

CRUISE REPORT: Repeat Hydrography on Line PR6:
WOCE Cruise No. 18DD9512/1

Chief Scientist: Phil Boyd
Ship: John P. Tully
Ports of Call: none
Cruise Dates: August 22 to September 13, 1995
Expedition Designation: 18DD9512/1

Cruise Narrative

Our repeat hydrography section was a joint program with Canadian JGOFS.

A full CTD survey along Line PR6 to a depth of 3000 m was completed , with CTD casts at 29 stations and rosette/hydro casts at 10 stations. Two additional surveys were conducted: a sawtooth survey to the N and S of Line P (up to 20 miles) from P26 to P19 involving underway sampling only, and a hydrographic survey from P19 to P12 involving both underway and CTD sampling. Salinity, oxygen and nutrients (NO₃ & NO₂, PO₄ and Si) were analyzed onboard ship.

A bio-optical mooring was deployed at Stn. PRS1 to assess temporal changes in phytoplankton biomass and production in relation to the mixed layer depth and PAR. The mooring was placed to within 2-3 m of its theoretical position.

JGOFS participants collected samples at 5 stations for abundance and activities of bacteria, phytoplankton, micro- and meso-zooplankton and incubated water to measure growth and grazing rates of various groups of plankton. The natural abundance of stable isotopes (¹⁵N and ¹³C) in suspended particulate matter was determined along Line P.

Cruise Summary Information

Cruise track

Line PR6 starts at the mouth of Juan de Fuca Strait on the west coast of Canada, and heads almost due west for 900 n mi. The terminal station is PRS1, formerly designated Ocean Weather Station Papa (50 N, 145 W).

Table of Stations by type

Sample type:	No. stations:	Max. depth (m):
CTD casts	29	3007 db
Rosette/Hydro casts	10	3862
Loop samples	30	5
Mooring	1	
Profiling Alace float	1	800 m

Floats and Drifters deployed

A profiling Alace float was deployed at station PRS1.

Principal Investigators

Howard Freeland	Ocean circulation	IOS
C.S. Wong	Climate chemistry	IOS
Frank Whitney	WOCE coordinator	IOS
Philip Boyd	JGOFS coordinator	UBC

Preliminary Results

A diatom patch was noticed in the vicinity of station P20, eliciting increased sampling in this area.

The temperature and salinity structure along Line PR6 define several regions:

1. very near the coast, cooler more saline waters are upwelled as previously described by Freeland and others.
2. two lenses of warm, low salinity water between P4 & 10, and P15 & 18 have different characteristics. The near shore pool with salinity less than 32 psu is restricted to the upper 20 m. Further offshore, fresh water appears to be mixed deeper but the mixed layer is thermally confined to the upper 20 m;
3. beyond P20, salinity increases abruptly by 0.2 psu at the surface and remains fairly uniform out to P26. The mixed layer deepens to 30 m.

Transmissivity is a good indicator of phytoplankton density (data collected at P2, 4, 12-20, 24 and 26). Although this data is sparser than T and S, regions with increased biomass can still be defined as:

1. upwelling near the coast which increases nutrient supply;
2. subsurface chlorophyll maximum between P4 and 12, which is formed by a nutricline below the nitrate depleted surface layer (trans. data only at P4 and 12);
3. a break in the subsurface chlorophyll layer coincident with a doming in salinity at P13;
4. a second subsurface chlorophyll layer from P15 to 19, which is also a region where a persistent current from the north (at P16) was noticed by the ship as it tried to hold station, and;
5. a region of high surface biomass seen at P20, followed by an increase in transmissivity towards P26. Nitrate is found in surface waters from P18, westward.

The two dominant features of biomass distribution apparently are nutrient supply and stratification.

Goals Achieved

CTD survey of Line PR6.

Successful Rosette casts at 10 stations on Line P.

Completion of JGOFS sampling for plankton and productivity measurements.

A mooring with an optical package and S4 current meter, both in the mixed layer, was deployed.

Problems and Goals not Achieved

The Alaskan Gyre component of the cruise was canceled in order to study the higher than normal abundance of large diatoms observed at Stn. P20.

Cruise Participants & Affiliations

Phil Boyd	Chief scientist	UBC
Reg Bigham	Watch, mooring	IOS
John Love	Salts, watch	IOS
Wendy Richardson	Oxygen, watch	IOS
Ron Bellegay	Watch, carbonates	IOS
Janet Barwell-Clarke	Nutrients, FD*, prod. expt.	IOS
Ou-Jin Jeong	mooring observer	IOS
Robert Goldblatt	Zooplankton biomass	UBC
Hugh Maclean	Watch, plankton sampling	UBC
Maureen Soon	particulate ¹³ C & ¹⁵ N	UBC
Michael Lipsen	bacteria enumeration	UBC
Delphine Thibault	Zooplankton excretion	Rimouski U.
Ken Crocker	Zooplankton grazing	Memorial U.
Jennifer Putland	Micro-zooplankton	Memorial U.
Paul Matthews	bacterial productivity	Memorial U.
Neil Price	Fe uptake	McGill
Maite Maldonado	bacteria respiration & production	McGill

IOS = Institute of Ocean Sciences, Sidney, B.C., Canada.

UBC = University of British Columbia, Vancouver, B.C., Canada

Measurement Techniques and Calibrations

CTD profiles

At all stations, a Guildline 8715 CTD coupled with a transmissometer was lowered to a maximum 3007 m.

Water sampling

A rosette holding a Guildline 8737 CTD and 23-10 L polycarbonate Niskin bottles was used for most water sampling. Go-Flo bottles clamped on Kevlar hydro line were used to collect clean water for plankton studies.

Each rosette/hydro station consisted of two casts - a down cast and an up cast. The CTD profile is taken from the down cast. The bottles were tripped on the up cast and CTD pressure (dbar) and CTD temperature (uncorrected) recorded from this upcast.

At each station, samples for surface chlorophyll, salinity and nutrients were collected from the ship's sea water loop which pumps water from about 5 m continuously into the laboratory.

Salinity

Samples were collected in glass bottles and analyzed onboard ship using a Guildline Model 8410 Portasal. The Portasal was standardized daily with IAPSO standard sea water.

Oxygen

An automated titration system (Brinkman Dosimat and Fiber Optic Probe Colorimeter) using the micro-Winkler method (Carpenter, 1965), titrated samples to the iodine end-point. Standards were prepared as outlined in WOCE Report 73/91.

Nutrients

Samples from hydro casts were collected in polystyrene tubes and refrigerated for a maximum of 12 h before being analyzed. Loop samples (USW) were stored up to 2 days at 4°C before being analyzed. NO₃+NO₂, PO₄ and Si were analyzed using a Technicon Autoanalyzer.

NO₃+NO₂ samples were reduced with Cd/Cu, then complexed with sulfanilamide and N-Naphthylethylene-diamine to form an azo dye (Technicon Method No. 158-71W/B). PO₄ produces a molybdenum blue complex in presence of acidic molybdate and ascorbic acid (Technicon Method No. 155-71W). Dissolved Si also forms a molybdenum blue complex and oxalic acid removes PO₄ interference (Technicon Method 186-72W).

Concentrated standards were freshly prepared the week before the cruise from oven dried reagents. Working standards were made every 1 to 2 days by diluting 1 to 6 mL of various stock solutions to 250 mL with 3.2% NaCl (w/v in double run Milli-Q water).

Table. Laboratory temperatures for nutrients.

Date	Temp (C)	Date	Temp (C)
Aug 24	23.8	Sept. 1	23.5 to 25.9
Aug 27	23.0 to 25.1	Sept. 2	20.0
Aug 28	24.2	Sept. 3	23.4 to 24.3
Aug 31	24.1 to 24.8	Sept. 8	20.6 to 21.8

TCO₂, ¹³C and Alkalinity - a single profile was collected at PRS1. Samples were fixed with HgCl₂ and refrigerated.

O18/O16 - samples were collected in 60 mL polyethylene bottles and refrigerated.

JGOFS sampling - Go-flo bottles were used to collect water for POC/N, DOC/N, chlorophyll, nano- and micro-plankton and incubation experiments. Deck incubations were conducted to measure growth rates of bacteria, phytoplankton and micro-zooplankton.

Sp FOR SALINITY, OXYGEN, AND NUTRIENTS

Duplicate samples came from Niskin bottles tripped within 1.3 m of each other.

Parameter	Depth Range (m)	Conc. Range	Sp
Salinity	10 to 3712	32.2 to 34.7	0.0044 (k=23)
Oxygen	10 to 3712	63.7 to 280.0 uM/kg	1.09 (k=22)
Silicate	10 to 3712	10.0 to 171uM/kg	0.42 (k=16)
Nitrate + Nitrite	10 to 3712	0.0 to 41.8 uM/kg	0.22 (k=16)
Phosphate	10 to 3712	0.34 to 2.95	0.017 (k=16)

Where the standard deviation of pairs $Sp = \{(\sum d^2)/2k\}^{1/2}$, d is the difference between pairs, and k is the number of pairs.

References

Carpenter, J.H. 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. *Limnol. Oceanogr.*, **10**: 141-143.

Technicon Industrial Method No. 155-71W. 1973. Orthophosphate in water and seawater.

Technicon Industrial Method No. 158-71W/A. 1977. Nitrate and nitrite in water and seawater.

Technicon Industrial Method No. 186-72W/B. 1977. Silicates in water and seawater.

WOCE Report 73/91. 1991. A comparison of methods for the determination of dissolved oxygen in seawater.