

**Summary of Hydrographic/CTD
Observations made along Line P and at
Station P: 1991-1999**

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by

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CONTENTS

ABSTRACT	IV
INTRODUCTION.....	1
SHIPS AND PERSONNEL	2
TABLE 1. LIST OF SHIPS, DATES, AND PERSONNEL, 1991 TO 1999.....	5
TABLE 2. TYPES OF SAMPLES TAKEN ON EACH MISSION.	17
WATER SAMPLING EQUIPMENT.....	19
TABLE 3 OF JGOFS AND WOCE DESIGNATED MISSIONS.	21
PLOTS OF CTD LOCATIONS FOR MISSIONS DONE 1991 TO 1999	23
FIGURE 1. IOS ROSETTE.....	35
FIGURE 2. GENERAL OCEANICS ROSETTE.....	36
FIGURE 3. HEAVE COMPENSATOR MOUNTED ON CCGS TULLY A-FRAME	37
FIGURE 4. CSS PARIZEAU.....	38
FIGURE 5. CCGS J.P. TULLY	39
FIGURE 6. CNAV ENDEAVOUR	40

ABSTRACT

Minkley, B.G., and F.A. Whitney. 2001. Summary of Hydrographic/CTD Observations made along Line P and at Station P: 1991-1999. Canadian Data Report of Hydrography and Ocean Sciences No. 156: 40 p.

A summary of 30 missions which sampled part or all of Line P between January 1991 and December 1999 is provided. Plots of mission tracks show the areas surveyed, participants are listed, and types of sampling, inventoried. A review of sampling equipment outlines the conversion from 1.7 litre Niskin bottles mounted on 5/32-inch wire hydro wire to CTD/Rosette cast sampling using 10 litre bottles. Missions which supported programs for World Ocean Circulation Experiment and Joint Global Ocean Flux Studies are listed.

A previous report contained observations for the period January 1980 to December 1989 and is found in Canadian Data Report of Hydrography and Ocean Sciences No.136, by Tabata and Brown.

Key words: North Pacific Ocean, open-ocean time-series, hydrographic/CTD data.

RÉSUMÉ

Ce rapport fourni un sommaire de 30 croisières océanographiques durant lesquelles la ligne P a été échantillonnée en tout ou en partie entre janvier 1991 et décembre 1999. Chaque sommaire comprend la région explorée représentée par la trajectoire du navire, la liste des participants, ainsi qu'un inventaire du type d'échantillons collectés. Une révision du matériel d'échantillonnage souligne la conversion de bouteilles Niskin de 1.7 litre montées sur un câble de 5/32" à des profils de CTD/Rosette utilisant des bouteilles de 10 litres. Les croisières faisant partie des programmes WOCE (World Ocean Circulation Experiment) et JGOFS (Joint Global Ocean Flux Studies) sont énumérées.

Un rapport précédant contenant les observations pour la période de janvier 1980 à décembre 1989 se trouve dans Canadian Data Report of Hydrography and Ocean Sciences, No 136, par Tabata et Brown.

INTRODUCTION

The Line P program has been an important part of ocean research in Canada since the 1950s. Considerable effort has been expended to keep this monitoring program viable in the Northeast Pacific Ocean, the result being that the time series of measurements is proving extremely valuable in demonstrating the impact of climate change and variability on oceans. Early history and data from this program have been summarized by Tabata and Peart (1985). Dr. Tabata was largely responsible for ensuring the quality of the large temperature, oxygen and salinity data set up to 1990.

In the early 1990s, the Line P program came under the umbrella of the World Ocean Circulation Experiment (WOCE). Funding became available to upgrade virtually every measurement. Over a period of three years, the Institute of Ocean Sciences (IOS) switched from hydrographic bottle casts to CTD/rosette casts, with the result that CTD and water sampling became much better meshed, and depth measurements for samples improved. This was also the era that saw improved horizontal positioning due to the increased use and availability of the GPS for ship's navigation. With time, we added instruments to the CTD/rosette package so that we now routinely profile particle distribution to deep ocean, and light and fluorescence to 400 m. Data from 15 Line P surveys between 1991 and 1997 were submitted to the WOCE Hydrographic Program Office, and are available from <http://oceanic.cms.udel.edu/woce/>; <ftp://nemo.ucsd.edu/woce/Data/Pacific/Repeat/PR6/>.

Improvements were also made to routine chemical analyses. More analyses were done on fresh samples at sea than ever before. In part this was possible because the research vessel, *CCGS JOHN P TULLY*, has adequate lab space in which to set up analytical instruments. In addition to oxygen and nutrients, in the past decade we have measured CFCs, iron, total CO₂, alkalinity, pCO₂, chlorophyll and dimethyl sulfide at sea.

Line P also became a focus of activity under the Joint Global Ocean Flux Study program (JGOFS). The Canadian JGOFS program, from 1992 to 1997, decided to concentrate effort on understanding the controls of biological growth in the Gulf of Alaska. Great effort to solve this riddle came from the University of British Columbia (UBC) and other Canadian universities and international collaborators. A result of this work was the publication of a special volume of *Deep Sea Research II* (vol. 46, No. 11-12, 1999) which contains a review of the Line P program (Whitney and Freeland, 1999) and an additional 25 papers on biological, geochemical and physical processes of the NE Pacific. Core measurements from JGOFS studies are available from the Marine Environment Data Service, Fisheries and Oceans at <http://www.meds-sdmm.dfo-mpo.gc.ca/>.

The focus on processes in the Northeast Pacific during WOCE and JGOFS have spurred several important findings that relate climate change and variability to ocean productivity. Freeland *et al* (1998) have shown that the upper ocean mixed layer has been shoaling over the past 40 years, with the result that nutrient supply to phytoplankton is weaker. Between the 1970s and 1990s, Whitney and Freeland (1999) found an approximately 30% decline in the winter supply of nitrate to surface waters. Also, about 40% of the interannual variability in this supply appears to be modulated by El Niño – La Niña cycles (Whitney *et al*, 1998). We are now

confident that iron is a limiting nutrient in open waters in this area (Boyd et al, 1996) and still are uncertain about the interactions of light, temperature and nutrient supply in controlling plankton growth. Also unresolved is the understanding of how various nutrients are transported to the surface ocean.

Interest in open ocean research remains strong. The Alaskan Gyre region of the Northeast Pacific is a major habitat of Pacific salmon and a sizeable heat sink/source which moderates Canadian west coast weather. We foresee the Line P program continuing as an important contribution in understanding the impacts of climate variability on world oceans.

SHIPS AND PERSONNEL

The majority of the scientific personnel participating in these mission were from IOS. A few members have made 10 or more trips to Ocean Station Papa during this decade:

	<i>Trips</i>		<i>trips</i>
Ron Bellegay	12	Wendy Richardson	16
Reg Bigham	10	Marie Robert	14
John Love	11	Tim Soutar	21
Hugh Maclean, UBC	21	Frank Whitney	19
Bernard Minkley	23		

In addition to IOS staff, personnel from the following agencies participated:

- Canadian Wildlife Service
- Japanese scientists from both industry and universities
- Memorial University, St. Johns, Newfoundland
- McGill University
- Pacific Biological Station, Nanaimo
- Pacific Oceanological Institute of Russia
- Princeton University
- Third Institute of Oceanography of China
- University of British Columbia
- University of Rimouski
- University of Southampton
- University of Toronto
- University of Victoria

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Whitney, F.A., C.S. Wong and P.W. Boyd. 1998. Interannual Variability in Nitrate Supply to Surface Waters of the Northeast Pacific Ocean. *Mar. Ecol. Prog. Ser.* 170, 15-23.

Table 1. List of ships, dates, and personnel, 1991 to 1999

Mission	ship	start date	end date	master	area
91-03	Tully	19-Feb-91	11-March-91	John Anderson	Line P, Line Z, line R, lines MB and MA
		CTD: Guildline 8715 SN 53501.			
		Ron	Bellegay	IOS	chief scientist
		Beg	Bigham	IOS	
		Gilles	Desmeules		
		Bernard	Minkley	IOS	
		Tim	Soutar	IOS	
		Darren	Tuele	IOS	
		Jinping	Wu	UBC	
91-08	Parizeau	28-Apr-91	10-May-91	John Campbell	line P, line R, line MA
		CTD: Guildline SN 53501 and 58483			
		Sus	Tabata	IOS	chief scientist
		Mary-Beth	Bérubé	IOS	
		John	Love	IOS	
		Bernard	Minkley	IOS	
		Graeme	Quin	contractor	
		Les	Spearing	IOS	
		Jin Ping	Wu	UBC	
91-15	Endeavour	17-Oct-91	1-Nov-91	W. McMunagle	Line P, line Z
		CTD: Guildline 8706 SN 43571 and 8715 SN 58483			
		Reversing thermometers used with 1.7 litre Niskin bottles.			
		Ron	Bellegay	IOS	chief scientist
		Mike	Dempsey	contractor	
		Hugh	Maclean	UBC	
		Bernard	Minkley	IOS	
		Robert	Mugo	UTC	
		Ron	Perkin	IOS	
		Tim	Soutar	IOS	
		Les	Spearing	IOS	
		Jinping	Wu	UBC	

- 92-01 Tully 03-Feb-92 14-Feb-92 John Anderson Line P, line R (partial)
 CTD: Guildline 8706 SN 43501 and 8715 SN 58483
- | | | | |
|--------------|----------------|-----------------------|------------------------|
| Frank | Whitney | IOS | chief scientist |
| Ron | Bellegay | IOS | |
| Keith | Johnson | IOS | |
| Robert | Millar | co-op student | |
| Bernard | Minkley | IOS | |
| Tom | Moore | Guildline Instruments | |
| Wendy | Richardson | IOS | |
| Les | Spearing | IOS | |
| Clayton | Stark | co-op student | |
| Shu Lun | Wang | UBC | |
- 92-06 Endeavour 26-Mar-92 13-April-91 W. McMunagle Line P line Z, line R,
 and line J
 CTD: Guildline 8715 SN 53501 and 8715 SN 58483
 Reversing thermometers used with 1.7 litre Niskin bottles.
- | | | | |
|------------|---------------|------------|------------------------|
| Ron | Perkin | IOS | chief scientist |
| Ron | Bellegay | IOS | |
| Reg | Bigham | IOS | |
| Bernard | Minkley | IOS | |
| Tim | Soutar | IOS | |
| Les | Spearing | IOS | |
| Jin Ping | Wu | UBC | |
- 92-15 Tully 08-Sep-92 29-Sept-92 Paul Frost Line P, line Z,
 line R (partial)
 CTD: Guildline SN 58483 and 59901 (testing only), Swann CTD winch
 General Oceanics Rosette frame.
 Reversing thermometers used for depths greater than 3000 m.
- | | | | |
|--------------|----------------|---------------|------------------------|
| Frank | Whitney | IOS | chief scientist |
| Reg | Bigham | IOS | |
| Marty | Davelaar | IOS | |
| Nick | Hall-Patch | Co-op student | |
| John | Love | IOS | |
| Hugh | Maclean | UBC | |
| Brad | McKelvey | UBC | |
| Bernard | Minkley | IOS | |
| Marie | Robert | contractor | |
| Tim | Soutar | IOS | |
| Diana | Varela | UBC | |

- 93-03 Tully 06-Mar-93 18-March-93 John Anderson Line P
 CTD: Guildline SN 59901 and 58483, Lantec winch used for Rosette casts.
 New and much larger A-frame on deck
 1 ½ “ diameter shock cords used to help eliminate ship motion from Rosette.
 Reversing thermometers used for depths greater than 3000 m.
- | | | | |
|------------|---------------|------------|------------------------|
| Ron | Perkin | IOS | chief scientist |
| Ron | Bellegay | IOS | |
| Philip | Boyd | UBC | |
| Anna | Flak | Poland | |
| John | Love | IOS | |
| Hugh | Maclean | UBC | |
| Bernard | Minkley | IOS | |
| Helen | Nicolidakas | UBC | |
| Wendy | Richardson | IOS | |
| Marie | Robert | contractor | |
| Tim | Soutar | IOS | |
| Diana | Varela | UBC | |
| Frank | Whitney | IOS | |
- 93-09 Tully 14-May-93 31-May-93 John Anderson Line P, line R, line J
 CTD: Guildline SN 59901 and 58483, Lantec winch used for Rosette casts
 1 ½ “ diameter shock cords used to help eliminate ship motion from Rosette.
 Strain gauge on wire to determine maximum loading of wire.
- | | | | |
|--------------|----------------|---------------|------------------------|
| Ron | Bellegay | IOS | |
| Reg | Bigham | IOS | |
| Philip | Boyd | UBC | |
| Sean | Doherty | UBC | |
| Nick | Hall-Patch | Co-op student | |
| Hugh | Maclean | UBC | |
| Bernard | Minkley | IOS | |
| Marie | Robert | contractor | |
| Steven | Ruskey | | |
| Tim | Soutar | IOS | |
| Diana | Verela | UBC | |
| Mark | Wen | UBC | |
| Frank | Whitney | IOS | chief scientist |
| Jin Ping | Wu | UBC | |

94-01 Tully 07-Feb-94 18-Feb-94 John Anderson Line P (partial)
 CTD: Guildline SN 59901, Lantec winch used for Rosette casts.
 A-frame mounted heavy compensator system.

Ron	Perkin	IOS	chief scientist
Ron	Bellegay	IOS	
Reg	Bigham	IOS	
Philip	Boyd	UBC	
Sean	Doherty	UBC	
Bill	Green	IOS	
John	Love	IOS	
Hugh	Maclean	UBC	
Bernard	Minkley	IOS	
Dario	Stucchi	IOS	
Diana	Varela	UBC	
Mark	Wen	UBC	
Frank	Whitney	IOS	

94-02 Tully 10-May-94 27-May-94 John Anderson Line P, R16, R12 and R8.
 CTD: Guildline SN 59901 and 58483, Lantec winch

Training mission in Saanich Inlet and Haro Strait for the following personnel:

Mary Beth Bérubé, Robin Brown, Tracy Feeney, Howard Freeland, John Garrett, Bill Green, Rhiannon, Johnson, Tom Juhasz, Bernard Minkley, Taimi Mulder, Ron Perkin, Wendy Richardson, Dennis Simmott, Terry Sowden, Carol Steward, Neil Sutherland, Sarah Thornton, Linda White, Frank Whitney, Bob Wilson.

Most of these people departed the ship in Esquimalt harbour and the following personnel joined the ship for mission out to Ocean Station Papa:

Frank	Whitney	IOS	chief scientist
Ron	Bellegay	IOS	
Reg	Bigham	IOS	
Philip	Boyd	UBC	
Marty	Davelaar	IOS	
Sean	Doherty	UBC	
Keith	Johnson	IOS	
John	Love	IOS	
Hugh	Maclean	UBC	
Bernard	Minkley	IOS	
Jim	Powlik	contractor	
Wendy	Richardson	IOS	
Marie	Robert	contractor	
Tim	Soutar	IOS	
Diana	Varela	UBC	
Mark	Wen	UBC	

94-03 Tully 06-Sep-94 9-Nov-94 John Anderson Line P, WOCE line P15N
CTD: Guildline SN 59901 and 58483, Lantec winch used.

John	Garrett	IOS	chief scientist
Andrei	Andreev	POI, Vladivostak	Russia
Ron	Bellegay	IOS	
Mary-Beth	Bérubé	IOS	
Reg	Bigham	IOS	
Valerie	Knight	contractor	
John	Love	IOS	
Bernard	Minkley	IOS	
Galina	Pavlova	POI, Vladivostak,	Russia
Leo	Rebele	UBC	
Marie	Robert	contractor	
Tim	Soutar	IOS	
Dario	Stucchi	IOS	
Sarah	Thornton	UBC	
Louise	Timmermans	UBC	
Pavel	Tishchenko	POI, Vladivostak	Russia
Linda	White	contractor	
Frank	Whitney	IOS	

95-01 Tully 07-Feb-95 23-Feb-95 Al Combs Line P
CTD: Guildline SN 59901 and 58483, Swann 329 winch used for rosette casts.

Frank	Whitney	IOS	chief scientist
Reg	Bigham	IOS	
Philip	Boyd	UBC	
Tracy	Feeney	UBC	
Robert	Goldblatt	UBC	
John	Love	IOS	
Hugh	Maclean	UBC	
Bernard	Minkley	IOS	
Tim	Soutar	IOS	

95-05 Tully 09-May-95 25-May-95 Al Coombs Line P, 130W grid
CTD: Guildline SN 59901 and 58483

Frank	Whitney	IOS	chief scientist
John	Berges	UBC	
Reg	Bigham	IOS	
Philip	Boyd	UBC	
Stuart	Brock	Co-op student	
John	Love	IOS	
Hugh	Maclean	UBC	
Bernard	Minkley	IOS	
Kate	Read		
Wendy	Richardson	IOS	
Tim	Soutar	IOS	
Sarah	Thornton	UBC	

95-12	Tully	22-Aug-95	13-Sept-95	Al Coombs	Line P
	CTD: Guildline SN 59901 and 58483				
	Philip	Boyd	UBC	chief scientist	
	Janet	Barwell-Clarke	contractor		
	Ron	Bellegay	IOS		
	Reg	Bigham	IOS		
	John	Love	IOS		
	Hugh	Maclean	UBC		
	Wendy	Richardson	IOS		
96-01	Tully	20-Feb-96	8-March-96	John Anderson	Line P
	CTD: Guildline SN 59901 and 58483				
	Frank	Whitney	IOS	chief scientist	
	Ron	Bellegay	IOS		
	Jim	Bishop	UVIC		
	Philip	Boyd	UBC		
	Stacey	Cooper	UVIC		
	Ken	Crocker	MUN		
	Robert	Goldblatt	UBC		
	Nick	Hall-Patch	Co-op student		
	Bernard	Minkley	IOS		
	Todd	Mudge	UVIC		
	Jennifer	Putland	MUN		
	Wendy	Richardson	IOS		
	Susanne	Roy	Rimouski U		
	Nelson	Sherry	UBC		
	Maureen	Soon	UBC		
	Tim	Soutar	IOS		

96-09 Tully 07-May-96 30-May-96 John Anderson Line P, 129W grid
CTD: Guildline SN 59901 and 58483

Philip	Boyd	UBC	chief scientist
Janet	Barwell-Clarke	contractor	
Ron	Bellegay	IOS	
Jim	Bishop	UVIC	
Ken	Crocker	MUN	
Robert	Goldblatt	UBC	
John	Love	IOS	
Hugh	Maclean	UBC	
Paul	Mathews	MUN	
Bernard	Minkley	IOS	
Ken	Morgan	CWS	
Todd	Mudge	UVIC	
Jennifer	Putland	MUN	
Wendy	Richardson	IOS	
Nelson	Sherry	UBC	
Robert	Schultz	UVIC	
Maureen	Soon	UBC	
Tim	Soutar	IOS	
Delphine	Thibault	Rimouski U	

96-18 Tully 12-Aug-96 6-Sept-96 John Anderson Line P, line R
CTD: Guildline SN 59901 and 58483

Frank	Whitney	IOS	chief scientist
Doug	Anderson	IOS	
Ron	Bellegay	IOS	
Michael	Bentley	contractor	
Philip	Boyd	UBC	
Ken	Crocker	MUN	
Edmund	Fok	IOS	
Robert	Goldblatt	UBC	
Julie	Granger	McGill U	
Hugh	Maclean	UBC	
Maite	Maldonado	McGill U	
Paul	Matthews	MUN	
Wendy	Richardson	IOS	
Nelson	Sherry	UBC	
Maureen	Soon	UTC	
Tim	Soutar	IOS	
Delphine	Thibault	Rimouski U	

97-02	Tully	10-Feb-97	28-Feb-97	Kay Gimbel	Line P
	CTD: Seabird 0437				
	Frank	Whitney	IOS	chief scientist	
	Laurent	Audaire			
	Michael	Bentley	contractor		
	Jim	Bishop	UVIC		
	Philip	Boyd	UBC		
	Robert	Goldblatt	UBC		
	John	Love	IOS		
	Hugh	Maclean	UBC		
	Maite	Maldonado	McGill U		
	Paul	Matthews	MUN		
	Bernard	Minkley	IOS		
	Todd	Mudge	UVIC		
	Wendy	Richardson	IOS		
	Nelson	Sherry	UBC		
	Maureen	Soon	UBC		
	Tim	Soutar	IOS		
	Todd	Wood	UVIC		
	Jim	Zakreski	contractor		
97-11	Tully	02-Jun-97	26-June-97	John Anderson	Lines P, Z and AB
	CTD: Seabird 0433				
	Philip	Boyd	UBC	chief scientist	
	Doug	Anderson	IOS		
	Janet	Barwell-Clarke	contractor		
	Michael	Bentley	contractor		
	Robert	Goldblatt	UBC		
	Tara	Ivanochko	UBC		
	Keith	Johnson	IOS		
	Hugh	Maclean	UBC		
	Bernard	Minkley	IOS		
	Wendy	Richardson	IOS		
	Nelson	Sherry	UBC		
	Maureen	Soon	UBC		
	Tim	Soutar	IOS		
	Nes	Sutherland	contractor		
	Darren	Tuele	IOS		

97-15	Tully	25-Aug-97	17-Sept-97	Paul Frost	Lines P and MS (south of P)
	CTD: Seabird 0437				
		Frank	Whitney	IOS	chief scientist
		Stuart	Brock	IOS	
		Lyle	Fairley	contractor	
		Kimio	Fukami	Japan	
		Takahiko	Inoue	Japan	
		Tara	Ivanochko	UBC	
		Keith	Johnson	IOS	
		Hiroshi	Kiyosawa	JAPAN	
		Hugh	Maclean	UBC	
		Bernard	Minkley	IOS	
		Jun	Nishioka	JAPAN	
		Wendy	Richardson	IOS	
		Marie	Robert	contractor	
		Mark	Schmidt	U. Delaware	
		Tim	Soutar	IOS	
		Nes	Sutherland	contractor	
		Shigenobu	Takeda	Japan	
97-37	Tully	20-Oct-97	30-Oct-97	Tom Hull	lines BP, G, D, line P (5 to 10), C, and B.
	CTD: Seabird 0437				
		Doug	Yelland	IOS	chief scientist
		Mike	Bentley	contractor	
		Beth	Bornhold	UBC	
		Bridgett	Ferris		
		Shannon	Harris	UBC	
		Hugh	Maclean	UBC	
		Bernard	Minkley	IOS	
		Doug	Moore	IOS	
		Jennifer	Putland	UBC	
		Marie	Robert	contractor	
		Steve	Romaine	IOS	
		Diana	Varela	UBC	
97-45	Laurier	01-Dec-97	4-Dec-97	Syd Webb	Line P (1-12)
	CTD: Seabird 0437				
		Marie	Robert	contractor	
		Sheila	Toews	contractor	
98-02	Laurier	18-Jan-98	21-Jan-98	Syd Webb	Line P (1-12), El Nino Watch
	CTD: Seabird 0437				
		Marie	Robert	contractor	
		Sheila	Toews	contractor	

98-03	Tully	16-Feb-98	6-March-98	Tom Hull	Line P
	CTD: Seabird 0437				
	Frank		Whitney	IOS	chief scientist
	Doug		Anderson	IOS	
	Michael		Bentley	contractor	
	David		Crawford	IOS	
	Tara		Ivanochko	UBC	
	Keith		Johnson	IOS	
	Michael		Lipsen	UBC	
	Hugh		Maclean	UBC	
	Bernard		Minkley	IOS	
	Tom		Plath	volunteer	
	Wendy		Richardson	IOS	
	Marie		Robert	contractor	
	Nes		Sutherland	contractor	
	S.		Takeda	Japan	
	Sheila		Toews	contractor	
98-13	Laurier	07-Apr-98	10-April-98	Norm Thomas	Line P (1-12)
	CTD: Seabird 0443				
		Doug	Anderson	IOS	
		Linda	White	contractor	
98-15	Tully	01-Jun-98	26-June-98	Paul Frost	Line P, line Z to Alaska, Bowie Seamount
	CTD: Seabird 0443 and 0437				
	Ron		Perkin	IOS	chief scientist
	Doug		Anderson	IOS	
	Janet		Barwell-Clarke	IOS	
	Michael		Bentley	contractor	
	David		Crawford	UBC	
	Keith		Johnson	IOS	
	Michael		Lipsen	UBC	
	Hugh		Maclean	UBC	
	Jun		Nishioka	UBC	
	Wendy		Richardson	IOS	
	Tim		Soutar	IOS	
	Nes		Sutherland	contract	
	Phillipe		Tortell	Princeton U	
	Darren		Tuele	IOS	
	Cathleen		Vestfalls	UBC	

98-29 Tully 24-Aug-98 20-Sept-98 John Anderson Line P, eddy
 CTD: Seabird 0443

Frank	Whitney	IOS	chief scientist
Elaine	Baird		contractor
David	Crawford		UBC
Keith	Johnson		IOS
Hiroshi	Kiyosawa		Japan
Michael	Lipsen		UBC
Hugh	Maclean		UBC
Adrian	Marchetti		IOS, student
Bernard	Minkley		IOS
Jennifer	Putland		contractor
Wendy	Richardson		IOS
Marie	Robert		contractor
Tim	Soutar		IOS
Nes	Sutherland		contractor

99-01 Tully 8-Feb-99 28-Feb-99 John Anderson Line P, eddy
 CTD: Seabird 0443

Frank	Whitney	IOS	chief scientist
Doug	Anderson		IOS
Michael	Bentley		contractor
David	Crawford		IOS
Keith	Johnson		IOS
Michael	Lipsen		UBC
Hugh	Maclean		UBC
Jun	Nishioka		Japan
Wendy	Richardson		IOS
Marie	Robert		contractor
Tim	Soutar		IOS
Nes	Sutherland		contractor
Cathleen	Vestfals		UBC

99-10	Tully	31-May-99	24-June-99	Bill Noon	Lines P1E and P
	CTD: Seabird 0443				
	Ron		Perkin		IOS chief scientist
	Michael		Arychuk		IOS
	Elaine		Baird		contractor
	Janet		Barwell-Clarke		IOS
	Michael		Bentley		contractor
	Vincent		Coronini		IOS, student
	Mary		Davelaar		IOS
	Michael		Lipsen		UBC
	Hugh		Maclean		UBC
	Angelica		Pena		IOS
	Melanie		Quenneville		contractor
	Wendy		Richardson		IOS
	Marie		Robert		contractor
	Tim		Soutar		IOS
	Nes		Sutherland		contractor
	Darren		Tuele		IOS
	Cathleen		Vestfals		UBC
99-21	Tully	23-Aug-99	14-Sept-99	Paul Frost	Line P, line Z to Alaska, Bowie Seamount
	CTD: Seabird 0437				
	Frank		Whitney		IOS chief scientist
	Doug		Anderson		IOS
	Michael		Arychuk		IOS
	Michael		Bentley		contractor
	Beth		Bornhold		IOS
	David		Crawford		U. Southampton
	Chantale		Freeman		UVIC
	Phoebe		Lam		Princeton U
	Michael		Lipsen		UBC
	Hugh		Maclean		UBC
	Jacqueline		O Connell		UBC
	Jennifer		Putland		contractor
	Marie		Robert		contractor
	Tim		Soutar		IOS
	Philippe		Tortell		Princeton U

Table 2. Types of samples taken on each mission.

mission	Start date	ship	Sal	oxy	nut	NH ₄	Chl	POC	DON	TCO ₂	Alk	pCO ₂	CFCs	Fe	¹³ C	¹⁸ O	DMS
91-03	19-Feb-91	T	X	X	X(f)			X		X	X						
91-08	28-Apr-91	P	X	X	X(f)												
91-15	17-Oct-91	E	X	X	X(f)												
92-01	03-Feb-92	T	X	X	X			X		X			X				
92-06	26-Mar-92	E	X	X	X			X									
92-15	08-Sep-92	T	X	X	X			X		X							
93-03	06-Mar-93	T	X	X	X			X		X			X		X		
93-09	14-May-93	T	X	X	X			X		X					X		
94-01	07-Feb-94	T	X	X	X												
94-02	10-May-94	T	X	X	X			X		X	X	X	X				
94-03	06-Sep-94	T	X	X	X					X	X		X		X		
95-01	07-Feb-95	T	X	X	X			X							X		
95-05	09-May-95	T	X	X	X		X	X		X		X	X		X		
95-12	22-Aug-95	T	X	X	X			X				X			X		
96-01	20-Feb-96	T	X	X	X		X	X	X	X	X	X			X	X	X
96-09	07-May-96	T	X	X	X		X	X	X	X	X	X			X	X	X
96-18	12-Aug-96	T	X	X	X	X	X	X	X	X	X	X			X	X	X
97-02	10-Feb-97	T	X	X	X	X	X		X	X	X	X			X	X	
97-11	02-Jun-97	T	X	X	X	X	X	X	X	X	X	X		X	X	X	X
97-15	25-Aug-97	T	X	X	X	X	X	X	X	X	X	X		X	X	X	X
97-37	20-Oct-97	T	X	X	X(f)	X	X										
97-45	01-Dec-97	L															
98-02	18-Jan-98	L	X	-	X(f)												
98-03	16-Feb-98	T	X	X	X		X	X	X			X		X	X	X	X
98-13	07-Apr-98	L	X	-	X(f)												
98-15	01-Jun-98	T	X	X	X	X	X	X		X	X	X		X	X	X	X
98-29	24-Aug-98	T	X	X	X	X	X	X	X	X	X		X	X		X	X
99-01	08-Feb-99	T	X	X	X		X	X		X	X	X	X	X	X	X	X
99-10	31-May-99	T	X	X	X	X	X	X		X	X	X	X		X		X
99-21	23-Aug-99	T	X	X	X	X		X		X	X	X	X	X	X	X	

Abbreviations:

T	<i>CCGS John P Tully</i>	E	<i>CNAV Endeavour</i>
P	<i>CCS Parizeau</i>	L	<i>CCGS Sir Wilfrid Laurier</i>
sal	Salinity	TCO ₂	Total carbon dioxide
oxy	dissolved oxygen	Alk	Alkalinity
nut	nutrients, Si, NO ₃ , PO ₄ (f = frozen)	pCO ₂	partial pressure of CO ₂ in water
NH ₄	Ammonium	CFCs	Chlorofluorocarbons
chl	Chlorophyll	Fe	Iron
POC	Particulate Organic Carbon (+ N)	¹³ C	Carbon 12/13 ratio in TCO ₂
DON	Dissolved Organic Nitrogen	¹⁸ O	Oxygen 16/18 ratio in water
DMS	dimethyl sulphide	X(f)	Nutrient samples frozen

WATER SAMPLING EQUIPMENT

Reversing Thermometers

Deep sea reversing thermometers had been used on all missions up to 92-01 to obtain water temperatures. These thermometers were mounted on 1.7 litre Niskin bottles which were clamped to 5/32 inch diameter hydro wire (Seale construction, right regular lay, improved plough steel, galvanized, torque-balanced). The Niskin bottles collected water for oxygen and salinity analyses. Two protected and one unprotected thermometer was mounted in each bottle. In September 1992 we started using a General Oceanic Rosette frame with 10 litre Niskin bottles. Reversing thermometers were not used with this Rosette. For pressures greater than 3000 dbars (maximum depth of CTD) a bottle cast was done using 1.7-litre bottles fitted with reversing thermometers. After March 1993 reversing thermometers were no longer required to obtain temperatures, as an improved pressure sensor on the CTD allowed profiles to reach the ocean bottom.

CTD's used during years 1991 to 1999

A digital CTD made by Guildline Instruments of Smith Falls, Ontario was used for missions 91-03 to 92-15. Digital CTD model number 8715, serial numbers 53501 and 58483 have the following specifications:

Parameter	Accuracy	Resolution	Stability
Conductivity	±.005 psu	.001 psu	.002 psu/6 month
Temperature	±.005°	.001°	.002/30 days
Pressure	±.15%	.15 % FS	FS = 3000 dbars

In September 1992, a Guildline CTD, model 8737 (WOCE) serial number 59901 was purchased to allow us to meet World Ocean Circulation Study (WOCE) requirements for CTD observations. During mission 92-15, the high precision Guildline CTD was tested. This new system has the following specifications:

Parameter	Accuracy	Resolution	Response
Conductivity	±.002 psu	.00006 psu	< 50 ms
Temperature	±.002°C	.0004°C	< 50 ms
Pressure	±2 dbars	.3 dbars	< 1 ms

Accuracy specified is for 30 days and includes linearity, resolution, hysteresis, temperature and calibration uncertainty relative to national standards.

During years 1993 to 1996, the WOCE CTD and CTD 58483 were used. Due to difficulties with the temperature sensors of these CTD's, a replacement system was purchased from Seabird Electronics, Seattle, Washington, USA. This system was a model SBE 11 *plus* deckunit, model SBE 911 *plus* CTD, and SBE Carousel water sampler model 32 for 24 bottles. The CTD has the following specifications:

Parameter	Accuracy	Resolution	Stability
Conductivity	±.003 psu	.0004 psu	.0003 psu/month
Temperature	±.001°	.0002°	.0002°/month
Pressure	±.015%	.001 % FS	.0015% full scale

Rosette

Prior to 1997, a rosette frame made by General Oceanics was used (Figure 2). This unit had a diameter of 152.4 cm and area of 18,200 cm², and could hold 24 ten-litre Niskin bottles. With 136 kg's of lead added to assist the frame to "fall", this unit required an additional 90 kg's of weight on a bridle suspended beneath the frame to stop it from tilting. The tilt angle was measured by two tilt sensors mounted on the rosette frame, and the signal feed into the CTD for logging. With no bridle on the Rosette frame, tilt angles greater than 45 degrees were measured. The 90 kg lead weight reduced tilt to a few degrees.

A more compact rosette frame but still holding 24 bottles, modelled on a unit designed by Pacific Marine Environmental Laboratory (PMEL), Seattle, Washington, USA, was built in June 1999 (Figure 1). This unit has a diameter of 121.9 cm, an area of 11,700 cm² and a height of 183 cm.

Water samplers from Ocean Test Equipment and from General Oceanics have both been used on these rosettes. In recent years, nylon coated steel springs have been used to close bottles instead of 11mm latex tubing. These springs are a good choice for relatively clean sampling and minimal Freon contamination. Sensors added to the Seabird CTD include transmissometers, fluorometers, an underwater light sensor, and a pH probe. Sea-bird CTD's make the addition of other sensors simple. In addition an independent 12 kHz pinger was used to detect the proximity of the CTD/rosette package to the bottom.

Heave Compensation:

On missions 93-03 and 93-09, a load accumulating system using Endeco 1" diameter shock-cords was used to decrease cable loading due to ships motion from the CTD/rosette package. This system consisted of:

1. three doubled 1" shock-cords spliced to a 1" square braid rope
2. A 1.5" double braid nylon pennant, longer than the shock-cords, all attached at both ends, by 4.25T shackles, to steel yokes.
3. One end is anchored to a load cell, a pennant from the outer end passes through a block and the pennant suspends the block through which the CTD/rosette is lowered.

In shallow depths the shock-cord acts as a spring to reduce motion on the rosette, at greater depths the shock-cord is at full stretch and the 1.5" double braid nylon pennant also carries the load. For safety reasons this system of heavy compensation was discontinued and replaced in September of 1993, with a pneumatic heave compensator installed on the large A-frame on the stern of the CCGS JOHN P. TULLY (figure 3).

The heave compensator consists of a double-ended air cylinder with double rope sheaves mounted on each rod end. Two equal lengths of wire rope are attached to fixed points on the underside of the cylinder. Each rope passes over one sheave at each end of the cylinder then through a swinging deflector sheave block and is terminated on the travelling Tri-plate block. When the load on the Tri-plate block increases (due to line tension), the trapped air pressure in the cylinder no longer fully supports the load and the cylinder compresses until a load/pressure equilibrium is again established. A decrease in line load similarly causes the cylinder to extend raising the Tri-plate. The trapped air is also contained in expansion chambers located adjacent to the cylinder. One chamber is permanently open to the cylinder charge pressure. When only the expansion chamber is in use, the compensator provides a "stiff" system. (A relatively large change in line tension is required to fully stroke the cylinder.) When the second larger expansion chamber is also utilized the compensator provides a "soft" system. (a much smaller change in line tension is required to stroke the cylinder.) The rod ends of the cylinder are connected to a

low pressure (approximately 5 psi.) expansion chamber to ensure that the cylinder does not suck in any moist air when it is being compressed. The large expansion chamber is always connected to the cylinder main charge pressure via a small orifice. This ensures that the large chamber slowly follows the system pressure and there will not be any major change of pressure and Tri-plate position when the expansion chamber is engaged.

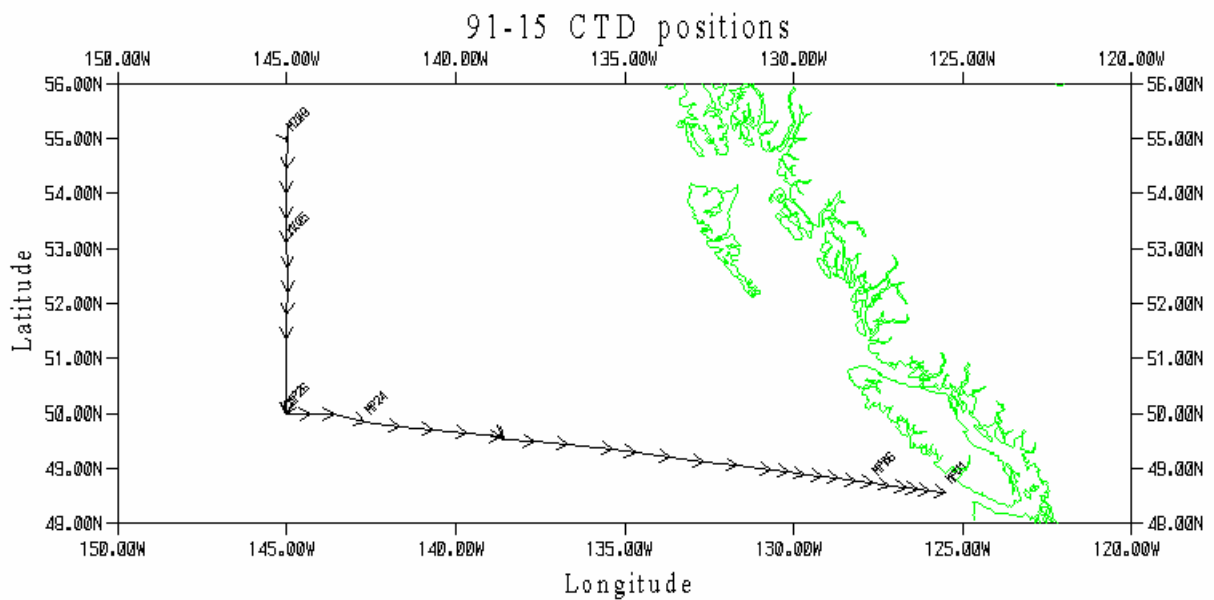
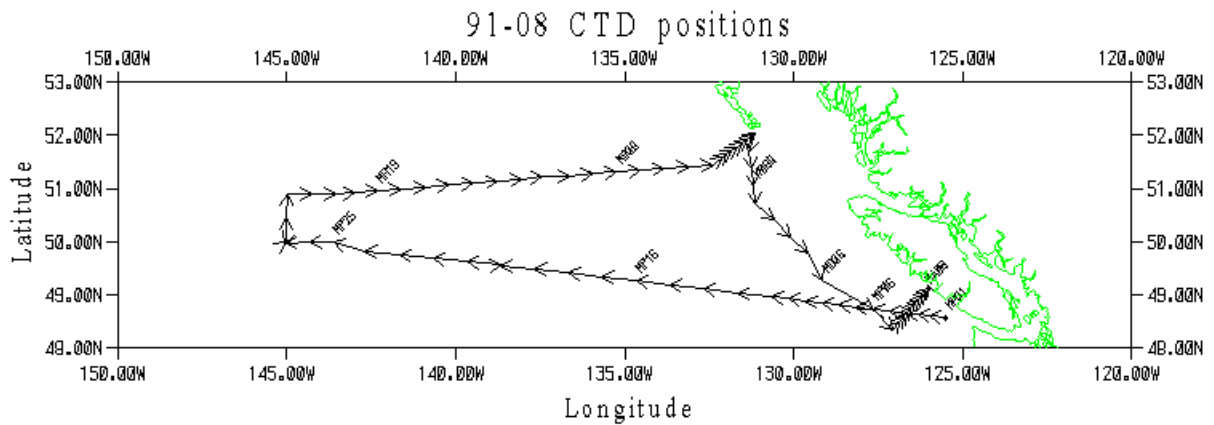
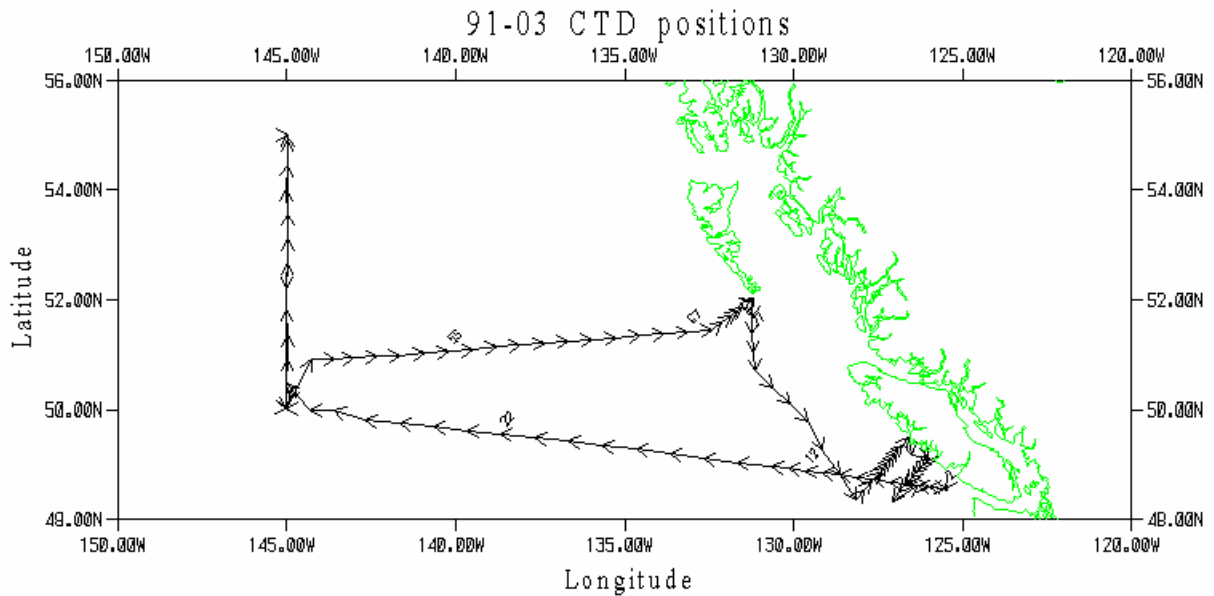
This system has been used on missions since 1994 to diminished cable loading during CTD/rosette casts. Also used on missions 93-03 and 93-09 was a cable tensiometer to measure maximum cable loading. Tension measurements were in the range of 1360 to 1812 kilograms, but did on occasion exceed 2265 kilograms when the Rosette was started back up after reaching maximum depth (4200 metres) or the ship manoeuvred to correct the wire angle.

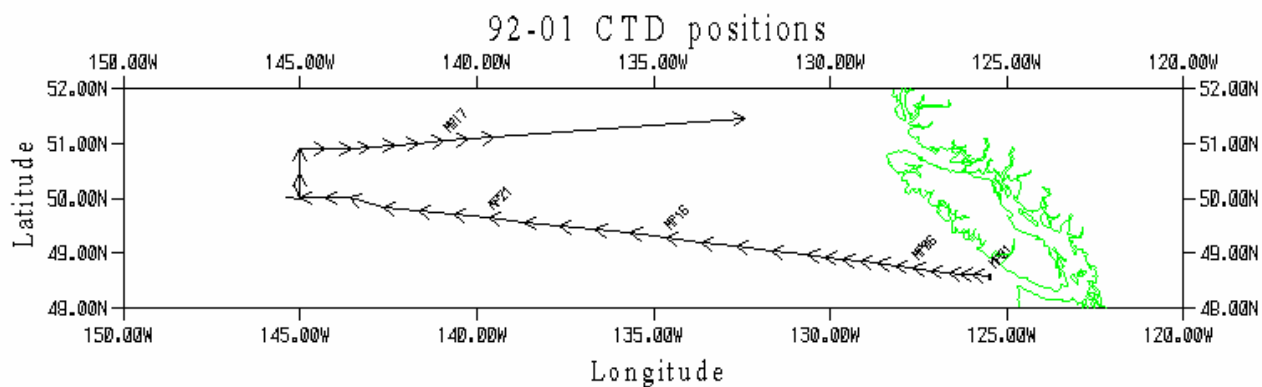
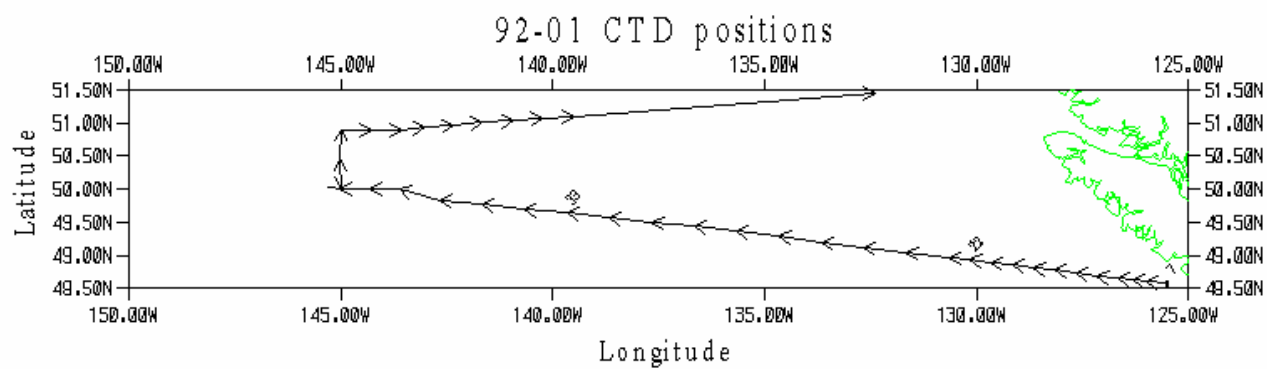
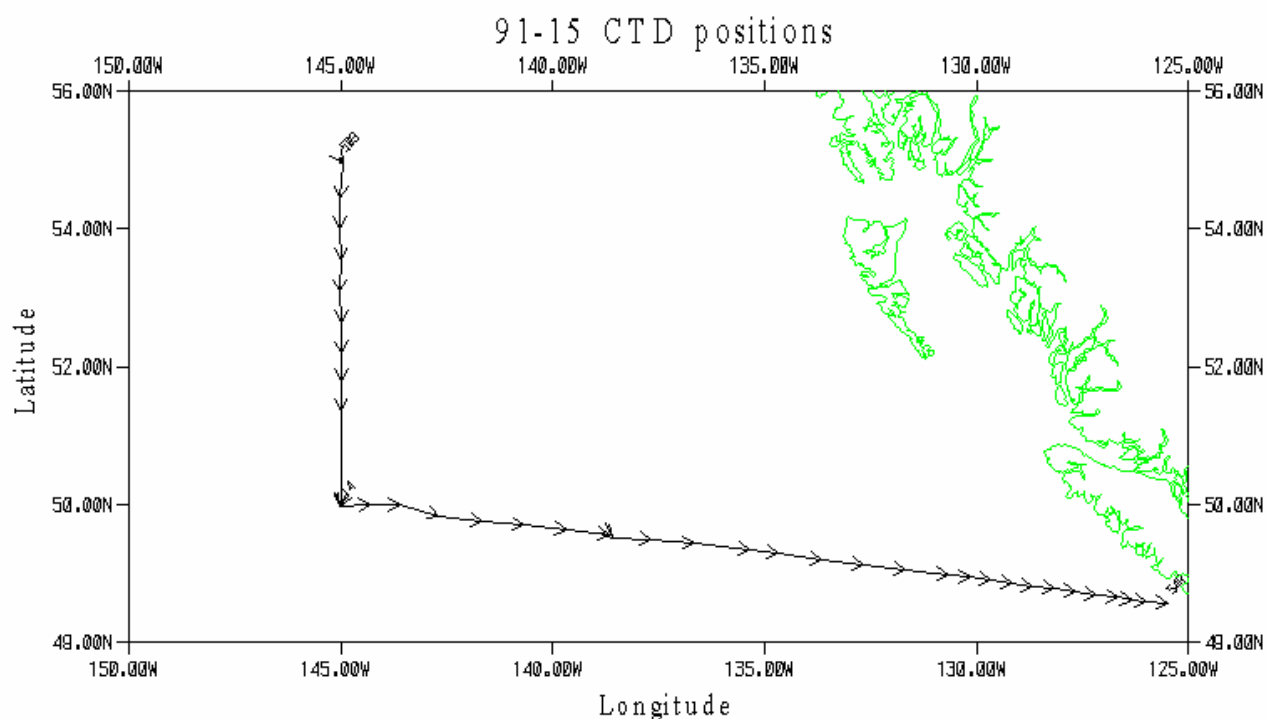
Table 3 of JGOFS and WOCE designated missions.

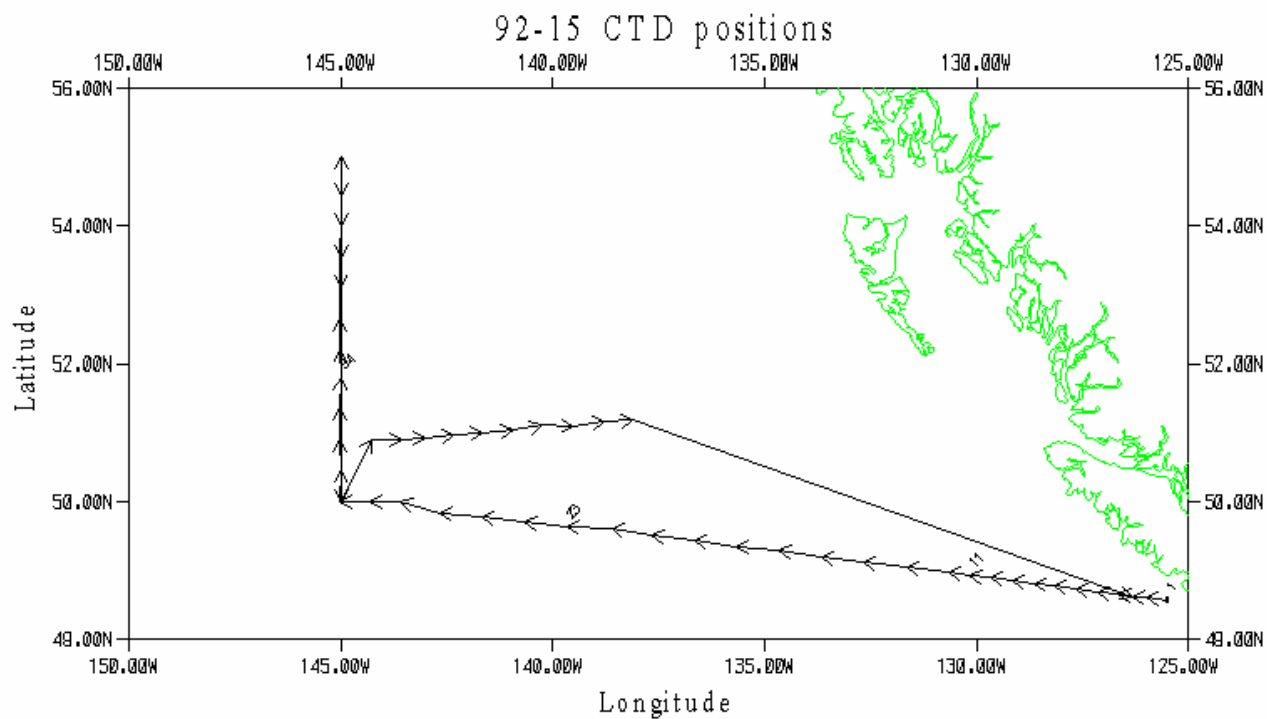
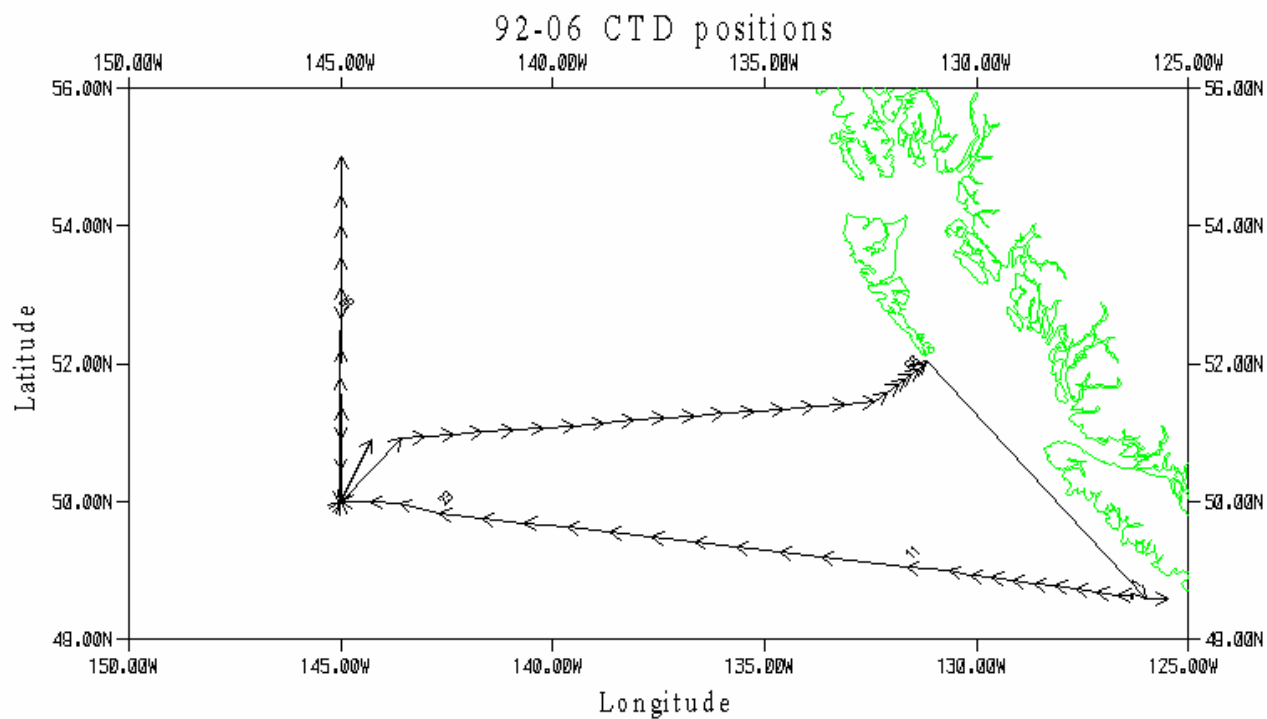
JGOFS = Joint Global Ocean Flux Study, WOCE = World Ocean Circulation Experiment

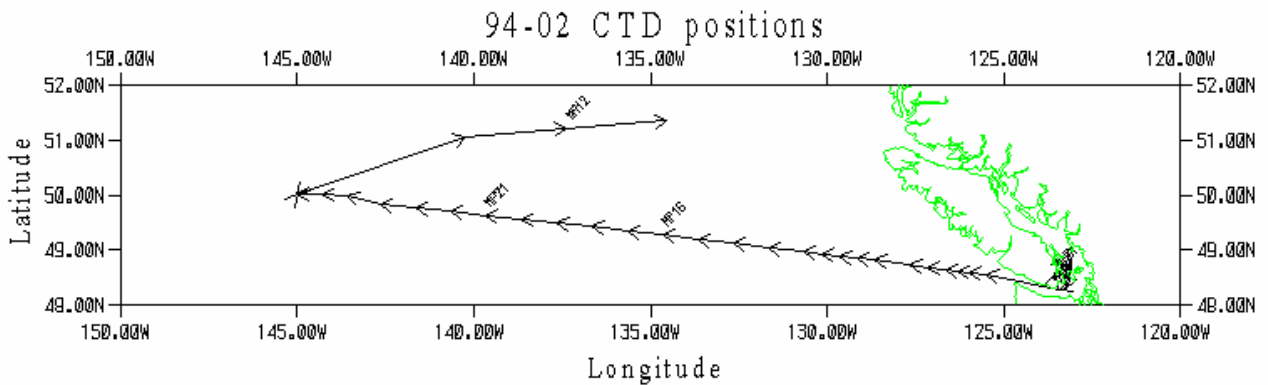
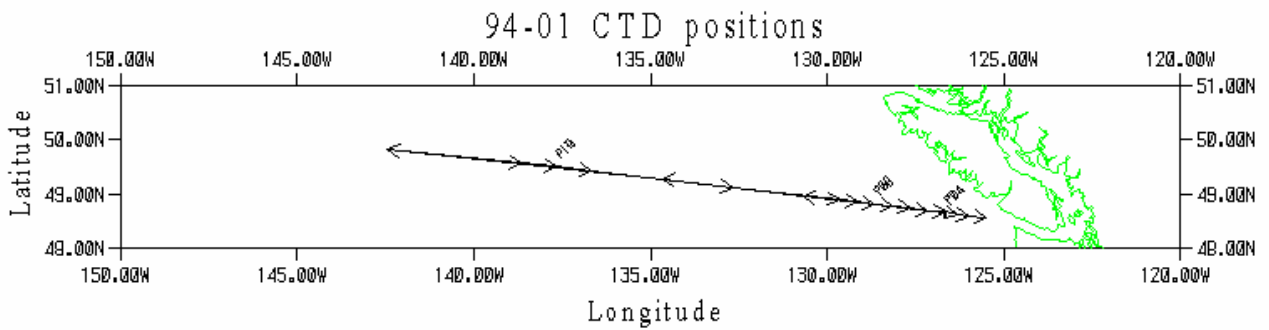
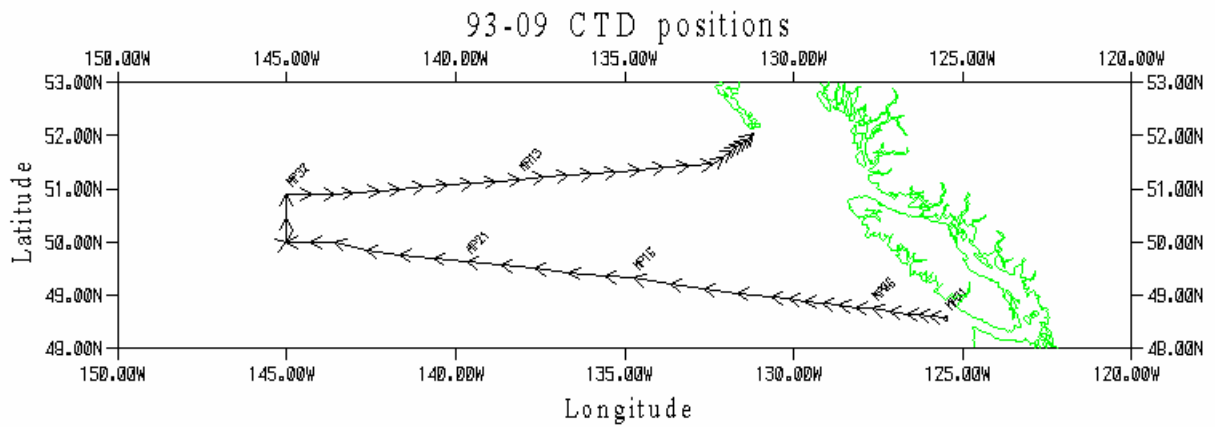
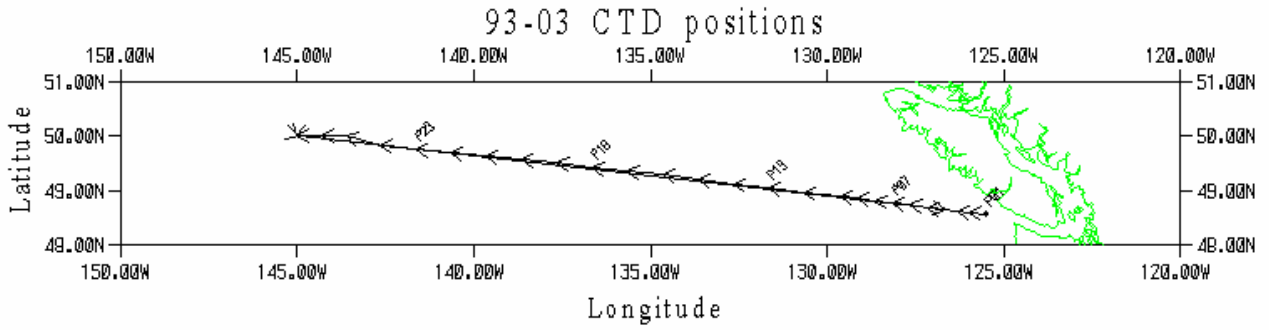
Mission	JGOFS	WOCE	Comments
91-03			
91-08			
91-15		X	First WOCE survey on line PR6 (line P)
92-01		X	
92-06		X	
92-15	X	X	First Canadian JGOFS mission
93-03	X	X	
93-09	X	X	
94-01	X	X	
94-02	X	X	
94-03		X	Line P and P15N (down 165°W)
95-01	X	X	
95-05	X	X	
95-12	X	X	
96-01	X	X	
96-09	X	X	
96-18	X	X	
97-02	X	X	Last WOCE repeat hydrographic line
97-11	X		Last JGOFS mission on line P
97-15			First attempt to deploy open ocean enclosures
97-37			GLOBEC mission
97-45			El Nino Watch
98-02			El Nino Watch
98-03			
98-13			El Nino Watch
98-15			
98-29			First eddy survey
99-01			
99-10			
99-21			

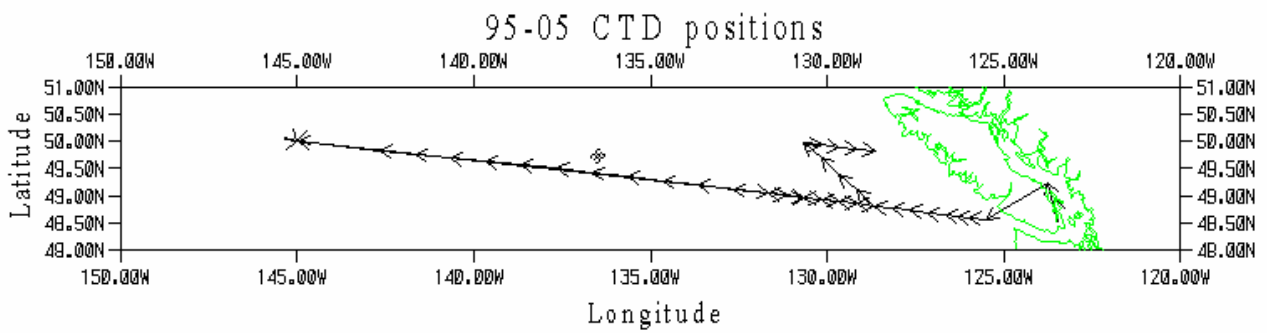
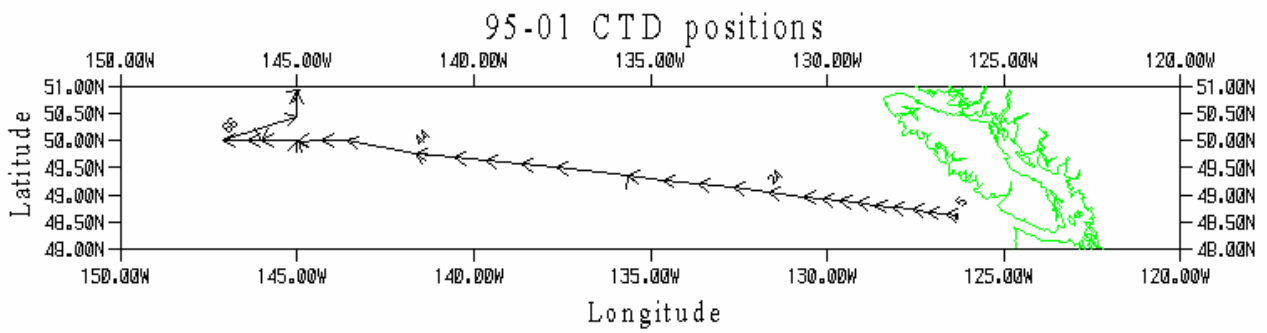
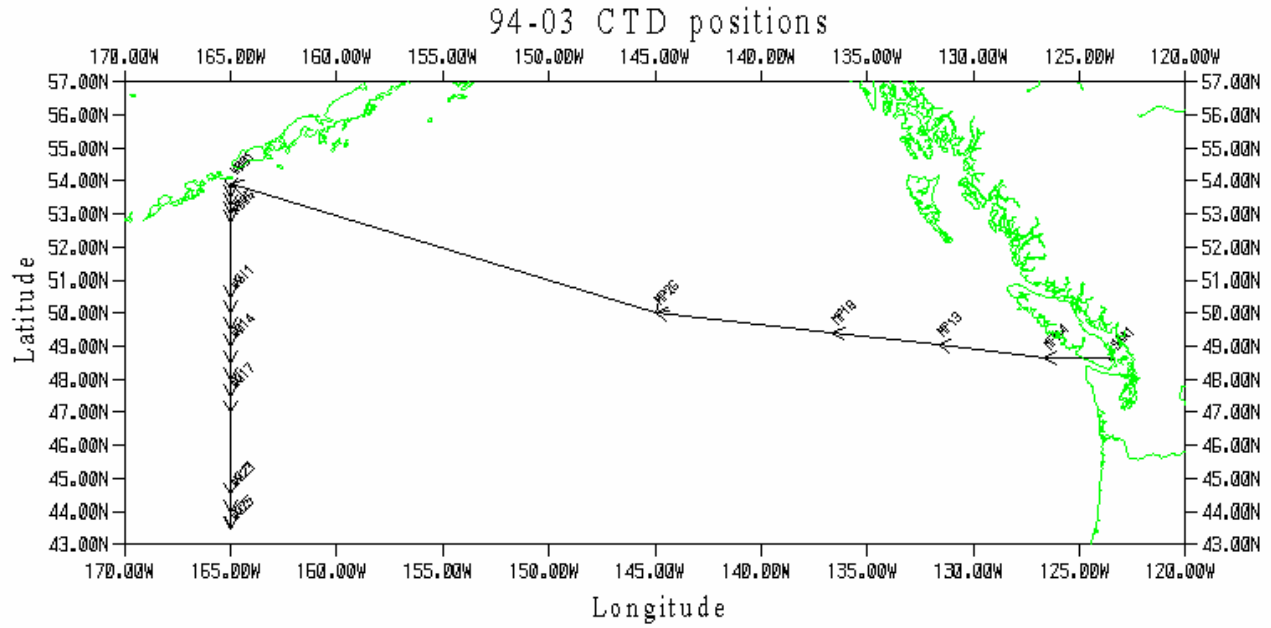
PLOTS OF CTD LOCATIONS FOR MISSIONS DONE 1991 TO 1999

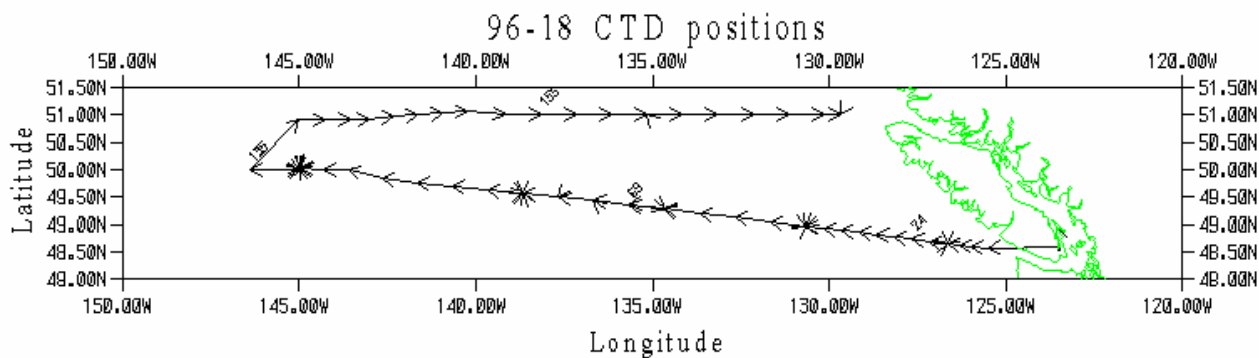
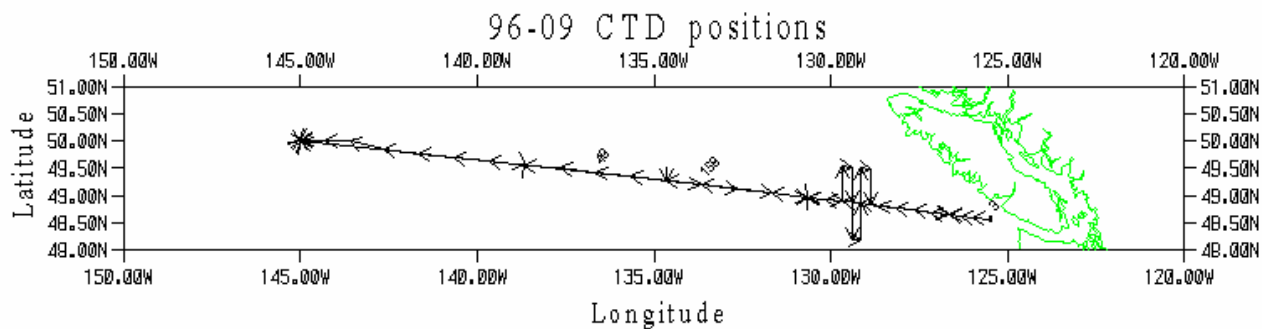
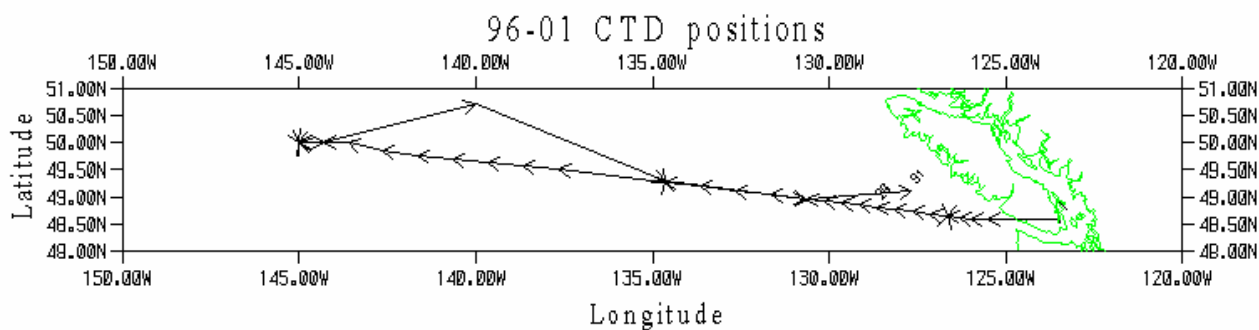
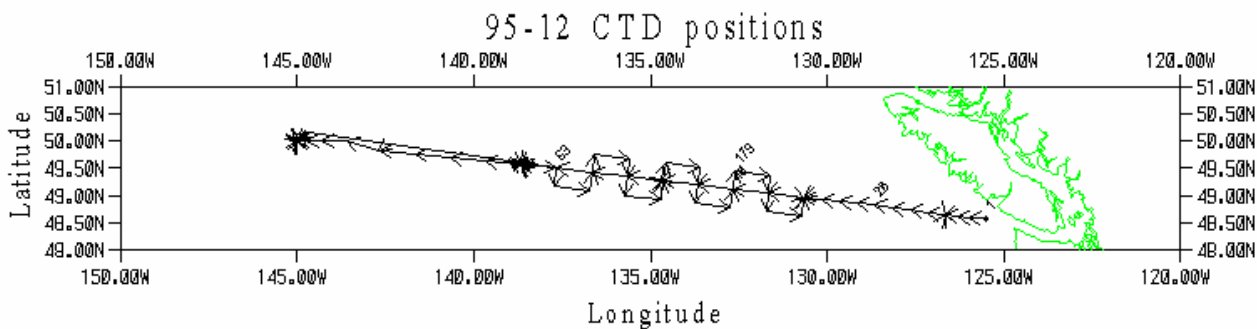


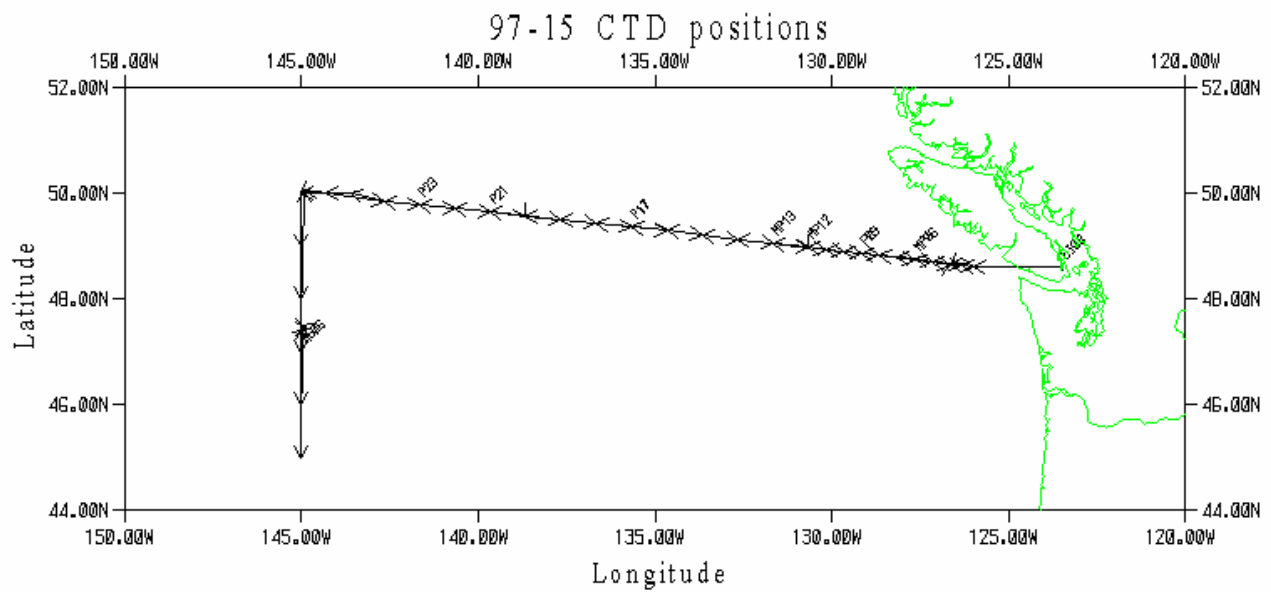
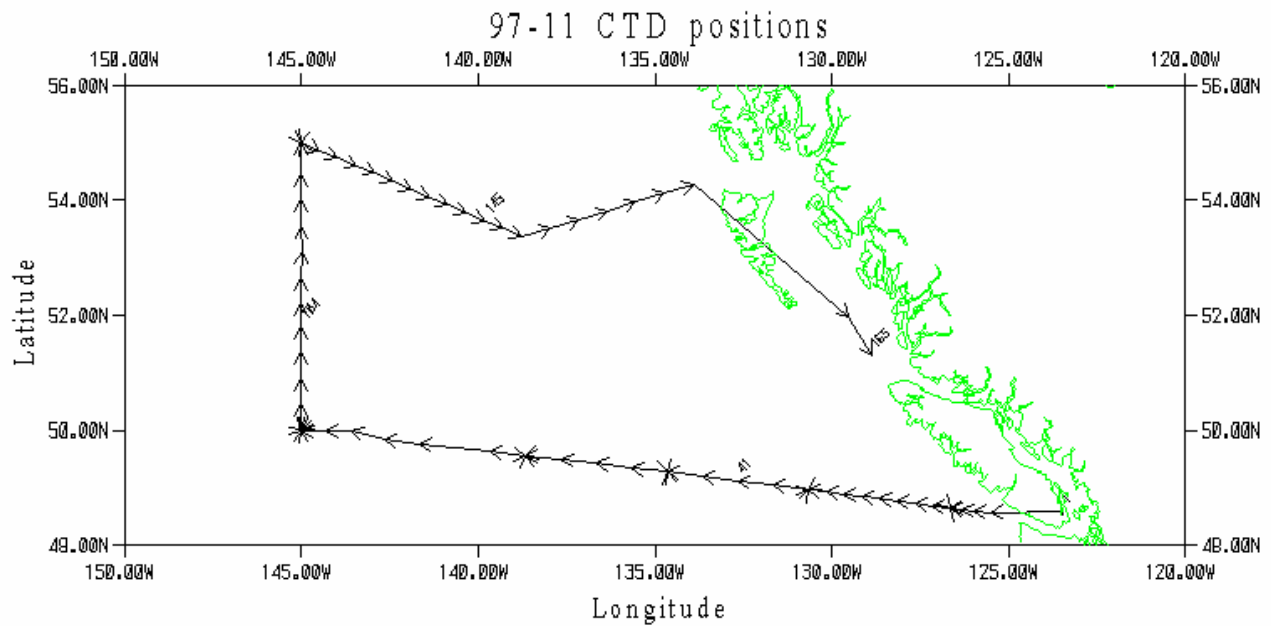
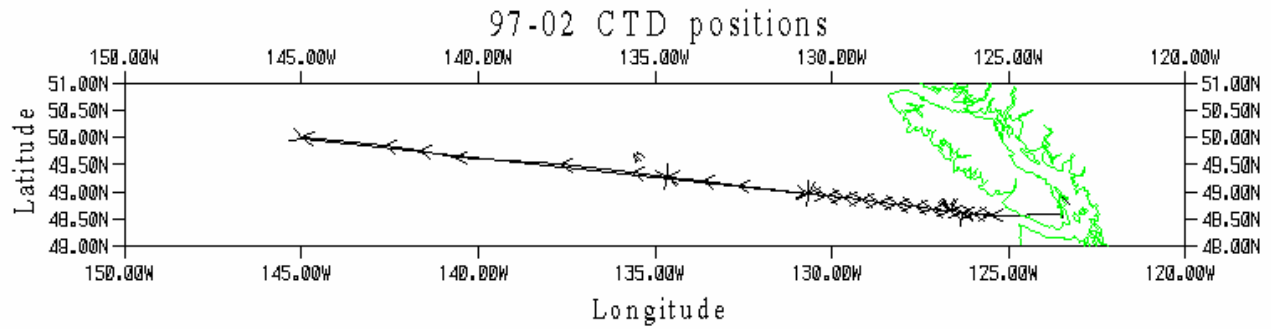


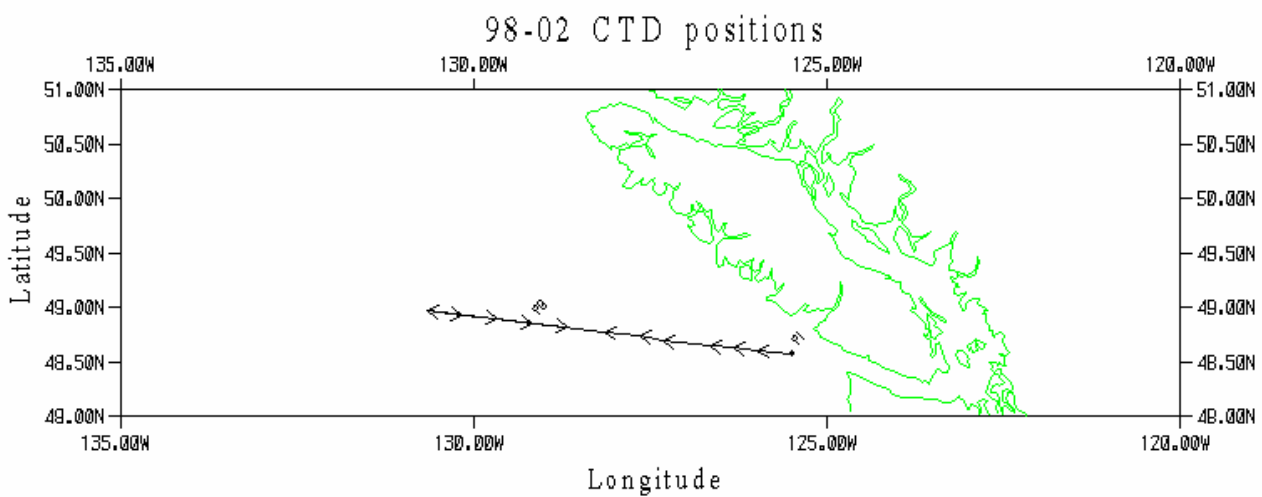
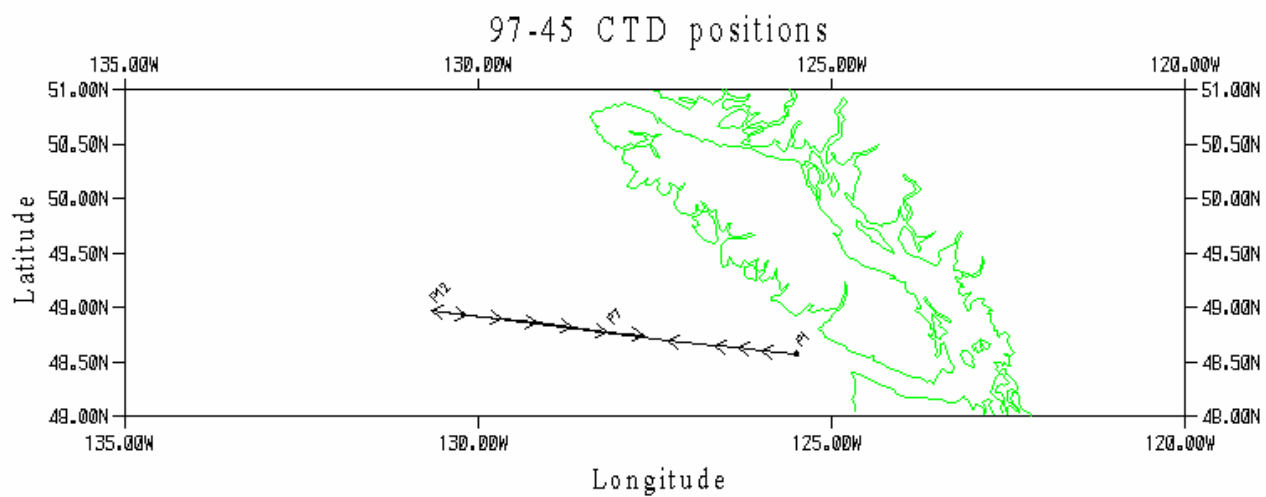
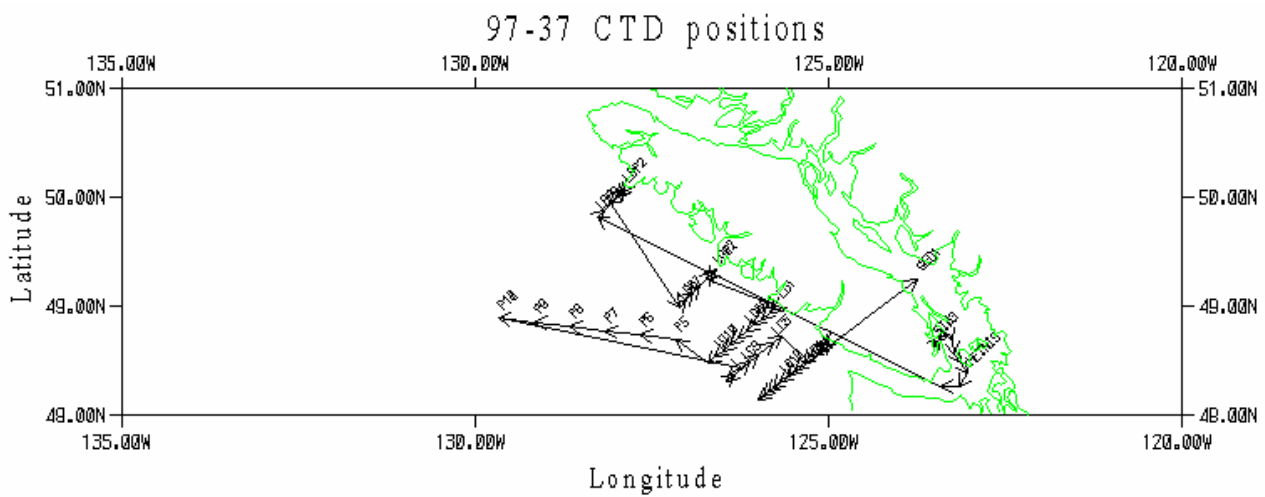


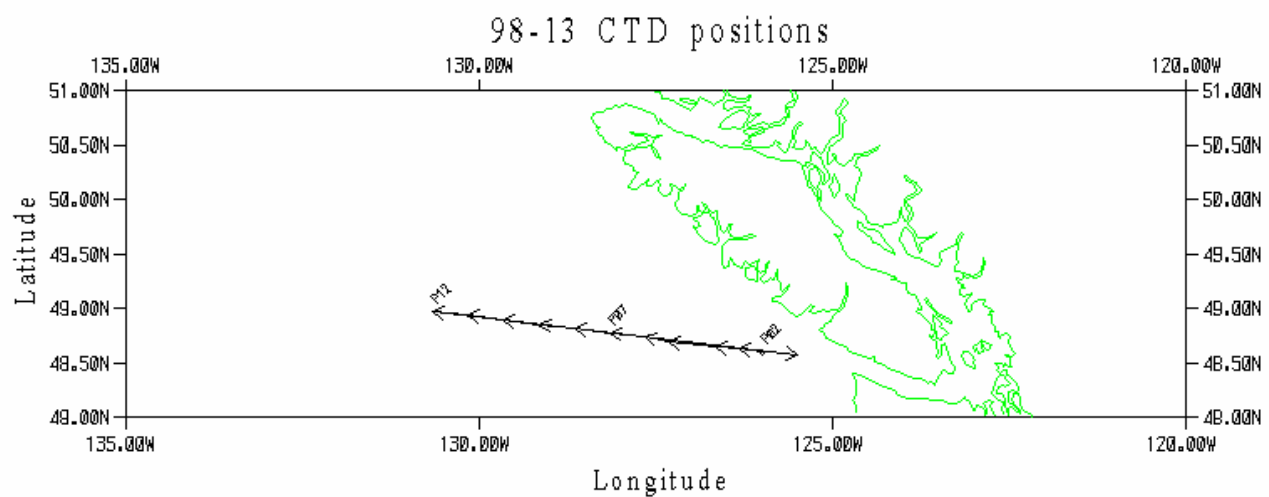
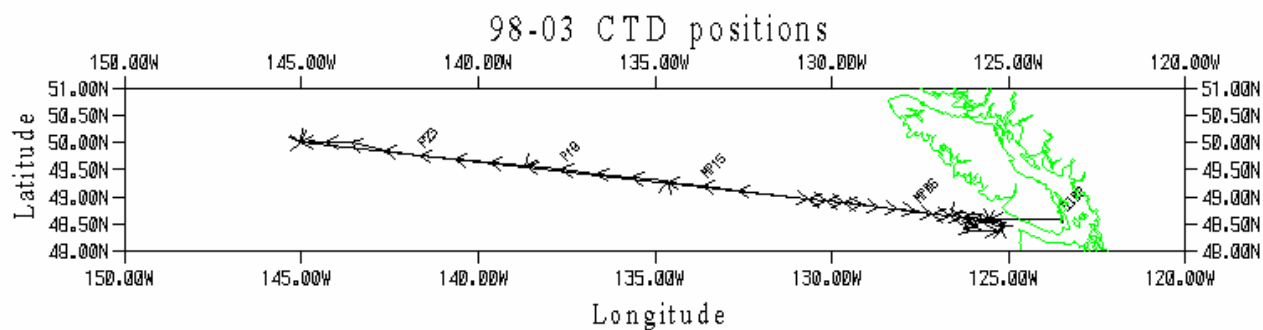


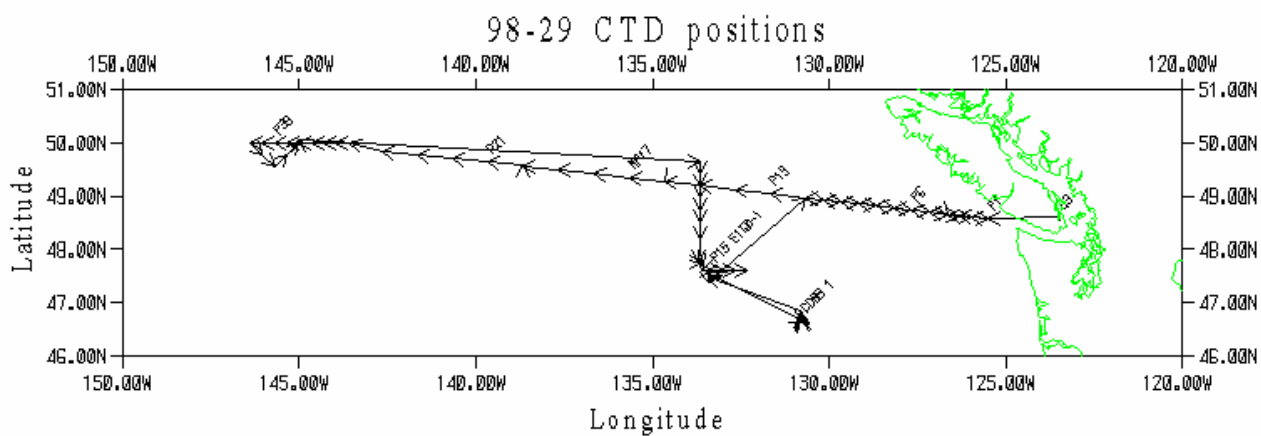
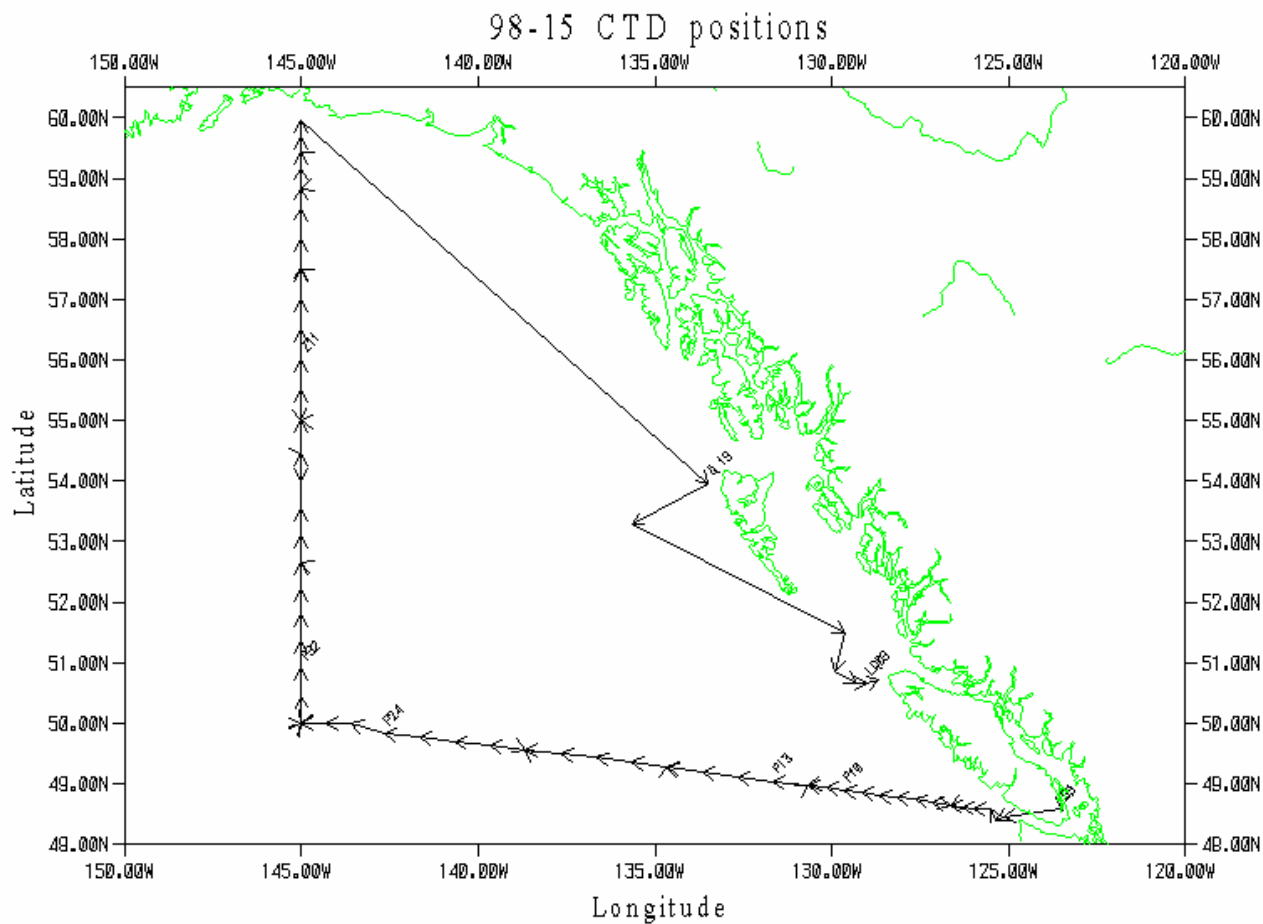


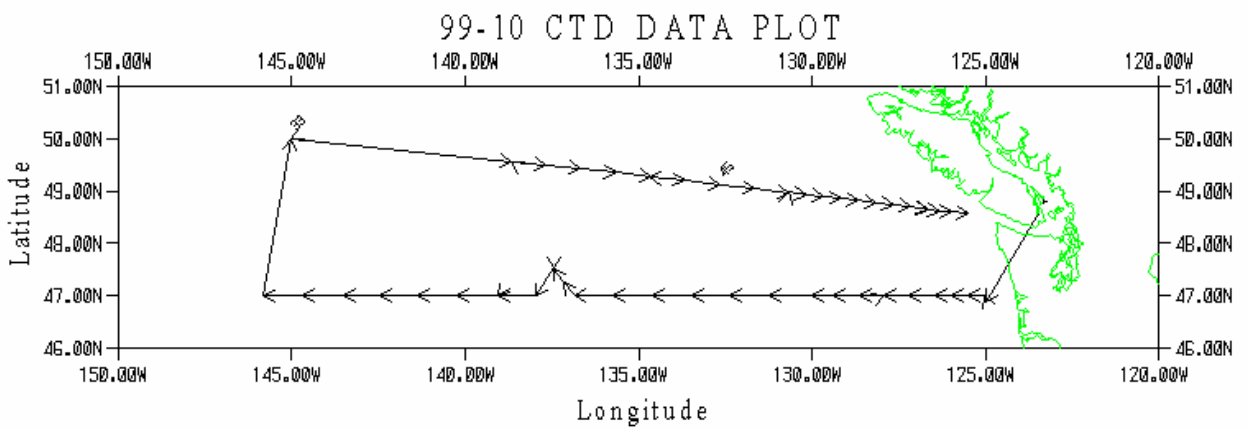
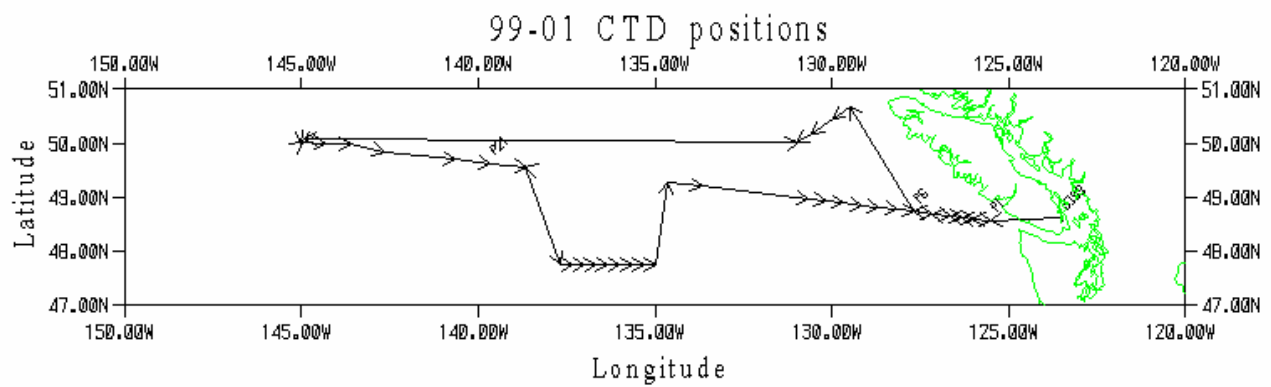












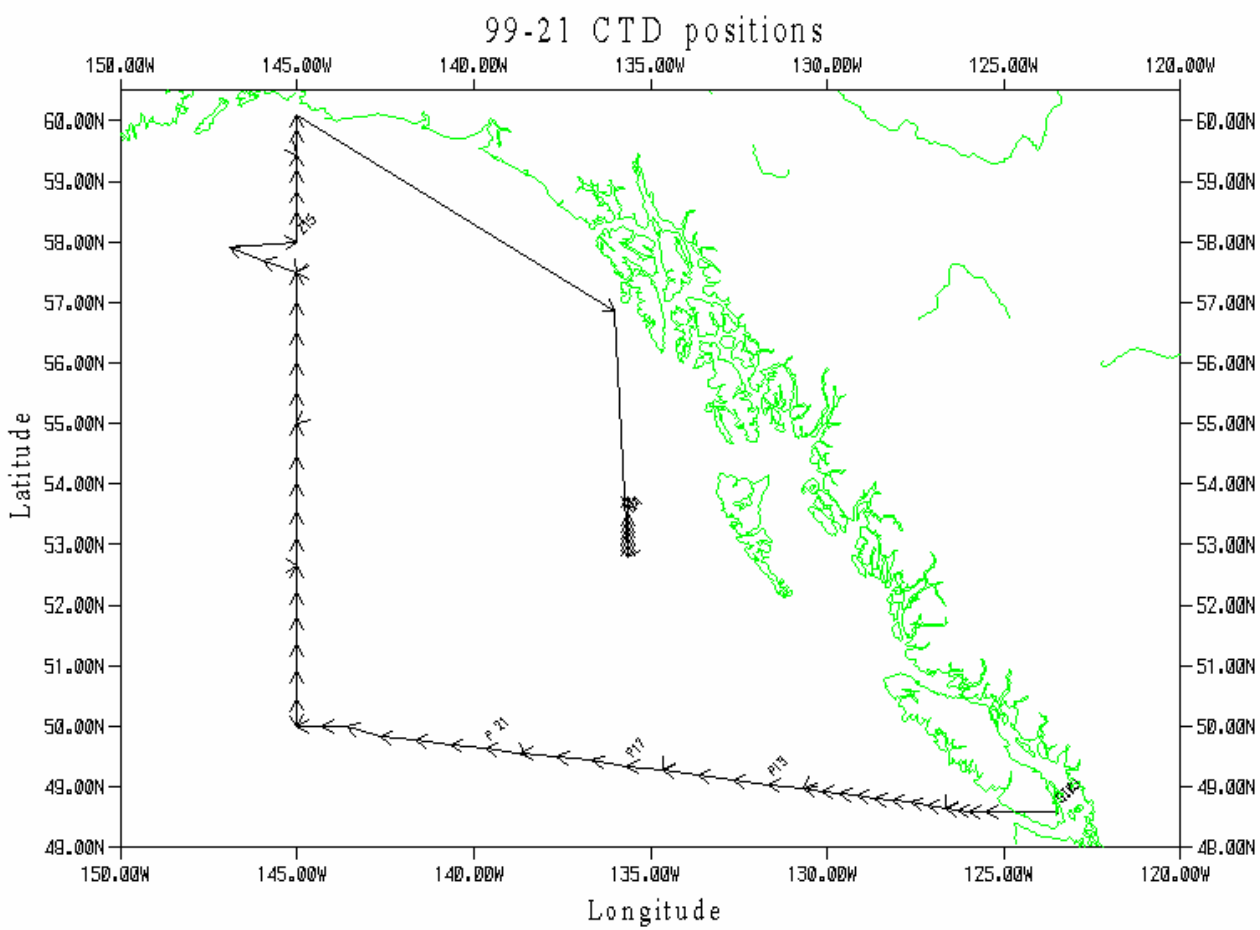
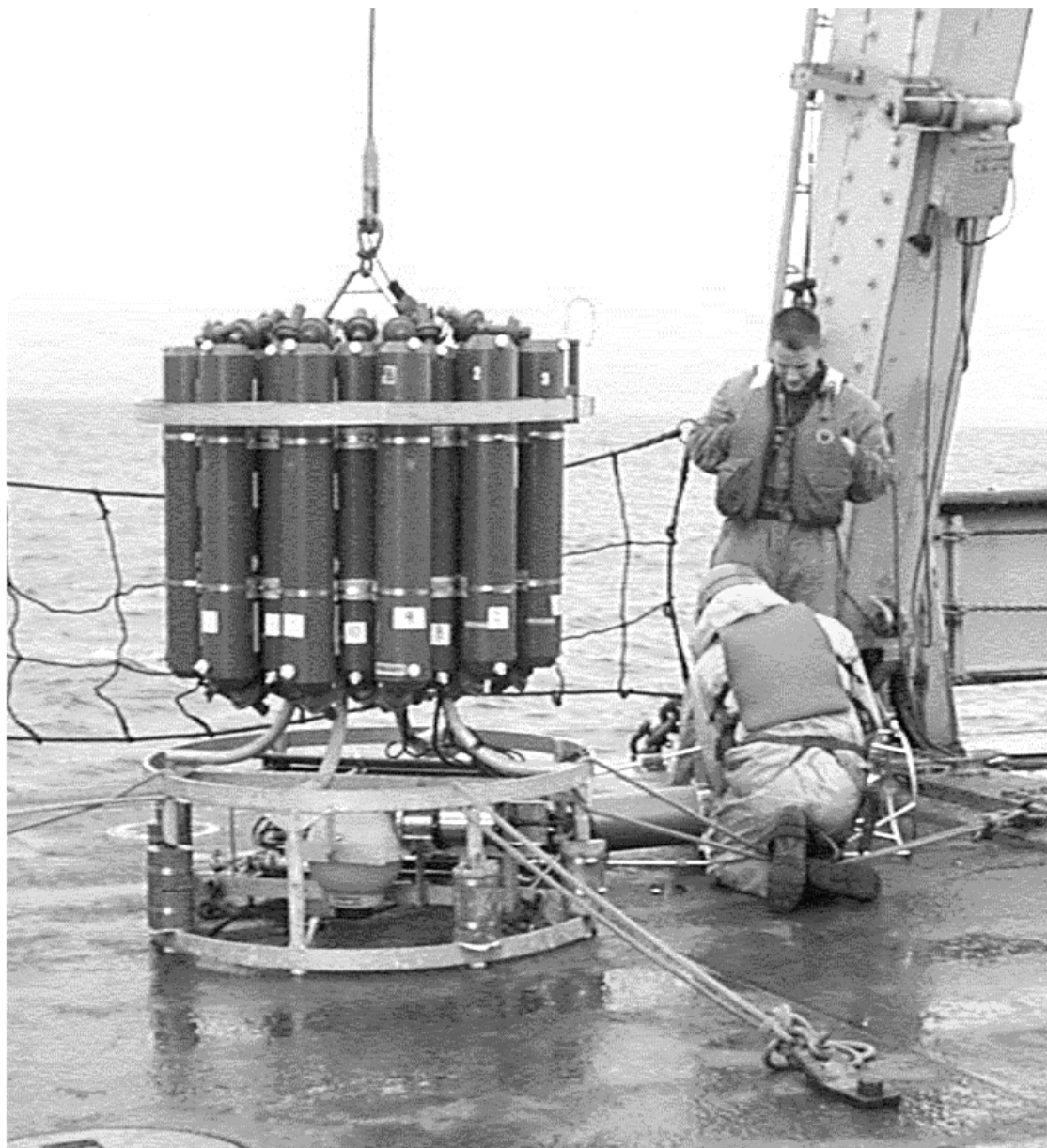


Figure 1. IOS Rosette



IOS Rosette on deck of J.P. Tully

Figure 2. General Oceanics Rosette



General Oceanics Rosette
showing 10 litre sampling bottles

Figure 3. Heave Compensator mounted on CCGS Tully A-frame

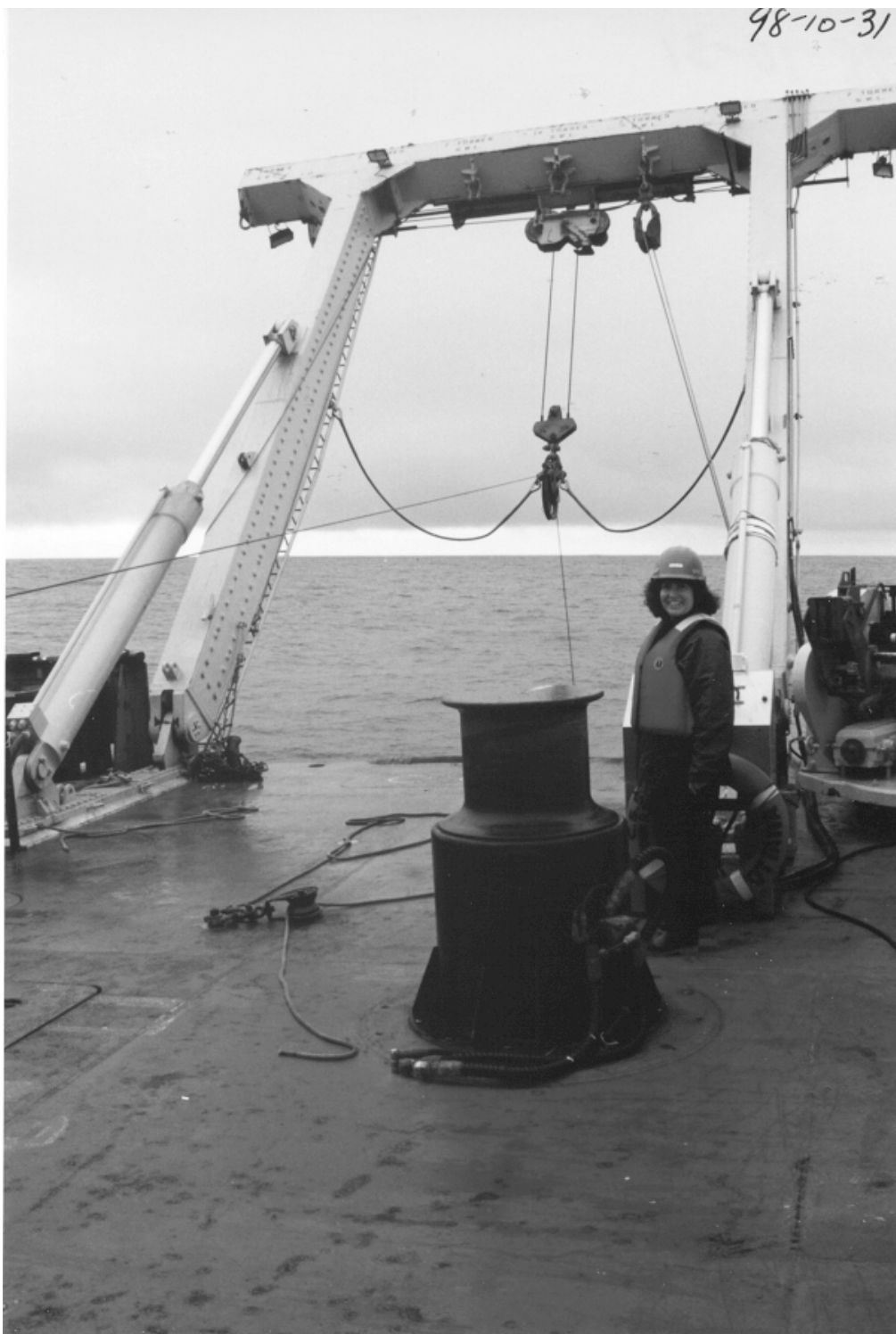


Figure 4. CSS Parizeau



CSS Parizeau

Figure 5. CCGS J.P. Tully



CCGS J.P. TULLY

Figure 6. CNAV Endeavour



CNAV Endeavour