

10. Microbial abundance and dynamics

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Aim: To compare abundance and organic nutrient uptake by dominant microbial groups in planktonic communities around the Crozet Islands.

Objectives

- 1) To determine the vertical distribution, abundance and flow cytometrically resolved community structure of nano- (2 – 20 μm) and pico- (0.2 – 2 μm) plankton in the top 200 m using flow cytometry;
- 2) To estimate the microbial turnover rates of common dissolved organic nutrients, to assess microbial competition and to relate the latter with community composition.
- 3) To collect samples for analyses of bacterioplankton community composition using molecular approach including fluorescence in situ hybridisation.
- 4) Underway sampling from the uncontaminated seawater supply: a) To assess microbial spatial variability at ten km scale; b) To test the capability of the CytoSense flow cytometer for automated underway analysis and to determine the distribution, abundance and community structure of phytoplankton (approx. 3 – 200 μm) in surface waters;



Phytoplankton concentration in the studied area varied between 2 to 10×10^3 cells ml^{-1} in surface waters, and bacterioplankton concentration varied about 20 fold, from $<100 \times 10^3$ cells ml^{-1} at 200m depth to 2×10^9 cells ml^{-1} in the surface waters (see Appendix at the end for examples of vertical distribution). Also a wide range of rates of microbial activity was observed. Flow sorting and scintillation counting were done on board the ship but the detailed analysis of the data will be done back in the UK. The molecular analysis will be also done after the cruise. When completed the data set will allow estimation of the rates of microbial nutrient uptake as well as linkage between microbial function, composition and hydrological structure of the water column.

Methods

Seawater samples were collected and analysed for determination of microbial concentration, biomass and composition. Fresh seawater samples were collected in acid washed 50 mL polypropylene tubes from a CTD system containing 24 x 20 L Niskin bottles. Samples were stored in a refrigerator and microorganisms were preserved with paraformaldehyde (1% final concentration) within 1-2 hours of collection. Phytoplankton samples were analysed unstained and bacterioplankton samples were stained with SYBR Green I nucleic acid dye. The bacterial samples were then left in the dark at 35°C for at least 1 hour before enumeration of bacterioplankton by a flow cytometer (FACSort BD). Table 10.1 summarises the CTD casts sampled and analysed during cruise D285. Samples

were also collected for later molecular identification of microorganisms. To correlate with high-resolution underway analyses samples were collected from the Ti-CTD casts at 5 m depth to determine microbial nutrient uptake and turnover rates by incubating samples with isotopically labelled precursor molecules: ^3H -leucine, ^{35}S -methionine, ^3H -glucose (Table 10.2).

Underway samples (Table 10.3) for analysis by FACSort were drawn and preserved with 1% paraformaldehyde automatically from the ships underway supply system by a Tecan Miniprep 60 robot. Samples for analysis by Cytosense flow cytometer were taken automatically by the instrument from the ships underway supply system.

10.1 CTD Sampling

A list of CTD's sampled is provided below for cruises D285 and D286 in tabular form, along with total numbers of bacterioplankton and phytoplankton cells recorded. Data for total numbers of individuals within different populations have also been recorded. After station 15496, it was decided that samples should not be taken from depths greater than 200m, owing to low phytoplankton and bacterioplankton abundance at greater depths. Alterations in bottle firing sequence however denoted that some stations had to be sampled to a depth of 250m, in order to obtain data for depths greater than 175m. No data were recorded for Bacterioplankton at station 15496 due to an error in the preservation / SYBR Green staining procedure. Samples were not analysed from Niskin bottles 17 and 18 (150 and 125 m) at station 15513 as the bottles misfired. Niskin bottles 17 at station 15553, 20 at station 15584 and 20 at station 15587 were not sampled, as they were observed to be leaking.

10.2 Underway sampling

Underway Sampling on D285

FACSort underway sampling began before Station J, at 14:30 on day 314 (09/11/04). Continuous Cytosense sampling began at Station J, at 11:15 on day 316 (11/11/04). Underway samples were drawn continuously throughout the survey and the results of sampling were related to ships navigational data in order to compare large-scale variation in community structure whilst steaming, to small-scale variation whilst on station. Variations in sampling frequency, with reasons for alteration are outlined below.

As Cytosense sampling is automated and not labour intensive, regular sampling is possible. Cytosense sampling frequency was altered from 15 minutes to 10 minutes at 18:00 on day 321. The decision was made in order to increase the resolution of the survey to coincide with the SeaSoar survey. Such frequent sampling had not been undertaken previously owing to concerns about the stability of the laser under conditions of such regular use. As the instrument suffered no ill effects during increased sampling, at the end of the first Sea Soar survey it was decided not to revert to the original 15 minute sampling interval.

The FACSort autoloader equipment was not used during D285 or D286 in order to allow a greater volume of water to be analysed per phytoplankton sample, facilitated by an external syringe pump. As the manual analysis of FACSort samples is more labour intensive than Cytosense, an initial half hourly sampling frequency was selected for this instrument. A change in frequency to hourly sampling at 05:00 on day 317 occurred in

order to accommodate time for shipboard data analysis. Sampling was again increased to half hourly intervals, at the expense of data analysis time throughout the period of the first Sea Soar survey, commencing at 18:30 on day 320, and returning to hourly sampling at 18:00 on day 325. The final half hourly sampling period (19:30, day 335 until 19:00 day 336,) was undertaken during a sea soar survey, and was possible owing to a decrease in CTD sampling.

Underway Sampling on D286

Hourly sampling for FACSORT analysis (Table 10.4) began before Station J, at 09:00 on day 349 (2004) and was continued throughout the cruise. Sampling was discontinued after leaving the area of study on day 016 (2005) due to a recurrent sampling error caused by stormy seas.

Cytosense sampling at 10 minute intervals began at 07:30 on day 349 (2004), and continued until 07:30 on day 018 (2005).

Table 10.4 Underway sampling (D285)

| | FACSORT | Cytosense |
|------------|-------------------|-------------------|
| JULIAN DAY | Sampling Interval | Sampling Interval |
| 314 | 30 minutes | |
| 315 | — | |
| 316 | — | 15 minutes |
| 317 | 60 minutes | — |
| 318 | — | — |
| 319 | — | — |
| 320 | 30 minutes | — |
| 321 | — | 10 minutes |
| 322 | — | — |
| 323 | — | — |
| 324 | — | — |
| 325 | 60 minutes | — |
| 326 | — | — |
| 327 | — | — |
| 328 | — | — |
| 329 | — | — |
| 330 | — | — |
| 331 | — | — |
| 332 | — | — |
| 333 | — | — |
| 334 | — | — |
| 335 | 30 minutes | — |
| 336 | 60 minutes | — |
| 337 | — | — |
| 338 | — | — |
| 339 | — | — |
| 340 | | |

Table 10.1 CTD casts sampled for determination of microbial concentrations (D285)

| Station number | Sample number | Location | Depth, m | Bacterioplankton, cells ml ⁻¹ | Phytoplankton, cells ml ⁻¹ |
|----------------|---------------|----------|----------|--|---------------------------------------|
| 15496 | 49610 | M3 | 175 | - | 1263.5 |
| 15496 | 49611 | M3 | 150 | - | 1253.9 |
| 15496 | 49612 | M3 | 100 | - | 3585.4 |
| 15496 | 49613 | M3 | 63 | - | 3101.5 |
| 15496 | 49615 | M3 | 42 | - | 3889.3 |
| 15496 | 49617 | M3 | 27 | - | 3996.2 |
| 15496 | 49619 | M3 | 15 | - | 3080.1 |
| 15496 | 49621 | M3 | 10 | - | 3859.0 |
| 15500 | 50015 | | 200 | 322421.9 | 817.2 |
| 15500 | 50016 | | 150 | 390015.8 | 1349.0 |
| 15500 | 50017 | | 100 | 650081.1 | 8301.5 |
| 15500 | 50018 | | 80 | 711117.5 | 8973.4 |
| 15500 | 50019 | | 60 | 707967.9 | 9337.8 |
| 15500 | 50020 | | 40 | 701561.7 | 9869.6 |
| 15500 | 50021 | | 20 | 725162.7 | 9866.6 |
| 15500 | 50022 | | 10 | 685432.7 | 9418.2 |
| 15500 | 50023 | | 5 | 664125.0 | 9797.3 |
| 15504 | 50415 | M2 | 250 | 174159.6 | 151.2 |
| 15504 | 50417 | M2 | 150 | 269463.2 | 338.5 |
| 15504 | 50418 | M2 | 125 | 309019.4 | 585.6 |
| 15504 | 50419 | M2 | 100 | 524356.2 | 4287.6 |
| 15504 | 50420 | M2 | 80 | 586166.5 | 6538.6 |
| 15504 | 50421 | M2 | 60 | 548153.6 | 7551.3 |
| 15504 | 50423 | M2 | 10 | 485080.3 | 7108.8 |
| 15504 | 50424 | M2 | 5 | 471555.9 | 6110.8 |
| 15506 | 50615 | | 250 | 206309.7 | 76.0 |
| 15506 | 50616 | | 175 | 290862.5 | 442.5 |
| 15506 | 50617 | | 150 | 381075.0 | 1016.4 |
| 15506 | 50618 | | 125 | 504856.2 | 2611.0 |
| 15506 | 50619 | | 100 | 567639.6 | 4463.8 |
| 15506 | 50620 | | 80 | 604824.8 | 6400.7 |
| 15506 | 50621 | | 60 | 593926.7 | 10243.5 |
| 15506 | 50622 | | 40 | 573268.5 | 10209.6 |
| 15506 | 50623 | | 10 | 515849.9 | 7996.1 |
| 15507 | 50715 | M6 | 250 | 338130.6 | 3212.9 |
| 15507 | 50716 | M6 | 175 | 266545.5 | 630.6 |
| 15507 | 50717 | M6 | 150 | 332052.9 | 1200.8 |
| 15507 | 50718 | M6 | 125 | 423793.4 | 3770.5 |
| 15507 | 50719 | M6 | 100 | 460979.5 | 6037.1 |
| 15507 | 50720 | M6 | 80 | 448410.1 | 6979.7 |
| 15507 | 50721 | M6 | 60 | 454198.1 | 7824.2 |
| 15507 | 50722 | M6 | 40 | 444712.7 | 7723.9 |
| 15507 | 50723 | M6 | 10 | 453311.3 | 7836.8 |
| 15507 | 50724 | M6 | 5 | 429412.2 | 8069.9 |
| 15513 | 51315 | | 250 | 202217.1 | 31.7 |

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|-------|--------|----|-----|-----------|---------|
| 15513 | 51316 | | 175 | 250051.8 | 147.5 |
| 15513 | 51319 | | 100 | 514558.9 | 1290.8 |
| 15513 | 51320 | | 80 | 703077.9 | 6728.2 |
| 15513 | 51321 | | 60 | 734112.0 | 9736.8 |
| 15513 | 51322 | | 40 | 693734.5 | 10438.2 |
| 15513 | 51323 | | 10 | 679751.6 | 10341.6 |
| 15513 | 51324 | | 5 | 689808.6 | 10034.8 |
| 15518 | 51814 | M3 | 175 | 415742.9 | 841.6 |
| 15518 | 51815 | M3 | 150 | 465082.6 | 1034.1 |
| 15518 | 51816 | M3 | 125 | 609469.7 | 1579.9 |
| 15518 | 51817 | M3 | 100 | 806595.3 | 3134.7 |
| 15518 | 51818 | M3 | 80 | 783775.3 | 3676.8 |
| 15518 | 51819 | M3 | 60 | 869325.9 | 7706.2 |
| 15518 | 51820 | M3 | 40 | 958844.0 | 13072.1 |
| 15518 | 51822 | M3 | 20 | 861064.9 | 12937.2 |
| 15518 | 51823 | M3 | 10 | 905178.4 | 13550.8 |
| 15518 | 51824 | M3 | 5 | 862545.5 | 13053.7 |
| 15520 | 52014 | | 200 | 133859.5 | - |
| 15520 | 52015 | | 150 | 274151.5 | 392.4 |
| 15520 | 52016 | | 100 | 311132.6 | 183.7 |
| 15520 | 52017 | | 80 | 513702.6 | 455.8 |
| 15520 | 52018 | | 60 | 939997.3 | 5981.0 |
| 15520 | 52019 | | 40 | 1069343.6 | 10877.8 |
| 15520 | 52021 | | 20 | 1043742.5 | 11057.1 |
| 15520 | 52022 | | 10 | 1067890.0 | 10245.7 |
| 15520 | 52023 | | 5 | 1084795.7 | 8167.2 |
| 15525 | 52513 | | 200 | 229002.7 | 132.8 |
| 15525 | 52514 | | 175 | 223623.6 | 126.1 |
| 15525 | 52515 | | 150 | 221577.1 | 159.3 |
| 15525 | 52516 | | 125 | 282176.8 | 165.2 |
| 15525 | 52517 | | 100 | 306762.6 | 242.7 |
| 15525 | 52518 | | 80 | 390308.2 | 465.4 |
| 15525 | 52519 | | 60 | 886959.8 | 1058.4 |
| 15525 | 52520 | | 40 | 984991.9 | 4367.2 |
| 15525 | 52522 | | 20 | 1003248.5 | 3530.1 |
| 15525 | 52523 | | 10 | 1017862.0 | 3949.7 |
| 15525 | 52524 | | 5 | 1010067.2 | 4165.9 |
| 15527 | 52713 | | 200 | 238569.5 | 218.3 |
| 15527 | 52714 | | 175 | 239174.0 | 255.2 |
| 15527 | 52715 | | 150 | 276214.2 | 216.1 |
| 15527 | 52716 | | 125 | 300107.4 | 238.2 |
| 15527 | 52717 | | 100 | 403577.9 | 579.7 |
| 15527 | 52718 | | 80 | 703867.9 | 1504.7 |
| 15527 | 52719 | | 60 | 757836.9 | 2730.5 |
| 15527 | 52720 | | 40 | 838048.8 | 9126.1 |
| 15527 | 52722 | | 20 | 833545.9 | 10306.9 |
| 15527 | 52723 | | 10 | 805022.3 | 9479.4 |
| 15527 | 52724 | | 5 | 907870.2 | 9385.7 |
| 15528 | 528013 | | 200 | 194140.9 | 103.3 |

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|-------|--------|-----|-----|------------|-------------|
| 15528 | 528014 | | 175 | 203425.0 | 125.4 |
| 15528 | 528015 | | 150 | 199341.5 | 184.4 |
| 15528 | 528016 | | 125 | 239333.8 | 354.8 |
| 15528 | 528017 | | 100 | 444496.9 | 1419.1 |
| 15528 | 528018 | | 80 | 517133.6 | 3437.9 |
| 15528 | 528019 | | 60 | 537803.8 | 7740.9 |
| 15528 | 528020 | | 40 | 513439.0 | 9212.4 |
| 15528 | 528022 | | 20 | 529401.0 | 9199.1 |
| 15528 | 528023 | | 10 | 500341.2 | 9365.8 |
| 15528 | 528024 | | 5 | 550373.6 | 9348.1 |
| 15532 | 532013 | M8E | 200 | 272612.8 | 90.7 |
| 15532 | 532014 | M8E | 175 | 267731.6 | 115.8 |
| 15532 | 532015 | M8E | 150 | 317977.6 | 180.7 |
| 15532 | 532016 | M8E | 125 | 398742.2 | 384.3 |
| 15532 | 532017 | M8E | 100 | 445880.1 | 648.3 |
| 15532 | 532018 | M8E | 80 | 908040.4 | 9960.3 |
| 15532 | 532019 | M8E | 60 | 1303883.7 | 13131.9 |
| 15532 | 532020 | M8E | 40 | 1091786.3 | 15135.9 |
| 15532 | 532022 | M8E | 20 | 1002901.3 | 19192.6 |
| 15532 | 532023 | M8E | 10 | 935027.9 | 20588.9 |
| 15532 | 532024 | M8E | 5 | 907804.5 | 20854.3 |
| 15539 | 53903 | M8W | 200 | 250263.615 | 199.1465603 |
| 15539 | 53905 | M8W | 175 | 320236.686 | 196.1962409 |
| 15539 | 53907 | M8W | 150 | 380371.429 | 242.6637717 |
| 15539 | 53910 | M8W | 125 | 440864.458 | 469.8383664 |
| 15539 | 53912 | M8W | 100 | 642734.043 | 598.9148407 |
| 15539 | 53913 | M8W | 80 | 656034.173 | 943.3646321 |
| 15539 | 53915 | M8W | 60 | 968269.494 | 2400.084842 |
| 15539 | 53917 | M8W | 40 | 930684.34 | 2286.497545 |
| 15539 | 53920 | M8W | 20 | 798626.374 | 6144.040176 |
| 15539 | 53922 | M8W | 10 | 790073.703 | 4640.114856 |
| 15540 | 54003 | M8W | 200 | 297493.348 | 387.9670027 |
| 15540 | 54005 | M8W | 175 | 306407.388 | 268.4790665 |
| 15540 | 54007 | M8W | 150 | 336406.883 | 380.5912042 |
| 15540 | 54009 | M8W | 125 | 451605.456 | 678.5734648 |
| 15540 | 54011 | M8W | 100 | 532140.575 | 814.2881578 |
| 15540 | 54013 | M8W | 80 | 677824.17 | 1005.32134 |
| 15540 | 54015 | M8W | 60 | 896258.152 | 2400.084842 |
| 15540 | 54017 | M8W | 40 | 787162.442 | 3554.397312 |
| 15540 | 54020 | M8W | 20 | 781771.654 | 3294.769204 |
| 15540 | 54022 | M8W | 10 | 815338.583 | 4151.836993 |
| 15544 | 54413 | M9 | 200 | 212699.443 | 267.7414867 |
| 15544 | 54414 | M9 | 175 | 479114.286 | 3578.737447 |
| 15544 | 54415 | M9 | 150 | 216193.439 | 469.1007866 |
| 15544 | 54416 | M9 | 125 | 263454.545 | 673.4104059 |
| 15544 | 54417 | M9 | 100 | 330008.451 | 1862.389129 |
| 15544 | 54418 | M9 | 80 | 479941.292 | 2593.330763 |
| 15544 | 54419 | M9 | 60 | 768498.516 | 8476.267672 |
| 15544 | 54420 | M9 | 40 | 560503.125 | 9379.802992 |

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|-------|-------|----|-----|------------|-------------|
| 15544 | 54422 | M9 | 20 | 577814.371 | 6506.191884 |
| 15544 | 54423 | M9 | 10 | 490977.509 | 3628.155297 |
| 15544 | 54424 | M9 | 5 | 542333.966 | 6938.413678 |
| 15546 | 54616 | | 200 | 181704 | 276.5924449 |
| 15546 | 54617 | | 150 | 202428.872 | 342.2370518 |
| 15546 | 54618 | | 100 | 336504.215 | 1006.796499 |
| 15546 | 54619 | | 80 | 415206.677 | 1500.237421 |
| 15546 | 54620 | | 60 | 443282.881 | 1817.396758 |
| 15546 | 54621 | | 40 | 680643.402 | 6461.937093 |
| 15546 | 54622 | | 20 | 711309.524 | 3515.30558 |
| 15546 | 54623 | | 10 | 570949.926 | 4835.573517 |
| 15546 | 54624 | | 5 | 609635.711 | 5187.399107 |
| 15547 | 54714 | | 200 | 213548.896 | 275.1172852 |
| 15547 | 54715 | | 150 | 257746.154 | 411.569558 |
| 15547 | 54716 | | 100 | 454521.531 | 1545.967372 |
| 15547 | 54717 | | 80 | 707735.849 | 3689.374425 |
| 15547 | 54718 | | 60 | 957418.033 | 7544.704317 |
| 15547 | 54719 | | 40 | 1279959.48 | 14632.84671 |
| 15547 | 54721 | | 20 | 1286971.9 | 16175.12618 |
| 15547 | 54722 | | 10 | 1283424.34 | 15854.27894 |
| 15547 | 54723 | | 5 | 1332864.16 | 15085.72073 |

Table 10.2 CTD casts sampled for determination of microbial concentrations (D286)

| Station number | Sample number | Location | Depth, m | Bacterioplankton cells ml ⁻¹ | Phytoplankton cells ml ⁻¹ |
|----------------|---------------|----------|----------|---|--------------------------------------|
| 15553 | 55314 | M9 | 200 | 303180.3797 | 350 |
| 15553 | 55315 | M9 | 175 | 333712.6246 | 202 |
| 15553 | 55316 | M9 | 150 | 409409.7421 | 300 |
| 15553 | 55318 | M9 | 100 | 515811.8406 | 1568 |
| 15553 | 55319 | M9 | 80 | 604910.1628 | 5721 |
| 15553 | 55320 | M9 | 60 | 651024.5902 | 10804 |
| 15553 | 55321 | M9 | 40 | 468089.3884 | 16244 |
| 15553 | 55322 | M9 | 20 | 634266.6667 | 12453 |
| 15553 | 55323 | M9 | 10 | 738499.7196 | 11329 |
| 15553 | 55324 | M9 | 5 | 757395.8333 | 11126 |
| 15556 | 55612 | | 200 | 219603.9067 | 359 |
| 15556 | 55613 | | 150 | 311295.2799 | 791 |
| 15556 | 55614 | | 100 | 364903.0234 | 761 |
| 15556 | 55615 | | 80 | 496508.8235 | 6243 |
| 15556 | 55616 | | 60 | 733258.2322 | 29453 |
| 15556 | 55617 | | 40 | 958015.2225 | 27127 |
| 15556 | 55618 | | 20 | 1008264.868 | 29946 |
| 15556 | 55621 | | 10 | 998963.3081 | 30080 |
| 15556 | 55623 | | 5 | 987460.733 | 30177 |
| 15557 | 55714 | | 200 | 256447.5874 | 401 |
| 15557 | 55715 | | 175 | 307675.0142 | 349 |
| 15557 | 55716 | | 150 | 362430.4009 | 316 |

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|-------|-------|-----|-----|-------------|-------|
| 15557 | 55718 | | 100 | 476592.0398 | 903 |
| 15557 | 55719 | | 80 | 548361.2233 | 2000 |
| 15557 | 55720 | | 60 | 766061.7978 | 14347 |
| 15557 | 55721 | | 40 | 943485.0993 | 31059 |
| 15557 | 55722 | | 20 | 981378.0207 | 32070 |
| 15557 | 55723 | | 10 | 973566.3717 | 31630 |
| 15557 | 55724 | | 5 | 917551.0204 | 30720 |
| 15562 | 56214 | M10 | 200 | 210498.3389 | 220 |
| 15562 | 56215 | M10 | 175 | 250332.9298 | 258 |
| 15562 | 56216 | M10 | 150 | 293606.5574 | 285 |
| 15562 | 56217 | M10 | 125 | 366017.2911 | 457 |
| 15562 | 56218 | M10 | 100 | 436115.6304 | 936 |
| 15562 | 56219 | M10 | 80 | 483840.4133 | 1375 |
| 15562 | 56220 | M10 | 60 | 560745.0524 | 8612 |
| 15562 | 56221 | M10 | 40 | 860150.289 | 18453 |
| 15562 | 56222 | M10 | 20 | 909050.2793 | 15168 |
| 15562 | 56223 | M10 | 10 | 891000 | 15218 |
| 15562 | 56224 | M10 | 5 | 809240.7199 | 14648 |
| 15565 | 56514 | | 200 | 206324.2009 | 124 |
| 15565 | 56515 | | 150 | 252901.3255 | 205 |
| 15565 | 56516 | | 125 | 298903.7571 | 328 |
| 15565 | 56517 | | 100 | 353191.0995 | 494 |
| 15565 | 56518 | | 80 | 427679.4616 | 447 |
| 15565 | 56519 | | 60 | 586793.9481 | 9193 |
| 15565 | 56520 | | 40 | 574156.9027 | 2878 |
| 15565 | 56521 | | 20 | 730178.8413 | 23211 |
| 15565 | 56523 | | 10 | 723863.7532 | 23331 |
| 15565 | 56524 | | 5 | 769766.9492 | 23346 |
| 15566 | 56610 | | 85 | 28517 | 3908 |
| 15566 | 56611 | | 75 | 23367 | 5762 |
| 15570 | 57008 | | 200 | 276802.0441 | 641 |
| 15570 | 57009 | | 150 | 503558.5831 | 903 |
| 15570 | 57019 | | 100 | 493370.0138 | 3082 |
| 15570 | 57020 | | 80 | 700203.8627 | 5445 |
| 15570 | 57021 | | 60 | 693619.8738 | 6994 |
| 15570 | 57022 | | 40 | 632756.0473 | 6096 |
| 15570 | 57023 | | 20 | 619927.4611 | 6206 |
| 15570 | 57024 | | 10 | 608351.735 | 5921 |
| 15573 | 57317 | M3 | 250 | 228840 | 164 |
| 15573 | 57318 | M3 | 125 | 470511.9543 | 414 |
| 15573 | 57319 | M3 | 100 | 565301.8868 | 1026 |
| 15573 | 57320 | M3 | 80 | 696503.3872 | 2919 |
| 15573 | 57321 | M3 | 60 | 925895.5614 | 6770 |
| 15573 | 57322 | M3 | 40 | 1381483.771 | 30017 |
| 15573 | 57323 | M3 | 20 | 1362712.902 | 30102 |
| 15573 | 57324 | M3 | 10 | 1301276.488 | 30918 |
| 15576 | 57616 | | 200 | 157287.2076 | 265 |
| 15576 | 57617 | | 150 | 228840 | 583 |
| 15576 | 57618 | | 100 | 470511.9543 | 561 |

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|-------|-------|----|-----|-------------|--------|
| 15576 | 57619 | | 80 | 565301.8868 | 4605 |
| 15576 | 57620 | | 60 | 696503.3872 | 21724 |
| 15576 | 57621 | | 40 | 925895.5614 | 20008 |
| 15576 | 57622 | | 20 | 1381483.771 | 22088 |
| 15576 | 57623 | | 10 | 1362712.902 | 22186 |
| 15576 | 57624 | | 5 | 1301276.488 | 22258 |
| 15582 | 58216 | M5 | 200 | 158329.1833 | 110 |
| 15582 | 58217 | M5 | 150 | 222732.2134 | 221 |
| 15582 | 58218 | M5 | 100 | 411097.0677 | 3294 |
| 15582 | 58219 | M5 | 80 | 368183.8454 | 13500 |
| 15582 | 58220 | M5 | 60 | 482338.0567 | 15167 |
| 15582 | 58221 | M5 | 40 | 467212.8784 | 17416 |
| 15582 | 58222 | M5 | 20 | 492835.277 | 22601 |
| 15582 | 58223 | M5 | 10 | 498591.8675 | 22337 |
| 15582 | 58224 | M5 | 5 | 555494.5055 | 23018 |
| 15584 | 58415 | | 200 | 152876.8963 | 215 |
| 15584 | 58416 | | 150 | 189695.1626 | 199 |
| 15584 | 58417 | | 125 | 280827.8633 | 474 |
| 15584 | 58418 | | 100 | 338736.9036 | 1578 |
| 15584 | 58419 | | 80 | 500518.5615 | 9308 |
| 15584 | 58421 | | 40 | 464627.1641 | 18870 |
| 15584 | 58422 | | 20 | 460901.5002 | 19001 |
| 15584 | 58423 | | 10 | 452342.9251 | 19229 |
| 15584 | 58424 | | 5 | 496074.104 | 18652 |
| 15585 | 58515 | | 200 | 156409.0279 | 19102 |
| 15585 | 58516 | | 150 | 195581.7139 | 14830 |
| 15585 | 58517 | | 125 | 229077.1043 | 34214 |
| 15585 | 58518 | | 100 | 384376.4495 | 361085 |
| 15585 | 58519 | | 80 | 462463.8408 | 574301 |
| 15585 | 58520 | | 60 | 494944.9359 | 701189 |
| 15585 | 58521 | | 40 | 481425.1247 | 596918 |
| 15585 | 58522 | | 20 | 488347.6155 | 531042 |
| 15585 | 58523 | | 10 | 491196.2839 | 424893 |
| 15585 | 58524 | | 5 | 502340.7516 | 434796 |
| 15586 | 58615 | | 200 | 104343.5157 | 104 |
| 15586 | 58616 | | 150 | 114547.2742 | 136 |
| 15586 | 58617 | | 125 | 398108.6517 | 947 |
| 15586 | 58618 | | 100 | 304112.0008 | 1643 |
| 15586 | 58619 | | 80 | 326274.3196 | 4948 |
| 15586 | 58620 | | 60 | 309804.3535 | 7800 |
| 15586 | 58621 | | 40 | 241988.5865 | 6601 |
| 15586 | 58622 | | 20 | 233829.7296 | 6935 |
| 15586 | 58623 | | 10 | 207224.9402 | 6265 |
| 15586 | 58624 | | 5 | 230615.9699 | 6282 |
| 15587 | 58715 | | 200 | 101742.3021 | 326 |
| 15587 | 58716 | | 150 | 152986.111 | 292 |
| 15587 | 58717 | | 125 | 245097.5692 | 652 |
| 15587 | 58718 | | 100 | 256274.7739 | 1013 |
| 15587 | 58719 | | 80 | 264686.9471 | 2519 |

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|-------|-------|----|-----|-------------|-------|
| 15587 | 58721 | | 40 | 306142.9061 | 4158 |
| 15587 | 58722 | | 20 | 316634.8141 | 4662 |
| 15587 | 58723 | | 10 | 282215.5552 | 4157 |
| 15587 | 58724 | | 5 | 278935.5597 | 3899 |
| 15589 | 58913 | M3 | 200 | 149014.1603 | 442 |
| 15589 | 58914 | M3 | 150 | 191026.2097 | 912 |
| 15589 | 58915 | M3 | 125 | 212282.4095 | 1483 |
| 15589 | 58916 | M3 | 100 | 244689.3224 | 4145 |
| 15589 | 58917 | M3 | 80 | 281575.4127 | 5926 |
| 15589 | 58918 | M3 | 60 | 298014.9503 | 7433 |
| 15589 | 58920 | M3 | 40 | 287209.9525 | 7497 |
| 15589 | 58921 | M3 | 20 | 268788.3293 | 7205 |
| 15589 | 58922 | M3 | 10 | 268429.7621 | 7141 |
| 15589 | 58924 | M3 | 5 | 248671.1179 | 7447 |
| 15596 | 59616 | M6 | 200 | 309603.253 | 111 |
| 15596 | 59617 | M6 | 150 | 189456.7789 | 162 |
| 15596 | 59618 | M6 | 100 | 438621.0851 | 984 |
| 15596 | 59619 | M6 | 80 | 576502.5673 | 1827 |
| 15596 | 59620 | M6 | 60 | 511321.0753 | 5894 |
| 15596 | 59621 | M6 | 40 | 526448.4955 | 5755 |
| 15596 | 59622 | M6 | 20 | 525612.027 | 5537 |
| 15596 | 59623 | M6 | 10 | 529247.7445 | 6825 |
| 15596 | 59624 | M6 | 5 | 514644.3124 | 6061 |
| 15600 | 60001 | M6 | 40 | 608957.0174 | 8048 |
| 15600 | 60003 | M6 | 40 | 580988.9394 | 8579 |
| 15600 | 60005 | M6 | 40 | 585454.5818 | 8845 |
| 15600 | 60007 | M6 | 40 | 572608.2454 | 8063 |
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| 15600 | 60011 | M6 | 40 | 520998.752 | 6644 |
| 15600 | 60013 | M6 | 40 | 586575.008 | 7906 |
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| 15600 | 60017 | M6 | 40 | 618054.8828 | 7361 |
| 15600 | 60019 | M6 | 40 | 613641.5933 | 10047 |
| 15600 | 60021 | M6 | 40 | 543808.3496 | 18668 |
| 15600 | 60023 | M6 | 40 | 580921.2316 | 8720 |
| 15606 | 60615 | M2 | 200 | 146204.1152 | 86 |
| 15606 | 60616 | M2 | 150 | 203275.2881 | 327 |
| 15606 | 60617 | M2 | 125 | 319191.8149 | 693 |
| 15606 | 60618 | M2 | 100 | 460344.654 | 1710 |
| 15606 | 60619 | M2 | 80 | 582554.7977 | 3144 |
| 15606 | 60620 | M2 | 60 | 602837.8819 | 10259 |
| 15606 | 60621 | M2 | 40 | 466222.1806 | 9210 |
| 15606 | 60622 | M2 | 20 | 490558.9195 | 9726 |
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| 15606 | 60624 | M2 | 5 | 413978.6699 | 8345 |
| 15614 | 61411 | | 200 | 138229.5767 | 284 |
| 15614 | 61412 | | 150 | 126556.9984 | 706 |
| 15614 | 61413 | | 125 | 160024.8337 | 696 |
| 15614 | 61414 | | 100 | 184350.0753 | 1353 |

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|-------|-------|--|-----|-------------|-------|
| 15614 | 61415 | | 80 | 249259.3742 | 2653 |
| 15614 | 61416 | | 70 | 325011.8506 | 3108 |
| 15614 | 61417 | | 60 | 272521.6361 | 3727 |
| 15614 | 61418 | | 50 | 300197.1041 | 5819 |
| 15614 | 61419 | | 40 | 304985.1509 | 6400 |
| 15614 | 61420 | | 30 | 323715.2918 | 11396 |
| 15614 | 61421 | | 20 | 420242.8395 | 28123 |
| 15614 | 61423 | | 10 | 469962.8015 | 28651 |
| 15614 | 61424 | | 5 | 475327.9529 | 29636 |
| 15620 | 62006 | | 200 | 212144.511 | 963 |
| 15620 | 62008 | | 150 | 244335.2086 | 665 |
| 15620 | 62011 | | 100 | 294660.9932 | 683 |
| 15620 | 62013 | | 80 | 335390.4966 | 1245 |
| 15620 | 62015 | | 60 | 383198.9085 | 1598 |
| 15620 | 62016 | | 50 | 423818.3949 | 2052 |
| 15620 | 62018 | | 40 | 464690.7676 | 2856 |
| 15620 | 62021 | | 20 | 639834.1801 | 14312 |
| 15620 | 62023 | | 10 | 776934.2022 | 14955 |
| 15623 | 62305 | | 200 | 235415.1783 | 621 |
| 15623 | 62306 | | 200 | 248251.0107 | 594 |
| 15623 | 62307 | | 150 | 282872.4447 | 882 |
| 15623 | 62308 | | 125 | 306083.4859 | 1644 |
| 15623 | 62309 | | 100 | 391160.1868 | 1198 |
| 15623 | 62310 | | 100 | 398006.1751 | 1220 |
| 15623 | 62311 | | 80 | 435399.0748 | 3125 |
| 15623 | 62312 | | 80 | 436729.0046 | 3346 |
| 15623 | 62313 | | 60 | 452626.9723 | 9990 |
| 15623 | 62314 | | 60 | 496505.6876 | 11247 |
| 15623 | 62315 | | 50 | 415782.0492 | 20473 |
| 15623 | 62316 | | 50 | 421805.2635 | 20653 |
| 15623 | 62317 | | 40 | 399762.4001 | 23631 |
| 15623 | 62318 | | 40 | 419643.0893 | 23001 |
| 15623 | 62319 | | 20 | 399732.2 | 22538 |
| 15623 | 62320 | | 20 | 409047.5532 | 23072 |
| 15623 | 62321 | | 10 | 376594.7396 | 24020 |
| 15623 | 62322 | | 10 | 369754.9893 | 24028 |
| 15623 | 62323 | | 5 | 399606.1104 | 21677 |
| 15623 | 62324 | | 5 | 392038.1816 | 23955 |
| 15628 | 62815 | | 200 | 175113.8502 | 240 |
| 15628 | 62816 | | 150 | 232516.3028 | 319 |
| 15628 | 62817 | | 125 | 247649.8784 | 401 |
| 15628 | 62818 | | 100 | 337004.5212 | 527 |
| 15628 | 62819 | | 80 | 318960.5823 | 786 |
| 15628 | 62820 | | 60 | 419707.6935 | 1449 |
| 15628 | 62821 | | 40 | 589355.3759 | 6053 |
| 15628 | 62822 | | 20 | 751350.2507 | 14867 |
| 15628 | 62823 | | 10 | 674827.8026 | 15307 |
| 15628 | 62824 | | 5 | 697764.8101 | 16140 |
| 15632 | 63215 | | 200 | 137348.7825 | 108 |

| | | | | | |
|-------|-------|--|-----|-------------|-------|
| 15632 | 63216 | | 150 | 155119.6896 | 163 |
| 15632 | 63217 | | 125 | 166874.9645 | 257 |
| 15632 | 63218 | | 100 | 214516.4907 | 651 |
| 15632 | 63219 | | 80 | 201091.58 | 1079 |
| 15632 | 63220 | | 60 | 268095.9711 | 2462 |
| 15632 | 63221 | | 40 | 418552.2164 | 5370 |
| 15632 | 63222 | | 20 | 345175.8866 | 19199 |
| 15632 | 63223 | | 10 | 352913.2299 | 19187 |
| 15632 | 63224 | | 5 | 447270.0641 | 20005 |

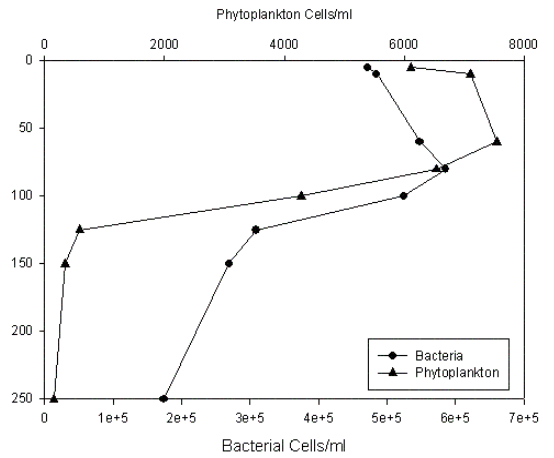
Table 10.3 CTD casts sampled for nutrient dynamic experiments

| Date | CTD | Lat, °S | Long, °E |
|--------|-------|---------|----------|
| 11-Nov | 15491 | 43.92 | 50.23 |
| 13-Nov | 15496 | 46.07 | 51.79 |
| 18-Nov | 15499 | 46.03 | 51.81 |
| 19-Nov | 15502 | 47.80 | 52.86 |
| 23-Nov | 15511 | 49.00 | 51.50 |
| 24-Nov | 15516 | 46.06 | 51.79 |
| 27-Nov | 15524 | 45.49 | 49.00 |
| 30-Nov | 15531 | 44.92 | 49.90 |
| 2-Dec | 15537 | 44.87 | 49.66 |
| 4-Dec | 15543 | 43.12 | 47.18 |

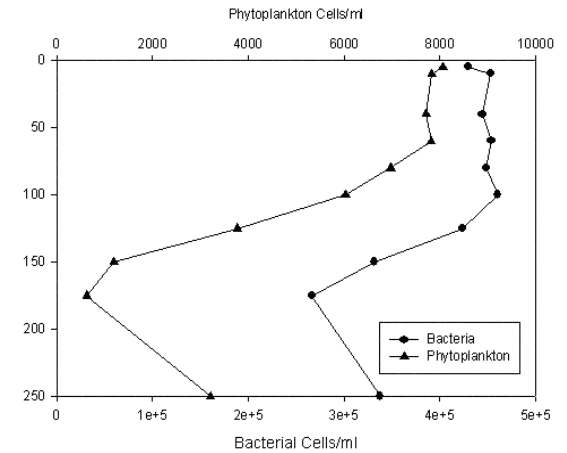
Appendix:

Plots of Raw CTD FC Data for Major Stations Sampled

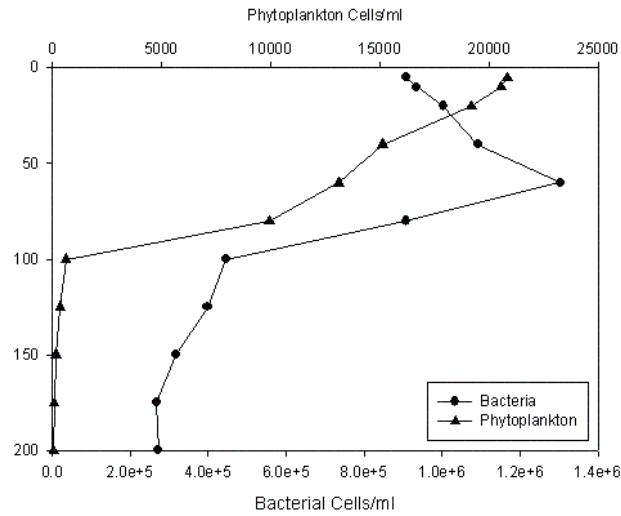
Bacteria and Phytoplankton Cell Counts at Station 15504 (M2)



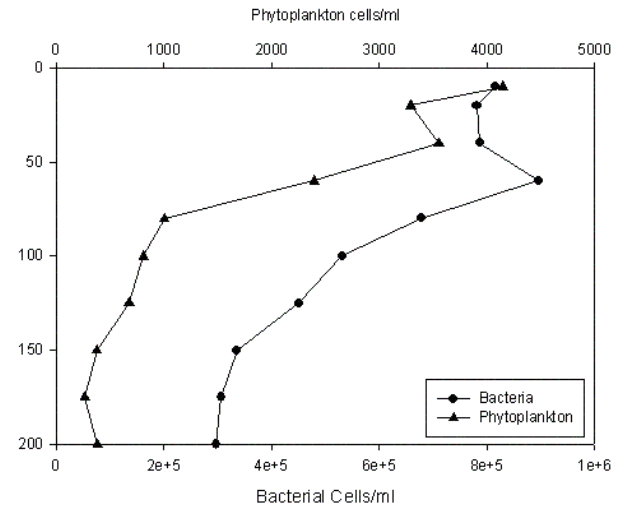
Bacterial and Phytoplankton Cell Counts/ml at Station 15507 (M6)



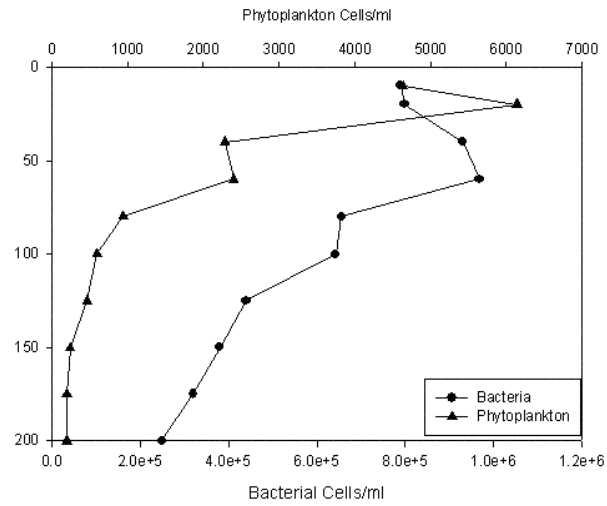
Bacterial and Phytoplankton Cells/ml at Station 15532 (M8 East)



Bacterial and Phytoplankton Cells/ml at Station 15540 (M8 West)



Bacterial and Phytoplankton Cells/ml at Station 15539 (M8 West)



Bacterial and Phytoplankton Cells/ml at Station 15544 (M9)

