	355.44
26	03/03/2006	13:10	09:40	9.71	277.76	20.39	1012.03	103.8	1728.75	10	622.99
27	01/03/2006	11:17	07:47	2.64	6.33	23.1	1018.01	103.49	1761.05	10	495.79
28	01/03/2006	13:57	10:27	9.09	305.19	21.23	1035.63	96.86	1717.01	10	412.46
29	01/03/2006	15:57	12:27	6.22	350.9	21.33	1020.01	103.8	1717.01	10	101.05
30	01/03/2006	17:39	14:09	4.12	290.42	21.51	1018.68	103.8	1719.94	10	-144.56
31	01/03/2006	20:20	16:50	2.18	285.5	21.23	1019.67	103.8	1737.56	0	-148.95
31	02/03/2006	11:12	07:42	2.49	68.56	22.35	1025.99	103.8	1740.5	10	469.48
31	02/03/2006	11:43	08:13	3.89	333.32	21.51	1034.3	102.35	1737.56	10	605.44
31	02/03/2006	12:13	08:43	3.81	286.91	21.7	1033.3	103.8	1728.75	10	592.29
32	02/03/2006	09:43	06:13	3.19	327.69	21.05	1023.99	103.8	1749.3	10	539.65
33	02/03/2006	07:00	03:30	2.41	127.63	20.67	1023.16	103.8	1725.82	10	-74.39
34	28/02/2006	07:51	04:21	5.28	340	16.78	1048.59	103.8	1813.9	10	-8.6
34	28/02/2006	08:11	04:41	5.21	344.92	16.87	1043.61	103.8	1816.83	10	30.88

Table 8. Continue

St No.	Date	Time		WS (m/s)	WD (Deg.)	A.Temp (ºC)	A. Press (hpa)	RH (%)	Visb. (m)	S.Dur (min)	NR (w/m^2)
		Local	*GMT*								
35	28/02/2006	12:18	08:48	7.54	278.47	20.21	1019.34	103.8	1799.22	10	693.16
36	28/02/2006	13:56	10:26	8.31	308.35	20.67	1021.33	103.8	1772.79	10	469.48
37	28/02/2006	17:00	13:30	9.25	303.78	21.05	1024.99	101.32	1755.18	10	-83.16
38	28/02/2006	19:10	15:40	9.95	290.77	21.14	1022.66	103.8	1758.11	0	-65.61
39	01/03/2006	06:21	02:51	3.34	350.19	20.86	1023.33	103.8	1740.5	0	-87.54
40	23/02/2006	06:34	03:04	4.35	290.77	18.72	1046.26	103.8	1769.86	0	-105.09
41	23/02/2006	09:05	05:35	6.06	262.29	19.46	1033.97	103.8	1758.11	0	101.05
42	23/02/2006	11:03	07:33	11.5	329.8	19.46	1030.31	103.8	1775.73	0	13.33
43	23/02/2006	14:27	10:57	3.34	301.32	18.72	1041.28	103.8	1746.37	0	17.72
43	23/02/2006	14:46	11:16	1.55	263	18.63	1040.61	103.8	1737.56	0	4.56
44	23/02/2006	17:55	14:25	2.49	65.75	19	1035.3	103.8	1737.56	0	-83.16
45	No Sampling										
46	No Sampling										
47	No Sampling										
48	No Sampling										
49	22/02/2006	05:39	02:09	4.74	355.47	19.37	1031.97	103.8	1758.11	0	-56.84
50	22/02/2006	07:40	04:10	1.94	61.88	19.65	1032.64	103.8	1769.86	10	-34.91
51	22/02/2006	09:28	05:58	4.66	299.21	20.11	1031.31	103.8	1775.73	10	447.55
52	22/02/2006	11:21	07:51	7.54	308.35	20.86	1020.67	103.8	1763.98	0	728.25
53	22/02/2006	12:45	09:15	2.02	169.47	21.98	1016.68	103.8	1740.5	0	522.11
54	22/02/2006	14:52	11:22	2.8	313.63	21.7	1008.54	103.8	1708.2	0	122.98
55	22/02/2006	16:26	12:56	6.76	306.24	21.42	1024.99	103.8	1711.14	0	-17.37
56	21/02/2006	06:50	03:20	8.31	333.32	20.39	1018.68	103.8	1769.86	0	-21.75
57	21/02/2006	09:29	05:59	6.68	77	20.39	1021.33	103.8	1805.09	4	57.19
58	21/02/2006	10:46	07:16	8.31	61.88	20.21	1022.33	103.8	1810.96	0	140.53
59	21/02/2006	12:42	09:12	4.2	81.22	20.67	1023.33	103.8	1784.54	0	399.3
60	21/02/2006	15:09	11:39	5.05	81.92	20.67	1018.68	103.8	1763.98	9	258.95
61	21/02/2006	16:34	13:04	6.22	63.99	20.39	1018.68	103.8	1769.86	10	13.33
61	21/02/2006	16:36	13:06	3.26	85.44	20.21	1015.19	103.8	1769.86	10	-83.16
62	21/02/2006	18:23	14:53	5.05	73.84	20.02	1016.51	103.8	1784.54	0	-74.39
63	No Sampling										
64	No Sampling										
65	15/02/2006	14:42	11:12	3.81	34.11	24.04	1027.65	103.8	1667.1	3	324.74
66	15/02/2006	16:22	12:52	3.19	264.4	24.42	1029.98	103.8	1664.16	10	39.65
67	15/02/2006	18:38	15:08	4.82	352.65	23.57	1033.97	103.8	1672.97	0	-96.32
68	15/02/2006	20:30	17:00	3.03	67.16	23.57	1029.98	103.8	1681.78	0	-127.02
69	15/02/2006	21:55	18:25	0.39	85.09	22.82	1043.61	103.8	1681.78	0	-109.47
70	14/02/2006	14:11	10:41	4.66	320.31	23.95	1011.7	103.8	1708.2	10	346.67
71	14/02/2006	16:49	13:19	3.5	14.06	23.1	1027.65	103.8	1711.14	7	-109.47

Table 8. Continue

St No.	Date	Time		WS (m/s)	WD (Deg.)	A.Temp (ºC)	A. Press (hpa)	RH (%)	Visb. (m)	S.Dur (min)	NR (w/m^2)
		Local	*GMT*								
72	14/02/2006	18:40	15:10	2.95	109	22.92	1034.63	103.8	1711.14	0	-83.16
72	15/02/2006	08:21	04:51	2.95	287.96	23.29	1034.63	102.97	1722.88	10	22.11
73	15/02/2006	10:36	07:06	4.12	107.94	23.85	1009.87	103.8	1722.88	0	381.76
74	No Sampling										
75	No Sampling										
76	13/02/2006	17:51	14:21	3.42	309.76	22.82	1047.93	103.8	1734.62	0	-83.16
77	13/02/2006	20:47	17:17	2.87	26.37	22.92	1049.92	103.8	1740.5	0	-48.07
77	14/02/2006	07:44	04:14	2.41	37.97	22.63	1051.08	103.8	1752.24	10	30.88
77	14/02/2006	07:54	04:24	2.56	41.84	22.73	1053.25	103.8	1755.18	10	44.04
78	14/02/2006	10:27	06:57	1.4	89.66	24.6	1035.3	103.8	1755.18	10	447.55
79	13/02/2006	07:56	04:26	1.01	95.99	21.79	1055.74	103.8	1746.37	4	30.88
79	13/02/2006	08:04	04:34	1.32	90.01	22.07	1055.24	103.8	1746.37	10	109.83
79	13/02/2006	10:02	06:32	3.65	11.95	23.38	1046.6	103.8	1766.92	10	188.77
80	13/02/2006	11:42	08:12	4.35	65.05	23.48	1043.94	103.8	1761.05	10	399.3
81	13/02/2006	12:42	09:12	6.14	57.66	23.76	1045.27	103.8	1749.3	10	544.04
82	13/02/2006	14:12	10:42	6.84	59.42	23.29	1047.1	103.8	1728.75	10	315.97
83	08/02/2006	12:51	09:21	3.5	96.34	24.79	1041.78	103.8	1790.41	10	355.44
84	08/02/2006	09:59	06:29	1.63	265.46	23.76	1039.95	103.8	1822.7	10	408.07
85	08/02/2006	07:39	04:09	6.29	348.79	23.1	1041.28	103.8	1813.9	10	-8.6
86	07/02/2006	17:54	14:24	1.48	109.35	23.48	1049.75	103.8	1775.73	0	-131.4
87	07/02/2006	11:47	08:17	3.11	314.33	23.2	1047.1	103.8	1787.47	10	390.53
88	06/02/2006	07:07	03:37	1.94	72.43	21.14	1052.75	103.8	1816.83	10	-78.77
89	06/02/2006	09:20	05:50	3.19	317.49	22.17	1048.92	103.8	1831.51	0	162.46
90	06/02/2006	10:57	07:27	3.81	333.32	22.54	1047.59	103.8	1819.77	10	443.16
91	06/02/2006	12.39	05:51	4.82	311.17	22.54	1047.1	103.8	1793.34	10	434.39
92	06/02/2006	15:20	11:50	5.05	2.81	23.29	1040.95	103.8	1758.11	10	101.05
93	05/02/2006	07:09	03:39	0.47	293.59	21.51	1038.29	103.8	1852.06	9	4.56
94	05/02/2006	10:06	06:36	0.7	319.25	22.45	1028.65	103.8	1855	0.7	319.25
95	05/02/2006	12:22	08:52	0.47	35.86	24.51	1024.66	103.8	1819.77	0	127.37
96	05/02/2006	14:40	11:10	0.78	351.6	22.92	1035.96	103.8	1790.41	0	175.62
97	05/02/2006	18:00	14:30	3.19	318.2	22.07	1037.95	103.8	1802.15	0	-109.47
98	04/02/2006	07:10	03:40								
99	03/02/2006	18:51	15:21								
100	03/02/2006	16:11	12:41								
101	03/02/2006	12:15	08:45								

Table 8. Continue

St No.	Date	Time		WS (m/s)	WD (Deg.)	A.Temp (ºC)	A. Press (hpa)	RH (%)	Visb. (m)	S.Dur (min)	NR (w/m^2)
		Local	*GMT*								
1a	No Sampling										
2a	No Sampling										
3a	No Sampling										
4a	No Sampling										
5a	06/03/2006	17:34	14:04	2.56	67.16	19.46	1027.32	103.8	1696.46	10	-109.47
6a	06/03/2006	15:28	11:58	2.8	38.32	20.02	1017.35	103.8	1690.58	10	438.78
7a	06/03/2006	12:17	08:47	4.82	47.47	19.93	1026.65	103.8	1717.01	10	649.3
8a	06/03/2006	10:24	06:54	8.94	40.08	19.46	1016.02	93.54	1728.75	10	346.67
9a	06/03/2006	07:32	04:02	7.15	45	18.72	1029.81	103.8	1719.94	10	-74.39
10a	02/03/2006	16:59	13:29	3.65	260.54	22.26	1028.65	103.8	1675.9	10	-109.47
11a	03/03/2006	15:35	12:05	12.9	321.01	20.11	1022.33	65.12	1705.26	10	144.91
12a	08/02/2006	18:32	15:02	3.73	3.87	24.79	103.8	1004.71	1787.47	0	-118.25
13a	No Sampling										
14a	08/02/2006	21:40	18:10	1.94	255.61	23.95	103.8	1016.02	1802.15	0	-109.47
14a	09/02/2006	07:20	03:50								
15a	09/02/2006	10:05	06:35								
16a	09/02/2006	11:12	07:42								
17a	No Sampling										
18a	06/02/2006	18.36	05:08	1.32	110.4	22.35	103.8	1049.75	1790.41	0	-113.86
19a	06/02/2006	20:20	16:50	3.11	278.47	22.26	103.8	1054.57	1790.41	0	-96.32
20a	06/02/2006	22:14	18:44	3.65	286.55	22.45	103.8	1047.26	1793.34	0	-87.54
21a	No Sampling										
22a	04/02/2006	09:19	05:49								
23a	04/02/2006	12:04	08:34								
24a	04/02/2006	15:26	11:56								
25a	04/02/2006	19:20	15:50								
26a	03/02/2006	07:52	04:22								
27a	08/03/2006	12:21	08:51	4.82	328.04	20.02	1035.13	103.8	1758.11	10	522.11
28a	08/03/2006	10:10	06:40	3.11	300.27	18.07	1051.08	103.8	1787.47	10	451.93

10. 1. 1. Air Temperature

During winter air temperature over the RSA is coldest in the northern part of the Gulf in the inner RSA and increases southward by heat exchange with the surface waters (Bower *et al.*, 1992). Figure 5 clearly shows this agreement in which maximum air temperatures are occurred in leg 1 over the Sea of Oman (Gulf of Oman). Maximum and minimum air temperatures recorded during this cruise were 24.9°C and 16.78 °C at stations 83 and 34 respectively with an average of 21.14°C. It is noted that the black lines illustrated in figures 5 to 11 represented that no data have been collected during the following periods.

From 9/2/2006 to 13/2/2006	Shifting from leg 1 to Leg 2
From 17/2/2006 to 21/2/2006	Bad weather during leg 2
From 24/2/2006 to 27/2 2006	Shifting from Leg 2 to Leg3

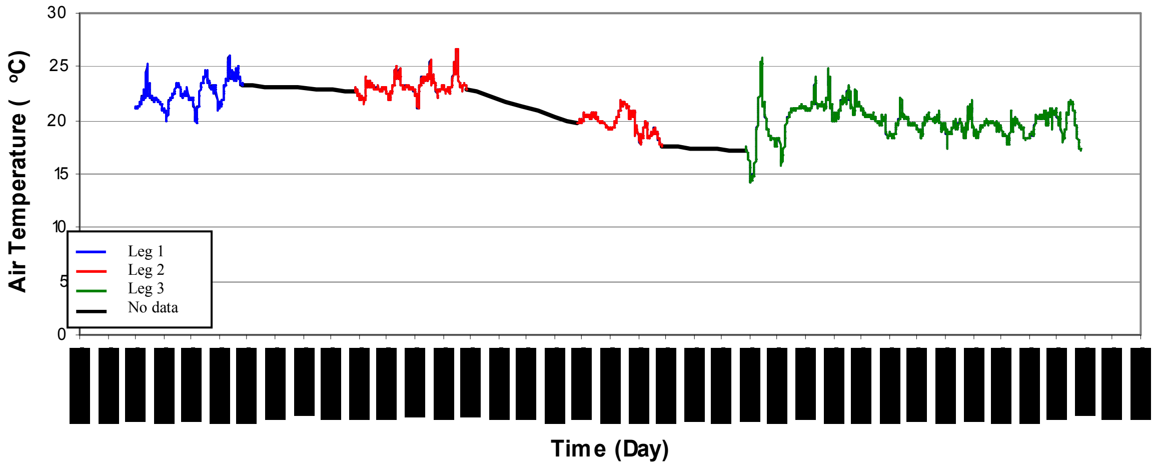


Figure 5. Air temperature during the ROPME winter cruise 2006

10. 1. 2. Air Pressure

Air pressures were mostly above 1005 hpa during the cruise but as it can be seen from figure 6, the pressure has dropped to 945 in leg 3 which brought a wind with a speed of 17 m/s (see also figure 7).

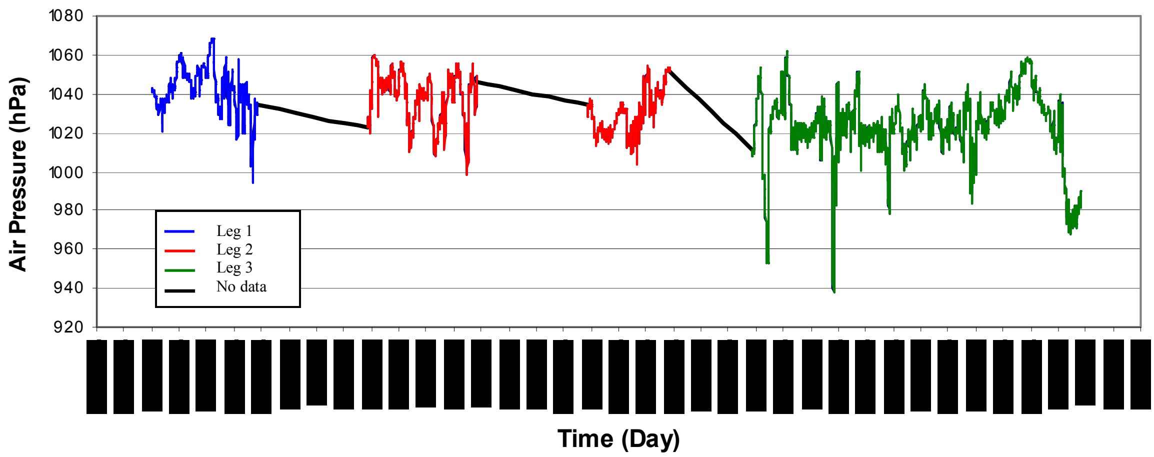


Figure 6. Air pressure during the ROPME winter cruise 2006

10. 1. 3. Wind speed and direction

The most known weather phenomenon in the RSA is the Shamal, a northwesterly wind which occurs yearly round (Perrone, 1981). As mentioned in table 8 and figure 8 average wind speed was 4.73 m/s and maximum and minimum wind speeds recorded in this cruise were 17 m/s and 0.39 m/s at stations 11a (leg 3) and 72 (leg 2) respectively. Also northern and northwesterly winds were recorded in all stations (figure 8). As can be seen from figures 7 the range of wind direction is very large, the reason is effect of ships movement in different direction during the cruise.

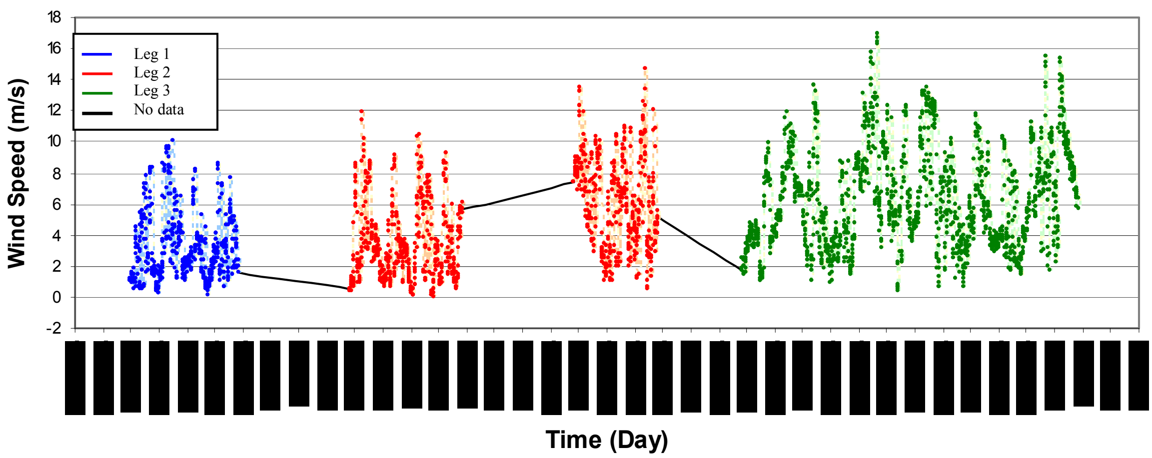


Figure 7. Wind speed during the ROPME winter cruise 2006

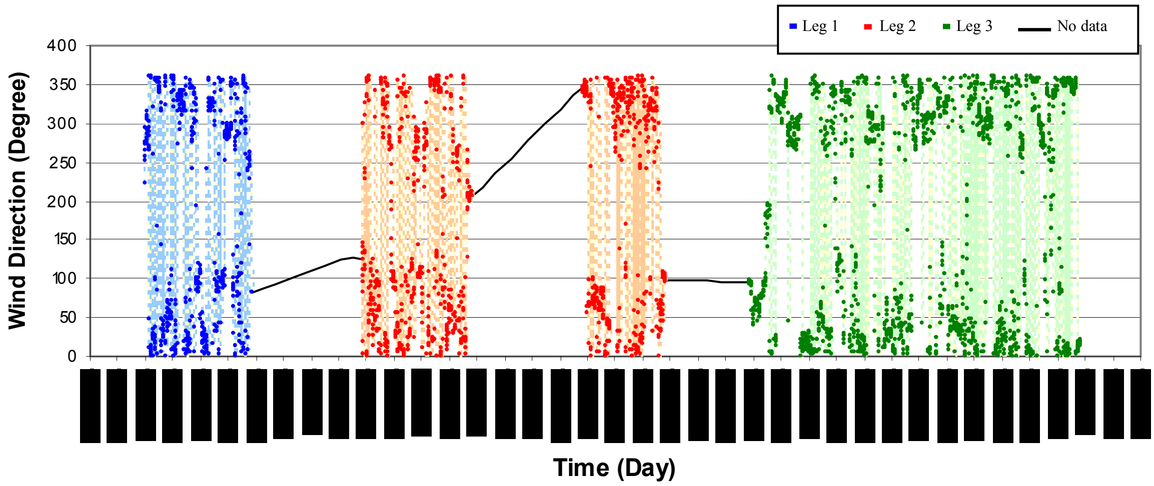


Figure 8. Wind direction during the ROPME winter cruise 2006

10. 1. 4. Relative humidity

As illustrated in table 8 relative humidity is about 103% in most stations and also the given relative humidity data to the authors had some errors which are obvious in table 8.

10. 1. 5. Visibility

Visibility in the atmosphere is of great interest for road and sea traffic and in navigation. The MIRA Visibility Sensor is designed to fulfill the demand for a small, low power unit to be operated with Aanderaa Measuring Stations. Visibility is often limited by fog and haze and the sensor is designed to detect these factors. The average visibility was recorded 1750 meters during this cruise.

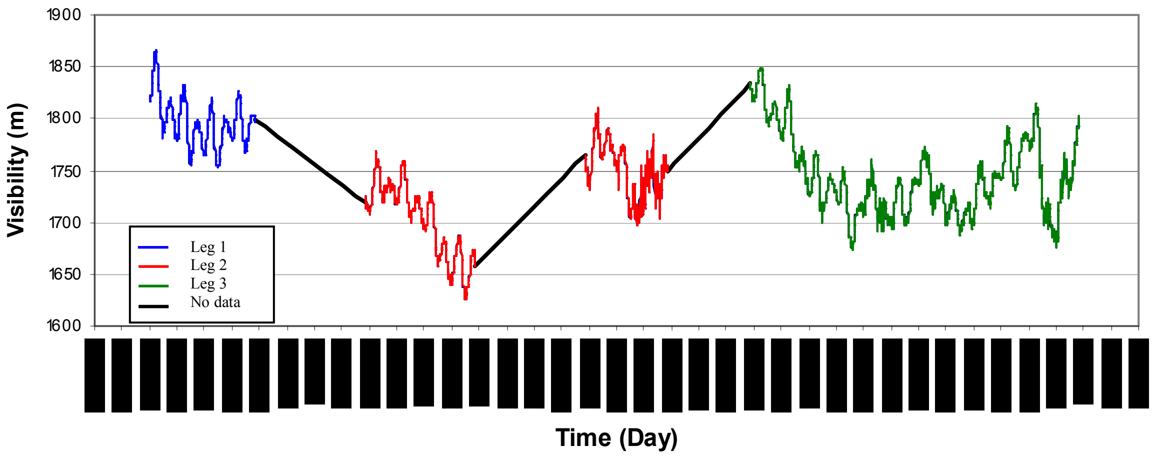


Figure 9. Visibility during the ROPME winter cruise 2006

10. 1. 6. Net Radiation

Average net radiation recorded during the cruise was 165.5w/m^2 with fluctuations between -100 and 500w/m^2 during days and nights (figure 10). This figure shows that during the cruise time, the RSA waters gain 165.5 w/m^2.

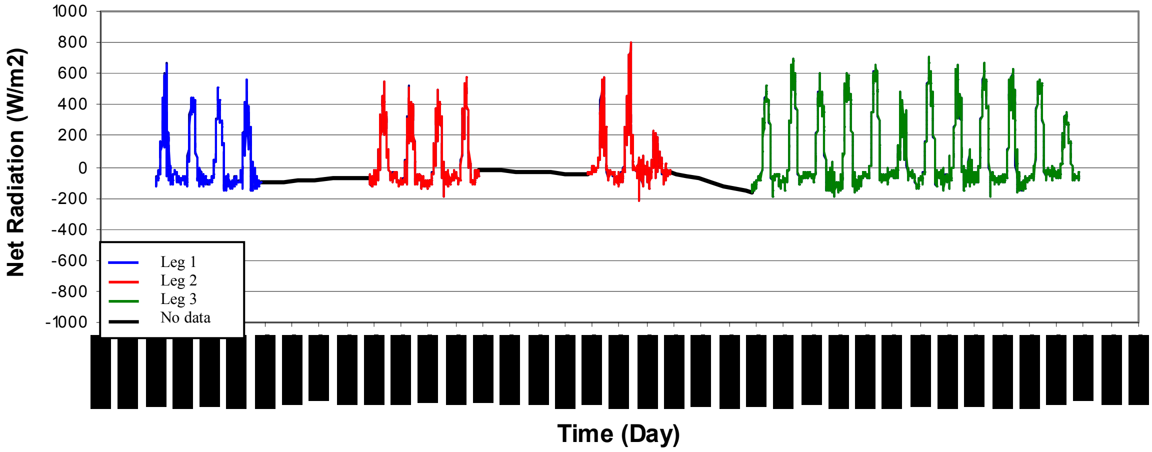


Figure 10. Net radiation during the ROPME winter cruise 2006

10. 1. 7. Sunshine Duration

The term "sunshine" is associated with the brightness of the solar disc exceeding the background of diffuse sky light, or, as is better observed by the human eye, with the appearance of shadows behind illuminated objects. According to WMO (2003), sunshine duration during a given period is defined as the sum of that sub-period for which the direct solar irradiance exceeds 120Wm^{-2}.

As illustrated in figure 11, the sunshine duration was about 10 hours during the cruise.

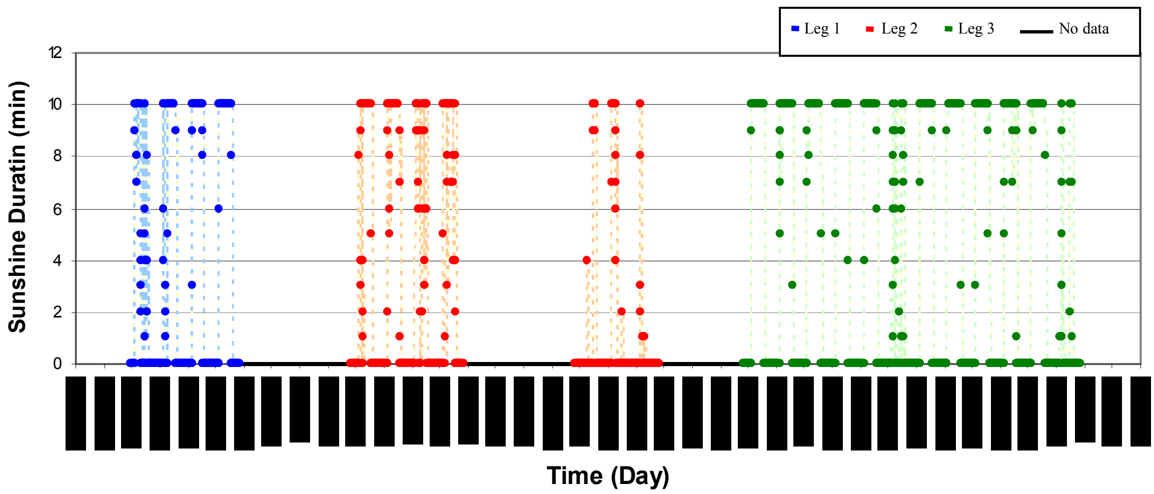


Figure 11. Sunshine duration during the ROPME winter cruise 2006.

10.2. Hydrography Results

The CTD-rosette system was in a number of aspects an essential part of the cruise. In the first place the CTD-Rosette combination provides the water from different depths for biological and chemical studies and secondly, the physical profiles determined with the CTD-system show the physical characteristics of the water column in the study area. The collected data by CTD and the vertical profiles of the acquired data are shown in Appendix A and Appendix B respectively.

Table 9 and figure 12 are a sample of these data and vertical profiles of CTD data at station number 82 which is situated at the Strait of Hormuz.

Table 9. CTD data at station number 82 situated at the Strait of Hormuz

Depth (m)	Temp. (^{0} C)	Cond. (mS/cm)	Sal. (psu)	Turb. (FTU)	Sound V (m/s)	Sigma T (kg/dm^3)	Time	Date
0.68	23.44	53.54	36.61	1.83	1532.32	25.03	12:42:11	13/02/2006
0.83	23.44	53.51	36.59	1.99	1532.29	25.02	12:42:12	13/02/2006
0.92	23.47	53.57	36.61	1.91	1532.40	25.02	12:42:23	13/02/2006
0.95	23.44	53.53	36.61	1.98	1532.32	25.03	12:42:15	13/02/2006
1.00	23.46	53.55	36.61	1.90	1532.36	25.03	12:42:09	13/02/2006
1.03	23.45	53.54	36.60	1.92	1532.34	25.02	12:42:17	13/02/2006
1.13	23.44	53.52	36.60	1.92	1532.30	25.02	12:42:16	13/02/2006
1.48	23.43	53.53	36.61	1.96	1532.30	25.04	12:42:41	13/02/2006
1.48	23.43	53.53	36.61	1.95	1532.31	25.03	12:42:42	13/02/2006
1.48	23.45	53.53	36.60	1.90	1532.33	25.02	12:42:44	13/02/2006
1.56	23.43	53.53	36.61	1.94	1532.31	25.03	12:42:46	13/02/2006
2.27	23.41	53.49	36.60	1.87	1532.26	25.04	12:42:47	13/02/2006
3.61	23.33	53.40	36.60	1.92	1532.07	25.07	12:42:49	13/02/2006
4.28	23.31	53.38	36.60	1.87	1532.03	25.08	12:42:50	13/02/2006
5.04	23.28	53.35	36.59	1.84	1531.98	25.08	12:42:51	13/02/2006
5.71	23.21	53.24	36.57	1.81	1531.77	25.09	12:42:52	13/02/2006
6.28	23.10	53.14	36.59	1.79	1531.51	25.14	12:42:53	13/02/2006
6.95	23.07	53.14	36.61	1.80	1531.49	25.17	12:42:54	13/02/2006
7.75	23.06	53.12	36.60	1.75	1531.47	25.16	12:42:55	13/02/2006
8.51	23.06	53.12	36.60	1.77	1531.48	25.17	12:42:56	13/02/2006
9.69	23.05	53.12	36.60	1.79	1531.48	25.18	12:42:58	13/02/2006
10.36	23.05	53.12	36.61	1.77	1531.50	25.19	12:42:59	13/02/2006
11.08	23.05	53.12	36.61	1.76	1531.50	25.19	12:43:00	13/02/2006
11.76	23.04	53.12	36.61	1.76	1531.50	25.19	12:43:01	13/02/2006
12.47	23.05	53.12	36.61	1.75	1531.52	25.20	12:43:02	13/02/2006
13.17	23.04	53.11	36.60	1.77	1531.51	25.20	12:43:03	13/02/2006
13.83	23.04	53.11	36.61	1.76	1531.53	25.20	12:43:04	13/02/2006
14.41	23.04	53.11	36.61	1.74	1531.53	25.21	12:43:05	13/02/2006
15.13	23.04	53.09	36.60	1.73	1531.53	25.20	12:43:06	13/02/2006
15.83	23.00	53.07	36.60	1.75	1531.46	25.22	12:43:07	13/02/2006
16.42	22.96	53.01	36.60	1.82	1531.35	25.23	12:43:08	13/02/2006
16.98	22.92	53.00	36.62	1.88	1531.29	25.26	12:43:09	13/02/2006
17.62	22.91	53.00	36.63	1.78	1531.28	25.28	12:43:10	13/02/2006
18.36	22.90	52.99	36.63	1.79	1531.27	25.28	12:43:11	13/02/2006
18.97	22.89	53.00	36.64	1.84	1531.27	25.30	12:43:12	13/02/2006
19.57	22.87	52.99	36.65	1.86	1531.24	25.31	12:43:13	13/02/2006
20.18	22.86	53.00	36.67	1.84	1531.25	25.33	12:43:14	13/02/2006
20.84	22.86	53.00	36.67	1.84	1531.26	25.33	12:43:15	13/02/2006
21.56	22.87	53.02	36.68	1.87	1531.29	25.34	12:43:16	13/02/2006
22.21	22.87	53.02	36.68	1.83	1531.31	25.35	12:43:17	13/02/2006
22.81	22.86	53.02	36.68	1.85	1531.31	25.35	12:43:18	13/02/2006
23.41	22.86	53.02	36.68	1.86	1531.31	25.36	12:43:19	13/02/2006
24.09	22.86	53.03	36.69	1.86	1531.33	25.37	12:43:20	13/02/2006
24.80	22.84	53.02	36.70	1.88	1531.29	25.38	12:43:21	13/02/2006
25.46	22.82	53.01	36.71	1.92	1531.28	25.39	12:43:22	13/02/2006
26.07	22.81	53.02	36.72	1.90	1531.27	25.41	12:43:23	13/02/2006
26.65	22.80	53.03	36.74	1.92	1531.27	25.43	12:43:24	13/02/2006
27.27	22.76	53.06	36.79	1.89	1531.25	25.48	12:43:25	13/02/2006
27.95	22.75	53.12	36.86	1.96	1531.29	25.54	12:43:26	13/02/2006

Table 9. Continue.

Depth (m)	Temp. (^{0} C)	Cond. (mS/cm)	Sal. (psu)	Turb. (FTU)	Sound V (m/s)	Sigma T (kg/dm^3)	Time	Date
28.64	22.73	53.14	36.88	1.89	1531.29	25.56	12:43:27	13/02/2006
29.30	22.73	53.14	36.88	1.96	1531.31	25.57	12:43:28	13/02/2006
29.89	22.73	53.16	36.90	1.91	1531.32	25.59	12:43:29	13/02/2006
30.51	22.73	53.17	36.91	1.91	1531.33	25.60	12:43:30	13/02/2006
31.15	22.73	53.17	36.91	1.89	1531.35	25.60	12:43:31	13/02/2006
31.82	22.73	53.18	36.92	1.93	1531.37	25.61	12:43:32	13/02/2006
32.40	22.73	53.19	36.93	1.89	1531.39	25.62	12:43:33	13/02/2006
33.02	22.73	53.20	36.93	1.90	1531.40	25.63	12:43:34	13/02/2006
33.66	22.73	53.21	36.94	1.89	1531.43	25.63	12:43:35	13/02/2006
34.36	22.72	53.21	36.94	1.90	1531.42	25.64	12:43:36	13/02/2006
34.94	22.72	53.21	36.95	1.91	1531.43	25.65	12:43:37	13/02/2006
35.47	22.72	53.21	36.95	1.91	1531.44	25.65	12:43:38	13/02/2006
36.05	22.72	53.23	36.96	1.92	1531.47	25.66	12:43:39	13/02/2006
36.65	22.71	53.23	36.96	1.91	1531.47	25.67	12:43:40	13/02/2006
37.28	22.72	53.24	36.97	1.93	1531.50	25.67	12:43:41	13/02/2006
37.95	22.72	53.25	36.98	1.88	1531.52	25.68	12:43:42	13/02/2006
38.51	22.72	53.25	36.98	1.96	1531.53	25.69	12:43:43	13/02/2006
39.05	22.72	53.25	36.98	1.91	1531.54	25.69	12:43:44	13/02/2006
39.64	22.72	53.27	37.00	1.90	1531.56	25.70	12:43:45	13/02/2006
40.30	22.71	53.27	37.00	1.90	1531.56	25.71	12:43:46	13/02/2006
40.90	22.71	53.28	37.01	1.91	1531.59	25.72	12:43:47	13/02/2006
41.45	22.71	53.29	37.01	1.90	1531.60	25.72	12:43:48	13/02/2006
42.02	22.72	53.30	37.01	1.90	1531.63	25.73	12:43:49	13/02/2006
42.64	22.72	53.30	37.02	1.97	1531.63	25.73	12:43:50	13/02/2006
43.26	22.71	53.31	37.03	1.91	1531.65	25.74	12:43:51	13/02/2006
43.83	22.71	53.32	37.04	1.88	1531.65	25.76	12:43:52	13/02/2006
44.43	22.69	53.34	37.07	1.82	1531.66	25.78	12:43:53	13/02/2006
45.03	22.69	53.34	37.07	1.86	1531.67	25.79	12:43:54	13/02/2006
45.63	22.69	53.35	37.08	1.91	1531.68	25.80	12:43:55	13/02/2006
46.23	22.68	53.37	37.10	1.95	1531.70	25.82	12:43:56	13/02/2006
46.84	22.68	53.39	37.12	1.91	1531.72	25.84	12:43:57	13/02/2006
47.41	22.68	53.40	37.12	1.87	1531.73	25.85	12:43:58	13/02/2006
47.99	22.68	53.43	37.15	1.86	1531.78	25.86	12:43:59	13/02/2006
48.59	22.69	53.46	37.16	1.83	1531.82	25.88	12:44:00	13/02/2006
49.16	22.69	53.46	37.16	1.83	1531.84	25.88	12:44:01	13/02/2006
49.73	22.70	53.49	37.18	1.90	1531.88	25.89	12:44:02	13/02/2006
50.38	22.70	53.50	37.18	1.85	1531.90	25.89	12:44:03	13/02/2006
51.02	22.71	53.52	37.19	1.89	1531.94	25.90	12:44:04	13/02/2006
51.58	22.71	53.53	37.19	1.82	1531.97	25.91	12:44:05	13/02/2006
52.11	22.72	53.55	37.20	1.84	1532.01	25.91	12:44:06	13/02/2006
52.64	22.73	53.57	37.21	1.86	1532.05	25.92	12:44:07	13/02/2006
53.20	22.75	53.61	37.23	1.88	1532.13	25.93	12:44:08	13/02/2006
53.83	22.77	53.65	37.24	1.84	1532.21	25.94	12:44:09	13/02/2006
54.43	22.78	53.66	37.24	1.79	1532.22	25.94	12:44:10	13/02/2006
54.93	22.77	53.67	37.26	1.81	1532.23	25.95	12:44:11	13/02/2006
55.42	22.76	53.66	37.25	1.78	1532.22	25.95	12:44:12	13/02/2006
55.98	22.76	53.65	37.24	1.81	1532.22	25.95	12:44:13	13/02/2006
56.57	22.75	53.63	37.24	1.81	1532.20	25.95	12:44:14	13/02/2006
57.17	22.73	53.59	37.23	1.83	1532.13	25.96	12:44:15	13/02/2006

Table 9. Continue.

Depth (m)	Temp. (^{0} C)	Cond. (mS/cm)	Sal. (psu)	Turb. (FTU)	Sound V (m/s)	Sigma T (kg/dm^3)	Time	Date
57.78	22.68	53.56	37.24	1.83	1532.04	25.98	12:44:16	13/02/2006
58.38	22.72	53.65	37.28	1.74	1532.20	26.00	12:44:17	13/02/2006
58.93	22.77	53.74	37.31	1.79	1532.36	26.01	12:44:18	13/02/2006
59.41	22.77	53.79	37.35	1.82	1532.41	26.04	12:44:19	13/02/2006
59.98	22.76	53.81	37.37	1.80	1532.43	26.06	12:44:20	13/02/2006
60.55	22.75	53.84	37.40	1.80	1532.45	26.09	12:44:21	13/02/2006
61.13	22.75	53.90	37.45	1.82	1532.50	26.13	12:44:22	13/02/2006
61.73	22.74	53.95	37.50	1.84	1532.54	26.18	12:44:23	13/02/2006
62.33	22.72	54.06	37.60	1.92	1532.61	26.26	12:44:24	13/02/2006
62.87	22.71	54.07	37.62	1.85	1532.62	26.28	12:44:25	13/02/2006
63.35	22.70	54.09	37.65	1.87	1532.62	26.31	12:44:26	13/02/2006
63.90	22.69	54.11	37.67	1.92	1532.63	26.33	12:44:27	13/02/2006
64.50	22.64	54.11	37.70	1.96	1532.57	26.37	12:44:28	13/02/2006
65.19	22.65	54.11	37.70	1.93	1532.58	26.37	12:44:29	13/02/2006
65.80	22.60	54.11	37.74	2.02	1532.53	26.42	12:44:30	13/02/2006
66.35	22.59	54.16	37.79	2.13	1532.55	26.46	12:44:31	13/02/2006
66.82	22.58	54.32	37.93	2.13	1532.68	26.57	12:44:32	13/02/2006
67.43	22.59	54.81	38.31	2.22	1533.14	26.86	12:44:33	13/02/2006
68.06	22.59	55.32	38.70	2.72	1533.60	27.16	12:44:34	13/02/2006
68.60	22.60	55.52	38.86	2.83	1533.79	27.28	12:44:35	13/02/2006
69.19	22.59	55.93	39.19	2.90	1534.14	27.54	12:44:36	13/02/2006
69.81	22.58	56.09	39.32	3.33	1534.27	27.64	12:44:37	13/02/2006
70.38	22.58	56.22	39.43	3.39	1534.40	27.73	12:44:38	13/02/2006
70.93	22.56	56.47	39.64	3.39	1534.60	27.90	12:44:39	13/02/2006
71.48	22.55	56.50	39.68	3.34	1534.62	27.93	12:44:40	13/02/2006
72.08	22.55	56.53	39.70	3.40	1534.65	27.95	12:44:41	13/02/2006
72.69	22.55	56.54	39.71	3.69	1534.67	27.95	12:44:42	13/02/2006
73.32	22.55	56.54	39.71	3.81	1534.68	27.96	12:44:43	13/02/2006
73.95	22.54	56.58	39.74	3.90	1534.71	27.99	12:44:44	13/02/2006
74.50	22.53	56.62	39.79	4.08	1534.74	28.03	12:44:45	13/02/2006
74.95	22.52	56.65	39.83	4.25	1534.76	28.07	12:44:46	13/02/2006
75.46	22.50	56.70	39.88	4.42	1534.78	28.12	12:44:47	13/02/2006
76.02	22.47	56.77	39.96	4.41	1534.81	28.18	12:44:48	13/02/2006
76.68	22.45	56.82	40.02	4.66	1534.82	28.24	12:44:49	13/02/2006
77.32	22.44	56.85	40.05	4.61	1534.85	28.27	12:44:50	13/02/2006
77.91	22.42	56.87	40.08	4.57	1534.84	28.30	12:44:51	13/02/2006
78.40	22.41	56.88	40.10	4.51	1534.85	28.32	12:44:52	13/02/2006
78.90	22.41	56.88	40.11	4.59	1534.86	28.33	12:44:53	13/02/2006
79.41	22.41	56.90	40.12	4.55	1534.88	28.34	12:44:54	13/02/2006
79.99	22.39	56.93	40.16	4.85	1534.89	28.38	12:44:55	13/02/2006
80.61	22.37	56.98	40.22	4.70	1534.92	28.43	12:44:56	13/02/2006
81.27	22.36	57.00	40.24	5.16	1534.92	28.46	12:44:57	13/02/2006
81.76	22.36	57.00	40.25	5.04	1534.93	28.46	12:44:58	13/02/2006
82.20	22.36	57.00	40.25	5.71	1534.93	28.47	12:44:59	13/02/2006

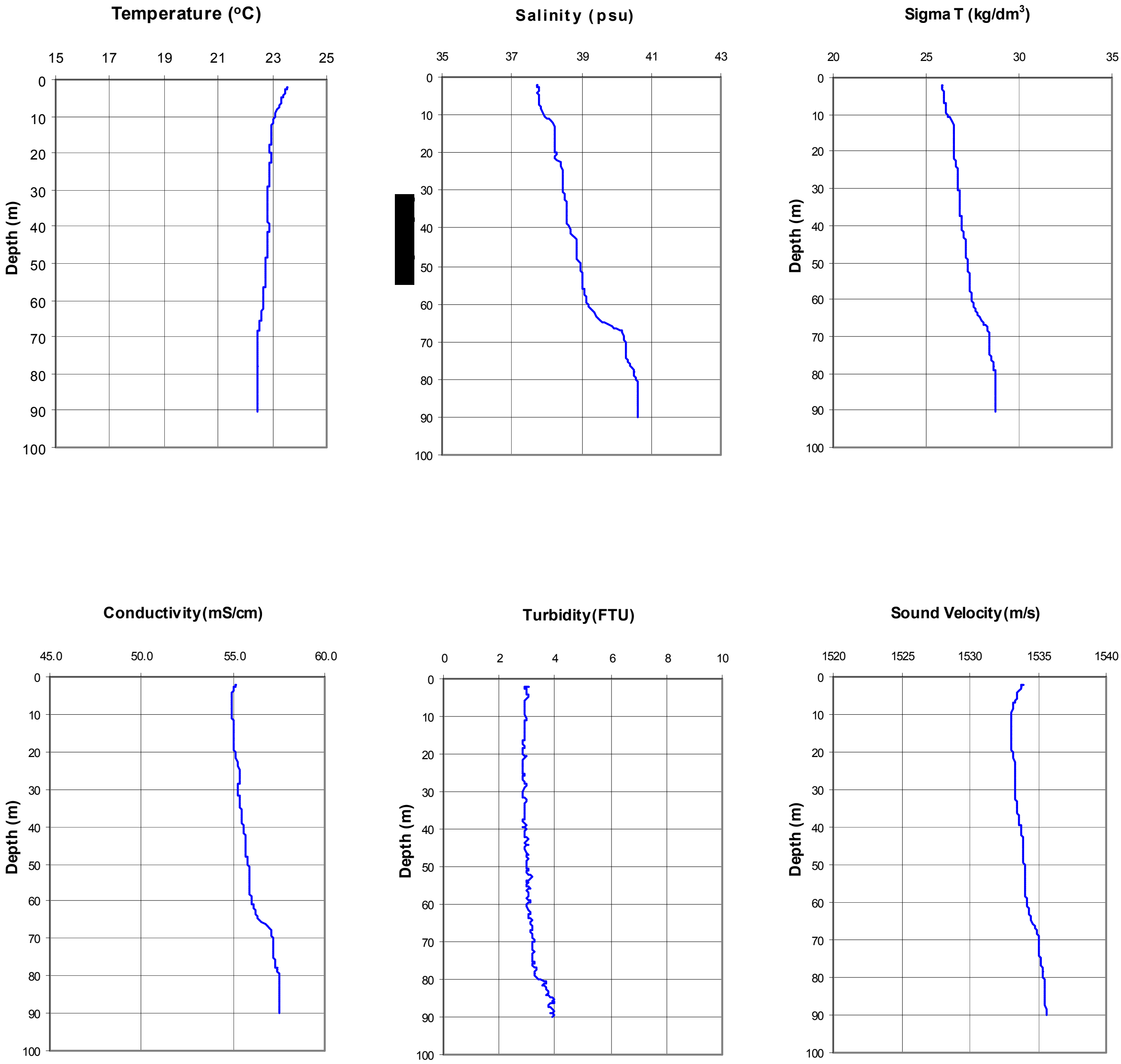


Figure 12. Vertical profile of CTD data at station number 82 situated at the Strait of Hormuz

Minimum, maximum and average of temperature, salinity and density values for all transects are given in table 10.

Table 10. Minimum, Maximum and Average values of temperature, salinity and density for all transects.

Tr No.	Temperature (°C)			Salinity(psu)			Sigma T (kg/dm^3)		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
1	16.952	19.401	18.083	37.746	41.135	40.385	27.389	30.279	29.426
2	16.574	19.482	18.407	39.95	41.114	40.867	29.228	30.298	29.748
2a	17.325	19.521	18.397	40.601	41.194	40.932	29.323	30.366	29.827
3	18.896	19.789	19.281	40.524	40.96	40.736	29.1	29.713	29.448
4	18.586	21.2	19.508	40.965	40.965	40.589	28.647	29.885	29.296
5	19.236	20.972	19.915	39.918	40.905	40.411	25.256	29.658	29.054
6	18.924	21.552	20.221	39.769	44.074	40.658	28.015	32.058	29.135
7	19.553	21.996	20.884	39.627	41.258	40.294	27.808	29.799	28.707
8	20.113	22.115	21.186	39.058	40.876	40.239	27.439	29.284	28.583
9	20.757	22.633	21.617	38.595	40.801	40.275	26.89	29.17	28.505
10	21.341	22.783	22.001	38.664	41.71	40.178	26.974	29.593	28.305
11	20.951	23.712	22.445	37.821	42.675	39.868	25.948	30.48	27.953
12	22.004	23.595	22.65	36.886	40.553	39.058	25.258	28.791	27.282
13	22.45	23.625	22.821	36.984	40.311	38.296	25.327	28.453	26.661
14	22.336	23.672	22.704	36.572	40.538	37.864	24.999	28.713	26.372
14a	22.165	23.346	22.807	36.509	40.194	37.441	25.059	28.455	26.011
15	22.619	24.16	23.095	36.53	40.053	38.098	24.853	28.325	26.489
15a	21.673	23.573	22.958	36.344	39.015	37.181	24.926	27.49	25.835
16	20.443	23.662	22.105	36.069	37.83	36.579	24.901	26.859	25.809
17	20.481	23.917	22.471	36.085	36.566	36.408	24.794	26.279	25.499
17a	19.895	23.384	22.001	36.109	36.657	36.442	24.972	26.671	25.667
18	18.735	23.292	21.829	36.07	36.75	36.465	25.076	26.915	25.708

Figure 13 displays average salinity, temperature and density from transect 1 to transect 18 which started from northern part of the Gulf and ended at the Sea of Oman. As it can be seen from this figure, salinity decreases from northern part of the Gulf towards the Sea of Oman. This is in agreement with previous studies presented by Emery (1952), Hunter (1982) and Sadrinasab & Keampf (2005).

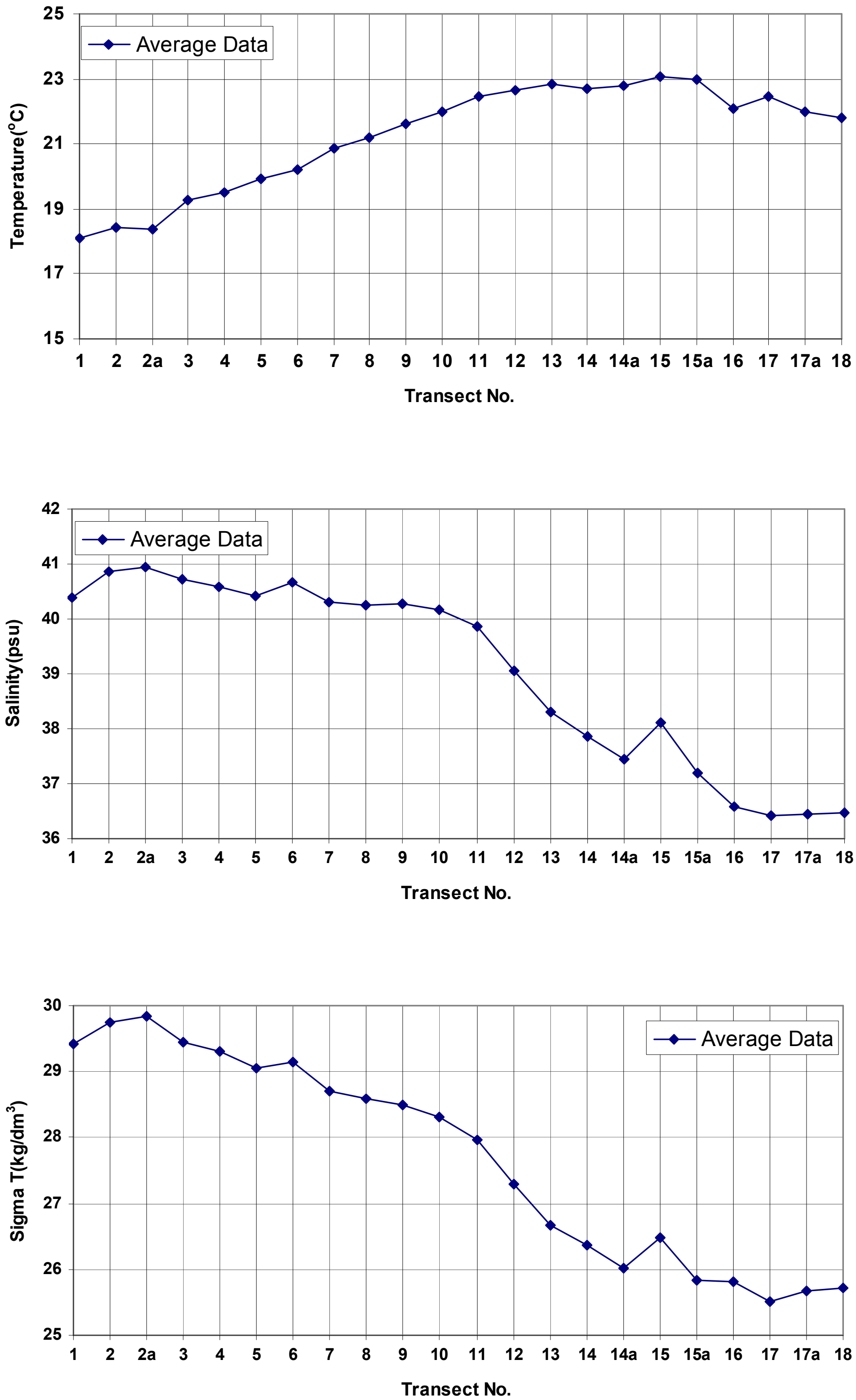


Figure 13. Averaged salinity, temperature and density for all transect

Figure 13 displays gradually increasing of temperature from northern part of the Gulf towards the Sea of Oman which is also in agreement with previous studies. As far as dense water formation in the Gulf is concerned, the densest water forms in winter at the northern end of the Gulf rather than along the warmer southern and western coasts (Swift and Bower 2003). This figure also shows that the density averaged in all transects which is coincident with Swift and Bower (2003) decreases from northern part of the Gulf towards the Sea of Oman.

Vertical profile of temperature, salinity and density for all transect are shown in figures 14 to 35. As mentioned in these figures maximum depths are along Iranian side and depth of water gradually increases from northern part of the Gulf towards Sea of Oman. Also minimum and maximum depths are found at transects 1 and 18 which are situated at the northern part of the Gulf and Sea of Oman respectively.

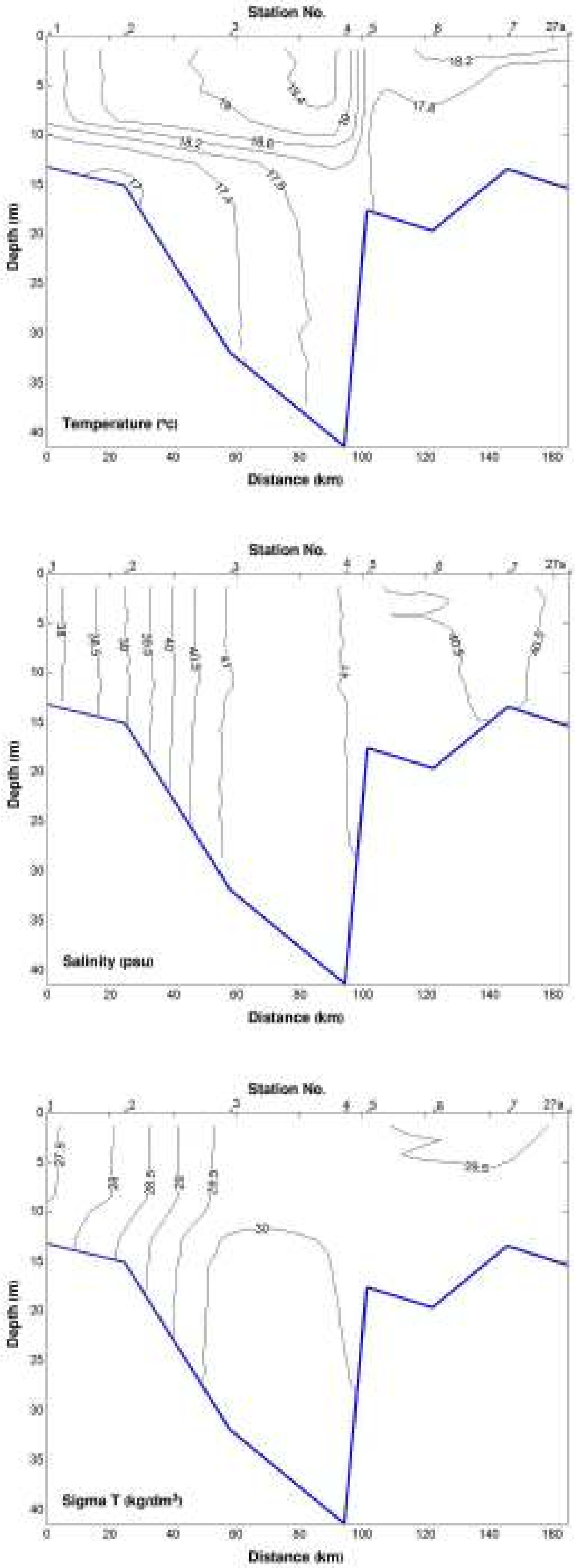


Figure 14. CTD cross section along transect 1 during leg 3 (winter 2006)

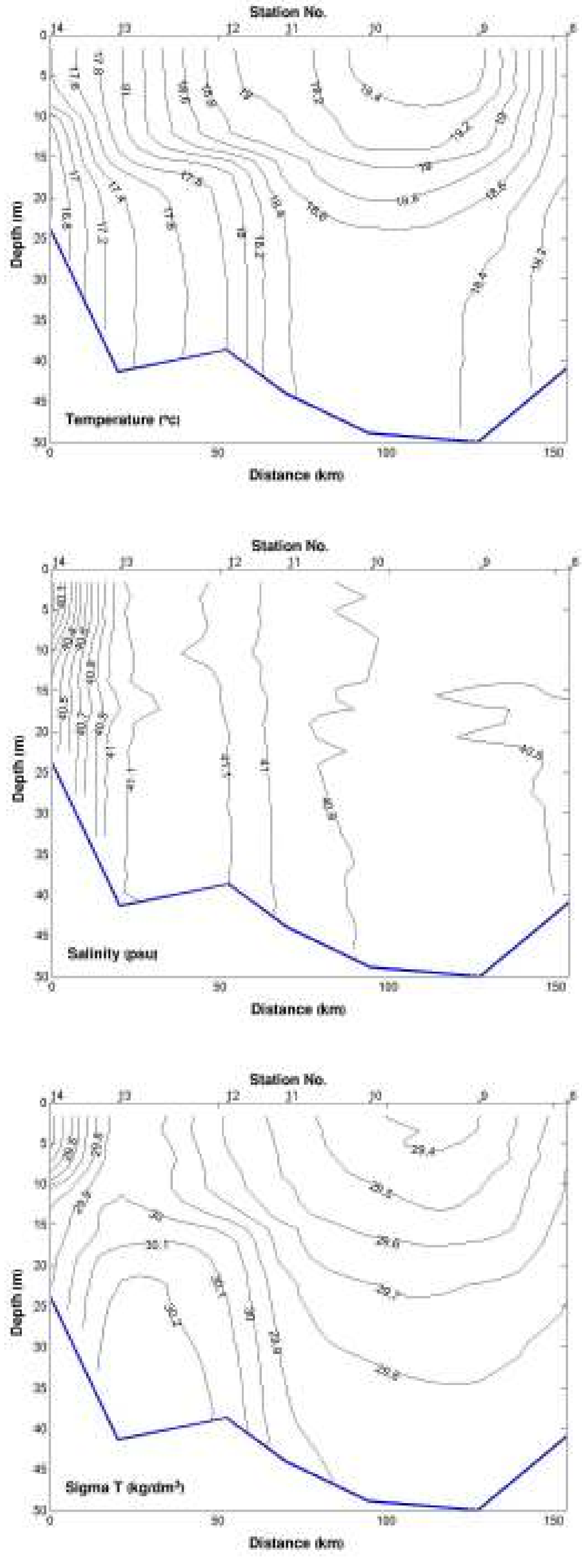


Figure 15. CTD cross section along transect 2 during leg 3 (winter 2006)

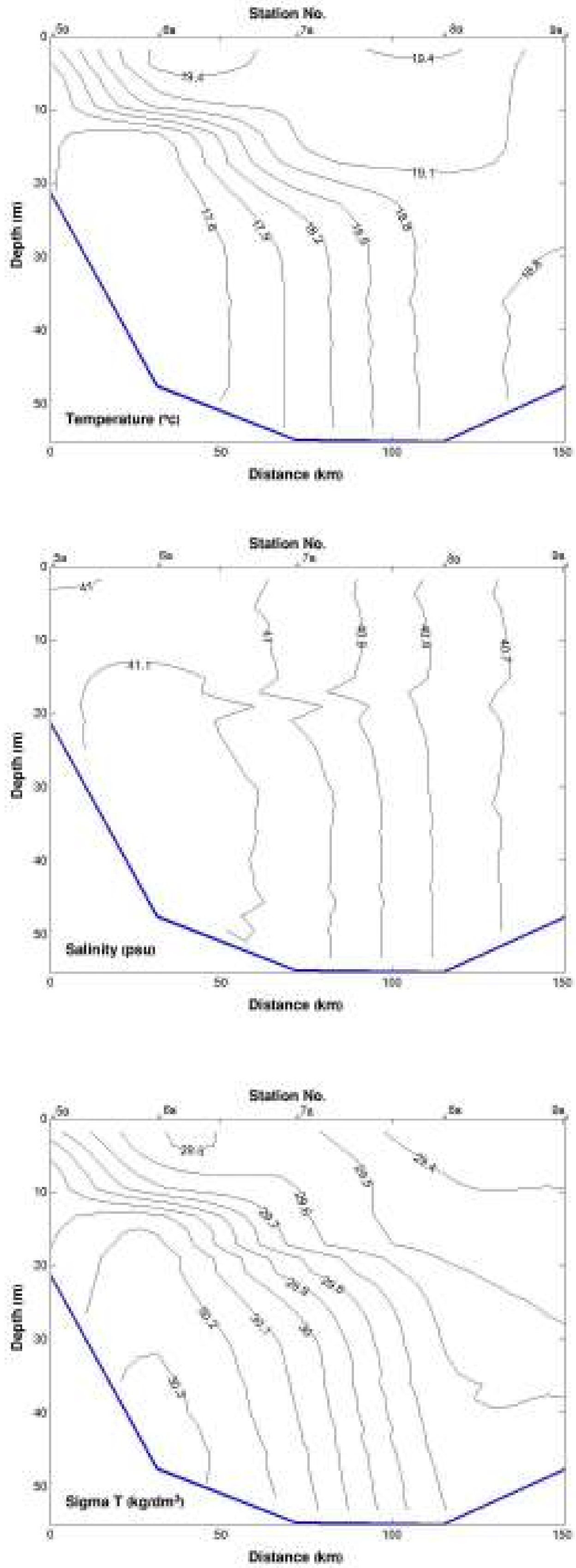


Figure 16. CTD cross section along transect 2a during leg 3 (winter 2006)

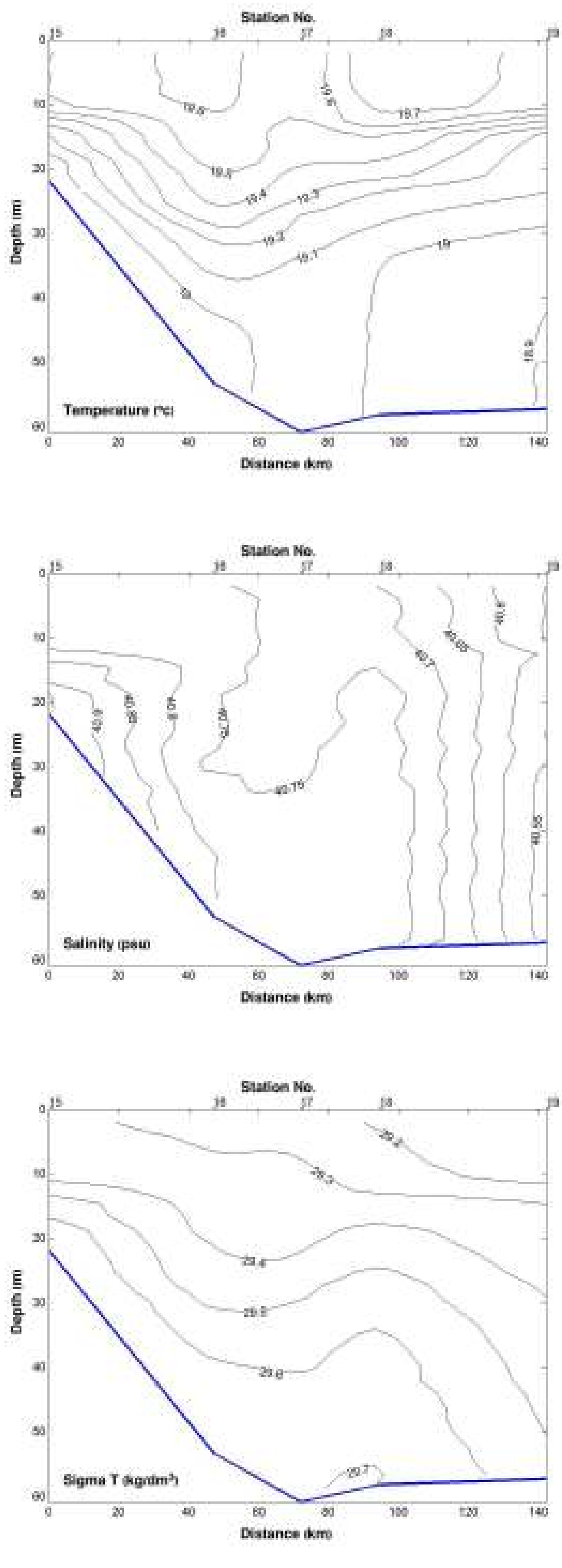


Figure 17. CTD cross section along transect 3 during leg 3 (winter 2006)

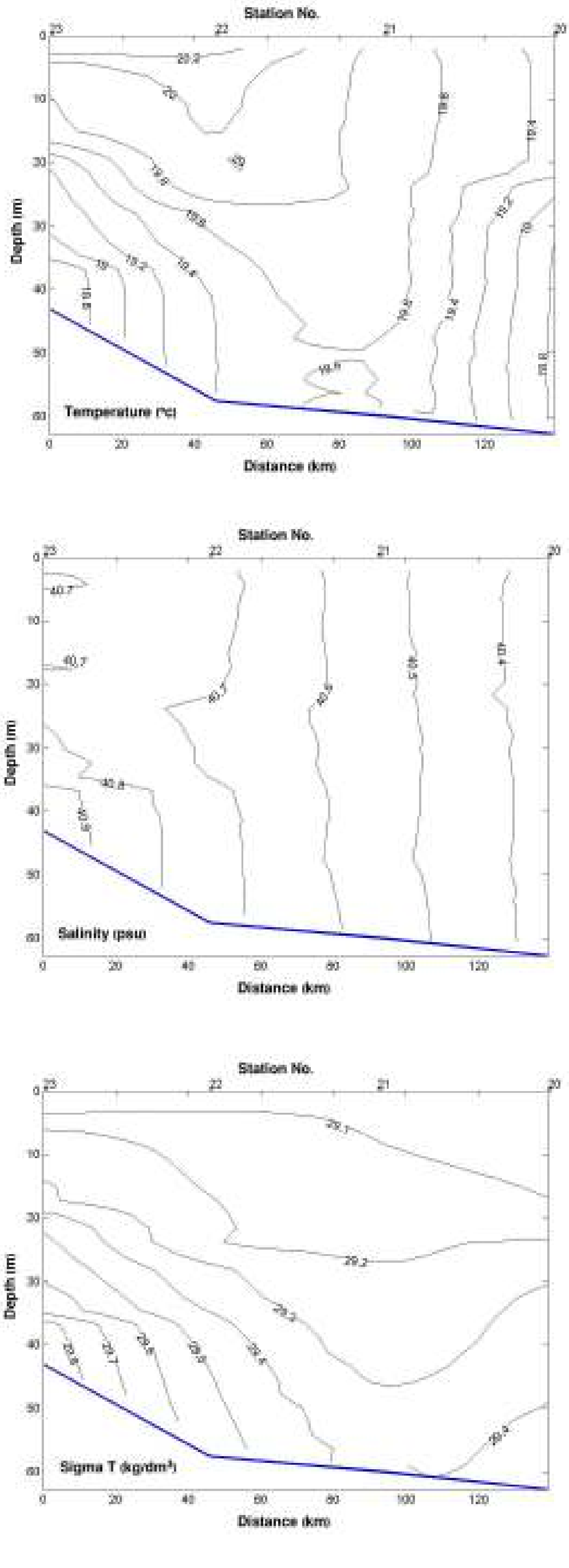


Figure 18. CTD cross section along transect 4 during leg 3 (winter 2006)

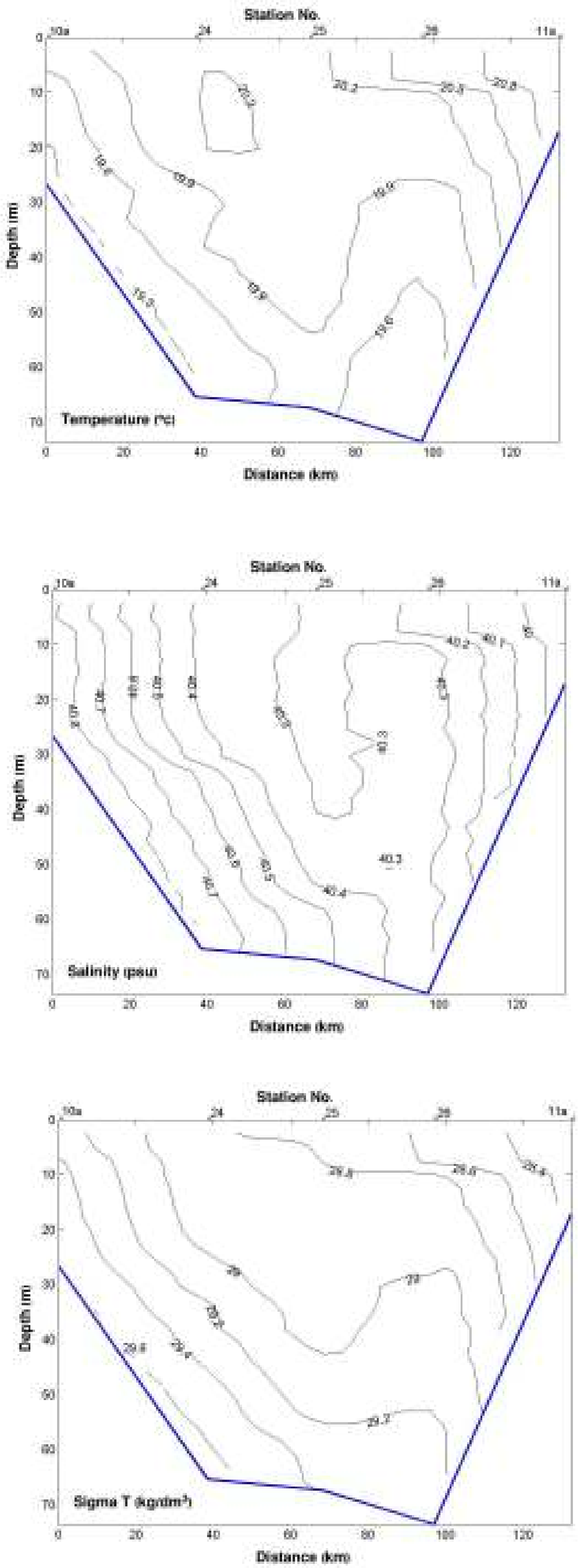


Figure 19. CTD cross section along transect 5 during leg 3 (winter 2006)

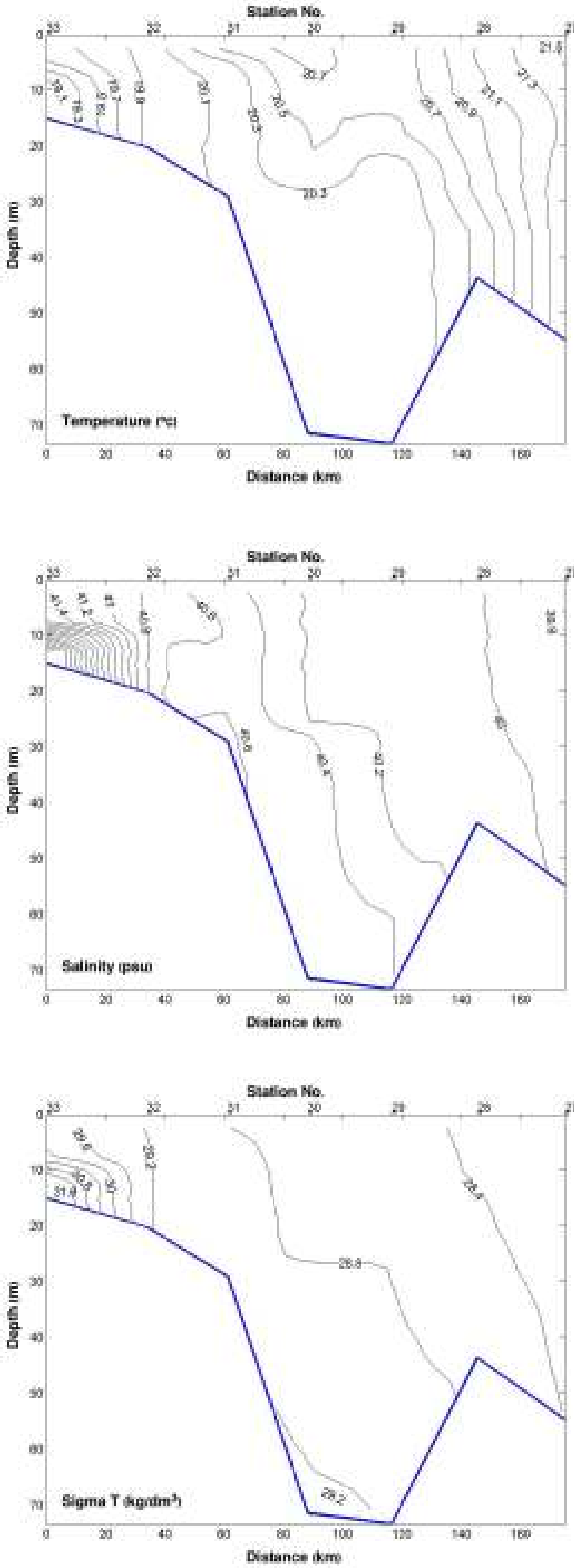


Figure 20. CTD cross section along transect 6 during leg 3 (winter 2006)

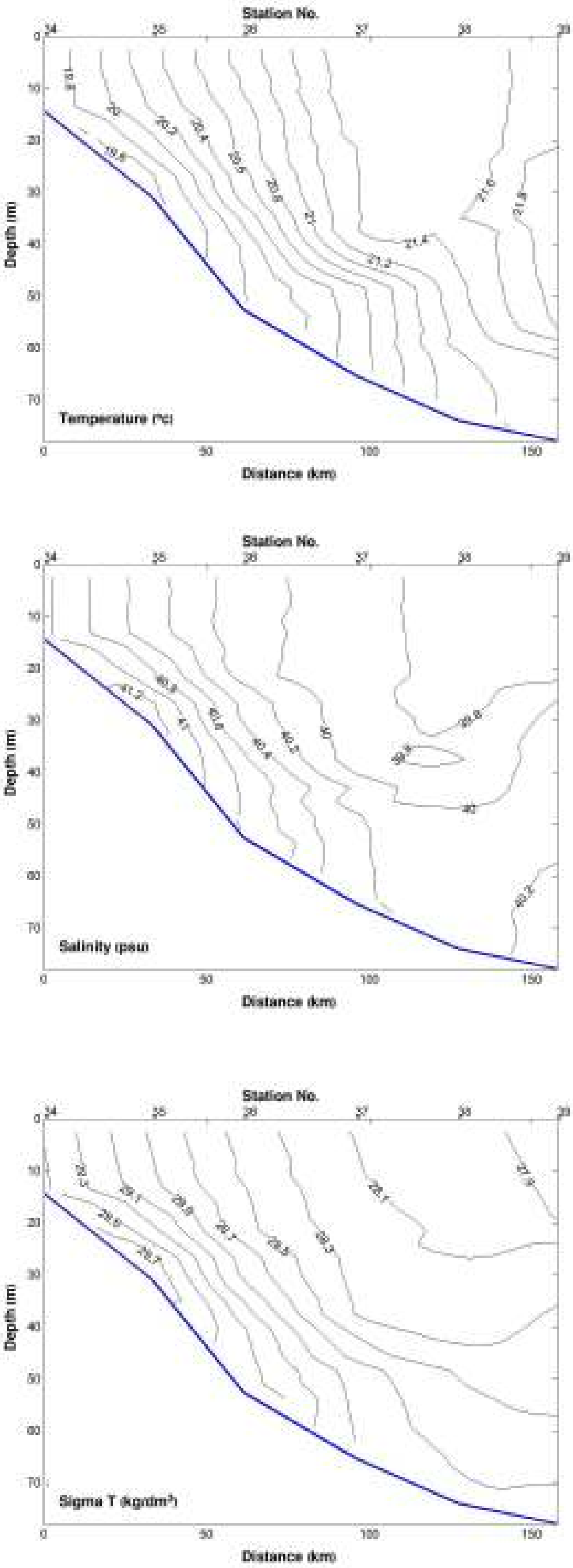


Figure 21. CTD cross section along transect 7 during leg 3 (winter 2006)

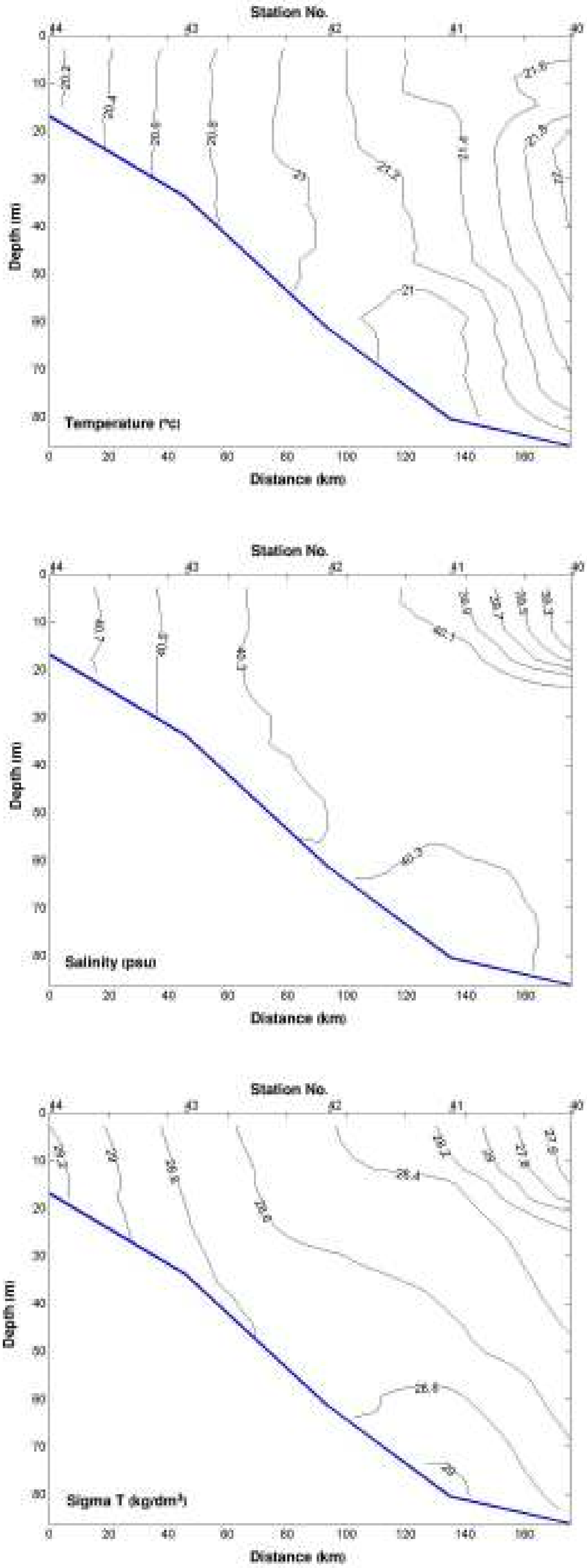


Figure 22. CTD cross section along transect 8 during leg 2 (winter 2006)

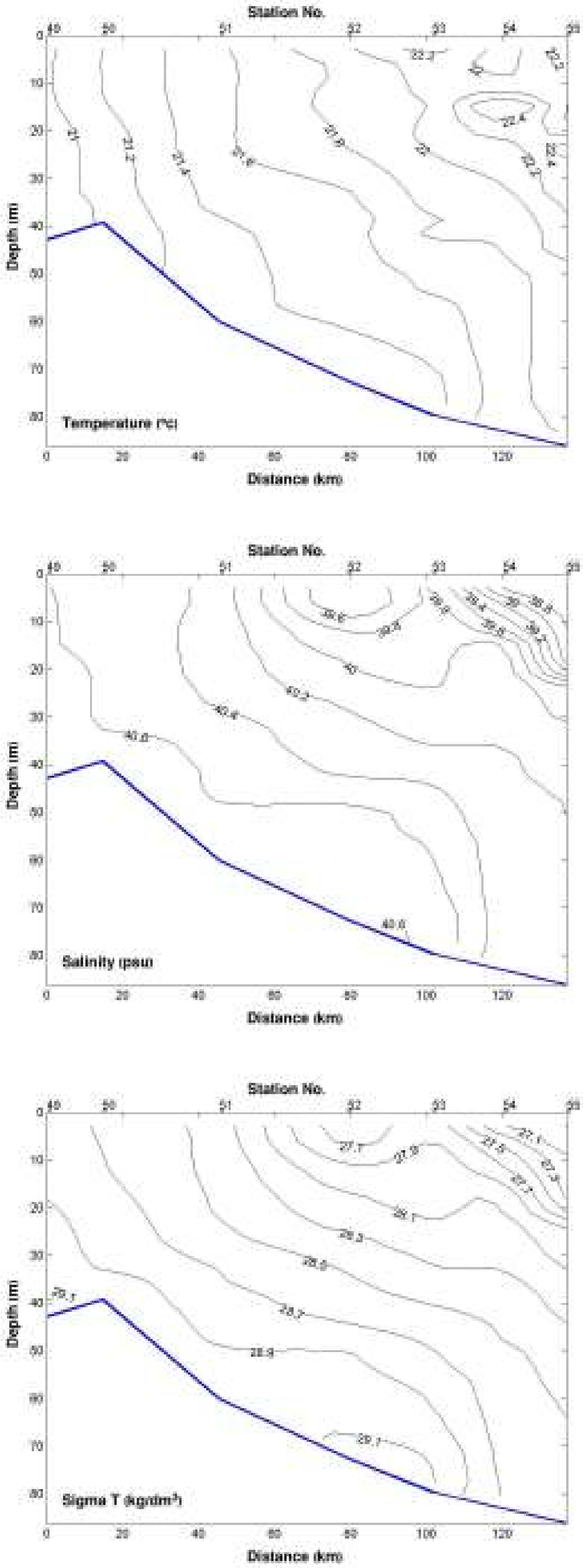


Figure 23. CTD cross section along transect 9 during leg 2 (winter 2006)

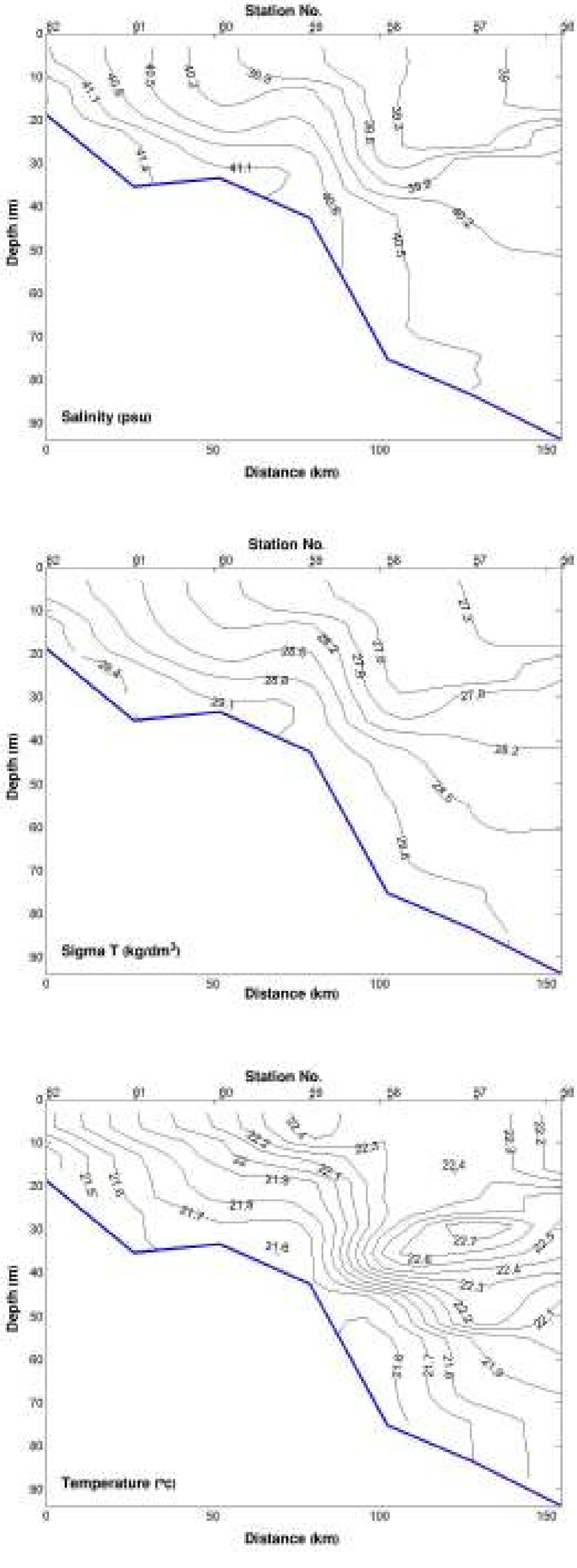


Figure 24. CTD cross section along transect 10 during leg 2 (winter 2006)

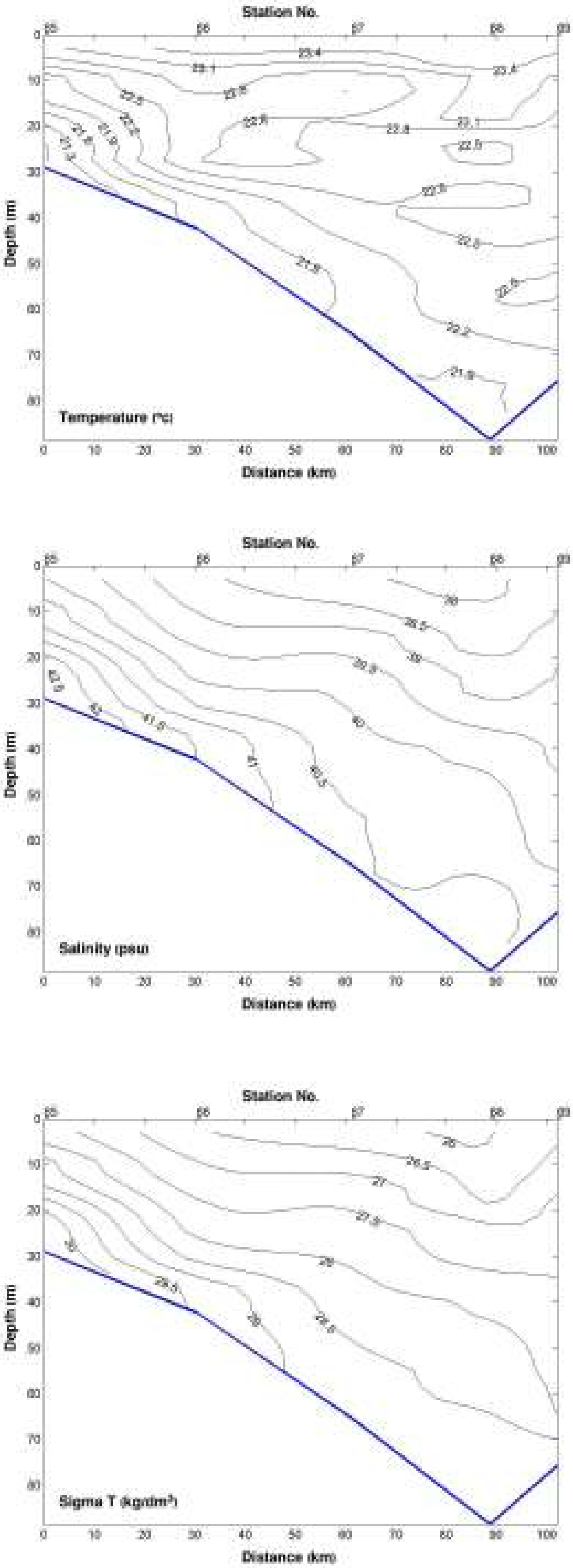


Figure 25. CTD cross section along transect 11 during leg 2 (winter 2006)

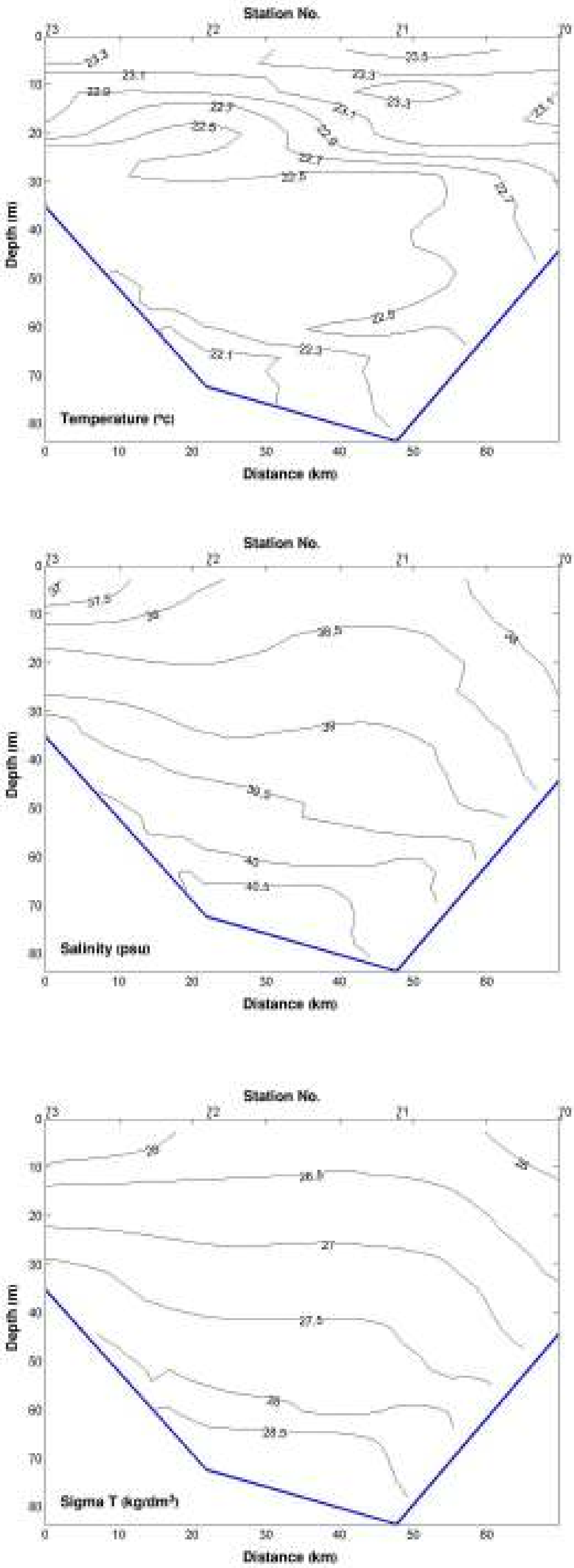


Figure 26. CTD cross section along transect 12 during leg 2 (winter 2006)

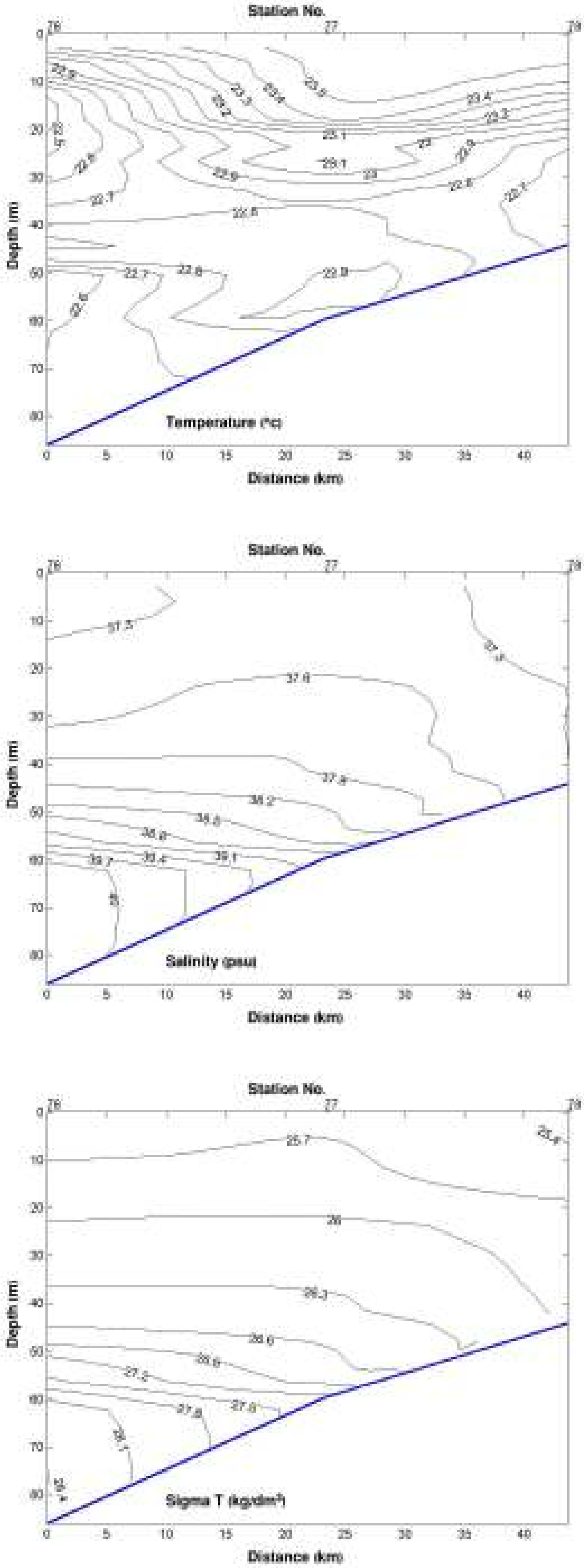


Figure 27. CTD cross section along transect 13 during leg 2 (winter 2006)

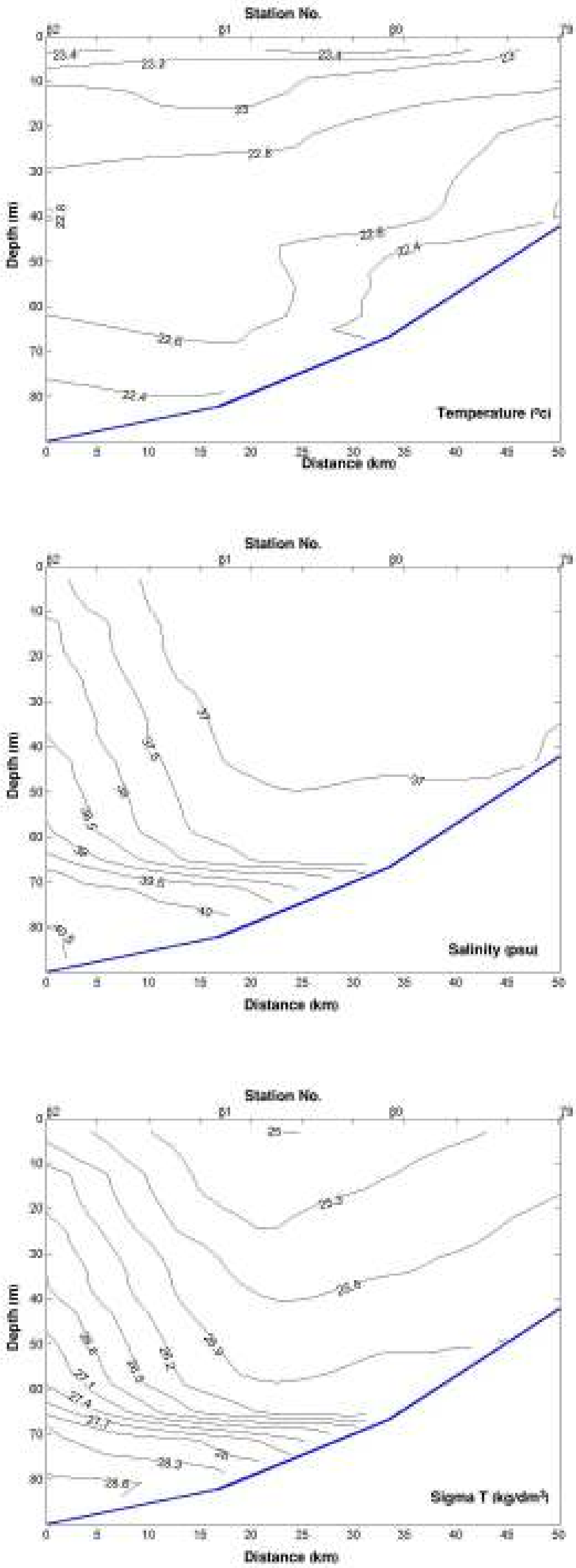


Figure 28. CTD cross section along transect 14 during leg 2 (winter 2006)

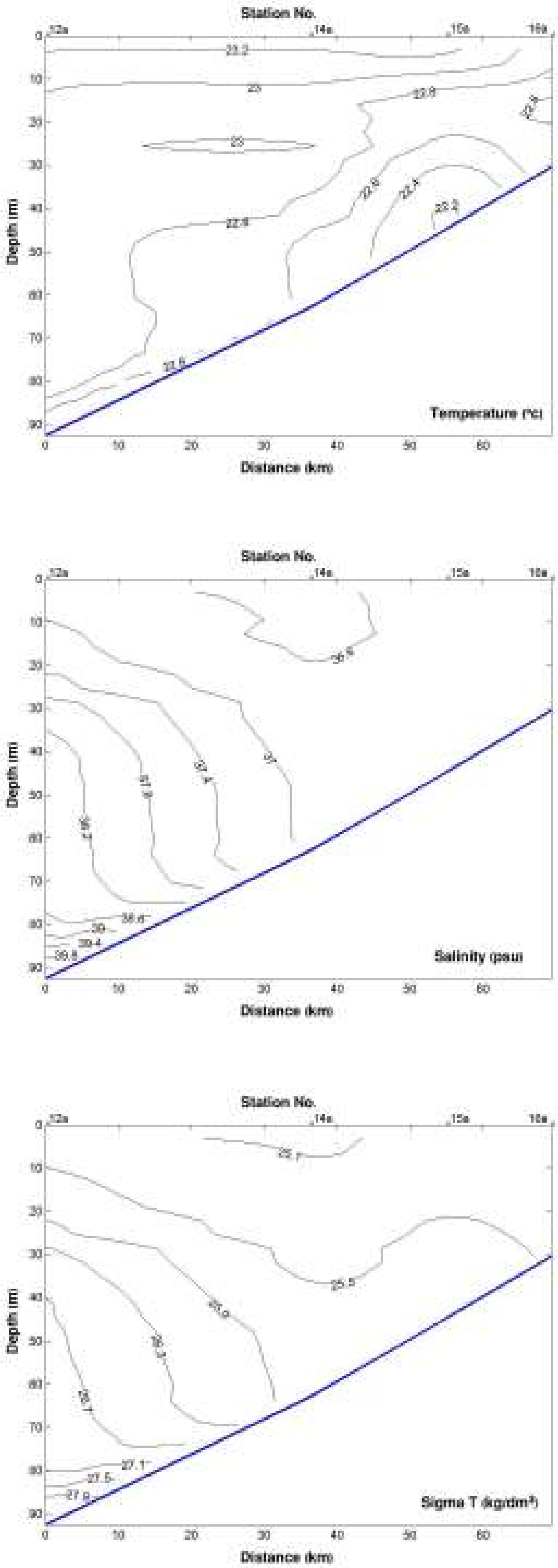


Figure 29. CTD cross section along transect 14a during leg 1 (winter 2006)

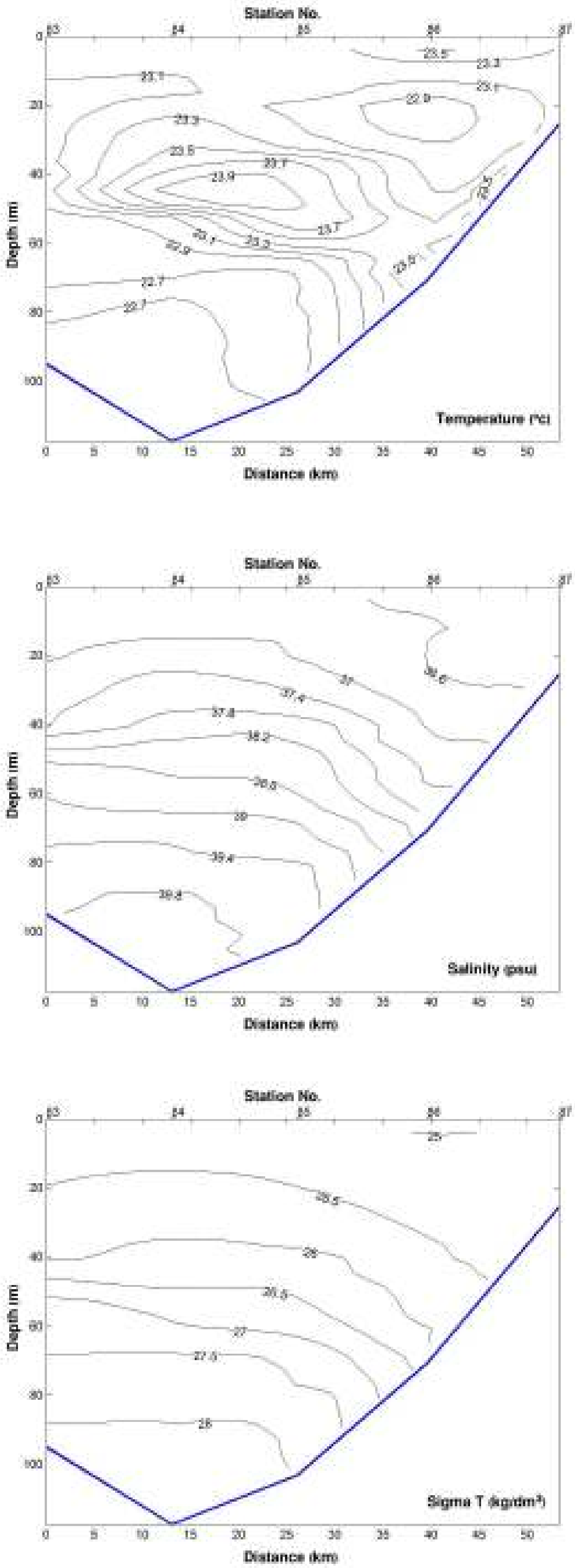


Figure 30. CTD cross section along transect 15 during leg 1 (winter 2006)

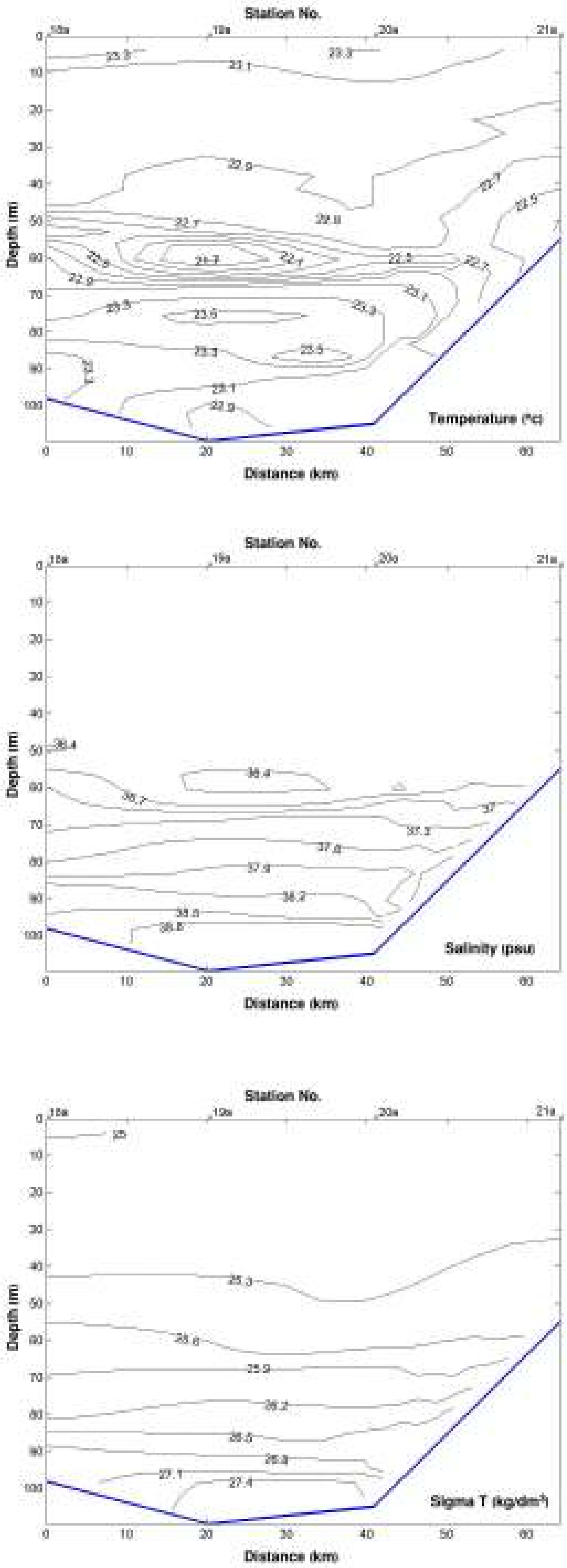


Figure 31. CTD cross section along transect 15a during leg 1 (winter 2006)

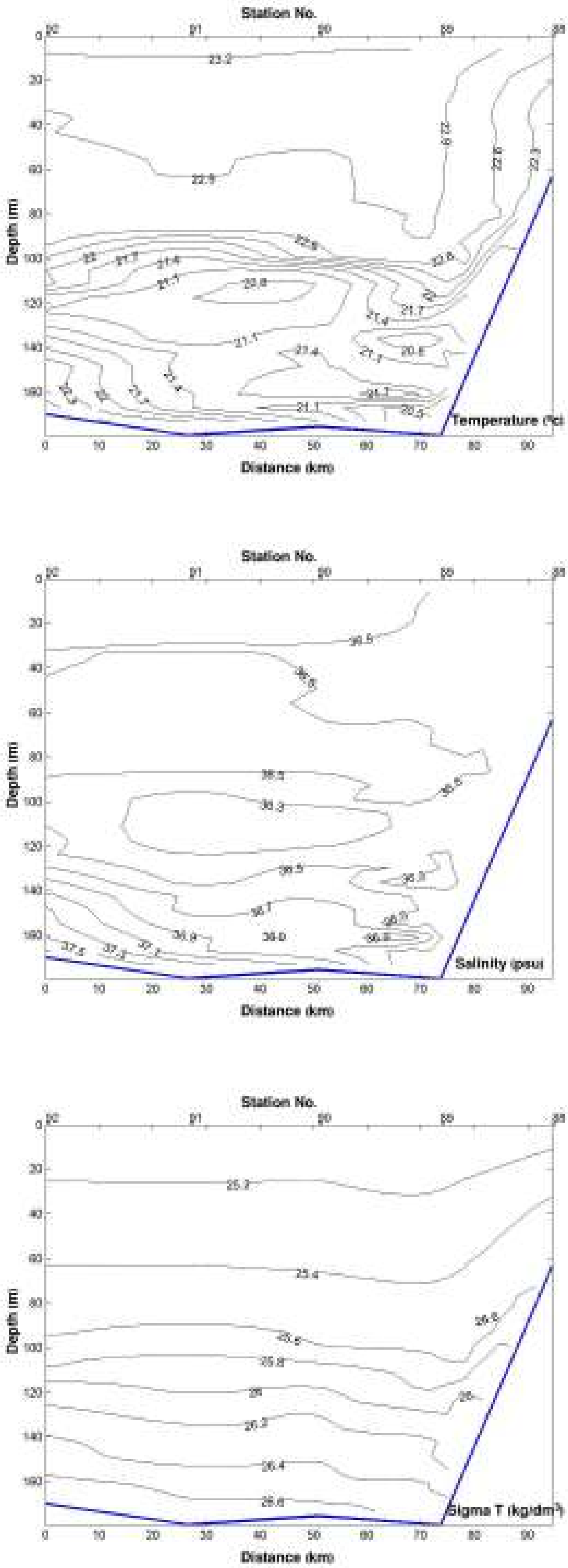


Figure 32. CTD cross section along transect 16 during leg 1 (winter 2006)

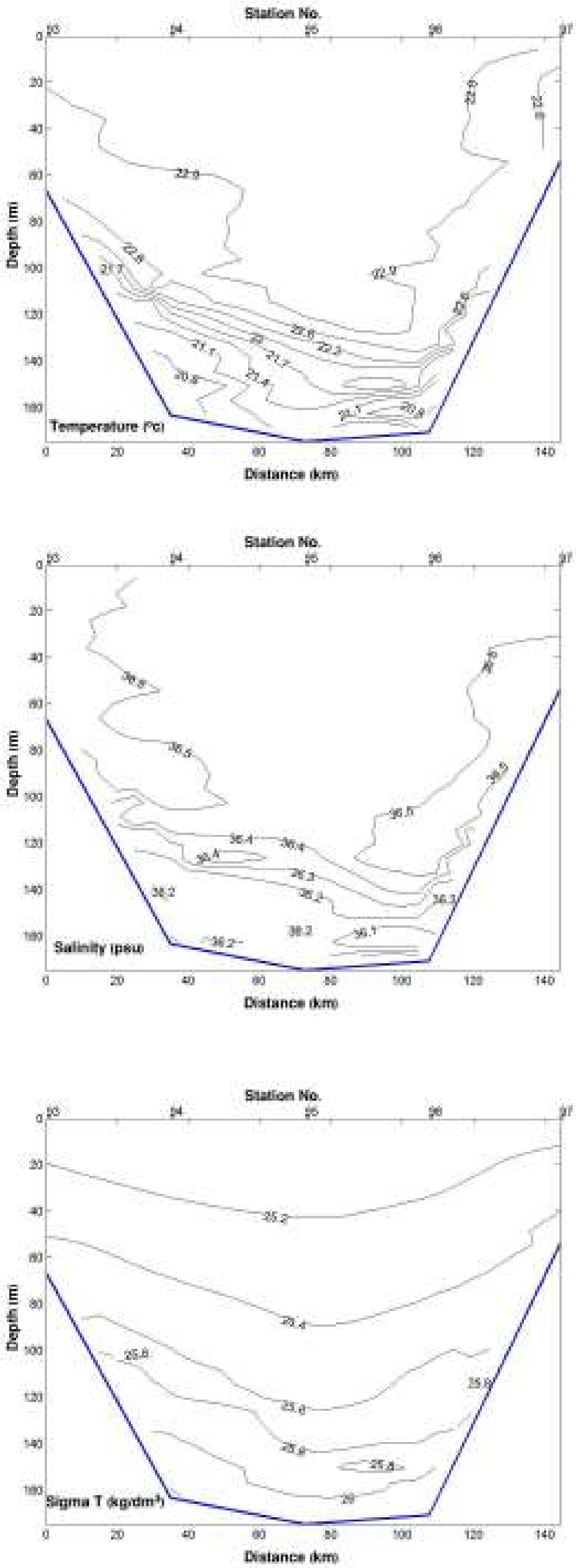


Figure 33. CTD cross section along transect 17 during leg 1 (winter 2006)

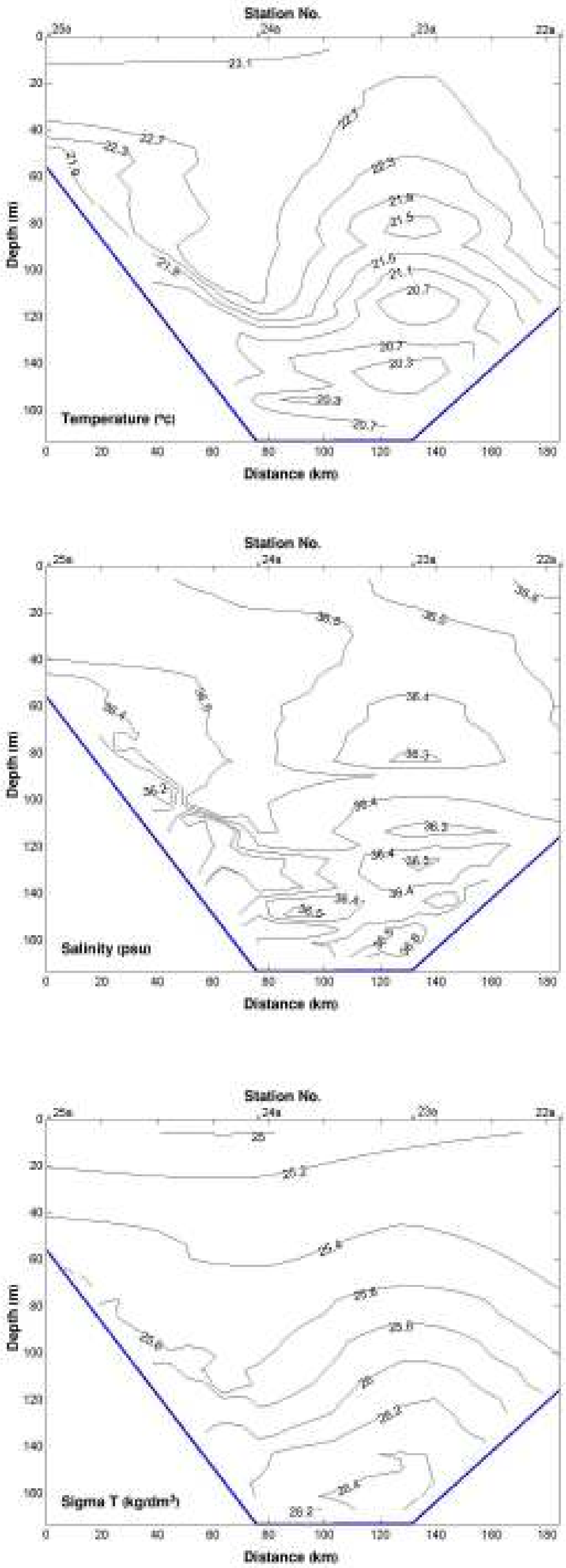


Figure 34. CTD cross section along transect 17a during leg 1 (winter 2006)

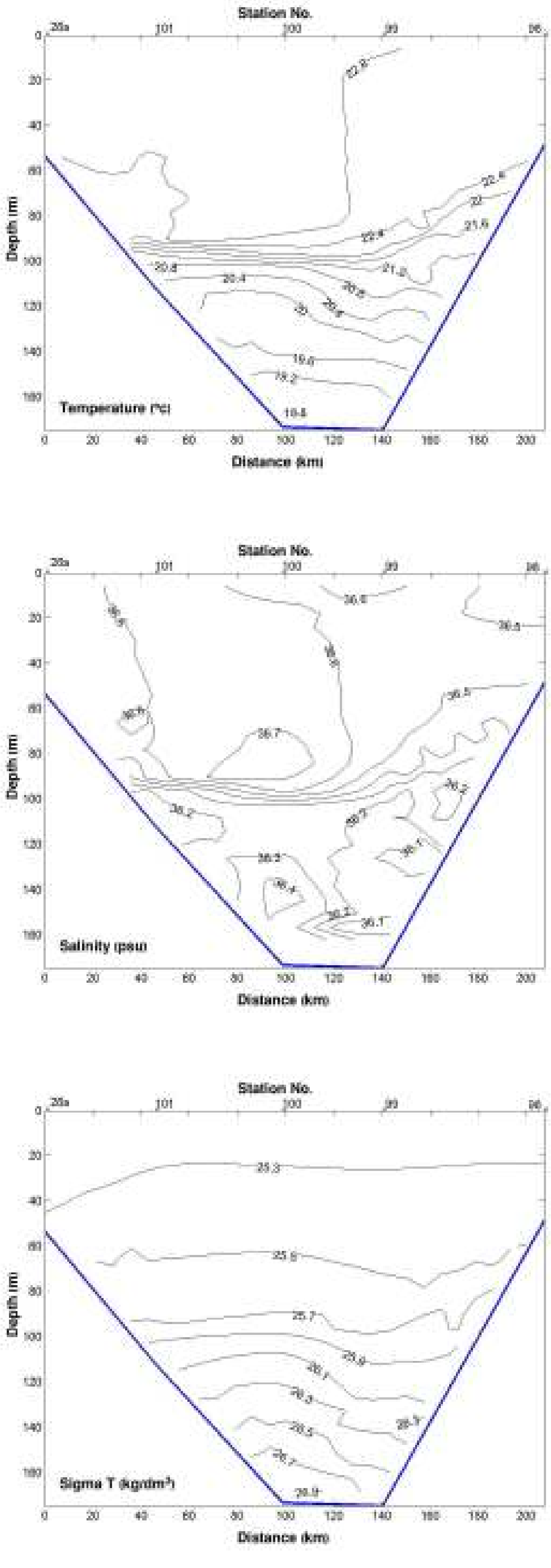


Figure 35. CTD cross section along transect 18 during leg 1 (winter 2006)

10.2.1. Distribution of salinity in the RSA

The inner RSA is a source region for one of the most saline water masses in the world ocean (Rochford, 1964). The salinity of water in this region is 40-41 psu over most of the Gulf and exceeds 50 psu in limited areas (Wyrtki, 1971; Johns *et al.*, 1990). Salinity of the inner RSA is high due to the arid climate, high rate of evaporation, low fresh water input and restricted exchange with the open ocean.

All previous investigations in the RSA are pointed out that physical Oceanographic conditions in this region are strongly controlled by the intensive evaporation. As a result of this, very high salinity waters exceeding 40 psu are found at the southern coasts of RSA. Figure 14 to 35 shows the salinity of transect from northern part of the Gulf in the inner RSA to the Sea of Oman. These figures clearly show the inflow of low-salinity surface water and the outflow of saline bottom water through the Strait of Hormuz. Under the influence of the Coriolis force, the surface inflow water moves along the Iranian coast towards the head of the Gulf. On the other hand, the outflow escapes the Gulf along the coast of Oman, which is in excellent agreement to previous studies (e.g.; Emery, 1956; Johns *et al.*, 2003, Sadrinasab and Kaempf 2006). Notice that the penetration of fresher sea water from Sea of Oman into inner RSA is evident in all transects along the Iranian coasts. Moreover the influence of Shat-al-Arab river discharge into the inner RSA is obvious in transects 1 and 2.

Figure 36 and 37 compare the lateral distributions of surface and bottom salinities in this cruise with finding of the model used by Kaempf and Sadrinasab (2006). These figures also clearly shows the inflow of low-salinity surface water and the outflow of saline bottom water through the Strait of Hormuz. It can be seen that inflow water from the Sea of Oman penetrates into the Gulf and occupies some area of the Gulf, which is in agreement with Johns *et al.* (2003) and Swift and Bower (2003).

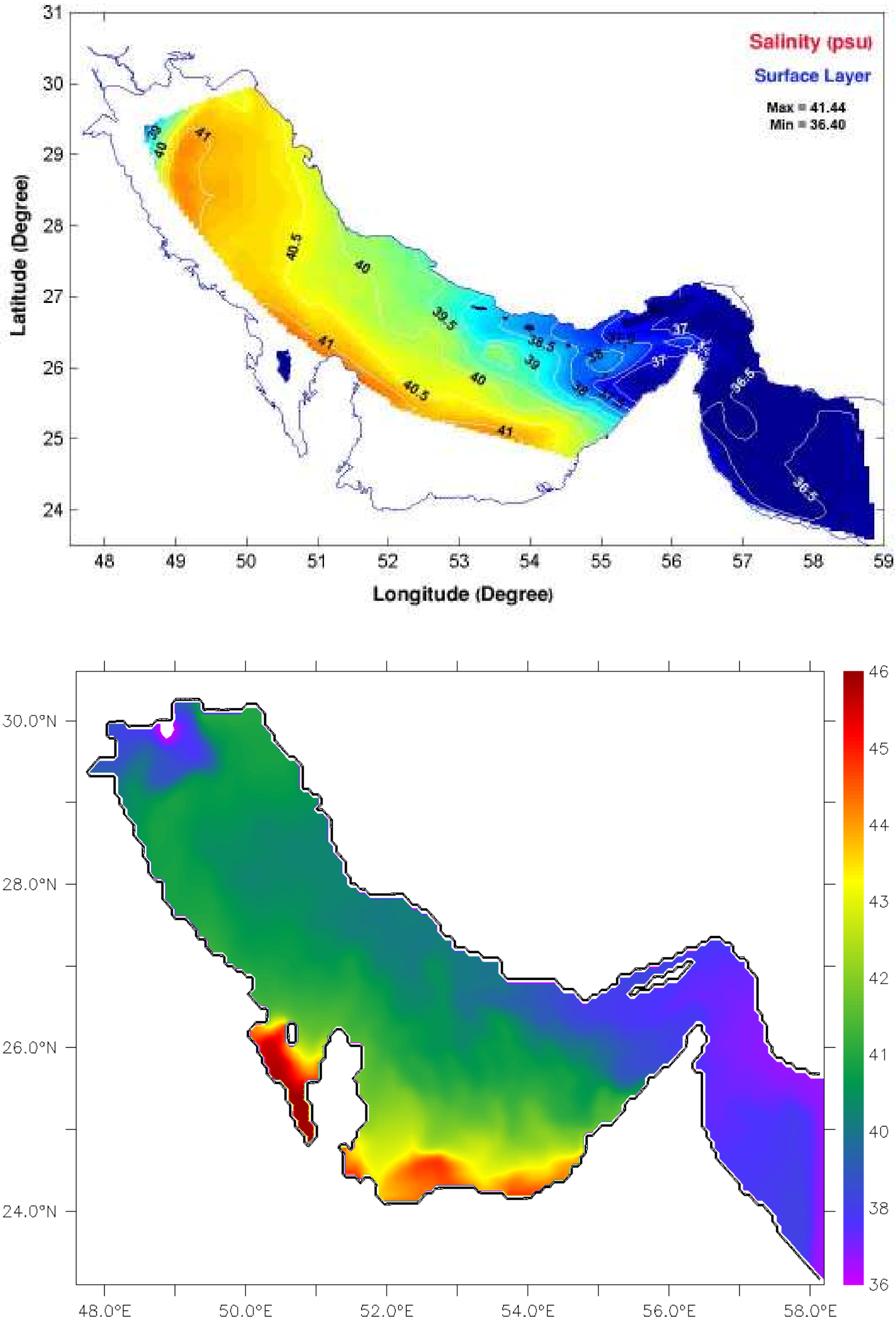


Figure 36. Upper- Lateral distribution of surface salinities during the ROPME winter cruise 2006. Lower- Simulated surface salinities (psu) in winter by Kaempf and Sadrinasab (2006).

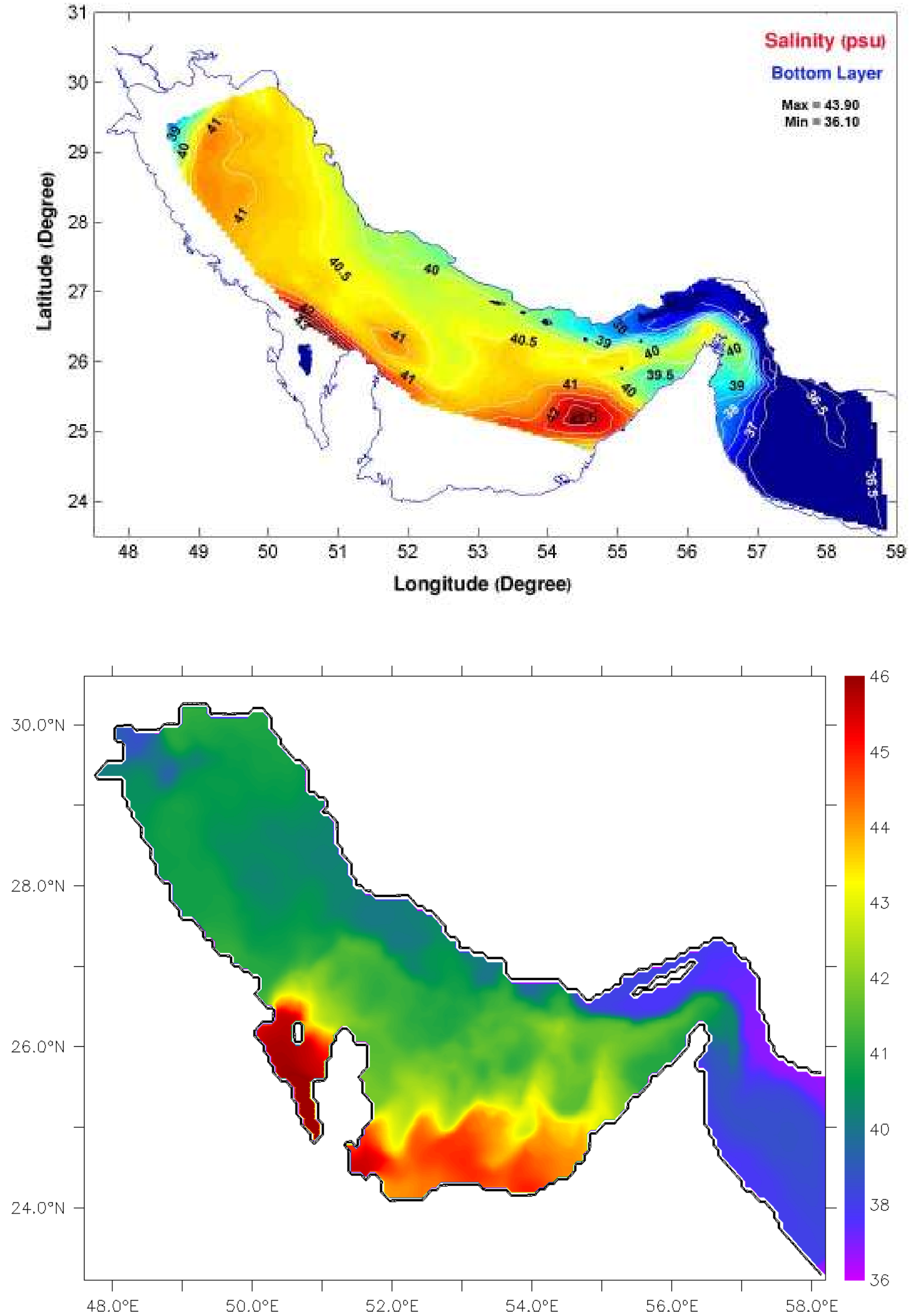


Figure 37. Upper- Lateral distribution of bottom salinities during the ROPME winter cruise 2006. Lower- Simulated bottom salinities (psu) in winter by Kaempf and Sadrinasab (2006).

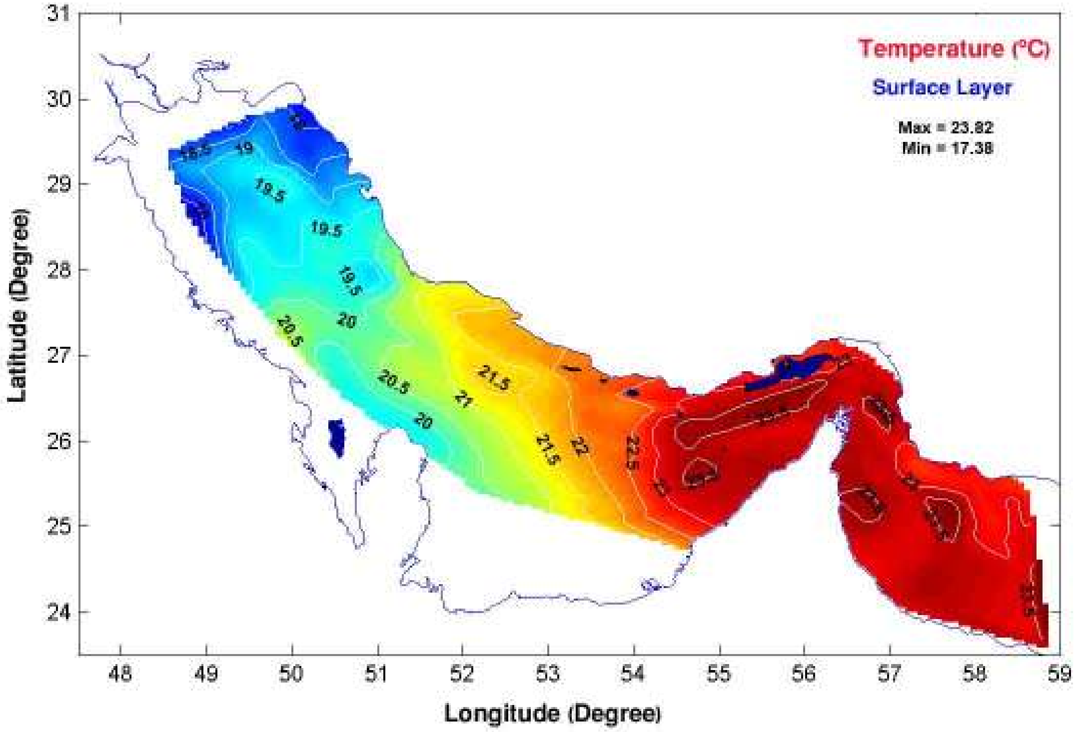
In the area off UAE coast near the Strait of Hormuz, low surface salinity water (<37.5) is found at the easternmost stations ($55^o40^{'}E$ see figure 36). This figure also shows that the origin of this low salinity water is associated with an inflow of water from the Sea of Oman through the Strait of Hormuz. This low salinity water was also detected in Mt. Mitchell cruise in winter, and salinity was less than 38 psu at that time. At the neighboring section (between 54^oE and 55^oE), salinity value is so high that a strong salinity front crossing the isobaths are formed in this area. Horizontal salinity difference of this front is relatively large in this cruise. Also high salinity water (about 43psu) is found off Bahrain(26^o $30^{'}$ N, $50^o30^{'}$ E) forming a strong salinity front which runs parallel to the isobaths. In Mt. Mitchell cruise, such high salinity water of more than 43 psu was only found at the sea surface off UAE coast (24^o $30^{'}N$, 52^o $30^{'}E$).

A extremely high salinity water (>43 psu also see figure 36) is found off Bahrain forming a strong salinity front. Vertical profiles of temperature and salinity at station 33 with the depth of 10 meters are shown in figure 20. Salinity increases from 42 psu at the depth of 8 meters to 43 psu the depth of 13 meters showing a sharp halocline, while temperature decreases by about 0.8 degree in this halocline. The origine of this high salinity water is belived to be formed by the strong evaporation in this area(Reynolds, 1993). Bottom salinities are higher than surface salinities almost everywhere in the domain (Figure 37). This salinity stratification is caused by the baroclinic density-driven flow. Note that the salinity patterns are rich in mesoscale eddies of 40-60 km in diameter.

10.2.2 . Distribution of Temperature in the RSA

Figure 38 and 39 compare the lateral distributions of surface and bottom salinities in this cruise with finding of the model used by Kaempf and Sadrinasab(2006). As illustrated in these figures surface temperatures are 19-23^{o}C throughout the RSA, except in the western shallows where temperatures are lower at ~18^{o}C. As it can be seen, the temperature in the bottom layer is lower with a weak inversion layer. These features were also reported in Mt. Mitchell cruise (Reynolds, 1993) as well as Kaempf and Sadrinasab (2006). Surface temperatures are 18^o-23.5^{o}C throughout the inner RSA and bottom temperature are about 1 degree lower than the surface temperature in the RSA.

In the ROPME Sea Area during winter, water temperature is lowest at the head of the Gulf and gradually increases towards the Strait of Hormuz (Emery 1956). Figures 38 illustrate the lateral distribution of temperature during the cruise. As can be seen, the water temperature of the inner Gulf is lower than the outside of the Gulf which is in agreement with previous studies (Emery, 1956). Furthermore the influence of fresher seawater from Sea of Oman are evident along Iranian coasts in these figures. Formation of dense water may begin as early as November when air temperatures decrease and wind speed increases (swift and Bower 2003).



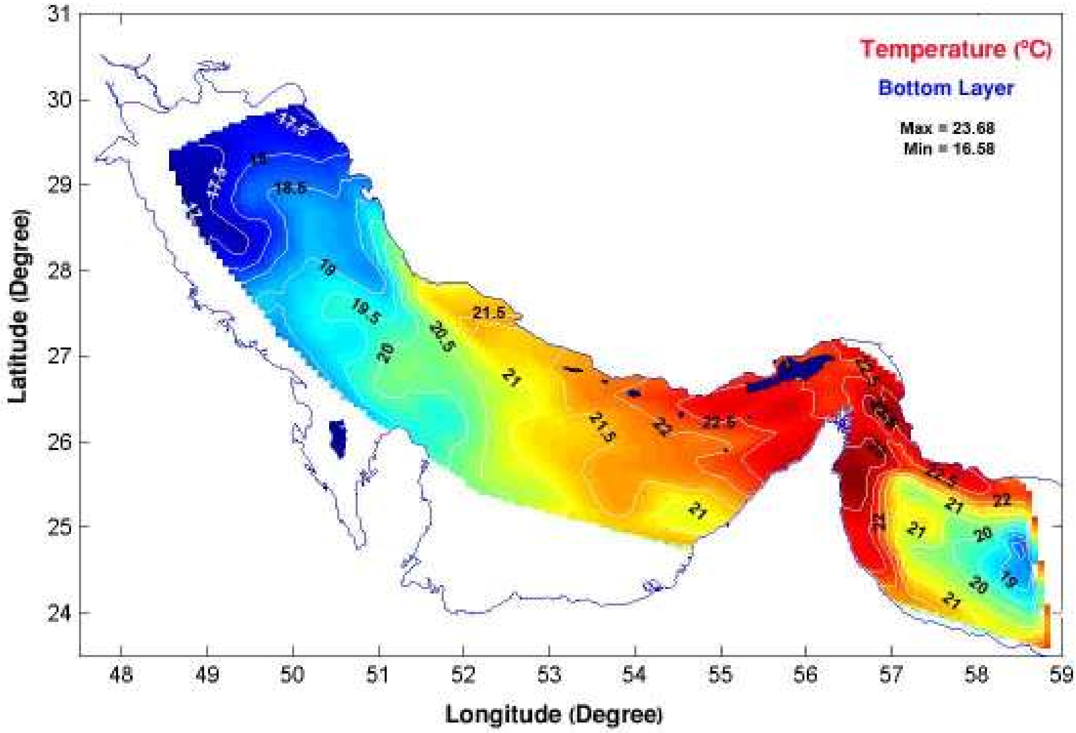


Figure 38. Lateral distribution of surface and bottom Temperature during in the cruise.

Figures 39 display variations of differences between bottom and surface temperatures in the study area. During winter, the cold wind blows over the RSA and surface bottom become colder than the beneath water. Hence the surface water becomes heavier and sinks down and mixing happens during this season. As illustrated in figure 39, during this cruise water column is well mixed in temperature in most regions of inner RSA with vertical maximum differences of about 2°C. As it is shown in the mentioned figure due to increases of depth in the Sea of Oman vertical difference of temperature reaches to 4°C. Overall, the water column is well mixed as a result of thermal convection.

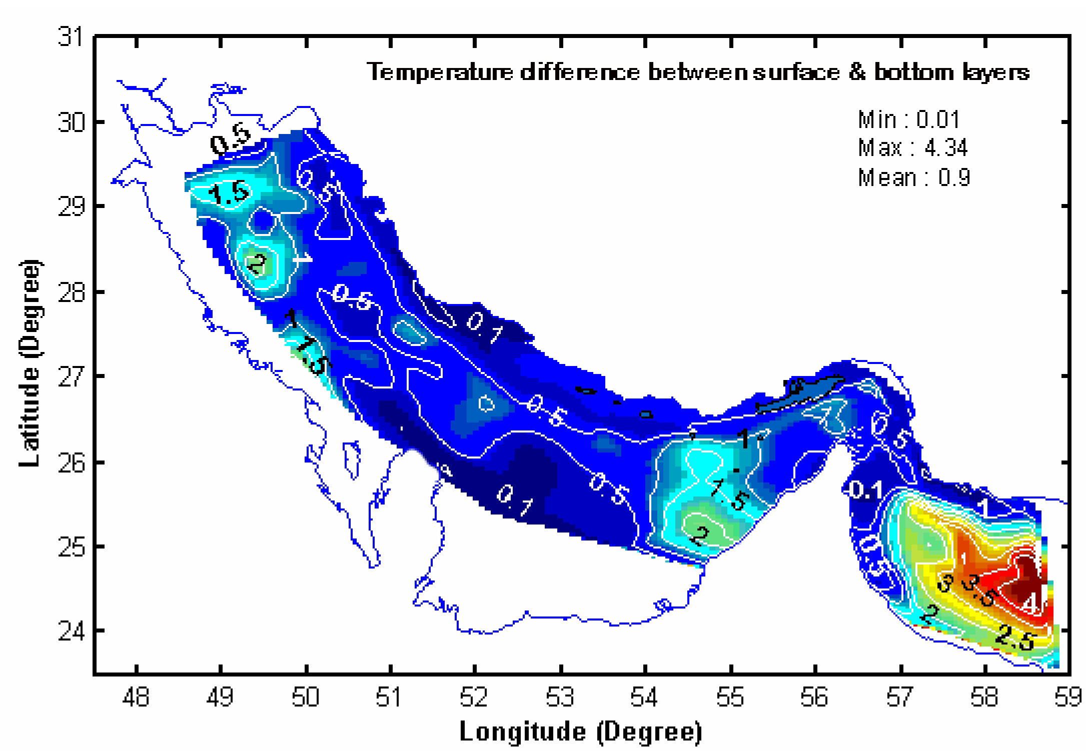
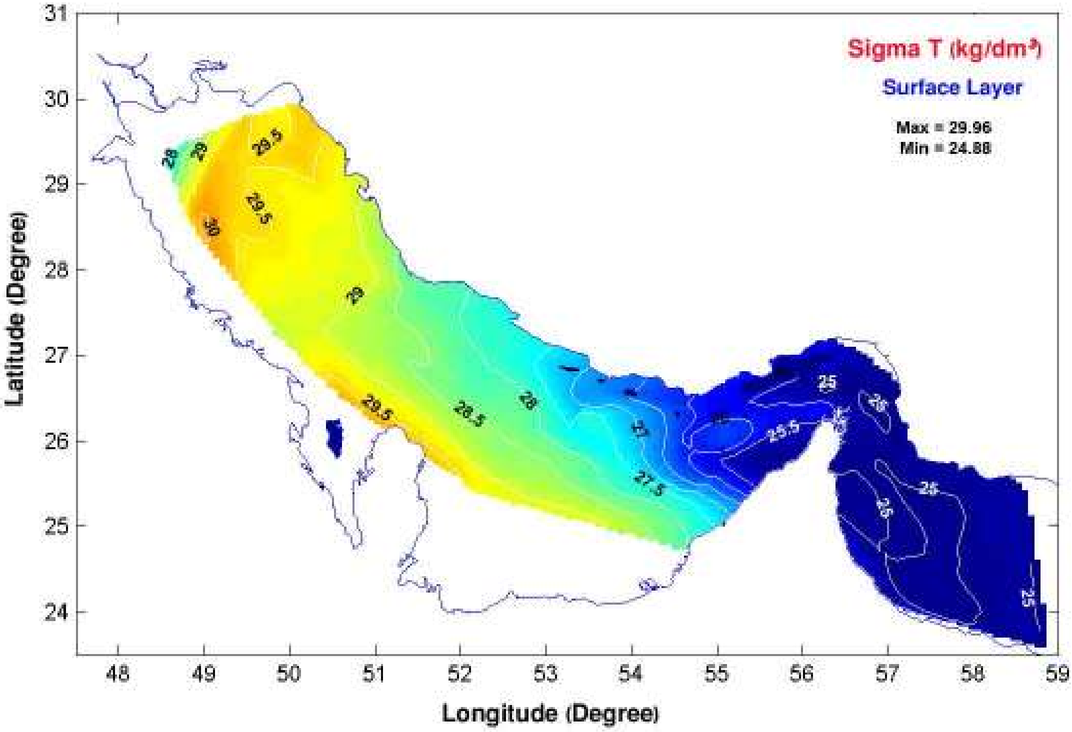


Figure 39 Distribution of temperature differences (°C) between surface and bottom layers in the RSA during winter cruise 2006.

10.2.3 Distribution of density in the RSA

Previous studies suggested that throughout the year, density decreases from head of the Gulf toward the Strait of Hormuz. Figures 14 to 35 illustrate vertical profiles of density in all transects which show the dense water in the bottom layers due to the spatial gradients in both salinity and temperature. Figure 40 displays lateral surface and bottom density (Sigma-T) in the study area during this cruise. Density varies between 1025 and 1031 kg m^{-3}. Minimum densities coincide with both the river plume from the Shatt-al-Arab River and inflow of low-density water from the Sea of Oman. Maximum densities are found in shallow regions along the southern coastline. In particular, densities approach peak values of 1031 kg m^{-3} north of Bahrain. Again the influence of fresher seawater from Sea of Oman into inner RSA along Iranian coasts is evident.



winter cruise 2006.

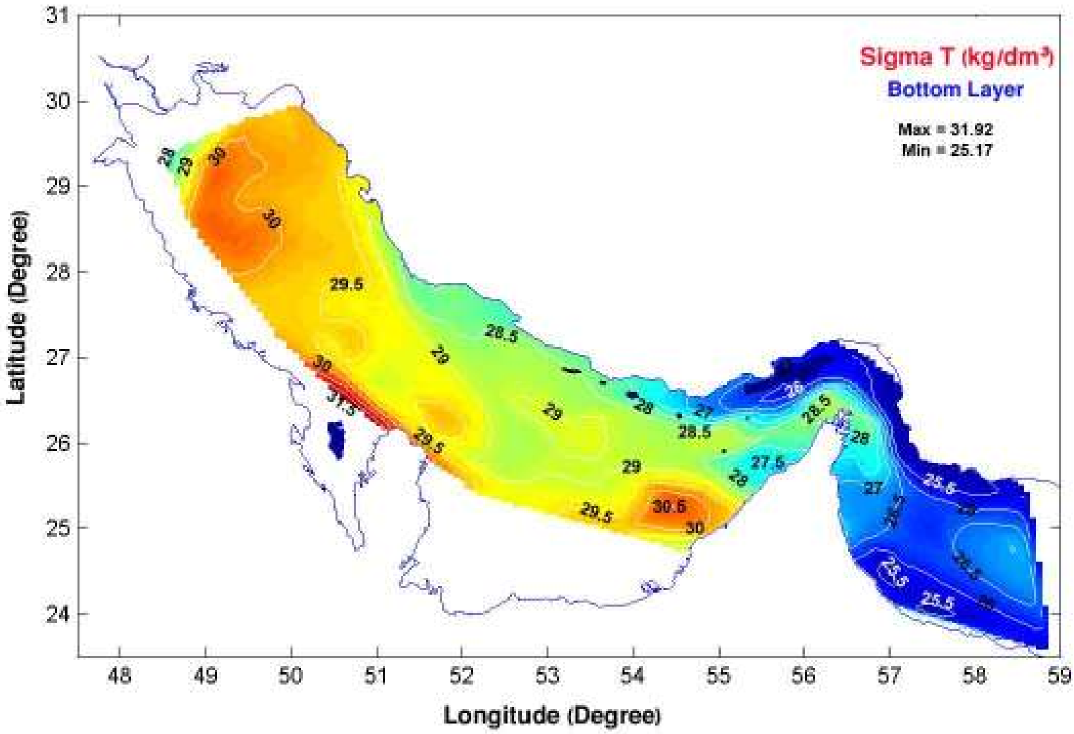


Figure 40. Lateral distribution of surface and bottom density (Sigma-T) during the ROPME winter cruise 2006.

10.2. 4 Circulation of water at the Strait of Hormuz

High evaporation in the inner RSA combined with restricted exchange with the Indian Ocean makes it an inverse estuary. Within the Strait of Hormuz, outflow of dense water from the Gulf is mostly confined to the southern side of the channel by geostrophy (Emery 1956, Chao *et al.*, 1992). On the other hand, to compensate for the evaporated mass of water and, hence, to conserve volume, surface water from the Sea of Oman flows into the inner RSA along the Iranian coast (Emery 1956). Figure 41 shows the vertical profiles of salinity, temperature and density at the Strait of Hormuz. This figure clearly shows that exchange of water between the inner RSA and the Sea of Oman wich is in agreement with Johns *et al.*, (2003). Inflow water moves into the inner RSA on the northern side of the channel; that is along the Iranian side, and at the surface occupies the entire width of the Strait. Outflow occurs on the southern side of the channel in form of a bottom-arrested plume of a width of ~30 km and a thickness of ~60-90 meters. Salinity of the deep outflow varies from 39.5 to 40.5 psu, which is close to the range of 39.3-40.8 psu reported by Johns *et al.* (2003).

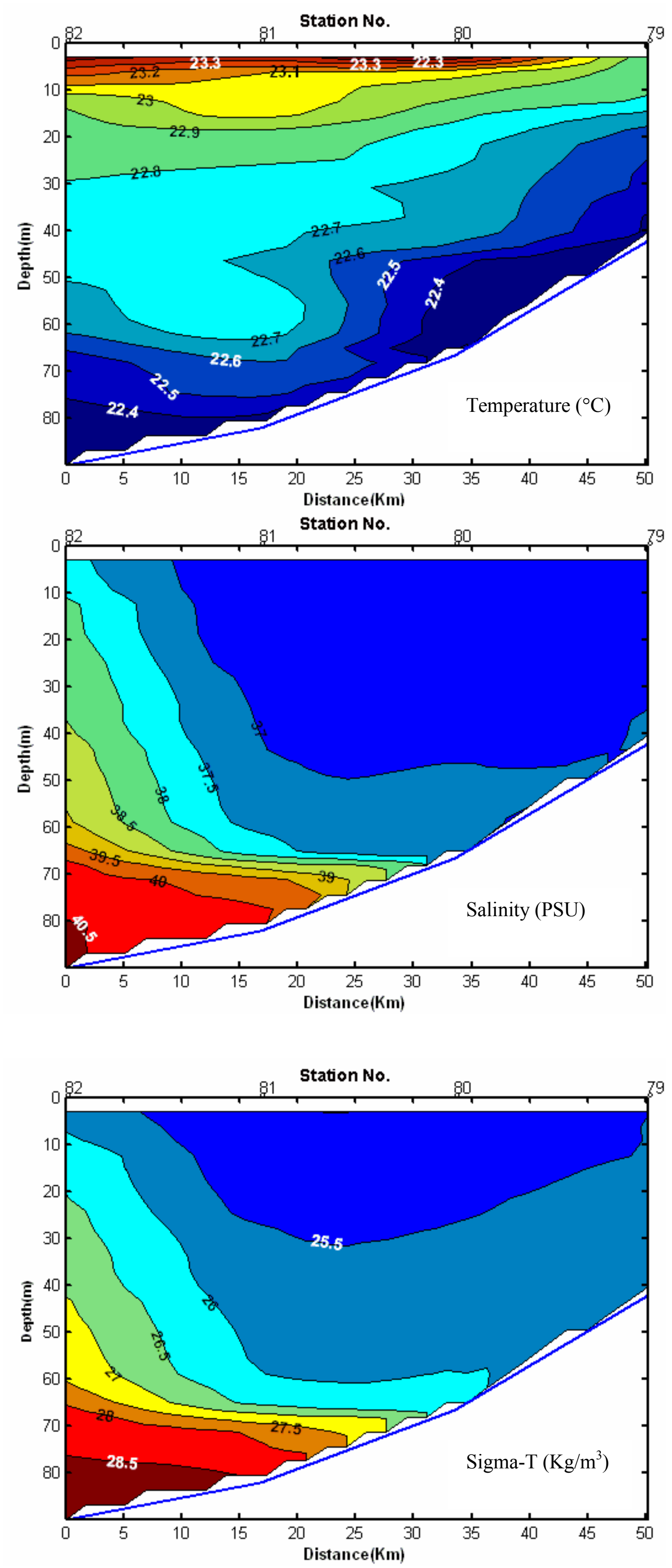


Figure 41. Vertical cross sections of salinity, temperature and density across the Strait of Hormuz.

11. Comparison of Cruise data with historical data.

Historical temperature-salinity observations in the RSA have been archived by the U.S. Naval Oceanographic Office (Alessi *et al.*, 1999). This data consists of a number of 1597 temperature-salinity profiles, including the Mt. Mitchell data, and spans observations over 73 years; that is, from 1923 to 1996. Figure 42 shows a composite of station locations. There is a clear lack of data in the southern shallows around Qatar and along the coast of the United Arab Emirates.

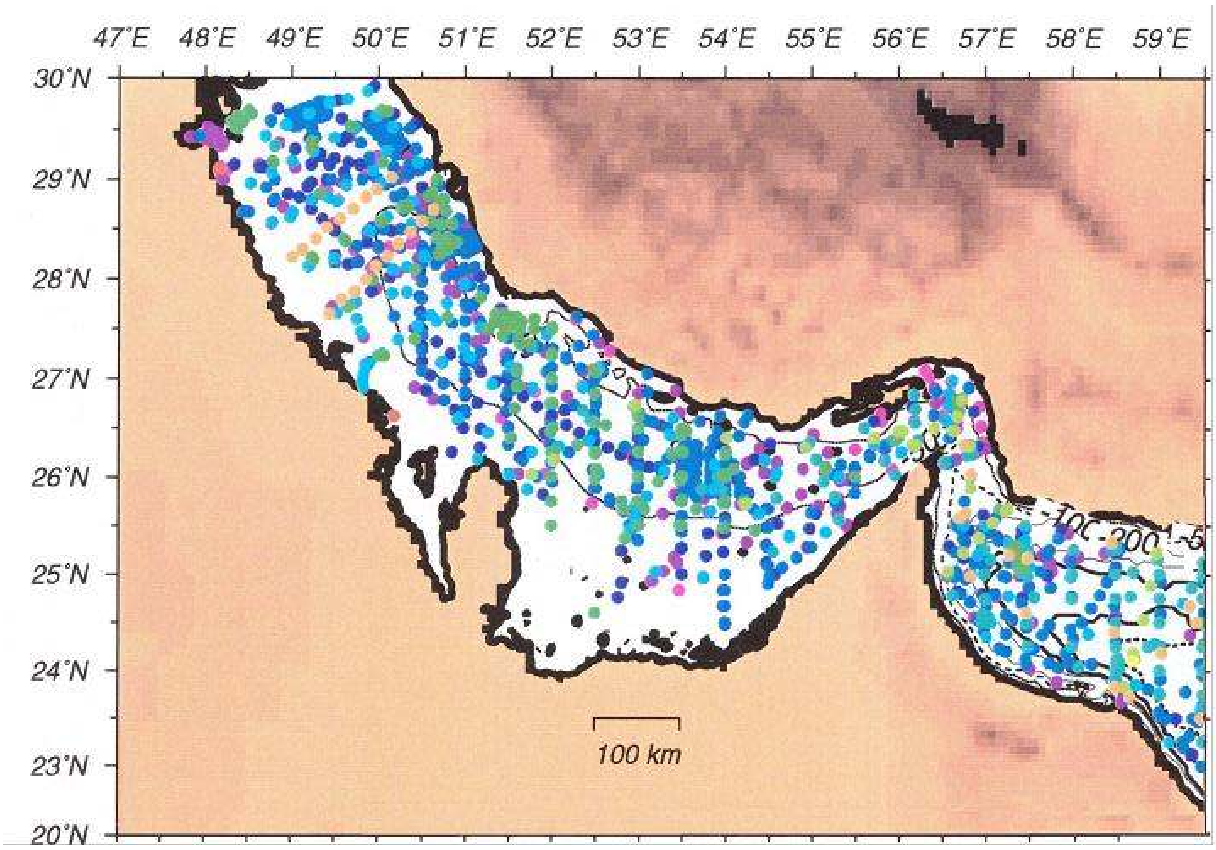


Figure 42. Geographical distribution of data in the RSA during 1923-1996. From Alessi *et al.* (1999)

To illustrate seasonal variations of temperature and salinity in different regions, Alessi *et al.* (1999) subdivided the RSA into 9 boxes (figure 43). Temperature-salinity diagrams have been constructed for each of these boxes on a seasonal basis. The winter Temperature-salinity diagrams of these 73 years observation are compared with the Temperature-salinity diagrams observation of this cruise. As the historical data have been collected during 3 months (winter season) and the cruise data have been collected during few days in winter the temperatures can be differ.

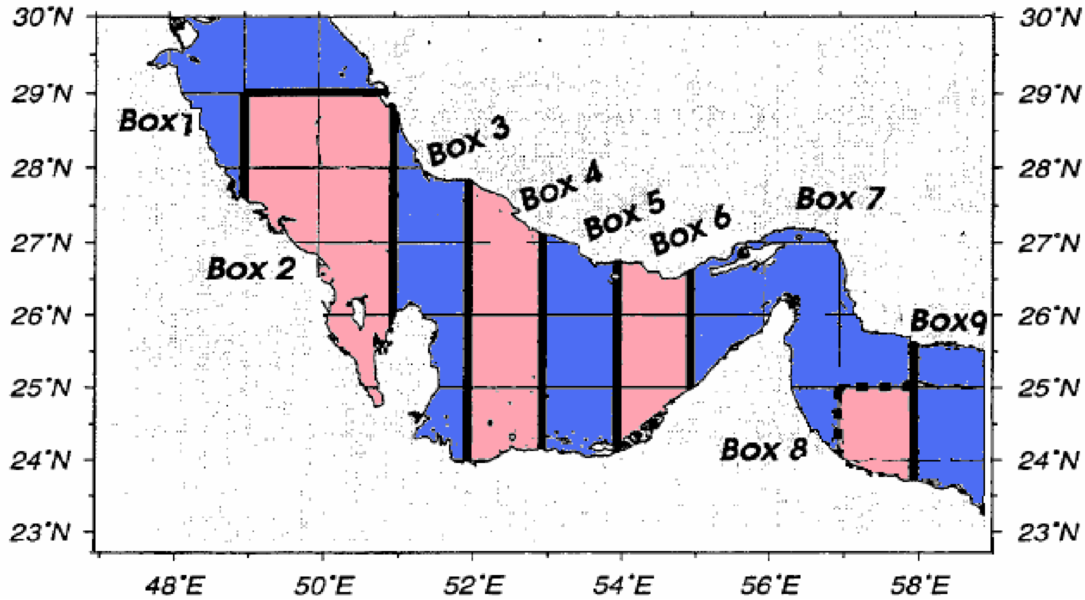


Figure 43. Location of boxes in the historical data studies.

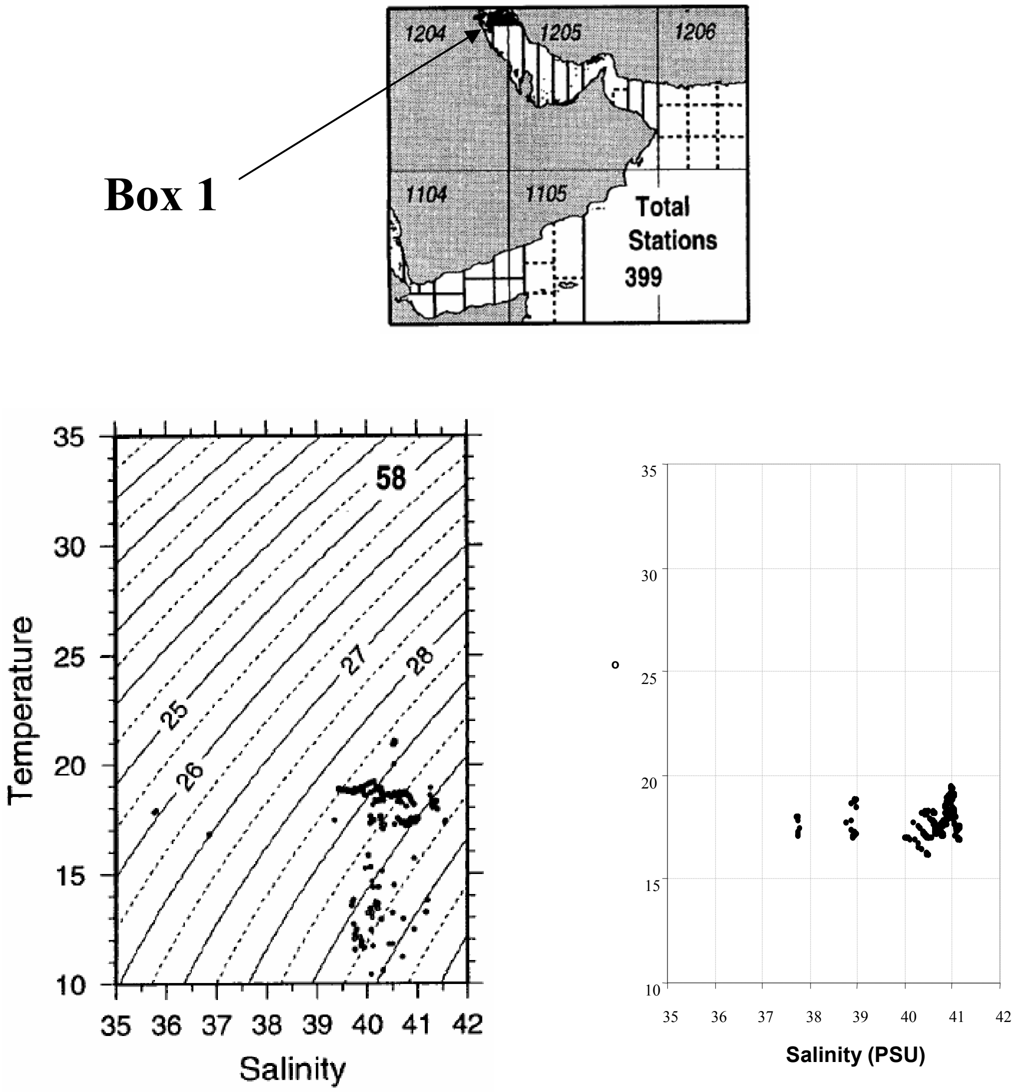


Figure 44. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 1.

The Shatt-al-Arab River discharges into this region. The historical salinity in this box varies between 37-41.5 psu, while the salinity data of this cruise for this box varies between 37.7-4.41 psu.. As can be seen salinity of the historical data are nearly the same and salinity of the cruise data for this box. The lowest salinities are belonging to river water which discharge into this box

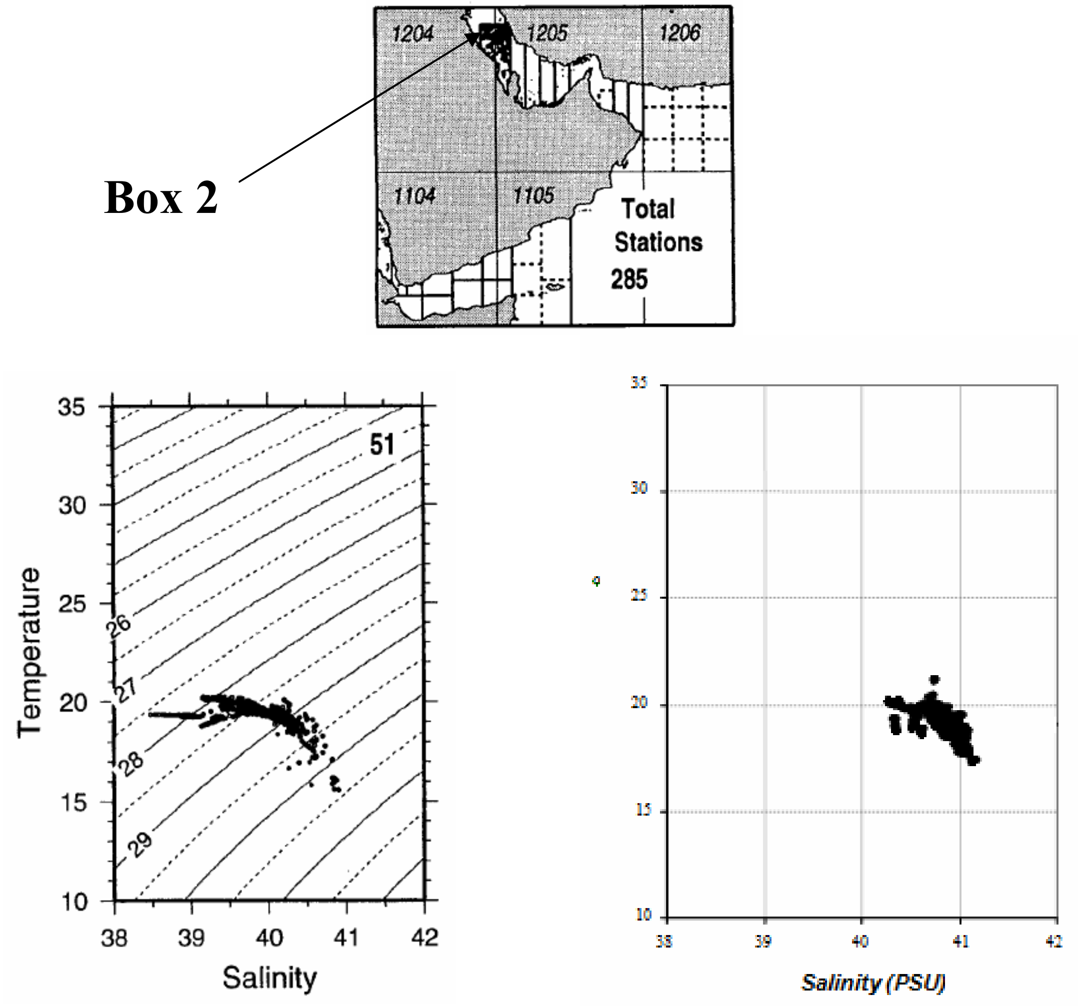


Figure 45. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 2.

The discharge of the river also reaches to this box along Saudi Arabian coasts. As illustrated in figure 43, the historical salinity in this box varies between 38.5-41 psu, while the salinity data of this cruise for this box varies between 40.3-41.2 psu. Salinity of the historical data are lower than the salinity of the cruise data. The reason is that, during the cruise we did not collect samples near the Saudi Arabian coasts which contain fresher river waters.

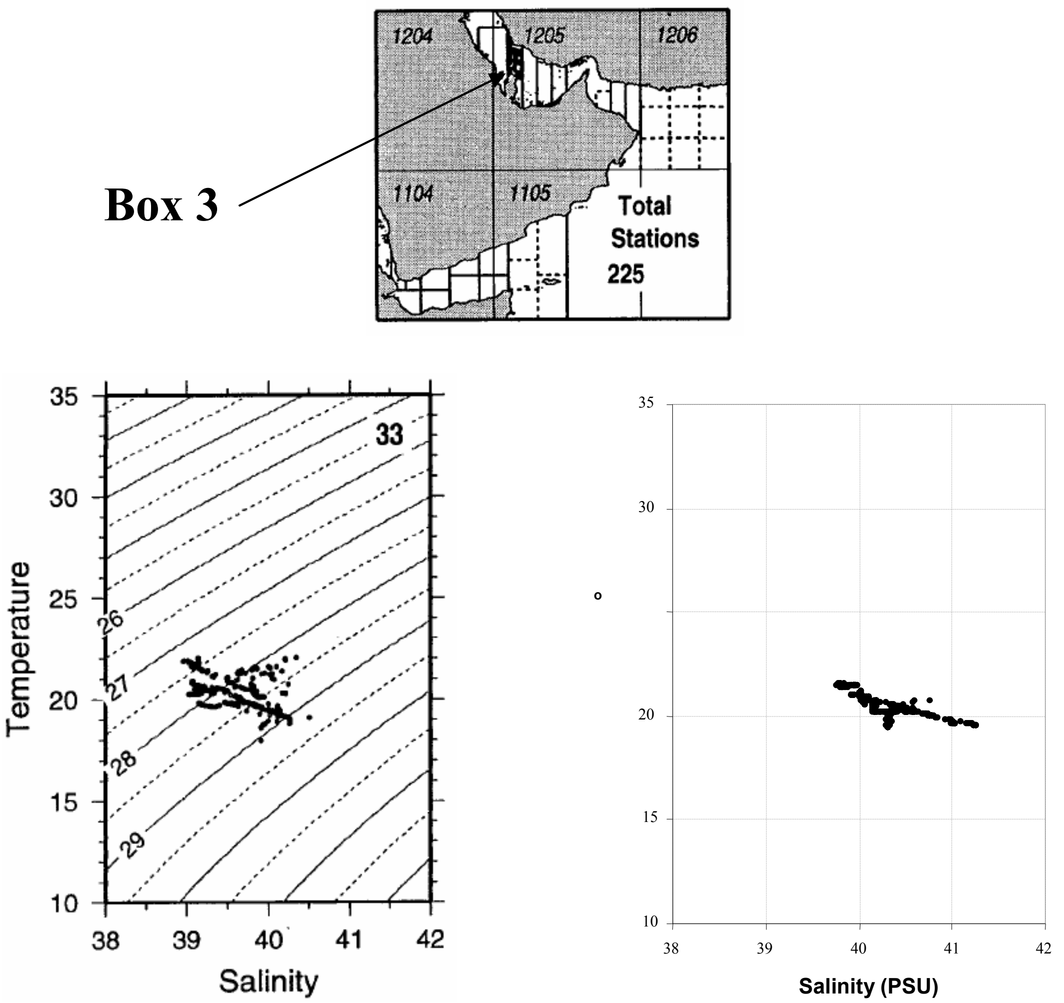
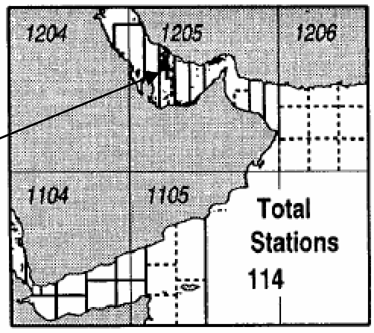
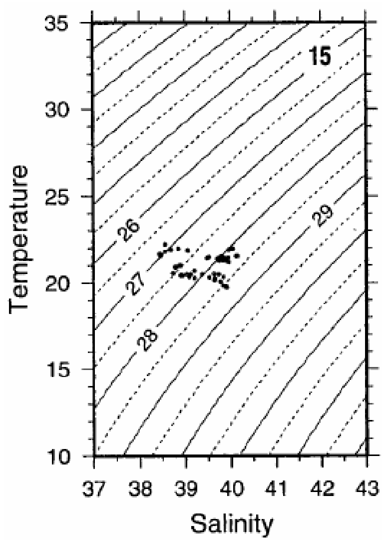


Figure 46. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 3.

The discharge of the river does not reach to this box. As illustrated in figure 46, the historical salinity in this box varies between 39-40.5psu, while the salinity data of this cruise for this box varies between 39.7-41.2psu. Salinity of the historical data are about 0.5psu lower than the salinity of the cruise data.

Box 4





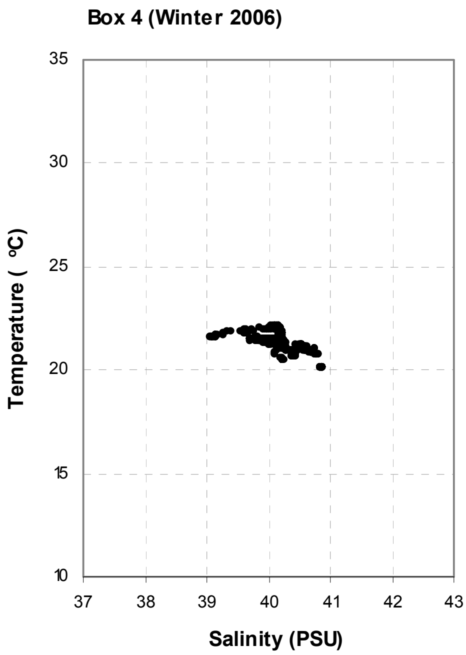


Figure 47. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 4.

The discharge of the river does not reach to this box. As illustrated in figure 47, the historical salinity in this box varies between 38.5-40.5psu, while the salinity data of this cruise for box 4 is between 39-41psu. Salinity of this box is lower than the salinity of box3. This is the indication of intrusion of fresher water from Sea of Oman up to this box.

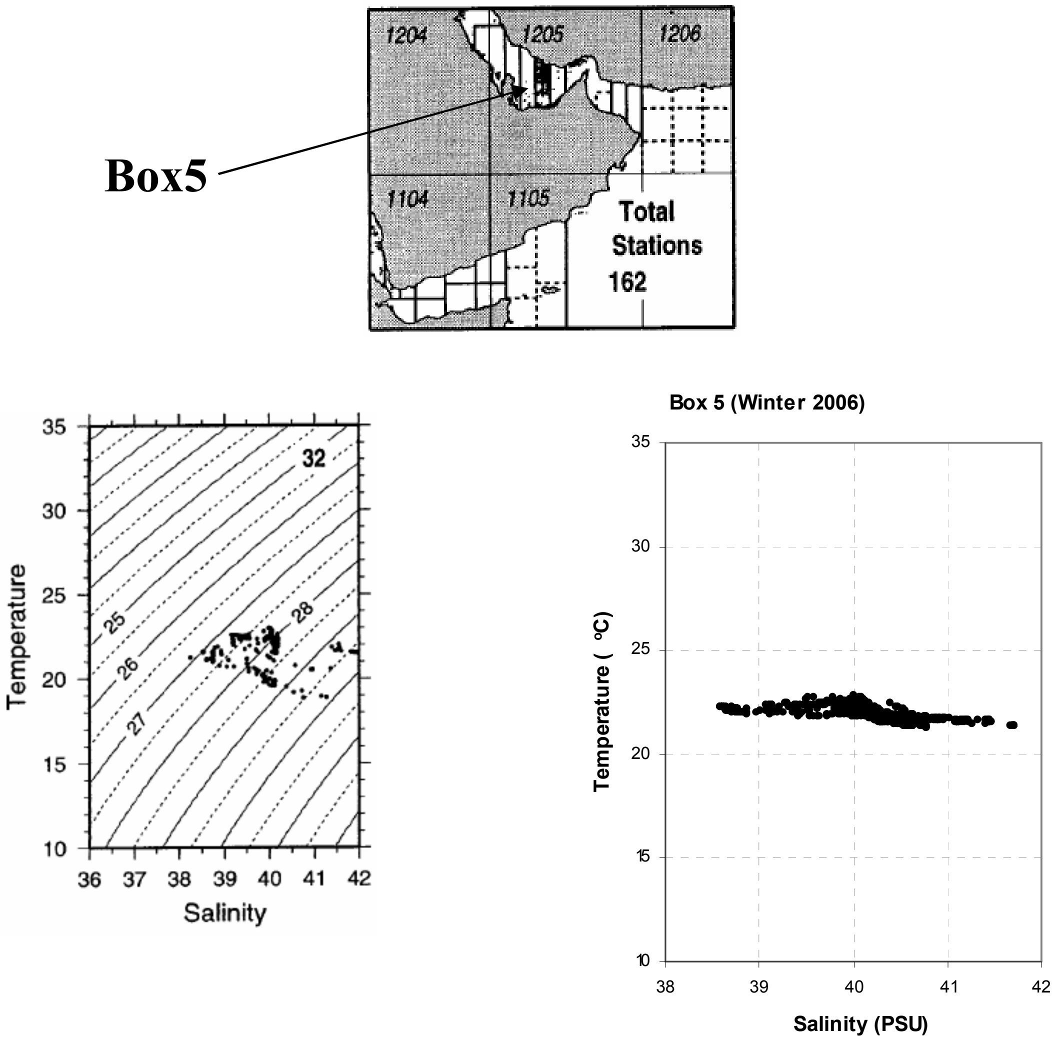


Figure 48. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 5.

The discharge of the river does not reach to this box. As illustrated in figure 48, the historical salinity in this box varies between 38.2-41.5psu, while the salinity data of this cruise for box 5 is between 38.6-41.8psu. In compare to previous box, salinity is reduces. This is due to that fresher water from Sea of Oman has penetrated into this box.

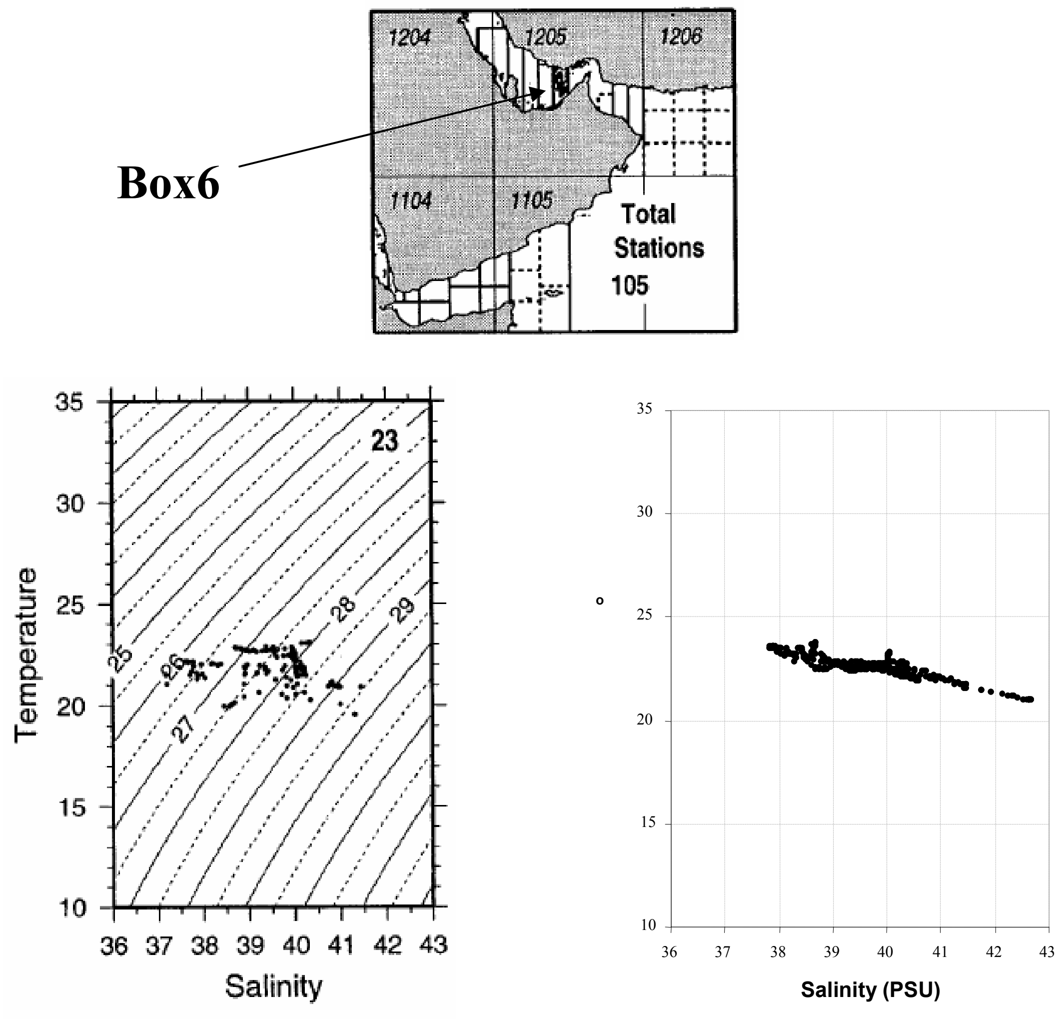


Figure 49. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 6.

As illustrated in figure 49, the historical salinity in this box varies between 37.5-41.5psu, while the salinity data of this cruise for box 6 is between 37.7-42psu. In compare to previous box, salinity is reduces. This is due to that more fresher water from Sea of Oman has penetrated into this box.

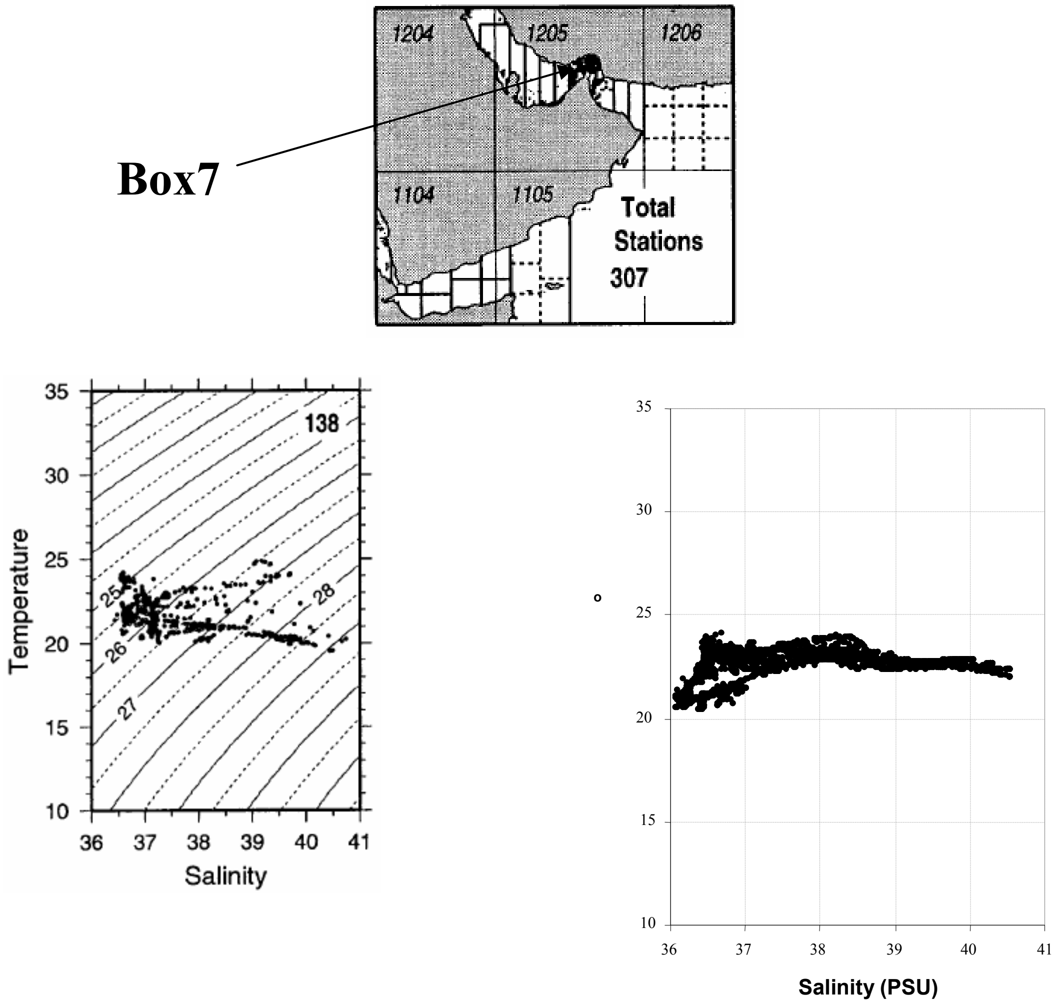


Figure 50. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 7.

This box covers the Strait of Hormuz which connects the inner RSA to the Sea of Oman. As illustrated in figure 50, the historical salinity in this box varies between 36.5-41psu, while the salinity data of this cruise for box 6 is between 36-40.7psu. In compare to previous box, salinity is reduces from 37.5 to 36psu which shows that the surface water in this box is the penetrated water from Sea of Oman.

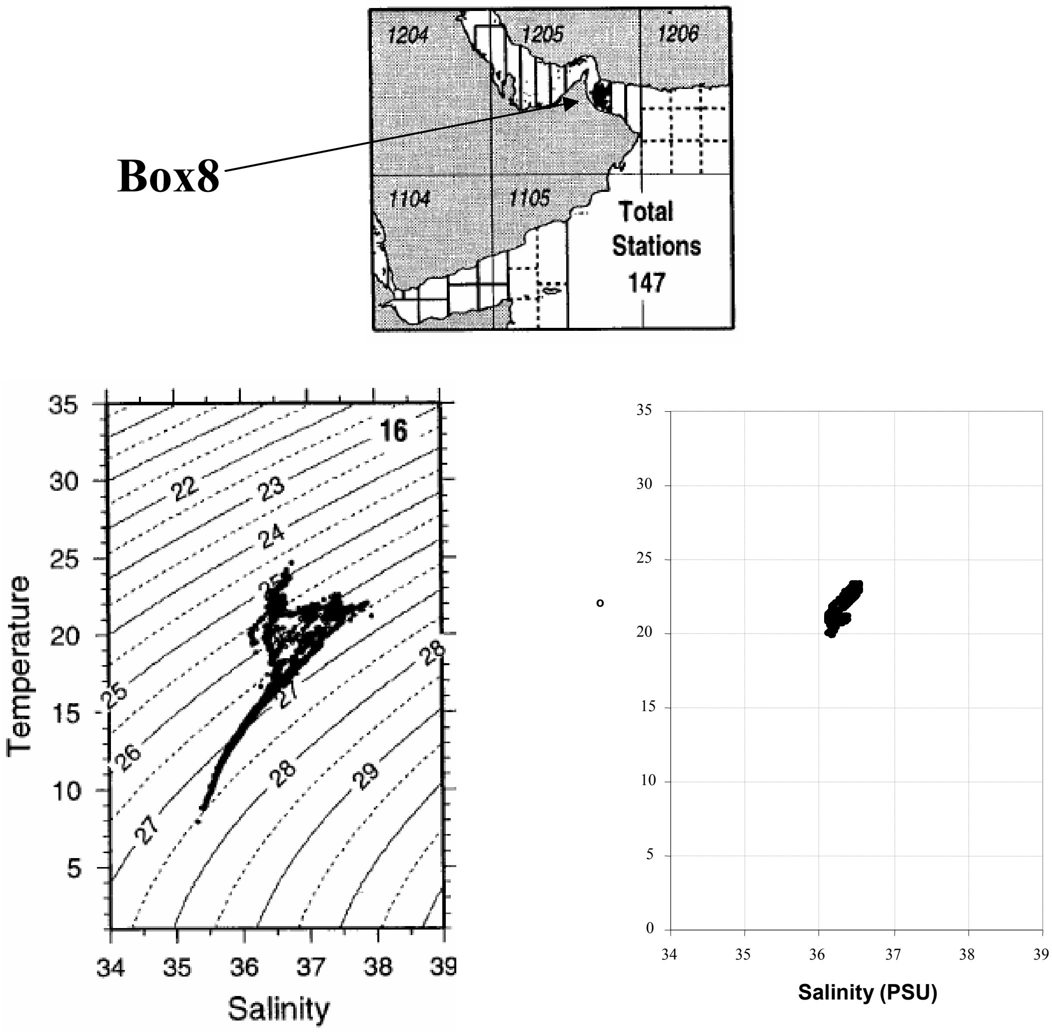


Figure 51. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 8.

As illustrated in figure 51, the historical salinity in this box varies between 35.5-38psu, while the salinity data of this cruise for box 6 is between 36-36.7psu. The lowest salinity of the historical data are belong to deep waters. But during the cruise we could measure the salinity of water up to 200 meters.

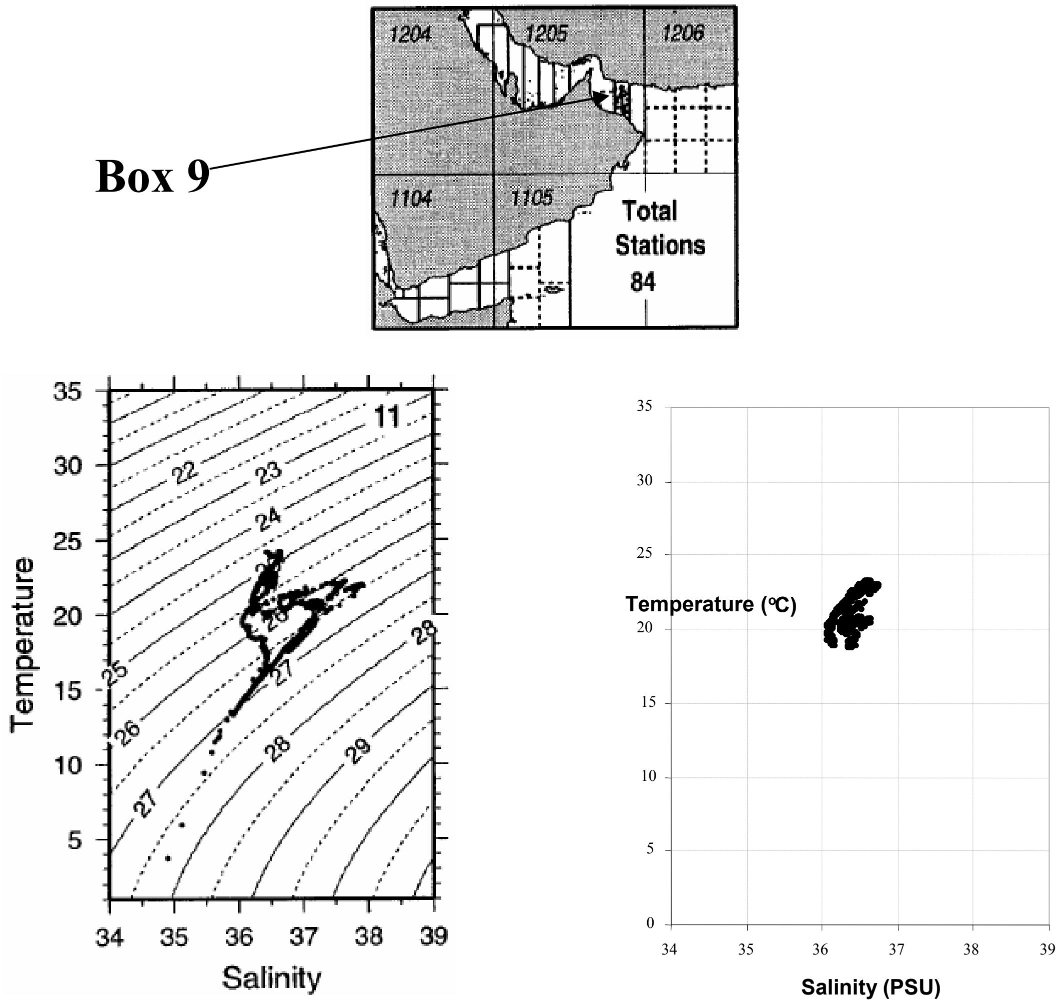


Figure 52. Comparison of winter 2006 cruise TS-diagram with historical TS-diagram for Box 9.

As illustrated in figure 52, the historical salinity in this box varies between 35-38psu, while the salinity data of this cruise for box 6 is between 36-36.7psu. The lowest salinity of the historical data are belong to deep waters. But during the cruise we could measure the salinity of water up to 200 meters.

12. Conclusions and Recommendations

In general all employed instrument except minor errors with Automatic Weather Station performed very well in this cruise. The following discussion which is a comparison between the results of this cruise and previous observations confirm and acknowledge the accuracy of physical properties measurement in this cruise.

High evaporation in the inner RSA combined with restricted exchange with the Indian Ocean makes the inner RSA an inverse estuary. The densest water forms in northern part of the Gulf as well as shallow waters along the coast of United Arab Emirates (Southern Shallows) and around Bahrain. This is associated with atmospheric cooling of extremely saline water masses. The data collected in this cruise suggest a flow out of the Gulf around the tip of the Musandem peninsula (56.6^{o}E) and into the northern Sea of Oman. Dense water formed in the Southern Shallows strengthens the bottom outflow through the Strait of Hormuz. The bottom outflow regime is confined to the eastern portion of the Gulf with a minor contribution of dense waters forming around Bahrain. The saline bottom waters that flow out through the Strait may originate from several locations in the Gulf. Collected data implicate a broad region of high salinity waters extending from Qatar eastward along the Emirate coast (Figure 36). Waters in this shallow region can reach very high salinities (>42 psu) and appear to form salty endpoint of the Gulf outflow.

Compared to the Gulf as a whole and the continental shelf outside the Gulf, the rate of vertical mixing is highest in the Strait of Hormuz channel around the Musandam Peninsula.

Intensified bottom outflow magnifies the influx of Indian Ocean Surface Water into the Gulf. This leads to the formation of the Iranian Coastal Jet and approaches the head of the Sea of Oman.

Within the Strait of Hormuz, outflow of dense water from the Gulf is mostly confined to the southern side of the channel by geostrophy (Emery 1956, Chao *et al.*, 1992). On the other hand, to compensate for the evaporated mass of water and, hence, to conserve volume, surface water from the Sea of Oman flows into the Gulf along the Iranian coast (Emery 1956). Figure 36 shows the averaged domain lateral distributions of surface and bottom salinities found in this cruise. This figure clearly shows the inflow of low-salinity surface water and the outflow of saline bottom water through the Strait of Hormuz. Under the influence of the Coriolis force, the surface inflow water moves along the Iranian coast towards the head of the Gulf. On the other hand, the outflow escapes the Gulf along the coast of Oman, which is in excellent agreement to previous studies (e.g.; Emery, 1956; Johns *et al.*, 2003; Sadrinasab and Keampf 2005). Unlike the Mediterranean or Red Sea the Gulf is shallow (<100 m) and there is no prominent sill to constrain the outflow. Notice that the surface inflow extends across the Strait of Hormuz, in agreement with Johns *et al.* (2003). The most saline (>41 psu) water is found in southern parts of the Gulf; that is, along the coasts of the

United Arab Emirates, Saudi Arabia and around Qatar. This is in agreement with Brewer *et al.* (1978), Hunter (1982), Chao *et al.* (1990) and Swift and Bower (2003). Simulated bottom salinities are higher than surface salinities almost everywhere in the domain (Figure 36).

Vertical transect of temperature, salinity and density are shown in figure 14 to 35. These figures illustrate lower density along Iranian side than southern part of the Gulf except in the northern part of the Gulf due to fresh water discharge from Shatt-al-Arab and Bahmanshir rivers.

Figure 29 (transect 14a) and figure 41 display vertical transects of temperature, salinity and density across the Strait of Hormuz at 56.6^{o}E in this cruise. This figure clearly shows that exchange of water between the Gulf and the Sea of Oman exists which is in agreement with other observational evidence (Johns *et al.*, 2003) and numerical models (Chao1992, Kaempf and Sadrinasab 2005). Inflow water moves into the Gulf on the northern side of the channel; that is along the Iranian side, and at the surface occupies the entire width of the Strait. Outflow occurs on the southern side of the channel in form of a bottom-arrested plume with a thickness of ~30 m. Salinity of the deep outflow varies from 39.5 to 40.5 psu, which is close to the range of 39.3-40.8 psu reported by Johns *et al.* (2003).

Effect of the Shat-al-Arab river is evidence as stratification, from river mouth to station 10a at transect number 5 (See figurs14 to 19). Also the area north of Qatar was almost perfectly mixed from top to bottom, while at the extreme northern end, the depth becomes shallow enough for the surface and bottom mixing to stir the water column over its full depth.

Usually in winter, wind speeds are higher and humidity is lower in the ROPME Sea Area, contributing to higher evaporation rates than in summer. Although the coast is open and circulation is largely unrestricted, evaporation rates are high enough to increase salinity to 41 psu (Figures 36) in the northern part of the Gulf.

Collected data suggested increases of salinity from Sea of Oman towards eastern part of the Gulf as well as from Iranian side towards southern part. Also these data clearly shows decreasing of temperature from Sea of Oman towards eastern part of the Gulf.

As far as the circulation of the water in the inner RSA is concerned, the northern Gulf is separated from the southern regime by a front that typically is found off Qatar (fig. 38). This front is appears weak during the cruise time. The location of this front appears in winter to be tied to the penetration of fresh inflow into the Gulf from the Strait of Hormuz. The available data suggests that much of this inflow may terminate in a counter-clockwise, cyclonic flow to the east of the mid-Gulf front.

In order to evaluate the findings of the cruise, the data have been compared with lateral salinity, temperature and density from Kaempf& Sadrinasab (2006) and also with historical TS-diagrams data from Alessi, *et.al* (1999) . There is excellent agreement between the cruise data with the model drown by Keampf and Sadrinasab (2006). Moreover the compared Ts-diagrams also showing good agreement in salinity component but due to small duration of measurement during the cruise, the temperatures are not comparable.

- The Automatic Weather Station (AWS) was fixed on board ship at the beginning of the cruise and removed at the end of the cruise. The AWS was transferred to the laboratory where the recorded data was downloaded. Unfortunately, as mentioned earlier there was some error in collecting the data during cruise. To avoid such problems it is recommended to download weather data at each station and have the confirmation of the team leader before proceeding to the next station.

- As it is clear in figures 7 and 8, winds speed and direction are affected by ships movement, to avoid such errors it is recommended to ask navigational officers on board to record ship's speed and direction during the cruise, to calculate the true winds speed and direction.

- The lateral salinity, temperature and density shown in figures 36 to 40, are the averaged of all cross sections that have been measured during the cruise, i.e., from 03/02/2006 to 09/03/2006 about 37 days. It is very important to noted that these figures are not the true picture of these parameters, because the first transect have been measured in the Sea of Oman on 03/02/2006 while the last transect have been taken at the head of the Gulf on 09/03/2006 within 37 days gap. It is very important to find a solution to show the true picture of the mentioned parameters for the next cruises.

- Meteorologists generally define four seasons in many climatic areas, winter, spring, summer and autumn (or fall). These are demarcated by the values of their average temperatures on a monthly basis, with each season lasting three months. Astronomically, the vernal equinox (usually 21 March in the Northern Hemisphere, and 22 September in the Southern Hemisphere), should be the first of spring (based on the angle of the sun and insolation). For most temperate regions, signs of spring appear long before the middle of March, but the folklore of 21 March being the "first day of spring" persists, and 21 June as the "first day of summer" is common in the USA. In South Africa, Australia and New Zealand, spring begins on 1 September, and has no relation to the vernal equinox. It is recommended to define a project by ROPME to find out the seasons in the RSA.

- As the maximum crane's wire length in the cruise was limited to 200 meters, to have a better understanding of the physical properties of the bottom layer in the Sea of Oman, it is also recommended to extend the length of the wire for the next cruises

- In this cruise as well as previous field observations, there is clearly lacked of measurement in the Southern Shallows, to cover the whole area of study, it is recommended to make an arrangement to measure southern shallows in the next cruises.

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