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Radiocarbon

An International Journal of Cosmogenic Isotope Research

^{14}C CYCLING AND THE OCEANS (In Tribute to Reidar Nydal)

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RADIOCARBON

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FROM THE EDITOR

The study of the global carbon cycle is not just an academic exercise anymore—such studies could lead to emissions control policies throughout the world. Quantitative work on the CO_2 greenhouse effect began over a century ago (1896, actually) with the Swedish physical chemist Svante Arrhenius. Although the idea had been around for a while, Arrhenius first calculated that doubling the Earth's atmospheric CO_2 would raise its atmospheric temperature 5–6°C. These calculations were simplistic by modern standards, but the idea is still considered valid by most atmospheric scientists. It is now recognized that the Earth's carbon cycle involves dynamic interactions of the atmosphere with the oceans and biosphere. On a geological time scale, carbonate sediments regulate the CO_2; on a human cultural time scale, the oceans play an important role in buffering the anthropogenic atmospheric CO_2. Inasmuch as the oceanographic papers in this issue deal with how radiocarbon contributes to our understanding of this part of the carbon cycle, they are relevant to the issue of the CO_2 greenhouse effect, and further our quantitative understanding of the carbon cycle through the global radioactive tracer experiment now underway.

This Oceanographic Issue is not exclusively about oceans. We also present a paper suggesting that ENSO may be detected by high-precision radiocarbon measurements, as well as a note on correcting varve counts using radiocarbon dating.

Finally, readers concerned with the production and use of high-precision calibrated radiocarbon dates should take note of the workshop report herein. As is the case for all human endeavors, perfection is a goal, not a state of being.

Austin Long

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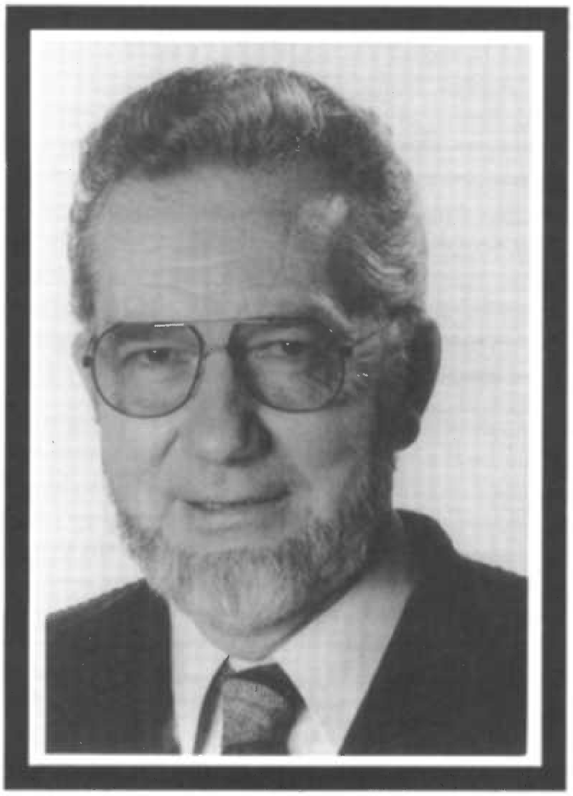

HENRY A. POLACH, 1925–1996

Henry Polach died in November 1996 at the age of 71 years. He was very much the father of radiocarbon dating in Australia, and a significant player on the worldwide stage of radiocarbon.

Henry was born in Czechoslovakia in 1925. He was educated there, and was involved in the resistance movement during the Second World War. This may have been an early indicator of his character, his spirit of freedom, and his willingness to take a somewhat independent and unconventional approach. He completed third-year medical study at the University of Brno, before being expelled from the University shortly after the 1948 coup d'état. He became a political refugee, and escaped to France, where he studied English, German and French at the Sorbonne. It was during this time he met and married Dilette.

Henry emigrated with his family to New Zealand in 1951, and worked at different jobs, often more than one at a time, sometimes as a carpenter, to make a new start and to provide for his family. In 1956 he was appointed as a Chemistry Technician at the Institute of Nuclear Sciences at Lower Hutt in New Zealand. In 1959 he was promoted to Technical Officer in Radiocarbon Dating under Dr. Athol Rafter. He was also a part-time student and gained a Certificate and then a Diploma (with honours) as a Science Technician.

In 1965, he was invited by the Australian National University to set up a Radiocarbon Dating facility, based on gas proportional counting. He accepted a position as a Research Officer, on a temporary basis. This was another new start for Henry and his family.

The new laboratory at ANU was a joint enterprise between the then Department of Geophysics and Geochemistry in the Research School of Physical Sciences, and the Department of Prehistory in the Research School of Pacific Studies. In the early days, Henry had many problems in setting up the gas proportional counter for dating, using methane as the counting gas. The major difficulty was background instability. After a frustrating time trying to find patterns within the data, Henry was able to show a direct correlation between background fluctuations and the operation of an EN tandem Van de Graaf accelerator situated nearby in the Department of Nuclear Physics, Research School of Physical Sciences. Fortunately, one of the Ph.D students in the Department of Geophysics and Geochemistry at that time happened to be Jerry Stipp, who had been working on the early development of the liquid scintillation counting technique before he came to Canberra. Working together, the two of them quietly set up benzene synthesis lines, and produced a few radiocarbon ages using borrowed liquid scintillation counting equipment.

Henry carried out a meticulous study of backgrounds and standards using both gas proportional counting and liquid scintillation counting, and also made contributions to the development of both methane and benzene synthesis techniques. This work convincingly showed that while gas proportional counting using existing housing and facilities was not a viable proposition, liquid scintillation counting certainly was. Shortly afterwards, Henry persuaded the Beckman Instrument Company to provide a liquid scintillation counter for the Radiocarbon Laboratory.

In 1967, Henry's position as a Research Officer was made permanent. A series of promotions followed in later years, with the most significant being to the academic position of Fellow in 1977, and later to Senior Fellow (the equivalent of Associate Professor). This was a noteworthy achievement, since Henry did not have a formal degree.

In 1970, Henry was awarded a Churchill Fellowship, which enabled him to travel outside Australia and visit radiocarbon facilities in various countries over a period of nine months. He made contact with most of the major radiocarbon practitioners, and several worldwide collaborations began. The 1972 International Radiocarbon Conference in New Zealand brought Henry firmly onto the international stage.

During the 1970s and 1980s, the ANU lab became very well known for its contributions to Australian prehistory and Quaternary research. This was due in large measure to Henry's commitment to ensuring that the work was of the highest technical quality and that the results were interpreted correctly.

Quite a few people received training in Henry's lab. John Head joined the lab in June 1967. John Chappell and Jim Bowler prepared most of the samples for their Ph.D studies. Others went on to establish and run other labs—Richard Gillespie and Mike Barbetti in Australia, Alan Hogg in New Zealand, Jindarom Chvajarenpun in Thailand, Sushil Gupta in India, Zhou Weijian and Zhou Mingfu in China. Henry maintained good contact and working relationships with these and many other labs, including the lab at the then Australian Atomic Energy Commission under Graeme Calf, and a growing number of overseas labs.

The 1980s saw Henry embark on a research venture with Wallac Oy in Finland, which produced the Quantulus liquid scintillation counter, a wonderful instrument for low-level counting of natural radiocarbon samples. These counters are now pretty well standard in radiocarbon laboratories throughout the world.

In retirement, Henry remained active in an advisory capacity. He endeavored to open the channels of communication with countries of eastern Europe (Poland, the Czech Republic, the Baltic countries, Ukraine, Russia) and visited there several times.

He was for a time Chairman of a committee sponsored by the International Atomic Energy Agency, Vienna, whose aim is to facilitate and improve on quality control and assurance in radiocarbon dating worldwide.

He was also a member of the Advisory Board of the National Science Foundation Radiocarbon Dating Facility at Woods Hole, USA, and a member of the Scientific Committee of the International Conference on Advances in Liquid Scintillation Spectrometry (LSC 92 Vienna), as well as co-editor of its proceedings.

Apart from his scientific contributions, Henry is perhaps best remembered for his generosity of spirit, his wise counsel, and his hospitality to visitors and friends.

The 1970s and 1980s were important decades for archaeometry in Australia, and the scientists who learned from and worked with Henry are now part of the middle or older generation—so it is quite appropriate to think of Henry as the father of radiocarbon dating in Australia.

John Head adds: "I joined the ANU Radiocarbon Laboratory in June 1967, and have vivid and fond memories of the dynamic and sometimes turbulent periods that have been part of Henry's contribution to ANU. Life was certainly never dull. I remember a remark made by Austin Long in a letter to me not long after Henry made one of his periodic visits to the University of Arizona: 'Henry has just sailed through Tucson and we are still bobbing in his wake'".

Mike Barbetti
Sydney, Australia

John Head
Canberra, Australia

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A TRIBUTE TO REIDAR NYDAL

Reidar Nydal has a very good "pioneer spirit", which influenced his work establishing the Radiological Dating Laboratory in Trondheim, Norway. He was often short of funding, but has tried to manage with the available resources. For example, much of the iron (10 tons) used to shield the proportional counters was from an old railway bridge. It was very important to find iron with low radioactivity, and this railway iron was made before radioactive isotopes were used in the production process. Also, much of the glassblowing needed during the establishment of the lab was done by Reidar himself.

Reidar was born on November 25, 1925 in Flora, north of Bergen, Norway. He was graduated from secondary school in 1946 and received his master's degree from the university of Oslo in 1953. In 1968, he defended his Ph.D. (Dr. Philos) thesis at the university of Oslo on "An investigation of radiocarbon from nuclear tests". Since 1953, he has worked with issues in radiocarbon dating, and took part in the establishment of the Radiological Dating Laboratory at the Norwegian Institute of Technology (NTH) at the University of Trondheim. He became head of the laboratory in 1960. His research has focused mainly on the development of conventional counting techniques for ^{14}C and the study of the carbon cycle in nature. His publications total more than 50 papers.

In 1986, he became professor at the Institute of Physics at NTH, and the contact with students, through teaching and guidance, has been, in his words "a valuable challenge during the last years." His teaching has been concerned mainly with topics involving radiocarbon dating, the carbon cycle and climate. During his career, Reidar has guided 17 project and diploma students and 2 Dr. Ing. (Ph.D.) students. His teaching compendium, "Global Transport Processes in Nature", has been selected since the middle of the 1980s by several students from all faculties of NTH.

Reidar started a study of ^{14}C from the distribution of nuclear tests in 1962. During the 1960s, he and his colleagues established 14 measuring stations for the lower atmosphere, from Madagascar in the south to Svalbard in the north. Until recently, the two stations at Fruholmen at Nordkapp and at Izana in the Canary Islands were still operating. He also made agreements with the Wilh. Wilhelmsen and Fred Olsewn shipping companies to collect water samples from the sea surface during their cruises around the world. Thus, the laboratory was able to measure ^{14}C in the Atlantic, Pacific and Indian Oceans. During recent years, only one ship collected samples from selected positions in the world's oceans. In this way, he has covered the world with time series of ^{14}C measurements since the 1960s. From 1989 to 1994, this carbon monitoring of the world also included deepwater profiles, especially in the Nordic Sea (between Norway and Greenland), an important area owing to its deepwater formation. Reidar himself participated in six of these cruises, showing great commitment both in the laboratory and on the ocean, to see the measurements from start to finish.

These time series measurements from the air and sea have been of major international significance. Since the start of nuclear testing, ^{14}C concentration in the atmosphere has doubled. The excess was transferred into nature through the carbon cycle, and by studying the carbon time series for the different natural reservoirs, especially through modeling, we gain important knowledge about the carbon cycle. It meant a great deal to Reidar to be mentioned by Linus Pauling when the latter received the Nobel Peace Prize in 1963. This environmental knowledge is especially important in current discussions about the increase in the greenhouse effect because of increased CO_2 in the atmosphere.

The Radiological Dating Laboratory hosted the 12th International Radiocarbon Conference in Trondheim in 1985, with Reidar as chairman of the Organizing Committee. Reidar was honored by the King of Norway, when in 1995 he received the Gold Royal Order of Merit. A special symposium was also held in his honor when he turned 70.

Reidar has been married to Eva since 1954. They have a daughter and two sons, and seven grandchildren so far. He has enjoyed skiing and fishing with his family, and teaching the children and grandchildren about how to stay overnight in a snow cave. In his spare time he has been involved in many social activities. For about 25 years he was active as a leader for the Boy Scouts, and for many years has been involved in the Y's mens club, a subdivision of the YMCA. He has also been heavily engaged in social work for the church. Kayak-building and kayaking has been one of his greatest passions throughout the years. He has built three large and stable sailing kayaks with his own hands. In the largest, he traveled about 1500 km, from Bergen to Tromsø, during five summer vacations. His wife and oldest son joined him on some of the stages. His great knowledge of weather and wind, as well as his childhood in western Norway, were useful to him during these journeys. In recent years he has also been engaged in bicycling. He completed "the great strength race" (a bicycle race from Trondheim to Oslo, about 540 km) for the first time when he was 67 years old, in less than 24 hours. About three months before the race he used a "gear bicycle" for the first time.

Reidar is a person with a big heart; he wants people around him to be happy and feel well. He has an unceremonious manner, and he very easily gets to know new people. His concern about other human beings is serious, and he always tries to be very supportive. Reidar has now retired as head of the Radiological Dating Laboratory, but is still spending several hours at his office at NTH. He enjoys reading e-mail from friends around the world. He is still lecturing, and tries to publish the large amount of data and knowledge that he has.

Reidar was my supervisor from 1989 to 1994, through my project, diploma and Dr. Ing. (Ph.D.) studies. I would like to take this opportunity to thank him for his never-ending enthusiasm, discussions, ideas, encouragement and friendship during the years we spent together. I was honored to be asked to write this tribute article about him for this special issue of *RADIOCARBON*.

Jorunn Skofteland Gislefoss
Spangereid, Norway

[RADIOCARBON, VOL. 38, NO. 3, 1996, P. 387–643]

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1996

^{14}C CYCLING AND THE OCEANS

INTRODUCTION

Furthering our understanding of how carbon is cycled within the oceans and between the ocean and the atmosphere, both in the past and present, is a critical issue today. Studies of global climate change require a better knowledge of how the ocean responds to changes in atmospheric CO_2 on short and long time scales than is currently available. Radiocarbon has proved to be an invaluable tool for studying carbon cycling. In paleoceanography, chronologies of the events recorded in sediments can be reconstructed. Currently, the incorporation of "bomb" ^{14}C into different pools of carbon can be used to track the short-term transfer of carbon from one pool to another as well as to set limits on rapid mixing rates that remained elusive prior to its production. Modeling of time-series records in surface waters will allow us to predict future changes in the carbon cycle. This special issue of *RADIOCARBON* contains papers demonstrating the power that radiocarbon studies bring to deciphering the oceans's carbon cycle.

This special issue originated in the "Carbon in the Oceans" workshop at the 15th International Radiocarbon Conference in Glasgow, Scotland. Such a unique group of talks was presented there that the decision was made to give the authors a choice of publishing either in the Proceedings (Volume 37, No. 2, 1995) or in a special "Oceans" issue. It became obvious that the issue could be dedicated to Reidar Nydal, one of the pioneers of measuring ^{14}C in the world's oceans and atmospheres, on the event of his retirement. Additional contributions have been solicited and accepted to help celebrate Reidar's career. Although it has taken some time to put together, this collection of papers provides a good sampling of the scientific questions concerning the ocean that radiocarbon can help address.

A number of papers discuss ^{14}C in the dissolved inorganic carbon (DIC) pool in the Atlantic and Pacific Oceans. Nydal and Gislefoss present an impressive 30-yr summary of atmospheric CO_2 and surface ocean DIC ^{14}C measurements. Additionally, the depth profiles they measured recently in the Nordic Seas extend the oceanographic time-series of the Geochemical Ocean Sections Study (GEOSECS) and Transient Traces in the Oceans (TTO) programs in this region, which are central to deepwater formation. Severinghaus *et al.* use $\Delta^{14}C$-DIC measurements collected along a transect in the subtropical North Atlantic Ocean to provide insight for upper ocean mixing in this dynamic region. The trio of papers by Key, Key *et al.* and Stuiver *et al.* present the first results from the Pacific program of the World Ocean Circulation Experiment (WOCE), a program that will greatly expand the database of oceanic ^{14}C measurements. Some of the important results presented in these papers are the agreement between the AMS and decay-counting techniques and the reproducibility of deepwater values over the 20-yr period from GEOSECS to WOCE. All of these papers document the increased penetration of the bomb signal into the thermocline over time, although the magnitude differs regionally.

The papers by Druffel, Ingram and Southon, and Honda use the record of $\Delta^{14}C$-DIC in the surface ocean that is preserved in calcareous organisms to study ocean mixing processes. Druffel uses the recent history of $\Delta^{14}C$ in corals from the tropical Atlantic to investigate water mass ventilation in this region. Ingram and Southon expand our knowledge of reservoir ages by examining ^{14}C in historic collections of shell from the eastern Pacific. Honda uses the $\Delta^{14}C$ of particulate inorganic carbon collected in sediment traps to examine surface ocean circulation and mixing in the Okhotsk and Bering Seas.

Finally, in a paper examining ^{14}C in tree rings, Damon *et al.* show that atmospheric ^{14}C values near the Arctic Circle are affected not only by regional events but by ENSO events as well.

This eclectic group of papers provides a broad sampling of the types of research ongoing in the fields of oceanography and climatology. This eclecticism is a reflection of Reidar Nydal's career for the past four decades, as is aptly described by Gislefoss in her tribute to him. The productivity and forthrightness of Professor Nydal is an inspiration to us all.

Ann P. McNichol

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FURTHER APPLICATION OF BOMB ^{14}C AS A TRACER IN THE ATMOSPHERE AND OCEAN

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ABSTRACT. Bomb ^{14}C from nuclear tests in the atmosphere has proved to be a particularly useful tool in the study of the carbon cycle. We provide here a *ca.* 30-yr time series of ^{14}C concentrations in the atmosphere between 28°N and 71°N and in the ocean surface between 45°S and 45°N. More recently (since 1990), a north-south profile also has been obtained for ^{14}C in the surface waters of the Atlantic Ocean. The measurements were performed using the conventional technique of beta counting of large samples (4 to 5 liter CO_2) in CO_2 proportional counters. These data show that the ^{14}C concentration in the atmosphere is leveling off with a time constant of 0.055 yr^{-1}, and is now approaching that of the ocean surface at lower latitudes.

Additional tracer studies have been concerned especially with the penetration of bomb ^{14}C into the deep ocean. The Norwegian and Greenland seas are of interest as a sink for atmospheric CO_2 and also a source of water for the deep Atlantic Ocean. During the last five years, several ^{14}C depth profiles have been measured from the Fram Strait (79°N) to south of Iceland (62°N), using the AMS technique available at the University of Arizona AMS Facility. We considered it important to repeat and compare a few of the profiles with those produced by the GEOSECS expedition in 1972 and the TTO expedition in 1981. The profiles show that water descending to the deep Atlantic Ocean is originating mainly from intermediate and surface depths in the Nordic Seas. However, the ventilation rate of the Norwegian Sea deepwater is too slow to be an important component in the transfer of water over the Greenland-Scotland Ridge.

INTRODUCTION

About 1000 nuclear tests, with a total strength of 500 MT (TNT equivalent), were carried out in the atmosphere from 1945 to 1962. About two-thirds of that energy was released at higher northern latitudes; mainly over Novaya Zemlya and mainly during the fall of 1961 and 1962 (UN Report 1964). The main atmospheric testing programs came to an end with the Test Ban Treaty of 5 August 1963 (The Moscow Treaty). France and China did not accept the Treaty immediately and continued to test smaller bombs in the atmosphere. France had its main testing period from 1966 to 1968 and carried these out in the Pacific Ocean. China carried out several tests over the Asian Continent (Lop Nor) until 1980, with the highest activity during the period 1968 to 1972. The total contribution from these post-1963 bomb tests was *ca.* 12% of the total power released into the atmosphere from nuclear testing.

We present here a further contribution to the carbon cycling research program, based on bomb ^{14}C as a tracer, which was initiated in our laboratory in 1962. From a noted doubling of the natural ^{14}C level at northern latitudes in 1962, the dispersion of bomb ^{14}C in the atmosphere and ocean surface has been studied extensively during subsequent years (Nydal and Løvseth 1983; Nydal *et al.* 1984). At present, the ^{14}C concentration in the atmosphere is approaching that of the ocean surface at lower latitudes. The tracing interest is now mainly concerned with the continuing penetration of bomb ^{14}C into the deep ocean. The arctic regions are especially in focus as they constitute sinks for atmospheric CO_2. Several cruises during recent years have been used to measure ^{14}C depth profiles in the Norwegian and Greenland Seas. These data are used to study the uptake of CO_2 in the Nordic Seas and its net transfer to the deepwater in the Atlantic Ocean (Nydal *et al.* 1991, 1992; Gislefoss *et al.* 1995).

SAMPLING AND MEASUREMENTS

The CO_2 sampling and conventional ^{14}C measurement of atmospheric CO_2 and ocean surface water are described in detail in earlier articles (Nydal and Løvseth 1983; Nydal *et al.* 1984). In brief summary: 1) sampling at ground level in the troposphere is performed with a solution of 1–2 liters NaOH (2%), which is exposed to the open air for several days. An absorption time of 7 days was generally applied from 1962–1981, but this was changed subsequently to 3–4 days. Depending on the air ventilation, between 3 and 6 liters of CO_2 are now absorbed over a period of 3 to 4 days; 2) sampling from the ocean surface is generally based on the recovery of 200 liters of seawater, collected at a depth of 5–10 m through the inlet of the pumping system of the ship. After acidifying the water (with H_3PO_4) to a pH value of *ca.* 3, a relative amount of between 4 and 6 liters of CO_2 is extracted in a flushing procedure on board the ship and absorbed in a bottle of 0.75 liters NaOH-solution (2%); 3) the conventional ^{14}C measurements were performed by beta counting 3–5 liters of CO_2 in proportional counters. The $^{14}C/^{13}C$ ratio is measured relative to the modern standard (NIST HOxII) and normalized for isotopic fractionation effects. The final ^{14}C enrichment for each sample is calculated and quoted in per mil excess above the pre-bomb level, according to the formula defined by Stuiver and Polach (1977)

$$\Delta^{14}C = \delta^{14}C - 2(\delta^{13}C + 25)\left(1 + \frac{\delta^{14}C}{1000}\right). \tag{1}$$

Until 1980, a counting time of 1–2 d per sample was used to ensure an analytical precision of *ca.* 10‰ (1 σ). After 1980, the counting time was increased to 4–5 days to obtain a better precision (4–5‰).

In earlier research from this laboratory, the $\Delta^{14}C$ values in the time series of bomb ^{14}C measurements were not corrected for radiometric decay of the modern reference standard, which is defined to equate AD 1950 with atmosphere. Compared to the earlier limit of error (up to 10‰) in those measurements, disregard for decay of the reference standard could be considered unimportant. However, after a decay period of 40 yr, the associated error of 5‰ is now comparable to the precision achieved in radiometric measurements. A retrospective correction for this decay has therefore been adopted for all our ^{14}C measurements, using the approximate correction formula

$$\Delta^{14}C_{corr} = \Delta^{14}C_{uncorr} + 1000[e^{\lambda(1950-t)} - 1] \tag{2}$$

where λ is 1/8267 (5730 yr half-life) and *t* is the year of sampling. The corrected ^{14}C data are also available from the CDIAC database held at the Oak Ridge National Laboratory, Tennessee, USA.

The ^{14}C deep-sea profiles were initially achieved using large samples (100–200 liters seawater) and the radiometric ^{14}C counting technique. This collection procedure was very time-consuming. However, the recent availability of accelerator mass spectrometry (AMS) for ^{14}C measurement allows sampling to be based on much smaller water samples (0.5 liter). This technique brings exciting new possibilities for tracing ^{14}C in the deep sea (Gislefoss 1994; Gislefoss *et al.* 1994). The AMS measurements reported here were carried out at the NSF-Arizona AMS Laboratory in Tucson, Arizona. The procedure involves CO_2 samples between 1 and 2 ml being converted to CO over hot Zn, and further reduction of the CO to graphite over an iron catalyst at 625°C (Slota *et al.* 1987). The graphite powder is then pressed into an aluminum target holder for the AMS analysis. The $^{14}C/^{13}C$ isotope ratio of the sample graphite target is measured and compared to that recorded by the reference standards. An analytical precision of 4–5‰ is indicated by replicate analyses using independently prepared targets. Details of the experimental procedures are given by Linick *et al.* (1986) and associated calculations are quantified by Donahue, Linick and Jull (1990).

ATMOSPHERE

In the early 1960s, our program of ^{14}C measurements in the troposphere was set up based on CO_2 collected at a total of 14 stations sited between Madagascar (21°S, 47°E) and Svalbard (78°N, 13°E) (Nydal 1968; Nydal and Løvseth 1983). Over the years, it has not been possible to continue with this large number of stations, and from 1978 onward, the sampling network was reduced to two stations at Fruholmen, Nordkapp (71°06'N, 23°59'E; 70 m above sea level (asl)) and Izana, Tenerife (28°22'N, 16°03'E; 2400 m asl). The curve for Fruholmen is complete between 1963 and 1993. The curve measured at the Canary Islands is largely complete over the period 1963–1992, but comprises measurements from two neighboring stations; one at Izana, Tenerife and the other at Mas Palomas, Gran Canaria (27°45'N, 15°40'W; 10–100 m asl).

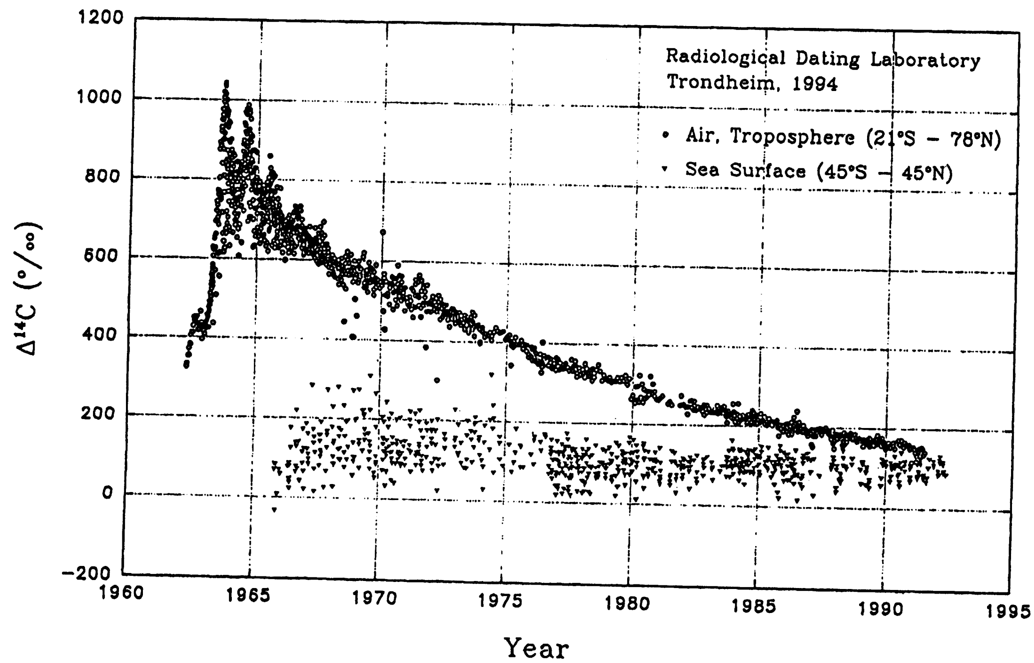

Fig. 1. ^{14}C in the troposphere and the ocean surface 1962–1992. Measurements only from Nordkapp (71°N) and Tenerife (28°N) after 1978.

A summary curve of the $\Delta^{14}C$ at all our tropospheric collection stations is given in Figure 1. The large seasonal variations in the troposphere values between 1963 and 1968 are caused mainly by the meteorological influx of ^{14}C from a concentration in the stratosphere 10 to 20 times higher during that early period (Feely, Katzman and Tucek 1966). The main exchange of CO_2 between the stratosphere and the troposphere occurs during the spring and summer, when the tropopause height increases toward higher latitudes. The magnitude of the seasonal variation in tropospheric ^{14}C concentration leveled off during the first years, until a further slight increase occurred from 1968 to 1972 as a result of French and Chinese tests. For subsequent years, the curve follows a more regular exponential decrease, with a decay constant of 0.055 yr^{-1}, calculated at Nordkapp from 1973 to 1992. Data in Figures 1 and 2 show that past AD 1980, there is a fairly close agreement between the curves recorded at Fruholmen (71°N) and Izana (28°N). Both collection stations enjoy relatively clean air and are within rapid circulation cells of the troposphere (Meijer *et al.* 1994).

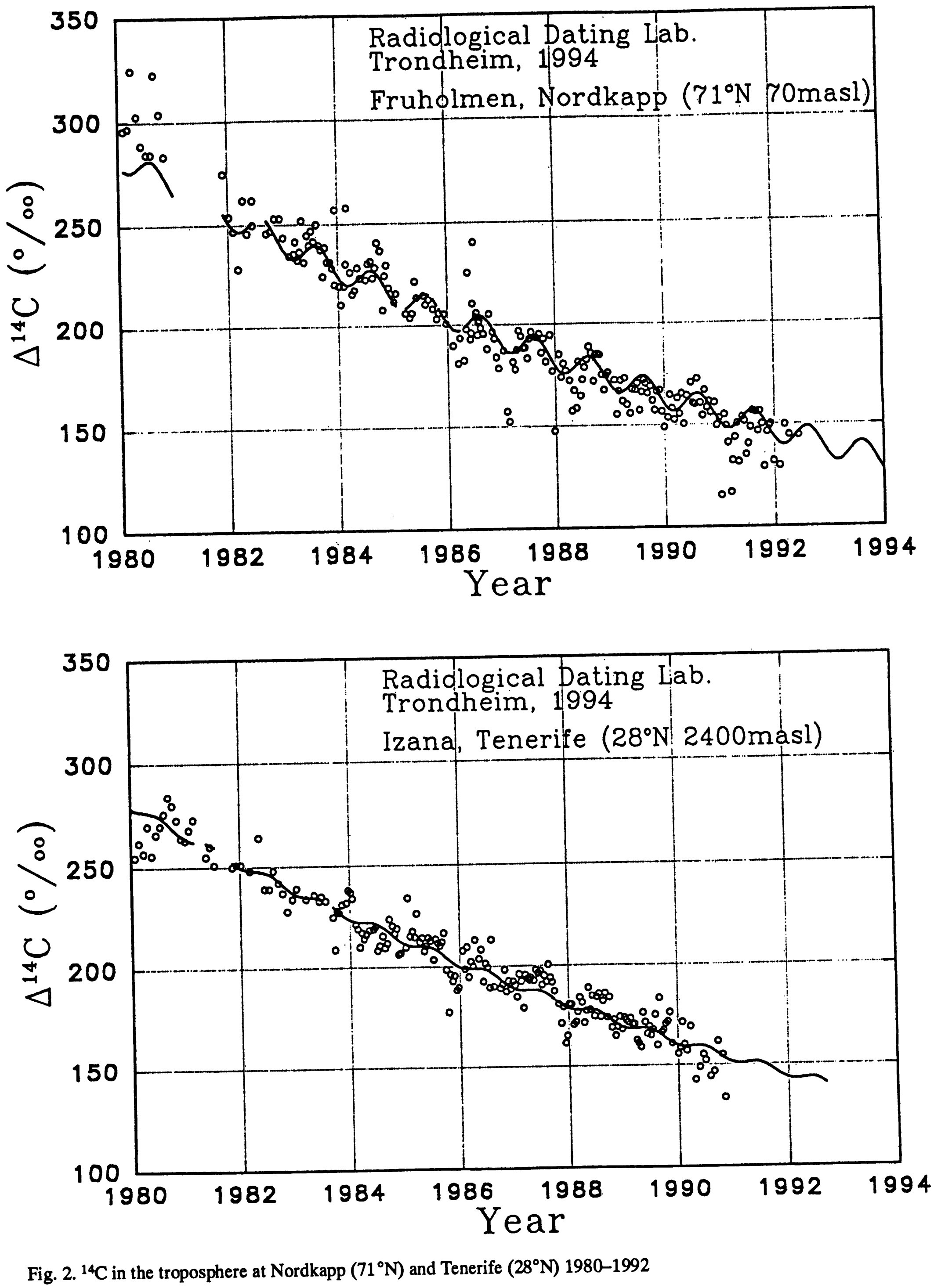

Fig. 2. ^{14}C in the troposphere at Nordkapp (71°N) and Tenerife (28°N) 1980–1992

It is interesting to speculate on a possible signal in ^{14}C from the Chernobyl event of 26 April 1986. Two values of 30–40‰ above the ambient level at Fruholmen coincide with the time of this event (Fig. 1). Due to weather patterns prevalent at the time of the explosion, a low-pressure feature passing over Chernobyl subjected northern Scandinavian countries to radioactive fallout a few days later. Even though ^{14}C from the Chernobyl event can be regarded as negligible on a global scale, it is not surprising to find a more local and transient increase in this area.

Direct comparison of the temporal ^{14}C concentrations recorded from the two operational stations between 1980 and 1992 (Fig. 2) reveal seasonal variations with summer maxima and winter minima. The higher amplitude is found at Fruholmen, where the temporal variations are also more regular. A major cause of this pattern is dilution of $^{14}CO_2$ by the excess of inactive CO_2 (^{14}C-depleted) discharged to the atmosphere as a result of the greater combustion of fossil fuel during winter. This dilution effect levels off during the summer season, due to atmospheric mixing and ongoing exchange between the atmosphere and the other carbon reservoirs (ocean and biosphere). A comparison with ^{14}C concentrations recorded at sampling stations in central Europe (Levin *et al.* 1995) also indicates that seasonal variation is greater in areas with higher combustion of fossil fuel. A model simulation of the later (1980 to 1992) seasonal trend in the tropospheric ^{14}C concentrations recorded at Fruholmen and Izana has been attempted using the function

$$F(t) = A \sin 2\pi(t - t_o) + B\, e^{-k(t - t_o)} \quad . \tag{3}$$

The parameters A, B and t_o (Table 1) are determined *via* a least-square fit, whereas the decay constant k is calculated independently from a longer period at Fruholmen (1973 to 1992). To comply with the present observations in the ocean surface, and to avoid the spurious effect of additional parameters during a relatively short period, the ultimate level for the function was chosen to be zero. With an amplitude of 6.6 ± 1.4‰ and a decay constant of 0.055 yr^{-1}, the function gives the better fit to the Fruholmen, Nordkapp data. For the curve at Izana, Tenerife, the amplitude term (A) was reduced to approximately one-third of that used for Nordkapp. The seasonal variation and some of the ^{14}C data at Izana are more irregular than at Nordkapp, and do not always fit well with the calculated cycle. This latter observation reflects the special meteorological condition at Izana, as discussed previously (Nydal 1968).

TABLE 1. Parameters Obtained in a Least-Square Procedure (Marquardt-Levenberg Algorithm) for the Function (2) to fit the Data Sets from 1980 to 1992 from Nordkapp and Tenerife

Parameter	Parameter explanation	Nordkapp	Tenerife
A	Amplitude of the yearly oscillations	6.3 ± 1.3‰	1.9 ± 1.0‰
t_o	Time at the turning point of the cycle	1980.38 ± 0.03 yr	1980.25 ± 0.09 yr
B	The $\Delta^{14}C$ value at the time t_o	279.1 ± 1.2‰	276.6 ± 1.6‰
	Mean deviation from the curve	6.9%	7.3%

A small contribution to the seasonal variation of the ^{14}C in the troposphere could be from a still enhanced concentration of the $^{14}CO_2$ in the stratosphere. According to Tans (1981) the amount of bomb ^{14}C input to the stratosphere might have been underestimated significantly from sampling flights that took place after the cessation of nuclear testing. A few bombs tested in the upper atmosphere were significantly larger than the average and, in such instances, the induced radioactivity may have reached greater altitudes than expected. For example, a single hydrogen bomb over Novaya Zemlya on 30 October 1961 had a recorded 58 MT yield (SIPRI Yearbook 1975). Further-more, a recently observed $\Delta^{14}C$ value of 250–275‰ at a height of 33–35 km (39.16°N, 141.83°E) by Nakamura *et al.* (1992) indicates a ^{14}C excess in the lower stratosphere that is still *ca.* 150‰ above the present tropospheric level. A progressively smaller part of this excess radioactivity will be transferred to the troposphere during spring and summer each year. However, according to the calculated residence time for ^{14}C in the upper stratosphere of 9.1 ± 0.2 yr, the present contribution from this source of bomb ^{14}C to the amplitude in the seasonal variation at ground level is <1‰.

OCEAN SURFACE

Prior to 1986, sampling of the ocean surface water was carried out from several ships crossing the Atlantic, Pacific and Indian Oceans (Nydal *et al.* 1984). During the last ten years, however, our sampling program has been restricted to a single ship of the Barber Line (MS *Tourcoing*), on its main global route from Europe, across the Atlantic Ocean to Panama, across the Pacific Ocean to New Zealand, northward to Japan and back across the North Pacific and Atlantic Oceans. In some cruises, the route to New Zealand has passed south through the Atlantic around the Cape of Good Hope to the Indian Ocean, with a return route through the Suez Canal and the Mediterranean Sea.

All of the ^{14}C measurements from ocean surface water that are shown in Figure 1 derive mainly from samples collected in the region 45°N to 45°S. The mean trend from all the scattered data approximates to a near-horizontal line at $\Delta^{14}C$ = 100‰, which is close to the present atmospheric level. A closer study of ^{14}C in the surface ocean layer shows a pattern of seasonal variations that are normally correlated with ocean temperature. The largest variations coincide with upwelling areas along the continental margins, and the smallest variations are recorded in those stable parts of the open ocean least influenced by vertical mixing. Figure 3 shows the latitudinal variation of $\Delta^{14}C$ in the surface of the Atlantic Ocean from the pre-bomb level until present. The pre-bomb level is established from data compiled by Broecker and Peng (1982), and 1972–1973 data are reproduced from the GEOSECS expedition (Broecker *et al.* 1985). Our data were obtained with the Norwegian research vessel RV *Andenes* on a cruise to the Antarctic in the winter of 1989–1990 (Table 2) and are supplemented by more recent measurements (1990–1992) from the Nordic Seas (Table 3). These ^{14}C data concur reasonably well with the GEOSECS data reported for both sides of the Atlantic Ridge, and indicate that only small changes in $\Delta^{14}C$ have occurred in the ocean surface during the last 20 yr. It must be emphasized that the GEOSECS data show differences in magnitude between each side of the Ridge (Fig. 3, I and II) and therefore our more recent data have to be compared with the geographically closest GEOSECS values.

One of the main trends in the $\Delta^{14}C$ curves for the Atlantic Ocean is an approximate symmetry around the equator. The most stable surface layers (which exhibit the highest $\Delta^{14}C$ values) coincide with the high-pressure zones along both sides of the equator at about 30°N and 30°S. A slight decrease in $\Delta^{14}C$ occurs along the equator, where upwelling water with a lower ^{14}C concentration displaces the surface water toward higher latitudes (Broecker and Peng 1982). There is, however, a more dramatic lowering of ^{14}C enrichments towards higher latitudes, where the more stable surface layer vanishes. The Arctic Ocean (including Nordic Seas) behaves somewhat differently from the Antarctic, mainly due to the geographic distribution of the adjacent land areas. The Antarctic Ocean is unique in that total global circulation of the ocean currents is not impeded (Pickard and Emery 1990). Upwelling and downwelling of water both occur in this region (Foldvik and Gammelsrød 1988). The upwelling water displaces the surface layers and dilutes its ambient $\Delta^{14}C$ value.

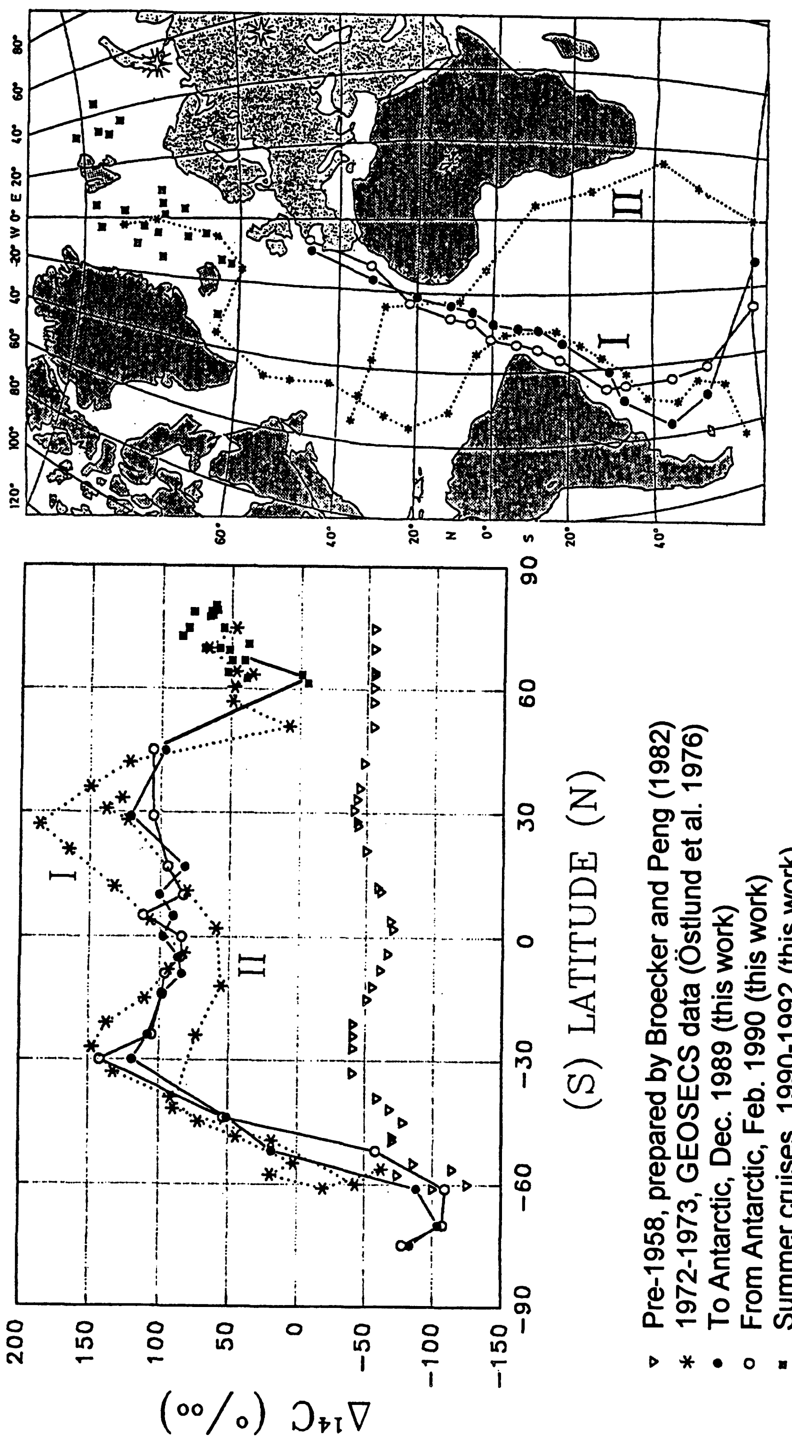

Fig. 3. A north-south profile of ^{14}C in the surface of the Atlantic Ocean 1989–1992

TABLE 2. ^{14}C Measurements in the Surface of the Atlantic Ocean from a Return Cruise to the Antarctic with RV *Andenes*, December 1989 to February 1990

Sample	Date (yy.mm.dd)	Location	$\delta^{14}C$ (‰)	$\delta^{13}C$ (‰)	$\Delta^{14}C$ (‰)
A-1	89.12.03	45°03'N 10°36'W	156	0.9	92.6 ± 5.7
A-2	89.12.08	29°34'N 20°00'W	181	0.5	117.2 ± 5.3
A-3	89.12.11	17°24'N 20°02'W	141	0.8	77.8 ± 4.1
A-4	89.12.12	10°00'N 22°21'W	161	1.5	96.1 ± 4.9
A-5	89.12.13	05°03'N 23°54'W	149	0.7	86.1 ± 4.4
A-6	89.12.14	00°24'N 25°41'W	157	0.9	93.6 ± 4.1
A-7	89.12.15	04°56'S 27°29'W	145	0.5	82.5 ± 4.3
A-8	89.12.16	09°46'S 29°00'W	143	1.2	79.5 ± 3.8
A-9	89.12.17	14°45'S 30°49'W	159	1.7	93.6 ± 3.9
A-10	89.12.21	24°34'S 37°48'W	171	1.8	104.0 ± 4.1
A-11	89.12.23	30°04'S 45°45'W	180	0.9	115.0 ± 4.2
A-12	89.12.30	44°37'S 56°14'W	111	2.3	46.5 ± 4
A-13	90.01.02	52°30'S 48°46'W	76	2.0	18.7 ± 4
A-14	90.01.08	61°42'S 14°12'W	−41	−0.6	−92.4 ± 3.8
A-15	90.01.16	70°03'S 12°35'W	−56	0.6	−108.4 ± 4.3
A-16	90.02.06	74°39'S 34°08'W	−37	−0.6	−88.1 ± 4.4
A-16(2)	90.02.09	73°58'S 33°01'W	−25	2.3	−82.2 ± 4.1
A-15(2)	90.02.16	70°03'S 12°35'W	−58	1.4	−111.4 ± 4.2
A-14(2)	90.02.25	59°54'S 28°12'W	−61	0.8	−113.3 ± 3.8
A-13(2)	90.02.28	52°19'S 37°03'W	−7	0.9	−62.6 ± 3.7
A-12(2)	90.03.01	44°58'S 38°47'W	111	2.8	49.2 ± 4.2
A-11(2)	90.03.05	30°23'S 41°36'W	185	1.2	118.9 ± 4
A-10(2)	90.03.06	25°00'S 42°41'W	168	1.7	101.4 ± 3.7
A-9(2)	90.03.13	13°26'S 34°28'W	161	2.4	93.9 ± 4.9
A-8(2)	90.03.14	09°38'S 32°44'W	157	1.6	91.7 ± 5.1
A-7(2)	90.03.15	05°04'S 30°34'W	146	2.0	80.5 ± 3.7
A-6(2)	90.03.16	00°25'S 28°29'W	146	1.9	80.1 ± 4.9
A-5(2)	90.03.17	04°50'N 26°08'W	154	1.5	89.1 ± 4.2
A-4(2)	90.03.19	10°09'N 23°50'W	143	1.1	79.0 ± 4.2
A-3(2)	90.03.20	16°39'N 20°56'W	136	1.6	71.6 ± 4.4
A-2(2)	90.03.24	30°13'N 14°40'W	165	0.9	100.8 ± 4.1
A-1(2)	90.03.27	44°36'N 08°51'W	164	0.2	101.6 ± 5

The southern limit of the Nordic Seas is determined by the shallow Greenland-Scotland Ridge, which serves to impede the exchange of water with the deep Atlantic Ocean. Toward the Atlantic Ocean there is very little upwelling, and sinking water generally is replaced from the Norwegian Atlantic and East Greenland surface currents. These features of the circulation pattern, together with a delay in downwelling caused by the shallow Greenland-Scotland Ridge, explains the fact that the present ^{14}C concentration in the surface water of the Nordic Seas exhibit a higher ^{14}C concentration ($\Delta^{14}C$ = +50‰) than occurs at corresponding latitudes in the Antarctic Ocean ($\Delta^{14}C$ = −100‰).

DEEP-SEA PROFILES IN THE NORDIC SEAS

During the last five years, our ^{14}C measurements of deep-sea profiles have been limited largely to the Nordic Seas, where the exchange processes are rapid enough to be studied within a limited period of time. The Greenland Sea is assumed to be one of the main source regions for deepwater formed at higher latitudes (Smethie *et al.* 1986). The surface and intermediate waters sink as a result of surface cooling and deep convection during the winter. A mixture of deepwater from the Greenland Sea (GSDW) and the Eurasian basins (EBDW) is further assumed to be brought down through gaps in the ridge, to form the Norwegian Sea deepwater (NSDW) (Swift and Koltermann 1988; Bourke *et al.* 1993). An excess of water is also passing over the Greenland-Scotland Ridge to contribute to the deepwater in the Atlantic Ocean (AODW) (Swift *et al.* 1980). The locations of our ^{14}C profiles were chosen to give an optimal view of the transfer of carbon in this area (Fig. 4). The profiles are located in the East Greenland Current (A,C,E) at central positions in the main basins (D,F,G,I) in the Norwegian Atlantic Current and West Spitsbergen Current (B,H,J,K) and the Atlantic Ocean south of Iceland (L,M,N). The ^{14}C deep-sea profiles monitored 20 yr earlier during the GEOSECS expedition (Östlund, Dorsey and Brecher 1976), and some TTO profiles taken in 1981 (Östlund and Rooth 1981) have provided an important comparison and allowed a study based on changes that have occurred over that period.

TABLE 3. ^{14}C Measurements in the Surface of the Nordic Seas 1990–1992

Trondheim ref.	Arizona/ Trondheim (T)	Depth (m)	Date (yy.mm.dd)	Location	$\delta^{13}C$ (‰)	$\Delta^{14}C$ (‰)
LA1-1	T	4	90.07.21	77°43'N 32°30'E	--	61.5 ± 4.4
LA2-2A	T	50	90.07.23	78°12'N 29°50'E	--	59.4 ± 4.6
LA3-1	T	6	90.07.23	79°22'N 30°20'E	2.25	56.2 ± 4.2
LA4-1	T	5	90.07.27	79°01'N 41°54'E	2.28	60.3 ± 3.8
LA5-2A	T	5	90.07.30	80°31'N 29°12'E	--	57.0 ± 3.6
LA7-1	T	5	90.08.03	79°27'N 05°52'E	2.15	57.1 ± 4.6
LA8-2A	T	5	90.08.06	78°52'N 04°06'W	1.83	72.8 ± 6.1
LA10-01	T	6	90.08.11	74°59'N 02°29'W	1.54	51.3 ± 3.6
GS14-1	AA-7190	0	90.07.30	67°00'N 05°00'W	1.92	45.8 ± 4.0
GS14-2	AA-7191	10	90.07.30	67°00'N 05°00'W	1.84	37.1 ± 4.0
GS16-2	T	4	90.08.07	70°00'N 00°01'E	2.33	54.2 ± 3.8
GS17-2	T	5	90.08.10	69°31'N 14°50'W	--	47.3 ± 4.0
GS18-1B	T	4	90.08.11	71°08'N 07°29'W	--	33.1 ± 4.5
GS19-1A	T	4	90.08.13	69°57'N 09°36'E	--	65.1 ± 3.7
LA15-2	AA-8730	10	91.08.16	74°59'N 11°31'W	1.44	77.5 ± 4.7
MO16-1	AA-11940	4.5	91.09.06	62°35'N 15°31'W	2.32	35.4 ± 4.3
JH5-212	AA-9871	3	92.07.15	64°00'N 04°60'W	1.85	49.2 ± 4.1
JH9-212	AA-10203	5	92.07.16	61°31'N 16°20'W	0.98	−9.2 ± 4.2
JH10-212	AA-10139	4	92.07.19	63°30'N 32°30'W	1.69	−4.4 ± 4.7

The cyclonic Greenland gyre is supported by the West Spitsbergen Current in the east and the East Greenland Current in the west. It is constrained between the Fram Strait in the north and the Norwegian Sea in the south. Four deep-sea profiles of $\Delta^{14}C$ were obtained in this area (A,B,C,D, in Fig. 5a). Profiles A and B show typical differences in water masses and exchange on each side of the Fram Strait.[1] The East Greenland Current profile (LA8, LA17) shows a linear gradient from the surface to a depth of 1000 m. Between 1000- and 2000-m depth, the curve is more irregular and certainly due to the influence of other water masses. This deeper part of the profile also has a slightly higher salinity than in the middle of the Greenland Sea (Nydal *et al.* 1991) and probably reflects the influence of the saltier EBDW. The apparent $\Delta^{14}C$ inversion between *ca.* 1200- and 1800-m depth also indicates the influence of water from the relatively young GSDW.

[1]Note that the alphabetic indices in Figure 4 correspond to the profiles shown in Figure 5a, b, c and d.

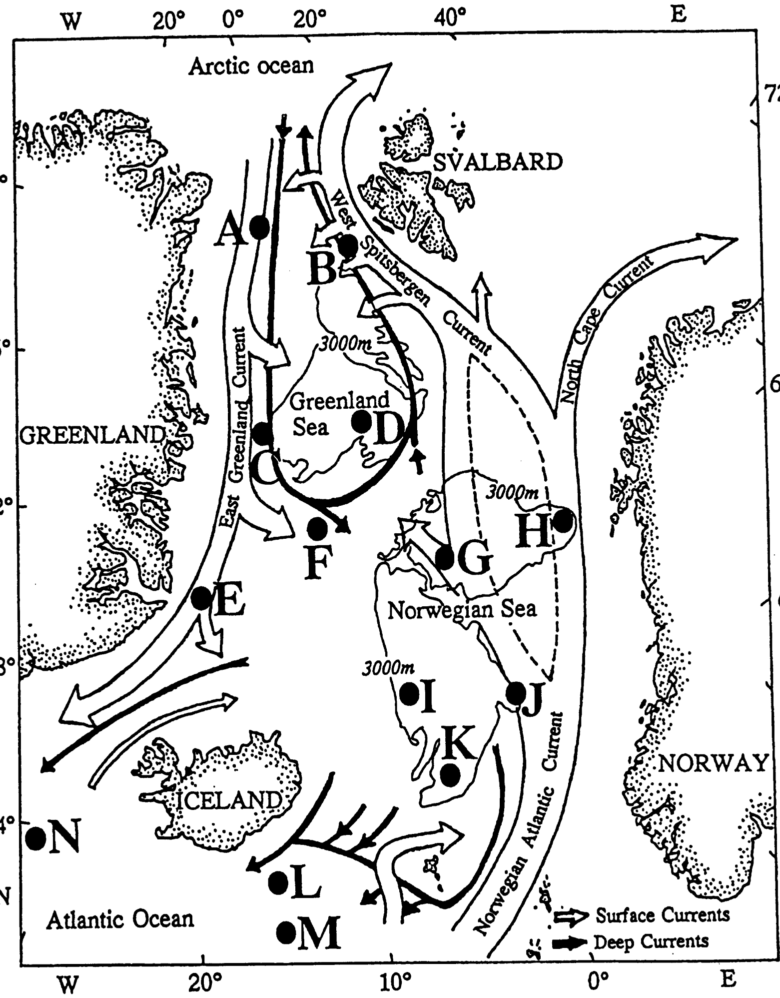

Fig. 4. Map of ^{14}C depth profiles in the Nordic Seas 1989–1992. The various letters A, B,...N indicate the approximate locations of the ^{14}C profiles seen in Fig. 5a,b,c,d.

The West Spitsbergen Current is a branch of the salty and warm Norwegian Atlantic Current. This is reflected in the $\Delta^{14}C$ values of the upper *ca.* 500 m of profile B (LA7), which records a small vertical gradient. The steepest gradient for vertical exchange occurs between 500 and 1000 m, where the $\Delta^{14}C$ values change by *ca.* 100‰. There is a further small decrease in $\Delta^{14}C$ down to 2000 m depth. The few neighboring TTO data from 1981 (Sta. 154 and 156) were collected closer to Svalbard, but they seem to support the shape of our profile.

Profile C (LA15), taken in the East Greenland Current, has a similar pattern to profile A. However, in this location, the linear trend extends to a depth below 2000 m. The curve is supplemented by three measurements from greater depth, taken just outside the shelf (LA14), which seem to fit well with the deepwater data for the northern profile (A). This feature indicates that the younger GSDW is affecting the profile at greater depth, *i.e., ca.* 2000–3000 m. The decrease in the ^{14}C concentrations below 3000 m suggests the influence of a deep current that may be connected to the NSDW.

In Profile D, data collected in the center of the Greenland gyre (LA10) are compared to the earlier GEOSECS (Sta. 17) and TTO (Sta. 148) profiles collected 18 and 9 yr earlier at approximately the same location. LA10 shows a $\Delta^{14}C$ range between +50‰ in the ocean surface to a mean value of −39 ± 2‰ (4 samples) below 2000 m depth. The lack of a $\Delta^{14}C$ depth gradient between 2000 and *ca.* 3500 m may indicate a well-mixed deep reservoir with a rapid internal circulation. We calculate that $\Delta^{14}C$ values in the deepest part of the profile have increased by 12 ± 2‰ relative to the GEOSECS profile recorded in 1972. An extrapolation back to the pre-bomb level (*ca.* 1960) in the deepwater is difficult to perform, because of little data and later change in deepwater formation (Schlosser *et al.* 1991). A linear increase in the sequestration rate of the tracer indicates, however, a pre-bomb $\Delta^{14}C$ level of *ca.* −60‰ for GDSW, a value close to that obtained for the surface water. The $\Delta^{14}C$ value of −59 ± 3‰ in the surface water is based on measurements of marine shells from Northern Norway and Spitsbergen (Mangerud and Gulliksen 1975). All of the TTO data from 1981 have $\Delta^{14}C$ values intermediate between the GEOSECS data and our 1990 values.

The area immediately south of the Greenland Sea, designated as the Norwegian and Icelandic Seas, is covered by four profiles (E,F,G,H; Fig. 5b), taken at virtually the same latitude, *i.e.,* 69° to 71°N. The upper parts of these profiles show a gradual change from the East Greenland Current (E) to the Lofoten Basin (H). Profile E, which includes two neighboring stations (GS17 and MO14), records a linear decrease in ^{14}C concentration from the surface to *ca.* 1500-m depth. The other profiles show a gradual eastward influence from the Norwegian Atlantic Current in the tendency to more uniform $\Delta^{14}C$ values in their upper depth ranges.

In Profile F (GS18), our measurements are compared with the TTO profile (Sta. 159) taken in 1981 at a slightly different location. If we assume that the two sampling locations represent the same water mass, then the comparison shows that the $\Delta^{14}C$ value below 500 m has increased by 15–20‰ between 1981 and 1990.

In Profile G (GS16), our measurements are compared with the GEOSECS (Sta. 18) and the TTO (Sta. 144) profiles. The earlier profiles show no significant input of bomb ^{14}C below 2000 m depth between 1972 and 1981. An increase of 7–8‰ was observed, however, in 1990. This is taken to indicate that the deep convection only reached this deepwater between 1981 and 1990. Compared to Profile D taken in the central Greenland Sea, the deepwater at location G is older and more in agreement with the water found at 2000 m depth in the periphery of the Greenland Gyre (C).

Farther south and into the more central part of the Norwegian Sea (Fig. 5c), we find that the deepwater becomes progressively older still. A comparison of the time-transient data in Profile I (GS14, MO10, GEOSECS (Sta. 19) and TTO (Sta. 144)) shows no significant differences in $\Delta^{14}C$ for water collected below 2000 m. The mean $\Delta^{14}C$ value of −73 ± 3‰ (6 samples) from the 1990–1991 measurements should not be much different from the pre-bomb level. The pre-bomb $\Delta^{14}C$ value in the NSDW is at least 10‰ lower than that of the surface water of the Greenland Sea. This corresponds to a decay of ^{14}C during a period of 100 yr from the surface to the deep Norwegian Sea. If the NSDW was mainly fed from the Greenland Sea, this period should be identical with the mean age of the NSDW. This water is, however, also in exchange with the EBDW, with other $\Delta^{14}C$ values that may modify the calculated age of the NSDW (Bønisch and Schlosser 1995).

The two profiles (J,K, Fig. 5c) measured in the southern Norwegian Sea indicate that the vertical mixing is faster at the periphery of the basin than in the central part. This is demonstrated clearly in Profile K, where our data (JH5) can be compared directly with that recorded at the GEOSECS station (19) in 1972. The other Profile J (weather ship station) over the slope of the Norwegian shelf is our only winter profile in the Nordic Seas. This profile has an identical pattern to a depth of *ca.*

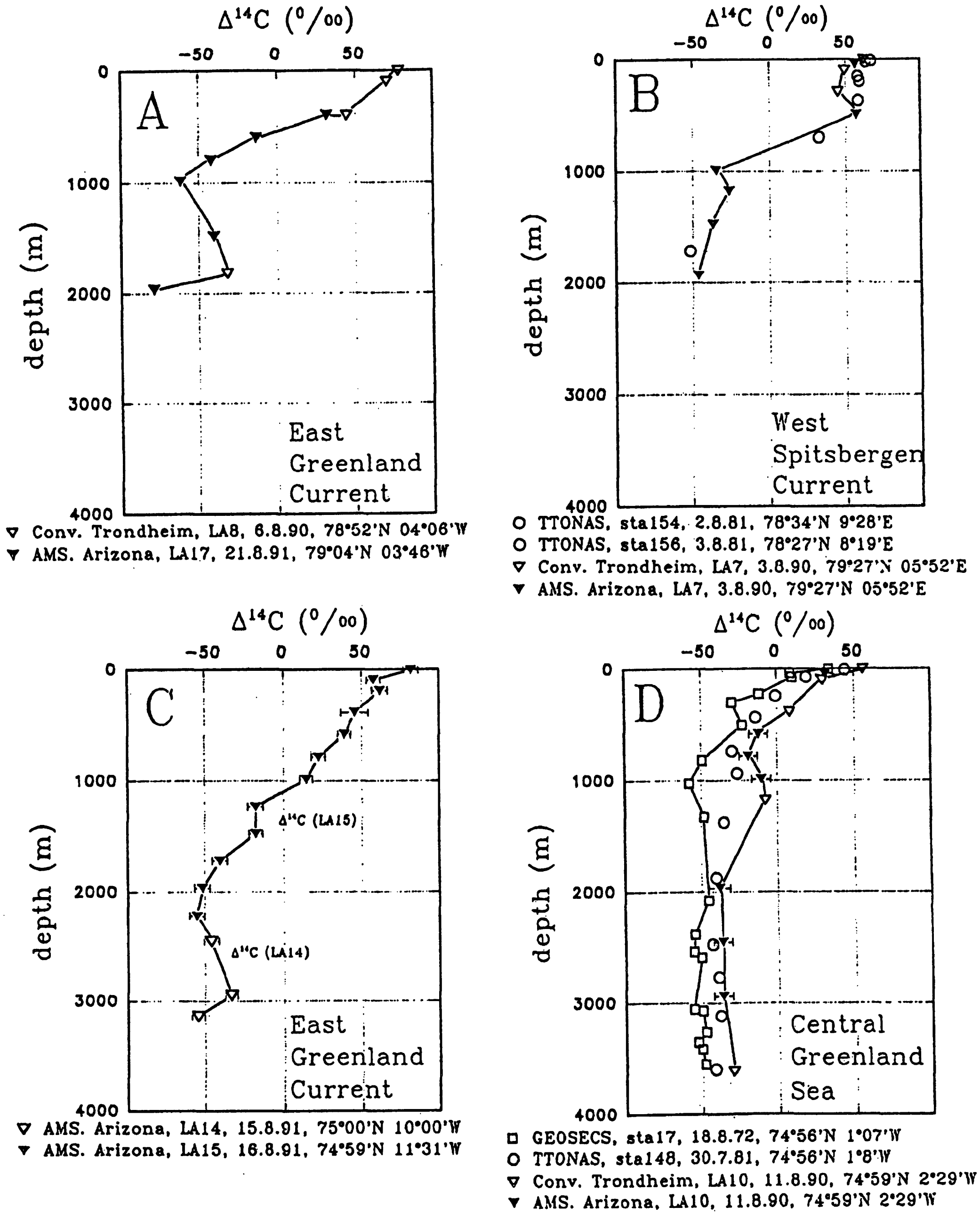

Fig. 5a. ^{14}C depth profiles in the Greenland Sea

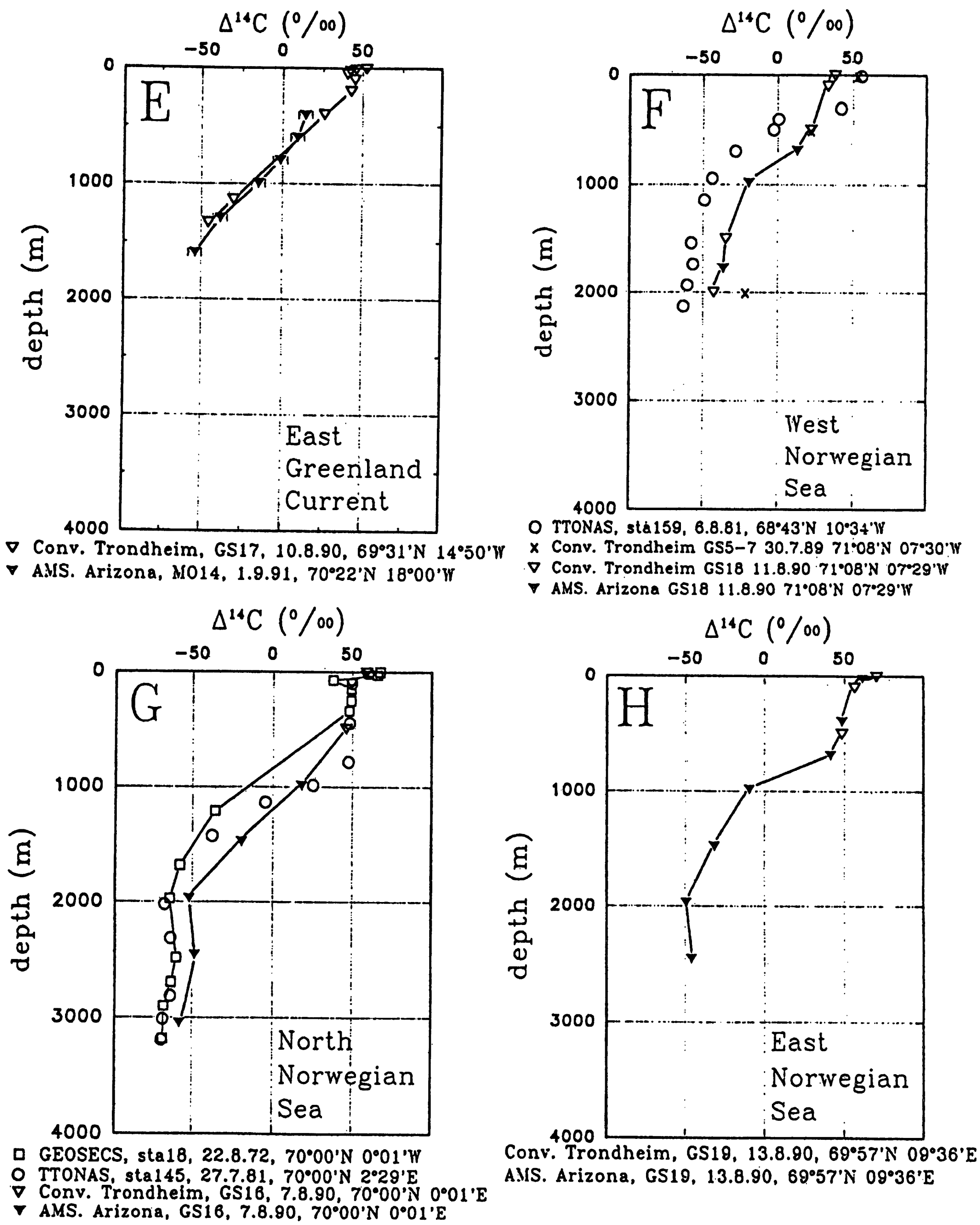

Fig. 5b. ^{14}C depth profiles in the Norwegian and Icelandic Seas

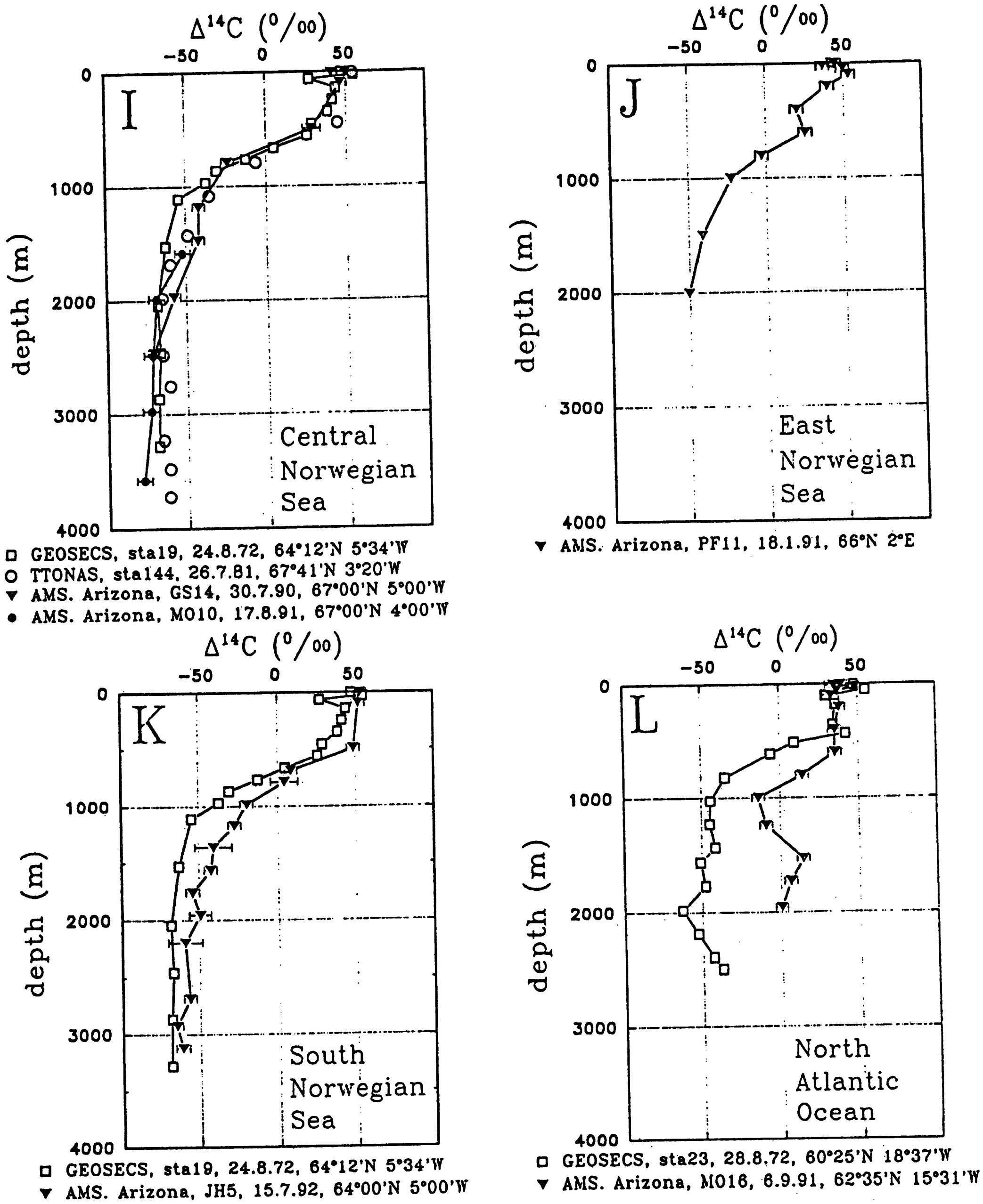

Fig. 5c. ^{14}C depth profiles from the Norwegian Sea to south of Iceland

2000 m where the recorded $\Delta^{14}C$ value is *ca.* −50‰. A similar value is recorded in all the profiles (B,H,J,K) taken along the shelf.

The most important changes in the ^{14}C depth profiles appear across the ridge and down to the North Atlantic Ocean. In profiles L (MO16) and M (JH9) our data are compared with the GEOSECS profile (Sta. 23) 1–2° further south; JH9 is also compared with the TTO profile (Sta. 142) some 8° further east (Fig. 5c,d). The two recent profiles, which are slightly apart, have the same trend as the GEOSECS profile. The comparison shows that a rapid downwelling occurs south of the ridge. The $\Delta^{14}C$ value below 1000 m is variable between +10 and −10‰, and this feature indicates that the NSDW makes a very small contribution to the overflow of water into the formation of the AODW. The downwelling water consists of mainly surface- and intermediate water, a result which is in accordance with that earlier pointed out by Heinze *et al.* (1990). The TTO profile from 1981 represents shallower water collected on the ridge further east.

Profile N, for the North Atlantic Ocean, compares our recent data (JH10) with the GEOSECS record (Sta. 11) obtained 3° further west (below the Denmark Strait) in 1972, and five TTO stations (164, 169, 170, 171) in the same general area sampled in 1981. The deepwater reflects surface and intermediate water from north of the ridge, in agreement with Strass *et al.* (1993) The TTO and GEOSECS profiles agree fairly well, but show a marked deviation from our profile (JH10). This raises the question as to whether this is caused by an unknown accident in sample treatment at this location, or by a temporary aberration due to local circumstances. During a later cruise (Nordic WOCE 1994) we were not able to reproduce this curve, but obtained data more in agreement with the TTO result.

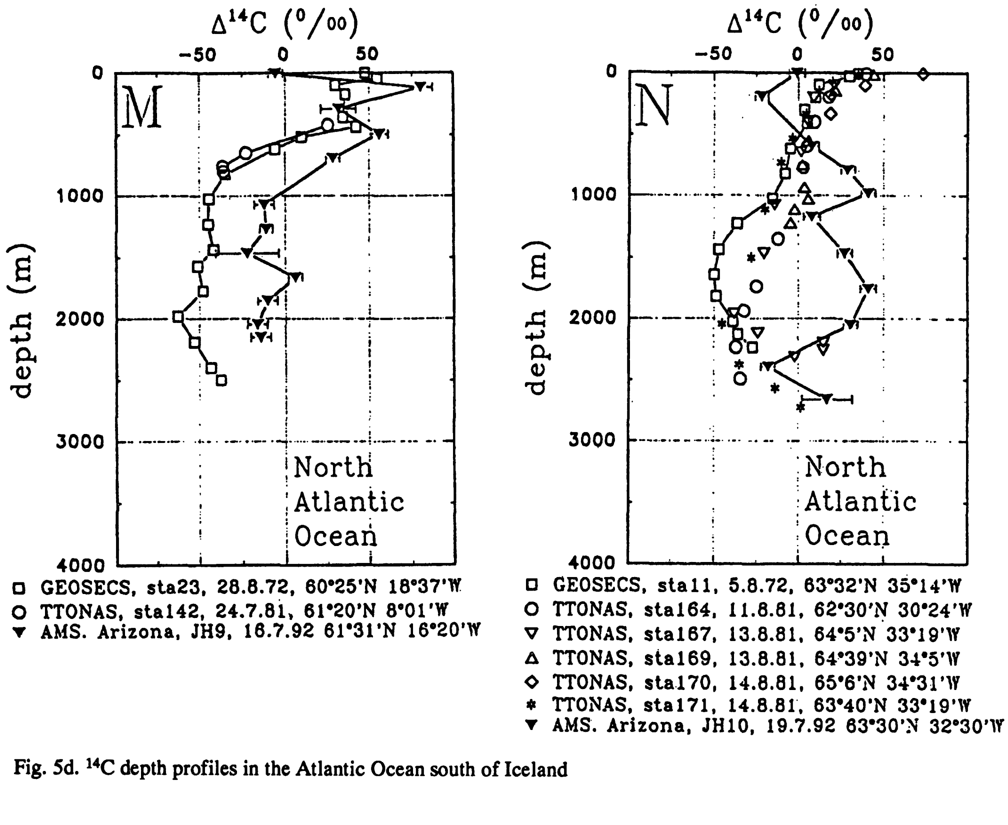

Fig. 5d. ^{14}C depth profiles in the Atlantic Ocean south of Iceland

SUMMARY AND CONCLUSION

In addition to those progressive changes recorded in the concentration of CO_2 in the atmosphere, the time-dependent distribution pattern for "bomb ^{14}C" introduced into the upper atmosphere during nuclear weapons test programs is an important tool for testing models that describe carbon exchange in nature. Here we have presented and discussed several such ^{14}C data sets recorded *via* samples collected over the past 30 yr from the lower atmosphere (troposphere) and oceans.

The trend in atmospheric ^{14}C concentrations recorded from northern Norway and the Canary Islands show large seasonal variations during the 1960s due to the net downward transfer of the major excess of "bomb ^{14}C" that had been injected directly into the stratosphere. Both curves indicate that, after 1972, the troposphere can be considered in general as a single well-mixed reservoir of "bomb ^{14}C", but with some very small localized disturbances still evident. Both sampling stations record an almost exponential decrease in the concentration of excess ^{14}C, with a rate constant of 0.055 yr^{-1}. Where small seasonal variations still occur, these are in the main due to localized dilution by ^{14}C-free CO_2 produced by the increased combustion of fossil fuels in winter. By 1992, the $\Delta^{14}C$ level in the lower atmosphere was *ca.* +100‰ above the pre-bomb level, and this was equal to the ^{14}C enrichment recorded in surface ocean water at equatorial latitudes (45°N to 45°S).

For the past 25 yr, the trend in $\Delta^{14}C$ in the equatorial surface ocean can be approximated by a horizontal line, *i.e.,* no significant temporal variation has occurred during that time. This feature reflects the role of the water mass as an effective buffer to ^{14}C exchange between the atmosphere and the intermediate and deep ocean carbon reservoirs. The $\Delta^{14}C$ profile of Atlantic Ocean surface water shows an approximate latitudinal symmetry around the equator poleward to 60°N/S, with the most stable regions coincident with the atmospheric high pressure cells at 30°N and 30°S. A slight decrease in ^{14}C concentration occurs at the equator, but a more dramatic lowering is evident toward higher latitudes, where the more stable surface layer vanishes.

The rate of further decrease in the amount of "bomb ^{14}C" in the atmosphere will be governed mainly by the ongoing exchange of CO_2 with the deep ocean. For the past five years, we have attempted to use ^{14}C as a tracer to study the transfer of carbon from the Nordic Seas to the deepwater reservoir of the Atlantic Ocean. Several deep-sea profiles have been produced to cover the North Atlantic Ocean from south of Iceland northward to the Fram Strait. These data have been compared with similar profiles obtained during the GEOSECS expedition in 1972 and the TTO expedition in 1981. Our measurements confirm that the water that is moving southward over the Greenland-Scotland Ridge into the deep Atlantic derives mainly from surface and intermediate depths in the Nordic Seas. The deepwater in the central region of the Norwegian Sea is too dense to have an important role in the mass transfer over the ridge. The obtained age of the NSDW is *ca.* 100 yr in the case that the main water derives from the surface of the Greenland Sea. The additional exchange of water between the NSDW and the EBDW may, however, modify this result.

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TRANSECT ALONG 24°N LATITUDE OF ^{14}C IN DISSOLVED INORGANIC CARBON IN THE SUBTROPICAL NORTH ATLANTIC OCEAN

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ABSTRACT. The distribution of bomb-produced ^{14}C in the ocean provides a powerful constraint for circulation models of upper ocean mixing. We report ^{14}C measurements from an east-west section of the main thermocline at 24°N latitude in the subtropical North Atlantic Ocean in summer 1992, and one profile from the Gulf of Mexico in 1993. Observed gradients reflect the transient invasion of bomb ^{14}C into the thermocline *via* mixing along isopycnals from the poleward outcrop, with progressively more sluggish mixing at greater depths. A slight deepening of the profile is observed over the 20-yr period since the GEOSECS survey at one location where the comparison is possible.

INTRODUCTION

The distribution in the ocean of ^{14}C produced by atmospheric nuclear weapons testing in the 1950s and early 1960s contains useful information about ocean mixing processes (Broecker *et al.* 1985). The penetration of bomb ^{14}C into ever deeper layers of the ocean constitutes a large-scale unintentional transient tracer experiment. According to the widely accepted oceanographic paradigm, the primary mode of entry into the ocean of bomb ^{14}C is mixing along surfaces of constant density (isopycnals) from the point at which these isopycnals intersect the surface wind-mixed layer in cold northern waters, known as the outcrop. Thus, mixing is primarily a horizontal phenomenon rather than a vertical one, and may involve travel of thousands of kilometers. As of 1992, some 30 yr after the peak of atmospheric bomb testing, little bomb ^{14}C had penetrated to the bottom of the main thermocline (that part of the ocean separating warm, less dense, seasonally ventilated shallower waters from cold, denser deepwater). Thus, this particular tracer is well suited at present to studies of mixing in the thermocline.

Our interest in the main thermocline stems from its being the region of the ocean in which most of the anthropogenic CO_2 taken up by the ocean is stored. As the mixed layer is nearly in equilibrium with atmospheric CO_2, air-sea exchange is relatively unimportant for the rate of ocean uptake of CO_2. Instead, it is the mixing of shallower and deeper reservoirs within the ocean that limits the rate of uptake (Siegenthaler and Sarmiento 1993), namely the mixing of surface waters along isopycnals with thermocline waters. When physically accurate general circulation models of the thermocline are capable of reproducing the observed ^{14}C distribution, given the known atmospheric ^{14}C boundary condition, the same model's estimates of oceanic uptake of CO_2 can be regarded with confidence. Taken together with other tracers that differ in the boundary condition, such as ^{85}Kr and the cholorfluorocarbons (which have air-mixed layer equilibration times of ~1 month versus ~10 yr for ^{14}C), ^{14}C provides a powerful verification tool for the physical transport in these models.

As an oceanographic contribution to the quincentennial celebration of Columbus's voyage of discovery in 1492, the Spanish naval vessel *Hesperides* made a transatlantic hydrographic and tracer section along Columbus's route at 24°N in July–August 1992 (Parilla *et al.* 1994). We took advantage of this ship of opportunity to take water samples for ^{14}C analysis. Eight density surfaces were

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sampled from the main thermocline to depths of ~850 m at nine stations with a regular spacing of ~500 km across the entire Atlantic Ocean. We present results here with no accompanying modeling attempt. It is our hope that modelers will use our results to improve and verify their own models.

METHODS

Samples were drawn from Niskin bottles that were tripped at target density surfaces, and the water was stored in 0.5-liter glass bottles with greased ground glass stopcocks. Samples were poisoned with $HgCl_2$ to prevent respiratory addition to the dissolved inorganic carbon (DIC) pool. In the laboratory, samples were acidified under vacuum and the CO_2 was collected over liquid N_2. Samples were graphitized and analyzed by accelerator mass spectrometry (AMS) at the AMS facility in Zürich, Switzerland. Results are reported in the ^{13}C-corrected $\Delta^{14}C$ in units of per mil (‰), as is customary (Stuiver and Polach 1977). Uncertainty (1 σ) is estimated at ± 5‰.

RESULTS

^{14}C depth profiles from analyses of waters above 1100 m are presented in Figure 1, and all analytical results are given in the Appendix along with density and depth. The first-order feature of the profiles in Figure 1 is the sharp gradient from high, post-bomb values in the upper 200 m to nearly pre-bomb values at 850 m depth. In keeping with the standard oceanographic paradigm, this gradient arises because mixing is less energetic on deeper isopycnals, since wind stress at the surface is the primary energy source for the mesoscale eddies that drive the bulk of the mixing (*e.g.*, Ledwell, Watson and

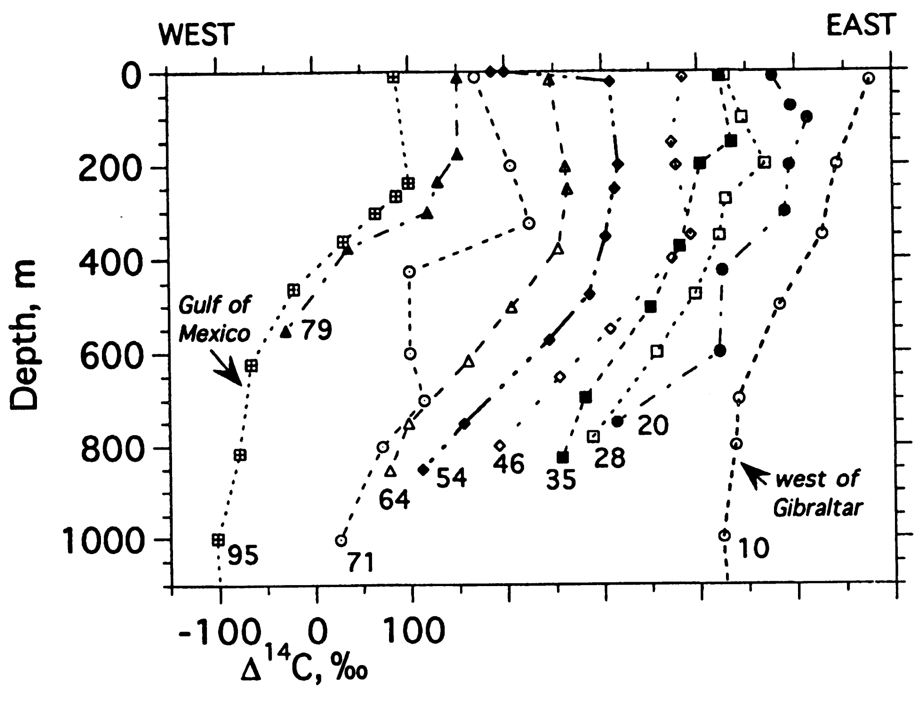

Fig. 1. $\Delta^{14}C$ along 24°N, Atlantic Ocean. Results of all analyses (except four that were deeper than 1100 m) are arranged by longitude. For clarity, all data sets have been separated by 50‰, such that each tick mark on the horizontal axis represents the zero for a successive profile. The labeled tick marks correspond to the Gulf of Mexico profile. Numbers near the bottom of each individual profile give the approximate longitude in degrees W.

Law 1993). Thus, at progressively deeper levels less ^{14}C is transported from the outcrop, which may be several thousand kilometers distant for this particular locality (Sarmiento 1983).

Figure 2 shows a "time series" at one station at 54°W longitude for which 1972 GEOSECS (Stuiver and Östlund 1980) data are available. Results at this station are plotted versus density rather than versus depth because the GEOSECS stations are not in the exact same spots as our survey. Because the isopycnals slope considerably in this region, the GEOSECS profiles differ by ~100‰ when plotted versus depth. In contrast, when plotted versus density the two 1972 profiles are nearly identical, as they should be given that mixing occurs along isopycnal surfaces.

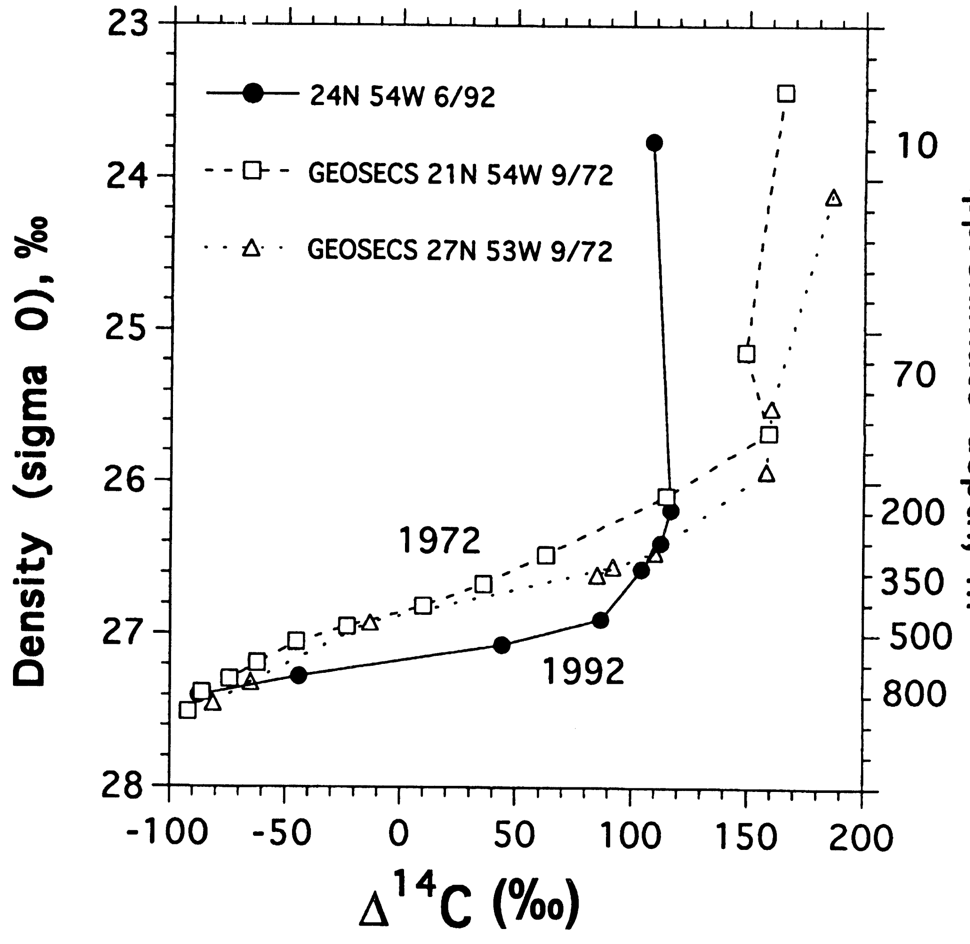

Fig. 2. Penetration of bomb ^{14}C into the main thermocline, 1972–1992. $\Delta^{14}C$ plotted *vs.* density at Station 66, 54°W longitude. GEOSECS data from nearby stations plotted for comparison (Stuiver and Östlund 1980). Note the ~200‰ difference in $\Delta^{14}C$ across the main thermocline between densities of 26.00 and 27.50. Also note the slight deepening of the profile in 1992 compared with the 1972 GEOSECS profiles.

In Figure 2, note the deepening of the profile that occurred in the 20-yr period spanned by the measurements. Although unsurprising, this deepening is evidence of ongoing mixing along the 26.00‰ to 27.00‰ isopycnals during this period. Also note the slight decrease in ^{14}C of surface waters, as expected from the decrease in the atmosphere over this period (Nydal and Løvseth 1983).

Figure 3 shows longitudinal transects of $\Delta^{14}C$ on three isopycnal surfaces, obtained by linear interpolation between shallower and deeper data points, as the samples did not fall exactly on these isopycnals. Note that there is a significant slope of the data toward the west, with higher values in the east. Since mixing occurs along isopycnals, these transects ought to be flat if mixing were rapid and complete along a given isopycnal. Instead, bomb ^{14}C might be entering the 24°N section first at the east, and later at the west. There might be an overall flow pattern from east to west at these main thermocline levels, and it would have to be somewhat sluggish for this along-isopycnal gradient to be preserved. Alternatively, outcrop-ward (N-S) along-isopycnal mixing might be more vigorous in the east than in the west, as isopycnals are bowed up closer to the surface in the east by the upwelling off the west coast of Africa, and so are exposed to more energy from wind stress than in the west. A third cause of the higher values in the east might be the injection of Mediterranean outflow water, which is rich in bomb ^{14}C due to the deep haline mixing of the Mediterrean Sea.

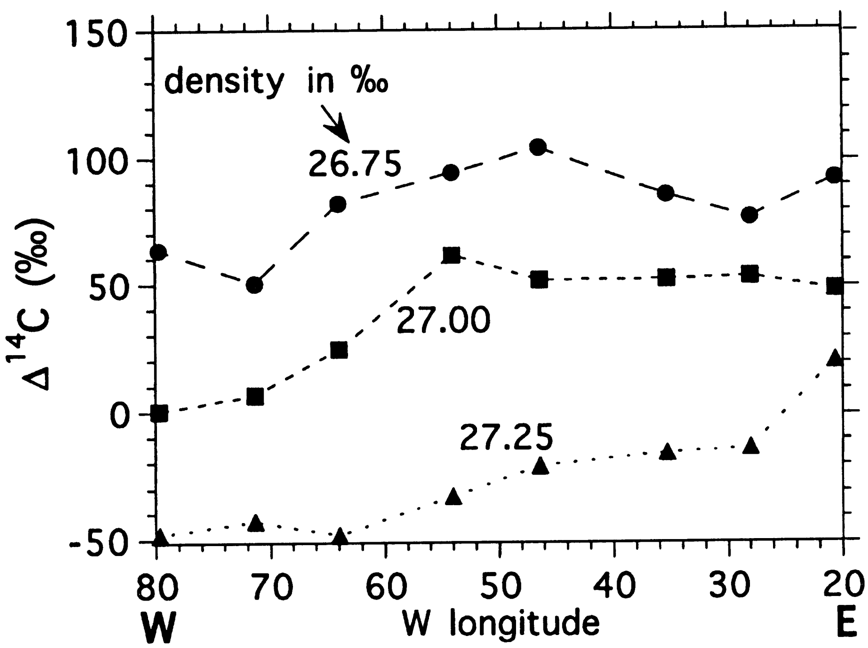

Fig. 3. East-west transects of $\Delta^{14}C$ along three isopycnal surfaces. Note the slight decrease in values toward the west. This may be due to poorer mixing in the west compared to the east, or to an overall slow east-to-west flow with ^{14}C entering first at the east. Mediterranean water may also contribute a high ^{14}C component to the eastern end of this gradient.

Bomb ^{14}C Inventories

To assess quantitatively the uptake of bomb ^{14}C for the purpose of comparison with models, we calculate the water column inventory of bomb ^{14}C at eight of our nine stations. We do this by subtracting from observed $\Delta^{14}C$ an estimate of the pre-bomb or natural $\Delta^{14}C$ using the measured SiO_2 and an empirical SiO_2–natural $\Delta^{14}C$ relation (Broecker *et al.* 1995). We then convert to atoms of ^{14}C per cm^2 of ocean surface using the measured hydrographic data and total DIC (TCO_2). Results are given in Table 1.

TABLE 1. Calculated Bomb ^{14}C Inventories along 24°N, Atlantic Ocean

Station	Location (lat., long.)		Sampling date (mo dy yr)	Inventory ($\times 10^9$ atoms ^{14}C)	Estimated surface natural $\Delta^{14}C$ (‰)
This Study					
13	24.50	−20.65	7 23 92	13.9	−60
24	24.50	−28.00	7 26 92	15.1	−61
35	24.50	−35.32	7 29 92	17.4	−61
53	24.48	−46.40	8 02 92	19.4	−61
66	24.48	−53.98	8 05 92	17.5	−61
81	24.48	−63.98	8 08 92	16.6	−61
92	24.48	−71.32	8 12 92	18.3	−62
107	26.05	−79.65	8 15 92	9.1	−61
GEOSECS					
31	27.0	−53.5	9 22 72	17.6	−44
33	21.0	−54.0	9 26 72	12.0	−50
115	28.0	−26.0	3 15 73	13.0	−43
117	30.7	−39.0	3 20 73	18.8	−41
TTO/TAS					
75	22.8	−37.3	1 12 83	16.8	−49
77	25.3	−34.9	1 14 83	18.3	−46
81	27.3	−29.3	1 16 83	18.3	−44
84	24.7	−26.9	1 18 83	15.1	−47
87	22.4	−24.7	1 19 83	10.3	−49

No clear pattern of variation emerges among the GEOSECS, TTO/TAS (Östlund 1983), and present study surveys of 1972, 1983 and 1992, respectively. We suspect that variations in the depth of isopycnals from station to station explains this, so comparison with earlier surveys is not warranted. However, note that the 1992 inventories show a crude maximum in the center of the gyre at 46°W longitude, as expected from the deeper isopycnals in this portion of the gyre.

Gulf of Mexico Profile

In addition to the 24°N transect, we sampled one station in the Gulf of Mexico on the cruise Gyre 93G01 on Jan 10, 1993 at a location of 26°40′N, 95°00′W. We followed the same sampling and analysis procedures as outlined above. Results are given in the Appendix, and show a pattern similar to the profiles of the 24°N transect.

SUMMARY

We present $^{14}C/C$ ratios of DIC in a transect of the main thermocline along 24°N latitude in the Atlantic Ocean taken in 1992. A large gradient of ~200‰ is seen between shallower and deeper portions of the thermocline, which we attribute to the transient penetration of the pulse of ^{14}C from atmospheric nuclear weapons testing 30 yr ago and the fact that deeper isopycnal surfaces are not as well ventilated as shallower ones. A comparison with 1972 GEOSECS data at one location reveals an ongoing penetration of the pulse to deeper levels. An decrease from east to west along isopycnal surfaces is suggestive of different mixing properties in the east compared to the west.

Acknowledgments

We gratefully acknowledge helpful discussions with William Smethie and Jordan Clark. We thank Antonio Cruzado and Frank Millero for providing us with prepublication SiO_2 and TCO_2 data, respectively. William Smethie and Millie Klas took the shipboard samples on our behalf. Guy Mathieu gave valuable laboratory instruction and advice. Peter Schlosser provided advice and financial support for the CO_2 extraction system. Irka Hajdas and Susan Ivy graphitized samples and ran the AMS analyses. J.P.S. was supported in this work by a Graduate Fellowship for Global Change sponsored by the U.S. Department of Energy and administered by Oak Ridge Institute for Science and Education.

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APPENDIX: RESULTS OF ^{14}C ANALYSES

Station	Date sampled	Location Lat.	Location Long.	Depth (m)	Temp (°C)	Density Sigma0 (‰)	$\Delta^{14}C$ (‰)	Comments
901	15-Jul-92	34°17′N	9°42′W	20			127	Mediterranean outflow
				200			93	(just west of Gibraltar)
				350			77	"Bio Hesperides VI"
				500			33	test cruise
				700			−10	(depths nominal)
				800			−13	
				1000			−26	
				1200			−19	
				1300			−40	
				1600			−52	
13	23-Jul-92	24°30′N	20°39′W	11	23.236	25.256	77	Hesperides VI cruise
				76	19.216	26.436	96	(E-W along 24°N lat)
				102	18.871	26.489	113	
				202	16.830	26.697	94	
				301	14.484	26.878	89	
				427	12.165	27.072	25	
				601	9.996	27.265	21	
				750	8.474	27.372	−86	
24	26-Jul-92	24°30′N	28°00′W	10	24.153	25.356	78	Hesperides VI cruise
				101	20.792	26.222	96	(E-W along 24°N lat)
				199	18.653	26.504	119	
				275	16.171	26.709	79	
				352	14.320	26.860	72	
				476	12.301	27.050	47	
				600	10.889	27.192	6	
				782	8.572	27.389	−61	
35	29-Jul-92	24°30′N	35°19′W	11	25.145	25.288	123	Hesperides VI cruise
				153	18.951	26.383	135	(E-W along 24°N lat)
				199	17.698	26.504	103	
				375	14.705	26.824	81	
				504	12.755	27.019	50	
				696	10.465	27.261	−19	
				827	8.635	27.427	−43	
53	2-Aug-92	24°29′N	46°24′W	12	26.713	24.676	135	Hesperides VI cruise
				153	19.155	26.221	123	(E-W along 24°N lat)
				202	18.622	26.329	128	
				351	16.900	26.574	143	
				401	16.189	26.660	123	
				552	12.859	26.981	58	
				653	11.072	27.166	5	
				800	8.677	27.371	−58	
66	5-Aug-92	24°29′N	53°59′W	23	27.824	23.753	109	Hesperides VI cruise
				200	19.707	26.182	117	(E-W along 24°N lat)
				252	18.346	26.402	113	
				353	17.026	26.571	104	
				476	14.578	26.902	87	
				574	12.640	27.070	44	
				752	9.826	27.277	−44	
				852	8.101	27.399	−88	
81	8-Aug-92	24°29′N	63°59′W	17	28.715	23.470	96	Hesperides VI cruise

Appendix (Continued)

Station	Date sampled	Location Lat.	Long.	Depth (m)	Temp (°C)	Density Sigma0 (‰)	$\Delta^{14}C$ (‰)	Comments
				203	18.865	26.329	112	(E-W along 24°N lat)
				252	18.157	26.445	114	
				379	16.711	26.649	104	
				502	14.656	26.878	55	
				618	12.358	27.061	10	
				751	9.908	27.262	−52	
				853	7.860	27.421	−72	
92	12-Aug-92	24°29′N	71°19′W	11	28.897	23.211	69	Hesperides VI cruise
				202	19.501	26.187	105	(E-W along 24°N lat)
				325	18.941	26.310	124	
				426	18.276	26.414	--	(excluded)
				602	15.283	26.756	--	(excluded)
				702	12.944	26.968	14	
				801	10.691	27.157	−29	
				1004	7.209	27.462	−74	
107	15-Aug-92	26°03′N	79°39′W	11	29.042	23.005	101	Hesperides VI cruise
				175	19.337	26.192	101	(E-W along 24°N lat)
				235	16.686	26.578	80	
				302	15.105	26.727	69	
				376	11.210	27.059	−14	
				551	6.345	27.432	−80	
5G	10-Jan-93	26°40′N	95°00′W	10	23.868	24.742	86	Gyre 93G01 cruise
				238	19.138	26.221	100	Gulf of Mexico
				267	17.672	26.410	87	Depths nominal
				303	16.152	26.599	65	Density values are
				362	13.783	26.839	31	Sigma - theta
				462	11.355	27.031	−21	
				623	8.561	27.227	−66	
				815	6.478	27.410	−79	
				1000	5.350	27.563	−102	
				1600	4.243	27.737	−91	

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WOCE PACIFIC OCEAN RADIOCARBON PROGRAM

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ABSTRACT. Fieldwork for the World Ocean Circulation Experiment (WOCE) radiocarbon program was recently completed. *Ca.* 9000 samples were collected for analysis using both conventional β-counting techniques and the newer AMS technique. The mean uncertainty for the β analyses is 3‰; for AMS analyses, *ca.* 4.5‰.

INTRODUCTION

The World Ocean Circulation Experiment (WOCE) has been an unprecedented effort to study large-scale ocean circulation, with fieldwork by scientists from more than 30 countries making many thousands of measurements. The overall goal of the program is to obtain a detailed description of the physical properties and circulation of the global ocean. These data will be used to determine the role of ocean circulation in global climate change and to help develop models that can be used to predict those changes.

A major component of WOCE was the "one-time survey". This phase of the fieldwork was conducted along both zonal and meridional hydrographic lines, on which stations were occupied with a nominal horizontal spacing of 30 nautical miles (~56 km, or ~0.5° latitude or longitude). At each station, discrete water samples (small-volume samples (SV)) were collected over the entire water column using a CTD equipped with a 24- to 36-place Rosette sampler. At some of the stations in the Pacific, the deep and bottom waters also were sampled using 250-liter stainless steel Gerard barrels to collect large-volume (LV) samples. Each small-volume sample was measured for pressure, temperature, salinity, oxygen, nitrate, nitrite, silicate and phosphate. Significant subsets of the SV samples were measured for chlorofluorocarbons, ^{3}H, ^{3}He, ^{13}C and ^{14}C. Through a collaborative effort with the Joint Global Ocean Flux Study (JGOFS) many of the SV samples were also measured for carbon species (generally TCO_2 and alkalinity). Pressure, temperature, salinity, silicate and ^{14}C were measured on all of the LV samples.

This paper gives an overview of the U.S. WOCE radiocarbon measurement program for the Pacific Ocean. All of the planned U.S. Pacific Ocean fieldwork has been completed. Table 1 summarizes the legs that were sampled for ^{14}C. For each entry, the table lists the cruise leg, the common cruise name (AKA, "also known as") and the official WOCE designation, the chief scientist for that leg, the dates of the cruise, the principal investigator (PI) responsible for ^{14}C collection and interpretation and the lab(s) responsible for the actual sample measurements.The Pacific Ocean stations that were sampled for ^{14}C are shown in Figure 1. Over 9000 samples were collected for ^{14}C analysis during this effort. Some of the apparent gaps in Figure 1 were filled by the sampling programs of other countries (primarily Australia, New Zealand and Japan). Some of the early results from these measurements are presented in this issue (Key *et al.* 1996; Stuiver *et al.* 1996).

METHODS

The goal of the WOCE Pacific radiocarbon program was to generate a data set of sufficient density and precision that the distribution could be described with reasonable accuracy in three dimensions. The GEOSECS survey of the Pacific deep and bottom waters (depths > ~1000m) clearly demonstrated that the meridional Δ^{14}C gradients were small (Östlund and Stuiver 1980). While no zonal

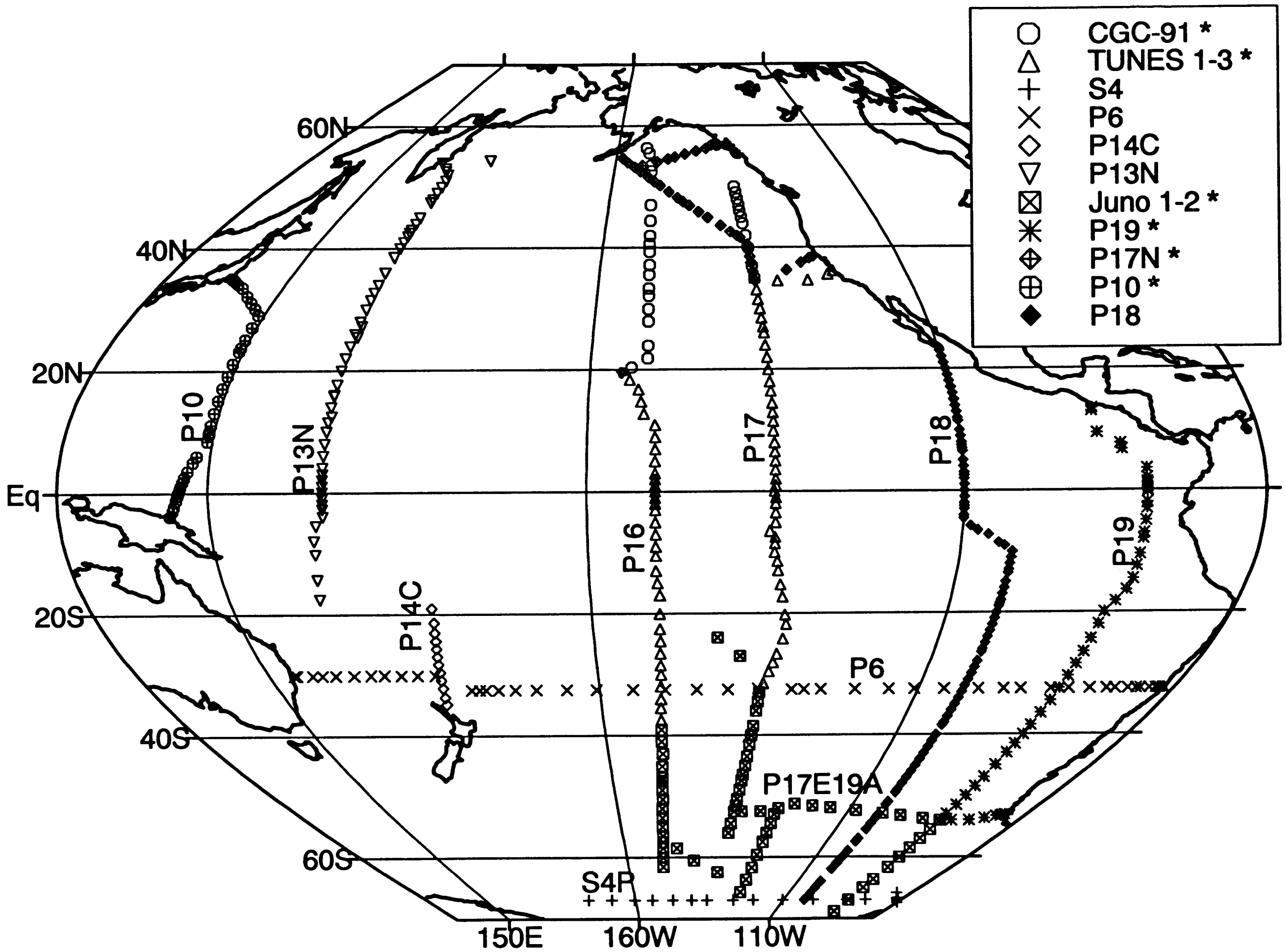

Fig. 1. Map of the stations sampled for $\Delta^{14}C$ as part of the U.S. WOCE effort in the Pacific Ocean. Details of the individual cruises are given in Table 1. Approximately every third station was sampled throughout the water column with the remainder sampled only through the thermocline. The station density on P18 appears to be greater but many of these stations were only sampled at the surface. Those cruises marked with ✳ in the legend were sampled using both the SV AMS technique and the LV β-counting method.

TABLE 1. WOCE Pacific Cruise Summary

Cruise	AKA WOCE name	Chief scientist	Cruise dates	^{14}C PI	Analytical lab AMS*/LV-β†
P17N‡	CGC-91 Leg 1 31DSCGC91/1	D.Weisgarver	2/16–2/28/1991	R. Key	NOSAMS[1] M. Stuiver
P16N	CGC-91 Leg 2 31DSCGC91/2	J. Bullister	3/7–4/8/1991	R. Key	NOSAMS[2] G. Östlund[3] M. Stuiver[4]
P17C	TUNES-1 31WTTUNES/1	M. Tsuchiya	5/31–7/11/1991	R. Key	NOSAMS[5] G. Östlund[6]
P16S17S	TUNES-2 31WTTUNES/2	J. Swift	7/16–8/25/1991	R. Key	NOSAMS[7] G. Östlund[8] M. Stuiver[9]
P16C	TUNES-3 31WTTUNES/3	L. Talley	8/31–10/1/1991	P. Quay	NOSAMS[10] M. Stuiver[11]
S4P	RUKDIOFFE6/1	Koshlyakov	2/14–4/6/1992	P. Schlosser	NOSAMS
P6E	316N138/3	H. Bryden	5/2–5/26/1992	R. Key	NOSAMS[12]
P6C	316N138/4	M. McCartney	5/30–6/7/1992	R. Key	NOSAMS[13]
P6W	316N138/4	J. Toole	6/13–6/30/92	R. Key	NOSAMS[14]
P14C	316N138/7	D. Roemmich	9/1–9/15/1992	R. Key	NOSAMS
P13N	CGC-92 Leg 1 3220CGC92/1	J. Bullister	8/3–9/10/1992	P. Quay	NOSAMS
P16A17A	Juno-1 316N138/9	J. Reid	10/6–11/26/1992	R. Key	NOSAMS[15] G. Östlund[16]
P17E19A	Juno-2 316N138/10	J. Swift	12/4/92–1/22/1993	R. Key	NOSAMS G. Östlund[17]
P19C	316N138/12	L. Talley	2/22–4/13/1993	R. Key	NOSAMS G. Östlund[18]
P17N	325021/1	D. Musgrave	5/15–6/26/1993	P. Quay R. Key	NOSAMS M. Stuiver
P10	3250TN026/1	M. Hall	10/5–11/10/1993	R. Key	NOSAMS M. Stuiver
P18S	31DSCGC94/2	B. Taft	2/22–3/2/1994	P. Quay	NOSAMS
P18N	31DSCGC94/3	G. Johnson	3/27–4/27/1994	P. Quay	NOSAMS

*NOSAMS determined $\delta^{13}C$ for all AMS^{14}C measurements except for legs on which P. Quay was PI.
†M. Stuiver determined $\delta^{13}C$ for all LV samples
‡Not an official WOCE cruise
[1]NOSAMS 1994a; [2]NOSAMS 1994a; [3]Östlund 1992a; [4]Stuiver 1994; [5]NOSAMS 1994c; [6]Östlund 1992b, 1994; [7]NOSAMS 1995a, 1996; [8]Östlund 1994, 1995; [9]Stuiver 1994; [10]NOSAMS 1996; [11]Stuiver 1994; [12]NOSAMS 1995b; [13]NOSAMS 1994b; [14]NOSAMS 1995b; [15]NOSAMS 1995c; [16]Östlund 1995; [17]Östlund 1994, 1995; [18]Östlund 1994, 1995

section was collected during GEOSECS, the data were sufficient to indicate that deep zonal $\Delta^{14}C$ gradients would be even smaller.

During the planning phase of WOCE, the accelerator mass spectrometry (AMS) technique for measuring ^{14}C was still relatively new in the United States. The general procedures had been worked out, but no lab was prepared to handle the large number of samples expected from the WOCE program, nor had it been demonstrated that the AMS technique could deliver the required precision on a routine basis. The National Ocean Sciences AMS Facility (NOSAMS) at Woods Hole Oceanographic Institution was established in 1989 to serve this purpose. In planning the WOCE Pacific fieldwork, it was recognized that sample collection would begin well before NOSAMS could deliver the high precision offered by conventional β-counting techniques. Therefore, both techniques were utilized.

On those legs which included both LV and SV sampling, the LV stations were spaced at an average interval of 5° (~300 nautical miles = ~555 km). LV stations normally included two casts of nine Gerard barrels each covering the water column from ~1000 m to the bottom. The upper kilometer of a LV station was covered by 16 SV samples taken from the CTD/Rosette cast. The legs that included both sample types are the ones that have more than one entry in the rightmost column of Table 1 and are indicated in Figure 1 by a ✳ in the legend. One to three SV stations were placed between each LV station. On SV stations only the upper thermocline region was sampled, using 16 SV samples.

^{14}C was extracted from the LV samples at sea as $^{14}CO_2$, absorbed on excess NaOH and returned to shore in well-sealed glass bottles using a modification of the technique described by Fonselius and Östlund (1959) (Key 1991; Key *et al.* 1991). Once ashore, the samples were sent to one of two labs for analysis: Tritium Laboratory, University of Miami, Miami, Florida (G. Östlund, director); or Quaternary Isotope Laboratory, University of Washington, Seattle (M. Stuiver, director). A short description of the measurement procedure and a cross-check between these two labs is available in Stuiver *et al.* (1974). Stuiver reports an error estimate for each analysis ranging from 2.5 to 4.0‰; Östlund reports a uniform sample error of 4‰. In both cases, the reported uncertainty is primarily counting error and does not include any error due to sample collection. All $\delta^{13}C$ measurements for the LV samples were made by Stuiver.

All SV ^{14}C samples were collected from standard CTD/Rosette casts into 500-ml glass bottles fitted with high-quality ground glass stoppers. The samples were poisoned with $HgCl_2$ immediately after collection, then returned to the U.S. for extraction and analysis at NOSAMS. Details of the extraction, counting, *etc.* are available from Key (1991), McNichol and Jones (1991), Gagnon and Jones (1993), Cohen *et al.* (1994), McNichol *et al.* (1994), Osborne *et al.* (1994), Schneider *et al.* (1994) and Séguin *et al.* (1994). All $\delta^{13}C$ analyses, except for the samples collected by Quay (who extracted and measured his own $\delta^{13}C$ values), were performed at NOSAMS.

The standards for the ^{14}C measurements were NBS oxalic acid standards (Östlund, RM 49 and SRM 4990C; Stuiver, RM 49 and SRM 4990C; NOSAMS, SRM 4990 and SRM 4990C). All results are reported as $\Delta^{14}C$, which is the deviation in per mil (‰) from unity of the sample to standard activity ratio, isotope-corrected to a sample $\delta^{13}C$ value of –25‰. (For more information on standards and calculation methods, see Broecker and Olson (1961), Stuiver and Robinson (1974) and Stuiver (1980).) As measurements were completed, the results were communicated from the analytical lab to the PI responsible for the cruise *via* periodic data reports (see footnotes to Table 1). R. Key gathered the $\Delta^{14}C$ data from the PI, merged it with hydrographic data supplied either by the chief scientist or by the WOCE Hydrographic Office (WHPO), added WOCE quality-control flags, and finally submitted the data to WHPO along with a final report for each leg (Key 1994, 1995, 1996a–i; Key and Quay 1996). All of the LV samples collected in the Pacific will be completed by 1997 and the Pacific SV samples by 1998.

DATA QUALITY

The precision of the LV technique was established during the GEOSECS program to be 2–4‰. This precision is primarily a function of sample counting time and has held constant throughout the succeeding large-scale ocean survey programs. What was unknown at the beginning of WOCE was the ultimate precision of the AMS technique and whether or not the AMS and LV data would be totally compatible, *i.e.,* no systematic errors would be found in either data set.

NOSAMS is currently running water samples with a mean "external" precision of 3.6‰. This precision is indicative of the AMS target preparation and counting and does not include any uncertainty due to sample collection, storage or stripping. A better estimate of the sample precision can be obtained by comparing the results from duplicate samples. A summary all of the true WOCE duplicates (*i.e.,* two different sample bottles rather than two analyses from the same bottle) analyzed at NOSAMS showed that the average of the standard deviation for each pair was 4.6‰. The reason for the difference between this number and the external precision estimate (3.6‰) is currently unknown, but must involve either sample collection or sample processing prior to counting. A reproducibility of 3‰ is needed for the AMS technique to be equivalent to the average uncertainty for the LV technique. Sample storage experiments at NOSAMS and other facilities have so far indicated that this is not a source of error.

Once all of the Pacific samples are completed, sufficient data will exist to make statistically significant comparisons between AMS and LV sampling. For now, the best that can be done is to graphically compare WOCE stations where the two techniques overlap, and to compare WOCE results in deepwater to GEOSECS results. Figure 2 shows results from TUNES-2 (P16S17S) station 179, Juno-1 (P16A17A) station 119 and P6C station 100 taken at *ca.* 33°S, 135°W. The TUNES station includes both LV and SV samples and was occupied on 7/1991. Stuiver analyzed the LV samples from this station. The Juno occupation was on 11/1992 at the same location as the TUNES station. Östlund measured the LV samples from Juno-1. The P6 station was *ca.* 250 nautical miles away (463 km) and was occupied on 7/1992. Each datum is shown with 2-σ error bars. At this scale, the agreement between the techniques appears to be good. The only possible systematic difference is in the upper thermocline, with the TUNES samples being slightly lower than those from Juno and P6. This apparent offset may be due to a real difference in the water column structure. A better place to compare the results is in the deepwater. The insert in the lower right portion of Figure 2 shows the data from the bottom 2 km on a greatly expanded scale. The pressure scale for the insert is aligned and scaled to match the pressure scale of the main figure. There is some structure in the $\Delta^{14}C$ signal, but there is no apparent systematic difference between the measurement techniques. This plot clearly demonstrates the need for very high-precision data in the deep and bottom waters.

Another data test can be made by comparing the new AMS data to existing historical data. Figure 3 shows a plot of WOCE P6 station 148 (32.5°S, 163.6°W; 6/1992) AMS results (NOSAMS 1994b) with GEOSECS station 306 (32.5°S, 165.2°W; 3/1974) LV results (Östlund and Stuiver 1980). The invasion of bomb ^{14}C into the thermocline is clearly evident. The deep- and bottom-water data are shown on an expanded scale in the insert in the lower right portion of the figure. The deepwater data (2500–4500 m) from the two stations appear to be the same. Below 4500 m the AMS $\Delta^{14}C$ results are slightly higher than the GEOSECS results. At this point it is difficult to determine if this difference is a measurement difference or a small bomb-produced ^{14}C signal that has been introduced into the bottom waters since the time of GEOSECS. The meaning of differences this small will require a careful statistical analysis of the full WOCE data set.

Conclusion

The Pacific Ocean WOCE program has generated a new high-quality data set for analyzing the distribution of ^{14}C. Comparison using currently available data indicates that measurements using the

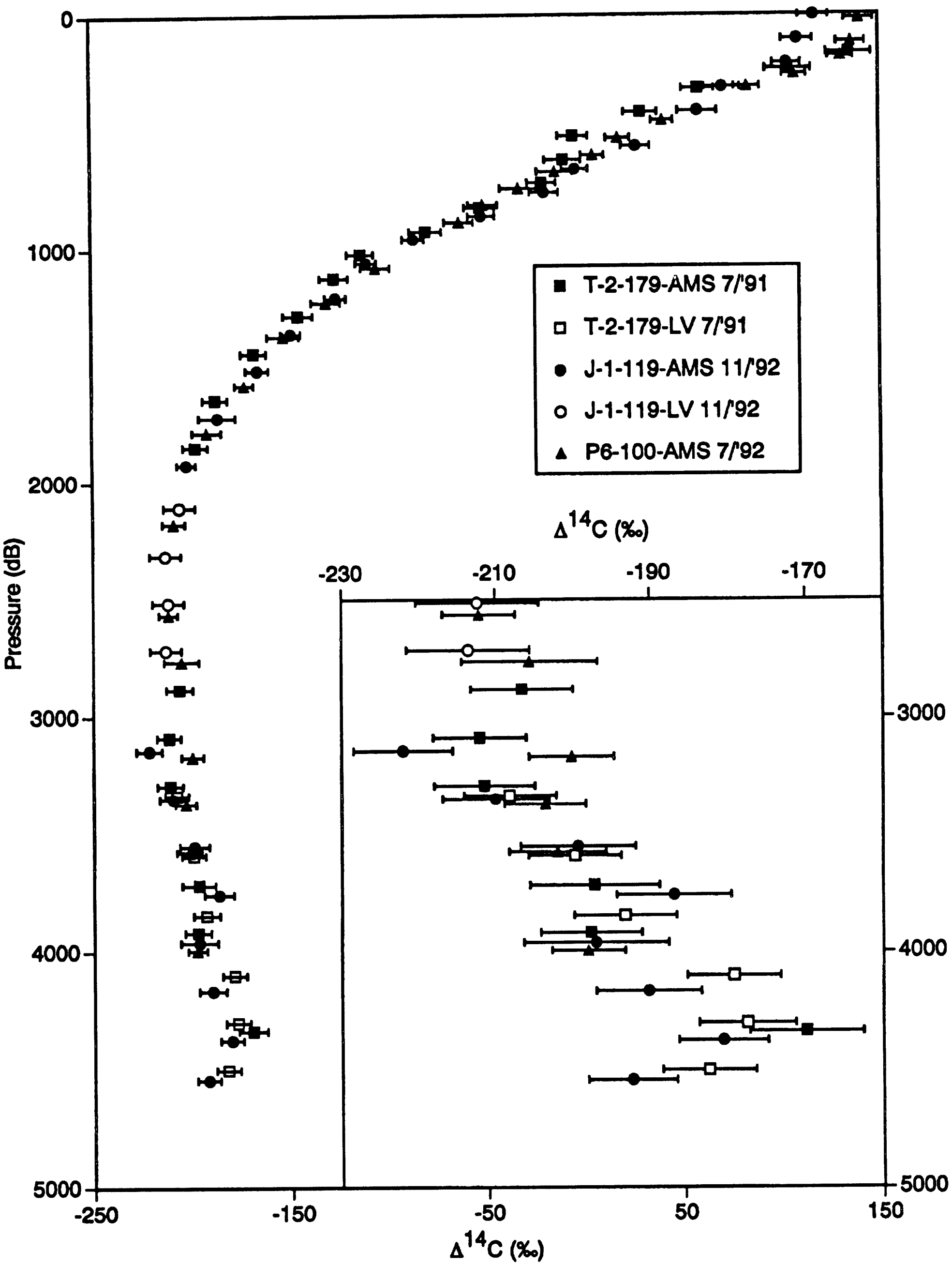

Fig. 2. Comparison of AMS and LV results for three stations in the south-central Pacific Ocean. The TUNES-2 station 179 data and the Juno-1 station 119 data were collected at the same location (33°S, 135°W), but 14 months apart (7/1991 and 11/1992, respectively). The P6 station 100 data (7/1992) were collected *ca.* 250 nautical miles (463 km) away (32.5°S, 130°W). The insert shows data from the bottom 2500 dB on an expanded scale. Both LV and AMS techniques were employed on the TUNES and Juno cruises while only AMS was used on P6. No systematic difference in techniques is evident for these data.

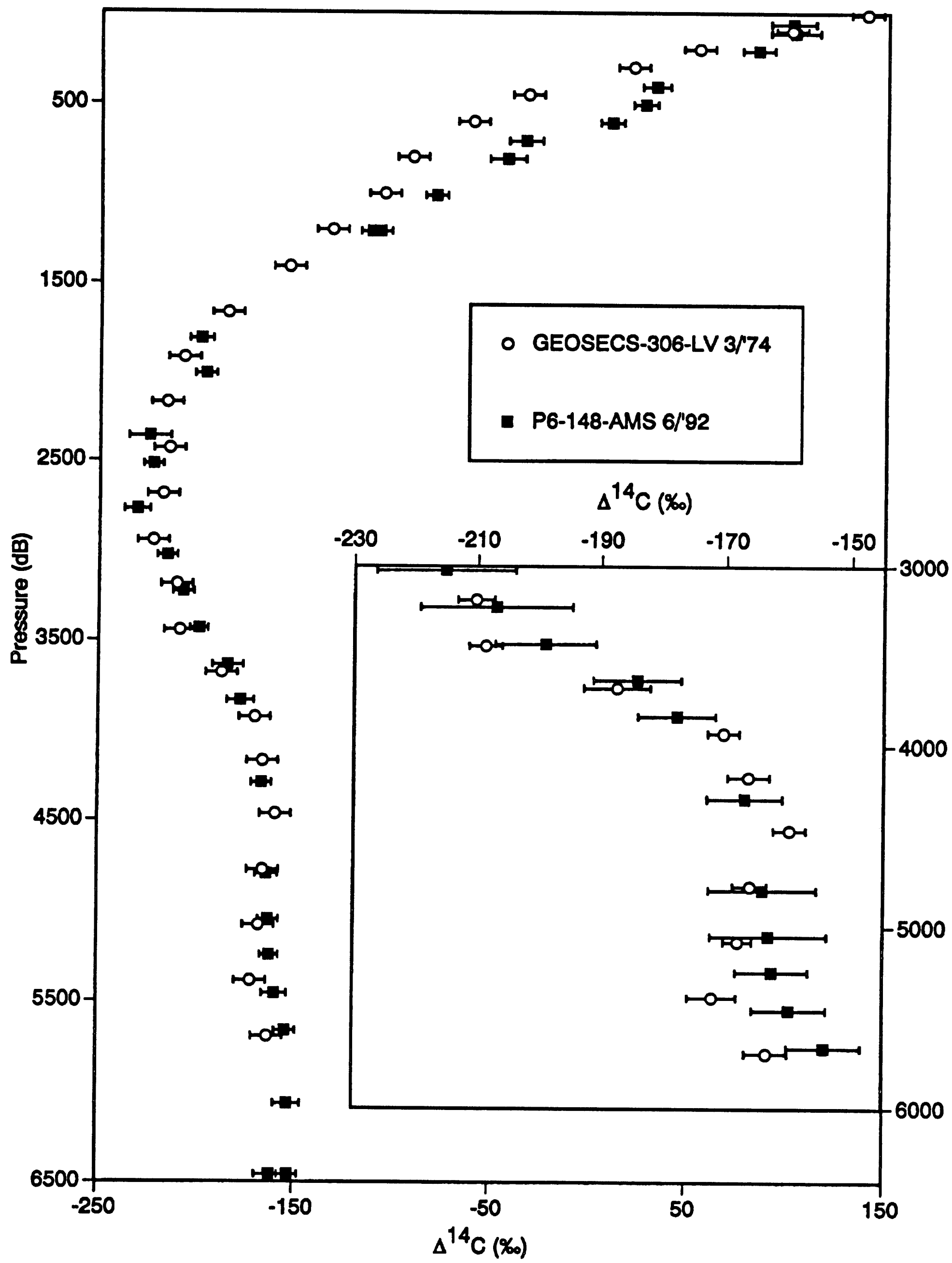

Fig. 3. Comparison of WOCE AMS (P6 station 148, 32.5°S, 163.6°W, 6/1992) results with GEOSECS (station 306, 32.5°S, 165.2°W, 3/1974) LV results. (Error bars represent the 2-σ range). Data from the 3000–6000 dB range is shown on an expanded scale in the insert. The invasion of bomb-produced ^{14}C during the time interval between the expeditions is clearly evident in the 250–1250 dB range. The deepwater values for the two stations appear to be the same. A statistical analysis of the entire WOCE data set will be required to determine if the slight difference *ca.* 5500 dB. is significant. If real, the direction of the bottom water difference is consistent with a very small addition of bomb-produced ^{14}C over the time interval.

newer AMS technique are comparable to the WOCE LV data as well as to the historical data. The combined WOCE data set is approximately an order of magnitude larger than all prior measurements in the Pacific combined.

ACKNOWLEDGMENTS

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WOCE AMS RADIOCARBON I: PACIFIC OCEAN RESULTS (P6, P16 AND P17)

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ABSTRACT. AMS radiocarbon results from the World Ocean Circulation Experiment in the Pacific Ocean show dramatic changes in the inventory and distribution of bomb-produced ^{14}C since the time of the GEOSECS survey (8/73–6/74). Near-surface $\Delta^{14}C$ values for the eastern portion of both the northern and southern subtropical gyres decreased by 25–50‰, with the change being greater in the north. Equatorial near-surface values have increased by *ca.* 25‰. Changes in the 250–750-m depth range are dramatically different between the northern and southern basins. The intermediate and mode waters of the southern basin have increased by as much as 75‰ since GEOSECS. Waters of similar density in the northern hemisphere are not exposed to the Southern Ocean circulation regime and are significantly less ventilated, showing maximum changes of *ca.* 50‰.

INTRODUCTION

This is the first in a series of papers reporting radiocarbon results from the World Ocean Circulation Experiment (WOCE). A general overview of the WOCE ^{14}C program was given by Key (1996). That paper shows WOCE Pacific Ocean cruise tracks with details of each leg, outlines the sampling strategy and method, and compares the early AMS and beta-counting results. Only results that were analyzed by accelerator mass spectrometry (AMS) are given here. We describe the AMS sampling and analysis method used during the WOCE program, present results from three sections in the Pacific Ocean, and qualitatively compare the results from one WOCE section to the GEOSECS data (Östlund and Stuiver 1980). In a companion paper, Stuiver *et al.* (1996) report on large-volume (LV) sample results from the sections discussed here.

METHODS AND PRECISION

On most Pacific WOCE legs, AMS ^{14}C sampling was limited to the upper water column (0–1200 m). Deep and bottom waters were generally sampled using LV samples that were subsequently extracted and analyzed using the β-counting technique. Full water column stations were spaced *ca.* 300 nautical miles apart (~556 km). The upper water column was sampled at one or more stations between each full depth station. On cruises that did not have a LV sampling component (*e.g.*, P6), the AMS technique was used for all samples.

As two very different techniques were used during the Pacific WOCE ^{14}C program, the accuracy of the AMS technique is just as important as the precision. This issue was addressed by Key (1996). With the data available so far, no statistically significant difference in accuracy has been found between the WOCE AMS measurements and the WOCE LV β-counting measurements. The same result was obtained when both WOCE methods were compared to GEOSECS results.

The internal precision of the AMS technique has improved from >10‰ in early 1992 to <4‰ for current measurements. The mean standard deviation of replicate samples is *ca.* 5‰. This value is still decreasing and should soon be as good as the precision obtained for the standard β-counting technique (~3‰). Details of the sample collection and analysis techniques and of the WOCE quality control procedures are given in Appendix I.

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Data Set

The AMS ^{14}C results measured so far for WOCE sections P6, P16 and P17 are listed in Appendix II. The location of the three sections is shown in Figure 1. Accompanying the $\Delta^{14}C$ data are pressure in decibars, temperature relative to the international temperature scale 1990, salinity relative to the Practical Salinity Scale and silicate concentration in μmol kg^{-1}. Also included are the quality control flag values assigned for the salinity, silicate and $\Delta^{14}C$ measurements. For details of the various legs that went into each section, see Key (1996).

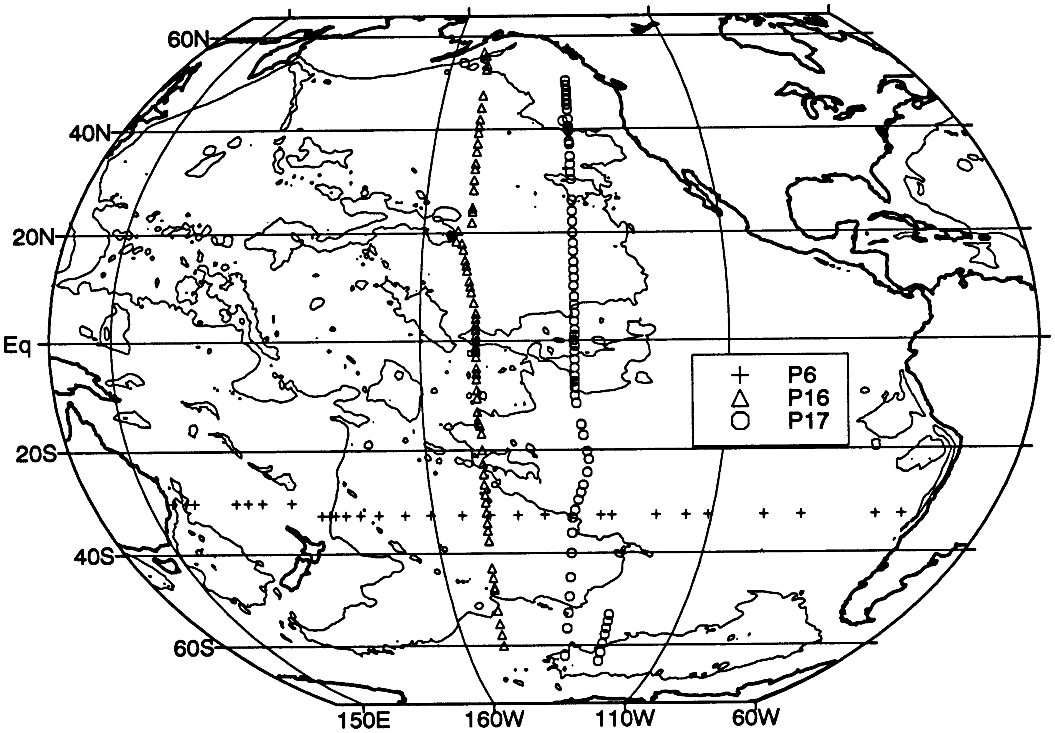

Fig. 1. Location of $\Delta^{14}C$ stations for WOCE sections P6, P16 and P17. Note that not all stations from the sections are shown, nor is data included here for all stations shown. Bathymetry shown is 4500 m.

Results

Because of the sample distribution, the WOCE Pacific Ocean AMS results are used primarily to study upper ocean processes, whereas the LV samples are used to study deep and bottom water processes. The upper ocean $\Delta^{14}C$ distribution is dominated by the influx of ^{14}C generated by atmospheric nuclear weapons tests during the 1960s. If one can differentiate the bomb ^{14}C from the natural background component, then this information can be used to calibrate numerical global ocean circulation models (*e.g.*, Toggweiler, Dixon and Bryan 1989), to determine upwelling and thermocline ventilation rates (*e.g.*, Toggweiler, Dixon and Broecker 1991; Quay, Stuiver and Broecker 1983) and to estimate the transfer of CO_2 from the atmosphere to the ocean (*e.g.*, Broecker and Peng 1974; Peng, Key and Östlund 1996). An attempt to separate the bomb and natural components will be the topic of future publications.

Östlund and Rooth (1990: Fig. 2) compared adjacent vertical sections of TTO (Transient Tracers in the Ocean) and GEOSECS data for the North Atlantic Ocean. A different technique is used here to compare WOCE section P17 to GEOSECS. Comparison of GEOSECS to P16 yields very similar qualitative results and is therefore omitted. Unfortunately, it is impossible to assemble a reasonable zonal $\Delta^{14}C$ section from GEOSECS data for the South Pacific. Therefore, the major features of WOCE section P6 are simply described. Quantitative estimates for the Pacific will be carried out in the near future once the entire WOCE Pacific ^{14}C data set is available.

GEOSECS data is especially sparse in the eastern Pacific. In order to prepare the figures that follow, the Pacific GEOSECS data from approximately the dateline eastward were considered representative of an average eastern Pacific section. This average GEOSECS section is then compared to WOCE section P17 along 135°W. Property maps on density (or depth) surfaces for the Pacific clearly indicate that the primary trend of the property isolines is east to west rather than north to south, so the errors of this comparison should be reasonably small.

Figure 2 compares the surface $\Delta^{14}C$ values from the eastern Pacific GEOSECS stations (0–100m depth range, 1973–1974, stations 287, 290, 293, 296, 322, 320, 317, 326, 331, 334, 337, 343, 347, 214 and 217) and the WOCE P17 section (0–50m depth range) along 135°W (1991–1992). The GEOSECS data includes samples collected from Gerard barrels and obtained by pumping. WOCE section P17 contains data from five cruises: P17N, P17C, P16S17S, P16A17A and NOAA cruise

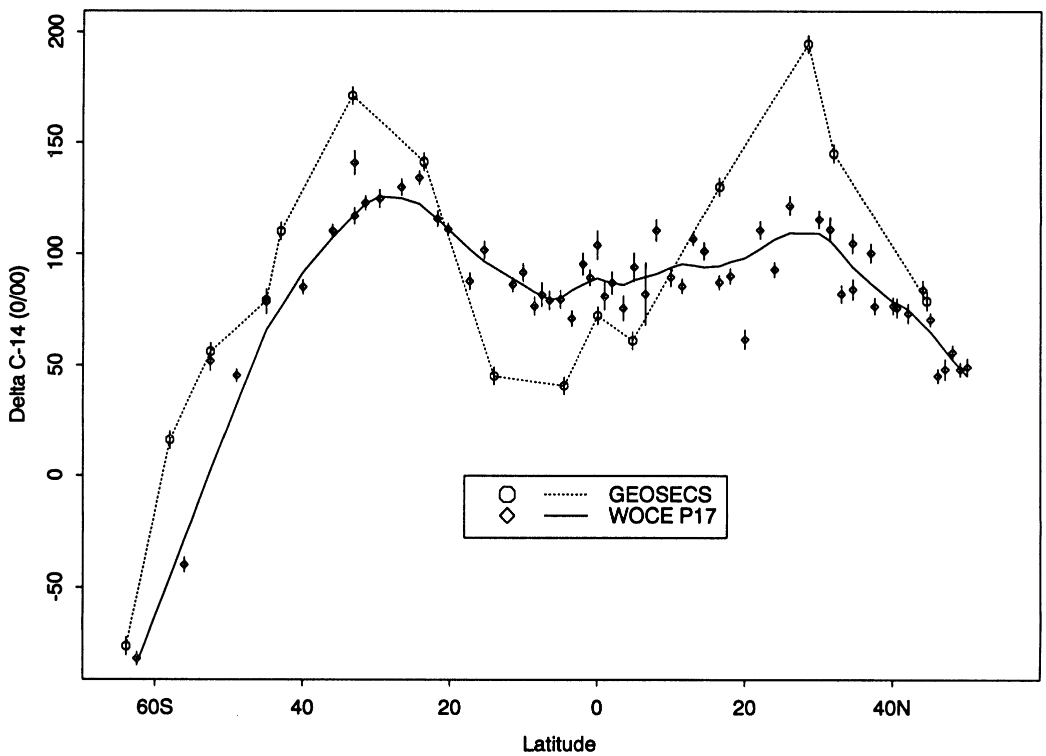

Fig. 2. Surface values from eastern Pacific GEOSECS section compared to WOCE section P17 data collected along 135°W. The values in the temperate zones of both hemispheres have decreased while the values in the tropical and equatorial latitudes have increased.

CGC-91 leg 1 (see Key 1996 for cruise details). The GEOSECS data are simply connected by a dotted line; a robust linear smoothing function was used to fit the WOCE data (solid line, data fraction per fit = 0.15; Cleveland 1979; Chambers *et al.* 1983).

During the early 1970s, the maximum $\Delta^{14}C$ values were almost always found in surface samples. GEOSECS sampling was carried out shortly after the maximum in atmospheric $\Delta^{14}C$ concentration in 1964–1965. At that time, air-sea gas exchange, forced by the large gradient between surface waters and the atmosphere, was the primary factor controlling the upper ocean ^{14}C concentration. Twenty years later, when the WOCE section was collected, the atmospheric concentration had dropped to *ca.* 25% of the 1965 maximum, and mixing and advection in the upper ocean had sufficient time to redistribute the surface signal into the interior. In the eastern Pacific WOCE sections, the maximum concentrations were frequently found below the surface at depths as great as 250 m.

The most obvious changes in surface concentration shown in Figure 2 are the mid-latitude decrease and the low-latitude equatorial increase. The mid-latitude change is greater in the North Pacific than in the South Pacific. At the time of GEOSECS, $\Delta^{14}C$ values as high as 205‰ were measured *ca.* 30°N (see also Broecker *et al.* 1985: Fig. 6). The highest North Pacific surface value measured on P17 was 122‰ at 25°N. During GEOSECS, the northern hemisphere mid-latitude surface values were higher than similar latitudes in the southern hemisphere, reflecting the fact that most of the atmospheric bomb testing was done in the north. This hemispheric difference is not apparent in the P17 WOCE data.

The Southern Ocean surface values decreased between GEOSECS and WOCE. It is possible that natural variations in the circumpolar circulation regime or differences in sampling location are responsible for the difference. A more plausible explanation is that the ^{14}C lost from the Southern Ocean surface waters has been flushed into the subsurface South Pacific.

During GEOSECS, the low-latitude eastern Pacific had a surface $\Delta^{14}C$ concentration of *ca.* 50‰. The concentration in this area increased to *ca.* 80‰ by the time of the WOCE occupation. During both surveys, the low-latitude surface minimum appears to be centered slightly south of the equator (Fig. 2). Both the equatorial $\Delta^{14}C$ increase and the displacement of the minimum south of the equator are consistent with the circulation scenario proposed by Toggweiler, Dixon and Broecker (1991). They argued that the low $\Delta^{14}C$ equatorial surface waters originated as ~15°C water that had upwelled off Peru and that the upwelled waters were, in turn, derived from the 11°–14°C thermostad water of the Equatorial Undercurrent. At the time of GEOSECS the undercurrent waters had not yet been contaminated by the bomb ^{14}C signal, but this situation changed by the time of the WOCE survey. Obviously, the partial WOCE data set presented here cannot prove this scenario.

The easiest way to visualize relative changes in the subsurface ^{14}C between GEOSECS and WOCE is to compare profiles of stations from the same area. Figure 3 shows results from two stations from each expedition. There are significant differences between the two GEOSECS profiles as well as between the GEOSECS and WOCE profiles. On average, the WOCE profiles have higher $\Delta^{14}C$ values down to a pressure of *ca.* 900 dB. The more northerly GEOSECS station (317) is significantly lower than the WOCE profiles in the 500–800 dB range, whereas the more southerly GEOSECS station is significantly lower in the 0–500 dB range. Overall, the differences are indicative of both the addition of, and redistribution of, bomb ^{14}C to the thermocline during the time interval separating the expeditions.

Figure 4 summarizes subsurface changes between GEOSECS and WOCE for the entire eastern Pacific. This section was prepared by individually gridding the eastern Pacific GEOSECS data

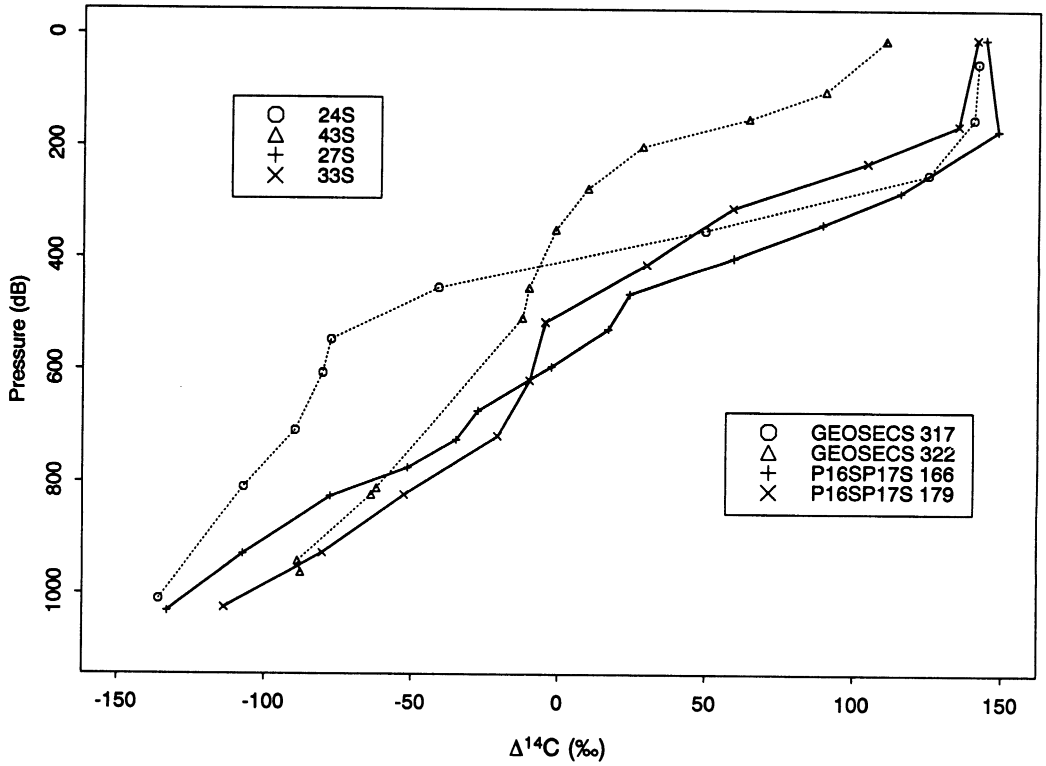

Fig. 3. Comparison of two profiles each from GEOSECS and WOCE. Although there are significant latitudinal differences in the GEOSECS stations, in general, the WOCE profiles (——) are more uniform and have higher $\Delta^{14}C$ values. All four stations are at ~130°W longitude.

(large dots) and the P17 data (small dots), then contouring the difference between the two gridded sections. The gridded values were calculated with a loess function (Chambers and Hastie 1991; Cleveland and Devlin 1988) using a smoothing parameter adjusted to compensate for the difference in data density (0.1 for WOCE; 0.2 for GEOSECS).

In Figure 4, the near-surface waters repeat the trend illustrated in Figure 2: an increase around the equator and decreases elsewhere. The decrease is larger in the northern gyre than in the southern, but the 0‰ isoline is at approximately the same depth. The equatorial near-surface increase extends down to *ca.* 150 m. In the 150–250-m zone, the waters just south of the equator show an increase in concentration, while those just north have generally decreased. A second zone of increased concentration is located in the 300–500-m depth range at the equator. This patch appears to be centered slightly north of the equator, but this offset may be an artifact of the GEOSECS sample locations and the gridding procedure.

The most remarkable feature in Figure 4 is the overall asymmetry about the equator. At the depth of mode and intermediate waters, $\Delta^{14}C$ values in the southern subtropical gyre increased by as much as 75‰. The equivalent northern gyre waters showed a maximum increase of only 50‰ and the aerial extent is significantly smaller than in the south. The difference is due to the fact that in the south, these density layers communicate freely with the circumpolar circulation regime (see Fig. 5). At the time of GEOSECS, very little, if any, of the bomb signal had penetrated the intermediate waters of

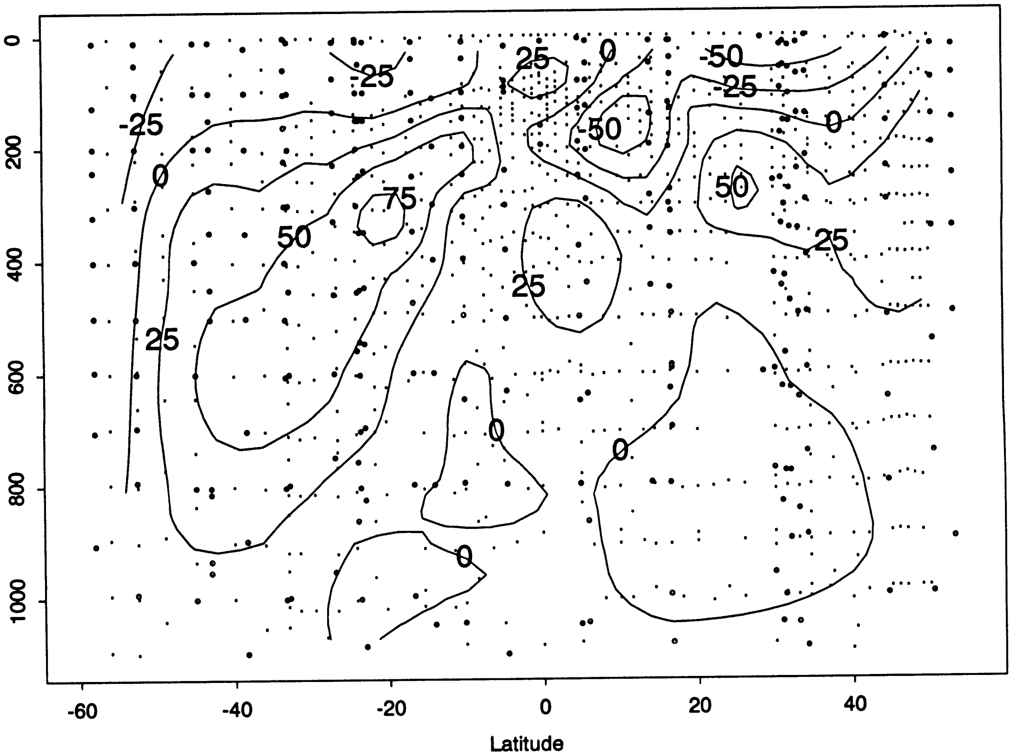

Fig. 4. Change in the $\Delta^{14}C$ (WOCE P17 (·); eastern Pacific GEOSECS (•)) from 1973 to 1992.

the southern gyre. By the early 1990s the bomb signal had penetrated northward to at least 10°S. The subtropical gyre intermediate waters in the North Pacific are not ventilated nearly so efficiently (see Talley 1993 for a detailed description). The flow pathway of the intermediate and mode waters from the circumpolar region into the subtropical gyre cannot be determined from the data now available. However, one can strongly infer the connection between the circumpolar circulation and the gyre ventilation by examining the WOCE data in density space rather than in depth space. Figure 5 shows $\Delta^{14}C$ contours for samples collected in the upper kilometer of WOCE section P17 that had a potential density (σ_θ) between 23.5 and 27.4 kg liter^{-1}. At the north end of the section only the 100‰ and 50‰ $\Delta^{14}C$ isolines intersect the ocean surface. At the southern end, contours at least as low as –50‰ outcrop. The fact that the 0‰ and –50‰ contours are essentially horizontal from the southern outcrop to *ca.* 25°S latitude implies that these levels can be ventilated primarily by advection. The mean trend of the deeper contours (–150‰ to 0‰) is upward to the north. As in Figure 4, there is an asymmetry about the equator. There is a distinct peak in the 50‰ and 0‰ contours centered *ca.* 8–10°N. This relative peak is present, but less pronounced in the deeper contours (–50‰ and –100‰) and is shifted slightly further northward than in the overlying contours. This peak in the contours represents a minimum in $\Delta^{14}C$ caused by upwelling and advection processes around the equator.

The comparison between WOCE P17 and GEOSECS described above would have been essentially the same if section P16 had been used. WOCE section P16 was a meridional section along *ca.* 152°W (Fig. 1). Sampling along this section involved 4 WOCE cruises: P16N, P16C, P16S17S and P16A17A (see Key 1996 for details). As with section P17, AMS sampling on P16 was restricted primarily to the upper water column and large-volume sampling was used for deep and bottom waters.

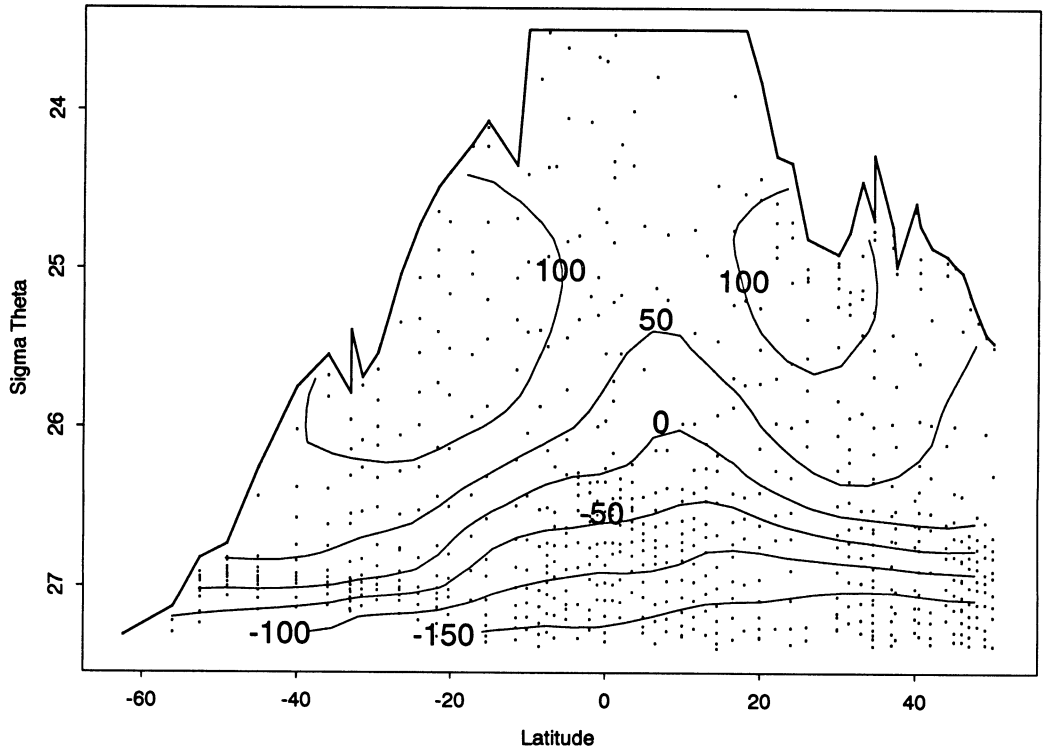

Fig. 5. $\Delta^{14}C$ contours in potential density anomaly space (σ_θ) for WOCE section P17. The heavy line represents the ocean surface. A few values were clipped by the plot boundary ($23.5 \leq \sigma_\theta \leq 27.4$) in the near-surface tropical waters, but no additional contour lines would have been drawn had the points not been omitted. The northernmost station was within 10 km of Kodiak Island, Alaska. The isopycnal surfaces having $\Delta^{14}C$ values of 0 or less do not outcrop at the north (at least at the time of year the samples were collected, May–June 1993).

Figure 6 shows the AMS results for section P16 contoured in potential density space. Data used in preparing the figure were limited to samples collected at pressures ≤ 1000 dB and potential densities between 23.5 and 27.4 kg liter^{-1}. The gridding technique was the same as for P17. One difference between Figure 5 and Figure 6 is the apparent outcrop of the 0‰ contour at the north end of P16. A detailed comparison of P16 and P17 will be presented when all of the measurements from both sections have been completed (~75% of the samples collected are reported here). Initial investigation indicates that the differences are consistent with the circulation described by Talley (1993).

WOCE section P6 (Fig. 1) was the first zonal section ever sampled for ^{14}C. This section was made up of three legs: P6E, P6C and P6W (see Key 1996 for details). Unlike most other Pacific WOCE cruises, only AMS samples were collected, *ca.* 70% of which have been measured. Those results are presented as a pressure section for the entire water column in Figure 7. The gridding technique was the same as for the previous sections. The contours in the upper water column are relatively flat except for a gentle eastward upslope for stations east of the dateline. This same trend exists in sections of other measured parameters (*e.g.*, salinity, nutrients). The deep- and bottom-water contours are significantly more interesting. Additional contours were added to Figure 7 at −175‰ and −225‰ to help detail these features.

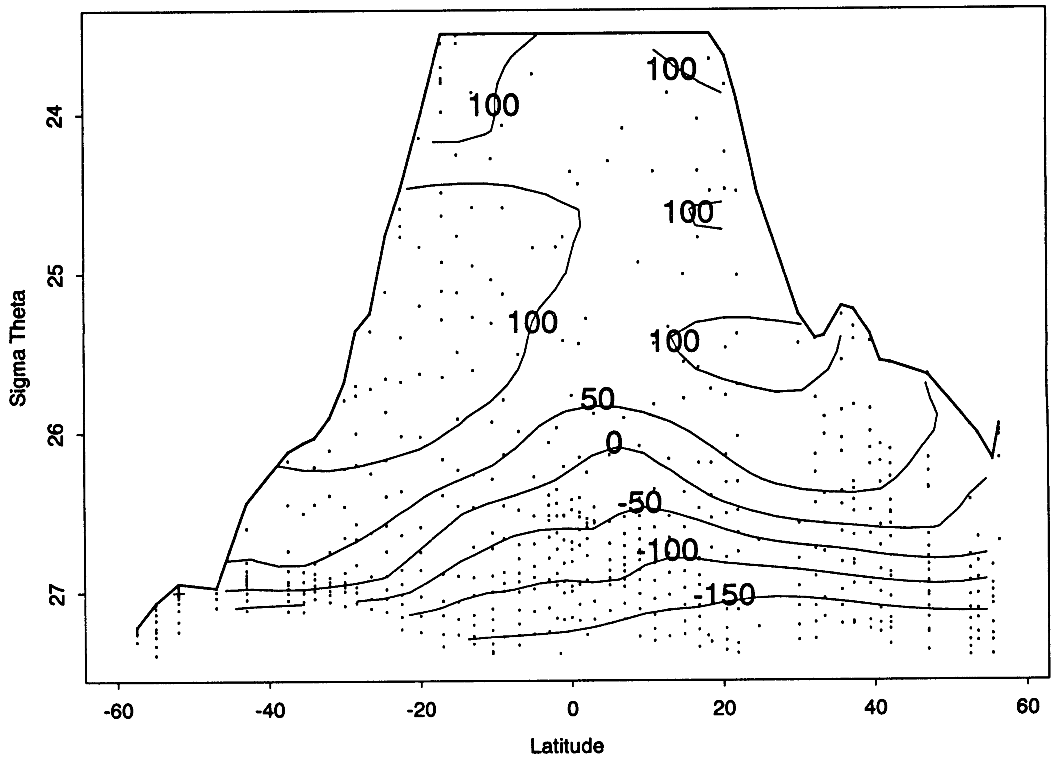

Fig. 6. $\Delta^{14}C$ contours for WOCE section P16 along *ca.* 152°W. The data used was limited to pressures < 1000 dB and $23.5 \leq \sigma_\theta \leq 27.4$. The heavy line is the ocean surface except near the equator where clipping eliminated a few data points. The gridding method was the same as used for Figure 1.

One prominent feature is the wedge of relatively "young" water ($\Delta^{14}C \geq -175‰$) at the seafloor between 180°W and 140°W. This is water that originates around Antarctica, subsequently passes through the Samoan Passage and eventually fills the abyssal North Pacific. Though not shown on this figure, the youngest waters in this mass are found somewhat off the bottom and against the ridge at the dateline. Two GEOSECS stations (241 & 251) sampled this water farther to the north, but the extent is much better defined here.

A second feature of the deepwater is the tongue of relatively old water ($\Delta^{14}C \leq -200‰$) extending westward from South America to ~175°E. This minimum was seen in both the eastern and western GEOSECS sections; however, those data gave no indication of the shape or extent of the tongue. What was totally missed by the GEOSECS sampling was the extreme minimum ($\Delta^{14}C \leq -225‰$) at 2000–2500 dB on the eastern side of the basin. Samples from a few WOCE stations very near the continental slope of South America have not been measured, but we now expect this mass of old water to extend to the slope. Toward the western end of this tongue (180°W–160°W), equally old values were found ($\Delta^{14}C \leq -225‰$); however, these minima were smoothed out by the gridding process. When contoured by hand, the western minima appear as discontinuous irregular blobs that are generally along the same density horizon as the minimum at the eastern side of the tongue. The current data set is insufficient to map the flow paths of these discrete minima to their origin; however, the $\Delta^{14}C$ values are sufficiently low that the water must be a mixture of deepwater from the North

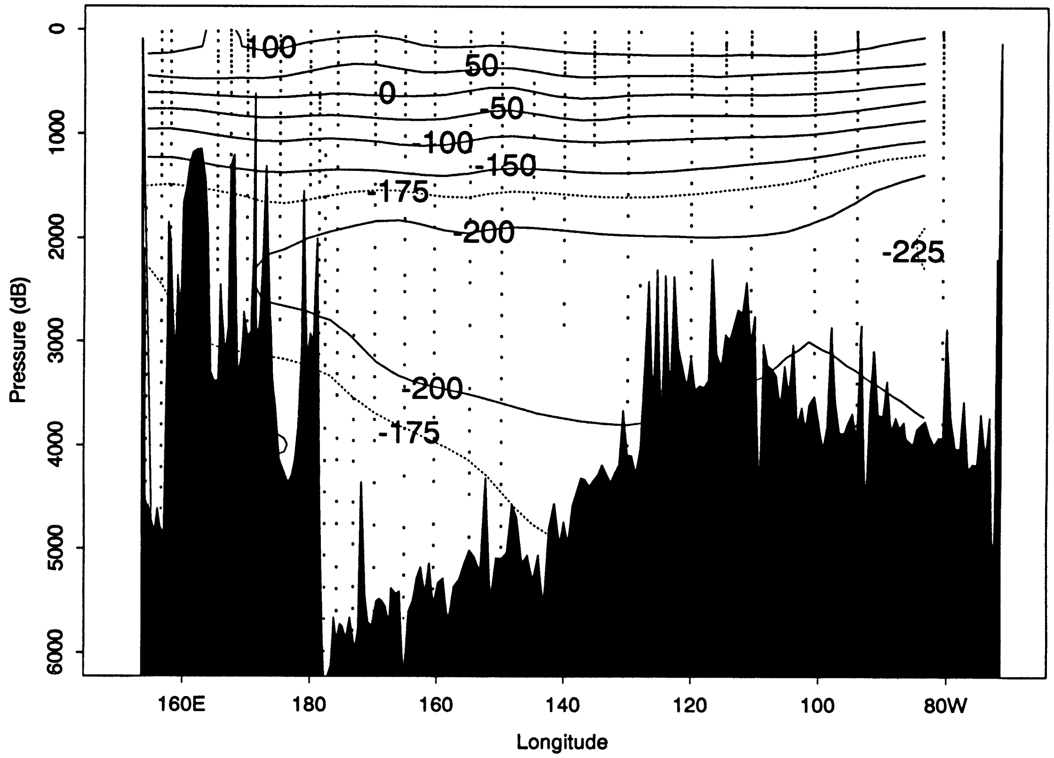

Fig. 7. $\Delta^{14}C$ on WOCE section P6 along *ca.* 32°S. Additional samples collected *ca.* 140°W and east of 80°W will eventually fill in the data gaps. The most important features to note are the relatively "young" (> –175‰) northward-flowing bottom waters *ca.* 170°W and the relatively "old" southward-flowing deepwaters (< –225‰) at 2500 dB east of 85°W.

Pacific with deep South Pacific water. The implication is that there are two major return pathways for North Pacific deepwater toward the circumpolar circulation regime.

A third, somewhat less prominent feature, is the near-bottom relative maximum ($\Delta^{14}C \geq -200‰$) on the eastern flank of the East Pacific Rise (~100°W). In map view, this feature appears as a northward-extending tongue. A similar tongue exists in maps of other properties (especially salinity). Data from sections P18, P19 and S4P may provide more detail about this feature.

Conclusion

The first published AMS results for the WOCE ^{14}C program clearly demonstrate the viability of this technique for measuring open-ocean thermocline values. Early calculations have indicated that there has been a 22% change in the bomb-produced $\Delta^{14}C$ inventory for the Northeast Pacific (Peng, Key and Östlund 1996). The figures presented here show that the changes in the Northeast Pacific have been confined to the upper 200–300 m of the water column. In the Southeast Pacific, these same isopleths have deepened by as much as 300 m, implying that changes in the bomb $\Delta^{14}C$ inventory in the South Pacific will be significantly greater than the 22% calculated for the North Pacific. In the deep- and bottom-water results from section P6, two return pathways for North Pacific deepwater are identified and the primary mass of northward-flowing water near the dateline is well delineated.

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Appendix I: Detailed Description of Methods

Small-volume water samples collected for AMS ^{14}C analysis were taken directly from 12-liter Niskin-type bottles used on Rosette/CTD casts. The samples were drawn into 500-ml borosilicate glass bottles with ground glass stoppers. The bottle was rinsed three times with sample water prior to filling (total rinse volume ~500 ml). A small headspace was left in the bottle for expansion. After filling, the water sample was poisoned with 0.1 ml of saturated $HgCl_2$ solution. On some cruises, the air temperature in the sampling area was low enough that a significant fraction of the $HgCl_2$ precipitated from the stock solution. In these cases, twice as much poison was added. The ground glass joint was wiped dry, then lubricated with Apiezon M® prior to sealing. After warming to room temperature, the bottles were wiped dry of condensation and the stopper further secured with a large rubber band. The sample bottles were stored and shipped in insulated plastic cases. Once filled with samples, each case was tied closed with an inventory list enclosed. The sample cases were always shipped *via* surface transportation with special care taken to avoid freezing conditions. All of the AMS samples collected by investigators in the U.S. are being analyzed at the National Ocean Sciences AMS Facility (NOSAMS) at Woods Hole Oceanographic Institution.

When WOCE samples arrive at NOSAMS, they are inventoried, assigned a receipt number, and placed in an analysis queue. Individual boxes of samples are transferred to the sample preparation laboratory, where the samples are acidified and stripped of CO_2 on an automated preparation line according to the method described in McNichol *et al.* (1994). CO_2 is extracted directly from the collection bottle after placing a stripping probe into the bottle while both are in a N_2-filled glove bag. Acid is added by syringe through a septum and CO_2 is stripped out by bubbling with N_2 gas on a glass vacuum line. The extracted, purified CO_2 is converted to a filamentous carbon/Fe mixture (referred to as graphite) by a catalytic hydrogen reduction (McNichol *et al.* 1994; Vogel *et al.* 1987). Prior to graphite reduction, a small portion of the CO_2 is removed for stable isotope analysis on a VG Optima mass spectrometer. Target quality is checked by a variety of means (Osborne *et al.* 1994). To introduce the samples to the AMS, the graphite is compressed to a target in an aluminum target holder using an automated press. Forty-three WOCE targets are loaded onto one AMS sample wheel, with the remaining positions occupied by standards and blanks. Each target is analyzed in the accelerator for nine 5-min runs, and the data are collected and analyzed according to published procedures (Schneider *et al.* 1995). *Ca.* 14% of the samples analyzed are standards or blanks.

As measurements are completed, NOSAMS submits quarterly data reports to the PI responsible for the samples. In addition to the $\Delta^{14}C$ data, the reports contain measured values for total inorganic carbon (TCO_2) and $\delta^{13}C$. The TCO_2 and $\delta^{13}C$ data are provided for quality control purposes. These TCO_2 measurements are not of sufficient quality to be useful as an oceanographic measurement. High-precision carbon system measurements were carried out, however, on all WOCE cruises on which ^{14}C samples were collected. The carbon measurements were made as part of the Department of Energy sponsored Global Survey of CO_2 in the Ocean, which was in turn a part of the National Science Foundation Joint Global Ocean Flux Study (JGOFS). These data will be published elsewhere by the various PIs in that survey. The $\delta^{13}C$ measurements are sufficiently precise to be useful for oceanographic work. All of the $\delta^{13}C$ results made as part of the AMS ^{14}C program were done either by NOSAMS or by P. Quay. As with the carbon system measurements, the $\delta^{13}C$ results will be reported elsewhere.

As part of the WOCE program, one or more "experts" is chosen to assure that the quality of each measurement meets the WOCE standards. The end result is that each hydrographic measurement is assigned a quality control flag. The WOCE quality control flag values relevant to the $\Delta^{14}C$ measurements are summarized in Table 1. Interpretation of these flags is unambiguous except for values 3 and 4. The following approach was used to assign these two flags:

- On a station-by-station basis, $\Delta^{14}C$ was plotted against pressure. Any points not lying on a generally "smooth" trend were noted.
- $\Delta^{14}C$ was next plotted against silicate concentration (see Broecker *et al.* 1995 for rationale) and deviant points noted. If a datum deviated from both the depth and silicate plots by more than twice the expected error or *ca.* 10‰, it was flagged 3. Any datum that was obviously very bad (> *ca.* 3 standard deviations from the trend) was flagged 4. Flag values of 3 were occasionally degraded to 4 if other measured values from the same Niskin bottle were also flagged 3 or 4.
- Wherever possible, data from depths > 1000 m were checked against GEOSECS data (Östlund and Stuiver 1980).
- Whenever possible, crossover points from different cruises were checked against each other.
- Neighboring stations were always checked against each other.
- Vertical sections against depth were prepared and manually contoured. If a datum that had been noted in the above steps, but not flagged 3 or 4, was also anomalous on the section plot, then that datum flag was degraded from 2 to 3.

TABLE 1. WOCE Quality Control Flag Values for ^{14}C Data

Flag value	Meaning
1	Sample was collected
2	Nominal result
3	Questionable result
4	Bad result
5	No result reported
6	Result of replicate analysis
9	No sample collected

This method is somewhat subjective. In general, the criteria used to judge the ^{14}C data were more lenient than for other measurements because of the difficulty and expense involved (any samples known to be bad at the time of collection were not analyzed or were at least noted on the sample collection sheets). All results, regardless of the final quality-control flag, have been left in the final reported data set so that anyone using the data can override the original quality-control decision. It is our belief that more points are flagged 2 that should be flagged 3 or 4 than *vice versa.* For replicate analyses (flag value 6), the value reported is the error-weighted mean. The uncertainty reported with replicates is the larger of the error-weighted standard deviation of the mean and the normal standard deviation.

When the WOCE Pacific sampling program began, NOSAMS was barely operational. The facility was planned and built for high-precision routine analysis of seawater samples, but in 1991 their "routine" precision, ultimate precision and real-world sample throughput were unknown. These were the primary reasons that the initial WOCE AMS sampling was restricted to the upper portion of the water column where the $\Delta^{14}C$ gradients were known to be relatively large. As the Pacific fieldwork progressed, NOSAMS demonstrated dramatic improvement in sample precision. In early 1992 the precision at NOSAMS was 16‰. This uncertainty had decreased to <6‰ by early 1993. By January, 1996, the exponentially decreasing trend in estimated precision was asymptotically approaching ~2.5‰. This estimate includes components for counting, background and blank. A more realistic estimate can be obtained by comparing the results from duplicate samples. A recent compilation of all WOCE AMS replicates indicated a mean precision ≤ 5‰. This estimate includes all error sources and should be a reliable mean precision estimate for the individual analyses reported here. The specific reason for the difference between the calculated estimate and the replicate estimate is unknown, but must be due to sample collection, sample storage or gas extraction.

APPENDIX II: WOCE CRUISE DATA, SECTIONS P6, P16 AND P17

WOCE Cruises P6E, P6C, P6W

5/2/92 – 5/26/92, 5/30/92 – 6/7/92, 6/13/92 – 6/30/92

H. Bryden, M. McCartney, J. Toole

Station 17

Latitude			32.500°S			Date					5/7/92
Longitude			76.002°W			Bottom depth					4170
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	10.1	17.848	34.071	2	0.00	2	70.33	3.57	2	3684
1	35	27.0	17.849	34.070	2	0.00	2	85.58	3.37	2	3683
1	34	52.5	17.954	34.160	2	0.00	2	68.40	4.61	2	3682
1	33	77.3	13.147	34.043	2	0.00	2	98.59	3.33	2	3980
1	32	103.1	11.695	33.994	2	1.34	2	81.85	3.50	2	3979
1	31	131.2	11.120	34.152	2	5.17	2	75.75	3.40	2	3978
1	30	152.3	10.443	34.191	2	6.68	2	64.90	3.83	2	3681
1	29	203.0	10.884	34.556	2	20.69	2	−1.41	4.54	2	3669
1	28	253.1	9.749	34.520	2	20.85	2	−19.99	3.34	2	3668
1	27	302.9	9.043	34.518	2	22.69	2	−45.53	3.54	2	3667
1	26	403.3	7.485	34.436	2	22.03	2	−45.64	3.43	2	3666
1	25	502.2	6.362	34.361	2	19.02	2	−37.71	2.94	2	3665
1	24	602.6	5.444	34.294	2	16.99	2	−43.37	5.33	2	3686
1	23	707.8	4.786	34.290	2	24.19	2	−78.63	3.98	2	3664
1	22	808.3	4.296	34.326	2	35.70	2	−95.53	3.05	2	3663
1	21	808.3	4.296	34.326	2	35.69	2	NA	NA	5	
1	20	1007.9	3.736	34.438	2	62.55	2	−162.84	2.70	2	3662
1	19	1007.9	3.736	34.440	2	62.55	2	−158.92	3.15	2	3685
1	18	1197.2	3.321	34.511	2	81.21	2	−190.31	3.35	2	3684
1	17	1197.2	3.321	34.511	2	81.55	2	−194.51	4.33	2	3683
1	16	1403.9	2.943	34.560	3	94.88	2	−187.93	2.78	2	3682
1	15	1499.1	2.814	34.577	2	100.04	2	−211.60	3.50	2	3980
1	14	1600.7	2.682	34.589	2	103.87	2	−217.44	2.62	2	3978
1	13	1600.7	2.682	34.589	2	103.69	2	−215.85	2.57	2	3979
1	12	1710.5	2.543	34.602	2	107.85	2	−200.21	5.21	2	3681
1	11	1906.2	2.330	34.623	2	113.68	2	−196.76	6.43	2	3680
1	10	1906.2	2.330	34.622	2	113.50	2	−189.95	10.02	2	3679
1	9	2202.0	2.241	34.630	2	115.00	2	−206.75	3.79	2	3678
1	8	2250.4	2.064	34.660	2	121.50	2	−233.77	10.51	2	3673
1	7	2753.2	1.853	34.669	2	122.98	2	−227.30	7.62	2	3677
1	5	3007.9	1.800	34.675	2	124.63	2	−210.28	2.70	2	3676
1	3	3596.1	1.653	34.690	2	123.62	2	−206.16	4.21	2	3675

Station 24

Latitude	32.500°S	Date	5/10/92
Longitude	80.655°W	Bottom depth	3920

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	11.1	18.711	34.596	2	0.12	2	94.42	3.14	2	3709
1	35	28.3	18.723	34.596	2	0.13	2	104.92	3.39	2	3708
1	34	53.8	18.720	34.595	2	0.13	2	91.08	4.20	2	4160
1	33	83.3	14.825	34.303	2	0.13	2	98.24	3.40	2	4158
1	32	130.5	13.258	34.149	2	0.29	2	100.38	3.42	2	4159
1	31	149.4	12.662	34.153	2	0.64	2	96.01	4.30	2	4161
1	30	209.4	10.630	34.137	2	2.12	2	100.69	3.17	2	3707
1	29	256.1	9.723	34.282	2	7.42	2	56.22	10.54	2	3706
1	28	301.6	9.071	34.379	2	13.05	2	24.18	9.88	2	3705
1	27	382.9	7.544	34.395	2	16.70	2	−15.31	5.48	2	3704
1	26	453.8	6.474	34.335	2	14.22	2	−4.21	2.76	2	3703
1	25	535.9	5.877	34.307	2	13.73	2	−20.29	2.70	2	3702
1	24	614.6	5.322	34.274	2	14.56	2	−22.02	3.23	2	3701
1	23	658.9	5.106	34.270	2	16.55	2	−39.41	2.78	2	3700
1	22	708.2	4.848	34.273	2	20.53	3	−53.89	6.51	2	3699
1	21	729.2	4.758	34.283	2	20.70	2	−56.68	5.58	2	3687
1	20	804.3	4.436	34.310	2	31.14	2	−88.69	2.96	2	3768
1	19	870.3	4.198	34.353	2	40.42	2	−120.85	2.77	2	3724
1	18	918.6	4.089	34.392	2	49.19	2	−145.56	2.65	2	3723
1	17	982.8	3.889	34.418	3	56.83	2	−151.38	3.31	2	3722
1	16	1071.0	3.694	34.470	2	69.42	2	−169.86	2.43	2	3721
1	15	1213.5	3.331	34.512	2	81.52	2	−184.28	2.36	2	3720
1	13	1419.5	3.003	34.561	2	95.62	2	−203.88	2.34	2	3718
1	12	1628.5	2.691	34.599	4	103.42	2	−215.21	3.05	2	3717
1	11	1822.1	2.450	34.611	2	110.72	2	−217.44	2.97	2	3716
1	9	2207.9	2.088	34.645	2	118.04	2	−227.70	2.28	2	3715
1	8	2406.7	1.980	34.655	2	119.70	2	−232.51	2.27	2	3719
1	7	2560.7	1.914	34.665	2	121.20	2	−225.87	2.75	2	3714
1	5	3000.1	1.809	34.678	2	124.05	2	−224.17	2.68	2	3713
1	4	3157.2	1.777	34.682	2	124.40	2	−219.13	3.09	2	3712
1	2	3787.6	1.637	34.694	2	123.84	2	−195.08	3.21	2	3711
1	1	3962.4	1.634	34.695	2	123.93	2	−191.47	2.45	2	3710

Station 44

Latitude	32.503°S	Date	5/16/92
Longitude	94.001°W	Bottom depth	3935

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	9.5	18.160	34.541	2	0.22	2	102.49	3.45	2	3782
1	35	21.2	18.165	34.540	2	0.22	2	116.10	4.95	2	4187

Station 44 (continued)

Latitude			32.503°S				Date			5/16/92
Longitude			94.001°W				Bottom depth			3935

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	33	46.5	18.166	34.540	2	0.22	2	121.00	3.74	2	3781
1	31	76.4	16.774	34.591	2	0.22	2	115.81	3.32	2	3804
1	30	97.3	15.247	34.453	2	0.37	2	121.03	3.71	2	3780
1	29	110.5	15.398	34.525	4	0.36	2	124.46	3.75	2	3779
1	28	131.3	14.291	34.326	2	0.36	2	112.08	3.72	2	3778
1	27	150.5	13.847	34.295	2	0.52	2	118.34	4.01	2	3777
1	26	177.4	13.338	34.349	2	0.67	2	106.18	3.65	2	3776
1	25	201.8	12.374	34.341	2	0.99	2	106.89	3.62	2	3775
1	24	249.8	10.789	34.291	2	1.60	2	97.24	5.55	2	3774
1	23	300.6	8.701	34.271	2	3.48	2	67.78	6.39	2	3773
1	22	399.9	6.727	34.305	2	7.07	2	25.56	2.81	2	3772
1	21	502.5	6.088	34.301	2	8.32	2	10.15	2.81	2	3771
1	20	651.9	5.443	34.267	2	10.97	2	−7.55	3.71	2	3770
1	19	777.5	4.824	34.260	2	17.83	2	−49.97	3.05	2	3798
1	18	852.3	4.491	34.277	2	24.24	2	−83.36	3.37	2	3797
1	17	953.4	4.026	34.317	2	35.47	2	−118.57	2.89	2	3796
1	16	1101.2	3.551	34.396	2	54.51	2	−141.51	3.21	2	3795
1	15	1205.1	3.343	34.463	2	68.86	2	−162.86	2.81	2	3794
1	14	1502.5	2.857	34.563	2	93.67	2	−197.05	3.32	2	3793
1	13	1601.8	2.660	34.579	2	97.73	2	−213.21	8.07	2	3792
1	12	1801.9	2.355	34.611	2	102.72	2	−213.31	2.67	2	3791
1	11	2002.8	2.152	34.631	2	107.24	2	−199.77	2.74	2	3790
1	10	2205.4	1.984	34.653	2	111.76	2	−199.18	3.25	2	3789
1	9	2401.9	1.858	34.670	2	115.03	2	−209.85	2.63	2	3788
1	8	2605.7	1.790	34.673	3	115.82	2	−213.11	3.27	2	3787
1	7	2808.1	1.761	34.685	2	117.69	2	−204.11	2.66	2	3786
1	6	3013.1	1.748	34.687	2	118.31	2	−208.58	2.67	2	3785
1	4	3394.6	1.747	34.691	2	119.40	2	−201.11	2.66	2	3784
1	3	3601.8	1.758	34.691	2	119.70	2	−197.87	2.37	2	3769
1	2	3802.7	1.771	34.692	2	119.70	2	−202.21	4.39	2	3783

Station 54

Latitude			32.499°S				Date			5/19/92
Longitude			100.666°W				Bottom depth			3523

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	12.8	19.645	35.171	2	0.46	2	156.92	5.33	2	3944
1	34	57.3	19.637	35.176	2	0.46	2	156.15	5.18	2	3943
1	33	82.5	19.582	35.166	2	0.45	2	151.07	3.50	2	3942

Station 54 (continued)

Latitude		32.499°S		Date	5/19/92
Longitude		100.666°W		Bottom depth	3523

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	31	131.4	17.092	34.955	2	0.45	2	159.74	3.67	2	3941
1	30	157.1	16.370	34.845	2	0.45	2	143.58	4.34	2	3940
1	29	205.1	15.440	34.717	2	0.44	2	114.46	3.59	2	3809
1	28	253.2	13.552	34.544	2	0.93	2	114.57	4.26	2	3808
1	27	303.7	10.900	34.383	2	2.08	2	82.81	4.73	2	3807
1	26	354.9	9.026	34.353	2	3.88	2	55.27	3.49	2	3806
1	25	405.5	7.647	34.319	2	5.52	2	16.82	5.57	2	3976
1	24	454.8	6.867	34.319	2	7.17	2	14.56	4.35	2	3805
1	23	505.7	6.486	34.323	2	7.81	2	5.39	3.78	2	3803
1	22	555.6	6.180	34.310	2	8.47	2	0.18	3.04	2	3802
1	21	605.4	5.931	34.295	2	8.96	2	−4.21	3.67	2	3801
1	20	657.4	5.701	34.282	2	9.78	2	−4.32	6.17	2	3800
1	19	705.4	5.503	34.270	2	10.76	2	−12.09	3.51	2	3799
1	18	756.6	5.283	34.261	2	12.40	2	−17.60	6.28	2	3960
1	17	805.8	5.085	34.258	2	14.21	2	−35.17	2.80	2	3959
1	16	905.5	4.597	34.272	2	22.91	2	−76.28	3.15	2	3958
1	15	1006.5	4.050	34.323	2	36.70	2	−115.47	2.82	2	3957
1	14	1129.9	3.626	34.403	2	54.92	2	−147.10	4.59	2	3956
1	13	1251.1	3.473	34.467	2	70.19	2	−161.43	2.79	2	3955
1	12	1352.3	3.274	34.513	2	80.21	2	−167.86	3.00	2	3954
1	11	1499.3	2.942	34.547	2	89.73	2	−178.42	2.53	2	3953
1	10	1701.7	2.573	34.584	2	98.26	2	−188.55	2.47	2	3952
1	8	2100.8	2.065	34.645	2	108.91	2	−196.53	2.47	2	3951
1	7	2301.0	1.926	34.666	2	111.69	2	−196.60	2.47	2	3950
1	6	2504.4	1.818	34.680	2	114.97	2	−192.71	2.53	2	3949
1	5	2700.0	1.752	34.683	2	117.10	2	−188.32	2.49	2	3948
1	3	3101.2	1.728	34.690	2	118.07	2	−192.79	2.56	2	3947
1	2	3330.9	1.736	34.691	2	118.39	2	−188.89	2.52	2	3946
1	1	3567.7	1.749	34.691	2	118.39	2	−181.42	2.61	2	3945

Station 69

Latitude		32.500°S		Date	5/23/92
Longitude		110.667°W		Bottom depth	3005

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	12.0	18.971	34.749	2	0.00	2	117.59	3.29	2	3981
1	34	56.9	18.913	34.745	2	0.17	2	123.47	3.13	2	3967
1	32	107.5	16.076	34.801	2	0.17	2	129.00	3.36	2	3966
1	31	131.2	15.129	34.649	2	0.17	2	119.65	3.39	2	3965
1	28	206.6	12.946	34.539	2	0.68	2	112.98	3.14	2	3964

Station 69 (continued)

Latitude			32.500°S			Date				5/23/92
Longitude			110.667°W			Bottom depth				3005

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	27	255.2	10.607	34.419	2	1.53	2	88.48	4.13	2	3963
1	23	456.8	6.975	34.369	2	6.13	2	28.64	3.55	2	3961
1	21	557.8	6.463	34.350	2	7.32	2	15.01	5.24	2	3997
1	20	608.3	6.280	34.334	2	8.17	2	8.29	4.78	2	3996
1	19	657.3	6.031	34.328	2	9.19	2	−5.17	3.05	2	3995
1	18	707.8	5.801	34.307	2	10.38	2	−15.87	4.12	2	3994
1	16	807.4	5.345	34.284	2	14.30	2	−48.97	2.96	2	3993
1	15	910.4	4.834	34.288	2	20.94	2	−79.45	4.07	2	3992
1	14	1009.3	4.323	34.318	2	30.14	2	−101.35	3.00	2	3991
1	13	1135.5	3.713	34.368	2	45.47	2	−127.37	3.26	2	3990
1	12	1211.4	3.452	34.408	2	53.64	2	−134.25	2.81	2	3989
1	10	1413.4	2.927	34.509	2	73.05	2	−168.99	3.03	2	3988
1	8	1692.5	2.385	34.597	2	92.29	2	−185.81	2.87	2	3987
1	6	2091.7	1.959	34.664	4	113.41	2	−209.37	4.47	2	3986
1	5	2295.2	1.840	34.664	2	118.87	2	−208.46	3.20	2	3985
1	4	2498.3	1.799	34.668	2	119.89	2	−213.77	2.78	2	3984
1	3	2704.0	1.781	34.673	2	120.23	2	−215.52	3.65	2	3983
1	1	3039.7	1.785	34.676	2	120.42	2	−203.85	2.90	2	3982

Station 85

Latitude			32.501°S			Date				6/4/92
Longitude			119.992°W			Bottom depth				3161

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	23.9	19.834	35.200	2	0.16	2	124.31	9.65	2	4013
1	33	122.4	17.588	35.158	2	0.07	2	119.78	4.32	2	4012
1	31	182.7	15.829	35.087	2	0.33	2	116.90	3.60	2	4011
1	30	232.7	14.550	34.968	2	0.78	2	116.48	4.75	2	4010
1	28	331.4	11.197	34.672	2	2.17	2	80.84	6.95	2	4009
1	27	382.3	9.908	34.560	2	2.94	2	58.97	5.02	2	4008
1	26	431.7	8.431	34.446	2	4.04	2	57.90	4.03	2	4007
1	25	482.3	7.420	34.378	2	5.61	2	25.34	2.49	2	4006
1	24	562.2	6.714	34.358	2	6.86	2	12.49	5.64	2	4005
1	23	636.7	6.264	34.332	2	7.96	2	−5.52	3.31	2	4004
1	20	862.9	5.160	34.287	2	15.88	2	−65.57	3.18	2	4003
1	19	964.4	4.707	34.301	2	23.70	2	−83.50	4.52	2	4002
1	18	1063.9	4.202	34.327	2	32.95	2	−105.37	6.26	2	4001
1	16	1265.1	3.362	34.424	2	55.78	2	−139.31	2.83	2	4000
1	14	1469.8	2.841	34.509	2	72.35	2	−168.20	2.72	2	3999

Station 85 (continued)

Latitude			32.501°S			Date				6/4/92
Longitude			119.992°W			Bottom depth				3161
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	12	1671.8	2.493	34.578	2	87.79	2	−177.31	2.98	2	3998
1	11	1772.1	2.375	34.603	2	94.14	2	−185.04	3.23	2	4063
1	10	1873.4	2.224	34.625	2	102.25	2	−197.64	2.27	2	4062
1	9	2024.3	2.100	34.636	2	108.45	2	−203.84	2.23	2	4061
1	7	2327.0	1.926	34.654	2	115.55	2	−208.21	3.00	2	4060
1	6	2480.5	1.826	34.661	2	119.50	2	−211.61	5.71	2	4059
1	4	2783.6	1.739	34.672	2	121.64	2	−209.42	2.53	2	3977
1	3	2959.8	1.723	34.674	2	121.59	2	−206.71	2.82	2	4015
1	2	3137.8	1.707	34.681	2	122.50	2	−205.12	12.32	2	4014

Station 100

Latitude			32.501°S			Date				6/8/92
Longitude			130.001°W			Bottom depth				4086
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	35	17.8	19.485	35.264	2	0.21	2	140.04	3.67	2	4087
1	33	118.0	16.077	35.118	2	0.40	2	135.87	3.58	2	4086
1	31	175.4	15.014	35.030	2	0.58	2	130.72	3.16	2	4085
1	29	250.4	13.059	34.896	2	1.64	2	107.40	3.01	2	4084
1	28	303.2	10.931	34.705	2	2.70	2	83.63	3.23	2	4083
1	25	447.4	7.364	34.409	2	5.70	2	40.64	2.80	2	4082
1	24	522.7	6.827	34.378	2	6.76	2	18.18	2.98	2	4081
1	23	598.1	6.476	34.357	2	7.99	2	5.35	2.90	2	4080
1	22	669.3	6.186	34.374	4	9.40	2	−14.08	4.50	2	4079
1	21	741.9	5.834	34.325	3	11.51	2	−32.53	4.62	2	4078
1	20	811.6	5.492	34.304	2	14.85	2	−50.81	3.79	2	4077
1	19	885.6	5.129	34.301	2	19.07	2	−63.21	3.74	2	4076
1	17	1082.9	4.104	34.338	2	36.30	2	−106.01	3.73	2	4075
1	16	1230.3	3.473	34.401	2	51.41	2	−131.33	3.67	2	4074
1	15	1374.8	2.986	34.476	2	66.87	2	−153.11	4.05	2	4073
1	14	1580.4	2.545	34.562	2	86.02	2	−173.17	2.36	2	4072
1	13	1782.6	2.305	34.607	2	99.37	2	−192.23	3.65	2	4095
1	11	2174.7	1.962	34.642	2	116.23	2	−209.24	2.91	2	4094
1	9	2565.1	1.774	34.663	2	121.14	2	−212.09	2.38	2	4093
1	8	2764.7	1.726	34.667	2	121.67	2	−205.53	4.42	2	4092
1	6	3168.5	1.631	34.676	2	122.19	2	−200.09	2.74	2	4091
1	5	3370.3	1.607	34.681	2	122.36	2	−203.51	2.65	2	4090
1	4	3575.5	1.577	34.684	2	122.01	2	−201.95	3.14	2	4089
1	2	3994.9	1.564	34.690	2	121.77	2	−197.98	2.38	2	4088

Station 127

Latitude	32.501°S	Date	6/19/92
Longitude	149.827°W	Bottom depth	5088

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	30.1	17.947	35.332	2	0.43	2	112.98	5.34	2	2461
1	34	119.9	16.832	35.418	2	0.71	2	123.19	3.68	2	2232
1	32	218.4	14.255	35.098	2	1.01	2	85.60	9.06	2	2260
1	30	318.3	11.149	34.804	2	3.01	2	37.30	5.03	2	2231
1	28	417.5	8.686	34.559	2	4.87	2	30.00	5.51	2	1980
1	27	518.9	7.510	34.452	2	5.73	2	5.88	7.25	2	2257
1	26	616.1	6.951	34.405	2	7.17	2	−0.09	3.28	2	1979
1	25	715.6	6.461	34.364	2	9.02	2	−47.64	6.22	2	2256
1	24	817.6	5.899	34.331	2	12.61	2	−57.19	2.85	6	1902,2144
1	23	918.2	5.285	34.316	2	19.06	2	−84.45	7.05	6	1903,1952
1	22	1015.9	4.715	34.325	2	27.08	2	−102.19	5.16	2	1904
1	21	1115.9	4.157	34.348	2	36.67	2	−123.36	7.46	2	1905
1	20	1316.3	3.320	34.428	2	56.16	2	−149.29	3.39	6	1906,1951
1	19	1517.6	2.793	34.523	2	77.65	2	−170.11	3.38	2	2929
1	18	1725.0	2.452	34.587	2	94.84	2	−204.73	10.56	2	1877
1	17	1931.3	2.247	34.621	2	107.00	2	−196.48	30.85	6	1907,2141
1	16	2134.9	2.102	34.638	2	114.03	2	−203.33	2.47	2	1878
1	15	2337.7	1.985	34.651	2	120.04	2	−231.49	7.08	2	1876
1	14	2540.5	1.881	34.661	2	124.63	2	−222.72	5.90	2	1879
1	13	2744.8	1.799	34.667	2	127.93	2	−230.94	5.47	6	1908,1949
1	12	2950.0	1.733	34.675	2	128.21	2	−206.21	2.64	2	1880
1	11	3151.8	1.663	34.682	2	127.36	2	−198.40	2.93	2	1881
1	10	3355.0	1.574	34.688	2	125.06	2	−212.14	6.58	2	1882
1	9	3557.5	1.480	34.695	2	122.77	2	−205.37	7.07	2	1883
1	8	3760.2	1.418	34.699	2	121.77	2	−209.08	8.70	2	2251
1	7	3966.1	1.361	34.702	2	121.20	2	−195.96	3.17	2	2262
1	6	4168.4	1.311	34.703	2	120.48	2	−170.39	4.40	2	2238
1	5	4369.9	1.276	34.707	2	120.20	2	−179.74	2.90	2	2237
1	4	4571.6	1.233	34.709	2	119.34	2	−179.15	4.14	2	2236
1	3	4775.9	1.202	34.710	2	119.06	2	−166.70	2.96	2	2235
1	2	4978.6	1.162	34.712	2	119.20	2	−160.56	3.25	2	2234
1	1	5176.0	1.144	34.713	2	119.50	2	−163.00	2.60	2	2233

Station 133

Latitude	32.503°S	Date	6/20/92
Longitude	154.842°W	Bottom depth	5007

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	18.4	18.324	35.367	2	0.37	2	100.32	6.48	2	2254
1	34	108.0	18.067	35.311	2	0.37	2	138.63	6.08	2	1997
1	33	157.4	15.451	35.254	2	0.64	2	89.51	5.06	3	1996
1	32	208.0	14.246	35.119	2	1.06	2	112.33	9.08	2	1994
1	31	257.7	12.766	34.962	2	2.02	2	88.01	2.96	2	2044
1	29	357.9	9.881	34.681	2	3.97	2	55.85	2.74	2	2050
1	28	408.1	8.580	34.556	2	4.95	2	28.68	4.41	2	1998
1	27	509.0	7.726	34.471	2	5.91	2	13.70	4.21	2	1471
1	26	610.4	6.931	34.402	2	7.44	2	−3.28	4.13	2	2020
1	23	911.6	5.282	34.319	2	19.13	2	−72.62	3.16	2	1469
1	22	1012.7	4.660	34.328	2	27.63	2	−92.18	3.11	2	1468
1	21	1162.2	3.867	34.370	2	42.40	2	−118.30	3.05	2	1467
1	20	1315.6	3.334	34.428	2	55.63	2	−126.09	2.99	2	1466
1	19	1466.7	2.878	34.512	2	72.76	2	−165.80	3.03	2	1465
1	18	1617.3	2.616	34.569	2	87.38	2	−173.31	2.96	2	1464
1	17	1821.2	2.349	34.614	2	103.67	2	−197.95	2.81	2	1472
1	16	2023.4	2.183	34.634	2	112.57	2	−195.14	2.86	2	1463
1	15	2227.6	2.053	34.646	2	120.51	2	−206.91	2.85	2	1462
1	14	2431.3	1.958	34.654	2	124.97	2	−211.31	2.84	2	1461
1	12	2838.3	1.807	34.668	2	129.14	2	−209.16	2.83	2	1460
1	9	3449.5	1.604	34.692	2	123.97	2	−197.92	2.86	2	1459
1	8	3652.9	1.530	34.700	2	120.48	2	−187.04	2.47	2	2230
1	7	3858.0	1.456	34.709	2	116.99	2	−187.91	2.94	2	2228
1	6	4059.2	1.363	34.710	2	116.71	2	−169.61	2.81	2	2227
1	5	4261.2	1.263	34.713	2	116.01	2	−179.15	2.77	2	1981
1	4	4468.3	1.189	34.712	2	117.68	2	−167.01	2.15	2	2226
1	3	4675.3	1.158	34.712	2	117.95	2	−191.91	4.61	3	2255
1	2	4881.0	1.124	34.712	2	118.78	2	−174.12	5.11	2	2003
1	1	5092.3	1.140	34.717	4	118.92	2	−172.10	3.22	2	2229

Station 140

Latitude	32.495°S	Date	6/23/92
Longitude	160.494°W	Bottom depth	5521

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	21.3	17.533	35.421	2	0.42	2	111.06	3.58	2	1478
1	34	111.7	17.069	35.370	2	0.43	2	117.43	3.82	2	1477
1	32	210.8	14.390	35.185	2	1.49	2	106.55	10.63	2	2004
1	31	310.6	11.230	34.846	2	3.14	2	80.03	6.40	2	2022
1	30	408.4	8.829	34.575	2	4.35	2	49.03	3.47	2	1475

Station 140 (continued)

Latitude	32.495°S	Date	6/23/92
Longitude	160.494°W	Bottom depth	5521

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	28	612.3	7.146	34.427	2	6.91	2	14.90	3.35	2	1474
1	27	711.7	6.732	34.388	2	8.26	2	−6.86	3.33	2	1473
1	26	813.9	6.136	34.347	2	11.42	2	−43.22	4.17	2	1691
1	24	1100.1	4.510	34.338	2	31.25	2	−113.15	5.55	2	1690
1	22	1492.2	2.917	34.503	2	71.79	2	−155.83	4.89	2	1688
1	21	1694.2	2.571	34.580	2	91.76	2	−174.32	4.24	2	1687
1	20	1894.1	2.374	34.613	2	103.93	2	−190.78	2.84	2	1686
1	19	2101.7	2.198	34.632	2	114.15	2	−208.56	3.55	2	1685
1	18	2304.8	2.080	34.645	2	120.17	2	−213.70	2.91	2	1684
1	17	2507.1	1.989	34.652	2	124.38	2	−219.96	7.52	2	1683
1	16	2709.1	1.913	34.659	2	127.24	2	−219.65	7.19	2	1682
1	15	2909.5	1.837	34.666	2	129.22	2	−232.22	4.85	2	1821
1	14	3108.1	1.759	34.674	2	129.07	2	−218.97	3.07	2	1681
1	13	3313.2	1.691	34.684	2	125.93	2	−216.42	3.50	2	1680
1	12	3526.5	1.621	34.698	2	120.23	2	−192.81	2.89	2	1679
1	11	3729.7	1.541	34.710	2	114.38	2	−179.90	2.93	2	1678
1	10	3932.7	1.436	34.716	2	112.15	2	−169.03	2.91	2	1677
1	9	4133.9	1.317	34.717	2	112.91	2	−168.85	7.65	2	2002
1	8	4343.2	1.182	34.715	2	115.92	2	−161.01	2.34	2	2049
1	7	4549.4	1.096	34.712	2	118.49	2	−181.82	6.51	4	1995
1	6	4759.2	1.061	34.710	2	120.01	2	−160.02	2.47	2	2048
1	5	4965.8	1.053	34.709	2	120.91	2	−155.79	2.53	2	2047
1	4	5173.2	1.066	34.708	2	121.08	2	−157.87	2.49	2	2046
1	3	5377.8	1.086	34.708	2	121.25	2	−154.39	2.39	2	2045
1	1	5622.8	1.117	34.709	2	120.87	2	−159.21	4.67	2	1993

Station 148

Latitude	32.500°S	Date	6/25/92
Longitude	165.166°W	Bottom depth	6329

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	35	63.2	16.574	35.380	2	0.61	2	102.05	5.63	2	1959
1	34	113.3	15.286	35.306	2	0.91	2	103.15	6.15	2	1958
1	33	212.6	12.705	35.044	2	2.57	2	84.62	4.07	2	1957
1	32	413.3	8.799	34.585	2	4.98	2	32.97	3.52	2	1956
1	31	513.4	7.798	34.480	2	5.88	2	27.34	3.11	2	1963
1	30	613.7	7.098	34.419	2	6.94	2	10.55	3.02	2	1962
1	29	714.5	6.535	34.371	2	9.35	2	−33.67	4.32	2	1961
1	28	815.2	5.963	34.338	2	12.81	2	−42.81	4.64	2	1960
1	27	1017.8	4.902	34.351	2	28.41	2	−79.28	2.89	2	1922,2114

Station 148 (continued)

Latitude			32.500°S			Date				6/25/92
Longitude			165.166°W			Bottom depth				6329
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	26	1218.0	3.675	34.389	2	47.33	2	−112.07	2.93	2	1921
1	25	1218.1	3.675	34.385	2	45.68	2	−107.91	2.92	2	1920
1	23	1814.5	2.428	34.606	2	102.23	2	−198.74	2.98	2	1926
1	22	2014.1	2.268	34.626	2	111.38	2	−196.35	2.70	2	1925
1	21	2362.4	2.048	34.645	2	122.03	2	−224.54	5.34	6	1924,2145
1	20	2518.8	1.975	34.652	2	125.19	2	−222.63	2.53	2	1954
1	19	2770.6	1.881	34.661	2	128.64	2	−230.75	3.35	2	2142
1	18	3023.9	1.790	34.672	2	129.25	2	−215.21	2.59	2	1913
1	17	3226.4	1.713	34.686	2	124.60	2	−206.99	2.73	2	1912
1	16	3432.6	1.629	34.698	2	119.95	2	−199.01	2.29	6	1911,1950
1	15	3636.9	1.541	34.712	2	113.95	2	−184.28	3.91	2	1910
1	13	3838.6	1.428	34.718	2	111.57	2	−177.91	3.43	2	2143
1	14	3838.6	1.428	34.717	2	111.86	2	−167.05	2.85	3	1915
1	12	4040.5	1.280	34.715	4	116.67	2	−155.83	2.72	4	1914
1	11	4292.9	1.120	34.710	4	119.82	2	−166.96	2.54	2	1784
1	9	4794.6	1.003	34.709	2	121.18	2	−164.10	2.88	2	1789
1	8	5049.1	1.009	34.707	2	121.63	2	−163.11	2.59	2	1788
1	7	5247.0	1.026	34.708	2	121.94	2	−162.55	2.33	2	1787
1	6	5457.6	1.051	34.706	2	121.94	2	−159.79	3.16	2	1786
1	5	5664.9	1.078	34.707	2	121.94	2	−154.26	2.67	2	1785
1	3	6069.3	1.132	34.706	2	122.11	2	−153.06	3.38	2	1783
1	24	6458.8	1.187	34.706	2	122.32	2	−161.93	3.67	2	1955
1	1	6459.0	1.187	34.707	2	122.42	2	−152.57	2.58	2	1782

Station 157

Latitude			32.492°S			Date				6/27/92
Longitude			169.845°W			Bottom depth				5601

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	18.2	16.690	35.515	2	−0.06	2	109.04	3.77	2	1704
1	34	107.0	16.089	35.472	2	0.14	2	102.76	3.77	2	1703
1	33	208.0	13.033	35.103	2	1.71	2	50.10	4.33	2	1702
1	32	308.4	10.771	34.816	2	3.62	2	47.14	9.86	2	1701
1	31	406.8	8.710	34.591	2	5.36	2	51.96	7.22	2	1700
1	30	507.6	7.758	34.487	2	5.38	2	33.66	4.63	2	1699
1	29	607.2	7.187	34.434	2	6.61	2	7.10	3.56	2	1698
1	28	707.3	6.658	34.386	2	8.52	2	−21.07	7.38	6	1354,1697
1	27	806.8	6.054	34.347	2	12.14	2	−30.52	2.87	2	2193
1	26	907.4	5.567	34.341	2	18.17	2	−51.13	2.88	2	2192
1	25	1004.7	4.955	34.345	2	26.25	2	−95.18	5.03	2	2191

Station 157 (continued)

Latitude			32.492°S				Date				6/27/92
Longitude			169.845°W				Bottom depth				5601
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	1099.5	4.349	34.356	2	35.02	2	−112.97	4.61	2	2223
1	22	1486.2	2.945	34.513	2	73.47	2	−179.86	6.31	2	2466
1	21	1687.2	2.572	34.585	2	93.39	2	−223.46	4.99	2	2221
1	20	1889.2	2.372	34.616	2	105.09	2	−191.96	6.11	3	2122
1	19	2092.9	2.214	34.633	2	113.35	2	−208.72	3.54	2	2465
1	18	2300.4	2.099	34.643	2	120.25	2	−222.81	3.45	2	2464
1	17	2508.6	2.003	34.654	2	124.22	2	−227.31	3.21	2	2121
1	16	2718.8	1.922	34.659	2	126.67	2	−201.13	2.76	2	2190
1	15	2928.1	1.846	34.665	2	128.41	2	−196.35	2.52	2	2189
1	14	3134.2	1.767	34.677	2	127.25	2	−193.83	3.01	2	2188
1	13	3341.3	1.691	34.692	2	120.77	2	−192.32	2.84	2	2222
1	12	3543.4	1.608	34.708	2	114.11	2	−191.56	5.49	2	2463
1	11	3749.6	1.482	34.719	2	109.17	2	−164.47	3.07	2	2117
1	10	3954.7	1.326	34.720	2	110.24	2	−155.95	5.51	2	2120
1	8	4362.1	1.091	34.712	2	117.35	2	−160.72	3.09	2	2116
1	7	4566.2	1.045	34.711	2	118.76	2	−201.04	5.32	4	2220
1	6	4770.5	1.027	34.709	2	120.00	2	−163.58	5.24	2	2119
1	4	5177.3	1.039	34.709	2	121.10	2	−169.36	3.20	2	2118
1	2	5590.2	1.086	34.708	2	121.35	2	−164.57	6.21	2	2462
1	1	5705.1	1.100	34.708	2	121.15	2	−163.55	3.11	2	2115

Station 165

Latitude			32.499°S				Date				6/29/92
Longitude			173.173°W				Bottom depth				5827
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	16	2942.0	1.825	34.675	2	126.04	2	−221.16	5.01	2	2209
1	15	3147.0	1.737	34.689	2	121.04	2	−214.97	4.76	2	2208
1	14	3346.7	1.660	34.707	2	114.05	2	−185.72	3.69	2	2207
1	13	3552.0	1.544	34.719	2	109.22	2	−175.71	4.39	2	2206
1	12	3753.3	1.425	34.721	2	109.73	2	−168.64	2.82	2	2205
1	11	3953.7	1.299	34.721	2	111.74	2	−172.06	3.40	2	2204
1	10	4150.1	1.193	34.717	2	114.40	2	−166.56	3.42	2	2203
1	9	4351.5	1.112	34.712	2	116.91	2	−183.28	2.94	4	2198
1	8	4551.0	1.067	34.712	2	118.57	2	−165.44	3.02	2	1696
1	7	4753.4	1.048	34.710	2	119.91	2	−155.50	2.55	2	2035
1	6	4953.7	1.040	34.708	2	120.58	2	−155.20	5.34	2	1353
1	5	5155.2	1.041	34.708	2	121.41	2	−173.89	3.47	4	1694
1	4	5358.3	1.054	34.705	2	121.59	2	−155.25	2.42	2	2034
1	3	5566.9	1.073	34.708	2	122.25	2	−149.80	8.02	2	2023

Station 165 (continued)

Latitude	32.499°S	Date	6/29/92
Longitude	173.173°W	Bottom depth	5827

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	2	5778.3	1.099	34.708	2	122.26	2	−163.46	3.29	2	1693
1	1	5938.4	1.118	34.710	2	122.11	2	−161.45	3.66	2	1692

Station 171

Latitude	32.501°S	Date	7/1/92
Longitude	175.750°W	Bottom depth	5868

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	24.7	16.588	35.555	2	1.08	2	114.34	3.85	2	2274
1	34	115.4	14.969	35.367	2	2.41	2	103.88	4.03	2	2273
1	33	213.1	13.107	35.127	2	4.07	2	63.77	7.19	2	2272
1	32	315.5	11.458	34.934	2	5.24	2	40.15	8.69	2	2271
1	31	413.0	9.814	34.736	2	6.57	2	33.12	3.40	2	2270
1	30	514.7	8.688	34.618	2	8.56	2	18.20	4.13	2	2269
1	29	615.9	7.645	34.507	2	10.06	2	−5.01	3.22	2	2268
1	28	717.0	6.839	34.437	2	12.39	2	−33.28	3.47	2	2218
1	27	815.5	6.287	34.404	2	17.38	2	−53.27	2.87	2	2217
1	26	914.7	5.444	34.349	2	21.38	2	−74.37	3.90	2	2267
1	25	1115.4	4.209	34.390	2	41.84	2	−125.62	4.13	2	2266
1	24	1318.3	3.423	34.471	2	63.65	2	−151.73	4.29	2	2265
1	23	1516.3	2.943	34.539	2	80.93	2	−173.91	3.44	2	2264
1	22	1715.9	2.655	34.583	2	94.72	2	−190.63	2.81	2	3725
1	21	1913.7	2.444	34.611	2	105.28	2	−215.56	5.04	2	2225
1	20	2113.9	2.314	34.626	2	111.29	2	−235.58	4.31	2	2224
1	19	2314.4	2.208	34.636	2	115.80	2	−214.36	2.65	2	2212
1	18	2513.1	2.104	34.646	2	119.82	2	−210.21	2.76	2	2211
1	17	2715.1	1.972	34.661	2	122.99	2	−209.09	3.71	2	2210
1	16	2913.7	1.856	34.687	2	114.85	2	−185.71	3.50	2	2216
1	15	3110.5	1.742	34.703	2	110.87	2	−171.33	3.52	2	2215
1	14	3311.9	1.635	34.718	2	106.21	2	−164.98	2.65	2	2214
1	13	3519.9	1.487	34.725	2	106.73	2	−155.76	2.65	2	2213
1	11	3934.5	1.200	34.717	2	113.44	2	−161.63	2.84	2	2798
1	10	4134.3	1.108	34.715	2	116.11	2	−164.92	3.61	2	2197
1	8	4545.1	1.040	34.709	2	119.49	2	−152.36	2.64	2	2196
1	7	4756.1	1.025	34.711	3	120.50	2	−154.97	2.69	2	2195
1	6	4965.5	1.032	34.708	2	121.19	2	−146.34	2.96	3	2194
1	5	5172.6	1.043	34.708	2	121.54	2	−170.60	2.60	2	2202
1	4	5381.4	1.060	34.709	2	121.39	2	−176.84	2.98	2	2201
1	3	5590.1	1.083	34.706	2	121.25	2	−174.56	2.63	2	2200
1	1	5981.1	1.132	34.708	2	121.63	2	−168.46	3.27	2	2199

Station 175

Latitude	32.500°S	Date	7/2/92
Longitude	177.667°W	Bottom depth	7310

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	1206.9	3.835	34.421	2	52.30	2	−130.27	6.30	2	2470
1	23	1410.3	3.183	34.502	2	72.90	2	−181.98	3.18	2	2394
1	22	1611.8	2.797	34.566	2	91.13	2	−183.84	3.31	2	2393
1	21	1814.8	2.551	34.596	2	101.54	2	−196.41	5.28	2	2469
1	20	2015.1	2.383	34.617	2	109.98	2	−214.09	3.42	2	2412
1	19	2219.9	2.268	34.630	2	114.70	2	−197.02	3.12	2	2397
1	18	2423.1	2.154	34.640	2	119.62	2	−217.56	6.15	2	2396
1	17	2623.8	2.053	34.648	2	123.75	2	−211.97	4.51	2	2799
1	16	2828.7	1.923	34.661	2	127.11	3	−218.01	5.62	2	2409
1	15	3031.4	1.837	34.673	2	125.75	3	−206.26	3.09	2	2395
1	14	3231.3	1.765	34.705	2	110.06	2	−174.58	5.61	2	2400
1	13	3531.4	1.536	34.723	2	106.34	2	−198.44	5.80	3	2605
1	12	3838.8	1.244	34.720	2	112.63	2	−151.58	4.55	2	2399
1	11	4144.6	1.066	34.712	2	118.14	2	−152.32	6.33	2	2398
1	10	4451.3	1.032	34.709	2	120.12	2	−157.52	6.17	2	2468
1	9	4756.3	1.022	34.709	2	121.12	2	−164.85	3.31	2	2392
1	8	5058.9	1.037	34.707	2	121.52	2	−163.30	3.14	2	2391
1	7	5365.4	1.061	34.707	2	121.93	2	−159.29	6.40	2	2390
1	6	5671.3	1.092	34.706	2	122.14	2	−169.47	5.84	2	2389
1	5	5982.2	1.127	34.706	2	122.16	2	−156.74	4.75	2	2388
1	4	6292.0	1.166	34.706	2	122.36	2	−178.46	7.02	2	2387
1	3	6498.2	1.193	34.706	2	122.38	2	−162.51	3.26	2	2467
1	2	6709.9	1.220	34.706	2	122.39	2	−177.20	4.64	2	2386
1	1	6904.1	1.250	34.709	3	122.50	2	−165.46	4.90	2	2385

Station 179

Latitude	32.499°S	Date	7/3/92
Longitude	178.648°W	Bottom depth	3455

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	605.1	7.925	34.521	2	7.94	2	19.55	3.64	2	1484
1	23	654.9	7.647	34.498	2	9.87	2	−7.14	3.48	2	1483
1	22	705.1	7.112	34.444	2	9.68	2	−12.97	3.45	2	1482
1	21	757.1	6.950	34.449	2	13.55	2	−42.57	3.22	2	1481
1	20	806.2	6.560	34.425	2	15.68	2	−56.12	5.21	2	3586
1	18	958.0	5.770	34.418	2	25.94	2	−85.41	3.04	2	1480
1	17	1059.4	5.134	34.416	2	34.45	2	−103.39	3.00	2	1479
1	16	1161.1	4.633	34.427	2	43.15	2	−122.19	5.16	2	2416
1	15	1261.9	4.238	34.442	2	51.08	2	−148.62	6.23	2	2415
1	14	1364.0	3.831	34.473	2	61.53	2	−147.70	5.98	2	2414

Station 179 (continued)

Latitude						32.499°S			Date			7/3/92
Longitude						178.648°W			Bottom depth			3455
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM	
1	13	1464.2	3.532	34.498	2	68.10	2	−144.53	4.36	2	2413	
1	12	1614.8	3.105	34.550	2	83.19	2	−146.07	8.15	2	2406	
1	11	1766.9	2.832	34.590	2	94.97	2	−160.39	6.15	2	2405	
1	10	1916.4	2.649	34.608	2	101.16	2	−207.36	5.26	2	2411	
1	9	2067.0	2.432	34.624	2	108.11	2	−195.76	4.69	2	2410	
1	8	2217.4	2.264	34.640	2	113.33	2	−214.71	12.42	2	2404	
1	7	2367.3	2.206	34.646	2	115.25	2	−209.15	5.21	2	2403	
1	6	2518.8	1.960	34.665	2	120.08	2	−230.94	5.73	3	2472	
1	5	2720.7	1.802	34.703	2	108.66	2	−178.61	4.19	2	2402	
1	4	2920.7	1.652	34.719	2	105.17	2	−161.14	4.87	2	2401	
1	3	3123.3	1.447	34.726	2	106.71	2	−165.89	4.79	2	2408	
1	2	3326.0	1.271	34.723	2	110.57	2	−173.58	9.15	2	2407	
1	1	3477.2	1.218	34.722	2	112.61	2	−168.69	4.68	2	2471	

Station 182

Latitude						32.500°S			Date			7/3/92
Longitude						179.918°E			Bottom depth			2914
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM	
1	36	17.7	16.518	35.593	2	1.29	2	95.95	9.61	2	1873	
1	33	128.2	15.534	35.420	2	1.48	2	105.56	3.30	2	1900	
1	31	207.7	13.750	35.245	2	3.56	2	66.88	4.04	6	1901,1948	
1	29	306.8	12.128	35.035	2	4.70	2	62.54	3.24	2	1874	
1	28	356.9	11.286	34.926	2	5.65	2	37.69	3.07	2	1875	
1	27	406.5	10.524	34.835	2	6.60	2	51.33	3.15	2	1871	
1	25	506.3	8.847	34.624	2	7.74	2	34.74	4.08	2	1899	
1	24	606.7	7.421	34.472	2	9.83	2	−3.95	3.18	2	1872	
1	23	707.2	6.950	34.437	2	11.93	2	−30.09	3.36	2	1458	
1	22	807.5	6.399	34.408	2	15.94	2	−54.32	3.31	2	1457	
1	21	906.2	5.865	34.389	2	21.08	2	−70.24	3.26	2	1456	
1	20	1002.3	5.368	34.390	2	28.14	2	−89.87	3.17	2	1455	
1	19	1100.6	4.772	34.399	2	37.67	2	−111.85	5.51	2	1454	
1	17	1297.5	3.765	34.452	2	58.66	2	−141.91	4.90	2	1453	
1	16	1395.0	3.413	34.488	2	68.97	2	−151.63	2.99	2	2019	
1	15	1492.1	3.086	34.528	2	80.41	2	−173.54	2.97	2	1451	

Station 194

Latitude	30.081°S	Date	7/15/92
Longitude	175.168°E	Bottom depth	4136

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	35	60.4	19.714	35.716	2	0.69	2	121.37	3.36	2	4032
1	34	109.6	18.967	35.641	2	1.05	2	117.74	3.49	2	4031
1	33	158.1	17.573	35.566	2	1.60	2	122.56	3.87	2	4030
1	32	206.8	16.962	35.537	2	1.79	2	116.53	4.14	2	4029
1	30	305.1	15.308	35.390	2	2.70	2	96.76	5.69	2	4028
1	28	402.1	13.452	35.186	2	4.16	2	83.51	5.39	2	4027
1	26	479.2	11.763	34.977	2	5.62	2	57.98	6.63	2	4026
1	25	585.7	9.874	34.757	2	7.82	2	18.54	4.12	2	4025
1	23	802.1	7.266	34.492	2	13.14	2	−18.39	4.56	2	4024
1	22	893.0	6.599	34.446	2	17.36	2	−57.60	3.20	2	4023
1	21	993.5	5.680	34.379	2	22.68	2	−80.08	2.96	2	4022
1	20	1094.7	5.124	34.381	2	30.58	2	−99.69	2.78	2	4021
1	19	1196.3	4.576	34.407	2	41.41	2	−118.80	2.79	2	4020
1	18	1296.5	4.012	34.457	2	55.73	2	−137.83	2.99	2	4019
1	17	1397.7	3.485	34.506	2	71.16	2	−163.09	2.69	2	4018
1	16	1499.2	3.211	34.544	2	81.43	2	−167.90	2.71	2	4017
1	15	1599.1	3.027	34.566	2	88.03	2	−180.87	2.75	2	4225
1	14	1699.7	2.801	34.591	2	95.38	2	−201.83	2.86	3	4224
1	13	1796.9	2.624	34.609	2	101.07	2	−187.50	5.21	2	4223
1	12	1983.9	2.382	34.629	2	108.60	2	−192.66	3.68	2	4222
1	11	2186.1	2.189	34.648	2	114.28	2	−201.20	2.65	2	4221
1	10	2390.1	2.056	34.660	3	117.59	2	−209.31	3.18	2	4220
1	9	2584.1	1.960	34.669	2	119.97	2	−199.73	5.10	2	4219
1	8	2789.0	1.903	34.673	2	121.62	2	−198.82	2.81	2	4218

Station 205

Latitude	30.080°S	Date	7/17/92
Longitude	169.997°E	Bottom depth	2945

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	9.0	18.423	35.662	2	0.62	2	109.59	3.37	2	4047
1	23	49.9	18.435	35.661	2	0.62	2	114.71	3.65	2	4046
1	22	99.5	18.416	35.660	2	0.81	2	101.45	3.33	2	4045
1	21	149.4	18.236	35.645	2	1.00	2	116.72	3.31	2	4044
1	20	199.2	16.794	35.494	2	1.76	2	107.73	3.51	2	4043
1	19	250.3	15.674	35.408	2	2.33	2	101.83	3.71	2	4058
1	18	300.0	14.770	35.320	2	4.95	2	82.40	3.44	2	4042
1	17	349.5	13.796	35.225	2	5.52	2	71.17	3.41	2	4041
1	16	399.6	13.067	35.155	2	4.58	2	62.58	3.80	2	4175
1	15	499.3	11.582	34.984	2	6.28	2	34.41	3.12	2	4174

Station 205 (continued)

Latitude				30.080°S			Date				7/17/92
Longitude				169.997°E			Bottom depth				2945
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	14	600.8	9.329	34.726	2	10.41	2	−7.14	4.45	2	4173
1	13	700.9	8.315	34.627	2	13.99	2	−19.98	3.99	2	4172
1	12	801.2	7.436	34.573	2	18.87	2	−44.01	3.09	2	4171
1	11	1003.5	5.595	34.492	2	37.27	2	−96.11	3.19	2	4057
1	10	1204.7	4.413	34.490	2	55.30	2	−130.92	3.05	2	4056
1	9	1405.0	3.588	34.536	2	73.51	2	−149.18	3.61	2	4055
1	8	1598.4	3.127	34.570	2	86.47	2	−169.66	3.42	2	4054
1	7	1801.6	2.646	34.613	2	101.68	2	−182.59	2.67	2	4053
1	6	2004.2	2.379	34.632	2	109.01	2	−189.90	2.68	2	4052
1	5	2206.2	2.177	34.649	2	114.26	2	−196.05	2.74	2	4051
1	3	2601.3	1.995	34.664	2	119.73	2	−199.23	2.76	2	4050
1	2	2803.5	1.916	34.674	2	122.17	2	−205.14	3.09	2	4049
1	1	2967.0	1.855	34.680	2	124.05	2	−209.03	2.84	2	4048

Station 210

Latitude				30.082°S			Date				7/18/92
Longitude				167.498°E			Bottom depth				1305
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	15	9.9	18.740	35.633	2	0.78	2	96.89	3.44	2	4201
1	14	49.4	18.750	35.638	2	0.78	2	76.88	3.89	2	4200
1	13	99.9	18.648	35.632	2	0.98	2	79.93	3.51	2	4199
1	12	149.9	18.222	35.578	2	1.16	2	81.36	3.62	2	4198
1	11	204.6	17.059	35.517	2	1.90	2	70.01	3.66	2	4197
1	10	253.0	16.252	35.454	2	2.28	2	96.63	5.00	2	4196
1	9	307.8	15.067	35.357	2	3.02	2	84.00	5.77	2	4195
1	8	354.3	14.173	35.270	2	3.58	2	72.26	3.55	2	4194
1	7	407.9	13.089	35.172	2	4.69	2	60.59	3.35	2	4040
1	6	507.3	10.981	34.917	2	7.47	2	37.55	3.92	2	4039
1	5	605.3	9.222	34.719	2	11.72	2	3.16	3.05	2	4038
1	4	806.7	7.420	34.590	2	20.60	2	−45.11	3.43	2	4037
1	3	999.7	5.650	34.460	2	33.53	2	−92.71	2.88	2	4036
1	2	1202.8	4.709	34.502	2	53.49	2	−122.80	2.85	2	4035
1	1	1307.9	3.902	34.542	2	70.78	2	−148.80	2.23	6	4033,4034

Station 214

Latitude	30.077°S	Date	7/19/92
Longitude	165.408°E	Bottom depth	3374

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	17.1	18.909	35.607	2	0.76	2	111.92	4.73	2	4182
1	34	108.4	18.891	35.613	2	0.77	2	94.99	5.08	2	4181
1	32	208.9	17.301	35.534	2	1.69	2	95.60	5.68	2	4180
1	31	257.0	16.660	35.482	2	2.06	2	100.30	5.03	2	4179
1	30	307.0	15.687	35.405	2	2.79	2	87.79	3.83	2	4178
1	29	407.2	13.619	35.224	2	3.89	2	68.40	3.54	2	4177
1	28	510.5	11.610	35.003	2	5.53	2	43.69	3.82	2	4176
1	27	607.4	9.752	34.767	2	9.00	2	14.10	5.08	2	4170
1	26	709.6	8.284	34.612	2	13.74	2	−27.80	2.92	2	4169
1	25	810.4	7.182	34.532	2	19.04	2	−48.83	2.83	2	4168
1	24	910.1	6.355	34.484	2	25.80	2	−78.82	2.95	2	4167
1	23	1013.0	5.512	34.462	2	35.84	2	−102.65	2.76	2	4166
1	22	1111.7	4.933	34.466	2	45.15	2	−124.08	2.70	2	4165
1	21	1211.2	4.424	34.496	2	56.83	2	−135.93	2.70	2	4164
1	20	1314.9	4.070	34.518	2	65.06	2	−157.61	2.72	2	4163
1	19	1410.9	3.603	34.548	2	76.74	2	−166.99	2.71	2	4162
1	18	1508.9	3.314	34.566	2	84.06	2	−165.79	4.00	2	4193
1	17	1604.9	3.095	34.583	2	90.27	2	−177.00	2.64	2	4192
1	16	1701.7	2.882	34.600	2	95.58	2	−190.80	2.87	2	4191
1	14	1906.4	2.539	34.628	2	103.64	2	−193.51	2.81	2	4190
1	13	2006.3	2.410	34.641	2	106.02	2	−209.97	2.80	2	4186
1	12	2108.8	2.296	34.650	2	108.59	2	−201.22	2.80	2	4185
1	11	2211.7	2.204	34.659	2	110.43	2	−200.51	2.82	2	4184
1	10	2313.0	2.138	34.665	2	111.91	2	−197.63	2.90	2	4183

Station 229

Latitude	30.085°S	Date	7/22/92
Longitude	158.001°E	Bottom depth	2015

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	18	19.4	20.590	35.535	2	0.68	2	108.88	3.49	2	4217
1	16	109.5	20.271	35.567	2	0.84	2	123.69	3.34	2	4216
1	15	209.6	17.922	35.526	2	1.91	2	124.82	4.74	2	4215
1	14	307.3	15.062	35.342	2	3.18	2	96.84	3.25	2	4214
1	13	408.7	12.708	35.101	2	5.16	2	49.29	6.13	2	4212
1	12	508.4	10.631	34.877	2	7.33	2	16.60	3.13	2	4211
1	11	605.5	9.103	34.692	2	10.41	2	1.52	4.57	2	4210
1	10	704.6	7.894	34.580	2	14.76	2	−28.74	3.15	2	4209
1	9	803.9	6.942	34.507	2	20.75	2	−88.33	3.16	2	4208
1	8	902.0	6.107	34.476	2	28.55	2	−96.68	4.32	2	4207

Station 229 (continued)

Latitude			30.085°S			Date				7/22/92
Longitude			158.001°E			Bottom depth				2015
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	6	1099.4	4.817	34.480	2	48.19	2	−135.44	5.55	2	4206
1	5	1301.2	3.739	34.525	2	72.01	2	−158.82	3.15	2	4205
1	4	1499.4	3.098	34.579	2	88.39	2	−189.69	2.57	2	4204
1	3	1698.9	2.642	34.626	2	94.76	2	−185.99	4.80	2	4203
1	2	1900.0	2.394	34.655	2	96.40	2	−191.55	5.42	2	4202
1	1	2025.5	2.237	34.678	2	94.89	2	−181.84	3.17	2	4213

Station 234

Latitude			30.083°S			Date					7/23/92
Longitude			156.530°E			Bottom depth					4821
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	26.9	20.275	35.551	2	0.78	2	109.87	3.36	2	3063
1	34	101.1	20.287	35.551	2	0.82	2	118.96	5.18	2	3317
1	33	201.8	18.985	35.563	2	1.50	2	105.65	4.40	2	3062
1	31	300.3	16.106	35.407	2	2.88	2	82.03	3.30	2	3061
1	30	401.9	13.199	35.209	3	4.12	2	76.69	4.33	2	3045
1	29	501.5	11.103	35.010	4	5.95	2	47.48	3.71	2	3044
1	28	602.3	9.474	34.729	2	9.70	2	−12.66	6.03	2	3056
1	27	702.0	8.114	34.601	2	13.83	2	−37.98	3.01	2	3055
1	25	802.9	6.918	34.507	2	20.63	2	−68.79	2.96	2	3054
1	24	902.0	6.040	34.472	2	29.33	2	−98.18	3.96	2	3053
1	23	1003.4	5.431	34.468	2	38.13	2	−107.74	2.87	2	3052
1	22	1103.4	4.798	34.477	2	48.84	2	−124.60	2.86	2	3060
1	21	1204.1	4.221	34.498	2	60.96	2	−159.35	2.76	2	3059
1	20	1302.3	3.753	34.529	2	73.45	2	−157.06	2.77	2	3058
1	19	1403.9	3.423	34.553	2	81.91	2	−172.32	3.00	2	3057
1	18	1605.7	2.925	34.598	2	93.25	2	−169.84	3.74	2	3389
1	17	1802.8	2.614	34.630	2	98.44	2	−189.55	3.55	2	3051
1	16	2004.2	2.390	34.660	2	94.67	2	−173.34	3.00	2	3050
1	15	2200.1	2.225	34.685	2	94.21	2	−171.73	2.94	2	3049
1	14	2402.8	2.056	34.707	2	95.14	2	−168.53	3.28	2	3043
1	13	2607.2	1.875	34.721	2	98.24	2	−167.55	2.95	2	3042
1	12	2802.0	1.702	34.725	2	102.48	2	−154.72	4.36	2	2971
1	10	3002.2	1.538	34.724	2	106.45	2	−160.76	3.12	2	2970
1	9	3203.5	1.397	34.722	2	109.96	2	−160.76	3.50	2	2969
1	8	3406.5	1.289	34.720	2	113.05	2	−159.76	4.28	2	2968
1	7	3603.9	1.230	34.718	2	114.87	2	−155.68	4.58	2	2967
1	6	3801.4	1.179	34.719	2	116.51	2	−168.03	4.15	2	2966
1	5	4004.9	1.162	34.718	2	117.64	2	−166.14	4.94	2	2965

Station 234 (continued)

Latitude	30.083°S	Date	7/23/92
Longitude	156.530°E	Bottom depth	4821

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	4	4206.2	1.168	34.718	2	118.21	2	−172.07	4.14	2	2964
1	3	4412.0	1.176	34.716	2	118.47	2	−174.23	4.10	2	2963
1	2	4611.7	1.184	34.721	4	118.63	2	−167.08	4.19	2	2962
1	1	4899.1	1.204	34.716	2	118.82	2	−173.62	3.89	2	2961

Station 239

Latitude	30.085°S	Date	7/24/92
Longitude	154.163°E	Bottom depth	4590

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	16	1723.0	2.771	34.610	2	94.52	2	−182.56	2.57	2	4297
1	15	1924.7	2.469	34.644	2	96.30	2	−193.31	3.81	2	4629
1	14	2123.5	2.275	34.675	2	94.68	2	−173.02	2.83	2	4296
1	13	2322.7	2.108	34.701	2	94.14	2	−173.00	2.31	2	4295
1	12	2520.3	1.953	34.715	2	96.28	2	−164.07	2.37	2	4294
1	11	2720.0	1.800	34.722	2	99.68	2	−183.25	2.09	2	4293
1	10	2920.9	1.626	34.727	2	103.80	2	−182.28	2.70	2	4292
1	9	3124.6	1.466	34.724	2	108.27	2	−174.28	2.15	2	4291
1	8	3327.5	1.322	34.722	2	111.66	2	−173.63	2.70	2	4290
1	7	3531.8	1.231	34.718	2	114.16	2	−169.59	2.49	2	4289
1	6	3735.7	1.176	34.718	2	115.95	2	−174.99	1.87	2	4288
1	5	3940.9	1.152	34.716	2	117.01	2	−176.69	2.72	2	4287
1	4	4145.4	1.148	34.715	2	117.55	2	−167.97	2.12	2	4286
1	3	4349.6	1.154	34.717	2	118.08	2	−176.35	1.85	2	4285
1	2	4556.2	1.159	34.713	2	118.62	2	−166.60	2.15	2	4284
1	1	4670.3	1.164	34.714	2	118.91	2	−175.77	2.56	2	4283

WOCE Cruise P16N

3/7/91 - 4/8/91

J. Bullister

Station 17

Latitude	20.397°N	Date	3/8/91
Longitude	154.236°W	Bottom depth	5455

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	23	6.9	23.773	34.915	2	2.45	2	104.6	3.4	2	3153
1	18	49.2	23.448	35.017	2	2.44	2	110.2	4.0	2	3152
1	14	101.1	22.640	35.262	2	2.23	2	120.2	4.0	2	3151
1	13	124.2	22.057	35.347	2	2.22	2	122.8	4.4	2	3149
1	11	203.3	16.209	34.686	2	5.50	2	121.4	6.0	2	3143
1	10	245.6	13.953	34.434	2	8.40	2	100.8	5.9	2	3142
1	9	302.9	11.152	34.209	2	13.42	2	78.4	7.8	2	3141
1	8	349.2	9.805	34.132	2	20.58	2	52.1	9.3	2	3148
1	7	403.4	8.593	34.132	2	36.29	2	−25.0	3.5	2	3147
1	6	498.3	7.077	34.198	2	56.71	2	−117.4	8.9	2	3146
1	5	599.5	5.949	34.283	2	74.91	2	−142.8	5.2	2	3145
1	4	685.5	5.728	34.395	2	80.00	2	−162.2	4.7	2	3139
1	3	800.1	5.053	34.437	2	91.62	2	−185.5	6.3	2	3144
1	2	898.5	4.635	34.468	2	99.73	2	−200.9	4.5	2	3138
1	1	997.5	4.220	34.491	2	107.67	2	−187.4	8.9	2	3140
2	23	1302.4	3.442	34.551	2	124.46	2	−223.0	4.4	2	3150

Station 20

Latitude	21.916°N	Date	3/10/91
Longitude	152.000°W	Bottom depth	5691

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	13	8.9	23.138	35.015	2	2.14	2	107.1	5.6	2	449
1	9	61.5	23.145	35.021	2	1.95	2	113.3	3.9	2	439
1	7	103.4	21.830	35.283	2	2.14	2	99.3	5.5	2	438
1	5	151.3	19.535	35.164	2	2.73	2	122.8	3.9	2	437
1	3	202.4	17.200	34.878	2	3.90	2	127.0	3.9	2	436
1	2	251.9	14.547	34.511	2	6.24	2	110.4	3.9	2	435
1	1	308.8	11.769	34.208	2	11.89	2	83.5	7.7	2	434
2	24	349.8	9.689	34.102	2	21.25	2	65.7	4.8	2	447
2	23	400.7	8.435	34.075	2	34.13	2	4.7	4.5	2	446
2	22	450.7	7.273	34.034	2	44.30	2	−43.8	5.9	2	445
2	21	497.7	6.383	34.037	2	58.43	2	−67.7	3.5	2	448
2	20	497.7	6.383	34.037	2	58.62	2	−78.9	3.7	2	444
2	18	698.9	4.846	34.263	2	95.20	2	−159.2	3.1	2	442
2	19	698.9	4.846	34.263	2	95.21	2	−172.0	3.9	2	443

Station 20 (continued)

Latitude	21.916°N	Date	3/10/91
Longitude	152.000°W	Bottom depth	5691

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	17	900.3	4.414	34.466	2	104.57	2	−190.5	3.1	2	441
2	16	997.8	4.082	34.494	2	111.78	2	−200.7	3.0	2	440

Station 22

Latitude	23.997°N	Date	3/12/91
Longitude	151.979°W	Bottom depth	5617

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	23	5.1	21.065	35.375	1	2.25	2	12.5	5.0	2	1650
1	19	40.5	21.041	35.377	1	1.85	2	114.8	5.3	2	1649
1	13	100.0	18.959	35.133	1	2.82	2	135.7	5.3	2	1648
1	12	126.6	17.891	35.003	1	3.41	2	129.0	6.7	2	1647
1	10	177.8	15.322	34.644	1	5.16	2	115.1	6.5	2	1646
1	9	199.9	13.853	34.427	1	7.32	2	114.7	5.2	2	1645
1	8	251.9	11.622	34.220	1	11.44	2	83.7	5.1	2	1644
1	7	300.3	10.667	34.181	1	14.77	2	77.3	7.6	2	1643
1	6	348.8	9.536	34.121	1	21.24	2	56.0	16.3	2	1640
1	5	399.0	8.439	34.064	1	29.89	2	23.5	4.9	2	1639
1	4	500.1	6.578	34.016	1	53.53	2	−59.3	5.3	2	1638
1	3	598.5	5.380	34.081	1	77.32	2	−126.9	4.4	2	1651
1	2	750.8	4.486	34.259	1	103.34	2	−176.5	4.2	2	1642
1	1	908.5	3.908	34.387	1	118.48	2	−201.0	4.1	2	1641

Station 28

Latitude	28.022°N	Date	3/15/91
Longitude	151.988°W	Bottom depth	5404

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	18	7.0	20.027	35.367	3	2.81	2	122.9	6.4	2	385
2	15	60.9	18.887	35.245	3	2.80	2	120.1	6.0	2	384
2	13	101.9	18.438	35.162	3	3.00	2	121.8	5.7	2	392
2	11	153.7	17.866	35.036	3	3.40	2	134.7	7.3	2	383
2	8	199.5	15.666	34.662	3	5.39	2	115.8	6.3	2	381
2	9	252.0	13.598	34.421	3	7.79	2	115.9	9.7	2	382
2	7	299.6	11.994	34.285	3	11.38	2	83.5	6.3	2	380
1	23	399.6	9.958	34.200	3	14.13	2	77.7	5.2	2	379
1	22	447.0	8.706	34.077	3	27.72	2	33.6	4.5	2	378
1	21	494.0	7.842	34.038	3	36.21	2	−3.0	6.6	2	2455
1	20	494.0	7.842	34.038	3	36.20	2	−3.8	9.0	2	391

Station 28 (continued)

Latitude	28.022°N	Date	3/15/91
Longitude	151.988°W	Bottom depth	5404

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	19	701.3	4.785	34.079	3	88.52	2	−140.8	5.3	2	390
1	18	701.3	4.785	34.080	3	88.72	2	−145.0	3.8	2	389
1	17	899.9	4.008	34.293	3	116.40	2	−199.9	4.7	2	388
1	16	998.8	3.799	34.365	3	123.54	2	−201.0	9.1	2	387
1	15	1099.6	3.565	34.424	3	129.47	2	−207.8	4.3	2	386

Station 31

Latitude	30.000°N	Date	3/16/91
Longitude	152.009°W	Bottom depth	5400

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	24	51.3	18.869	35.261	2	2.64	2	123.5	11.7	6	5,11
2	22	151.8	16.974	34.885	2	3.91	2	109.0	3.3	6	605,3039
2	18	498.8	7.689	34.038	2	37.84	2	11.8	2.8	2	2771
2	17	601.1	5.867	34.008	2	63.86	2	−97.5	16.2	2	10
2	16	700.3	4.846	34.072	2	86.54	2	−120.1	9.4	2	57
2	15	799.8	4.355	34.163	2	102.47	2	−160.5	8.6	2	9
2	14	898.0	4.032	34.274	2	115.17	2	−175.0	18.5	6	56,2770
2	13	998.1	3.714	34.347	2	125.34	2	−192.3	8.6	2	14
2	11	1599.8	2.479	34.567	2	154.93	2	−238.8	8.6	6	6,8
2	10	1900.0	2.088	34.605	2	163.92	2	−265.8	2.4	6	55,2253
2	9	1900.0	2.088	34.606	2	163.92	2	−263.1	5.4	6	4,12,69
2	4	4407.6	1.483	34.688	2	158.83	2	−230.3	4.0	6	303,304,305

Station 34

Latitude	32.168°N	Date	3/18/91
Longitude	152.004°W	Bottom depth	5262

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	11	81.2	16.639	34.747	2	4.16	2	123.4	4.8	2	1770
2	7	124.4	16.633	34.747	2	4.15	2	109.6	4.6	2	1769
2	5	176.2	13.066	34.228	2	7.14	2	88.6	4.6	2	1768
2	4	249.1	11.083	34.194	2	12.54	2	82.3	4.7	2	1767
2	3	300.4	10.296	34.161	2	15.74	2	73.2	5.0	2	2457
1	23	550.6	6.244	33.993	2	55.23	2	−62.9	4.8	2	1765
1	21	650.8	5.014	34.018	2	78.65	2	−104.0	3.5	2	2456
1	19	798.8	4.163	34.140	2	104.51	2	−172.4	3.5	2	1775
1	18	899.1	3.849	34.229	2	117.66	2	−184.5	3.5	2	1771
1	17	999.0	3.592	34.326	2	128.81	2	−197.5	3.9	2	1772

Station 34 (continued)

Latitude	32.168°N	Date	3/18/91
Longitude	152.004°W	Bottom depth	5262

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	16	1098.8	3.384	34.389	2	135.86	2	−213.9	4.8	2	1774
1	15	1298.1	2.967	34.486	2	147.34	2	−225.6	3.3	2	1773
1	14	1298.1	2.967	34.486	2	147.32	2	−227.9	3.4	2	1764
1	13	1897.8	2.055	34.600	2	171.00	2	−245.5	3.6	2	1763

Station 36

Latitude	33.333°N	Date	3/18/91
Longitude	152.000°W	Bottom depth	5563

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	31.6	15.523	34.396	2	5.52	2	100.2	6.0	2	1722
1	22	152.2	12.053	34.127	2	9.08	2	83.1	4.6	2	1724
1	21	175.6	11.638	34.166	2	11.26	2	79.1	4.1	2	1723
1	20	175.6	11.638	34.166	2	11.25	2	78.2	4.1	2	1572
1	18	350.5	9.324	34.123	2	22.15	2	54.2	3.9	2	1733
1	17	450.6	7.672	34.035	2	36.06	2	6.6	4.1	2	1732
1	16	550.2	6.123	33.991	2	56.80	2	−50.8	4.0	2	2458
1	15	550.2	6.123	33.991	2	56.78	2	−64.3	3.7	2	1725
1	14	750.7	4.299	34.094	2	97.64	2	−157.3	4.7	2	789
1	13	849.7	3.899	34.192	2	113.92	2	−179.5	2.7	2	1726
1	12	1000.7	3.530	34.318	2	129.92	2	−197.8	2.7	2	1727
1	11	1000.7	3.530	34.319	2	129.89	2	−202.6	2.7	2	1728
1	9	1246.5	3.029	34.455	2	146.22	2	−223.4	2.6	2	1729
1	7	1372.8	2.814	34.493	2	152.22	2	−238.1	3.1	2	1721
1	8	1372.8	2.814	34.493	2	152.25	2	−231.2	2.6	2	1730

Station 39

Latitude	35.608°N	Date	3/20/91
Longitude	152.007°W	Bottom depth	5705

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	19	6.0	14.721	33.930	2	4.37	2	105.5	5.5	2	622
1	18	75.6	14.614	33.967	2	4.35	2	96.1	4.2	2	621
1	17	123.4	13.366	33.998	2	5.32	2	99.1	10.6	2	620
1	16	151.0	11.515	33.945	2	8.46	2	86.4	6.1	2	619
1	15	176.1	10.646	33.966	2	10.82	2	98.1	10.5	2	618
1	14	199.7	10.267	33.992	2	12.77	2	86.9	5.6	2	617
1	13	301.5	9.076	34.050	2	20.86	2	59.7	3.6	2	616
1	12	351.0	8.445	34.032	2	26.18	2	39.6	3.4	2	615

Station 39 (continued)

Latitude	35.608°N	Date	3/20/91
Longitude	152.007°W	Bottom depth	5705

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	11	453.2	7.056	33.990	2	43.40	2	3.8	4.9	2	614
1	10	547.0	5.562	33.990	2	66.26	2	−71.5	5.9	2	613
1	9	646.7	4.535	34.061	2	91.09	2	−121.2	6.5	2	612
1	8	747.9	4.089	34.132	2	105.19	2	−153.2	3.7	2	2459
1	7	847.2	3.691	34.222	2	120.81	2	−181.9	8.7	2	610
1	6	1073.0	3.223	34.370	2	140.48	2	−203.0	5.5	2	609
1	5	1175.4	3.080	34.441	2	148.70	2	−225.0	9.6	2	608
1	4	4006.2	1.475	34.683	2	162.60	2	−228.6	6.5	2	607

Station 41

Latitude	37.183°N	Date	3/21/91
Longitude	151.967°W	Bottom depth	5572

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
4	22	8.6	14.433	−9	9	−9	9	92.0	3.3	6	279,280
4	12	62.1	13.987	33.894	2	4.73	2	99.8	4.2	2	278
4	8	101.6	14.009	34.000	2	5.29	2	100.7	5.7	2	277
4	6	151.2	11.866	33.986	2	8.00	2	100.9	6.9	2	276
4	3	306.0	9.245	34.069	2	20.50	2	62.2	10.2	2	275
4	2	350.5	8.680	34.040	2	24.41	2	45.1	10.0	2	274
4	1	395.7	8.146	34.029	2	30.08	2	17.3	5.7	2	273
3	23	499.4	6.918	33.996	2	44.20	2	−4.8	8.7	2	272
3	21	599.9	5.666	33.989	2	65.29	2	−69.5	8.8	2	271
3	19	699.1	4.740	34.039	2	85.31	2	−116.7	3.4	2	270
3	17	899.4	3.739	34.210	2	119.23	2	−176.7	3.0	2	269

Station 44

Latitude	39.350°N	Date	3/22/96
Longitude	151.987°W	Bottom depth	5412

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	23	8.6	12.888	33.662	2	4.14	2	95.4	7.4	2	1058
1	21	77.2	12.625	33.657	2	3.75	2	90.6	6.3	2	1014
1	20	127.0	10.926	33.798	2	7.88	2	79.3	6.2	2	1013
1	19	151.5	10.343	33.848	2	10.44	2	72.0	5.7	2	1011
1	18	177.0	10.172	33.944	2	13.20	2	69.4	5.7	2	1017
1	17	201.5	10.118	34.059	2	15.75	2	76.1	6.0	2	1015
1	16	201.5	10.118	34.058	2	15.75	2	75.8	6.2	2	1016
1	14	349.4	8.128	34.015	2	27.37	2	33.3	6.0	2	1005

Station 44 (continued)

Latitude	39.350°N	Date	3/22/96
Longitude	151.987°W	Bottom depth	5412

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	15	349.4	8.128	34.015	2	27.37	2	36.8	6.0	2	1010
1	13	450.2	6.911	33.985	2	64.96	2	−74.1	2.9	2	1097
1	12	651.8	4.727	34.041	2	84.29	2	−109.2	4.3	2	997
1	11	651.8	4.727	34.042	2	84.27	2	−110.9	4.4	2	998
1	10	819.4	3.665	34.194	2	115.51	2	−170.3	3.1	6	999,1358
1	9	924.4	3.556	34.243	2	124.44	2	−181.7	5.2	2	1000
1	7	1074.9	3.194	34.332	2	139.15	2	−198.7	2.6	6	1001,1357
1	8	1074.9	3.194	34.331	2	138.56	2	−197.9	4.1	2	1002

Station 46

Latitude	40.674°N	Date	3/23/91
Longitude	152.022°W	Bottom depth	5021

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	31.8	11.366	33.512	2	4.15	2	71.3	4.2	2	1064
1	22	126.7	10.068	33.891	2	12.53	2	70.0	4.7	2	1065
1	21	150.0	9.799	33.966	2	15.52	2	72.5	3.9	2	1066
1	20	199.6	9.368	34.047	2	20.31	2	42.0	5.9	2	1091
1	18	350.7	7.233	33.974	2	35.49	2	21.8	9.3	2	1068
1	17	449.1	6.162	33.955	2	52.52	2	−29.4	9.1	2	1069
1	16	548.9	5.211	33.997	2	72.86	2	−82.5	5.8	2	1070
1	15	648.0	4.486	34.073	2	92.31	2	−125.3	5.2	2	1071
1	14	749.5	4.059	34.150	2	106.99	2	−154.3	8.2	2	1072
1	13	849.2	3.711	34.218	2	119.30	2	−173.1	3.1	2	1061
1	12	923.1	3.503	34.262	2	126.92	2	−181.0	4.6	2	1062
1	11	1072.5	3.164	34.335	2	139.98	2	−196.7	3.0	2	1063
1	10	1175.5	2.938	34.381	2	148.11	2	−218.7	5.9	2	1080
1	9	1375.9	2.634	34.452	2	159.23	2	−216.9	4.4	2	792
1	8	1502.2	2.481	34.486	2	164.06	2	−233.8	5.8	2	1082

Station 48

Latitude	41.998°N	Date	3/23/91
Longitude	151.987°W	Bottom depth	5117

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
4	22	8.1	10.047	33.231	2	6.56	2	59.1	6.8	2	194
4	17	103.2	9.002	33.708	2	15.55	2	58.7	8.0	2	193
4	16	127.8	8.908	33.811	2	17.31	2	53.3	5.6	6	267,268
4	15	151.0	8.687	33.864	2	19.76	2	41.3	6.4	2	192

Station 48 (continued)

Latitude	41.998°N	Date	3/23/91
Longitude	151.987°W	Bottom depth	5117

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
4	13	202.5	8.478	34.013	2	24.64	2	56.3	4.2	2	195
4	12	250.7	7.881	33.984	2	27.68	2	21.2	10.4	2	196
4	11	298.9	7.244	33.968	2	34.23	2	16.0	5.7	2	197
4	10	350.3	6.402	33.930	2	43.32	2	−3.5	5.9	2	198
4	8	449.0	5.489	33.931	2	59.85	2	−36.0	3.9	2	199
4	6	552.4	4.773	33.991	2	80.29	2	−93.1	3.3	2	191
4	4	648.8	4.313	34.089	2	97.39	2	−131.2	3.5	2	190
1	18	798.3	3.698	34.220	2	119.48	2	−173.8	3.2	2	189
1	17	849.4	3.559	34.247	2	124.47	2	−180.5	4.4	2	200
1	15	997.7	3.208	34.321	2	137.76	2	−199.4	2.8	2	188
1	14	1247.6	2.768	34.416	2	154.85	2	−220.8	3.2	2	187
1	13	1499.5	2.422	34.493	2	166.09	2	−234.4	3.8	2	186

Station 51

Latitude	44.419°N	Date	3/25/91
Longitude	151.997°W	Bottom depth	5201

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	22	8.4	8.613	32.994	3	10.95	2	55.8	7.8	6	1179,1251
1	20	78.8	8.582	33.003	3	11.31	2	47.0	8.7	2	1057
1	19	126.7	7.178	33.515	3	22.52	2	29.4	14.0	2	1056
1	18	152.6	7.756	33.754	3	23.87	2	38.2	3.7	2	1054
1	17	176.6	7.992	33.952	3	26.60	2	19.4	10.1	2	1053
1	15	202.4	7.482	33.967	3	31.27	2	10.8	8.2	2	1050
1	14	349.4	5.420	33.952	3	74.35	2	−99.7	7.7	2	1052
1	13	548.8	4.456	34.047	3	90.46	2	−146.5	3.8	2	2454
1	12	648.7	4.121	34.124	3	103.86	2	−119.2	4.8	2	1051
1	11	749.1	3.794	34.194	3	115.91	2	−173.4	11.4	2	1055
1	10	847.6	3.516	34.253	3	125.99	2	−178.5	4.8	2	977
1	9	922.6	3.339	34.289	3	132.04	2	−195.0	6.9	2	976
1	7	1172.9	2.863	34.394	3	151.19	2	−206.5	4.6	2	1049
1	6	1374.9	2.593	34.457	3	160.85	2	−228.8	3.9	2	1048
1	5	1498.5	2.423	34.489	3	165.97	2	−235.1	9.6	2	1047
1	4	1998.9	1.974	34.581	3	176.77	2	−252.4	5.1	2	1046

Station 55

Latitude	47.000°N	Date	3/27/91
Longitude	152.000°W	Bottom depth	5167

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	19	5.2	7.564	32.844	2	13.21	2	41.5	6.4	6	632,1652
1	13	42.2	7.566	32.847	2	13.41	2	40.7	3.8	2	631
1	9	101.1	6.473	33.313	2	23.19	2	37.0	3.7	2	630
1	8	126.8	6.446	33.415	2	24.16	2	36.2	3.7	2	629
1	7	150.8	6.434	33.547	2	27.78	2	27.0	4.3	2	628
1	5	202.9	5.762	33.807	2	41.47	2	0.4	3.6	2	627
1	4	251.7	5.151	33.817	2	51.84	2	−22.3	3.6	2	626
1	3	302.6	4.745	33.893	2	66.21	2	−68.7	6.8	2	625
1	2	350.6	4.446	33.906	2	75.30	2	−75.6	5.9	2	624
1	1	402.8	4.351	33.968	2	83.52	2	−88.3	4.1	2	2460
4	23	500.8	4.118	34.029	2	96.52	2	−120.5	3.6	2	638
4	21	599.4	3.913	34.118	2	108.15	2	−148.0	4.5	2	637
4	19	648.5	3.810	34.187	2	117.92	2	−163.3	3.0	2	636
4	17	797.8	3.438	34.257	2	128.08	2	−179.4	3.0	2	635
4	15	997.1	3.054	34.347	2	142.54	2	−194.9	3.6	2	634
4	13	1250.1	2.666	34.436	2	157.78	2	−212.3	3.6	2	633

Station 58

Latitude	53.495°N	Date	3/30/91
Longitude	152.001°W	Bottom depth	4714

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	23	34.7	4.045	32.776	2	33.47	2	34.7	3.2	2	926
1	22	63.6	4.033	32.776	2	33.46	2	29.9	3.8	2	921
1	21	101.1	4.083	33.595	2	39.99	2	10.6	3.1	2	919
1	20	149.0	4.186	33.797	2	77.14	2	−68.5	2.9	2	931
1	19	202.1	4.022	33.901	2	88.79	2	−88.7	2.8	2	932
1	18	297.6	3.855	34.008	2	101.93	2	−123.3	2.4	2	917
1	17	401.8	3.728	34.110	2	113.31	2	−150.0	2.4	2	916
1	16	495.7	3.591	34.171	2	120.44	2	−161.4	2.5	2	922
1	15	600.9	3.357	34.252	2	130.90	2	−188.7	4.6	2	1012
1	14	697.2	3.183	34.297	2	137.69	2	−187.0	2.7	2	924
1	12	950.8	2.790	34.389	2	150.73	2	−213.3	2.2	2	918
1	11	1200.4	2.490	34.460	2	160.97	2	−224.6	3.3	2	925
1	10	1447.3	2.280	34.508	2	167.68	2	−228.4	2.2	2	920
1	9	1693.4	2.113	34.545	2	172.51	2	−240.9	2.2	2	935

Station 60

Latitude	55.445°N	Date	3/31/91
Longitude	152.628°W	Bottom depth	5158

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
4	21	7.8	3.139	32.861	2	35.27	2	13.3	6.1	2	3135
4	18	33.5	3.121	32.861	2	35.42	2	6.8	5.9	2	3136
4	15	61.5	3.053	32.860	2	35.36	2	7.2	5.9	2	3134
4	13	82.6	3.035	32.859	2	35.13	2	13.7	7.4	2	3133
4	8	140.8	4.127	33.821	2	80.79	2	−82.7	4.7	2	3132
4	5	201.2	4.044	33.950	2	93.11	2	−102.4	15.0	2	3131
4	4	247.8	3.989	34.000	2	99.01	2	−117.2	5.3	2	3130
4	2	350.0	3.843	34.088	2	108.96	2	−150.6	4.0	6	2772,3129
4	1	350.0	3.843	34.089	2	109.09	2	−149.8	4.9	2	3137
3	23	499.7	3.556	34.205	2	123.64	2	−145.4	8.3	2	3128
3	21	599.7	3.389	34.257	2	131.16	2	−213.1	18.1	3	3127
3	19	700.9	3.233	34.299	2	137.24	2	−173.6	7.0	2	3126
3	17	901.0	2.916	34.367	2	147.73	2	−195.7	6.7	2	3125
3	15	1074.7	2.651	34.425	2	156.79	2	−214.0	4.0	2	3124
3	13	1498.3	2.161	34.532	2	170.35	2	−233.3	3.9	2	3123

Station 64

Latitude	56.295°N	Date	4/1/91
Longitude	153.233°W	Bottom depth	272

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	12	7.1	3.695	32.659	2	33.00	2	19.7	3.1	2	915
1	10	29.2	3.717	32.667	2	32.96	2	9.3	3.1	2	897
1	9	51.4	3.744	32.686	2	33.34	2	132.2	3.4	4	896
1	8	77.6	3.658	32.697	2	33.72	2	23.5	3.1	2	895
1	7	97.8	3.714	32.714	2	34.30	2	16.4	3.1	2	914
1	5	125.5	4.055	32.786	2	34.66	2	23.2	3.0	2	894
1	3	199.6	5.333	33.137	2	42.23	2	7.3	3.0	2	893
1	1	238.9	5.124	33.765	2	64.06	2	−36.6	2.9	2	892

Station 66

Latitude	52.491°N	Date	4/2/91
Longitude	152.020°W	Bottom depth	4431

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	31.9	4.106	32.714	2	−9	9	24.1	4.8	2	359
1	22	105.7	4.360	33.332	2	53.83	2	−25.1	4.3	2	356
1	21	131.4	4.345	33.766	2	71.52	2	−49.2	3.3	2	358
1	20	151.7	4.118	33.844	2	81.38	2	−75.0	3.9	2	355

Station 66 (continued)

Latitude		52.491°N					Date			4/2/91
Longitude		152.020°W					Bottom depth			4431
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	19	203.3	3.943	33.912	2	90.87	2	−93.5	4.1	2	360
1	18	298.8	3.784	34.009	2	102.60	2	−122.0	4.0	2	354
1	17	399.0	3.743	34.108	2	111.77	2	−138.0	3.6	2	353
1	16	499.0	3.553	34.178	2	120.78	2	−157.7	4.1	2	352
1	15	600.1	3.384	34.238	2	128.42	2	−180.1	5.0	2	351
1	14	701.2	3.197	34.291	2	136.29	2	−191.1	4.5	2	350
1	13	803.2	3.036	34.331	2	141.94	2	−201.0	3.0	2	349
1	12	898.9	2.889	34.368	2	146.99	2	−214.3	3.0	2	348
1	10	1201.2	2.542	34.450	2	159.22	2	−225.2	2.9	2	376
1	9	1447.8	2.292	34.506	2	167.03	2	−203.0	4.4	3	375
1	8	1697.9	2.113	34.544	2	170.91	2	−236.8	4.8	2	346

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J. Swift

Station 125

Latitude	6.512°S	Date	7/22/91
Longitude	135.012°W	Bottom depth	4474

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.4	27.461	35.241	2	2.54	2	79.50	4.01	2	1602
1	4	97.8	27.400	35.277	2	2.44	2	78.27	4.01	2	1601
1	6	128.4	24.424	36.096	2	1.95	2	77.52	4.08	2	1600
1	9	206.9	13.624	34.970	2	22.08	2	−2.15	4.81	2	1599
1	10	267.7	11.742	34.858	2	25.02	2	−35.74	4.75	2	1598
1	11	307.9	11.113	34.819	2	27.66	2	−51.24	7.26	2	1597
1	12	368.5	10.170	34.758	2	32.35	2	−69.20	3.67	2	1596
1	13	430.7	9.311	34.703	2	34.11	2	−84.30	4.56	2	1595
1	14	492.1	8.455	34.651	2	37.53	2	−105.84	5.31	2	1594
1	15	552.5	7.686	34.606	2	39.29	2	−80.92	3.79	4	1593
1	16	613.9	7.133	34.578	2	42.03	2	−114.36	5.25	2	1592
1	17	734.6	6.137	34.549	2	54.06	2	−143.30	3.96	2	1591
1	18	918.5	4.896	34.536	2	71.85	2	−170.99	8.97	2	1590
1	19	1121.3	4.094	34.556	2	90.42	2	−204.68	10.17	3	1589

Station 127

Latitude	7.522°S	Date	7/22/91
Longitude	135.003°W	Bottom depth	4387

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	10.3	27.648	35.162	2	2.34	2	81.93	5.25	2	1813
1	4	93.3	26.733	35.938	2	2.15	2	83.29	6.90	2	1812
1	6	126.7	24.448	36.114	2	1.76	2	94.89	8.90	2	1811
1	7	154.5	22.300	36.026	2	1.76	2	118.04	3.80	2	1810
1	8	185.8	18.786	35.537	2	3.52	2	118.97	3.63	2	1809
1	9	227.1	14.387	35.042	2	9.87	2	51.36	10.12	2	1818
1	10	277.3	11.799	34.835	2	19.45	2	−26.77	7.64	2	2021
1	11	327.8	10.275	34.764	2	25.41	2	−58.94	2.94	2	1820
1	12	373.3	9.625	34.720	2	29.32	2	−74.56	3.07	2	1819
1	13	418.7	9.049	34.686	2	32.35	2	−91.93	2.82	2	1808
1	14	465.2	8.635	34.656	2	33.53	2	−95.83	2.66	2	1807
1	15	511.8	8.083	34.624	2	35.29	2	−96.68	2.65	2	1806
1	16	588.7	7.380	34.590	2	40.08	2	−108.74	3.24	2	1805
1	17	714.3	6.219	34.548	2	51.22	2	−131.45	2.77	2	1804
1	18	863.9	5.191	34.534	2	66.37	2	−154.84	2.89	2	1816
1	19	1114.1	4.055	34.551	2	87.10	2	−174.17	2.69	2	1815

Station 129

Latitude	8.513°S	Date	7/2391
Longitude	134.892°W	Bottom depth	4507

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	0.2	27.686	35.307	2	1.88	2	76.96	4.04	2	1992
2	3	67.5	27.741	36.120	2	1.67	2	65.81	6.34	2	2418
2	4	97.9	26.325	36.147	2	1.66	2	59.85	9.65	2	1991
2	6	144.7	22.232	36.050	2	2.03	2	104.16	5.45	2	2042
2	7	185.3	19.742	35.720	2	2.22	2	123.25	3.07	2	2043
2	8	227.1	16.228	35.219	2	5.91	2	82.52	3.73	2	1990
2	10	288.4	11.561	34.791	2	23.41	2	−43.56	3.58	2	1989
2	11	349.4	10.031	34.737	2	27.30	2	−56.92	3.16	2	2041
2	12	411.2	9.144	34.685	2	30.40	2	−113.26	4.43	3	2259
2	13	488.7	8.278	34.634	2	35.26	2	−118.11	6.31	3	2258
2	37	563.7	7.609	34.598	2	38.94	2	−126.08	4.11	2	2000
2	15	666.9	6.587	34.552	2	46.72	2	−144.86	5.49	2	1988
2	16	768.5	5.657	34.533	2	58.03	2	−161.50	5.40	2	1987
2	17	871.9	5.046	34.531	2	67.01	2	−168.41	5.72	2	1986
2	18	974.2	4.424	34.537	2	77.97	2	−165.43	2.81	2	2040
2	19	1128.9	3.882	34.555	2	88.79	2	−180.51	2.30	2	2039

Station 132

Latitude	10.055°S	Date	7/24/91
Longitude	134.957°W	Bottom depth	4444

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	0.2	27.402	35.790	2	1.46	2	91.73	4.02	2	1360
2	4	85.4	27.521	36.125	2	1.46	2	77.56	3.98	2	1363
2	6	125.6	24.610	36.240	2	1.85	2	88.91	4.00	2	1362
2	7	150.6	22.512	36.152	2	1.46	2	111.51	4.06	2	1361
2	8	192.7	19.722	35.730	2	1.86	2	124.29	6.62	2	1447
2	9	244.9	15.142	35.114	2	6.06	2	93.72	6.23	2	1446
2	10	292.0	11.634	34.700	2	16.81	2	4.02	4.14	2	1445
2	11	336.8	9.962	34.668	2	24.73	2	−59.53	4.01	2	1444
2	12	407.4	8.607	34.628	2	29.91	2	−73.64	3.68	2	1443
2	13	485.8	7.636	34.590	2	35.68	2	−82.97	2.66	2	2033
2	37	587.0	6.768	34.553	2	42.62	2	−108.43	4.53	2	1985
2	15	710.3	5.948	34.532	2	52.40	2	−135.80	3.70	2	1709
2	16	813.3	5.277	34.528	2	62.66	2	−150.74	7.13	2	1708
2	17	914.6	4.844	34.528	2	69.80	2	−193.70	8.34	3	1707
2	18	1017.3	4.399	34.536	2	78.50	2	−171.19	3.59	2	1706
2	19	1119.5	4.044	34.546	2	85.73	2	−170.34	7.90	2	1705

Station 135

Latitude	11.487°S	Date	7/25/91
Longitude	134.700°W	Bottom depth	4277

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	27.188	35.846	4	1.86	4	86.37	3.13	2	5936
1	4	101.6	24.992	36.320	2	1.76	2	94.72	2.76	2	5935
1	5	122.5	23.775	36.277	2	2.44	2	98.84	2.72	2	5934
1	6	153.6	22.000	36.095	2	1.86	2	109.33	3.10	2	5933
1	7	183.6	20.293	35.824	2	1.86	2	115.06	2.88	2	5929
1	8	214.3	17.828	35.415	2	3.03	2	108.14	2.84	2	5928
1	9	267.2	13.325	34.833	2	11.83	2	44.07	3.17	2	5927
1	10	317.3	11.367	34.714	2	21.50	2	−25.25	5.04	2	5926
1	12	370.0	9.958	34.662	2	25.61	2	−56.98	3.22	2	5925
1	13	429.8	8.718	34.631	2	30.01	2	−81.19	2.54	2	5924
1	37	512.4	7.695	34.593	2	36.66	2	−114.38	2.44	2	5923
1	15	615.2	6.612	34.550	2	45.75	2	−118.41	4.09	2	5922
1	16	716.6	5.902	34.531	2	53.37	2	−135.99	2.65	2	5921
1	17	820.2	5.332	34.523	2	59.92	2	−142.80	2.32	2	5920
1	18	922.6	4.730	34.529	2	71.36	2	−162.08	3.10	2	5919
1	19	1025.3	4.371	34.538	2	79.37	2	−168.63	2.29	2	5918

Station 138

Latitude	12.933°S	Date	7/26/91
Longitude	134.383°W	Bottom depth	4398

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	1.9	26.825	36.260	2	1.90	2	79.94	2.82	2	6977
1	3	85.6	26.853	36.839	2	1.69	2	86.90	3.20	2	6976
1	4	106.4	25.119	36.348	2	1.69	2	97.62	3.39	2	6975
1	5	127.1	24.529	36.409	2	1.69	2	113.29	3.77	2	6974
1	6	168.0	22.923	36.283	2	1.68	2	118.84	3.24	2	6973
1	7	208.6	20.896	35.963	2	1.68	2	129.30	3.09	2	6972
1	8	259.8	17.82	35.424	2	2.06	2	131.79	2.99	2	6971
1	9	336.1	11.819	34.697	2	16.32	2	24.86	3.21	2	6970
1	10	413.3	9.459	34.623	2	26.34	2	−69.93	2.64	2	6969
1	12	535.6	7.590	34.563	2	32.49	2	−100.41	3.25	2	6968
1	13	617.7	6.596	34.522	2	38.46	2	−111.00	2.58	2	6967
1	37	719.9	5.890	34.510	2	47.91	2	−122.30	2.50	2	6966
1	15	822.8	5.280	34.502	2	55.64	2	−141.38	2.53	2	6965
1	16	924.7	4.749	34.506	2	63.56	2	−147.74	2.49	2	6964
1	17	1026.8	4.297	34.521	2	72.87	2	−166.62	2.40	2	6963
1	18	1130.4	3.888	34.535	2	82.40	2	−178.29	2.48	2	6962

Station 143

Latitude	15.377°S	Date	7/28/91
Longitude	133.893°W	Bottom depth	4221

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
3	1	2.9	26.565	36.606	2	1.44	2	101.81	3.88	2	3213
3	4	121.4	25.761	36.473	2	1.40	2	103.56	3.84	2	3212
3	5	144.3	23.854	36.337	2	1.39	2	124.27	3.92	2	3211
3	6	172.8	22.501	36.506	4	1.38	4	100.47	3.83	4	3210
3	7	200.0	21.657	36.144	2	1.37	2	125.07	4.24	2	3209
3	8	246.6	19.634	35.757	2	1.36	2	129.40	3.85	2	3208
3	9	294.9	16.129	35.186	2	2.68	2	104.94	6.36	2	3220
3	10	345.3	12.341	34.715	2	8.04	2	53.66	3.23	2	3203
3	11	397.1	10.164	34.545	2	16.26	2	−21.59	3.01	2	3202
3	12	448.4	8.446	34.514	2	24.11	2	−86.29	3.62	2	3201
3	13	498.1	7.722	34.510	2	26.78	2	−91.64	3.73	2	3200
3	37	602.7	6.625	34.506	2	36.16	2	−111.55	3.18	2	3219
3	15	710.2	5.816	34.498	2	46.89	2	−128.82	4.94	2	3199
3	16	812.7	5.270	34.496	2	54.76	2	−136.27	3.82	2	3198
3	17	918.3	4.768	34.506	2	64.56	2	−166.96	3.48	2	3197
3	18	1023.6	4.350	34.519	2	73.82	2	−175.36	3.51	2	3364

Station 147

Latitude	17.348°S	Date	7/29/91
Longitude	133.470°W	Bottom depth	4384

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	3.1	26.035	36.576	2	1.57	2	87.90	3.71	2	6877
1	3	106.7	25.970	36.561	2	1.00	2	102.17	5.15	2	6876
1	5	157.4	23.695	36.281	2	1.20	2	51.70	3.49	4	6875
1	6	182.5	23.083	36.287	2	1.01	2	126.33	3.80	2	6874
1	7	209.0	22.486	36.239	2	1.02	2	136.36	3.91	2	6873
1	9	285.1	18.706	35.574	2	1.41	2	131.68	4.05	2	6872
1	10	337.5	15.547	35.096	2	2.38	2	126.36	4.79	2	6871
1	11	389.0	11.389	34.632	2	7.78	2	57.83	3.57	2	6870
1	12	439.2	9.106	34.462	2	13.37	2	−9.08	3.44	2	6869
1	13	495.7	7.440	34.415	2	19.15	2	−57.17	3.23	2	6868
1	37	556.8	6.488	34.375	2	20.12	2	−48.81	5.13	3	6867
1	15	618.0	5.905	34.390	2	27.44	2	−83.07	3.76	2	6866
1	16	720.5	5.473	34.454	2	43.83	2	−123.60	2.60	2	6984
1	17	823.6	5.081	34.481	2	54.26	2	−143.40	3.40	2	6983
1	18	926.0	4.678	34.496	2	62.58	2	−156.10	2.90	2	6982
1	19	1079.5	4.135	34.517	2	74.22	2	−170.70	2.80	2	6981

Station 153

Latitude	20.282°S	Date	7/3091
Longitude	132.827°W	Bottom depth	4414

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	2.8	25.183	36.420	2	1.66	2	80.69	9.19	3	3230
2	4	132.1	24.922	36.347	2	1.46	2	118.38	9.47	2	3229
2	5	157.6	23.327	36.129	2	1.46	2	121.11	6.01	2	3228
2	7	209.4	21.555	36.062	2	1.46	2	149.00	5.68	2	3227
2	8	260.7	19.016	35.625	2	1.47	2	127.53	4.77	2	3226
2	9	311.8	16.744	35.281	2	1.47	2	107.45	4.78	2	3225
2	10	373.4	14.174	34.967	2	3.22	2	82.59	4.82	2	3224
2	11	435.0	10.965	34.626	2	6.26	2	28.97	4.69	2	3223
2	12	496.1	8.180	34.419	2	11.05	2	0.13	4.64	2	3222
2	13	556.6	6.785	34.361	2	14.66	2	−48.00	4.41	2	3221
2	37	628.6	6.062	34.331	2	16.23	2	−70.39	3.34	2	3218
2	15	690.0	5.700	34.333	2	21.02	2	−89.68	3.30	2	3217
2	17	823.1	5.185	34.397	2	38.42	2	−124.33	3.52	2	3216
2	19	1028.0	4.277	34.486	2	64.42	2	−162.85	3.04	2	3215
2	20	1233.8	3.450	34.529	2	82.80	2	−184.61	2.98	2	3214

Station 156

Latitude	21.768°S	Date	7/3191
Longitude	132.532°W	Bottom depth	3822

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	2.5	24.281	36.227	2	1.48	2	115.99	3.66	2	6893
1	4	140.7	23.296	36.033	2	1.07	2	108.35	4.74	2	6892
1	5	166.5	22.286	35.971	2	1.07	2	135.55	3.72	2	6891
1	6	198.2	21.602	35.930	2	1.06	2	136.89	3.79	2	6890
1	7	250.0	19.617	35.689	2	1.05	2	146.46	4.35	2	6889
1	8	310.8	17.369	35.371	2	1.43	2	148.69	4.03	2	6888
1	9	373.8	14.338	35.002	2	2.58	2	118.70	4.28	2	6887
1	10	434.5	11.522	34.674	2	5.29	2	90.05	4.93	2	6886
1	11	496.0	8.689	34.453	2	8.96	2	26.82	4.51	2	6885
1	12	568.1	6.879	34.357	2	12.25	2	−20.08	3.44	2	6884
1	13	627.9	6.161	34.332	2	15.14	2	−46.46	3.23	2	6883
1	37	669.1	5.817	34.321	2	17.27	2	−56.47	3.40	2	6882
1	15	708.3	5.524	34.321	2	20.95	2	−72.42	3.27	2	6881
1	16	768.6	5.116	34.331	2	27.14	2	−101.41	7.85	2	6880
1	17	870.0	4.646	34.394	2	44.21	2	−126.82	3.07	2	6879
1	18	970.2	4.367	34.453	2	58.01	2	−149.96	3.81	2	6878

Station 161

Latitude	24.212°S	Date	8/2/91
Longitude	132.675°W	Bottom depth	3810

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	4.1	22.082	35.704	3	1.27	2	134.37	3.06	2	6722
1	3	87.0	22.099	35.695	2	1.25	2	124.62	3.13	2	6721
1	7	139.3	20.645	35.605	2	1.01	2	129.04	2.93	2	6720
1	9	169.0	19.568	35.569	2	0.98	2	130.32	3.81	2	6719
1	10	207.6	18.410	35.466	2	0.97	2	126.86	3.22	2	6718
1	11	255.4	17.054	35.359	2	1.35	2	120.97	2.92	2	6717
1	12	301.5	15.752	35.225	2	1.73	2	116.60	2.90	2	6716
1	13	350.1	13.833	35.025	2	2.50	2	83.98	2.93	2	6706
1	37	403.2	11.241	34.720	2	4.25	2	54.58	3.02	2	6705
1	15	506.1	8.092	34.435	2	7.57	2	5.33	3.08	2	6704
1	16	607.3	6.411	34.368	2	9.13	2	−12.22	4.18	2	6703
1	17	713.7	5.661	34.299	2	13.82	2	−51.87	2.71	2	6702
1	18	818.2	5.057	34.299	2	21.65	2	−87.13	4.52	2	6701
1	19	918.2	4.470	34.341	2	36.34	2	−117.07	3.48	2	6613
1	20	1012.6	4.032	34.399	2	51.64	2	−133.33	3.20	2	6612

Station 166

Latitude	23.643°S	Date	8/3/91
Longitude	133.295°W	Bottom depth	4037

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	61	7.6	20.626	35.581	2	1.17	2	143.99	4.24	2	3333
2	5	170.6	19.153	35.460	2	0.98	2	148.24	4.12	2	3332
2	7	282.1	15.429	35.213	2	1.27	2	115.41	4.07	2	3331
2	68	340.3	13.720	35.030	2	2.05	2	89.33	3.91	2	3330
2	69	400.1	11.308	34.769	2	3.62	2	59.21	3.78	2	3329
2	70	464.4	8.845	34.519	2	5.38	2	23.98	3.68	2	3328
2	11	526.7	7.400	34.414	2	6.45	2	16.73	3.91	2	3327
2	12	594.3	6.735	34.372	2	7.63	2	−2.54	3.71	2	3326
2	13	671.9	6.198	34.333	2	9.58	2	−27.50	4.63	2	3325
2	37	723.7	5.956	34.319	2	11.15	2	−34.85	3.77	2	3324
2	15	774.3	5.595	34.304	2	13.69	2	−51.37	3.62	2	3323
2	16	825.8	5.263	34.297	2	17.01	2	−77.66	3.60	2	3322
2	17	928.7	4.651	34.314	2	28.84	2	−107.30	3.47	2	3321
2	18	1031.3	4.179	34.352	2	40.57	2	−132.95	3.40	2	3320
2	19	1131.9	3.716	34.408	2	54.36	2	−144.97	3.98	2	3319
2	21	1375.8	2.987	34.512	2	80.26	2	−175.42	3.39	2	3318
2	31	3380.6	1.572	34.681	2	125.21	2	−210.34	2.12	2	4270
2	32	3588.2	1.537	34.684	2	125.40	2	−196.27	2.17	2	4271

Station 166 (continued)

Latitude	23.643°S	Date	8/3/91
Longitude	133.295°W	Bottom depth	4037

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	33	3796.3	1.531	34.686	2	125.11	2	−189.98	3.07	2	4272
2	38	4099.8	1.544	34.688	2	125.11	2	−176.04	2.97	2	4273

Station 169

Latitude	28.102°S	Date	8/5/91
Longitude	133.680°W	Bottom depth	4192

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	2.8	19.591	35.544	2	1.53	2	126.23	3.00	2	6961
1	5	106.6	18.859	35.445	2	1.12	2	130.56	2.96	2	6960
1	6	142.8	17.780	35.381	2	1.12	2	121.57	2.92	2	6959
1	7	177.8	16.943	35.361	2	1.50	2	125.56	3.09	2	6958
1	68	220.0	15.955	35.281	2	1.50	2	112.37	3.74	2	6957
1	69	260.8	14.851	35.166	2	1.69	2	107.20	4.22	2	6956
1	70	337.2	12.085	34.844	2	3.25	2	71.80	2.88	2	6955
1	11	413.5	9.286	34.564	2	5.39	2	39.25	3.67	2	6954
1	12	489.6	7.783	34.432	2	6.75	2	21.06	3.80	2	6953
1	13	566.0	6.835	34.369	2	7.92	2	0.59	2.85	2	6952
1	37	668.9	6.087	34.322	2	10.65	2	−28.16	2.67	2	6951
1	15	771.7	5.517	34.296	2	15.13	2	−57.23	3.36	2	6950
1	16	873.3	4.944	34.300	2	23.13	2	−80.37	2.58	2	6949
1	17	976.0	4.427	34.328	2	33.09	2	−104.65	2.91	2	6948
1	18	1027.2	4.229	34.344	2	37.77	2	−101.35	2.74	3	6947
1	19	1079.0	3.950	34.371	2	45.00	2	−131.22	2.57	2	6739
1	30	3083.4	1.651	34.674	2	126.98	2	−219.65	3.35	2	4329
1	32	3504.1	1.553	34.683	2	125.95	2	−209.15	2.09	2	4328
1	34	3925.0	1.508	34.690	2	124.72	2	−201.39	2.19	2	4327
1	38	4252.5	1.518	34.692	2	124.50	2	−197.78	2.12	2	4324

Station 172

Latitude	29.560°S	Date	8/5/91
Longitude	134.065°W	Bottom depth	4177

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	61	3.5	18.164	35.403	2	1.47	2	125.05	3.95	2	3347
2	5	117.7	17.468	35.307	2	1.27	2	131.75	4.41	2	3346
2	6	149.2	16.605	35.291	2	1.37	2	124.07	4.33	2	3345
2	7	180.2	15.792	35.257	2	1.56	2	116.01	4.22	2	3344
2	68	210.5	14.906	35.152	2	1.56	2	99.94	4.14	2	3365

Station 172 (continued)

Latitude	29.560°S	Date	8/5/91
Longitude	134.065°W	Bottom depth	4177

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	69	262.3	13.391	35.000	2	2.93	2	89.03	3.72	2	3343
2	70	313.0	11.734	34.817	2	3.52	2	67.68	4.87	2	3342
2	11	387.2	9.270	34.566	2	5.47	2	38.57	4.76	2	3341
2	12	462.2	7.744	34.438	2	6.26	2	34.22	4.24	2	3340
2	13	538.9	6.918	34.385	2	7.63	2	−9.84	3.82	2	3366
2	37	615.0	6.422	34.349	2	9.09	2	−6.36	3.62	2	3339
2	15	718.6	6.002	34.321	2	11.24	2	−27.09	3.56	2	3338
2	16	822.9	5.310	34.298	2	17.50	2	−73.96	3.54	2	3337
2	18	1030.1	4.141	34.345	2	39.20	2	−122.92	4.49	2	3336
2	19	1133.1	3.704	34.392	2	51.52	2	−145.15	3.31	2	3335
2	21	1287.4	3.160	34.470	2	69.51	2	−172.74	3.14	2	3334
2	30	3093.0	1.643	34.675	2	127.55	2	−207.87	2.99	2	4274
2	31	3299.6	1.585	34.680	2	126.87	2	−221.33	4.48	2	4275
2	33	3705.4	1.496	34.688	2	125.01	2	−223.14	2.45	2	4276
2	35	4114.6	1.492	34.693	2	124.52	2	−208.20	2.08	2	4277

Station 176

Latitude	31.510°S	Date	8/7/91
Longitude	134.617°W	Bottom depth	4303

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	2.8	16.809	35.170	2	1.47	2	123.20	3.14	2	6738
1	6	159.7	16.421	35.115	2	0.78	2	116.10	3.13	2	6737
1	68	211.6	14.746	35.063	2	1.17	2	112.10	2.92	2	6727
1	69	260.8	13.440	34.930	2	2.15	2	101.55	3.01	2	6726
1	70	312.2	11.239	34.734	2	3.32	2	63.39	3.56	2	6725
1	12	412.6	8.186	34.463	2	5.08	2	38.94	3.68	2	6724
1	37	516.5	7.140	34.402	2	6.75	2	22.35	4.61	2	6723
1	15	619.6	6.549	34.357	2	8.31	2	−2.49	2.85	2	6732
1	16	722.5	6.030	34.323	2	10.75	2	−37.15	2.65	2	6731
1	17	824.7	5.594	34.303	2	14.08	2	−64.41	2.63	2	6730
1	18	926.3	4.996	34.302	2	22.19	2	−78.63	2.49	2	6729
1	19	1030.3	4.406	34.328	2	32.46	2	−104.99	2.46	2	6728
1	20	1133.0	3.866	34.362	2	43.51	2	−131.41	2.68	2	6736
1	21	1286.2	3.221	34.445	2	62.76	2	−156.88	2.56	2	6735
1	22	1439.7	2.853	34.502	2	75.47	2	−170.76	3.05	2	6734
1	23	1645.1	2.503	34.569	2	92.67	2	−189.48	2.29	2	6733
1	30	3068.7	1.667	34.673	2	127.16	2	−213.27	2.22	2	4334
1	32	3470.8	1.580	34.682	2	126.09	2	−203.19	2.09	2	4333

Station 176 (continued)

Latitude	31.510°S	Date	8/7/91
Longitude	134.617°W	Bottom depth	4303

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	34	3877.7	1.439	34.693	2	124.42	2	−193.90	3.37	2	4331
1	35	4126.9	1.354	34.701	2	122.76	2	−200.65	2.05	2	4330

Station 179

Latitude	33.015°S	Date	8/8/91
Longitude	135.028°W	Bottom depth	4468

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	61	8.1	16.480	35.199	2	1.05	2	140.98	5.30	2	3405
2	5	161.9	15.352	35.075	2	0.99	2	134.84	5.68	2	3404
2	7	229.3	13.244	34.945	2	2.14	2	104.26	5.78	2	3403
2	69	311.4	10.498	34.664	2	3.29	2	58.80	4.08	2	3355
2	11	412.2	7.989	34.451	2	5.23	2	29.73	4.23	2	3354
2	13	514.4	6.902	34.381	2	7.16	2	−4.65	3.84	2	3353
2	37	618.2	6.403	34.347	2	8.72	2	−9.86	4.64	2	3352
2	15	717.2	6.010	34.321	2	10.67	2	−20.73	3.63	2	3402
2	16	823.1	5.481	34.301	2	14.99	2	−52.56	3.90	2	3401
2	17	927.2	4.889	34.308	2	24.03	2	−80.23	4.06	2	3400
2	18	1025.0	4.311	34.328	2	33.47	2	−113.60	3.42	2	3399
2	19	1127.8	3.763	34.368	2	44.68	2	−127.17	3.58	2	3398
2	20	1287.1	3.208	34.434	2	59.07	2	−145.49	3.74	2	3351
2	21	1445.3	2.827	34.502	2	73.31	2	−168.31	3.18	2	3350
2	22	1642.5	2.521	34.567	2	89.42	2	−187.94	3.12	2	3349
2	23	1846.0	2.296	34.607	2	102.03	2	−198.03	3.11	2	3348
2	28	2883.6	1.709	34.670	2	126.08	2	−206.53	3.32	2	3411
2	29	3089.6	1.655	34.673	2	126.25	2	−212.00	3.03	2	3410
2	30	3292.9	1.615	34.680	2	125.81	2	−211.41	3.28	2	3409
2	32	3716.0	1.487	34.692	2	124.72	2	−197.17	4.18	2	3408
2	33	3920.3	1.401	34.698	2	123.46	2	−197.60	3.28	2	3407
2	35	4333.1	1.307	34.705	2	121.76	2	−169.92	3.65	2	3406

Station 180

Latitude	37.513°S	Date	8/12/91
Longitude	150.517°W	Bottom depth	5527

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	61	4.2	13.384	34.746	2	1.47	2	108.32	4.15	2	3367
2	4	132.1	12.963	34.702	2	1.17	2	90.78	4.74	2	3368
2	5	172.7	11.184	34.619	2	1.76	2	69.77	3.83	2	3369

Station 180 (continued)

Latitude	37.513°S	Date	8/12/91
Longitude	150.517°W	Bottom depth	5527

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	7	233.1	9.280	34.566	2	3.52	2	60.28	3.84	2	3370
2	69	314.9	8.119	34.493	2	4.89	2	43.03	5.18	2	3371
2	70	392.6	7.740	34.468	2	5.67	2	76.69	4.47	4	3372
2	11	469.4	7.411	34.442	2	6.84	2	37.25	3.76	2	3431
2	12	546.0	7.115	34.414	2	7.63	2	23.83	3.57	2	3430
2	13	621.7	6.760	34.385	2	8.80	2	11.45	6.21	2	3429
2	37	724.9	6.325	34.352	2	11.24	2	−27.64	4.39	2	3428
2	15	827.8	5.844	34.328	2	14.96	2	−50.44	4.95	2	3427
2	16	931.5	5.266	34.326	2	21.80	2	−77.59	3.76	2	3426
2	17	1033.6	4.618	34.329	2	30.11	2	−110.83	5.43	2	3425
2	18	1187.8	3.857	34.363	2	43.11	2	−121.54	3.51	2	3424
2	19	1341.4	3.255	34.426	2	57.48	2	−142.94	3.26	2	3423
2	20	1543.5	2.823	34.527	2	78.01	2	−175.30	3.73	2	3422
2	21	1799.4	2.513	34.597	2	98.24	2	−193.79	3.68	2	3373
2	22	2052.0	2.311	34.623	2	109.48	2	−200.22	3.18	2	3374
2	23	2297.6	2.135	34.641	2	117.00	2	−208.43	3.09	2	3375
2	24	2555.0	2.008	34.653	2	122.86	2	−218.11	4.07	2	3376
2	25	2809.1	1.899	34.662	2	127.85	2	−208.41	3.60	2	3377
2	26	3050.8	1.814	34.671	2	128.24	2	−212.16	5.03	2	3378
2	27	3291.1	1.740	34.685	2	125.11	2	−165.52	4.31	4	3379
2	28	3528.9	1.683	34.701	2	117.58	2	−188.05	3.78	2	3380
2	29	3778.7	1.547	34.713	2	114.16	2	−190.58	3.37	2	3381
2	30	4023.2	1.407	34.714	2	114.75	2	−189.31	3.24	2	3382
2	31	4278.0	1.265	34.714	2	117.39	2	−193.33	3.16	3	3383
2	32	4546.9	1.180	34.712	2	119.24	2	−190.74	3.23	3	3384
2	33	4810.4	1.141	34.710	2	120.32	2	−176.40	3.31	2	3385
2	34	5111.7	1.116	34.709	2	121.98	2	−182.83	3.46	3	3386
2	35	5381.0	1.125	34.708	2	122.76	2	−167.21	3.78	2	3387
2	38	5641.6	1.153	34.709	2	122.96	2	−167.68	4.47	2	3388

Station 184

Latitude	35.485°S	Date	8/13/91
Longitude	150.508°W	Bottom depth	5372

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	6.7	14.298	34.918	2	1.27	2	107.38	3.80	2	5224
1	5	190.0	11.343	34.724	2	2.05	2	75.98	3.92	2	5223
1	68	352.2	8.107	34.497	2	5.28	2	54.34	4.15	2	5222
1	70	485.1	7.372	34.439	2	6.65	2	32.64	4.08	2	5221
1	12	639.2	6.711	34.381	2	8.99	2	2.77	5.40	2	5201

Station 184 (continued)

Latitude	35.485°S	Date	8/13/91
Longitude	150.508°W	Bottom depth	5372

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	13	720.0	6.365	34.354	2	11.05	2	−13.52	4.08	2	5200
1	37	818.8	5.774	34.326	2	15.45	2	−36.32	4.28	2	5199
1	15	917.3	5.167	34.319	2	22.68	2	−74.83	4.30	2	5198
1	16	1019.1	4.551	34.330	2	31.29	2	−80.88	5.74	2	5197
1	18	1269.6	3.392	34.402	2	52.99	2	−125.71	4.44	2	5194
1	19	1418.7	2.944	34.486	2	69.70	2	−148.34	3.68	2	5193
1	20	1609.6	2.665	34.563	2	87.98	2	−164.99	3.92	2	5192
1	21	1798.3	2.464	34.598	2	100.00	2	−179.23	3.72	2	5191
1	22	1992.0	2.264	34.624	2	109.67	2	−201.72	3.34	2	5190
1	23	2186.7	2.115	34.639	2	116.32	2	−207.54	3.42	2	5189
1	24	2376.5	2.000	34.650	2	122.28	2	−215.02	4.34	2	5188
1	29	3636.8	1.528	34.695	2	123.06	2	−193.26	2.97	2	3416
1	31	4149.9	1.312	34.708	2	118.46	2	−187.65	3.34	2	3415
1	33	4649.0	1.155	34.709	2	120.51	2	−167.10	2.97	2	3414
1	35	5163.8	1.116	34.708	2	122.76	2	−165.86	4.61	2	3413
1	38	5439.3	1.139	34.708	2	122.76	2	−164.68	3.80	2	3412

Station 187

Latitude	34.008°S	Date	8/15/91
Longitude	150.522°W	Bottom depth	5303

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	61	3.0	15.054	35.091	2	1.27	2	117.62	3.49	2	3484
2	6	190.4	13.861	34.986	2	1.17	2	93.68	4.21	2	3485
2	68	250.2	12.304	34.881	2	2.35	2	83.05	3.22	2	3486
2	70	373.1	8.714	34.548	2	4.69	2	41.12	4.32	2	3487
2	11	445.7	8.018	34.492	2	5.28	2	33.67	3.14	2	3488
2	12	513.2	7.612	34.460	2	5.87	2	42.56	3.65	2	3489
2	13	615.1	7.095	34.415	2	7.23	2	23.03	3.19	2	3490
2	37	719.3	6.541	34.366	2	9.29	2	0.43	4.57	2	3440
2	15	822.7	5.905	34.327	2	13.30	2	−47.35	4.29	2	3439
2	17	1023.3	4.720	34.321	2	28.35	2	−87.44	4.09	2	3438
2	18	1122.7	4.119	34.346	2	38.42	2	−109.97	4.04	2	3437
2	19	1270.8	3.493	34.397	2	51.72	2	−136.32	3.92	2	3436
2	20	1422.2	3.036	34.466	2	66.48	2	−148.31	4.00	2	3435
2	21	1630.8	2.628	34.559	2	87.19	2	−169.58	4.44	2	3434
2	22	1828.2	2.382	34.609	2	104.20	2	−186.98	8.62	2	3433
2	23	2009.4	2.214	34.630	2	112.02	2	−209.18	3.42	2	3432
2	29	3478.7	1.580	34.690	2	127.06	2	−200.97	3.09	2	3421
2	31	3988.9	1.362	34.706	2	121.30	2	−191.64	3.10	2	3420

Station 187 (continued)

Latitude	34.008°S	Date	8/15/91
Longitude	150.522°W	Bottom depth	5303

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	33	4507.8	1.194	34.710	2	120.22	2	−165.40	3.19	2	3419
2	35	5124.9	1.135	34.709	2	122.66	2	−164.14	3.25	2	3418
2	38	5398.3	1.152	34.709	2	122.27	2	−168.96	3.17	2	3417

Station 191

Latitude	31.997°S	Date	8/16/91
Longitude	150.500°W	Bottom depth	5167

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	3.3	16.519	35.359	2	1.27	2	137.77	2.95	2	5673
1	64	170.5	15.090	35.193	2	1.42	2	112.24	4.22	2	5672
1	6	254.5	13.151	35.026	2	2.59	2	78.35	4.66	2	5671
1	68	363.9	9.781	34.678	2	4.77	2	40.09	2.66	2	5670
1	70	484.4	7.711	34.467	2	5.74	2	24.12	2.81	2	5669
1	11	544.9	7.344	34.436	2	6.73	2	30.15	2.62	3	5668
1	12	604.9	7.009	34.405	2	8.12	2	−5.40	2.61	2	5667
1	13	675.2	6.574	34.369	2	9.11	2	−13.14	4.20	2	5301
1	37	757.1	6.213	34.344	2	11.30	2	−38.49	3.05	2	5300
1	15	838.0	5.734	34.326	2	15.30	2	−62.30	2.90	2	5299
1	17	1012.1	4.767	34.324	2	28.33	2	−108.19	3.46	2	5298
1	19	1214.5	3.648	34.384	2	48.82	2	−128.30	2.57	2	5297
1	20	1370.4	3.094	34.464	2	66.96	2	−142.17	2.74	2	5296
1	21	1524.0	2.744	34.530	2	81.53	2	−165.87	2.50	2	5295
1	22	1730.7	2.453	34.588	2	98.87	2	−183.64	4.42	2	5294
1	23	1939.0	2.216	34.624	2	111.83	2	−212.54	2.44	2	5293
1	28	3187.5	1.642	34.680	2	131.19	2	−204.50	3.81	2	3602
1	29	3449.0	1.533	34.690	2	127.40	2	−206.79	4.30	2	3601
1	31	3971.3	1.353	34.700	2	124.67	2	−192.83	4.12	2	3600
1	33	4488.0	1.250	34.707	2	121.53	2	−167.13	4.48	2	3599
1	39	5013.4	1.162	34.706	4	121.73	4	−166.27	5.59	2	3598
1	38	5257.0	1.176	34.709	2	121.73	2	−161.33	4.19	2	3597

Station 195

Latitude	30.013°S	Date	8/17/91
Longitude	150.487°W	Bottom depth	4412

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	1.3	18.003	35.532	2	1.61	2	123.55	2.72	2	5688
1	5	143.6	17.112	35.392	2	1.31	2	110.30	3.04	2	5687

Station 195 (continued)

Latitude		30.013°S					Date			8/17/91
Longitude		150.487°W					Bottom depth			4412
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	7	241.9	14.617	35.206	2	2.47	2	93.30	2.75	2	5686
1	68	299.7	12.692	34.997	2	3.05	2	79.37	2.67	2	5685
1	69	355.9	10.698	34.769	2	4.63	2	63.49	4.05	2	5684
1	11	471.7	8.090	34.500	2	6.39	2	21.24	2.70	2	5683
1	12	536.4	7.365	34.438	2	6.97	2	25.21	2.85	2	5682
1	13	614.4	6.879	34.395	2	8.15	2	−8.51	2.64	2	5678
1	37	691.4	6.506	34.363	2	9.33	2	−18.31	2.53	2	5677
1	16	868.8	5.522	34.323	2	15.32	2	−56.32	2.49	2	5676
1	17	1019.2	4.589	34.327	2	30.38	2	−99.19	2.96	2	5675
1	18	1168.5	3.807	34.385	2	48.28	2	−124.70	2.49	2	5674
1	19	1367.7	3.136	34.470	2	67.64	2	−159.63	3.36	2	5681
1	20	1570.0	2.657	34.551	2	87.31	2	−194.99	3.77	3	5694
1	21	1771.9	2.385	34.599	2	103.06	2	−191.15	2.23	2	5680
1	22	1981.0	2.199	34.626	2	113.56	2	−202.72	2.20	2	5679
1	28	3015.2	1.670	34.675	2	132.66	3	−213.77	3.83	2	4957
1	29	3228.4	1.582	34.681	2	129.48	2	−203.48	3.47	2	4956
1	31	3648.4	1.426	34.698	2	125.87	2	−196.11	2.52	2	4955
1	33	3863.7	1.355	34.698	2	124.37	2	−185.09	2.53	2	4954
1	39	4278.4	1.299	34.701	2	123.70	2	−176.46	3.35	2	4953
1	38	4442.3	1.284	34.702	2	123.47	2	−176.40	3.08	2	4952

Station 198

Latitude		28.497°S					Date			8/18/91
Longitude		150.497°W					Bottom depth			4948
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	61	0.8	19.427	35.584	2	1.22	2	117.43	4.24	2	3506
2	5	154.6	17.779	35.484	2	1.01	2	120.52	5.76	2	3505
2	6	185.8	17.431	35.452	2	1.01	2	122.87	5.79	2	3504
2	7	227.4	16.286	35.405	2	1.62	2	107.54	5.22	2	3503
2	68	268.9	15.029	35.291	2	2.03	2	109.34	4.92	2	3502
2	70	359.8	11.718	34.898	2	4.06	2	61.81	4.18	2	3501
2	11	412.0	10.547	34.744	2	4.87	2	49.97	4.25	2	3500
2	12	488.4	8.702	34.556	2	5.88	2	27.42	5.87	2	3499
2	37	643.4	6.863	34.392	2	8.73	2	−7.09	5.25	2	3498
2	15	719.6	6.427	34.360	2	10.55	2	−31.38	4.26	2	3497
2	16	822.3	5.660	34.324	2	16.24	2	−60.60	3.31	2	3496
2	18	1028.0	4.613	34.339	2	32.28	2	−112.66	3.53	2	3495
2	20	1284.3	3.333	34.418	3	55.88	2	−137.18	7.05	2	3494
2	21	1439.5	2.877	34.509	2	77.74	2	−161.96	2.75	2	3493

Station 198 (continued)

Latitude	28.497°S	Date	8/18/91
Longitude	150.497°W	Bottom depth	4948

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	22	1645.8	2.545	34.573	2	95.23	2	−181.21	2.74	2	3492
2	24	1851.9	2.259	34.619	2	109.96	2	−203.27	2.68	2	3491
2	25	2057.9	2.094	34.638	2	119.80	2	−215.47	3.74	2	3596
2	27	2574.8	1.827	34.662	2	131.84	2	−219.87	3.59	2	3595
2	29	3092.6	1.664	34.677	2	132.92	2	−217.67	3.69	2	3594
2	30	3352.6	1.555	34.685	2	129.74	2	−214.22	3.93	2	3593
2	31	3613.9	1.447	34.692	2	126.15	2	−206.79	3.36	2	3592
2	32	3872.6	1.361	34.698	2	125.10	2	−190.97	3.39	2	3591
2	33	4185.8	1.316	34.702	2	124.69	2	−181.70	3.38	2	3590
2	34	4497.3	1.315	34.702	2	124.06	2	−185.58	3.84	2	3589
2	39	4759.6	1.336	34.704	2	123.65	2	−187.68	3.83	2	3588
2	38	5030.2	1.368	34.704	2	124.08	2	−179.89	3.27	2	3587

Station 202

Latitude	26.510°S	Date	8/20/91
Longitude	150.497°W	Bottom depth	4739

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	2.0	19.898	35.603	2	1.37	2	144.52	4.38	2	5179
1	5	164.0	19.331	35.544	2	1.27	2	133.19	2.94	2	4942
1	6	204.6	17.769	35.499	2	1.47	2	127.09	3.67	2	4941
1	68	306.5	14.471	35.203	2	2.25	2	87.02	3.25	2	4940
1	70	408.9	11.023	34.803	2	4.59	2	60.73	3.98	2	4939
1	12	553.6	7.747	34.462	2	6.65	2	21.20	3.80	2	4938
1	37	675.0	6.308	34.365	4	9.78	4	−16.20	3.32	2	4936
1	13	675.0	6.914	34.370	4	9.19	4	−20.52	6.39	2	4937
1	15	777.7	5.895	34.325	2	13.88	2	−45.81	2.84	2	4935
1	16	870.6	5.323	34.315	2	19.94	2	−76.13	2.82	2	4934
1	18	1072.1	4.280	34.361	2	40.57	2	−104.80	2.49	2	4933
1	19	1225.9	3.580	34.435	2	60.12	2	−137.63	2.43	2	4932
1	21	1632.9	2.507	34.575	2	99.41	2	−181.99	2.31	2	4931
1	23	2048.3	2.082	34.635	2	119.84	2	−211.66	2.41	2	4930
1	25	2466.3	1.871	34.657	2	129.22	2	−218.02	2.28	2	4929
1	27	2865.7	1.762	34.665	2	131.07	2	−216.51	2.35	2	4928
1	28	3073.4	1.678	34.672	2	130.10	2	−209.55	2.35	2	4951
1	30	3592.9	1.543	34.685	2	127.46	2	−199.60	3.21	2	4947
1	32	4013.0	1.392	34.696	2	125.40	2	−185.68	2.32	2	4946
1	33	4226.4	1.330	34.700	2	124.72	2	−178.13	2.34	2	4945
1	39	4641.2	1.315	34.703	2	123.35	2	−174.83	2.51	2	4944
1	38	4824.0	1.334	34.704	2	123.74	2	−176.41	2.74	2	4943

Station 206

Latitude	24.495°S	Date	8/21/91
Longitude	150.485°W	Bottom depth	4917

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	2.8	21.888	35.670	2	1.37	2	130.56	4.26	2	5187
1	5	180.0	20.365	35.578	2	1.37	2	139.18	4.93	2	5186
1	7	256.3	18.123	35.530	2	1.37	2	128.75	4.90	2	5185
1	68	287.6	17.053	35.460	2	1.56	2	127.54	4.14	2	5184
1	69	326.2	15.197	35.297	2	2.34	2	105.81	4.12	2	5183
1	70	376.5	13.205	35.042	2	3.13	2	87.94	4.89	2	5182
1	11	430.8	11.068	34.753	2	4.79	2	58.92	5.35	2	5181
1	12	483.1	9.325	34.576	2	6.45	2	26.70	3.11	2	4965
1	13	553.6	7.567	34.428	2	8.11	2	−8.60	3.75	2	4964
1	37	635.1	6.553	34.360	2	9.97	2	−30.93	3.61	2	4963
1	15	715.9	5.877	34.321	2	13.88	2	−57.43	3.70	2	4962
1	16	817.4	5.141	34.317	2	22.88	2	−95.12	2.86	2	4961
1	18	1018.5	4.057	34.393	2	49.37	2	−133.90	2.75	2	4960
1	20	1276.3	3.080	34.505	2	79.18	2	−167.87	2.66	2	4959
1	22	1626.8	2.410	34.592	2	105.08	2	−197.08	4.12	2	5180
1	24	2032.4	2.071	34.636	2	121.30	2	−215.37	2.51	2	4958
1	26	2430.0	1.888	34.646	4	127.07	2	−224.59	2.63	2	3645
1	30	3454.4	1.548	34.682	2	126.77	2	−216.23	3.49	2	3644
1	31	3720.7	1.508	34.688	2	127.06	2	−214.30	2.68	2	3643
1	32	3987.5	1.449	34.693	2	126.97	2	−208.12	2.65	2	3642
1	33	4247.3	1.395	34.697	2	125.30	2	−187.66	3.81	2	4950
1	34	4504.3	1.370	34.700	2	123.74	2	−180.47	2.38	2	4949
1	38	4983.0	1.388	34.702	2	124.13	2	−176.01	3.03	2	4948

Station 210

Latitude	22.503°S	Date	8/22/91
Longitude	150.513°W	Bottom depth	4463

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	61	0.8	23.551	35.924	2	1.76	2	107.55	3.37	2	3629
2	3	72.6	23.055	35.885	2	1.56	2	132.58	3.36	2	3628
2	64	102.8	22.448	35.792	2	1.46	2	129.57	3.65	2	3627
2	5	126.1	21.979	35.707	2	1.47	2	116.18	3.39	2	3626
2	7	202.5	19.316	35.584	2	1.47	2	129.47	4.90	2	3625
2	68	254.9	17.867	35.474	2	1.47	2	105.42	4.10	2	3624
2	69	305.6	15.873	35.299	2	2.05	2	108.39	5.52	2	3623
2	70	367.3	13.186	34.999	2	3.71	2	78.27	3.20	2	3622
2	11	438.7	10.573	34.715	2	5.47	2	14.42	3.09	2	3621
2	12	507.3	8.060	34.471	2	7.33	2	−4.06	8.35	2	3620
2	13	569.3	6.915	34.375	2	9.78	2	−13.81	6.80	2	3619

Station 210 (continued)

Latitude		22.503°S					Date		8/22/91		
Longitude		150.513°W					Bottom depth		4463		
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	37	644.0	6.098	34.326	2	12.61	2	−41.48	3.36	2	3618
2	15	731.7	5.527	34.313	2	18.58	2	−67.27	3.87	2	3617
2	16	824.9	4.946	34.330	2	28.16	2	−95.12	2.59	2	3616
2	17	913.1	4.538	34.368	2	40.08	2	−130.43	4.11	2	3604
2	19	1135.9	3.616	34.466	2	67.55	2	−171.23	5.68	2	3603
2	20	1266.6	3.137	34.517	2	81.82	2	−203.88	2.50	3	3641
2	21	1416.9	2.816	34.554	2	94.04	2	−191.24	2.76	2	3640
2	23	1723.3	2.346	34.604	2	109.87	2	−216.75	2.64	2	3639
2	25	2029.6	2.114	34.632	2	118.86	2	−222.16	2.68	2	3638
2	27	2443.2	1.889	34.652	2	126.58	2	−219.35	2.70	2	3637
2	29	2854.7	1.733	34.666	2	126.68	2	−212.51	2.76	2	3636
2	30	3062.9	1.656	34.673	2	128.63	2	−212.88	2.68	2	3635
2	32	3534.1	1.531	34.683	2	126.38	2	−220.34	2.69	2	3634
2	33	3793.6	1.460	34.689	2	124.62	2	−193.02	4.32	2	3633
2	34	4054.2	1.411	34.693	2	124.42	2	−216.24	3.00	2	3632
2	39	4316.3	1.370	34.697	2	124.13	2	−203.27	3.94	2	3631
2	38	4529.2	1.369	34.699	2	123.25	2	−189.40	2.72	2	3630

Station 215

Latitude		20.008°S					Date		8/24/91		
Longitude		150.505°W					Bottom depth		3729		
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	61	1.5	25.470	36.112	2	1.22	2	106.44	5.85	6	5575,5762
1	64	123.9	24.754	35.961	2	0.58	2	109.94	10.86	6	5574,5761
1	6	177.7	22.325	35.918	2	0.57	2	125.88	2.85	2	5573
1	68	223.9	20.701	35.806	2	0.56	2	129.93	2.28	6	5572,5760
1	70	296.4	18.218	35.519	2	1.81	2	122.65	5.67	2	5759
1	11	351.2	15.425	35.171	2	2.64	2	87.03	4.63	2	5570
1	13	457.0	10.724	34.686	2	6.60	2	16.86	2.12	6	5569,5757, 6943,6944
1	37	506.7	9.110	34.540	2	8.06	2	−11.41	7.00	6	5568,5756
1	15	552.6	7.921	34.446	2	10.14	2	−21.52	3.08	2	5551
1	16	655.4	6.453	34.400	2	21.83	2	−71.82	6.35	6	5703,5704
1	17	759.3	5.543	34.410	2	33.52	2	−99.02	2.02	6	5701,5702
1	18	861.7	4.791	34.428	2	46.06	2	−136.35	9.71	6	5699,5700
1	20	1062.8	3.876	34.484	2	66.55	2	−163.50	6.20	6	5697,5698
1	21	1215.8	3.339	34.518	2	79.98	2	−184.68	3.06	6	5693,5696
1	22	1422.0	2.799	34.564	2	94.75	2	−205.91	6.82	6	6945,6946
1	24	1819.1	2.320	34.615	2	110.86	2	−220.79	3.54	6	5689,5690

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J. Reid

Station 14

Latitude	42.995°S	Date	10/16/92
Longitude	150.501°W	Bottom depth	5198

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	2	54.6	9.7551	34.2848	2	2.20	2	68.33	2.65	2	4313
2	3	94.3	8.9572	34.3245	2	2.38	2	55.79	3.37	2	4312
2	5	159.7	8.2804	34.4583	2	4.49	2	41.89	3.16	2	4311
2	7	209.0	7.9445	34.4623	2	5.05	2	39.92	2.34	2	4310
2	8	258.2	7.7115	34.4487	2	5.61	2	36.67	2.34	2	4309
2	9	308.7	7.5476	34.4393	2	6.18	2	32.72	4.24	2	4630
2	10	359.0	7.4586	34.4410	2	6.36	2	37.56	5.06	2	4305
2	11	433.5	7.2177	34.4198	2	7.13	2	17.61	2.81	2	4304
2	12	508.2	7.0677	34.4056	2	7.50	2	16.23	6.16	2	4306
2	13	608.6	6.7478	34.3781	2	8.85	2	3.14	4.17	2	4303
2	14	709.7	6.3459	34.3475	2	11.18	2	−21.85	6.35	2	4302
2	15	808.3	5.8581	34.3257	2	15.26	2	−49.59	4.81	2	4301
2	16	907.5	5.2573	34.3194	2	21.88	2	−52.03	3.58	2	4300
2	17	1007.7	4.6824	34.3278	2	29.28	2	−72.81	5.55	2	5195
2	18	1107.8	4.1016	34.3377	2	36.88	2	−89.84	2.69	2	4299
2	19	1257.5	3.4909	34.3780	2	48.20	2	−119.76	2.63	2	4298
2	20	1408.5	3.0850	34.4346	2	59.14	2	−129.24	2.20	2	4318
2	21	1609.9	2.7292	34.5216	2	73.04	2	−152.85	3.06	2	4317
2	22	1811.2	2.5212	34.5896	2	86.02	2	−166.78	2.15	2	4316
2	23	2012.0	2.3423	34.6258	2	101.24	2	−195.63	2.13	2	4315
2	24	2214.4	2.1904	34.6431	2	110.18	2	−202.09	2.41	2	4314
2	25	2418.3	2.0714	34.6558	2	114.76	2	−208.19	3.54	2	4631
2	26	2619.2	1.9625	34.6667	2	118.16	2	−215.18	2.99	2	4308
2	27	2823.6	1.8745	34.6757	2	119.54	2	−217.74	3.27	2	4307

Station 22

Latitude	47.003°S	Date	10/18/92
Longitude	150.488°W	Bottom depth	4882

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	24	601.9	6.7163	34.3733	2	8.74	2	26.01	4.66	2	4344
1	25	699.2	6.3656	34.3466	2	10.70	2	3.93	5.65	2	4343
1	26	802.5	5.9489	34.3247	2	14.22	2	−19.50	5.21	2	4342
1	27	904.0	5.4294	34.3196	2	19.90	2	−49.54	3.32	2	4341
1	28	1005.1	4.9088	34.3221	2	26.56	2	−63.86	5.42	2	4340
1	29	1209.6	3.8247	34.3468	2	41.27	2	−93.11	2.69	2	4339

Station 22 (continued)

Latitude	47.003°S	Date	10/18/92
Longitude	150.488°W	Bottom depth	4882

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	30	1412.7	3.1533	34.4170	2	56.77	2	−122.90	2.74	2	4338
1	31	1616.3	2.8256	34.5095	2	72.50	2	−146.32	2.60	2	4337
1	32	1815.9	2.5968	34.5748	2	85.72	2	−169.32	2.43	2	4336
1	33	2011.3	2.4280	34.6170	2	96.62	2	−183.98	2.18	2	4335
1	34	2203.7	2.2761	34.6391	2	105.37	2	−185.89	2.83	2	4441
1	35	2404.6	2.1572	34.6558	2	109.36	2	−192.20	2.93	2	4440
1	36	2607.2	2.0593	34.6739	2	109.34	2	−190.25	2.70	2	4439
1	2	3004.3	1.8436	34.6962	2	113.53	2	−198.51	2.79	2	4438
1	3	3209.9	1.7536	34.7139	2	108.10	2	−182.48	3.27	2	4437
1	4	3409.8	1.6517	34.7231	2	106.08	2	−169.37	2.83	2	4436
1	5	3614.2	1.5069	34.7237	2	108.07	2	−173.42	2.84	2	4435

Station 23

Latitude	47.496°S	Date	10/19/92
Longitude	150.490°W	Bottom depth	4667

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	10	4267.8	1.1812	34.7164	2	118.07	2	−166.58	2.89	2	4434
1	11	4497.4	1.1712	34.7158	2	119.24	2	−163.74	3.29	2	4433

Station 32

Latitude	51.986°S	Date	10/22/92
Longitude	150.485°W	Bottom depth	4383

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	10.3	7.3529	34.4195	4	11.13	4	12.03	3.32	4	4431
1	2	43.1	7.2929	34.4458	2	6.70	2	29.74	3.33	2	4432
1	4	108.3	7.0491	34.4184	2	6.69	2	22.87	3.26	2	4430
1	6	208.3	6.9142	34.4030	2	6.69	2	23.87	3.32	2	4429
1	8	317.8	6.6204	34.3668	2	7.26	2	27.29	3.72	2	4428
1	10	433.3	6.2297	34.3220	2	9.17	2	5.43	3.17	2	4427
1	12	516.9	5.7801	34.2791	2	11.67	2	−11.49	3.70	2	4426
1	13	547.3	5.8820	34.3067	2	13.40	2	−25.98	3.30	2	4425
1	14	566.4	5.9789	34.3340	2	15.51	2	−36.67	7.95	2	4424
1	15	610.8	5.4403	34.2862	2	17.05	2	−43.86	3.11	2	4423
1	16	689.2	5.1586	34.3058	2	22.24	2	−42.09	3.33	2	4350
1	17	787.7	4.6590	34.3241	2	29.17	2	−54.67	3.05	2	4349
1	18	888.7	3.9096	34.3016	2	34.56	2	−67.62	2.88	2	4348
1	19	1037.6	3.4311	34.3517	2	45.35	2	−94.37	2.94	2	4347

Station 32 (continued)

Latitude			51.986°S					Date			10/22/92
Longitude			150.485°W					Bottom depth			4383
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	20	1185.5	3.0774	34.4117	2	55.96	2	−119.09	4.04	2	4346
1	21	1385.2	2.8466	34.5050	2	71.24	2	−146.42	3.99	2	4345
1	22	1575.9	2.5798	34.5635	2	78.22	2	−165.99	3.16	2	4450
1	23	1780.2	2.4140	34.6178	2	80.16	2	−165.97	4.03	2	4451
1	24	1985.1	2.2931	34.6649	2	84.82	2	−162.57	2.84	2	4445
1	25	2191.1	2.1842	34.6975	2	86.38	2	−165.25	3.94	2	4444
1	26	2394.1	2.0853	34.7195	2	87.93	2	−166.17	3.94	2	5695
1	27	2596.1	1.9335	34.7339	2	91.84	2	−159.96	2.85	2	4443
1	28	2800.6	1.7716	34.7376	2	95.94	2	−156.71	2.87	2	4442

Station 38

Latitude			54.982°S					Date			10/24/92
Longitude			150.509°W					Bottom depth			3782
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	7.1	2.8604	33.9587	2	11.40	2	−24.63	3.74	2	4632
2	3	107.2	2.7637	33.9557	2	11.40	2	−22.50	3.68	2	4457
2	4	157.3	2.7655	33.9575	2	11.39	2	−32.91	4.15	2	4456
2	5	206.9	2.8384	34.0004	2	13.71	2	−31.56	3.45	2	4455
2	6	257.5	3.7272	34.1481	2	19.91	2	−43.46	3.21	2	4454
2	7	308.8	3.6907	34.1933	2	25.33	2	−57.13	3.16	2	4453
2	8	359.3	3.4253	34.2209	2	29.59	2	−55.66	3.36	2	4422
2	9	389.1	3.1439	34.2131	2	32.31	2	−49.22	3.93	2	5196
2	10	429.7	2.9200	34.2296	2	36.57	2	−75.41	3.02	2	4421
2	11	510.1	3.0391	34.3102	2	44.32	2	−106.13	3.54	2	4459
2	12	611.1	2.7204	34.3479	2	52.09	2	−116.88	3.29	2	4458
2	13	711.6	2.5937	34.4092	2	59.86	2	−122.80	5.09	2	4452
2	14	812.0	2.5146	34.4680	2	65.69	2	−129.67	3.05	2	4449
2	15	912.7	2.4296	34.5368	2	71.93	2	−137.09	3.05	2	4448
2	16	1014.4	2.3829	34.5763	2	74.65	2	−136.81	3.05	2	4447
2	17	1114.8	2.3468	34.6133	2	77.58	2	−148.73	2.87	2	4446
2	18	1215.9	2.2876	34.6412	2	79.53	2	−145.21	3.38	2	4648
2	19	1317.6	2.2363	34.6622	2	80.90	2	−147.25	3.29	2	4647
2	20	1418.7	2.1763	34.6836	2	82.07	2	−147.98	2.99	2	4646
2	21	1519.8	2.1197	34.7032	2	83.82	2	−170.83	2.98	4	4645
2	22	1619.6	2.0336	34.7166	2	85.98	2	−151.82	3.04	2	4644
2	23	1770.3	1.9299	34.7307	2	89.31	2	−151.38	2.89	2	4643
2	24	1920.6	1.7818	34.7374	2	93.43	2	−153.40	2.98	2	4642
2	25	2173.2	1.6009	34.7368	2	98.75	2	−156.95	3.05	2	4641

Station 43

Latitude	57.494°S	Date	10/26/92
Longitude	150.497°W	Bottom depth	3117

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	6	6.8	0.5538	33.9403	2	26.22	2	−60.19	4.34	2	4664
2	7	56.5	0.5379	33.9403	2	26.22	2	−47.21	4.07	2	4663
2	8	80.9	0.4829	33.9484	2	26.79	2	−61.58	3.18	2	4547
2	9	106.8	0.4360	33.9662	2	28.14	2	−58.62	4.46	2	4662
2	10	131.1	0.4370	33.9826	2	30.26	2	−62.64	4.15	2	4661
2	11	157.3	0.8126	34.0719	2	37.59	2	−72.41	7.92	2	4660
2	13	227.7	2.2252	34.3129	2	53.63	2	−95.11	3.09	2	4658
2	14	268.0	2.2562	34.3764	2	59.63	2	−108.57	3.23	2	4657
2	15	307.1	2.3351	34.4329	2	63.89	2	−123.23	3.31	2	4656
2	16	358.7	2.3241	34.4715	2	67.57	2	−119.26	3.22	2	4655
2	17	434.2	2.2801	34.5321	2	72.61	2	−134.97	3.31	2	4654
2	18	508.2	2.2671	34.5771	2	75.52	2	−147.35	2.90	2	4653
2	19	610.4	2.2272	34.6312	2	79.02	2	−141.65	3.69	2	4652
2	20	711.6	2.1812	34.6572	2	80.77	2	−146.66	3.43	2	4650
2	21	813.2	2.1273	34.6844	2	82.72	2	−148.51	3.24	2	4649
2	22	912.3	2.0593	34.7051	2	84.47	2	−152.92	2.92	2	4640
2	23	1014.7	1.9944	34.7167	2	85.83	2	−150.48	3.07	2	4639
2	24	1114.3	1.9155	34.7267	2	88.17	2	−155.33	2.90	2	4638
2	25	1266.3	1.8116	34.7346	2	91.10	2	−152.96	3.03	2	4637
2	26	1419.0	1.6737	34.7378	2	95.22	2	−154.77	2.97	2	4636
2	27	1568.6	1.5628	34.7390	2	98.55	2	−149.89	3.10	2	4635
2	28	1720.3	1.4419	34.7351	2	102.68	2	−157.59	3.10	2	4634
2	29	1823.9	1.3740	34.7337	2	104.85	2	−162.58	3.33	2	4633

Station 48

Latitude	59.996°S	Date	10/27/92
Longitude	150.538°W	Bottom depth	2833

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	14	116.7	−1.1473	34.1954	2	64.58	2	−94.68	4.13	3	5054
2	16	157.4	0.7916	34.5536	2	83.19	2	−142.58	3.12	2	4554
2	18	207.2	1.6667	34.6885	2	88.02	2	−139.61	2.96	2	4553
2	19	257.7	1.7397	34.7115	2	88.58	2	−145.18	4.22	2	5053
2	20	307.4	1.6737	34.7199	2	90.32	2	−149.37	2.86	2	4552
2	21	406.7	1.5688	34.7244	2	93.62	2	−144.86	2.91	2	4551
2	22	505.6	1.5039	34.7313	2	97.33	2	−151.04	2.73	2	4550
2	23	603.6	1.3920	34.7313	2	100.05	2	−148.99	2.86	2	4549
2	24	754.3	1.2761	34.7289	2	103.97	2	−158.96	2.78	2	4548
2	25	904.7	1.1752	34.7267	2	107.49	2	−162.73	3.47	2	4546
2	26	1055.8	1.0593	34.7226	2	110.83	2	−156.37	4.17	2	4672

Station 48 (continued)

Latitude		59.996°S					Date		10/27/92		
Longitude		150.538°W					Bottom depth		2833		
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	27	1208.6	0.9434	34.7175	2	114.17	2	−157.21	4.68	2	4671
2	28	1413.6	0.8146	34.7124	2	118.92	2	−161.34	4.11	2	4670
2	29	1615.5	0.7067	34.7079	2	124.08	2	−163.48	7.41	2	5052
2	30	1818.4	0.6567	34.7061	2	127.66	2	−167.39	4.13	2	4669

Station 56

Latitude		62.444°S					Date		111/1/92		
Longitude		135.098°W					Bottom depth		4755		
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	57.7	−0.3753	33.9976	2	45.12	2	−82.04	3.05	2	4568
2	4	177.3	1.3408	34.3706	2	67.14	2	−120.66	4.00	2	4567
2	5	226.6	1.4364	34.4876	2	75.30	2	−128.76	2.94	2	4566
2	6	305.7	1.9068	34.6054	2	80.88	2	−134.07	3.08	2	4565
2	7	353.0	1.9663	34.6333	2	82.66	2	−142.32	3.02	2	4564
2	8	402.2	1.9639	34.6567	2	83.65	2	−145.79	3.58	2	4563
2	9	496.9	1.9247	34.6901	2	86.44	2	−149.27	2.99	2	4562
2	10	642.6	1.8136	34.7137	2	89.64	2	−153.23	3.07	2	4561
2	11	783.4	1.6938	34.7235	2	93.04	2	−159.26	2.94	2	4560
2	13	926.0	1.5756	34.7302	2	97.04	2	−153.70	2.97	3	4559
2	14	1070.7	1.4402	34.7304	2	101.67	2	−159.63	3.57	2	4558
2	15	1213.7	1.3159	34.7292	2	106.30	2	−154.17	3.06	3	4557
2	16	1357.8	1.2131	34.7265	2	109.33	2	−158.47	5.29	2	4556
2	17	1503.5	1.1146	34.7226	2	112.77	2	−164.47	3.23	2	4555
2	18	1646.9	1.0207	34.7192	2	115.61	2	−162.44	2.75	2	5383

Station 73

Latitude		56.034°S					Date		11/792		
Longitude		135.028°W					Bottom depth		3195		
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	2.6	1.9514	33.9524	2	18.58	2	−39.72	3.32	2	4584
2	4	85.3	0.4759	33.9409	2	31.09	2	−59.37	5.43	2	4583
2	9	206.7	1.3331	34.0974	2	40.48	2	−72.86	3.24	2	4582
2	11	306.8	2.5998	34.3474	2	52.99	2	−104.91	3.23	2	4581
2	13	406.8	2.4540	34.4332	2	62.60	2	−112.72	3.17	2	4580
2	14	507.5	2.4290	34.5086	2	69.07	2	−126.77	5.37	2	4579
2	15	606.6	2.3820	34.5570	2	72.81	2	−137.13	3.94	2	4578
2	16	705.4	2.3091	34.6049	2	76.35	2	−147.81	4.16	2	4577

Station 73 (continued)

Latitude		56.034°S					Date			11/792
Longitude		135.028°W					Bottom depth			3195
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	17	806.3	2.2412	34.6301	2	78.71	2	−139.42	5.19	2	4576
2	18	905.2	2.2092	34.6635	2	80.69	2	−148.00	3.54	2	4575
2	19	1005.9	2.1343	34.6867	2	82.66	2	−154.73	2.88	2	4574
2	20	1107.4	2.0843	34.7015	2	84.04	2	−151.03	2.89	2	4573
2	21	1209.0	2.0224	34.7139	2	85.82	2	−156.74	3.10	2	4572
2	22	1307.3	1.9674	34.7233	2	87.41	2	−154.91	2.93	2	4571
2	23	1409.5	1.9085	34.7297	2	89.19	2	−148.25	2.90	2	4570
2	24	1509.6	1.8346	34.7344	2	90.98	2	−156.07	2.91	2	4569

Station 80

Latitude		52.521°S					Date			11/9/92
Longitude		135.000°W					Bottom depth			4325
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	8.7	8.0740	34.4407	2	4.82	2	51.88	4.37	2	5025
2	5	108.8	7.5318	34.4499	2	5.59	2	49.06	3.18	2	5024
2	7	222.3	7.1550	34.4168	2	7.00	2	30.83	5.81	2	5023
2	8	293.3	6.8831	34.3851	2	7.80	2	21.47	2.84	2	5022
2	10	382.1	6.6619	34.3676	2	7.78	2	15.77	2.89	2	5021
2	12	538.7	6.0739	34.3269	2	13.06	2	−19.32	2.75	2	5020
2	13	600.5	5.4430	34.2533	2	14.06	2	−13.75	2.99	2	5019
2	14	667.5	5.1861	34.2609	2	16.69	2	−40.53	4.06	2	5018
2	15	810.8	4.6868	34.3071	2	27.65	2	−68.35	3.75	2	5017
2	16	911.0	4.1487	34.3232	2	34.34	2	−75.62	2.67	2	5016
2	17	1011.5	3.7728	34.3463	2	41.64	2	−89.75	2.56	2	5015
2	18	1110.2	3.3796	34.3665	2	47.93	2	−107.30	2.60	2	5014
2	19	1210.5	3.1021	34.3998	2	54.42	2	−136.27	5.00	3	5013
2	20	1308.4	2.9753	34.4520	2	62.34	2	−127.27	2.57	2	5012
2	21	1506.9	2.6240	34.5220	2	71.09	2	−135.96	2.59	2	5011
2	22	1705.8	2.4572	34.5957	2	79.85	2	−151.90	2.55	2	5010

Station 87

Latitude		49.000°S					Date			11/11/92
Longitude		134.957°W					Bottom depth			4985
Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	3.8	8.4019	34.3899	2	3.59	2	45.30	2.92	2	5043
2	3	58.4	7.9572	34.4142	2	3.54	2	53.99	2.93	2	5042
2	4	108.3	7.8708	34.4213	2	3.94	2	32.78	3.32	2	5041

Station 87 (continued)

Latitude	49.000°S	Date	11/11/92
Longitude	134.957°W	Bottom depth	4985

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	5	157.7	7.7054	34.4399	2	4.75	2	29.87	6.36	2	5040
2	7	208.0	7.5716	34.4394	2	5.13	2	36.20	6.12	2	5036
2	9	267.6	7.4734	34.4452	2	5.30	2	34.53	5.43	2	5035
2	10	354.6	7.4096	34.4498	2	5.49	2	34.08	3.59	2	5034
2	11	393.0	7.3478	34.4421	2	5.68	2	34.34	3.17	2	5033
2	12	434.0	7.2470	34.4266	2	6.07	2	31.27	3.15	2	5032
2	13	501.9	7.1119	34.4141	2	6.47	2	29.01	3.16	2	5031
2	14	650.2	6.6384	34.3620	2	8.13	2	18.47	3.24	2	5030
2	16	780.4	6.0708	34.3026	2	9.13	2	11.45	3.21	2	5029
2	17	899.8	5.6775	34.3185	2	17.06	2	−33.04	6.75	2	5028
2	18	1051.6	4.8601	34.3238	2	26.67	2	−54.03	3.06	2	5382
2	19	1202.8	4.1732	34.3322	2	35.03	2	−79.81	3.06	2	5027
2	20	1404.9	3.3401	34.3963	2	51.57	2	−109.00	2.89	2	5026

Station 95

Latitude	45.004°S	Date	11/13/92
Longitude	134.979°W	Bottom depth	5010

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	9.6	10.1800	34.1483	2	2.63	2	78.87	5.53	2	4759
2	3	88.0	9.2825	34.1847	2	2.41	2	74.40	3.31	2	4758
2	5	177.6	7.7166	34.3615	2	4.45	2	53.43	3.44	2	4757
2	6	228.2	7.4368	34.4003	2	5.67	2	50.71	2.83	2	4756
2	7	279.0	7.2589	34.4017	2	6.27	2	45.54	2.77	2	4755
2	8	368.1	7.0281	34.3915	2	7.29	2	34.33	3.21	2	5051
2	9	455.3	6.8652	34.3823	2	7.69	2	24.91	3.55	2	5050
2	10	552.7	6.6484	34.3659	2	8.30	2	11.47	3.10	2	5049
2	11	650.1	6.3616	34.3436	2	9.72	2	−1.45	3.42	2	5047
2	12	747.4	5.9449	34.3165	2	12.58	2	−23.36	3.82	2	5046
2	13	845.5	5.4034	34.2979	2	17.67	2	−36.84	3.06	2	5045
2	14	945.1	4.8059	34.3036	2	25.42	2	−67.93	2.76	2	5044
2	15	945.1	4.8059	34.3040	2	25.41	2	−77.53	3.25	4	5048
2	16	1140.8	3.8647	34.3403	2	39.90	2	−110.20	2.90	2	5039
2	17	1240.5	3.4391	34.3741	2	48.46	2	−125.67	2.83	2	5038
2	18	1365.8	3.1134	34.4226	2	57.24	2	−132.83	2.56	2	5037

Station 105

Latitude	40.009°S	Date	11/16/92
Longitude	134.988°W	Bottom depth	5033

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
3	1	4.5	12.9005	34.1459	2	1.55	2	85.30	3.04	2	4774
3	3	66.2	11.5392	34.1510	2	1.28	2	83.04	2.84	2	4773
3	5	126.8	10.0870	34.2865	2	1.42	2	68.67	2.88	2	4772
3	6	156.8	9.1926	34.3375	2	1.80	2	74.33	2.98	2	4771
3	7	186.8	8.3332	34.3817	2	3.01	2	50.06	4.17	2	4770
3	8	226.4	7.7656	34.4011	2	3.60	2	52.41	2.86	2	4769
3	9	306.9	7.3199	34.4196	2	5.22	2	41.68	3.12	2	4768
3	10	407.5	7.0601	34.4004	2	5.81	2	40.82	3.26	2	4767
3	11	508.4	6.7993	34.3804	2	7.85	2	25.45	2.90	2	4766
3	12	608.7	6.4885	34.3563	2	9.27	2	11.63	2.83	2	4765
3	14	809.8	5.4993	34.3093	2	18.75	2	−48.11	2.65	2	4764
3	15	910.0	4.9767	34.3126	2	24.73	2	−65.80	2.67	2	4763
3	16	1011.2	4.4392	34.3248	2	32.16	2	−88.47	2.96	2	4762
3	17	1162.4	3.6698	34.3600	2	44.58	2	−115.07	2.55	2	4761
3	18	1315.2	3.1084	34.4226	2	58.05	2	−139.56	2.78	2	4760

Station 113

Latitude	35.999°S	Date	11/1992
Longitude	134.997°W	Bottom depth	4783

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (µmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	4.2	15.1566	34.4952	2	1.96	2	110.44	2.98	2	4790
2	3	57.2	14.6937	34.5293	2	1.75	2	101.29	3.93	2	4789
2	5	97.4	14.1679	34.5593	2	1.76	2	102.97	2.97	2	4788
2	7	208.3	11.8810	34.7084	2	2.62	2	73.78	2.79	2	4787
2	8	259.0	10.0101	34.5607	2	3.69	2	52.03	2.80	2	4786
2	9	307.5	8.9048	34.5030	2	4.33	2	49.59	2.81	2	4785
2	10	408.8	7.5038	34.4325	2	6.04	2	32.85	2.84	2	4784
2	11	487.9	7.0931	34.4068	2	6.90	2	26.78	2.73	2	4783
2	12	607.4	6.6504	34.3723	2	8.61	2	17.39	4.41	2	4782
2	13	709.4	6.2587	34.3433	2	10.53	2	−7.11	2.92	2	4781
2	14	812.2	5.7251	34.3178	2	14.80	2	−39.02	2.62	2	4780
2	15	912.6	5.1116	34.3129	2	21.83	2	−73.75	3.49	2	4779
2	16	1064.1	4.1924	34.3368	2	36.12	2	−111.00	2.54	2	4778
2	17	1214.7	3.4790	34.3911	2	50.41	2	−132.14	2.50	2	4777
2	18	1214.7	3.4790	34.3909	2	50.41	2	−130.36	2.48	2	4776
2	19	1519.0	2.7327	34.5295	2	78.41	2	−170.98	2.76	2	4775

Station 119

Latitude	33.000°S	Date	11/20/92
Longitude	135.000°W	Bottom depth	4472

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	2.7	17.7857	35.0857	2	2.54	2	117.21	3.73	2	5063
2	4	105.1	16.3631	35.0574	2	2.06	2	108.84	3.93	2	5062
2	7	206.0	14.2999	35.0130	2	2.21	2	103.54	3.52	2	5061
2	9	305.5	11.1644	34.7336	2	3.83	2	71.10	4.44	2	5060
2	11	407.2	8.2992	34.5851	4	5.67	2	58.43	4.95	2	5059
2	13	557.9	6.8612	34.3822	2	8.34	2	27.13	3.61	2	5058
2	14	658.0	6.4076	34.3502	2	9.78	2	−3.74	3.32	2	5057
2	15	759.2	5.8390	34.3160	2	12.68	2	−19.54	3.67	2	5056
2	16	859.2	5.2485	34.3044	2	18.91	2	−51.64	3.44	2	5055
2	17	959.9	4.7719	34.3120	2	26.19	2	−86.43	2.76	2	4797
2	18	1061.4	4.2094	34.3377	2	36.60	2	−110.69	2.72	2	4796
2	19	1212.8	3.5290	34.3949	2	51.39	2	−126.40	2.64	2	4795
2	20	1364.2	3.0194	34.4692	2	66.63	2	−149.23	2.53	2	4794
2	21	1516.5	2.7097	34.5294	2	79.39	2	−166.48	2.91	2	4793
2	22	1719.0	2.4140	34.5890	2	95.35	2	−186.76	4.63	2	4792
2	23	1922.8	2.2192	34.6214	2	106.11	2	−202.56	2.34	2	4791
2	29	3144.0	1.6467	34.6781	2	124.22	2	−221.98	3.22	2	5072
2	30	3348.7	1.6138	34.6815	2	124.18	2	−209.93	3.47	2	5079
2	31	3552.0	1.5828	34.7107	4	124.36	2	−199.31	3.73	2	5078
2	32	3756.8	1.5249	34.6903	2	123.47	2	−186.91	3.70	2	5077
2	33	3961.6	1.4360	34.6982	2	122.58	2	−196.96	4.68	2	5076
2	34	4166.3	1.3540	34.7052	2	121.04	2	−190.17	3.39	2	5075
2	35	4371.4	1.3201	34.7070	2	120.80	2	−180.59	2.86	2	5074
2	36	4540.1	1.3261	34.7078	2	120.55	2	−192.27	2.86	2	5073

Woce Cruise P16C

12/4/92 – 1/22/93
J. Swift

Station 222

Latitude	17.510°S	Date	9/1/91
Longitude	150.481°W	Bottom depth	3600

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	4.2	26.663	35.977	2	0.87	2	116.95	3.82	2	6516
1	35	32.0	26.547	36.122	2	0.88	2	101.89	3.60	2	6515
1	34	56.8	26.264	36.092	2	0.89	2	105.01	3.10	2	6514
1	33	82.2	26.186	36.081	2	0.90	2	88.56	3.27	2	6513
1	32	108.4	26.157	36.080	2	0.91	2	117.45	3.61	2	6512
1	31	132.8	25.619	36.091	2	0.92	2	121.68	3.03	2	6270
1	30	157.9	23.988	36.103	2	1.12	2	124.95	3.24	2	6269
1	29	183.5	23.567	36.132	2	0.94	2	119.41	6.43	2	6268
1	28	209.5	22.432	36.079	2	1.14	2	122.30	4.13	2	6267
1	27	234.4	21.492	35.967	2	1.15	2	149.63	7.61	2	6266
1	26	258.2	20.248	35.759	2	1.56	2	142.82	7.93	2	6265
1	25	309.2	17.989	35.472	2	2.17	2	119.23	3.29	2	6503
1	24	358.2	14.677	35.143	2	4.55	2	92.52	3.66	2	6264
1	23	408.7	11.893	34.702	2	9.51	2	29.42	4.98	2	6263
1	22	507.7	7.910	34.475	2	21.21	2	−72.27	2.77	2	6262
1	21	601.8	6.478	34.439	2	24.59	2	−88.53	3.85	2	6261
1	20	698.1	5.739	34.438	2	36.30	2	−126.52	2.67	2	6260
1	19	793.6	4.913	34.463	2	49.60	2	−146.22	3.34	2	6259
1	18	890.0	4.362	34.480	2	60.14	2	−149.30	6.00	2	6258
1	17	988.1	3.874	34.500	2	70.28	2	−171.54	2.59	2	6257
1	15	1187.4	3.320	34.535	2	84.42	2	−185.30	2.83	2	6256

Station 226

Latitude	14.999°S	Date	9/3/91
Longitude	150.835°W	Bottom depth	4528

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	5.8	27.424	36.231	2	1.61	2	108.10	2.99	2	6487
1	35	47.8	27.398	36.213	2	1.60	2	106.26	2.93	2	6486
1	34	88.2	27.434	36.292	2	1.80	2	107.84	3.64	2	6485
1	33	128.6	25.244	36.297	2	1.79	2	110.88	2.86	2	6484
1	32	168.2	23.457	36.256	2	1.98	2	138.51	4.60	2	6483
1	31	209.1	21.963	36.155	2	1.57	2	158.74	3.65	2	6482
1	30	260.5	19.075	35.622	2	2.76	2	152.39	2.92	2	6481
1	29	311.7	16.112	35.233	2	4.55	2	114.93	3.10	2	6511
1	28	361.4	13.495	34.907	2	9.15	2	70.18	3.72	2	6575

Station 226 (continued)

Latitude	14.999°S	Date	9/3/91
Longitude	150.835°W	Bottom depth	4528

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	27	412.4	11.388	34.670	2	14.56	2	−8.75	3.19	2	6495
1	25	514.2	8.042	34.518	2	26.38	2	−93.37	2.68	2	6494
1	23	617.3	6.585	34.466	2	35.62	2	−114.92	2.66	2	6493
1	21	718.3	5.721	34.465	2	43.08	2	−127.81	2.83	2	6492
1	19	808.3	5.019	34.480	2	55.57	2	−147.96	2.95	2	6491
1	17	1025.3	4.018	34.512	2	72.73	2	−168.41	2.66	2	6490
1	16	1230.9	3.358	34.553	2	88.27	2	−181.11	2.25	2	6489
1	11	2261.5	1.993	34.651	2	125.02	2	−214.96	2.23	2	6488
1	6	3347.8	1.596	34.685	2	128.97	2	−191.99	2.28	3	6480

Station 230

Latitude	12.993°S	Date	9/4/91
Longitude	151.003°W	Bottom depth	4595

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	5.0	28.209	36.172	2	1.42	2	75.14	3.61	2	5227
1	35	46.3	28.111	36.234	2	1.62	2	79.09	3.63	2	5226
1	34	85.1	27.738	36.341	2	1.23	2	83.40	3.63	2	5225
1	33	124.8	26.664	36.368	2	1.23	2	114.16	4.07	2	5220
1	32	167.0	24.208	36.314	2	1.23	2	113.76	3.75	2	5219
1	31	207.6	22.288	36.058	2	1.24	2	120.09	3.84	2	5218
1	30	248.6	20.039	35.667	2	1.84	2	134.26	4.90	2	5211
1	29	289.5	17.196	35.167	2	4.61	2	117.78	4.15	2	5210
1	28	331.0	13.333	34.907	2	8.38	2	67.43	4.43	2	5209
1	27	370.7	11.539	34.720	2	13.73	2	12.90	4.05	2	5208
1	26	410.9	9.841	34.653	2	17.90	2	−26.36	4.09	2	5207
1	25	461.6	8.463	34.612	2	23.84	2	−66.20	4.69	2	5206
1	24	512.8	7.435	34.558	2	26.03	2	−89.02	2.43	2	6293
1	23	614.4	6.215	34.510	2	35.55	2	−110.79	2.59	2	6294
1	22	717.6	5.575	34.487	2	42.89	2	−124.80	2.29	2	6295
1	21	814.5	5.025	34.492	2	52.60	2	−136.45	2.25	2	6296
1	20	912.4	4.662	34.502	2	60.34	2	−153.77	2.28	2	6297
1	19	1015.7	4.249	34.521	2	71.83	2	−162.91	2.60	2	6298
1	18	1120.7	3.885	34.533	2	78.37	2	−174.25	2.83	2	6299
1	10	2567.6	1.895	34.665	2	131.11	2	−227.23	2.67	2	6300

Station 235*

Latitude	10.508°S	Date	9/691
Longitude	150.988°W	Bottom depth	4910

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
4	36	4.0	28.556	35.834	2	0.60	2	95.02	3.77	2	5230
4	35	49.8	28.545	35.834	2	0.45	2	81.50	2.78	2	5718
4	34	99.7	28.123	35.929	2	0.88	2	82.35	2.97	2	5717
4	33	150.0	25.364	36.377	2	0.93	2	98.04	2.98	2	5716
4	32	201.6	22.380	36.208	2	0.59	2	105.88	3.00	2	5715
4	31	240.4	19.701	35.599	2	1.79	2	120.88	2.81	2	5714
4	30	281.7	15.786	35.163	2	4.72	2	91.73	2.78	2	5713
4	29	322.6	12.880	34.825	2	10.71	2	43.80	4.27	2	5712
4	28	363.5	10.383	34.659	2	18.25	2	−30.88	2.54	2	5711
4	27	388.9	9.830	34.665	2	23.09	2	−61.05	3.86	2	5710
4	26	439.6	8.609	34.626	2	27.57	2	−84.58	2.58	2	5709
4	25	491.2	7.719	34.586	2	33.00	2	−100.56	3.26	2	5229
4	24	592.9	6.733	34.547	2	41.69	2	−120.70	4.09	2	5228
4	23	693.5	6.080	34.525	2	50.76	2	−139.27	3.16	2	5708
4	22	797.8	5.499	34.518	2	57.35	2	−151.83	2.48	2	5707
4	21	899.3	4.812	34.522	2	67.21	2	−156.02	3.38	2	5205
4	20	999.1	4.375	34.533	2	74.18	2	−167.23	3.29	2	5204
4	19	1203.9	3.642	34.555	2	88.84	2	−188.85	3.68	2	5203

*The Gerard casts on this station were run by the AMS technique as well as by the normal β counting technique.

Station 238

Latitude	9.000°N	Date	9/791
Longitude	150.996°W	Bottom depth	3840

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	4.5	28.449	35.792	2	0.70	2	77.26	3.91	2	6531
1	34	58.6	28.348	35.860	2	0.74	2	79.34	3.36	2	6530
1	33	82.5	28.289	35.895	2	0.95	2	81.89	3.84	2	6529
1	32	109.5	27.862	35.976	2	0.96	2	90.13	3.55	2	6605
1	31	135.0	25.702	36.240	2	1.17	2	96.38	3.10	2	6604
1	30	158.9	24.325	36.366	2	1.00	2	110.39	3.04	2	6603
1	29	198.4	21.576	36.026	2	1.20	2	129.30	3.29	2	6602
1	28	239.4	17.792	35.601	2	2.38	2	120.19	3.18	2	6601
1	27	278.7	14.682	35.112	2	8.39	2	69.52	4.44	2	6600
1	26	320.4	12.064	34.835	2	16.96	2	−15.42	2.77	2	6599
1	25	361.8	10.569	34.745	2	22.01	2	−51.71	3.21	2	6598
1	24	413.6	9.045	34.690	2	25.91	2	−80.64	2.69	2	6597
1	23	464.2	8.364	34.639	2	30.78	2	−96.59	2.80	2	6596
1	22	516.1	7.889	34.611	2	34.29	2	−98.08	3.66	2	6595

Station 238 (continued)

Latitude	9.000°N	Date	9/791
Longitude	150.996°W	Bottom depth	3840

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	21	617.8	6.779	34.580	4	38.97	2	−117.00	2.69	2	6594
1	20	720.1	5.902	34.583	4	49.46	2	−128.82	2.76	2	6593
1	19	821.8	5.234	34.527	2	61.92	2	−157.27	2.74	2	6592
1	17	1027.2	4.188	34.541	2	79.23	2	−176.69	2.49	2	6591
1	15	1231.7	3.587	34.573	2	94.81	2	−202.55	3.02	2	5706

Station 242

Latitude	7.018°S	Date	9/891
Longitude	151.003°W	Bottom depth	5182

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	5.3	28.274	35.309	2	1.07	2	77.24	2.95	2	6582
1	35	48.8	28.286	35.346	2	1.07	2	74.52	3.17	2	6581
1	34	108.8	28.591	36.023	2	0.89	2	86.90	3.76	2	6580
1	32	209.4	19.120	35.661	2	3.20	2	112.19	3.31	2	6579
1	31	250.9	15.067	35.033	2	11.10	2	45.36	2.81	2	6578
1	30	290.8	11.879	34.823	2	17.66	2	−11.33	2.93	2	6577
1	29	331.1	10.289	34.734	2	23.26	2	−45.93	2.71	2	6576
1	28	371.6	9.520	34.678	2	26.16	2	−84.92	2.97	2	6528
1	27	411.6	8.824	34.651	2	27.91	2	−87.85	2.00	6	6526,6527
1	26	461.7	8.297	34.614	2	31.97	2	−100.26	3.33	2	6525
1	25	509.9	7.723	34.590	2	34.68	2	−101.77	2.66	2	6524
1	24	600.2	6.797	34.569	2	44.92	2	−119.96	2.67	2	6523
1	23	699.7	5.985	34.543	2	53.04	2	−138.94	2.73	2	6522
1	22	802.5	5.372	34.536	2	61.74	2	−142.32	2.69	2	6521
1	21	906.0	4.862	34.538	2	69.68	2	−156.81	2.81	2	6520
1	20	1004.8	4.434	34.545	2	78.57	2	−173.44	2.56	2	6519
1	19	1199.7	3.758	34.562	2	90.58	2	−199.14	3.60	2	6518
1	12	2618.6	1.856	34.667	2	138.12	2	−221.08	2.56	3	6517

Station 246

Latitude	5.013°S	Date	9/10/91
Longitude	151.005°W	Bottom depth	4985

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	36	5.9	28.199	35.403	2	1.48	2	87.71	2.79	2	5938
2	35	58.3	28.042	35.399	2	1.49	2	86.10	2.77	2	5937
2	34	96.9	27.706	35.435	2	1.69	2	84.22	4.45	2	5932
2	33	135.5	26.858	36.297	2	1.09	2	94.97	4.15	2	5931

Station 246 (continued)

Latitude	5.013°S	Date	9/10/91
Longitude	151.005°W	Bottom depth	4985

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	32	174.5	22.348	35.933	2	1.30	2	123.76	4.82	2	5930
2	30	254.6	13.473	34.963	2	16.24	2	3.31	4.31	2	6590
2	29	305.9	11.779	34.850	2	19.89	2	−25.24	3.00	2	6589
2	28	356.8	10.459	34.766	2	26.96	2	−73.45	3.04	2	6588
2	27	408.3	9.481	34.732	2	32.82	2	−94.37	2.84	2	6587
2	26	460.9	8.835	34.687	2	36.04	2	−96.59	3.18	2	6586
2	25	511.3	8.134	34.642	2	34.25	2	−101.50	3.23	2	6585
2	23	630.1	6.856	34.589	2	40.91	2	−104.67	2.88	2	6584
2	21	813.5	5.477	34.541	2	59.08	2	−152.24	2.70	2	6583

Station 250

Latitude	3.007°S	Date	9/11/91
Longitude	151.013°W	Bottom depth	4765

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	4.5	27.580	35.421	2	1.62	2	90.04	2.80	2	6472
1	35	59.2	27.353	35.449	2	1.62	2	83.64	3.38	2	6471
1	34	106.8	27.282	35.442	2	1.83	2	90.02	3.89	2	6469
1	32	164.2	14.955	35.094	2	15.16	2	26.90	2.57	2	6470
1	31	195.2	12.771	34.930	2	21.73	2	−19.61	2.98	2	5948
1	30	226.5	12.287	34.889	2	22.32	2	−24.95	2.44	2	5947
1	29	259.4	11.728	34.837	2	23.53	2	−31.56	2.72	2	5946
1	28	311.7	11.482	34.815	2	24.33	2	−32.97	2.48	2	5945
1	26	414.9	10.602	34.743	2	30.91	2	−85.61	3.69	2	6012
1	25	465.1	9.516	34.674	2	38.07	2	−102.74	4.50	2	5943
1	24	516.2	8.490	34.632	2	42.26	2	−106.84	2.58	2	5942
1	22	618.8	6.950	34.577	2	50.03	2	−123.92	3.39	2	5941
1	20	822.3	5.678	34.555	2	66.35	2	−144.07	2.40	2	5940
1	18	1026.3	4.481	34.553	2	83.28	2	−165.61	2.60	2	5939

Station 256

Latitude	1.998°S	Date	9/1291
Longitude	150.991°W	Bottom depth	4749

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	4.9	27.584	35.426	2	3.07	2	88.99	3.08	2	6064
1	35	47.4	27.543	35.422	2	2.87	2	92.23	2.92	2	6063
1	34	85.8	27.262	35.422	2	3.45	2	85.00	3.11	2	6062
1	33	116.0	26.919	35.469	2	3.26	2	87.54	3.03	2	6061

Station 256 (continued)

Latitude	1.998°S	Date	9/1291
Longitude	150.991°W	Bottom depth	4749

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	32	146.8	21.642	35.670	2	5.54	2	102.10	2.73	2	6468
1	31	178.5	14.888	34.958	2	21.04	2	1.52	2.96	2	6467
1	30	209.6	12.799	34.894	2	23.88	2	−16.46	2.64	2	6466
1	29	249.7	12.290	34.873	2	23.31	2	−37.28	2.60	2	6465
1	28	310.9	11.713	34.835	2	27.28	2	−45.58	3.07	2	6464
1	27	360.9	10.918	34.781	2	25.01	2	−64.50	4.55	2	6463
1	26	412.0	10.039	34.714	2	31.63	2	−75.92	2.63	2	6462
1	25	462.1	8.902	34.667	2	36.16	2	−94.58	3.14	2	6461
1	24	514.2	8.248	34.632	2	37.48	2	−98.99	2.61	2	6460
1	21	719.8	6.307	34.554	2	57.88	2	−134.36	2.60	2	6459
1	18	1026.2	4.514	34.553	2	84.70	2	−175.39	2.52	2	6458

Station 262

Latitude	1.007°S	Date	9/14/91
Longitude	150.997°W	Bottom depth	4720

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	5.4	27.915	35.421	2	3.60	2	88.89	3.20	2	6715
1	35	47.1	27.093	35.419	2	3.60	2	92.30	2.88	2	6714
1	34	76.4	26.537	35.361	2	4.00	2	88.97	2.84	2	6713
1	33	105.2	26.222	35.581	2	3.80	2	83.51	2.80	2	6712
1	32	135.3	22.130	35.765	2	4.99	2	91.11	3.96	2	6075
1	31	166.1	19.140	35.561	2	7.36	2	84.06	2.93	2	6074
1	30	208.3	14.186	35.074	2	16.10	2	16.61	2.73	2	6072
1	29	260.5	11.969	34.892	2	22.04	2	−21.62	3.54	2	6071
1	28	310.5	11.723	34.838	2	24.62	2	−24.38	2.72	2	6070
1	27	361.9	10.647	34.776	2	31.38	2	−58.67	2.77	2	6069
1	26	412.8	9.644	34.743	2	34.15	2	−73.89	2.80	2	6068
1	25	463.0	8.663	34.688	2	37.92	2	−94.96	2.60	2	6067
1	24	514.7	8.029	34.654	2	40.71	2	−101.98	2.61	2	6066
1	21	719.3	6.298	34.562	2	56.59	2	−136.05	2.60	2	6065
1	18	1024.6	4.496	34.555	2	85.75	2	−178.20	2.46	2	6073

Station 268

Latitude	0.005°S	Date	9/15/91
Longitude	150.999°W	Bottom depth	4340

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	7.2	27.123	34.884	2	3.70	2	−16.12	3.91	4	6479
1	35	41.7	26.179	35.031	2	3.71	2	102.77	2.83	2	6478
1	34	71.9	26.017	35.091	2	4.32	2	97.83	2.97	2	6477
1	33	102.1	25.198	35.166	2	5.12	2	101.94	2.70	2	6476
1	32	141.4	22.152	35.237	2	7.30	2	98.96	2.80	2	6711
1	31	186.2	15.938	34.999	2	12.46	2	63.45	3.15	2	6710
1	29	269.5	12.486	34.892	2	19.23	2	−8.44	4.46	2	6709
1	28	307.9	11.998	34.853	2	22.40	2	−22.11	4.45	2	6708
1	27	350.5	10.620	34.789	2	29.75	2	−51.43	3.80	2	6707
1	26	390.2	10.126	34.736	2	34.72	2	−71.79	3.67	2	6611
1	25	432.2	9.528	34.704	2	35.52	2	−81.01	3.19	2	6610
1	24	472.7	8.178	34.630	2	42.48	2	−101.25	3.61	2	6609
1	23	513.5	7.881	34.613	2	44.08	2	−109.68	2.79	2	6608
1	20	717.4	6.348	34.555	2	58.60	2	−141.11	4.95	2	6607
1	17	1025.3	4.661	34.554	2	84.42	2	−177.31	2.53	2	6606

Station 274

Latitude	0.993°N	Date	9/16/91
Longitude	150.998°W	Bottom depth	3803

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	35	5.1	27.442	34.836	2	3.00	2	74.86	4.05	3	5246
1	34	36.5	26.707	34.869	2	3.20	2	92.97	3.65	2	5245
1	33	65.8	26.362	35.033	2	3.79	2	94.05	3.96	2	5244
1	32	92.1	26.063	35.138	2	4.01	2	92.32	3.59	2	5243
1	31	122.0	21.234	35.004	2	7.73	2	110.46	3.88	2	5242
1	30	153.2	16.712	34.805	2	14.59	2	64.65	4.68	2	5241
1	29	195.9	13.373	34.783	2	20.48	2	18.36	3.50	2	5240
1	28	236.4	12.337	34.840	2	22.25	2	−5.36	3.75	2	5239
1	27	277.1	11.839	34.836	2	24.21	2	−29.21	4.33	2	5238
1	26	313.1	11.637	34.825	2	25.97	2	−35.89	3.96	2	5237
1	25	352.7	11.057	34.792	2	29.31	2	−53.86	3.43	2	5236
1	36	391.9	10.355	34.754	2	−9	9	−70.95	3.87	2	5235
1	22	469.5	8.280	34.636	2	41.66	2	−113.12	4.10	2	5234
1	20	596.4	7.096	34.576	2	51.26	2	−132.28	3.22	2	5233
1	19	696.7	6.217	34.556	2	58.70	2	−141.23	3.29	2	5232
1	16	1006.2	4.703	34.555	2	83.56	2	−163.45	3.11	2	5231

Station 280

Latitude	1.996°N	Date	9/1791
Longitude	151.002°W	Bottom depth	4409

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	6.0	27.624	34.744	2	1.91	2	98.64	2.82	2	6314
1	35	44.9	27.531	34.739	2	1.91	2	103.30	2.82	2	6313
1	34	75.7	26.592	34.875	2	2.69	2	91.13	2.90	2	6312
1	33	105.3	26.181	34.862	2	4.26	2	98.45	2.82	2	6475
1	32	146.8	17.045	34.707	2	16.42	2	37.45	2.66	2	6474
1	31	188.0	12.728	34.737	2	22.30	2	4.09	2.98	2	6473
1	29	269.4	11.511	34.810	2	26.03	2	−37.50	3.51	2	6507
1	28	309.9	11.293	34.794	2	28.19	2	−54.11	3.01	2	6506
1	27	360.9	11.066	34.768	2	29.76	2	−54.33	3.49	2	6505
1	26	411.5	10.399	34.712	2	30.16	2	−64.38	2.92	2	6509
1	25	463.4	9.562	34.662	2	36.63	2	−92.72	5.52	2	6508
1	24	565.7	8.373	34.615	2	42.13	2	−110.27	2.96	2	6510
1	20	822.0	5.436	34.544	2	68.02	2	−157.43	2.45	2	6700
1	17	1180.0	4.069	34.570	2	98.99	2	−198.88	2.61	2	6504

Station 286

Latitude	2.978°N	Date	9/18/91
Longitude	151.003°W	Bottom depth	5087

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	35	5.3	27.624	34.755	2	2.50	2	90.98	2.86	2	6327
1	34	58.4	27.506	34.743	2	2.50	2	95.54	3.03	2	6326
1	33	108.6	25.524	34.950	2	3.89	2	91.67	3.14	2	6325
1	32	134.2	24.941	34.903	2	4.70	2	86.32	3.06	2	6324
1	31	159.6	14.478	34.727	2	13.39	2	59.01	2.50	2	6323
1	30	185.3	11.915	34.761	3	6.29	3	63.97	2.81	3	6322
1	29	210.7	11.665	34.755	2	24.08	2	−35.98	5.65	2	6321
1	28	236.5	11.456	34.817	2	25.27	2	−31.76	2.77	2	6320
1	27	261.5	11.216	34.778	2	24.68	2	−34.45	2.58	2	6319
1	26	312.2	10.898	34.764	2	26.87	2	−79.42	2.42	3	6318
1	24	619.0	7.350	34.596	2	50.83	2	−125.32	2.55	2	6390
1	23	721.2	6.325	34.564	2	58.03	2	−128.56	2.70	2	6316
1	20	1028.7	4.650	34.554	2	85.80	2	−169.12	2.41	2	6315

Station 290

Latitude	4.996°N	Date	9/20/91
Longitude	151.003°W	Bottom depth	5060

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	5.8	28.901	34.483	2	2.02	2	96.00	4.17	2	6402
1	35	39.5	28.721	34.801	2	2.43	2	72.68	7.48	2	6401
1	34	79.3	27.694	34.977	2	2.85	2	88.08	3.80	2	6400
1	33	118.3	26.567	34.925	2	4.06	2	99.93	2.78	2	6399
1	32	157.8	20.963	34.718	2	13.64	2	65.77	1.92	6	6397,6398
1	31	204.4	12.833	34.625	2	24.61	2	−10.71	3.38	2	6396
1	30	247.4	10.468	34.594	2	30.61	2	−38.59	2.49	2	6395
1	29	295.5	9.956	34.655	2	30.62	2	−48.93	2.54	2	6394
1	28	352.7	9.348	34.657	2	33.02	2	−63.55	2.50	2	6393
1	27	410.1	8.890	34.645	2	35.62	2	−81.02	2.54	2	6392
1	26	461.4	8.510	34.627	2	37.43	2	−96.62	2.54	2	6391
1	25	512.4	8.182	34.618	2	41.03	2	−98.35	2.70	2	6330
1	22	718.2	6.739	34.566	2	57.03	2	−136.31	2.98	2	6329
1	19	1024.7	4.697	34.559	2	89.77	2	−179.44	3.80	2	6328

Station 294

Latitude	6.959°N	Date	9/21/91
Longitude	151.348°W	Bottom depth	5384

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	8.1	28.881	33.934	2	2.01	2	94.95	3.06	2	6059
1	35	56.8	28.888	33.985	2	1.83	2	97.53	3.01	2	6060
1	34	107.3	22.086	34.858	2	5.61	2	98.57	3.06	2	6058
1	33	148.0	13.960	34.621	2	18.35	2	26.06	2.94	2	6057
1	32	189.0	10.993	34.676	2	30.08	2	−56.86	2.64	2	6056
1	31	230.6	10.436	34.685	2	31.68	2	−64.37	2.66	2	6055
1	30	270.9	9.988	34.683	2	32.48	2	−70.90	2.95	2	6054
1	29	310.8	9.537	34.677	2	33.49	2	−78.64	3.59	2	6053
1	28	362.2	9.155	34.657	2	34.89	2	−78.16	2.75	2	6052
1	27	411.6	8.870	34.646	2	36.28	2	−90.31	3.05	2	6050
1	26	462.4	8.495	34.637	2	39.27	2	−92.86	2.97	2	6049
1	25	512.5	8.112	34.620	2	43.85	2	−109.58	3.56	2	5952
1	24	613.3	7.145	34.580	2	51.99	2	−124.62	3.01	2	5951
1	23	712.9	6.304	34.560	2	65.12	2	−145.27	2.95	2	5950
1	20	1014.7	4.707	34.560	2	89.75	2	−188.97	2.52	2	5949

Station 298

Latitude	8.943°N	Date	9/22/91
Longitude	151.755°W	Bottom depth	5056

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	13.9	28.455	33.797	2	1.73	2	107.79	3.05	2	5262
1	35	47.0	27.306	34.442	2	1.92	2	102.93	3.58	2	5261
1	34	76.3	17.959	34.544	2	6.07	2	84.74	4.36	2	5260
1	33	108.9	12.869	34.563	2	24.45	2	−15.50	3.78	2	5259
1	32	138.9	11.756	34.703	2	28.59	2	−58.94	3.96	2	5258
1	31	169.1	11.199	34.718	2	30.76	2	−69.12	3.70	2	5257
1	30	210.6	10.700	34.705	2	32.53	2	−79.17	3.61	2	5256
1	29	250.3	10.271	34.693	2	33.71	2	−92.02	3.39	2	5255
1	28	291.5	9.866	34.689	2	35.09	2	−85.68	5.14	2	5254
1	27	341.3	9.336	34.655	2	39.83	2	−99.87	3.27	2	5253
1	26	392.5	8.870	34.636	2	42.58	2	−102.36	3.22	2	5252
1	25	453.0	8.293	34.601	2	48.51	2	−115.58	3.15	2	5248
1	24	512.2	7.553	34.576	2	54.43	2	−129.49	3.24	2	5251
1	23	612.4	6.752	34.556	2	63.31	2	−140.99	3.21	2	5250
1	21	815.3	5.340	34.543	2	80.68	2	−162.49	3.66	2	5249
1	19	1016.6	4.439	34.560	2	96.66	2	−185.42	2.70	2	6051

Station 302

Latitude	10.907°N	Date	9/2391
Longitude	152.112°W	Bottom depth	5345

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	6.4	28.419	33.818	2	1.99	2	88.79	3.44	2	5292
1	35	33.0	26.830	34.378	2	1.96	2	99.34	3.75	2	5291
1	34	58.7	20.020	34.480	2	3.50	2	89.59	3.31	2	5290
1	33	83.9	16.766	34.826	2	3.87	2	110.69	3.44	2	5289
1	32	109.4	13.618	34.422	2	10.74	2	67.31	2.87	2	5288
1	30	160.8	11.087	34.474	2	28.44	2	−34.58	8.70	6	5286,5287
1	29	211.0	10.271	34.597	2	34.53	2	−77.56	3.27	2	5285
1	28	263.1	9.543	34.602	2	38.04	2	−85.07	4.87	2	5284
1	27	313.6	8.896	34.591	2	41.96	2	−113.99	2.86	2	5910
1	26	415.7	8.032	34.558	2	51.20	2	−113.89	2.66	2	5283
1	25	517.9	7.093	34.533	2	60.24	2	−137.31	4.13	2	5282
1	24	620.3	6.253	34.518	2	70.67	2	−152.15	4.85	2	5281
1	23	722.9	5.599	34.526	2	80.70	2	−180.10	3.72	2	5280
1	22	825.1	5.066	34.537	2	88.76	2	−175.02	3.43	2	5279
1	20	1029.7	4.177	34.562	2	104.49	2	−200.42	4.48	2	5247

Station 306

Latitude	12.865°N	Date	9/2591
Longitude	152.503°W	Bottom depth	5561

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	7.3	28.268	34.093	2	1.99	2	106.35	3.78	2	6253
1	35	38.8	27.851	34.271	2	1.99	2	101.28	3.44	2	6088
1	34	68.4	22.543	34.742	2	1.99	2	100.41	3.38	2	6087
1	33	109.2	16.761	34.689	2	4.56	2	108.88	3.42	2	6086
1	32	160.5	11.440	34.314	2	23.51	2	1.42	3.09	2	6085
1	31	211.1	10.446	34.546	2	34.17	2	−65.30	3.15	2	6084
1	30	262.1	9.880	34.594	2	37.73	2	−81.49	3.45	2	6083
1	29	313.7	9.194	34.576	2	42.08	2	−98.77	2.76	2	6082
1	28	414.9	8.311	34.551	2	50.37	2	−117.51	2.20	6	6080,6081
1	27	517.9	7.238	34.527	2	59.27	2	−137.51	2.46	2	6079
1	26	619.2	6.515	34.524	2	68.56	2	−152.02	2.50	2	6078
1	24	825.6	5.246	34.528	2	85.18	2	−177.56	3.31	2	6077
1	22	1028.1	4.250	34.549	2	101.02	2	−198.84	2.44	2	6076
1	20	1439.5	3.096	34.590	2	126.36	2	−223.55	2.38	2	5278

Station 310

Latitude	14.839°N	Date	9/26/91
Longitude	152.891°W	Bottom depth	5815

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	6.9	27.863	34.158	2	2.36	2	100.47	3.81	2	6457
1	35	58.5	24.818	34.468	2	2.35	2	96.31	3.04	2	6414
1	34	109.9	18.269	34.736	2	3.13	2	104.92	3.04	2	6413
1	33	136.2	15.355	34.556	2	6.84	2	100.46	3.01	2	6412
1	32	161.1	13.354	34.306	2	14.36	2	59.26	3.04	2	6411
1	31	212.6	11.257	34.539	2	30.18	2	−40.47	2.75	2	6410
1	30	263.4	10.066	34.551	2	34.52	2	−82.38	3.83	2	6409
1	29	313.4	9.419	34.560	2	38.47	2	−91.32	8.76	6	6407,6408
1	28	415.3	8.385	34.553	2	45.79	2	−111.85	2.41	2	6406
1	27	515.8	7.446	34.506	2	57.25	2	−129.71	2.80	2	6405
1	26	617.2	6.602	34.496	2	69.72	2	−149.33	2.34	2	6404
1	25	719.1	5.820	34.503	2	80.80	2	−171.41	2.27	2	6403
1	24	818.6	5.220	34.510	2	90.05	2	−189.52	2.56	2	6255
1	22	1018.8	4.319	34.540	2	105.87	2	−207.90	2.54	2	6254

Station 314

Latitude	16.802°N	Date	9/2891
Longitude	153.267°W	Bottom depth	5185

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	36	7.5	26.800	34.572	2	2.08	2	92.91	2.91	2	5277
2	34	74.6	24.330	34.863	2	2.09	2	111.37	3.08	2	5276
2	33	105.4	22.625	34.982	2	2.09	2	113.67	2.89	2	5275
2	32	134.6	21.184	34.880	2	2.72	2	108.47	2.95	2	5274
2	31	164.9	19.125	34.712	2	5.19	2	111.61	3.49	2	5273
2	30	214.7	14.502	34.355	2	13.83	2	80.33	3.61	2	5272
2	29	266.9	11.232	34.295	2	27.17	2	−7.16	3.32	2	5271
2	28	317.0	8.984	34.168	2	40.55	2	−33.65	3.80	2	5270
2	27	358.8	7.820	34.353	2	45.89	2	−76.80	2.73	2	5269
2	26	400.0	8.581	34.486	2	48.35	2	−106.10	3.96	2	5268
2	25	441.3	7.865	34.484	2	53.28	2	−114.41	2.60	2	5267
2	24	482.0	7.374	34.473	2	57.19	2	−117.00	2.56	2	5266
2	23	575.2	6.503	34.483	2	67.05	2	−127.79	2.59	2	5265
2	22	675.5	5.887	34.479	2	77.14	2	−151.29	2.58	2	5264
2	21	777.2	5.273	34.480	2	87.42	2	−162.02	2.54	2	5263
2	20	932.5	4.591	34.517	2	100.37	2	−193.25	2.70	2	6252
2	19	1085.7	3.972	34.538	2	112.70	2	−214.68	2.76	2	6251
2	18	1289.9	3.443	34.563	2	124.41	2	−232.87	2.52	2	6250

Station 319

Latitude	18.400°N	Date	9/29/91
Longitude	154.474°W	Bottom depth	5162

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	36	7.2	26.617	34.775	2	2.29	2	101.07	4.29	2	6286
1	34	90.2	23.554	34.846	2	2.04	2	112.83	6.00	2	6285
1	33	130.6	20.588	34.833	2	3.23	2	110.97	6.08	2	6284
1	31	210.8	13.574	34.284	2	12.84	2	101.70	6.42	2	6283
1	30	262.4	10.613	34.152	2	19.86	2	38.29	5.12	2	6282
1	29	312.3	9.272	34.123	2	28.50	2	12.96	7.39	2	6281
1	28	363.6	8.231	34.098	2	40.57	2	−31.58	2.04	6	6276,6277, 6278,6279, 6280
1	27	413.9	7.181	34.144	2	49.60	2	−67.90	4.23	2	6275
1	26	525.6	5.978	34.252	2	74.37	2	−136.52	4.00	2	6274
1	25	617.4	5.427	34.385	2	85.81	2	−194.37	2.81	4	6273
1	23	821.7	4.647	34.486	2	100.08	2	−196.51	3.82	2	6272
1	21	1025.3	4.023	34.520	2	111.13	2	−212.35	3.24	2	6271

WOCE Cruise P17C

5/31/91 – 7/11/91

M. Tsuchiya

Station 1

Latitude	36.172°N	Date	6/2/91
Longitude	121.737°W	Bottom depth	557

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	19	2.1	10.124	33.733	2	27.97	2	28.30	7.50	2	2786
1	20	11.0	9.896	33.790	2	28.66	2	25.87	4.29	2	2707
1	21	16.3	9.421	33.818	2	30.03	2	19.27	3.57	2	2706
1	22	41.9	9.099	33.871	2	31.69	2	18.31	3.74	2	2785
1	23	66.8	8.805	33.928	2	33.54	2	7.55	3.46	2	2705
1	24	92.7	8.678	33.971	2	35.79	2	7.71	3.09	2	2784
1	25	117.1	8.590	33.998	2	37.06	2	−6.42	3.56	2	2704
1	26	141.4	8.489	34.029	2	38.24	2	−9.08	3.11	2	2783
1	27	166.6	8.391	34.060	2	39.80	2	−13.49	13.69	2	2848
1	28	190.7	8.175	34.076	2	42.63	2	−21.44	3.47	2	2703
1	29	242.6	8.002	34.093	2	44.30	2	−35.10	6.82	2	2782
1	31	292.7	7.759	34.106	2	48.01	2	−58.68	10.73	2	2781
1	30	292.7	7.759	34.106	2	48.11	2	−76.63	8.40	3	2702
1	32	394.1	7.279	34.135	2	55.15	2	−65.27	4.19	4	2701
1	33	442.7	6.647	34.135	3	66.49	2	−117.08	4.19	2	2700
1	34	491.7	6.371	34.216	3	72.06	2	−142.76	10.57	2	2780

Station 5

Latitude	35.548°N	Date	6/3/91
Longitude	122.863°W	Bottom depth	3403

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	2	39.6	11.222	33.120	2	7.17	2	68.55	3.03	2	2031
1	3	65.6	11.103	33.223	2	8.72	2	49.16	2.87	2	2032
1	5	112.4	8.695	33.415	2	20.55	2	50.18	2.87	2	2030
1	7	167.4	8.097	33.884	2	32.36	2	19.70	4.70	2	8773
1	10	261.0	7.269	34.030	2	47.46	2	−33.95	2.59	2	6916
1	13	404.1	5.816	34.076	2	70.11	2	−96.43	2.44	2	6917
1	14	455.7	5.519	34.099	2	76.69	2	−125.40	4.60	2	8769
1	15	506.9	5.605	34.214	2	82.68	2	−134.50	8.30	2	8770
1	17	604.7	5.151	34.280	2	92.73	2	−161.90	4.90	2	8771
1	19	705.3	4.689	34.334	2	103.37	2	−180.00	2.20	2	2029
1	20	805.3	4.413	34.387	2	109.75	2	−202.85	3.77	2	2001
1	21	909.4	4.152	34.414	2	115.74	2	−196.01	2.17	2	2028
1	23	1109.0	3.545	34.471	2	129.46	2	−213.49	2.15	2	2027

Station 10

Latitude	34.582°N	Date	6/5/91
Longitude	126.400°W	Bottom depth	4682

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	1.5	14.809	33.065	2	2.58	2	85.98	2.76	2	1117
1	4	86.1	12.644	32.966	2	3.50	2	69.96	3.10	2	1116
1	5	111.1	11.026	-9	5	-9	5	-75.76	2.73	4	1115
1	6	136.4	9.437	-9	5	-9	5	-189.75	2.44	4	1114
1	7	161.9	8.696	33.477	2	22.59	2	46.72	3.03	2	1113
1	8	188.4	8.526	33.709	2	26.97	2	34.21	2.99	2	1112
1	9	214.3	8.290	33.876	2	30.58	2	24.12	2.64	2	1111
1	10	253.2	7.777	33.976	2	36.11	2	4.65	4.09	2	1110
1	11	303.9	7.131	34.025	2	47.56	2	-31.88	2.63	2	1109
1	12	358.9	6.492	34.034	2	56.71	2	-51.54	2.72	2	1108
1	13	407.4	5.938	34.045	2	66.24	2	-80.36	2.33	2	1107
1	14	506.4	5.446	34.150	2	81.31	2	-127.61	2.22	2	1106
1	15	602.6	5.046	34.241	2	92.55	2	-157.90	2.14	2	1105
1	16	706.3	4.592	34.304	2	103.41	2	-178.66	2.69	2	1104
1	17	807.3	4.274	34.371	2	111.97	2	-188.68	2.15	2	1103
1	19	1010.9	3.685	34.449	2	125.27	2	-211.76	2.70	2	1102

Station 14

Latitude	34.585°N	Date	6/7/91
Longitude	131.320°W	Bottom depth	5135

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	2	29.7	15.344	33.034	2	2.82	2	78.02	3.52	2	2713
1	3	48.7	14.433	32.930	2	2.83	2	76.79	3.00	6	2712,2797
1	5	101.5	12.478	33.103	2	4.61	2	84.99	3.55	2	2711
1	6	121.9	11.573	33.096	2	6.38	2	76.20	3.56	2	2710
1	7	138.1	10.419	33.119	2	8.74	2	52.85	8.57	2	2709
1	8	163.6	8.715	33.190	2	14.24	2	46.18	3.26	2	2796
1	9	216.5	8.239	33.771	2	27.76	2	35.74	3.09	2	2795
1	10	232.1	8.368	33.919	2	32.08	2	13.08	3.21	2	2794
1	11	268.6	7.888	33.971	2	31.68	2	17.30	3.07	2	2793
1	12	397.2	6.105	33.964	2	57.94	2	-38.60	2.80	2	2792
1	14	600.0	4.817	34.138	2	93.13	2	-143.16	2.60	2	2790
1	15	698.3	4.510	34.234	2	104.65	2	-162.19	2.53	2	2789
1	16	796.8	4.320	34.324	4	112.46	2	-188.44	2.72	2	2788
1	18	993.7	3.674	34.416	4	128.06	2	-207.61	2.76	2	2787
1	19	1202.8	3.235	34.491	4	138.00	2	-222.57	2.82	2	2708
1	13	5225.4	1.590	34.675	4	157.15	2	-213.17	2.69	3	2791

Station 17

Latitude	34.598°N	Date	6/8/91
Longitude	134.963°W	Bottom depth	5129

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	1.3	15.915	33.068	2	3.23	2	84.33	4.40	6	2699,2779
2	3	78.8	13.785	33.155	2	3.13	2	83.88	5.48	2	2698
2	6	152.4	9.795	33.105	2	10.18	2	75.15	5.32	2	2697
2	8	203.0	8.356	33.433	2	18.39	2	78.09	2.99	2	2778
2	9	252.8	8.009	33.809	2	23.67	2	46.77	3.44	2	2696
2	10	302.4	7.699	33.972	2	37.55	2	7.18	4.08	2	2777
2	11	353.9	6.886	33.975	2	46.65	2	−17.56	3.39	2	2695
2	12	404.7	6.291	33.997	2	57.31	2	−50.36	2.81	2	2776
2	13	502.6	5.187	34.023	2	77.16	2	−105.75	3.14	2	2694
2	14	606.7	4.682	34.089	2	91.43	2	−148.85	3.16	2	2693
2	15	705.4	4.358	34.187	2	104.23	2	−163.94	2.99	2	2692
2	16	808.3	4.107	34.299	2	114.88	2	−176.95	2.50	2	2775
2	17	907.0	3.879	34.370	2	121.62	2	−194.98	2.51	2	2774
2	18	1009.7	3.642	34.434	2	127.48	2	−209.19	3.13	2	2691
2	19	1212.0	3.200	34.497	2	137.25	2	−213.84	2.65	2	2773

Station 20

Latitude	33.065°N	Date	6/9/91
Longitude	134.997°W	Bottom depth	4761

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	1.5	17.240	33.682	2	3.63	2	82.33	3.87	2	1220
1	2	71.8	17.332	34.309	2	3.20	2	89.81	21.00	2	1261
1	4	137.9	17.264	34.571	2	3.39	2	110.67	3.87	2	1218
1	5	153.6	16.500	34.408	2	3.58	2	112.73	5.14	2	1217
1	6	174.9	14.430	34.108	2	4.81	2	104.27	4.95	2	1216
1	8	228.0	10.553	33.780	2	11.60	2	80.69	5.46	2	3356
1	10	306.7	8.616	33.982	3	24.36	2	43.98	3.68	2	1215
1	11	353.6	7.741	33.982	2	34.24	2	25.69	4.36	2	1214
1	12	405.9	7.069	33.992	2	44.93	2	−21.86	6.19	2	1213
1	14	507.8	5.767	34.019	2	66.28	2	−78.55	3.36	2	1212
1	15	607.4	4.870	34.089	2	87.64	2	−139.65	3.15	2	1211
1	16	709.7	4.445	34.195	2	102.39	2	−166.07	3.23	2	1210
1	17	812.3	4.155	34.291	2	112.80	2	−200.76	5.98	2	1263
1	18	905.2	3.936	34.362	2	120.74	2	−215.13	4.89	2	1208
1	20	1008.9	3.722	34.408	2	126.12	2	−210.29	4.18	2	1207
1	22	1618.8	2.513	34.560	2	153.63	2	−241.33	4.21	2	1206

Station 23

Latitude	31.532°N	Date	6/10/91
Longitude	135.002°W	Bottom depth	4562

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	1.2	17.553	34.196	2	3.49	2	111.13	5.44	2	1163
1	3	80.6	16.320	34.300	2	3.64	2	123.50	4.00	2	1249
1	4	111.7	16.269	34.382	2	3.82	2	124.37	7.17	2	1161
1	5	131.4	15.737	34.308	2	4.00	2	119.71	4.31	2	1160
1	6	181.0	10.933	33.906	2	8.87	2	86.07	4.21	2	1159
1	7	223.3	9.948	33.929	2	12.91	2	95.58	7.23	2	1157
1	8	244.2	9.644	33.974	2	15.73	2	81.90	4.01	2	1156
1	9	275.4	8.965	33.986	2	20.38	2	65.42	4.63	2	1155
1	10	320.8	8.264	34.014	2	30.93	2	39.60	3.97	2	1154
1	11	405.7	6.872	33.976	2	45.10	2	−21.58	5.57	6	1158,1250
1	12	461.2	6.247	33.981	2	56.86	2	−47.80	3.69	2	1153
1	13	506.2	5.721	34.000	2	65.97	2	−79.77	14.43	2	1152
1	14	605.4	4.889	34.082	2	87.46	2	−128.71	3.45	2	1151
1	15	710.7	4.332	34.200	2	106.71	2	−167.70	3.29	2	1150
1	16	810.3	4.054	34.297	2	116.85	2	−182.13	3.95	6	1149,1256
1	18	1002.7	3.647	34.427	2	128.93	2	−216.79	5.73	2	1148

Station 26

Latitude	30.033°N	Date	6/11/91
Longitude	134.952°W	Bottom depth	5181

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	1.4	18.452	34.669	2	3.51	2	115.73	3.99	2	1203
2	2	65.4	18.515	34.751	2	3.31	2	100.85	9.03	2	1204
2	3	86.1	18.426	34.751	2	2.91	2	115.34	4.14	2	1205
2	4	111.0	18.290	34.801	2	2.92	2	127.59	3.94	2	1202
2	5	141.2	18.101	34.818	2	2.93	2	122.10	3.98	2	1201
2	6	177.0	17.162	34.671	2	3.54	2	106.80	4.41	2	1200
2	7	207.8	14.903	34.339	2	4.36	2	122.01	3.97	2	1199
2	8	242.6	12.454	34.129	2	8.03	2	105.00	4.23	2	1198
2	9	276.6	10.886	34.028	2	11.90	2	93.98	4.02	2	1197
2	10	327.1	9.597	34.028	2	19.02	2	58.46	4.91	2	1196
2	11	403.5	8.147	34.019	2	32.43	2	26.76	3.79	2	1195
2	12	485.7	6.832	34.012	2	50.52	2	−31.03	3.19	6	1194,1265
2	13	611.2	5.489	34.093	2	77.74	2	−111.84	3.58	2	1193
2	14	704.7	4.794	34.193	2	95.41	2	−147.78	3.24	2	1192
2	15	815.0	4.362	34.295	2	109.01	2	−187.54	3.46	2	1229
2	16	917.0	4.129	34.365	2	116.52	2	−219.41	11.57	2	1264

Station 29

Latitude	28.498°S	Date	6/12/91
Longitude	134.997°W	Bottom depth	3843

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	1.6	18.462	34.633	2	3.29	2	NA	NA	5	--
1	2	81.4	18.462	34.805	2	3.05	2	NA	NA	5	--
1	3	127.2	18.364	34.854	2	2.81	2	131.60	3.50	2	7068
1	5	176.7	18.027	34.808	2	2.53	2	124.80	3.60	2	7067
1	6	203.2	16.415	34.524	2	3.49	2	NA	NA	5	--
1	8	253.3	11.95	34.008	2	9.65	2	86.20	2.80	2	7706
1	10	316.5	9.449	34.018	2	21.24	2	NA	NA	5	--
1	12	413.5	7.633	34.014	2	38.08	2	5.50	2.60	2	7705
1	14	607.9	5.004	34.062	2	83.72	2	NA	NA	5	--
1	21	1467.1	2.818	34.556	2	144.28	2	−233.50	2.20	2	7704
1	25	2076.2	1.960	34.627	2	166.68	2	NA	NA	5	--
1	26	2230.6	1.837	34.634	2	169.31	2	−258.00	3.50	2	7686
1	27	2376.0	1.749	34.642	2	170.12	2	NA	NA	5	--
1	28	2532.5	1.683	34.648	2	170.53	2	NA	NA	5	--
1	29	2690.2	1.629	34.654	2	169.93	2	NA	NA	5	--
1	30	2837	1.594	34.659	2	169.94	2	NA	NA	5	--

Station 32

Latitude	27.000°S	Date	6/13/91
Longitude	134.998°W	Bottom depth	4127

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	1.2	19.829	35.076	2	3.25	2	NA	NA	5	--
1	2	74.4	19.338	34.972	2	3.23	2	112.60	3.60	2	7370
1	3	115.2	18.308	34.817	2	3.20	2	121.30	5.00	2	7271
1	4	151.0	17.154	34.648	2	3.78	2	127.90	5.30	2	7270
1	5	175.6	15.345	34.369	2	5.57	2	NA	NA	5	--
1	6	202.0	12.971	34.073	2	8.35	2	93.90	4.00	3	7269
1	7	228.9	11.254	34.008	2	11.53	2	105.30	4.40	2	7268
1	8	252.1	10.568	34.017	2	14.31	2	91.80	3.20	2	7267
1	9	275.5	9.766	34.042	2	17.89	2	NA	NA	5	--
1	10	312.7	8.962	34.043	2	24.87	2	51.40	3.40	2	7089
1	11	348.4	8.377	34.033	2	30.65	2	40.70	3.10	2	7088
1	12	378.1	7.856	34.024	2	36.82	2	4.40	2.50	2	7195
1	13	404.7	7.372	34.025	2	43.98	2	−15.80	3.10	2	7087
1	14	470.5	6.214	34.047	2	62.54	2	−84.10	3.10	2	7194
1	15	640.7	4.946	34.201	2	92.86	2	−161.70	2.60	2	7193
1	16	704.1	4.680	34.258	2	99.99	2	−210.6	4.80	3	7108

Station 34

Latitude	26.040°N	Date	6/14/91
Longitude	134.970°W	Bottom depth	4571

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	13	0.9	20.131	35.105	2	2.64	2	121.96	4.19	2	3114
2	14	107.0	19.393	35.092	2	2.83	2	115.20	3.12	2	3113
2	15	128.2	19.015	35.033	2	2.83	2	112.35	3.35	2	3112
2	16	152.8	18.421	34.867	2	3.03	2	123.83	3.14	2	3111
2	17	175.3	16.767	34.659	2	4.20	2	115.85	3.12	2	3110
2	18	202.4	14.859	34.420	2	5.57	2	105.80	3.31	2	3109
2	19	227.0	12.914	34.159	2	7.63	2	94.35	3.89	2	3108
2	20	253.3	11.379	34.027	2	10.27	2	83.74	3.25	2	3068
2	21	278.2	10.371	33.998	2	14.47	2	69.70	4.18	2	3107
2	22	303.9	9.652	34.032	2	19.66	2	52.20	4.20	2	7091
2	23	354.1	8.482	34.027	2	29.92	2	20.20	3.00	2	7090
2	26	507.2	6.032	34.072	2	67.18	2	-91.70	4.70	2	7071
2	27	603.4	5.232	34.159	2	84.38	2	-143.60	2.70	2	7070
2	28	704.5	4.745	34.273	2	98.85	2	-176.30	3.40	2	7069
2	29	806.9	4.507	34.392	2	106.07	2	−189.94	2.95	2	5585
2	30	907.3	4.068	34.436	2	114.09	2	−202.33	2.81	2	5584
2	31	1009.7	3.862	34.485	2	118.09	2	−200.53	3.01	2	5583
2	32	1212.7	3.452	34.526	2	127.08	2	−219.04	2.93	2	5582
2	33	1417.9	3.002	34.558	2	137.63	2	−246.69	2.83	2	5581
2	34	1614.8	2.652	34.580	2	146.43	2	−246.87	3.38	2	5580
2	35	1819.2	2.369	34.600	2	152.39	2	−252.52	3.66	2	5579
2	36	2022.0	2.110	34.616	2	158.25	2	−259.51	2.30	2	5578
2	1	2223.0	1.938	34.632	2	164.11	2	−257.70	3.10	2	5577
2	2	2431.6	1.772	34.643	2	167.53	2	−256.49	2.41	2	5576

Station 38

Latitude	23.998°N	Date	6/1591
Longitude	135.000°W	Bottom depth	4851

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.6	21.359	34.911	2	2.80	2	92.99	3.38	2	5755
1	2	78.4	20.029	34.926	2	2.80	2	95.84	3.40	2	5754
1	3	102.4	19.985	35.033	2	2.80	2	105.96	3.52	2	5753
1	5	153.1	18.456	34.890	2	3.60	2	106.81	3.03	2	5752
1	7	203.3	14.275	34.301	2	6.80	2	100.49	3.35	2	5751
1	9	254.2	11.264	34.055	2	12.99	2	68.51	3.36	2	5750
1	10	303.2	9.444	34.059	2	21.78	2	40.18	3.13	2	5749
1	11	358.5	8.108	34.069	2	37.35	2	−14.84	6.09	2	5748
1	12	413.5	7.149	34.104	2	52.32	2	−65.58	3.64	2	5593
1	13	510.2	6.036	34.170	2	71.66	2	−132.29	3.43	2	5592

Station 38 (continued)

Latitude	23.998°N	Date	6/1591
Longitude	135.000°W	Bottom depth	4851

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	14	605.3	5.390	34.311	2	87.00	2	−159.24	3.63	2	5591
1	16	802.5	4.858	34.450	2	97.71	2	−188.30	3.31	2	5590
1	18	992.6	4.243	34.492	2	109.22	2	−205.15	2.97	2	5589
1	19	1208.7	3.681	34.532	2	121.74	2	−226.23	3.99	2	5588
1	20	1419.6	3.173	34.555	2	132.86	2	−235.32	2.81	2	5587
1	21	1614.6	2.776	34.581	2	142.57	2	−241.36	3.81	2	5586

Station 42

Latitude	22.037°N	Date	6/16/91
Longitude	134.997°W	Bottom depth	5225

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.5	21.478	34.899	2	2.82	2	110.75	3.97	2	5777
1	2	54.8	20.753	35.024	2	2.45	2	107.03	3.03	2	5776
1	3	84.5	20.350	35.042	2	2.62	2	116.90	4.83	2	5775
1	4	109.2	19.778	35.039	2	2.62	2	113.04	4.68	2	5774
1	5	129.8	19.506	35.035	2	2.43	2	107.76	3.33	2	5773
1	7	225.0	13.944	34.336	2	8.53	2	97.02	2.22	6	5771,5772
1	8	254.1	11.461	34.069	2	15.00	2	34.99	4.85	2	5770
1	9	297.8	10.087	34.135	2	23.26	2	28.95	5.94	2	5769
1	10	356.9	8.251	34.116	2	39.61	2	−44.16	7.68	2	5768
1	11	405.7	7.309	34.142	2	52.18	2	−80.06	2.64	2	5767
1	15	809.5	4.972	34.469	2	94.69	2	−192.09	2.46	2	5766
1	17	1015.9	4.181	34.507	2	109.38	2	−206.00	2.39	2	5765
1	19	1418.1	3.085	34.567	2	133.58	2	−240.48	2.58	2	5764
1	21	1821.1	2.390	34.604	2	148.97	2	−256.32	2.47	2	5763

Station 46

Latitude	19.982°N	Date	6/18/91
Longitude	135.017°W	Bottom depth	5257

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	0.4	22.655	34.727	2	2.83	2	61.69	4.47	2	3083
2	3	77.7	21.059	34.931	2	2.83	2	87.33	3.64	2	3082
2	4	102.0	20.588	34.933	2	2.64	2	100.87	3.71	2	3081
2	5	127.3	19.941	34.905	2	2.44	2	84.67	3.64	3	3080
2	6	178.7	16.668	34.539	2	4.40	2	107.39	3.61	2	3079
2	7	203.1	14.593	34.279	2	7.14	2	111.07	3.46	2	3078
2	8	221.8	13.113	34.159	2	10.36	2	97.17	3.23	2	3077

Station 46 (continued)

Latitude	19.982°N	Date	6/18/91
Longitude	135.017°W	Bottom depth	5257

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	9	258.3	10.477	34.046	2	20.05	2	52.12	3.12	2	3076
2	10	304.0	9.083	34.105	2	31.00	2	7.31	9.15	2	3075
2	11	355.2	8.290	34.208	2	45.17	2	−58.30	3.97	2	3074
2	12	406.6	7.800	34.287	2	54.07	2	−81.87	2.89	2	3073
2	13	503.7	6.868	34.378	2	66.77	2	−121.85	2.91	2	3072
2	14	606.1	6.099	34.420	2	77.92	2	−147.24	3.57	2	3071
2	15	708.7	5.457	34.454	2	88.08	2	−154.98	2.91	2	3070
2	16	811.5	5.000	34.475	2	95.70	2	−184.57	3.50	6	3231,3357
2	17	908.8	4.594	34.494	2	103.52	2	−194.74	2.62	2	3069

Station 50

Latitude	18.000°N	Date	6/19/91
Longitude	135.005°W	Bottom depth	5028

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	24.429	34.500	2	3.72	2	68.77	5.30	2	6979
1	2	26.0	24.418	34.499	2	3.54	2	90.11	3.31	2	6912
1	3	114.2	20.442	34.834	2	3.73	2	101.84	4.71	2	6913
1	4	154.1	16.837	34.528	2	6.66	2	97.13	3.54	2	6914
1	5	179.7	13.242	34.205	2	13.98	2	61.69	3.61	2	6915
1	7	232.2	10.47	34.248	2	29.53	2	−10.51	3.01	2	7150
1	8	263.3	9.688	34.268	2	34.83	2	−22.33	3.64	2	6902
1	9	303.3	9.368	34.367	2	40.50	2	−54.87	3.59	2	7040
1	10	354.1	8.496	34.348	2	47.63	2	−88.42	3.26	2	6901
1	11	405.0	7.757	34.383	2	56.58	2	−140.51	5.21	3	6978
1	12	504.0	6.874	34.417	2	67.54	2	−120.28	3.42	2	7065
1	13	606.8	6.069	34.439	2	78.31	2	−161.44	2.64	2	6980
1	15	813.8	4.972	34.483	2	96.20	2	−168.06	3.38	2	7064
1	17	1009.0	4.185	34.518	2	111.34	2	−209.86	3.04	2	6911
1	19	1417.1	3.049	34.576	2	134.51	2	−225.02	4.40	2	7063

Station 53

Latitude	16.500°N	Date	6/20/91
Longitude	135.000°W	Bottom depth	4849

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.9	25.257	34.499	2	2.39	2	87.40	3.05	2	5567
1	3	88.7	22.352	34.711	2	2.02	2	96.94	4.28	2	5566
1	5	134.7	18.869	34.601	2	2.76	2	100.94	4.17	2	5565

Station 53 (continued)

Latitude	16.500°N	Date	6/20/91
Longitude	135.000°W	Bottom depth	4849

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	6	151.6	16.424	34.441	2	5.07	2	102.64	2.78	2	5564
1	7	178.8	13.702	34.269	2	14.43	2	44.44	2.88	2	5563
1	8	191.0	12.853	34.286	2	18.23	2	26.84	2.57	2	5562
1	9	252.6	10.600	34.435	2	32.59	2	−47.09	2.47	2	5561
1	10	303.4	9.932	34.517	2	38.43	2	−76.89	2.55	2	5560
1	11	354.4	9.026	34.504	2	45.20	2	−104.72	2.38	2	5559
1	12	405.9	8.465	34.490	2	49.37	2	−107.17	3.27	2	5558
1	13	506.6	7.253	34.458	2	61.88	2	−132.65	3.15	2	5557
1	14	602.9	6.441	34.455	2	71.99	2	−146.69	2.64	2	5556
1	15	707.7	5.633	34.482	2	84.13	2	−165.23	2.39	2	5555
1	17	912.7	4.685	34.516	2	99.71	2	−195.86	2.21	2	5554
1	19	1216.6	3.689	34.556	2	119.74	2	−221.59	2.69	2	5553
1	21	1618.1	2.761	34.599	2	139.78	2	−240.57	2.13	2	5552

Station 57

Latitude	14.462°N	Date	6/21/91
Longitude	134.978°W	Bottom depth	4983

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	0.2	25.923	34.501	2	2.96	2	101.29	3.92	2	3207
2	2	42.5	24.363	34.456	2	2.94	2	94.00	4.87	2	3206
2	3	62.2	24.087	34.479	2	2.91	2	92.76	3.76	2	3205
2	4	102.3	19.470	34.435	2	4.75	2	87.58	5.05	2	3204
2	5	122.0	15.145	34.370	2	16.31	2	51.44	3.73	2	3194
2	6	142.3	12.780	34.333	2	21.51	2	22.61	5.01	2	3193
2	7	161.4	11.424	34.322	2	25.60	2	6.47	3.19	2	3122
2	8	182.3	11.198	34.393	2	29.49	2	−13.77	3.18	2	3121
2	9	221.6	10.739	34.540	2	34.69	2	−50.84	3.60	2	3120
2	10	301.6	9.516	34.533	2	42.32	2	−86.13	3.95	2	3196
2	11	401.8	8.128	34.509	2	53.32	2	−109.14	3.47	2	3195
2	12	503.6	7.036	34.479	2	64.69	2	−130.39	3.92	2	3119
2	13	605.7	6.239	34.487	2	75.50	2	−154.07	8.69	2	3118
2	14	706.2	5.555	34.498	2	85.00	2	−172.76	4.01	2	3117
2	15	805.4	5.053	34.516	2	92.07	2	−185.37	2.50	2	3116
2	16	913.8	4.586	34.532	2	100.26	2	−197.74	2.74	2	3115

Station 60

Latitude	13.002°N	Date	6/22/91
Longitude	135.003°W	Bottom depth	4907

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	26.962	34.237	2	2.33	2	106.88	2.95	2	5722
1	3	41.9	24.442	34.479	2	2.12	2	104.50	3.02	2	5721
1	5	95.9	17.790	34.459	2	6.92	2	85.48	2.78	2	5720
1	7	136.7	12.505	34.491	2	23.95	2	−3.85	2.74	2	5719
1	8	156.5	11.954	34.555	2	26.72	2	−17.72	3.48	2	5789
1	9	176.9	11.601	34.623	2	28.75	2	−44.05	3.07	2	5788
1	10	201.1	11.359	34.674	2	30.04	2	−50.58	3.52	2	5787
1	11	253.5	10.362	34.625	2	34.66	2	−70.30	3.37	2	5786
1	12	303.3	9.839	34.617	2	37.25	2	−87.57	3.32	2	5785
1	13	381.8	9.421	34.648	2	39.28	2	−102.49	2.64	2	5784
1	14	502.8	7.951	34.540	2	53.73	2	−111.95	2.94	2	5783
1	15	604.9	7.007	34.515	2	64.67	2	−138.76	3.05	2	5782
1	16	708.7	6.217	34.518	2	72.63	2	−153.29	3.03	2	5781
1	18	907.4	5.034	34.527	2	92.45	2	−181.88	2.53	2	5780
1	20	1208.8	3.922	34.564	2	111.17	2	−205.25	2.39	2	5779
1	22	1612.5	2.943	34.600	2	131.18	2	−229.33	3.16	2	5778

Station 63

Latitude	11.503°N	Date	6/23/91
Longitude	135.000°W	Bottom depth	4893

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	27.962	34.039	2	2.35	2	85.72	3.04	2	5738
1	4	76.2	18.782	34.569	2	5.96	2	90.10	2.69	2	5737
1	5	87.2	15.793	34.487	2	11.54	2	53.29	2.68	2	5736
1	6	107.9	13.377	34.553	2	24.05	2	−7.26	2.76	2	5735
1	7	128.8	12.450	34.690	2	28.64	2	−47.40	2.49	2	5734
1	8	151.6	11.816	34.721	2	29.71	2	−50.85	2.51	2	5733
1	9	217.3	11.001	34.727	2	31.96	2	−68.48	2.46	2	5732
1	10	263.4	10.546	34.712	2	33.82	2	−73.85	2.43	2	5731
1	11	355.0	9.811	34.676	2	38.80	2	−86.18	2.63	2	5730
1	12	457.7	8.793	34.612	2	45.16	2	−104.20	3.55	2	5729
1	13	555.1	7.763	34.561	2	54.84	2	−132.12	5.09	2	5728
1	14	656.7	6.713	34.525	2	66.28	2	−141.33	3.78	2	5727
1	15	759.7	5.938	34.525	2	77.62	2	−177.88	2.81	2	5726
1	16	856.6	5.391	34.533	2	85.24	2	−164.09	3.31	2	5725
1	17	1010.4	4.664	34.546	2	96.77	2	−181.90	2.44	2	5724
1	18	1216.3	3.945	34.569	2	110.07	2	−197.20	2.25	2	5723

Station 66

Latitude	9.965°N	Date	6/2491
Longitude	135.057°W	Bottom depth	4811

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	0.2	28.330	33.852	2	2.29	2	89.59	4.00	2	1748
2	3	52.4	25.070	34.484	2	4.16	2	96.10	4.47	2	1747
2	6	93.4	13.589	34.615	2	24.75	2	−4.72	3.76	2	1746
2	7	127.8	11.958	34.725	2	29.56	2	−49.31	3.59	2	1745
2	8	152.7	11.589	34.728	2	29.75	2	−39.54	4.57	2	791
2	9	202.5	10.828	34.711	2	32.16	2	−69.24	3.97	2	1743
2	10	253.7	10.367	34.705	2	33.83	2	−89.43	3.43	2	1742
2	11	304.3	9.976	34.689	2	35.49	2	−84.50	3.48	2	1741
2	12	354.6	9.601	34.671	2	38.27	2	−83.57	5.65	2	1740
2	13	404.4	9.103	34.650	2	41.42	2	−101.20	3.46	2	1739
2	14	507.5	8.040	34.593	2	51.96	2	−147.14	3.27	2	1738
2	15	603.9	7.006	34.548	2	62.32	2	−142.29	3.26	2	1737
2	16	708.3	6.263	34.541	2	70.27	2	−159.74	5.45	2	790
2	17	809.5	5.593	34.539	2	78.95	2	−169.99	3.16	2	1736
2	18	911.0	5.079	34.549	2	85.97	2	−180.06	3.13	2	1735
2	19	1009.0	4.702	34.554	2	91.87	2	−179.52	3.14	2	1734

Station 70

Latitude	8.000°N	Date	6/25/91
Longitude	134.998°W	Bottom depth	4743

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.4	28.251	33.775	2	2.75	2	110.73	4.80	2	1762
1	3	33.4	27.793	34.054	2	2.54	2	99.41	4.37	2	3585
1	5	55.7	18.679	34.577	2	5.55	2	104.86	6.15	2	1761
1	6	66.4	16.692	34.485	2	10.01	2	76.83	4.75	2	1760
1	8	91.7	12.751	34.606	2	25.39	2	−10.90	4.27	2	3358
1	9	120.9	11.999	34.727	2	28.95	2	−33.98	4.18	2	1759
1	10	182.6	10.774	34.711	2	30.89	2	−58.41	4.18	2	1758
1	12	299.7	9.847	34.689	2	34.80	2	−66.49	3.80	2	1757
1	13	400.9	9.097	34.662	2	41.22	2	−94.63	3.80	2	1756
1	14	504.8	8.045	34.607	2	51.56	2	−112.42	3.69	2	1755
1	15	605.9	6.889	34.560	2	63.15	2	−135.88	3.60	2	1754
1	16	708.9	5.947	34.542	2	75.27	2	−154.02	3.64	2	1753
1	17	811.5	5.319	34.546	2	83.09	2	−168.92	3.55	2	1752
1	19	1010.8	4.456	34.564	2	98.54	2	−191.39	3.54	2	1751
1	21	1411.9	3.185	34.600	2	125.02	2	−226.59	3.46	2	1750

Station 73

Latitude	6.523°N	Date	6/26/91
Longitude	135.000°W	Bottom depth	4638

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	28.986	34.244	2	2.72	2	82.27	13.91	2	1045
1	3	51.8	28.050	34.777	2	2.68	2	93.86	7.85	2	981
1	4	77.1	23.028	34.813	2	5.73	2	93.56	5.24	2	980
1	5	102.5	17.686	34.696	2	12.77	2	58.10	4.43	2	979
1	6	128.6	12.897	34.647	2	25.79	2	−5.33	5.14	2	1044
1	7	150.9	11.623	34.670	2	29.21	2	−37.37	3.83	2	1043
1	8	172.4	11.198	34.707	2	30.09	2	−50.01	3.53	2	1042
1	9	201.9	10.568	34.695	2	31.16	2	−58.97	3.62	2	1041
1	10	252.5	10.060	34.691	2	32.77	2	−66.98	6.95	2	1040
1	11	303.2	9.747	34.683	2	33.47	2	−60.18	6.11	2	1028
1	12	358.2	9.325	34.664	2	35.99	2	−90.81	7.38	2	1039
1	13	409.5	8.959	34.649	2	38.87	2	−94.82	6.77	2	1038
1	14	509.9	7.872	34.606	2	51.17	2	−133.04	5.61	3	1037
1	15	609.5	6.823	34.571	2	60.94	2	−123.72	3.25	2	1036
1	16	709.8	5.920	34.557	2	72.70	2	−160.61	3.96	2	1035
1	18	914.3	4.759	34.558	2	88.97	2	−179.61	6.67	2	1034

Station 76

Latitude	4.992°N	Date	6/2791
Longitude	134.972°W	Bottom depth	4578

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	0.2	28.566	34.400	2	3.07	2	94.13	6.41	2	1178
2	3	81.0	27.934	34.837	2	3.21	2	91.52	7.43	2	1177
2	4	110.5	24.505	34.869	2	4.81	2	89.33	4.63	2	1176
2	5	121.2	19.501	34.777	2	8.90	2	84.76	4.46	2	1190
2	6	142.7	15.393	34.672	2	19.08	2	23.49	4.55	2	1189
2	7	167.4	11.358	34.644	2	30.15	2	−37.57	4.30	2	1188
2	8	206.5	10.480	34.653	2	31.74	2	−44.06	4.09	2	1184
2	9	231.2	10.141	34.656	2	32.62	2	−47.24	4.49	2	1183
2	10	257.4	9.934	34.664	2	33.32	2	−71.90	5.80	2	1175
2	11	307.9	9.611	34.676	2	33.48	2	−72.77	4.20	2	1174
2	12	357.9	9.305	34.664	2	35.61	2	−102.03	8.10	3	1248
2	13	408.0	8.944	34.651	2	38.82	2	−95.46	2.99	6	1172,1246
2	14	503.4	8.078	34.618	2	46.50	2	−87.22	3.38	2	1171
2	15	603.4	7.204	34.582	2	54.71	2	−130.77	2.94	2	1170
2	16	730.3	6.098	34.553	2	65.79	2	−150.64	2.90	2	1169
2	17	785.8	5.591	34.551	2	74.19	2	−159.56	3.77	2	1255

Station 79

Latitude	3.517°N	Date	6/28/91
Longitude	135.002°W	Bottom depth	4311

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	28.489	34.597	2	2.86	2	75.94	5.51	2	992
1	2	49.3	28.225	34.617	2	2.86	2	64.99	4.88	2	1182
1	3	96.2	26.505	34.796	2	3.94	2	85.73	8.49	2	990
1	4	111.7	22.310	34.826	2	7.18	2	83.23	6.20	2	989
1	5	122.3	20.965	34.786	2	9.89	2	68.53	4.69	2	988
1	6	142.7	13.326	34.875	2	22.16	2	−0.67	4.56	2	987
1	7	162.4	12.829	34.887	2	24.32	2	−17.29	5.66	2	986
1	8	202.2	12.137	34.843	2	25.22	2	−27.29	5.27	2	1009
1	9	228.0	11.763	34.821	2	27.38	2	−37.26	5.18	2	1008
1	10	253.0	11.625	34.813	2	27.19	2	−45.57	5.51	2	1006
1	11	304.8	11.096	34.776	2	27.91	2	−58.46	16.49	2	1004
1	12	344.2	10.719	34.747	2	28.99	2	−63.15	5.23	2	1003
1	13	398.5	10.084	34.709	2	31.51	2	−75.04	4.06	2	1181
1	14	452.2	9.354	34.664	2	35.12	2	−68.60	4.48	2	984
1	15	504.1	8.627	34.637	2	42.51	2	−104.91	3.79	2	3359
1	16	584.8	7.486	34.591	2	52.07	2	−121.78	5.52	2	982

Station 86

Latitude	2.000°N	Date	6/29/91
Longitude	134.990°W	Bottom depth	4510

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	12	0.2	27.550	34.865	2	2.90	2	87.20	4.87	2	788
1	1	65.9	26.654	34.835	2	2.89	2	93.95	7.26	2	1073
1	2	82.1	23.432	34.794	3	4.95	2	76.49	5.22	2	1076
1	3	92.4	21.465	34.793	2	9.66	2	69.27	5.23	2	1077
1	4	102.8	17.646	34.741	2	14.19	2	48.46	5.60	2	1078
1	5	118.5	16.049	34.736	2	17.77	2	33.43	3.68	2	1079
1	6	158.6	12.871	34.868	2	23.23	2	−10.56	5.29	2	1074
1	7	178.3	12.536	34.868	2	24.35	2	−24.84	10.08	2	1075
1	8	209.0	12.172	34.845	2	25.47	2	−25.66	4.64	2	1083
1	9	262.0	11.643	34.816	2	25.83	2	−41.40	6.70	2	1084
1	10	323.6	10.970	34.772	2	29.41	2	−77.37	7.48	2	1085
1	11	384.8	10.103	34.730	2	34.51	2	−71.92	3.95	2	1086
1	13	421.0	9.636	34.688	2	33.92	2	−78.68	5.71	2	1089
1	14	507.1	8.198	34.623	2	43.56	2	−119.76	4.90	2	1090
1	15	604.5	6.888	34.569	2	53.00	2	−125.41	5.28	2	1092
1	16	705.9	6.038	34.550	2	60.93	2	−140.89	5.69	2	1088

Station 92

Latitude	0.990°N	Date	6/30/91
Longitude	135.000°W	Bottom depth	4260

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	27.280	35.043	2	2.84	2	81.28	5.94	2	408
1	3	78.1	24.215	34.931	2	5.22	2	88.54	4.34	2	406
1	4	92.6	21.343	34.889	2	7.44	2	96.63	5.97	2	405
1	5	103.1	20.947	34.878	2	8.17	2	95.08	6.00	2	404
1	6	111.1	19.295	34.847	2	9.83	2	91.12	5.73	2	403
1	7	123.6	17.584	34.779	2	12.06	2	70.23	5.69	2	402
1	8	133.0	15.480	34.793	2	15.58	2	38.78	5.28	2	401
1	9	143.8	14.774	34.753	2	17.43	2	39.62	5.57	2	400
1	10	154.3	13.219	34.751	2	20.78	2	15.31	5.30	2	399
1	11	198.9	12.181	34.853	2	22.62	2	−44.92	5.60	2	398
1	12	250.6	11.758	34.833	2	26.71	2	−42.20	4.62	2	397
1	13	301.6	11.483	34.815	2	26.88	2	−36.91	5.01	2	396
1	14	365.5	10.101	34.721	2	32.47	2	−75.21	5.48	2	395
1	15	409.8	9.567	34.696	2	36.56	2	−92.32	4.95	2	394
1	16	511.5	7.941	34.613	2	42.90	2	−107.75	4.79	2	393
1	17	600.7	7.057	34.581	2	49.42	2	−125.83	3.64	2	407

Station 98

Latitude	0.003°N	Date	7/191
Longitude	135.157°W	Bottom depth	4317

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
2	1	0.2	27.431	35.346	2	3.13	2	104.00	6.46	2	3360
2	2	67.0	26.058	35.429	2	3.71	2	85.97	3.80	2	930
2	3	72.8	24.835	35.393	2	5.18	2	94.39	3.61	2	929
2	4	84.8	21.235	35.356	2	6.55	2	87.64	5.18	2	928
2	5	113.0	19.277	35.126	2	8.99	2	117.21	6.44	3	1033
2	6	143.6	17.705	35.244	2	8.60	2	57.85	11.25	2	1026
2	7	176.9	15.167	35.024	2	13.09	2	45.82	12.04	2	1018
2	8	208.6	13.340	34.906	2	17.49	2	27.27	4.08	2	1019
2	9	234.3	13.080	34.948	2	17.30	2	−7.00	5.69	2	995
2	10	309.1	11.662	34.825	2	27.95	2	−55.89	8.93	2	1024
2	11	363.3	10.214	34.744	2	34.60	2	−52.18	5.12	2	1032
2	12	434.6	9.063	34.679	2	39.39	2	−96.37	3.61	2	1031
2	13	505.8	8.106	34.631	2	43.30	2	−120.97	6.32	2	1030
2	14	606.7	7.059	34.582	2	49.85	2	−138.12	3.83	2	1029
2	15	708.8	6.160	34.558	2	60.12	2	−131.30	4.85	2	996
2	16	807.8	5.275	34.550	2	72.04	2	−166.31	5.95	2	994

Station 104

Latitude	0.993°S	Date	7/3/91
Longitude	135.002°W	Bottom depth	4479

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	27.439	35.356	2	2.83	2	89.40	3.39	2	1802
1	2	51.4	26.898	35.388	2	3.03	2	93.87	3.43	2	1803
1	3	73.9	25.208	35.508	2	3.52	2	88.95	3.71	2	1814
1	4	94.4	22.417	35.677	2	3.91	2	84.67	3.45	2	1800
1	5	104.2	20.827	35.665	2	5.66	2	100.07	3.01	2	1801
1	6	113.0	19.821	35.625	2	5.76	2	80.24	3.31	2	1799
1	7	140.3	15.519	35.173	2	10.94	2	18.84	7.98	2	1999
1	8	177.6	13.165	34.969	2	17.00	2	−4.43	6.68	2	3361
1	9	202.9	12.165	34.868	2	22.97	2	3.32	3.64	2	1792
1	10	228.9	12.015	34.850	2	24.24	2	−3.65	4.76	2	1791
1	11	275.7	11.487	34.815	2	28.44	2	−30.42	2.80	2	1790
1	12	306.2	11.201	34.803	2	28.64	2	−44.68	3.40	2	1798
1	13	355.3	10.156	34.742	2	34.31	2	−86.51	2.72	2	1793
1	14	415.3	9.496	34.700	2	37.63	2	−88.03	2.82	2	1797
1	15	505.7	7.965	34.620	2	43.69	2	−102.41	2.78	2	1796
1	16	605.9	7.086	34.581	2	47.90	2	−115.97	2.84	2	1795

Station 110

Latitude	1.973°S	Date	7/4/91
Longitude	135.002°W	Bottom depth	4435

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	27.729	35.374	2	2.76	2	95.52	4.80	2	786
1	4	76.2	27.509	35.363	2	2.90	2	96.68	4.80	2	785
1	5	97.0	23.225	35.260	2	4.62	2	63.28	4.76	2	3362
1	6	110.8	19.596	35.394	2	6.91	2	82.10	4.73	2	783
1	7	153.2	12.988	34.933	2	23.05	2	−10.48	6.93	2	782
1	8	178.7	12.548	34.901	2	24.57	2	−19.44	4.34	2	781
1	10	279.7	11.447	34.816	2	27.43	2	−25.19	10.02	2	780
1	11	312.3	11.218	34.806	2	27.60	2	−48.83	4.28	2	779
1	12	368.9	10.005	34.739	2	27.39	2	−56.53	4.18	2	778
1	13	424.9	9.163	34.693	2	34.30	2	−83.12	5.61	2	777
1	14	485.3	8.307	34.642	2	37.55	2	−98.46	4.11	2	776
1	15	554.9	7.390	34.593	2	43.69	2	−95.62	6.68	3	3363
1	16	644.9	6.484	34.560	2	51.94	2	−123.33	4.11	2	774
1	17	710.8	5.964	34.551	2	59.43	2	−135.37	6.50	2	773
1	18	812.7	5.375	34.544	2	67.29	2	−147.64	5.24	2	828

Station 118

Latitude	3.488°S	Date	7/5/91
Longitude	135.002°W	Bottom depth	4672

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	27.761	35.320	2	3.02	2	71.34	3.47	2	1132
1	2	79.1	27.750	35.318	2	3.21	2	79.54	3.51	2	1131
1	4	99.6	26.425	35.440	2	3.02	2	68.23	2.63	2	1130
1	6	121.3	21.563	35.586	2	4.91	2	83.61	2.89	2	1129
1	7	132.0	18.761	35.303	2	10.21	2	61.78	2.63	2	1128
1	8	142.8	13.389	34.958	2	21.56	2	−2.94	2.47	2	1127
1	9	152.6	13.111	34.924	2	23.26	2	−4.23	2.47	2	1126
1	10	177.3	12.833	34.905	2	23.83	2	−15.91	2.57	2	1125
1	11	220.6	12.395	34.880	2	25.34	2	−27.54	2.70	2	1124
1	12	281.6	11.799	34.854	2	28.93	2	−46.38	3.09	2	1123
1	13	353.4	10.320	34.768	2	34.42	2	−82.04	6.21	2	1122
1	14	425.5	8.985	34.686	2	40.66	2	−93.43	4.23	2	1121
1	16	606.8	6.863	34.580	2	52.20	2	−124.62	3.36	2	1120
1	19	907.6	4.996	34.552	2	77.93	2	−160.39	2.27	2	1119
1	23	1718.3	2.632	34.619	2	125.97	2	−222.91	2.09	2	1118

Station 121

Latitude	5.008°S	Date	7/6/91
Longitude	135.008°W	Bottom depth	4658

Cast	Bot.	Pres. (dB)	Temp. (°C)	Salt	F	Si (μmol/kg)	F	$\Delta^{14}C$ (‰)	Err. (‰)	F	OSNUM
1	1	0.2	27.647	35.111	2	3.03	2	79.98	3.96	2	912
1	2	57.2	27.639	35.162	2	3.03	2	78.63	4.53	2	913
1	3	76.7	25.413	35.517	2	3.22	2	72.33	4.14	2	911
1	4	91.2	24.020	35.540	2	3.61	2	77.40	4.97	2	910
1	5	111.4	21.170	35.490	2	4.30	2	76.85	3.65	2	909
1	6	129.2	18.991	35.534	2	5.08	2	101.48	4.64	2	908
1	7	141.3	16.908	35.294	2	8.70	2	68.14	7.00	2	993
1	8	161.8	14.979	35.121	2	11.14	2	59.13	4.86	2	906
1	9	192.8	13.307	34.949	2	18.67	2	−1.92	3.91	2	1020
1	10	279.7	11.016	34.808	2	27.27	2	−43.54	2.87	2	904
1	11	305.0	10.737	34.787	2	27.66	2	−48.54	2.87	2	903
1	12	362.7	10.101	34.747	2	35.38	2	−77.76	2.80	2	902
1	13	452.1	8.901	34.680	2	37.44	2	−102.97	4.64	2	901
1	14	559.2	7.641	34.609	2	44.08	2	−107.30	4.70	2	900
1	15	656.6	6.811	34.572	2	48.58	2	−125.67	2.66	2	899
1	16	763.0	5.944	34.548	2	57.97	2	−130.85	2.83	2	898

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LARGE-VOLUME WOCE RADIOCARBON SAMPLING IN THE PACIFIC OCEAN

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ABSTRACT. At the University of Miami Tritium Laboratory and the University of Washington Quaternary Isotope Laboratory, more than 1000 large-volume Pacific Ocean radiocarbon samples were measured for the WOCE program. Here we present a comprehensive data set, and a brief discussion of our findings.

INTRODUCTION

An overview of the World Ocean Circulation Experiment (WOCE) Pacific Ocean radiocarbon program, and a rationale plus sampling strategy for large-volume (250-liter Gerard barrels) collection of deeper waters, is given by R. M. Key in this issue (Key 1997; Key, Quay and NOSAMS 1997). Here we report the sample radiocarbon activities, as measured by the University of Miami's Tritium Laboratory and the University of Washington's Quaternary Isotope Laboratory, through beta counting of CO_2 gas. These laboratories also produced the GEOSECS ^{14}C data set (Stuiver and Östlund 1983, 1980; Östlund and Stuiver 1980).

CO_2 was extracted from acidified ocean water samples following the procedure established for GEOSECS samples (Stuiver *et al.* 1974). The reported $\Delta^{14}C$ values were calculated according to Stuiver and Polach (1977), with appropriate corrections for the decay of the NBS ^{14}C standard (Stuiver 1980). The standard error (1 σ) is primarily counting error and ranges from 4‰ (rounded upwards) for Miami to 2.5–4.0‰ for Seattle. The standard error for "routine" operation (~2 days counting time) approaches 4‰, whereas the higher precision relates to samples counted for 4 days. Errors due to sample collection are not included. For the proper calculation of $\Delta^{14}C$ values, $\delta^{13}C$ was measured on the CO_2 gas prepared for ^{14}C counting. These $\delta^{13}C$ determinations were all made in Seattle, for GEOSECS as well as for the large-volume (LV) WOCE samples. The GEOSECS and WOCE LV $\delta^{13}C$ measurements have long-term internal consistency in that they were all measured relative to a single CO_2 laboratory standard. The $\delta^{13}C$ value of the laboratory standard was calibrated early on against the PDB scale on a Nuclide mass spectrometer using isotope standards supplied by the NBS (National Bureau of Standards). Total Carbon $\delta^{13}C$ values, based on complete CO_2 recovery of acidified samples, were not determined by us. As the relatively slow CO_2 extraction of the 250-liter LV samples may not always have been taken to completion (100% yield) the reported sample gas $\delta^{13}C$ need not be identical to Total Carbon $\delta^{13}C$.

We report here the $\Delta^{14}C$ results for 1088 large-volume WOCE samples (Table A.1). A complete listing of the WOCE cruises can be found in Key (1997). Small-volume sample results obtained through accelerator mass spectrometry (AMS) are discussed in this issue by Key, Quay and NOSAMS (1997).

The transects and LV sampling stations are depicted in Figure 1. We also provide a plot of $\Delta^{14}C$ *vs.* depth for the individual station data (Fig. A.1). Profiles (splined) for stations along the ~151.0°W longitude trajectory are summarized in Figure 2. In Figure 2 the northernmost stations are to the left, the southernmost stations to the right. All stations north of the Antarctic circumpolar current have their oldest waters at mid-depth (~2500 m) and the gradual "aging" (loss of ^{14}C) from south to north is evident. The pocket of "oldest" water at mid-depth between 10° and 30° N in the eastern Pacific

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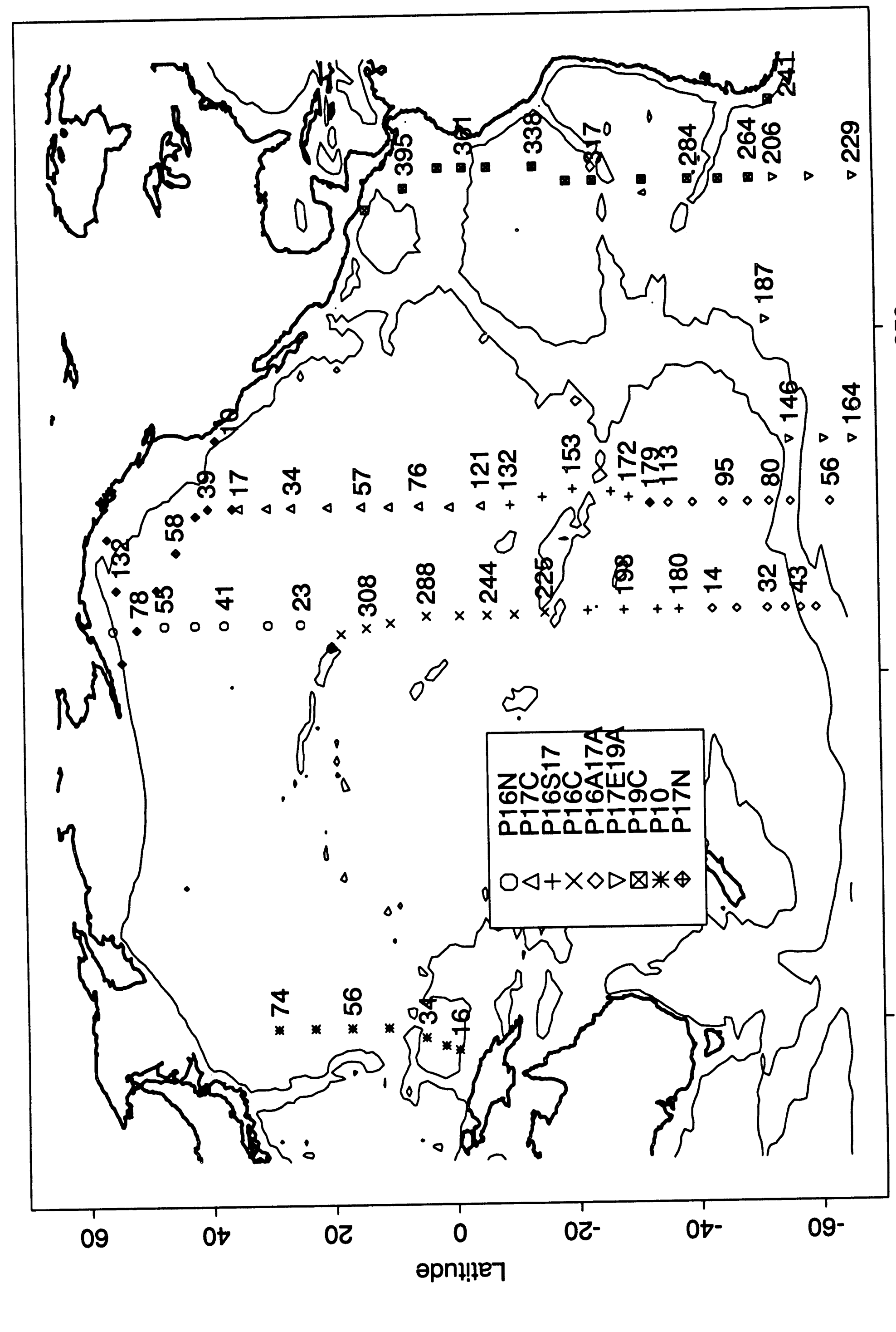

Fig. 1. WOCE LV stations and cruise nomenclature

(Östlund and Stuiver, 1980, Plate 2) with $\Delta^{14}C$ values of ~ −250‰ now extends to 42°N. The "wavy" splines of the northernmost sections point toward more complex ocean circulation patterns. Composite vertical $\Delta^{14}C$ cross-sections are not reported here; they will be discussed by Key and coworkers in a future paper (Key *et al.*, ms.). Ocean circulation and time-dependent ^{14}C change relative to the GEOSECS $\Delta^{14}C$ baseline also will be discussed in that paper.

The data set given below represents the main body of LV WOCE $\Delta^{14}C$ measurements. The WOCE $\Delta^{14}C$ measurements of Miami are now complete. The Seattle deepwater samples of the Western Pacific P10 track still have to be measured.

THE TABLES AND FIGURES

In the Appendix, data are presented in Tables A.1 and Figure A.1. Accompanying the $\Delta^{14}C$ values (in ‰, relative to age-corrected NBS Oxalic Acid ^{14}C activity and normalized on $\delta^{13}C_{PDB} = -25‰$) in the tables are the standard deviation ($\sigma^{14}C$ in ‰), depth (in meters, calculated from pressure data), potential temperature (θ in °C), Quaternary Isotope Laboratory (QL) numbers, Miami Tritium Laboratory (ML) numbers (marked with asterisks in the table), salinity (in ‰, relative to the Practical Salinity Scale) and $\delta^{13}C$ (‰, relative to the PDB standard) of the CO_2 counting gas. The order in which the stations are given in the table follows the Fig. 1 north-south and south-north trajectories. Quality control warnings (flags) that apply to a small fraction of the measurements have not been included. The reader is referred to a more comprehensive data set that will be available in electronic format through the various WOCE data distribution centers via the Internet once the $\Delta^{14}C$ measurements are all completed and the hydrographic data released (http://whpo.whoi.edu).

Depth–$\Delta^{14}C$ relationships are plotted for each station, with cruise and station information in the lower right-hand corner of each quadrant (Fig. A.1).

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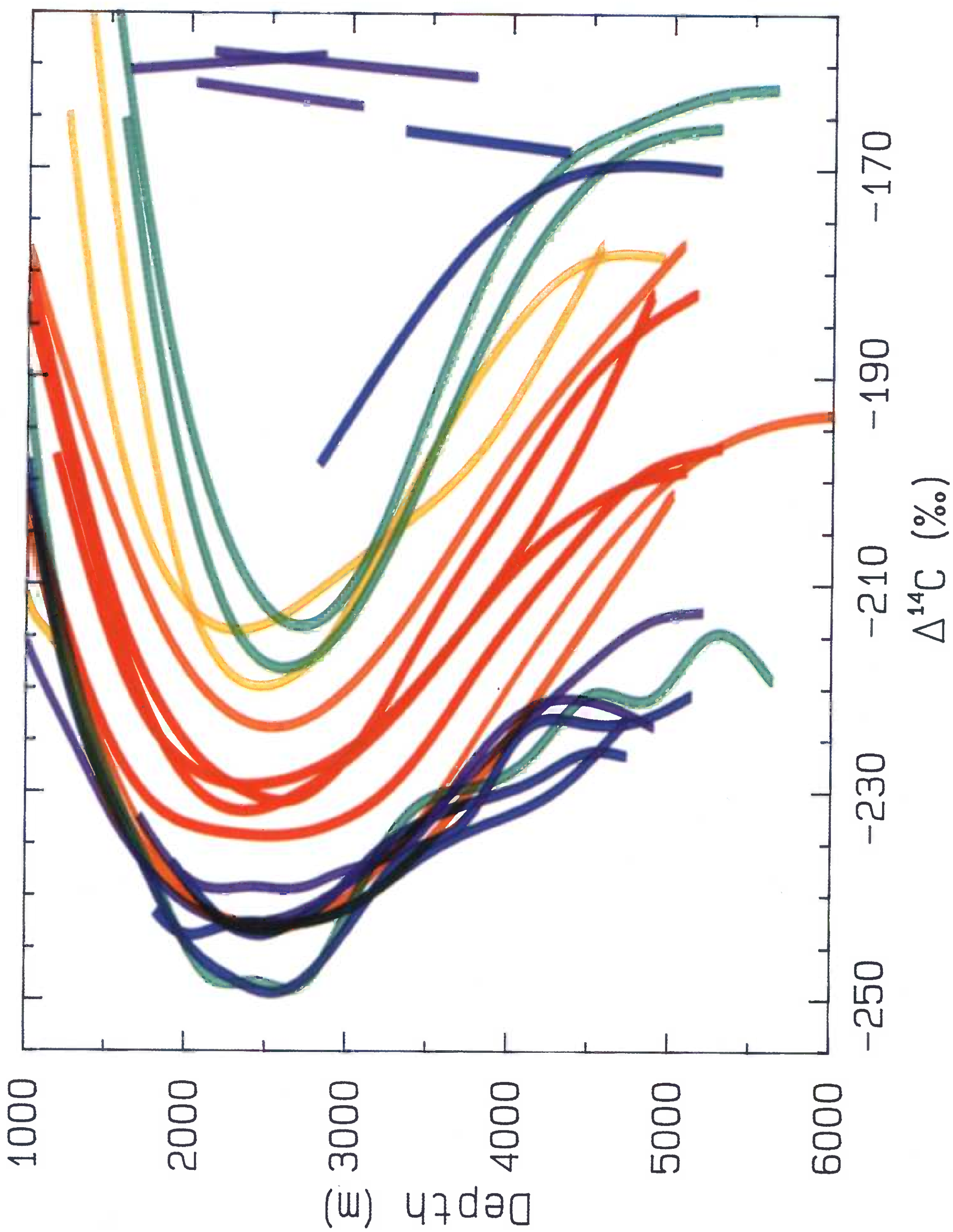
Fig. 2 *(next page)*. Splined WOCE $\Delta^{14}C$ profiles along *ca.* 151.0°W longitude. The color code relates to latitude: violet = >50°S or >50°N (Stations 48, 43, 38, 32 or 78, 60), blue = 40–50°S or °N (22, 14 or 48, 55, 68), green = 30–40°S or °N (180, 187 or 41), yellow = 20–30°S or °N (198, 210 or 23), orange = 10–20°S or °N (225, 235 or 308, 317) and red = 10°S–10°N (244, 259, 288, 300). The $\Delta^{14}C$ data of stations 31 and 225 have more scatter than those of the other stations and were not plotted in Fig. 2. The ^{14}C data were smoothed using a spline function (Reinsch 1967) with a smoothing parameter, S, equal to the number of data points for the station.


Depth (m)
1000
2000
3000
4000
5000
6000
−250
−230
−210
−190
−170
Δ14C (‰)

APPENDIX

Table A.1

Cruise: P16N **Station: 60** **55°27′N 152°38′W** **31 Mar 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	6	5190*	12.8	4.0	3.080	32.860	−0.4
182	306	5189*	−132.0	4.0	3.869	34.050	−2.1
183	611	5188*	−186.7	4.0	3.309	34.265	−2.0
184	918	5187*	−210.5	4.0	2.839	34.378	−2.0
185	1225	5186*	−221.8	4.0	2.350	34.471	−1.5
194	1525	5183*	−230.3	4.0	2.060	34.535	−1.7
187	1533	5185*	−234.4	4.0	2.040	34.536	−1.6
281	3006	5182*	−238.9	4.0	1.322	34.661	−2.9
282	3952	5181*	−225.5	4.0	1.157	34.681	−0.4
283	4474	5180*	−218.3	4.0	1.111	34.686	−0.3
284	4887	5179*	−212.9	4.0	1.089	34.689	−1.1
285	5195	5178*	−212.9	4.0	1.080	34.690	−2.2

Cruise: P16N **Station: 55** **47°0′N 152°0′W** **27 Mar 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	7	5199*	39.2	4.0	7.609	32.845	−0.4
382	152	5198*	27.2	4.0	6.347	33.523	0.1
383	304	5197*	−47.0	4.0	4.877	33.850	−1.2
384	509	5196*	−118.9	4.0	4.033	34.049	−2.1
385	766	5195*	−181.0	4.0	3.437	34.247	−2.1
387	1024	5194*	−203.5	4.0	2.940	34.358	−1.0
390	1280	5193*	−223.8	4.0	2.534	34.446	−1.5
393	1535	5192*	−231.0	4.0	7.309	34.504	−1.8
394	1786	5191*	−243.0	4.0	2.019	34.553	−1.7
281	1826	5208*	−240.0	4.0	2.006	34.553	−1.6
294	2028	5200*	−244.3	4.0	1.832	34.584	−1.4
282	2230	5207*	−242.3	4.0	1.696	34.603	−1.4
283	2640	5206*	−242.7	4.0	1.520	34.636	−1.2
284	3053	5205*	−240.8	4.0	1.347	34.658	−1.4
285	3472	5204*	−236.1	4.0	1.247	34.672	−1.8
287	3894	5203*	−232.8	4.0	1.163	34.680	−1.4
290	4313	5202*	−229.7	4.0	1.156	34.683	−0.6
293	4731	5201*	−222.9	4.0	1.127	34.683	−0.4

Cruise: P16N **Station: 48** **42°0′N 151°59′W** **23 Mar 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
281	6	5237*	56.8	4.0	10.089	33.239	−0.5
282	262	5236*	27.6	4.0	7.774	33.985	−0.7
283	523	5235*	−81.0	4.0	4.869	33.975	−2.3
284	786	5233*	−169.7	4.0	3.773	34.196	−1.4
285	1052	5234*	−200.5	4.0	3.077	34.338	−2.7
287	1318	5232*	−222.7	4.0	2.591	34.438	−2.6
290	1636	5220*	−232.3	4.0	2.199	34.518	−3.0
293	1952	5219*	−244.1	4.0	1.887	34.579	−1.5
294	2264	5218*	−249.0	4.0	1.654	34.617	−1.0
381	2273	5217*	−245.7	4.0	1.683	34.615	−1.3

*QL = Quaternary Isotope Laboratory; ML = Miami Tritium Laboratory (ML codes are marked with an * in table)

382	2594	5216*	−249.7	4.0	1.527	34.637	−1.7
383	2907	5215*	−245.3	4.0	1.390	34.653	−1.8
384	3372	5214*	−235.0	4.0	1.266	34.659	−1.4
385	3785	5213*	−233.8	4.0	1.204	34.679	−2.0
387	4041	5212*	−223.2	4.0	1.167	34.682	−0.8
390	4505	5211*	−223.8	4.0	1.134	34.685	−1.3
393	4817	5210*	−223.1	4.0	1.146	34.684	−1.4
394	5134	5209*	−220.4	4.0	1.156	34.690	−1.2

Cruise: P16N **Station: 41** **37°11′N 151°58′W** **21 Mar 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	5	3136	88.4	3.2	14.429	33.878	0.2
182	310	3137	57.9	2.8	9.455	34.068	0.2
183	614	3138	−71.7	2.3	5.369	33.986	−0.6
184	918	3139	−176.6	2.4	3.594	34.218	−1.0
185	1222	3140	−212.3	2.3	2.905	34.402	−3.2
187	1528	3141	−228.8	2.3	2.455	34.512	−2.1
190	1834	3142	−238.9	2.1	2.065	34.577	−0.9
193	2141	3143	−248.5	2.3	1.783	34.612	−0.9
194	2451	3144	−245.8	3.6	1.579	34.633	−0.7
281	2717	3145	−249.7	2.4	1.437	34.649	−0.6
282	3075	3146	−239.2	2.4	1.325	34.663	−0.4
283	3434	3147	−231.2	2.2	1.241	34.673	−0.5
284	3795	3148	−229.6	2.3	1.174	34.680	−0.5
285	4157	3149	−226.7	2.4	1.164	34.684	−0.4
287	4522	3150	−219.6	2.4	1.122	34.687	−0.5
290	4889	3151	−221.9	2.3	1.108	34.688	−0.5
293	5259	3152	−214.4	1.6	1.101	34.690	−0.9
294	5633	3153	−219.5	2.2	1.092	34.689	−0.2

Cruise: P16N **Station: 31** **30°0′N 152°1′W** **16 Mar 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1003				3.537	34.369	
382	1312	3121	−222.7	2.2	2.918	34.506	−2.2
383	1622	3122	−240.4	2.2	2.330	34.566	−1.2
384	1933	3123	−244.8	2.1	1.938	34.606	−1.2
389	2194				1.699	34.651	
385	2242	3124	−247.0	2.2	1.749	34.632	−1.9
387	2548	3125	−242.9	2.2	1.511	34.649	−2.6
481	2805	3126	−238.1	2.0	1.390	34.661	−0.9
482	3220	3127	−228.8	2.2	1.272	34.673	−2.0
483	3739	3128	−225.6	1.5	1.176	34.674	−0.6
484	4053	3129	−237.8	1.6	1.142	34.685	−0.9
485	4367	3130	−219.7	2.2	1.130	34.688	−0.8
487	4681	3131	−217.6	2.1	1.104	34.689	−0.6
490	4996	3132	−215.4	2.3	1.086	34.690	−0.5
493	5312	3133	−212.8	1.7		34.691	−0.9

Cruise: P16N **Station: 23** **24°40′N 152°0′W** **12 Mar 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
281	504	3112	−41.2	2.6	6.743	34.018	−1.7
282	812	3113	−187.9	2.3	4.266	34.326	−2.0
283	1120	3114	−213.0	2.2	3.419	34.507	−2.2
285	1231	3116	−215.8	2.2	3.169	34.532	−3.4

289	1341	3118	−219.9	2.2	2.950	34.534	−1.7
284	1381	3115	−227.8	2.1	2.879	34.559	−2.9
287	1521	3117	−231.0	2.3	2.624	34.576	−1.9
290	1671	3119	−234.3	1.7	2.423	34.587	−1.5
291	1947	3120	−239.0	2.2	2.016	34.612	−2.2

Cruise: P16C **Station: 317** **18°1′N 153°29′W** **28 Sep 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
184	816	5990*	−183.1	4.0	4.893	34.483	−1.7
481	1002	5989*	−205.0	4.0	4.083	34.518	−1.3
483	1252	5988*	−224.4	4.0	3.348	34.558	−0.7
484	1503	5987*	−232.3	4.0	2.793	34.583	−0.5
487	1753	5596*	−241.5	4.0	2.328	34.605	−1.5
489	2005	5595*	−237.6	4.0	2.001	34.626	1.8
494	2257	5598*	−240.4	4.0	1.782	34.640	−0.7
485	2508	5597*	−240.0	4.0	1.603	34.653	−0.8
493	2759	5599*	−240.2	4.0	1.492	34.682	−1.2
181	2973	5986*	−242.7	4.0	1.413	34.670	−0.9
183	3225	5985*	−241.6	4.0	1.320	34.673	−0.9
490	3457	5984*	−245.9	4.0	1.268	34.663	−1.1
187	3732	5983*	−230.3	4.0	1.200	34.677	−1.0
189	3987	5982*	−224.6	4.0	1.124	34.681	−1.1
194	4241	5981*	−218.9	4.0	1.096	34.688	−0.1
185	4496	5980*	−209.7	4.0	1.058	34.690	−0.5
190	4753	5979*	−211.3	4.0	1.008	34.692	0.4
193	5009	5978*	−199.4	4.0	0.987	34.690	−1.4

Cruise: P16C **Station: 308** **13°52′N 152°41′W** **25 Sep 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
481	1003	5578*	−195.7	4.0	4.232	34.540	−1.5
483	1301	5591*	−222.5	4.0	3.285	34.578	−0.8
484	1599	5594*	−232.3	4.0	2.518	34.606	−0.9
487	1897	5575*	−242.1	4.0	2.059	34.629	−1.5
489	2197	5574*	−243.3	4.0	1.778	34.648	−1.6
494	2495	5564*	−239.5	4.0	1.614	34.661	−1.3
485	2797	5573*	−243.9	4.0	1.498	34.668	−1.5
490	3097	5566*	−236.3	4.0	1.381	34.674	−1.0
493	3397	5565*	−237.5	4.0	1.313	34.678	−0.7
181	3690	5563*	−230.9	4.0	1.214	34.682	−1.2
183	3993	5311*	−213.0	4.0	1.123	34.687	−0.1
184	4298	5310*	−214.3	4.0	1.051	34.686	−1.4
187	4604	5561*	−208.1	4.0	0.997	34.690	0.2
189	4918	5560*	−195.2	4.0	0.960	34.692	−1.2
194	5220	5592*	−198.4	4.0	0.961	34.697	−0.1
185	5530	5562*	−195.1	4.0	0.932	34.696	−0.8
190	5842	5590*	−191.0	4.0	0.930	34.695	−0.1
193	6156	5593*	−196.9	4.0	0.946	34.692	−0.3

Cruise: P16C **Station: 300** **9°56′N 151°56′W** **23 Sep 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
481	1006	5309*	−194.4	4.0	4.311	34.556	−1.7
483	1255	5308*	−219.1	4.0	3.407	34.582	−2.7
484	1504	5244*	−226.8	4.0	2.842	34.603	−2.0
487	1754	5242*	−235.0	4.0	2.407	34.626	−1.8

489	2003	5241*	−230.8	4.0	2.050	34.640	−1.8
494	2253	5238*	−229.6	4.0	1.861	34.652	−1.5
485	2504	5243*	−234.8	4.0	1.682	34.662	−1.2
490	2754	5240*	−234.1	4.0	1.600	34.675	−1.7
493	3005	5239*	−230.4	4.0	1.508	34.671	−0.8
281	3285	5307*	−233.5	4.0	1.412	34.676	−1.4
283	3547	5306*	−226.7	4.0	1.288	34.681	−0.2
284	3788	5305*	−213.9	4.0	1.184	34.684	−0.9
287	4045	5230*	−210.7	4.0	1.089	34.689	0.2
289	4292	5228*	−211.8	4.0	1.013	34.693	−1.3
294	4547	5227*	−206.5	4.0	0.984	34.695	−0.5
285	4789	5259*	−190.9	4.0	0.975	34.696	−1.2
290	5061	5231*	−200.3	4.0	0.952	34.696	−1.2
293	5317	5229*	−198.0	4.0	0.959	34.694	−1.2

Cruise: P16C Station: 288 4°0′N 151°1′W 19 Sep 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
383	1184	5552*	−189.1	4.0	4.077	34.569	−0.9
384	1383	5551*	−216.2	4.0	3.325	34.591	−2.2
387	1581	5558*	−217.4	4.0	2.796	34.610	−1.1
389	1782	5557*	−228.9	4.0	2.454	34.625	−0.7
394	1982	5554*	−224.0	4.0	2.229	34.637	−1.2
385	2234	5559*	−237.5	4.0	1.932	34.652	−1.1
390	2486	5556*	−227.6	4.0	1.713	34.663	−1.6
393	2739	5555*	−237.7	4.0	1.621	34.667	−0.9
181	3017				1.467	34.674	
183	3268	5545*	−224.0	4.0	1.306	34.681	−0.3
184	3520				1.222	34.683	
187	3772	5546*	−212.4	4.0	1.147	34.688	−1.4
189	4024				1.071	34.692	
194	4277	5548*	−203.5	4.0	1.034	34.693	−0.3
185	4531	5547*	−203.3	4.0	1.005	34.696	−0.8
190	4786	5550*	−197.4	4.0	0.995	34.695	−0.6
193	5091	5549*	−200.8	4.0	0.939	34.696	−0.3

Cruise: P16C Station: 259 1°30′S 150°59′W 13 Sep 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	984	3365	−179.1	2.0	4.442	34.556	−0.3
383	1182	3366	−192.7	2.4	3.800	34.571	−0.2
384	1381	3367	−205.5	2.4	3.159	34.592	−0.3
387	1581	3369	−215.1	2.7	2.668	34.613	−0.2
389	1781	3370	−229.1	2.3	2.424	34.629	−0.2
393	1983	3372	−230.0	2.3		34.644	−0.4
394	2186	3373	−232.3	3.0	1.917	34.651	−0.4
385	2389	3368	−232.1	2.3	1.751	34.663	−0.2
390	2594	3371	−228.3	2.6	1.556	34.665	−0.3
281	2813	3356	−226.5	2.1	1.516	34.670	−0.6
283	3156	3357	−226.4	2.0	1.395	34.676	−0.1
284	3459	3358	−218.6	2.3	1.238	34.683	−0.1
287	3762	3360	−212.1	2.1	1.119	34.692	−0.3
289	4067	3361	−205.3	2.4	1.086	34.693	−0.1
293	4270	3363	−203.8	2.4	1.054	34.694	0.0
294	4474	3364	−197.4	2.0	0.992	34.696	−0.1
285	4678	3359	−186.8	2.4	0.949	34.699	−0.1
290	4883	3362	−180.0	2.5	0.848	34.701	0.1

Cruise: P16C **Station: 244** **6°1´S 151°0´W** **9 Sep 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
481	1086	3347	−183.4	2.1	3.907	34.557	−0.2
483	1283	3348	−195.9	2.2	3.355	34.578	−0.3
484	1482	3349	−210.6	2.1	2.973	34.596	−0.4
487	1681	3351	−218.8	2.1	2.679	34.609	0.0
489	1880	3352	−219.8	2.2	2.347	34.625	−0.3
493	2130	3354	−229.5	2.1	2.030	34.643	−0.3
494	2380	3355	−225.6	2.2	1.801	34.657	−0.3
485	2632	3350	−234.6	2.3	1.641	34.671	−0.2
490	2886	3353	−227.8	2.1		34.671	−0.4
281	3133	3338	−226.2	2.2	1.417	34.678	−0.3
283	3389	3339	−214.3	2.4	1.304	34.684	−0.2
284	3644	3340	−208.7	2.3	1.219	34.690	−0.1
287	3898	3342	−205.5	2.2	1.114	34.692	−0.2
289	4151	3343	−199.3	2.2	1.028	34.696	−0.1
293	4403	3345	−189.4	2.1	0.981	34.697	0.0
294	4654	3346	−188.1	2.2	0.942	34.700	−1.2
285	4903	3341	−183.4	2.2	0.913	34.701	−0.1
290	5150	3344	−182.7	2.2		34.701	0.1

Cruise: P16C **Station: 235** **10°31´S 150°58´W** **5 Sep 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	984	3329	−167.7	3.3	4.362	34.527	−0.4
383	1233	3330	−189.6	3.0	3.459	34.560	−0.3
384	1482	3331	−200.6	2.5	2.785	34.600	−0.3
387	1728	3333	−211.1	2.4	2.350	34.615	−2.9
385	1813	3332	−215.1	2.2			−0.2
390	1988	3337	−220.8	2.5			−0.2
389	1993	3334	−218.3	2.0	1.992	34.640	−0.2
393	2231	3335	−219.4	2.2	1.824	34.653	−0.2
394	2484	3336	−226.4	2.2	1.664	34.666	−0.3
181	3293	3321	−214.9	2.0	1.362	34.682	−0.9
184	3543	3322	−209.0	2.1	1.249	34.684	−0.4
187	3793	3324	−202.6	2.7	1.164	34.691	−0.4
189	4044	3325	−192.7	2.6	1.060	34.693	−0.8
193	4297	3327	−188.3	3.7	0.973	34.706	−0.3
194	4552	3328	−188.2	3.8	0.925	34.703	−0.3
185	4807	3323	−182.2	2.4	0.886	34.704	−0.2
190	5067	3326	−178.8	4.1	0.826	34.705	−0.3

Cruise: P16C **Station: 225** **15°31´S 150°40´W** **2 Sep 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	988	3313	−164.5	2.5	3.893	34.515	−0.2
383	1240	3314	−184.7	2.2			−0.2
384	1491	3315	−193.8	1.9	2.653	34.590	−0.5
387	1738	3316	−203.3	1.7	2.302	34.612	−0.4
389	1983	3317	−189.9	1.7	2.026	34.633	−0.3
490	2234	3318	−203.1	3.0			0.0
493	2484	3319	−210.5	3.2			−0.3
494	2738	3320	−211.8	3.3			−0.1
189	3285	3309	−201.8	2.2	1.295	34.689	−0.6
190	3535	3310	−191.0	2.2	1.198	34.691	−0.5
193	3788	3311	−190.7	2.3	1.152	34.692	−0.9

194	4044	3312	−191.8	2.3	1.131	34.692	−0.7
185	4270	3308	−191.6	2.2	1.057	34.694	−0.5

Cruise: P16S17 Station: 210 22°30´S 150°30´W 22 Aug 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
490	2	3307	117.5	3.1	23.558	35.924	1.1
381	1237	3299	−170.4	3.7	3.062	34.517	0.0
383	1386	3300	−188.4	3.2	2.772	34.553	0.1
384	1586	3301	−197.9	2.7	2.430	34.585	−0.2
387	1790	3303	−201.4	3.5	2.187	34.610	−0.3
389	1987	3304	−209.8	3.1	2.003	34.631	−0.2
393	2239	3305	−214.5	3.5	1.814	34.647	−0.3
394	2490	3306	−213.8	3.1	1.698	34.656	−0.2
385	2791	3302	−210.1	2.3	1.538	34.666	−0.1
181	3156	3292	−206.3	3.5	1.405	34.676	−0.2
183	3409	3293	−200.8	3.1	1.302	34.682	−0.1
184	3662	3294	−203.0	3.5	1.207	34.689	−0.2
187	3915	3295	−198.3	3.5	1.142	34.692	−0.3
189	4169	3296	−185.3	3.2	1.075	34.695	−0.3
193	4372	3297	−185.0	3.2	1.014	34.698	−0.4
194	4575	3298	−175.5	3.5	0.981	34.700	0.0

Cruise: P16S17 Station: 198 28°30´S 150°30´W 18 Aug 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
490	2	3291	127.9	2.9	19.432	35.584	1.1
381	1234	3283	−140.1	3.3	3.489	34.415	0.3
383	1486	3284	−165.2	3.0	3.091	34.522	0.1
384	1736	3285	−193.9	3.0	2.300	34.598	−0.2
299	1852				2.135	34.619	
387	1987	3287	−215.6	2.9	2.032	34.629	−0.3
389	2239	3288	−217.1	3.0	1.843	34.659	−0.4
393	2541	3289	−216.1	2.5	1.679	34.659	−0.4
394	2868	3290	−218.9	2.3	1.521	34.669	−0.2
385	3194	3286	−202.4	3.3	1.391	34.678	−0.3
181	3430	3276	−200.0	2.9	1.280	34.686	−0.3
183	3683	3277	−191.9	3.3	1.166	34.692	−0.2
184	3937	3278	−188.2	3.0	1.052	34.698	−0.3
187	4189	3279	−180.6	3.1	0.995	34.700	−0.5
189	4443	3280	−177.9	3.3	0.957	34.703	−0.6
193	4695	3281	−176.7	3.0	0.947	34.704	−0.4
194	4947	3282	−180.9	3.1	0.944	34.703	−0.4

Cruise: P16S17 Station: 187 34°0´S 150°30´W 14 Aug 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
490	4	3275	124.1	3.8		35.091	1.1
381	1591	3267	−166.9	3.0		34.545	0.1
383	1786	3268	−189.5	3.0	2.315	34.601	−0.1
384	1982	3269	−202.4	3.2	2.101	34.627	−0.2
387	2227	3271	−213.6	3.0	1.903	34.643	−0.3
389	2474	3272	−219.0	2.6	1.763	34.655	−0.4
393	2728	3273	−213.7	2.3	1.642	34.663	−0.5
394	2983	3274	−216.7	2.5	1.529	34.671	−0.2
385	3244	3270	−208.3	2.9	1.425	34.680	−0.2
181	3464	3260	−197.6	3.1	1.306	34.692	−0.3

183	3768	3261	−187.7	2.8	1.157	34.702	0.1
184	4071	3262	−175.5	3.0	1.027	34.707	−0.1
187	4376	3263	−175.3	3.1	0.877	34.710	−0.3
189	4681	3264	−165.5	2.9	0.775	34.710	−0.2
193	4986	3265	−166.3	3.0	0.729	34.709	−0.1
194	5292	3266	−169.3	3.3	0.692	34.708	−0.3

Cruise: P16S17 Station: 180 37°30′S 150°30′W 12 Aug 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
490	4	3259	113.4	3.9		34.743	1.1
381	1332	3251	−130.2	3.2	3.183	34.422	0.2
383	1627	3252	−164.2	3.3	2.605	34.552	−0.6
384	1926	3253	−194.1	2.9	2.274	34.613	−0.8
387	2224	3255	−200.4	3.2	2.031	34.638	−0.7
389	2523	3256	−212.0	2.9	1.847	34.651	−1.0
393	2822	3257	−215.8	3.3	1.682	34.665	−0.4
394	3123	3258	−213.0	3.0	1.555	34.675	−0.8
385	3427	3254	−192.9	3.0	1.427	34.691	−0.9
181	3841	3244	−176.1	3.0	1.198	34.712	−0.1
183	4129	3245	−170.9	3.1	1.002	34.713	0.0
184	4420	3246	−166.8	3.3		34.711	−0.3
187	4714	3247	−168.4	2.3	0.761	34.710	−0.2
189	5016	3248	−163.9	3.0		34.708	−0.5
193	5324	3249	−159.7	3.4	0.669	34.707	−0.3
194	5639	3250	−163.9	3.1	0.648	34.707	−0.7

Cruise: P16A17A Station: 14 43°0′S 150°30′W 16 Oct 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	2824	5874*	−202.2	4.0	1.662	34.680	−0.7
182	3129	5873*	−196.0	4.0	1.505	34.696	0.0
183	3434	5872*	−177.8	4.0	1.349	34.713	−0.6
184	3740	5871*	−177.1	4.0	1.131	34.718	−1.0
187	4047	5870*	−167.9	4.0	0.951	34.715	−1.1
189	4355	5869*	−167.5	4.0	0.821	34.713	−1.1
190	4664	5868*	−168.0	4.0	0.767	34.713	−0.2
192	4974	5867*	−173.0	4.0	0.759	34.713	−0.8
193	5286	5866*	−173.8	4.0	0.731	34.712	−1.1

Cruise: P16A17A Station: 22 47°0′S 150°29′W 18 Oct 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
281	3340	5880*	−165.0	4.0	1.455	34.722	−0.9
282	3546	5879*	−169.5	4.0	1.297	34.724	−0.7
283	3750	5878*	−166.5	4.0	1.134	34.723	−0.5
284	3952	5877*	−165.9	4.0	1.001	34.721	−0.1
287	4152	5876*	−167.9	4.0	0.912	34.717	0.1
289	4347	5875*	−168.9	4.0	0.832	34.715	−0.4

Cruise: P16A17A Station: 38 54°59′S 150°30′W 24 Oct 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	2144	5892*	−157.4	4.0	1.487	34.736	−1.4
182	2349	5891*	−158.3	4.0	1.294	34.731	−0.5
183	2551	5890*	−159.5	4.0	1.120	34.727	−1.6
184	2759	5889*	−158.0	4.0	0.904	34.719	0.4

185	2963	5888*	−165.7	4.0	0.776	34.715	−2.8
187	3165	5884*	−162.6	4.0	0.691	34.710	−1.4
189	3368	5887*	−159.2	4.0	0.662	34.710	−2.2
190	3570	5886*	−158.8	4.0	0.622	34.709	−1.8
193	3770	5885*	−160.4	4.0	0.612	34.708	−2.6

Cruise: P16A17A Station: 43 57°30′S 150°30′W 26 Oct 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	1877				1.203	34.731	
182	2027	5896*	−155.6	4.0	1.093	34.727	−2.4
183	2176	5895*	−167.9	4.0	1.002	34.724	0.2
184	2324	5894*	−163.1	4.0	0.902	34.721	−1.5
185	2473	5893*	−164.4	4.0	0.799	34.715	−0.6
187	2622				0.730	34.713	
189	2769	5883*	−161.0	4.0	0.639	34.710	−1.6
190	2917	5882*	−167.6	4.0	0.596	34.708	−1.3
193	3063	5881*	−160.6	4.0	0.593	34.707	−3.7

Cruise: P16A17A Station: 48 59°59′S 150°32′W 27 Oct 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	1623	5914*	−158.1	4.0	0.600	34.708	−1.3
182	1775	5913*	−163.4	4.0	0.550	34.706	−1.6
183	1928	5912*	−161.3	4.0	0.530	34.705	−0.9
184	2079	5911*	−159.3	4.0	0.479	34.704	−1.3
185	2230				0.366	34.702	
187	2381	5910*	−159.3	4.0	0.308	34.701	−1.2
189	2531	5909*	−155.5	4.0	0.237	34.700	−1.2
190	2681	5908*	−163.5	4.0	0.146	34.699	−2.2
193	2829	5907*	−158.2	4.0	0.115	34.699	−1.7

Cruise: P16A17A Station: 56 62°27′S 135°6′W 1 Nov 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1412	5932*	−164.6	4.0	1.079	34.725	−0.6
382	1613	5931*	−159.9	4.0	0.917	34.720	−1.9
383	1814	5930*	−165.9	4.0	0.804	34.716	2.2
384	2016	5926*	−163.6	4.0	0.710	34.711	−0.9
385	2218	5925*	−150.5	4.0	0.586	34.708	−1.1
387	2420	5924*	−160.5	4.0	0.531	34.706	−0.8
389	2622	5929*	−160.2	4.0	0.455	34.704	−2.0
390	2825	5928*	−165.7	4.0	0.340	34.703	−0.4
393	3029	5927*	−156.7	4.0	0.234	34.703	−1.1
181	3289	5923*	−160.5	4.0	0.162	34.701	−1.2
182	3546	5921*	−150.4	4.0	0.070	34.702	−1.4
183	3803	5922*	−157.2	4.0	−0.032	34.701	−0.4
184	4060	5920*	−153.4	4.0	−0.069	34.700	−0.3
185	4316	5919*	−154.0	4.0	−0.087	34.701	−0.8
187	4572	5918*	−153.3	4.0	−0.094	34.700	−1.2
189	4828	5917*	−153.8	4.0	−0.093	34.700	−0.8
190	5082	5916*	−152.5	4.0	−0.103	34.700	−0.2
193	5336	5915*	−154.2	4.0	−0.104	34.701	−1.1

Cruise: P16A17A Station: 73 56°2′S 135°2′W 7 Nov 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	1601	5933*	−154.1	4.0	1.688	34.735	−0.8
182	1802	5941*	−152.1	4.0	1.495	34.737	−0.4
183	2004	5940*	−163.0	4.0	1.321	34.734	−1.2
184	2207	5939*	−157.8	4.0	1.157	34.728	−1.3
185	2410	5938*	−160.4	4.0	1.013	34.724	−0.1
187	2613	5937*	−156.9	4.0	0.917	34.720	−1.2
189	2817	5936*	−152.1	4.0	0.820	34.717	−0.5
190	3022	5935*	−154.8	4.0	0.724	34.714	−0.6
193	3215	5934*	−158.7	4.0	0.608	34.711	−0.8

Cruise: P16A17A Station: 80 52°31′S 135°0′W 9 Nov 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1604	5959*	−152.0	4.0	2.469	34.554	−0.4
382	1755	5958*	−148.1	4.0	2.298	34.606	−1.1
383	1906	5957*	−156.2	4.0	2.206	34.639	−0.7
384	2057	5956*	−159.3	4.0	2.115	34.670	−0.4
385	2208	5955*	−165.8	4.0	1.983	34.688	−0.5
387	2360	5954*	−164.9	4.0	1.901	34.705	−0.7
389	2511	5953*	−158.6	4.0	1.799	34.719	−0.3
390	2663	5952*	−170.9	4.0	1.677	34.725	0.6
393	2815	5951*	−162.5	4.0	1.545	34.728	−0.7
181	2936	5950*	−161.4	4.0	1.455	34.726	−1.1
182	3136	5949*	−165.9	4.0	1.260	34.724	−0.5
183	3337	5948*	−166.2	4.0	1.182	34.722	−0.2
184	3538	5947*	−174.6	4.0	1.074	34.719	0.2
185	3739	5946*	−172.0	4.0	1.014	34.718	−0.3
187	3940	5945*	−172.1	4.0	0.983	34.717	−0.6
189	4141	5944*	−172.2	4.0	0.961	34.716	−1.0
190	4343	5943*	−170.5	4.0	0.949	34.716	−0.2
193	4545	5942*	−167.0	4.0	0.945	34.716	−0.8

Cruise: P16A17A Station: 87 49°0′S 134°57′W 11 Nov 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1438	5976*	−118.4	4.0	3.194	34.400	−0.8
382	1611	5975*	−139.0	4.0	2.804	34.467	−0.2
383	1791	5974*	−152.4	4.0	2.562	34.534	−0.9
485	1884	5972*	−161.6	4.0	2.422	34.576	−0.8
484	1972	5973*	−162.3	4.0	2.398	34.589	−1.0
487	2324	5971*	−181.5	4.0	2.101	34.654	−1.6
489	2502	5970*	−178.1	4.0	1.996	34.676	0.1
490	2680	5969*	−167.3	4.0	1.920	34.703	−1.1
493	2861	5968*	−165.6	4.0	1.776	34.712	−1.4
181	3054	5967*	−170.5	4.0	1.669	34.726	0.2
182	3285	5966*	−168.3	4.0	1.421	34.726	−1.0
183	3514	5965*	−176.2	4.0	1.232	34.720	−0.1
184	3743	5964*	−176.5	4.0	1.111	34.718	−0.2
185	3973	5963*	−168.6	4.0	0.989	34.716	−0.1
187	4203	5977*	−167.3	4.0	0.955	34.715	−0.1
189	4433	5962*	−171.9	4.0	0.929	34.715	−0.4
190	4664	5961*	−176.1	4.0	0.912	34.714	−0.6
193	4895	5960*	−175.1	4.0	0.895	34.713	−2.0

Cruise: P16A17A Station: 95 45°0′S 134°59′W 13 Nov 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1443				2.818	34.459	
382	1593	6089*	–147.4	4.0	2.529	34.528	–0.5
383	1743				2.368	34.582	
384	1892	6088*	–172.6	4.0	2.227	34.617	–0.3
385	2042				2.096	34.641	
387	2191	6086*	–196.8	4.0	1.985	34.653	–1.5
389	2340				1.864	34.661	
390	2488	6087*	–203.8	4.0	1.742	34.665	–1.5
181	2770	6085*	–209.9	4.0	1.618	34.674	–0.1
182	3023				1.496	34.681	
183	3277	6084*	–203.3	4.0	1.393	34.691	–1.0
184	3528				1.280	34.698	
185	3780	6083*	–187.0	4.0	1.448	34.704	–0.9
187	4030				1.032	34.709	
189	4279	6082*	–179.4	4.0	0.927	34.712	–0.6
190	4525	6081*	–173.4	4.0	0.831	34.711	–0.6
193	4771				0.793	34.711	

Cruise: P16A17A Station: 105 40°0′S 134°59′W 16 Nov 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
481	1358				2.973	34.429	
482	1559				2.561	34.525	
483	1760	6097*	–176.1	4.0	2.337	34.595	–0.8
484	1961	6096*	–195.9	4.0	2.123	34.634	0.2
485	2163	6095*	–210.4	4.0	1.948	34.650	–0.2
487	2365	6094*	–216.4	4.0	1.812	34.658	–1.0
489	2567				1.706	34.667	
490	2770				1.599	34.674	
493	2973				1.501	34.682	
181	3147				1.445	34.691	
182	3404	6092*	–193.9	4.0	1.292	34.699	–0.6
183	3661				1.170	34.704	
184	3916	6099*	–196.4	4.0	1.025	34.707	–0.9
185	4171	6091*	–183.2	4.0	0.929	34.708	–0.7
281	4391	6090*	–179.0	4.0	0.885	34.709	–0.5
282	4660				0.864	34.711	
283	4921				0.838	34.711	
284	5173				0.832	34.711	

Cruise: P16A17A Station: 113 36°0′S 135°0′W 19 Nov 1992

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1506				2.684	34.516	
382	1657	6106*	–182.8	4.0	2.415	34.572	0.0
383	1809	6105*	–183.7	4.0	2.254	34.603	–1.5
384	1961	6104*	–203.8	4.0	2.133	34.624	0.2
385	2112	6103*	–205.8	4.0	1.982	34.638	–1.0
387	2264	6102*	–214.9	4.0	1.880	34.648	–0.5
389	2415				1.788	34.658	
390	2567				1.686	34.662	
393	2718	6101*	–215.4	4.0	1.603	34.667	–2.1
181	2934	6100*	–194.7	4.0	1.514	34.673	–0.7
182	3164				1.414	34.680	

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
183	3392				1.309	34.686	
184	3621				1.231	34.693	
185	3849				1.100	34.700	
187	4077	6098*	−179.4	4.0	0.988	34.706	−0.4
189	4306				0.934	34.708	
190	4535				0.898	34.709	
193	4764				0.891	34.709	

Cruise: P16A17A **Station: 119** **33°0′S 135°0′W** **20 Nov 1992**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	1899				2.089	34.619	
182	2106	6110*	−206.3	4.0	1.904	34.639	−0.4
183	2310	6109*	−213.6	4.0	1.758	34.652	−0.7
184	2514	6108*	−212.3	4.0	1.671	34.659	−1.0
185	2716	6107*	−213.5	4.0	1.555	34.667	−1.4

Cruise: P16S17 **Station: 179** **33°1′S 135°1′W** **8 Aug 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
490	4	3243	−188.3	3.0		35.174	−0.3
381	1218	3240	126.6	3.9	3.341	34.402	0.4
383	1464	3241	−126.8	3.9	2.688	34.508	−0.7
384	1701	3242	−161.3	3.1	2.312	34.585	−0.2
181	3077				1.442	34.673	
183	3335	3234	−208.1	3.0	1.358	34.680	−0.5
184	3591	3235	−199.7	3.0	1.273	34.687	−0.9
187	3846	3236	−193.2	3.3	1.149	34.695	−0.4
189	4099	3237	−179.2	3.0	1.015	34.685	0.0
193	4300	3238	−177.5	3.1	0.963	34.704	−0.2
194	4498	3239	−182.4	3.0	0.941	34.683	−0.3

Cruise: P16S17 **Station: 172** **29°34′S 134°4′W** **5 Aug 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
490	5	3233	127.4	3.5		33.421	0.8
385	1237	3229	−153.5	4.3		34.450	0.0
299	1287				3.083	34.469	−0.1
381	1487	3226	−177.7	3.1	2.607	34.540	−0.3
383	1739	3227	−198.2	2.8	2.211	34.599	−0.4
384	1989	3228	−216.4	2.8	1.983	34.627	−0.8
387	2243	3230	−211.8	4.1	1.813	34.643	−0.5
389	2495	3231	−215.7	2.9	1.673	34.655	−0.6
393	2748	3232	−216.6	2.9	1.552	34.665	−0.6
183	2992	3220	−207.2	2.9	1.431	34.672	−0.4
184	3241	3221	−205.8	2.7	1.357	34.678	−0.2
187	3493	3222	−207.1	2.5		34.685	−0.1
189	3752	3223	−201.1	3.3	1.208	34.689	−0.2
193	4018	3224	−197.4	3.0	1.169	34.692	−0.1
194	4237	3225	−189.6	3.4	1.145	34.693	−0.1

Cruise: P16S17 **Station: 166** **26°38′S 133°18′W** **3 Aug 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
481	5	3218	130.1	3.6			0.6
185	449	3205	15.4	3.3	8.712	34.484	0.6
187	745	3206	−39.8	3.2	5.944	34.321	0.5

189	1121	3207	−139.1	3.6	3.756	34.433	0.0
381	1407	3211	−177.8	3.0	2.791	34.527	−0.2
387	1546	3214	−182.5	3.0	2.543	34.557	−0.3
383	1701	3212	−200.0	3.0	2.224	34.596	−0.2
384	1947	3213	−210.5	2.9	1.966	34.630	−0.4
390	2399	3215	−211.6	2.2	1.681	34.652	−0.5
190	2435	3208	−210.5	2.9	1.678	34.655	−0.6
393	2620	3216	−216.3	3.2	1.593	34.660	−0.6
193	2638	3209	−206.9	3.0	1.591	34.662	−0.3
194	2778	3210	−210.1	3.0	1.529	34.668	−0.2
394	2907	3217	−211.2	2.9	1.460	34.670	−0.4

Cruise: P16S17 Station: 153 20°17′S 132°50′W 30 Jul 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	8	3196	111.2	2.7		36.426	1.3
383	1190	3197	−169.8	3.0	3.016	34.523	0.2
384	1393	3198	−192.4	3.3	2.842	34.558	−0.2
385	1595	3199	−195.7	3.0	2.390	34.590	−0.2
387	1797	3200	−197.9	3.7	2.137	34.615	−0.2
389	1998	3201	−202.6	3.4	1.952	34.632	−0.1
390	2198	3202	−216.0	3.2	1.847	34.645	−0.2
393	2397	3203	−221.3	2.9	1.731	34.656	−0.1
394	2596	3204	−220.1	3.1	1.644	34.662	−0.2
181	2844	3187	−214.4	3.2	1.572	34.667	−0.2
183	3046	3188	−207.7	3.0	1.484	34.671	−0.1
184	3248	3189	−205.2	2.9	1.396	34.684	−0.1
185	3450	3190	−207.9	3.2	1.385	34.680	−0.3
187	3653	3191	−208.2	2.9	1.364	34.679	−0.1
189	3853	3192	−211.7	3.2	1.353	34.680	−0.2
190	4055	3193	−212.8	2.9	1.350	34.679	−0.4
193	4255	3194	−208.5	3.1	1.347	34.680	−0.2
194	4455	3195	−204.6	2.2	1.343	34.680	0.1

Cruise: P16S17 Station: 143 15°23′S 133°53′W 28 Jul 1991

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
483	3	3179	89.4	3.8	26.399	36.591	1.5
484	993	3180	−161.0	3.2	4.421	34.513	0.0
485	1195	3181	−187.3	3.3			−0.1
487	1397	3182	−205.6	3.1	3.108	34.572	−0.2
489	1598	3183	−209.7	3.2	2.657	34.594	−0.5
490	1798	3184	−217.0	3.0	2.245	34.620	−0.2
493	1996	3185	−219.8	3.1	1.982	34.639	0.0
494	2193	3186	−220.5	3.0	1.827	34.651	−0.5
181	2356	3169	−223.1	3.1	1.725	34.662	−0.1
183	2632	3170	−215.5	3.3	1.582	34.671	−0.2
284	2862	3171	−217.9	3.2	1.502	34.676	−0.1
285	3123	3172	−218.5	3.3	1.418	34.681	−0.3
287	3381	3173	−218.1	3.2		34.686	−0.1
289	3635	3174	−210.8	3.2	1.269	34.687	−0.2
290	3884	3175	−205.5	3.1	1.252	34.689	−0.1
293	4080	3176	−203.6	3.2	1.219	34.690	−0.2
294	4261	3177	−201.7	3.1	1.197	34.691	−0.1

Cruise: P16S17 **Station: 132** **10°2′S 134°58′W** **24 Jul 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	6	3160	76.5	3.6	27.469	35.767	1.7
383	1090	3161	−178.0	3.1	4.036	34.545	−0.1
384	1291	3162	−195.3	3.2	3.345	34.569	−0.1
385	1492	3163	−200.9	2.6	2.863	34.592	−0.2
387	1743	3164	−224.4	2.2	2.398	34.617	−0.3
389	1992	3165	−226.8	2.1	2.081	34.638	−0.4
390	2241	3166	−229.8	2.2	1.853	34.656	−0.6
181	2428	3154	−224.6	3.1	1.718	34.665	−0.2
183	2729	3155	−219.9	3.1	1.593	34.672	−0.2
184	2929	3156	−221.1	2.0	1.486	34.677	−0.4
185	3180	3157	−211.6	3.0		34.686	−0.3
187	3429	3158	−208.2	2.1	1.290	34.685	−0.3
189	3678	3159	−208.9	2.2	1.254	34.687	−0.3
393	4055	3167	−221.1	1.8	1.154	34.690	−0.4
394	4360	3168	−213.7	1.8	1.110	34.693	−0.6

Cruise: P17C **Station: 121** **5°8′S 135°3′W** **6 Jul 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
285	739	5332*	−142.4	4.0	6.441	34.559	−0.5
287	1053	5331*	−172.1	4.0	4.326	34.550	−1.7
485	1151	5330*	−182.5	4.0	4.050	34.557	−0.9
481	1196	5329*	−189.0	4.0	3.779	34.565	−0.7
288	1405	5328*	−206.5	4.0	3.207	34.592	−1.6
483	1546	5325*	−217.0	4.0	2.809	34.604	−1.2
484	1747	5324*	−213.0	4.0	2.516	34.619	−1.5
389	1921	5323*	−214.1	4.0	2.323	34.629	−1.6
390	2220	5322*	−223.5	4.0	1.992	34.647	−1.9
393	2535	5321*	−221.6	4.0	1.699	34.666	−0.3
281	2673	5320*	−228.2	4.0	1.627	34.669	−1.3
394	2864	5319*	−226.4	4.0	1.541	34.673	−0.8
284	2938	5318*	−222.8	4.0	1.514	34.674	−0.7
487	3282	5317*	−218.6	4.0	1.344	34.682	−1.6
489	3536	5316*	−213.9	4.0	1.250	34.686	−1.0
490	3790	5315*	−216.1	4.0	1.165	34.690	−1.9
493	4044	5314*	−203.2	4.0	1.108	34.693	−1.9
494	4299	5313*	−195.8	4.0	1.061	34.695	−1.5

Cruise: P17C **Station: 98** **0°0′18" S 135°9′W** **1 Jul 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
388	495				8.059	34.627	
188	617	5334*	−128.6	4.0	7.010	34.591	−0.9
381	694	5350*	−135.5	4.0	6.107	34.559	−2.0
384	892	5349*	−171.0	4.0	4.738	34.552	−0.7
385	1093	5348*	−188.4	4.0	3.877	34.570	−1.0
387	1291	5347*	−208.6	4.0	3.285	34.591	−0.3
389	1492	5346*	−213.9	4.0	2.863	34.606	−0.7
390	1694	5345*	−227.7	4.0	2.501	34.623	−1.4
393	1894	5344*	−228.0	4.0	2.172	34.698	−1.6
394	2096	5343*	−232.5	4.0	1.934	34.651	−1.0
181	2363	5342*	−230.0	4.0	1.787	34.659	−0.9
184	2615	5341*	−229.9	4.0	1.617	34.667	−1.3
185	2867	5340*	−224.9	4.0	1.522	34.671	−1.8

187	3118	5339*	−229.8	4.0	1.370	34.688	−0.4
189	3623	5338*	−209.9	4.0	1.155	34.690	−0.7
190	3877	5337*	−212.4	4.0	1.095	34.694	−0.8
193	4129	5336*	−205.2	4.0	1.084	34.693	0.0
194	4382	5335*	−205.3	4.0	1.092	34.693	−0.9

Cruise: P17C **Station: 76** **5°0′N 134°59′W** **27 Jun 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	5	5355*	91.1	4.0	28.457	34.369	0.0
384	593	5354*	−125.7	4.0	7.184	34.585	−1.0
385	839	5353*	−168.6	4.0	5.211	34.551	−0.9
387	1087	5352*	−187.5	4.0	4.279	34.565	−1.7
388	1338	5351*	−211.0	4.0	3.397	34.590	−1.8
389	1588	5367*	−233.2	4.0		34.613	−1.3
390	1841	5366*	−234.1	4.0	2.339	34.632	−1.0
393	2095	5365*	−231.1	4.0	2.021	34.647	−0.4
394	2350	5356*	−235.3	4.0	1.767	34.660	−1.2
181	2607	5364*	−232.0	4.0	1.663	34.666	−1.0
184	2858	5363*	−230.7	4.0	1.569	34.670	−0.8
185	3117	5362*	−226.2	4.0	1.421	34.676	−1.9
187	3362	5361*	−221.3	4.0	1.304	34.682	−1.8
188	3614	5360*	−215.4	4.0	1.199	34.686	−1.0
189	3868	5359*	−214.2	4.0	1.136	34.690	−1.8
190	4121	5358*	−208.1	4.0	1.095	34.691	−1.6
193	4376	5357*	−204.7	4.0	1.053	34.693	−1.3
194	4630	5368*	−208.8	4.0	1.039	34.693	−0.8

Cruise: P17C **Station: 66** **9°59′N 135°2′W** **24 Jun 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	889	5392*	−173.2	4.0	5.095	34.550	−1.8
384	1117	5391*	−193.0	4.0	4.222	34.564	−1.6
385	1420	5390*	−222.8	4.0	3.374	34.565	−0.5
387	1658	5389*	−225.9	4.0	2.750	34.606	−0.5
488	1876	5388*	−240.8	4.0	2.308	34.626	−2.0
489	2107	5387*	−240.3	4.0	1.982	34.644	−0.8
490	2338	5386*	−238.6	4.0	1.785	34.657	−0.9
493	2567	5385*	−233.5	4.0	1.674	34.664	−1.1
494	2801	5383*	−233.0	4.0	1.576	34.668	−1.5
181	3004	5384*	−229.6	4.0	1.498	34.673	−0.5
184	3246	5376*	−234.3	4.0	1.377	34.677	−1.5
185	3489	5375*	−235.6	4.0	1.284	34.679	0.3
187	3730	5374*	−220.7	4.0	1.181	34.684	−1.4
188	3971	5373*	−212.6	4.0	1.106	34.687	−0.9
189	4213	5372*	−212.4	4.0	1.070	34.691	−0.9
190	4555	5371*	−209.1	4.0	1.041	34.692	−0.9
193	4696	5370*	−205.2	4.0	1.044	34.693	0.8
194	4936	5369*	−203.2	4.0	1.035	34.689	−1.1

Cruise: P17C **Station: 57** **14°29′N 134°59′W** **21 Jun 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	992	5410*	−203.4	4.0	4.278	34.540	−1.9
383	1241	5409*	−221.3	4.0	3.485	34.568	−1.3
384	1490	5408*	−229.2	4.0	2.885	34.596	−0.8
389	1511	5407*	−230.6	4.0	2.926	34.597	−1.0

385	1742	5406*	−239.7	4.0		34.615	−2.0
387	1992	5405*	−250.0	4.0	2.068	34.632	−0.5
390	2495	5404*	−244.0	4.0	1.674	34.657	−0.9
393	2747	5403*	−237.4	4.0	1.538	34.666	−1.1
394	2999	5402*	−242.3	4.0	1.445	34.671	−0.9
181	3076	5401*	−239.8	4.0	1.419	34.672	−1.2
183	3301	5400*	−230.8	4.0	1.327	34.658	0.3
184	3527	5399*	−230.6	4.0	1.252	34.679	−0.8
185	3754	5398*	−230.9	4.0	1.188	34.682	−1.5
187	3982	5397*	−213.1	4.0	1.172	34.687	−2.3
189	4211	5396*	−208.0	4.0	1.068	34.690	−1.6
190	4442	5395*	−213.8	4.0	1.057	34.691	−0.3
193	4674	5394*	−217.4	4.0	1.042	34.691	−2.1
194	4907	5393*	−211.2	4.0	1.044	34.691	−0.2

Cruise: P17C **Station: 46** **19°59′N 135°0′W** **17 Jun 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	894	5411*	−196.4*	4.0	4.569	34.491	−1.4
383	1142	5431*	−219.4	4.0	3.635	34.536	−1.3
384	1391	5430*	−229.0	4.0	2.990	34.569	−1.9
385	1640	5429*	−248.4	4.0	2.505	34.598	−1.4
387	1890	5428*	−250.6	4.0	2.139	34.617	−2.0
389	2141	5427*	−251.0	4.0	1.861	34.632	−1.1
390	2394	5434*	−248.0	4.0	1.662	34.647	−1.5
393	2649	5426*	−238.4	4.0	1.524	34.657	−1.8
394	2907	5425*	−247.0	4.0	1.413	34.666	−1.7
181	3201	5424*	−242.3	4.0	1.325	34.673	−1.1
183	3453	5423*	−240.2	4.0	1.250	34.678	−0.4
184	3703	5422*	−217.3	4.0	1.299	34.679	−2.5
185	3957	5421*	−225.7	4.0	1.166	34.683	0.7
187	4209						
189	4465	5420*	−210.7	4.0	1.077	34.689	0.0
190	4721	5419*	−211.0	4.0	1.057	34.692	−0.5
193	4978	5418*	−208.7	4.0	1.033	34.691	−0.8
194	5243	5412*	−205.3	4.0	1.022	34.693	−0.8

Cruise: P17C **Station: 34** **26°1′N 135°0′W** **14 Jun 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	2281	5441*	−228.7	4.0	1.721	34.636	−1.3
183	2582	5440*	−248.0	4.0	1.498	34.652	−1.4
184	2883	5439*	−244.1	4.0	1.363	34.663	−0.5
185	3186	5438*	−240.5	4.0	1.285	34.670	−1.4
187	3489	5437*	−236.0	4.0	1.225	34.676	−1.0
189	3793	5436*	−239.4	4.0	1.194	34.671	−1.5
190	4099	5435*	−225.9	4.0	1.170	34.680	−0.6
193	4406	5433*	−229.5	4.0	1.162	34.679	−1.8
194	4714	5432*	−230.8	4.0	1.148	34.683	−1.3

Cruise: P17C **Station: 26** **30°1′N 134°58′W** **11 Jun 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
388	176	5459*	103.8	4.0		34.718	1.2
385	543	5458*	−74.6	4.0	6.291	34.026	−1.0
387	795	5457*	−176.0	4.0	4.379	34.277	−2.0
383	893	5456*	−184.9	4.0	4.112	34.361	−1.0

384	1092	5455*	−209.1	4.0	3.480	34.447	−1.8
393	1190	5454*	−217.3	4.0	3.226	34.486	−2.2
390	1191	5453*	−216.3	4.0	3.234	34.484	−1.1
394	1291	5452*	−229.4	4.0	3.068	34.513	−1.0
389	1895	5451*	−242.5	4.0	2.070	34.602	−1.3
183	2748	5450*	−242.9	4.0	1.454	34.656	−2.0
184	2997	5449*	−237.5	4.0	1.371	34.664	−1.5
185	3247	5448*	−237.3	4.0	1.279	34.671	−0.5
187	3497	5447*	−229.7	4.0	1.215	34.676	−1.0
188	3749	5446*	−230.1	4.0	1.179	34.681	−1.0
189	3999	5445*	−229.7	4.0	1.171	34.682	−1.1
190	4253	5444*	−229.7	4.0	1.173	34.683	−0.1
193	4506	5443*	−224.3	4.0	1.163	34.684	−1.0
194	4761	5442*	−221.9	4.0	1.153	34.677	−1.4

Cruise: P17C **Station: 17** **34°36′N 134°59′W** **8 Jun 1991**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
590	244	5460*	45.3	4.0	8.174	33.813	−0.3
593	497	5462*	−95.9	4.0		34.068	−1.2
594	755				4.109	34.254	
383	990	5476*	−185.2	4.0	3.602	34.432	−0.7
384	1242	5475*	−208.2	4.0	3.003	34.508	−1.3
385	1493	5474*	−220.0	4.0	2.568	34.554	−1.5
387	1743	5473*	−227.3	4.0	2.177	34.587	−1.4
388	1992				1.904	34.605	
489	2249	5471*	−224.9	4.0	1.680	34.619	−1.3
183	3156	5470*	−217.8	4.0	1.342	34.658	−0.6
184	3409	5469*	−214.5	4.0	1.254	34.666	−0.8
185	3660	5468*	−208.6	4.0	1.227	34.670	0.2
187	3912	5467*	−218.7	4.0	1.187	34.675	−0.3
188	4165	5466*	−210.8	4.0	1.158	34.673	−0.3
189	4419				1.151	34.675	
190	4674	5465*	−217.3	4.0	1.145	34.681	−2.1
193	4931	5464*	−213.0	4.0	1.130	34.682	−0.8
194	5189	5463*	−206.5	4.0	1.072	34.682	−0.9

Cruise: P17N **Station: 10** **38°14′N 124°58′W** **17 May 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1811	3410	−242.6	2.2	2.165	34.592	−1.8
382	1964	3411	−245.6	2.0	1.936	34.602	−2.5
383	2116	3412	−244.5	2.0	1.805	34.618	−2.2
384	2271	3413	−242.1	2.1	1.703	34.630	−1.9
385	2424	3414	−247.8	2.0	1.620	34.638	−0.9
387	2576	3415	−243.7	2.2	1.577	34.645	−1.5
389	2728	3416	−249.6	2.3	1.514	34.633	−1.1
390	2880				1.451	34.659	
181	2954	3401	−228.1	2.3	1.434	34.659	−1.9
182		3402	−240.8	2.1		34.664	−1.5
393	3027	3417	−244.8	2.0	1.408	34.661	−1.3
183	3252	3403	−237.2	2.4	1.347	34.667	−1.9
184	3404	3404	−233.0	2.4	1.312	34.671	−1.6
185	3507	3405	−238.5	2.3	1.272	34.673	−0.7
187	3610	3406	−235.0	2.1	1.261	34.674	−1.1

189	3726	3407			1.230	34.677	
190	3821	3408	−229.7	3.7	1.205	34.679	−2.6
193	3928	3409	−224.7	1.5	1.171	34.684	−1.2

Cruise: P17N **Station: 28** **35°35′N 134°59′W** **23 May 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1917	3426	−246.0	2.2	2.028	34.601	−2.2
382	2093	3427	−246.3	2.2	1.846	34.616	−1.6
383	2270	3428	−247.7	2.3	1.703	34.628	−1.8
384	2445	3429	−246.9	2.0	1.599	34.638	−1.7
385	2622	3430	−248.4	2.1	1.514	34.646	−0.9
387	2799	3431	−242.9	2.4	1.449	34.653	−1.4
389		3432	−242.4	2.2		34.659	−1.5
390	3155	3433	−242.0	1.8	1.327	34.664	−1.5
393	3337	3434	−242.8	2.1	1.280	34.670	−1.3
181	3560	3418	−235.1	2.1	1.228	34.675	−1.6
182	3764	3419	−232.5	2.1	1.197	34.678	−1.5
183	3969	3420	−227.7	1.6	1.155	34.681	−2.1
184	4173				1.143	34.683	
185	4377	3421	−225.9	2.2	1.129	34.685	−0.4
187	4583	3422	−228.2	2.2	1.135	34.686	−1.3
189	4788	3423	−223.6	2.1	1.120	34.686	−1.0
190	4994	3424	−218.4	1.7	1.117	34.687	−1.3
193	5198	3425	−224.4	2.0	1.114	34.687	−1.0

Cruise: P17N **Station: 39** **39°36′N 135°0′W** **26 May 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1965	3444	−237.5	2.5	1.857	34.599	−1.5
382	2116	3445	−242.9	2.2	1.755	34.613	−1.6
383	2268	3446	−243.5	2.6	1.664	34.624	−1.9
384	2419	3447	−244.4	2.3	1.601	34.633	−1.2
385	2574	3448	−245.4	2.2	1.519	34.640	−0.9
387	2727	3449	−244.5	2.3	1.485	34.646	−1.4
389	2880	3450	−243.2	2.2	1.412	34.652	−1.3
390	3036	3451	−242.6	2.6	1.368	34.656	−1.2
393	3192	3452	−243.1	2.4	1.353	34.660	−1.2
181	3464	3435	−235.6	2.2	1.286	34.666	−1.5
182	3641	3436	−232.8	2.3	1.288	34.666	−1.6
183	3819	3437	−231.8	2.4	1.210	34.675	−2.7
184	3996	3438	−227.9	2.5	1.220	34.679	−1.2
185	4174	3439	−225.7	2.0	1.162	34.683	−0.6
187	4352	3440	−221.6	2.2	1.152	34.684	−1.5
189	4531	3441	−220.7	2.2	1.140	34.685	−0.8
190	4710	3442	−218.7	2.2	1.132	34.685	−2.1
193	4889	3443	−223.9	2.5	1.127	34.687	−0.9

Cruise: P17N **Station: 48** **41°40′N 135°59′W** **28 May 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1912	3462	−243.1	2.1	1.891	34.590	−1.9
382	2040				1.801	34.604	
383	2193	3463	−245.9	2.6	1.670	34.618	−2.3
384	2294	3464	−249.5	1.6	1.632	34.625	−2.3
385	2420	3465	−249.7	2.9	1.552	34.633	−1.1
387	2548	3466	−246.4	2.3	1.511	34.639	−1.8

389	2673	3467	−245.0	2.1	1.460	34.645	−1.3
390	2800	3468	−244.3	2.7	1.418	34.648	−1.9
393	2924	3469	−241.4	2.3	1.379	34.655	−1.5
181	3024	3453	−247.1	2.9	1.359	34.656	−0.9
182	3151	3454	−238.4	2.4	1.327	34.660	−0.9
183	3279	3455	−239.1	2.2	1.305	34.663	−1.6
184	3407	3456	−236.8	2.8	1.292	34.667	−1.0
185	3534	3457	−237.3	2.4	1.260	34.668	−0.7
187	3686	3458	−233.4	2.1	1.254	34.671	−0.8
189	3839	3459	−234.5	2.7	1.235	34.673	−0.6
190	3992	3460	−233.2	2.3	1.215	34.676	−0.9
193	4144	3461	−230.4	2.1	1.214	34.677	−1.4

Cruise: P17N **Station: 58** **44°58′N 141°14′W** **31 May 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1965	3479	−234.3	2.1	1.847	34.584	−1.3
382		3480	−239.3	2.2		34.597	−1.3
383	2217	3481	−242.1	2.3	1.668	34.609	−1.7
384	2342	3482	−244.9	2.1	1.628	34.617	−1.4
385	2468	3483	−244.6	2.2	1.558	34.627	−1.4
387	2594	3484	−240.6	2.2	1.487	34.638	−1.0
389	2721	3485	−242.5	2.2	1.416	34.646	−1.0
390	2848	3486	−236.3	1.6	1.373	34.653	−1.1
393	2975	3487	−238.5	2.3	1.335	34.654	−0.9
181	3148	3470	−239.6	2.1	1.318	34.661	−1.3
182		3471	−235.0	2.7		34.665	−1.6
183	3451	3472	−233.4	2.3	1.239	34.670	−2.1
184	3603	3473	−228.7	2.1	1.214	34.674	−1.1
185	3755	3474	−232.1	2.7	1.207	34.676	−0.9
187	3934	3475	−227.4	2.2	1.198	34.679	−1.3
189	4114	3476	−228.3	2.2	1.185	34.680	−1.3
190	4293	3477	−223.2	2.8	1.187	34.681	−1.0
193	4474	3478	−225.2	2.3	1.175	34.682	−1.1

Cruise: P17N **Station: 68** **48°13′N 146°41′W** **3 Jun 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1916	3497	−235.9	2.2	1.890	34.572	−2.8
382	2068	3498	−239.0	2.1	1.779	34.588	−2.6
383	2220	3499	−242.9	1.5	1.697	34.602	−3.1
384	2372	3500	−242.8	2.1	1.625	34.614	−2.1
385	2524	3501	−247.4	2.1	1.523	34.627	−1.0
387	2676	3502	−237.9	2.1	1.480	34.636	−2.0
389	2828	3503	−242.1	2.0	1.417	34.643	−2.5
390	2981	3504	−241.9	2.1	1.363	34.653	−2.3
393	3134	3505	−234.2	2.1	1.315	34.660	−2.0
181	3300	3488	−233.0	2.4	1.274	34.663	−1.5
182	3478	3489	−234.0	2.3	1.256	34.670	−1.8
183	3655	3490	−231.0	2.1	1.198	34.674	−1.9
184	3834	3491	−230.6	2.2	1.209	34.677	−1.2
185	4011	3492	−229.7	2.1	1.170	34.679	−1.0
187	4188	3493	−231.6	2.2	1.180	34.678	−2.9
189	4369	3494	−226.3	1.5	1.161	34.682	−1.2
190	4549	3495	−222.8	2.2	1.161	34.683	−1.8
193	4730	3496	−228.9	2.3	1.157	34.682	−1.8

Cruise: P17N Station: 78 51°29′N 152°30′W 8 Jun 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1708	3515	−229.9	2.0	2.036	34.539	−1.9
382	1886	3516	−239.4	2.2	1.923	34.565	−2.1
383	2062	3517	−240.2	2.1	1.790	34.584	−2.0
384	2239	3518	−240.8	2.1	1.706	34.603	−2.1
385	2415	3519	−234.3	2.0	1.621	34.617	−0.9
387	2592	3520	−240.5	1.5	1.547	34.628	−1.4
389	2769	3521	−241.8	2.0	1.462	34.639	−1.8
390	2946	3522	−234.3	2.0	1.406	34.648	−1.6
393	3133	3523	−236.9	2.1	1.349	34.656	−1.4
181	3384	3506	−237.8	2.1	1.275	34.664	−1.4
182	3586	3507	−231.6	2.1	1.235	34.670	−1.2
183	3788	3508	−226.0	2.1	1.194	34.673	−1.6
184	3990	3509	−222.9	2.1	1.172	34.677	−1.3
185	4193	3510	−220.9	2.1	1.160	34.679	−0.6
187	4371	3511	−221.3	2.1	1.149	34.681	−1.0
189	4548	3512	−221.4	2.0	1.145	34.682	−0.7
190	4726	3513	−221.9	2.1	1.139	34.683	−0.9
193	4903	3514	−224.3	2.0	1.144	34.684	−1.4

Cruise: P17N Station: 86 53°59′N 157°22′W 10 Jun 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	2017	3533	−243.0	2.1	1.695	34.603	−2.2
382	2192	3534	−236.9	2.2	1.592	34.617	−1.1
383	2369	3535	−239.6	2.0	1.507	34.631	−1.5
384	2546	3536	−241.8	2.0	1.453	34.640	−1.2
385	2723	3537	−236.4	2.1	1.397	34.648	−0.6
387	2900	3538	−239.1	2.0	1.351	34.653	−1.2
389	3078	3539	−231.8	2.2	1.295	34.661	−0.9
390	3284	3540			1.253	34.667	
393	3491	3541	−226.6	2.1	1.208	34.673	−1.1
181	3787	3524	−226.5	2.1	1.155	34.679	−1.3
182	4043	3525	−221.9	2.1	1.118	34.683	−1.6
183	4299	3526	−215.3	2.1	1.109	34.684	−2.1
184	4557	3527	−219.8	2.1	1.089	34.687	−0.9
185	4813	3528	−215.6	2.1	1.069	34.685	−0.6
187	5018	3529	−215.4	2.1	1.083	34.688	−0.9
189	5223	3530	−208.4	1.5	1.060	34.689	−0.8
190	5429	3531	−210.0	1.5	1.064	34.690	−1.3
193	5633	3532	−206.8	2.1	1.061	34.689	−1.1

Cruise: P17N Station: 132 54°50′N 146°44′W 18 Jun 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1661	3551	−235.4	2.2	2.030	34.540	−1.6
382	1812	3552	−240.6	2.0	1.909	34.562	−1.2
383	1963	3553	−232.7	2.1	1.788	34.583	−1.2
384	2114	3554	−234.3	2.0	1.697	34.599	−1.3
385	2266	3555	−238.5	1.6	1.644	34.611	−0.6
387	2418	3556	−242.2	2.1	1.572	34.620	−1.1
389	2570	3557	−237.9	2.1	1.519	34.630	−0.6
390	2722	3558	−235.0	2.2	1.456	34.639	−1.2
393	2875	3559	−237.6	2.1	1.413	34.647	−0.9
181	2998	3542	−235.6	2.0	1.381	34.651	−1.6

182	3150	3543	−231.2	1.7	1.327	34.657	−1.2
183	3302	3544	−236.4	1.6	1.283	34.663	−2.5
184	3454	3545	−231.8	2.2	1.248	34.668	−1.4
185	3607	3546	−230.4	2.1	1.223	34.672	−0.6
187	3759	3547	−224.1	1.7	1.197	34.675	−1.5
189	3913	3548	−224.8	2.2	1.173	34.678	−0.8
190	4066	3549	−217.1	2.5	1.151	34.681	−2.3
193	4221	3550	−221.6	2.1	1.134	34.684	−1.3

Cruise: P17N **Station: 141** **56°13′N 139°11′W** **20 Jun 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1510	3569	−229.0	2.1	2.289	34.489	−1.4
382	1611	3570	−231.2	2.2	2.152	34.511	−1.5
383	1713	3571	−233.8	2.1	2.035	34.534	−2.3
384	1814	3572	−232.9	2.2	1.948	34.554	−1.6
385	1910	3573	−239.3	2.1	1.861	34.567	−0.9
387	1920	3574	−235.7	2.2	1.870	34.567	−1.3
389	2016	3575	−236.0	2.1	1.801	34.579	−1.0
390	2117	3576			1.726	34.593	
393	2217	3577	−238.4	2.4	1.676	34.603	−1.1
181	2346	3560	−238.4	1.8	1.618	34.615	−1.5
182	2466	3561	−239.0	1.7	1.568	34.622	−1.5
183	2476	3562	−241.8	2.2	1.537	34.624	−2.6
184	2600	3563	−237.4	2.1	1.497	34.632	−1.4
185	2724	3564	−236.3	2.2	1.466	34.639	−1.1
187	2876	3565	−236.4	2.1	1.403	34.647	−1.1
189	3031	3566	−231.0	2.1	1.355	34.654	−1.3
190	3185	3567	−231.2	2.1	1.310	34.661	−1.1
193	3339	3568	−226.9	2.2	1.260	34.670	−1.0

Cruise: P17E19S **Station: 164** **66°20′S 126°6′W** **26 Dec 1992**

Cast/Bottle	Depth	QL/ ML(*)	$\Delta^{14}C$	σ^{14} C	θ	Salinity	$\delta^{13}C$
381	1055	6043*	−149.0	4.0	1.605	34.7305	−2.6
382	1232	6042*	−152.0	4.0	1.436	34.7321	−1.7
383	1408	6041*	−158.5	4.0	1.293	34.7307	−2.5
384	1584	6040*	−156.4	4.0	1.172	34.7278	−1.5
385	1761	6039*	−157.5	4.0	1.056	34.7232	−2.6
387	1938	6038*	−154.4	4.0	0.957	34.7211	−0.6
389	2115	6037*	−163.0	4.0	0.855	34.7170	−0.9
390	2292	6036*	−159.9	4.0	0.764	34.7142	−1.7
393	2469	6031*	−161.7	4.0	0.682	34.7111	−1.8
281	2691	6035*	−163.8	4.0	0.534	34.7076	−0.2
282	2945	6034*	−163.3	4.0	0.400	34.7052	−2.0
283	3200	6033*	−158.0	4.0	0.265	34.7035	−2.7
284	3454	6032*	−161.2	4.0	0.162	34.7033	−1.2
285	3709	6030*	−165.0	4.0	0.102	34.7029	−1.8
287	3963	6029*	−161.1	4.0	0.036	34.7025	−1.6
289	4217	6028*	−162.3	4.0	0.000	34.7027	−1.4
290	4420	6027*	−157.4	4.0	−0.035	34.7023	−1.2
293	4522	6026*	−161.4	4.0	−0.055	34.7021	−1.9

Cruise: P17E19S **Station: 157** **61°38′S 126°2′W** **23 Dec 1992**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	955	6014*	−149.0	4.0	1.977	34.6819	−1.3
382	1157	6013*	−149.1	4.0	1.820	34.7144	−1.4
383	1358	6025*	−156.0	4.0	1.656	34.7284	−2.0
384	1560	6024*	−155.4	4.0	1.493	34.7319	−1.8
385	1761	6023*	−157.5	4.0	1.304	34.7300	
387	1963	6022*	−160.8	4.0	1.140	34.7265	−2.0
389	2165	6021*	−154.5	4.0	0.983	34.7214	−0.6
390	2367	6020*	−156.8	4.0	0.862	34.7173	0.5
393	2569	6019*	−159.1	4.0	0.756	34.7140	−1.7
181	2778				0.621	34.7084	
182	3032	6017*	−165.3	4.0	0.509	34.7055	−1.1
183	3286				0.367	34.7029	
184	3539	6016*	−158.6	4.0	0.247	34.7017	−1.5
185	3792	6015*	−154.8	4.0	0.122	34.7013	−2.6
187	4045				0.074	34.7015	

Cruise: P17E19S **Station: 146** **56°0′S 125°56′W** **19 Dec 1992**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1203	6012*	−136.8	4.0	2.411	34.5509	−0.7
382	1354	6011*	−142.5	4.0	2.271	34.5960	−0.3
383	1505	6010*	−150.8	4.0	2.190	34.6386	−1.8
384	1656	6009*	−150.0	4.0	2.089	34.6738	−1.2
385	1808	6008*	−147.2	4.0	2.007	34.7001	−1.7
387	1959	6007*	−156.5	4.0	1.896	34.7160	−1.1
389	2111	6006*	−157.5	4.0		34.7259	−2.3
390	2263	6005*	−157.9	4.0	1.654	34.7312	0.4
393	2416	6004*	−158.3	4.0	1.493	34.7329	−1.3
181	2558	6003*	−158.9	4.0	1.373	34.7258	−1.3
182	2757	6002*	−158.0	4.0	1.188	34.7268	−0.4
183	2957	6001*	−165.8	4.0	1.062	34.7228	−0.6
184	3156	6000*	−167.8	4.0	0.985	34.7189	−2.1
185	3356	5999*	−166.2	4.0	0.897	34.7163	−0.5
187	3556	5994*	−162.7	4.0	0.789	34.7165	−1.5
189	3756	5993*	−158.8	4.0	0.672	34.7123	−0.7
190	3956	5992*	−162.7	4.0	0.583	34.7111	0.0
193	4156	5991*	−163.3	4.0	0.513	34.7093	−2.6

Cruise: P17E19S **Station: 187** **52°24′S 108°32′W** **3 Jan 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	749	5901*	−22.2	4.0		34.268	−1.4
382	900	5902*	−54.2	4.0	4.519	34.281	0.1
383	1052	5903*	−86.4	4.0	3.801	34.307	−2.2
384	1203				3.194	34.349	
385	1355				2.825	34.421	
387	1506	6075*	−132.3	4.0	2.595	34.483	−1.4
389	1658				2.444	34.540	
390	1809	6074*	−150.8	4.0	2.284	34.595	−1.9
393	1959				2.192	34.637	
181	2105					34.665	
182	2334	6072*	−165.5	4.0	1.913	34.692	−1.7
183	2563				1.716	34.706	
184	2793	6073*	−177.6	4.0	1.528	34.710	−1.0

185	3022	6071*	−177.6	4.0	1.398	34.713	−1.5
187	3253	6080*	−169.1	4.0	1.307	34.717	−1.8
189	3483				1.128	34.671	
190	3714	6070*	−171.2	4.0	0.861	34.710	−0.8
193	3945	6069*	−176.9	4.0	0.701	34.712	−1.7

Cruise: P17E19S Station: 229 67°2′S 87°59′W 16 Jan 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
483	703	5588*	−145.1	4.0	2.029	34.6318	−2.0
381	801				2.013	34.6601	
484	904				1.966	34.6860	
382	1004	5589*	−151.8	4.0	1.900	34.7019	−3.1
485	1103				1.833	34.7141	
487	1303	5587*	−153.9	4.0	1.681	34.7274	−2.1
489	1504	5586*	−156.8	4.0	1.527	34.7321	−0.8
490	1706	5585*	−154.2	4.0	1.354	34.7312	−2.8
493	1910	5584*	−158.4	4.0		34.7278	−2.6
181	2626	5583*	−157.4	4.0	0.759	34.7157	−2.6
182	2852	5577*	−154.7	4.0	0.641	34.7114	−2.6
183	3078	5582*	−157.8	4.0	0.523	34.7098	−2.1
184	3305				0.395	34.7070	
185	3527	5576*	−165.2	4.0	0.286	34.7052	−0.8
187	3754				0.195	34.7052	
189	3979	5581*	−164.2	4.0	0.153	34.7042	−3.3
190	4205	5580*	−161.9	4.0	0.110	34.7042	−1.6
193	4431	5579*	−162.8	4.0	0.067	34.7040	−2.9

Cruise: P17E19S Station: 218 59°59′S 87°57′W 13 Jan 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1500	5629*	−156.5	4.0	2.042	34.6755	−2.2
382	1649	5628*	−155.4	4.0	1.941	34.6977	−1.6
383	1800	5627*	−162.4	4.0	1.840	34.7140	−3.3
384	1950	5626*	−157.5	4.0	1.730	34.7234	−1.8
385	2101	5625*	−166.6	4.0	1.618	34.7278	−1.4
387	2252	5624*	−162.8	4.0	1.507	34.7289	−2.1
389	2403	5623*	−166.9	4.0	1.376	34.7272	−0.6
390	2553	5622*	−166.7	4.0	1.275	34.7272	−2.3
393	2705	5621*	−166.3	4.0	1.173	34.7242	−0.5
181	2886	5620*	−172.2	4.0	1.049	34.7225	−1.5
182	3165				0.827	34.7174	
183	3445	5619*	−160.7	4.0	0.635	34.7125	−2.2
184	3723	5618*	−163.0	4.0	0.461	34.7086	−2.2
185	4002				0.306	34.7064	
187	4281	5617*	−162.6	4.0	0.228	34.7053	−2.8
189	4559				0.179	34.7049	
190	4836	5616*	−163.1	4.0	0.147	34.7043	−0.7
193	5115	5615*	−167.4	4.0	0.125	34.7041	0.1

Cruise: P17E19S Station: 206 54°0′S 88°0′W 10 Jan 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1257	5630*	−125.6	4.0	2.813	34.4137	0.1
382	1408				2.603	34.4789	
383	1560	5652*	−145.2	4.0	2.443	34.5319	−0.9
384	1710	5651*	−154.4	4.0	2.322	34.5830	−0.9

385	1861	5650*	−158.6	4.0	2.210	34.6241	−0.5
387	2013	5649*	−156.0	4.0	2.109	34.6563	−1.5
389	2165				2.007	34.6809	
390	2315	5648*	−173.5	4.0	1.885	34.6959	−0.1
393	2467				1.754	34.7010	
181	2678	5647*	−173.8	4.0	1.627	34.7102	−1.0
182	2982	5646*	−174.5	4.0	1.402	34.7187	−2.5
183	3288	5645*	−174.1	4.0	1.206	34.7224	−0.8
184	3593	5636*	−163.0	4.0	0.971	34.7193	−1.1
185	3899	5635*	−166.6	4.0	0.696	34.7134	−1.5
187	4205	5634*	−164.7	4.0	0.450	34.7089	−2.3
189	4511	5633*	−172.0	4.0	0.310	34.7066	−0.8
190	4818	5632*	−156.7	4.0	0.266	34.7060	−1.7
193	5124	5631*	−165.4	4.0	0.239	34.7059	−2.5

Cruise: P19C **Station: 264** **49°59′S 88°0′W** **3 Mar 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1028	5655*	−97.0	4.0	3.434	34.322	−1.8
382	1203	5654*	−122.8	4.0	3.008	34.396	−2.5
383	1378				2.747	34.482	
384	1552	5653*	−166.5	4.0	2.563	34.541	−2.3
385	1727	5668*	−180.5	4.0	2.356	34.587	−2.0
387	1902	5667*	−190.8	4.0	2.204	34.618	−2.5
389	2077	5666*	−176.1	4.0	2.052	34.648	2.7
390	2252	5665*	−179.0	4.0	1.935	34.672	−2.3
393	2428	5664*	−191.4	4.0	1.777	34.680	−0.8
181	2644				1.696	34.691	
182	2897	5663*	−192.5	4.0	1.529	34.698	−1.4
183	3151	5662*	−180.9	4.0	1.395	34.710	−0.8
184	3405	5661*	−176.9	4.0	1.217	34.715	−0.3
185	3657	5660*	−169.1	4.0	0.915	34.715	−1.2
187	3911	5659*	−172.8	4.0	0.668	34.711	0.2
189	4165	5658*	−168.4	4.0	0.496	34.711	−1.3
190	4418	5657*	−168.3	4.0	0.414	34.709	−0.2
193	4672	5656*	−172.0	4.0	0.368	34.708	−0.5

Cruise: P19C **Station: 274** **45°0′S 88°1′W** **6 Mar 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1106	5600*	−127.6	4.0	3.317	34.375	−0.3
382	1257	5601*	−150.4	4.0	3.001	34.454	−0.7
187	1336	5602*	−182.5	4.0	2.874	34.548	−1.1
383	1557				2.625	34.556	
189	1669	5603*	−188.2	4.0	2.458	34.579	−1.2
190	1819				2.290	34.602	
193	1976	5614*	−203.4	4.0	2.144	34.623	−1.3
384	2159	5613*	−203.1	4.0	1.993	34.641	−1.0
385	2308	5612*	−207.4	4.0	1.856	34.656	−1.2
181	2408				1.814	34.666	
182	2611	5611*	−208.1	4.0	1.671	34.677	−1.1
183	2813	5610*	−203.8	4.0	1.620	34.684	−0.3
184	3014	5609*	−194.6	4.0	1.527	34.689	0.0
185	3215	5608*	−190.8	4.0	1.405	34.697	−0.8
387	3461	5607*	−184.3	4.0	1.137	34.704	−1.9
389	3663	5606*	−180.2	4.0	0.871	34.708	−1.4

390	3860	5605*	−171.7	4.0	0.716	34.712	−0.8
393	4060	5604*	−171.8	4.0	0.680	34.710	−0.7

Cruise: P19C Station: 284 40°0´S 87°59´W 9 Mar 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1052	5681*	−114.3	4.0	3.513	34.347	−1.0
382	1202	5680*	−147.4	4.0	3.144	34.427	−2.3
383	1352				2.905	34.503	
384	1501	5679*	−194.5	4.0	2.735	34.551	−1.0
385	1652				2.498	34.584	
387	1802	5678*	−209.4	4.0	2.332	34.604	−1.0
389	1953				2.162	34.622	
390	2104	5677*	−213.4	4.0		34.637	−1.9
393	2255				1.886	34.650	
181	2471	5676*	−212.7	4.0	1.769	34.661	−1.2
182	2671				1.657	34.670	
183	2871	5675*	−193.2	4.0	1.582	34.676	−7.0
184	3072	5674*	−212.6	4.0	1.524	34.681	−0.5
185	3274	5673*	−204.2	4.0	1.427	34.689	−0.8
187	3477	5672*	−195.4	4.0	1.222	34.698	0.2
189	3681	5671*	−191.8	4.0	1.165	34.701	−0.8
190	3887	5670*	−187.1	4.0	1.139	34.702	−1.5
193	4093	5669*	−185.8	4.0	1.135	34.702	−0.5

Cruise: P19C Station: 299 32°30´S 88°0´W 12 Mar 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1155	5682*	−165.6	4.0	3.399	34.467	−3.0
382	1279	5692*	−189.0	4.0	3.180	34.520	−2.0
383	1404	5691*	−193.4	4.0	2.996	34.551	−2.6
384	1528	5690*	−197.3	4.0	2.769	34.571	−2.9
385	1653				2.557	34.588	
387	1780	5689*	−208.4	4.0	2.389	34.601	−1.3
389	1905				2.193	34.619	
390	2032	5688*	−205.9	4.0	2.027	34.631	−1.5
393	2161	5687*	−205.9	4.0	1.920	34.643	−2.0
181	2318	5686*	−204.1	4.0	1.790	34.658	−2.4
182	2494				1.668	34.670	
183	2670	5685*	−209.3	4.0	1.599	34.679	−2.2
184	2847				1.545	34.685	
185	3023	5684*	−206.6	4.0	1.502	34.688	−0.9
187	3200				1.465	34.690	
189	3377	5683*	−203.7	4.0	1.425	34.692	−1.5
190	3553				1.394	34.693	
193	3731				1.375	34.694	

Cruise: P19C Station: 317 24°19´S 88°0´W 16 Mar 1993

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1251	5708*	−190.3	4.0	3.341	34.537	−0.6
382	1401				2.970	34.563	
383	1550	5705*	−209.1	4.0	2.675	34.582	−3.9
384	1701	5704*	−210.3	4.0	2.460	34.597	−1.3
385	1852				2.256	34.615	
387	2001	5703*	−205.4	4.0	2.065	34.630	−0.7
389	2152	5702*	−212.2	4.0	1.945	34.641	−2.5

390	2302	5701*	−211.5	4.0	1.824	34.653	−2.3
393	2451	5700*	−212.0	4.0	1.742	34.669	−1.4
181	2557	5699*	−212.2	4.0	1.685	34.668	−2.5
182	2758				1.630	34.674	
183	2960	5698*	−211.1	4.0	1.563	34.678	−3.9
184	3162	5697*	−228.0	4.0	1.552	34.681	−2.8
185	3363	5696*	−214.3	4.0	1.515	34.684	−2.9
187	3565	5695*	−217.2	4.0	1.492	34.686	−4.0
189	3767	5694*	−216.9	4.0	1.483	34.687	−3.1
190	3970				1.476	34.688	
193	4172	5693*	−216.9	4.0	1.473	34.688	−2.4

Cruise: P19C **Station: 326** **19°59′S** **88°0′W** **19 Mar 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1379	5716*	−203.1	4.0	3.025	34.569	−1.9
382	1529	5724*	−212.6	4.0	2.682	34.591	−2.7
383	1680	5723*	−223.7	4.0	2.435	34.610	−1.8
384	1830	5722*	−221.9	4.0	2.269	34.621	−2.4
385	1981	5721*	−219.7	4.0	2.069	34.634	−1.1
387	2132	5720*	−223.5	4.0	1.933	34.645	−1.0
389	2283	5719*	−210.3	4.0	1.825	34.655	−1.2
390	2434	5718*	−219.6	4.0	1.728	34.663	−2.1
393	2585	5717*	−217.0	4.0	1.652	34.669	−1.7
181	2733	5725*	−214.4	4.0	1.612	34.674	−1.7
182	2933	5715*	−222.7	4.0	1.543	34.679	−0.5
183	3134	5714*	−215.8	4.0	1.516	34.683	−1.4
184	3335	5713*	−214.7	4.0	1.477	34.685	−0.8
185	3537	5712*	−211.2	4.0	1.468	34.687	−1.9
187	3740	5711*	−215.9	4.0	1.450	34.688	−0.2
189	3944				1.442	34.688	
190	4149	5710*	−212.4	4.0	1.432	34.688	−1.3
193	4355	5709*	−215.9	4.0	1.421	34.689	−0.9

Cruise: P19C **Station: 338** **14°34′S** **85°50′W** **22 Mar 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1301	6060*	−201.2	4.0	3.484	34.561	−0.8
382	1474	6059*	−214.2	4.0	3.001	34.586	−1.9
383	1649	6058*	−219.1	4.0	2.640	34.609	−3.5
384	1823	6057*	−222.4	4.0	2.365	34.625	−1.1
385	1997	6056*	−234.4	4.0	2.120	34.640	−1.4
387	2171	6055*	−232.8	4.0	1.951	34.651	−1.9
389	2345				1.608	34.660	
390	2522	6054*	−230.4	4.0	1.714	34.667	−2.0
393	2697	6053*	−233.1	4.0	1.651	34.672	−1.0
181	2878	6052*	−230.5	4.0	1.612	34.676	−2.0
182	3104	6051*	−229.2	4.0	1.546	34.678	−1.3
183	3331	6050*	−226.4	4.0	1.525	34.681	−3.2
184	3558	6049*	−221.1	4.0	1.500	34.684	−1.4
185	3785	6048*	−217.8	4.0	1.469	34.686	−1.7
187	4013	6047*	−210.5	4.0	1.441	34.688	−1.3
189	4242	6046*	−212.6	4.0	1.413	34.690	−2.2
190	4471	6045*	−207.6	4.0	1.405	34.690	−2.5
193	4701	6044*	−212.2	4.0	1.408	34.690	−0.6

Cruise: P19C **Station: 353** **7°0´S 85°50´W** **26 Mar 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1184	6119*	−203.6	4.0	3.675	34.574	−2.2
382	1307				3.257	34.593	
383	1428				2.998	34.607	
384	1552	6118*	−216.3	4.0	2.702	34.621	−1.9
385	1675				2.517	34.630	
387	1799	6122*	−231.3	4.0	2.349	34.637	−1.8
389	1925	6121*	−230.7	4.0	2.218	34.642	−0.3
390	2053	6120*	−228.2	4.0	2.042	34.652	−2.5
393	2181				1.924	34.657	
281	2300				1.858	34.661	
282	2501				1.687	34.670	
283	2702	6117*	−225.3	4.0	1.603	34.674	−1.1
284	2903	6116*	−227.8	4.0	1.544	34.678	−2.1
285	3103	6115*	−227.0	4.0	1.527	34.680	−2.4
287	3304	6114*	−227.4	4.0	1.519	34.681	−1.1
289	3505	6113*	−218.0	4.0	1.505	34.683	−1.5
290	3708	6112*	−223.9	4.0	1.489	34.684	−2.2
293	3910	6111*	−218.0	4.0	1.479	34.686	−1.1

Cruise: P19C **Station: 361** **3°0´S 85°50´W** **28 Mar 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1123	6068*	−184.8	4.0	4.085	34.577	−2.0
382	1222				3.748	34.587	
383	1323	6067*	−207.5	4.0	3.440	34.594	−3.2
384	1427				3.180	34.608	
385	1519	6066*	−213.2	4.0	2.956	34.614	−1.3
387	1617				2.790	34.622	
389	1725	6065*	−226.3	4.0	2.661	34.627	−1.7
390	1818				2.509	34.633	
393	1922	6064*	−225.0	4.0	2.331	34.643	−1.3
181	2020				2.251	34.647	
182	2168	6063*	−225.0	4.0	2.037	34.657	−2.2
183	2322				1.927	34.662	
184	2479	6062*	−227.2	4.0	1.778	34.668	−1.0
185	2623				1.644	34.674	
187	2770	6061*	−226.4	4.0	1.583	34.677	−1.6
189	2927				1.551	34.694	
190	3073	5856*	−228.2	4.0	1.531	34.681	−2.5
193	3227	5855*	−224.6	4.0	1.534	34.681	−1.1

Cruise: P19C **Station: 379** **1°0´N 85°50´W** **31 Mar 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
181	1328	5865*	−206.7	4.0	3.397	34.599	−2.0
182	1503	5864*	−212.7	4.0	2.944	34.616	−1.4
183	1679	5863*	−218.1	4.0	2.631	34.629	−1.1
184	1854	5862*	−223.8	4.0	2.357	34.641	−1.5
185	2028	5861*	−224.3	4.0	2.102	34.654	−2.2
187	2205	5860*	−226.4	4.0	1.959	34.661	−1.6
189	2380	5859*	−228.0	4.0	1.907	34.664	−1.1
190	2554	5858*	−222.2	4.0	1.875	34.666	−5.2
193	2730	5857*	−229.4	4.0	1.838	34.667	−1.9

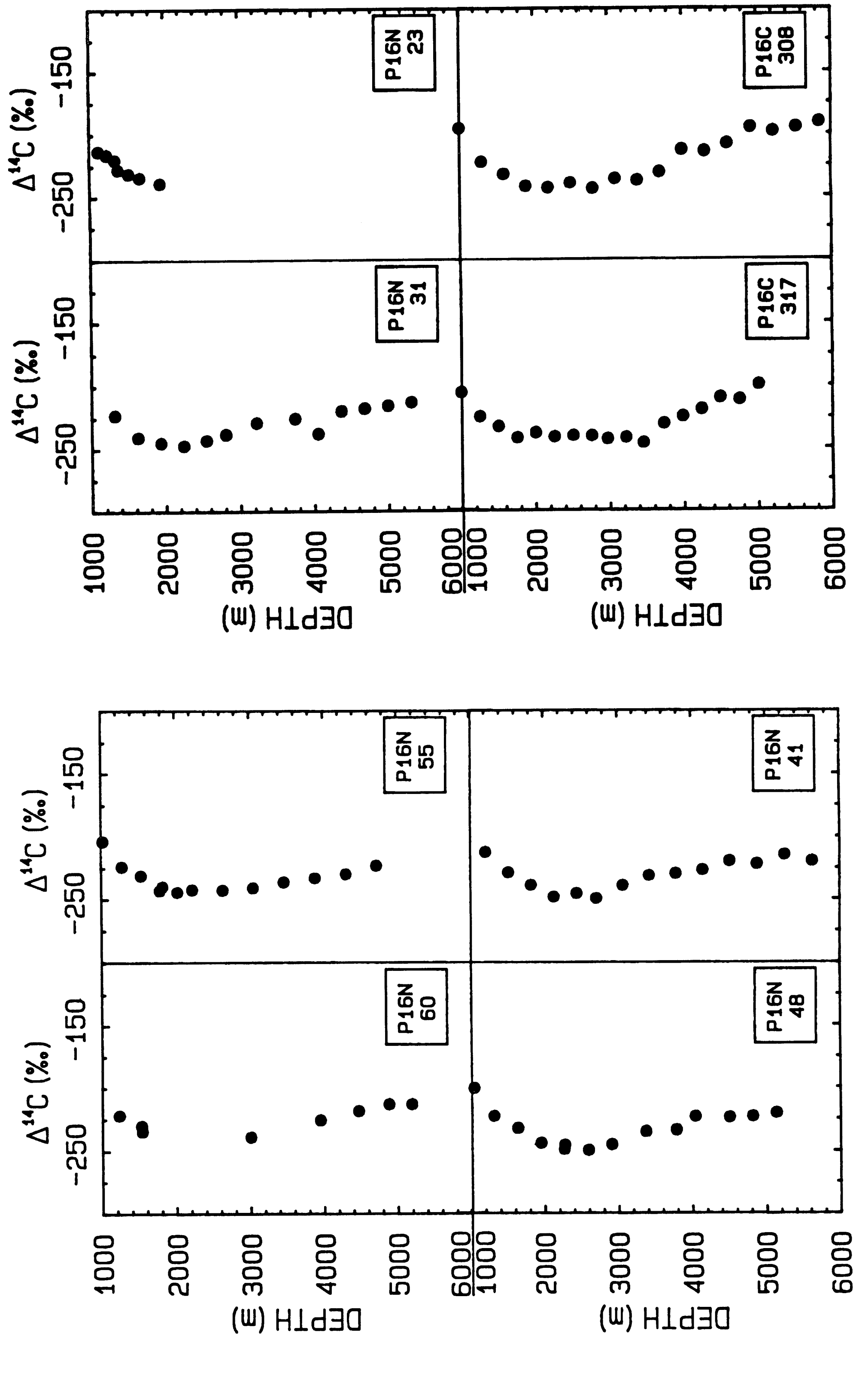
Cruise: P19C **Station: 395** **6°44′N 88°46′W** **4 Apr 1993**

Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1348	5854*	−207.2	4.0	3.438	34.600	−1.5
382	1448				3.107	34.606	
383	1548	5853*	−229.0	4.0	2.870	34.617	−4.0
384	1648				2.641	34.625	
385	1747				2.480	34.630	
387	1847	5852*	−233.9	4.0	2.316	34.637	−1.8
389	1947				2.197	34.642	
390	2049	5851*	−227.0	4.0	2.067	34.649	−4.6
393	2148	5850*	−234.2	4.0	1.944	34.655	−1.9
181	2262	5849*	−233.4	4.0	1.841	34.660	−1.1
182	2414	5848*	−233.3	4.0	1.716	34.665	−1.9
183	2567	5847*	−234.2	4.0	1.641	34.669	−3.0
184	2718				1.615	34.670	
185	2869	5846*	−240.0	4.0	1.584	34.672	−1.1
187	3018				1.595	34.671	
189	3166	5845*	−231.3	4.0	1.585	34.671	−1.1
190	3312				1.580	34.672	
193	3459	5844*	−236.3	4.0	1.577	34.672	0.4

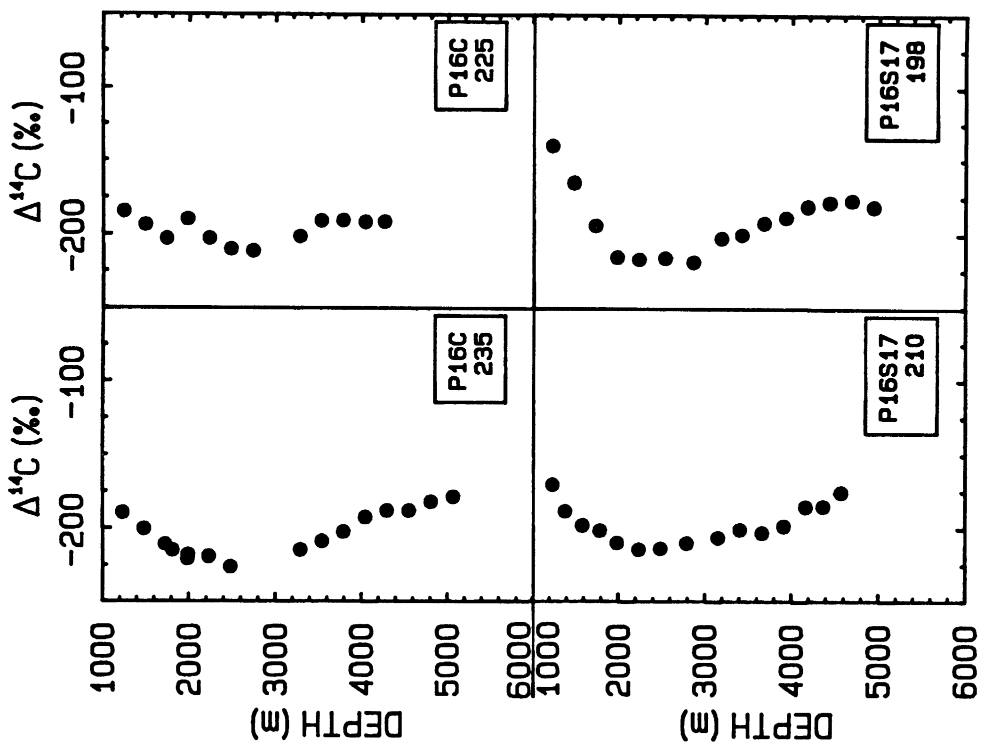
Cruise: P19C **Station: 413** **13°1′N 91°47′W** **8 Apr 1993**

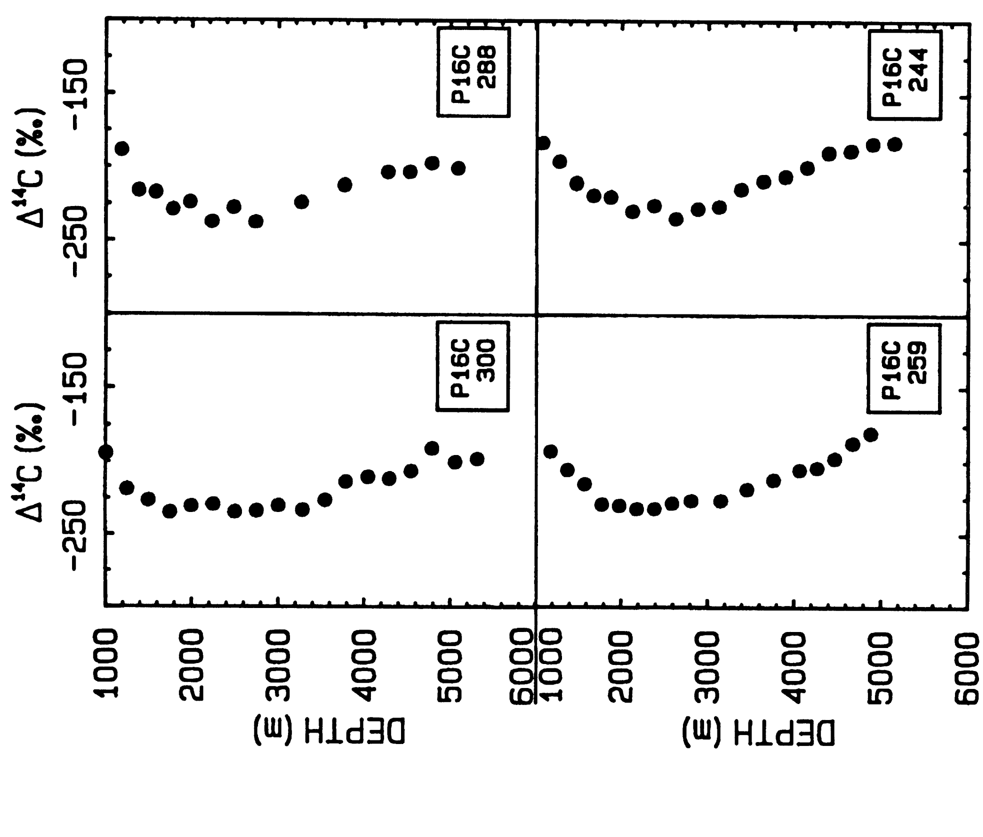
Cast/Bottle	Depth	QL/ML(*)	$\Delta^{14}C$	$\sigma^{14}C$	θ	Salinity	$\delta^{13}C$
381	1643	5831*	−234.4	4.0	2.736	34.617	−1.8
382	1843	5832*	−235.1	4.0	2.413	34.631	−1.4
383	2043				2.112	34.644	
384	2243				1.890	34.655	
385	2444	5833*	−238.4	4.0	1.701	34.663	−1.4
387	2645	5843*	−232.9	4.0	1.642	34.667	−1.1
389	2846	5842*	−235.2	4.0	1.618	34.669	−1.4
390	3047	5841*	−223.9	4.0	1.605	34.670	−5.2
393	3249	5840*	−237.1	4.0	1.602	34.670	−0.3
181	3626	5839*	−230.6	4.0	1.607	34.672	−1.9
182	3879				1.581	34.671	
183	4129	5838*	−227.5	4.0	1.586	34.672	−1.2
184	4383				1.573	34.672	
185	4637	5837*	−233.9	4.0	1.579	34.672	−1.0
187	4892				1.588	34.672	
189	5147	5836*	−230.5	4.0	1.582	34.672	−0.6
190	5555	5835*	−222.3	4.0	1.578	34.672	−3.1
193	5966	5834*	−233.1	4.0	1.580	34.673	−1.7

Fig. A.1 (begins next page). $\Delta^{14}C$ *vs.* depth is plotted for individual station data. For most stations AMS samples were collected above 1000 m by NOSAMS. The profiles given here are for >1000 m depth. See Table A.1 for additional data.



P16N 23
P16N 31
P16C 308
P16C 317
P16N 55
P16N 60
P16N 41
P16N 48
Δ14C (‰)
DEPTH (m)


Δ14C (‰)
-200
-100
DEPTH (m)
1000
2000
3000
4000
5000
6000
P16C 225
P16C 235
P16S17 198
P16S17 210


Δ14C (‰)
-250
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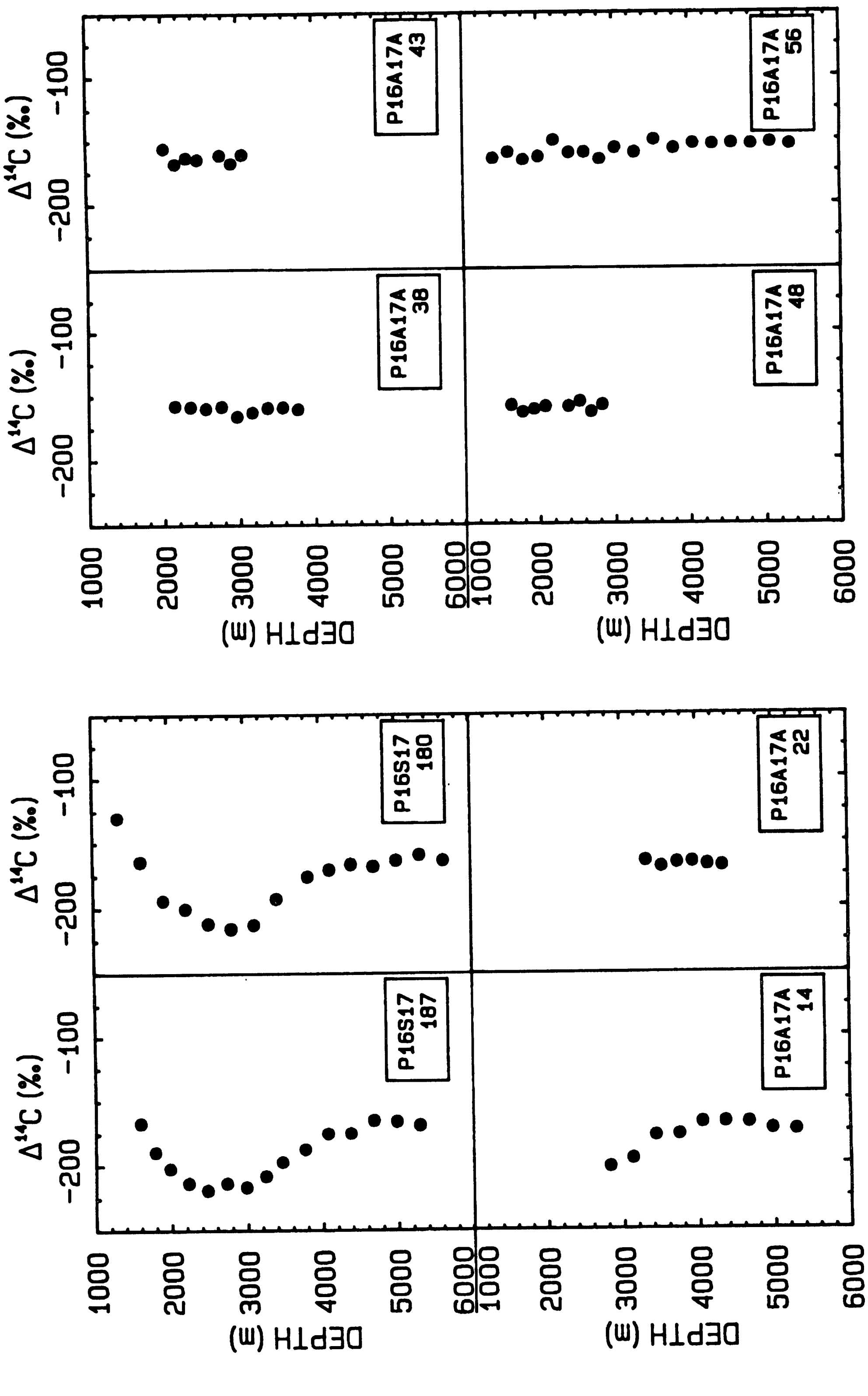
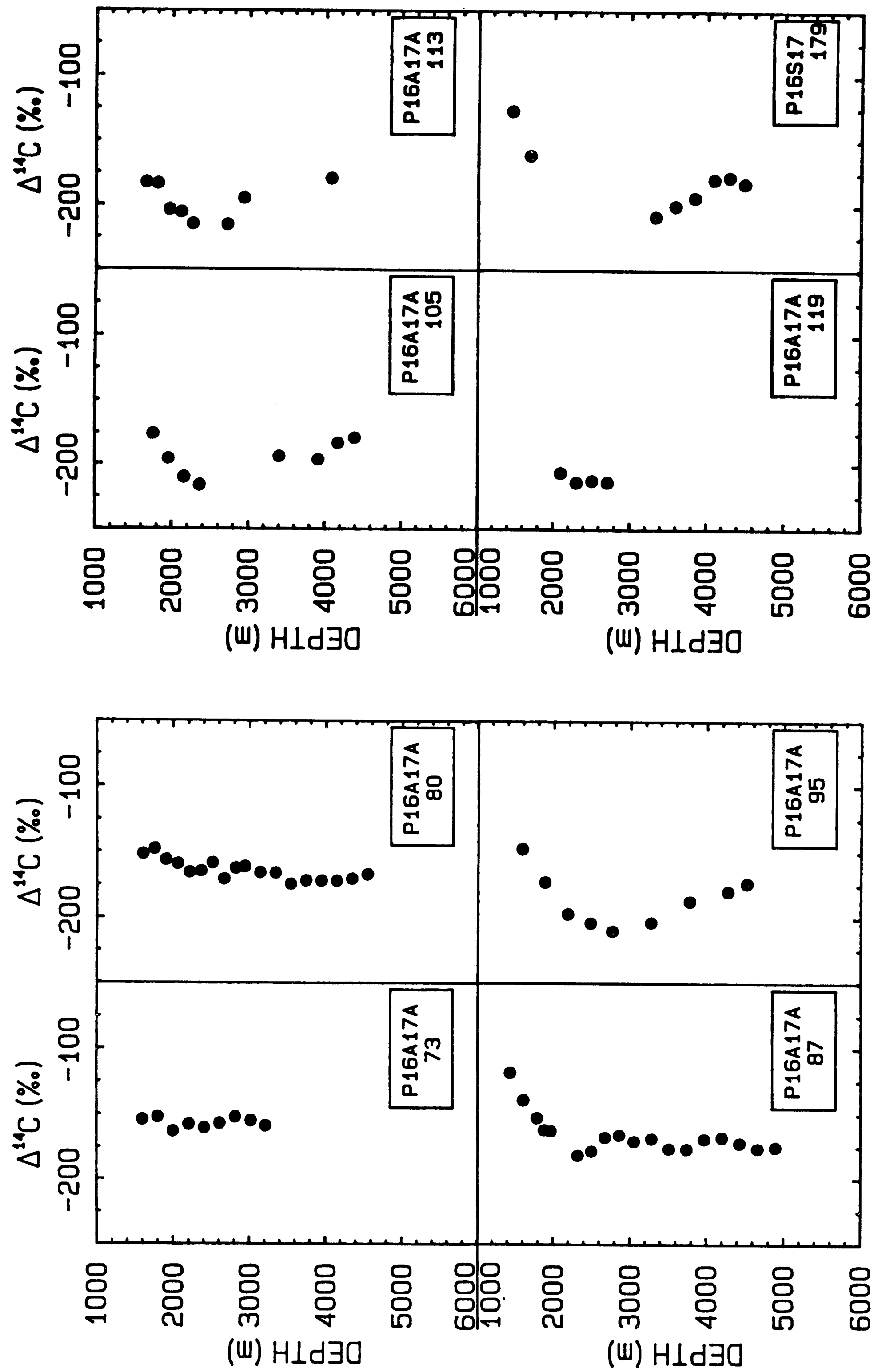
DEPTH (m)
1000
2000
3000
4000
5000
6000
P16C 288
P16C 300
P16C 244
P16C 259



Δ14C (‰)
-200
-100
DEPTH (m)
1000
2000
3000
4000
5000
6000
P16A17A 43
P16A17A 38
P16A17A 56
P16A17A 48
P16S17 180
P16S17 187
P16A17A 22
P16A17A 14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-100
-200
DEPTH (m)
1000
2000
3000
4000
5000
6000
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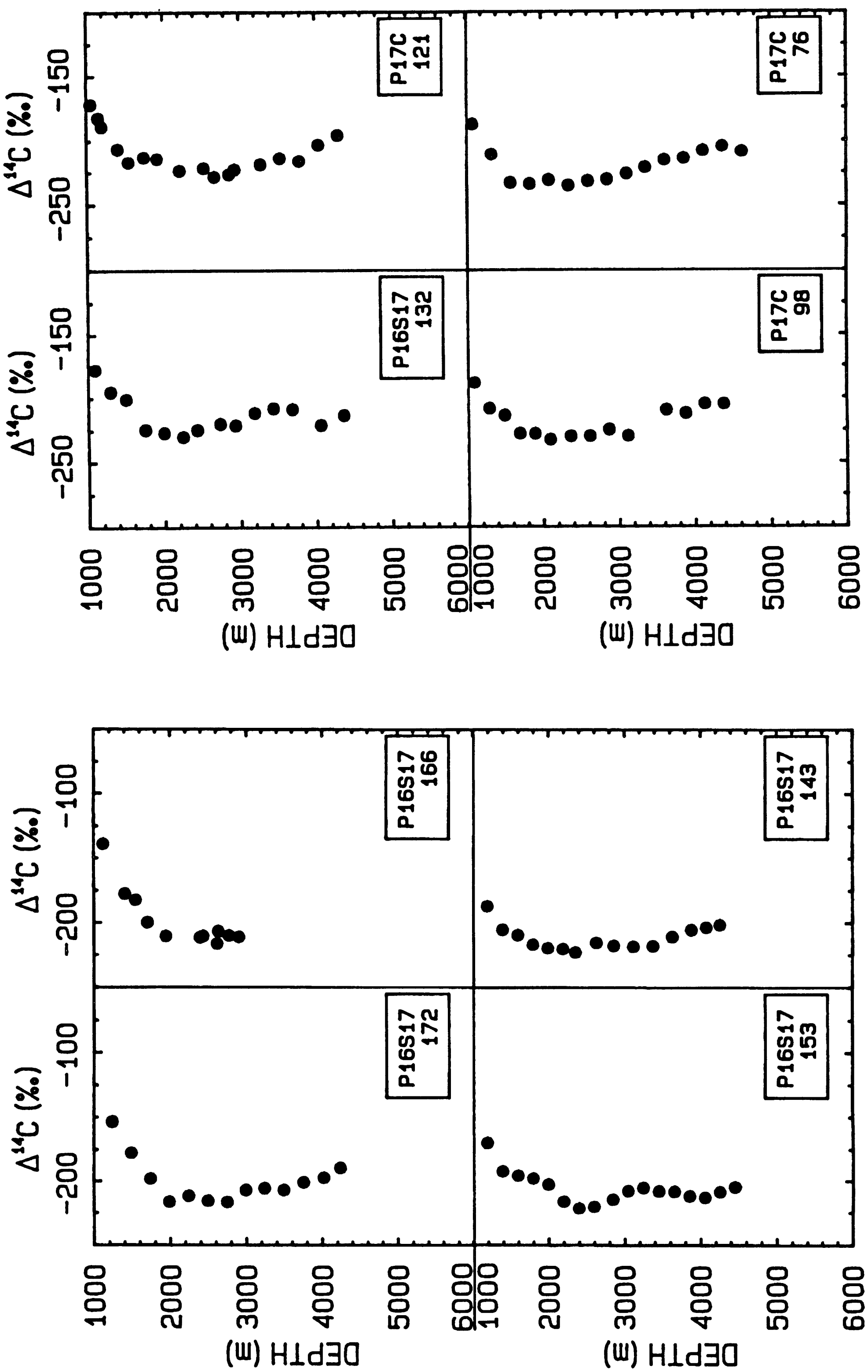
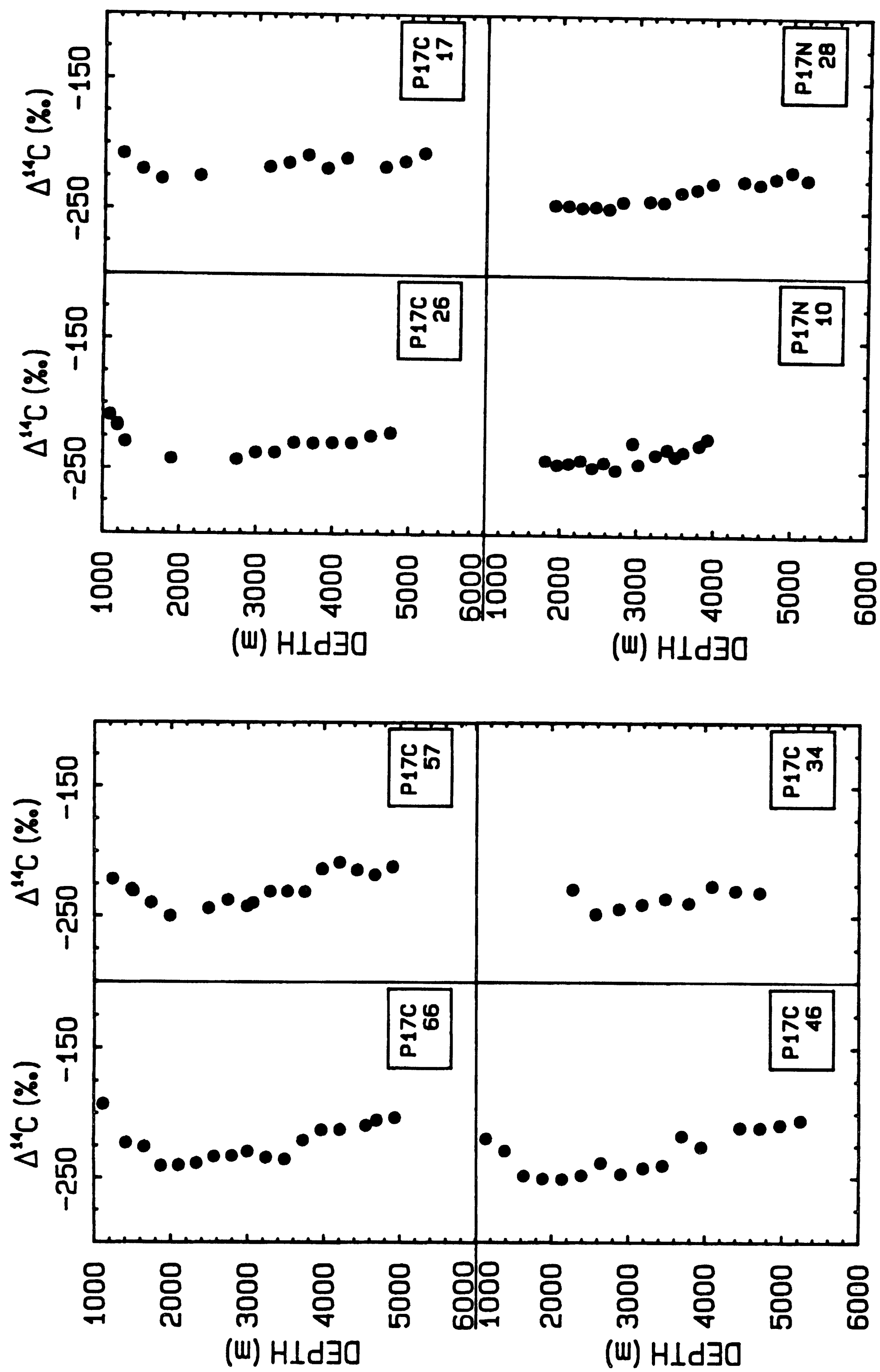
P16A17A 105
P16A17A 119
P16A17A 80
P16A17A 95
P16A17A 73
P16A17A 87


P17C 121
P16S17 132
P17C 76
P17C 98
P16S17 166
P16S17 172
P16S17 143
P16S17 153
Δ14C (‰)
DEPTH (m)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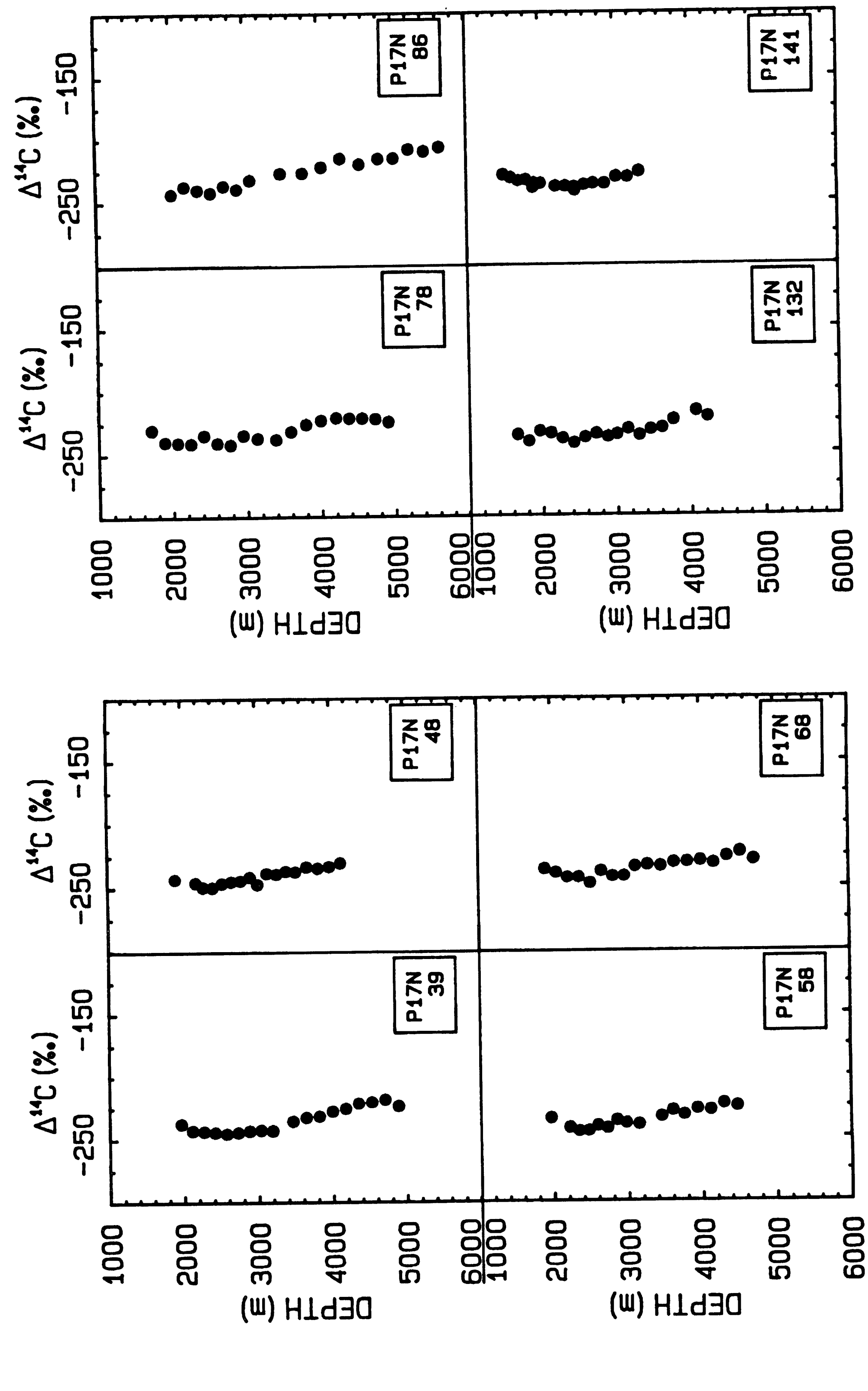
P17C 26
P17N 28
P17N 10
P17C 57
P17C 66
P17C 34
P17C 46
Δ¹⁴C (‰)
−250
−150
DEPTH (m)
1000
2000
3000
4000
5000
6000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P17N 78
P17N 141
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P17N 39
P17N 68
P17N 58
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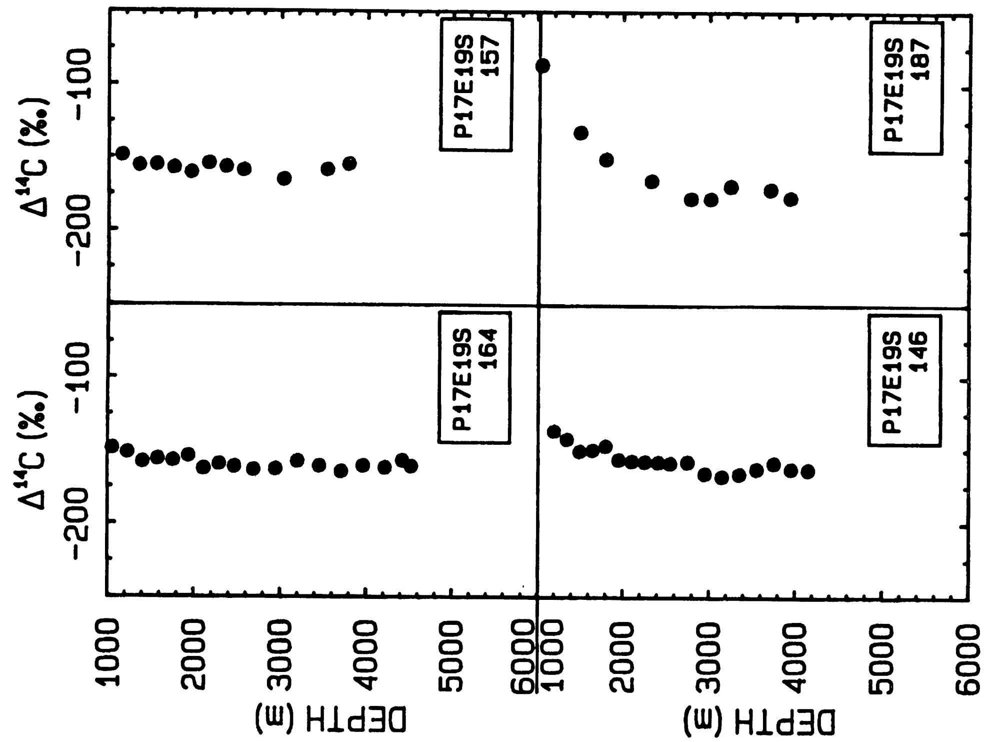
2000
3000
4000
5000
6000


P17E19S 157
P17E19S 187
P17E19S 164
P17E19S 146
Δ14C (‰)
DEPTH (m)
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-200
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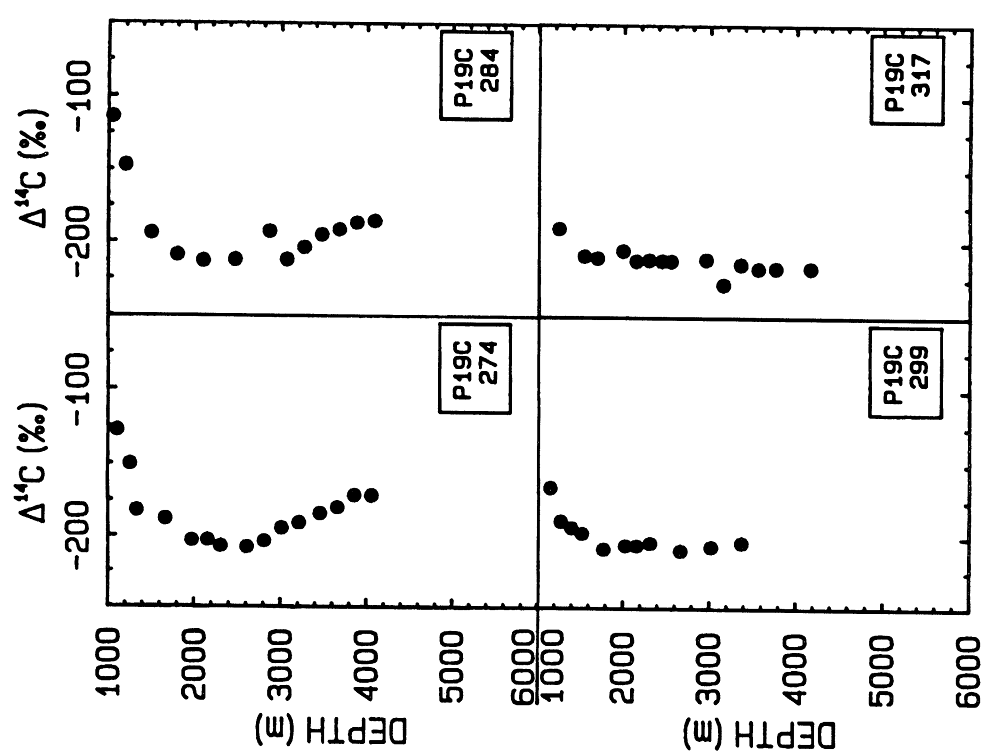
2000
3000
4000
5000
6000


P19C 284
P19C 317
P19C 274
P19C 299
Δ14C (‰)
DEPTH (m)
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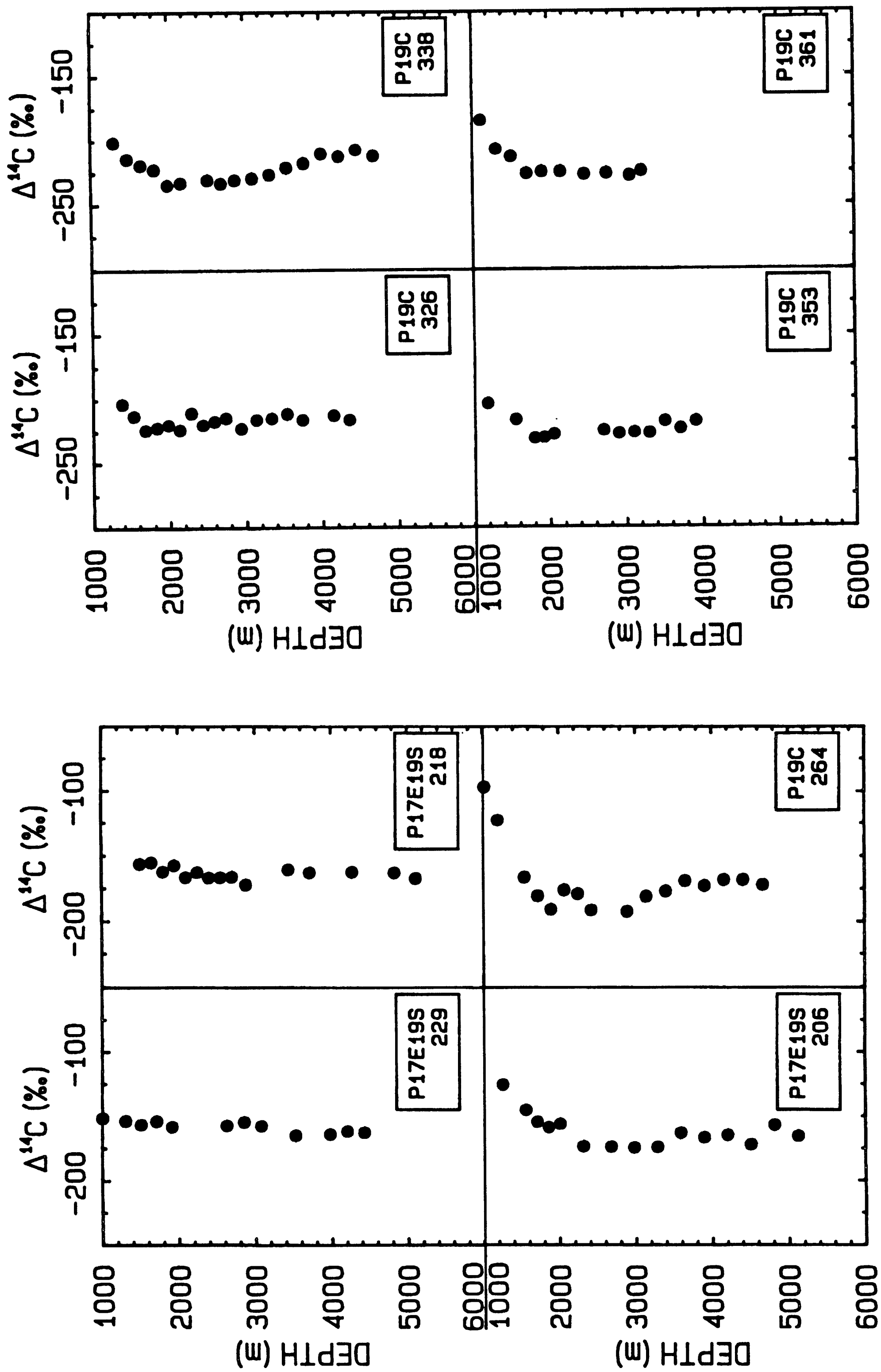
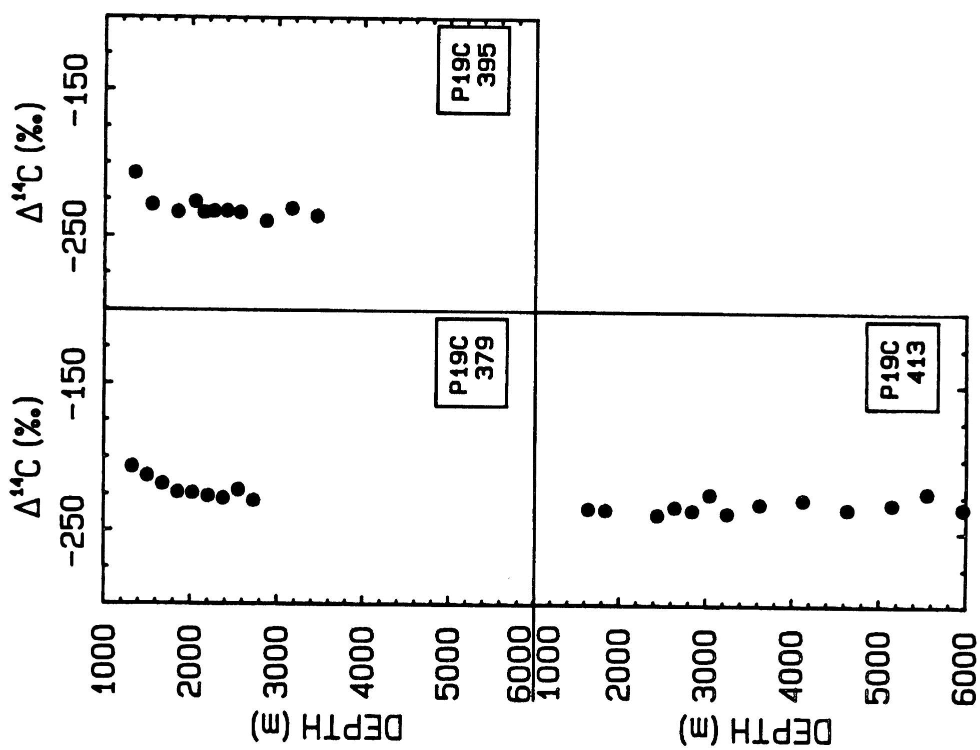
-200
1000
2000
3000
4000
5000
6000


P19C 338
P19C 361
P19C 326
P19C 353
P17E19S 218
P19C 264
P17E19S 229
P17E19S 206
Δ¹⁴C (‰)
DEPTH (m)
-150
-250
-100
-200
1000
2000
3000
4000
5000
6000


P19C 395
P19C 379
P19C 413
$\Delta^{14}C$ (‰)
$\Delta^{14}C$ (‰)
-250
-150
-250
-150
DEPTH (m)
DEPTH (m)
1000
2000
3000
4000
5000
6000
1000
2000
3000
4000
5000
6000

[RADIOCARBON, VOL. 38, NO. 3, 1996, P. 563–572]

POST-BOMB RADIOCARBON RECORDS OF SURFACE CORALS FROM THE TROPICAL ATLANTIC OCEAN

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ABSTRACT. $\Delta^{14}C$ records are reported for post-bomb corals from three sites in the tropical Atlantic Ocean. In corals from 18°S in the Brazil Current, $\Delta^{14}C$ values increased from *ca.* –58‰ in the early 1950s to +138‰ by 1974, then decreased to 110‰ by 1982. Shorter records from 8°S off Brazil and from the Cape Verde Islands (17°N) showed initially higher $\Delta^{14}C$ values before 1965 than those at 18°S, but showed lower rates of increase of $\Delta^{14}C$ during the early 1960s. There is general agreement between the coral results and $\Delta^{14}C$ of dissolved inorganic carbon (DIC) measured in seawater previously for locations in the tropical Atlantic Ocean. $\Delta^{14}C$ values at our tropical ocean sites increased at a slower rate than those observed previously in the temperate North Atlantic (Florida and Bermuda), owing to the latter's proximity to the bomb ^{14}C input source in the northern hemisphere. Model results show that from 1960–1980 the Cape Verde coral and selected DIC $\Delta^{14}C$ values from the North Equatorial Current agree with that calculated for the North Atlantic based on an isopycnal mixing model with a constant water mass renewal rate between surface and subsurface waters. This is in contrast to $\Delta^{14}C$ values in Bermuda corals that showed higher post-bomb values than those predicted using a constant water mass renewal rate, hence indicating that ventilation in the western north Atlantic Ocean had decreased by a factor of 3 during the 1960s and 1970s (Druffel 1989).

INTRODUCTION

Radiocarbon measurement of a banded coral reveals the $^{14}C/^{12}C$ ratio of the dissolved inorganic carbon (DIC) in the seawater that surrounded the coral at the time of accretion. Coral $\Delta^{14}C$ records for the past several hundred years have been reported previously for surface waters of the Atlantic and Pacific Oceans (Druffel and Linick 1978; Druffel 1987; Nozaki *et al.* 1978; Toggweiler, Dixon and Broecker 1991). Post-bomb records have been presented for a variety of locations in the Pacific (Druffel 1981; Druffel 1987; Konishi, Tanaka and Sakanoue, 1982; Toggweiler, Dixon and Broecker 1991), the Indian (Toggweiler 1983) and the Atlantic (Druffel and Linick 1978; Druffel 1989) oceans. Some of the information regarding ocean circulation obtained from coral $\Delta^{14}C$ records include the following: 1) a reduction in water mass renewal rate in the Sargasso Sea was observed during the 1960s and 1970s from coral $\Delta^{14}C$ records (Druffel 1989); 2) from the pre-bomb distribution of $\Delta^{14}C$ in the temperate and tropical Pacific it appears that Subantarctic Mode Water ventilates several features in the equatorial Pacific (Toggweiler *et al.* 1991); 3) seasonally varying transequatorial transport of surface waters in the mid-Pacific (Druffel 1987) controls the distribution of bomb ^{14}C in this area, as observed in coral $\Delta^{14}C$ records.

Time histories of $\Delta^{14}C$ from banded corals at three surface locations in the tropical Atlantic are presented here. Patterns reveal differences between these and previously published data sets from Florida (Druffel and Suess 1983) and Bermuda (Druffel 1989). Comparisons are presented between observed and model-calculated $\Delta^{14}C$ trends for the temperate and tropical North Atlantic.

METHODS

All corals used for this project were collected live from 3–4 m depth at locations well flushed by open ocean waters (see Fig. 1). A large coral colony (0.5 m diameter) of *Mussismilia braziliensis* (CABO) was collected from the southwest shore of the Timbabas Reefs located on the northwest Abrolhos Bank (17°30′S, 39°20′W) by S. Trumbore in December 1982. A small colony of *Mussismilia braziliensis* (CL17) was collected in July 1964 by J. Laborel from Sirbia Island in the Parcel dos Abrolhos Reefs (17°49′S, 30°44′W) (Bahia, Brazil). Small colonies were collected by J. Laborel from two other sites in the Atlantic: 1) *Montastrea cavernosa* (CL04) from Porto de Galinhas (Pernambuco, Brazil; 8°30′S, 35°00′E) on 3 December 1963; and 2) *Porites astreoides* ssp. *hentscheli* (CL19) from the north coast of São Vicente in the Islands of Cape Verde (17°N, 25°W) on 9 August 1970.

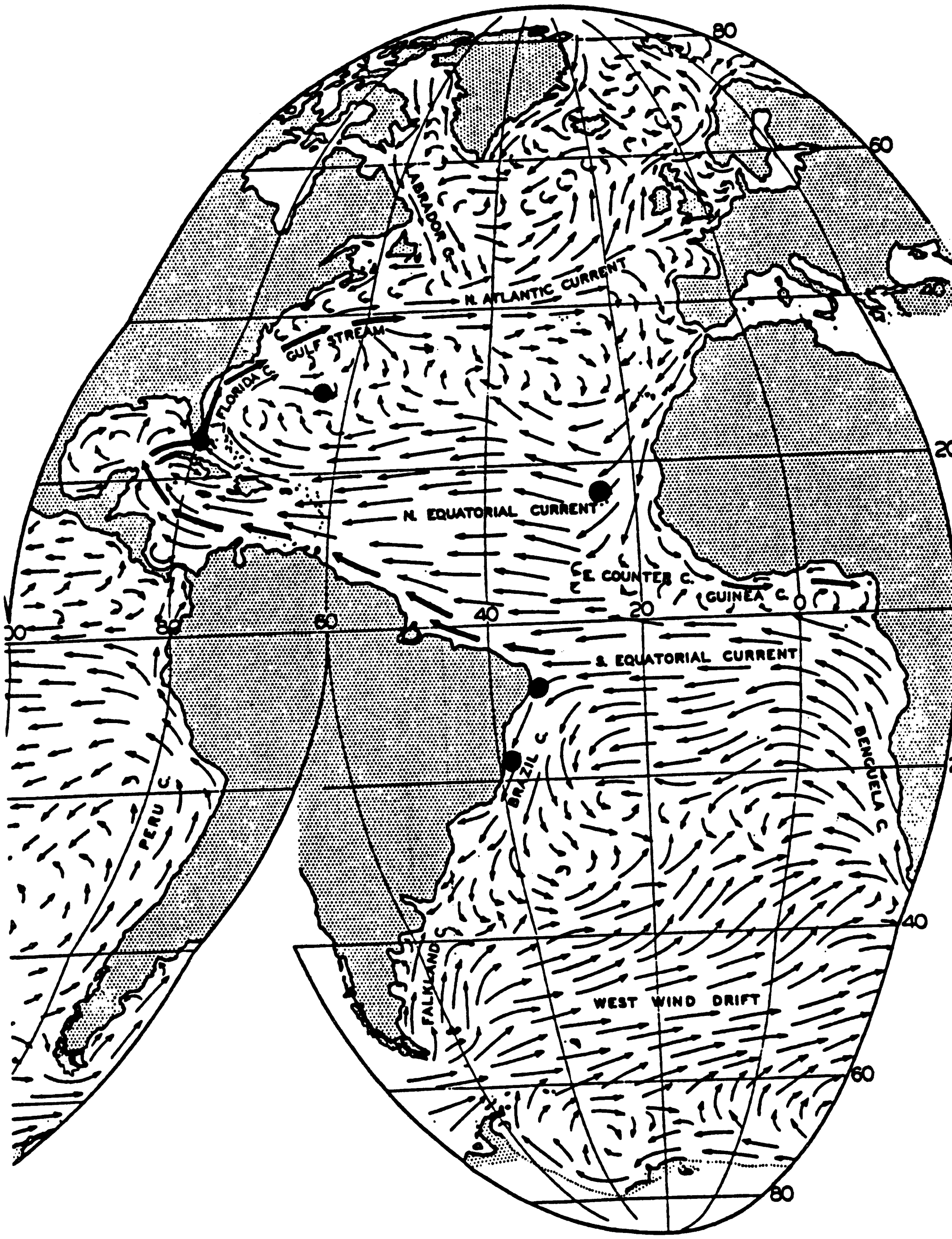

Fig. 1. Map of surface currents in the Atlantic (Sverdrup, Johnson and Fleming 1942). ● = locations of coral collection sites discussed in this paper. (Reprinted by permission of Prentice-Hall, Inc.)

Methods used to clean, X-ray and section the corals were reported previously (Griffin and Druffel 1985). Annual coral bands were taken from all specimens and subjected to ^{14}C analysis. Two bands from the small Abrolhos coral (CL17) were sectioned into half-year bands and analyzed for ^{14}C. Visual inspection of the X-radiographs indicate that the high-density bands for the southern hemisphere corals accreted during the beginning of the calendar year (January–March); the Cape Verde coral accreted its high-density band from about April through June of each year. The bands were drawn at the bottom of the high-density band for all the corals except the small Abrolhos coral, where they were drawn at the top of the high density band. Thus, the midpoint of each band was approximately the beginning of the calendar year for the small Abrolhos and Cape Verde corals (*i.e.*, 19xx.0) and in the middle of the year for the Porto de Galinhas and large Abrolhos corals (19xx.5).

We acidified *ca.* 25 g of coralline aragonite (a crystalline form of calcium carbonate) to produce 5.5 liters of CO_2 gas. The gas samples were converted to acetylene gas via a lithium carbide intermediate and purified through charcoal at 0°C. Samples from the large Abrolhos coral (CABO) were counted for 6–7 2-day periods in 1.5-liter quartz gas proportional beta counters at the WHOI Radiocarbon Laboratory in 1992 according to standard procedures (Druffel and Griffin 1993; Griffin and Druffel 1985). Samples from the three other corals were counted in 2.2-liter quartz gas proportional beta counters at the Mt. Soledad Radiocarbon Laboratory from 1980 to 1981.

Radiocarbon results for the annual coral samples are reported as $\Delta^{14}C$ in Table 1. Uncertainties for the $\Delta^{14}C$ measurements of the large Abrolhos coral (CABO) samples are ±3.0‰ and include counting statistics and laboratory reproducibility errors. The average statistical counting error of each analysis is ±2.1‰, and includes background and standard (HOxI) measurement errors. The laboratory reproducibility error was determined from multiple, high-precision analyses of a modern coral standard. The standard deviation of 10 results, each with a statistical error of 2.1‰, was 3.0‰. Thus, at this precision level, the laboratory error constitutes *ca.* 40% additional error. To obtain our total error, we multiply the statistical error by 1.4. The uncertainties of the $\Delta^{14}C$ results for the small coral heads (LJ numbers) was ±4–5‰ and was based only on the counting uncertainty of the sample, oxalic acid-1 standard and background. The $\delta^{13}C$ values were measured on the reburned acetylene gas and were used to correct the $\Delta^{14}C$ results according to standard techniques for age-corrected geochemical samples (Stuiver and Polach 1977).

Results

Figure 2 presents the $\Delta^{14}C$ results for the four Atlantic corals. The Florida coral record is also shown for comparison (Druffel and Suess 1983). Prior to the introduction of bomb-produced ^{14}C to the oceans (~1956–1958), the average pre-bomb $\Delta^{14}C$ value from six measurements of the large Abrolhos coral (CABO) was −57.9 ± 4.5‰ (sd). All three of the pre-bomb $\Delta^{14}C$ values obtained from the small Abrolhos coral head (CL17) were −56‰. Two pre-bomb $\Delta^{14}C$ values from the coral 8°S off Brazil (−64‰, −49‰; CL04) averaged the same (−56 ± 4‰) as the Abrolhos corals, though the range (15‰) was high.

In all of the coral records, the $\Delta^{14}C$ values increased steadily after 1957–1958 due to the input of bomb ^{14}C from the atmosphere to surface ocean. There is also an initial leveling off of $\Delta^{14}C$ values in 1960–1961, similar to that found 1–2 yr earlier in the Florida corals (see Fig. 2) (Druffel and Suess 1983). Between 1962 and 1968, the long Abrolhos record (CABO) showed a large, steady rise of $\Delta^{14}C$ values, then a slower rise to 1974 when the highest value of 138‰ was attained. After 1974, $\Delta^{14}C$ values declined slowly to a low of 110‰ by 1982. There is agreement (within 2σ uncertainty) between the annual $\Delta^{14}C$ values for the two Abrolhos coral records. The two bands from CL17 that

TABLE 1. Radiocarbon Values for Two Abrolhos Reef Corals, and for the Porto de Galinhas and Cape Verde Island Corals Used in this Study

	Abrolhos, Brazil		Abrolhos, Brazil		Porto de Galinhas		Cape Verde	
Year (AD)	(CABO) $\Delta^{14}C$	WH#	(CL17) $\Delta^{14}C$	LJ#	(CL04) $\Delta^{14}C$	LJ#	(CL19) $\Delta^{14}C$	LJ#
1949.5	−66.3	1029						
1950.5	−54.2	846						
1951.5	−55.8	1031						
1952.5	−54.4	852			−64	5212		
1953.5	−58.7	1028						
1954.5								
1955.5	−57.9	1012						
1956.0			−56	5178				
1956.5	−53.1	1013			−49	5211		
1957.0			−56	5177				
1957.5	−51.3	1014						
1958.0			−56	5176				
1958.5	−51.7	1017			−34	5206		
1959.0			−29	5175				
1959.5	−35.2	1023			−20	5205		
1960.0			−25	5174				
1960.5	−24.8	1027			−16	5204		
1960.7			−27	5173				
1961.3			1	5171				
1961.5	−22.5	1025			−16	5203		
1962.0			−16	5172			15	5275
1962.5	−15.0	1018			9	5201		
1962.7			−12	5169				
1963.0						5202	20	5274
1963.3			17	5168				
1963.5	0.4	847			12			
1964.0			6	5170			40	5273
1964.5	26.2	1022						
1965.0							53	5272
1965.5	41.2	850						
1966.0							43	5271
1966.5	65.4	1019						
1967.0							58	5269
1967.5	80.2	1016						
1968.0								
1968.5	104.7	1024						
1969.0							53	5263
1969.5	108.0	1015						
1970.0							40	5264
1970.5	111.9	848						
1971.5	116.9	1034						
1972.5	125.4	1036						
1973.5	119.6	1092						
1974.5	137.8	1033						
1975.5	129.6	1040						
1976.5	124.5	1045						
1977.5	125.2	1030						
1978.5	123.7	1035						
1979.5	117.5	1042						
1980.5	124.0	1038						
1981.5	118.9	1032						
1982.5	110.0	849						

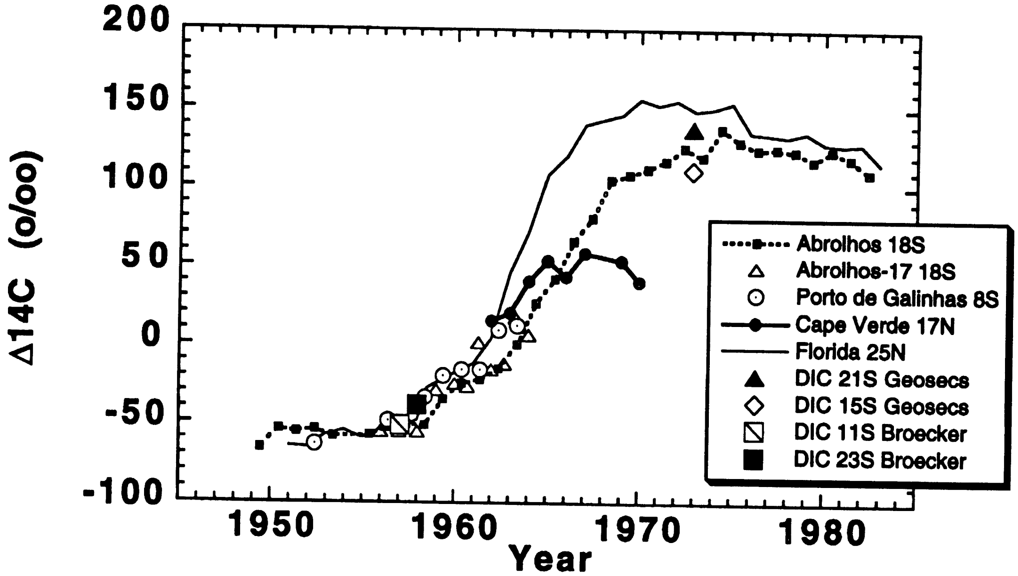

Fig. 2. $\Delta^{14}C$ measurements in annual coral bands from three locations in the tropical Atlantic Ocean: Abrolhos reefs (△) = CL17; (■)= CABO), Porto de Galinhas (○) and Cape Verde Islands (●). $\Delta^{14}C$ measurements for coral from Florida (23°43'N, 66°06'W) are included as an example of a temperate North Atlantic coral record. The $\Delta^{14}C$ results from seawater DIC were measured by two groups of investigators: 1) GEOSECS – November 1972, Stns. 56 and 54 (21°S, 33°W, 138 ± 4‰ at 25 m and 15°S, 30°W, 111 ± 4‰ at 20 m, respectively) (Stuiver and Ostlund, 1980); 2) Pre-bomb Atlantic study – January and December 1957, Stns. 35 and 36 (11°S, 32°W, −52 ± 7‰ at 0 m, and 23°S, 38°W, −39 ± 7‰ at 0 m, respectively) (Broecker *et al.* 1960). The size of the points is approximately equal to the 2 σ uncertainty of the $\Delta^{14}C$ measurements.

were split into half-year increments and analyzed separately revealed 28–29‰ higher values in the second half of the bands (midpoints 1961.3 and 1963.3) than in the first half. This illustrates that the minimum amplitude of the seasonal variability of the ^{14}C signature in the Brazil Current was at least 25‰ during the early 1960s, the period when the gradient between atmospheric CO_2 and surface ocean DIC $\Delta^{14}C$ values was highest.

The Porto de Galinhas (8°S) $\Delta^{14}C$ values were higher than the annual Abrolhos (18°S) values during the post-bomb period of 1956–1963. The offset ranges from 5–10‰ during most years and is 24‰ in 1962, a period when atmospheric values were near their peak. Porto de Galinhas $\Delta^{14}C$ values were lower than the values of the 6-month samples 1961.3 and 1963.3. The $\Delta^{14}C$ in 1952 (−64 ± 4‰) was lower (by 10‰) than that at Abrolhos (−54.4 ± 3.0‰), likely due to upwelling at the site nearer the equator (8°S).

The $\Delta^{14}C$ data from Cape Verde coral in the tropical North Atlantic (17°N) covers the post-bomb period from 1962–1970. The 1962 $\Delta^{14}C$ value (15 ± 4‰) is high and similar to that (4 ± 4‰) found at Florida (24°N) in the western North Atlantic. The $\Delta^{14}C$ values increase with time to 1967 when the highest value (58‰) is found. A decrease is apparent in the $\Delta^{14}C$ value of 1970 (40‰), at the same time that the Abrolhos coral $\Delta^{14}C$ values are still rising.

Discussion

Surface Currents in the Tropical Atlantic. The coral $\Delta^{14}C$ records presented here are from three major surface current systems in the Atlantic (Fig. 1). First, the Abrolhos Banks corals (18°S) lie in the Brazil Current that travels southward along the Brazil coast. This current is the southern arm of the South Equatorial Current (SEC), which lies between 5°N and 8°S during most of the year. The SEC also flows through our second coral site, Porto de Galinhas (8°S). This major warm current travels westward along the equator and is influenced by equatorial upwelling of deeper waters that contain lower $\Delta^{14}C$.

The third water mass is the North Equatorial Current (NEC) that flows through the Cape Verde Islands coral site (Fig. 1). This cool, dense water mass is transported from east to west between 30°N and 10°N. It is fed by the southwestern currents off the west coast of North Africa which originate in the northwest Atlantic. Wind-driven upwelling occurs close to the African coast, but its influence here is not as widespread as that off the west coasts of North and South America. The Cape Verde Islands are located 600 km west of northwest Africa, where upwelling is not strong.

Correlation with Seawater DIC $\Delta^{14}C$ Values. The coral results and $\Delta^{14}C$ of DIC in seawater from the tropical Atlantic are compared in Figure 2. The two $\Delta^{14}C$ values from surface seawater DIC (111‰, 138‰) collected from 15°S and 21°S, respectively, off the coast of Brazil during GEOSECS in 1972 (Stuiver and Ostlund 1980), bracket the two coral $\Delta^{14}C$ values for 1972 and 1973 (119.6 and 125.4‰, respectively) from the Abrolhos reefs (18°S). In addition, earlier $\Delta^{14}C$ measurements of surface DIC $\Delta^{14}C$ in 1957 by Broecker *et al.* (1960) from 11°S (–52 ± 7‰) and 23°S (–39 ± 7‰) agree with the $\Delta^{14}C$ values for Porto de Galinhas (–49 ± 5‰, 1956) and Abrolhos corals (–51 ± 3‰, 1957), respectively. This agreement confirms that the average annual coral $\Delta^{14}C$ record agrees with measurements of DIC $\Delta^{14}C$ in open ocean waters that feed the coastal areas off Brazil. No local seawater DIC $\Delta^{14}C$ values were available for comparison during the time period covered by the Cape Verde coral (1962–1970).

Broecker *et al.* (1960) reported that the pre-bomb DIC $\Delta^{14}C$ values in the surface Atlantic Ocean increased from the south to the north. The average $\Delta^{14}C$ value of 16 South Atlantic (0°–40°S) surface samples was –57‰ and that of 18 North Atlantic (15°–40°N) surface samples was –49‰. By correcting for a small amount of bomb ^{14}C that had already entered the ocean by the time these measurements were made, they estimated that the average pre-bomb $\Delta^{14}C$ values were –63‰ and –52‰ in the South and North Atlantic surface waters, respectively. The pre-bomb $\Delta^{14}C$ time histories from the South Atlantic corals (Abrolhos and Porto de Galinhas) averaged –56 to –58‰, agreeing within the measurement uncertainty with the average surface DIC $\Delta^{14}C$ value (–63‰) (Broecker *et al.* 1960). The North Atlantic corals from Florida and Bermuda had pre-bomb $\Delta^{14}C$ values of –59.5 ± 3.1‰ (sd, N = 6) and –45.8 ± 0.9‰ (sd, N = 3) (Druffel, in preparation), respectively, which compare well with the average pre-bomb surface DIC $\Delta^{14}C$ value (–52‰) for the North Atlantic.

The Pre-Bomb $\Delta^{14}C$ Signature. There is an offset of *ca.* 10‰ between the average pre-bomb $\Delta^{14}C$ (–56‰ to –58‰) at three of the coral sites (Florida, Porto and Abrolhos; Fig. 2) and that of Bermuda (–46‰, Druffel, in preparation). This offset was not anticipated, considering the dissimilarities of the post-bomb records between Florida and Abrolhos (Fig. 1) and the similarities between the Abrolhos and Bermuda post-bomb records (Fig. 3). Nonetheless, the low pre-bomb $\Delta^{14}C$ values for Florida, Porto and Abrolhos are likely related to the fact that water supplying these regions originates from the SEC. The SEC is heavily influenced by upwelling associated with divergence at the equator, which brings low $\Delta^{14}C$ waters from subsurface layers to the surface. The water is transported relatively quickly (within 1 yr) from the SEC to the Florida Straits *via* the Gulf Stream and to the coast of Brazil *via* the Brazil Current (Fig. 1). In contrast, the Sargasso Sea is fed by several currents but is mainly an anticyclonic gyre whose main mixing mode throughout most of the year is downwelling of water to relatively shallow depths. A larger influence from atmospheric CO_2 is obtained under these conditions than for the locations closer to continents and influenced by SEC and upwelling.

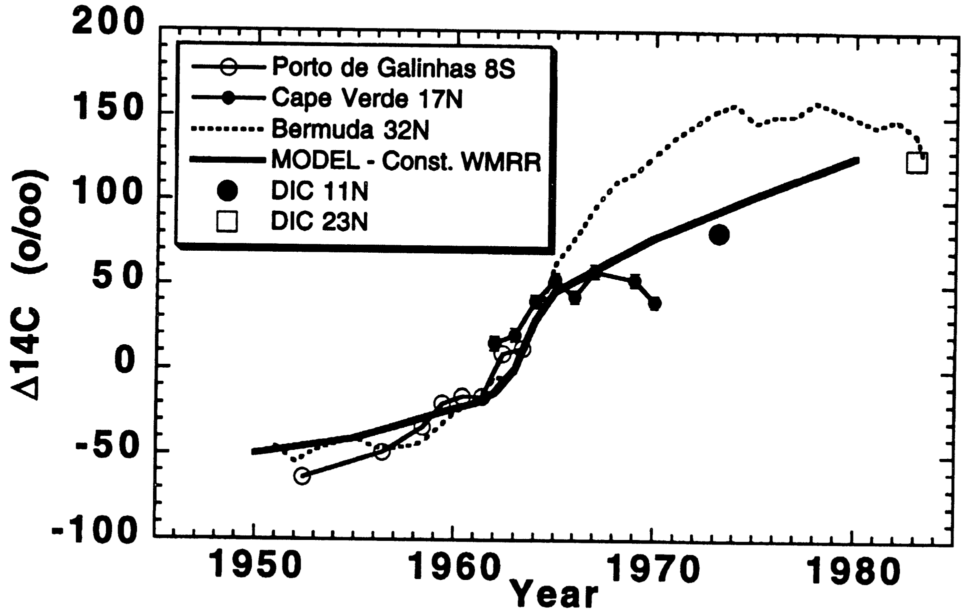

Fig. 3. Model calculated $\Delta^{14}C$ time history for the North Atlantic surface waters using model of Druffel (1989) with constant water mass renewal rate (WMRR) (▬), coral $\Delta^{14}C$ measurements for Cape Verde Islands (-●-), Porto de Galinhas (-o-), Bermuda coral (-----) (Druffel 1989) and DIC $\Delta^{14}C$ measurements made previously (single points) for the NEC: 1. GEOSECS, March 1973, Stn 113 (11°N, 21°W, 81‰, 1 m depth) (Stuiver and Ostlund 1980); 2. TTO, 1983, Stn 75 (23°N, 37°W, 126‰, surface) (Ostlund and Grall, 1992).

Lag Time Between the Bomb Signal in North and South Atlantic. Compared to coral $\Delta^{14}C$ records from Florida in the Northwestern Atlantic, the Brazil (Abrolhos) $\Delta^{14}C$ record is delayed by *ca.* 1 yr during the late 1950s to 1960 and delayed 2–3 yr from the early 1960s to the mid-1970s (see Fig. 2). Maximum values were reached between 1970 and 1972 at Florida, whereas they were reached much later (1974) at the Abrolhos site. This delay agrees with measurements of tropospheric bomb $^{14}CO_2$ (Levin *et al.* 1985; Nydal and Lovseth 1983) that showed a similar delay between the northern hemisphere (where the bomb ^{14}C entered the troposphere) and the southern hemisphere owing to the 1–2 yr mixing time of CO_2 in the troposphere.

In addition to north-south differences, another trend is apparent in these data. In areas that are influenced by horizontal transport of water, and very little by upwelling, $\Delta^{14}C$ values rise more quickly. This is because surface waters are in contact with the atmosphere for a longer period of time and fewer subsurface waters low in ^{14}C are being entrained into the surface waters. The best example of this is in the Florida coral $\Delta^{14}C$ record, which rose faster than all of the other Atlantic records owing to its position in the fast-flowing Gulf Stream (Fig. 2). In contrast is the Bermuda record, whose $\Delta^{14}C$ values rose more slowly in the 1960s and achieved a maximum $\Delta^{14}C$ value 4 yr later than the Florida record (Druffel 1989) (Fig. 3). This delay is due to the dilution of surface ^{14}C levels in the Sargasso Sea by low $\Delta^{14}C$ subsurface waters during 18°C-mode water formation in late winter (Druffel 1989).

How do these trends in the temperate North Atlantic compare to the $\Delta^{14}C$ time histories reported here for the tropical Atlantic? There are two causes of differences in these $\Delta^{14}C$ records: 1) north-south differences caused by the lag in the atmospheric $^{14}CO_2$ signal, and 2) varying degrees of entrainment of low ^{14}C subsurface water into the surface, which causes differences in the slope of $\Delta^{14}C$ *vs.* time during the 1960s. The slopes of all five coral $\Delta^{14}C$ records in Figures 2 and 3 were measured for the most sensitive part of the ^{14}C rise, *i.e.*, between 1962 and 1965. This is also when atmospheric $\Delta^{14}C$ records rose the fastest (Levin *et al.* 1985; Nydal and Lovseth 1983). The slopes are as follows: Florida (34‰ yr^{-1}) > Bermuda (23‰ yr^{-1}) > Abrolhos (20‰ yr^{-1}) > Cape Verde (13‰ yr^{-1}) = Porto de Galinhas (14‰ yr^{-1}). The Porto de Galinhas slope was based only on three $\Delta^{14}C$ results because the coral was collected before the 1965 cutoff. Comparison of these slopes is a relative measure of the contribution of low ^{14}C subsurface waters into the surface layers where the corals lived. Porto de Galinhas (8°S) and Cape Verde (17°N) appear to have the largest amount of dilution of surface waters due to upwelling in the SEC and NEC, respectively.

Comparison of Tropical Atlantic Coral Records with Model-Calculated $\Delta^{14}C$. Bomb ^{14}C time histories in surface ocean waters provide a sensitive record of the balance between the three processes controlling ^{14}C in the surface ocean: 1) exchange of CO_2 between atmosphere and surface ocean; 2) vertical mixing between surface and subsurface water masses; and 3) lateral advection of waters from sources that contain different $\Delta^{14}C$ signatures.

It is useful to parameterize mixing in the Atlantic using the bomb $\Delta^{14}C$ time histories as a mixing constraint. The records reported here cover only parts of the post-bomb period, making it difficult to construct a complete ocean model at this time. Therefore, we compare the tropical results reported here with a model that was previously constructed for the North Atlantic (Druffel 1989).

A multibox isopycnal mixing model was used to estimate the ventilation rate of the upper water column in the Sargasso Sea (Druffel 1989). The reader is referred to the original paper for specific details of the model (Druffel 1989). In brief, high-precision $\Delta^{14}C$ from two sites in the North Atlantic, Florida (representative of Gulf Stream input) and Bermuda (representative of Sargasso Sea) were used to parameterize this mixing model. The model reproduced actual mixing processes that occur in the upper ocean, *i.e.*, transport of ocean water along isopycnals. There were three surface boxes (Gulf Stream, Slope Water to the north and Sargasso Sea) and seven subsurface boxes that mixed along surfaces of constant density (σ_θ = 26.4–27.0) with the surface Sargasso Sea box. The CO_2 gas exchange rate was calculated as a function of the gas exchange piston velocity and was a function of wind speed (Jenkins 1988; Roether 1986). The atmospheric $\Delta^{14}C$ time history of Levin *et al.* (1985) was used. A 0.1-yr time interval was chosen on the basis of stability requirements. The water mass renewal rate (WMRR) was the ventilation or exchange rate between the surface Sargasso Sea box and each of the subsurface isopycnal boxes (in yr^{-1}).

When a constant WMRR was used to estimate the ventilation of the upper water column in the Sargasso Sea surface box, disagreement between the calculated $\Delta^{14}C$ record and the actual record for the Sargasso Sea at Bermuda was obtained (Fig. 3). Therefore, an inverse model was used, *i.e.*, the WMRR was calculated for the post-bomb period in order to satisfy the post-bomb $\Delta^{14}C$ time history in the Bermuda corals. Results showed that the WMRR in the Sargasso Sea was high during 1963–1964, decreased by a factor of 3 during the late 1960s and remained low during most of the 1970s (Druffel 1989).

This model took into account mixing of water masses in the western North Atlantic. But what about waters in the eastern North Atlantic, such as the NEC that laves the Cape Verde Islands? The NEC is supplied mostly by waters from the north that originate in part, from the Gulf Stream. The NEC is also influenced by upwelling of waters from subsurface depths. In a sense, the waters feeding the NEC and the Sargasso Sea are similar, given the Gulf Stream source and the convective overturning during 18°C-mode water formation during late winter in the northern Sargasso Sea. Thus, it is instructive to compare the model estimates of $\Delta^{14}C$ for the Sargasso Sea (Bermuda) with the limited $\Delta^{14}C$ record obtained from the NEC (Cape Verde Islands).

Figure 3 shows the Bermuda and Cape Verde Islands $\Delta^{14}C$ records along with the model-calculated $\Delta^{14}C$ record for the Sargasso Sea using a constant WMRR of 0.44 yr^{-1} for the σ_θ 26.4 isopycnal. Of course, the Bermuda and the model-calculated records do not agree, owing to the fact that the WMRR varied by a factor of 3 during the post-bomb period (Druffel 1989). However, the Cape Verde Islands data, up to 1967, and subsequent DIC $\Delta^{14}C$ values agree with the model calculated $\Delta^{14}C$ records. This agreement may be fortuitous, or may indicate that the eastern fringes of the Sargasso Sea were not affected by a decrease in ventilation (WMRR) during the 1960s and 1970s. Druffel (1989) noted evidence suggesting that the western fringe of the Sargasso Sea may have also undergone a decrease in ventilation during the period 1960–1980. The evidence presented here suggests that this reduction in ventilation could have been restricted to the western North Atlantic and may not have extended into the eastern basin.

Correlation with ENSO. The ENSO signal in the Atlantic is not as well defined as it is in the Pacific. A correlation between low $\Delta^{14}C$ values in post-bomb corals from Florida and some ENSO events (1969, 1972–1973, 1976) is evident, whereas there is no apparent correlation with the Bermuda coral data. It is noted that a low $\Delta^{14}C$ value was obtained for the Abrolhos coral in 1973, coincident with the major ENSO event of 1972–1973 (Fig. 2). Also, low $\Delta^{14}C$ values for the 1969–1970 coral bands at Cape Verde were noticed (Fig. 2), and are coincident with the moderate ENSO event of 1969. It is difficult to discern lower $\Delta^{14}C$ values previous to 1970, owing to both the small signal expected in pre-bomb times (<1957) and the expected swamping of the signal during the time of maximum bomb ^{14}C input to the ocean (1957–1969). Druffel and Griffin (1993) attributed low ^{14}C in Australian corals during ENSO to the southward displacement of the Pacific SEC, which brought low-^{14}C waters directly into the Coral Sea. The origin of the low $\Delta^{14}C$ values during ENSO events in the Atlantic may be the diversion of low ^{14}C waters from areas of high divergence into the regions inhabited by the corals.

Conclusion

$\Delta^{14}C$ values at our Abrolhos site in the South Atlantic increased at a slower rate than those from corals in the northern hemisphere. This is attributed to the delayed bomb ^{14}C signal in atmospheric CO_2 and to the influence of upwelling in its source waters from the SEC. The calculated $\Delta^{14}C$ record for the surface ocean during the post-bomb period using an isopycnal mixing model of the North Atlantic (Druffel 1989) and constant WMRR agreed better with the Cape Verde coral $\Delta^{14}C$ time history than with that at Bermuda during the 1960s and 1970s. This agreement may indicate that the decrease in ventilation (WMRR) of the thermocline observed from 1963–1980 in the North Atlantic (Druffel 1989) was restricted to the western North Atlantic and may not have extended into the eastern basin.

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RESERVOIR AGES IN EASTERN PACIFIC COASTAL AND ESTUARINE WATERS

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ABSTRACT. We have refined marine reservoir age estimates for eastern Pacific coastal waters with radiocarbon measurements of mollusk shells collected prior to 1950. We have also investigated interspecific variability in ^{14}C ages for historic and ancient shells from San Francisco Bay.

INTRODUCTION

Globally, ocean surface waters are depleted in radiocarbon content relative to the atmosphere by an amount equivalent to 400 ^{14}C yr. Regionally the oceans deviate from this value, reflecting variations in upwelling (Stuiver, Pearson and Braziunas 1986), freshwater inflow in coastal regions (Spiker 1980), and interhemispheric variations in atmospheric ^{14}C content (Stuiver and Braziunas 1993). Knowledge of the value of the regional deviation from the ocean reservoir age (or ΔR) is necessary to accurately calibrate ^{14}C ages of marine materials. Since the 1950s, determination of ΔR values by surface water ^{14}C measurements has been precluded due to the artificially high ^{14}C activity in surface waters from nuclear testing. Thus, ΔR values in coastal waters must be determined indirectly from ^{14}C measurements of carbonate shells or other marine materials of known age collected prior to 1950.

Previous ^{14}C measurements of known-age mollusk shells indicate an average ΔR for coastal California of 225 ± 15 yr, for seven analyses (Berger, Taylor and Libby 1966; Robinson and Trimble 1981), corresponding to a significant ^{14}C depletion. This is attributed to upwelling of "old" Pacific Intermediate Water, driven by a divergence in surface ocean flow patterns created by winds blowing southward along the California coast (Dorman and Palmer 1980; Robinson 1980). Other studies suggest that the ΔR values along the California coast are variable, with values as great as 500 yr (Bouey and Basgall 1991). The ΔR value has been shown to decrease from 185 ± 20 yr off Mexico (8 analyses), to 5 ± 50 yr in Central American and Equadorean waters (9 analyses), and to increase again to 190 ± 40 yr off Peru and northern Chile (3 analyses; Taylor and Berger 1967).

Due to the small number of samples, and large spatial and possibly temporal variability in upwelling in these coastal areas, more analyses are clearly necessary. So is characterization of the effects of other processes such as freshwater inflow, carbon recycling, and variable growth habits of marine organisms. In this study, we measured the ^{14}C ages of historically collected mollusk shells from coastal California, Mexico, Central America and Chile to better constrain the modern ΔR values in these regions. In addition, ^{14}C ages of historically collected mollusks, as well as fossil mollusks separated from sediments cored in San Francisco Bay, were used to assess interspecific differences in reservoir ages in modern and ancient estuarine environments.

METHODS

Modern (pre-bomb) mollusk specimens used in this study were provided by the Museum of Paleontology at the University of California, Berkeley, and the Natural History Museum in Santa Barbara.

Species used in the study are native oysters, clams and mussels (*Ostrea lurida, Macoma balthica, Mytilus californianus* and *Mytilus edulis*). In most cases, it is uncertain whether these specimens were collected live or not. These species were chosen because they commonly occur in archaeological coastal deposits (shellmounds) and geological sediments along coastal California (Fig. 1). They may also provide information about the causes of interspecific ^{14}C age differences.

In addition to historically collected material, we separated these same mollusk species from estuarine sediments cored in San Francisco Bay. Mollusks from the same stratigraphic level in the core were ^{14}C-dated to determine differences in apparent ages between species that might be useful in assessing various processes leading to interspecies differences. This information is also useful in illustrating the range in ^{14}C ages obtainable from the same stratigraphic level in geological sediments using different carbonate shell material.

Fig. 1. California sampling locations for this study: SB = Stinson Beach; SFB = San Francisco Bay; ES = Elkhorn Slough; PP = Point Pinos; CB = Carmel Bay; PB = Pelican Bay; SBB = Santa Barbara Basin; SP = San Pedro; NBa = Newport Bay; NBe = Newport Beach; DM = Del Mar; MBe = Mission Beach; MBa = Mission Bay.

Radiocarbon Analysis

Radiocarbon analyses were performed at the Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory (Davis *et al.* 1990). Shell samples (*ca.* 8 mg of carbonate) were etched with 0.5N hydrochloric acid and rinsed with deionized water. Carbonate samples were placed in a 10-ml vacutainer (disposable blood sample vial), which was evacuated through the rubber stopper using a hypodermic needle. After evacuation to below 20 mtorr, 0.5 ml of phosphoric acid was added to the vacutainer with a syringe, and the sample was hydrolyzed for 30–60 min at 90°C to generate CO_2. This was reduced to graphite using hydrogen with a cobalt catalyst (Vogel, Nelson and Southon 1987). $^{14}C/^{13}C$ ratios were measured by AMS, and ^{14}C ages were determined following the conventions of Stuiver and Polach (1977) and Donahue, Linick and Jull (1990).

TABLE 1. ^{14}C Ages on Known Age Mollusks

CAMS no.	Sample	Museum no.	Date	Location* (lat./long.)	$\delta^{13}C$† (‰)	$D^{14}C$ (‰)	$\Delta^{14}C$ (‰)	^{14}C age	Model age	ΔR
San Francisco Bay Estuary										
15700	Mytilus 4	R-1776	1943	Pt. Richmond, San Pablo Bay 38°N, 122.5°W	−2	−107.3 ± 5.9	−101.5 ± 6.2	910 ± 50	477	435 ± 53
15701	Ostrea 1	R-1776	1943	Pt. Richmond, San Pablo Bay 38°N, 122.5°W	0	−89.4 ± 6.7	−83.6 ± 7.0	705 ± 60	477	275 ± 59
15702	Macoma 15	R-1776	1943	Pt. Richmond, San Pablo Bay 38°N, 122.5°W	0	−98.8 ± 9.0	840 ± 80	477 ± 80	477	359 ± 80
8139	Mytilus	--	1939	San Francisco Bay 37.7°N, 122.2°W	−2	−111.5 ± 10.7	−105.2 ± 10.9	950 ± 100	474	476 ± 97
8140	Mytilus 18	--	1939	San Francisco Bay 37.7°N, 122.2°W	−2	−84.9 ± 7.4	−78.5 ± 7.7	710 ± 60	474	238 ± 65
8141	Mytilus 19	--	1939	San Francisco Bay 37.7°N, 122.2°W	−2	−94.4 ± 7.4	−88.1 ± 7.7	800 ± 70	474	322 ± 66
8873	Mytilus 20	--	1939	San Francisco Bay 37.7°N, 122.2°W	−2	−117.0 ± 7.8	−117.0 ± 8.1	1000 ± 70	474	526 ± 71
18486	Macoma 3	R-1670	1899	San Francisco Bay 37.7°N, 122.2°W	−0.79	−88.2 ± 5.3	−82.0 ± 5.7	740 ± 50	467	275 ± 47
Mean							**−92.8 ± 42**			**365 ± 35**
Northern California Coast										
16293	Macoma 6	R-1652	1936	Stinson Beach, Marin Co. 37.9°N, 122.7°W	2	−155.4 ± 4.1	−148.7 ± 4.6	1360 ± 40	472	885 ± 39
16295	Mytilus 15	1652	1936	Stinson Beach, Marin Co. 37.9°N, 122.7°W	0	−88.8 ± 5.5	−82.1 ± 5.9	750 ± 50	472	275 ± 48
16296	Ostrea 3	1652	1936	Stinson Beach, Marin Co.,CA 37.9°N, 122.7°W	2	−93.3 ± 5.5	−86.6 ± 5.9	790 ± 50	472	315 ± 49
16294	Macoma 12	R-1755	1930	Elkhorn Slough, Monterey Bay, 36.8°N, 121.8°W	2	−102.7 ± 5.4	−97.3 ± 5.8	870 ± 50	467	403 ± 48
18494	Mytilus 12	1775	1939	Point Pinos, Pacific Grove 36.7°N, 121.9°W	−0.2	−85.4 ± 5.9	−79.1 ± 6.2	720 ± 50	474	243 ± 52
18497	Mytilus 16	1774	1939	Carmel Bay, Monterey 36.6°N, 121.9°W	0.17	−82.3 ± 6.0	−75.9 ± 6.3	690 ± 50	474	216 ± 53
Mean (Macoma 6 omitted)							**−84.2 ± 3.7**			**290 ± 35**
Santa Barbara Channel										
‡	Mytilus	43190	1936	Santa Barbara 34.6°N, 119.7°W	0.29	−94.6 ± 3.3	−87.9 ± 3.9	800 ± 30	478	320 ± 29
‡	Mytilus	431902	1936	Santa Barbara 34.6°N 119.7°W	0.13	−87.2 ± 6.3	−80.5 ± 6.6	730 ± 60	478	255 ± 55
16297	Mytilus 9	E-1064	1949	Pelican Bay, Santa Cruz Is. 34.1°N, 119.7°W	0	−72.7 ± 4.8	−62.6 ± 5.2	610 ± 40	482	124 ± 42
				Mean			−77.0 ± 7.5			233 ± 60
Southern California Coast										
18503	Ostrea 8	D-7921	1895	San Pedro, Los Angeles 33.7°N, 118.2°W	2.79	−87.0 ± 6.3	−80.4 ± 6.6	730 ± 55	469	263 ± 55
18501	Ostrea 6	E-6358	1948	Newport Bay, Orange Co. 33.6°N, 117.9°W	2	−101.4 ± 5.9	−91.2 ± 6.2	860 ± 50	481	378 ± 53

TABLE 1. (Continued)

CAMS no.	Sample	Museum no.	Date	Location* (lat./long.)	$\delta^{13}C$† (‰)	$D^{14}C$ (‰)	$\Delta^{14}C$ (‰)	^{14}C age	Model age	ΔR
18502	Ostrea 7	E-6162	1948	Newport Bay, Orange Co. 33.6°N, 117.9°W	1.64	−998.0 ± 0.8	–	49,990 ± 3200	–	–
18500	Ostrea 5	A-3991	1890	Newport Beach, Orange Co 33.6°N, 117.9°W	2.66	−131.0 ± 6.7	123.8 ± 7.0	1130 ± 60	471	657 ± 62
18495	Mytilus 13	A-3991	1890	Newport Beach, Orange Co 33.6°N, 117.9°W	0.27	−82.4 ± 5.9	−75.2 ± 6.2	690 ± 50	471	220 ± 52
16298	Macoma 14	A-3991	1890	Newport Beach, Orange Co 33.6°N, 117.9°W	2	−139.5 ± 4.8	−132.3 ± 5.2	1210 ± 45	471	736 ± 45
18496	Mytilus 14	E-6138	1948	Del Mar, San Diego 32.9°N, 117.3°W	−0.25	−76.7 ± 4.9	−57.4 ± 5.3	560 ± 40	481	82 ± 42
18487	Macoma 10	B-829	1939	Mission Bay, San Diego 32.8°N, 117.2°W	1.64	−76.7 ± 4.9	−70.4 ± 5.3	640 ± 40	474	167 ± 43
18493	Mytilus 8	E-6168	1948	Mission Bay, San Diego 32.8°N, 117.2°W	−0.38	−81.2 ± 5.2	−70.9 ± 5.6	680 ± 45	481	199 ± 45
18488	Macoma 13	R-1655	1938	Mission Beach, San Diego 32.8°N, 117.3°W	2.64	−417.0 ± 3.8	–	4330 ± 50	–	–
18498	Ostrea 2	1655	1938	Mission Beach, San Diego 32.8°N, 117.3°W	2.71	−149.0 ± 5.6	−142.6 ± 5.9	1300 ± 50	473	823 ± 53
Mean (Macoma 13, 14 & Ostrea 2, 5, 7 omitted)							**−74.3 ± 4.6**			**220 ± 40**
Gulf of California										
18489	Macoma 16	B-839	1940	Miramar Beach, Guaymas, Mexico 28°N, 111°W	1.82	−101.7 ± 5.9	−95.5 ± 6.2	860 ± 50	475	387 ± 53
18499	Ostrea 4	A-3646	1940	Carmen Is., Baja, Mexico 26°N, 110°W	2.86	−107.3 ± 6.2	−101.0 ± 6.5	910 ± 60	475	436 ± 56
Mean							**−98.3 ± 4.5**			**410 ± 40**
Central America										
18491	Macoma 18	S-78	1932	San Jose de Guate, Guatemala 14.0°N, 90.9°W	1.83	−80.8 ± 6.0	−75.6 ± 6.3	680 ± 50	469	208 ± 52
18492	Mytilus 3	R-1659	1938	Gulf of Fonseca, Honduras 13.2°N, 87.6°W	−0.41	−75.8 ± 6.3	−69.4 ± 6.6	630 ± 50	473	160 ± 55
18490	Macoma 17	A-4010	1939	Corinto, Nicaragua 12.5°N, 87.2°W	1.62	−88.5 ± 5.9	−82.2 ± 6.2	740 ± 50	472	272 ± 52
Mean							**−75.7 ± 3.7**			**215 ± 30**
Central Chile										
17919 17992	Mytilus 2	R-1763	1939	Valparaiso, Chile 33.1°S, 71.8°W	1.98	−62.4 ± 6.1	−56.0 ± 6.4	520 ± 50	474	43 ± 52
Southern Chile										
17918	Mytilus1	R-1766	1939	Puerto Natales, Chile 51.7°S, 72.5°W	−2.32	−80.8 ± 4.7	−74.4 ± 5.1	680 ± 40	474	203 ± 41

*All locations are in California unless otherwise noted
†$\delta^{13}C$ values shown as single digits are estimated
‡Mean of several determinations

Results and discussion

Radiocarbon ages for modern shell samples are listed in Table 1, together with ^{14}C depletions ($\Delta^{14}C$) and ΔR values. Data from this work, and from previous studies compiled by Stuiver, Pearson and Braziunas (1986) are shown in Figure 2. Ages of fossil mollusk shells from San Francisco Bay sediment cores are listed in Table 2 (see also Fig. 3). The $\Delta^{14}C$ values for the modern shells were corrected for the ^{14}C decay that occurred between the growth year (collection year) and 1950, and for the input to the oceans of ^{14}C-depleted fossil-fuel carbon. We have used ^{14}C data from banded corals (Druffel and Suess 1983), and the calculations of Stuiver, Pearson and Braziunas (1986), to correct for this fossil-fuel influence. ΔR values were calculated by comparing global marine surface ages from an ocean model (Stuiver and Braziunas 1993) with the measured ^{14}C ages. We have calculated regional means from our ΔR data, but these should be used cautiously, since there may be inherent variability in ΔR in some of the areas studied (see below). In addition, because it was not certain which of the samples were collected live, those samples with unusually high ΔR values were assumed to have been reworked, and thus were not used in calculating the mean ΔR values.

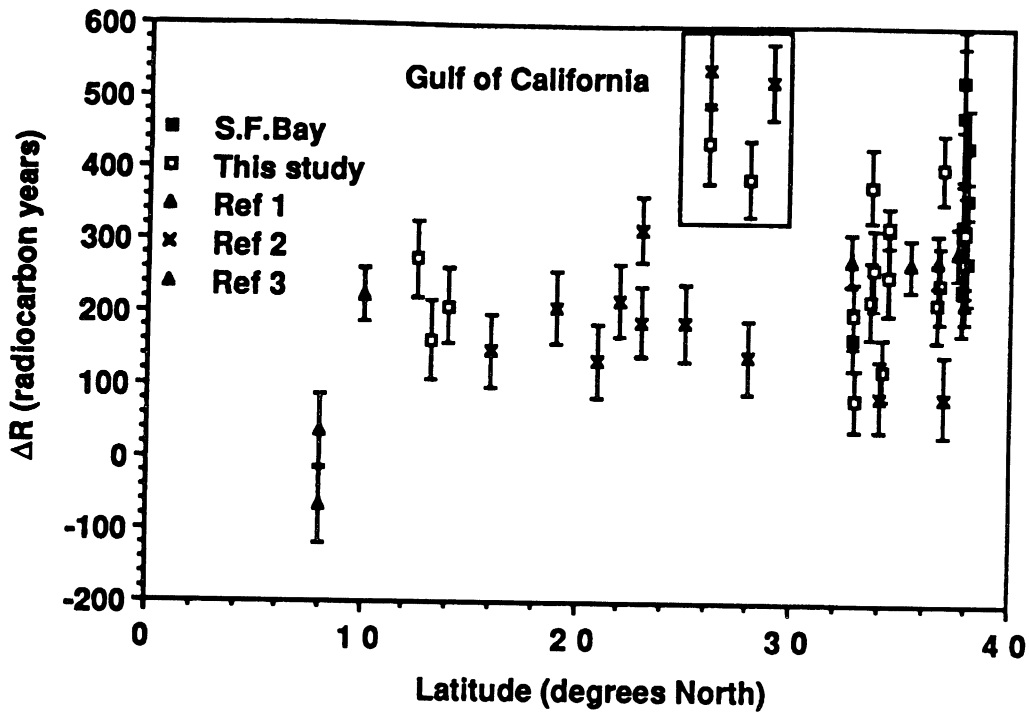

Fig. 2. ΔR results from this investigation compared with those from three previous studies. San Francisco Bay data are plotted separately, since these waters are strongly influenced by river input. Ref 1: Robinson and Trimble (1980); Ref 2: Berger, Taylor and Libby (1966); Ref 3: Taylor and Berger (1967).

Modern Shells and Eastern Pacific Reservoir Ages

The coastal samples from Northern California show large reservoir ages (low $\Delta^{14}C$), due to intense upwelling in this region. The estuarine $\Delta^{14}C$ values from San Francisco Bay are generally lower than those of the coastal samples. There is a large input of freshwater to the estuary from the Sacramento–San Joaquin River system, producing salinities as low as 10–20‰ in Bay waters, and our results suggest that pre-bomb freshwater entering the Bay was significantly depleted in ^{14}C. Recent measurements of ^{14}C in Sacramento River water show $\Delta^{14}C$ values 70‰ below those of the post-bomb atmosphere, and groundwater ^{14}C activities near the Sacramento River are *ca.* 65 pMC (L. Davisson, LLNL, personal communication).

TABLE 2. ^{14}C Ages for Mollusks from San Francisco Bay Sediment Cores

Depth (cm)	^{14}C age *Macoma*	*Mytilus*	*Ostrea*
CP-1			
173	1910 ± 220	--	960 ± 120
CP-2			
453	4680 ± 80	--	4540 ± 70
CP-3			
9	2540 ± 70	--	3210 ± 60
65	3650 ± 60	--	4160 ± 60
86	3610 ± 70	--	4280 ± 60
133	3680 ± 70	--	5040 ± 60
143	4110 ± 60	--	4520 ± 60
161	4200 ± 70	--	4860 ± 60
OP-1			
5	750 ± 60	1650 ± 60	
29	1110 ± 60	1700 ± 70	1090 ± 70
57	1410 ± 60	1890 ± 70	900 ± 70
65	730 ± 70	1830 ± 100	
402	3310 ± 70	3760 ± 70	
523	5070 ± 60	4850 ± 90	
OP-2			
257	1310 ± 60	1110 ± 70	
740	6270 ± 60	6200 ± 70	

The data in Figure 2 suggest an increase in ΔR for coastal California waters of 50–100 yr at *ca.* 33–34°N latitude. This is plausible on oceanographic grounds, because the coastline trends sharply eastward below Pt. Conception at the western end of the Santa Barbara Basin (see Fig. 1). For much of the year, the California Current continues on a more southerly course, and the Southern California Bight to the southeast is occupied by a northward-flowing countercurrent. Coastal waters to the south are less subject to upwelling, and are less influenced by the southward advection of water from the strong upwelling regions further north (Dorman and Palmer 1980).

A feature of the southern California data was the high proportion of outliers. Six of the 11 samples gave results consistent with those of Berger, Taylor and Libby (1966), but two samples (Macoma-13 and Ostrea-7) were clearly reworked, and three others gave ΔR values of *ca.* 700 yr. We have tentatively assumed that these are also reworked and have excluded them from calculation of the regional mean ΔR. The five outliers are from, or adjacent to, estuaries (Newport Bay and Mission Bay) and could possibly result from reworking during flood events, if some of this material were redeposited on nearby oceanfront beaches. Erosion from uplifted beach bluff deposits is another possible mechanism for producing reworked material.

The presence of these samples in the museum collections may be an indicator that reworked specimens are relatively common in some California beach deposits. If this is true, it suggests that the probability of error in dating natural shell deposits is high, unless multiple samples are dated to reveal the presence of reworked material. Midden samples, which were collected live, would not be subject to this difficulty. If estuarine reworking is involved, choosing only open-ocean species may reduce the likelihood of error. Note, however, that reworking is not the only possible explanation for high mollusk reservoir ages. Dye (1994) has shown that ^{14}C ages for limpet, cowrie and gastropod species found on Pleistocene limestone substrates in Hawaii are significantly older than those for specimens found on lava, and the likely effect on shell ages of dissolved geologic carbonate in river water has long been recognized (Berger, Taylor and Libby 1966).

The high ΔR values from the Gulf of California samples are consistent with previous data (Berger, Taylor and Libby 1966) and with expectations for this known region of strong upwelling (Schrader *et al.* 1980). The Central American data agree with previous results (Berger, Taylor and Libby 1966; Taylor and Berger 1967), which show ΔR relatively constant with latitude, down to 10°N (Fig. 2). Below that latitude, coastal waters as far south as the Galapagos are strongly influenced by equatorial water masses that are better equilibrated with the atmosphere than the waters of the California Current system further north. A sample from far southern Chile shows a larger ΔR than a specimen from Valparaiso, suggesting a stronger influence of ^{14}C-depleted Southern Ocean water on the former. This is consistent with a previous study in the Beagle Channel, Tierra del Fuego (Albero, Angiolini and Piana 1986), which also showed large reservoir ages.

San Francisco Bay Mollusks

The results from in and around San Francisco Bay show that the natural variability in ^{14}C ages is much greater than the analytical uncertainty associated with the measurements. Three species of mollusk collected from Stinson Beach, just outside the Bay, reveal that the ^{14}C age of carbonate collected at the same time in the same environment may not necessarily have the same age. Ages of coexisting mollusks collected in 1936 differ by several hundred years, with a *Macoma* shell (reworked?) having the oldest age. Perhaps more significantly, modern mussels (*Mytilus californianus*), collected in 1939 from the central part of the Bay, show a spread of almost 300 yr. The mean ΔR of 375 yr in Table 1 thus represents a modern average value for San Francisco Bay, but wide variations about this mean are present.

Fossil mollusk shells from San Francisco Bay sediment cores show large differences in ^{14}C activity between mollusk types from the same stratigraphic level. For example, in core CP-3, taken in the south-central part of San Francisco Bay, *Ostrea lurida* is consistently older than *Macoma balthica*, by an average of 900 ^{14}C yr (Table 2; Fig. 3), but a single *Ostrea* sample from core CP-1 is younger than the *Macoma* shell. In core OP-1, *Mytilus edulis* is consistently older than *Macoma* by 450–1100 yr (six samples), whereas in OP-2 *Mytilus* is younger than *Macoma* by 70–220 yr (two samples). This variability in the species age offsets between cores (while age offsets are generally systematic within individual cores) suggests that several factors may contribute to the ^{14}C age differences we observe.

One possible influence is the life habitat of the mollusk species. Clams, which are infauna, burrow into the sediment, to a depth of 5–15 cm. In contrast, oysters and mussels are epifaunal, living close to the sediment-water interface. Thus, oyster and mussel fossils from the same stratigraphic level would be expected to have an older age than coexisting clams. In most (but not all) cases, the data in Table 2 do show *Macoma* having the youngest ages. However, in core CP-3 (Fig. 3), for example, the age differences of 400–1400 yr correspond to depth differences of 30–110 cm, an order of magnitude deeper than clams actually live.

Another factor may be the effect of different feeding modes. Oysters and mussels obtain carbon directly from the water from phytoplankton. *Macoma* also feeds on surface deposits, deriving carbon not only from phytoplankton and phytobenthos, but from other sources such as river-borne organic detritus, decaying vascular plants transported from marshes, and microbes in the sediment (Nichols and Pamatmat 1988). Tanaka, Monaghan and Rye (1986) have shown that 23–85% of the carbon incorporated into shell carbonate of mollusks is metabolic. No studies to date have evaluated the relative sources of carbon to mollusks in San Francisco Bay. However, a feeding preference for river-borne vascular plant debris or other terrestrial organic matter, which could have a young ^{14}C age relative to the coastal ocean, might give a younger age for some mollusk shells.

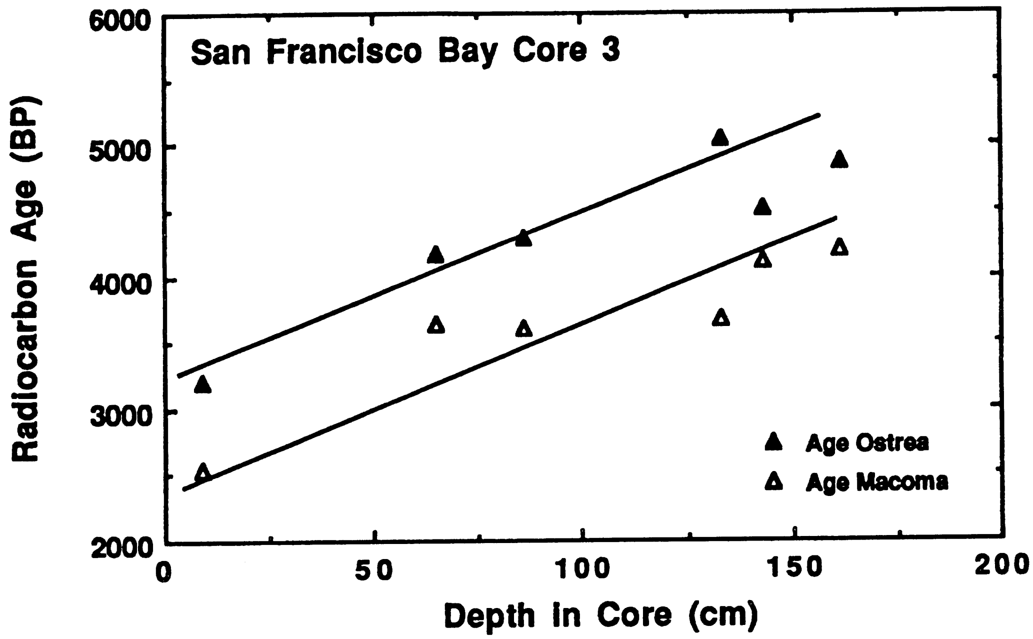

Fig. 3. ^{14}C ages for oysters (*Ostrea lurida*) and clams (*Macoma balthica*) from sediment core CP-3 from south San Francisco Bay

A third possible explanation for age variations is seasonal differences in growth. Post-bomb measurements by Robinson (1980) showed seasonal swings of up to 130‰ in the $\Delta^{14}C$ of California coastal surface waters. Allowing for the reduced atmosphere-surface-deepwater ^{14}C gradient in pre-bomb times, seasonal variations of up to 30‰ seem plausible. Upwelling off California occurs during the late spring to early summer. Studies of the growth rates of *Macoma* in San Francisco Bay indicate that the clam grows much of its shell during the spring and fall (Nichols and Thompson 1982; Thompson and Nichols 1988), implying that it may have an older apparent age than a mollusk species that grew primarily in winter. However, because no comparable studies have been done with oysters or mussels in San Francisco Bay, the apparent age of *Macoma* relative to these other mollusks cannot be assessed. Note that this mechanism does not just apply in San Francisco Bay: seasonality of mollusk growth rates in a variable upwelling environment could contribute to the variability of coastal reservoir ages as well.

Conclusion

We have refined reservoir ages and ΔR values of eastern Pacific coastal waters with ^{14}C measurements on mollusk shells collected prior to 1950. Our results are generally in agreement with data from previous studies, and are consistent with known patterns of ocean circulation. The highest ΔR values are found in the Gulf of California, and ΔR increases toward the northern California coast: both are areas of strong upwelling. Data from two estuaries and nearby beaches in southern California included several outliers. The spurious ^{14}C ages may have resulted from processes such as reworking of mollusk shells during, *e.g.*, storms or flood events. Thus, particular care may be required in using shell for dating California geological coastal deposits. Other dating problems may arise because reservoir ages from areas of seasonal upwelling, or from boundaries between different ocean circulation regimes, may vary significantly on seasonal, interannual, or longer time scales.

Evidence of serious problems in the dating of mollusks from estuaries is given by the San Francisco Bay results. Known-age *Mytilus edulis* from a single location in the Bay showed an age spread of almost 300 yr; and *Mytilus, Macoma* and *Ostrea* shells separated from the same level in sediment cores gave highly discrepant results, with age offsets as high as 1400 yr. Possible mechanisms for these variations include differences in habitat and feeding patterns, and the effects of seasonal changes in growth rates coupled with temporal upwelling and freshwater inflow variations. The variability in the results from different sediment cores within the Bay suggests that the causes are complex.

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INORGANIC RADIOCARBON IN TIME-SERIES SEDIMENT TRAP SAMPLES: IMPLICATION OF SEASONAL VARIATION OF ^{14}C IN THE UPPER OCEAN

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ABSTRACT. In order to verify sediment trap samples as indicators of upper ocean ^{14}C concentrations, particulate inorganic radiocarbon (PIC$\Delta^{14}C$) collected by time-series sediment traps in the Sea of Okhotsk and the Bering Sea was measured by accelerator mass spectrometry (AMS). All of the PIC$\Delta^{14}C$ measurements were < 0‰, in contrast to GEOSECS ^{14}C data in the upper ocean from the northwestern North Pacific. This difference is attributed to the upwelling of deepwater that contains low $\Delta^{14}C$ of dissolved inorganic carbon (DIC$\Delta^{14}C$) and to the decrease over time of surface DIC$\Delta^{14}C$ owing to the decrease of atmospheric $\Delta^{14}C$ values. In addition, PIC$\Delta^{14}C$ values showed significant seasonal variability: PIC$\Delta^{14}C$ collected in the fall was the greatest (−22‰ on average), whereas PIC$\Delta^{14}C$ collected in winter showed an average minimum of −48‰. It is likely that this difference was caused by changes in mixed layer thickness. Although some uncertainties remain, further study on PIC$\Delta^{14}C$ will enable us to estimate seasonal variability in DIC$\Delta^{14}C$ and air-sea CO_2 exchange rate.

INTRODUCTION

Radiocarbon is a useful tracer in oceanography. This nuclide has been utilized for studies of ocean circulation (Östlund and Stuiver 1980; Östlund *et al.* 1987), land–ocean-water interaction (Tanaka, Monaghan and Rye 1986), the tracing of anthropogenic material (Broecker *et al.* 1985), diets of deep organisms (Williams *et al.* 1981; Williams, Druffel and Smith 1987; Pearcy and Stuiver 1983), and the origin and age of suspended particle or dissolved organic carbon (Druffel *et al.* 1992). In addition, ^{14}C can be used in estimating the CO_2 exchange rate at the ocean surface. Broecker and Peng (1982) calculated the CO_2 invasion rate and estimated the average CO_2 exchange rate to be *ca.* 18 mol m^{-2} yr^{-1} using the atmospheric ^{14}C concentration and a "representative" surface ocean ^{14}C concentration. However, surface $\Delta^{14}C$ values are variable because of changes in the CO_2 exchange rate and in the surface mixed layer thickness, as Broecker and Peng (1980) found when they documented seasonal change in the GEOSECS surface ^{14}C data. Therefore, it is of interest to clarify the seasonal variability of ^{14}C in the surface ocean and to verify the "representative value" (annual mean value) of the ^{14}C concentration in the surface ocean. The time-history and seasonal change of the surface ^{14}C value have been determined from the ^{14}C record of coral reefs (Nozaki *et al.* 1978; Druffel 1989; Druffel and Linick 1978; Druffel and Suess 1983). However, a coral reef can record DIC$\Delta^{14}C$ values of the upper ocean only near the coastal zone and at low latitudes (< 35°).

Time-series sediment traps deployed in the pelagic ocean have provided us a variety of information, such as the seasonal and annual variability of pelagic ocean productivity and the material cycle (*e.g.*, Honjo and Manganini 1993; Honjo *et al.* 1995). Most particulate organic carbon and inorganic carbon is assimilated or calcified in the upper ocean by biological activity and is in isotopic equilibrium with the ambient seawater in which it is produced (*e.g.*, Curry, Thunell and Honjo 1983; Curry and Crowley 1987; Rau *et al.* 1992). Therefore, particulate carbon collected by sediment traps records the DIC$\Delta^{14}C$ of the upper ocean. Druffel *et al.* (1986) measured ^{14}C values of a sediment trap sample from the Gulf of Alaska. They showed that PIC$\Delta^{14}C$ agreed with DIC$\Delta^{14}C$ in the upper ocean. However, they performed only one six-month collection and could not observe seasonal variability in DIC$\Delta^{14}C$. Since then, there have been few papers devoted to ^{14}C analysis on sediment trap samples because of sample size limitations for beta counting. The development of accelerator mass spectrometry (AMS) (Beukens 1992; Gove 1992) allows us to measure ^{14}C on small samples such as sediment trap samples. In order to verify the possibility of using sediment trap samples as "recorders" of DIC$\Delta^{14}C$ in the upper ocean and to detect the seasonal variability in DIC$\Delta^{14}C$, we measured PIC$\Delta^{14}C$ in sediment trap samples.

Sampling and Analytical Methods

Sediment trap experiments were carried out in the Sea of Okhotsk (1990–1991) (Honjo *et al.*, in press) and in the Bering Sea (1991–1992) (Honjo *et al.* ms.). Time-series sediment traps with 21 rotary collectors (Honjo and Doherty 1988) were deployed at 258 m and 1058 m water depth in the Sea of Okhotsk and at 3137 m water depth in the Bering Sea. The trap site in the sea of Okhotsk was covered with sea ice for a short period (1–10 April 1991) (Japan Meteorological Agency 1991) and the Bering Sea trap site was not ice covered (NOAA Sea Ice data produced by Grumbine (1996)). Therefore, the effect of sea ice cover on the biogeochemistry and material exchange at the air-sea boundary can be neglected in this study. Collected materials were preserved with 3% buffered formalin during one-year experiments.

Three sediment trap samples representing the fall, winter and spring seasons were selected from each sediment trap for this analysis (Table 1, Fig. 1). The winter samples from the Sea of Okhotsk were so small that four interval samples were combined for ^{14}C analysis. Samples < 1 mm in diameter were filtered, rinsed with distilled water and dried in an oven at 50°C for 24 h in the laboratory at Woods Hole Oceanographic Institution (WHOI). The samples were sequentially pulverized with an agate mortar and pestle. In a vacuum line, the samples were acidified with concentrated H_3PO_4 and extracted CO_2 was converted to graphite over reduced Fe catalyst using H_2 (McNichol *et al.* 1992). ^{14}C measurements were performed by the National Ocean Science AMS facility (NOSAMS) at WHOI (Jones *et al.* 1990; Von Reden *et al.* 1992). Concentrations of ^{14}C are reported here as $\Delta^{14}C$, which is the per mil deviation from the activity of 19th century wood (Stuiver and Polach 1977) assuming that $\delta^{13}C$ is 0‰. 1 σ counting error is 3–5‰. $^{13}C/^{12}C$ was also analyzed using a VG Micromass 602E mass spectrometer at WHOI. Ratios of $^{13}C/^{12}C$ are expressed as $\delta^{13}C$, which is the

TABLE 1. Total mass flux, chemical composition, and $\Delta^{14}C$ and $\delta^{13}C$ values of PIC in sediment trap samples from the Sea of Okhotsk and the Bering Sea. (Errors for carbon isotopes are 1 σ values of the counting statistics.)

Region	Trap depth (m)	Sampling period	Total mass flux (mg/ m^2/day)	OM* (%)	SiO_2 (%)	$CaCO_3$ (%)	Lith.* (%)	$\Delta^{14}C$ (‰)	$\delta^{13}C$ (‰)
Okhotsk Sea (53°N, 150°E) water depth 1166 m Aug 1991 – Aug 1991	258	09/16/90–10/03/90 F†	117	36	25	37	2	−25 ± 3	0.02 ± 0.10
		12/29/90–03/09/91 W	10	n.d.‡	n.d.	n.d.	n.d.	−12 ± 3	0.43 ± 0.10
		05/17/91–06/03/91 S	426	13	80	6	1	−39 ± 4	-0.20 + 0.10
	1058	09/16/90–10/03/90 F	208	12	33	49	6	−21 ± 4	0.14 ± 0.10
		12/29/90–03/09/91 W	34	18	44	19	19	−48 ± 5	-0.35 ± 0.10
		05/17/91–06/03/91 S	296	11	79	6	4	−31 ± 5	-0.11 ± 0.10
Bering Sea (58°N, 179°E) water depth 3783 m Jul 1991–Jul 1992	3137	10/13/91–10/31/92 F	198	11	48	26	15	−21 ± 4	0.21 ± 0.10
		02/12/92–02/29/92 W	55	13	49	13	25	−48 ± 4	0.49 ± 0.10
		06/13/92–06/30/92 S	1008	11	78	3	8	−60 ± 4	-0.71 ± 0.10

*OM = organic matter; Lith. = lithogenic material
†F, W, S = sample represents fall, winter or spring, respectively
‡n.d. = no data; sample volume too small to be analyzed

per mil difference in the isotopic ratio between the sample and the PDB standard. 1 σ counting error is *ca.* 0.1‰.

RESULTS

Figure 1 shows seasonal variability in total mass flux and the chemical composition of sediment trap samples (Honjo *et al.* in press; ms.). The material flux is characterized as follows:

1. Total mass flux in both regions increased in late fall and in late spring.
2. In the Sea of Okhotsk, the fraction of carbonate increased in the fall season, whereas that of SiO_2 increased in the spring season.
3. In the Bering Sea, the proportion of SiO_2 was dominant all year around, especially in the late spring when total mass flux was > 1000 mg m^{-2} day^{-1}.
4. The fraction of lithogenic materials was < 25%.

$\Delta^{14}C$ values of sediment trap PIC samples are shown in Table 1 and Figure 2 with other sediment data. All $\Delta^{14}C$ values are negative. $\Delta^{14}C$ of the winter sample collected at 258 m in the Sea of Okhotsk shows the maximum value of −12‰, and the minimum value (−60‰) is that of the spring sample collected at 3137 m in the Bering Sea. It is notable that the mass flux of the former was the smallest and the latter was the largest among the samples used for ^{14}C analysis (Fig. 1, Table 1). $\Delta^{14}C$ values of samples collected in the same season (3 samples in fall, 2 samples in winter and 2 samples in spring) are equal within the measurement uncertainty, except the $\Delta^{14}C$ of the winter sample (258 m) from the Sea of Okhotsk and that of the spring sample from the Bering Sea. The PIC$\Delta^{14}C$ value in fall is the highest (−22‰ on average) and PIC$\Delta^{14}C$ value in winter is the lowest (−48‰ on average). The average of PIC$\Delta^{14}C$ from 7 samples is −33‰ and the difference of PIC$\Delta^{14}C$ between fall and spring is 26‰. PIC$\Delta^{14}C$ does not correlate well with total mass flux or organic carbon ($r < 0.6$). However, a plot of PIC$\Delta^{14}C$ *vs.* PIC$\delta^{13}C$ shows good correlation after eliminating one sample ($\delta^{13}C = 0.02\ \Delta^{14}C + 0.62$, $r = 0.99$) (Fig. 3A). In addition, PIC$\Delta^{14}C$ and the ratio of the lithogenic material's concentration to total carbonate concentration (Lith/$CaCO_3$) correlate well ($r = 0.8$), as shown in Figure 3B.

DISCUSSION

Do the Negative PIC$\Delta^{14}C$ Values Found in This Study Reflect DIC$\Delta^{14}C$ in the Upper Ocean or Do They Reflect Some Other Low $\Delta^{14}C$ Carbon Source?

Formalin Effect

We did not measure DIC$\Delta^{14}C$ in the Bering Sea and the Sea of Okhotsk in the early 1990s. However, the $\Delta^{14}C$ values found in our sediment trap sample are much lower than the $\Delta^{14}C$ values in surface water in the northeastern North Pacific obtained by the GEOSECS Pacific expedition in the early 1970s (Östlund and Stuiver 1980). PIC$\Delta^{14}C$ values are also lower than the mean DIC$\Delta^{14}C$ in the upper 100 m from the northwestern North Pacific in the early 1980s (*ca.* 35‰ in April 1983 at 45°N, 160°E; Tsunogai *et al.* 1995). One reason for such low values might be contamination of samples with formalin used as a preservative during the experiment. Formalin is made of petroleum, *i.e.*, from "dead" carbon ($\Delta^{14}C$ = −1000‰). In addition, $\delta^{13}C$ of formalin is −30 to −40‰—lower than that of living marine organisms (Fry, personal communication). Some previous reports documented that formalin decreased $\delta^{13}C$ of organic carbon by a few parts per mil (Mullin, Rau and Eppley 1984; Manganini *et al.* 1994; Lindsey, Minagawa and Kawaguchi 1995).

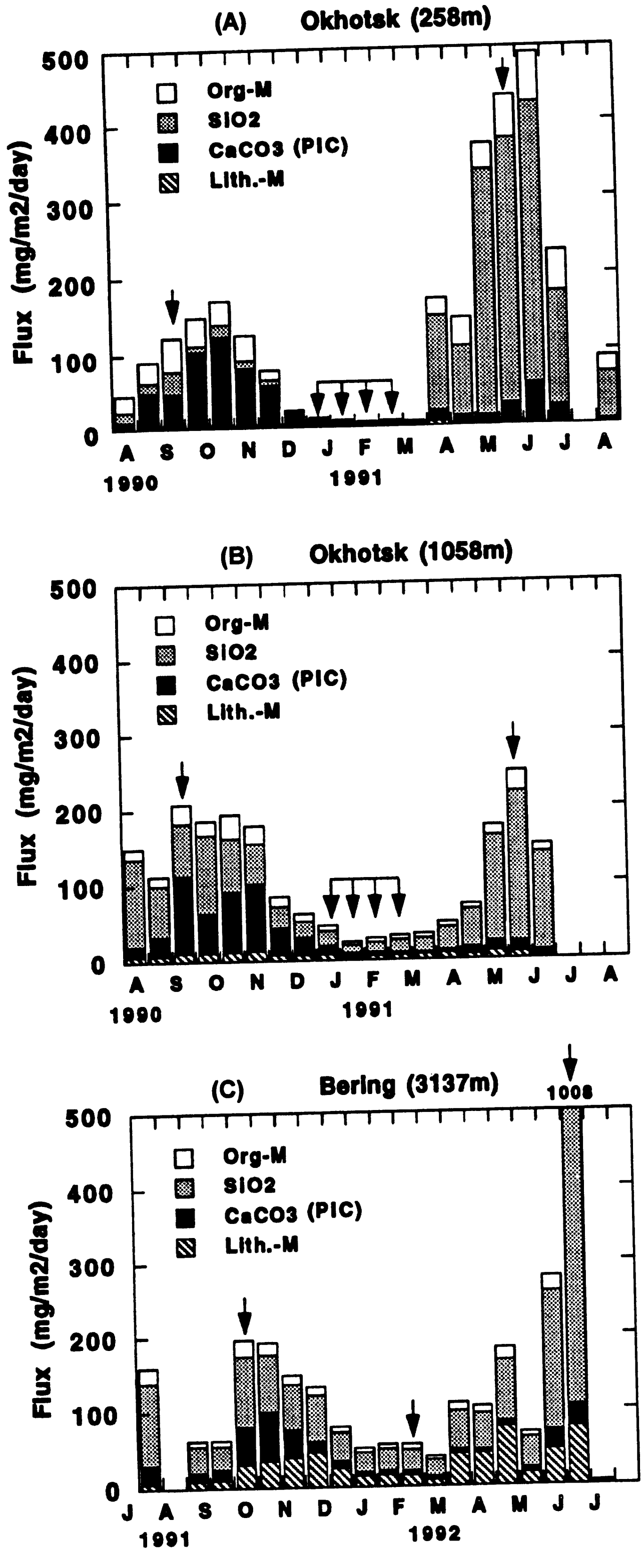

Fig. 1. Seasonal variability in total mass flux and chemical composition of sediment trap samples from: (A) the Sea of Okhotsk (258 m); (B) the Sea of Okhotsk (1058 m); and (C) the Bering Sea (3137 m). Arrows show samples used for PIC^{14}C analysis in this study.

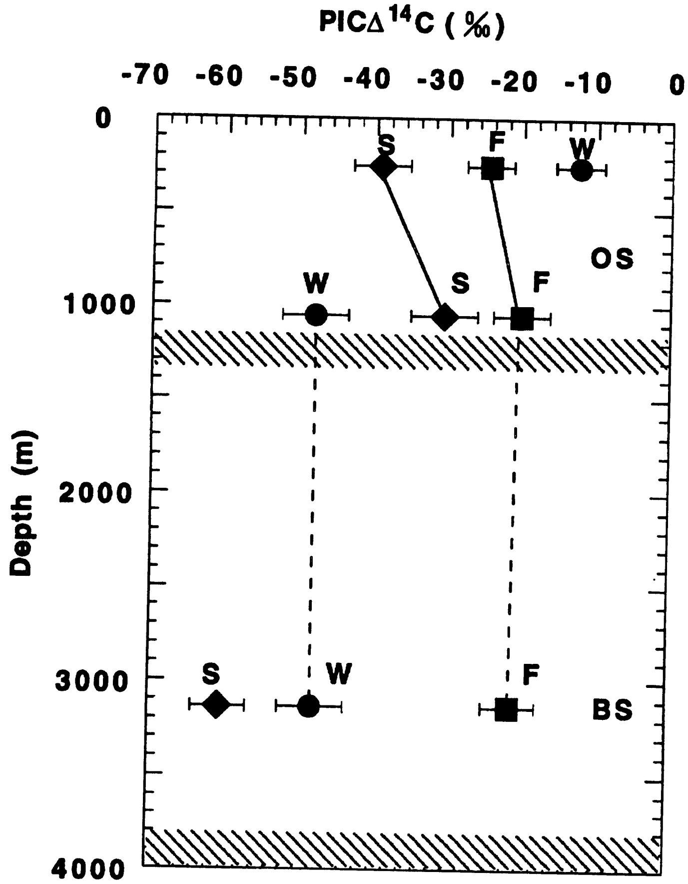

Fig 2. Vertical profile of PICΔ^{14}C of sediment trap sample from the Sea of Okhotsk (OS) and Bering Sea (BS). Letters W, S and F indicate PICΔ^{14}C of samples collected in winter, spring and fall, respectively. Hatched areas indicate the sea floors for each area.

On the other hand, there have been few reports on the effect of formalin on inorganic carbon isotope values. From stoichiometry, formalin should not bind to inorganic carbon, and it is unlikely that CO_2 is extracted from organic carbon in our samples during acidification for ^{14}C analysis. In addition, the relation between $\Delta^{14}C$ and $\delta^{13}C$ observed on our sediment trap samples cannot be explained as a result of formalin. Assuming that (1) the $\Delta^{14}C$ value and $\delta^{13}C$ value of formalin were: −1000‰ and −30 to −40‰, respectively; (2) initial (not contaminated) PICΔ^{14}C and PICδ^{13}C for all samples were 0‰ and 0.6‰, respectively; and (3) both carbon isotopes change with the degree of contamination by formalin, *i.e.*, with the proportion of formalin-carbon to total PIC, then the observed relation between the two carbon isotopes should be in the hatched area in Figure 4. Figure 4 also shows PICΔ^{14}C and PICδ^{13}C, and DICΔ^{14}C and DICδ^{13}C at the GEOSECS Bering Sea station (Stn. G219: 53.6°N, 177.2°E) observed in October 1973. The trend between PICΔ^{14}C and PICδ^{13}C corresponds well to that between DICΔ^{14}C and DICδ^{13}C, in contrast to the trend caused by formalin. Although the absolute $\delta^{13}C$ values between sea ater and the sediment trap samples differ, this can be explained by the biological fractionation effect between them reported previously ($\delta^{13}C$ of planktonic foraminifera test such as *G. bulloides* and *N. pachyderm* is *ca.* 1‰ lower than that of seawater; Kahn and Williams 1981). Based on these considerations, the effect of formalin on PICΔ^{14}C and PICδ^{13}C is not significant in this study.

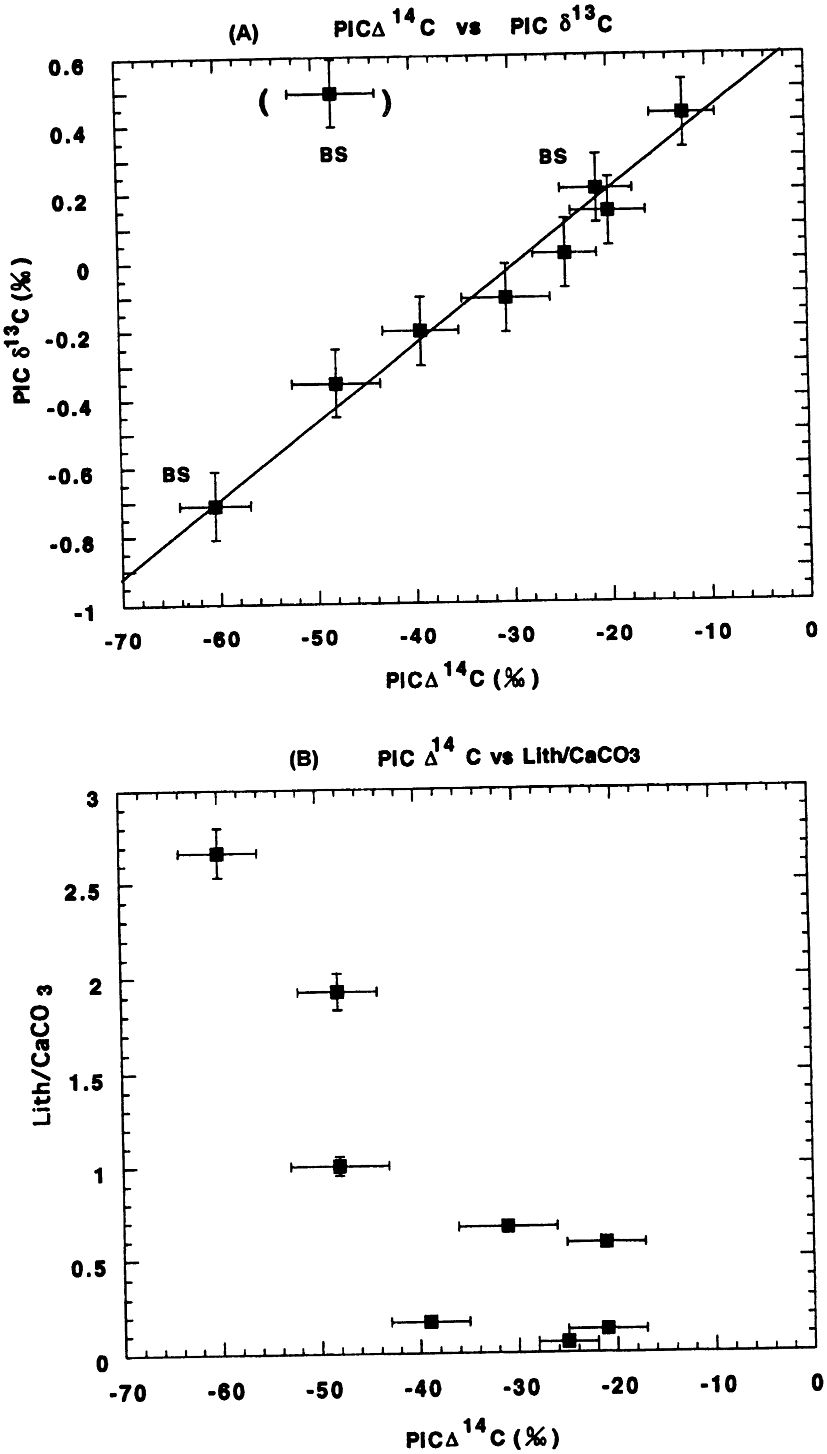

Fig. 3. Relation between (A) PICΔ^{14}C and PICδ^{13}C and (B) PICΔ^{14}C and ratio of concentration of lithogenic materials to total carbonate concentration (Lith/$CaCO_3$)

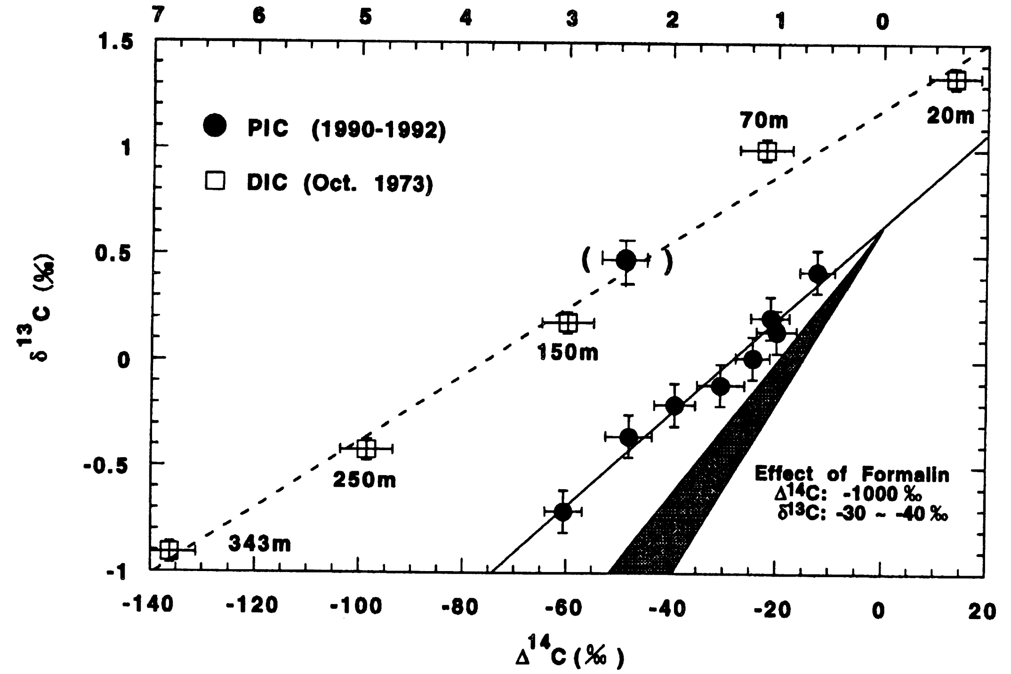

Fig. 4. DIC$\Delta^{14}C$ and DIC$\delta^{13}C$ (□) in the Bering Sea station G219 in October 1973 (Östlund and Stuiver 1980). ● = PIC$\Delta^{14}C$ and PIC$\delta^{13}C$. If initial values of PIC$\Delta^{14}C$ and PIC$\delta^{13}C$ for all samples are 0‰ and 0.62‰, respectively, and samples were significantly contaminated by formalin with a low $\Delta^{14}C$ value of −1000 ‰ and a low $\delta^{13}C$ value of −30 to −40‰, PIC$\Delta^{14}C$ and PIC$\delta^{13}C$ values should change within the hatched area.

Ocean Surface $\Delta^{14}C$ in the Bering Sea and the Sea of Okhotsk

The GEOSECS $\Delta^{14}C$ data in the northwestern North Pacific were obtained in the early 1970s (Östlund and Stuiver 1980). As a whole, upper ocean $\Delta^{14}C$ values in the northern North Pacific and the Equatorial zone are lower than those of other areas because subsurface water upwelling with low $\Delta^{14}C$ dilutes $\Delta^{14}C$ in the upper ocean, and bomb-produced ^{14}C is transported laterally to mid-latitudes (Broecker *et al.* 1985). In particular, the $\Delta^{14}C$ value of upper water in the Bering Sea is low (+13‰ at 20 m water depth at Stn. G219) in October 1973 and the mean $\Delta^{14}C$ value of the upper 100 m was calculated to be −5‰. Alderman, Honjo and Curry (1996) analyzed species composition and isotopic variability ($\delta^{13}C$ and $\delta^{18}O$) of planktonic foraminifera in our sediment trap samples from the Sea of Okhotsk. They found that the fractions of *N. pachyderma* and *G. bulloides* are 57% and 31% of total foraminifera flux, respectively, and that both species calcified between 20 m and 50 m water depth. If the remains of inorganic carbon collected in our sediment traps were produced by phytoplankton (cocolithophorids), such as *Emiliani huxleyi* that lived near the surface in the northwestern North Pacific (Honjo and Okada 1974), PIC$\Delta^{14}C$ values should reflect DIC$\Delta^{14}C$ in this upper layer.

Moreover, when our sediment trap experiments were carried out in the early 1990s, *ca.* 20 yr had passed since the GEOSECS Pacific expedition. As shown in the coral reef record from Florida (Druffel and Linick 1978; Druffel and Suess 1983) and Pacific corals (Druffel 1987), $\Delta^{14}C$ in the surface ocean has been decreasing at mid-gyre regions since GEOSECS observation. Broecker *et al.* (1985) assumed that this decreasing trend of $\Delta^{14}C$ can be applied to all of the ocean, including upwelling areas such as the northern North Pacific and the equatorial zone. Using this assumption and extrapolating the decreasing trend, as shown in Figure 5, we estimate surface $\Delta^{14}C$ values in the Bering Sea and northwestern North Pacific (Table 2). Although estimated $\Delta^{14}C$ values for the northwestern North Pacific (Stn. G217, G218, G222) do not reach negative values, $\Delta^{14}C$ for the Bering Sea (G219) is estimated to be –20‰, which is close to our observed values in the fall season (–21 to –25‰).

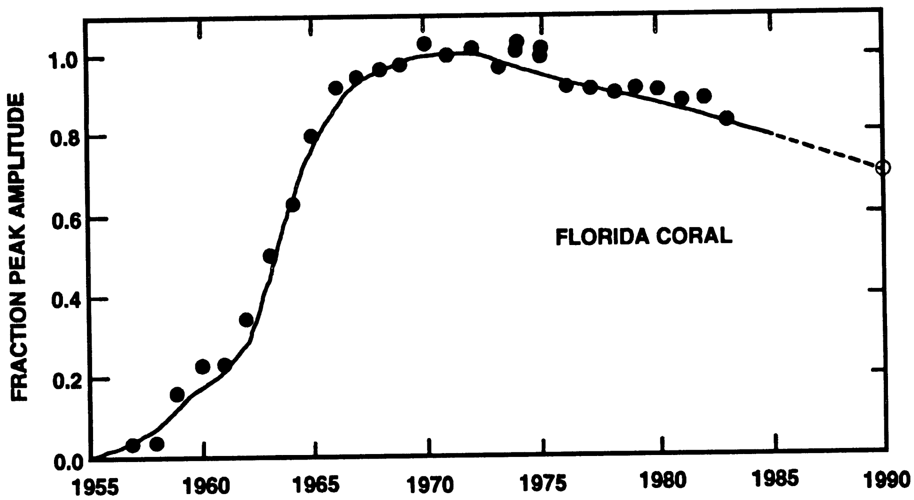

Fig. 5. Shape of $\Delta^{14}C$ *vs.* time trend adopted for all surface ocean sites (Broecker *et al.* 1985). It is based on a model run that fits the ring-dated coral results obtained by Druffel and Linick (1978) and Druffel and Suess (1983) for the Florida Straits.

TABLE 2. Time History of DIC$\Delta^{14}C$ of Surface Water in the Northwestern North Pacific Expected with the Time Trend in Figure 5

Year		1955	1973	1985	1990
Fraction peak amplitude*		0.00	1.00	0.79	0.70
Station	Lat., Long.	$\Delta^{14}C_{(1955)}$* (‰)	$\Delta^{14}C_{(1973)}$† (‰)	$\Delta^{14}C_{(1985)}$‡ (‰)	$\Delta^{14}C_{(1990)}$‡ (‰)
G217	44.36°N, 176.50°W	–80	68	37	24
G218	50.26°N, 176.35°W	–90	63	31	17
G219 (Bering Sea)	53.60°N, 177.18°W	–100	14	–10	–20
G222	40.10°N, 160.30°W	–70	84	52	38

*Broecker *et al.* (1985)
†Östlund and Stuiver (1980)
‡$\Delta^{14}C_{(year)} = (\Delta^{14}C_{(1973)} - \Delta^{14}C_{(1955)}) \times FPA_{(year)} + \Delta^{14}C_{(1955)}$

There is no DIC$\Delta^{14}C$ data for the Sea of Okhotsk. However, $\Delta^{14}C$ for the pre-bomb period recorded in bivalve shells from the surface of the Sea of Okhotsk and the Bering Sea were both *ca.* –110‰, (J. Southon, personal communication 1996). This indicates that both regions have similar ocean structure and DIC$\Delta^{14}C$, and that the time histories of $\Delta^{14}C$ in both oceans after nuclear testing are also similar. Therefore, it is likely that the $\Delta^{14}C$ values of the sediment trap samples reflect DIC$\Delta^{14}C$

of the upper ocean in the Bering Sea and the Sea of Okhotsk, and that $\Delta^{14}C$ values in the upper ocean in both areas were negative in the early 1990s.

What Causes the Seasonal Variability in Surface ^{14}C?

As mentioned above, PIC$\Delta^{14}C$ values showed significant seasonal variation: high PIC$\Delta^{14}C$ in fall and low PIC$\Delta^{14}C$ in winter, with a difference of *ca*. 30‰. What causes this seasonal variability in PIC$\Delta^{14}C$ (or DIC$\Delta^{14}C$)?

Biological activity in the upper ocean changes seasonally, as results of sediment trap experiments show, becoming higher in spring and summer than in winter. When organic carbon is assimilated in and removed from the upper ocean, the lighter stable carbon isotope (^{12}C) is used preferentially and both $\delta^{13}C$ and $\Delta^{14}C$ of seawater should become higher. However, DIC$\Delta^{14}C$ does not change, because it is corrected for isotope fractionation. The CO_2 exchange rate at the air-sea boundary also changes seasonally. The faster the CO_2 exchange rate, the greater the increase in $\Delta^{14}C$ of surface seawater, because atmospheric $\Delta^{14}C$ is higher than that of surface seawater (*e.g.*, Nydal and Lovseth 1983). In general, the CO_2 exchange rate could increase in winter because it is said to be wind-dependent (Tans, Fung and Takahashi 1990). If the CO_2 exchange rate affected $\Delta^{14}C$ of surface seawater significantly, $\Delta^{14}C$ of surface seawater could be higher in winter than in fall. However, the observed change in DIC$\Delta^{14}C$ is completely opposite to this. It is, therefore, unlikely that the above two phenomena change DIC$\Delta^{14}C$ of the upper ocean significantly.

Another possibility is the change in mixed layer thickness. Dodimead (1967) reported that the thickness of the winter mixed layer reached *ca.* 150 m in the northwestern North Pacific (subarctic zone). In the case of the Sea of Okhotsk, the thickness of the winter mixed layer should be, at most, 150 m, because of the existence of a dichothermal layer (cold halocline; Kitani (1973)). Assuming that the upper ocean is stratified in the fall season and that the upper 150 m is well mixed in winter, we calculated the difference between $\Delta^{14}C$ values in summer and winter using GEOSECS $\Delta^{14}C$ data at the Bering Stn. G219 (Östlund and Stuiver 1980). As shown in Figure 6, the mean values of $\Delta^{14}C$ for each layer of 0–50 m, 50–100 m and 100–150 m were +3, –22 and –60‰, respectively. Assuming that there is no CO_2 exchange at two boundaries (the atmosphere / the upper layer and the lower layer / water mass below 150 m) and total dissolved carbon (ΣCO_2) for each layer is the same, $\Delta^{14}C$ of the mixed layer of 150 m in the winter can be estimated to be –26‰ (Fig. 6). The difference of $\Delta^{14}C$ in the upper 50 m between summer and winter is 29‰, which is approximately coincident with the difference between fall values and winter values observed in our sediment trap samples (26‰). Therefore, it can be concluded that much of the observed difference in $\Delta^{14}C$ is attributable to the change of surface mixed layer thickness.

However, it is still difficult to explain the maximum and minimum $\Delta^{14}C$ values. The maximum value of $\Delta^{14}C$ (–12‰) is obtained from the winter sample in the Okhotsk shallow sediment trap, and the total mass flux of this sample is quite small. At least two processes could increase the $\Delta^{14}C$ values: 1) contamination of air with high $\Delta^{14}C$ during sample preparation or analysis and; 2) "fresh" terrestrial material input. Because of the relatively small volume, these processes might affect PIC$\Delta^{14}C$ significantly.

On the other hand, the minimum value (–60‰) is obtained from the Bering spring sample, which is the largest mass flux among the sample set due to the spring bloom. One possibility is input of old resuspended sea-floor sediment. We used the bulk carbonate for $\Delta^{14}C$ analysis. Although we assume that this carbonate consisted of tests of cocolithophorids and foraminifera living in the upper ocean, old terrestrial inorganic carbon might be included. Negative $\Delta^{14}C$ values observed recently in sediment trap samples from other locations were attributed to the input of old terrestrial material or sea-

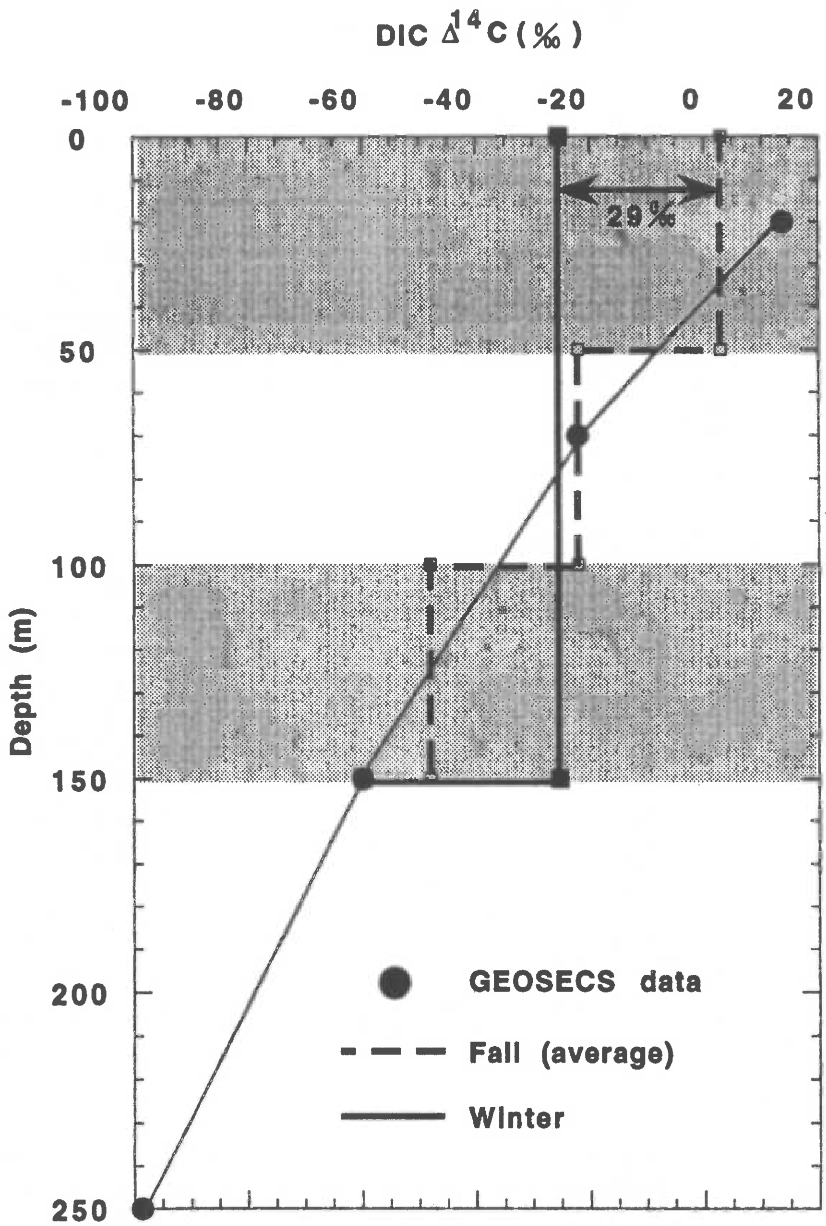

Fig. 6. Expected seasonal change in DICΔ^{14}C in the upper ocean. DICΔ^{14}C values are obtained from GEOSECS data (Östlund *et al.* 1987). The change in DICΔ^{14}C between fall and winter is calculated to be 29‰.

floor sediment resuspended on the deep-sea floor (Anderson *et al.* 1994; Nakatsuka 1995). In the case of the Bering spring sample, the Lith/$CaCO_3$ ratio was the highest among sediment-trap samples used in this study (Table 1). If lithogenic materials collected by the sediment trap were derived from sea-floor sediment, and the carbonate concentration in sea-floor sediment was 5%, *ca.* 13% of the total carbonate collected by sediment trap could be that of sea-floor sediment. Assuming that

$\Delta^{14}C$ of carbonate without sea-floor carbonate is –35‰, which is the average PIC$\Delta^{14}C$ of the Okhotsk spring samples, the $\Delta^{14}C$ of sea-floor carbonate is estimated to be –227‰. Walsh *et al.* (1985) measured $\Delta^{14}C$ of carbonate in sea-floor sediment on the shelf (390 m) and slope (1500 m) in the Bering Sea. The $\Delta^{14}C$ of carbonate in surface sediments (upper 20 cm) on the shelf and slope were *ca.* –400‰ and –160‰, respectively. Estimated $\Delta^{14}C$ (–227‰) is thus within the range observed by Walsh *et al.* (1985). The good correlation between PIC$\Delta^{14}C$ and Lith/$CaCO_3$ can be seen in Figure 3B. Although the carbonate concentrations and $\Delta^{14}C$ values in sea-floor sediment are unknown, good correlation between them might mean that the higher the contribution of carbonate in lithogenic material to total carbonate collected by sediment traps, the lower the PIC$\Delta^{14}C$. It is, therefore, likely that the lower values are attributed to the presence of a resuspended carbonate component in the trap material, and it is possible that resuspended carbonate affects PIC$\Delta^{14}C$ slightly.

Conclusion

Particulate inorganic ^{14}C in sediment trap samples from the Sea of Okhotsk and the Bering Sea were analyzed by NOSAMS. $\Delta^{14}C$ showed negative values and varied seasonally. It is likely that these results are principally due to the decrease of bomb-produced ^{14}C concentration in the ocean surface since the GEOSECS period, and the seasonal changes in mixing layer thickness, respectively. Time-series sediment trap sample data appear to be useful for the determination of DIC$\Delta^{14}C$ in the upper ocean. However, this trial is just the first step toward applying sediment trap sample $\Delta^{14}C$ to determine the seasonal variability in mixed layer thickness or CO_2 exchange rate. In further experiments, the following procedures are strongly recommended: 1) carbonate of sediment trap samples used for ^{14}C analysis should be well characterized, *i.e.,* only carbonate produced in the upper ocean should be used and; 2) a sediment trap should be deployed just below the euphotic zone, and a conductivity/temperature/depth probe (CTD) that can observe the conservative quantities such as salinity and temperature should also be deployed to observe the change in ocean structure and detect the change in DIC$\Delta^{14}C$ by CO_2 exchange.

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[RADIOCARBON, VOL. 38, No. 3, 1996, P. 597–602]

REGIONAL RADIOCARBON EFFECT DUE TO THAWING OF FROZEN EARTH

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ABSTRACT. Accelerator mass spectrometry (AMS) measurement of 25 single-year tree rings from AD 1861–1885 at *ca.* ±3.5‰ precision shows no evidence of an anomalous 11-yr cycle of ^{14}C near the Arctic Circle in the Mackenzie River area. However, the $\Delta^{14}C$ measurements are lower on average by 2.7 ± 0.9 ($\bar{\sigma}$)‰ relative to ^{14}C measurements on tree rings from the Pacific Northwest (Stuiver and Braziunas 1993). We attribute this depression of $\Delta^{14}C$ to thawing of the ice and snow cover followed by melting of frozen earth that releases trapped ^{14}C-depleted CO_2 to the atmosphere during the short growing season from May through August. Correlation of $\Delta^{14}C$ with May–August estimated temperatures yields a correlation index of r = 0.60. The reduction in $\Delta^{14}C$ is dominated by seven years of anomalous depletion. These years are 1861, 1867–1869, 1879–1880 and 1883. The years 1867–1869 are coincident with a very strong ENSO event.

INTRODUCTION

This work is a continuation of a preliminary study of $\Delta^{14}C$ variations in tree rings (*Picea glauca*, white spruce) from the Grand View site, Mackenzie River area of the Northwest Territories of Canada at 67°N, 130°W (Damon *et al.* 1992). The preliminary study was prompted by a report that $\Delta^{14}C$ measurements on tree rings from that site "exhibit a 10‰ fluctuation with an 11-yr periodicity anticorrelated with the solar activity cycle" (Fan *et al.* 1986: 300). Such a large variation in the 11-yr Schwabe cycle is not predicted from global carbon cycle models that yield a peak-to-trough variation of *ca.* 2‰ (*e.g.*, Damon, Sternberg and Radnell 1983; Stuiver and Braziunas 1993). This large variation would require a highly significant regional effect and, consequently, demanded verification. Our preliminary study did not verify an anomalous variation in the 11-yr $\Delta^{14}C$ cycle. However, both studies suggested a smaller regional effect involving significantly lower average $\Delta^{14}C$ measurement of 2.6 ± 0.9 ($\bar{\sigma}$) ‰ when compared to trees from the U.S. Pacific Northwest (Stuiver and Braziunas 1993). We suggested that this lowering could be caused by release of ^{14}C-depleted CO_2 from the continuous thawing of frozen earth during the relatively short growing season near the Arctic Circle. As pointed out in our preliminary paper, such effects are not unprecedented, and the effect observed for the Grand View site would require addition of only 5% ^{14}C-depleted CO_2 to the prevailing air mass during the short growing season.

To further confirm this regional effect, we obtained additional measurements on previously measured samples and extended the measurements back to AD 1861, providing a set of 25 $\Delta^{14}C$ measurements.

METHODS

The methodology is essentially the same as in the preliminary paper (Damon *et al.* 1992) except for the introduction of a 32-position carousel to the accelerator mass spectrometer. Eight positions are occupied by 4 each of NIST Oxalic Acid I and II (HOxI and HOxII). Typically two blanks are included, leaving 22 positions for samples to be measured.

The analysis provides the measured ratios, $^{14}C/^{13}C$ for the samples and standards. The ratios are corrected for isotope fractionation. It is customary to normalize the standards to the year 1950 AD, corrected to remove the Suess effect (which is dominated by a decrease in the atmospheric isotopic ^{14}C

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concentration due to the combustion of fossil fuels, but also includes the lesser effects of a decreasing magnetic field and increasing solar activity). The normalization factors when measuring $^{14}C/^{13}C$ ratios are as follows (Donahue, Linick and Jull 1990):

$$(14/13)_{1950[-25]} = 0.9558\ (14/13)_{HOxI[-19]} = 0.7404\ (14/13)_{HOxII[-17.8]} \tag{1}$$

where the isotopic composition of HOxI relative to the PDB stable carbon isotope standard is –19‰ and for HOxII, –17.8‰. From the corrected ratios, a fraction modern is obtained, defined as

$$F = \frac{(^{14}C/^{13}C)_{sample}}{(^{14}C/^{13}C)_{STD}} \tag{2}$$

The quantity F is then used to calculate $\Delta^{14}C$ in Equation 3

$$\Delta^{14}C = [(Fe^{\lambda(1950-\tau)} - 1)\ 1000 \tag{3}$$

where τ is the sample age measured in calendar years and λ is based on the 5730-yr half life ($\lambda = 1/8270\ yr^{-1}$). The normalization in Equation (1) is such that $\Delta^{14}C$ passes through zero in the mid-19th century prior to the Suess effect.

May through August temperatures were estimated using tree-ring density data measured by X-ray and image analysis (Thetford, D'Arrigo and Jacoby 1991).

Results and Discussion

The Mackenzie River data are presented in Table 1 and are plotted along with the Pacific Northwest data of Stuiver and Braziunas (1993) in Figure 1. Data from the Grand View site are lower than the data from the Pacific Northwest by –2.7 ± 0.9 ($\bar{\sigma}$) ‰. However, the difference would not be significant if 7 yr of the 25-yr sequence less than –10.0‰ were eliminated from the comparison (1861, 1867–1869, 1879–1880 and 1883). The remaining 18 results would differ from the Pacific Northwest data by only –0.4 ± 0.7 ($\bar{\sigma}$) ‰. This is excellent but fortuitous agreement because the two sites are not environmentally equivalent. In evaluating this –2.7‰ average depression of $\Delta^{14}C$ at the Grand View site relative to the Pacific Northwest, it should be recalled that there is evidence for a marine west coast USA regional effect involving an average depression of *ca.* –4‰ relative to Irish oak or Douglas-fir from the Santa Catalina Mountains near Tucson (Damon 1995; McCormac *et al.* 1995). This has been attributed to the upwelling of ^{14}C-depleted CO_2 along the Pacific west coast. This implies a Grand View site average depression relative to the Irish and Santa Catalina sites of *ca.* –6.7% (*ca.* 56 yr). Even if we eliminate the 7 most negative $\Delta^{14}C$ values from the Grand View site, agreement of the remaining 18 with the Pacific Northwest implies that both sites are depleted with respect to the Irish and Santa Catalina sites. However, there appears to be secular variation in depletion for both the Grand View site and the Pacific Northwest. In the earlier paper (Damon *et al.* 1992), we suggested that this relative depression could be the result of the thawing of frozen earth, releasing ^{14}C-depleted CO_2 during the short growing season (May–August). The extent of thawing would depend on temperatures during the growing season, with variance from season to season resulting in more or less depletion.

If this hypothesis is valid, there should be a relation between $\Delta^{14}C$ and prevailing temperatures during the growing season in the Mackenzie region. High average May through August temperatures would result in deeper melting of frozen earth with continuous release of ^{14}C-depleted CO_2, and, presumably, the deeper the melt zone, the more ^{14}C-depleted the released CO_2. Figure 1 shows a plot

TABLE 1. Analytic Data for Cellulose from Annual Tree Rings from the Grand View Site, NWT (67°N, 130°W)

Date (AD)	F_m*	N	$\Delta^{14}C$ (‰)	$\pm \bar{\sigma}$ (‰)	$\delta^{13}C$ (‰)
1861	0.9775	3	−11.9	3.7	−23.2
1862	0.9845	3	− 5.0	3.6	−24.2
1863	0.9870	3	− 5.1	3.7	−23.0
1864	0.9837	3	− 6.0	3.8	−24.7
1865	0.9908	3	1.0	3.5	−23.4
1866	0.9833	3	− 6.7	3.4	−23.9
1867	0.9788	3	−11.3	3.5	−23.0
1868	0.9705	3	−19.8	3.4	−24.3
1869	0.9768	3	−13.6	3.3	−23.8
1870	0.9882	8	− 2.2	2.2	−22.8
1871	0.9833	7	− 7.3	2.3	−25.2
1872	0.9866	9	− 4.0	2.1	−23.5
1873	0.9844	9	− 6.4	2.1	−23.5
1874	0.9818	4	− 9.1	3.2	−22.7†
1875	0.9818	5	− 9.3	3.4	−22.7†
1876	0.9853	5	− 5.8	2.7	−23.1
1877	0.9828	4	− 8.5	7.5	−22.7†
1878	0.9888	5	− 2.6	3.4	−21.8
1879	0.9813	5	−10.2	2.8	−22.7†
1880	0.9794	4	−12.3	3.5	−22.7†
1881	0.9854	4	− 4.4	3.6	−23.1
1882	0.9866	4	− 5.3	3.2	−22.7†
1883	0.9810	3	−11.0	3.4	−22.7†
1884	0.9897	4	− 2.4	2.7	−23.3
1885	0.9892	5	− 3.0	2.7	−22.7†

*F_m = weighted average of N analyses
†Average of 7 analyses

of May–August temperatures (inverted scale) for a site in the Franklin Mountains near the Grand View site compared with the $\Delta^{14}C$ from the Grand View site. Visual inspection suggests that a correlation may exist. Figure 2 presents a plot of $\Delta^{14}C$ *vs.* May–August average temperature. The quadratic polynomial curve fitted by minimum least squares deviation provides a reasonable fit to the data as shown. Only 5 of the 25 samples lie outside of 1 s.d. from the curve. The year 1868 plots at 3 σ from the curve but appears to be the culmination of the most intense negative fluctuation of $\Delta^{14}C$ from 1867–1869 (Fig. 1), which is accompanied by a maximum of temperatures (Fig. 1). It is interesting that the years 1867–1869 exactly coincide with a very strong ENSO event (Quinn 1992). The correlation index for the curve in Figure 2 is 0.60, indicating that 36% of the variation can be explained by the dependence of $\Delta^{14}C$ on May–August temperatures, where at first there is little dependence of $\Delta^{14}C$ on temperatures and then a significant decrease of $\Delta^{14}C$ when the growing season temperature exceeds 11.5°C. The scatter about the quadratic polynomial curve in Figure 2 is compatible with the $\Delta^{14}C$ measurement errors. However, because 11.5°C appears to be a threshold below which $\Delta^{14}C$ is independent of temperature, an equally good fit could be obtained with two straight lines.

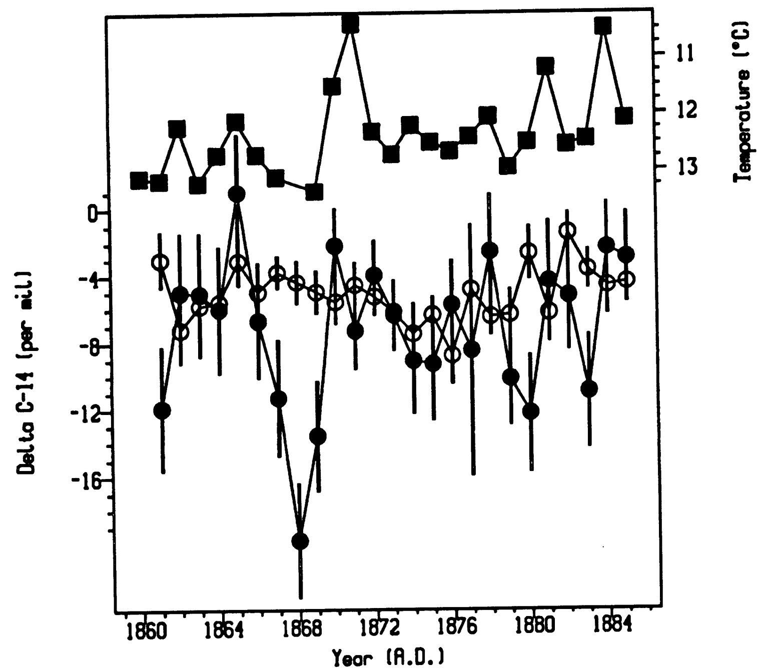

Fig. 1. $\Delta^{14}C$ from two locations for the interval AD 1861 to AD 1885. ● = data from Table 1 (Grand View site); O = data from the Pacific Northwest, USA (Stuiver and Braziunas 1993). ■ = estimated May through August temperatures determined densitometrically for trees from a nearby site.

Conclusion

The following conclusions seem to be warranted by the data:

1. There is no evidence for an anomalously intense 11-yr cycle at high latitudes in the Mackenzie River area during the time period AD 1861–1885.
2. There is an average difference of -2.7 ± 0.9 ($\bar{\sigma}$) ‰ between $\Delta^{14}C$ values for tree rings from the Pacific Northwest, USA compared with tree rings from the Grand View site near the Arctic Circle, N.W.T., Canada. However, this difference is dominated by seven years: 1861, 1867–1869, 1879–1880 and 1883. The years 1867–1869 coincide exactly with a very strong ENSO event.
3. The correlation index for a quadratic polynomial fit to $\Delta^{14}C$ *vs*. May through August temperatures in that area is $r = 0.60$, suggesting that 36% of the variance is related to temperature. Measurement errors are compatible with the scatter about the quadratic polynomial curve.
4. The −2.7‰ depletion of $\Delta^{14}C$ in tree rings from the Grand View area corresponds to a *ca*. 22-yr older apparent age when compared to tree rings from the Pacific Northwest, USA. On the other hand, Douglas-fir from the Santa Catalina Mountains near Tucson and Irish oak (Damon 1995; McCormac *et al.* 1995) would yield apparent ages *ca*. 33 yr (+4‰) younger than tree rings from the Pacific Northwest. We conclude from this that regional effects are not negligible, even within the northern hemisphere, and must be taken into consideration in the calibration of ^{14}C dates.

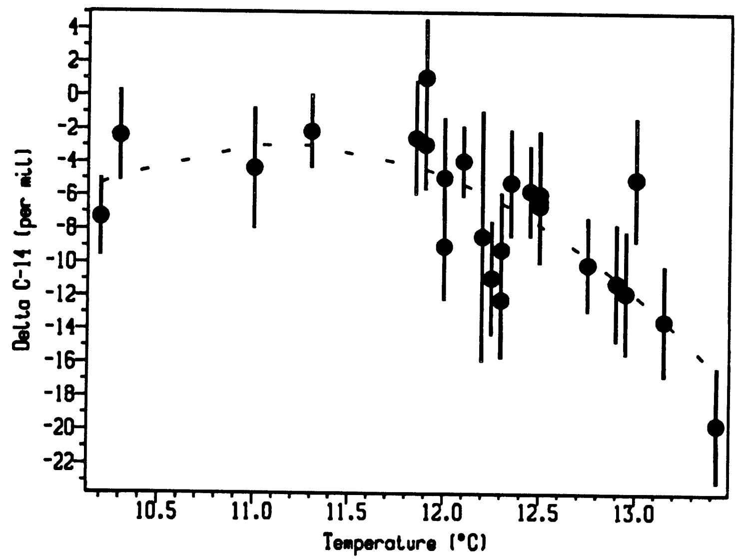

Fig. 2. $\Delta^{14}C$ *vs.* May through August estimated temperatures. With no points eliminated, the correlation index $r = 0.60$ suggests that the $T - \Delta^{14}C$ relationship explains 36% of the variance. Eliminating the one anomalous point increases the correlation to 41%. The scatter about the quadratic polynomial reference line is explainable by the $\Delta^{14}C$ measurement errors. There is little variation below 11.5°C, which appears to be a threshold. Hence, the curve could be replaced by two straight lines as an equally good fit.

A negative $\Delta^{14}C$ for tree rings from the Grand View area implies the addition of ^{14}C-depleted CO_2 into the prevailing atmosphere accessible to the trees during the growing season in that area. The most likely source of ^{14}C-depleted CO_2 is its release during the thawing of ice, snow and frozen earth. We documented the existence of a similar effect for radon in a previous paper (Damon *et al.* 1992). A study of CO_2 in soil gas above the water table from the western Great Plains of the United States has shown that CO_2 and $^{14}CO_2$ are biologically generated, with partial pressures 1–2 orders of magnitude greater than those in the atmosphere (Haas *et al.* 1983; Thorstenson *et al.* 1983). Hence, the diffusion gradient of CO_2 is toward the surface and, as a consequence, surface $\Delta^{14}C$ is depleted by as much as 23% relative to the open atmosphere. $\Delta^{14}C$ decreased with depth until the water table was reached. The ^{14}C concentration at depth but above the water table reduced to as little as a few percent modern. If, as seems likely, a similar $\Delta^{14}C$ gradient exists at the Grand View site, ^{14}C-depleted CO_2, like radon, would be trapped below the ice and snow cover during the long season of freezing temperatures until it is released during the thaw in late spring. Subsequently, melting of frozen earth would release more ^{14}C-depleted CO_2; the deeper the melting, the more ^{14}C-depleted the CO_2. Therefore, there would be a tendency toward lower $\Delta^{14}C$ values in seasons with warmer May through August temperatures, as shown in Figure 2. For example, let us assume that the trapped CO_2 is 25% depleted and has the same $\delta^{13}C$ as the average in Table 1 (–23.5‰). If the atmosphere at tree level contains 5% of the released soil gas, it would be depleted in ^{14}C by –11.5‰ and its $\delta^{13}C$ would be –7.8‰. The –0.8 ‰ shift in $\delta^{13}C$ is small compared to the spread of $\delta^{13}C$ values in Table 1 of 3.4‰. Thus, variation other than the admixing of soil gas dominates the $\delta^{13}C$ measurements, considering that measured precision is < ±0.1‰.

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NOTES AND COMMENTS

TOWARD AN ABSOLUTE CHRONOLOGY AT ELK LAKE, MINNESOTA

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ABSTRACT. Radiocarbon measurements on organic carbon from the varved cores of Elk Lake, Minnesota suggest that the varve count may underestimate calendar years by 18% for the most recent 3800 varve years.

INTRODUCTION

Anderson *et al.* (1993) report a Holocene chronology constructed by counting varves in a 22-m series of cores recovered from the deepest portion of Elk Lake in Minnesota (47°12′N, 95°15′W). Sprowl (1993) used multiple varve counts from four parallel cores recovered from Elk Lake to estimate the counting precision of Elk Lake varves. He found that the imprecision averaged 12% at the 95% confidence level. However, Sprowl observed that counting errors were probably not normally distributed since the probability of counting too few varves seemed greater than that of counting too many. The problem of uncounted varves suggests that Elk Lake varve years underestimate calendar years by an unknown amount.

Anderson *et al.* (1993) reported 16 radiocarbon measurements on organic material from the Elk Lake cores. The purpose of the present analysis is to estimate the fraction of uncounted varves at Elk Lake using these ^{14}C measurements.

METHODS

Two equations are involved in this problem. First is the relation between the ^{14}C ages of lacustrine and terrestrial samples

$$A_{atm}(t) = A_{lake}(t) - A_{old}(t)\,. \tag{1}$$

In this equation, $A_{atm}(t)$ is the ^{14}C age of a terrestrial sample, $A_{lake}(t)$ is the ^{14}C age of an organic sample that grew in Elk Lake, and $A_{old}(t)$ is the contribution to the ^{14}C age of the lake sample from the presence of old carbon in Elk Lake (*i.e.*, due to the reservoir effect).

The second equation provides an explicit relation between Anderson's varve number and calendar years, t

$$t = -((1+f)V + 23)\,. \tag{2}$$

In this equation, f is the fraction of varves that have gone uncounted and V is the varve number (counted from the top of the core). The time variable, t, is chosen to be zero in AD 1950, in agreement with the standard ^{14}C convention. The value 23 results from the fact that $t = 0$ corresponds to AD 1927 in the varve chronology (Anderson *et al.* 1993: 40). (AD 1927 is the estimated date of the uppermost varve to be recovered for the Elk Lake chronology. This date is based upon a known (AD 1903) horizon. More recent varves are suspected to have been disrupted by coring activities since 1967.)

The time-dependent reservoir effect at Elk Lake, $A_{old}(t)$ in Equation (1), is unknown. The lake is located in calcareous glacial till, so the effect is substantial. It is necessary to approximate this quantity in some way in order to proceed.

The climate at Elk Lake has shifted from postglacial through prairie to modern mesic forest stages during the >10,000 yr of the lake's history (Anderson 1993). It is unlikely that the contribution of old carbon to the lake has been constant throughout these climate changes. However, the shift to modern climatic conditions took place *ca.* 3800 varve yr ago. It seems reasonable to expect the long-term average of the reservoir effect to have been approximately constant for at least the past 2800 varve yr. Weathering rates of the calcareous till surrounding the lake would not be expected to change significantly during this latter part of the modern climatic stage at Elk Lake. Thus, I have approximated $A_{old}(t)$ by a constant, A_{old}, and restricted the following analysis to the past 2800 varve yr.

To solve Equations (1) and (2) in this approximation, I proceeded as follows. Nine of Anderson's ^{14}C samples fall within the past 2800 varve yr. I chose a value for f, and used it to compute t for each of these nine samples. $A_{atm}(t)$ can then be obtained from the calibration table of Stuiver and Becker (1993). According to Equation (1), with A_{old} substituted for $A_{old}(t)$, a plot of $A_{atm}(t)$ *vs.* $A_{lake}(t)$ for these nine samples should yield a straight line with unit slope for the correct choice of f. I used a standard unweighted linear regression analysis to compute the slope of $A_{atm}(t)$ *vs.* $A_{lake}(t)$ for various choices of f.

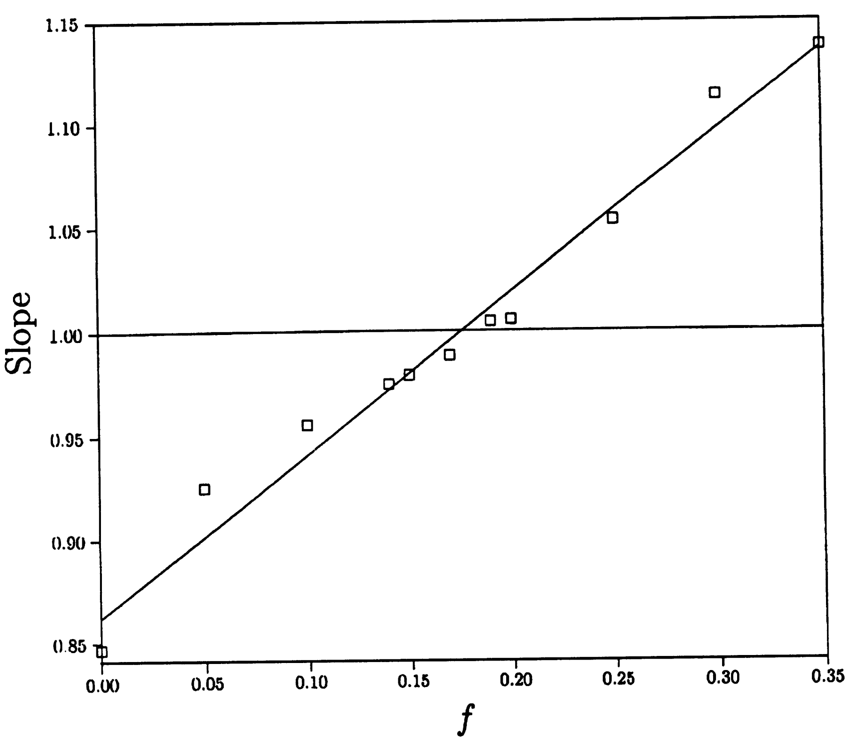

Fig. 1. Calculated slopes of $A_{atm}(t)$ versus $A_{lake}(t)$ for nine ^{14}C samples resulting from various choices of f. The diagonal line results from a linear regression applied to the data points shown.

Results

Figure 1 shows the calculated slopes resulting from different choices of f. The line drawn through the data intersects the slope = 1 line at $f = 0.18 \pm 0.02$. (The reservoir effect for this value of f is found to be 600 ^{14}C yr.) This implies that 18% of annual varves have gone undetected in the Elk Lake varve chronology during the most recent 2800 varve yr. This is a large percentage, but it is not incommensurate with Sprowl's measured varve counting imprecision of 12% at Elk Lake mentioned above.

Conclusion

This result implies that the end of the prairie period at Elk Lake, which occurred 3800 varve yr ago, should be dated to 2500 BC.

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REPORT: SUMMARY OF THE WORKSHOP "ASPECTS OF HIGH-PRECISION RADIOCARBON CALIBRATION"

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From October 4 to 6, 1996, a workshop addressing various aspects of high-precision radiocarbon calibration was held in the Wissenschaftsforum, Heidelberg, Germany. The participants are listed above. The discussion and conclusions of the workshop are summarized in the following sections.

1. Corrections of the Hohenheim German Oak and Pine Chronology

Recently, in an intercomparison of the Hohenheim German oak chronology (Becker 1993) and the Göttingen chronology (Leuschner and Delorme 1988), an error was discovered in the former (Leuschner, in preparation). Due to an error in adding sections at 5241 BC, 41 yr are missing in the published Hohenheim chronology. After correction of the error, the two chronologies synchronize over their entire common length, back to 7200 BC.

The correction leads to a 41-yr shift to older ages for all calibration data based on the Hohenheim German oak chronology prior to 5241 BC. This error explains 41 yr of the 54-yr discrepancy between the Seattle and Belfast data sets, as mentioned in Stuiver and Pearson (1993) and Pearson and Stuiver (1993), and in a footnote in the output of the program CALIB Version 3 (Stuiver and Reimer 1993). It was pointed out earlier that this discrepancy may have been caused by an error in the dendroscale (*e.g.*, McCormac, Baillie and Pilcher 1995).

Before 7200 BC, the Hohenheim German oak is again externally replicated piece-wise by a floating section of the Göttingen chronology, back to 7800 BC. Due to the removal of suspect trees in the course of rebuilding the Hohenheim chronologies, an interval of low replication prior to 7800 BC now exists. Therefore, the earliest oak section (*ca.* 8050–7800 BC) is considered to be floating.

In addition, the tentative ring-width synchronization between German pine and German oak as given by Bernd Becker (Becker 1993; Kromer and Becker 1993) is no longer considered valid. At present, the German pine chronology must be regarded as floating. ^{14}C-based evidence (wiggle-matching of oak and pine at 8800 ^{14}C BP and the slope of the long-term Δ^{14}C (Björck *et al.* 1996)), however, enables its approximate absolute placement. This leads to a likely estimated minimum shift by +120 dendroyears to older ages for the pine chronology when compared to the tentative tree-ring synchronization of Becker (1993).

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2. ^{14}C Calibration Data Sets

The Belfast laboratory presented evidence to support the original ^{14}C data set based on Irish oak (Pearson *et al.* 1986) and expressed concern about the shift of *ca.* 18 yr toward older dates given in the revised 1993 Calibration Issue of *Radiocarbon* (Pearson, Becker and Qua 1993). They stated that ongoing measurements between Belfast and the University of Waikato Laboratories that repeat the 2nd millennium AD Irish oak, at decadal intervals, in both laboratories, will provide firm evidence for the absolute activity of the Irish oak and the validity of either the 1993 or 1986 data sets. The results of this exercise will be complete in *ca.* 2 yr and will be published in *Radiocarbon.*

3. Location-Dependent ^{14}C Differences (Northern Hemisphere)

Damon, Chen and Linick (1989), Jirikowic and Kalin (1993) and McCormac, Baillie and Pilcher (1995) have suggested that differences may exist between the activities of wood from different locations. McCormac, Baillie and Pilcher (1995) showed measured differences between Irish oak, German oak and North American wood when contemporaneous samples of these woods were dated in the same laboratory. The issue was discussed during the workshop using all available published high-precision ^{14}C data sets and comparing data over their respective common intervals (see references cited above, plus Vogel *et al.* 1993; Vogel and van der Plicht 1993; Linick *et al.* 1986; Kalin *et al.* 1995; van der Plicht, Jansma and Kars 1995). Because of possible laboratory offsets it was agreed that only comparisons made in a single laboratory were valid for regional comparisons. The correction of the dates for the error in the German dendrochronology of 41 yr improves the compatibility of the Belfast and Seattle measurements in the interval 5180–5500 BC. However, at the time of writing, the wood used in the German oak / Irish oak comparison (McCormac, Baillie and Pilcher 1995) does not seem to have been affected by the dendrochronological error, and thus an unexplained offset still exists between German and Irish oak of 39 ± 8 yr in the interval 4910–5170 BC. This requires further investigation.

Small systematic differences that exist over the length of the calibration chronologies may represent laboratory offsets. This statement does not rule out location-dependent ^{14}C anomalies in special situations, *e.g.*, due to release of aged $^{14}CO_2$ from soils during thawing in arctic areas (Damon 1995) or phase differences on the scale of a few years (Jirikowic and Kalin 1993); these conditions, however, do not apply to the decadal or bidecadal tree-ring series used for ^{14}C calibration.

The relation between European and North American wood has been studied using Douglas-fir and bristlecone pine (BCP) for the American side, and the European oak series for Europe. Douglas-fir does not show a measurable difference (> 15 yr) from German and Irish oak for the substantial data set that was established for the time interval AD 900–1840 (Pearson *et al.* 1986; Kalin *et al.* 1995; Stuiver and Becker 1993; van der Plicht and McCormac 1995). The same conclusion is drawn from the comparison of BCP with German oak at 2000 BC (Vogel *et al.* 1993). In the comparison at 500 BC (McCormac, Baillie and Pilcher 1995), Irish oak appears systematically younger by *ca.* 40 yr, and in the 7th millennium BC, ^{14}C offsets between German oak (corrected dendroscale) and BCP (Linick *et al.* 1986) are even larger during intervals of up to a century.

Presently the causes of these discrepancies cannot be resolved; it was noted, however, that they are largest for older intervals, and for large differences in the years when the ^{14}C analyses were made in the respective laboratories. In addition, errors in wood selection and/or ring-width synchronization have been noted in the course of the cooperation between dendrochronology and ^{14}C dating. Therefore, the workshop participants agreed on further intercomparison of BCP to the European oak series at selected intervals to help resolve this open issue.

Further support for only minimal intrahemispheric gradients was offered from the presentation of the modern atmospheric $^{14}CO_2$ network (Levin *et al.* 1992). When the present-day fossil-fuel $^{14}CO_2$ depression of the mid-Northern Hemisphere is scaled to the ^{14}C-depleted North Pacific source of CO_2, an atmospheric signal of 0.5–1‰ is estimated for the preindustrial situation. This estimate is identical to the GC-model results of Braziunas, Fung and Stuiver (1995), which show strong zonal homogeneity in the Northern Hemisphere, with maximum gradient of +1‰ in mid-latitudes, from which all tree-ring chronologies used for ^{14}C calibration derive.

4. Error Estimates During Wiggle-Matching

Some calibration programs offer the option of wiggle-matching of floating ^{14}C series, usually from tree rings, to the calibration data set, taking into account only the quoted (Poisson) error of the individual ^{14}C dates. This procedure leads to unrealistically precise ranges of the fitted age (*e.g.*, below one decade), since a variety of other error factors of larger magnitude are not allowed for. Realistic error calculation must include allowance for appropriate interlaboratory offsets, the mismatch of the fitted series to the (bi-)decadal spacing of the calibration set and location-dependent anomalies in ^{14}C activity. Each of these errors is in the order of ±10–15 yr under optimal conditions; hence realistic errors on wiggle-matches should be on the order of 20–30 ^{14}C yr at a minimum. This error must then further be translated into calendar years according to the shape of the calibration curve.

It is therefore recommended that in future releases of these programs, user-alterable defaults for additional error components be implemented.

5. Future Revisions of the Calibration Data Sets

The corrections mentioned above entail small revisions of the published ^{14}C calibration data sets, over three separate intervals:

- For the period AD 1950 to 5500 BC, a return to the Belfast 1986 data would result in an average shift of 9 yr to younger ages as compared to the INTCAL93 data set (Stuiver and Reimer 1993). This correction is small with respect to the uncertainty of even high-precision ^{14}C dates and should not concern most users.
- The interval 5500–7800 BC needs to be corrected for the 41-yr shift of the Hohenheim German oak, which is the only source of European wood for ^{14}C calibration in this interval. The (dendroscale-corrected) published results (Pearson, Becker and Qua 1993; Stuiver and Becker 1993) will be complemented by additional German oak measurements performed in Seattle and Heidelberg since 1993.
- For the earliest Holocene interval, back to *ca.* 11,600 cal BP, only approximate calibrated ages can be obtained from the floating German oak and pine sections, as outlined above.

These changes will be incorporated into revised calibration data sets; we envisage making them available on the Internet at the time of the 16th International Radiocarbon Conference in Groningen.

6. Concluding Remarks

The issues discussed at the workshop reflect advances in high-precision ^{14}C measurement techniques, which are the basis for state-of-the-art ^{14}C applications in geophysics and carbon cycle studies, *e.g.*, of solar modulation of ^{14}C production or of isotopic signatures in atmospheric CO_2 as indicators of the contribution of the various carbon reservoirs to the carbon cycle.

For calibrating of Neolithic and younger archaeological samples, the revisions to the published data set appear of very minor importance. For the older intervals, the changes introduced by the modifications of the tree-ring scale result in a closer agreement of ^{14}C-calibrated archives with other time scales, *e.g.,* from ice cores or varved sediments, at the end of the Late Glacial (Björck *et al.* 1996).

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BOOK REVIEW

Learning from Things: Method and Theory of Material Culture Studies. Edited by W. David Kingery. Washington, D. C., Smithsonian Institution Press, 1996: 262 p.

David Kingery, a renowned ceramic engineer, has dedicated the past decade or so of his career to archaeology. Specifically, he has focused his energy on the cross-disciplinary investigation of material culture. Through his own research, and more importantly by sponsoring interdisciplinary conferences and providing the framework for easier between-college study at the University of Arizona, he has been successful in breaking down traditional barriers. This endeavor, however, is like swimming upstream against an ever-increasing current, as the trend in science is to become more specialized and to communicate less with people outside one's narrow interest. In this climate, interdisciplinary communication is more important than ever, and Kingery is to be commended for his dogged determination to make it happen. This book, assembled from a series of papers presented at a conference held at the Smithsonian Institution, grapples with the facts that the study of material culture is inherently interdisciplinary, and that the relationship between people and things is multileveled yet understandable. Kingery's guiding principle is that "things . . . are probably the truest representations we have of values and meanings within a society" (ix).

After an introduction by Kingery, the volume is divided into four sections: Paradigms for Material Culture Studies, Material Culture in the History of Technology, Formation Processes, and Materials Science in Material Culture Studies. The diversity of these approaches suggests that the relationship between people and things is so rich that there is plenty of room for investigative variety. In Kingery's words, "Artifacts are tools, as well as signals, signs, and symbols" (p. 1). But J. D. Prown makes the observation that investigators can come from very different and often opposing perspectives, using the analogy of the age-old feud between the "cowman and farmer", with the farmer being the hard scientist and the cowman the soft scientist. Neither approach, according to Prown, is inherently superior. Reality "probably resides neither in the artifact and its contextual data . . . nor in the culturally conditioned mind of the perceiver" (p. 26).

One difficulty inherent in books written by scholars from varied disciplines is ambiguity of audience. And in this volume some chapters seem to be written for a general audience, others for people only outside the field under discussion, and still others for people within the discipline. The latter is best represented by Joseph Corn, who writes a self-reflexive chapter on whether historians of technology actually consider things. He examined articles from *Technology and Culture* and found that slightly more than half of the authors do not deal with objects at all and that only 15% (mostly archaeologists) used any material data. But Corn finds, after interviewing many of the authors, that they actually had prior knowledge of the material discussed in their work and at some point in their life many had an "artifactual apprenticeship". Acknowledging that a working knowledge of the material of interest is important, Corn appeals directly to his colleagues to make more explicit their artifactual apprenticeships.

The other extreme is provided by many of the chapters in Part Four (Materials Science in Material Culture Studies), in which the authors are speaking predominantly to non–materials scientists. The chapters by D. Killick and M. S. Tite, on microscopy and dating, respectively, offer summaries designed for the nonspecialist. Kingery's chapter does explore the role of materials science in material culture studies, but I wish archaeologists would become more engaged in this debate.

If we are to fully understand the relationship between people and things, we must also consider the role of gender in shaping our perceptions of technology, as R. Oldenziel does in exploring the evolving relationship between material objects and other aspects of technology. She argues that taxonomies used by historians of technology carry implicit gender codings that highlight production instead of consumption. By redefining the boundaries of objects to include not only creation but use, one obtains a fuller, engendered perception of that technology.

One key to understanding material culture, past and present, is formation processes. That is, scholars of material culture must understand how their evidence has come to be. The authors in Part Three explore how objects from private and personal collections and historical records are both collected and preserved. M. B. Schiffer describes the diverse sources he used, including collectors, companies and trade magazines, to get information about subminiature tubes in portable radios. K. Kristiansen explores the political and economic factors that led to museum formation and eventually preservation laws in Denmark. He notes that museums were formed and collections grew because development was destroying archaeological sites. Once museum collections were full and the pace of development slowed, site preservation laws were implemented. I especially enjoyed M. Akin's paper exploring the formation of private collections. She investigated the processes that led to private collections, but more importantly she discussed how much the composition of a particular collection tells us about the collector. The Great Basin of the United States has a long history of ethnographic field work, and C. S. and D. D. Fowler explore the formation of museum collections of that material predominantly between 1871 and 1940. They not only discuss the biases inherent in collecting, but they describe how much of the early material was poorly documented and badly curated, with information either lost or destroyed as a result. In the final paper in this section, Parezo explores the processes governing the formation of archival records and the wide range of behaviors by scholars that ultimately produces this written historical record.

Humans, unlike any other species, cannot be considered apart from their things. This book is part of the ongoing quest to understand the complex relationship between people and their artifacts. The readers of *Radiocarbon* may not learn much from the materials science section, because its chapters (including the one on dating by Tite) are simply summaries meant for the nonspecialist. But the primary message of this section is the way technical analyses interdigitate with material culture studies. Apart from the minor stylistic flaw of a citation style that is inconsistent from one chapter to the next, this is overall a well-written and well-edited volume that has much to offer to those who "learn from things".

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RADIOCARBON UPDATES

Publication Received

West Virginia Archeologist 47(1&2), 1995. The Kentucky, Ohio and West Virginia Radiocarbon Database by Robert F. Maslowski, Charles M. Niquette and Derek M. Wingfield.

> This publication contains 1919 radiocarbon dates for archeological sites and objects in Kentucky, Ohio and West Virginia. These data represent most radiocarbon dates available for the region up to August 1996. The database is presented in a tabular format in ascending order of radiocarbon age. The database includes site numbers, site names, components, time periods, lab numbers, ^{14}C age, sigma, calibrated age and references.
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> The publication is available from the Council for West Virginia Archaeology, P.O. Box 1596, Huntington, West Virginia 25716-1596 USA. Cost is $12.00 + $1.50 shipping and handling.
>
> The database and bibliography are also available on disk from Charles M. Niquette, Cultural Resource Analysts, Inc., 143 Walton Ave. Lexington, Kentucky 40508 USA, for $35 + 1.50 shipping and handling.

H. E. Gove 1997 *Relic, Icon or Hoax? Carbon Dating the Turin Shroud.* Bristol and Philadelphia, Institute of Physics Publishing: 336p. ISBN 0-7503-0398-0. [A review of this book is scheduled to appear in the next issue of *RADIOCARBON*.]

New Laboratory

Dr. Michael Buzinny informs us that his new facility in Kiev is currently operational and involved in environmental ^{14}C studies, at the following address:

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Retirements and Laboratory Relocation

We note Jerry Stipp's transition from Beta Analytic to an undisclosed commercial endeavor with more detail than the usual cryptic bare-facts comments, not only because he kindly provided a mini-autobiography, but also because he helped change the technology and the economics of radiocarbon dating. Jerry has been involved in radiocarbon dating since 1958. He worked with John Noakes and Murray Tamers on the development of the benzene synthesis for radiocarbon dating, essentially the same procedures now used by most β-counting labs. In 1979 he and Murray founded Beta Analytic, Inc., and saw it grow into the largest commercial radiocarbon dating laboratory. From 1968 to 1992 he was on the faculty of Department of Geology and the graduate Marine School at the University of Miami. "Retired" may not be the correct term. Stay tuned.

Dr. Roy Switsur has recently retired as Director of the Cambridge University Radiocarbon Research Laboratory and will be relocating as head of a ^{14}C laboratory that will be part of the Cambridge Environmental Research Centre at Anglia University (about a mile from the Godwin Institute). The new lab will be based on liquid scintillation spectrometry using Quantulus™ and Packard™ instrumentation. The facility will be available for collaborative research projects with other interested institutions involving radiocarbon and tritium measurements in archaeological, geological or environmental studies. Commercial radiocarbon dating will also be available. The lab will maintain close contact with the Godwin Institute, Cambridge University (where Switsur has graduate students), for dendrochronology and dendroclimatology including investigations of stable isotopes in tree rings. Switsur noted that "retirement is in name only and the daily work goes on unchanged!"

Laboratory Closure

We learn from Dr. Harry Gove that the Nuclear Structure Research Laboratory at the University of Rochester no longer has the capability of making cosmogenic radioisotope measurements, and we therefore bid it farewell from our list of active radiocarbon laboratories. Dr. Gove provides us with this brief history of accelerator mass spectrometry at the University of Rochester:

> The MP tandem Van de Graaff accelerator at the University of Rochester's Nuclear Structure Research Laboratory ceased operation in the summer of 1995. From 1977 until 1995 it was employed about 20% of the time for accelerator mass spectrometry (AMS). In 1977 it was shown at Rochester that ^{14}C could be detected by AMS in milligram samples of carbon of organic origin using a tandem accelerator and that $^{14}C/C$ ratios could be measured to less than one part in 1015. Because carbon dating by AMS requires tandems with terminal voltages no higher than 2 MV, the use of an MP tandem with a terminal potential of over 12 MV for the detection of ^{14}C did not make sense and its use for this purpose at Rochester was substantially reduced. In 1978 the radioisotope ^{36}Cl was first measured at Rochester, and since then the main AMS work at Rochester has involved that isotope. The higher energies available from an MP tandem permit the elimination of interference from the stable isobar ^{36}S. It was at Rochester that ^{36}Cl was first measured in the nuclear bomb pulse in groundwater. Another radioisotope first measured by AMS at Rochester was ^{129}I. Both it and ^{36}Cl were measured extensively at Rochester in a wide variety of samples including soil and groundwater in the vicinity of nuclear fuel reprocessing plants until the MP tandem was shut down.

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ALG	Algiers	Algeria
ANTW	Antwerp	Belgium
ANU	Australian National University	Australia
ANUA	ANU Accelerator	Australia
B	Bern	Switzerland
Ba	Bratislava	Slovakia
Beta	Beta Atantic	USA
Birm	Birmingham	USA
Bln	Berlin	Germany
BM	British Museum	England
BS	Birbal Sahni Institute	India
BSG	Brock University	Canada
CAMS	Center for Accelerator Mass Spectrometry	USA
CENA	Centro Energia Nuclear na Agricultura	Brazil
CG	Institute of Geology	China
CH	Chemistry Laboratory	India
CRCA	Cairo	Egypt
CU	Charles University	Czech Republic
DE	USGS, Denver	USA
Deb	Debrecen	Hungary
DEM	Demokritos	Greece
DRI	Desert Research Institute	USA
ENEA	ENEA, Bologna	Italy
ETH	ETH/AMS Facility	Switzerland
F	Florence	Italy
Fr	Freiberg	Germany
Fra	Frankfurt	Germany
FZ	Fortaleza	Brazil
GAK	Gakushuin University	Japan
Gd	Gliwice	Poland
Gif	Gif sur Yvette	France
Gif A	Gif sur Yvette and Orsay	France
GIN	Geological Institute	Russia
GrN	Groningen	The Netherlands
GrA	Groningen Accelerator	The Netherlands
GSC	Geological Survey	Canada
GU	Scottish Universities Research & Reactor Centre	Scotland
GX	Geochron Laboratories	USA
HAM	Hamburg	Germany
HAR	Harwell	England
Hd	Heidelberg	Germany
Hel	Helsinki	Finland
HL	Second Institute of Oceanography	China
Hv	Hannover	Germany
I	Teledyne Isotopes	USA
IAEA	International Atomic Energy Agency	Austria
IAEA-MEL	Marine Environmental Laboratory	Monaco
ICEN	Instituto Tecnológico e Nuclear	Portugal
IEMAE	Institute of Evolutionary Morphology and Animal Ecology	Russia
IGAN	Institute of Geography	Russia
IOAN	Institute of Oceano-graphy	Russia
IRPA	Royal Institute of Cultural Heritage	Belgium
ISGS	Illinois State Geological Survey	USA
IVAN	Institute of Volcanology	Ukraine
IWP	Institute of Water Problems	Russia
JGS	Geological Survey of Japan	Japan
JUBR	Biren Roy Research Laboratory	India
K	National Museum	Denmark
KAERI	Korean Atomic Energy Research Institute	Korea
KCP	National Cultural Property Research Institute	Korea
KI	Kiel	Germany
KIEV	Institute of Radio-Geochemistry of the Environment	Ukraine
KN	Köln	Germany
KR	Krakow	Poland
KRIL	Krasnoyarsk Institute	Russia
KSU	Kyoto Sangyo University	Japan
L	Lamont-Doherty	USA
LAR	Liège State University	Belgium
LE	St. Petersburg	Russia
LOD	Lodz	Poland
LP	La Plata	Argentina
Lu	Lund	Sweden
LU	St. Petersburg State Univesity	Russia
Lv	Louvain-la-Neuve	Belgium
Ly	University of Lyon	France
MAG	Quaternary Geology and Geochronology Laboratory	Russia
METU	Middle East Technical University	Turkey
MGU	Moscow	Russia
ML	Miami	USA
N	Nishina Memorial	Japan

[2]Only those laboratories with code designations are listed here.

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NZ	New Zealand	New Zealand
NZA	New Zealand	New Zealand
OBDY	ORSTOM Bondy	France
OxA	Oxford Radiocarbon Accelerator Unit	England
PI	Permafrost Institute	Russia
PKU	Peking University	China
PRIME	Purdue Rare Isotope Measurement Laboratory	USA
PRL	Physical Research Laboratory	India
Pta	Pretoria	South Africa
Q	Cambridge	England
QL	Quaternary Isotope Laboratory	USA
R	Rome	Italy
RCD	Radiocarbon Dating	England
Riga	Institute of Science	Latvia
Rome	Department of Earth Sciences, Rome	Italy
RT	Rehovot	Israel
S	Saskatchewan	Canada
Sac	Instituto Tecnológico e Nuclear	Portugal
SOAN	Institute of Geology and Geophysics	Russia
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St	Stockholm	Sweden
Su	Finland	Finland
SUA	Sydney University	Australia
SWA	Swansea	Wales
T	Trondheim	Norway
TA	Tartu	Estonia
TAM	Texas A & M University	USA
TB	Tblisi	Georgia
TK	University of Tokyo	Japan
TKU	Turku	Finland
Tln	Tallinn	Estonia
TO	IsoTrace Laboratory	Canada
TUNC	Tehran University Nuclear Centre	Iran
Tx	Texas	USA
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UCLA	University of California, Los Angeles	USA
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UtC	Utrecht van der Graaf Laboratorium	The Netherlands
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NOTICE TO READERS AND CONTRIBUTORS

The purpose of *RADIOCARBON* is to publish technical and interpretive articles on all aspects of ^{14}C and other cosmogenic isotopes. In addition, we present regional compilations of published *and unpublished* dates along with interpretive text. Besides the triennial Proceedings of Radiocarbon Conferences, we publish Proceedings of conferences in related fields and Special Issues that focus on particular themes. Organizers interested in such arrangements should contact the Managing Editor for information.

Our regular issues include NOTES AND COMMENTS, LETTERS TO THE EDITOR, RADIOCARBON UPDATES and BOOK REVIEWS. Authors are invited to extend discussions or raise pertinent questions regarding the results of investigations that have appeared on our pages. These sections also include short technical notes to disseminate information concerning innovative sample preparation procedures. Laboratories may also seek assistance in technical aspects of radiocarbon dating. We include a list of laboratories and a general index for each volume.

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For	*Date*
Vol. 39, No. 2, 1997	May 1, 1997
Vol. 39, No. 3, 1998	September 1, 1997
Vol. 40, No. 1, 1998	January 1, 1998

Half-life of ^{14}C. In accordance with the decision of the Fifth Radiocarbon Dating Conference, Cambridge, England, 1962, all dates published in this volume (as in previous volumes) are based on the Libby value, 5568 yr, for the half-life. This decision was reaffirmed at the 11th International Radiocarbon Conference in Seattle, Washington, 1982. Because of various uncertainties, when ^{14}C measurements are expressed as dates in years BP, the accuracy of the dates is limited, and refinements that take some but not all uncertainties into account may be misleading. The mean of three recent determinations of the half-life, 5730 ± 40 yr, (*Nature*, 1962, Vol. 195, No. 4845, p. 984), is regarded as the best value presently available. Published dates in years BP can be converted to this basis by multiplying them by 1.03.

AD/BC Dates. In accordance with the decision of the Ninth International Radiocarbon Conference, Los Angeles and San Diego, California, 1976, the designation of AD/BC, obtained by subtracting AD 1950 from conventional BP determinations is discontinued in *RADIOCARBON*. Authors or submitters may include calendar estimates as a comment, and report these estimates as cal AD/BC, citing the specific calibration curve used to obtain the estimate. Calibrated dates should be reported as "cal BP" or "cal AD/BC" according to the consensus of the Twelfth International Radiocarbon Conference, Trondheim, Norway, 1985.

Measuring ^{14}C. In Volume 3, 1961, we endorsed the notation Δ, (Lamont VIII, 1961), for geochemical measurements of ^{14}C activity, corrected for isotopic fractionation in samples and in the NBS oxalic-acid standard. The value of $\delta^{14}C$ that entered the calculation of Δ was defined by reference to Lamont VI, 1959, and was corrected for age. This fact has been lost sight of, by editors as well as by authors, and recent papers have used $\delta^{14}C$ as the observed deviation from the standard. At the New Zealand Radiocarbon Dating Conference it was recommended to use $\delta^{14}C$ only for age-corrected samples. Without an age correction, the value should then be reported as percent of modern relative to 0.95 NBS oxalic acid (Proceedings of the 8th Conference on Radiocarbon Dating, Wellington, New Zealand, 1972). The Ninth International Radiocarbon Conference, Los Angeles and San Diego, California, 1976, recommended that the reference standard, 0.95 NBS oxalic acid activity, be normalized to $\delta^{13}C = -19‰$.

In several fields, however, age corrections are not possible. $\delta^{14}C$ and Δ, uncorrected for age, have been used extensively in oceanography, and are an integral part of models and theories. Thus, for the present, we continue the editorial policy of using Δ notations for samples not corrected for age.

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