11. NITROGEN FIXATION BY *TRICHODESMIUM*

The nitrogen-fixing pelagic cyanobacterium, *Trichodesmium*, is a seasonally conspicuous element of phytoplankton populations within the GBR (Marshall, 1933; Revelante and Gilmartin, 1982; Furnas, 1992). It can found at any time of the year throughout the GBR, but is most conspicuous during the summer months (October - April) when large surface slicks are frequently observed, particularly in inshore waters. Despite a large body of anecdotal information on sightings of *Trichodesmium* surface slicks throughout the GBR, there is little, if any, quantitative data on the spatial distribution (vertically, horizontally) of *Trichodesmium* populations or temporal variations in its abundance within regional areas. Two time series of quantitative data are currently available, the pioneering observations of Marshall (1933) near Low Isles (16°S) over an annual cycle and a two year time series published by Revelante and Gilmartin (1982) for inner shelf waters off Townsville (19°S). At present the only data set for which numerical values are available is that of Marshall. *Trichodesmium* population dynamics at both sites are characterized by a series of short-term fluctuations in colony numbers with only a moderate degree of seasonality. Table 27 summarizes seasonal differences in the abundance of *Trichodesmium* populations off Low Isles during 1928-29. All data are presented as depth weighted mean water column concentrations of *Trichodesmium* colonies. Most colonies observed tend to be of the fusiform or (tuft) type, with the remainder of the radial or puff morphology. No quantitative estimates are available for either the number of filaments (trichomes) per colony in GBR waters or number of cells per trichome. By visual inspection, most fusiform colonies consist of only a small number of trichomes, but puffs appear to have a much larger number of trichomes. Individual trichomes are also frequently observed on filters. Cook (quoted in Beaglehole, 1955) first described the presence of *Trichodesmium* in the GBR and noted that colonies consisted of 30-40 filaments, a number consistent with the generally slender morphology of most bundle colonies.

Very broad, first-order estimates of the contribution of atmospheric nitrogen fixed by *Trichodesmium* in the central GBR can be made from the available quantitative data (Table 27) and published measurements of *Trichodesmium* nitrogen fixation rates. Estimates of pelagic N_2 fixation by *Trichodesmium* are directly dependent upon both the nominal N_2 fixation rate per trichome and the number of trichomes per colony. Both estimates are variable over more than one order of magnitude. As N_2 fixation is an energy intensive process, fixation rates are known to be strongly dependent upon ambient light intensity (Gallon and Stal, 1992). Not surprisingly, most colonies of *Trichodesmium* occur in the upper 10 m of the water column (Furnas, unpubl. data), though they are found throughout the water column under normal conditions. Pronounced surface slicks of *Trichodesmium* readily form under calm conditions, visually exaggerating the apparent abundance of local populations.

Recently published measurements of N_2 fixation rates by *Trichodesmium* fall within a 30-fold range (0.53 to 18 pmol N trichome^{-1} hr^{-1}; Carpenter et al., 1987; Carpenter and Capone, 1992). Based on the seasonal mean and median colony concentrations calculated from Marshall's data (Table 27), a 10-hour period of active fixation per day and a nominal estimate of 40 trichomes per colony (Cook's estimate), the above range of trichome specific N_2 fixation rates translate to annual fixation estimates of 191-6,493 x 10^3 and 256-8,692 x 10^3 kmol of nitrogen for the Cairns and Tully boxes, respectively, based on the seasonal mean colony concentrations and 140-4,764 x 10^3 and 188-6,382 x 10^3 kmol of nitrogen based on the seasonal median estimates. The calculation assumes significant N_2 fixation is largely restricted to the top 10 m of the water column and that cellular abundances and fixation rates are uniform over the entire area of each box, a highly doubtful assumption. Accordingly, the estimates given should be considered as covering the extreme maximal range. A sampling program was recently instituted by the Biological Oceanography group to quantify the spatial and temporal variability of *Trichodesmium* populations throughout the GBR; however, given the observed variability in

Trichodesmium abundance off Cairns and Townsville, it should be a number of years before sufficient data is available to derive population estimates with some statistical estimation of variability at the regional scale. Initial indications suggest that *Trichodesmium* concentrations in outer-shelf waters are considerably lower than inshore, which would affect areal weighting of the estimates calculated above.

Table 27. Preliminary estimates of nitrogen fixation by *Trichodesmium* in the Cairns and Tully boxes. Calculations are based on the seasonal depth-weighted mean and median abundances of colonies as counted by Marshall (1933) near Low Isles and the range of published fixation rates in the literature. Fixation is assumed to extend to the bottom or 10 m, whichever is shallower. Volumes are in litres.

Box	Season		colonies litre	trichomes colony	kmol trichome-hr	hours day	days	Inshore volume	Offshore volume	kmol
Cairns	Winter	Mean	22.7	40	5.30E-16	10	153	1.90E+12	5.56E+13	42337
		Median	5.1	40	5.30E-16	10	153	1.90E+12	5.56E+13	9512
	Summer	Mean	57.6	40	5.30E-16	10	212	1.90E+12	5.56E+13	148855
		Median	50.6	40	5.30E-16	10	212	1.90E+12	5.56E+13	130765
									Mean Total	191192
									Median Total	140276
Tully	Winter	Mean	22.7	40	5.30E-16	10	153	1.50E+12	7.52E+13	56445
		Median	5.1	40	5.30E-16	10	153	1.50E+12	7.52E+13	12681
	Summer	Mean	57.6	40	5.30E-16	10	212	1.90E+12	7.52E+13	199491
		Median	50.6	40	5.30E-16	10	212	1.90E+12	7.52E+13	175247
									Mean Total	255935
									Median Total	187929
Cairns	Winter	Mean	22.7	40	1.80E-14	10	153	1.90E+12	5.56E+13	1437863
		Median	5.1	40	1.80E-14	10	153	1.90E+12	5.56E+13	323044
	Summer	Mean	57.6	40	1.80E-14	10	212	1.90E+12	5.56E+13	5055437
		Median	50.6	40	1.80E-14	10	212	1.90E+12	5.56E+13	4441061
									Mean Total	6493300
									Median Total	4764105
Tully	Winter	Mean	22.7	40	1.80E-14	10	153	1.50E+12	7.52E+13	1916984
		Median	5.1	40	1.80E-14	10	153	1.50E+12	7.52E+13	430688
	Summer	Mean	57.6	40	1.80E-14	10	212	1.90E+12	7.52E+13	6775165
		Median	50.6	40	1.80E-14	10	212	1.90E+12	7.52E+13	5951794
									Mean Total	8692149
									Median Total	6382482