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Technical Progress Report

# Measurements of Surface Ocean Carbon Dioxide Partial Pressure During WOCE

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*Technical Progress Report*

Progress during the past year of research under "Measurements of Surface Ocean Carbon Dioxide Partial Pressure During WOCE" (DE-FG03-90ER60981) has been significant. As was described in our previous progress report, the startup phase of this research was severely frustrated by delays in the U.S. WOCE Hydrographic Program (WHP), which in turn were caused by delays in the mid-life refit of the R/V *Knorr*. As a result the high latitude southeastern Pacific work (WHP lines P19S and P16S) originally scheduled for the 1990-1991 austral summer has still not been carried out.

As a substitute, the smaller R/V *Thomas Washington* was pressed into service during mid-1991 to carry out lower-latitude portions of the WHP P16 and P17 lines — the TUNES Expedition. Because this ship is much smaller than the R/V *Knorr*, she could not carry a full complement of WHP programs and seagoing personnel and was restricted by her size and the time of year to lower-latitude work. Our original proposal for carbon dioxide measurements was designed to divide the work between legs in which we participated as part of the WHP dissolved CFC program (under separate NSF funding) and legs in which we entrusted the operation of our system to other CFC or carbon dioxide laboratories with expertise in gas chromatography.

Since we were not involved in any CFC work on the substituted *Washington* expedition, and since all the seagoing programs on the *Washington* were additionally stressed by a shortage of people and space, this placed our carbon dioxide program at an unwelcome disadvantage. We nevertheless arranged for our system to be operated on leg 1 by the University of Miami CFC group (R. Fine and K. Sullivan), on leg 2 by the LDGO carbon dioxide and CFC groups (T. Takahashi, W. Smethie and G. Mathieu), and on leg 3 by the PMEL CFC group (J. Bullister and D. Wisegarver).

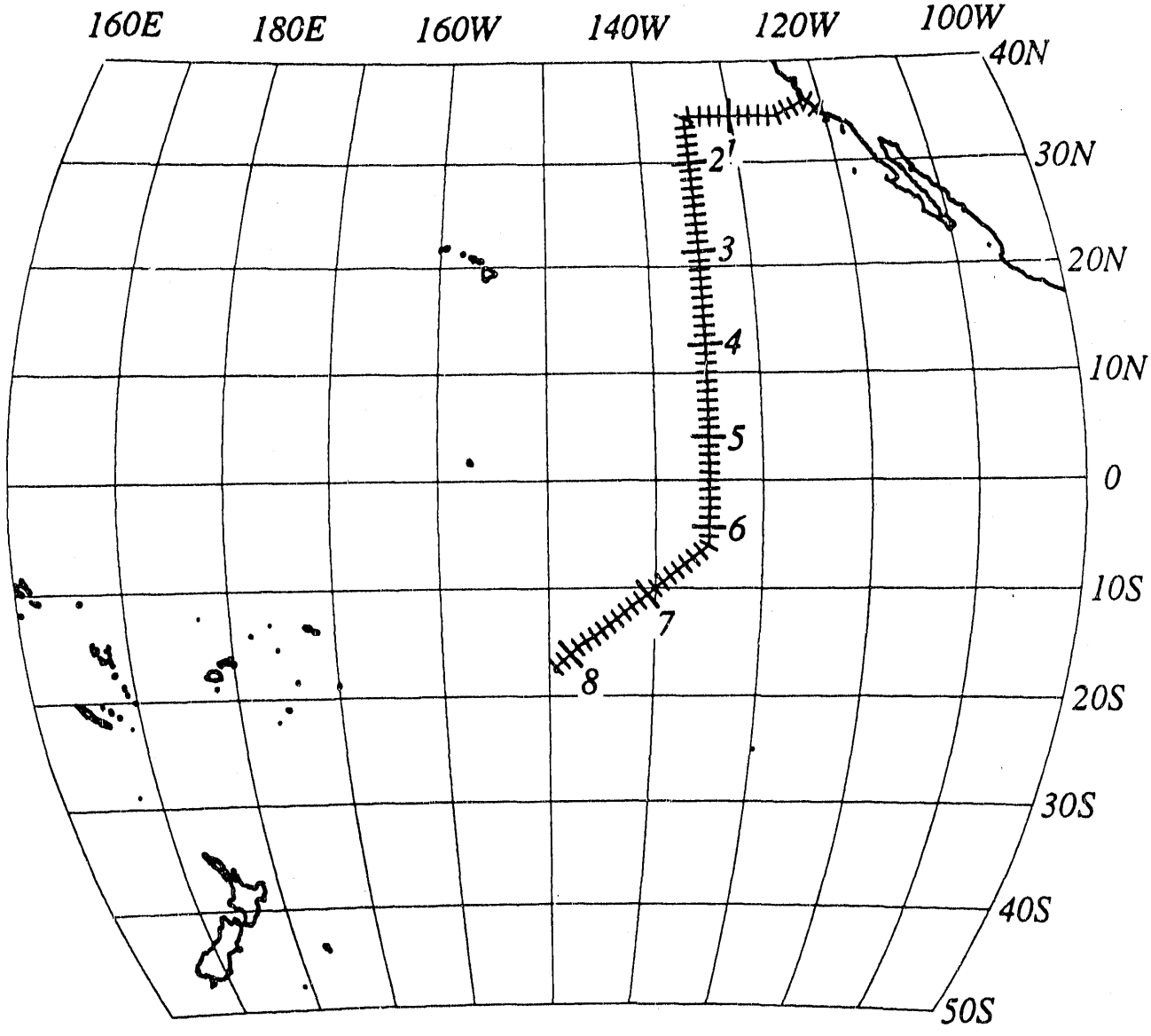
Unfortunately, the success was only mixed. Despite our efforts to "cookbook" the operation of our system, there were more data lost on this one expedition that had occurred in the previous 13 years of operating our system. We believe the errors came largely as a result of a lack of close attention by already-overworked shipboard personnel. Obvious difficulties with the instrument were sometimes not noticed for many days and were sometimes not attended to for several additional days. Record keeping was spotty. On leg 2 alone, we lost data over about 3000 km of ship track, including the southernmost portion of the expedition, and we lost our entire low-standard gas supply (which should normally last for years of continuous operation). On leg 3, the SIO ODF group was no longer responsible for the hydrographic work and their underway data logging system (which included logging of our equilibrator temperatures) was neglected. As a result we were forced to rely on spotty manual observations and station CTD temperatures to reconstruct our equilibrator temperature solubility corrections for portions of that leg. We did not get our usual reliable data return, but the results were surely worth the effort, especially for this vast and rarely-visited region of the world oceans.

The preliminary results for carbon dioxide and nitrous oxide are shown in the following 6 figures. A map of the cruise track is shown for each leg, marked with cumulative distance. Following the track is a plot showing the carbon dioxide and nitrous oxide results as a function of distance along the track. The results are plotted as dry gas mole fractions (in ppm and ppb, respectively) in air and in gas equilibrated with surface

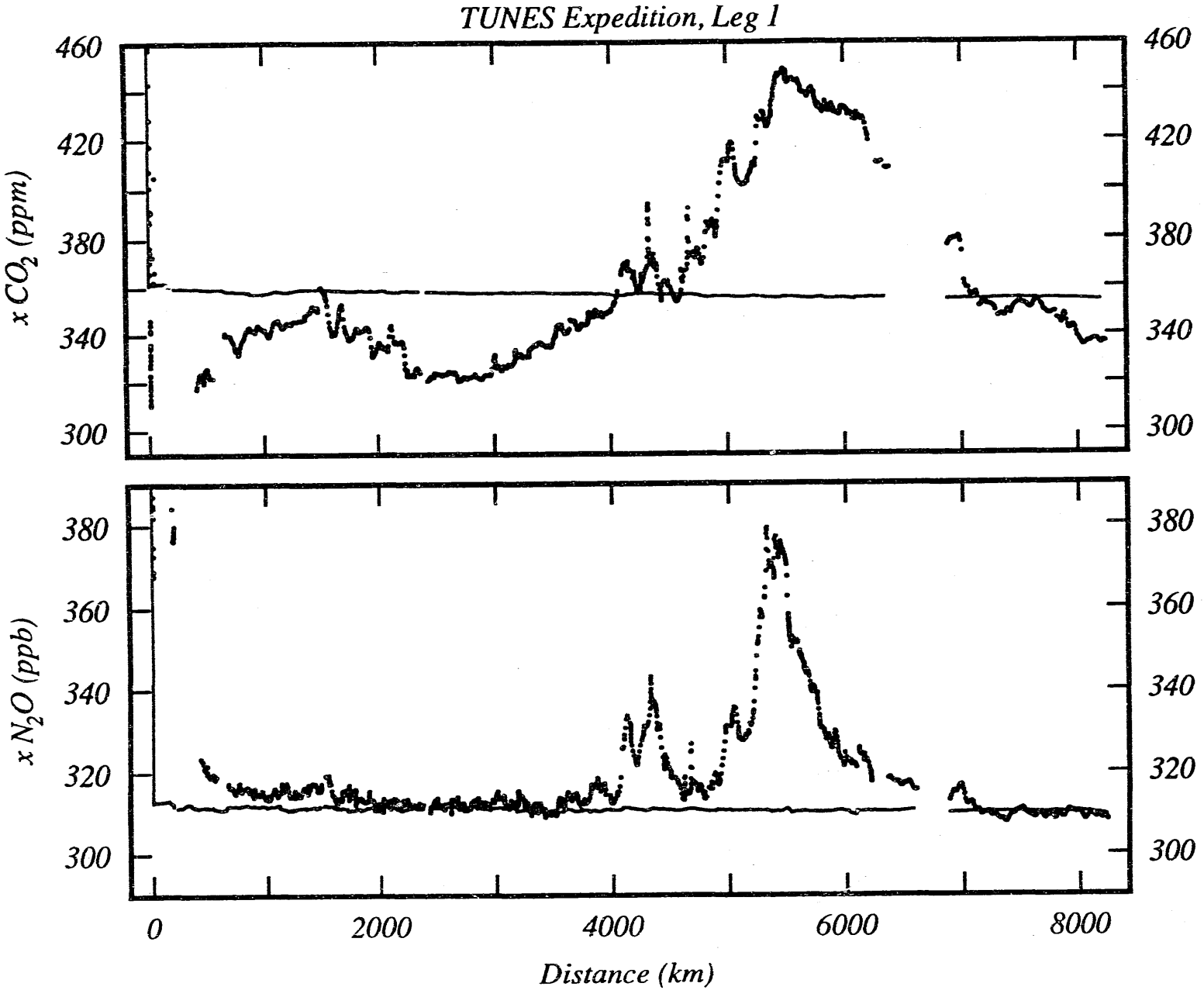
seawater at a total pressure equal to the barometric pressure. The air data are plotted as a 20-point running mean, and appear as a roughly horizontal line. The seawater data are plotted as individual points, using a 5-point gaussian smoother. The losses of data mentioned above are clearly shown by the gaps in the record.

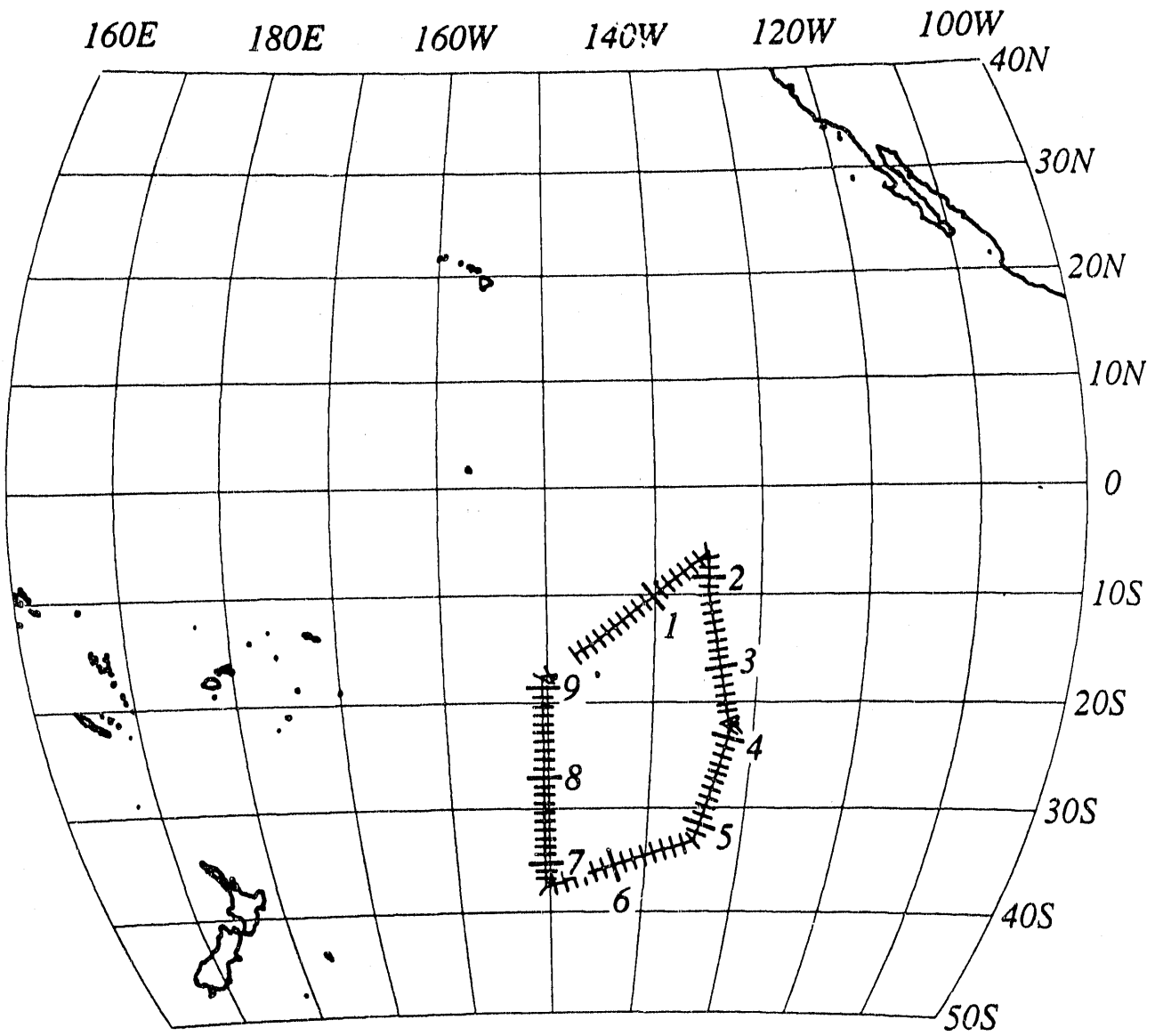
The results of our measurements generally fit the conventional view of surface water carbon dioxide and nitrous oxide partial pressures in this region. On the equator there is a sharp nitrous oxide maximum believed to be caused by vertical mixing with the equatorial undercurrent. Excess carbon dioxide in the equatorial region is spread over a much wider latitudinal range, reflecting the longer exchange time of this gas and its advection from the coastal upwelling region to the east. South of about 17°S carbon dioxide is as much as 15% undersaturated, and nitrous oxide is about 2% undersaturated. These results are consistent with wintertime cooling and the longer exchange time of carbon dioxide.

Our plans for the coming grant year are to install our system aboard R/V *Knorr*, which just recently left the shipyard and is scheduled to carry out WHP line P6 across the entire Pacific at 32.5°S and on WHP lines P16S, P17S and P19S. This will involve operations on 5 or 6 expedition legs, and will enable us to approach our original projection of 3 WHP legs per year despite the delay in the start of the program. The budget for the third year of the program remains as originally projected. There will, however, be a larger than expected carryover of first and second year funds into the third year, reflecting the unanticipated delays in the field program.

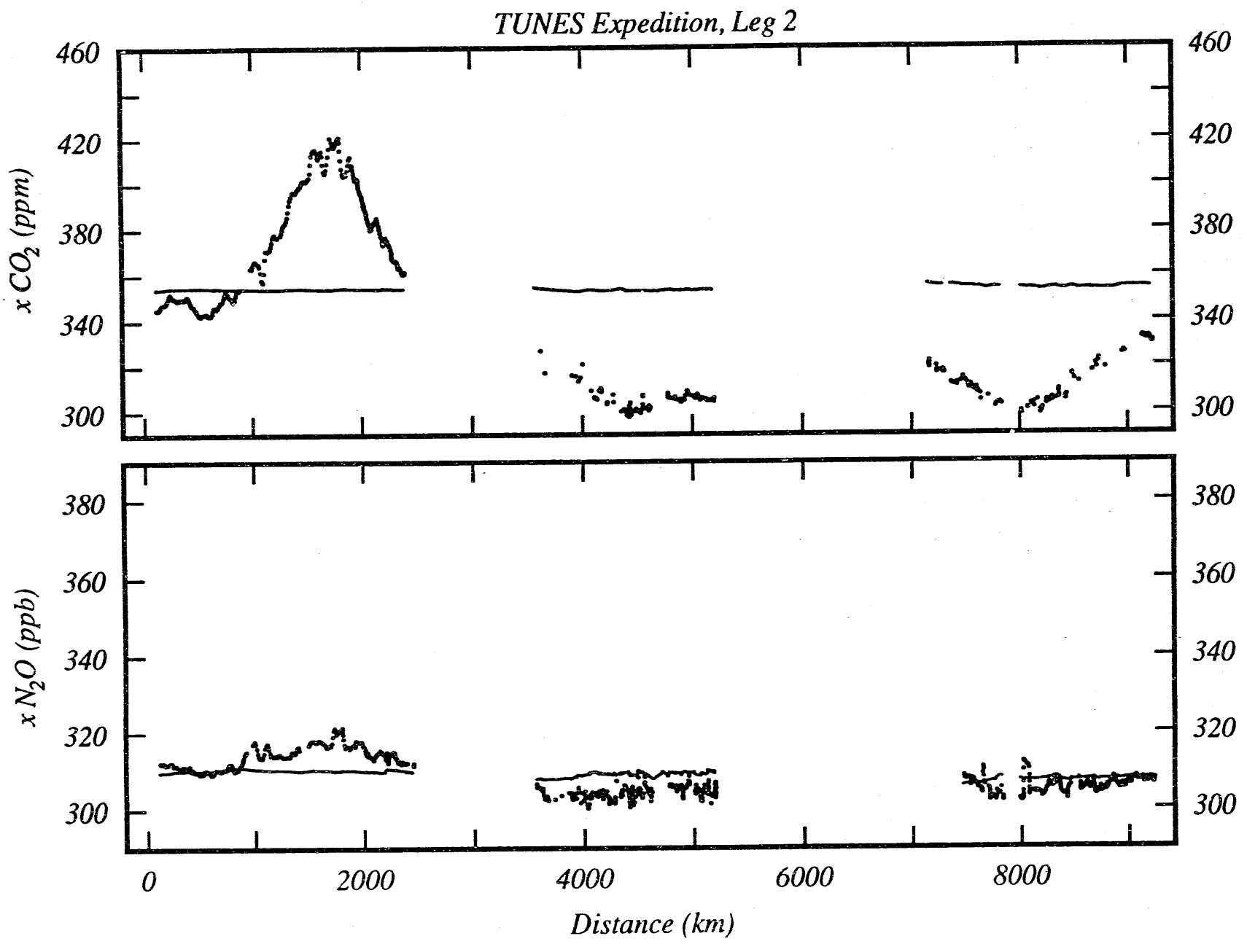


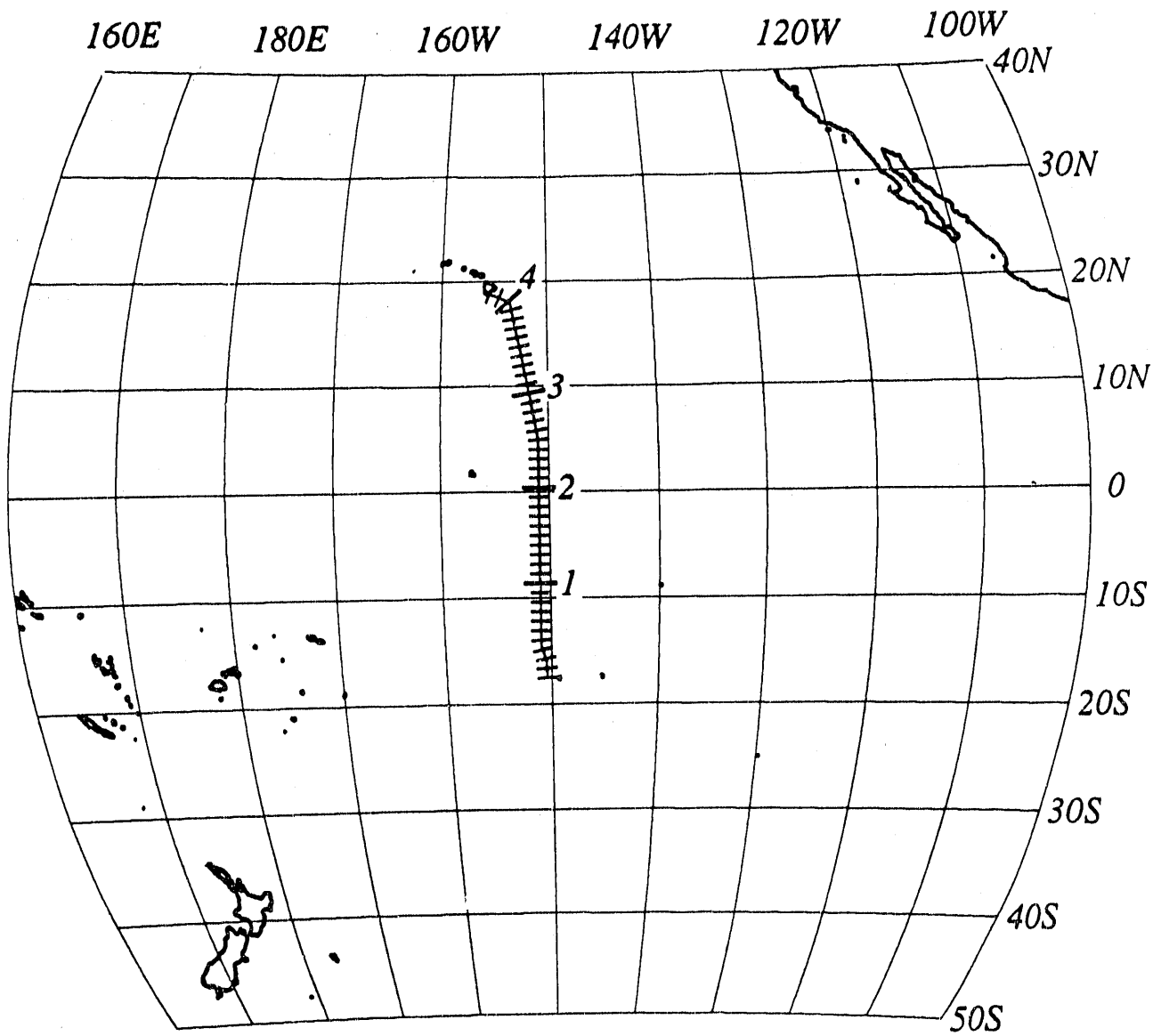

Track of the R/V *Thomas Washington*, TUNES Expedition leg 1, San Diego to Papeete, 31 May 1991 to 11 July 1991. Cumulative distance along the track is labeled in units of $10^3$ km.


TUNES Expedition, Leg 1
460
420
380
340
300
x $CO_2$ (ppm)
380
360
340
320
300
x $N_2O$ (ppb)
0
2000
4000
6000
8000
Distance (km)

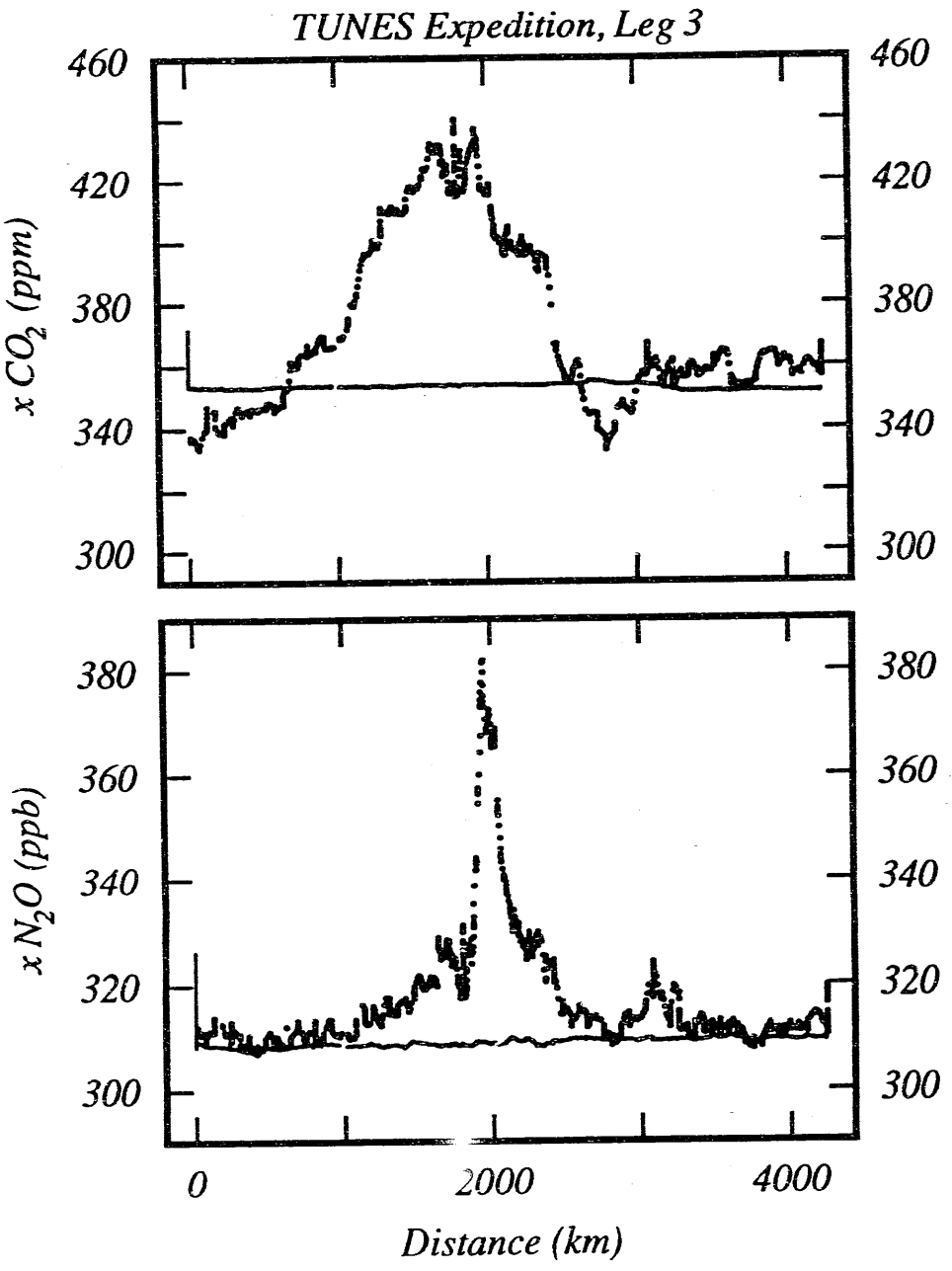



Track of the R/V *Thomas Washington*, TUNES Expedition leg 2, Papeete to Papeete, 16 July 1991 to 25 August 1991. Cumulative distance along the track is labeled in units of $10^3$ km.


TUNES Expedition, Leg 2
460
420
380
340
300
x CO2 (ppm)
380
360
340
320
300
x N2O (ppb)
0
2000
4000
6000
8000
Distance (km)




Track of the R/V *Thomas Washington*, TUNES Expedition leg 3, Papeete to Honolulu, 31 August 1991 to 1 October 1991. Cumulative distance along the track is labeled in units of $10^3$ km.


TUNES Expedition, Leg 3
460
420
380
340
300
x $CO_2$ (ppm)
380
360
340
320
300
x $N_2O$ (ppb)
0
2000
4000
Distance (km)

# END

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