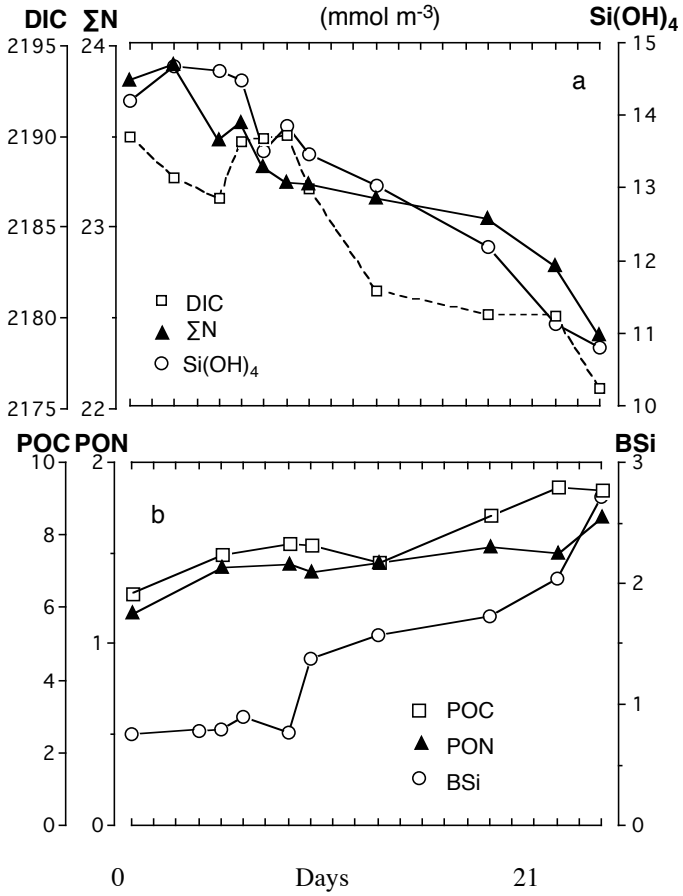
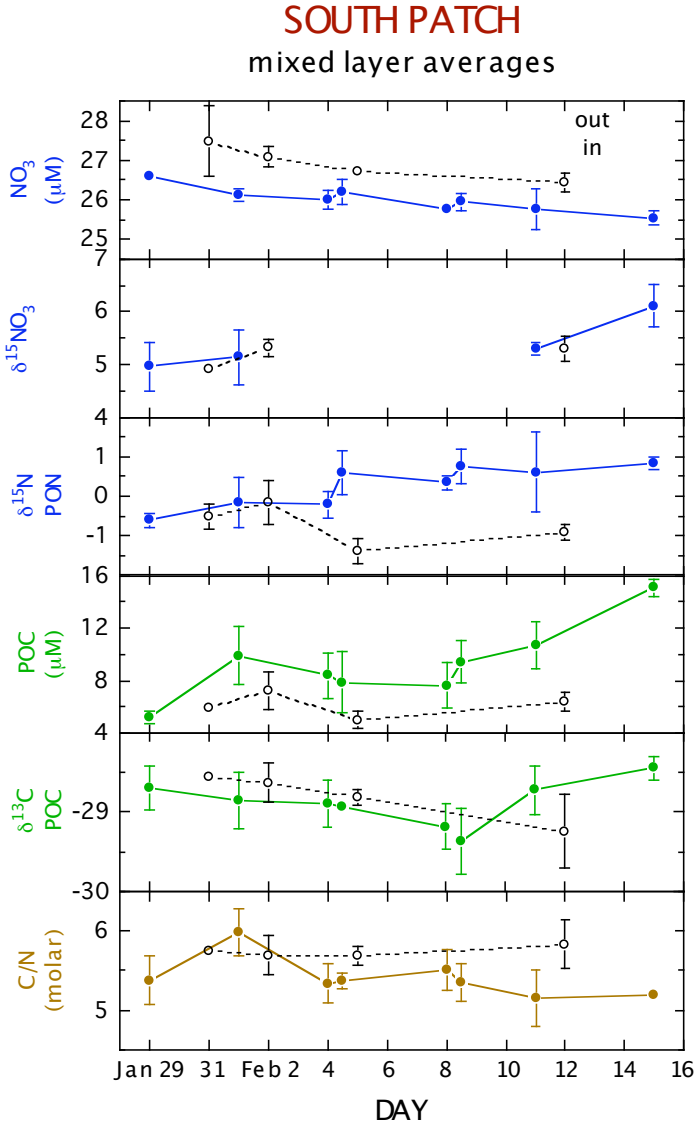


Fig. 1 Time-series results from EisenEx experiment. ΣN is equivalent to NO_3^-. The units mmol m^{-3} are equivalent to μM

While most of our effort has been focused on the SOFeX experiment in 2002, the previous year we had an opportunity for a modest set of samples to be collected for isotopic analysis during the European-led EisenEx experiment. In the Atlantic sector of the Southern Ocean, fertilization of the central portion of cold-core eddy to the north of the Antarctic Circumpolar Current produced a relatively modest biological response. Over the 3-week observation period, NO_3^- decreased by only 1.5 μM (Fig. 1) and chlorophyll increased by 4-fold. The corresponding POC increase from of 4 μM, though, was far less than expected from the decrease in DIC (15 μM). The 10+ μM imbalance is interpreted as reflecting the majority of the Fe-stimulated primary productivity having been channeled into carbon export/sequestration. Over the same period, POC $\delta^{13}C$ increased by at least 3‰ in response to a combination of reduced [CO_{2aq}] or more likely increased phytoplankton growth rates. Since there was less than a doubling of POC, the contrast in $\delta^{13}C$ between pre- and post-fertilization phytoplankton production is at least double the observed change. A priori, we would have predicted little change in $\delta^{15}N$ from the low relative drawdown of NO_3^- and this is what we observed.



The SOFeX experiment carried out 2 Fe fertilizations in the S.E. Pacific sector of the Southern Ocean to the southwest of New Zealand. The first was in low silicate, high NO_3^- Subantarctic waters north of the polar front (North Patch). The second was in high silicate, high NO_3^- Antarctic waters sorth of the polar front (South Patch). Total experiment time was about 40 days, with observations focused at both the beginning and end of this period for the north patch. In both there was substantial phytoplankton blooms and moderate drawdowns of macronutrients (Table 1; Fig. 2). As in EisenEx, comparison of DIC decrease with POC increase suggests the majority of the stimulated production was exported from the patches. Silicate to NO_3^- drawdown ratio was about 2.5, similar to EisenEx observations. This result indicates an important role for diatoms in both patches despite low initial silicate in the north patch. The reduction from typical Southern Ocean values of 4 to 5 is consistent with reduction but not elimination of Fe stress. Fe-replete diatoms would be expected to use silicate and NO_3^- in 1:1 ratio. Results to date were presented in a special session at the Fall 2002 AGU meeting (www.agu.org/meetings/fm02/waisfm02.html). Our group made two presentations at this meeting.

Table 1. Summary of biogeochemical changes during SOFeX (from K. Coale).

	North Patch	South Patch
$\Delta\Sigma CO_2$	-14 μM	-23 μM
Δ Si	-2.5 μM	-3.7 μM
ΔPO_4^{-3}	-0.06 μM	-0.22 μM
ΔNO_3	-2.4 μM	-3.2 μM
Δ Chl a	2 μg/L	4 μg/L
Δ POC	6.8 μM	8.2 μM
Δ PON	1 μM	1.5 μM
107,000 kg chl/22 days		
10,000 tons of Carbon fixed/22 days		

We carried out intensive sampling in both the North and South Patches. Laboratory analyses to date have first emphasized the South Patch and those results are summarized in fig. 2. We obtain C and N content data along with our isotopic results and representative POM concentration profiles illustrate in detail the stimulation of organic C production. The 3-fold increase in PON and POC occurred within the 40 to 50 m surface layer. In contrast, the out-patch station showed no clear progressive change. Averaging over the mixed layer, produces a detailed time-series of increasing POM concentration in the S. Patch. Results from Kenneth Coale's group are in close agreement.

Overall low POM $\delta^{13}C$ values (-29 ‰; Fig. 2) are consistent with previous observations for this region at this season. Higher $\delta^{13}C$ in >54 μm particles (initial results, data not shown) are also consistent with expectations for large diatoms. However, there is surprisingly little change in POM $\delta^{13}C$ during SOFeX in the S. Patch. The little variation observed is furthermore not monotonic, suggesting time-varying influences. As discussed above, physiological factors including growth rate are most important in determining the isotopic fractionation factor for inorganic carbon assimilation (ε_p) and thus $\delta^{13}C$. The % drawdown of DIC is insufficient to produce a change in $\delta^{13}C$ or lowering of $[CO_{2aq}]$. M Landry's phytoplankton growth measurements showed that in the S. Patch, despite blooming diatom population, growth rates remained relatively low, between 0.3 and 0.4 day^{-1}. These low growth rates would be expected to keep ε_p near its maximal values and keep $\delta^{13}C$ fairly low. During EisenEx, the decrease in ΣCO_2 was even less and the increase in $\delta^{13}C$ should have corresponded to substantially higher phytoplankton growth rates.

In polar HNLC waters, phytoplankton $\delta^{15}N$ is primarily determined by the degree of NO_3^- drawdown and the fractionation factor for NO_3^- uptake by phytoplankton. An expectation was that Fe-stimulated drawdown of NO_3^- would cause an increase in $\delta^{15}N$ in both NO_3^- and particles. The magnitude of the change in $\delta^{15}N$ would be contingent on the degree of NO_3^- drawdown. The EisenEx and SOFeX results have so far confirmed this perspective. Whereas the small NO_3^- depletion during EisenEx produced no significant increase in $\delta^{15}N$, there was a substantial rise during SOFeX (Fig. 2). S. Patch $\delta^{15}N$ of PN and NO_3^- increased by 1-2‰ as $[NO_3^-]$ decreased by a factor of 2 greater than in EisenEx. There is also a clear contrast between in- and out-patch stations. The isotopic fractionation factor for NO_3^- was near 5-6‰ and appears to have been unaffected by Fe fertilization, although further analyses of $\delta^{15}N$ on collected samples are needed.