Southeast Asian Fisheries Development Center

Analysis and Pre-Estimation of Nutrients in Vietnamese Waters

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ABSTRACT

The distribution of nutrients (Silica, Phosphate, Ammonium, Nitrate, Nitrite and Sulfate) in the Vietnamese waters was studied in the SEAFDEC Interdepartmental Collaborative Research Survey: Area IV. The samples were collected by M.V. SEAFDEC on the 30 April to 29 May 1999 (post monsoon period). Fifty-eight stations (2m from surface and 100 m from surface) were established in this study. The average of Silica at the surface layer is 25.96μM and at the bottom layer is 30.69μM. The average of Phosphate at the surface layer is 0.890 μM and at the bottom layer is 1.353μM. The average of Ammonium at the surface layer is 2.805μM and at the bottom layer is 2.538μM. The average of Nitrate at the surface layer is 5.593μM and at the bottom layer is 6.810μM. The average of Nitrite at the surface layer is 0.169μM and at the bottom layer is 0.197μM. The average of Sulfate at the surface layer is 26.903 μM and at the bottom layer is 27.831μM. The results indicated that the concentrations of Silica, Phosphate, Nitrate, Nitrite and Sulfate in deep water were higher in the surface water, but the Ammonium is inverse.

Key words: Nutrients, Vietnamese waters, along coastline

Introduction

One of most important problems in the oceanographic study is determination and estimation of nutrient composition and the their relationship in the development, revolution, biotransformation etc. in the seawater and sediments with sea-biologists. Phytoplanktons are primary producer in the sea. They require dissolved inorganic nutrients for their growth. Through photosynthesis, they produce food for supporting all trophic levels in the sea. Phytoplanktons provide food for zooplankton which are then consumed by organisms higher up in the food chain. Based on international and Vietnamese references, focused into six parameters in nutrients: Silicate, Inorganic Phosphate, Ammonia, Nitrate, Nitrite and Sulfate.

Materials and Methods

The present reference method designed to provide the user with reliable techniques for the determination of six chemical parameters of general application to basic oceanographic studies, whether at sea or within coastal lagoons and estuaries. It is interesting to note that, although techniques have existed for these parameters for more than haft a century, the general analytical precision and accuracy of them have been poor. This is partly due to the ease with samples may be contaminated during handling and the tendency (particularly with nutrients) for the analyses to break down or react during storage.

The marine analytical chemist is faced with two major problems. Firstly, to procedure correct analytical results in the rather complicated seawater matrix; and secondly, to obtain representative samples from a highly variable environment over which he has no control. The latter problem is complicated by fact that the constituents (dissolved or dispersed) in the sea have three-dimensional pattern of distribution, i.e. they vary from place to place, with depth and with time because of physical and biogeochemical processes. In addition, the sample itself may drastically change its composition after having been enclosed in the sampler and removed from its natural environment. Therefore, the most refined techniques and skilled work on the part of the analyst will not produce automatically a representative value if the sampling procedure is influenced by significant errors.

Sampling

Fifty-eight stations from offshore of Vietnam from latitude 7°N to 21°N and longitude 103°E to 112°E were established in this study (Plan 1).

M.V. SEAFDEC collected the water samples on 30 April 1999 to 29 May 1999 (post-northeast monsoon period). Water sampler attached to a rosette system collected the water at each station during cruise on two levels (surface and bottom). The water samples were transferred into PE bottles.

The samples were analyzed in laboratory of the Department for Analytical Science and Technique of the Institute of Chemistry, National Center for Natural Science and Technology of Vietnam (NCST).

All bottles, filter membranes and labwares that would be in contact with samples were carefully pre-washed by 10% suprapure HNO_3 acid and Milli-Q water.

Merck standard solutions diluted by Milli-Q water was used as standards.

The concentrations of nutrients were measured using GBC UV-VIS CINTRA 40 Spectrometer and Ion - Chromatograph Metrohm concerning 709 IC Pump, 732 IC Detector and 733 IC Separator.

Analytical methods

Determination of dissolved silicon

The determination of dissolved silicon compounds is based on the formulation of a heteropoly acid when the sample is treated with a molybdate solution. This silicomolybdic acid is then reduced to an intensely blue-colored complex by adding ascorbic acid as a reductant. The color is formed within 30 minute, determined at 810nm wave length, and is stable for several hours.

Measure 50cm^3 of the sample with a graduated cylinder and transfer it into the plastic reaction bottle. Add 1.5cm^3 of the mixed reagent and mix well. After 10-20 minute add 1cm^3 oxalic acid immediately followed by 1cm^3 ascorbic acid. Mix well between the additions. Measure the absorbency after 30-40 minute in a cell of suitable length at 810nm against distilled water as reference.

Determination of dissolved inorganic phosphate

The phosphate ions in the sample react in acidic solution with ammonium molybdate to yield a phospho-molybdate complex. This heteropoly to a blue-coloured complex, the absorbency of which is then measured in a spectrophotometer at 882nm.

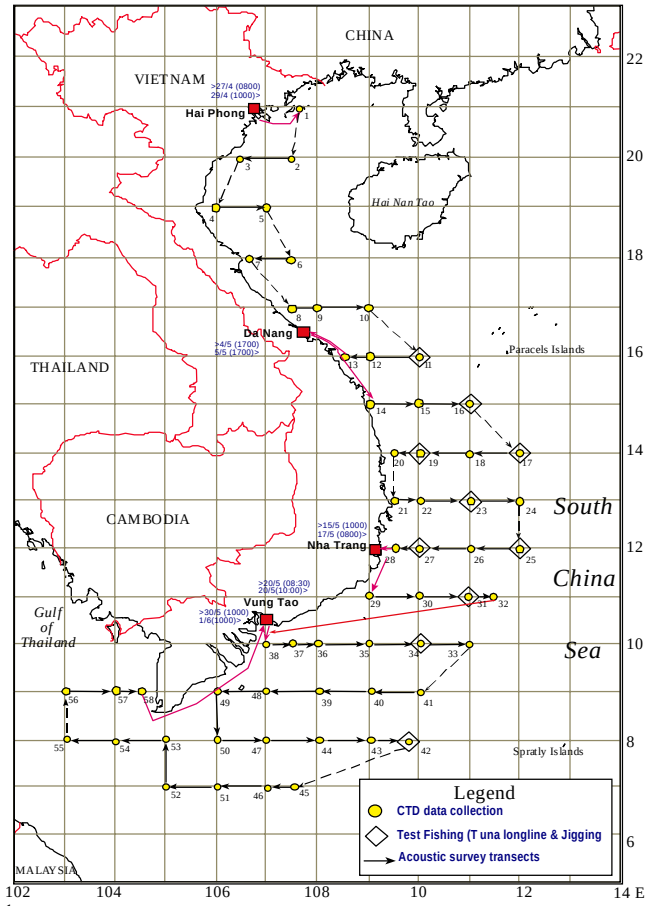
Transfer two 50cm^3 portions of the sample to two reaction flasks. One of the portions is regarded as the sample, the other one as the turbidity blank. To each of the portions add 1.5cm^3 of the mixed reagent ascorbic acid solution. Mix well between the additions. After 10 minute measure the absorbency of the sample and the turbidity blank at 882nm against acidified distilled water as reference.

Determination of Ammonia

The method is specific for ammonia and is based on the formation of the blue colored indophenol by phenol and hypochlorite in the presence of the NH_4^+ and NH_3 species. The reaction requires an elevated temperature or a catalyst. The colour is measured at 630nm and is stable for at least 30 hours.

Measure 50cm^3 of the sample with a graduated cylinder and transfer it into the reaction flasks. Add 2cm^3 phenol reagent, 1cm^3 buffer solution and 2cm^3 hypochlorite reagent. Mix well by swirling between the additions. Close the reaction bottles properly and keep them in a dark place during the reaction time.

Measure the absorbency after 6 hours in a cell of suitable length at 630nm and use a cuvette of similar length filled with distilled water as reference.



Plan 1. The survey stations for the SEAFDEC Area IV: Vietnamese Waters.

Determination of Nitrate

The method generally applied for the determination of nitrate is based on its reduction to nitrite, which is then determined colorimetrically via the formation of an azo dye. Nitrate is reduced to nitrite in a reduction column filled with copper-coated cadmium granules.

Transfer 25cm^3 of the sample into the reaction flask 100cm^3, add 25cm^3 of the buffer solution and mix well. If nitrate concentrations of more than about 15mmol/dm^3 are expected 25cm^3 of the sample must be diluted with 75cm^3 of the buffer solution.

Pass about 20cm^3 of the mixture through the reduction column in order to rinse the system and to adjust the time of passage. Discard this fraction. Then pass another fraction through the column until the level in the Erlenmeyer flask has reached the 25cm^3 mark.

Determination of Nitrite

The photometry determination of nitrite is based on the reaction of nitrite with an aromatic amine (sulfanilamide) which leads (at pH 1.5 - 2.0) to the formation of a diazonium compound. This diazo compound then couples with a second aromatic amine N-(1-naphtyl)-ethylenediamine to form the azo dye with a molar absorptivity of about 46,000.

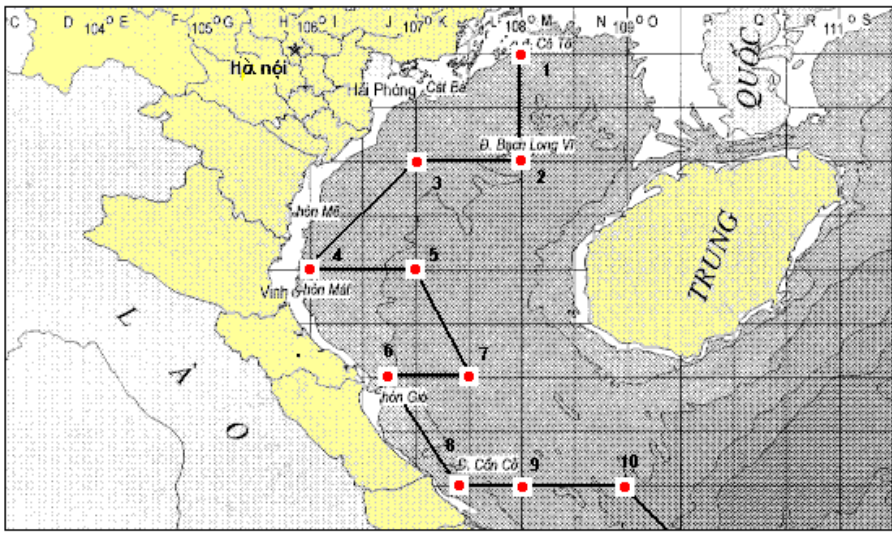
Transfer 50cm^3 of the sample into reaction bottle and add 1cm^3 of the sulfanilamide reagent. Then mix well. After reaction time about 1 minute, add 1cm^3 of the diamine solution. Shake the flask and allow the azo dye to develop for at least 20-30 minute. Measure the absorbance in a cell of suitable length at 540nm against distilled water as reference. The colour intensity is constant for about two hours.

Determination of Sulfate

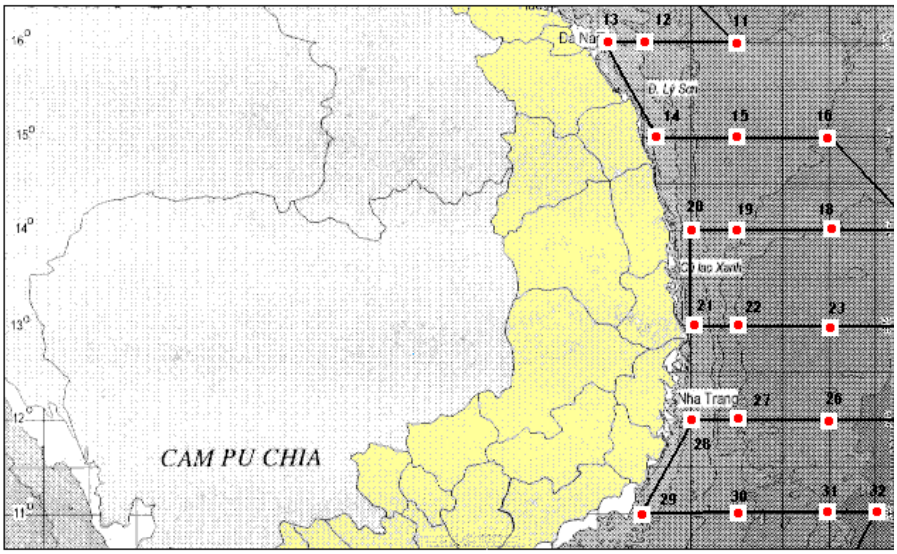
The volume of the water samples to be employed for gravimeter determination of sulfate must be measured so that it contains between 10 and 500mg sulfate ions. Where necessary a larger volume of water must be reduced to 400ml and / or in the case of lower concentrations of sulfate ions to 100ml. Hydrochloric acid is added to this volume until any sediment possibly present or any salt precipitate (calcium sulfate) is redissolved. In principle, the entire contents of the sampling should be used for an analysis. Care should be taken that the hydrochloric acid employed for acidification and / or for dissolving residue and salt precipitates does not comprise more than 1ml per 100ml of the reduced solution. Any precipitates not dissolving (e.g. silicic acid) or other substances remaining undissolved are filtered off before precipitation of sulfate.

The solution prepared for precipitation is heated to boiling point and an excess of hot barium chloride solution added at boiling heat. After completion of precipitation, the sample is allowed to continue to boil for a further 30 minutes and then covered with a watch glass overnight. On the next day, the barium sulfate precipitation is filtered off, either through a paper filter or through a filtering crucible A1 that has been baked at 800^o C and weighed.

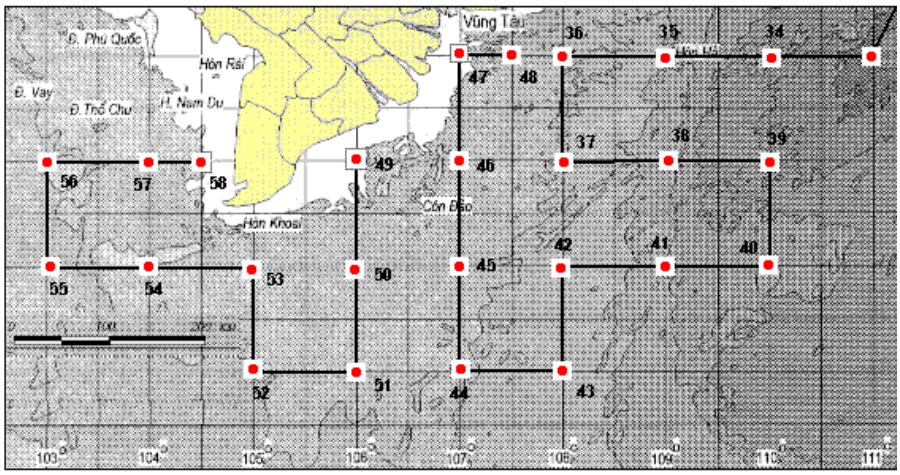
The precipitate is washed with hot water until a negative chloride reaction is detected in the filtrate. 1mg barium sulfate corresponds to 0.4115mg SO_4^{2-}. The sulfate content of the water analyzed is calculated from the quantity of barium sulfate weighed.



Plan 2. The survey stations for the Northern region.



Plan 3. the survey stations for the middle region.



Plan 4. The survey stations for the southern region.

Results and Discussion

With a long coastline (more than 2000 km) and large continental shelf, the marine environment of Vietnam is characterized by a wide range of geomorphological, climatic, hydrological and economical conditions. (Plan 1). In addition, could separated the Vietnamese coastline in three zones (sub-regions): Tonkin gulf (gulf of Northern region), sea of Middle region and sea of Southern region. In the Southern region, could divided into two sub-zone insisting of Southeastern and Southwestern regions. (Plans 2, 3 and 4).

The concentration of determined nutrients of survey cruises at surface (2m from surface of water) and bottom layer (100 m from surface of water) of sampling stations are presented in Tables 1, 2,3,4,5,6,7,8 and 9.

Silica

Table 1.1 and1.2 shows concentrations of silica from 58 sampling stations in surface and bottom layers. Generally, bottom samples have higher concentration than surface samples. Highest concentration of silicate is 55,60µM equals 3.340mg/l in stations 16B and 18B belongs to the middle region. In the seaside of this region there are several mines containing SiO_2, Al_2O_3, $CaCO_3$ etc. Lower concentration is in stations 23B, 24B and 25B with 49.91-51.09µM (2.994 - 3.065mg/l). Especially in station 38B in southern region silicate concentration is rather high - 51.41mM (3.084mg/l). Lowest concentration of silicate is 17.69µM (1.061mg/l) in stations 1S, 2S, 4S and 5S in northern region. Variations of silicate concentration in whole Vietnamese marine region are shown in Fig. 1. Average value in surface layer is 25.96µM (1.557mg/l) and in bottom layer - 30.69µM (1.841 mg/l). Generally, previous results (from 1996-1997) of Vietnam in middle region are compatible.

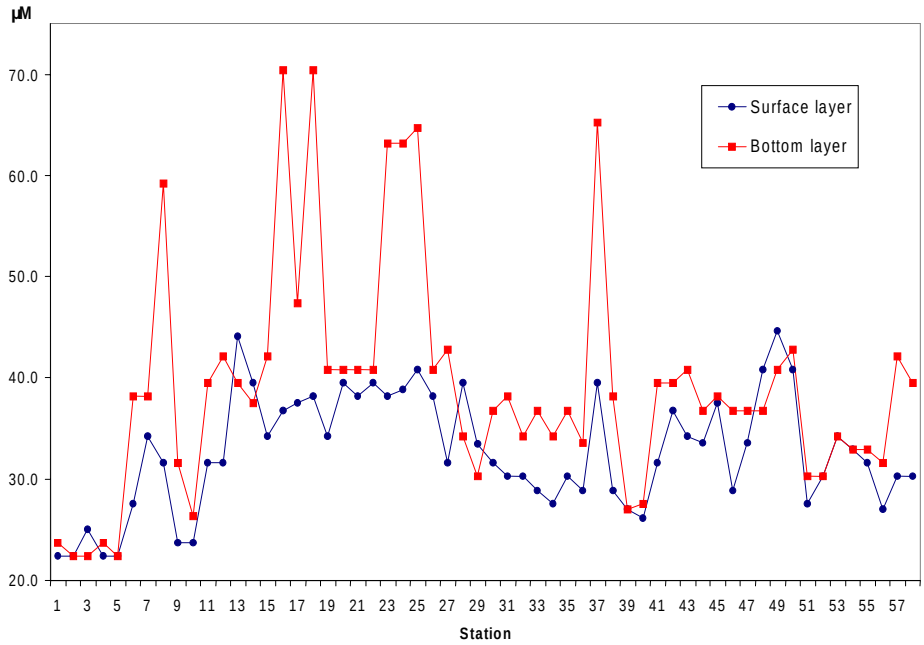


Fig. 1. Concentration of SiO_2 in both surface and bottom layers

Table 1.1. SiO_2 - Concentration(μM).

Station	Samples	SiO_2 (μM)	Station	Samples	SiO_2 (μM)	Station	Samples	SiO_2 (μM)
1	1S	17.69	**21**	21S	30.17	**41**	41S	24.95
	1B	18.72		21B	32.22		41B	31.19
2	2S	17.69	**22**	22S	31.19	**42**	42S	29.04
	2B	17.69		22B	32.22		42B	31.19
3	3S	19.74	**23**	23S	30.17	**43**	43S	27.01
	3B	17.69		23B	49.91		43B	32.22
4	4S	17.69	**24**	24S	30.64	**44**	44S	26.53
	4B	18.72		24B	49.91		44B	29.04
5	5S	17.69	**25**	25S	32.22	**45**	45S	29.61
	5B	17.69		25B	51.09		45B	30.17
6	6S	21.8	**26**	26S	30.17	**46**	46S	22.82
	6B	30.17		26B	32.22		46B	29.04
7	7S	27.01	**27**	27S	24.95	**47**	47S	26.53
	7B	30.17		27B	33.8		47B	29.04
8	8S	24.95	**28**	28S	31.19	**48**	48S	32.22
	8B	46.75		28B	27.01		48B	29.04
9	9S	18.72	**29**	29S	26.45	**49**	49S	35.3
	9B	24.95		29B	23.93		49B	32.22
10	10S	18.72	**30**	30S	24.95	**50**	50S	32.22
	10B	20.77		30B	29.04		50B	33.8
11	11S	24.95	**31**	31S	23.93	**51**	51S	21.79
	11B	31.19		31B	30.17		51B	23.93
12	12S	24.95	**32**	32S	23.93	**52**	52S	23.93
	12B	33.25		32B	27.01		52B	23.93
13	13S	34.83	**33**	33S	22.82	**53**	53S	27.01
	13B	31.19		33B	29.04		53B	27.01
14	14S	31.19	**34**	34S	21.8	**54**	54S	25.98
	14B	29.61		34B	27.01		54B	25.98
15	15S	27.01	**35**	35S	23.93	**55**	55S	24.95
	15B	33.25		35B	29.04		55B	25.98
16	16S	29.04	**36**	36S	22.82	**56**	56B	21.32
	16B	55.6		36B	26.53		56B	24.95
17	17S	29.61	**37**	37S	31.19	**57**	57S	23.93
	17B	37.43		37B	21.32		57B	33.25
18	18S	30.17	**38**	38S	30.17	**58**	58S	23.93
	18B	55.6		38B	51.41		58B	31.19
19	19S	27.01	**39**	39S	21.32	***Note:***		
	19B	32.22		39B	21.32	***S: Surface layer, 2m***		
20	20S	31.19	**40**	40S	20.61	***B: Bottom layer, ≥ 100m***		
	20B	32.22		40B	21.79			

Table 1.2. SiO_2 – Concentration (mg/l).

Station	Samples	SiO_2 (mg/L)	Station	Samples	SiO_2 (mg/L)	Station	Samples	SiO_2 (mg/L)
1	1S	1.06	**21**	21S	1.81	**41**	41S	1.50
	1B	1.12		21B	1.93		41B	1.87
2	2S	1.06	**22**	22S	1.87	**42**	42S	1.74
	2B	1.06		22B	1.93		42B	1.87
3	3S	1.18	**23**	23S	1.81	**43**	43S	1.62
	3B	1.06		23B	3.00		43B	1.93
4	4S	1.06	**24**	24S	1.84	**44**	44S	1.59
	4B	1.12		24B	3.00		44B	1.74
5	5S	1.06	**25**	25S	1.93	**45**	45S	1.78
	5B	1.06		25B	3.07		45B	1.81
6	6S	1.31	**26**	26S	1.81	**46**	46S	1.37
	6B	1.81		26B	1.93		46B	1.74
7	7S	1.62	**27**	27S	1.50	**47**	47S	1.59
	7B	1.81		27B	2.03		47B	1.74
8	8S	1.50	**28**	28S	1.87	**48**	48S	1.93
	8B	2.81		28B	1.62		48B	1.74
9	9S	1.12	**29**	29S	1.59	**49**	49S	2.12
	9B	1.50		29B	1.44		49B	1.93
10	10S	1.12	**30**	30S	1.50	**50**	50S	1.93
	10B	1.25		30B	1.74		50B	2.03
11	11S	1.50	**31**	31S	1.44	**51**	51S	1.31
	11B	1.87		31B	1.81		51B	1.44
12	12S	1.50	**32**	32S	1.44	**52**	52S	1.44
	12B	2.00		32B	1.62		52B	1.44
13	13S	2.09	**33**	33S	1.37	**53**	53S	1.62
	13B	1.87		33B	1.74		53B	1.62
14	14S	1.87	**34**	34S	1.31	**54**	54S	1.56
	14B	1.78		34B	1.62		54B	1.56
15	15S	1.62	**35**	35S	1.44	**55**	55S	1.50
	15B	2.00		35B	1.74		55B	1.56
16	16S	1.74	**36**	36S	1.37	**56**	56B	1.28
	16B	3.34		36B	1.59		56B	1.50
17	17S	1.78	**37**	37S	1.87	**57**	57S	1.44
	17B	2.25		37B	1.28		57B	2.00
18	18S	1.81	**38**	38S	1.81	**58**	58S	1.44
	18B	3.34		38B	3.09		58B	1.87
19	19S	1.62	**39**	39S	1.28	***Note:***		
	19B	1.93		39B	1.28	***S: Surface layer, 2m***		
20	20S	1.87	**40**	40S	1.24	***B: Bottom layer, ≥ 100m***		

Phosphate

Table 2.1,2.2 and 2.3 are the results for phosphate concentration calculating in PO_4 and P. Generally phosphate concentration as well as Silicate, the samples in bottom layer are higher than surface layer. Highest concentration is found in station 8B, C= 3.84μM PO_4 - 1.25μM P (equivalent 0.364mg/l -0.039 mg/l), then they are stations 1B, C=3.47μM PO_4 -1.13 μM P (0.33 - 0.035mg/l), 2B,C=3.05μM PO_4 - 1.00 μM P (0.289 -0.031mg/l). Lowest concentration 0.51μM PO_4 - 0.16 μM P (equivalent 0.048 - 0.005mg/l) is in station 58S belongs to southern region. Variation of phosphate concentration in two layers of seawater is not much, but comparing to other areas in the region, phosphate concentrations in Vietnam sea are higher . Variation of phosphate concentration in 58 sampling station is shown in Fig. 2. Average concentration of phosphate in surface layer is 0.890μM PO_4 - 0.290μM P (0.084 - 0.009 mg/l) and in bottom layer is 1.353μM PO_4 - 0.442μM P (0.128 - 0.013mgl).

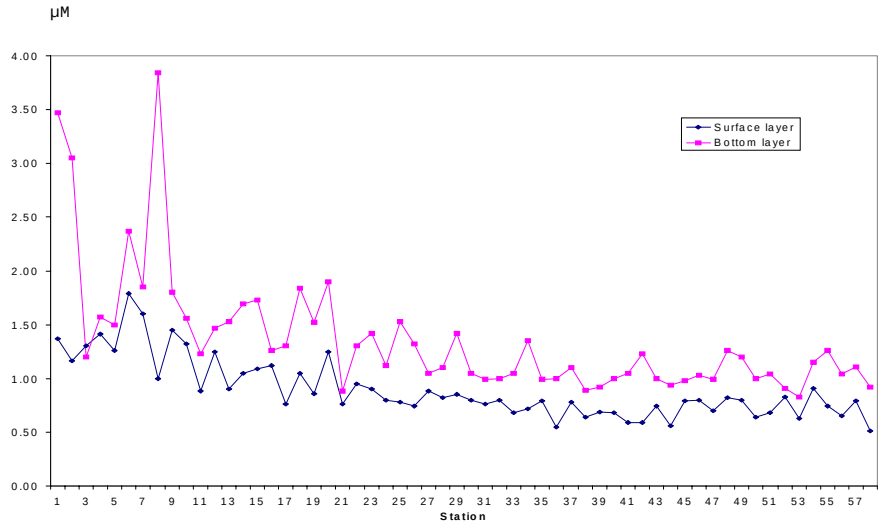


Fig. 2. Concentration of PO_4 (III) in both surface and bottom layers.

After viewing the Fig. 2., we can conclude that, the concentration of phosphate in the North region is higher than in both others. And according to Riley J.P., the dissolved inorganic phosphate is used by all species of phytoplankton. Phosphate is taken up by phytoplankton following photosynthetic activities at the surface layer. This explains for the phenomenon of concentration of phosphate in surface layer higher than in bottom layer.

Ammonium

The results for ammonium concentration in Vietnamese waters are shown in the Table 3.1,3.2 and 3.3. The results have shown that ammonium concentrations in surface layer are higher than in bottom layer. Suggestion reason by the equation between ammonia and ammonium shifts from depth to surface. Highest concentrations 4.44mM NH_4 - 3.45mM N (equivalent 0.080 - 0.0483mg/l) are found in station 29S and 4.43mM NH_4 (0.0789 mg/l) in station 55S. Lowest concentrations are 1.11mM NH_4 - 0.86mM N (0.020 - 0.012mg/l) in stations 7B, 26B and 40B. In middle region, ammonium concentrations are in more variation than other regions. Variation of ammonium concentration in the whole marine environment of Vietnam is shown in the Fig. 3

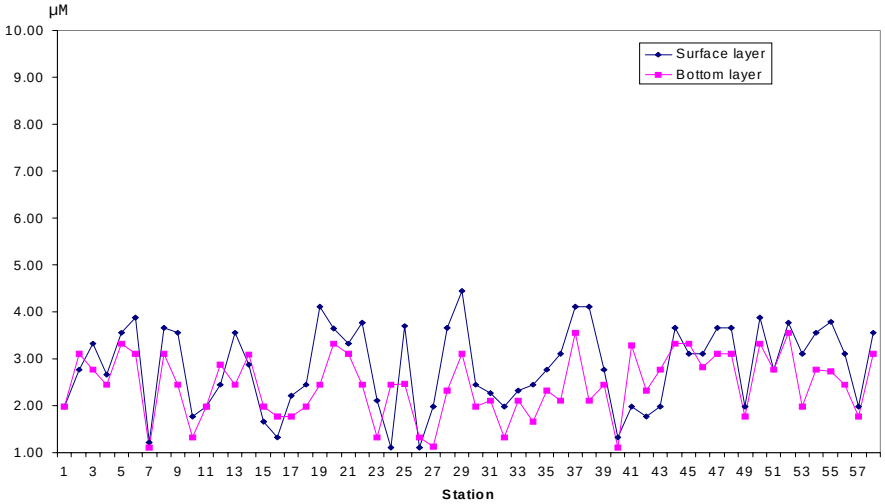


Fig. 3. Concentration of NH_4^+ in both surface and bottom layers.

Average concentration of ammonium in surface samples is 2.805µM NH_4 - 2.182 µM N (0.050 - 0.030 mg/l) and in the bottom is2.538µM NH_4 -1.974µM N (0.0456 - 0.0276mg/l).

Table 2.1. PO_4^{3-} - Concentration(µM).

Station	Samples	PO_4^{3-} (µM)	Station	Samples	PO_4^{3-} (µM)	Station	Samples	PO_4^{3-} (µM)
1	1S	1.37	**21**	21S	0.76	**41**	41S	0.59
	1B	3.47		21B	0.88		41B	1.05
2	2S	1.16	**22**	22S	0.95	**42**	42S	0.59
	2B	3.05		22B	1.30		42B	1.23
3	3S	1.30	**23**	23S	0.90	**43**	43S	0.74
	3B	1.20		23B	1.42		43B	1.00
4	4S	1.41	**24**	24S	0.80	**44**	44S	0.56
	4B	1.57		24B	1.12		44B	0.94
5	5S	1.26	**25**	25S	0.78	**45**	45S	0.79
	5B	1.50		25B	1.53		45B	0.98
6	6S	1.79	**26**	26S	0.74	**46**	46S	0.80
	6B	2.37		26B	1.32		46B	1.03
7	7S	1.60	**27**	27S	0.88	**47**	47S	0.70
	7B	1.85		27B	1.05		47B	0.99
8	8S	1.00	**28**	28S	0.82	**48**	48S	0.82
	8B	3.84		28B	1.10		48B	1.26
9	9S	1.45	**29**	29S	0.85	**49**	49S	0.80
	9B	1.80		29B	1.42		49B	1.20
10	10S	1.32	**30**	30S	0.80	**50**	50S	0.64
	10B	1.56		30B	1.05		50B	1.00
11	11S	0.88	**31**	31S	0.76	**51**	51S	0.68
	11B	1.23		31B	0.99		51B	1.04
12	12S	1.25	**32**	32S	0.80	**52**	52S	0.83
	12B	1.47		32B	1.00		52B	0.91
13	13S	0.90	**33**	33S	0.68	**53**	53S	0.63
	13B	1.53		33B	1.05		53B	0.83
14	14S	1.05	**34**	34S	0.72	**54**	54S	0.91
	14B	1.69		34B	1.35		54B	1.15
15	15S	1.09	**35**	35S	0.79	**55**	55S	0.74
	15B	1.73		35B	0.99		55B	1.26
16	16S	1.12	**36**	36S	0.55	**56**	56B	0.65
	16B	1.26		36B	1.00		56B	1.04
17	17S	0.76	**37**	37S	0.78	**57**	57S	0.79
	17B	1.30		37B	1.10		57B	1.11
18	18S	1.05	**38**	38S	0.64	**58**	58S	0.51
	18B	1.84		38B	0.89		58B	0.92
19	19S	0.86	**39**	39S	0.69	***Note:***		
	19B	1.52		39B	0.92	***S: Surface layer, 2m***		
20	20S	1.25	**40**	40S	0.68	***B: Bottom layer, ≥ 100m***		
	20B	**1.90**		40B	1.00			

Table 2.2. PO_4^{3-} - Concentration (mg/l).

Station	Samples	PO_4^{3-} (mg/L)	Station	Samples	PO_4^{3-} (mg/L)	Station	Samples	PO_4^{3-} (mg/L)
1	1S	0.130	21	21S	0.072	41	41S	0.056
	1B	0.329		21B	0.084		41B	0.100
2	2S	0.110	22	22S	0.090	42	42S	0.056
	2B	0.299		22B	0.123		42B	0.117
3	3S	0.123	23	23S	0.085	43	43S	0.070
	3B	0.114		23B	0.135		43B	0.095
4	4S	0.134	24	24S	0.076	44	44S	0.053
	4B	0.149		24B	0.106		44B	0.089
5	5S	0.120	25	25S	0.074	45	45S	0.075
	5B	0.142		25B	0.145		45B	0.093
6	6S	0.170	26	26S	0.070	46	46S	0.076
	6B	0.225		26B	0.125		46B	0.098
7	7S	0.152	27	27S	0.084	47	47S	0.066
	7B	0.176		27B	0.100		47B	0.094
8	8S	0.095	28	28S	0.078	48	48S	0.078
	8B	0.365		28B	0.104		48B	0.120
9	9S	0.138	29	29S	0.081	49	49S	0.076
	9B	0.171		29B	0.135		49B	0.114
10	10S	0.125	30	30S	0.076	50	50S	0.061
	10B	0.148		30B	0.100		50B	0.095
11	11S	0.084	31	31S	0.072	51	51S	0.065
	11B	0.117		31B	0.094		51B	0.099
12	12S	0.119	32	32S	0.076	52	52S	0.079
	12B	0.140		32B	0.095		52B	0.086
13	13S	0.085	33	33S	0.065	53	53S	0.060
	13B	0.145		33B	0.100		53B	0.079
14	14S	0.100	34	34S	0.068	54	54S	0.086
	14B	0.160		34B	0.128		54B	0.109
15	15S	0.103	35	35S	0.075	55	55S	0.070
	15B	0.164		35B	0.094		55B	0.120
16	16S	0.106	36	36S	0.052	56	56B	0.062
	16B	0.120		36B	0.095		56B	0.099
17	17S	0.072	37	37S	0.074	57	57S	0.075
	17B	0.123		37B	0.104		57B	0.105
18	18S	0.100	38	38S	0.061	58	58S	0.048
	18B	0.175		38B	0.084		58B	0.087
19	19S	0.082	39	39S	0.066	***Note:***		
	19B	0.144		39B	0.087	***S: Surface layer, 2m***		
20	20S	0.119	40	40S	0.065	***B: Bottom layer, ≥ 100m***		
	20B	0.180		40B	0.095			

Table 2.3. PO_4^{3-} -P: Concentration (μg/l).

St.	Sp	P (μM)	P (μg/l)	St	Sp	P (μM)	P (μg/l)	St	Sp	P (μM)	P (μg/l)
1	1S	0.45	13.86	**21**	21S	0.25	7.69	**41**	41S	0.19	5.97
	1B	1.13	35.10		21B	0.29	8.90		41B	0.34	10.62
2	2S	0.38	11.73	**22**	22S	0.31	9.61	**42**	42S	0.19	5.97
	2B	1.00	30.85		22B	0.42	13.15		42B	0.40	12.44
3	3S	0.42	13.15	**23**	23S	0.29	9.10	**43**	43S	0.24	7.49
	3B	0.39	12.14		23B	0.46	14.36		43B	0.33	10.12
4	4S	0.46	14.26	**24**	24S	0.26	8.09	**44**	44S	0.18	5.66
	4B	0.51	15.88		24B	0.37	11.33		44B	0.31	9.51
5	5S	0.41	12.75	**25**	25S	0.25	7.89	**45**	45S	0.26	7.99
	5B	0.49	15.17		25B	0.50	15.48		45B	0.32	9.91
6	6S	0.58	18.11	**26**	26S	0.24	7.49	**46**	46S	0.26	8.09
	6B	0.77	23.97		26B	0.43	13.35		46B	0.34	10.42
7	7S	0.52	16.19	**27**	27S	0.29	8.90	**47**	47S	0.23	7.08
	7B	0.60	18.71		27B	0.34	10.62		47B	0.32	10.01
8	8S	0.33	10.12	**28**	28S	0.27	8.29	**48**	48S	0.27	8.29
	8B	1.25	38.84		28B	0.36	11.13		48B	0.41	12.75
9	9S	0.47	14.67	**29**	29S	0.28	8.60	**49**	49S	0.26	8.09
	9B	0.59	18.21		29B	0.46	14.36		49B	0.39	12.14
10	10S	0.43	13.35	**30**	30S	0.26	8.09	**50**	50S	0.21	6.47
	10B	0.51	15.78		30B	0.34	10.62		50B	0.33	10.12
11	11S	0.29	8.90	**31**	31S	0.25	7.69	**51**	51S	0.22	6.88
	11B	0.40	12.44		31B	0.32	10.01		51B	0.34	10.52
12	12S	0.41	12.64	**32**	32S	0.26	8.09	**52**	52S	0.27	8.40
	12B	0.48	14.87		32B	0.33	10.12		52B	0.30	9.21
13	13S	0.29	9.10	**33**	33S	0.22	6.88	**53**	53S	0.21	6.37
	13B	0.50	15.48		33B	0.34	10.62		53B	0.27	8.40
14	14S	0.34	10.62	**34**	34S	0.23	7.28	**54**	54S	0.30	9.21
	14B	0.55	17.10		34B	0.44	13.66		54B	0.38	11.63
15	15S	0.36	11.03	**35**	35S	0.26	7.99	**55**	55S	0.24	7.49
	15B	0.56	17.50		35B	0.32	10.01		55B	0.41	12.75
16	16S	0.37	11.33	**36**	36S	0.18	5.56	**56**	56B	0.21	6.58
	16B	0.41	12.75		36B	0.33	10.12		56B	0.34	10.52
17	17S	0.25	7.69	**37**	37S	0.25	7.89	**57**	57S	0.26	7.99
	17B	0.42	13.15		37B	0.36	11.13		57B	0.36	11.23
18	18S	0.34	10.62	**38**	38S	0.21	6.47	**58**	58S	0.17	5.16
	18B	0.60	18.61		38B	0.29	9.00		58B	0.30	9.31
19	19S	0.28	8.70	**39**	39S	0.23	6.98	***Note:***			
	19B	0.50	15.38		39B	0.30	9.31	***S: Surface layer, 2m***			
20	20S	0.41	12.64	**40**	40S	0.22	6.88	***B: Bottom layer, ≥ 100m***			
	20B	0.62	19.22		40B	0.33	10.12				

Table 3.1. NH_4^+ - Concentration (μM).

Station	Samples	NH_4^+ (μM)	Station	Samples	NH_4^+ (μM)	Station	Samples	NH_4^+ (μM)
1	1S	1.99	**21**	21S	3.33	**41**	41S	1.99
	1B	1.99		21B	3.11		41B	3.29
2	2S	2.77	**22**	22S	3.77	**42**	42S	1.77
	2B	3.11		22B	2.44		42B	2.33
3	3S	3.32	**23**	23S	2.11	**43**	43S	1.99
	3B	2.77		23B	1.33		43B	2.77
4	4S	2.66	**24**	24S	2.44	**44**	44S	3.66
	4B	2.44		24B	1.11		44B	3.32
5	5S	3.55	**25**	25S	3.88	**45**	45S	3.11
	5B	3.32		25B	2.77		45B	3.32
6	6S	3.88	**26**	26S	1.33	**46**	46S	3.11
	6B	3.11		26B	1.11		46B	3.66
7	7S	1.22	**27**	27S	1.99	**47**	47S	3.66
	7B	1.11		27B	1.13		47B	3.11
8	8S	3.66	**28**	28S	3.66	**48**	48S	3.66
	8B	3.11		28B	2.33		48B	3.11
9	9S	3.55	**29**	29S	4.44	**49**	49S	1,99
	9B	2.44		29B	3.11		49B	1.77
10	10S	1.77	**30**	30S	2.44	**50**	50S	3.88
	10B	1.33		30B	1.99		50B	3.32
11	11S	1.99	**31**	31S	2.27	**51**	51S	2.77
	11B	1.99		31B	2.11		51B	2.77
12	12S	2.88	**32**	32S	1.99	**52**	52S	3.77
	12B	2.44		32B	1.33		52B	3.55
13	13S	3.55	**33**	33S	2.33	**53**	53S	3.11
	13B	2.44		33B	2.11		53B	1.99
14	14S	3.55	**34**	34S	2.44	**54**	54S	3.55
	14B	2.88		34B	1.66		54B	2.77
15	15S	1.99	**35**	35S	2.77	**55**	55S	4.43
	15B	1.66		35B	2.32		55B	2.22
16	16S	1.77	**36**	36S	3.11	**56**	56B	3.11
	16B	1.33		36B	2.11		56B	2.44
17	17S	2.22	**37**	37S	4.10	**57**	57S	1.99
	17B	1.77		37B	3.55		57B	1.77
18	18S	2.44	**38**	38S	4.10	**58**	58S	3.55
	18B	1.99		38B	2.11		58B	3.11
19	19S	4.10	**39**	39S	2.77	***Note:***		
	19B	2.44		39B	2.44	***S: Surface layer, 2m***		
20	20S	4.10	**40**	40S	1.33	***B: Bottom layer, ≥100m***		
	20B	3.55		40B	1.11			

Table 3.2. NH_4^+ - Concentration (mg/L).

Station	Samples	NH_4^+ (mg/L)	Station	Samples	NH_4^+ (mg/L)	Station	Samples	NH_4^+ (mg/L)
1	1S	0.036	**21**	21S	0.060	**41**	41S	0.036
	1B	0.036		21B	0.056		41B	0.059
2	2S	0.050	**22**	22S	0.068	**42**	42S	0.032
	2B	0.056		22B	0.044		42B	0.042
3	3S	0.060	**23**	23S	0.038	**43**	43S	0.036
	3B	0.050		23B	0.024		43B	0.050
4	4S	0.048	**24**	24S	0.020	**44**	44S	0.066
	4B	0.044		24B	0.044		44B	0.060
5	5S	0.064	**25**	25S	0.050	**45**	45S	0.056
	5B	0.060		25B	0.070		45B	0.060
6	6S	0.070	**26**	26S	0.020	**46**	46S	0.056
	6B	0.056		26B	0.024		46B	0.066
7	7S	0.022	**27**	27S	0.036	**47**	47S	0.066
	7B	0.020		27B	0.020		47B	0.056
8	8S	0.066	**28**	28S	0.066	**48**	48S	0.066
	8B	0.056		28B	0.042		48B	0.056
9	9S	0.064	**29**	29S	0.080	**49**	49S	0.036
	9B	0.044		29B	0.056		49B	0.032
10	10S	0.032	**30**	30S	0.044	**50**	50S	0.070
	10B	0.024		30B	0.036		50B	0.060
11	11S	0.036	**31**	31S	0.041	**51**	51S	0.050
	11B	0.036		31B	0.038		51B	0.050
12	12S	0.044	**32**	32S	0.036	**52**	52S	0.068
	12B	0.052		32B	0.024		52B	0.064
13	13S	0.064	**33**	33S	0.042	**53**	53S	0.056
	13B	0.044		33B	0.038		53B	0.036
14	14S	0.052	**34**	34S	0.044	**54**	54S	0.064
	14B	0.064		34B	0.030		54B	0.050
15	15S	0.030	**35**	35S	0.050	**55**	55S	0.040
	15B	0.036		35B	0.042		55B	0.080
16	16S	0.024	**36**	36S	0.056	**56**	56B	0.056
	16B	0.032		36B	0.038		56B	0.044
17	17S	0.040	**37**	37S	0.074	**57**	57S	0.036
	17B	0.032		37B	0.064		57B	0.032
18	18S	0.044	**38**	38S	0.074	**58**	58S	0.064
	18B	0.036		38B	0.038		58B	0.056
19	19S	0.074	**39**	39S	0.050	***Note:***		
	19B	0.044		39B	0.044	***S: Surface layer, 2m***		
20	20S	0.064	**40**	40S	0.024	***B: Bottom layer, ≥ 100m***		
	20B	0.074		40B	0.020			

Table 3.3. NH_4^+ - N: Concentration (μg/L).

St	Sp	N (μM)	N(μg/l)	St	Sp	N (μM)	N(μg/l)	St	Sp	N (μM)	N(μg/l)
1	1S	1.55	21.67	**21**	21S	2.59	36.26	**41**	41S	1.55	21.67
	1B	1.55	21.67		21B	2.42	33.86		41B	2.56	35.82
2	2S	2.15	30.16	**22**	22S	2.93	41.05	**42**	42S	1.38	19.27
	2B	2.42	33.86		22B	1.90	26.57		42B	1.81	25.37
3	3S	2.58	36.15	**23**	23S	1.64	22.98	**43**	43S	1.55	21.67
	3B	2.15	30.16		23B	1.03	14.48		43B	2.15	30.16
4	4S	2.07	28.96	**24**	24S	0.86	12.09	**44**	44S	2.85	39.85
	4B	1.90	26.57		24B	1.90	26.57		44B	2.58	36.15
5	5S	2.76	38.66	**25**	25S	2.15	30.16	**45**	45S	2.42	33.86
	5B	2.58	36.15		25B	3.02	42.25		45B	2.58	36.15
6	6S	3.02	42.25	**26**	26S	0.86	12.09	**46**	46S	2.42	33.86
	6B	2.42	33.86		26B	1.03	14.48		46B	2.85	39.85
7	7S	0.95	13.28	**27**	27S	1.55	21.67	**47**	47S	2.85	39.85
	7B	0.86	12.09		27B	0.88	12.30		47B	2.42	33.86
8	8S	2.85	39.85	**28**	28S	2.85	39.85	**48**	48S	2.85	39.85
	8B	2.42	33.86		28B	1.81	25.37		48B	2.42	33.86
9	9S	2.76	38.66	**29**	29S	3.45	48.35	**49**	49S	1.54	21.56
	9B	1.90	26.57		29B	2.42	33.86		49B	1.38	19.27
10	10S	1.38	19.27	**30**	30S	1.90	26.57	**50**	50S	3.02	42.25
	10B	1.03	14.48		30B	1.55	21.67		50B	2.58	36.15
11	11S	1.55	21.67	**31**	31S	1.77	24.72	**51**	51S	2.15	30.16
	11B	1.55	21.67		31B	1.64	22.98		51B	2.15	30.16
12	12S	1.90	26.57	**32**	32S	1.55	21.67	**52**	52S	2.93	41.05
	12B	2.24	31.36		32B	1.03	14.48		52B	2.76	38.66
13	13S	2.76	38.66	**33**	33S	1.81	25.37	**53**	53S	2.42	33.86
	13B	1.90	26.57		33B	1.64	22.98		53B	1.55	21.67
14	14S	2.24	31.36	**34**	34S	1.90	26.57	**54**	54S	2.76	38.66
	14B	2.76	38.66		34B	1.29	18.08		54B	2.15	30.16
15	15S	1.29	18.08	**35**	35S	2.15	30.16	**55**	55S	1.73	24.17
	15B	1.55	21.67		35B	1.80	25.26		55B	3.45	48.24
16	16S	1.03	14.48	**36**	36S	2.42	33.86	**56**	56B	2.42	33.86
	16B	1.38	19.27		36B	1.64	22.98		56B	1.90	26.57
17	17S	1.73	24.17	**37**	37S	3.19	44.64	**57**	57S	1.55	21.67
	17B	1.38	19.27		37B	2.76	38.66		57B	1.38	19.27
18	18S	1.90	26.57	**38**	38S	3.19	44.64	**58**	58S	2.76	38.66
	18B	1.55	21.67		38B	1.64	22.98		58B	2.42	33.86
19	19S	3.19	44.64	**39**	39S	2.15	30.16	***Note:***			
	19B	1.90	26.57		39B	1.90	26.57	***S: Surface layer, 2m***			
20	20S	2.76	38.66	**40**	40S	1.03	14.48	***B: Bottom layer, ≥ 100m***			
	20B	3.19	44.64		40B	0.86	12.09				

Nitrate

Results for nitrate concentrations are shown in Table 4.1,4.2 and 4.3. Highest concentration of nitrate is 11.16µM NO_3 - 2.52µM N (0.692 - 0.035mg/l) in the station 1B, and then they are 10.19µM NO_3 - 2.30µM N (0.63 - 0.032mg/l) in station 2B, 10.87µM NO_3 - 2.45µM N (0.674 - 0.034mg/l) in station 3B; 10.68µM NO_3 - 2.41µM N (0.66 - 0.033mg/l) in station 11B. Generally, nitrate concentration in northern region is higher to compare to two other regions. Lowest concentration 1.95µM - 0,44 µM (0.120 - 6,16mg/l) is found in station 30S. All the results show that the concentration in bottom layer always higher in the surface layer. It can be explained by the exchanging and/or disintegrating of phytoplankton. It suggests the same phenomena with the phosphate concentration. Average concentration of nitrate in surface layer (2m depth comparing to the sea surface) is 5.59 - 1.26µM and in bottom layer (100m comparing to the sea surface) is 6.81 - 1.39µM. Variation of nitrate concentration along the Vietnamese seaside are shown in Fig. 4.

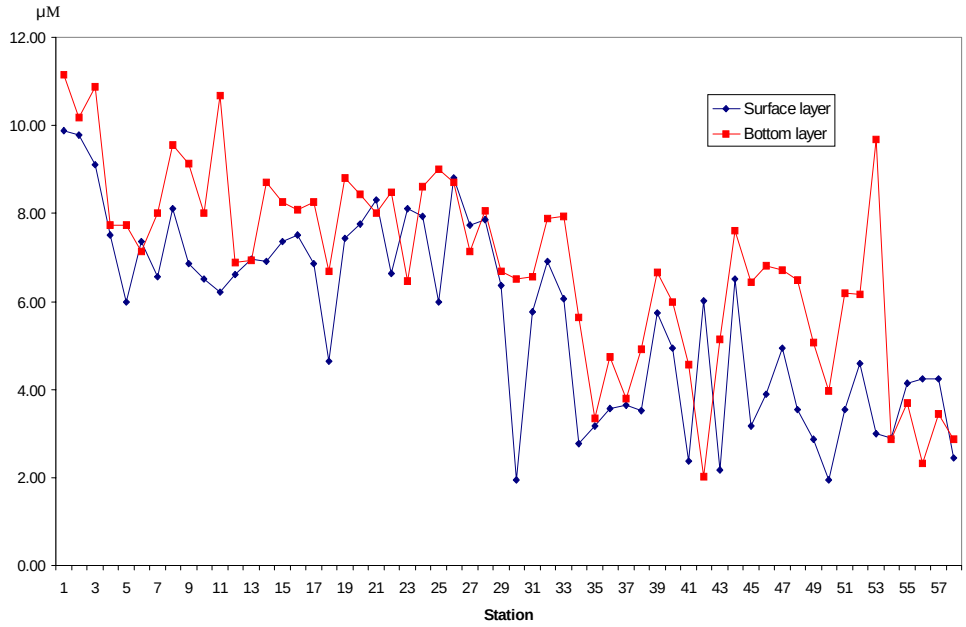


Fig. 4. Concentration of NO_3^- in both surface and bottomlayers.

Nitrite

Nitrite and nitrate concentrations always have the relations, but since the sampling stations are far away from laboratories and they have to transferred by ships, therefore the duration time from sampling to analyses often longer than limitation values of standard. Though it can be considered it is some part of nitrite had been oxidized into nitrate and made the results not correctly. On the other hand, nitrite concentration in seawater usually is low. With these reasons we cannot find out the clear relations between the surface and bottom layers. Highest concentration 0.60µM NO_2 - 0.18µM N (0.0287 - 0.014 mg/l) is found in station 13S and lowest concentrations 0.04µM NO_2- 0.012µM N (0.0019 - 0.00017mg/l) in some stations 41S and 50S (Table 5.1,5.2 and 5.3). As well as nitrate, nitrite concentration in northern region is higher and more variable than in middle and southern regions. Variation of nitrite concentration along Vietnamese seaside is shown in Fig. 5. Average concentration of nitrite in surface layer is 0.169µM NO_2 - 0.051µM N and in the bottom layer is 0.197µM NO_2 - 0.059µM N.

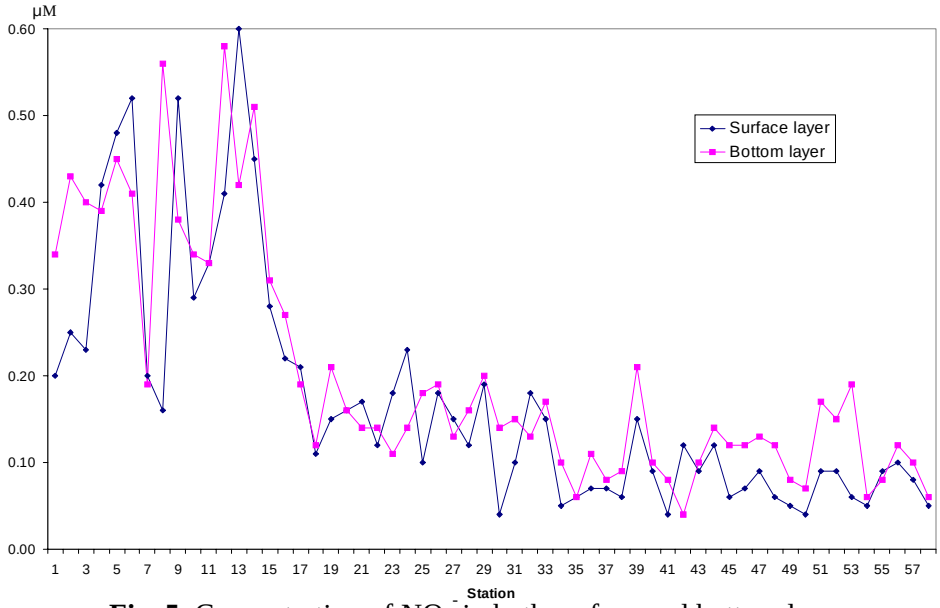


Fig. 5. Concentration of NO_2^- in both surface and bottom layers.

Sulfate

The results for sulfate concentration are shown in Table 6.1 and 6.2. According to molecular mass of sulfate anion high, even though these are sulfate content of dissolved salts, the concentrations in bottom layer are always higher than in surface layer. Highest concentration of sulfate 35.38µM (3.398 mg/l) is found in station 3B in northern region, this is suitable with the results of ammonium, nitrate, nitrite. Lowest concentration is 21.63µM (2.0778mg/l) in station 38S. Variation of sulfate concentration along the Vietnam seaside is shown in the Fig. 6. Average concentration of sulfate in surface layer is 26.903 µM and in bottom layer is 27.831µM.

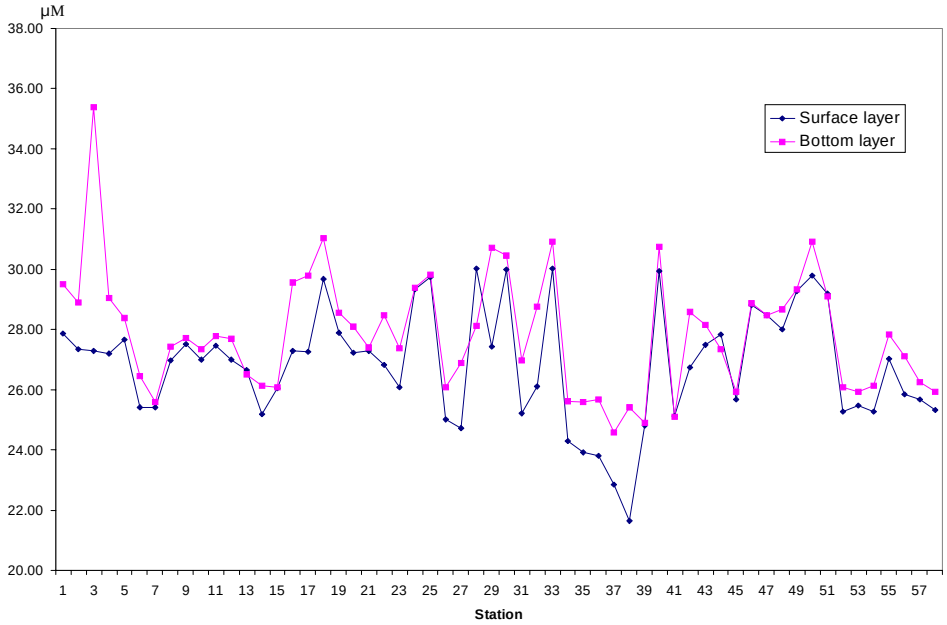


Fig. 6. Concentration of SO_4^{2-} in both surface and bottom layers.

Fig. 7 shows generally the chart of 5 parameters for nutrient along the Vietnamese seaside. Sulfate concentration is in unit of µM therefore it cannot be shown in the same scale.

As said in the introduction of this report, Vietnamese seaside curved as an S, therefore the variation of nutrients is not the same. Specially in northern region with estuary characteristics is characterized by N/P ratios which are likely due to fertilizer applications and sewage discharges in the drainage area. In the estuary, phosphate shows a maximum value probably due to remobilization from solid phases (See Fig. 8.1.)

To compare the concentrations of nutrients more clearly, the results can be shown in Table 7 and in Fig. 8.1, 8.2 and 8.3 as well as in Fig.9.1, 9.2 and 9.3 and also in the tables respectively (Table 8.1, 8.2a,8.2b,8.3a,8.3b,9.1,9.2 and 9.3) for all three regions.

Table 4.1. NO_3^- - Concentration (μM).

Station	Samples	NO_3^- (μM)	Station	Samples	NO_3^- (μM)	Station	Samples	NO_3^- (μM)
1	1S	9.87	**21**	21S	8.32	**41**	41S	2.37
	1B	11.16		21B	8.00		41B	4.56
2	2S	9.79	**22**	22S	6.63	**42**	42S	2.02
	2B	10.19		22B	8.47		42B	6.02
3	3S	9.10	**23**	23S	8.10	**43**	43S	2.16
	3B	10.87		23B	6.47		43B	5.15
4	4S	7.52	**24**	24S	7.94	**44**	44S	6.50
	4B	7.74		24B	8.61		44B	7.60
5	5S	5.98	**25**	25S	6.00	**45**	45S	3.16
	5B	7.74		25B	9.00		45B	6.44
6	6S	7.35	**26**	26S	8.81	**46**	46S	3.90
	6B	7.13		26B	8.71		46B	6.81
7	7S	6.55	**27**	27S	7.74	**47**	47S	4.95
	7B	8.02		27B	7.13		47B	6.71
8	8S	8.10	**28**	28S	7.85	**48**	48S	3.55
	8B	9.55		28B	8.06		48B	6.48
9	9S	6.85	**29**	29S	6.37	**49**	49S	2.87
	9B	9.13		29B	6.68		49B	5.06
10	10S	6.52	**30**	30S	1.95	**50**	50S	1.95
	10B	8.00		30B	6.50		50B	3.97
11	11S	6.21	**31**	31S	5.76	**51**	51S	3.55
	11B	10.68		31B	6.56		51B	6.19
12	12S	6.61	**32**	32S	6.90	**52**	52S	4.60
	12B	6.89		32B	7.89		52B	6.16
13	13S	6.97	**33**	33S	6.05	**53**	53S	3.00
	13B	6.94		33B	7.94		53B	9.69
14	14S	6.92	**34**	34S	2.76	**54**	54S	2.90
	14B	8.71		34B	5.65		54B	2.87
15	15S	7.37	**35**	35S	3.18	**55**	55S	4.15
	15B	8.27		35B	3.34		55B	3.68
16	16S	7.50	**36**	36S	3.56	**56**	56B	4.24
	16B	8.09		36B	4.74		56B	2.31
17	17S	6.87	**37**	37S	3.63	**57**	57S	4.24
	17B	8.27		37B	3.79		57B	3.45
18	18S	4.63	**38**	38S	3.52	**58**	58S	2.45
	18B	6.68		38B	4.92		58B	2.87
19	19S	7.44	**39**	39S	5.73	***Note:***		
	19B	8.81		39B	6.65	***S: Surface layer, 2m***		
20	20S	7.76	**40**	40S	4.95	***B: Bottom layer, ≥ 100m***		
	20B	8.42		40B	6.00			

Table 4.2. NO_3^- Concentration (mg/L).

Station	Sample	NO_3^{--} (mg/L)	Station	Samples	NO_3^{--} (mg/L)	Station	Samples	NO_3^{--} (mg/L)
1	1S	0.612	**21**	21S	0.516	**41**	41S	0.147
	1B	0.692		21B	0.496		41B	0.283
2	2S	0.607	**22**	22S	0.411	**42**	42S	0.373
	2B	0.632		22B	0.525		42B	0.125
3	3S	0.564	**23**	23S	0.502	**43**	43S	0.134
	3B	0.674		23B	0.401		43B	0.319
4	4S	0.466	**24**	24S	0.492	**44**	44S	0.403
	4B	0.480		24B	0.534		44B	0.471
5	5S	0.371	**25**	25S	0.372	**45**	45S	0.196
	5B	0.480		25B	0.558		45B	0.399
6	6S	0.456	**26**	26S	0.546	**46**	46S	0.242
	6B	0.442		26B	0.540		46B	0.422
7	7S	0.406	**27**	27S	0.480	**47**	47S	0.307
	7B	0.497		27B	0.442		47B	0.416
8	8S	0.502	**28**	28S	0.487	**48**	48S	0.220
	8B	0.592		28B	0.500		48B	0.402
9	9S	0.425	**29**	29S	0.395	**49**	49S	0.178
	9B	0.566		29B	0.414		49B	0.314
10	10S	0.404	**30**	30S	0.121	**50**	50S	0.121
	10B	0.496		30B	0.403		50B	0.246
11	11S	0.385	**31**	31S	0.357	**51**	51S	0.220
	11B	0.662		31B	0.407		51B	0.384
12	12S	0.410	**32**	32S	0.428	**52**	52S	0.285
	12B	0.427		32B	0.489		52B	0.382
13	13S	0.432	**33**	33S	0.375	**53**	53S	0.186
	13B	0.430		33B	0.492		53B	0.601
14	14S	0.429	**34**	34S	0.171	**54**	54S	0.180
	14B	0.540		34B	0.350		54B	0.178
15	15S	0.457	**35**	35S	0.197	**55**	55S	0.257
	15B	0.513		35B	0.207		55B	0.228
16	16S	0.465	**36**	36S	0.221	**56**	56B	0.263
	16B	0.502		36B	0.294		56B	0.143
17	17S	0.426	**37**	37S	0.225	**57**	57S	0.263
	17B	0.513		37B	0.235		57B	0.214
18	18S	0.287	**38**	38S	0.218	**58**	58S	0.152
	18B	0.414		38B	0.305		58B	0.178
19	19S	0.461	**39**	39S	0.355	***Note:***		
	19B	0.546		39B	0.412	***S: Surface layer, 2m***		
20	20S	0.481	**40**	40S	0.307	***B: Bottom layer, ≥ 100m***		
	20B	0.522		40B	0.372			

Table 4.3. NO_3^-- N: Concentration.

St	Sp	N (µM)	N(µg/l)	St	Sp	N (µM)	N (µg/l)	St	Sp	N (µM)	N(µg/l)
1	1S	2.23	31.20	**21**	21S	1.88	26.30	**41**	41S	0.54	7.49
	1B	2.52	35.28		21B	1.81	25.29		41B	1.03	14.42
2	2S	2.21	30.95	**22**	22S	1.50	20.96	**42**	42S	1.36	19.03
	2B	2.30	32.21		22B	1.91	26.78		42B	0.46	6.39
3	3S	2.05	28.77	**23**	23S	1.83	25.61	**43**	43S	0.49	6.83
	3B	2.45	34.36		23B	1.46	20.45		43B	1.16	16.28
4	4S	1.70	23.77	**24**	24S	1.79	25.10	**44**	44S	1.47	20.55
	4B	1.75	24.47		24B	1.94	27.22		44B	1.72	24.03
5	5S	1.35	18.90	**25**	25S	1.35	18.97	**45**	45S	0.71	9.99
	5B	1.75	24.47		25B	2.03	28.45		45B	1.45	20.36
6	6S	1.66	23.24	**26**	26S	1.99	27.85	**46**	46S	0.88	12.33
	6B	1.61	22.54		26B	1.97	27.53		46B	1.54	21.53
7	7S	1.48	20.71	**27**	27S	1.75	24.47	**47**	47S	1.12	15.65
	7B	1.81	25.35		27B	1.61	22.54		47B	1.52	21.21
8	8S	1.83	25.61	**28**	28S	1.77	24.82	**48**	48S	0.80	11.22
	8B	2.16	30.19		28B	1.82	25.48		48B	1.46	20.49
9	9S	1.55	21.65	**29**	29S	1.44	20.14	**49**	49S	0.65	9.07
	9B	2.06	28.86		29B	1.51	21.12		49B	1.14	16.00
10	10S	1.47	20.61	**30**	30S	0.44	6.16	**50**	50S	0.44	6.16
	10B	1.81	25.29		30B	1.47	20.55		50B	0.90	12.55
11	11S	1.40	19.63	**31**	31S	1.30	18.21	**51**	51S	0.80	11.22
	11B	2.41	33.76		31B	1.48	20.74		51B	1.40	19.57
12	12S	1.49	20.90	**32**	32S	1.56	21.81	**52**	52S	1.04	14.54
	12B	1.51	21.78		32B	1.78	24.94		52B	1.39	19.47
13	13S	1.57	22.03	**33**	33S	1.37	19.13	**53**	53S	0.68	9.48
	13B	1.57	21.94		33B	1.79	25.10		53B	2.19	30.63
14	14S	1.56	21.88	**34**	34S	0.62	8.73	**54**	54S	0.65	9.17
	14B	1.97	27.53		34B	1.28	17.86		54B	0.65	9.07
15	15S	1.66	23.30	**35**	35S	0.72	10.05	**55**	55S	0.94	13.12
	15B	1.87	26.14		35B	0.75	10.56		55B	0.83	11.63
16	16S	1.69	23.71	**36**	36S	0.80	11.25	**56**	56B	0.96	13.40
	16B	1.83	25.57		36B	1.07	14.98		56B	0.52	7.30
17	17S	1.55	21.72	**37**	37S	0.82	11.48	**57**	57S	0.96	13.40
	17B	1.87	26.14		37B	0.86	11.98		57B	0.78	10.91
18	18S	1.05	14.64	**38**	38S	0.79	11.13	**58**	58S	0.55	7.75
	18B	1.51	21.12		38B	1.11	15.55		58B	0.65	9.07
19	19S	1.68	23.52	**39**	39S	1.29	18.11	***Note:***			
	19B	1.99	27.85		39B	1.50	21.02	***S: Surface layer, 2m***			
20	20S	1.75	24.53	**40**	40S	1.12	15.65	***B: Bottom layer, ≥ 100m***			
	20B	1.90	26.62		40B	1.35	18.97				

Table 5.1. NO_2^- - Concentration (μM).

Station	Samples	NO_2^- (μM)	Station	Samples	NO_2^- (μM)	Station	Samples	NO_2^- (μM)
1	1S	0.20	**21**	21S	0.17	**41**	41S	0.04
	1B	0.34		21B	0.14		41B	0.08
2	2S	0.25	**22**	22S	0.12	**42**	42S	0.12
	2B	0.43		22B	0.14		42B	0.04
3	3S	0.23	**23**	23S	0.18	**43**	43S	0.09
	3B	0.40		23B	0.11		43B	0.10
4	4S	0.42	**24**	24S	0.23	**44**	44S	0.12
	4B	0.39		24B	0.14		44B	0.14
5	5S	0.48	**25**	25S	0.10	**45**	45S	0.06
	5B	0.45		25B	0.18		45B	0.12
6	6S	0.52	**26**	26S	0.18	**46**	46S	0.07
	6B	0.41		26B	0.19		46B	0.12
7	7S	0.20	**27**	27S	0.15	**47**	47S	0.09
	7B	0.19		27B	0.13		47B	0.13
8	8S	0.16	**28**	28S	0.12	**48**	48S	0.06
	8B	0.56		28B	0.16		48B	0.12
9	9S	0.52	**29**	29S	0.19	**49**	49S	0.05
	9B	0.38		29B	0.20		49B	0.08
10	10S	0.29	**30**	30S	0.04	**50**	50S	0.04
	10B	0.34		30B	0.14		50B	0.07
11	11S	0.33	**31**	31S	0.10	**51**	51S	0.09
	11B	0.33		31B	0.15		51B	0.17
12	12S	0.41	**32**	32S	0.18	**52**	52S	0.09
	12B	0.58		32B	0.13		52B	0.15
13	13S	0.60	**33**	33S	0.15	**53**	53S	0.06
	13B	0.42		33B	0.17		53B	0.19
14	14S	0.45	**34**	34S	0.05	**54**	54S	0.05
	14B	0.51		34B	0.10		54B	0.06
15	15S	0.28	**35**	35S	0.06	**55**	55S	0.09
	15B	0.31		35B	0.06		55B	0.08
16	16S	0.22	**36**	36S	0.07	**56**	56B	0.10
	16B	0.27		36B	0.11		56B	0.12
17	17S	0.21	**37**	37S	0.07	**57**	57S	0.08
	17B	0.19		37B	0.08		57B	0.10
18	18S	0.11	**38**	38S	0.06	**58**	58S	0.05
	18B	0.12		38B	0.09		58B	0.06
19	19S	0.15	**39**	39S	0.15	***Note:***		
	19B	0.21		39B	0.21	***S: Surface layer, 2m***		
20	20S	0.16	**40**	40S	0.09	***B: Bottom layer, ≥ 100m***		
	20B	0.16		40B	0.10			

Table 5.2. NO_2^- - Concentration (mg/L).

Station	Samples	NO_2^- (mg/L)	Station	Samples	NO_2^- (mg/L)	Station	Samples	NO_2^- (mg/L)
1	1S	0.010	**21**	21S	0.008	**41**	41S	0.002
	1B	0.016		21B	0.007		41B	0.004
2	2S	0.012	**22**	22S	0.006	**42**	42S	0.006
	2B	0.021		22B	0.007		42B	0.002
3	3S	0.011	**23**	23S	0.009	**43**	43S	0.004
	3B	0.019		23B	0.005		43B	0.005
4	4S	0.020	**24**	24S	0.011	**44**	44S	0.006
	4B	0.019		24B	0.007		44B	0.007
5	5S	0.023	**25**	25S	0.005	**45**	45S	0.003
	5B	0.022		25B	0.009		45B	0.006
6	6S	0.025	**26**	26S	0.009	**46**	46S	0.003
	6B	0.020		26B	0.009		46B	0.006
7	7S	0.010	**27**	27S	0.007	**47**	47S	0.004
	7B	0.009		27B	0.006		47B	0.006
8	8S	0.008	**28**	28S	0.006	**48**	48S	0.003
	8B	0.027		28B	0.008		48B	0.006
9	9S	0.025	**29**	29S	0.009	**49**	49S	0.002
	9B	0.018		29B	0.010		49B	0.004
10	10S	0.014	**30**	30S	0.002	**50**	50S	0.002
	10B	0.016		30B	0.007		50B	0.003
11	11S	0.016	**31**	31S	0.005	**51**	51S	0.004
	11B	0.016		31B	0.007		51B	0.008
12	12S	0.020	**32**	32S	0.009	**52**	52S	0.004
	12B	0.028		32B	0.006		52B	0.007
13	13S	0.029	**33**	33S	0.007	**53**	53S	0.003
	13B	0.020		33B	0.008		53B	0.009
14	14S	0.022	**34**	34S	0.002	**54**	54S	0.002
	14B	0.024		34B	0.005		54B	0.003
15	15S	0.013	**35**	35S	0.003	**55**	55S	0.004
	15B	0.015		35B	0.003		55B	0.004
16	16S	0.011	**36**	36S	0.003	**56**	56B	0.005
	16B	0.013		36B	0.005		56B	0.006
17	17S	0.010	**37**	37S	0.003	**57**	57S	0.004
	17B	0.009		37B	0.004		57B	0.005
18	18S	0.005	**38**	38S	0.003	**58**	58S	0.002
	18B	0.006		38B	0.004		58B	0.003
19	19S	0.007	**39**	39S	0.007	***Note:***		
	19B	0.010		39B	0.010	***S: Surface layer, 2m***		
20	20S	0.008	**40**	40S	0.004	***B: Bottom layer, ≥ 100m***		
	20B	0.008		40B	0.005			

Table 5.3. NO_2^- - N: Concentration.

St	Sp	N(μM)	N(μg/l)	St	Sp	N (μM)	N(μg/l)	St	Sp	N(μM)	N(μg/l)
1	1S	0.50	6.94	**21**	21S	0.05	0.72	**41**	41S	0.01	0.17
	1B	0.84	11.80		21B	0.04	0.60		41B	0.02	0.34
2	2S	0.62	8.67	**22**	22S	0.04	0.51	**42**	42S	0.04	0.51
	2B	1.07	14.92		22B	0.04	0.60		42B	0.01	0.17
3	3S	0.57	7.98	**23**	23S	0.05	0.77	**43**	43S	0.03	0.38
	3B	0.99	13.88		23B	0.03	0.47		43B	0.03	0.43
4	4S	1.04	14.57	**24**	24S	0.07	0.98	**44**	44S	0.04	0.51
	4B	0.97	13.53		24B	0.04	0.60		44B	0.04	0.60
5	5S	1.19	16.65	**25**	25S	0.03	0.43	**45**	45S	0.02	0.26
	5B	1.12	15.61		25B	0.05	0.77		45B	0.04	0.51
6	6S	1.29	18.04	**26**	26S	0.05	0.77	**46**	46S	0.02	0.30
	6B	1.02	14.23		26B	0.06	0.81		46B	0.04	0.51
7	7S	0.50	6.94	**27**	27S	0.05	0.64	**47**	47S	0.03	0.38
	7B	0.47	6.59		27B	0.04	0.55		47B	0.04	0.55
8	8S	0.40	5.55	**28**	28S	0.04	0.51	**48**	48S	0.02	0.26
	8B	1.39	19.43		28B	0.05	0.68		48B	0.04	0.51
9	9S	1.29	18.04	**29**	29S	0.06	0.81	**49**	49S	0.02	0.21
	9B	0.94	13.18		29B	0.06	0.85		49B	0.02	0.34
10	10S	0.72	10.06	**30**	30S	0.01	0.17	**50**	50S	0.01	0.17
	10B	0.84	11.80		30B	0.04	0.60		50B	0.02	0.30
11	11S	0.82	11.45	**31**	31S	0.03	0.43	**51**	51S	0.03	0.38
	11B	0.82	11.45		31B	0.05	0.64		51B	0.05	0.72
12	12S	1.02	14.23	**32**	32S	0.05	0.77	**52**	52S	0.03	0.38
	12B	1.44	20.12		32B	0.04	0.55		52B	0.05	0.64
13	13S	1.49	20.82	**33**	33S	0.05	0.64	**53**	53S	0.02	0.26
	13B	1.04	14.57		33B	0.05	0.72		53B	0.06	0.81
14	14S	1.12	15.61	**34**	34S	0.02	0.21	**54**	54S	0.02	0.21
	14B	1.26	17.69		34B	0.03	0.43		54B	0.02	0.26
15	15S	0.69	9.71	**35**	35S	0.02	0.26	**55**	55S	0.03	0.38
	15B	0.77	10.76		35B	0.02	0.26		55B	0.02	0.34
16	16S	0.55	7.63	**36**	36S	0.02	0.30	**56**	56B	0.03	0.43
	16B	0.67	9.37		36B	0.03	0.47		56B	0.04	0.51
17	17S	0.52	7.29	**37**	37S	0.02	0.30	**57**	57S	0.02	0.34
	17B	0.47	6.59		37B	0.02	0.34		57B	0.03	0.43
18	18S	0.27	3.82	**38**	38S	0.02	0.26	**58**	58S	0.02	0.21
	18B	0.30	4.16		38B	0.03	0.38		58B	0.02	0.26
19	19S	0.37	5.20	**39**	39S	0.05	0.64				
	19B	0.52	7.29		39B	0.06	0.89	***Note:***			
20	20S	0.40	5.55	**40**	40S	0.03	0.38	***S: Surface layer, 2m***			
	20B	0.40	5.55		40B	0.03	0.43	***B:Bottom layer,≥ 100m***			

Table 6.1. SO_4^{2-} - Concentration (μM).

Station	Samples	SO_4^{2-} (μM)	Station	Samples	SO_4^{2-} (μM)	Station	Samples	SO_4^{2-} (μM)
1	1S	27.87	**21**	21S	27.30	**41**	41S	25.13
	1B	29.51		21B	27.41		41B	25.11
2	2S	27.35	**22**	22S	26.83	**42**	42S	26.73
	2B	28.90		22B	28.48		42B	28.58
3	3S	27.30	**23**	23S	26.07	**43**	43S	27.48
	3B	35.38		23B	27.38		43B	28.14
4	4S	27.19	**24**	24S	29.33	**44**	44S	27.84
	4B	29.05		24B	29.38		44B	27.34
5	5S	27.66	**25**	25S	29.73	**45**	45S	25.67
	5B	28.38		25B	29.83		45B	25.92
6	6S	25.41	**26**	26S	25.02	**46**	46S	28.81
	6B	26.46		26B	26.09		46B	28.87
7	7S	25.42	**27**	27S	24.73	**47**	47S	28.47
	7B	25.60		27B	26.88		47B	28.46
8	8S	26.98	**28**	28S	28.13	**48**	48S	28.02
	8B	27.43		28B	30.02		48B	28.67
9	9S	27.53	**29**	29S	28.30	**49**	49S	29.27
	9B	27.72		29B	30.96		49B	29.32
10	10S	26.99	**30**	30S	30.00	**50**	50S	29.78
	10B	27.34		30B	30.45		50B	30.92
11	11S	27.45	**31**	31S	26,96	**51**	51S	29.18
	11B	27.79		31B	25.20		51B	29.10
12	12S	27.01	**32**	32S	26.10	**52**	52S	25.26
	12B	27.68		32B	28.75		52B	26.08
13	13S	26.65	**33**	33S	30.02	**53**	53S	25.48
	13B	26.51		33B	30.91		53B	25.93
14	14S	25.19	**34**	34S	24.28	**54**	54S	25.27
	14B	26.12		34B	25.63		54B	26.14
15	15S	26.04	**35**	35S	23.93	**55**	55S	27.04
	15B	26.08		35B	25.59		55B	27.84
16	16S	27.30	**36**	36S	23.80	**56**	56B	25.84
	16B	29.56		36B	25.67		56B	27.10
17	17S	27.25	**37**	37S	22.84	**57**	57S	25.66
	17B	29.79		37B	24.58		57B	26.26
18	18S	29.67	**38**	38S	21.63	**58**	58S	25.33
	18B	31.04		38B	25.42		58B	25.92
19	19S	27.89	**39**	39S	24.82	***Note:***		
	19B	28.55		39B	24.90	***S: Surface layer, 2m***		
20	20S	27.24	**40**	40S	29.95	***B: Bottom layer, ≥ 100m***		
	20B	28.10		40B	30.73			

Table 6.2. SO_4^{2-} - Concentration (mg/L).

Station	Samples	SO_4^{2-} (mg/L)	Station	Samples	SO_4^{2-} (mg/L)	Station	Samples	SO_4^{2-} (mg/L)
1	1S	2.68	**21**	21S	2.62	**41**	41S	2.41
	1B	2.83		21B	2.63		41B	2.41
2	2S	2.63	**22**	22S	2.58	**42**	42S	2.57
	2B	2.78		22B	2.74		42B	2.75
3	3S	2.62	**23**	23S	2.50	**43**	43S	2.64
	3B	3.40		23B	2.63		43B	2.70
4	4S	2.61	**24**	24S	2.82	**44**	44S	2.67
	4B	2.79		24B	2.82		44B	2.63
5	5S	2.66	**25**	25S	2.86	**45**	45S	2.47
	5B	2.73		25B	2.87		45B	2.49
6	6S	2.44	**26**	26S	2.40	**46**	46S	2.77
	6B	2.54		26B	2.51		46B	2.77
7	7S	2.44	**27**	27S	2.38	**47**	47S	2.73
	7B	2.46		27B	2.58		47B	2.73
8	8S	2.59	**28**	28S	2.88	**48**	48S	2.69
	8B	2.63		28B	2.70		48B	2.75
9	9S	2.64	**29**	29S	2.97	**49**	49S	2.81
	9B	2.66		29B	2.72		49B	2.82
10	10S	2.59	**30**	30S	2.88	**50**	50S	2.86
	10B	2.63		30B	2.93		50B	2.97
11	11S	2.64	**31**	31S	2.42	**51**	51S	2.80
	11B	2.67		31B	2.59		51B	2.80
12	12S	2.59	**32**	32S	2.51	**52**	52S	2.43
	12B	2.66		32B	2.76		52B	2.51
13	13S	2.56	**33**	33S	2.88	**53**	53S	2.45
	13B	2.55		33B	2.97		53B	2.49
14	14S	2.42	**34**	34S	2.33	**54**	54S	2.43
	14B	2.51		34B	2.46		54B	2.51
15	15S	2.50	**35**	35S	2.30	**55**	55S	2.60
	15B	2.51		35B	2.46		55B	2.67
16	16S	2.62	**36**	36S	2.29	**56**	56B	2.48
	16B	2.84		36B	2.47		56B	2.60
17	17S	2.62	**37**	37S	2.19	**57**	57S	2.46
	17B	2.86		37B	2.36		57B	2.52
18	18S	2.85	**38**	38S	2.08	**58**	58S	2.43
	18B	2.98		38B	2.44		58B	2.49
19	19S	2.68	**39**	39S	2.38			
	19B	2.74		39B	2.39			
20	20S	2.62	**40**	40S	2.88			
	20B	2.70		40B	2.95			

Note:
S: Surface layer, 2m
B: Bottom layer, ≥ 100m

Table 7. Comparison of nutrient concentrations in the Vietnamese Waters.

NORTHERN REGION							
Name		**SiO_2 (µM)**	**PO_4^{3-} (µM)**	**NH_4^+ (µM)**	**NO_3^- (µM)**	**NO_2^- (µM)**	**SO_4^{2-} (µM)**
Surface	Average	20.16	1.37	2.84	7.76	0.32	26.97
	Max	27.00	1.79	3.88	9.87	0.52	27.87
	Min	17.68	1	1.22	5.98	0.16	25.41
Bottom	Average	24.32	2.22	2.47	8.95	0.39	28.58
	Max	46.74	3.84	3.32	11.16	0.56	35.38
	Min	17.68	1.2	1.11	7.13	0.19	25.6
MIDDLE REGION							
Name		**SiO_2 (µM)**	**PO_4^{3-} (µM)**	**NH_4^+ (µM)**	**NO_3^- (µM)**	**NO_2^- (µM)**	**SO_4^{2-} (µM)**
Surface	Average	28.63	0.91	2.60	6.85	0.21	27.41
	Max	34.82	1.25	4.44	8.81	0.60	30.96
	Min	23.92	0.74	1.11	1.95	0.04	24.73
Bottom	Average	35.90	1.35	2.34	7.90	0.22	28.15
	Max	55.58	1.9	4.10	10.68	0.58	31.04
	Min	23.92	0.88	1.13	6.47	0.11	26.08
SOUTHERN REGION							
Name		**SiO_2 (µM)**	**PO_4^{3-} (µM)**	**NH_4^+ (µM)**	**NO_3^- (µM)**	**NO_2^- (µM)**	**SO_4^{2-} (µM)**
Surface	Average	25.96	0.70	2.92	3.84	0.08	26.44
	Max	35.29	0.91	4.10	6.5	0.15	30.02
	Min	20.61	0.51	1.33	1.95	0.04	21.63
Bottom	Average	28.87	1.05	2.70	5.19	0.11	27.27
	Max	51.39	1.35	4.43	9.69	0.21	30.92
	Min	21.32	0.83	1.11	2.02	0.04	24.58

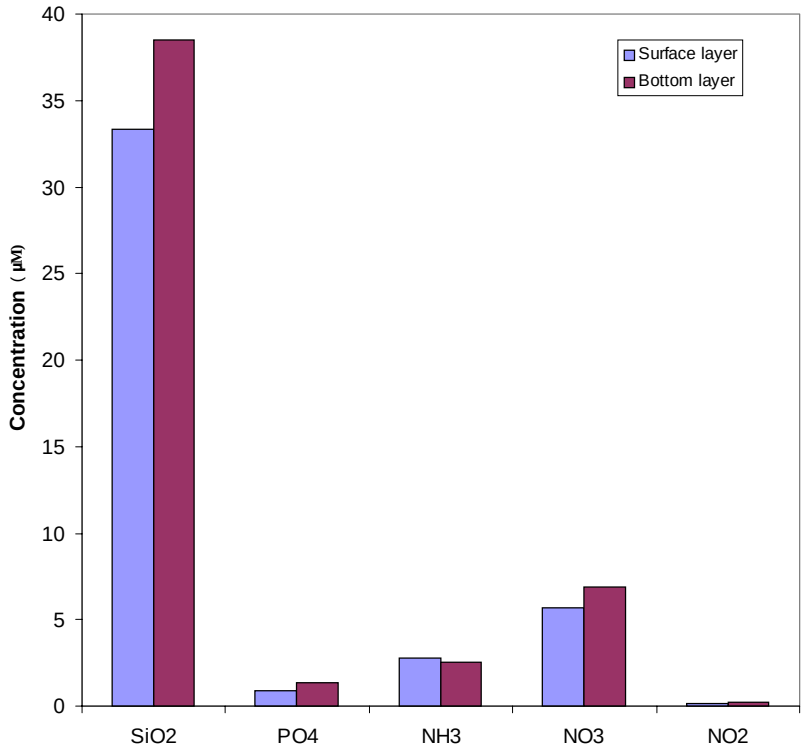


Fig. 7. Variation of 5 nutrient parameters.

Table 8.1. Comparison of nutrients in seawater.

NORTH REGION

SURFACE LAYER

Colors	PO_4(μM)		SiO2(μM)		NO_3(μM)		NO_2(μM)		NH_4(μM)	
Low (yellow)	2S	1.16	1S	17.69	5S	5.98	1S	0.20	1S	1.99
	8S	1.00	2S	17.69	7S	6.55	2S	0.25	7S	1.22
			4S	17.69	10S	6.52	3S	0.23	10S	1.77
			5S	17.69			7S	0.20		
			9S	18.72			8S	0.16		
			10S	18.72						
Medium (green)	1S	1.37	3S	19.74	4S	7.52	10S	0.29	2S	2.77
	3S	1.30	6S	21.8	6S	7.35			4S	2.66
	4S	1.41			9S	6.85				
	5S	1.26								
	9S	1.45								
	10S	1.32								
High (rose)	6S	1.79	7S	27.01	1S	9.87	4S	0.42	3S	3.32
	7S	1.60	8S	24.95	2S	9.79	5S	0.48	5S	3.55
					3S	9.10	6S	0.52	6S	3.88
					8S	8.10	9S	0.52	8S	3.66
									9S	3.55

BOTTOM LAYER

Colors	PO_4(μM)		SiO_2(μM)		NO_3(μM)		NO_2(μM)		NH_4(μM)	
Low (yellow)	3B	1.20	1B	18.72	4B	7.74	7B	0.19	7B	1.11
	4B	1.57	2B	17.69	5B	7.74			10B	1.33
	5B	1.50	3B	17.69	6B	7.13				
	10B	1.56	4B	18.72	7B	8.02				
			5B	17.69	10B	8.00				
Medium (green)	7B	1.85	6B	30.17	8B	9.55	1B	0.34	1B	1.99
	9B	1.80	7B	30.17	9B	9.13	3B	0.40	4B	2.44
			9B	24.95			4B	0.39	9B	2.44
							6B	0.41		
							9B	0.38		
							10B	0.34		
High (rose)	1B	3.47	8B	46.75	1B	11.16	2B	0.43	2B	3.11
	2B	3.05	10B	55.60	2B	10.19	5B	0.45	3B	2.77
	6B	2.38			3B	10.87	8B	0.56	5B	3.32
	8B	3.84							6B	3.11
									8B	3.11

Table 8.2a. Comparison of nutrients in seawater.

MIDDLE REGION

SURFACE LAYER

Colors	PO_4(μM)		SiO2(μM)		NO_3(μM)		NO_2(μM)		NH_4(μM)	
Low (yellow)	17S	0.76	11S	24.95	18S	4.63	18S	0.11	15S	1.66
	19S	0.86	12S	24.95	30S	1.95	19S	0.15	16S	1.33
	21S	0.76	27S	24.95	31S	5.76	20S	0.16	24S	1.11
	24S	0.80	30S	24.95			21S	0.17	26S	1.11
	25S	0.78	31S	23.93			22S	0.12		
	26S	0.74	32S	23.93			23S	0.18		
	28S	0.82					25S	0.10		
	29S	0.85					26S	0.18		
	30S	0.80					27S	0.15		
	31S	0.76					28S	0.12		
	32S	0.80					30S	0.04		
							31S	0.10		
							32S	0.18		
Medium (green)	13S	0.90	15S	27.01	11S	6.21	11S	0.33	11S	1.99
	14S	1.05	16S	29.04	12S	6.61	12S	0.41	12S	2.44
	15S	1.09	17S	29.61	13S	6.97	15S	0.28	14S	2.88
	18S	1.05	18S	30.17	14S	6.92	16S	0.22	17S	2.22
	22S	0.95	19S	27.01	17S	6.87	17S	0.21	18S	2.44
	23S	0.90	21S	30.17	22S	6.63	24S	0.23	23S	2.11
	27S	0.88	23S	30.17	25S	6.00	29S	0.19	25S	2.77
			24S	30.64	29S	6.37			27S	1.99
			26S	30.17	32S	6.90			30S	2.44
			29S	26.45					31S	2.27
									32S	1.99
High (rose)	12S	1.25	13S	34.83	15S	7.37	13S	0.60	13S	3.55
	16S	1.12	14S	31.19	16S	7.50	14S	0.45	19S	4.10
	20S	1.25	20S	31.19	19S	7.44			20S	3.55
			22S	31.19	20S	7.76			21S	3.33
			25S	32.22	21S	8.32			22S	3.77
			28S	31.19	23S	8.10			28S	3.66
					24S	7.94			29S	4.44
					26S	8.81				
					27S	7.74				
					28S	7.85				

Table 8.2b. Comparison of nutrients in seawater.

MIDDLE REGION

BOTTOM LAYER										
Colors	**PO_4(μM)**		**SiO_2(μM)**		**NO_3(μM)**		**NO_2(μM)**		**NH_4(μM)**	
Low (yellow)	21B	0.88	28B	27.01	12B	6.89	18B	0.12	16B	1.77
	30B	1.05	29B	23.93	13B	6.94	20B	0.16	17B	1.77
	31B	0.99	32B	27.01	18B	6.68	21B	0.14	23B	1.33
	32B	1.00			23B	6.47	22B	0.14	26B	1.33
					27B	7.13	23B	0.11	27B	1.33
					29B	6.68	24B	0.14	32B	1.33
					30B	6.50	25B	0.18		
					31B	6.56	27B	0.13		
							28B	0.16		
							30B	0.14		
							31B	0.15		
							32B	0.13		
Medium (green)	11B	1.23	11B	31.19	15B	8.27	11B	0.33	11B	1.99
	12B	1.47	12B	33.25	16B	8.09	15B	0.31	12B	2.88
	13B	1.53	13B	31.19	17B	8.27	16B	0.27	13B	2.44
	14B	1.69	14B	29.61	20B	8.42	17B	0.21	15B	1.99
	15B	1.73	15B	33.25	21B	8.00	19B	0.19	18B	1.99
	16B	1.26	17B	37.43	22B	8.47	26B	0.19	19B	2.44
	17B	1.30	19B	32.22	24B	8.61	29B	0.20	22B	2.44
	19B	1.52	20B	32.22	28B	8.06			24B	2.44
	20B	1.90	21B	32.22	32B	7.89			28B	2.33
	22B	1.30	22B	32.22					30B	1.99
	23B	1.42	26B	32.22					31B	2.11
	24B	1.12	27B	33.80						
	25B	1.53	30B	29.04						
	26B	1.32	31B	30.17						
	27B	1.05								
	28B	1.10								
	29B	1.42								
High (rose)	15B	1.73	16B	55.60	11B	10.68	12B	0.58	14B	3.55
	18B	1.84	18B	55.60	14B	9.00	13B	0.42	20B	4.10
			23B	49.91	19B	8.81	14B	0.51	21B	3.11
			24B	49.91	25B	8.71			25B	3.88
			25B	51.09	26B	8.71			29B	3.11

Table 8.3a . Comparison of nutrients in seawater.

SOUTH REGION

SURFACE LAYER										
Colors	**PO_4(µM)**		**SiO2(µM)**		**NO_3(µM)**		**NO_2(µM)**		**NH_4(µM)**	
Low (yellow)	36S	0.55	33S	22.82	34S	2.76	34S	0.05	40S	1.33
	38S	0.64	34S	21.80	41S	2.37	41S	0.04	41S	1.99
	41S	0.59	36S	22.82	43S	2.16	49S	0.05	42S	1.77
	42S	0.59	39S	21.32	49S	2.87	50S	0.04	43S	1.99
	44S	0.56	40S	20.61	50S	1.95	54S	0.05	49S	1.99
	50S	0.64	46S	22.82	54S	2.90	58S	0.05	57S	1.99
	53S	0.63	51S	21.79	58S	2.45				
	56S	0.65	56S	21.32						
	58S	0.51								
Medium (green)	33S	0.68	35S	23.93	35S	3.18	35S	0.06	33S	2.33
	34S	0.72	41S	24.95	36S	3.56	36S	0.07	34S	2.44
	35S	0.79	42S	29.04	37S	3.63	37S	0.06	35S	2.77
	37S	0.78	43S	27.01	38S	3.52	38S	0.06	36S	3.11
	39S	0.69	44S	26.53	45S	3.16	45S	0.06	39S	2.77
	40S	0.68	45S	29.61	46S	3.90	46S	0.07	51S	2.77
	43S	0.74	47S	26.53	48S	3.55	48S	0.06	53S	3.11
	45S	0.79	52S	23.93	51S	3.55	53S	0.06	55S	2.22
	46S	0.80	53S	27.01	52S	4.60	57S	0.08	56S	3.11
	47S	0.70	54S	25.95	53S	3.00				
	48S	0.82	55S	24.95	55S	4.15				
	49S	0.80	57S	23.93	56S	4.24				
	51S	0.68	58S	23.93	57S	4.24				
	52S	0.83								
	55S	0.74								
	57S	0.79								
High (rose)	54S	0.91	37S	31.19	33S	6.05	33S	0.15	37S	4.10
			38S	30.17	39S	5.73	39S	0.15	38S	4.10
			48S	32.22	40S	4.95	40S	0.09	44S	3.66
			49S	35.30	42S	6.02	42S	0.12	45S	3.11
			50S	32.22	44S	6.50	43S	0.09	46S	3.11
					47S	4.95	44S	0.12	47S	3.66
							47S	0.09	48S	3.66
							51S	0.09	50S	3.88
							52S	0.09	52S	3.77
							55S	0.09	54S	3.55
							56S	0.10	58S	3.55

Table 8.3b. Comparison of nutrients in seawater.

SOUTH REGION

BOTTOM LAYER

Colors	$PO_4(\mu M)$		$SiO_2(\mu M)$		$NO_3(\mu M)$		$NO_2(\mu M)$		$NH_4(\mu M)$	
Low (yellow)	38B	0.89	37B	21.32	35B	3.34	35B	0.06	34B	1.66
	39B	0.92	39B	21.32	37B	3.79	42B	0.04	40B	1.11
	53B	0.83	40B	21.79	42B	2.02	50B	0.07	49B	1.77
			51B	23.93	50B	3.97	54B	0.06	53B	1.99
			52B	23.93	54B	2.87	58B	0.06	57B	1.77
			54B	24.98	55B	3.68				
			55B	25.98	56B	2.31				
			56B	24.95	57B	3.45				
					58B	2.87				
Medium (green)	33B	1.05	33B	29.04	34B	5.65	34B	0.10	33B	2.11
	35B	0.99	34B	27.01	36B	4.74	36B	0.11	35B	2.32
	36B	1.00	35B	29.04	38B	4.92	37B	0.08	36B	2.11
	37B	1.10	36B	26.53	39B	6.65	38B	0.09	38B	2.11
	40B	1.00	41B	31.10	40B	6.00	40B	0.10	39B	2.44
	41B	1.05	42B	31.19	41B	4.56	41B	0.08	42B	2.33
	43B	1.00	43B	32.22	43B	5.15	43B	0.10	43B	2.77
	44B	0.94	44B	29.04	45B	6.44	44B	0.14	47B	3.11
	45B	0.98	45B	30.17	48B	6.48	45B	0.12	48B	3.11
	46B	1.03	46B	29.04	49B	5.06	46B	0.12	51B	2.77
	47B	0.99	47B	29.04	51B	6.19	47B	0.13	54B	2.77
	50B	1.00	48B	29.04	52B	6.16	48B	0.12	56B	2.44
	51B	1.04	49B	32.22			49B	0.08		
	52B	0.91	50B	33.80			55B	0.08		
	54B	1.15	53B	27.01			56B	0.12		
	56B	1.04	57B	33.25			57B	0.10		
	57B	1.11	58B	31.25						
	58B	0.92								
High (rose)	34B	1.35	38B	51.41	33B	7.94	33B	0.17	37B	3.55
	42B	1.23			44B	7.60	39B	0.21	41B	3.29
	48B	1.28			46B	6.81	51B	0.17	44B	3.32
	49B	1.20			47B	6.71	52B	0.15	45B	3.32
	55B	1.26			53B	9.69	53B	0.19	46B	3.66
									50B	3.32
									52B	3.55
									55B	4.43
									58B	3.11

Table 9.1. Comparison of SO_4 concentration.

NORTH REGION

	Surface layer		Bottom layer	
	Position	*Concentration*	*Position*	*Concentration*
Low (yellow)	6S	25.41	6B	26.46
	7S	25.42	7B	25.60
			8B	27.43
			9B	27.72
			10B	27.34
Medium (green)	8S	26.98	2B	28.90
	10S	26.99	5B	28.38
			4B	29.05
High (Rose)	1S	27.87	1B	29.51
	2S	27.35	3B	35.38
	3S	27.30		
	4S	27.19		
	5S	27.66		
	9S	27.53		

Table 9.2. Comparison of SO_4 concentration.

MIDDLE REGION

	Surface layer		Bottom layer	
	Position	*Concentration*	*Position*	*Concentration*
Low (yellow)	13S	26.65	11B	27.79
	14S	25.19	12B	27.68
	15S	26.04	13B	26.51
	22S	26.88	14B	26.12
	23S	26.07	15B	26.08
	26S	26.02	21B	27.41
	27S	24.73	23B	27.38
	31S	25.30	26B	26.09
	32S	26.10	27B	26.88
			31B	26.96
Medium (Green)	11S	27.45	19B	28.55
	12S	27.01	20B	28.10
	16S	27.30	22B	28.48
	17S	27.25	32B	28.75
	19S	27.89		
	20S	27.24		
	21S	27.30		
High (Rose)	18S	29.67	16B	29.56
	24S	29.33	17B	29.79
	25S	29.73	18B	31.04
	28S	28.13	24B	29.38
	29S	28.30	25B	29.83
	30S	30.00	28B	30.02
			29B	30.96
			30B	30.45

Table 9.3. Comparison of SO_4 concentration.

SOUTH REGION

	Surface layer		Bottom layer	
	Position	***Concentration***	***Position***	***Concentration***
Low (yellow)	34S	24.28	34B	26.63
	35S	23.93	35B	25.59
	36S	23.80	36B	25.67
	37S	22.84	37B	24.58
	38S	21.63	38B	24.90
	39S	24.82	39B	25.13
	41S	25.13	41B	25.13
	42S	26.73	44B	27.34
	45S	25.67	45B	25.92
	52S	25.26	52B	26.08
	53S	25.48	53B	25.93
	54S	25.27	54B	26.14
	56S	25.84	55B	27.84
	57S	25.66	56B	27.10
	58S	25.33	57B	26.26
			58B	25.92
Medium (Green)	43S	27.48	42B	28.52
	44S	27.84	43B	28.14
	46S	28.81	46B	28.47
	47S	28.47	47B	28.46
	48S	28.02	48B	28.67
	55S	27.04	49B	29.32
			51B	29.18
High (Rose)	33S	30.02	33B	30.91
	40S	29.95	40B	30.73
	49S	29.27	50B	30.92
	50S	29.78		
	51S	29.10		

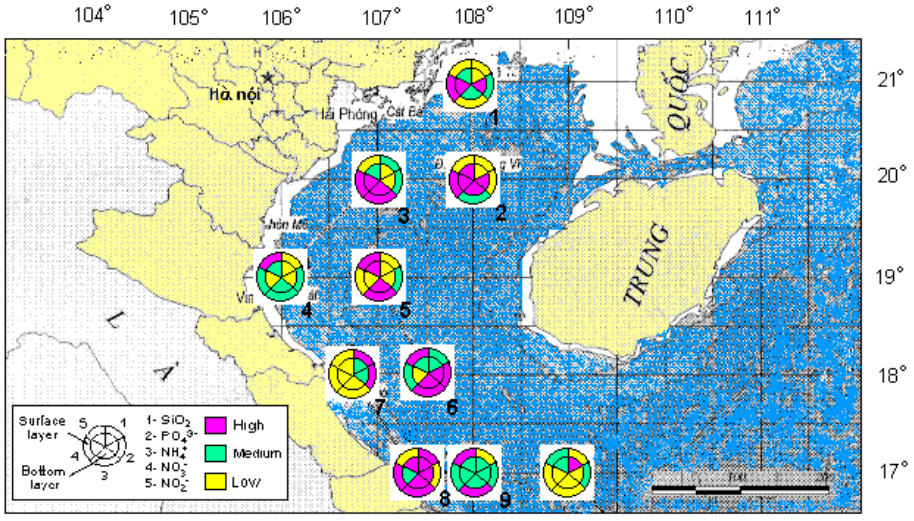


Fig. 8.1. Comparison of nutrient concentration in the northern region.

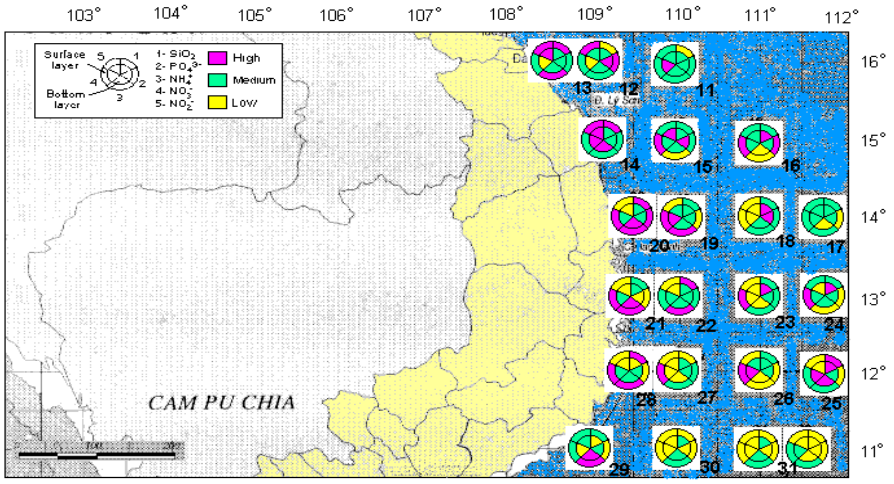


Fig. 8.2. Comparison of nutrient concentration in the middle region.

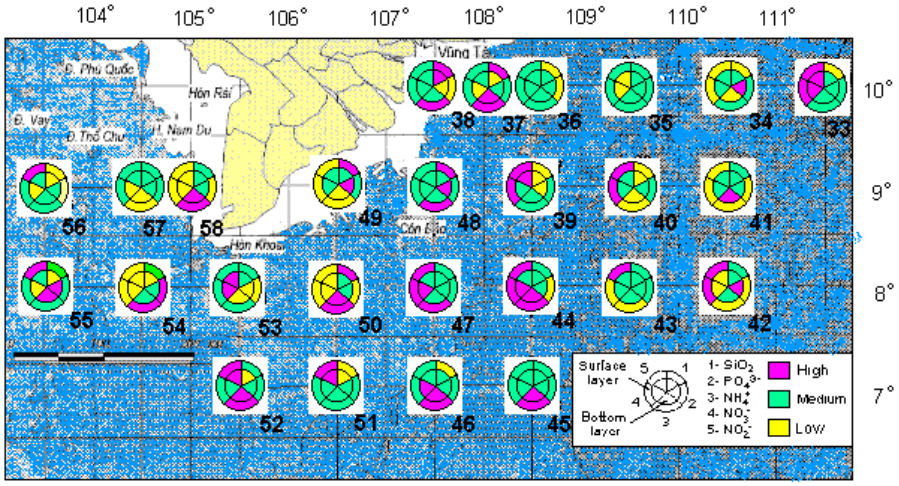


Fig. 8.3. Comparison of nutrient concentration in the southern region.

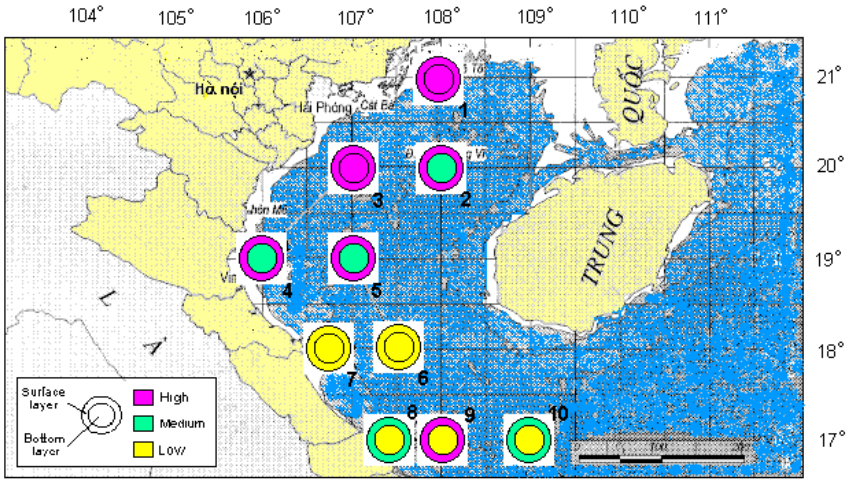


Fig. 9.1. Comparison of SO_4^{2-} concentration in the northern region.

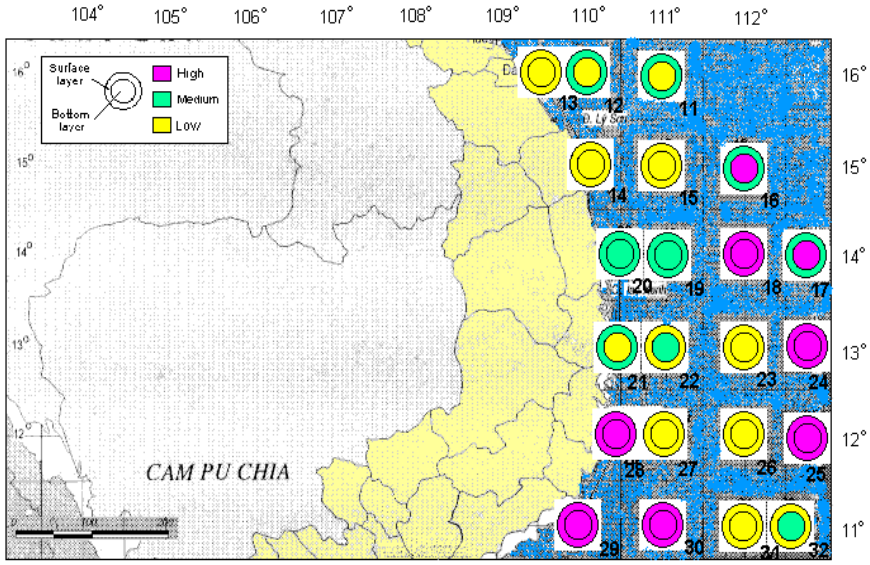


Fig. 9.2. Comparison of SO_4^{2-} concentration in the middle region.

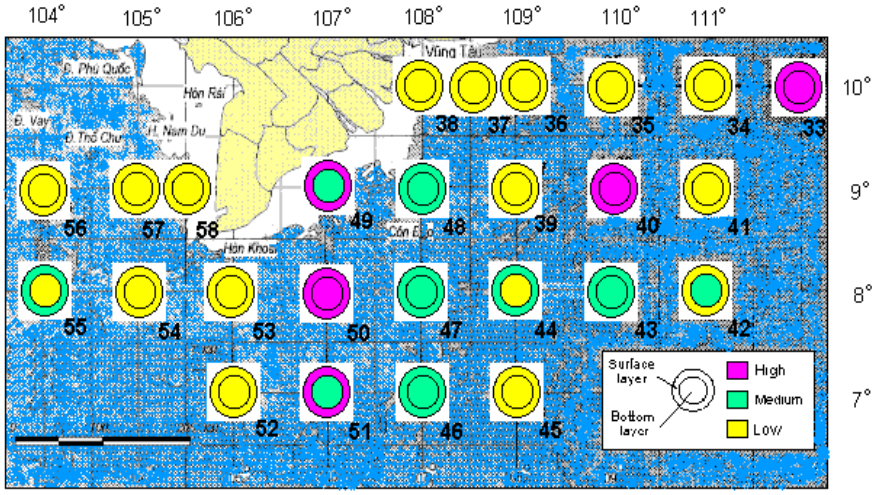


Fig. 9.3. Comparison of SO_4^{2-} concentration in the southern region.

Conclusion

This is the first result we have got through the sampling procedure in summer of 1999. Higher silica, nitrate and phosphate concentrations are found in deeper water than surface water. The same observation of nutrients was found in several areas in the South China Sea. All most all of nutrients are fit to Vietnam Standard TCVN –1995 for marine- and aquaculture and in some stations it also fit the standard for swimming beach.

Studies on the relationship between nutrient concentration and other oceanographic parameters and then the fisheries resources in this study area are needed.

The coming sampling time is expected in the year of 2000 for further results to update the data in this report.

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