Calculation Program for Land-based Pollution Load in the Northwest Pacific

Operational Manual

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(Ver. 1)

Wastewater System Division
Water Quality Control Department
National Institute for Land and Infrastructure Management
Ministry of Land, Infrastructure, Transport and Tourism

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Operational Manual
of
Calculation Program
for
Land-based Pollution Load in the Northwest Pacific

PREFACE

This program provides a system for modelling that assists to estimate the land-based pollution load discharging into the Northwest Pacific from Japan, Korea, China, and Russia. The program is one of the major components for the modelling of water quality of the sea area.

Water quality in the Northwest Pacific will be analyzed and projected by transferring the results obtained by ocean water quality prediction simulation. The result of the analysis will enable to project variation of the marine environment according to scenarios applied, and it is expected to propose effective measures to improve marine environment in the Northwest Pacific.

Overviews and operating method of the land-based pollution load calculation program are provided in the Operational Manual.

1. Overview of the Program

In this program, current and future projection of the land-based pollution loads discharged into the Northwest Pacific from Japan, China, Korea and Russia will be automatically calculated by preparing the five basic data files; step1 to step5 shown in **Figure 1.1**. The calculation results will be automatically summarized into three tables (pollution loads per ocean area, per pollution sources and per sub-block river catchments). Time-series graphs of discharged pollution loads can be obtained by using the graphing program.

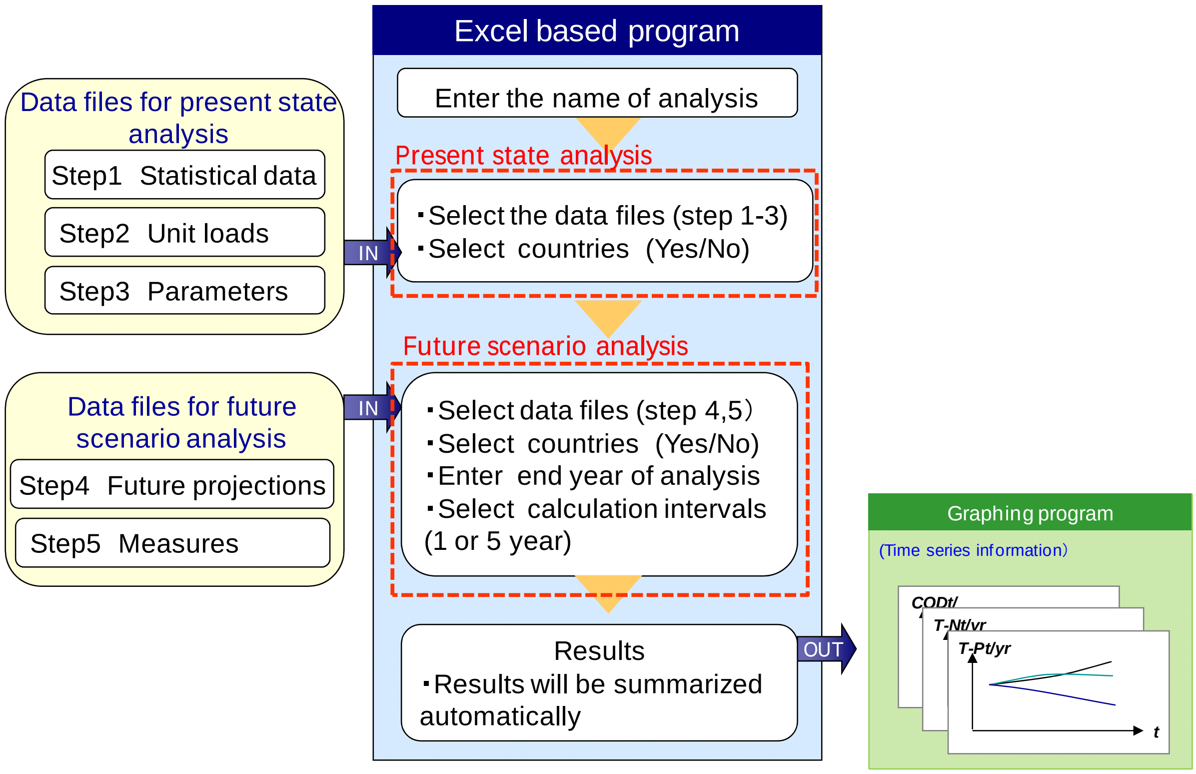


Figure 1.1 Overview of Land-based pollution load calculation program

2. **Study area**

The land-based pollution load calculation program was established for Northwest Pacific (Japan Sea, East China Sea, Yellow Sea and Bohai Sea) waters around China, Korea, Japan and Russia as shown in **Figure 2.1**. In Russia, three political regions; Primorskii Krai, Sakhalin Oblast and Khabarovsk Krai are the part of the Northewest Pacific region. However, only Primorskii Krai was included in the study area because the statistical data for Sakhalin Oblast and Khabarovsk Krai were not obtained in this study.

The calculation will be done in a sub-block level as shown in **Figure 2.2** to **Figure 2.5**.

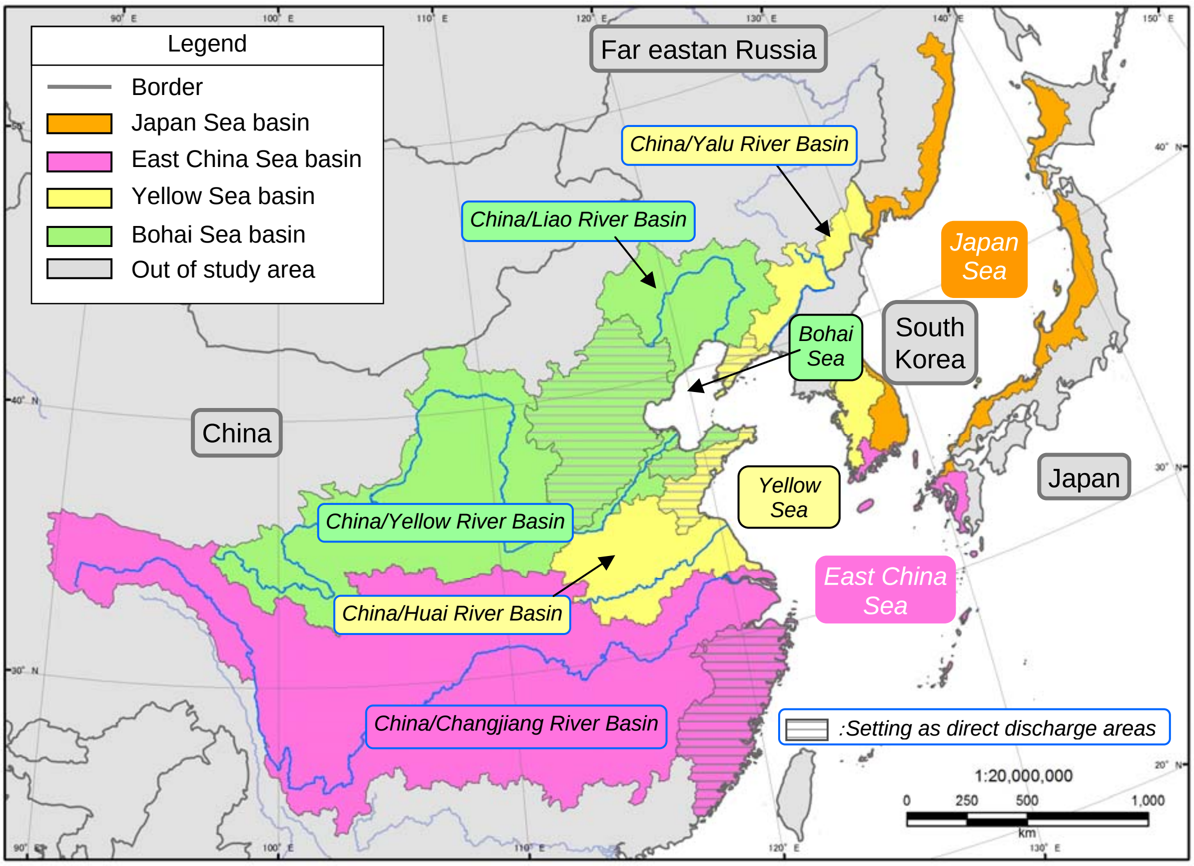


Figure 2.1 Study Area

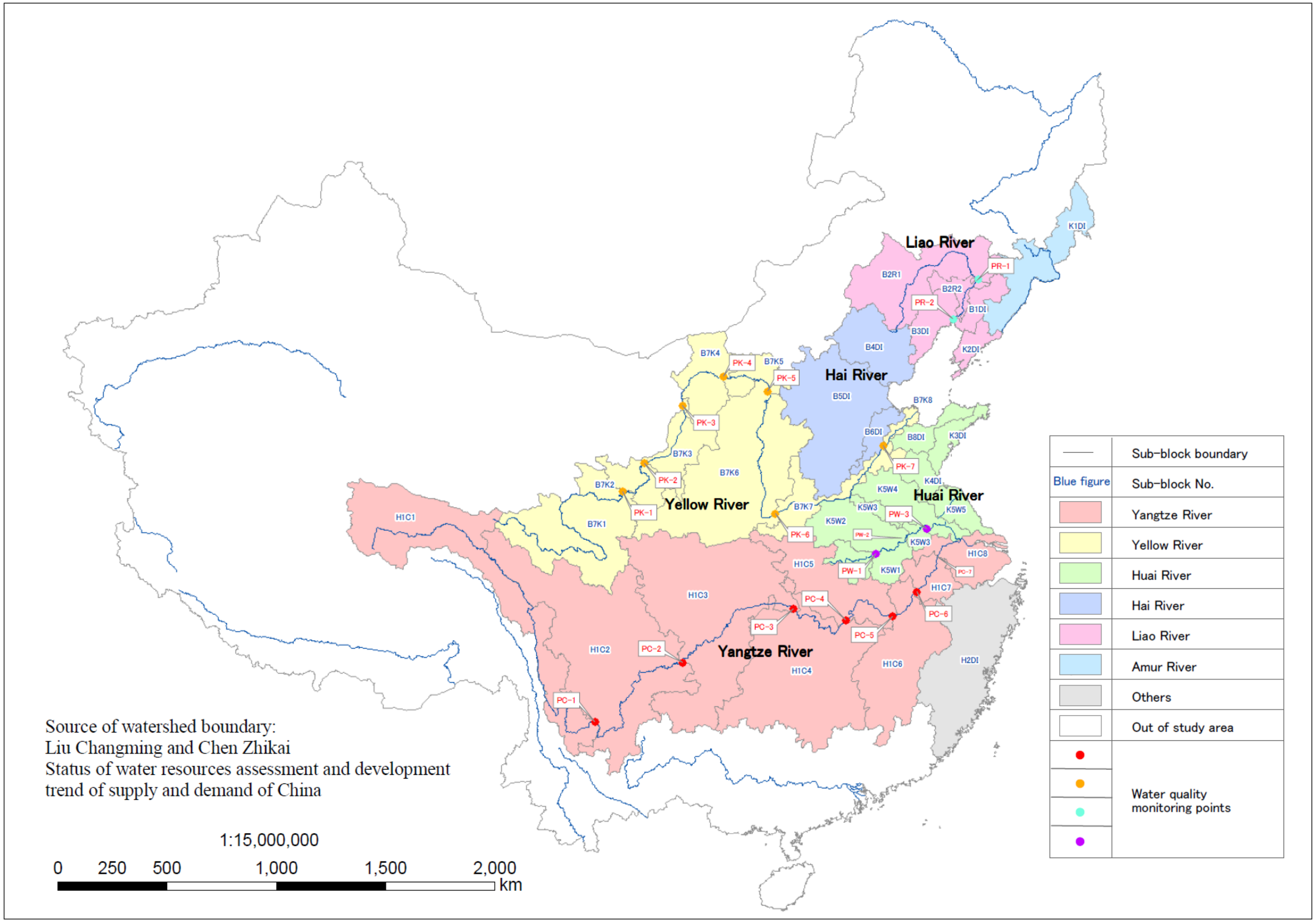


Figure 2.2 Sub-block catchment in China

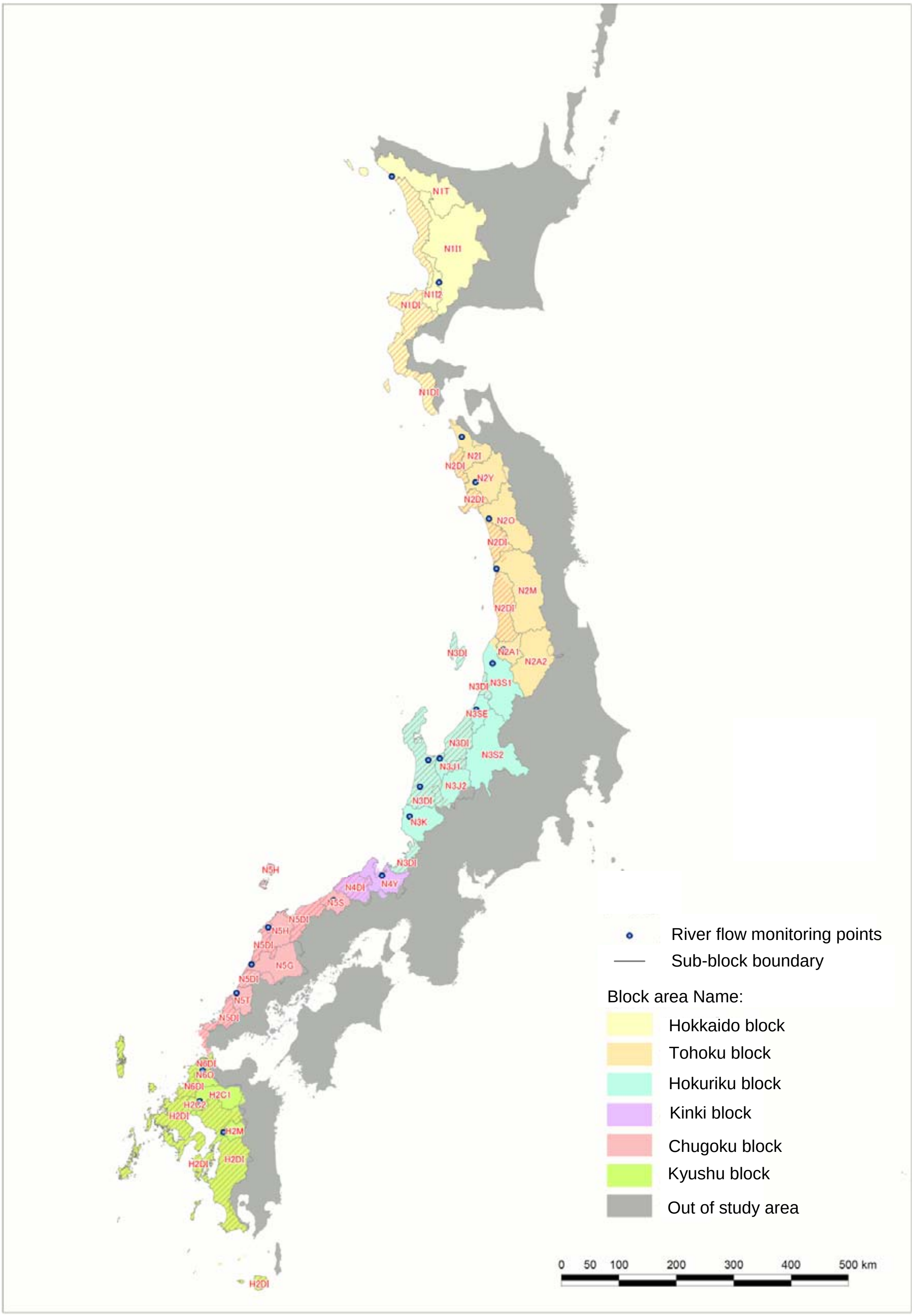


Figure 2.3 Sub-block catchment in Japan

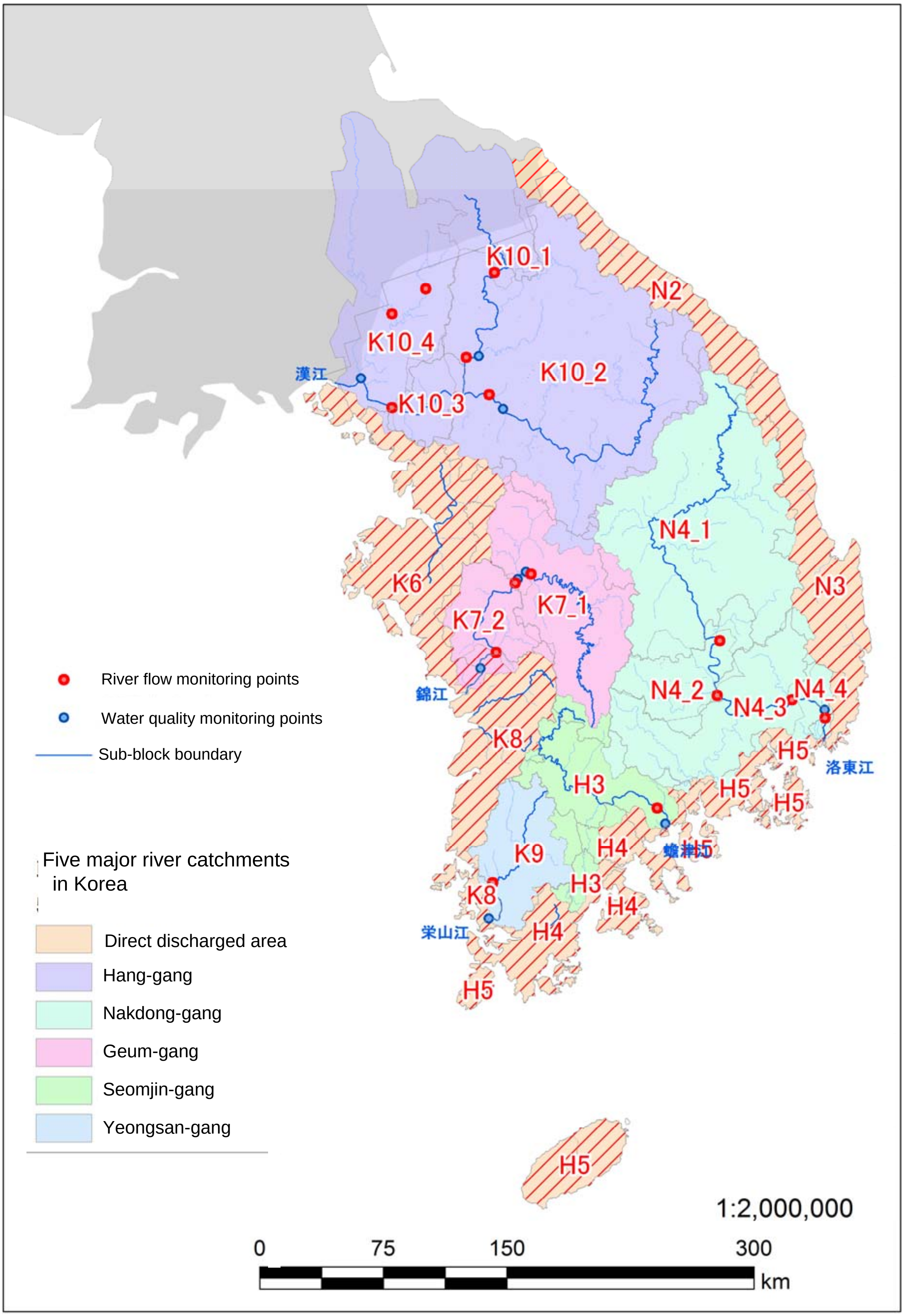


Figure 2.4 Sub-block catchment in Korea

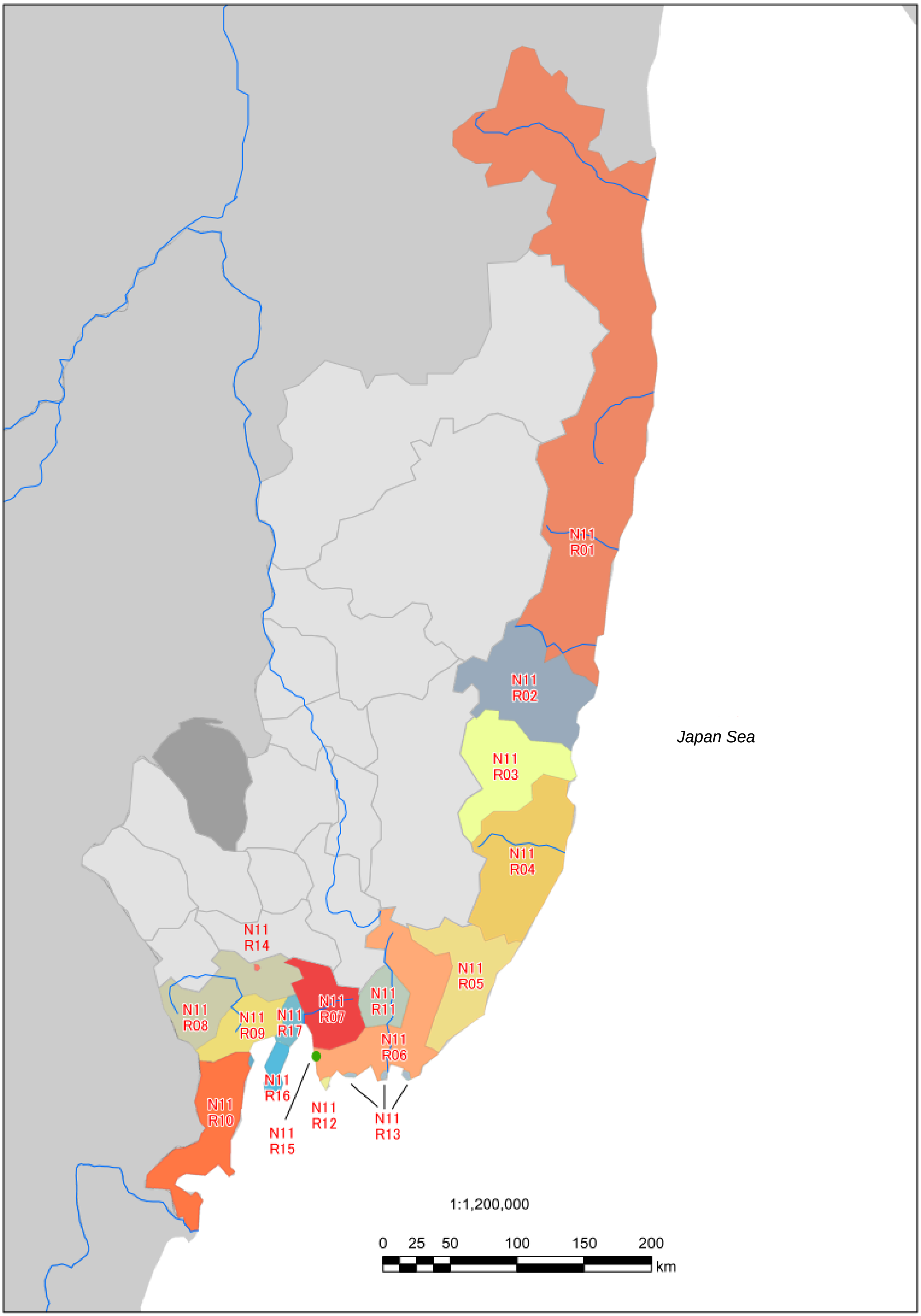


Figure 2.5 Sub-block catchment in Russia

3. **Structures and Items of Data Files**

Five input data files need to be prepared before starting the calculation program. The structure of the data files area is shown in following **Table 3.1**.

Table 3.1 Input data files of the calculation program

File Name	Sheet Name	Parameters included in each sheet
Statistical data	MuniFrame_C, J, K or R	Population, Flow of industrial effluent etc.
	ProveFrame_C, J, K or R	
Unit Loading Factors	Unit Load_C, J, K, or R	Generated unit load of domestic discharge, Removal ratio in Sewage Treatment Plant etc.
	Industrial_C, J, K, or R	Water quality of industrial effluents etc.
Parameters	Parameters_ C, J, K, or R	Correction of unit load in block level
Future Projection	Total pop. (A)	Total number of future population
	Urban pop. (B)	Municipal population number in the future
	Industrial production (C)	Industrial production in the future
	Industrial discharges (D)	Flow of industrial effluents in the future
Measures	Policy	Coverage ratio of sewage treatment facility in the future
	Nonpoint	Progress of non-point pollution measurements

All items used in each data file are shown in **Table 3.2** to **Table 3.4**. Mandatory field data items required in the calculation are different among four counties depending on their available statistical data.

Table 3.2 Code table (1/3)

File name (Sheet name)	Code	Data Item	Categories		Unit
Statistical data	[1]	Population and wastewater treatment	Population	Total	person
	[2]			Urban area	person
	[3]			Rural area	person
	[4]		Coverage ratio of domestic wastewater treatment in urban area	Sewerage System	%
	[5]			Domestic Wastewater treatment tank	%
	[6]		Coverage ratio of domestic wastewater treatment in rural area	Rural sewerage treatment system	%
	[7]			Domestic Wastewater treatment tank	%
	[8]		Sewered Population in urban area	Sewerage System	person
	[9]			Domestic Wastewater treatment tank	person
	[10]			Untreated	person
	[11]		Sewered Population in rural area	Rural sewerage treatment system	person
	[12]			Domestic Wastewater treatment tank	person
	[13]			Untreated	person
	[14]		Percentage of population served by Advanced wastewater treatment /Sewered polulation in urban area	Sewerage System	%
	[15]			Domestic Wastewater treatment tank	%
	[16]		Percentage of population served by Advanced wastewater treatment /Sewered polulation in rural area	Rural sewerage treatment system	%
	[17]			Domestic Wastewater treatment tank	%
	[18]	Industrial discharge	Industrial discharges	Total	m^3/yr.
	[19]			Connected to Sewerage System	m^3/yr.
	[20]		Percentage of industrial discharges connected to Sewerage system		%
	[21]		Industrial production		currency unit
	[22]		Industrial discharges per industrial production		m^3/currency unit
	[23]		Industrial discharges meeting Discharge Standard		%
	[24]	Livestock	Livestock numbers	Livestock 1	head
	[25]			Livestock 2	head
	[26]			Livestock 3	head
	[27]			Livestock 4	head
	[28]			Livestock 5	head
	[29]			Livestock 6	head
	[30]	Land use	Land area	Total area	km^2
	[31]			Forest	km^2
	[32]			Paddy field	km^2
	[33]			Dry field	km^2
	[34]			Urban area	km^2

Table 3.3 Code table (2/3)

File name (Sheet name)	Code	Data Item	Categories		Unit
Unit Loading factors (Unit loads)	a	Domestic Discharges in Urban Area	Discharged load (Conventional)	Served by sewerage system	t/yr./person
	b			Domestic wastewater treatment tank	t/yr./person
	c			Others (Vault toilet etc.)	t/yr./person
	a'		Discharged load (Advanced)	Served by sewerage system	t/yr./person
	b'			Domestic wastewater treatment tank	t/yr./person
	c'			Others (Vault toilet etc.)	t/yr./person
	u		Removal ration (Conventional)	Wastwater treatment plant	%
	u'		Removal ration (Advanced)	Wastwater treatment plant	%
	d	Domestic Discharges in Rural Area	Discharged load (Conventional)	Served by Rural sewerage treatment system	t/yr./person
	e			Domestic wastewater treatment tank	t/yr./person
	f			Others (Vault toilet etc.)	t/yr./person
	d'		Discharged load (Advanced)	Served by Rural sewerage treatment system	t/yr./person
	e'			Domestic wastewater treatment tank	t/yr./person
	f'			Others (Vault toilet etc.)	t/yr./person
	g	Livestock Discharges	Discharged load	Livestock 1	t/head/yr.
	h			Livestock 2	t/head/yr.
	i			Livestock 3	t/head/yr.
	j			Livestock 4	t/head/yr.
	k			Livestock 5	t/head/yr.
	l			Livestock 6	t/head/yr.
	g'		Discharged load after conducting measures	Livestock 1	t/head/yr.
	h'			Livestock 2	t/head/yr.
	I'			Livestock 3	t/head/yr.
	j'			Livestock 4	t/head/yr.
	k'			Livestock 5	t/head/yr.
	l'			Livestock 6	t/head/yr.
	m	Nonpoint Discharges	Discharged load	Forest area	$t/km^2/yr.$
	n			Paddy field	$t/km^2/yr.$
	o			Dry field	$t/km^2/yr.$
	p			Urban area	$t/km^2/yr.$
	m'		Discharged load after conducting measures	Forest area	$t/km^2/yr.$
	n'			Paddy field	$t/km^2/yr.$
	o'			Dry field	$t/km^2/yr.$
	p'			Urban area	$t/km^2/yr.$
Unit Loading factors (Industrial)	q	Water quality of Industrial Discharges	Outside of sewered area (Discharged directory into environmental water)	Improperly treated industrial discharges	mg/L
	r			Discharges standard for industrial effluents	mg/L
	s		Sewered area (Discharged into sewerage)		mg/L

Table 3.4 Code table (3/3)

File name (Sheet name)	Code	Data Item	Categories		Unit
Parameters	A	Calibration	Discharged Loads from Urban Area		-
	B		Discharged Loads from Rural Area		-
	C		Discharged Loads from Livestock	Livestock 1	-
	D			Livestock 2	-
	E			Livestock 3	-
	F			Livestock 4	-
	G			Livestock 5	-
	H			Livestock 6	-
	I		Discharged Loads from Nonpoint Sources	Forest	-
	J			Paddy field	-
	K			Dry field	-
	L			Urban area	-
	M		Loss by River Withdrawal for Agricultural Used		-
	M'		= 1 - M		-
	N	Reduction Rate	Purification at Water Bodies		-
	i	Allocation Rate	Mar. to May	Spring	-
	ii		Jun. to Aug.	Summer	-
	iii		Sep. to Nov.	Autumn	-
	iv		Dec. to Feb.	Winter	-
Future projection (Total pop. (A))	Ac	Projection of future population		Country level	person
	Ap			Province level	person
	Am			Municipality level	person
Future projection (Urban pop. (B))	Bc	Increase rate of urban population rate		Country level	-
	Bp			Province level	-
	Bm	Projection of future urban population rate		Municipality level	-
Future projection (Industrial production (C))	Cc	Annual GDP growth rate		Country level	-
	Cp			Province level	-
	Cm	Industrial Production		Municipality level	currency unit
Future projection (Industrial discharges (D))	Dp	Industrial discharges per industrial production		Province level	m^3/currency unit
	Dm	Industrial discharges		Municipality level	m^3/yr.
Measures (Policy)	[4]t_{goal}	Coverage Ratio of Domestic Wastewater Treatment in Goal Year	Urban Area	Sewerage system	%
	[5]t_{goal}			Domestic Wastewater treatment tank	%
	[6]t_{goal}		Rural Area	Rural sewerage treatment system	%
	[7]t_{goal}			Domestic Wastewater treatment tank	%
	[14]t_{goal}	Percentage of Population Served by Advanced Wastewater Treatment in Goal year	Urban Area	Sewerage system	%
	[15]t_{goal}			Domestic Wastewater treatment tank	%
	[16]t_{goal}		Rural Area	Rural sewerage treatment system	%
	[17]t_{goal}			Domestic Wastewater treatment tank	%
	[20]t_{goal}	Percentage of Industrial Discharges Treated Properly in Goal Year	Percentage of Industrial Discharges Connected to Sewerage System		%
	[23]t_{goal}		Meeting discharge standard for industrial effluents discharged directory into environmental water		%
Measures (Nonpoint pollution)	I	Progress of Measures in Goal Year	Percentages of Livestock Numbers Conducting Measures against Livestock Discharges	Livestock 1	%
	J			Livestock 2	%
	K			Livestock 3	%
	L			Livestock 4	%
	M			Livestock 5	%
	N			Livestock 6	%
	O		Percentages of Area Conducting Measures against Nonpoint Pollutions	Forest	%
	P			Paddy field	%
	Q			Dry field	%
	R			Urban area	%

a) Step1: Statistical data sheet

Statistical data in a certain year (hereinafter called “Base year”) are to be filled in this [Statistical data] file. The statistical data file consists of two sheets. One is [MuniFrame_C, J, K or R], which is for municipal data entry, and the other is [ProvFrame_C, J, K or R], which is for provincial data entry.

This statistical data will be the base data in both current status calculation and future scenario analysis. Mandatory field data items are different from country to country depending on their government’s statistical data types.

Procedure for [MuniFrame_C, J, K or R] data sheet entry:

In this data sheet, municipal populations, coverage ratios of wastewater treatment facilities, sewered populations, percentages of population served by advanced wastewater treatment, amounts of industrial effluents and the number of livestock animals are to be filled in.

1) Enter the statistical data year in a green colored cell.
2) Enter the statistical data in blue colored cells.

*Note: There is no necessity to enter the statistical data for any municipalities which you need not to include in the calculation.

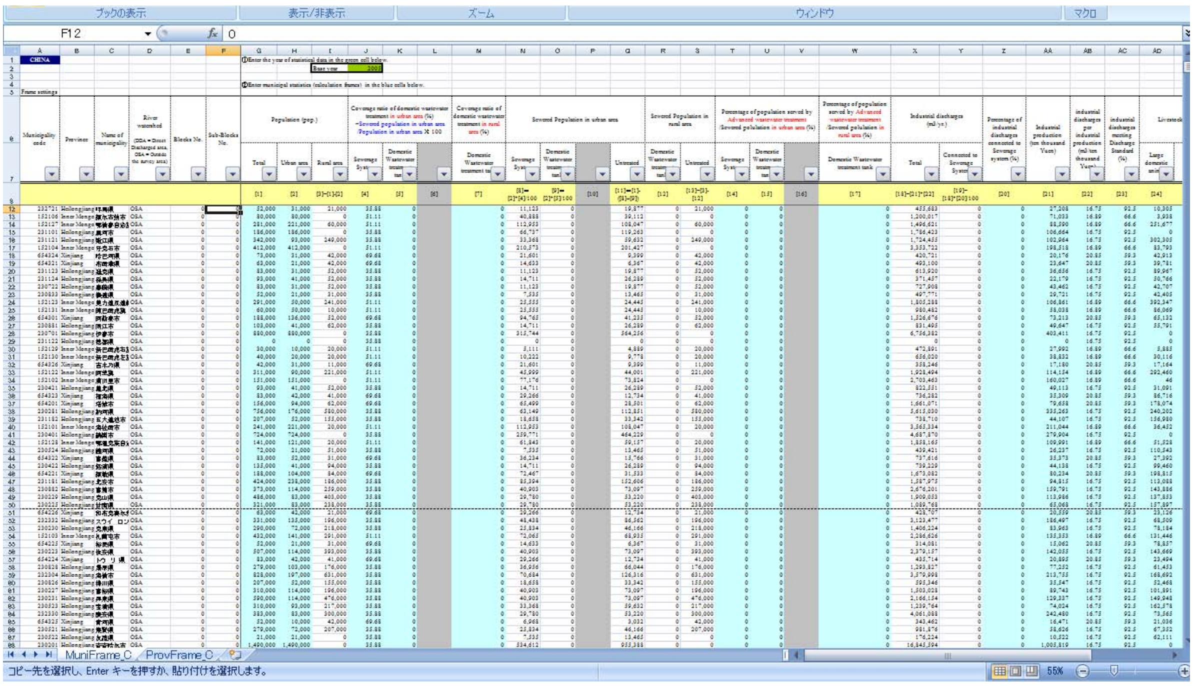


Figure 3.1 Data entry screen of [MuniFrame_c] data sheet in the Statistical data file (a case in China)

Procedure for [ProvFrame_C, J, K or R] data sheet entry:

In this data sheet, population and industrial wastewater flow in provincial levels are to be filled in.

1) Enter the statistical data in blue colored cells.

*Notes: In Korea, it is not needed to handle the data sheet because the provincial data will be automatically calculated based on previously entered municipal data.

CHINA

Base year 2005

①Enter provincial statistics in the blue cells below.

Municipality code	prefecture	Population (pop.) Total	Urban area	Rural area	Industrial discharges	Industrial production	Industrial discharges per	Industrial discharges
		[1]'	[2]'	[3]'	[18]'	[22]'	[9]'	[20]'
Whole of China		1,282,132,400	556,935,100	725,197,300	24,311,180,000	854,236,800	28.46	
110000	Beijing	15,360,000	12,840,000	2,520,000	128,130,000	17,070,400	7.51	99.43
120000	Tianjin	10,425,300	7,830,600	2,594,700	300,810,000	18,850,400	15.96	99.60
130000	Hebei	68,440,000	25,800,000	42,640,000	1,245,330,000	46,652,100	26.69	96.30
140000	Shanxi	33,518,500	14,114,600	19,403,900	320,990,000	21,176,800	15.16	88.87
150000	Inner Mongolia	23,861,000	11,262,000	12,599,000	249,670,000	14,778,800	16.89	66.62
210000	Liaoning	42,200,000	24,770,000	17,430,000	1,050,720,000	34,895,800	30.11	95.09
220000	Jilin	27,150,000	14,260,000	12,890,000	411,890,000	13,639,400	30.2	81.23
230000	Heilongjiang	38,180,000	20,273,600	17,906,400	451,580,000	26,963,000	16.75	92.47
310000	Shanghai	17,780,000	15,840,000	1,940,000	510,970,000	41,295,200	12.37	97.05
320000	Jiangsu	74,680,000	37,420,000	37,260,000	2,963,180,000	93,346,900	31.74	97.51
330000	Zhejiang	48,940,000	27,420,000	21,520,000	1,924,260,000	63,493,400	30.31	96.65
340000	Anhui	61,140,000	21,700,000	39,440,000	634,870,000	18,184,500	34.91	97.37
350000	Fujian	35,320,000	16,710,000	18,610,000	1,309,390,000	28,424,300	46.07	97.66
360000	Jiangxi	43,066,400	15,934,600	27,131,800	539,720,000	14,555,000	37.08	92.13
370000	Shandong	92,390,000	41,580,000	50,810,000	1,390,710,000	95,685,800	14.53	98.23
410000	Henan	93,710,000	28,720,000	64,990,000	1,234,760,000	48,960,100	25.22	91.94
420000	Hubei	57,070,000	24,650,000	32,420,000	924,320,000	24,365,500	37.94	87.55
430000	Hunan	63,200,000	23,380,000	39,820,000	1,224,400,000	21,899,100	55.91	89.74
440000	Guangdong	91,850,000	55,730,000	36,120,000	2,315,680,000	104,820,300	22.09	83.90
450000	Guangxi	46,550,000	15,650,000	30,900,000	1,456,090,000	12,648,400	115.12	83.70
460000	Hainan	8,263,100	3,734,900	4,528,200	74,280,000	1,561,600	47.57	93.62
500000	Chongqing	27,970,000	12,640,000	15,330,000	848,850,000	10,233,500	82.95	93.66
510000	Sichuan	82,080,000	27,090,000	54,990,000	1,225,900,000	25,270,800	48.51	88.26
520000	Guizhou	37,250,000	10,010,000	27,240,000	148,500,000	7,142,400	20.79	67.70
530000	Yunnan	44,424,400	13,105,200	31,319,200	329,280,000	11,808,300	27.89	80.96
540000	Tibet	2,760,000	740,000	2,020,000	9,910,000	174,800	56.69	0.00
610000	Shaanxi	37,180,000	13,840,000	23,340,000	428,190,000	15,536,000	27.56	92.73
620000	Gansu	25,917,200	7,780,300	18,136,900	167,980,000	6,858,000	24.49	73.23
630000	Qinghai	5,425,000	2,129,000	3,296,000	76,190,000	2,039,400	37.36	44.57
640000	Ningxia	5,950,000	2,520,000	3,430,000	214,110,000	2,290,700	93.47	67.76

Figure 3.2 Data entry screen of [ProvFrame_c] data sheet in the Statistical data file (a case in China)

b) Step2: Unit Loading Factors

Unit loading factors and reduction rates of COD, T-N and T-P at wastewater treatment facilities are to be set in this [Unit loading factors] file. This data file consists of two sheets. One is [Unit Load_C, J, K, or R], which is for uniform unit loading factors throughout the country, and the other is [Industrial_C, J, K, or R], which is for unit loading factors related to industrial wastewater set in provincial or municipal level.

Procedure for [Unit Load_C, J, K, or R] data sheet entry:

1) Enter the unit loading factors values in blue colored cells.

   Remarks:

   *Notes1: In this data sheet, unit loading factors related to non-point sources (ex. forest, paddy field, dry filed, urban area etc.) are set in uniform values throughout the country even they vary widely depending on different regions. Therefore, the unit loading factors set in this data sheet are able to be calibrated in sub-block level in the parameters file as will hereinafter be described in step 3.

   *Notes2: In code: m'~p', enter the unit loading factors expected to be discharged after implementation of certain countermeasures against non-point pollutions (refer to **Figure 3.3**). However, no need to enter code: m'~p' if measures against non-point source pollution are not planned in the scenario in the measures file as will hereinafter be described in step 5.

Table Type :	Unit Load
Country :	China
Description :	

Notes : Enter water quality of industrial discharges (Blue cells)

Classification		Unit	COD_{Mn}	T-N	T-P	Code
Domestic discharges (Urban area)						
Generated load [1]	Served by sewerage system	g/day/person	28	10	1	
		t/yr/person	0.0102	0.0037	0.0004	
	Domestic wastewater treatment tank	g/day/person	28	10	1	
		t/yr/person	0.0102	0.0037	0.0004	
	Others (Vault toilet etc.)	g/day/person	16.5	2.5	0.5	
		t/yr/person	0.006	0.0009	0.0002	
Removal Ratio (Conventional) [2]	Wastewater treatment plant	%	80	30	60	u
	Domestic wastewater treatment tank	%	80	42	38	
	Others	%				
Removal Ratio (Advanced) [2]'	Wastewater treatment plant	%	90	75	85	u'
	Domestic wastewater treatment tank	%	85	67	38	
	Others	%				
Discharged load (Conventional) [1]*[2]	Served by sewerage system	t/yr/person	0.00204	0.00259	0.00016	a
	Domestic wastewater treatment tank	t/yr/person	0.00204	0.002146	0.000248	b
	Others (Vault toilet etc.)	t/yr/person	0.006	0.0009	0.0002	c
Discharged load (Advanced) [1]*[2]'	Served by sewerage system	t/yr/person	0.00102	0.000925	0.00006	a'
	Domestic wastewater treatment tank	t/yr/person	0.00153	0.001221	0.000248	b'
	Others (Vault toilet etc.)	t/yr/person	0.006	0.0009	0.0002	c'
Domestic discharges (Rural area)						
Generated load [3]	Served by Rural sewerage treatment system	g/day/person				
		t/yr/person				
	Domestic wastewater treatment tank	g/day/person	20	8	0.8	
		t/yr/person	0.0073	0.00292	0.00029	
	Others (Vault toilet etc.)	g/day/person	12.5	2	0.4	
		t/yr/person	0.0045625	0.00073	0.00015	
Removal Ratio (Conventional) [4]	Served by Rural sewerage treatment system	%				
	Domestic wastewater treatment tank	%	80	42	38	
	Others (Vault toilet etc.)	%				
Removal Ratio (Advanced) [4]'	Served by Rural sewerage treatment system	%				
	Domestic wastewater treatment tank	%	85	67	38	
	Others (Vault toilet etc.)	%				
Discharged load (Conventional) [3]*[4]	Served by Rural sewerage treatment system	t/yr/person				d
	Domestic wastewater treatment tank	t/yr/person	0.00146	0.0016936	0.0001798	e
	Others (Vault toilet etc.)	t/yr/person	0.0045625	0.00073	0.00015	f
Discharged load (Advanced) [3]*[4]'	Served by Rural sewerage treatment system	t/yr/person				d'
	Domestic wastewater treatment tank	t/yr/person	0.001095	0.0009636	0.0001798	e'
	Others (Vault toilet etc.)	t/yr/person	0.0045625	0.00073	0.00015	f'
Livestock discharges						
Generated load [5]	Large animals (Cattle, horse, etc.)	g/head/day	65.06	108.77	14.55	
	Swine	g/head/day	8.38	14.06	3.67	
	Sheep	g/head/day	3.28	6.25	1.23	
		g/head/day				
		g/head/day				
		g/head/day				
Discharged rate (%) [6]	Large animals (Cattle, horse, etc.)	%	2.9	4.2	1.3	
	Swine	%	3.8	6.0	3.7	
	Sheep	%	3.8	6.0	3.7	
		%				
		%				
		%				
Discharged rate (%) in case conduction measurements [7]	Large animals (Cattle, horse, etc.)	%				
	Swine	%				
	Sheep	%				
		%				
		%				
		%				
Discharged load [5]*[6]	Large animals (Cattle, horse, etc.)	t/head/year	0.000689	0.001667	0.000069	g
	Swine	t/head/year	0.000116	0.000308	0.00005	h
	Sheep	t/head/year	0.000045	0.000137	0.000017	i
		t/head/year				j
		t/head/year				k
		t/head/year				l
Discharged load in case conduction measurements [5]*[7]	Large animals (Cattle, horse, etc.)	t/head/year				g'
	Swine	t/head/year				h'
	Sheep	t/head/year				I'
		t/head/year				j'
		t/head/year				k'
		t/head/year				l'
Runoff from nonpoint sources						
Discharged load	Forest area	kg/ha/yr	20.7	4.2	0.17	
		t/km2/yr	2.07	0.42	0.017	m
	Discharged load from paddy field	kg/ha/yr	42.9	11	1.13	
		t/km2/yr	4.29	1.1	0.113	n
	Discharged load from dry field	kg/ha/yr	19.1	32.2	0.36	
		t/km2/yr	1.91	3.22	0.036	
	Urban area	kg/ha/yr	51.1	12.1	0.81	
		t/km2/yr	5.11	1.21	0.081	
Discharged load after conductiong measurers against nonpoint sources	Forest area	kg/ha/yr				
		t/km2/yr				
	Discharged load from paddy field	kg/ha/yr				
		t/km2/yr				n'
	Discharged load from dry field	kg/ha/yr				
		t/km2/yr				o'
	Urban area	kg/ha/yr				
		t/km2/yr				p'

Unit loading factors after implementation of measures against non-point pollution.

Figure 3.3 Data entry screen of [Unit Load _c] data sheet in the Unit Loading factors file (a case in China)

Procedure for [Industrial _C, J, K, or R] data sheet entry:

1) Enter the water quality of industrial effluents in blue colored cells.

   *Notes1: In this data sheet, the water quality of industrial wastewater is set for three cases; improper direct discharge into environmental waters, direct discharge into environmental waters after proper treatment, and discharge into the sewerage system.

Table Type :	Water quality of industrila discharges
Country :	China
Description :	

Notes : Enter water quality of industrial discharges (Blue cells)

Municipality code	[English]		[Local language]		[Language of your country]		Water quality of industrila discharges (mg/L)								
							Out of sewered area (=Discharged dicectory into environmental water)						Sewered area =Discharged into swerage		
	Province	Municipalities	省	降低行政区域	一級行政区	地級、県級行政単位	Improperly treated industrial discharges (mg/L)			Discharge standard for industrial effluents discharged directory into environmental water					
							COD	T-N	T-P	COD	T-N	T-P	COD	T-N	T-P
Code							q			r			s		
110000	Beijing		北京市		北京市		200	26	3	66.7	25	0.3	200	26	3
120000	Tianjin		天津市		天津市		200	26	3	66.7	25	0.3	200	26	3
130000	Hebei		河北省		河北省		200	26	3	66.7	25	0.3	200	26	3
140000	Shanxi		山西省		山西省		200	26	3	66.7	25	0.3	200	26	3
150000	Inner Mongolia		内蒙古自治区		内モンゴル自治区		200	26	3	66.7	25	0.3	200	26	3
210000	Liaoning		辽宁省		遼寧省		200	26	3	66.7	25	0.3	200	26	3
220000	Jilin		吉林省		吉林省		200	26	3	66.7	25	0.3	200	26	3
230000	Heilongjiang		黑龙江省		黒竜江省		200	26	3	66.7	25	0.3	200	26	3
310000	Shanghai		上海市		上海市		200	26	3	66.7	25	0.3	200	26	3
320000	Jiangsu		江苏省		江蘇省		200	26	3	66.7	25	0.3	200	26	3
330000	Zhejiang		浙江省		浙江省		200	26	3	66.7	25	0.3	200	26	3
340000	Anhui		安徽省		安徽省		200	26	3	66.7	25	0.3	200	26	3
350000	Fujian		福建省		福建省		200	26	3	66.7	25	0.3	200	26	3
360000	Jiangxi		江西省		江西省		200	26	3	66.7	25	0.3	200	26	3
370000	Shandong		山东省		山東省		200	26	3	66.7	25	0.3	200	26	3
410000	Henan		河南省		河南省		200	26	3	66.7	25	0.3	200	26	3
420000	Hubei		湖北省		湖北省		200	26	3	66.7	25	0.3	200	26	3
430000	Hunan		湖南省		湖南省		200	26	3	66.7	25	0.3	200	26	3
440000	Guangdong		广东省		広東省		200	26	3	66.7	25	0.3	200	26	3
450000	Guangxi		广西壮族自治区		広西チワン族自治区		200	26	3	66.7	25	0.3	200	26	3
460000	Hainan		海南省		海南省		200	26	3	66.7	25	0.3	200	26	3
500000	Chongqing		重庆市		重慶市		200	26	3	66.7	25	0.3	200	26	3
510000	Sichuan		四川省		四川省		200	26	3	66.7	25	0.3	200	26	3
520000	Guizhou		贵州省		貴州省		200	26	3	66.7	25	0.3	200	26	3
530000	Yunnan		云南省		雲南省		200	26	3	66.7	25	0.3	200	26	3
540000	Tibet		西藏自治区		チベット自治区		200	26	3	66.7	25	0.3	200	26	3
610000	Shaanxi		陕西省		陝西省		200	26	3	66.7	25	0.3	200	26	3
620000	Gansu		甘肃省		甘粛省		200	26	3	66.7	25	0.3	200	26	3
630000	Qinghai		青海省		青海省		200	26	3	66.7	25	0.3	200	26	3
640000	Ningxia		宁夏回族自治区		寧夏回族自治区		200	26	3	66.7	25	0.3	200	26	3
650000	Xinjiang		新疆维吾尔自治区		新疆ウイグル自治区		200	26	3	66.7	25	0.3	200	26	3

Figure 3.4 Data entry screen of [Industrial_c] data sheet in the Unit Loading factors file (a case in China)

c) Step3: Parameters

Unit loading factors regarding livestock discharges and non-point pollution sources such as, forest, paddy field, etc. previously set in Step 2 will be calibrated in sub-block levels in the [parameters] file. The sheet is only one named [Parameters_ C, J, K, or R] in the file.

1) Enter the data in blue colored cells.

*Note1: Code A (discharge rate of pollution loads from urban area) and Code B (discharge rate of pollution loads from rural area) only for China are required to be filled. This is because the rates of delivered loads reaching the coast seem to be greatly varied by regions in China, where the target area is vast and the river withdrawal for agricultural use is huge unlike in other three countries. "A" the urban area includes pollution loads of domestic discharges from urban area and wastewater treatment plant, industrial wastewater discharges, and nonpoint sources loads from urban area. "B" the rural area includes domestic discharges from rural area and domestic wastewater treatment tank, livestock discharges, and nonpoint sources loads from paddy field, dry field and forest area.

*Note2: Code i~iv (refer to **Figure 3.5**); seasonal allocation ratio is the conversion rate of pollution loads to four seasons (spring: Mar. to May, summer: Jun. to Aug., autumn: Sep. to Nov., and winter: Dec. to Feb.) from the annual average discharge loads. Default values of the seasonal allocation ratios are calculated based on seasonal precipitation / annual precipitation in year 2005.

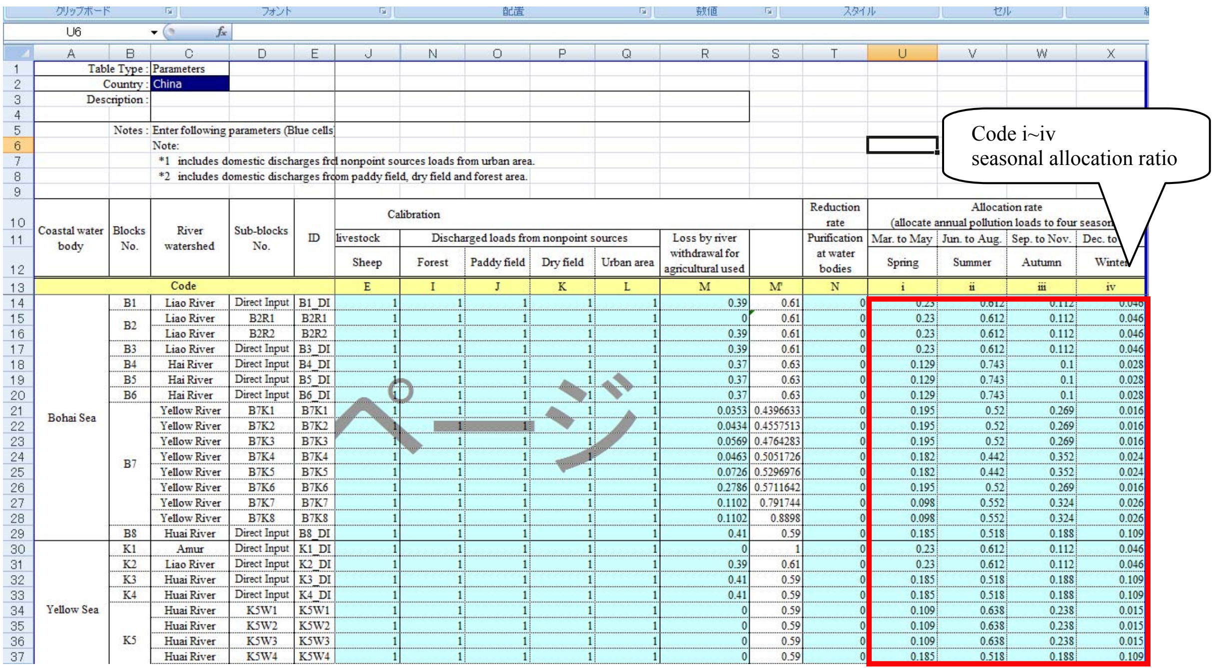


Table Type : Parameters
Country : China
Description :
Notes : Enter following parameters (Blue cells)
Note:
*1 includes domestic discharges fro nonpoint sources loads from urban area.
*2 includes domestic discharges froom paddy field, dry field and forest area.

Coastal water body	Blocks No.	River watershed	Sub-blocks No.	ID	Calibration: livestock – Sheep	Discharged loads from nonpoint sources – Forest	Paddy field	Dry field	Urban area	Loss by river withdrawal for agricultural used		Reduction rate – Purification at water bodies	Allocation rate (allocate annual pollution loads to four season): Mar. to May – Spring	Jun. to Aug. – Summer	Sep. to Nov. – Autumn	Dec. to – Winter
Code					E	I	J	K	L	M	M'	N	i	ii	iii	iv
Bohai Sea	B1	Liao River	Direct Input	B1_DI	1	1	1	1	1	0.39	0.61	0	0.23	0.612	0.112	0.046
	B2	Liao River	B2R1	B2R1	1	1	1	1	1	0	0.61	0	0.23	0.612	0.112	0.046
		Liao River	B2R2	B2R2	1	1	1	1	1	0.39	0.61	0	0.23	0.612	0.112	0.046
	B3	Liao River	Direct Input	B3_DI	1	1	1	1	1	0.39	0.61	0	0.23	0.612	0.112	0.046
	B4	Hai River	Direct Input	B4_DI	1	1	1	1	1	0.37	0.63	0	0.129	0.743	0.1	0.028
	B5	Hai River	Direct Input	B5_DI	1	1	1	1	1	0.37	0.63	0	0.129	0.743	0.1	0.028
	B6	Hai River	Direct Input	B6_DI	1	1	1	1	1	0.37	0.63	0	0.129	0.743	0.1	0.028
	B7	Yellow River	B7K1	B7K1	1	1	1	1	1	0.0353	0.4396633	0	0.195	0.52	0.269	0.016
		Yellow River	B7K2	B7K2	1	1	1	1	1	0.0434	0.4557513	0	0.195	0.52	0.269	0.016
		Yellow River	B7K3	B7K3	1	1	1	1	1	0.0569	0.4764283	0	0.195	0.52	0.269	0.016
		Yellow River	B7K4	B7K4	1	1	1	1	1	0.0463	0.5051726	0	0.182	0.442	0.352	0.024
		Yellow River	B7K5	B7K5	1	1	1	1	1	0.0726	0.5296976	0	0.182	0.442	0.352	0.024
		Yellow River	B7K6	B7K6	1	1	1	1	1	0.2786	0.5711642	0	0.195	0.52	0.269	0.016
		Yellow River	B7K7	B7K7	1	1	1	1	1	0.1102	0.791744	0	0.098	0.552	0.324	0.026
		Yellow River	B7K8	B7K8	1	1	1	1	1	0.1102	0.8898	0	0.098	0.552	0.324	0.026
	B8	Huai River	Direct Input	B8_DI	1	1	1	1	1	0.41	0.59	0	0.185	0.518	0.188	0.109
Yellow Sea	K1	Amur	Direct Input	K1_DI	1	1	1	1	1	0	1	0	0.23	0.612	0.112	0.046
	K2	Liao River	Direct Input	K2_DI	1	1	1	1	1	0.39	0.61	0	0.23	0.612	0.112	0.046
	K3	Huai River	Direct Input	K3_DI	1	1	1	1	1	0.41	0.59	0	0.185	0.518	0.188	0.109
	K4	Huai River	Direct Input	K4_DI	1	1	1	1	1	0.41	0.59	0	0.185	0.518	0.188	0.109
	K5	Huai River	K5W1	K5W1	1	1	1	1	1	0	0.59	0	0.109	0.638	0.238	0.015
		Huai River	K5W2	K5W2	1	1	1	1	1	0	0.59	0	0.109	0.638	0.238	0.015
		Huai River	K5W3	K5W3	1	1	1	1	1	0	0.59	0	0.109	0.638	0.238	0.015
		Huai River	K5W4	K5W4	1	1	1	1	1	0	0.59	0	0.185	0.518	0.188	0.109

Figure 3.5 Data entry screen of Parameters file (a case in China)

d) Step4: Future Projection

The [future projection] file consists of four data sheets; [Total pop. (A)], [City pop. (B)], [Industrial production (C)] and [Industrial discharges (D)]. The sheet (A) is for data entry for total future population, (B) for future population living in urban area, (C) for growth the growth rate industrial production ≈ GDP growth rate/future industrial productions and (D) for industrial wastewater flow per industrial production or generated industrial wastewater flow. Mandatory field data items in this data sheet are different among countries depending on their available statistical data as shown in Appendix 1.

Procedure for [Total pop. (A)] data sheet entry:

1) Enter the base year (statistical data year entered at Step1) in a red colored cell.
2) Select the projected future population data level (Whole of country, Province or Municipality) with a list box in a green colored cell.
3) Enter the projected future population in blue colored cells which will automatically be colored depending on the data level selected at previous step (if you select "Whole of country" filled out a Table1, "Province" filled out a Table2 and "Municipality" filled out a Table3 respectively).

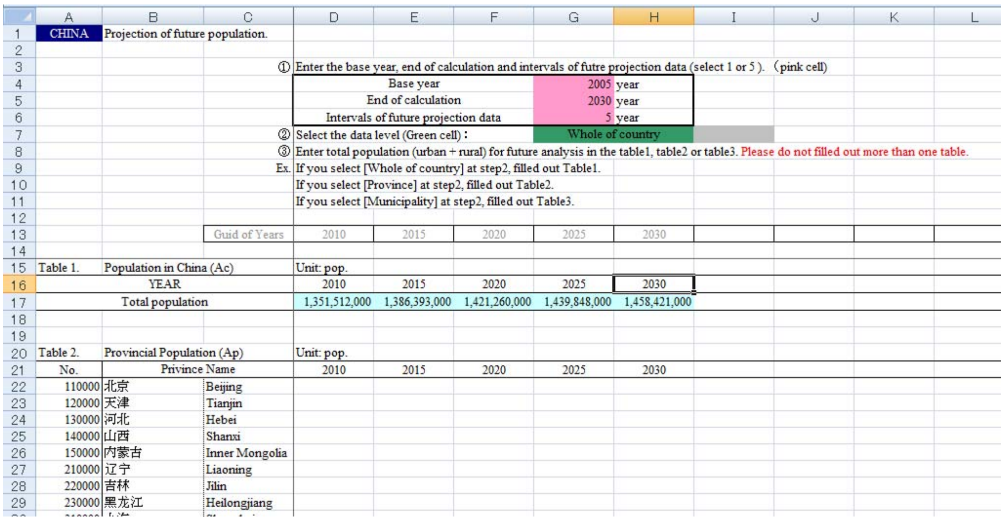


Figure 3.6 Data entry screen of [Total pop. (A)] data sheet in the Future Projection file (the case in China)

Procedure for [Urban pop. (B)] data sheet entry:

1) Select interval year (1 or 5) of the future projection in a red colored cell.
2) Select the projected data level (Whole country, Province or Municipality) in a green colored cell.
3) Enter the projected increase-decrease rate of "Urban population / Total population" relative to the base year in blue colored cells which will automatically colored depending on the data level selected at previous step (if you select "country", fill out Table1. The way, "Province", fill out Table 2).
4) However, if you select [Municipality] at previous step, enter the rate of urban population to total population in municipal level into the Table3.

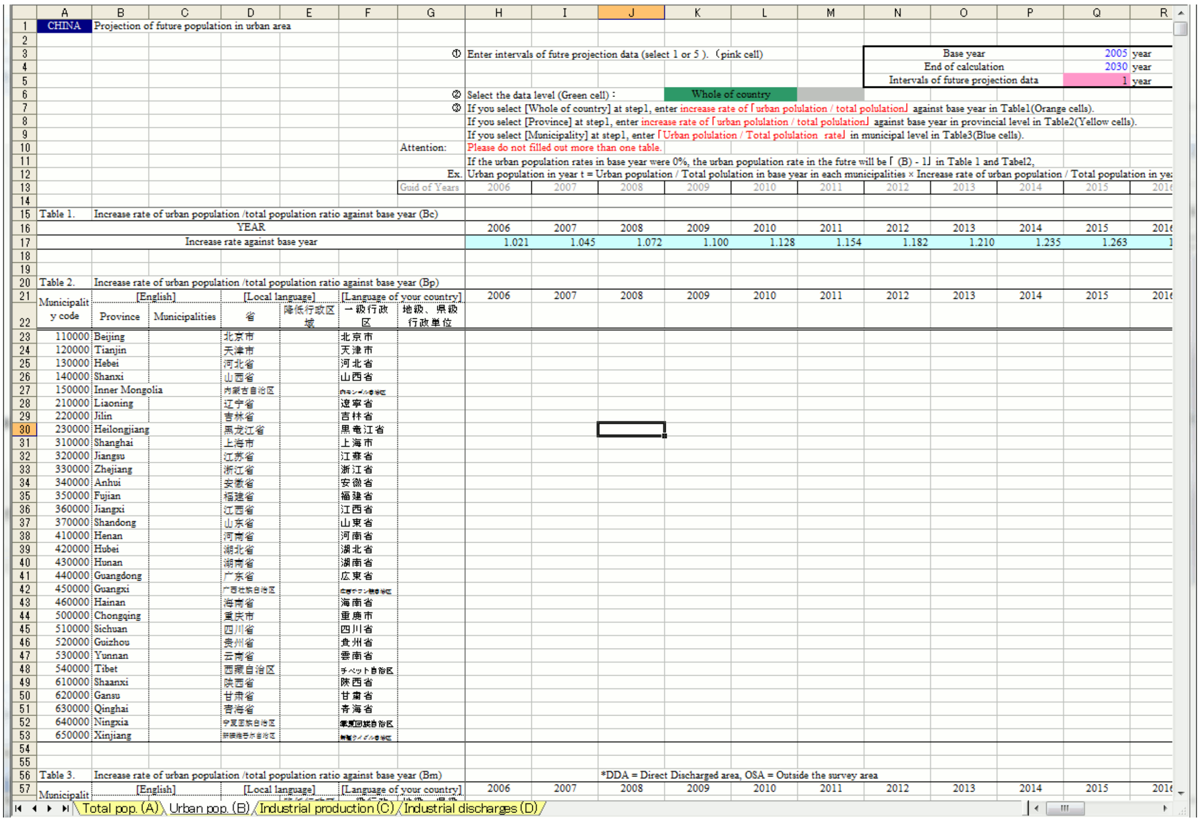


Figure 3.7 Data entry screen of [Urban pop. (B)] data sheet in the Future Projection file (a case in China)

Procedure for [Industrial production (C)] data sheet entry:

Projected future industrial productions are to be entered in this data sheet. However, if you are going to enter the industrial wastewater data in municipal level in the next step in [Industrial discharges (D)] data sheet (hereinafter be described in detail), <u>DO NOT enter</u> this data sheet.

1) Select interval year (1 or 5) for the future projection in a red colored cell.
2) Select the projected data level (Whole country, Province or Municipality) in a green colored cell.
3) Enter the projected <u>increase rate</u> of industrial production (≈ GDP) in the blue colored cells which will automatically be colored depending on the data level selected at previous step (if you select "Whole country" fill out the Table1. In the same way, for "Province" fill out the Table2 and for "Municipality" fill out the Table3 respectively).
4) However, if you select [Municipality] at previous step, enter industrial production in municipal level into the Table3.

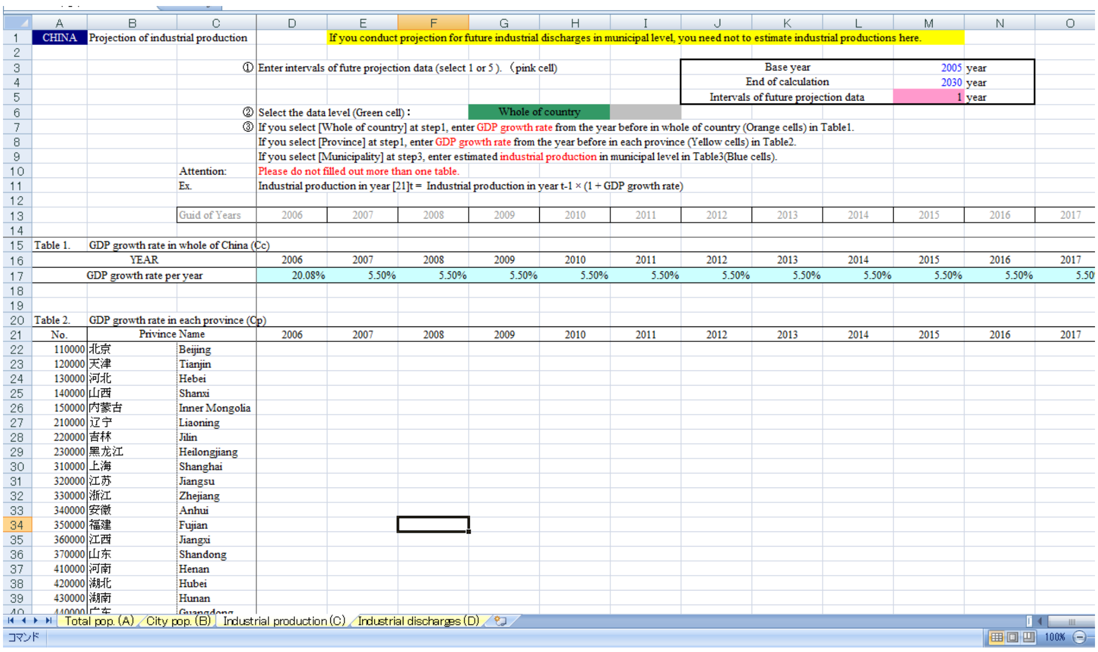


Figure 3.8 Data entry screen of [Industrial production (C)] data sheet in the Future Projection file (a case in China)

Procedure for [Industrial discharges (D)] data sheet entry:

1) Select interval year (1 or 5) for the future projection at a red colored cell.
2) Select the projected data level (Whole country, Province, Municipality) at the green colored cell.
3) Enter the projected "Average industrial discharge per Industrial production" into the blue colored cells which will be automatically colored depending on the data level selected at previous step (if you select "Whole country" fill out the Table1. In the same way, for "Province" fill out the Table2 and for "Municipality" fill out the Table3 respectively). However, if you select [Municipality] at previous step, enter industrial discharges in a municipal level into the Table3.

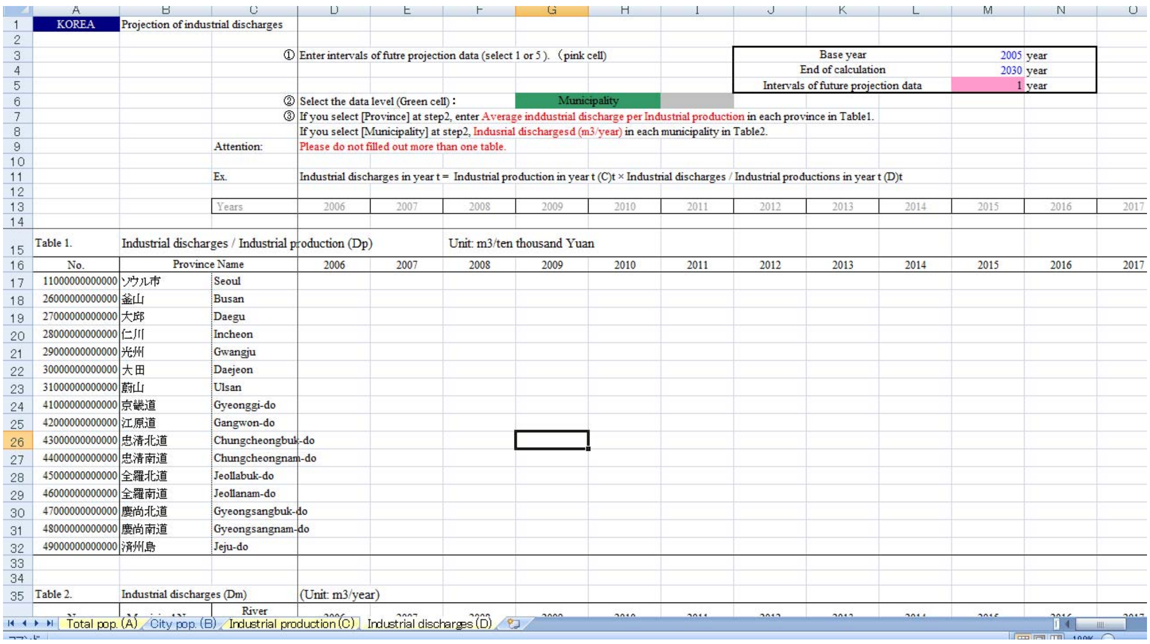


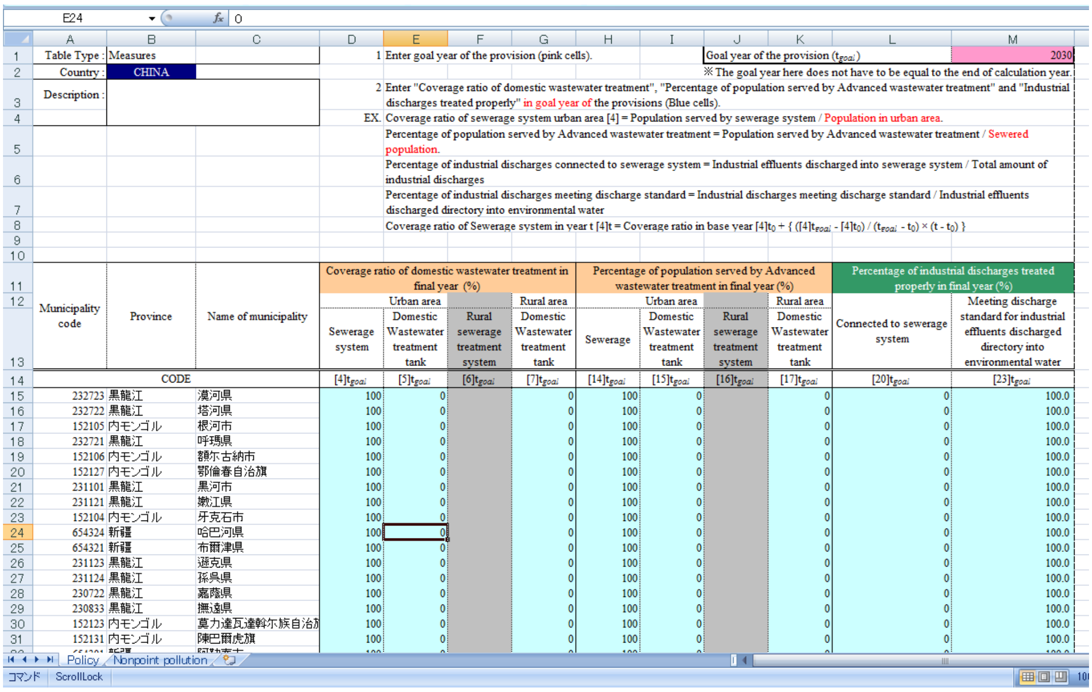
Figure 3.9 Data entry screen of [Industrial discharges (D)] data sheet in the Future Projection file (a case in China)

e) Step5: Measures

A scenario of future countermeasures against land-based pollution loads is set in this file. This file consists of two data sheets [Policy] and [Nonpoint]. Future coverage ratios of domestic wastewater treatments, percentages of population served by advanced wastewater treatments and percentages of industrial wastewater flow treated properly in the target year are to be entered in the [Policy] data sheet. Future improvement of non-point source pollution by some countermeasures is set in the [Nonpoint] data sheet.

<u>Procedure for [Policy] data sheet entry:</u>

1) Enter the target year (completion year of the measures) in a red colored cell.
2) Enter the coverage ratio of domestic wastewater treatment system, percentages of population served by advanced wastewater treatments and percentages of industrial wastewater treated in the goal year based in blue colored cells.



E24 | fx 0

Table Type : Measures
Country : CHINA
Description :

1 Enter goal year of the provision (pink cells). | Goal year of the provision (t_{goal}) | 2030

※The goal year here does not have to be equal to the end of calculation year.

2 Enter "Coverage ratio of domestic wastewater treatment", "Percentage of population served by Advanced wastewater treatment" and "Industrial discharges treated properly" in goal year of the provisions (Blue cells).

EX. Coverage ratio of sewerage system urban area [4] = Population served by sewerage system / Population in urban area.

Percentage of population served by Advanced wastewater treatment = Population served by Advanced wastewater treatment / Sewered population.

Percentage of industrial discharges connected to sewerage system = Industrial effluents discharged into sewerage system / Total amount of industrial discharges

Percentage of industrial discharges meeting discharge standard = Industrial discharges meeting discharge standard / Industrial effluents discharged directory into environmental water

Coverage ratio of Sewerage system in year t $[4]t$ = Coverage ratio in base year $[4]t_0 + \{ ([4]t_{goal} - [4]t_0) / (t_{goal} - t_0) \times (t - t_0) \}$

Municipality code	Province	Name of municipality	Coverage ratio of domestic wastewater treatment in final year (%)				Percentage of population served by Advanced wastewater treatment in final year (%)				Percentage of industrial discharges treated properly in final year (%)	
			Urban area			Rural area	Urban area			Rural area		
			Sewerage system	Domestic Wastewater treatment tank	Rural sewerage treatment system	Domestic Wastewater treatment tank	Sewerage	Domestic Wastewater treatment tank	Rural sewerage treatment system	Domestic Wastewater treatment tank	Connected to sewerage system	Meeting discharge standard for industrial effluents discharged directory into environmental water
CODE			$[4]t_{goal}$	$[5]t_{goal}$	$[6]t_{goal}$	$[7]t_{goal}$	$[14]t_{goal}$	$[15]t_{goal}$	$[16]t_{goal}$	$[17]t_{goal}$	$[20]t_{goal}$	$[23]t_{goal}$
232723	黒龍江	漠河県	100	0		0	100	0		0	0	100.0
232722	黒龍江	塔河県	100	0		0	100	0		0	0	100.0
152105	内モンゴル	根河市	100	0		0	100	0		0	0	100.0
232721	黒龍江	呼瑪県	100	0		0	100	0		0	0	100.0
152106	内モンゴル	額尓古納市	100	0		0	100	0		0	0	100.0
152127	内モンゴル	鄂倫春自治旗	100	0		0	100	0		0	0	100.0
231101	黒龍江	黒河市	100	0		0	100	0		0	0	100.0
231121	黒龍江	嫩江県	100	0		0	100	0		0	0	100.0
152104	内モンゴル	牙克石市	100	0		0	100	0		0	0	100.0
654324	新疆	哈巴河県	100	0		0	100	0		0	0	100.0
654321	新疆	布爾津県	100	0		0	100	0		0	0	100.0
231123	黒龍江	遜克県	100	0		0	100	0		0	0	100.0
231124	黒龍江	孫呉県	100	0		0	100	0		0	0	100.0
230722	黒龍江	嘉蔭県	100	0		0	100	0		0	0	100.0
230833	黒龍江	撫遠県	100	0		0	100	0		0	0	100.0
152123	内モンゴル	莫力達瓦達斡尓族自治	100	0		0	100	0		0	0	100.0
152131	内モンゴル	陳巴爾虎旗	100	0		0	100	0		0	0	100.0

Policy / Nonpoint pollution

Figure 3.10 Data entry screen of [Policy] data sheet in the Measure file (a case in China)

Procedure for [Nonpoint] data sheet entry:

1) Enter the base year of the calculation in a red colored cell. The target year will be automatically filled in linked from [Policy] data sheet.
2) Enter the progress of the measures against the nonpoint pollution (= Discharged nonpoint pollution loads in the target year / Discharged nonpoint pollution loads in the base year) in blue colored cells.

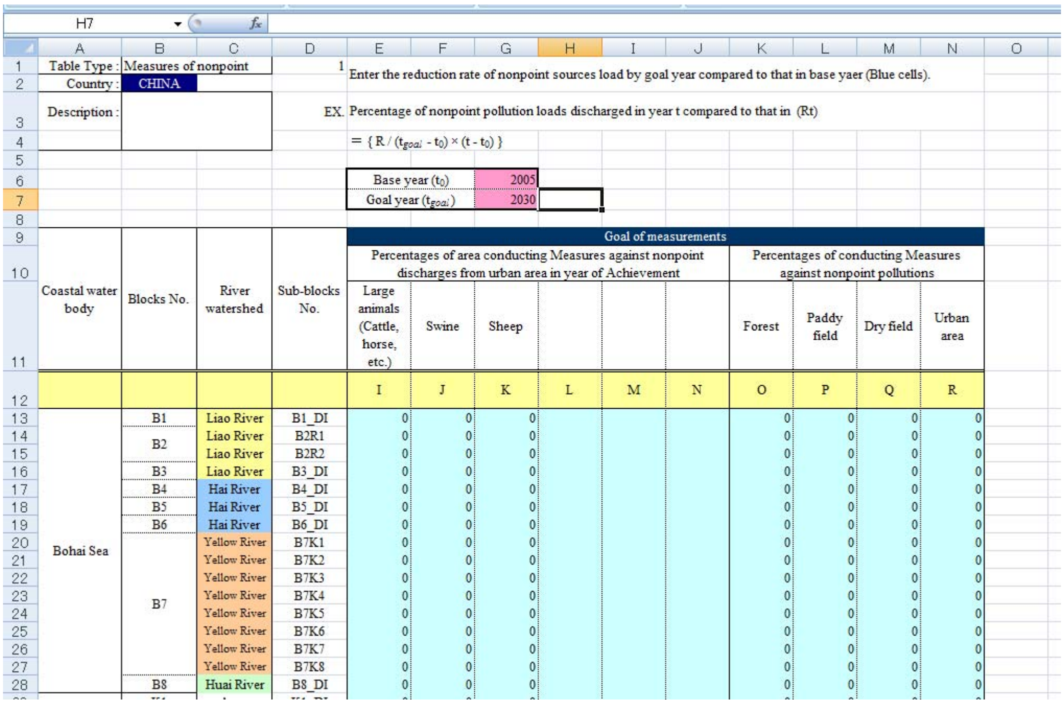


Table Type : Measures of nonpoint

Country : CHINA

Description :

1 Enter the reduction rate of nonpoint sources load by goal year compared to that in base yaer (Blue cells).

EX. Percentage of nonpoint pollution loads discharged in year t compared to that in (Rt)

$= \{ R / (t_{goal} - t_0) \times (t - t_0) \}$

Base year (t_0)	2005
Goal year (t_{goal})	2030

				Goal of measurements									
				Percentages of area conducting Measures against nonpoint discharges from urban area in year of Achievement						Percentages of conducting Measures against nonpoint pollutions			
Coastal water body	Blocks No.	River watershed	Sub-blocks No.	Large animals (Cattle, horse, etc.)	Swine	Sheep				Forest	Paddy field	Dry field	Urban area
				I	J	K	L	M	N	O	P	Q	R
Bohai Sea	B1	Liao River	B1_DI	0	0	0				0	0	0	0
	B2	Liao River	B2R1	0	0	0				0	0	0	0
		Liao River	B2R2	0	0	0				0	0	0	0
	B3	Liao River	B3_DI	0	0	0				0	0	0	0
	B4	Hai River	B4_DI	0	0	0				0	0	0	0
	B5	Hai River	B5_DI	0	0	0				0	0	0	0
	B6	Hai River	B6_DI	0	0	0				0	0	0	0
	B7	Yellow River	B7K1	0	0	0				0	0	0	0
		Yellow River	B7K2	0	0	0				0	0	0	0
		Yellow River	B7K3	0	0	0				0	0	0	0
		Yellow River	B7K4	0	0	0				0	0	0	0
		Yellow River	B7K5	0	0	0				0	0	0	0
		Yellow River	B7K6	0	0	0				0	0	0	0
		Yellow River	B7K7	0	0	0				0	0	0	0
		Yellow River	B7K8	0	0	0				0	0	0	0
	B8	Huai River	B8_DI	0	0	0				0	0	0	0

Figure 3.11 Data entry screen of [Nonpoint] data sheet in the Measure file (a case in China)

4. Formulas for Modelling

Previously mentioned data files are the input data of the calculation program. The calculation formulas used in the program are built up based on the following step.

Land-based pollution loads in the base year are calculated by the calculation formulas shown in the following a). While, in the future scenario analysis, future frames are firstly calculated by the formula shown in the following b). Then the pollution loads in the future are calculated by the calculation formulas shown in the following a). All the calculations will be done automatically in the program.

a) Formula of Land-based Pollution Loads Calculation

Basic calculation formula is same among four countries (China, Korea, Japan and Russia). The structure of the formula is “Statistical data x Progress of the measures x Unit loading factors x Other parameters” as shown below. Refer to **Table 4.1** for more details.

Statistical data	*	Measures	*	Unit Loading factors	*	Parameters
(Population, Industrial wastewater flow)		(Coverage ratio of sewerage system etc.)		(Discharged loads per person, water quality of industrial wastewater etc.)		(Calibration of unit load in sub-block level etc.)

Table 4.1 Pollution-source-wise Calculation formula

Source of pollution loads		Name of input data file:	Statistical data		Measures		Unit load		Parameters
A1-1 Domestic discharg in urban area	1	Direct discharge	[10]			×	c	×	A × M' × (1-N)
	3	Domestic wastwater tank (Conventional)	[9] × (100-[15])%			×	b	×	A × M' × (1-N)
	3'	Domestic wastwater tank (Advanced)	[9] × [15]%			×	b'	×	A × M' × (1-N)
A1-2 Domestic discharg in rural area	4	Direct discharge	[13]			×	f	×	B × M' × (1-N)
	2	Rural sewerage system (Conventional)	[11] × (100-[16])%			×	d	×	A × M' × (1-N)
	5	Domestic wastwater tank (Conventional)	[12] × (100-[17])%			×	e	×	B × M' × (1-N)
	2'	Rural sewerage system (Advanced)	[11] × [16]%			×	d'	×	A × M' × (1-N)
	5'	Domestic wastwater tank (Advanced)	[12] × [17]%			×	e'	×	B × M' × (1-N)
A2 Industrial effluent (out of sewerage system)	6	Meeting discharge standard	[18]-[19] × [23]%			×	r	×	A × M' × (1-N)
	7	Not meeting discharge standard	[18]-[19] × (100-[23])%			×	q	×	A × M' × (1-N)
A3 Livestock	8	Livestock1 (Without Measures)	[24]	×	(100-I)%	×	g	×	B × C × M' × (1-N)
	9	Livestock2 (Without Measures)	[25]	×	(100-J)%	×	h	×	B × D × M' × (1-N)
	10	Livestock3 (Without Measures)	[26]	×	(100-K)%	×	i	×	B × E × M' × (1-N)
	11	Livestock4 (Without Measures)	[27]	×	(100-L)%	×	j	×	B × F × M' × (1-N)
	12	Livestock5 (Without Measures)	[28]	×	(100-M)%	×	k	×	B × G × M' × (1-N)
	13	Livestock6 (Without Measures)	[29]	×	(100-N)%	×	l	×	B × H × M' × (1-N)
	8'	Livestock1 (Taking Measures)	[24]	×	I%	×	g'	×	B × C × M' × (1-N)
	9'	Livestock2 (Taking Measures)	[25]	×	J%	×	h'	×	B × D × M' × (1-N)
	10'	Livestock3 (Taking Measures)	[26]	×	K%	×	I'	×	B × E × M' × (1-N)
	11'	Livestock4 (Taking Measures)	[27]	×	L%	×	j'	×	B × F × M' × (1-N)
	12'	Livestock5 (Taking Measures)	[28]	×	M%	×	k'	×	B × G × M' × (1-N)
	13'	Livestock6 (Taking Measures)	[29]	×	N%	×	l'	×	B × H × M' × (1-N)
A4 Discharge from sewerage treatment plant	14	Domestic source (Conventional)	[8] × (100-[14])%			×	a	×	A × M' × (1-N)
	15	Industrial source (Conventional)	[19] × (100-[14])%			×	s × (100-u)%	×	A × M' × (1-N)
	14'	Domestic source (Advanced)	[8] × [14]%			×	a'	×	A × M' × (1-N)
	15'	Industrial source (Advanced)	[19] × [14]%			×	s × (100-u')%	×	A × M' × (1-N)
B1 Forest	16	Without Measures	[30]	×	(100-O)%	×	m	×	B × I × M' × (1-N)
	16'	Taking Measures	[30]	×	O%	×	m'	×	B × I × M' × (1-N)
B2 Paddy area	17	Without Measures	[31]	×	(100-P)%	×	n	×	B × J × M' × (1-N)
	17'	Taking Measures	[31]	×	P%	×	n'	×	B × J × M' × (1-N)
B3 Dry ares	18	Without Measures	[32]	×	(100-Q)%	×	o	×	B × K × M' × (1-N)
	18'	Taking Measures	[32]	×	Q%	×	o'	×	B × K × M' × (1-N)
B4 Urban area	19	Without Measures	[33]	×	(100-R)%	×	p	×	A × L × M' × (1-N)
	19'	Taking Measures	[33]	×	R%	×	p'	×	A × L × M' × (1-N)
Remarks									Excluding China: A=B=1

*Signs show the codes of **Table 3.2** to **Table 3.4**.

b) Calculation Formula for the Future Scenario Analysis

Future frames are calculated based on two input data files [Future Projection] and [Measures] with the following Formula 1. Administrative unit of the future frame projection in the [Future Projection] file is selectable either “Whole country”, “Province” or “Municipality”. If you select “whole country” or “province” in the future projection, future frames in municipal level will be calculated based on statistical data of the base year ([Statistical data] file) with the following Formula 2 to compute the land-based pollution loads.

Calculation formulas of the municipal future frames are different among four countries as shown in the following **Table 4.2** to **Table 4.5,** since the available statistical data in municipal level are different among the countries. Capital letter “C”, “P” or “M” in the following Tables mean the administrative unit of the data. ”C” means whole country, “P” is for province and “M” is for municipality.

Calculation of Future Frame in Year t

Formula1: Municipality level

Statistical data in the [Future Projection] file * Percentage set in [Measures] file

(Population in year t etc.) (Coverage ratio of sewerage system etc.)

Formula 2: Whole country or province level

Statistical data in the [Future Projection] * [Statistical Data_MuniFrame] / [Statistical Data_ProveFrame]

Data level: “C” or “P” in year t, “M” in the base year, , “C” or “P” in the base year

Table 4.2 Future Frames Calculation Formulas (China)

t_0 : Base year data	C: Whole of country data	: Statistical data file
t : (Base year + m) year data	P: Provincial data	: Future projection file
t_{goal} : Goal year data	M: Municipal data	: Measure file
m : $(t-t_0) / (t_{goal}-t_0)$		

Population (pop.)	Total	[1] t = [1]t_0 (M) × (A)t (C, P) ÷ [1']t_0 (C, P) or, = (A)t (M)
	Urban area	[2] t = [2]t_0 (M) ÷ [1]t_0 (M) × (B)t (C, P) × [1]t (M) or, = (B)t (M)
	Rural area	[3] t = [1]t − [2]t
Coverage Ratio of Sewerage treatment in urban area (%)	Sewerage System	[4] t = [4]t_0 (M) + m × ([4]t_{goal} (M) − [4]t_0 (M))
	Domestic Wastewater treatment tank	[5] t = [5]t_0 (M) + m × ([5]t_{goal} (M) − [5]t_0 (M))
Coverage ratio of Sewerage treatment in rural area (%)	Rural sewerage treatment system	[6]
	Domestic Wastewater treatment tank	[7] t = [7]t_0 (M) + m × ([7]t_{goal} (M) − [7]t_0 (M))
Sewered Population in urban area	Sewerage System	[8] t = [2]t × [4]t
	Domestic Wastewater treatment tank	[9] t = [2]t × [5]t
	Untreated	[10] t = [2]t − [8]t − [9]t
Sewered Population in rural area	Rural sewerage treatment system	[11]
	Domestic Wastewater treatment tank	[12] t = [3]t × [7]t
	Untreated	[13] t = [3]t − [12]t
Percentage of population served by Advanced wastewater treatment /Sewered polulation in urban area (%)	Sewerage System	[14] t = [14]t_0 (M) + m × ([14]t_{goal} (M) − [14]t_0 (M))
	Domestic Wastewater treatment tank	[15] t = [15]t_0 (M) + m × ([15]t_{goal} (M) − [15]t_0 (M))
Percentage of population served by Advanced wastewater treatment /Sewered polulation in rural area (%)	Rural sewerage treatment system	[16]
	Domestic Wastewater treatment tank	[17] t = [17]t_0 (M) + m × ([17]t_{goal} (M) − [17]t_0 (M))
Industrial discharges (m3/yr.)	Total	[18] t = [21]t (M) × (D)t (P) or, = (D)t (M)
	Connected to Sewerage System	[19] t = [18]t × [20]t
Percentage of industrial discharges connected to Sewerage system (%)		[20] t = [20]t_0 (M) + m × ([20]t_{goal} (M) − [20]t_0 (M))
Industrial production (ten thousand yuen)		[21] t = [21]t_{-1} (M) × (1 + (C)t (C,P)) or, = (C)t (M)
Industrial discharges per industrial production (m3/ten thousand Yuen)		[22] t = (D)t (M)
Industrial discharges meeting Discharge Standard (%)		[23] t = [23]t_0 (M) + m × ([23]t_{goal} (M) − [23]t_0 (M))

Table 4.3 Future Frames Calculation Formulas (Japan)

t_0 : Base year data t : (Base year + m) year data t_{goal} : Goal year data m : $(t-t_0)$ / $(t_{goal}-t_0)$		C: Whole of country data P: Provincial data M: Municipal data				(orange) : Statistical data file (green) : Future projection file (blue) : Measure file				
Population (pop.)	Total	[1] t	=	[1]t_0 M	×	(A)t C, P	÷	[1']t_0 C, P	or, =	(A)t M
	Urban area	[2] t	=	[2]t_0 M	÷	[1]t_0 M	×	[1]t M		
	Rural area	[3] t	=	[1]t	−	[2]t				
Coverage Ratio of Sewerage treatment in urban area (%)	Sewerage System	[4] t	=	[4]t_0 M	+	m	× (	[4]t_{goal} M	−	[4]t_0 M)
	Domestic Wastewater treatment tank	[5] t	=	[5]t_0 M	+	m	× (	[5]t_{goal} M	−	[5]t_0 M)
Coverage ratio of Sewerage treatment in rural area (%)	Rural sewerage treatment system	[6] t	=	[6]t_0 M	+	m	× (	[6]t_{goal} M	−	[6]t_0 M)
	Domestic Wastewater treatment tank	[7] t	=	[7]t_0 M	+	m	× (	[7]t_{goal} M	−	[7]t_0 M)
Sewered Population in urban area	Sewerage System	[8] t	=	[2]t	×	[4]t				
	Domestic Wastewater treatment tank	[9] t	=	[2]t	×	[5]t				
	Untreated	[10] t	=	[2]t	−	[8]t	−	[9]t		
Sewered Population in rural area	Rural sewerage treatment system	[11] t	=	[3]t	×	[6]t				
	Domestic Wastewater treatment tank	[12] t	=	[3]t	×	[7]t				
	Untreated	[13] t	=	[3]t	−	[11]t	−	[12]t		
Percentage of population served by Advanced wastewater treatment /Sewered polulation in urban area (%)	Sewerage System	[14] t	=	[14]t_0 M	+	m	× (	[14]t_{goal} M	−	[14]t_0 M)
	Domestic Wastewater treatment tank	[15] t	=	[15]t_0 M	+	m	× (	[15]t_{goal} M	−	[15]t_0 M)
Percentage of population served by Advanced wastewater treatment /Sewered polulation in rural area (%)	Rural sewerage treatment system	[16] t	=	[16]t_0 M	+	m	× (	[16]t_{goal} M	−	[16]t0 M)
	Domestic Wastewater treatment tank	[17] t	=	[17]t_0 M	+	m	× (	[17]t_{goal} M	−	[17]t_0 M)
Industrial discharges (m3/yr.)	Total	[18] t	=	[18]t_0 M						
	Connected to Sewerage System	[19] t	=	[18]t	×	[20]t				
Percentage of industrial discharges connected to Sewerage system (%)		[20] t	=	[20]t_0 M	+	m	× (	[20]t_{goal} M	−	[20]t_0 M)
Industrial production		[21]								
Industrial discharges per industrial production		[22]								
Industrial discharges meeting Discharge Standard (%)		[23] t	=	[23]t_0 M	+	m	× (	[23]t_{goal} M	−	[23]t_0 M)

Table 4.4 Future Frames Calculation Formulas (Korea)

t_0 : Base year data t : (Base year + m) year data t_{goal} : Goal year data m : $(t - t_0) / (t_{goal} - t_0)$	C: Whole of country data P: Provincial data M: Municipal data	(orange) : Statistical data file (green) : Future projection file (blue) : Measure file	

Population (pop.)	Total	[1] t = [1]t_0 (M) × (A)t (C, P) ÷ [1']t_0 (C, P) or, = (A)t (M)
	Urban area	[2] t = [2]t_0 (M) ÷ [1]t_0 (M) × [1]t (M)
	Rural area	[3] t = [1]t − [2]t
Coverage Ratio of Sewerage treatment in urban area (%)	Sewerage System	[4] t = [4]t_0 (M) + m × ([4]t_{goal} (M) − [4]t_0 (M))
	Domestic Wastewater treatment tank	[5] t = [5]t_0 (M) + m × ([5]t_{goal} (M) − [5]t_0 (M))
Coverage ratio of Sewerage treatment in rural area (%)	Rural sewerage treatment system	[6]
	Domestic Wastewater treatment tank	[7] t = [7]t_0 (M) + m × ([7]t_{goal} (M) − [7]t_0 (M))
Sewered Population in urban area	Sewerage System	[8] t = [2]t × [4]t
	Domestic Wastewater treatment tank	[9] t = [2]t × [5]t
	Untreated	[10] t = [2]t − [8]t − [9]t
Sewered Population in rural area	Rural sewerage treatment system	[11]
	Domestic Wastewater treatment tank	[12] t = [3]t × [7]t
	Untreated	[13] t = [3]t − [12]t
Percentage of population served by Advanced wastewater treatment /Sewered polulation in urban area (%)	Sewerage System	[14] t = [14]t_0 (M) + m × ([14]t_{goal} (M) − [14]t_0 (M))
	Domestic Wastewater treatment tank	[15] t = [15]t_0 (M) + m × ([15]t_{goal} (M) − [15]t_0 (M))
Percentage of population served by Advanced wastewater treatment /Sewered polulation in rural area(%)	Rural sewerage treatment system	[16]
	Domestic Wastewater treatment tank	[17] t = [17]t_0 (M) + m × ([17]t_{goal} (M) − [17]t_0 (M))
Industrial discharges (m3/yr.)	Total	[18] t = [21]t (M) × (D)t (P) or, = (D)t (M)
	Connected to Sewerage System	[19] t = [18]t × [20]t
Percentage of industrial discharges connected to Sewerage system (%)		[20] t = [20]t_0 (M) + m × ([20]t_{goal} (M) − [20]t_0 (M))
Industrial production (million won)		[21] t = [21]t_{-1} (M) × (1 + (C)t (C,P)) or, = (C)t (M)
Industrial discharges per industrial production (m3/million won)		[22] t = (D)t (M)
Industrial discharges meeting Discharge Standard (%)		[23] t = [23]t_0 (M) + m × ([23]t_{goal} (M) − [23]t_0 (M))

Table 4.5 Future Frames Calculation Formulas (Russia)

t_0 : Base year data
t : (Base year + m) year data
t_{goal} : Goal year data
m : $(t-t_0) / (t_{goal}-t_0)$

C: Whole of country data
P: Provincial data
M: Municipal data

(orange) : Statistical data file
(green) : Future projection file
(blue) : Measure file

Population (pop.)	Total	[1] t = [1]t_0 M × (A)t C, P ÷ [1']t_0 C, P or, = (A)t M
	Urban area	[2] t = [2]t_0 M ÷ [1]t_0 M × [1]t M
	Rural area	[3] t = [1]t − [2]t
Coverage Ratio of Sewerage treatment in urban area (%)	Sewerage System	[4] t = [4]t_0 M + m × ([4]t_{goal} M − [4]t_0 M)
	Domestic Wastewater treatment tank	[5] t = [5]t_0 M + m × ([5]t_{goal} M − [5]t_0 M)
Coverage ratio of Sewerage treatment in rural area (%)	Rural sewerage treatment system	[6]
	Domestic Wastewater treatment tank	[7] t = [7]t_0 M + m × ([7]t_{goal} M − [7]t_0 M)
Sewered Population in urban area	Sewerage System	[8] t = [2]t × [4]t
	Domestic Wastewater treatment tank	[9] t = [2]t × [5]t
	Untreated	[10] t = [2]t − [8]t − [9]t
Sewered Population in rural area	Rural sewerage treatment system	[11]
	Domestic Wastewater treatment tank	[12] t = [3]t × [7]t
	Untreated	[13] t = [3]t − [12]t
Percentage of population served by Advanced wastewater treatment /Sewered polulation in urban area (%)	Sewerage System	[14] t = [14]t_0 M + m × ([14]t_{goal} M − [14]t_0 M)
	Domestic Wastewater treatment tank	[15] t = [15]t_0 M + m × ([15]t_{goal} M − [15]t_0 M)
Percentage of population served by Advanced wastewater treatment /Sewered polulation in rural area (%)	Rural sewerage treatment system	[16]
	Domestic Wastewater treatment tank	[17] t = [17]t_0 M + m × ([17]t_{goal} M − [17]t_0 M)
Industrial discharges (m3/yr.)	Total	[18] t = [18]t_0 M
	Connected to Sewerage System	[19] t = [18]t × [20]t
Percentage of industrial discharges connected to Sewerage system (%)		[20] t = [20]t_0 M + m × ([20]t_{goal} M − [20]t_0 M)
Industrial production		[21]
Industrial discharges per industrial production		[22]
Industrial discharges meeting Discharge Standard (%)		[23] t = [23]t_0 M + m × ([23]t_{goal} M − [23]t_0 M)

5. **Operation method for using Land-based Pollution Load Calculation Program**

The program file named (VBA) Calculation model.xls is used to estimate the amount of land-based pollution loads discharged into the North East Pacific. The system of the program is the Microsoft Office Excel. The program file consists of two data sheets as shown in **Table 5.1**.

Table 5.1 Composition of the Calculation Program File

File Name	Sheet Name	Operation tems
(VBA)Calculation model Ver XXX.xls Note: XXX shows the version.	Analysis Condition	✓ Enter information of new scenario ✓ Conduct calculation for the base year ✓ Conduct future scenario analysis ✓ View the results table ✓ Graphing the calculation results ✓ Operation of Scenario setting
	Setting of Name	✓ Naming the new calculation range (Only need to use if you delete or add the new municipal in the base data files at step1 to 5)

The followings are the user guide of this program.

a) Architecture of the data sheet for the Analysis Condition

I. Field of Scenario Setting and Execution of Analysis

Files and analytic period data for the analysis are shown in the green colored frame (Left side).

II. Field of Registry of the Scenarios

Operation of entry, deletion and registry of the registered scenarios will be executed in the purple colored frame (Right side) part in the right.

III. Field of Graph generation from the Analysis

Operation of making graph is presented in the orange colored part (Right side) .

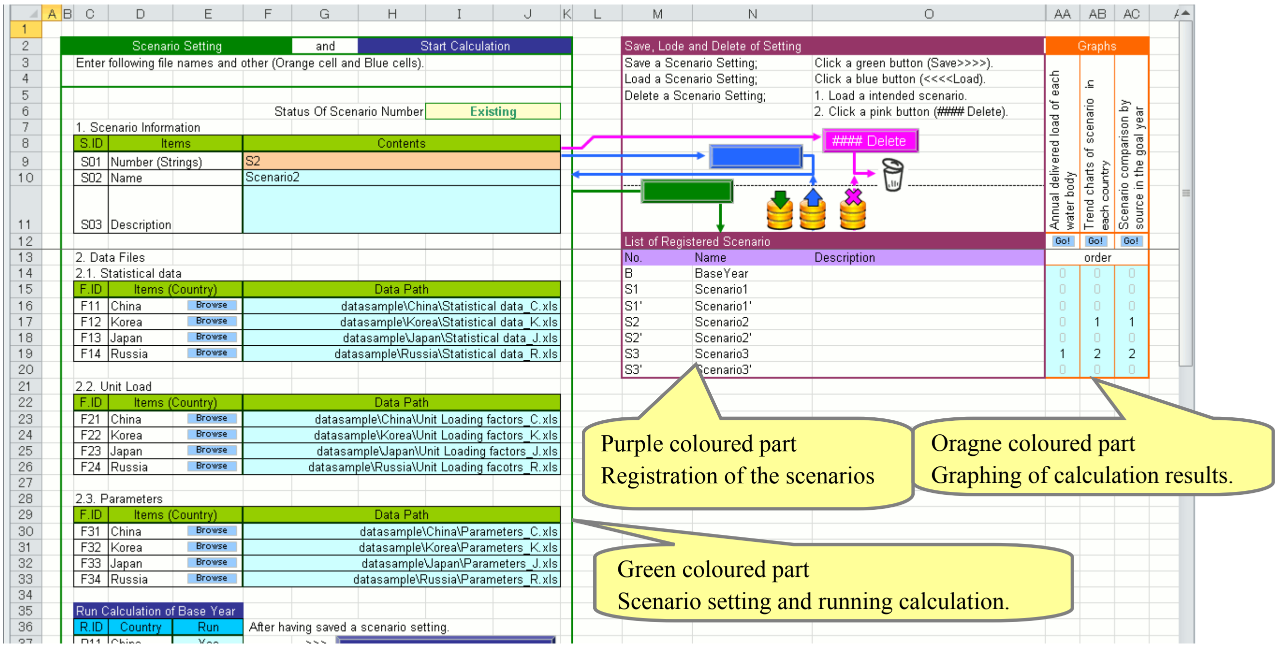


Figure 5.1 Architecture of [Analysis Condition] data sheet

b) New Entry of Scenairo Information

1) Enter the Number, Name and the explanation of the calculation in S01~S03 (refer to **Figure 5.2-I**).
2) Click green [Save>>>>] bottom to save the data (refer to **Figure 5.2-II**).
3) Check the title of "Status of Scenario Number" changes to [Exiting] from [New] (refer to **Figure 5.2-III**).

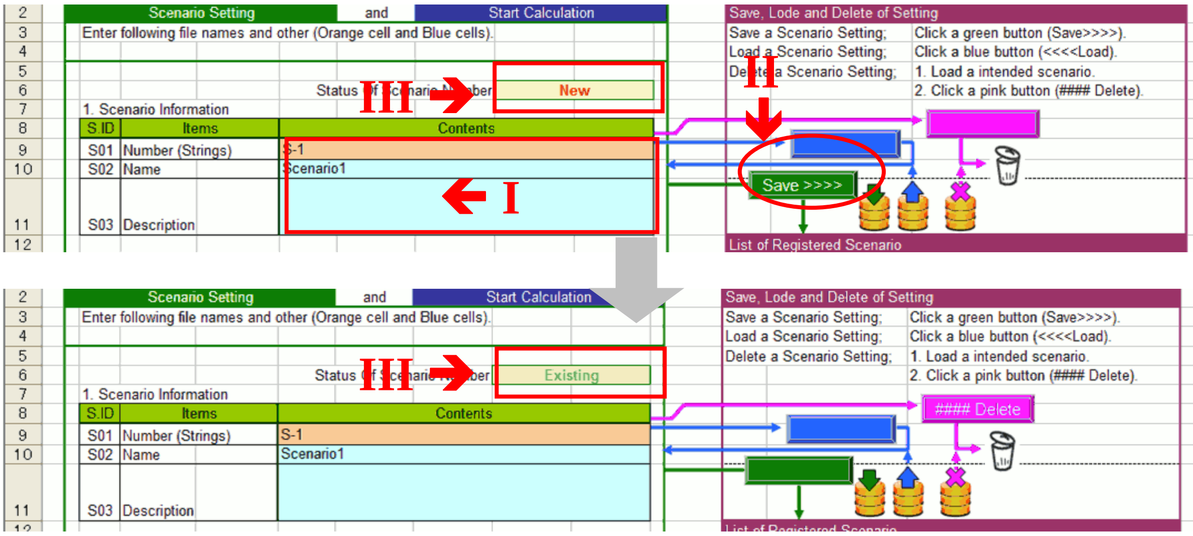


Figure 5.2 Process screen of the Calculation Program file (1)

c) Conduct the Calculation in the Base Year

1) Specify the input data files; 2.1Statistical data (F11~F14), 2.2Unit Load (F21~F24) and 2.3Parameters (F31~F34) with [Browse] button (refer to **Figure 5.3-I**).

2) Select the country you want to calculate with [Yes/No] button in the list box (R11~R14) (refer to **Figure 5.3-II**).

3) Click blue [Calculation of Base Year] button to start the calculation in the base year. Then five results files; named "Name of calculation_country_0Summary, _1COD, _2TN, _3TP and _9Frame" are automatically created in the new folder "Number of calculation_Name of calculation" which is also created automatically (refer to **Figure 5.4**). The details of the contents of the results files will be described later in e) View the Results Table.

This calculation process 1) to 3) is recommended to repeat by changing the values in the [Parameter] file to raise the precision of the calculation results.

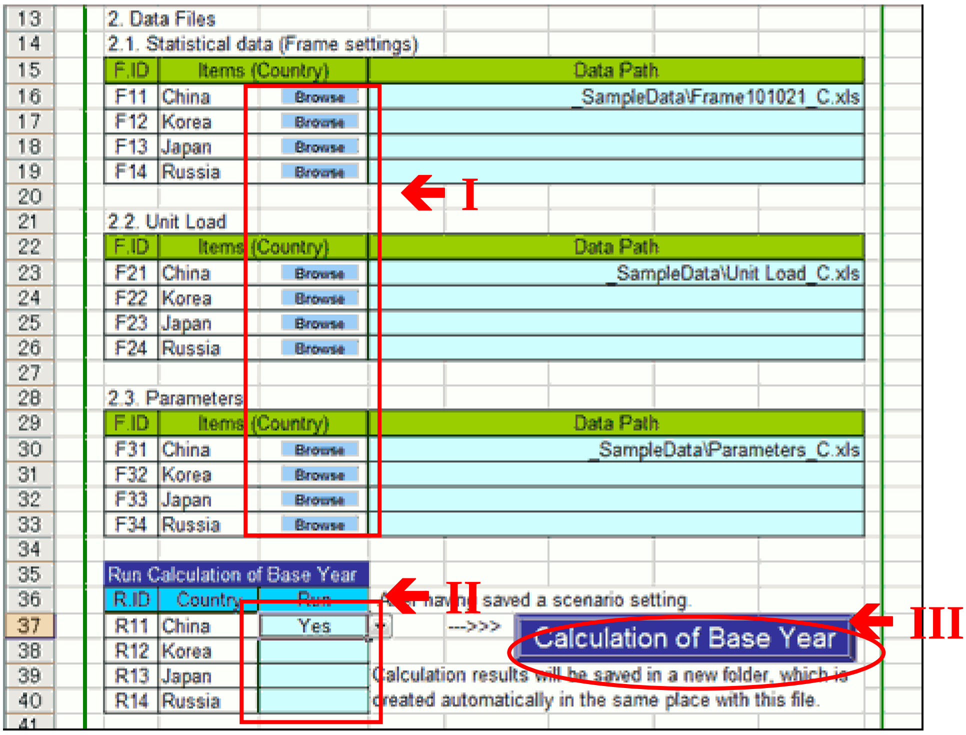


Figure 5.3 Process Screen of the Calculation Program file (2)

Figure 5.4 List of Result Files of the Calculation in the Base Year (sample)

d) Conduct Future Scenario Analysis

1) Specify the input data files; 2.4Future Projection (F41~F44) and 2.5Measures (F51~F54) with [Browse] button (refer to **Figure 5.5-I**).
2) Select the country to analyze with [Yes/No] button in the list box (R21~R24).
3) Enter start and target year of the future analysis (R25, R26).
   Start year: Same as "Base year" of the files [Statistical data], [Future Projection] and [Measures].
   End year: Same as "End of calculation" of the [Future Projection] file and "Goal year" of the [Measures] file.
4) Select the output interval with [5/1] button in the list box (R27).
   When selecting with [1] button, select "Intervals of future projection data" with [1] button and enter the data of all years in all sheets of the [Future Projection] file. After that click green [Save>>>>] bottom to save the data (refer to **Figure 5.2**).
5) Click blue [Scenario Analysis] button to start the scenario analysis to estimate the land-based pollution loads discharged in the future.

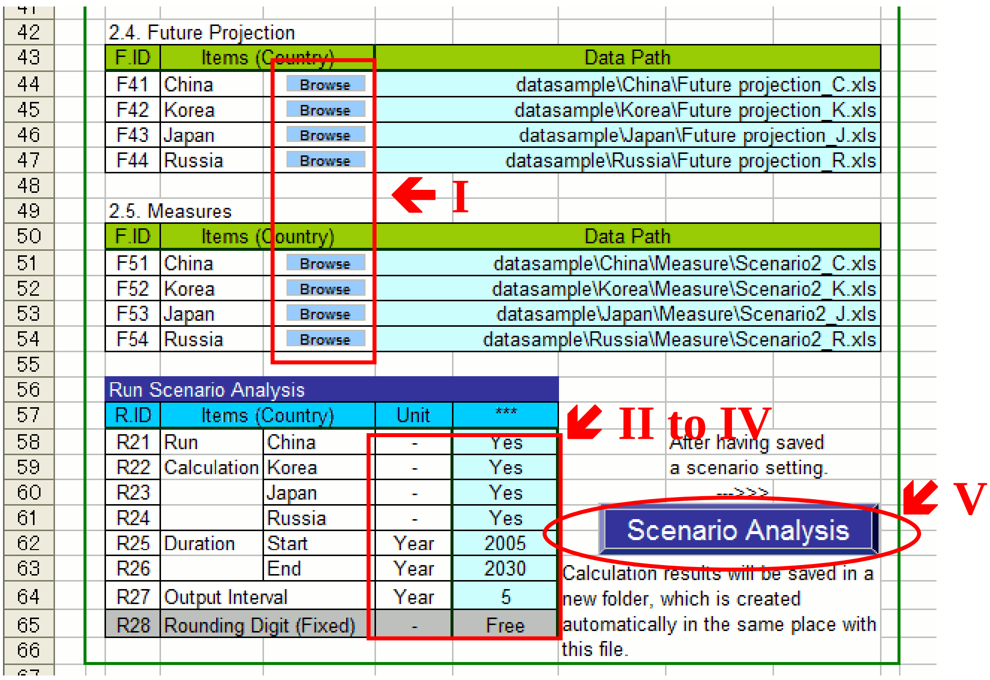


Figure 5.5 Process Screen of the Calculation Program file (3)

e) View the Results Table

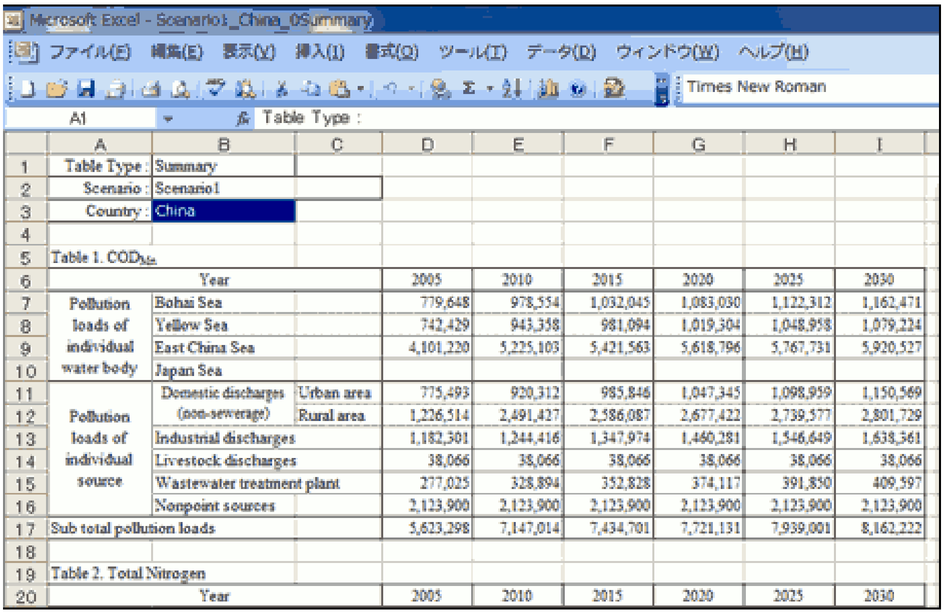
Five files of the result; named “Name of calculation_country_0Summary, _1COD, _2TN, _3TP and _9Frame” will be automatically created in the new folder “Number of calculation_Name of calculation” which is also created automatically after completion of the calculation (refer to **Figure 5.6**).

Figure 5.6　Inside the result folder created in the Calculation Program

Followings show a part of the contents of results tables (a case in China)

(1)File1: Name of calculation_country_0Summary

Estimated pollution loads discharged into Bohai Sea, Yellow Sea, East China Sea and Japan Sea are summarized as shown in following **Figure 5.7**.

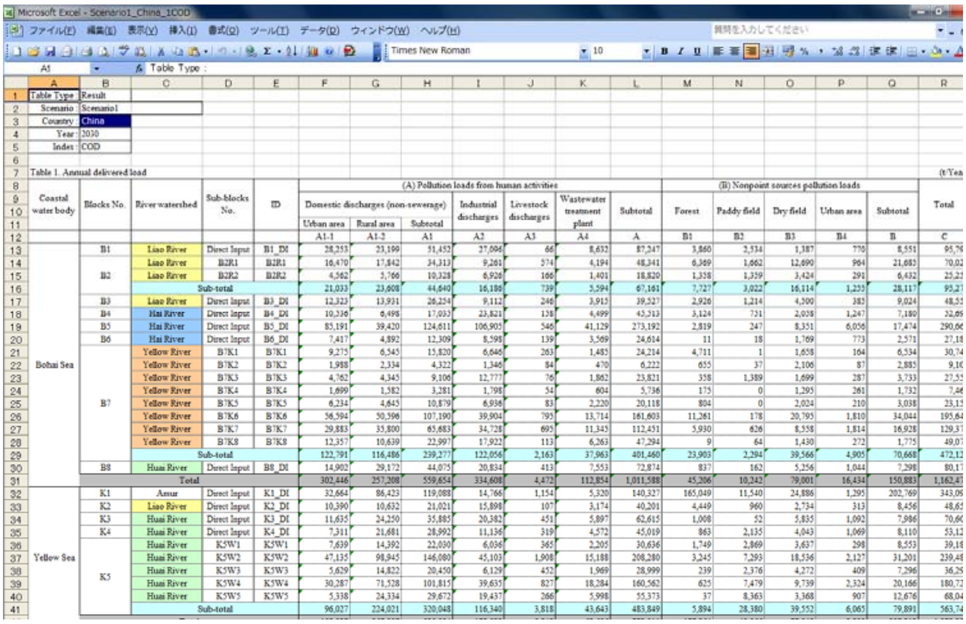


	A	B	C	D	E	F	G	H	I
1	Table Type :	Summary							
2	Scenario :	Scenario1							
3	Country :	China							
4									
5	Table 1. COD_{Mn}								
6	Year			2005	2010	2015	2020	2025	2030
7	Pollution loads of individual water body	Bohai Sea		779,648	978,554	1,032,045	1,083,030	1,122,312	1,162,471
8		Yellow Sea		742,429	943,358	981,094	1,019,304	1,048,958	1,079,224
9		East China Sea		4,101,220	5,225,103	5,421,563	5,618,796	5,767,731	5,920,527
10		Japan Sea							
11	Pollution loads of individual source	Domestic discharges (non-sewerage)	Urban area	775,493	920,312	985,846	1,047,345	1,098,959	1,150,569
12			Rural area	1,226,514	2,491,427	2,586,087	2,677,422	2,739,577	2,801,729
13		Industrial discharges		1,182,301	1,244,416	1,347,974	1,460,281	1,546,649	1,638,361
14		Livestock discharges		38,066	38,066	38,066	38,066	38,066	38,066
15		Wastewater treatment plant		277,025	328,894	352,828	374,117	391,850	409,597
16		Nonpoint sources		2,123,900	2,123,900	2,123,900	2,123,900	2,123,900	2,123,900
17	Sub total pollution loads			5,623,298	7,147,014	7,434,701	7,721,131	7,939,001	8,162,222
18									
19	Table 2. Total Nitrogen								
20	Year			2005	2010	2015	2020	2025	2030

Figure 5.7　Screen of a result file named “Name of calculation_country_0Summary”

(2) File2: Name of calculation_ country_02COD

Estimated COD_{Mn} loads depend on different pollution sources are summarized in sub-block level as shown in following **Figure 5.8**.



Coastal water body	Blocks No.	River watershed	Sub-blocks No.	ID	(A) Pollution loads from human activities: Domestic discharges (non-sewerage) Urban area A1-1	Rural area A1-2	Subtotal A1	Industrial discharges A2	Livestock discharges A3	Wastewater treatment plant A4	Subtotal A	(B) Nonpoint sources pollution loads: Forest B1	Paddy field B2	Dry field B3	Urban area B4	Subtotal B	Total C
Bohai Sea	B1	Liao River	Direct Input	B1_DI	28,253	23,199	51,452	27,096	66	8,632	87,247	3,860	2,534	1,387	770	8,551	95,7[illegible]
	B2	Liao River	B2R1	B2R1	16,470	17,842	34,313	9,261	574	4,194	48,341	6,369	1,662	12,690	964	21,683	70,02
		Liao River	B2R2	B2R2	4,562	5,766	10,328	6,926	166	1,401	18,820	1,358	1,359	3,424	291	6,432	25,2[illegible]
		Sub-total			21,033	23,608	44,640	16,186	739	5,594	67,161	7,727	3,022	16,114	1,255	28,117	95,2[illegible]
	B3	Liao River	Direct Input	B3_DI	12,323	13,931	26,254	9,112	246	3,915	39,527	2,926	1,214	4,500	385	9,024	48,5[illegible]
	B4	Hai River	Direct Input	B4_DI	10,336	6,498	17,033	23,821	138	4,499	45,513	3,124	721	2,038	1,247	7,180	32,6[illegible]
	B5	Hai River	Direct Input	B5_DI	85,191	39,420	124,611	106,905	546	41,129	273,192	2,819	247	8,351	6,056	17,474	290,6[illegible]
	B6	Hai River	Direct Input	B6_DI	7,417	4,892	12,309	8,598	139	3,569	24,614	11	18	1,769	773	2,571	27,18
	B7	Yellow River	B7K1	B7K1	9,275	6,545	15,820	6,646	263	1,485	24,214	4,711	1	1,658	164	6,534	30,74
		Yellow River	B7K2	B7K2	1,988	2,334	4,322	1,346	84	470	6,222	655	37	2,106	87	2,885	9,10
		Yellow River	B7K3	B7K3	4,762	4,345	9,106	12,777	76	1,862	23,821	358	1,389	1,699	287	3,733	27,5[illegible]
		Yellow River	B7K4	B7K4	1,699	1,582	3,281	1,798	54	604	5,736	175	0	1,295	261	1,732	7,46
		Yellow River	B7K5	B7K5	6,234	4,645	10,879	6,936	83	2,220	20,118	804	0	2,024	210	3,038	23,1[illegible]
		Yellow River	B7K6	B7K6	56,594	50,596	107,190	39,904	795	13,714	161,603	11,261	178	20,795	1,810	34,044	195,64
		Yellow River	B7K7	B7K7	29,883	35,800	65,683	34,728	695	11,345	112,451	5,930	626	8,558	1,814	16,928	129,37
		Yellow River	B7K8	B7K8	12,357	10,639	22,997	17,922	113	6,263	47,294	9	64	1,430	272	1,775	49,07
		Sub-total			122,791	116,486	239,277	122,056	2,163	37,963	401,460	23,903	2,294	39,566	4,905	70,668	472,12
	B8	Huai River	Direct Input	B8_DI	14,902	29,172	44,075	20,834	413	7,553	72,874	837	162	5,256	1,044	7,298	80,17
	Total				302,446	257,208	559,654	334,608	4,472	112,854	1,011,588	45,206	10,242	79,001	16,434	150,883	1,162,47
Yellow Sea	K1	Amur	Direct Input	K1_DI	32,664	86,423	119,088	14,766	1,154	5,320	140,327	165,049	11,540	24,886	1,295	202,769	343,09
	K2	Liao River	Direct Input	K2_DI	10,390	10,632	21,021	15,898	107	3,174	40,201	4,449	960	2,734	313	8,456	48,65
	K3	Huai River	Direct Input	K3_DI	11,635	24,250	35,885	20,382	451	5,897	62,615	1,008	52	5,835	1,092	7,986	70,60
	K4	Huai River	Direct Input	K4_DI	7,311	21,681	28,992	11,136	319	4,572	45,019	863	2,135	4,043	1,069	8,110	53,12
	K5	Huai River	K5W1	K5W1	7,639	14,392	22,030	6,036	365	2,205	30,636	1,749	2,869	3,637	298	8,553	39,18
		Huai River	K5W2	K5W2	47,135	98,945	146,080	45,103	1,908	15,188	208,280	3,245	7,293	18,536	2,127	31,201	239,48
		Huai River	K5W3	K5W3	5,629	14,822	20,450	6,129	452	1,969	28,999	239	2,376	4,272	409	7,296	36,29
		Huai River	K5W4	K5W4	30,287	71,528	101,815	39,635	827	18,284	160,562	625	7,479	9,739	2,324	20,166	180,72
		Huai River	K5W5	K5W5	5,338	24,334	29,672	19,437	266	5,998	55,373	37	8,363	3,368	907	12,676	68,04
		Sub-total			96,027	224,021	320,048	116,340	3,818	43,643	483,849	5,894	28,380	39,552	6,065	79,891	563,74

Figure 5.8　Screen of a result file named “Name of calculation_ country_0Summary”

f) Graphing the Results

This program generates following three graphs automatically (refer to **Figure5.9**).

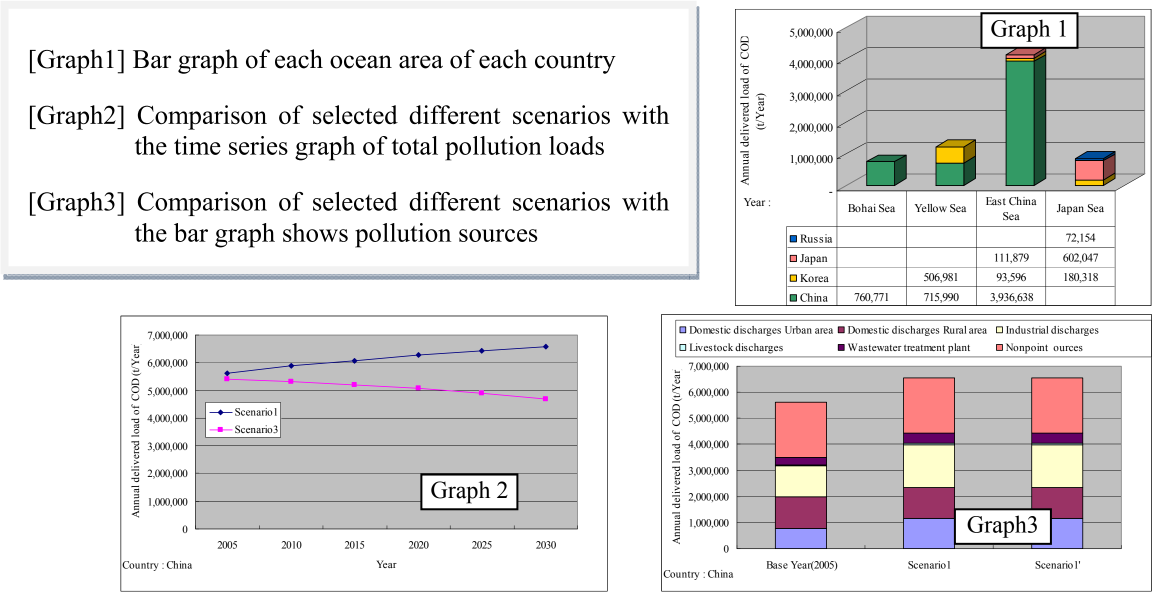


Figure 5.9 Graphing of Calculation Results (sample)

The procedures to create graphs are shown below:

- Graph1
  1) Select a scenario for drawing a graph with [1] button in the list box [0/1] (refer to **Figure 5.10-I**). Do not select more than one scenario in this step since function of Graph 1 is limited for one calculation.
  2) Press [Go] button in the left shown in the **Figure 5.10-II** to draw graph1.

- Graph2
  1) Select several scenarios to compare the results in the graph 2 by entering an integer number 1, 2.... in blue colored cells shown in the **Figure 5.10-III**. The selected scenarios must have the same calculation start/target year and intervals (1 or 5) to create a time series graph.
  2) Press [Go] button in the middle shown in the **Figure 5.10-II** to draw graph2.

- Graph3
  1) Select several scenarios to compare the results in the graph 3 by entering an integer number 1, 2.... in blue colored cells shown in the **Figure 5.10-IV**.
  2) Press [Go] button in the right shown in the **Figure 5.10-II** to draw graph3.

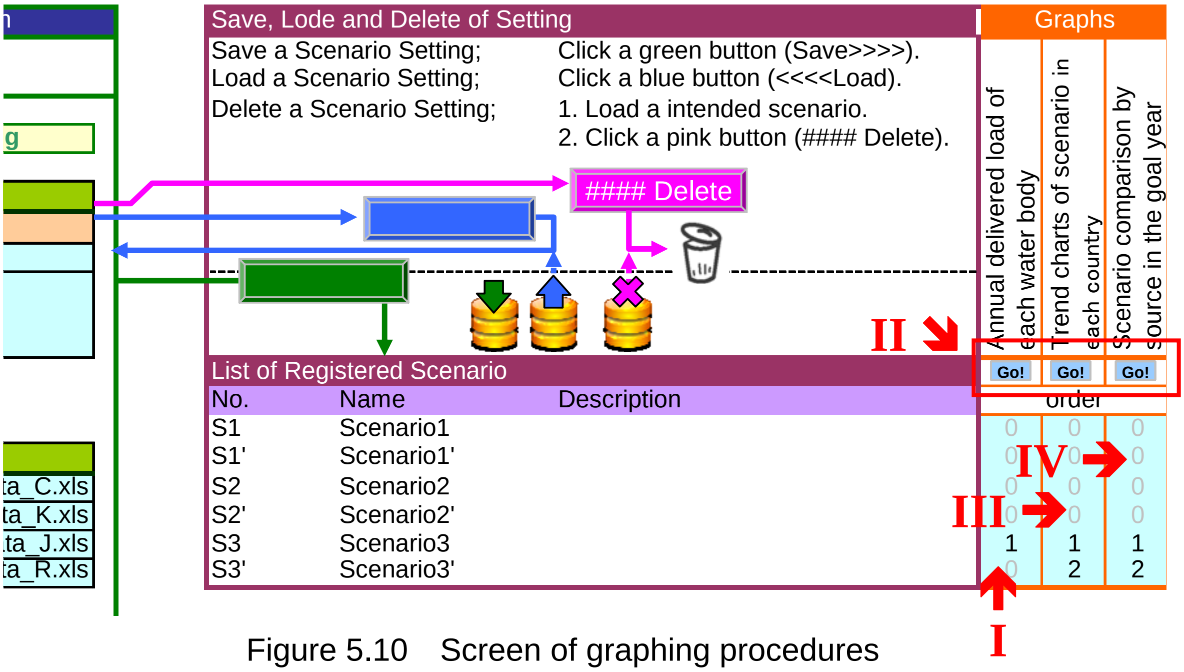


Figure 5.10 Screen of graphing procedures

Created graphs will be saved in the Graph folder.

g) Operation of Scenario Setting

The scenario setting will be executed in connection with the part of scenario information of “Scenario setting and start calculation” part. Once a scenario is registered, the registered scenario will be displayed in the “List of Registered Scenario” as shown below:

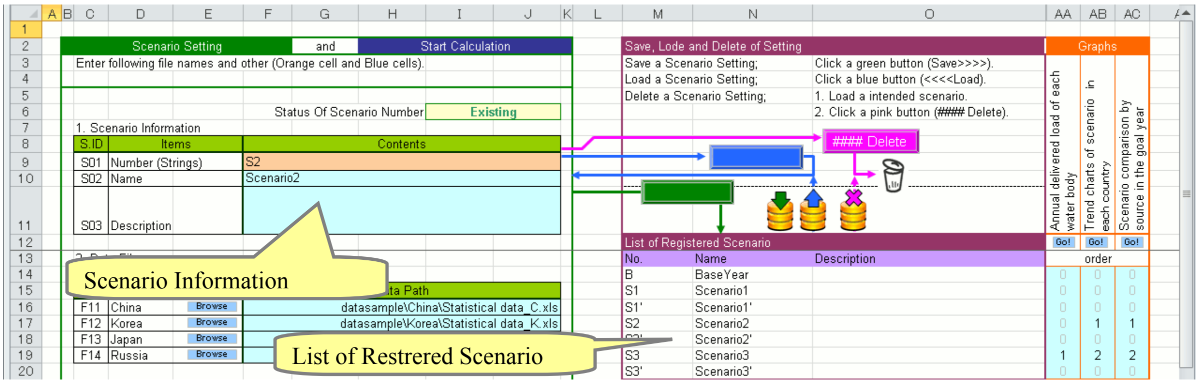


Figure 5.11 Operation screen of scenaio setting

(1) Registration of Scenario

Registration of a scenario will be conducted to save the scenario condition which was set in the “Scenario Setting and Start Calculation” part. When the condition status is ready for registration, the green colored [Save>>>>] button becomes effective. Once the scenario is registered by [Save>>>>] button, No., name and description of the scenario will be added in the List of Registered Scenario.

Registration Category	Display of [Status of Scenario Number] in the top of “Scenario Setting and Start Calculation” part	Effective button in the “Registration of Scenario” part
Registration of new scenario	New	Save
Overwrite of existing scenario	Existing(Modified)	Save, Load

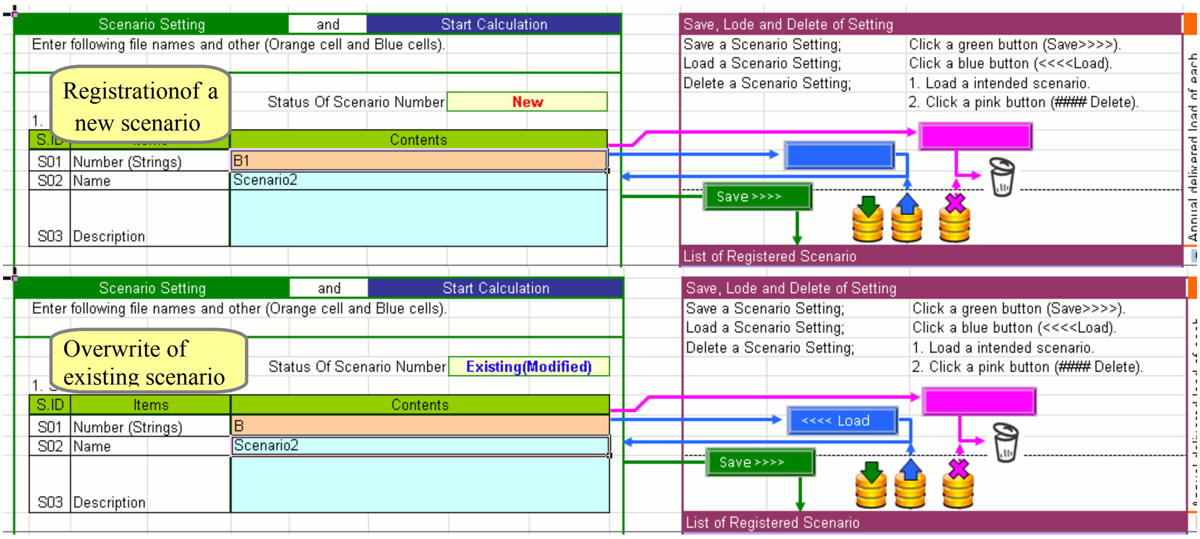


Figure 5.12 Status of scenario number and effective button in each registration category

(2) Reload of Existing Scenario

1) Enter the scenario number in the orange colored cell in 1. Scenario Information in "Scenario Setting and Star Calculation" part to reload existing scenario.

2) Press [<<<<Load] button.

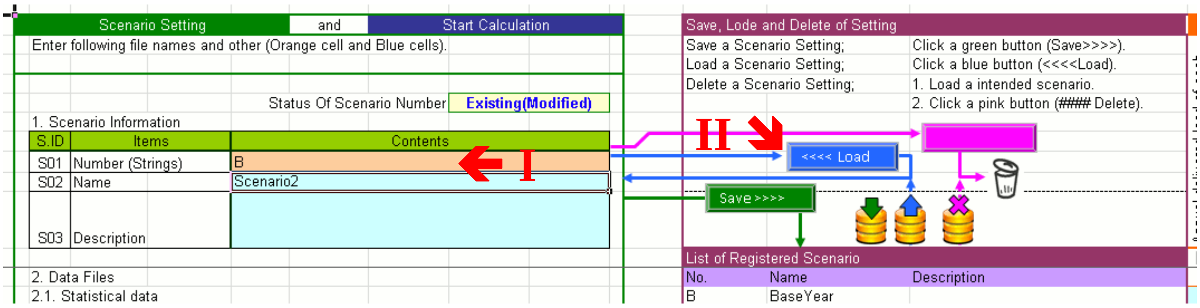


Figure 5.13 Operaion Screen of Reload of exisnting scenario

(3) Delete of Registered Scenario

1) Reload the scenario to be delete.

2) Press [#### Delete] button.

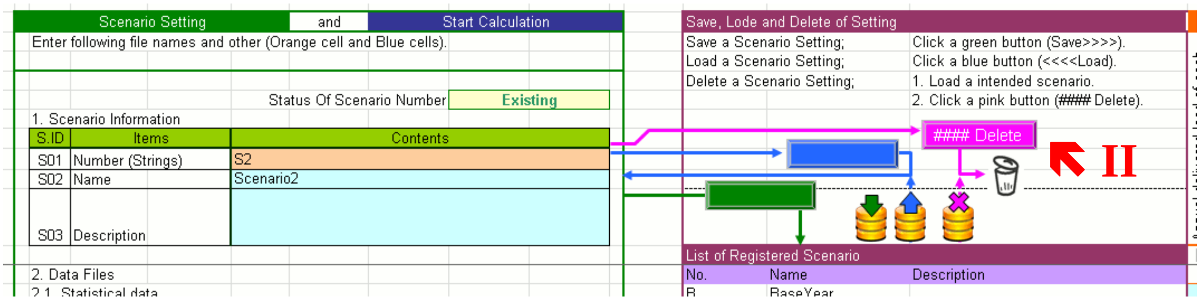


Figure 5.14 Operation Screen of Deletion of the Scenario

The scenario will be deleted from the List of Registered Scenario.

h) Naming Calculation Range

In this program, serial numbers (names) are set to the target (the North East Pacific regions) province and municipality of the four countries based on the status of 2005. The calculation range in the program is set by this naming system. Renaming will be required when the number of target municipalities is changed as shown below:

1) Display [SettingOfNames] sheet of the program file.
2) Enter the new number of target municipalities in green colored cells shown in **Figure 5.15-I**.
3) Select the country (China/Korea/Japan/Russia) for change in the list box shown in **Figure 5.15-II**.
4) Press [Setting of "Name" on the Data Sheet] button shown in the **Figure 5.15-III**. Then a dialog box comes up asking "You are going to set the data sheet of [selected country]. Are you all right?". Then press [Yes] and select the input data files; Statistical data, Future Projection, Parameter, Unit Loading factors and Measure to rename the calculation range of them.

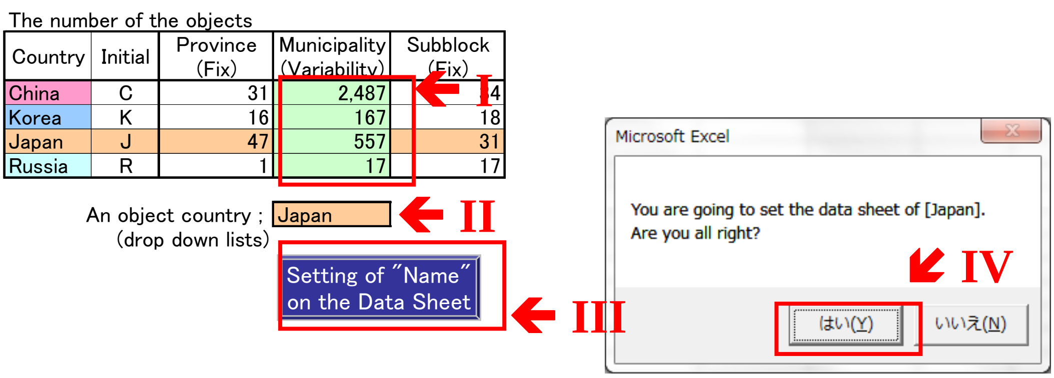


Figure 5.15 Screen of Renamimg Calculation Range to change the number of municipalities

6. **Sample Data Files**

In this program, the sample data files (the files [Statistical data], [Unit Loading Factors], [Parameters], [Future Projection] and [Measures] of each country) to estimate the land-based pollution load discharging into the Northwest Pacific from Japan, Korea, China, and Russia are provided as adjunct data in the [data sample] folder. The base year, the goal year and the interval year of these data are shown below:

- Base year: 2005
- Goal year: 2030
- Interval year: 5

Scenario1, Scenario1', Scenario2, Scenario2', Scenario3 and Scenario3' are provided for future scenario analysis. The contents of each scenario in 2030 are shown below:

Country	Area	Items	Scenario1	Scenario1'	Scenario2	Scenario2'	Scenario3	Scenario3'
China	Urban areas	coverage ratios of domestic wastewater treatments	63%	63%	100%	100%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	100%	0%	100%	0%	100%
	Rural areas	coverage ratios of domestic wastewater treatments	0%	0%	0%	0%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	0%	0%	0%	0%	100%
Japan	Urban areas	coverage ratios of domestic wastewater treatments	81%	81%	100%	100%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	100%	0%	100%	0%	100%
	Rural areas	coverage ratios of domestic wastewater treatments	61%	61%	61%	61%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	0%	0%	0%	0%	100%
Korea	Urban areas	coverage ratios of domestic wastewater treatments	95%	95%	100%	100%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	100%	0%	100%	0%	100%
	Rural areas	coverage ratios of domestic wastewater treatments	0%	0%	0%	0%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	0%	0%	0%	0%	100%
Russia	Urban areas	coverage ratios of domestic wastewater treatments	15%	15%	100%	100%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	100%	0%	100%	0%	100%
	Rural areas	coverage ratios of domestic wastewater treatments	15%	15%	15%	15%	100%	100%
		percentages of population served by advanced wastewater treatments	0%	0%	0%	0%	0%	100%

Percentages of population served by advanced wastewater treatments: The rate of the population served by advanced wastewater treatments to the population served by sewerage system and domestic wasterwater treatment tank

Subject to percentages of population served by advanced wastewater treatments in urban areas: The population served by sewerage system

Appendix 1　Reference materials about pollution load calculation program

(1) Statistical data items need to be entered in the input data files of the program

■ Step1　[Statistical data] file

Table 1　Data items in the [MuniFrame] sheet (municipal data)

Categories	Items	China	Korea	Japan	Russia
Population	Total population	●	●		●
	Urban population	●	●		●
Coverage ratio of conventional treatment system	Sewerage system in urban area	●			●
	Domestic wastewater treatment tank in urban area	●			●
	Rural sewerage treatment system in rural area				
	Domestic wastewater treatment tank in rural area	●			●
Sewered poplation	Sewerage system in urban area		●	●	
	Domestic wastewater treatment tank in urban area		●	●	
	Untreated in urban area			●	
	Rural sewerage treatment system in rural area			●	
	Domestic wastewater treatment tank in rural area		●	●	
	Untreated in rural area			●	
Coverage ratio of advanced treatment system	Sewerage system in urban area	●	●	●	●
	Domestic wastewater treatment tank in urban area	●	●	●	●
	Rural sewerage treatment system in rural area			●	
	Domestic wastewater treatment tank in rural area	●	●	●	●
Industrial discharges	Industrial discharges		●		●
	Industrial production	●	●	●	
	Industrial discharges per industrial production	●			
	Percentage of industrial discharges connected to sewerage system	●	●	●	●
	Industrial discharges meeting discharge standard, which is directory discharged in environmental waters	●	●		
Number of livestock	Large domestic animal	●			●
	Daily cattle		●		
	Cattle		●	●	●
	Horse		●		
	Swine	●	●	●	●
	Sheep, Deer	●	●		●
	Poultry		●		

Sources:

China Population Data: Website of National Bureau of Statistics of China

Korea Sewage Treatment Data: Statistical sewerage data provided by Ministry of Environment in Korea

Japna Sewage Treatment Data: Public Enterprise yearbook published by Ministry of Internal Affairs and Communications of Japan, sewerage statistics published by Japan sewerage works association, Year book of Public Utility published by Ministry of Internal Affairs and Communications, Data of Ministry of Environment

Russia Population Data: Statistical database system provided by Russian Federation, Year book of Primorskii Krai

China Industrial Discharges: Website of National Bureau of Statistics of China

Korea Industrial Discharges: Mining and manufacture survey published by Statistical Information Service of Korea, Generation and treatment of industrial wastewater issued by Ministry of Environment

Japan Industrial Discharges: Production survey (2005) published by Ministry of Economy, Trade and Industry of Japan

Russia Industrial Dischargese: Statistical database system provided by Russian Federation

China Livestock Data: Agricultural Yearbook in China

Korea Livestock Data: Statistical Report on treatment of livestock effluents published by Ministry of Environment in Korea

Japan Livestock Data: Preliminary Statistical Report on Agriculture, Forestry and Fisheries published by Ministry of Agriculture, Forestry and Fisheries of Japan

Russia Livestock Data: Statistical database system provide by Russian Federation

Table 2 Data items in the [ProveFrame] sheet (provincial data)

Categories	Items	China	Korea	Japan	Russia
Population	Total population	●		●	●
	Urban population	●			
Industrial discharges	Industrial discharges	●		●	●
	Industrial production	●		●	
	Industrial discharges per industrial production			●	
	Industrial discharges meeting discharge standard, which is directory discharged in environmental waters	●		●	

Sources: Same to Table 1

■ Step2 [Unit Loading Factors] file

Table 3 Data items in the [Unit Load] sheet (uniform value throughout the country)

Categories	Items	China	Korea	Japan	Russia
Discharged load per person in urban area	Sewerage system	●	●	●	●
	Domestic wastewater treatment tank	●	●	●	●
	Directory discharged sewerage	●	●	●	●
	Reduction rate in sewerage treatment plant (Conventional / Advanced methods)	●	●	●	●
	Reduction rate in domestic wastewater treatment tank (Conventional / Advanced methods)	●	●	●	●
Discharged load per person in rural area	Rural sewerage treatment system			●	
	Domestic wastewater treatment tank	●	●	●	●
	Directory discharged sewerage	●	●	●	●
	Reduction rate in rural sewerage treatment system (Conventional / Advanced methods)			●	
	Reduction rate in domestic wastewater treatment tank (Conventional / Advanced methods)	●	●	●	●
Livestock loads per head	Generated loads of large domestic animal per head	●			●
	Generated loads of daily cattle per head		●		
	Generated loads of cattle per head		●	●	●
	Generated loads of horse per head		●		
	Generated loads of swine per head	●	●	●	●
	Generated loads of sheep and deer per head	●	●		●
	Generated loads of poultry per head		●		
	Discharged rate of large domestic animal per head (before / after measures)	●			●
	Discharged rate of daily cattle per head (before / after measures)		●		
	Discharged rate of cattle per head (before / after measures)		●	●	●
	Discharged rate of horse per head (before / after measures)		●		
	Discharged rate of swine per head (before / after measures)	●	●	●	●
	Discharged rate of sheep and deer per head (before / after measures	●	●		●
	Discharged rate of poultry per head (before / after measures)		●		
Non-point discharges per hector	Forest (before / after measures)	●	●	●	●
	Paddy field (before / after measures)	●	●	●	●
	Dry field (before / after measures)	●	●	●	●
	Urban area (before / after measures)	●	●	●	●

Sources:

Unit load of China: Project for Water Environmental Management Plan in Great Lakes in China (JICA)

Unit load of Japan: Guideline and Interpretation on Regional Sewerage System Comprehensive Development Plan in Japan

Unit load of Korea: Technical Guidance on Total Water Pollution Volumetric Control in Korea, Data shortage is compensated by Japanese data

Unit load of Russia: Referred to Chinese data

Reduction rate and discharge load: Referred to "Guideline and Interpretation on Regional Sewerage System Comprehensive Development Plan in Japan" and "Guideline and Interpretation on Sewerage System Plan and Design in Japan"

Table 4 Data items in the [Industrial] sheet(Provincial data in China and Japan, Municipal data in Korea and Russia)

Categories	Items	China	Korea	Japan	Russia
Water quality of industrial discharge	Improperly treated industrial discharges	●			●
	Industrial discharges standard for effluent discharged to environmental waters	●	●	●	●
	Industrial discharges connected to sewerage system	●		●	

Sources:

Discarge quality of China: Secondary class effluent concentration stipulated in Environmental Standard in China, Project for Water Environmental Management Plan in Great Lakes in China (JICA)

Discharge quality of Japan: "Industrial Statistics (Land and water use) in Japan", "Guideline and Interpretation on Regional Sewerage System Comprehensive Development Plan" and "Surcharge Standard Values (each Prefecture)"

Discharge quality of Korea: Industrial wastewater regulation values states in "Laws on water quality and aquatic system preservation" in Korea

Discharge quality of Russia: Referred to Chinese data

■ Step3 [Parameters] file

Table 5 Data items in [Parameter] sheet(Sub-block data)

Categories	Items	China	Korea	Japan	Russia
Calibration values	Discharged loads from urban area	●			
	Discharged loads from rural area	●			
	Discharged loads from livestock	●	●	●	●
	Discharged loads from forest	●	●	●	●
	Discharged loads from paddy field	●	●	●	●
	Discharged loads from dry field	●	●	●	●
	Discharged loads from urban area of non-point	●	●	●	●
	Loss by river with drawel	●	●	●	●
	Purification at water bodies	●	●	●	●
Allocation rate	Seasonal allocation ratio	●	●	●	●

Sources:

Calibratoin values of China: Calculating based on Actual measured values published in Public Report on Water Resources in China

Calibration values of Japan, Korea and Russia: Calculating based on Actual measured values

Loading by four seasons: Calculating based on Rainfalls described in Table 9 to12

■ Step4 [Future Projection] file for the future projection

Table 6 Data items in the [Total pop. (A)], [Urban pop. (B)], [Industrial production (C)] and [Industrial discharges (D)] sheet

Categories	Items	China	Korea	Japan	Russia
Population	Total population	●	●	●	●
Urban population	Growth rate of urban population / total poplation, or urban poplation in municipal level	●	●		●
Industrial production	Growth rate of GDP or industrial production in municipal level (No need to enter if you will enter the industrial discharges in municipal level)	●	●		
Industrial discharges	Industrial discharged per production in provincial or industrial discharged in municipal	●	●		

Sources:

Population: World statistics data issues by Statistical Bureau, ministry of Internal Affairs and Communications in Japan

Industrial Production: Referred to GDP future projection, GDP projection is quoted from reports issued by "Japanese Economical Association"

Industrial Unit Discharge in China: Products and wastewater amount published in Home Page of National Bureau of Statistics of China

Industrial Unit Discharge in Korea: Products (Mining and manufacture survey issued by Korean Statistical Information Service), wastewater amount (Generation and treatment of industrial wastewater issued by Ministry of Environment)

■ Step5 [Measure] file

Table 7 Data items in the [Policy] sheet

Categories	Items	China	Korea	Japan	Russia
Coverage ratio of conventional treatment system	Sewerage system	●	●	●	●
	Domestic wastewater treatment tank in urban area	●	●	●	●
	Rural sewerage treatment system			●	
	Domestic wastewater treatment tank in rural area	●	●	●	●
Coverage ratio of advanced treatment system	Sewerage system	●	●	●	●
	Domestic wastewater treatment tank in urban area	●	●	●	●
	Rural sewerage treatment system			●	
	Domestic wastewater treatment tank in rural area	●	●	●	●
Industrial discharges	Percentage of industrial discharges connected to sewerage system	●	●	●	●
	Industrial discharges meeting discharge standard, which is directory discharged in environmental waters	●	●	●	●

No sources are available

Table 8 Data items in the [Nonpoint] sheet

Categories	Items	China	Korea	Japan	Russia
Livestock	Progress of measures against livestock discharges	●	●	●	●
Other non-point sources	Progress of measures against non-point discharges (Forest, paddy field, dry field, urban area)	●	●	●	●

*All measures taking rates are set by 0%

(2) **Rainfall data**

Monthly rainfalls Data in 2005 collected to estimate seasonal delivered load.

1) China

Rainfall data in China is shown in Table 9.

Table 9 Rainfall in China (2005)

Name of watershed		City		Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep.	Oct.	Nov.	Annual	Block No.
				Winter			Spring			Summer			Autumn				
Chang Jiang River	Upper stream	Chong qing	Rainfall (mm)	13.1	10.3	27.5	69.3	79.4	182.1	137.4	101.7	221.8	62.2	83.4	31.6	1,019.8	C1～2
			Ratio (-)	0.01	0.01	0.03	0.07	0.08	0.18	0.13	0.10	0.22	0.06	0.08	0.03	1.00	
				0.050			0.324			0.452			0.174				
	Middle stream	Wuhan	Rainfall (mm)	1.2	32.9	110.6	46.6	65.9	176.6	179.5	108.6	93.0	150.0	8.3	143.4	1,116.6	C3～6
		Changsha		44.8	75.1	190.8	106.8	92.2	400.8	272.1	66.7	80.4	47.5	64.4	159.3	1,600.9	
		Average		23.0	54.0	150.7	76.7	79.1	288.7	225.8	87.7	86.7	98.8	36.4	151.4	1,358.8	
			Ratio (-)	0.02	0.04	0.11	0.06	0.06	0.21	0.17	0.06	0.06	0.07	0.03	0.11	1.00	
				0.168			0.327			0.294			0.211				
	Down stream	Shanghai	Rainfall (mm)	21.7	73.0	124.9	42.7	33.1	75.6	37.3	118.6	307.4	101.5	39.3	84.7	1,059.8	C7～8
		Hefei		8.3	24.5	72.8	51.9	71.7	87.0	44.3	272.0	212.6	134.9	27.1	84.2	1,091.3	
		Average		15.0	48.8	98.9	47.3	52.4	81.3	40.8	195.3	260.0	118.2	33.2	84.5	1,075.6	
			Ratio (-)	0.01	0.05	0.09	0.04	0.05	0.08	0.04	0.18	0.24	0.11	0.03	0.08	1.00	
				0.151			0.168			0.462			0.219				
Yellow River	Upper stream-1	Xian	Rainfall (mm)	0.0	0.0	9.1	5.6	19.2	43.1	67.1	45.6	127.4	104.2	117.9	2.2	541.4	K1～3
		Lanzhou		0.1	1.5	4.7	14.8	5.5	106.0	71.5	120.5	32.8	38.8	31.9	3.3	431.4	
		Xining		0.0	1.7	6.2	19.1	8.5	61.7	79.7	106.8	106.3	66.5	26.0	1.6	484.1	
		Average		0.0	1.1	6.7	13.2	11.1	70.3	72.8	91.0	88.8	69.8	58.6	2.4	485.6	
			Ratio (-)	0.00	0.00	0.01	0.03	0.02	0.14	0.15	0.19	0.18	0.14	0.12	0.00	1.00	
				0.016			0.195			0.520			0.269				
	Upper stream-2	Yinchuan	Rainfall (mm)	0.100	0.000	1.700	0.000	0.000	13.600	2.000	11.500	19.600	19.700	6.700	0.000	74.9	K4～5
			Ratio (-)	0.001	0.000	0.023	0.000	0.000	0.182	0.027	0.154	0.262	0.263	0.089	0.000	1.00	
				0.024			0.182			0.442			0.352				
	Middle stream	Xian	Rainfall (mm)	0.0	0.0	9.1	5.6	19.2	43.1	67.1	45.6	127.4	104.2	117.9	2.2	541.4	K6
		Lanzhou		0.1	1.5	4.7	14.8	5.5	106.0	71.5	120.5	32.8	38.8	31.9	3.3	431.4	
		Xining		0.0	1.7	6.2	19.1	8.5	61.7	79.7	106.8	106.3	66.5	26.0	1.6	484.1	
		Average		0.0	1.1	6.7	13.2	11.1	70.3	72.8	91.0	88.8	69.8	58.6	2.4	485.6	
			Ratio (-)	0.00	0.00	0.01	0.03	0.02	0.14	0.15	0.19	0.18	0.14	0.12	0.00	1.00	
				0.016			0.195			0.520			0.269				
	Down stream	Jinan	Rainfall (mm)	4.5	0.0	20.6	0.2	28.9	65.6	118.8	252.9	161.0	286.9	19.2	6.8	965.4	K7～8
			Ratio (-)	0.00	0.00	0.02	0.00	0.03	0.07	0.12	0.26	0.17	0.30	0.02	0.01	1.00	
				0.026			0.098			0.552			0.324				
Hai River	Upper stream	Zhengz hou	Rainfall (mm)	2.3	0.0	8.3	9.6	13.3	56.5	132.9	214.4	118.0	133.3	35.3	4.9	728.8	W1～3
			Ratio (-)	0.00	0.00	0.01	0.01	0.02	0.08	0.18	0.29	0.16	0.18	0.05	0.01	1.00	
				0.015			0.109			0.638			0.238				
	Down stream	Nanjing	Rainfall (mm)	11.4	25.5	71.1	43.8	80.9	58.6	63.6	235.9	214.9	85.8	37.9	62.9	992.3	W4
			Ratio (-)	0.01	0.03	0.07	0.04	0.08	0.06	0.06	0.24	0.22	0.09	0.04	0.06	1.00	
				0.109			0.185			0.518			0.188				
Liao River	Entire area	Shenyang	Rainfall (mm)	18.6	13.4	5.8	0.0	74.4	114.3	132.6	179.9	191.1	48.5	40.8	2.8	822.2	R1～2, B1, K2
			Ratio (-)	0.02	0.02	0.01	0.00	0.09	0.14	0.16	0.22	0.23	0.06	0.05	0.00	1.00	
				0.046			0.230			0.612			0.112				
Huai Rivr	Entire area	Beijing	Rainfall (mm)	1.0	1.5	10.0	0.2	17.0	68.4	66.4	96.1	123.4	24.5	1.8	0.4	410.7	B4～6
		Tianjin		0.8	1.6	6.0	0.0	8.5	37.4	170.9	154.2	209.0	29.2	0.9	0.0	618.5	
		Shijiazhuang		0.8	1.9	15.5	0.2	11.2	39.6	43.3	89.7	101.7	83.6	2.0	0.0	389.5	
		Average		0.9	1.7	10.5	0.1	12.2	48.5	93.5	113.3	144.7	45.8	1.6	0.1	472.9	
			Ratio (-)	0.00	0.00	0.02	0.00	0.03	0.10	0.20	0.24	0.31	0.10	0.00	0.00	1.00	
				0.028			0.129			0.743			0.100				
Other	Entire area	Nanchang	Rainfall (mm)	32.3	91.7	225.8	129.2	166.7	362.7	156.3	97.0	47.1	216.9	90.9	292.1	1,908.7	H2
			Ratio (-)	0.02	0.05	0.12	0.07	0.09	0.19	0.08	0.05	0.02	0.11	0.05	0.15	1.00	
				0.183			0.346			0.157			0.314				

Source: National Bureau of Statistics of China (http://www.stats.gov.cn/tjsj/ndsj/)

2) Japan

Table 10 Rainfall in Japan (2005)

Area		City	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Annual
			Winter			Spring			Summer			Autumn			
Hokkaido	Rainfall (mm)	Sapporo	153.5	120.5	124.0	55.0	62.0	51.0	119.0	114.0	126.0	72.0	150.5	89.0	1,236.5
	Ratio (-)		12.41%	9.75%	10.03%	4.45%	5.01%	4.12%	9.62%	9.22%	10.20%	5.82%	12.17%	7.20%	100.00%
			32.19%			13.58%			29.04%			25.19%			100.00%
From Tohoku to Kinki (Coastal area)	Rainfall (mm)	Akita	187.5	96.5	124.0	67.5	84.0	112.5	189.5	172.5	93.0	242.5	226.0	225.5	1,821.0
		Niigata	166.5	122.5	141.5	53.0	49.5	169.5	103.5	193.0	76.5	212.5	231.0	294.0	1,813.0
		Kanazawa	264.5	199.0	179.5	77.0	126.0	147.5	295.0	182.0	103.0	186.0	198.5	587.0	2,545.0
		Maizuru	165.5	194.0	154.5	54.5	61.0	77.0	185.0	38.5	99.5	98.0	150.0	347.5	1,625.0
		Average	196.0	153.0	149.9	63.0	80.1	126.6	193.3	146.5	93.0	184.8	201.4	363.5	1,951.1
	Ratio (-)	Average	10.05%	7.84%	7.68%	3.23%	4.11%	6.49%	9.91%	7.51%	4.77%	9.47%	10.32%	18.62%	100.00%
			25.57%			13.83%			22.19%			38.41%			100.00%
From Tohoku to Kinki (Inland)	Rainfall (mm)	Fukushima	97.5	74.5	85.0	34.5	61.0	64.0	117.0	249.0	127.5	40.5	41.0	76.5	1,068.0
		Nagano	85.5	40.0	55.0	14.0	28.5	79.5	148.5	167.5	88.0	39.0	34.5	88.0	868.0
		Average	91.5	57.3	70.0	24.3	44.8	71.8	132.8	208.3	107.8	39.8	37.8	82.3	968.5
	Ratio (-)	Average	9.45%	5.92%	7.23%	2.51%	4.63%	7.41%	13.71%	21.50%	11.13%	4.11%	3.90%	8.50%	100.00%
			22.60%			14.55%			46.34%			16.51%			100.00%
Chugoku	Rainfall (mm)	Matsue	124.0	100.0	144.5	41.5	54.5	26.0	333.5	73.0	116.5	117.5	147.0	195.0	1,473.0
	Ratio (-)		8.42%	6.79%	9.81%	2.82%	3.70%	1.77%	22.62%	4.96%	7.91%	7.98%	9.98%	13.24%	100.00%
			25.02%			8.29%			35.49%			31.20%			100.00%
Kyushu (Northern part)	Rainfall (mm)	Fukuoka	47.0	91.0	93.0	36.0	62.5	15.0	301.0	73.5	115.0	18.5	109.0	58.5	1,020.0
	Ratio (-)		4.61%	8.92%	9.12%	3.53%	6.13%	1.47%	29.50%	7.21%	11.27%	1.81%	10.69%	5.74%	100.00%
			22.65%			11.13%			47.98%			18.24%			100.00%
Kyushu (Southern part)	Rainfall (mm)	Kumamoto	48.0	99.5	128.0	92.0	135.0	92.5	365.0	73.0	147.0	41.0	72.5	31.0	1,324.5
	Ratio (-)		3.62%	7.51%	9.66%	6.95%	10.19%	6.98%	27.57%	5.51%	11.10%	3.10%	5.47%	2.34%	100.00%
			20.79%			24.12%			44.18%			10.91%			100.00%

Source: Japan Meteorological Agency

3) Korea

Table 11 Rainfall in Korea (2005)

Area		City	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Annual	Block No.
			Winter			Spring			Summer			Autumn				
Northarn part	Rainfall (mm)	Seoul	10.3	4.5	17.2	12.5	94.7	85.8	168.5	269.4	285.0	313.3	52.6	44.6	1,358.4	N10, N2, K6
		Inje	6.1	10.0	23.2	29.0	74.0	73.5	193.0	215.5	236.0	226.5	39.5	42.0	1,168.3	
		Icheon	7.6	2.2	20.0	28.5	70.5	60.5	153.5	291.5	306.5	274.5	47.0	41.0	1,303.3	
		Yeongwol	10.6	2.9	13.6	48.7	57.5	50.6	146.5	332.6	240.5	273.5	59.0	16.1	1,252.1	
		Chungju	11.7	2.8	20.8	43.1	63.1	53.9	178.7	381.6	226.1	320.0	63.4	15.7	1,380.9	
		Cheongju	11.3	4.6	13.8	36.8	66.1	50.7	170.5	373.1	332.7	295.5	54.6	16.0	1,425.7	
		Average	9.6	4.5	18.1	33.1	71.0	62.5	168.5	310.6	271.1	283.9	52.7	29.2	1,314.8	
	Ratio (-)	Average	0.73%	0.34%	1.38%	2.52%	5.40%	4.75%	12.81%	23.63%	20.62%	21.59%	4.01%	2.22%	1.0000	
			2.45%			12.67%			57.06%			27.82%			1.0000	
Southarn part	Rainfall (mm)	Miryang	0.5	7.5	20.0	89.0	91.5	64.0	141.0	206.5	244.0	72.0	8.0	27.5	971.5	Other blocks
		Imsil	41.5	15.8	29.4	61.7	52.0	60.5	173.0	452.5	415.5	63.0	18.5	35.0	1,418.4	
		Taegu	2.8	6.5	16.6	67.1	44.8	32.6	119.0	193.6	280.2	49.9	6.7	14.5	834.3	
		Juam dam	32.1	9.7	35.4	73.6	96.2	88.5	182.5	331.5	185.6	44.5	14.7	40.1	1,134.4	
		Kwangju	66.6	10.6	48.3	66.7	92.5	74.1	185.0	273.8	303.3	108.5	17.4	42.8	1,289.6	
		Gunsan	55.1	6.5	40.5	39.6	51.7	80.6	132.0	550.2	321.4	176.0	29.6	25.3	1,508.5	
		Kumsan	22.6	9.4	34.0	51.0	31.5	65.5	191.0	411.5	387.0	118.0	23.0	30.5	1,375.0	
		Andong	2.9	5.5	14.0	41.7	50.2	45.5	139.5	209.5	227.6	115.9	20.1	9.3	881.7	
		Average	28.0	8.9	29.8	61.3	63.8	63.9	157.9	328.6	295.6	93.5	17.3	28.1	1,176.7	
	Ratio (-)	Average	2.38%	0.76%	2.53%	5.21%	5.42%	5.43%	13.41%	27.93%	25.12%	7.95%	1.47%	2.39%	1.0000	
			5.67%			16.06%			66.46%			11.81%			1.0000	

Source: Korea Meteorological Administration
(http://www.kma.go.kr/weather/observation/past_table.jsp?stn=108&yy=2000&obs=21&x=32&y=11)

4) Russia

Table 12 Average Rainfall in Primorskii Krai

Area		City	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep.	Oct.	Nov.	Annual
			Winter			Spring			Summer			Autumn			
Primorskii Krai	Rainfall (mm)	Vladivostok	18.0	15.0	19.0	25.0	54.0	61.0	100.0	124.0	153.0	126.0	66.0	38.0	799.0
	Ratio (-)		2.25%	1.88%	2.38%	3.13%	6.76%	7.63%	12.52%	15.52%	19.14%	15.77%	8.26%	4.76%	100%
			6.51%			17.52%			47.18%			28.79%			100%

Source: World Meteorological Organization, World Weather Information Service

(http://www.worldweather.org/107/c00664.htm)

(3) Land Use

Data of land use (data of year 2000) in China is remote sensing data provided by Imura laboratory in Nagoya University.

Data of land use in Japan, Korea and Russia were collected from United States Geological Survey (http://edc2.usgs.gov/glcc/glcc.php). The data is based on satellite images divided into 1km mesh for the land use categorization.

Land use area of researched area in each country is shown in **Table 13** and **Figure 1**.

Table 13 Land Use Area in Researched Area in China, Japan, Korea and Russia

(Unit: km^2)

		Total	Forest	Paddy field	Dry field	Urban area
China	Bohai Sea	1,319,286	211,871	20,347	402,110	5163.1
	Yellow Sea	383,423	113,161	41,077	156,478	3082.1
	East China Sea	2,066,942	832,069	215,893	208,401	5,217
	Subtotal	3,769,651	1,157,101	277,317	766,989	13,462
	(Ratio)		(30.7%)	(7.4%)	(20.3%)	(0.4%)
Japan	Japan Sea	119,802	73,981	11,246	15,621	778
	East China Sea	20,829	15,083	2,062	1,317	190
	Subtotal	140,631	89,064	13,308	16,938	968
	(Ratio)		(63.3%)	(9.5%)	(12.0%)	(0.7%)
Korea	Japan Sea	33,310	8,429	5,145	5,193	223
	East China Sea	13,348	4,903	3,746	1,717	32
	Yellow Sea	51,608	12,228	10,152	4,490	529
	Subtotal	98,266	25,560	19,043	11,400	784
	(Ratio)		(26.0%)	(19.4%)	(11.6%)	(0.8%)
Russia	Japan Sea	67,303	63,604	619	2,640	435
	(Ratio)		(94.5%)	(0.9%)	(3.9%)	(0.6%)
Total		4,075,851	1,335,329	310,287	797,967	15,649
(Ratio)			(32.8%)	(7.6%)	(19.6%)	(0.4%)

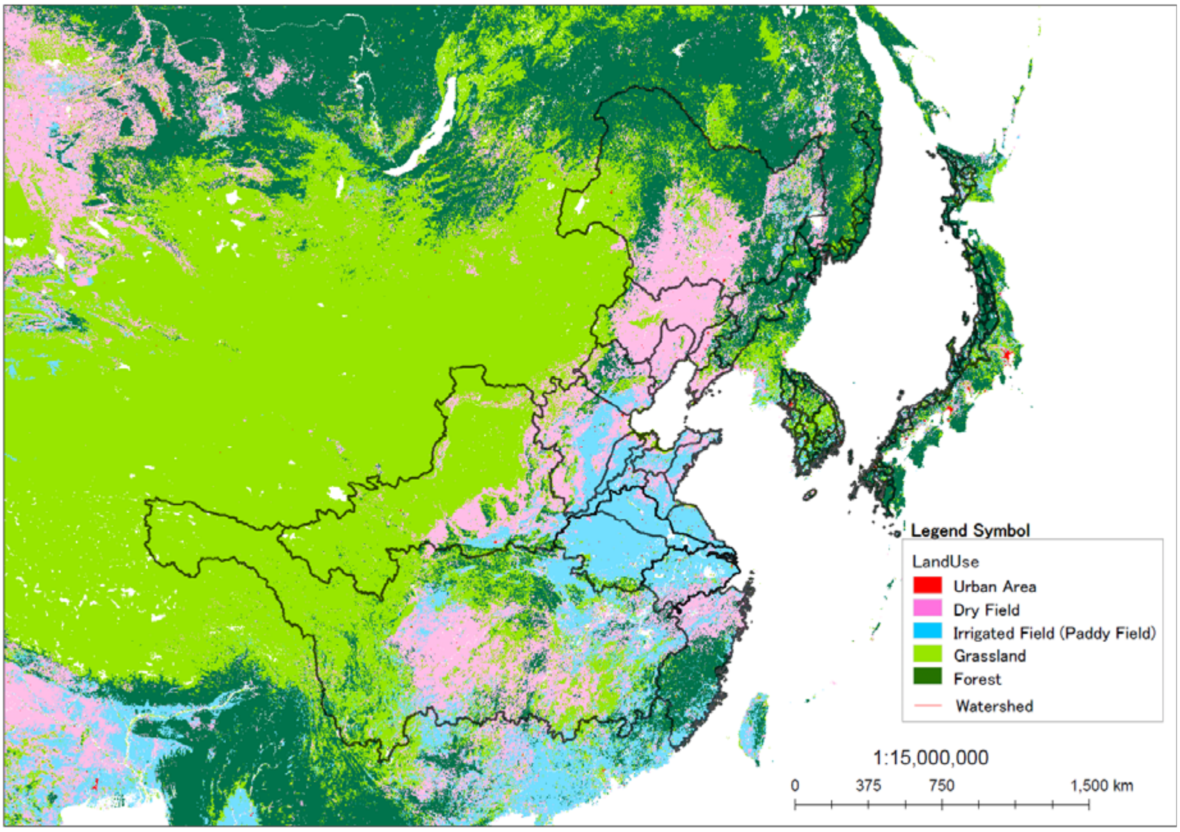


Figure 1　Land Use

(4) **Livestocks**

Livestock Numbers in Researched Area are shown in **Table 14**. Future projection of the livestocks numbers was not carried out in this study. Therefore, in this study, we have assumed that the livestocks numbers are not changed in the future.

Table 14 Livestock Numbers in Researched Area in 2005

(Unit: ten thousand head)

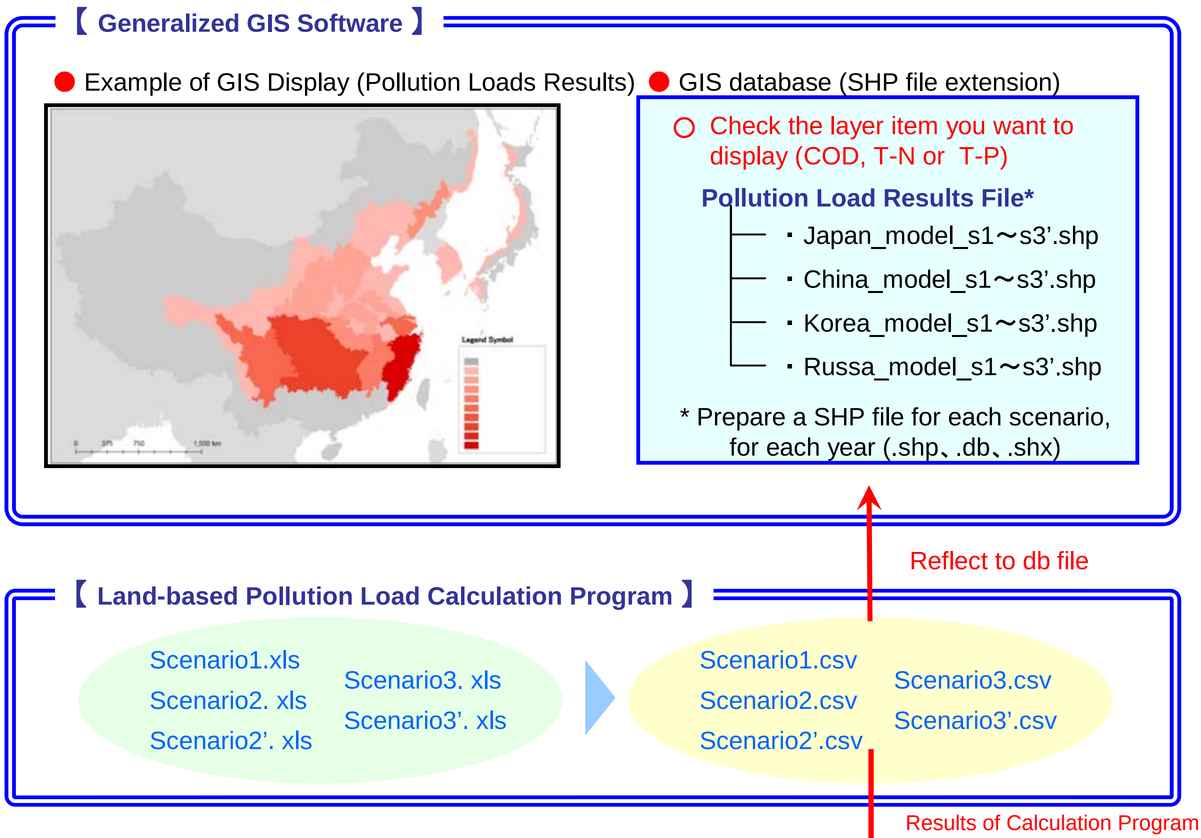
		Large domestic animal	Cattle	Swine	Sheep	Horse
China	Bohai Sea	4,124	—	9,135	13,134	—
	Yellow Sea	2,057	—	7,578	5,933	—
	East China Sea	4,246	—	21,227	5,241	—
	Subtotal	10,427	—	37,940	24,308	—
Japan	Japan Sea	—	42	35	—	—
	East China Sea	—	49	84	—	—
	Subtotal	—	91	119	—	—
Korea	Japan Sea	—	68	241	6	0.1
	East China Sea	—	29	100	6	0.5
	Yellow Sea	—	137	661	12	0.5
	Subtotal	—	234	1,002	24	1.1
Russia	Japan Sea	1.5	0.8	0.8	0.5	—
Total						

Source:
China: Agricultural Yearbook in China
Japan:Preliminary Statistical Report on Agriculture, Forestry and Fisheries published by Ministry of Agriculture, Forestry and Fisheries of Japan.
Korea: Statistical Report on treatment of livestock effluents published by Ministry of Environment in Korea.
Russia: Statistical database system published by Russian Federation.

(5) Data transfer to the GIS system

The function of drawing a map with the GIS software is not introduced the Program. However, distribution of the pollution loads calculated in the Program can be shown in a GIS map if the user prepares the GIS software by their own.

Figure 2 shows the image of data transfer to the GIS database. In this case, SHP files for each scenario in each year were prepared/registered and the results of Program in CSV files were transferred to DB files (Following data were prepared by using the ESRI ArcGIS).



Coastal water body	Blocks No.	River watershed	Sub-blocks No.	ID	(A) Pollution loads from human activities								(B) Nonpoint sources pollution loads					Total
					Domestic discharges (non-sewerage)			Industrial discharges	Livestock discharges	Wastewater treatment plant	Subtotal	Forest	Paddy field	Dry field	Urban area	Subtotal	
					Urban area	Rural area	Subtotal										
					A1-1	A1-2	A1	A2	A3	A4	A	B1	B2	B3	B4	B	C
Bohai Sea	B1	Liao River	Direct Input	B1_DI	25,113	2,174	27,287	27,096	66	7,673	62,122	3,860	2,534	1,387	770	8,551	70,673
		Liao River	B2R1	B2R1	15,515	5,687	21,202	9,261	574	3,938	34,974	6,369	1,662	12,690	964	21,685	56,659
		Liao River	B2R2	B2R2	4,255	2,039	6,294	6,926	166	1,307	14,692	1,358	1,359	3,424	291	6,432	21,124
	B2	Sub-total			19,770	7,725	27,496	16,186	739	5,245	49,666	7,727	3,022	16,114	1,255	28,117	77,784
	B3	Liao River	Direct Input	B3_DI	11,200	4,046	15,246	9,112	246	3,555	28,158	2,926	1,214	4,500	385	9,024	37,182
	B4	Hai River	Direct Input	B4_DI	9,810	3,108	12,919	23,821	158	4,212	41,110	3,124	751	2,058	1,247	7,180	48,291
	B5	Hai River	Direct Input	B5_DI	76,288	12,820	89,109	106,905	546	36,383	232,944	2,819	247	8,351	6,056	17,474	250,418
	B6	Hai River	Direct Input	B6_DI	7,054	2,361	9,415	8,598	139	3,385	21,537	11	18	1,769	773	2,571	24,108
		Yellow River	B7K1	B7K1	8,495	2,180	10,675	6,646	263	1,356	18,940	4,711	1	1,658	164	6,534	25,473
		Yellow River	B7K2	B7K2	1,874	1,162	3,036	1,346	84	443	4,909	655	37	2,106	87	2,885	7,793
		Yellow River	B7K3	B7K3	4,370	1,108	5,478	12,777	76	1,710	20,041	358	[illegible]	[illegible]	[illegible]	[illegible]	23,774
		Yellow River	B7K4	B7K4	1,699	443	2,142	1,798	54	604	4,598	175	0	1,295	261	1,732	6,329
		Yellow River	B7K5	B7K5	5,624	779	6,403	6,936	83	2,003	15,425	804	0	2,024	210	3,038	18,463
		Yellow River	B7K6	B7K6	52,577	19,007	71,585	39,904	795	12,770	125,054	11,261	178	20,795	1,810	34,044	159,098
		Yellow River	B7K7	B7K7	28,109	14,874	42,983	34,728	695	10,636	89,043	5,930	626	8,558	1,814	16,928	105,971
		Yellow River	B7K8	B7K8	10,989	1,408	12,397	17,922	113	5,570	36,002	9	64	1,430	272	1,775	37,777
	B7	Sub-total			113,738	40,961	154,698	122,056	2,163	35,093	314,010	23,903	2,294	39,566	4,905	70,668	384,678
	B8	Huai River	Direct Input	B8_DI	13,623	9,092	22,715	20,834	413	6,905	50,867	837	162	5,256	1,044	7,298	58,165
	Total				276,597	82,288	358,885	334,608	4,472	102,450	800,415	45,206	10,242	79,001	16,434	150,883	951,298

Figure 2 Image of link the Calculation Program to GIS

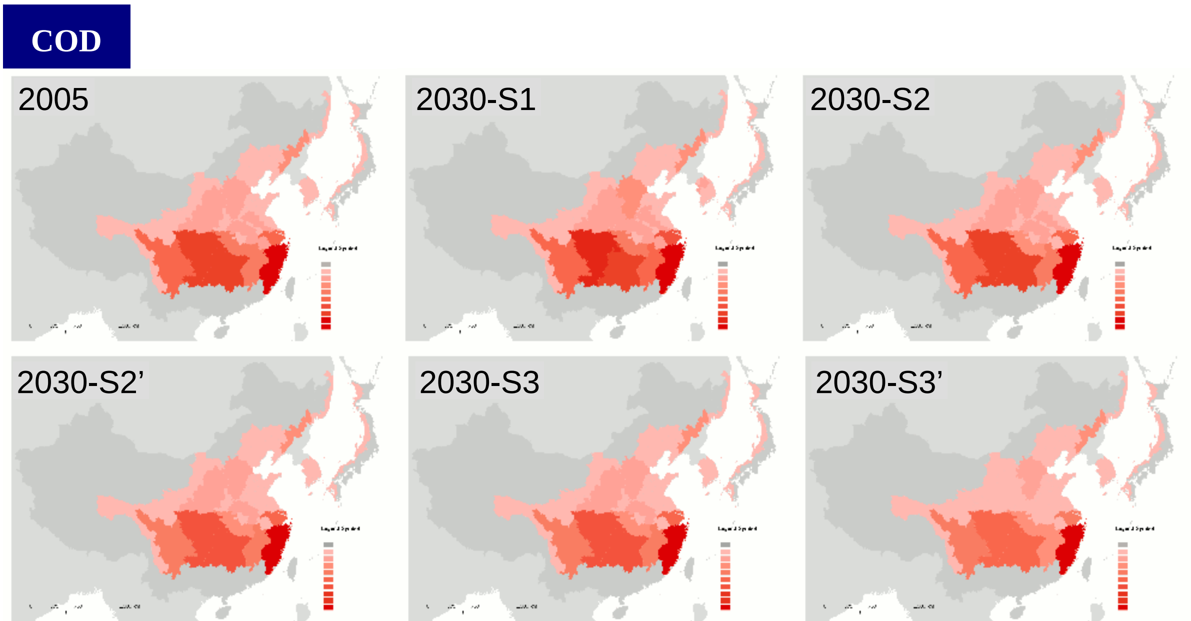
Results of Scenario Analysis conducted by the calculation program

Five scenarios Analysis shown in **Table 15** were carried out using the calculation program in this study. The base year of this analysis was 2005 and the goal year was set in 2030.

Figure 3 to **Figure 5** show the distribution of pollution loads in the base year (2005) and in 2030 of five different scenarios calculated by the Program.

Table 15 Scenarios used for future scenario analysis

Scenario1	Keep the current situation (2005)
Scenario2	In the case of coverage ratio of conventional sewerage system reaches to 100% in urban areas by 2030 (100% of industrial discharges meeting regulations by 2030)
Scenario2’	In the case of coverage ratio of **advanced** sewerage system reaches to 100% in urban areas by 2030
Scenario3	In case of coverage ratios of conventional sewerage system and domestic wastewater treatment tank reach to 100% in urban and rural areas by 2030 (100% of industrial discharges meeting regulations by 2030)
Scenario3’	In case of coverage ratios of **advanced** sewerage system and **advanced** domestic wastewater treatment tank (in urban and rural areas) reach to 100%



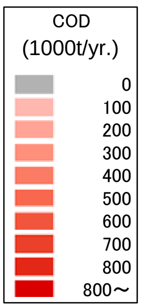


Figure 3 Comparison of COD_{Mn} Distribution Results of base year calculation in 2005 and the scenario analysis in 2030

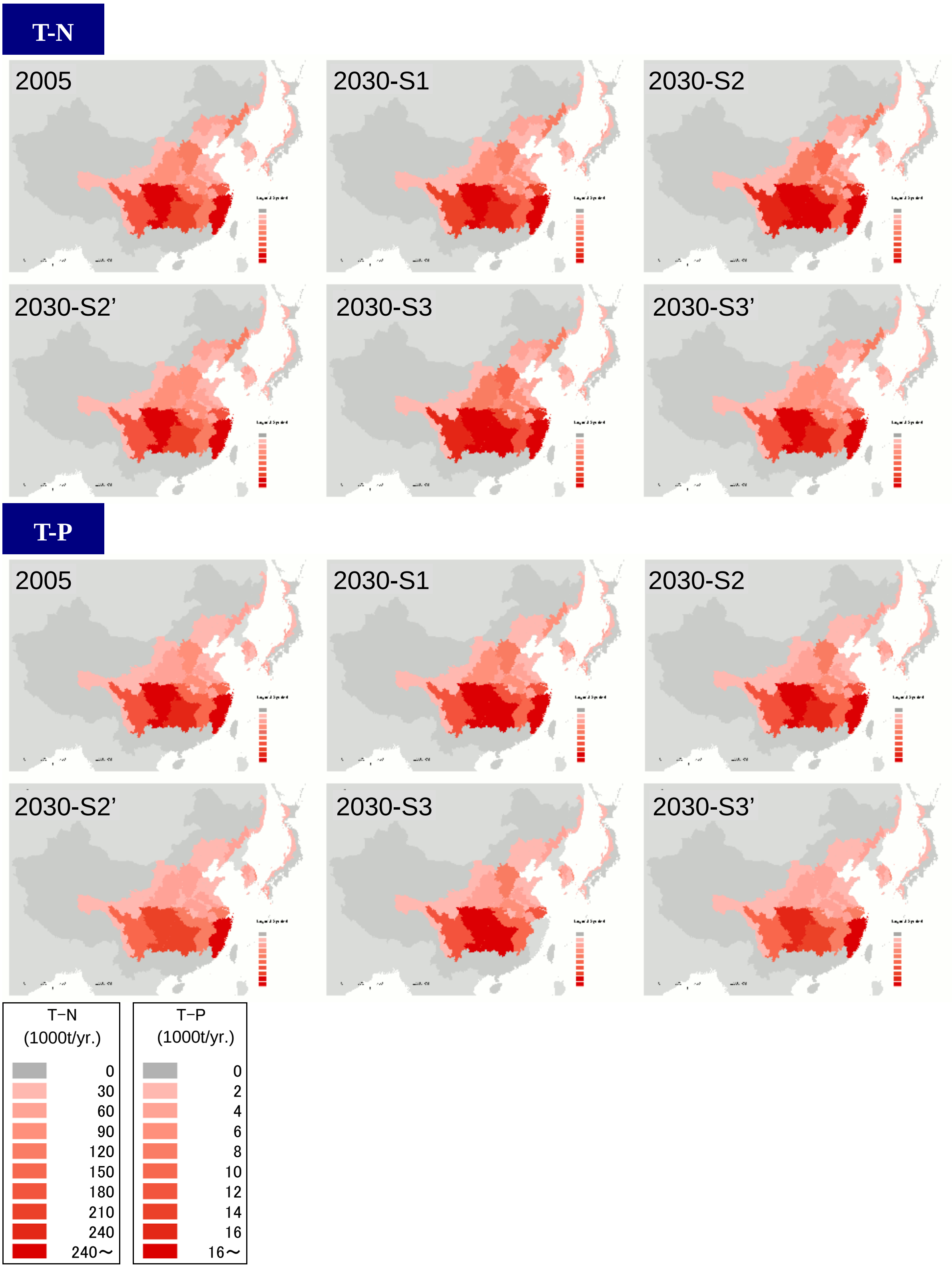


Figure 4 Comparison of T-N, T-P Distribution Results of base year calculation in 2005 and the scenario analysis in 2030

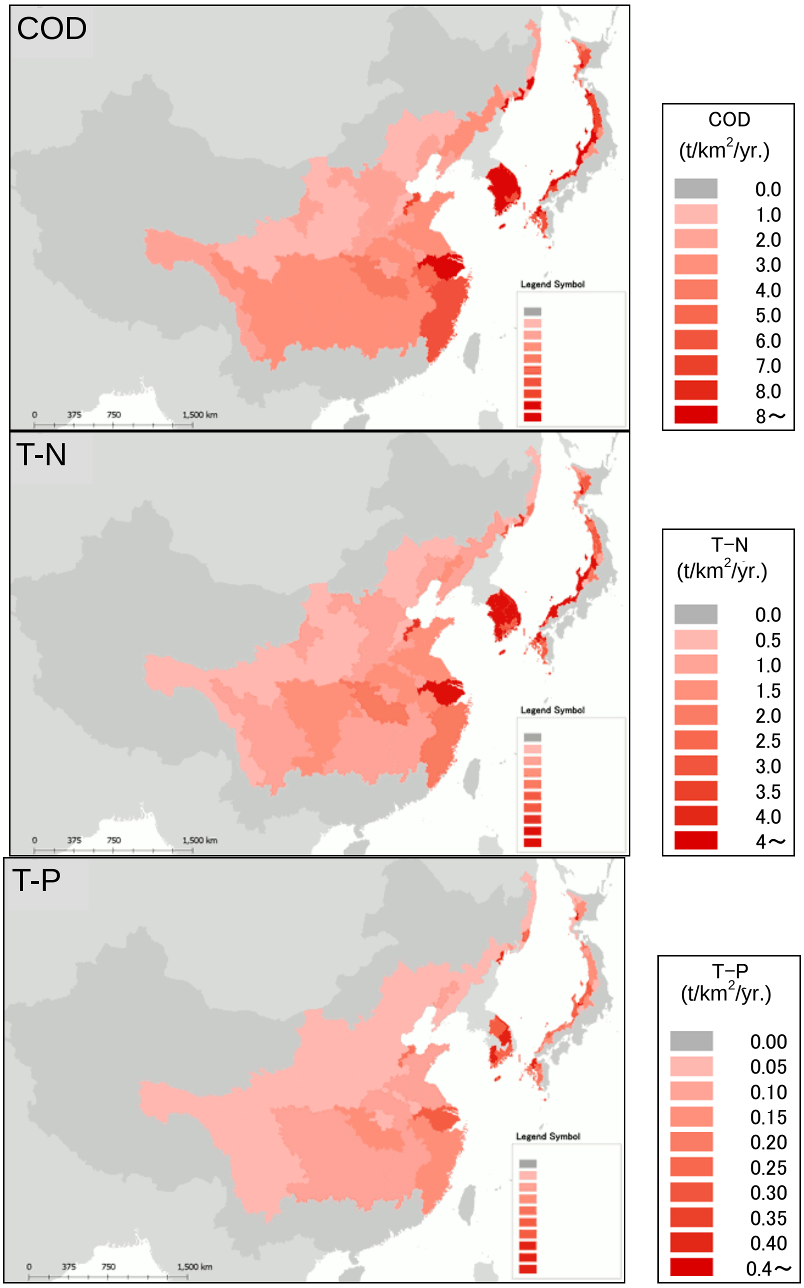


Figure 5　Results of Pollution Loads per Land area in the Base Year calculation in 2005

Appendix 2　Point of view about ocean water quality prediction simulation

Point of view about simulation to estimate the water quality in the Northwest Pacific in the future was straightened. By this simulation, tidal current and water temperature, COD, T-N and T-P in the Japan Sea, the Bohai Sea, the Yellow Sea and the East China Sea were calculated. Here are its outline and setup example of the simulation model.

1. Hydrodynamics model

1.1 Flow of the hydrodynamics model

(1) Computation grid and water depth

After the computational domain and the grid size are decided, the water depth data is created. The data are downloaded from ETOPO1 on the home page of NGDC (National Geophysical Data Center) http://www.ngdc.noaa.gov/mgg/global/global.html. (Table 1.1 shows example of water depth data creation.)

(2) River discharges

After the year for calculation is decided, the river discharges is set by values referred in simulating the land-based pollution and another research results. (Table 1.2 shows example of river discharge setup.)

(3) Meteorological conditions

Meteorological data required to perform the time-variant simulation are wind velocity, air temperature, humidity, solar radiation and cloudiness. In the simulation for Japanese areas (about 10km x 10km), the observational data of a nearby meteorological office is used, but for wide areas like Northwest Pacific, global weather databases are needed. For example, there is NCEP FNL (http://dss.ucar.edu/datasets/ds083.2/) which is an American troposhere weather database. It has a grid resolution of 1 degree of both longitude and latitude and a time resolution of every 6 hour.

(4) Initial conditions and boundary conditions

To perform the time-variant simulation, it is necessary to set up the initial conditions and boundary conditions of current direction, flow velocity, water temperature, and salt content, which are a predictive variable. For example, a ocean prediction model, which is operated by Forecast Ocean Plus, inc. (FOP) is one of them, cover wide areas like the Northwest Pacific. Required initial conditions and boundary conditions can be set up by purchasing this data.

(5) Hydrodynamics model development

As a hydrodynamics model, the model which can predict the time-variant advection and diffusion of horizontal and vertical direction is used. For example, Princeton Ocean Model (http://www.aos.princeton.edu/WWWPUBLIC /htdocs.pom/) widely used in the ocean can be obtained and used.

(6) Calculation and verification of model calculation

Calculation conditions are set up and hydrodynamics calculation is performed. Calculation results verify by comparison of surface water temperature between satellite data and simulation data. If there are problems in reproducibility, the calculation conditions are changed and the calculation is performed again.

The drawing software of various is utilizable for the display of calculation results. For example, Tecplot (made by HULINKS) and ArcGIS (made by ESRI) are used.

(7) Re-calculation when conditions change

When the year for calculation is changed, it re-calculates by re-setting up river discharge conditions, meteorological conditions, initial conditions and boundary conditions. Also when river discharges change, it is necessary to re-calculate by changing only river discharge conditions.

1.2 Development example of the hydrodynamics model

1.2.1 Setup condition of hydrodynamics model development

(1) Model concept

Fundamental factors of currents in oceans are 1)tidal current, 2)density current, 3)wind driven current, 4)ocean current. Explanations of each current are as follows.

1) tidal current: induced by up and down motion of water surface by tides
2) density current: induced by special density difference
3) wind driven current: induced by surface winds
4) ocean current: large scale circulations, for example Kuroshio

The relevant area in this study is so large that ocean currents (Kuroshio), density currents (for example, near river mouth of Chang River) and wind driven currents are important compared with tidal currents. This makes use of Princeton Ocean Model (POM) that takes so-called σ-coordinates as vertical coordinate and has been developed by Mellor et al.(2002)[1] and Ezer and Mellor(2004)[2].

The σ-coordinates are defined as follows.

$$\sigma = \frac{z-\eta}{H+\eta} \quad \text{.......} \quad (1)$$

where, σ : σ-coordinate, z : z -coordinate, η : water surface elevation from a still water surface, H : bottom topography downward positive from a still water surface. $\sigma = 0$ when z=η and $\sigma = -1$ when z=-H. This means that $\sigma = 0$ at the water surface and $\sigma = -1$ at the bed.

The same vertical coordinates are adopted in the water quality model.

Figure 1.1 shows an example of generalized σ-coordinate.

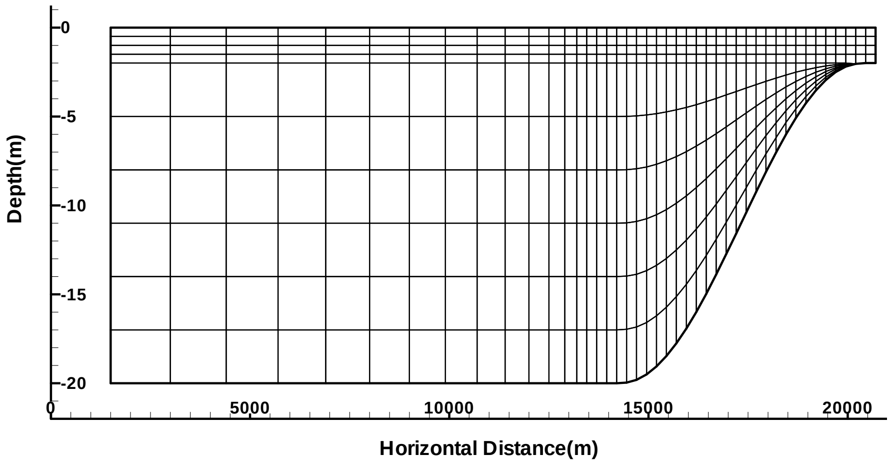


Figure 1.1 An example of generalized σ-coordinate

(2) Fundamental equations

Fundamental equations adopted here are 1. Continuity equation, 2. Momentum equations based on the hydrostatic assumption and Bussinesq approximation, 3. Conservation equations on the water temperature

[1] Mellor, G. L., S. Hakkinen, T. Ezer and R. Patchen(2002) : A generalization of a sigma coordinate ocean model and an intercomparison of model vertical grids, In: Ocean Forecasting: Conceptual Basis and Applications, N. Pinardi and J. D. Woods (Eds.), Springer, Berlin, 55-72.

[2] Ezer, T. and G. L. Mellor(2004) : A generalized coordinate ocean model and a comparison of the bottom boundary layer dynamics in terrain-following and in z-level grids, Ocean Modelling, 6, 379-403

and salinity, and 4. Conservation equations on the turbulence moments. These equations are as follows on the σ-coordinate.

＜Continuity equation＞

$$\frac{\partial DU}{\partial x}+\frac{\partial DV}{\partial y}+\frac{\partial \omega}{\partial \sigma}+\frac{\partial \eta}{\partial t}=0 \quad (2)$$

＜Momentum equations＞

x-direction

$$\frac{\partial DU}{\partial t}+\frac{\partial U^2 D}{\partial x}+\frac{\partial UVD}{\partial y}+\frac{\partial U\omega}{\partial \sigma}-fVD+gD\frac{\partial \eta}{\partial x}+\frac{gD^2}{\rho_0}\int_\sigma^0\left[\frac{\partial \rho'}{\partial x}-\frac{\sigma'}{D}\frac{\partial D}{\partial x}\frac{\partial \rho'}{\partial \sigma'}\right]d\sigma'=\frac{\partial}{\partial \sigma}\left[\frac{K_M}{D}\frac{\partial U}{\partial \sigma}\right]+F_x \quad (3)$$

y-direction

$$\frac{\partial DV}{\partial t}+\frac{\partial UVD}{\partial x}+\frac{\partial V^2 D}{\partial y}+\frac{\partial V\omega}{\partial \sigma}+fUD+gD\frac{\partial \eta}{\partial y}+\frac{gD^2}{\rho_0}\int_\sigma^0\left[\frac{\partial \rho'}{\partial y}-\frac{\sigma'}{D}\frac{\partial D}{\partial y}\frac{\partial \rho'}{\partial \sigma'}\right]d\sigma'=\frac{\partial}{\partial \sigma}\left[\frac{K_M}{D}\frac{\partial V}{\partial \sigma}\right]+F_y \quad (4)$$

＜Conservation equations on the water temperature and salinity＞

$$\frac{\partial DT}{\partial t}+\frac{\partial TUD}{\partial x}+\frac{\partial TVD}{\partial y}+\frac{\partial T\omega}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_H}{D}\frac{\partial T}{\partial \sigma}\right]+F_T-\frac{\partial R}{\partial z} \quad (5)$$

$$\frac{\partial DS}{\partial t}+\frac{\partial SUD}{\partial x}+\frac{\partial SVD}{\partial y}+\frac{\partial S\omega}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_H}{D}\frac{\partial S}{\partial \sigma}\right]+F_S \quad (6)$$

＜Conservation equations on the turbulence moments＞

$$\frac{\partial Dq^2}{\partial t}+\frac{\partial q^2 UD}{\partial x}+\frac{\partial q^2 VD}{\partial y}+\frac{\partial q^2\omega}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_q}{D}\frac{\partial q^2}{\partial \sigma}\right]+\frac{2K_M}{D}\left[\left(\frac{\partial U}{\partial \sigma}\right)^2+\left(\frac{\partial V}{\partial \sigma}\right)^2\right]+\frac{2g}{\rho_0}K_H\frac{\partial \tilde{\rho}}{\partial \sigma}-\frac{2Dq^3}{B_1 l}+F_q \quad (7)$$

$$\frac{\partial Dq^2 l}{\partial t}+\frac{\partial q^2 lUD}{\partial x}+\frac{\partial q^2 lVD}{\partial y}+\frac{\partial q^2 l\omega}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_q}{D}\frac{\partial q^2 l}{\partial \sigma}\right]+E_1 l\left(\frac{K_M}{D}\left[\left(\frac{\partial U}{\partial \sigma}\right)^2+\left(\frac{\partial V}{\partial \sigma}\right)^2\right]+E_3\frac{g}{\rho_0}K_H\frac{\partial \tilde{\rho}}{\partial \sigma}\right)\tilde{W}-\frac{Dq^3}{B_1}\tilde{W}+F_l \quad (8)$$

where,

D	: total depth (H+η)
U,V	: velocity components in x, y-directions
ω	: vertical velocity components in σ-coordinate
η	: water surface elevation
f	: Coriolis coefficient
g	: gravitational force
ρ	: water density
ρ_0	: reference water density（1025kg/m^3）
K_M	: vertical eddy viscosity
F_x	: horizontal eddy viscosity term with respect to U
F_y	: horizontal eddy viscosity term with respect to V
T	: water temperature
S	: salinity
F_T	: horizontal eddy diffusion term with respect to T
F_S	: horizontal eddy diffusion term with respect to S
K_H	: vertical eddy diffusion coefficient with respect to T, S
$\frac{\partial R}{\partial z}$	: short wave radiation divergence in vertical
q^2	: turbulence kinematic energy
K_q	: vertical eddy diffusion coefficient with respect to q^2
l	: turbulence length scale
F_q	: horizontal eddy diffusion term with respect to q^2
F_l	: horizontal eddy diffusion term with respect to $l\,q^2$
$B_1, E_1, E_3,$	: empirical coefficients related to turbulence closure
σ'	: integral constant

The relationship between vertical velocity in σ-coordinate and z-coordinate is as follows where ω denotes vertical velocity in σ-coordinate and W in z-coordinate.

$$W = \omega + U\left(\sigma\frac{\partial D}{\partial x} + \frac{\partial \eta}{\partial x}\right) + V\left(\sigma\frac{\partial D}{\partial y} + \frac{\partial \eta}{\partial y}\right) + \sigma\frac{\partial D}{\partial t} + \frac{\partial \eta}{\partial t} \quad \text{......................................} \quad (9)$$

$\widetilde{W}$ is a proximity function and is defined as

$$\widetilde{W} = 1 + E_2 \left(l / kL \right)$$

where,

$$L^{-1} = \left(\eta - z \right)^{-1} + \left(H - z \right)^{-1}$$

E_2 : empirical coefficients related to turbulence closure model

k : Karman constant

Note that $\partial\widetilde{\rho} / \partial\sigma = \partial\rho / \partial\sigma - c_s^{-2} \partial p / \partial\sigma$, c_s is sound velocity in water, p is hydrostatic pressure.

Horizontal viscosity and diffusion terms are defined as follows.

$$F_x = \frac{\partial H \tau_{xx}}{\partial x} + \frac{\partial H \tau_{xy}}{\partial y} \quad (10)$$

$$F_y = \frac{\partial H \tau_{xy}}{\partial x} + \frac{\partial H \tau_{yy}}{\partial y} \quad (11)$$

where,

$$\tau_{xx} = 2A_M \frac{\partial U}{\partial x}, \tau_{xy} = A_M \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} \right), \tau_{yy} = 2A_M \frac{\partial V}{\partial y} \quad (12)$$

and,

$$F_\phi = \frac{\partial H q_x}{\partial x} + \frac{\partial H q_y}{\partial y} \quad (13)$$

where,

$$q_x = A_H \frac{\partial \phi}{\partial x}, q_y = A_H \frac{\partial \phi}{\partial y} \quad (14)$$

ϕ denotes $T, S, q^2, q^2 l$. A_M is horizontal eddy viscosity coefficient and A_H is horizontal eddy diffusion coefficient.

(3) Mode split

Mode splitting method is taken as numerical integration as done in the POM(Princeton Ocean Model http://www.aos.princeton.edu/WWWPUBLIC/htdocs.pom/). Mode split is the separation of surface elevation computation and 3d structure of velocities, water temperature and salinity. Propagation of water surface has a speed of gravity wave, $\sqrt{gH}$, its speed is faster than other velocities, for example 3d velocities.

Computational time step, which affects computer CPU time, is basically controlled by the fastest speed among various phase speeds related to phenomena described in the fundamental equations. In general, the phenomenon having the fastest phase speed is the surface gravity wave that has a phase speed of $\sqrt{gH}$. At that time, in order for numerical computation to proceed stably, the computational time step must be smaller than $DS/\sqrt{gH}$, where DS is grid spacing. Computational efficiency is considered very bad if all phenomena are computed with this same time step. Therefore, to avoid this bad efficiency, mode split method is introduced. The computation of water surface elevation, which requires short time step, is executed using a 2-dimensional depth averaged model, which is called as the external mode. Computations of other phenomena including 3d velocities and temperature are carried out with longer time step, which computation is called as internal mode. The ratio of internal mode time step to the external mode time step is usually taken as 5 to 30.

The 2-dimensional depth averaged model used in the external mode computation is presented bellow. In this model, interactions with internal mode are taken into account as shown bellow.

＜Continuity equation＞

$$\frac{\partial \eta}{\partial t}+\frac{\partial \overline{U}D}{\partial x}+\frac{\partial \overline{V}D}{\partial y}=0 \quad (15)$$

＜Momentum equations＞

x-direction

$$\frac{\partial \overline{U}D}{\partial t}+\frac{\partial \overline{U}^2 D}{\partial x}+\frac{\partial \overline{U}\overline{V}D}{\partial y}-\tilde{F}_x - f\overline{V}D + gD\frac{\partial \eta}{\partial x} = -<wu(0)>+<wu(-1)>$$

$$+G_x - \frac{gD}{\rho_0}\int_{-1}^{0}\int_{\sigma}^{0}\left[D\frac{\partial \rho'}{\partial x}-\sigma'\frac{\partial D}{\partial x}\frac{\partial \rho'}{\partial \sigma'}\right]d\sigma' d\sigma \quad (16)$$

y-direction

$$\frac{\partial \overline{V}D}{\partial t}+\frac{\partial \overline{U}\overline{V}D}{\partial x}+\frac{\partial \overline{V}^2 D}{\partial y}-\tilde{F}_y + f\overline{U}D + gD\frac{\partial \eta}{\partial y} = -<wv(0)>+<wv(-1)>$$

$$+G_y - \frac{gD}{\rho_0}\int_{-1}^{0}\int_{\sigma}^{0}\left[D\frac{\partial \rho'}{\partial y}-\sigma'\frac{\partial D}{\partial y}\frac{\partial \rho'}{\partial \sigma'}\right]d\sigma' d\sigma \quad (17)$$

Vertically integrated velocity is defined as

$$\overline{U}=\int_{-1}^{0}U d\sigma \quad (18)$$

Wind stress components are $-<wu(0)>$ and $-<wv(0)>$, on the other hand bottom stress components are $-<wu(-1)>$ and $-<wv(-1)>$.

F_x and F_y are defined as follows.

$$F_x = \frac{\partial}{\partial x}\left[H 2\overline{A}_M \frac{\partial \overline{U}}{\partial x}\right] + \frac{\partial}{\partial y}\left[H\overline{A}_M\left(\frac{\partial \overline{U}}{\partial y} + \frac{\partial \overline{V}}{\partial x}\right)\right] \quad (19)$$

$$F_y = \frac{\partial}{\partial y}\left[H 2\overline{A}_M \frac{\partial \overline{V}}{\partial y}\right] + \frac{\partial}{\partial x}\left[H\overline{A}_M\left(\frac{\partial \overline{U}}{\partial y} + \frac{\partial \overline{V}}{\partial x}\right)\right] \quad (20)$$

So-called dispersion terms are defined as follows.

$$G_x = \frac{\partial \overline{U}^2 D}{\partial x} + \frac{\partial \overline{U}\overline{V}D}{\partial y} - \widetilde{F}_x - \frac{\partial \overline{U^2} D}{\partial x} - \frac{\partial \overline{UV}D}{\partial y} + \overline{F_x} \quad (21)$$

$$G_y = \frac{\partial \overline{U}\overline{V}D}{\partial x} + \frac{\partial \overline{V}^2 D}{\partial y} - \widetilde{F}_y - \frac{\partial \overline{UV}D}{\partial x} - \frac{\partial \overline{V^2} D}{\partial y} + \overline{F_y} \quad (22)$$

(4) Computation grid and water depth

Figure 1.2 shows the computational domain. Based on consideration of computer CPU time and special resolution, grid spacing is taken as 40km. Y-coordinate denotes the distance from the equator, and X-coordinate denotes the distance from a reference.

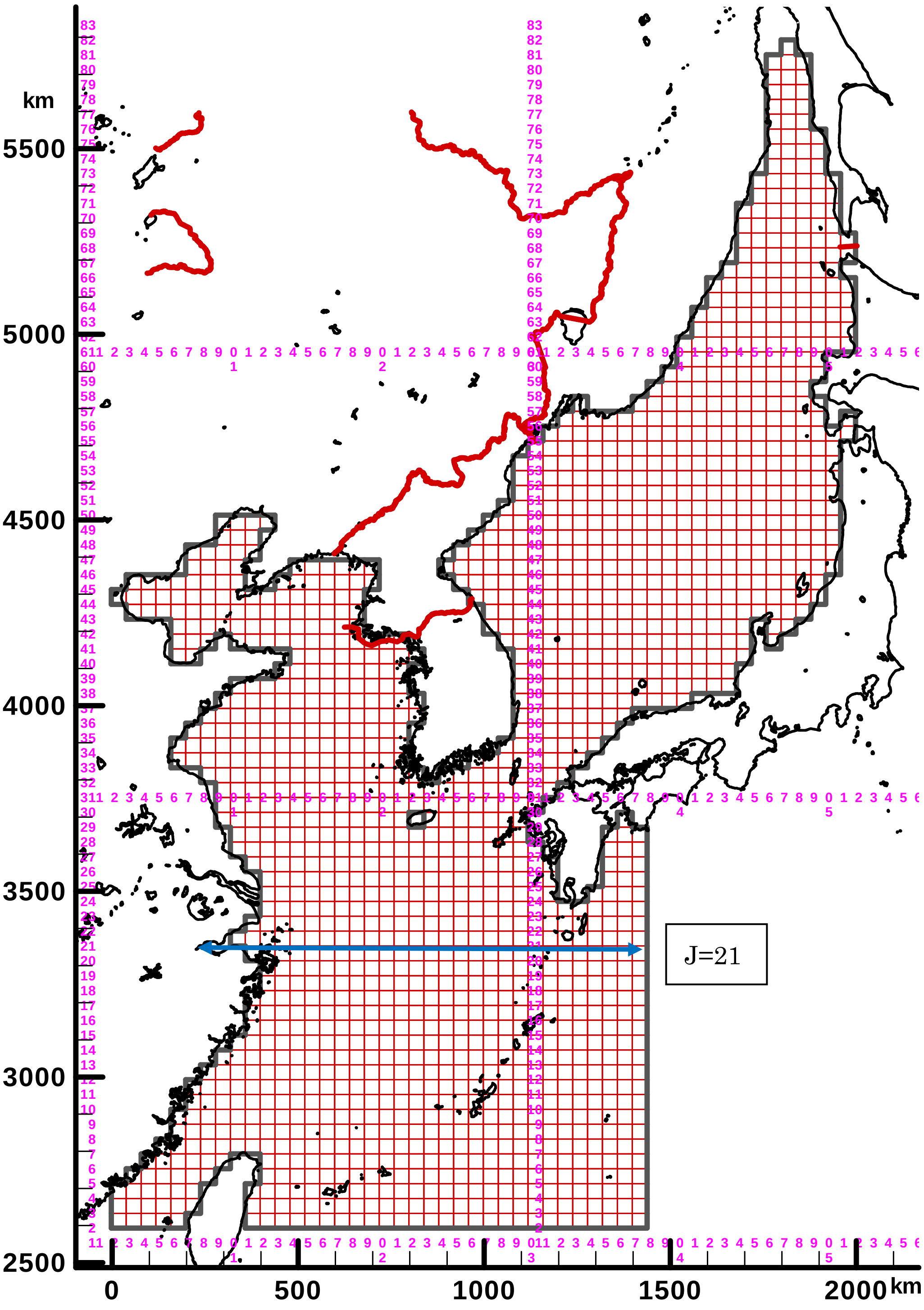


Figure 1.2 Computation grid

Figure 1.3 shows the water depth distribution used in the simulation. The data are downloaded from ETOPO1 on the home page of NGDC(National Geophysical Data Center) http://www.ngdc.noaa.gov/mgg/global/global.html.

Table 1.1 shows example of water depth data creation.

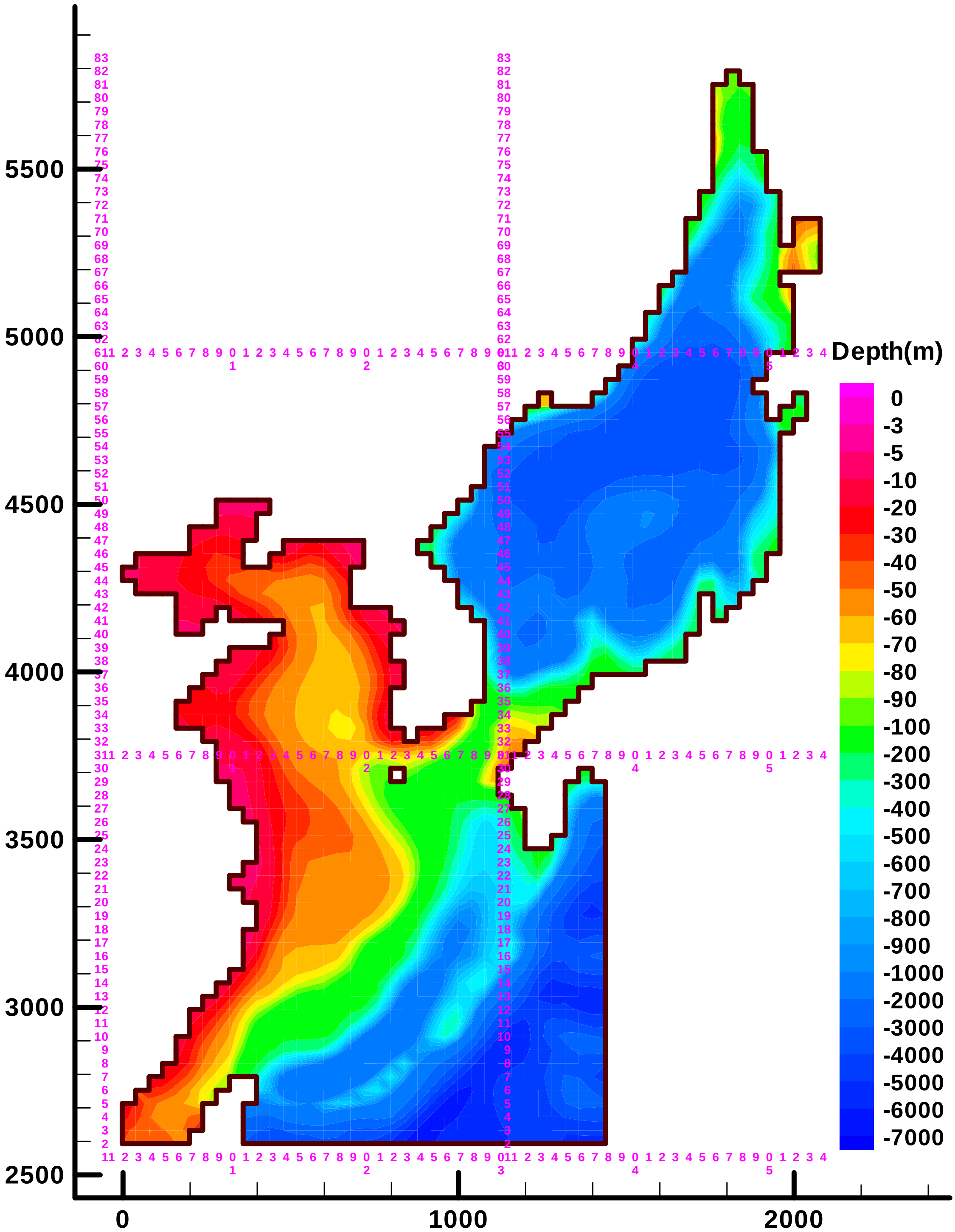


Figure 1.3 Water depth data used in the simulation

Table 1.1 Example of water depth data creation

```
Nihon kinkai (10f7.1) Item=DEP Unit=m Power=1
 1  56  83   0   0   0   0   0   0   10.0  10.0 100.0  0.0
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      1- 1
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      1- 2
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      1- 3
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      1- 4
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      1- 5
 -999.  -999.  -999.  -999.  -999.  -999.                                  1- 6
 -999.    40.0   48.0   52.0   37.0   63.0 -999.  -999.  -999.  -999.      2- 1
 3081.0 3607.0 3405.0 3422.0 3838.0 3473.0 2996.0 3418.0 3867.0 4489.0     2- 2
 4555.0 6086.0 6186.0 6330.0 5811.0 5832.0 5799.0 5611.0 5513.0 5278.0     2- 3
 4683.0 4280.0 4191.0 5240.0 5287.0 5299.0 5367.0 -999.  -999.  -999.      2- 4
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      2- 5
 -999.  -999.  -999.  -999.  -999.  -999.                                  2- 6
 -999.    34.0   50.0   51.0   56.0   59.0   17.0 -999.  -999.  -999.      3- 1
 2086.0 2995.0 3133.0 2109.0 1618.0 1523.0 2172.0 2484.0 2471.0 2131.0     3- 2
 1807.0 2659.0 5666.0 6500.0 6270.0 5903.0 5771.0 5633.0 5458.0 4753.0     3- 3
 4386.0 4212.0 4414.0 4503.0 4414.0 4322.0 4074.0 -999.  -999.  -999.      3- 4
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      3- 5
 -999.  -999.  -999.  -999.  -999.  -999.                                  3- 6
 -999.    17.0   40.0   54.0   69.0   55.0   65.0 -999.  -999.  -999.      4- 1
 1647.0 1725.0  825.0  538.0  638.0  338.0  243.0  733.0 1167.0 1545.0     4- 2
 1422.0 1655.0 2402.0 5343.0 6500.0 6500.0 5862.0 5702.0 5130.0 4640.0     4- 3
 4176.0 4027.0 4403.0 3670.0 3201.0 3023.0 3047.0 -999.  -999.  -999.      4- 4
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      4- 5
 -999.  -999.  -999.  -999.  -999.  -999.                                  4- 6
 -999.  -999.    41.0   41.0   51.0   57.0   70.0   88.0 -999.  -999.      5- 1
 -999.   427.0  870.0 1179.0 1482.0 1630.0 1015.0  431.0  227.0  392.0     5- 2
  779.0 1489.0 1788.0 2432.0 5374.0 6500.0 6183.0 5642.0 5128.0 4394.0     5- 3
 4073.0 4314.0 4367.0 3406.0 1929.0 2168.0 2635.0 -999.  -999.  -999.      5- 4
 -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.  -999.      5- 5
 -999.  -999.  -999.  -999.  -999.  -999.                                  5- 6
(The rest is omitted.)
```

- Numerical value: Water depth (m) of each grid
- "-999.": Land (grid of the outside for calculation)

(5) Vertical discretisation

River water flowing into the sea tends to mainly flow on the ocean surface because of its lightness compared with dense sea water. Therefore, it seems efficient to concentrate analysis near the ocean surface for the present study whose objective is to evaluate the influence of land originated pollution loads on the ocean water quality.

Under above conditions, vertical discretisation is set up as three steps general sigma-coordinate. The first step is from the surface to 10m depth, which are divided 5 layers with each layer of 2m thickness. The second step is from 10m to 100m depth, which are also divided 5 layers with same thickness. The last step is from 100m to the sea bed, which are also divided 5 layers with same thickness. The vertical coordinate at J=21 section (its location is shown in Figure1.2) is presented in Figure1.4.

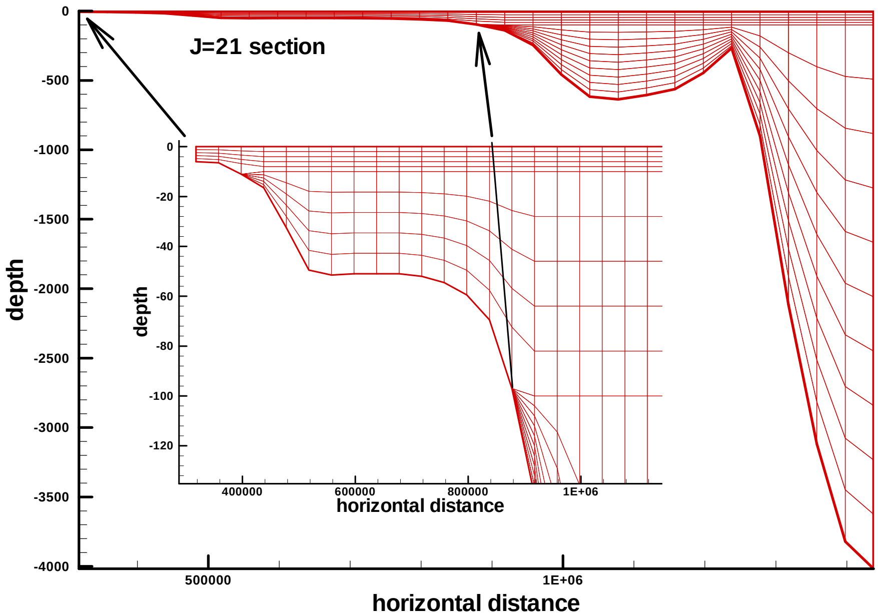


Figure 1.4 Vertical discretisation

(6) External forces in time variation

In the relevant area which is located in a climate zone of temperate monsoon, there are seasonal variations in winds and river discharges that drive ocean currents. In the literatures, it is shown that ocean currents in Yellow Sea and East China Sea respond to these seasonal variations in external forces, and they show remarkable variations in flow rate and path. Therefore, in order to reproduce these flow conditions well in the relevant area, it is considered to be important to set up external forces in the flow simulation as realistic time series. Time series data of ocean currents, river discharges, meteorological conditions were collected and compiled for a year of 2005, and they are utilized as input data for the simulation.

Tidal currents, which are induced by up down motion of water surface elevation, are mainly back and forth motion with a dominant periodicity of 12 hours, and they may be the most significant flow factor in coastal waters. However, they do not convey materials in the sea for a long distance in one direction because of their nature of reciprocating motion. The main objective of the present study is evaluation of impact on water quality in a large horizontal and long time scales, therefore the flow simulation model takes factors of ocean currents, wind driven currents and river induced density currents into account, but does not take tidal currents.

1) River discharges

After the year for calculation is decided, the river discharges is set by values referred in simulating the land-based pollution and another research results. The locations of river discharges are shown in Figure 1.5 - Figure 1.8. Table 1.2 shows example of river discharge setup.

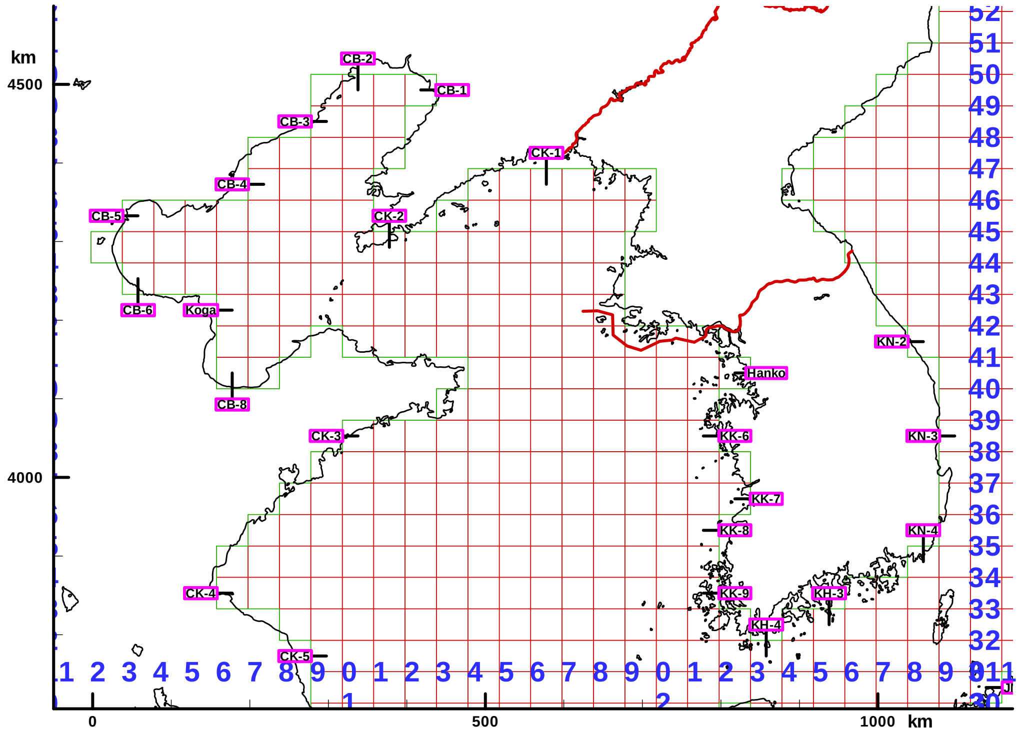


Figure 1.5 Locations of river discharges (Coast of China and Korea)

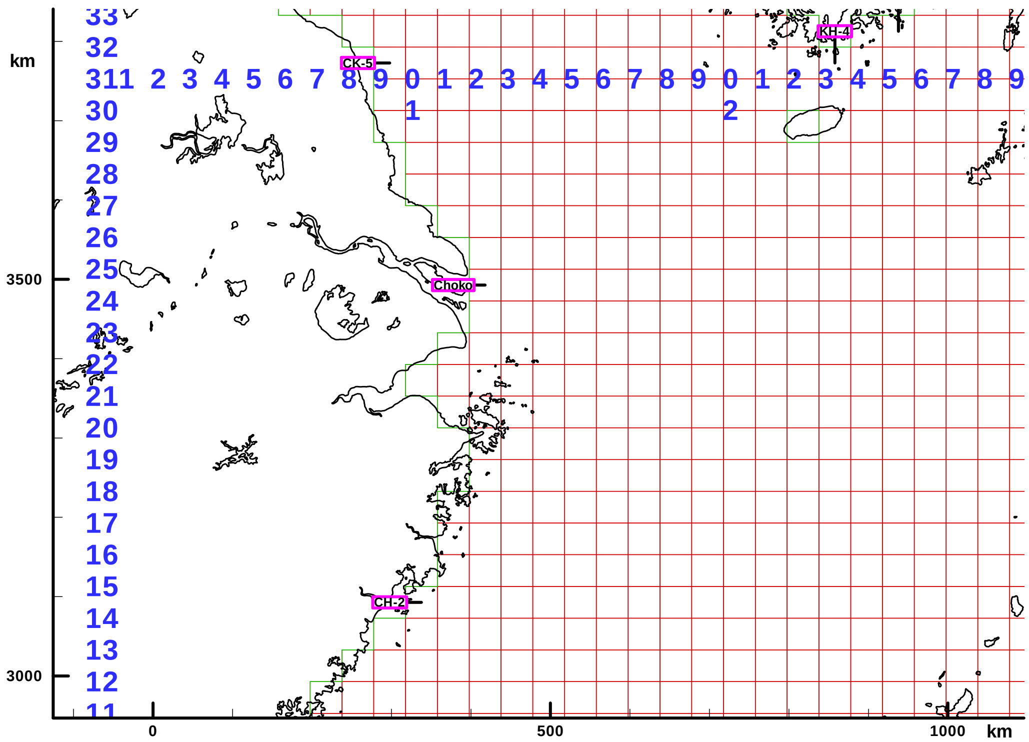


Figure 1.6 Locations of river discharges (Coast of China)

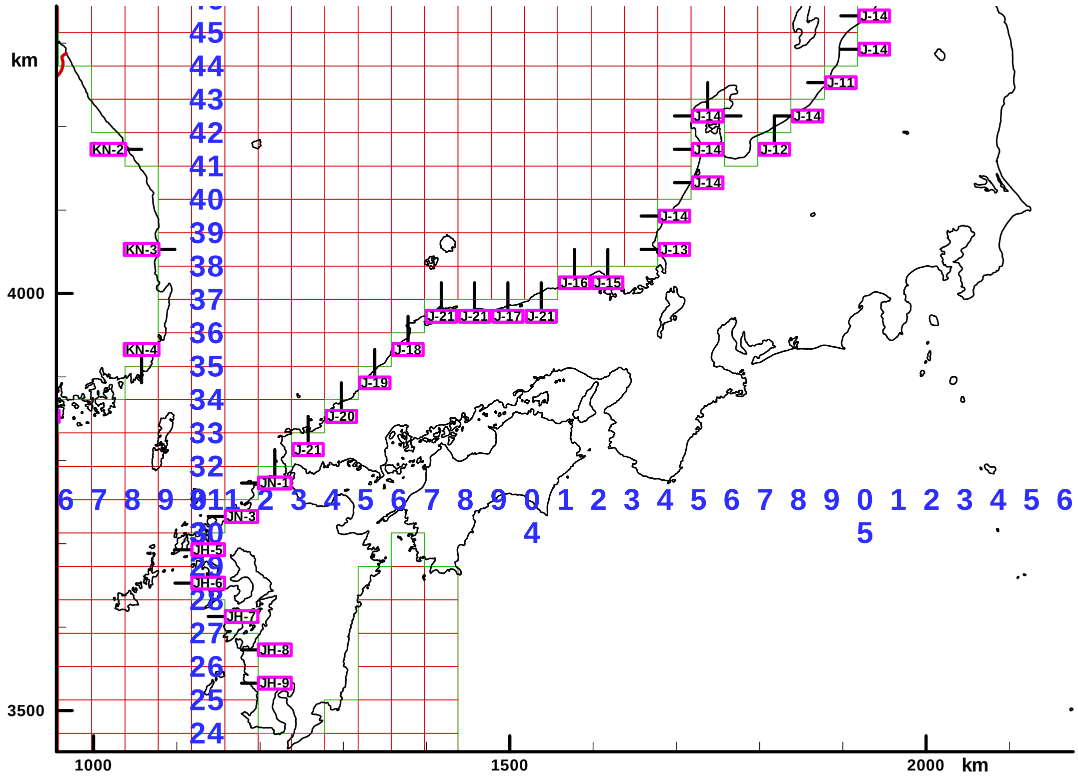


Figure 1.7 Locations of river discharges (Coast of Korea and Japan)

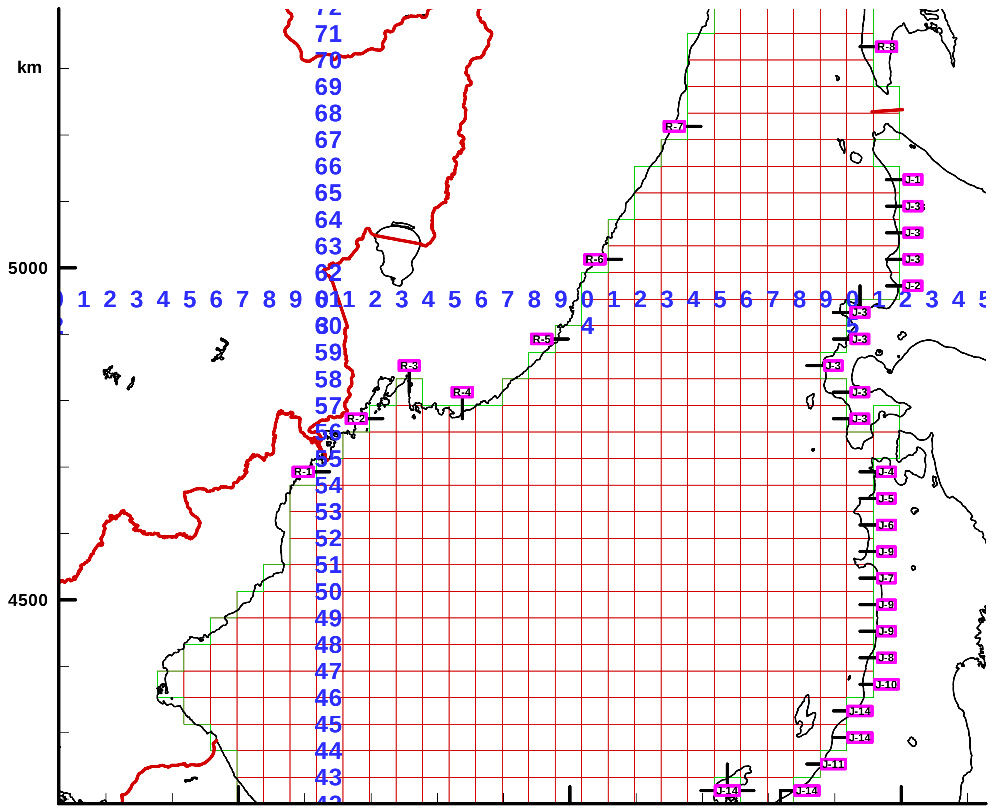


Figure 1.8 Locations of river discharges (Coast of Russia and Japan)

Table 1.2 Example of river discharge setup

year	mmddhhmm	m3/s	S(psu)	T(deg-C)	
2005	01150000	318.000	0.000	20.000	Yellow River
2005	02150000	256.000	0.000	20.000	Yellow River
2005	03150000	200.000	0.000	20.000	Yellow River
2005	04150000	107.000	0.000	20.000	Yellow River
2005	05150000	87.800	0.000	20.000	Yellow River
2005	06150000	186.000	0.000	20.000	Yellow River
2005	07150000	1560.000	0.000	20.000	Yellow River
2005	08150000	550.000	0.000	20.000	Yellow River
2005	09150000	242.000	0.000	20.000	Yellow River
2005	10150000	2930.000	0.000	20.000	Yellow River
2005	11150000	854.000	0.000	20.000	Yellow River
2005	12150000	405.000	0.000	20.000	Yellow River
2005	01150000	847.580	0.000	20.000	Huai River
2005	02150000	711.530	0.000	20.000	Huai River
2005	03150000	1883.420	0.000	20.000	Huai River
2005	04150000	657.470	0.000	20.000	Huai River
2005	05150000	273.820	0.000	20.000	Huai River
2005	06150000	378.440	0.000	20.000	Huai River
2005	07150000	9940.360	0.000	20.000	Huai River
2005	08150000	6417.630	0.000	20.000	Huai River
2005	09150000	3348.330	0.000	20.000	Huai River
2005	10150000	933.000	0.000	20.000	Huai River
2005	11150000	695.820	0.000	20.000	Huai River
2005	12150000	460.430	0.000	20.000	Huai River
2005	01150000	14074.200	0.000	20.000	Change River
2005	02150000	15676.180	0.000	20.000	Change River
2005	03150000	23342.640	0.000	20.000	Change River
2005	04150000	23113.790	0.000	20.000	Change River
2005	05150000	30780.250	0.000	20.000	Change River
2005	06150000	54008.470	0.000	20.000	Change River
2005	07150000	47257.380	0.000	20.000	Change River
2005	08150000	40277.450	0.000	20.000	Change River
2005	09150000	67167.300	0.000	20.000	Change River
2005	10150000	38675.550	0.000	20.000	Change River
2005	11150000	25173.460	0.000	20.000	Change River
2005	12150000	14989.650	0.000	20.000	Change River

- Numerical value: Discharge (m/sec), saline matter (psu) and water temperature (℃) of each river
- Daily discharge: Calculation by linear interpolation

The target year is 2005. Among a number of river discharge data, time series of Chang River and Yellow River are shown in Figure 1.9. According to Figure 1.9, 2005 is considered to be a ordinary year in terms of river discharge.

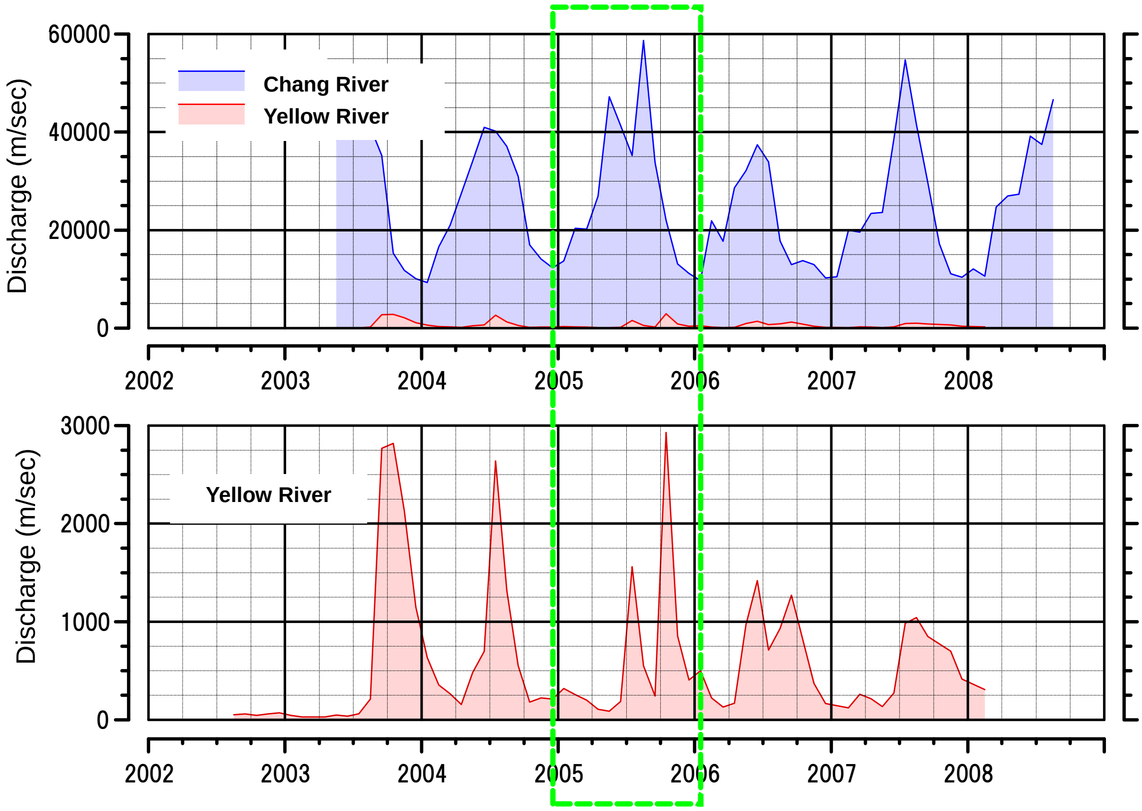
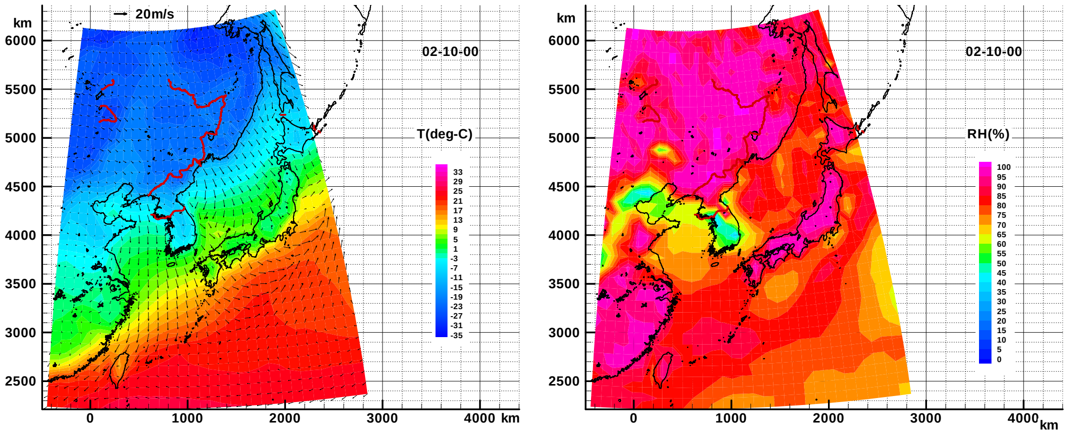
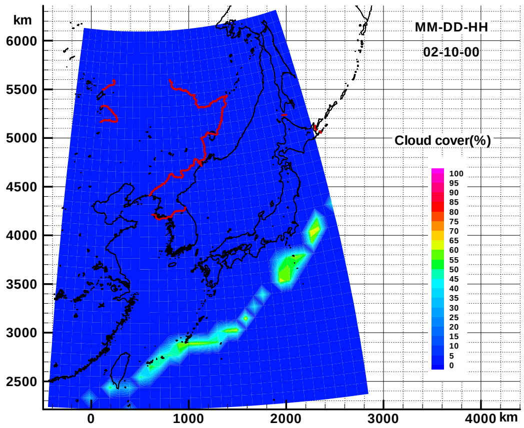


Figure 1.9 Time series of Chang River and Yellow River

2) Meteorological conditions

Meteorological data are necessary to compute wind stresses and heat and water fluxes at the sea surface. Mandate items are wind components, air temperature, relative humidity, solar radiation (short wave radiation) and cloudiness. In present days, a various of meteorological agencies in the world provide global meteorological data through the internet. Here, we downloaded necessary data from an archive of NCEP FNL (http://dss.ucar.edu/datasets/ds083.2/) which has a grid resolution of 1 degree of both longitude and latitude and a time resolution of every 6 hour. Figure 1.10 shows a part of downloaded data.

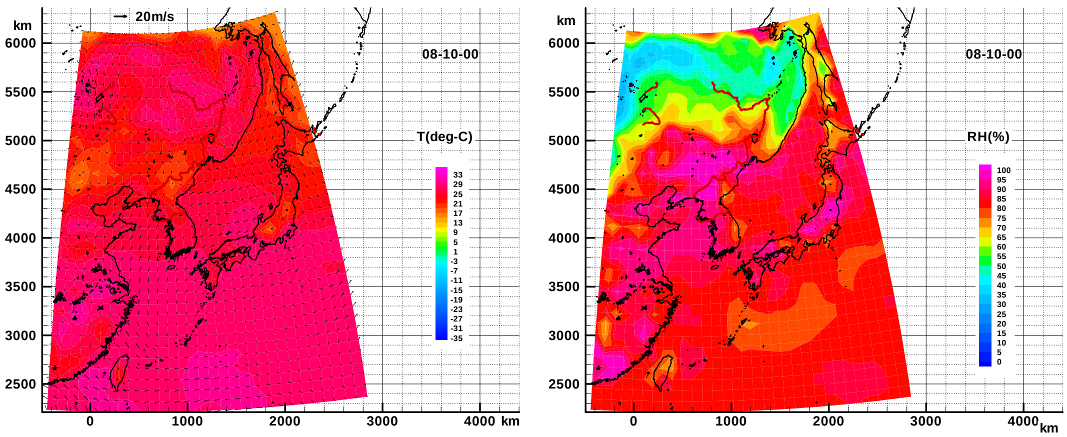


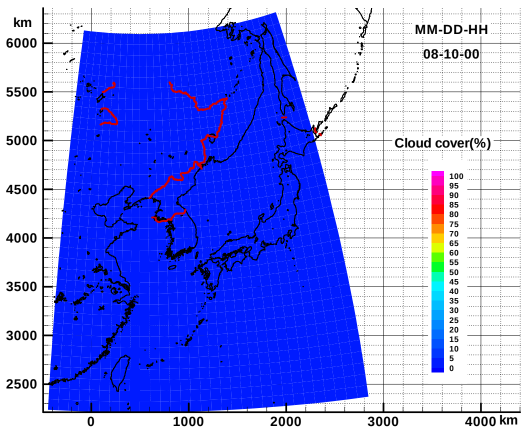


upper left: air temp., wind vector

upper right: humidity

lower left: cloudiness





upper left: air temp., wind vector

upper right: humidity

lower left: cloudiness

Figure 1.10 Meteorological conditions as input (upside: February, downside: August)

(7) Boundary conditions

Open boundary conditions are given as for the current velocity components, water temperature and salinity. In order to obtain necessary time series of data, outputs of a large scale simulation model treating whole North Pacific are utilized. It is possible to use a ocean prediction model which is operated by, for example, Forecast Ocean Plus, inc. (FOP).

Figure 1.11 and Figure 1.12 show examples of simulation results of FOP.

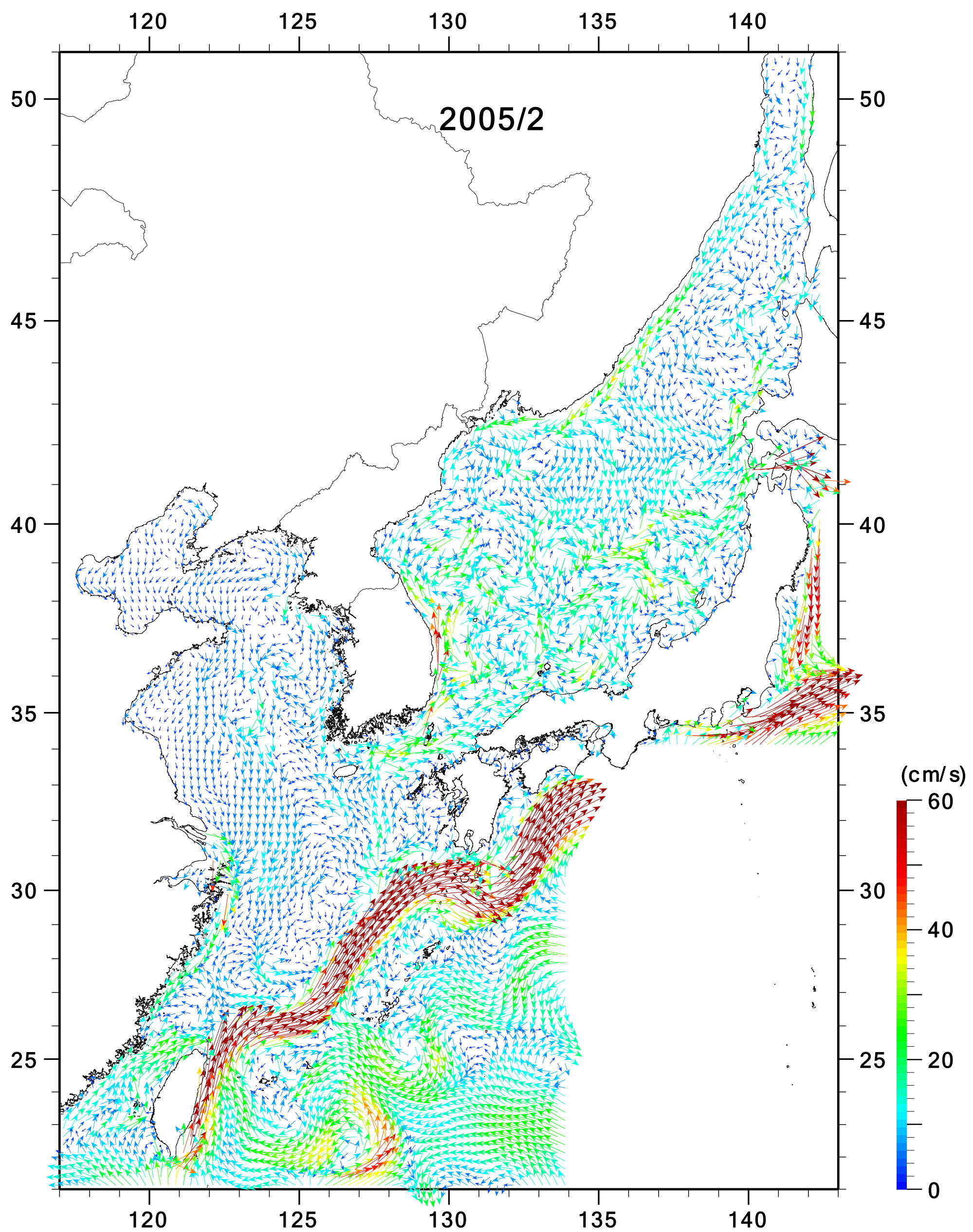


Figure 1.11 Simulation result of FOP utilized as boundary conditions (Winter (February))

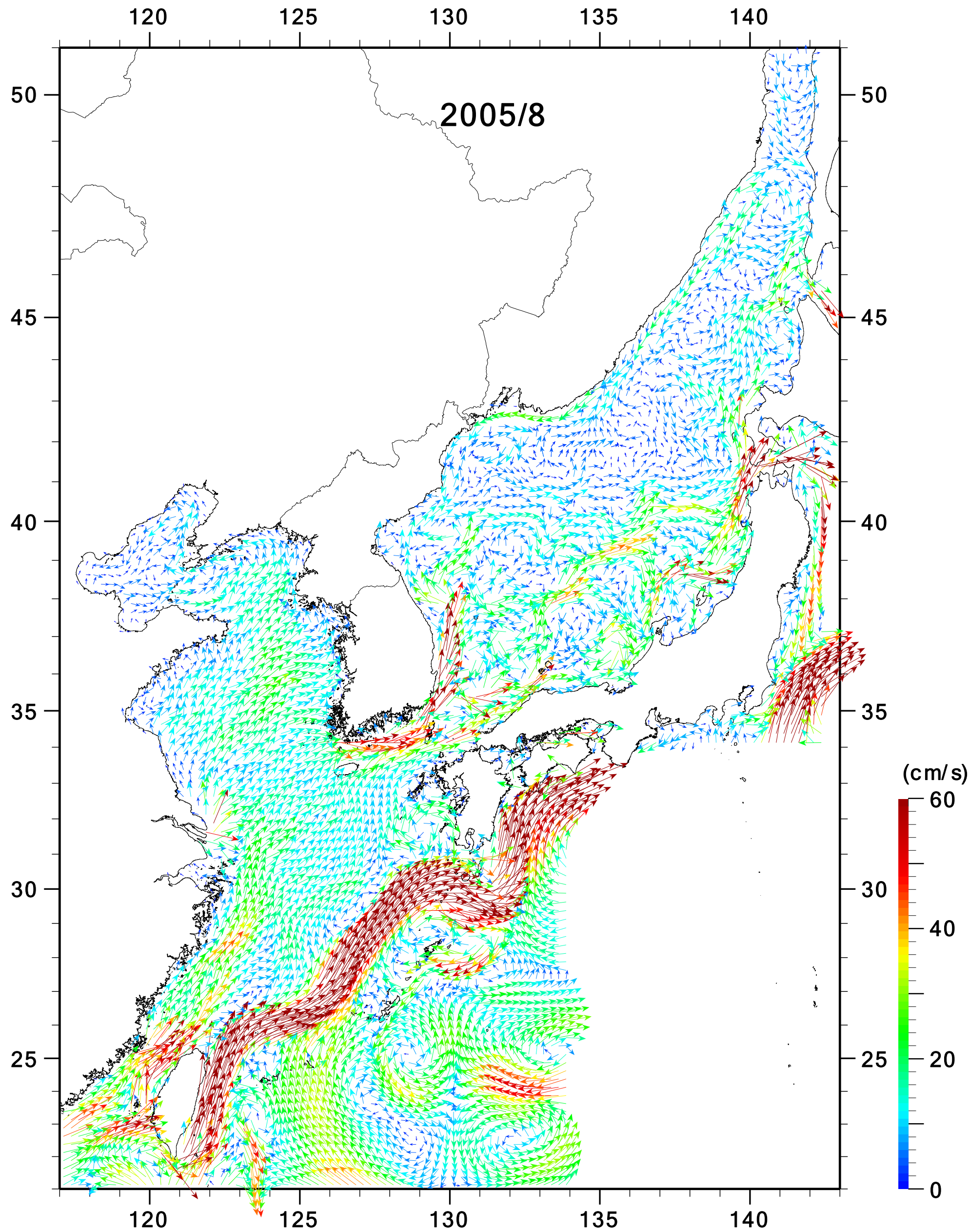


Figure 1.12 Simulation result of FOP utilized as boundary conditions (Summer (August))

Figure 1.13 shows location of south boundary condition where time series of water temperature, salinity and current velocities are set as boundary conditions and they are shown in Figure 1.14.

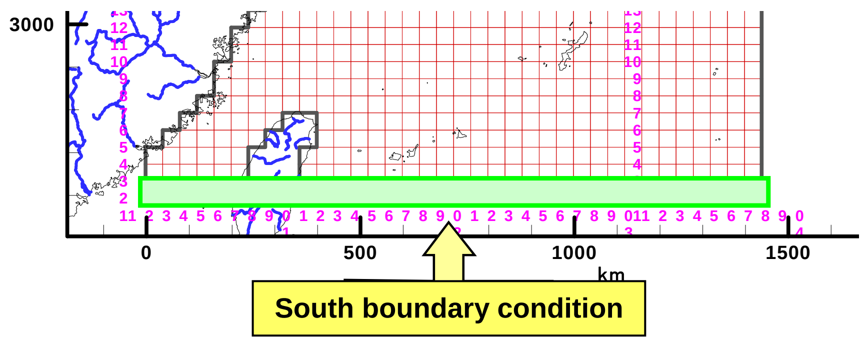


Figure 1.13 Location of south boundary condition

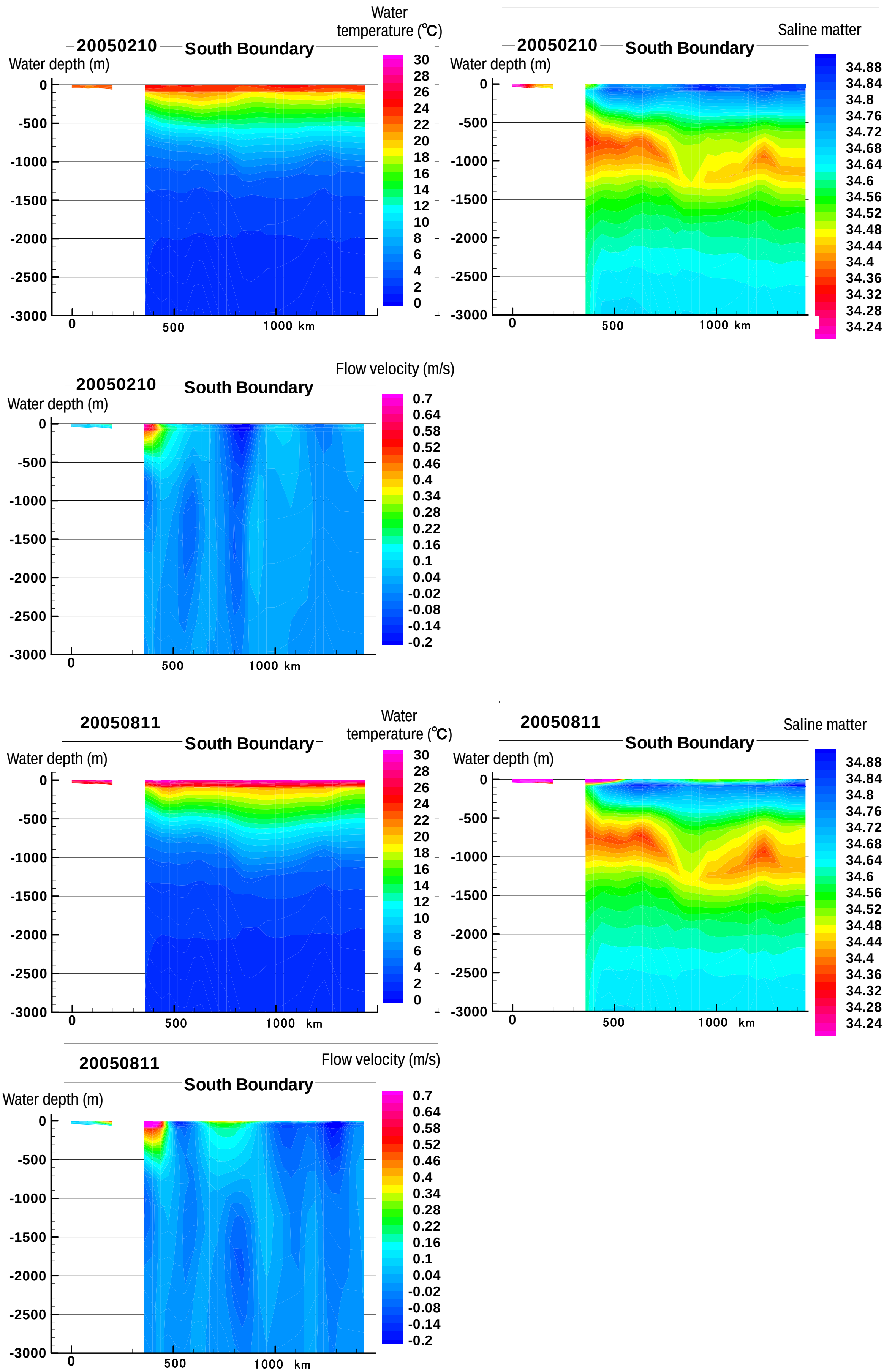


Figure 1.14 South boundary conditions (upside: February, downside: August)

1.2.2 Verification of model calculation

Figure 1.15 shows comparison of water temperature between satellite (MODIS) and simulation.

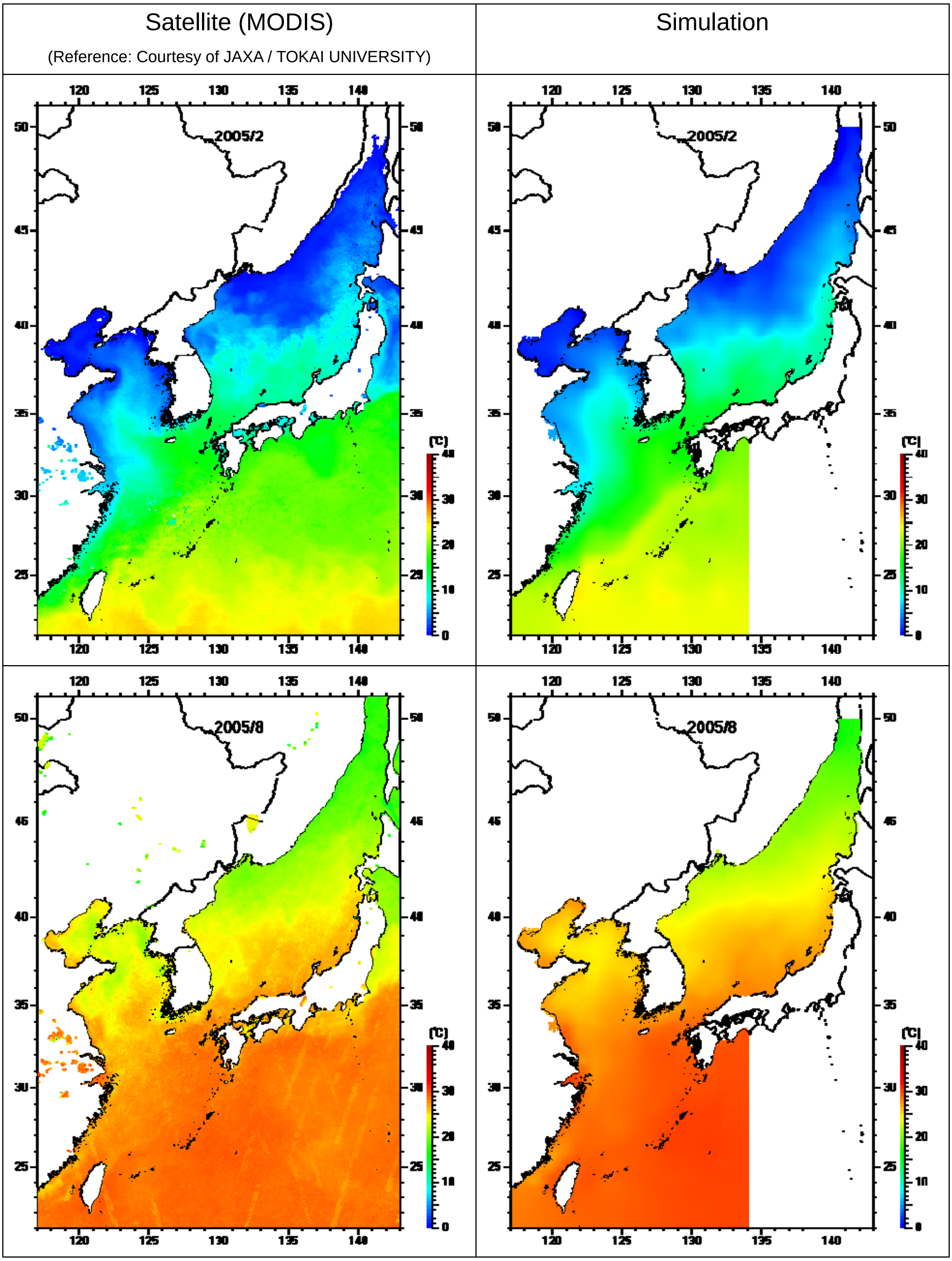


Figure 1.15 Comparison of water temperature between satellite (MODIS) and simulation (February, August)

2. Water quality model

2.1 Flow of the water quality model

(1) Calculation range

Fundamentally, the calculation range is set up in the calculation range of a hydrodynamics model.

(2) Load discharge

The pollutant loads which flow into ocean from each country are set up using the calculated values by the land-based pollution load model. (2.2.1(8) shows setup example of load discharge.) The pollutant loads calculated by the land-based pollution load model are COD, T-N and T-P of seasonal average. According to the calculation items of the water quality model, it is necessary to fractionate these.

(3) Initial conditions and boundary conditions

To perform the time-variant simulation, it is necessary to set up the initial conditions and boundary conditions of water quality items which are a predictive variable. Observed values of the year for calculation are collected and each conditions are set up.

(4) Water quality model development

As a water quality model, there are various models. For example, there are it considering the primary production of the phytoplankton, it considering also the zooplankton, it considering the higher order living things, and it calculating about the bed material to consider the interaction of the water quality and the bed material. The kind of model is decided based on the characteristic of object water areas and the purpose of analysis. A water quality model is based on a diffusion equation. A fundamental equation is a equation which added the biological and chemical reaction term to it.

By way of example, 2.2.1(7) shows the Fortran program of a fundamental equation, a reaction term about phytoplankton, and a term of photosynthesis of phytoplankton.

(5) Calculation and Verification of model calculation

Calculation conditions are set up and water quality calculation is performed. Calculation results verify by comparison of chlorophyl-a between satellite and simulation, and comparison of water quality between observed data and calculated data. If there are problems in reproducibility, the calculation conditions are changed and the calculation is performed again.

The drawing software of various marketing is utilizable for the display of calculation results. For example, Tecplot (made by HULINKS) and ArcGIS (made by ESRI) are used.

Moreover, by taking out the water quality concentration of calculation grids with observed data, the calculation results can be evaluated by spreadsheet software, such as Microsoft Excel.

(6) Scenario calculation and evaluation

By making into input conditions the pollutant loads of each scenario calculated by the land-based pollution load model, the influence which a scenario has on marine environment can be evaluated. In the case of a scenario without change of the river discharges, the hydrodynamic calculation result of the present condition can be used.

The calculation results can be evaluated by creating horizontal distribution figures using drawing software. Also, by taking out the water quality concentration of arbitrary calculation grids, the calculation results can be evaluated by spreadsheet software, such as Microsoft Excel.

2.2 Development example of the water quality model

2.2.1 Setup condition of water quality model development

(1) Horizontal and vertical grid system

The grid system in horizontal and vertical direction follows hydrodynamics model. Therefore, the model construction and the parameter were set expressible of spatial concentration distributions.

(2) Model concept

In the main enumeration, in order to evaluate the environmental impacts to our country according to the load change into the sea area by the change in the social infrastructure maintenance such as an economic activity and drainage in foreign countries (China, Korea, and Russia), the application of the water quality model, considering the primary production of the phytoplankton shown in Figure 2.1, was examined.

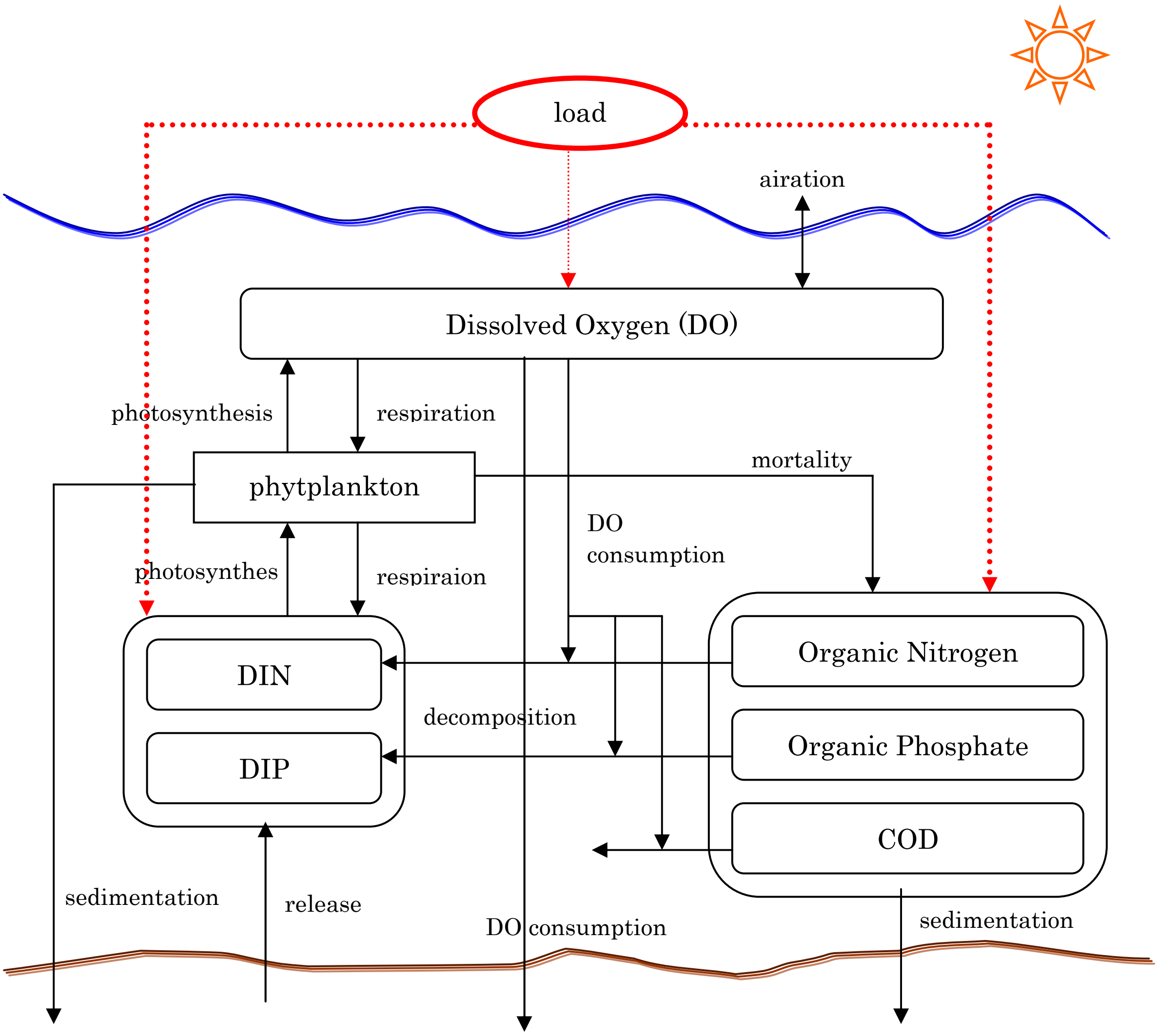


Figure 2.1 Concept of water quality model

Adopting the water quality model like Figure 2.1 made possible to evaluate not only COD, nitrogen, and phosphorus that indicate the eutrophication situation, but also changes in the Chl-a concentration that indicate the red tide.

(3) Calculation items

Calculation items in water quality model are shown in Table 2.1

Table 2.1 Calculation items in water quality model

Variable name	Calculation item	unit
PHY	Concentration of phytplankton	μ g/L
DO	DO concentration	mgO/L
POC	POC(Particulate Organic Carbon) concentration	mgC/L
DOC	DOC(Dissolved Organic Carbon) concentration	mgC/L
PON	PON(Particulate Organic Nitrogen) concentration	mgN/L
DON	DON(Dissolved Organic Nitrogen) concentration	mgN/L
POP	POP(Particulate Organic Phosphate) concentration	mgP/L
DOP	DOP(Dissolved Organic Phosphate) concentration	mgP/L
NH_4-N	NH_4-N concentration	mgN/L
NO_x-N	NO_X-N concentration (nitrate and nitrite)	mgN/L
PO_4-P	PO_4-P concentration	mgP/L
ODU	ODU(Oxygen Demand Unit) concentration ($\sum H_2S$, Mn^{2+}, Fe^{2+}, CH_4)	mgO/L

Because the densities of COD, total nitrogen (T-N), and total phosphorus (T-P) are not immediate calculation items, for this model, they are converted from the densities of analytical items in the water quality model, as follows.

(COD) = (phytplanktonic COD) + (particulate COD) + (dissolved COD)

(T-N) = (phytplanktonic N+ (PON) + (DON) + (NH4-N) + (NOX-N)

(T-P) = (phytplanktonic P) + (POP) + (DOP) + (PO4-P)

For the water quality models in recent years, many ways are contrived,-- a)the organic matters are divided into the particulate and the dissolved matters, b)two or more kinds of phytoplanktons are considered, c)the zooplankton is considered, and d)the device according to the purpose is performed as the interaction with the bottom mud is considered.

The model construction was done with the calculation items for the basic materials shown above, from aiming at the evaluation of the change in the amount of pollution load (COD,T-N,T-P) generated from land areas, after reproduction of general current state with limited data for the vast North Pacific Ocean.

(4) Basic equation

The basic equation of the water quality forecasting model was an addition of the change term of a biological and a chemical process to the basic equation of the hydrodynamics model.

$$\frac{\partial DC}{\partial t}+\frac{\partial CUD}{\partial x}+\frac{\partial CVD}{\partial y}+\frac{\partial CW}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_H}{D}\frac{\partial C}{\partial \sigma}\right]+F_C+Q\pm R$$

Here, D: total depth, C: concentration、U,V,W: velocity components、K_H: vertical eddy diffusion coefficient. F_C: horizontal eddy diffusion term, Q: load discharge、R: biological and chemical reaction term.

Moreover, the horizontal diffusion term is defined as well as the hydrodynamics model.

(5) Phenomena considered by model

The phenomena and the process under considering in the model are shown in Table 2.2.

Table 2.2 Phenomena considered in this model

state variable	+	−	±
phytplankton(PHY)	photosynthesis	extra-release respiration mortality sedimantation	—
Dissolved Oxygen(DO)	photosynthesis	respiration by PHY decomposition of POM decomposition of DOM nitrification DO consumption on the bottom Oxidation of ODU	airation
Particulate Organic Matter (POM)	mortality of phytplankton load discharge	decomposition sedimentation	—
Dissolved Organic Matter (DOM)	Extra-release of phytplankton decomposition of POM load discharge	decomposition	—
NH_4-N	respiration of phytplankton decomposition of POM decomposition of DOM load discharge	photosynthesis nitirification	release from bottom
NO_X-N	nitrification load discharge	photosynthesis	release from bottom
PO_4-P	respiration of phytplankton decomposition of POM decomposition of DOM load discharge	photosynthesis	release from bottom
Oxygen Demand Unit (ODU)	decomposition of POM decomposition of DOM release from bottom	Oxidation	—

(6) Parameters

Various coefficients of the water quality model are shown in Table 2.3.

Table 2.3(1) Parameters for phytoplankton equations

parameter	unit	value	reference
■phytplankton			
maximum photosynthesis rate (0℃)	1/day	0.59	(1)
temperature coefficient for photosynthesis	-	*0.0633*	(1)
respiration rate (0℃)	1/day	*0.001*	M
temperature coefficient for respiration	-	*0.0524*	(4)
mortality rate (0℃)	1/day	*0.01*	M
temperature coefficient for mortality	-	*0.0693*	(4)
half saturation concentration of PO4-P	mg/L	*0.003*	(2)
half saturation concentration of NH4-N	mg/L	*0.020*	M
half saturation concentration of NO3-N	mg/L	*0.033*	M
extra-release rate for photosynthesis	-	*0.12*	(3)
optical light intensity	$MJ/m^2/day$	*8.56*	(2)
dissipative coefficient for light intensity	-	$0.3428-0.0056*Chla+0.0634*Chla^{2/3}$	(5)
Carbon/Chl-a rate	-	*47.6*	(2)
sedimentation rate	m/day	*0.1*	M

Table 2.3(2) Parameters for particulate organic matter equations

parameter	unit	value	reference
■Particulate Organic Matter			
decomposition rate of POC (0℃)	1/day	*0.040*	M
temperature coefficient for decomposition of POC	-	*0.07*	(4)
decomposition rate of PON (0℃)	1/day	*0.025*	M
temperature coefficient for decomposition of PON	-	*0.07*	(4)
decomposition rate of POP (0℃)	1/day	*0.040*	M
temperature coefficient for decomposition of POP	-	*0.07*	(4)
sedimentation rate	m/day	*0.5*	M

Table 2.3(3) Parameters for dissolved organic matter equations

parameter	unit	value	reference
■Dissolved Organic Matter			
decomposition rate of DOC (0℃)	1/day	*0.01*	M
temperature coefficient for decomposition of DOC	-	*0.0693*	(4)
decomposition rate of DON (0℃)	1/day	*0.01*	M
temperature coefficient for decomposition of DON	-	*0.0693*	(4)
decomposition rate of DOP (0℃)	1/day	*0.004*	M
temperature coefficient for decomposition of DOP	-	*0.0693*	(4)
dissolved rate for decomposition of POC	-	*0.80*	M
dissolved rate for decomposition of PON	-	*0.80*	M
dissolved rate for decomposition of POP	-	*0.80*	M

M shows tuning parameter

Table 2.3(4) Parameters for DO equations

parameter	unit	value	reference
■DO			
Carbon/Oxygen rate of phytoplankton (by weight)	-	*3.42*	(2)
half saturation concentration of DO for decomposition of POM	mg/L	*0.099*	(7)
half saturation concentration of DO for decomposition of DOM	mg/L	*0.099*	(7)
Oxidation rate of ODU	1/day	*135.0*	(8)
aeration rate	m/day	*2.25*	(9)

Table 2.3(5) Other parameters

parameter	unit	value	reference
Carbon/Nitrogen rate of phytoplankton (by weight)	-	*6.1*	(2)
Carbon/Phosphate rate of phytoplankton (by weight)	-	*8.0*	(2)
maximum nitrification rate (0℃)	1/day	*0.003*	M
temperature coefficient for nitrification	-	*0.0693*	M
half saturation concentration of DO for nitrification	mg/L	*0.5*	M

M shows tuning parameter

■Reference for Table 2.3

(1) Eppley, R. W. (1972): Temperature and phytoplankton growth in the sea, Fish. Bull., 70, 1063-1085.

(2) Horiguchi F., Nakata K. (1995): Water Quality Analysis of Tokyo Bay using Mathematical Model, Journal of Advanced Marine Science and Technology Society,Vol.1,No.1,71-92. (in Japanese)

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(8) NERI Technical Report(2004): A model set-up for an oxygen and nutrient flux model for Aarhus Bay(Denmark), No.483, pp.1-67

(9) Hirayama K., Matsuo T., Imaoka M., Hirayama K. (1995): Presentation of an equation for estimating reaeration coefficients based on a turbulence intensity model, *Journal of the Japan Society of Civil Engineers*, No.521/Ⅱ-32, pp.181-191. (in Japanese)

(7) Program example of the water quality model

[Basic formulas of the prediction model]

$$\frac{\partial C \cdot h}{\partial t} = \text{(Advective term)} + \text{(Diffusion term)} + \text{(Biological and chemical reaction term)}$$

C: concentration of water quality term, h: layer thickness

$$\text{(Advective term)} = -u\frac{\partial C}{\partial x} - v\frac{\partial C}{\partial x} - w\frac{\partial C}{\partial z}$$

$$\text{(Diffusion term)} = \frac{\partial}{\partial x}\left(K_h \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_h \frac{\partial C}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial C}{\partial z}\right)$$

K_h: horizontal eddy diffusion coefficient, K_z: vertical eddy diffusion coefficient

Phytoplankton（the nth layer）

$$\frac{d}{dt}\left(Phy^{(n)} \cdot H^{(n)}\right) = +\mathrm{Pr}^{(n)} \cdot (1-\varepsilon) \cdot H^{(n)} - \mathrm{Re}\,s_{Phy} \cdot Phy^{(n)} \cdot H^{(n)}$$

Production term － Extracellular secretion term Respiration term

$$- Mor_{Phy} \cdot Phy^{(n)} \cdot H^{(n)} + \mathrm{S}_{\mathrm{Phy}}^{(\mathrm{n\text{-}1})} \cdot Phy^{(n-1)} - S_{Phy}^{(n)} \cdot Phy^{(n)}$$

Plant death term Sedimentation from the upper layer Sedimentation to the lower layer

0 (in case of n=1)

$P_r^{(n)}$: production output by phytoplankton

$$P_r^{(n)} = Phy^{(n)} \cdot \mu\,\mathrm{max} \cdot f(T) \cdot f(N,P) \cdot f(I)$$

μ max: maximum specific growth rate (/s)

$f(T)$: temperature(T) dependence term of growth rate

$$f(T) = \exp\left(Q_{10}V_{Phy} \cdot T^{(n)}\right)$$

$Q_{10}V_{phy}$: temperature constant

$f(N, P)$: nutrient dependence term of growth rate

$$f(N,P) = \frac{IP^{(n)}}{K_{IP} + IP^{(n)}} \cdot \frac{IN^{(n)}}{K_{IN} + IN^{(n)}}$$

K_{IP}: half saturation concentration of phosphorus (g/m^3)

K_{IN}: half saturation concentration of nitrogen (g/m^3)

$f(I)$: underwater illumination intensity(I) dependence term of growth rate

$$f(I) = \frac{I^{(n)}}{I_{OPT}} \exp\left(1 - \frac{I^{(n)}}{I_{OPT}}\right)$$

ε : extracellular secretion coefficient

Res_{Phy}: respiration rate of phytoplankton (/s)

Mor_{Phy}: plant death rate of phytoplankton (/s)

＜Fortran program example＞

```
c====================    Phyto plankton        ====================
c--------------------                  FI                 --------------------
!          zup = zenten(nhor)
           zup = radiation(nb) * 86400.0 / 1000000.0                    !W/m2 -> MJ/m2/day
           do L=1,lay
              FC = (s(8,L,nb)*0.50+s(10,L,nb)/rCChl)* 1000.      ! mgC/L => ug/L
              dk = syousanA*FC+syousanB
              zdown = zup*exp(-dk*DZ(L,nb))
              heikin = (zup-zdown)/(DZ(L,nb)*dk)
              FI = heikin/FIopt*exp(1.0-heikin/FIopt)
              zup = zdown
c----- define solar on surface sediment
              if(L.eq.lay) then
                mb = nbmb(nb)
                solarb(mb)= solarb(mb) + heikin/float(idtm(idom))*sect(L,nb)      ! (MJ/m2/day)
              endif
c--------------------                  FNP                --------------------
              FP = s(1,L,nb) / (halfIP    + s(1,L,nb))
              ratio_pphy=exp(-gams_pphy*s(4,L,nb))
              rp_nh4 = s(4,L,nb)/(halfNH4+s(4,L,nb))*(1.0-ratio_pphy)
              rp_nox = s(5,L,nb)/(halfNOx+s(5,L,nb))*ratio_pphy
              if(rp_nh4.lt.0.0001) rp_nh4 = 0.0
              if(rp_nox.lt.0.0001) rp_nox = 0.0
              FN= rp_nh4 + rp_nox
              if((FN.le.0.0).or.(FP.le.0.0)) then
                FNP = 0.0
              else
                FNP = 2.0/((1.0/FN + 1.0/FP))
              endif
c--------------------                  FT                 --------------------
              T = wtemp(L,nb)
              FT = exp( Q10phy*(T-TbasePphy)**2. )
c----------------- Calculation Production    -----------------
              fPRO(10,L) = + vmax*FT*FNP*FI*s(10,L,nb)*vol(L,nb)            ! CHL
              fPRO( 1,L) = - fPRO(10,L)/rCPphy                              ! IP
              if((rp_nh4.eq.0.0).and.(rp_nox.eq.0.0)) rp_nh4 = 1.0        ! Prevention of divergence
              fPRO( 4,L) = - fPRO(10,L)/rCNphy*rp_nh4/(rp_nh4+rp_nox) ! NH4N(-)
              fPRO( 5,L) = - fPRO(10,L)/rCNphy*rp_nox/(rp_nh4+rp_nox) ! NOX(-)
              fPRO(11,L) = + fPRO(10,L)*rOCphy                              ! DO
```

(8) Setup example of load discharge

2005	Scenario1					
Summer (June - August)		Calculation loads		COD	T−N	T−P
Sea area	Block	Subblock	River Basin	Total	Total	Total
Bohai Sea	B1	Direct Discharge	Liao River	26449	8529	724
	B2	B2R1	Liao River	26170	18058	693
		B2R2	Liao River	8723	5448	222
		Total		34893	23506	915
	B3	Direct Discharge	Liao River	15809	8284	445
	B4	Direct Discharge	Hai River	17437	7146	421
	B5	Direct Discharge	Hai River	92151	36670	2736
	B6	Direct Discharge	Hai River	9193	4648	280
	B7	B7K1	Yellow River	9585	3616	245
		B7K2	Yellow River	3123	2394	82
		B7K3	Yellow River	7335	3235	178
		B7K4	Yellow River	1834	1345	50
		B7K5	Yellow River	5366	2846	152
		B7K6	Yellow River	57121	30389	1567
		B7K7	Yellow River	36313	17165	1035
		B7K8	Yellow River	11187	5037	336
		Total		131864	66027	3644
	B8	Direct Discharge	Huai River	18948	9908	568
	Total			346744	164719	9734
Yellow Sea	K1	Direct Discharge	Amur	150480	55198	2255
	K2	Direct Discharge	Liao River	14896	6409	347
	K3	Direct Discharge	Huai River	17290	9797	499
	K4	Direct Discharge	Huai River	14436	7278	434
	K5	K5W1	Huai River	14297	7168	431
		K5W2	Huai River	80140	38435	2532
		K5W3	Huai River	13317	7648	428
		K5W4	Huai River	44588	21019	1390
		K5W5	Huai River	18402	8059	533
		Total		170744	82329	5313
	Total			367846	161010	8847
East China Sea	H1	H1C1	Chang River	26835	8301	408
		H1C2	Chang River	182772	70741	4305
		H1C3	Chang River	184600	79111	4709
		H1C4	Chang River	182814	57297	4307
		H1C5	Chang River	90761	37377	2540
		H1C6	Chang River	101408	29388	2378
		H1C7	Chang River	41815	11479	1169
		H1C8	Chang River	140066	50145	3509
		Total		951070	343840	23324
	H2	Direct Discharge	Etc.	173953	55238	3391
	Total			1125023	399077	26715
Total				1839612	724807	45296

- Numerical value: Inflow pollutant loads (COD_{Mn}(kg/day), T-N(kg/day) and T-P(kg/day)) of each river basin
- Objective of model calculation: Daily pollutant loads

(9) Boundary conditions

The grid positions where the boundary conditions were set followed the hydrodynamics model. For the water quality model, the boundary concentrations were given to the boundary meshes as fixed values. Some discrete observed values were interpolated to the targets between the time-spaces and the fixed boundary concentrations were set.

3. Point of view about the water quality prediction simulation of Northwest Pacific using the hydrodynamics model and the water quality model

The environmental influence to Northwest Pacific caused by economic actions of Japan, China, Korea, and Russia was evaluated using the hydrodynamics model and the water quality model. The outputs of calculation based on present situation and scenarios referent by the land-based pollution load model were used. The procedure is shown below.

3.1 Scheme of water quality prediction simulation

The whole scheme of water quality prediction simulation is shown in Figure 3.1.

Firstly, calculation in order to acquisition present marine pollution was carried out with reconstructed Ocean Simulation model. Inflow and land based pollution loads were adopted the calculation results by the land-based pollution load model.

Secondly, in the prediction cases, the distributions of water quality concentrations were calculated using the loads in the future according to the scenarios that were used to calculate the land-based pollution load. Each scenario was constructed in comparison of 'economic development (increase of pollution loads)' and 'diffusion of mitigation measures for conservation of water quality environment (decrease of loads discharged)'.

If river discharges changed in the scenarios, hydrodynamics model had to be rerun under the new conditions, because river discharges changed the density distributions in the ocean and that changed ocean current distributions. Since river discharges were supposed not to change in this study, the output of current for the present situation by the hydrodynamics model was used in the future scenarios.

Thirdly, water qualities were calculated under each condition of loads from land to sea that was estimated according to each scenario, using model and parameters that were confirmed adequately.

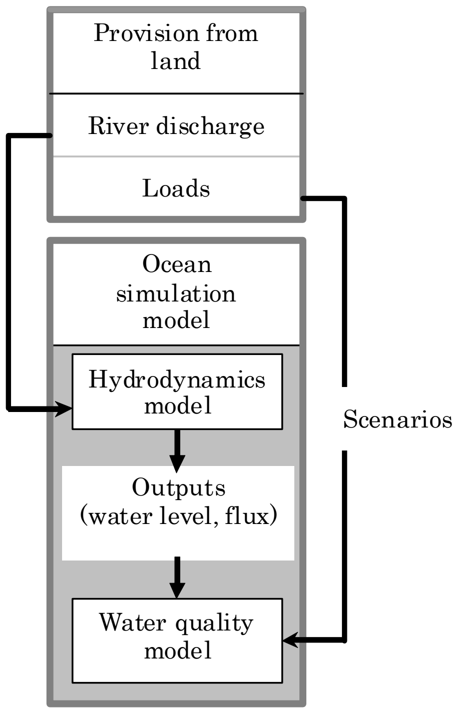


Figure 3.1 Scheme of water quality prediction simulation

The example of comparisons between observational results at the fixed points of the Japanese coast (shown in Figure 3.2) and the numerical calculation results are shown in Figure 3.3. Maximum values (max), minimum values (min), and mean values (ave) during the observation period of 2005 are shown respectively.

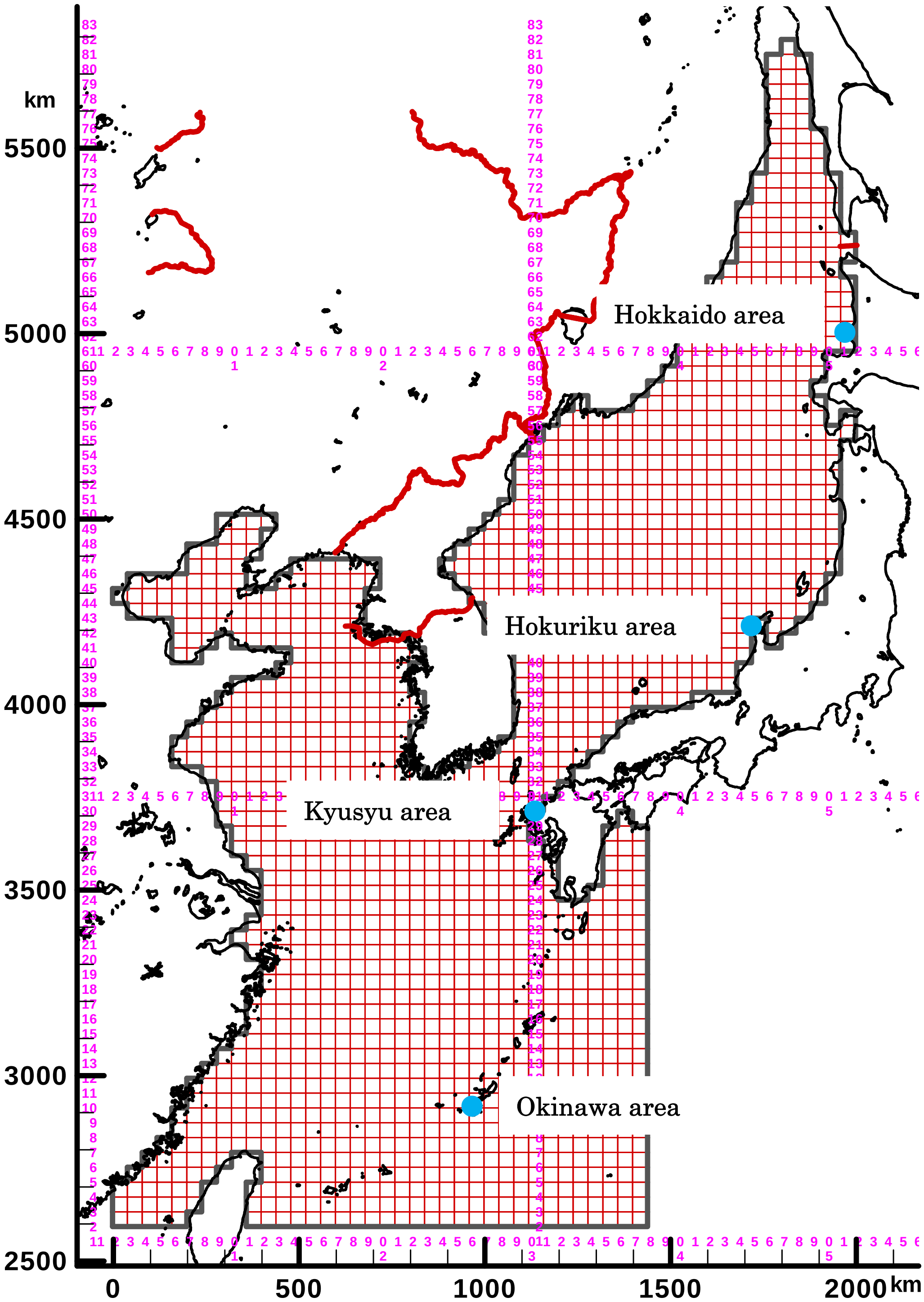


Figure 3.2 Points where actual measurement value and calculation value were compared

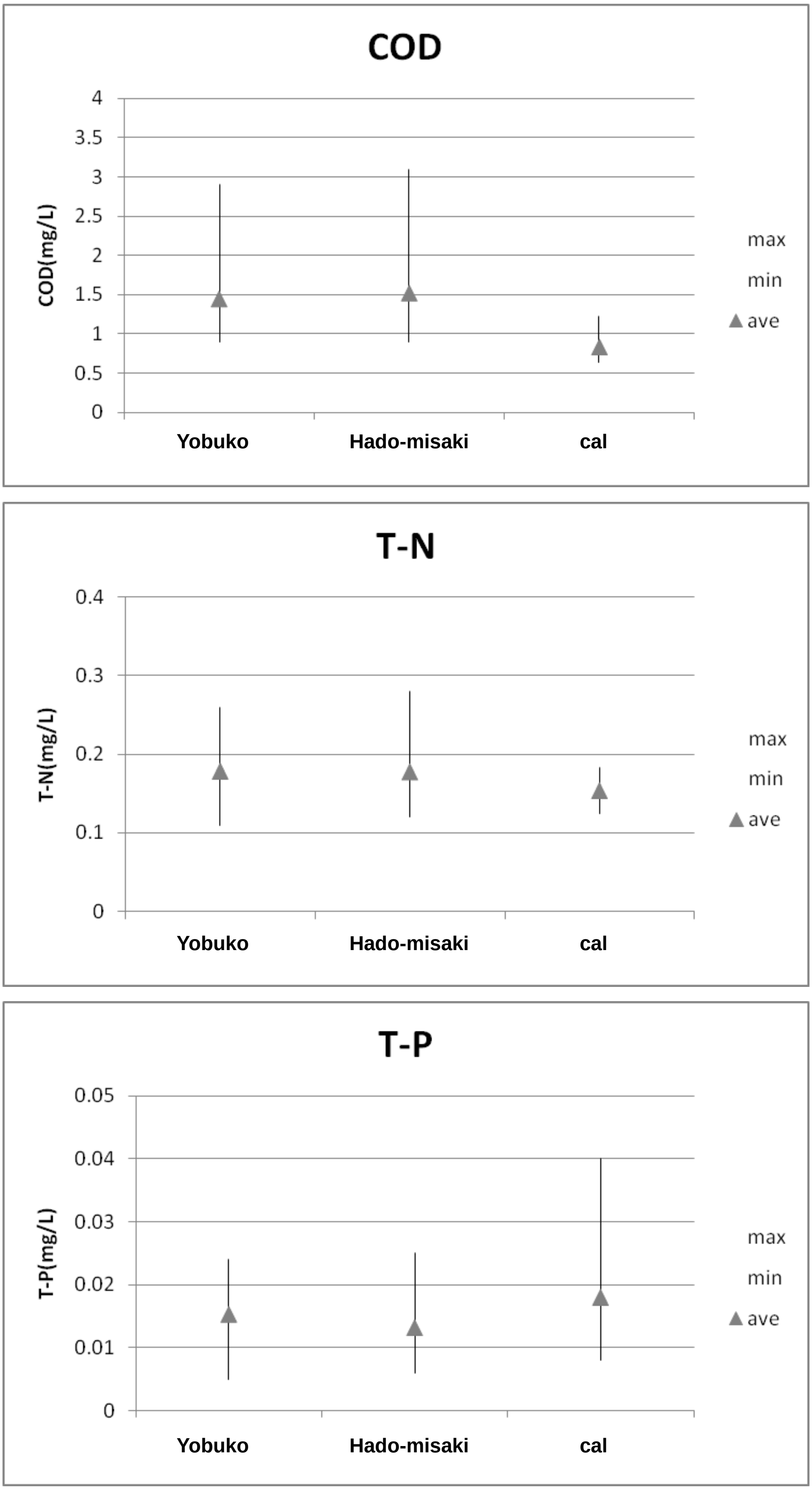


Figure 3.3 Comparison between observed values and calculation values in Kyusyu area

Observed value source: Public water area water quality measurement result

The initial conditions for prediction calculations were determined like this: Outputs of previous step year (5 years ago (case of Figure 3.4)) of the target year were distributed to the all areas and the all levels. The calculation of each year was carried out for 3 cycles (1 cycle was equivalent to 1 year.) until the annual level of water quality became steady. Then the outputs of the last cycle (for 1 year of the 3rd cycle) was evaluated. Figure 3.4 shows an example of the method of making initial conditions in each year. Figure 3.5 shows outputs under 2005 conditions.

Calculation of present situation (2005 target) (3 cycles)

↓

Calculation on a scenario for 2010 (3 cycles)

↓

Calculation on a scenario for 2015 (3 cycles)

↓

Calculation on a scenario for 2020 (3 cycles)

↓

Calculation on a scenario for 2025 (3 cycles)

↓

Calculation on a scenario for 2030 (3 cycles)

Figure 3.4 An example of method of making initial conditions in each year

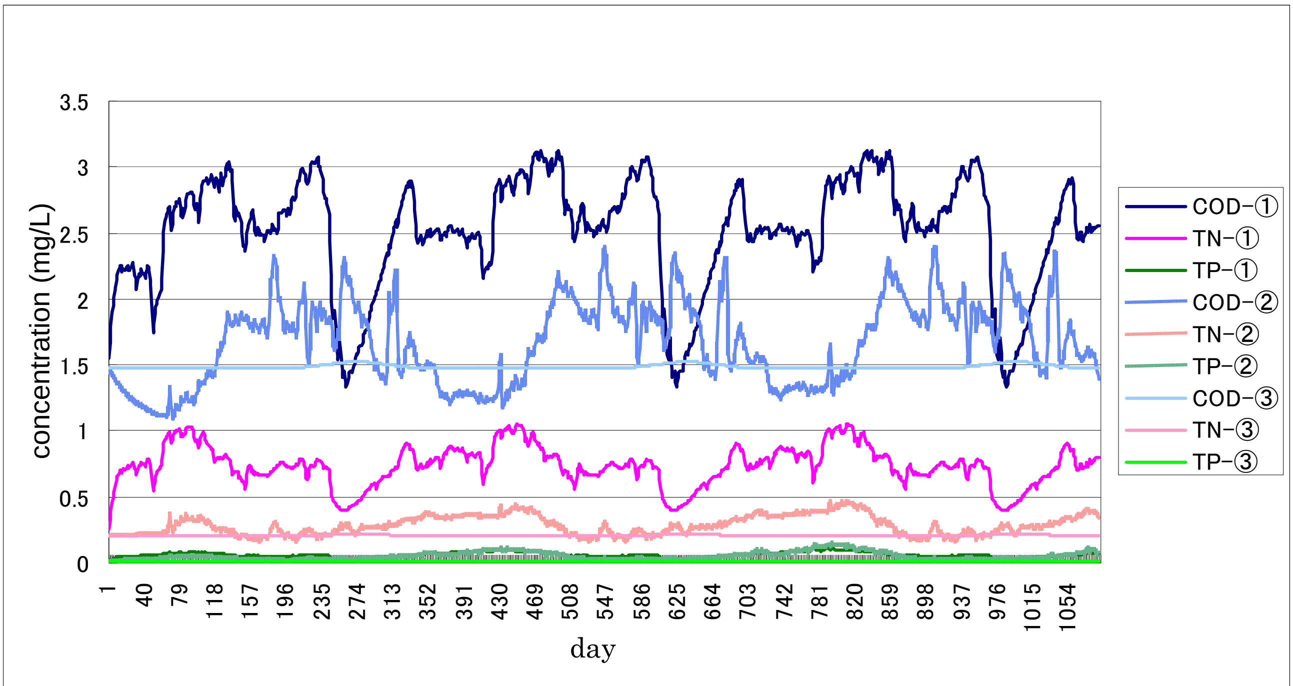


Figure 3.5 Outcomes (COD_{Mn}, TN, TP) from calculation during 3 cycles in 2005

(①river mouth of the Chang River, ②120km offshore of ①, ③southern boundary)

Appendix 3 Examination example of water quality in Northwest Pacific based on future scenarios

The example of future water quality prediction in the Northwest Pacific by using the land-based pollution load model and the water quality simulation model on Reference2 is shown below.

1. Setting of scenarios to predict pollutant loads

1.1 Target year

The target year was assumed to be 2030.

1.2 Values of future frame

Future frames (2005-2030) were estimated by the following procedures.

(1) Population

Future population was set up based on World Statistics published by Statistics Bureau, Ministry of Internal Affairs and Communications. These values were shown in Table 1.

Table 1 Estimates of future population at each country

	China	Korea	Japan	Russia
1950	554,760	18,859	84,115	102,702
1960	657,492	25,003	94,302	119,906
1970	830,675	31,922	104,665	130,392
1980	998,877	38,124	117,060	138,655
1990	1,149,069	42,869	123,611	148,615
2000	1,269,962	46,780	126,926	147,423
2010	1,351,512	48,673	127,176	140,318
2020	1,421,260	49,221	122,735	132,407
2030	1,458,421	48,411	115,224	123,915
2040	1,448,355	45,961	105,695	115,782
2050	1,408,846	42,327	95,152	107,832

*United Nations, World Population Prospects

(2) Industrial Production

Future industrial production was predicted to predict industrial wastewater discharge. Future industrial production was predicted based on growth in GDP. Future industrial production in GDP was predicted for China and Korea because the industrial production of Japan and Russia set up having no change in the future.

Future growth in GDP of China and Korea was set by the results of prediction conducted by Japan Center of Economic Research. Future growth in GDP of each country was shown in Table 2.

Table 2 Predicted values of GDP growth rate

	2001-2005 (experience)	2006-2020	2021-2030	2031-2040	2041-2050
China	9.3	5.5	3.8	1.9	0.9
Korea	4.4	3.4	1.7	0.8	0.1

*Japan Center of Economic Research

(3) Livestock numbers and land area

Frames for nonpoint sources load such as livestock numbers and land area were kept constant till 2030 using the data in 2005.

(4) Wastewater treatment plant coverage

Decrease of pollutant loads by promoting sewer system infrastructure was predicted. The five scenarios were assumed according to the stage of completion of the measure in the future as follows.

Scenario1: Keep the current situation

Scenario2: In case of coverage ratio of sewerage system reaches to 100% in urban areas by 2030 (100% of industrial discharges meeting regulations by 2030)

Scenario2’: In case of coverage ratio of advanced wastewater treatment reaches to 100% in urban areas by 2030

Scenario3: In case of coverage ratios of sewerage system and domestic wastewater treatment tank (in urban and rural areas) reaches to 100% by 2030

Scenario3’: In case of coverage ratios of advanced wastewater treatment and advanced domestic wastewater treatment tank (in urban and rural areas) reaches to 100% by 2030

Wastewater treatment plant coverage among the scenarios in 2030 was shown in Table 3.

Table 3 Wastewater treatment plant coverage among the scenarios in 2030

		Scenario1	Scenario2	Scenario2'	Scenario3	Scenario3'
China	Urban area	63%	100%	(Advanced treatment) 100%	100%	(Advanced treatment) 100%
	Rural area	0%	0%	0%	100%	(Advanced treatment) 100%
Japan	Urban area	81%	100%	(Advanced treatment) 100%	100%	(Advanced treatment) 100%
	Rural area	61%	61%	61%	100%	(Advanced treatment) 100%
Korea	Urban area	95%	100%	(Advanced treatment) 100%	100%	(Advanced treatment) 100%
	Rural area	0%	0%	0%	100%	(Advanced treatment) 100%
Russia	Urban area	15%	100%	(Advanced treatment) 100%	100%	(Advanced treatment) 100%
	Rural area	15%	15%	15%	100%	(Advanced treatment) 100%

2. Calculaton of the land-based pollutant loads

The scenario-based pollution loads in 2030 by the above-mentioned setup were shown in Figure 1 to Figure 4. These were calculated by the calculation model of the land-based pollutant loads.

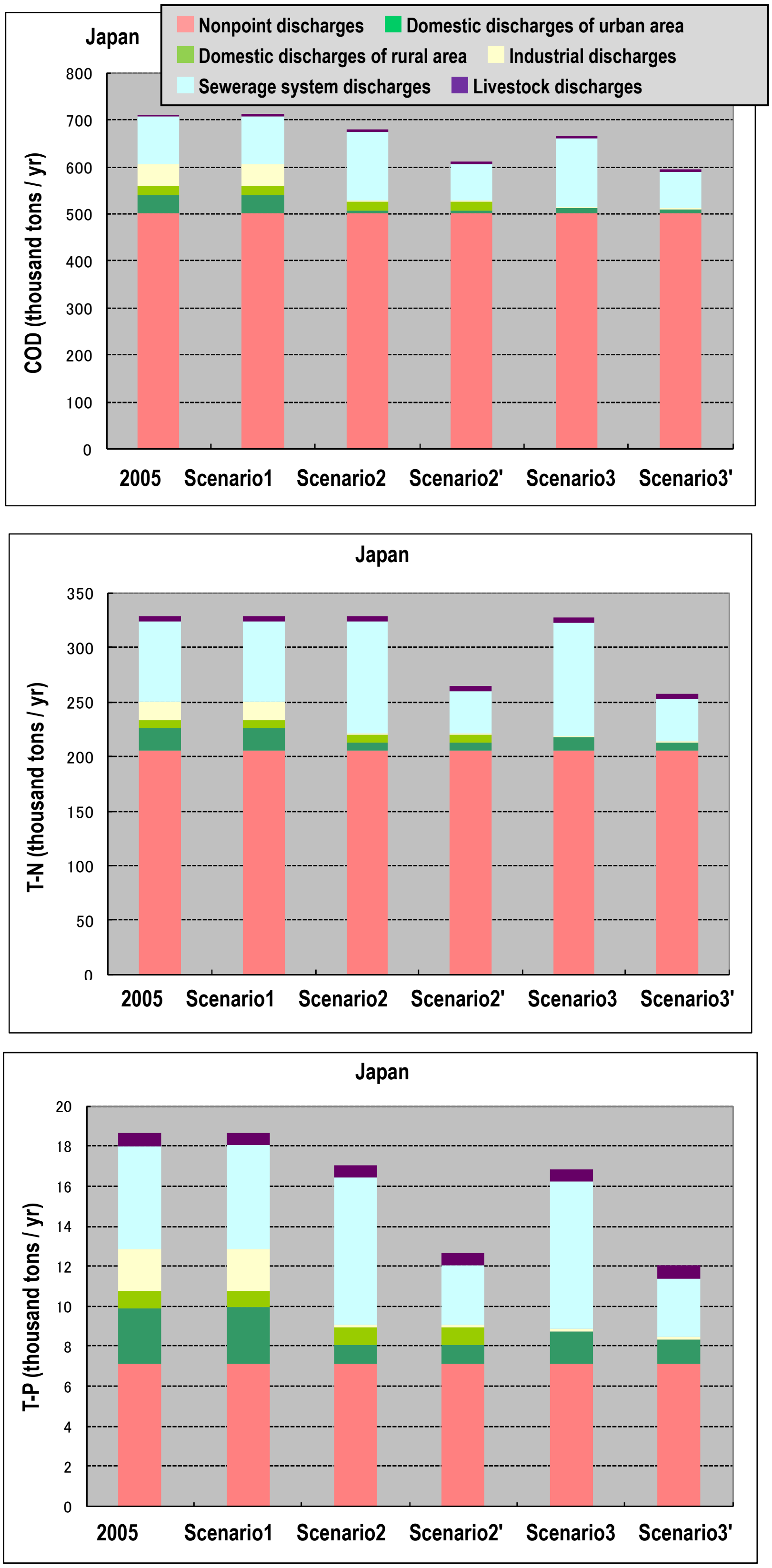


Figure 1 Scenario-based pollution loads in 2030 (Japan) (COD_{Mn}, T-N, T-P)

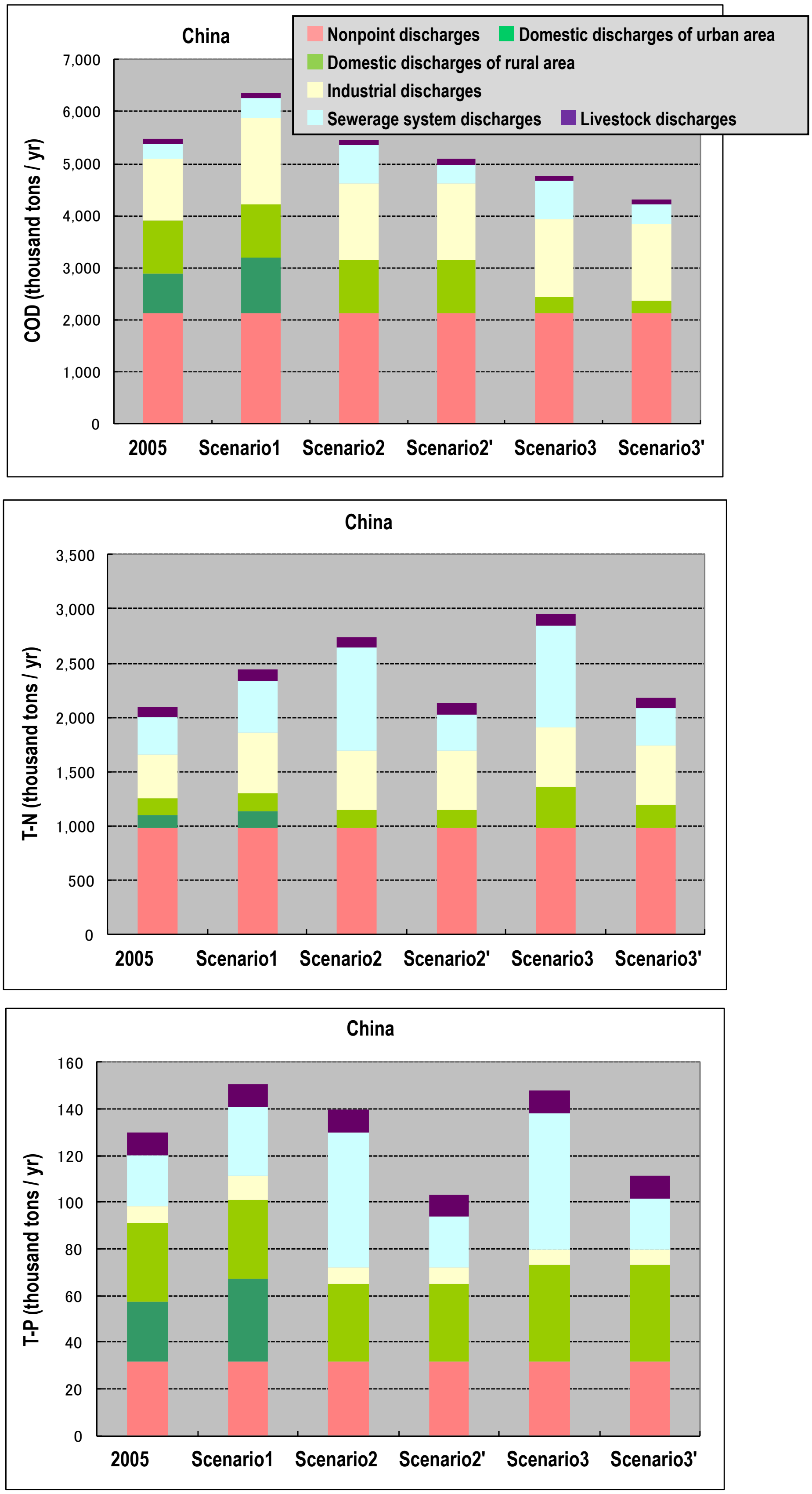


Figure 2　Scenario-based pollution loads in 2030 (China) (COD_{Mn}, T-N, T-P)

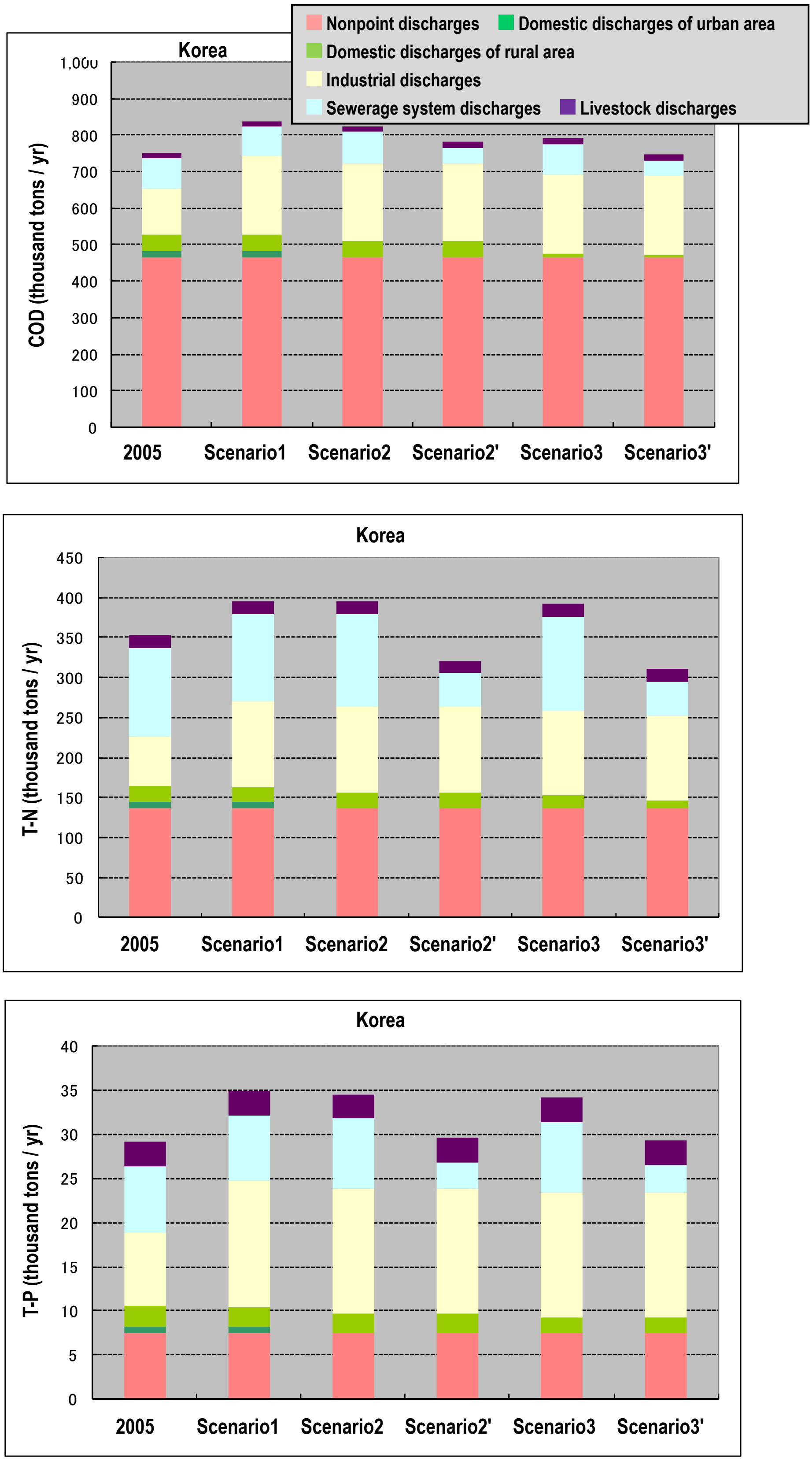


Figure 3 Scenario-based pollution loads in 2030 (Korea) (COD_{Mn}, T-N, T-P)

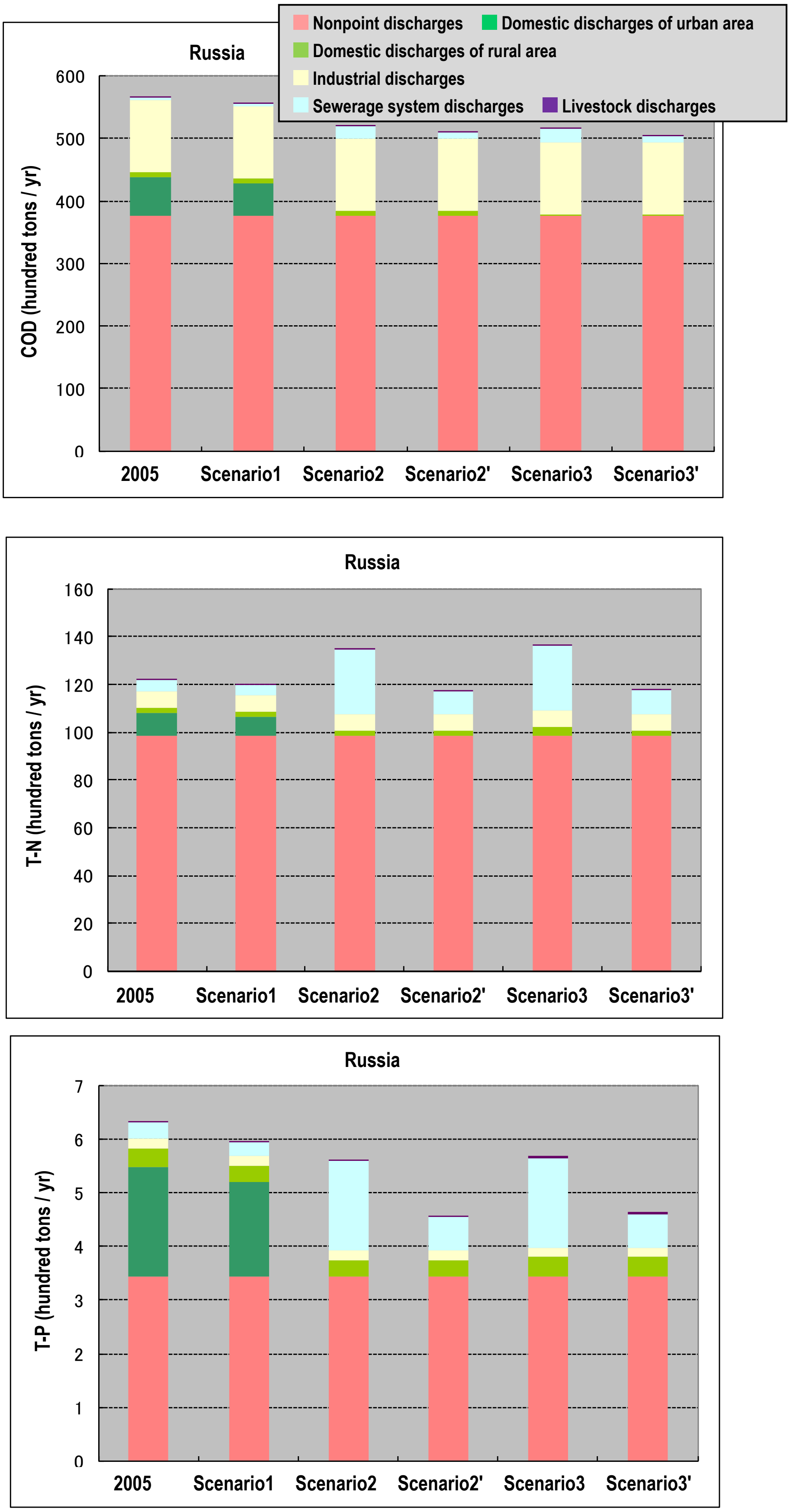


Figure 4 Scenario-based pollution loads in 2030 (Russia) (COD_{Mn}, T-N, T-P)

3. Prediction of water quality in the future

The changes in the water quality concentration in the estuaries of the main rivers in each country were arranged to evaluate the changes in the loading amount from land areas. The nine points at where the concentrations picked up were shown in Figure 5.

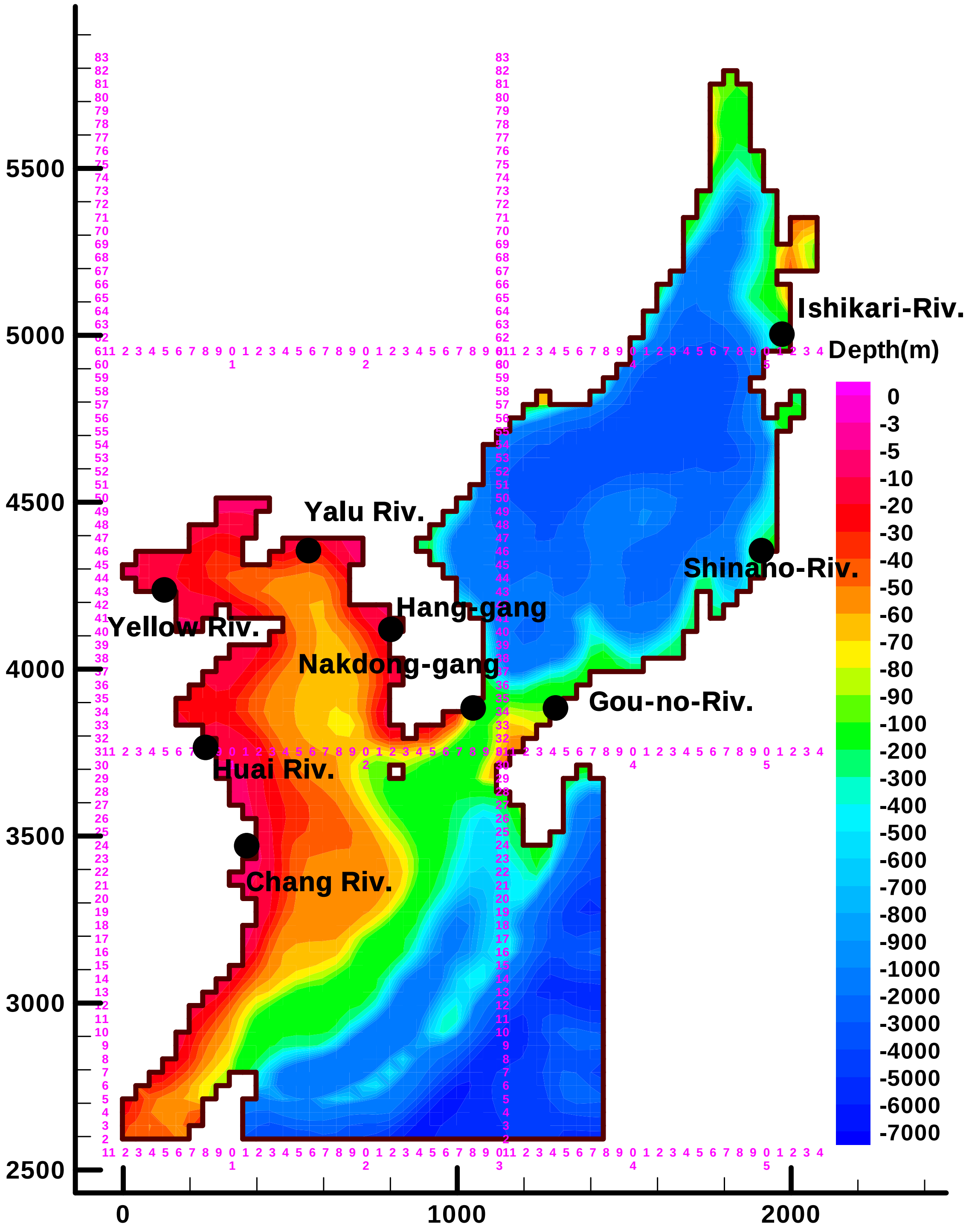


Figure 5　Points where comparative concentration was done for scenario evaluation

The calculated land-based pollution loads were used as input data of water quality simulation model on Reference2. In doing so, the water quality at each point was predicted.

(1)Prediction of future water quality at each point

The predicted values of yearly averaged concentrations in the estuaries in each scenario calculation in 2030 were shown in Figure 6. "-0l" in figure means surface results and "-05" means the fifth layer (roughly by 10m) results. Moreover, the predicted values of monthly averaged concentrations in the surface in Chang River, Yellow River, Hang-gang, and the Shinano River were shown in Figure 7.

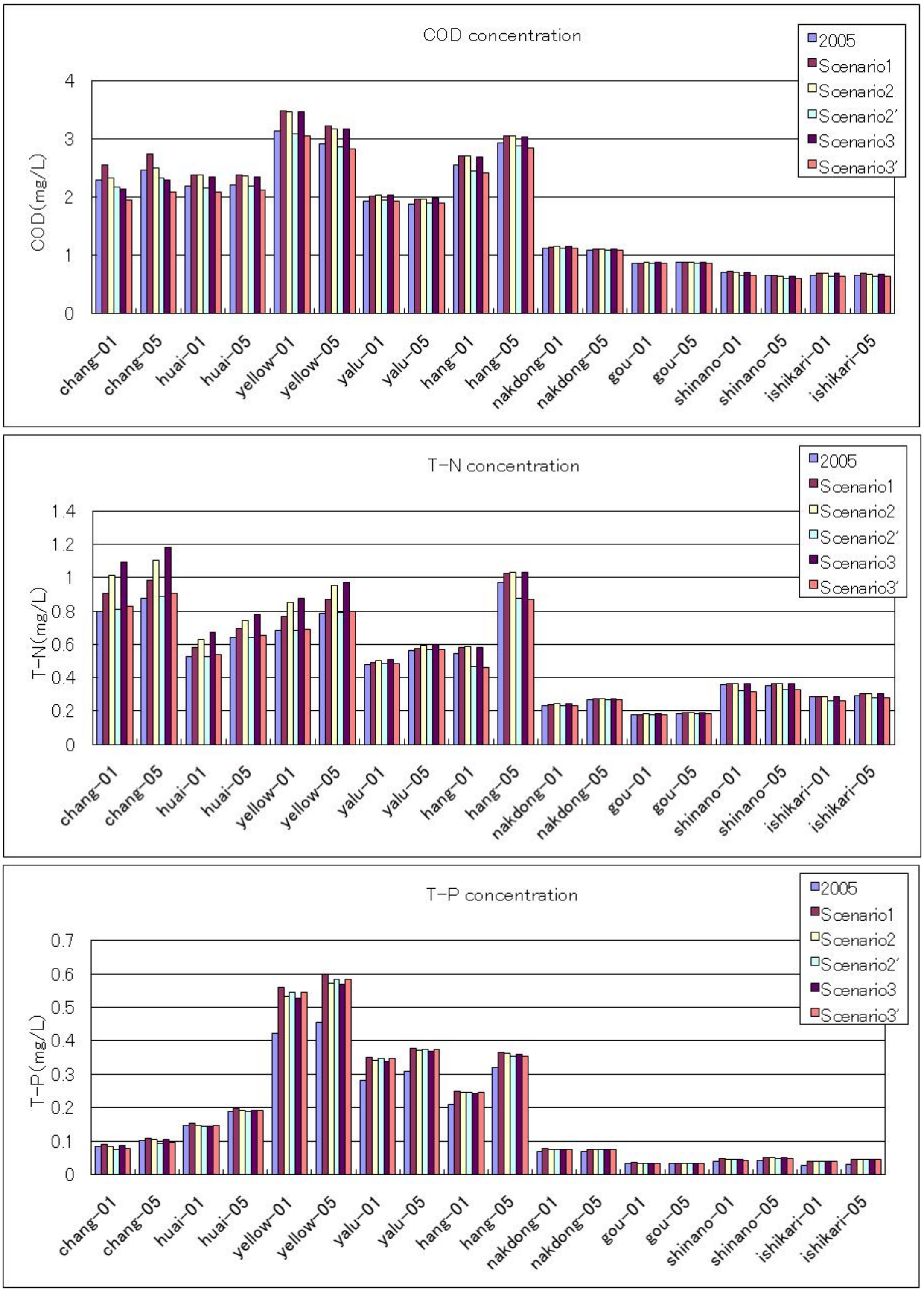


Figure 6 Predicted values of yearly averaged concentrations in coastal areas in each scenario calculation (2030) (COD_{Mn}, T-N, T-P)

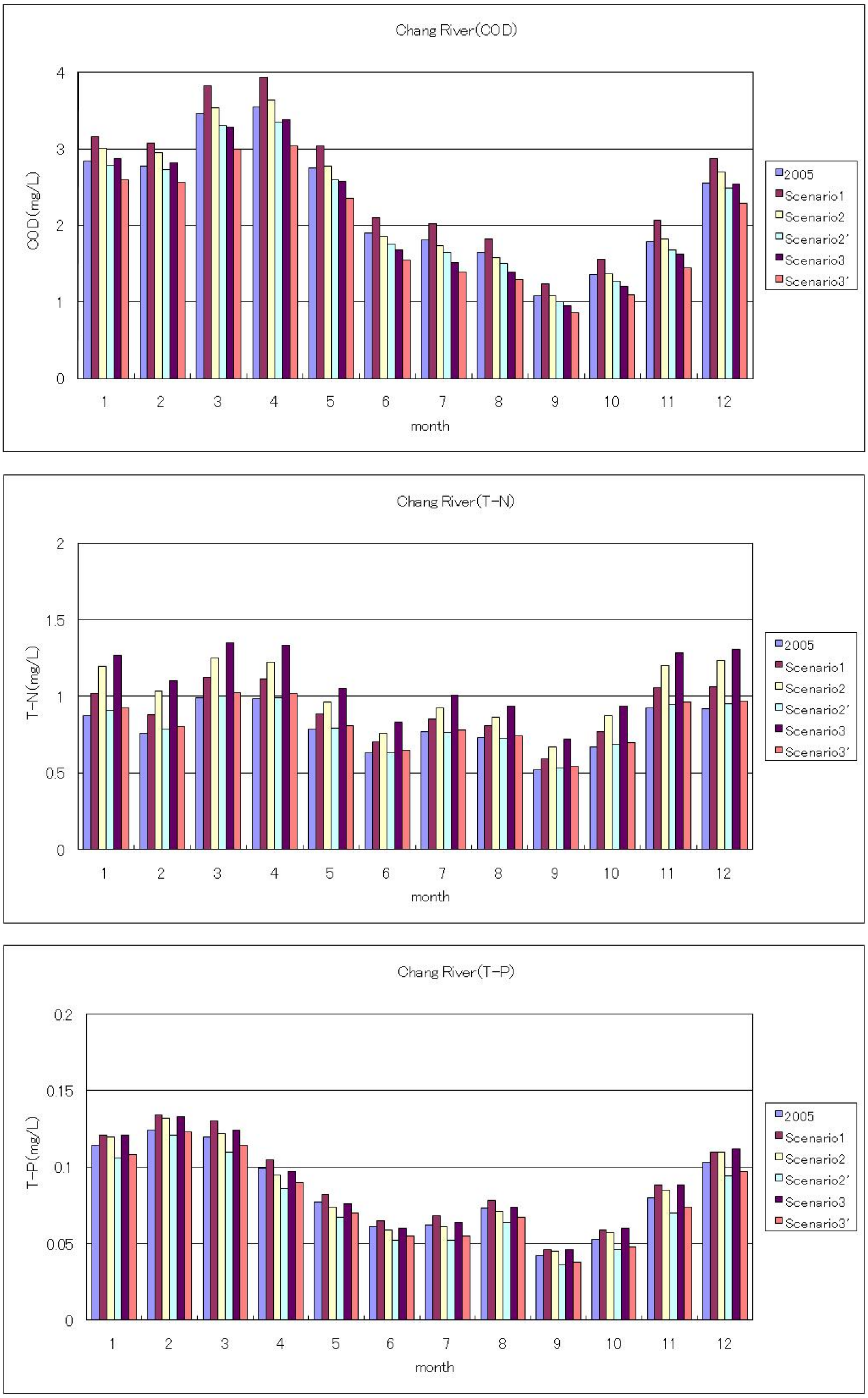
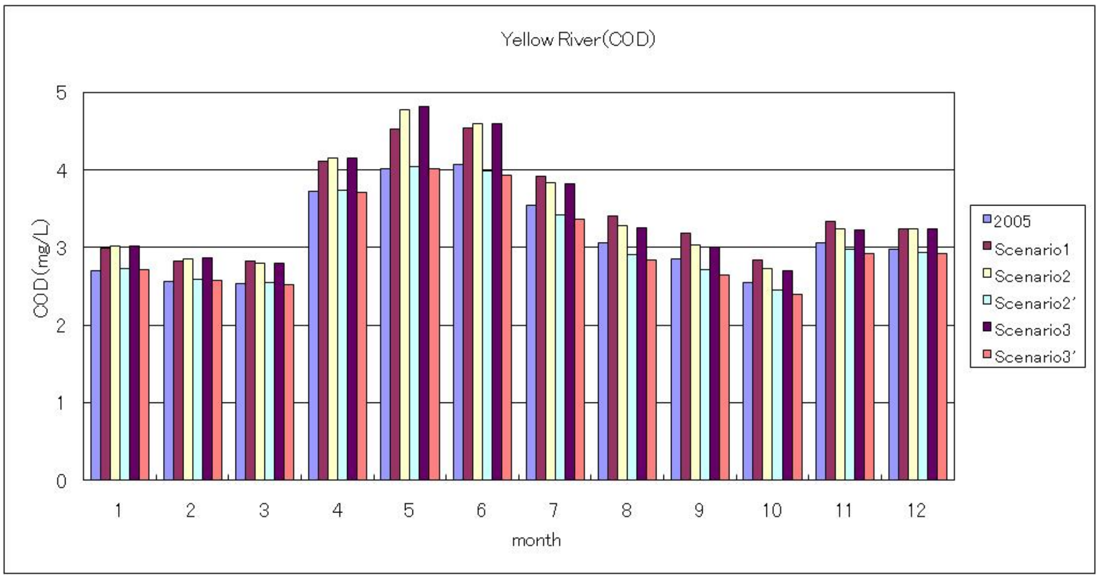
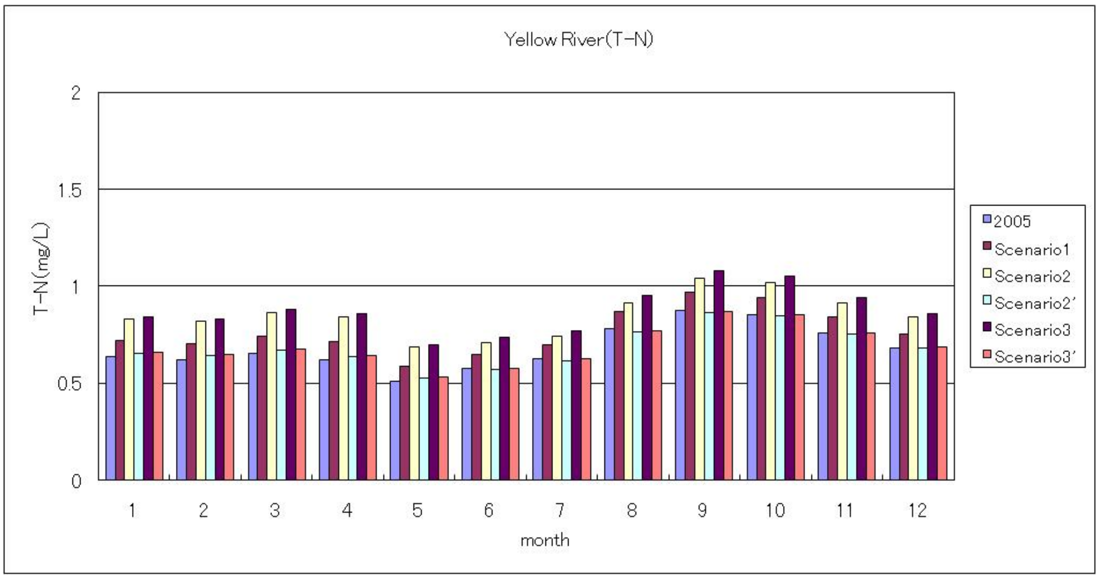


Figure 7(1) Predicted values of monthly averaged concentrations in Chang River (2030) (COD_{Mn}, T-N, T-P)





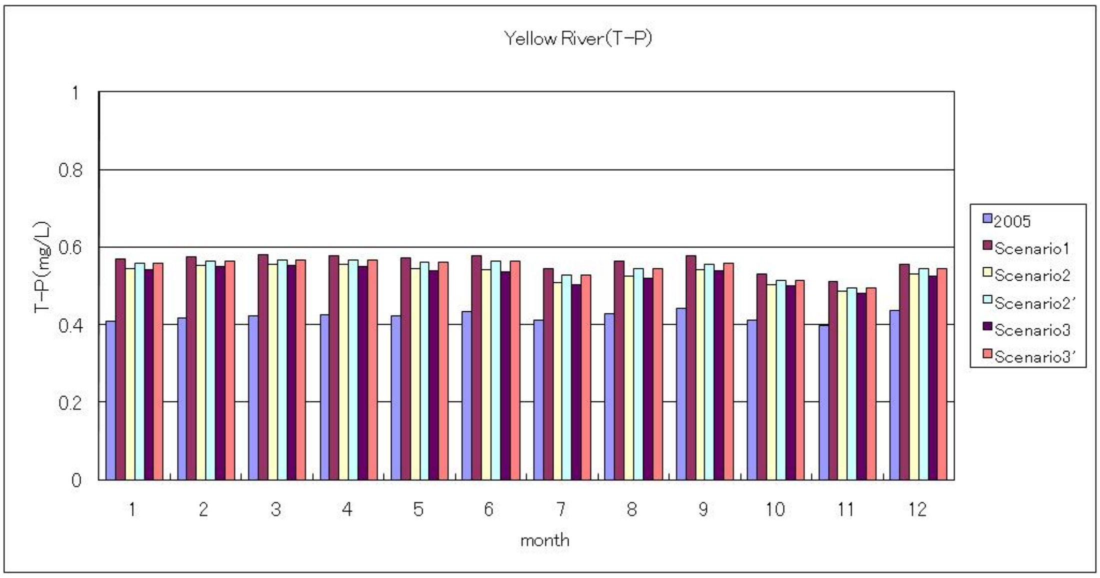
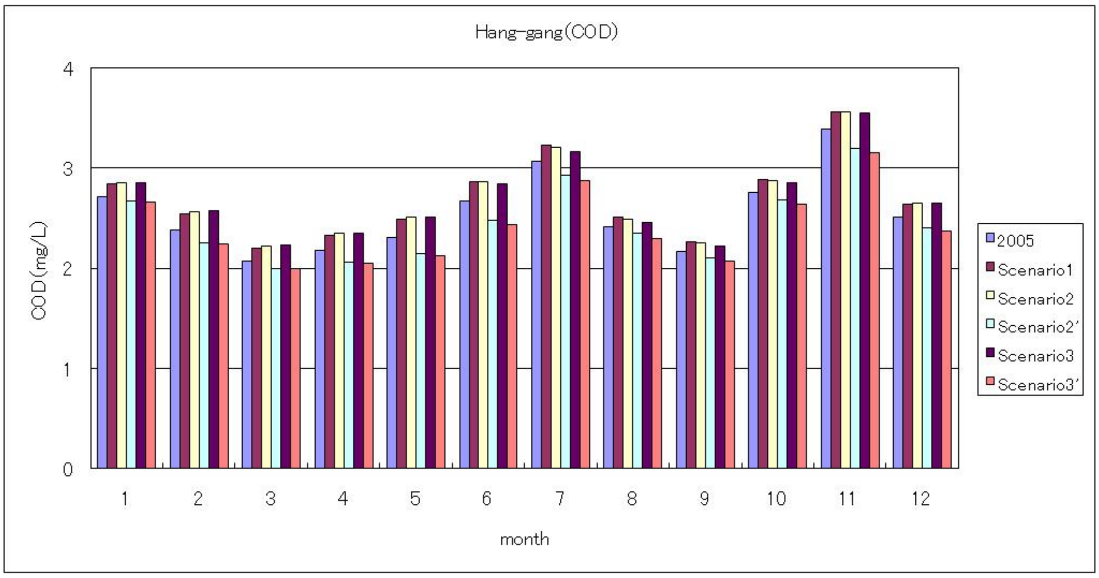
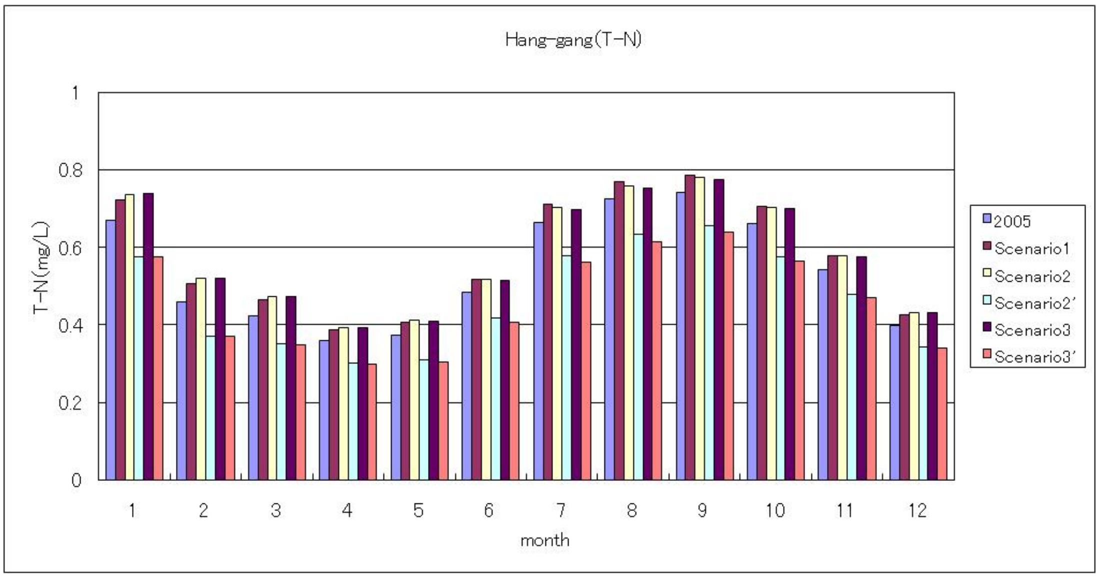


Figure 7(2) Predicted values of monthly averaged concentrations in Yellow River (2030) (COD_{Mn}, T-N, T-P)





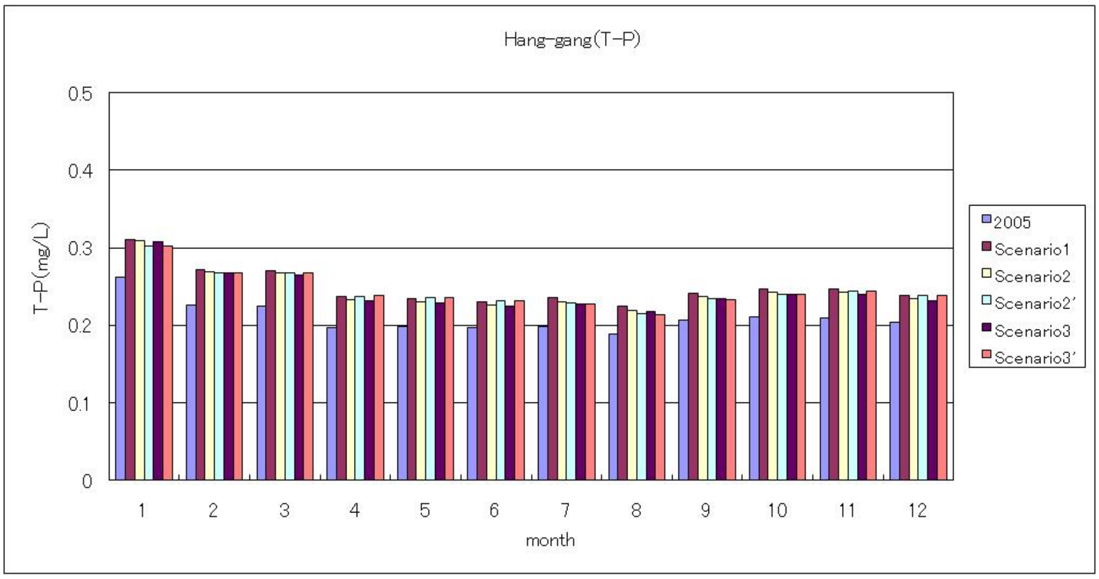
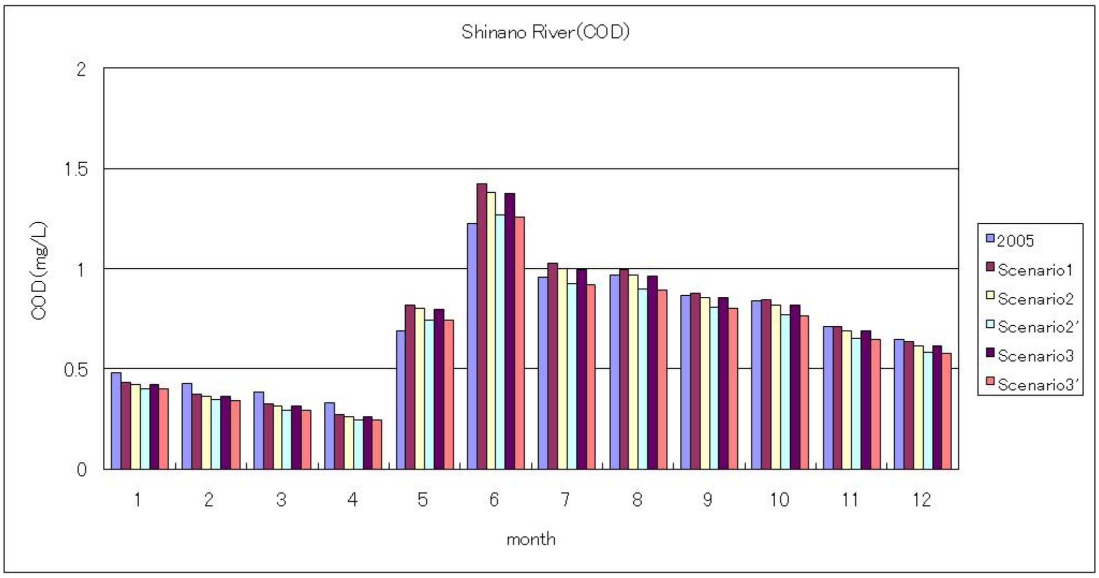
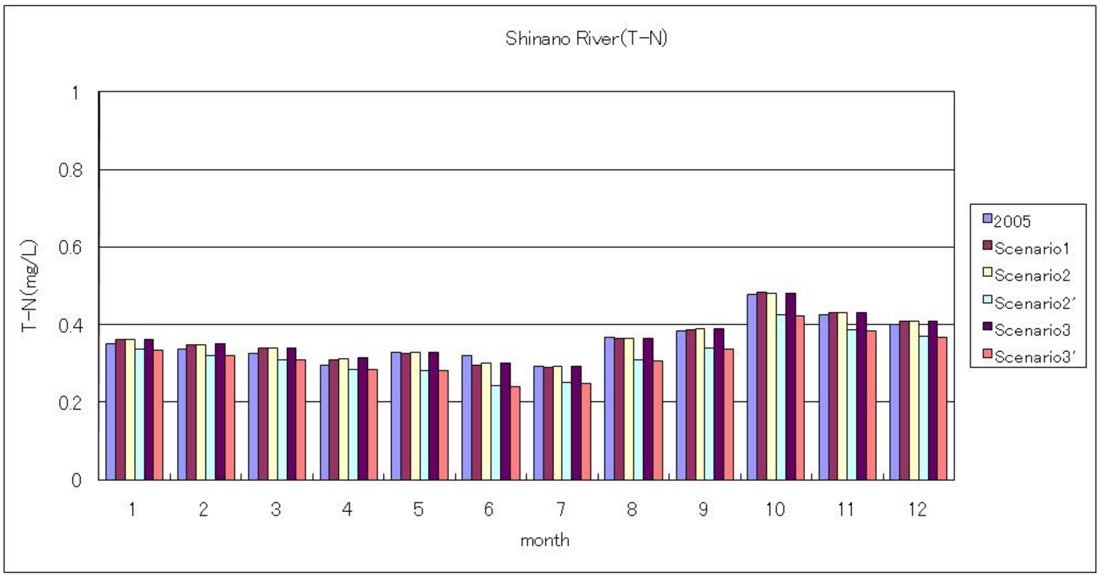


Figure 7(3) Predicted values of monthly averaged concentrations in Hang-gang (2030) (COD_{Mn}, T-N, T-P)





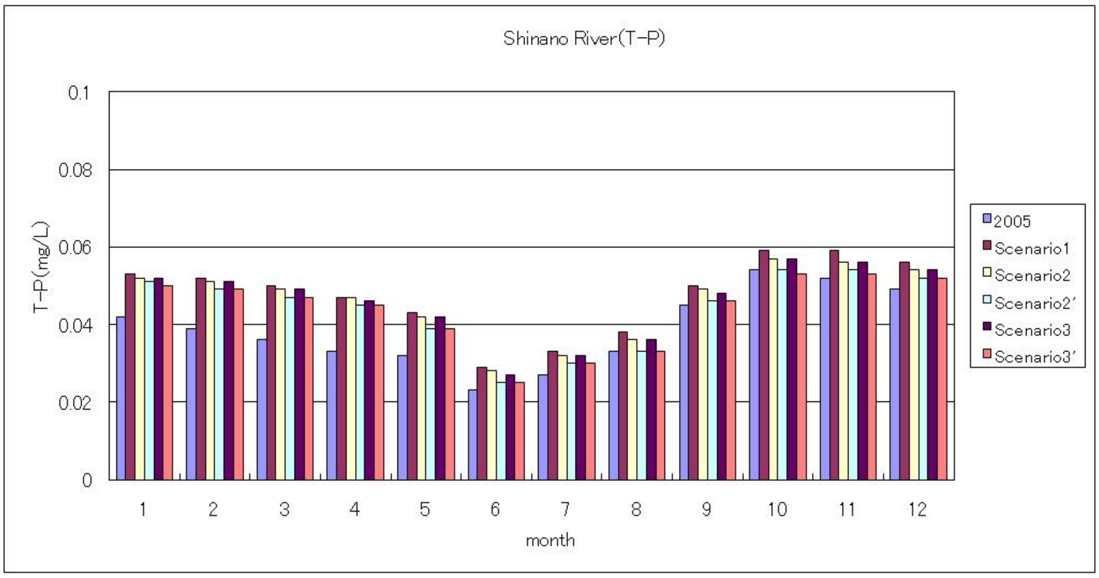


Figure 7(4) Predicted values of monthly averaged concentrations in Shinano River (2030) (COD_{Mn}, T-N, T-P)

(2)Predicted water quality distributions in Northwest Pacific

The distributions of water quality concentrations (COD_{Mn}, T-N, T-P) of the first layer (surface) in respective scenario calculations at 2005 and 2030 were shown in Figure 8 to Figure 10.

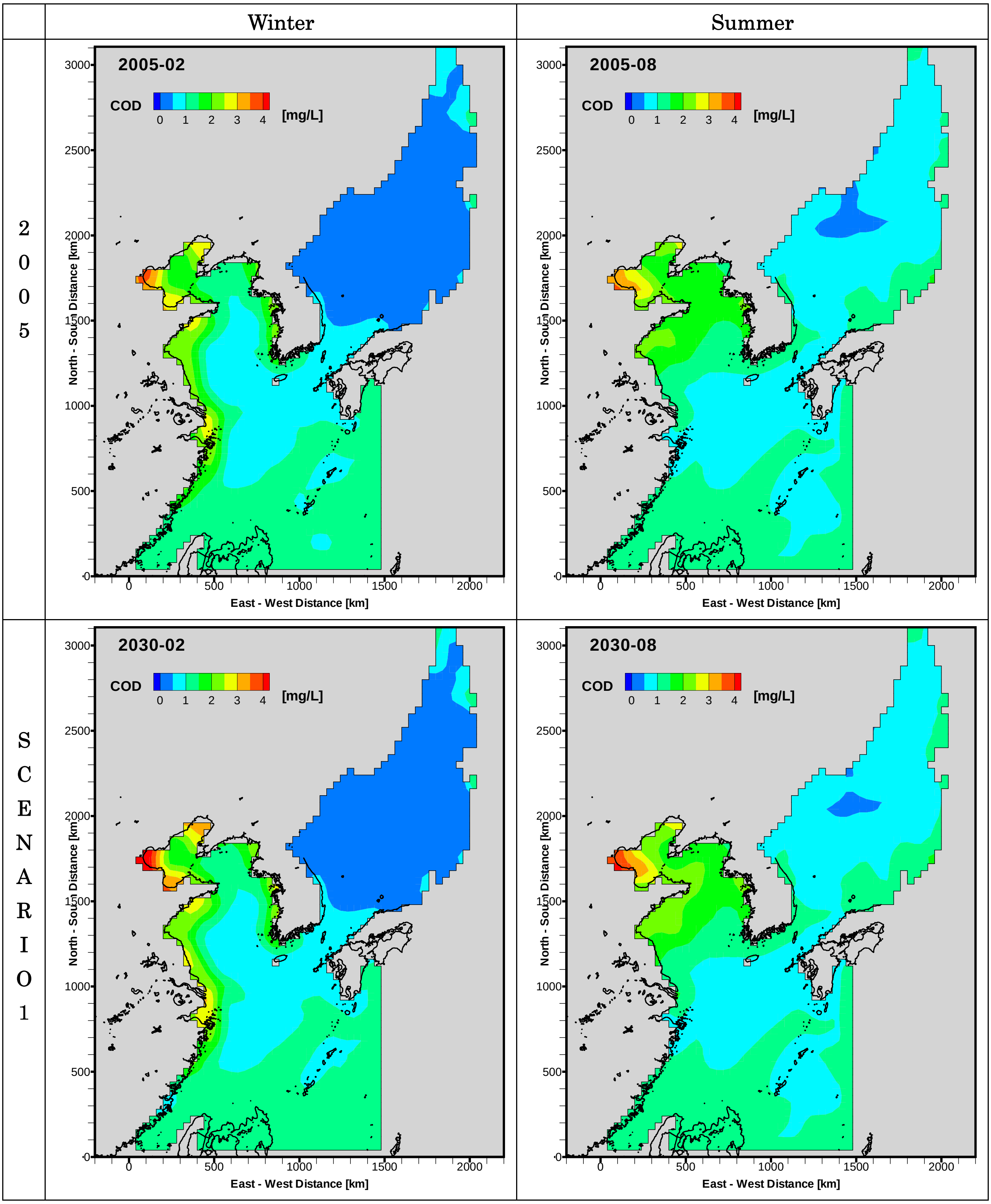


Figure 8(1) Water quality distributions (2005, Scenario 1 in 2030, COD_{Mn})

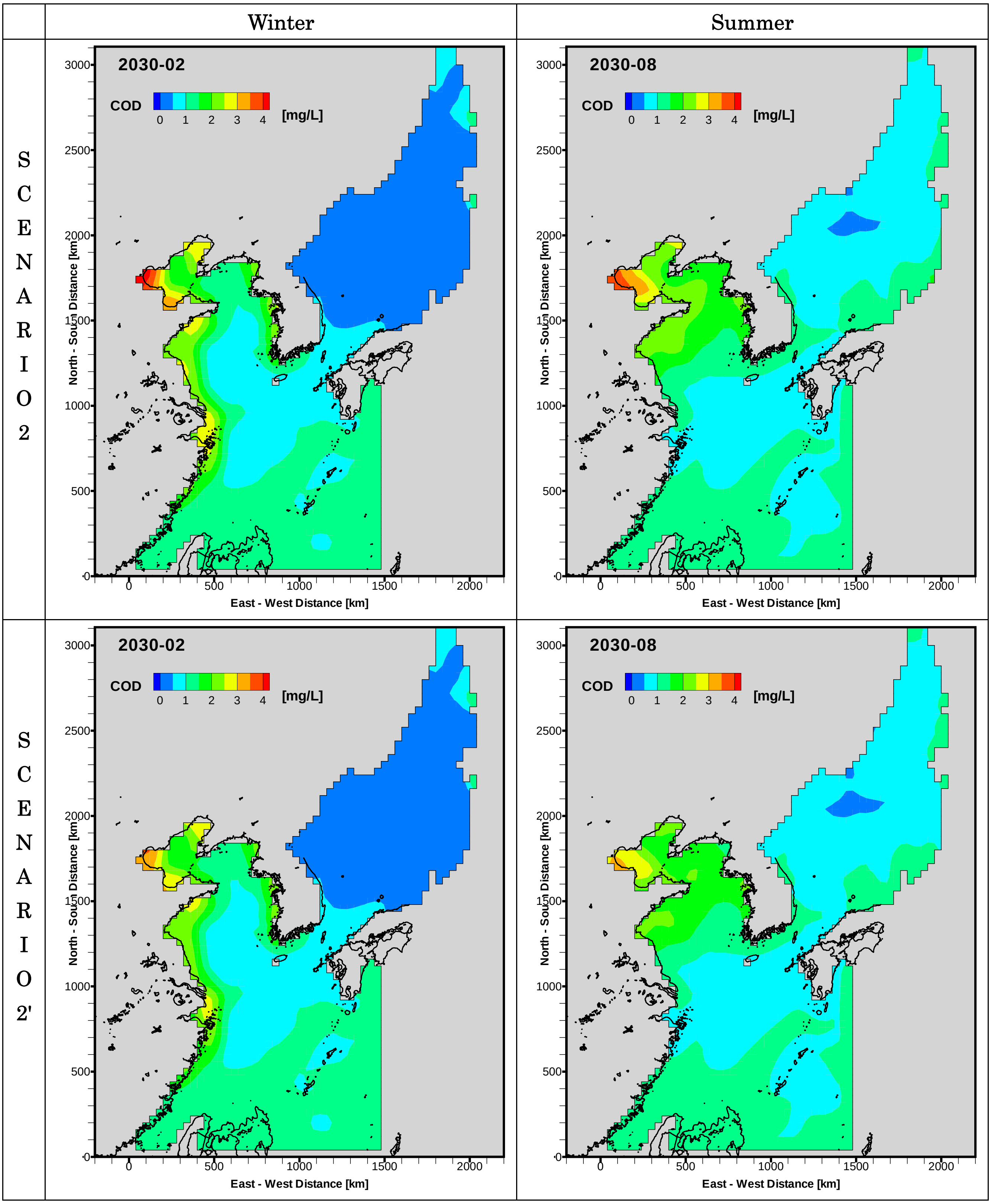


Figure 8(2) Water quality distributions (Scenario 2 and Scenario 2' in 2030, COD_{Mn})

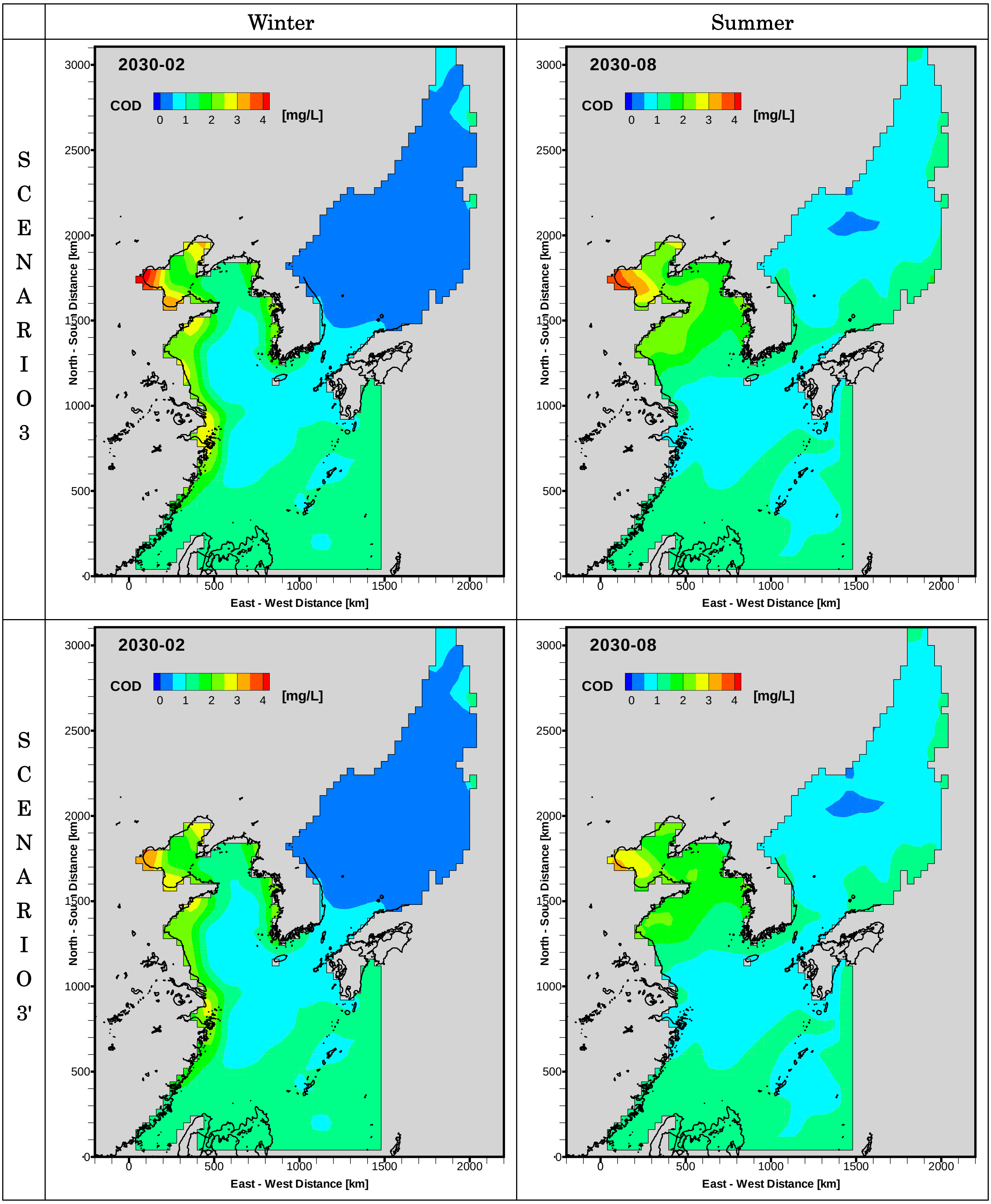


Figure 8(3) Water quality distributions (Scenario 3 and Scenario 3' in 2030, COD_{Mn})

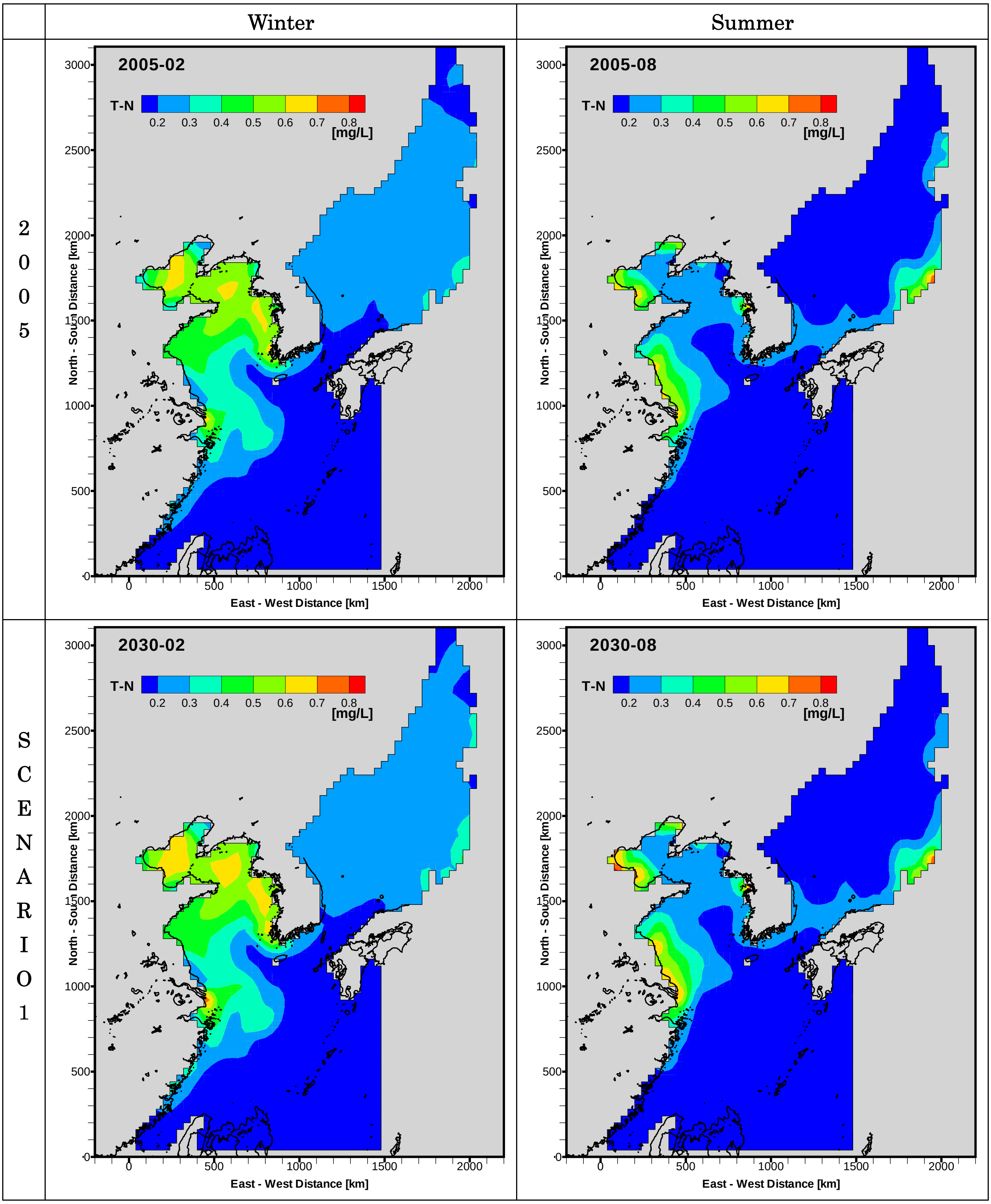


Figure 9(1) Water quality distributions (2005, Scenario 1 in 2030, T-N)

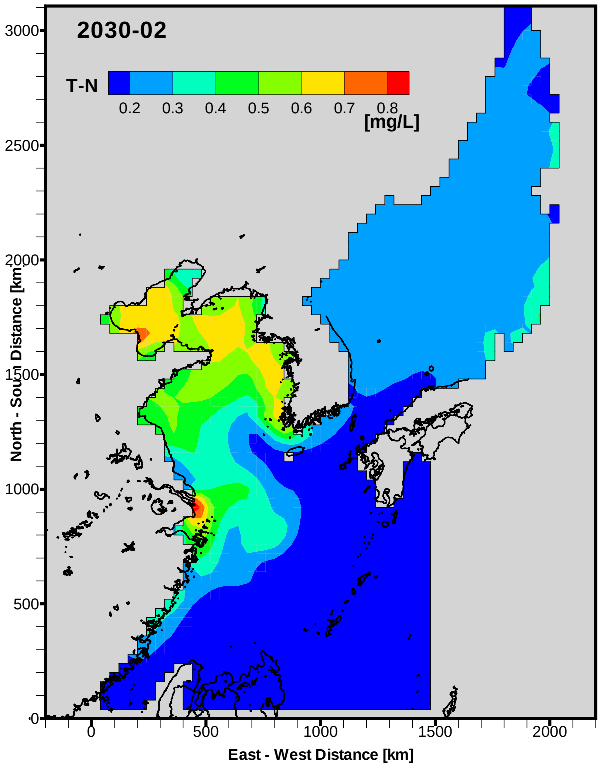
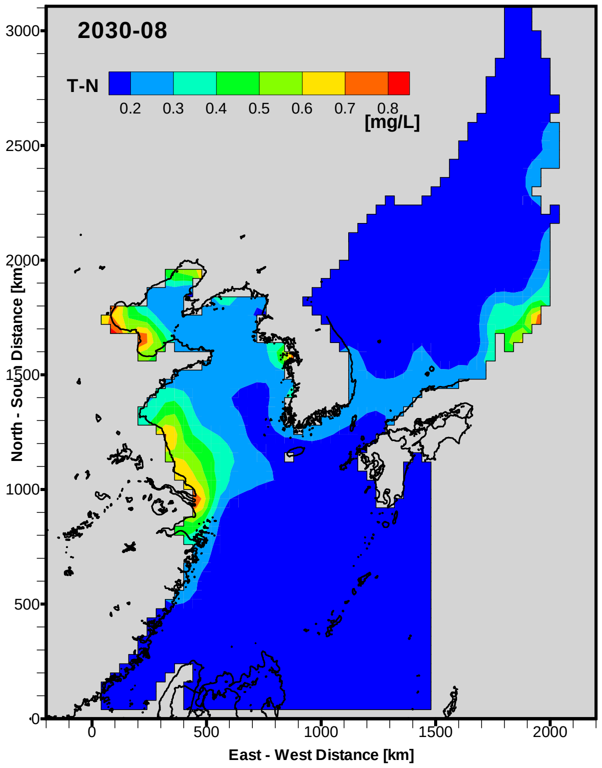
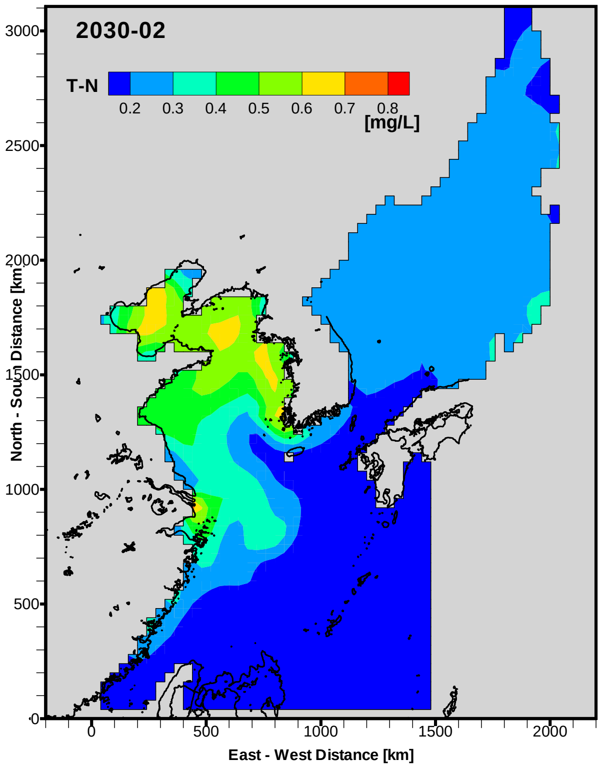
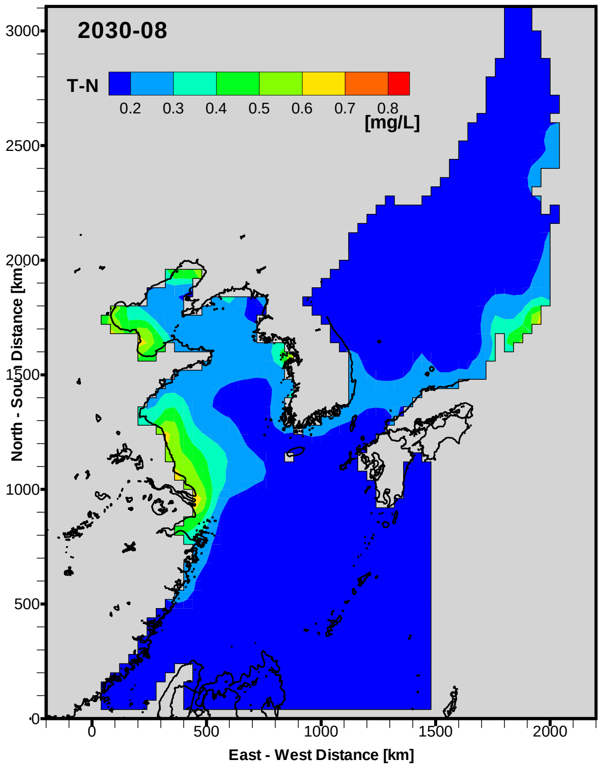
	Winter	Summer
SCENARIO 2		
SCENARIO 2'		

Figure 9(2) Water quality distributions (Scenario 2 and Scenario 2’ in 2030, T-N)

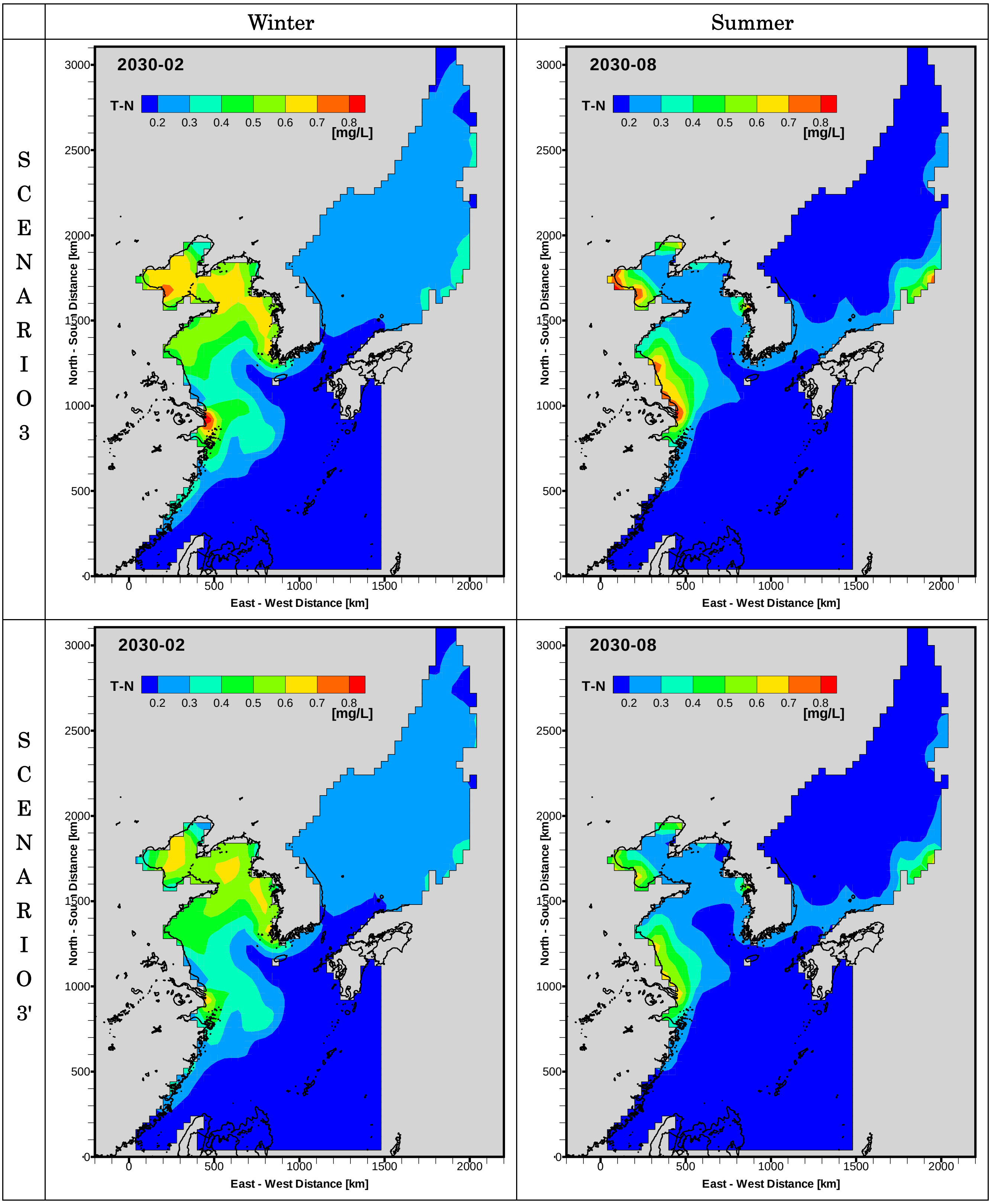


Figure 9(3) Water quality distributions (Scenario 3 and Scenario 3’ in 2030, T-N)

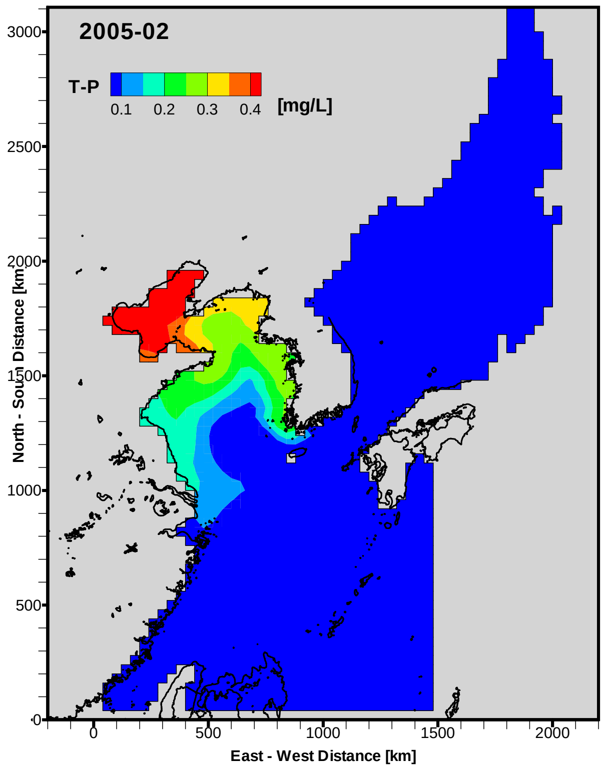
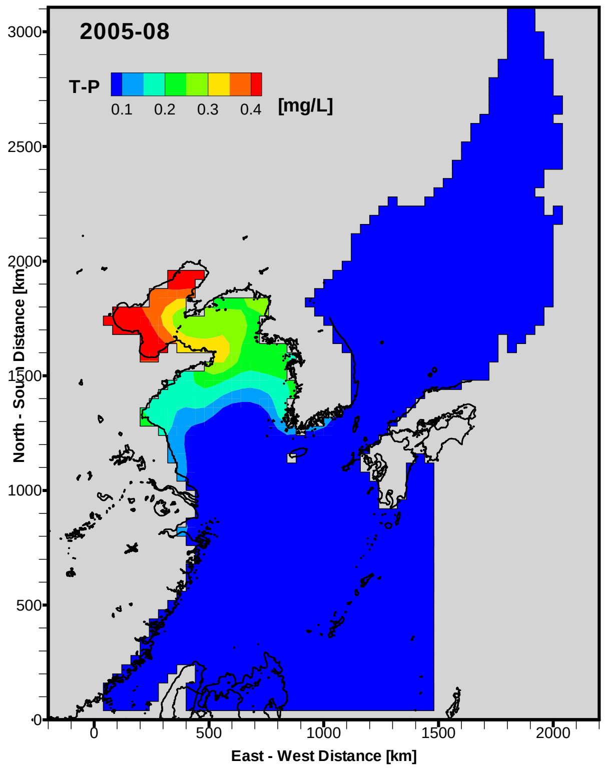
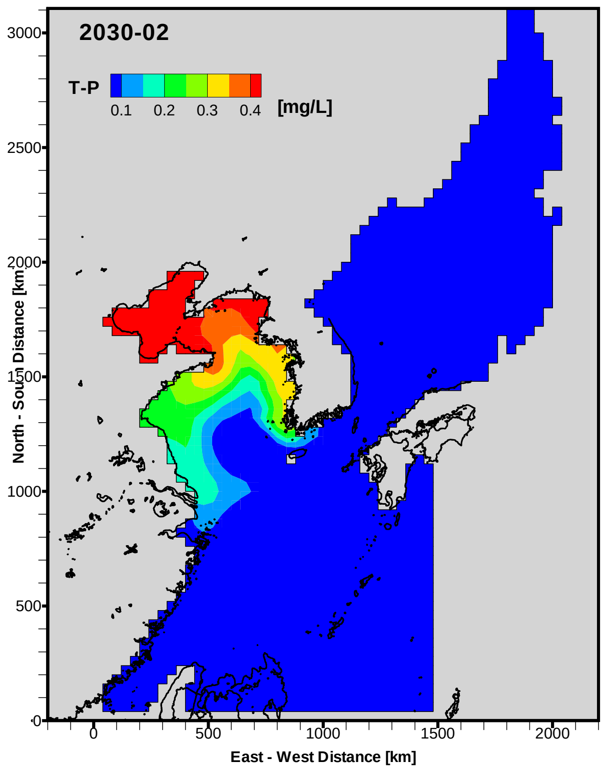
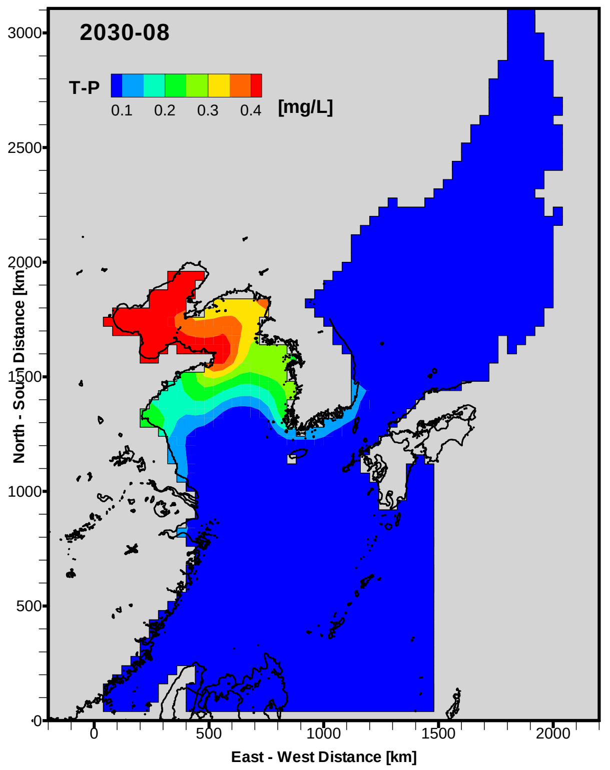
	Winter	Summer
2005		
SCENARIO 1		

Figure 10(1) Water quality distributions (2005, Scenario 1 in 2030, T-P)

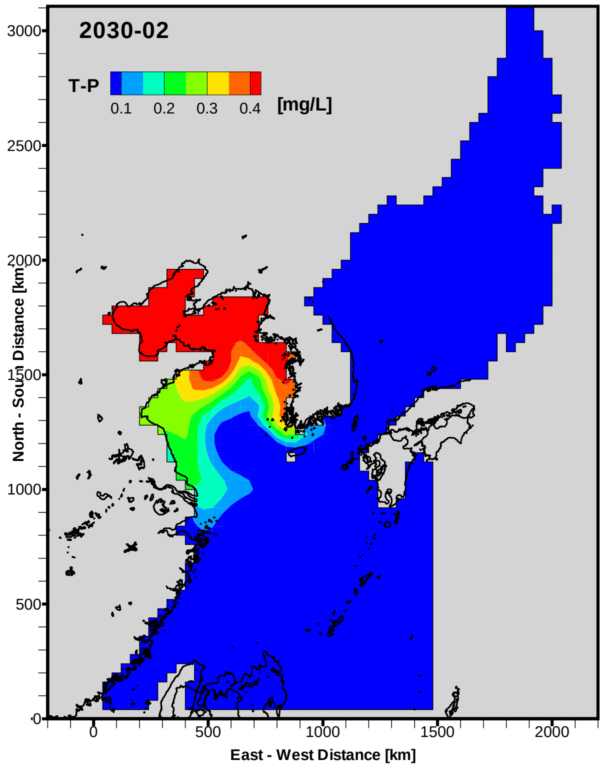
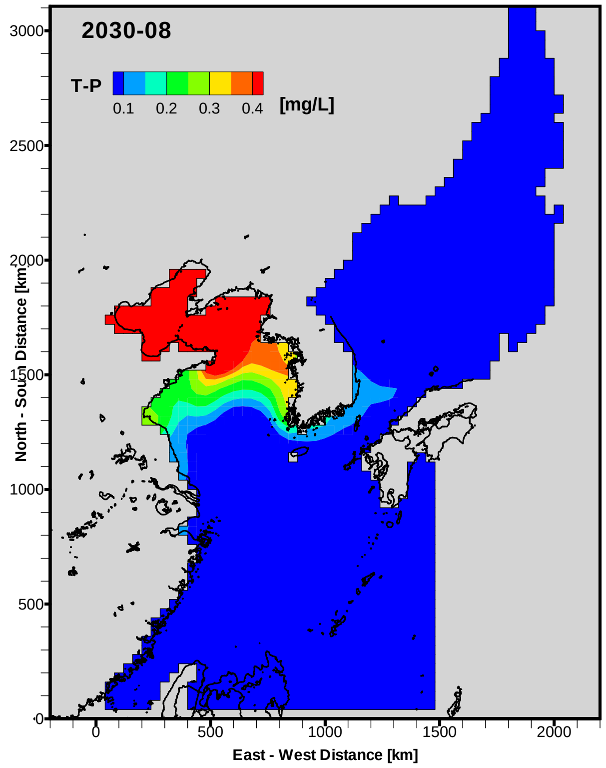
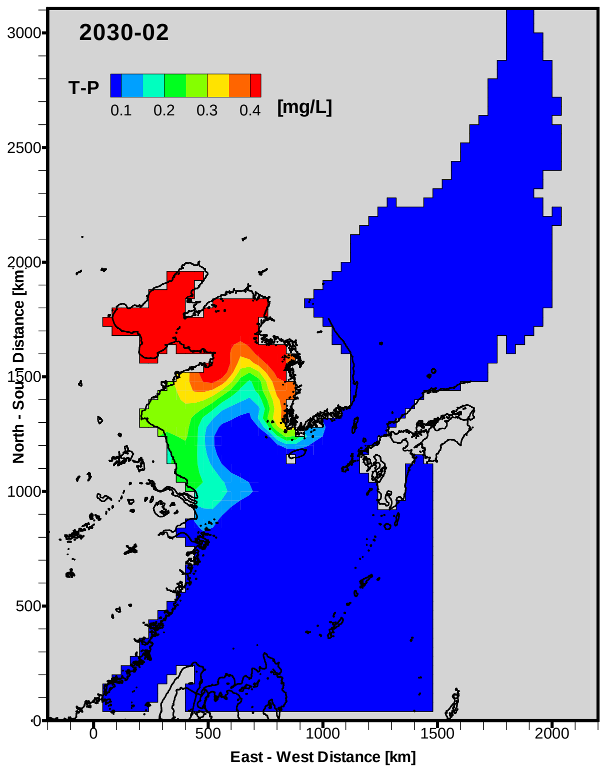
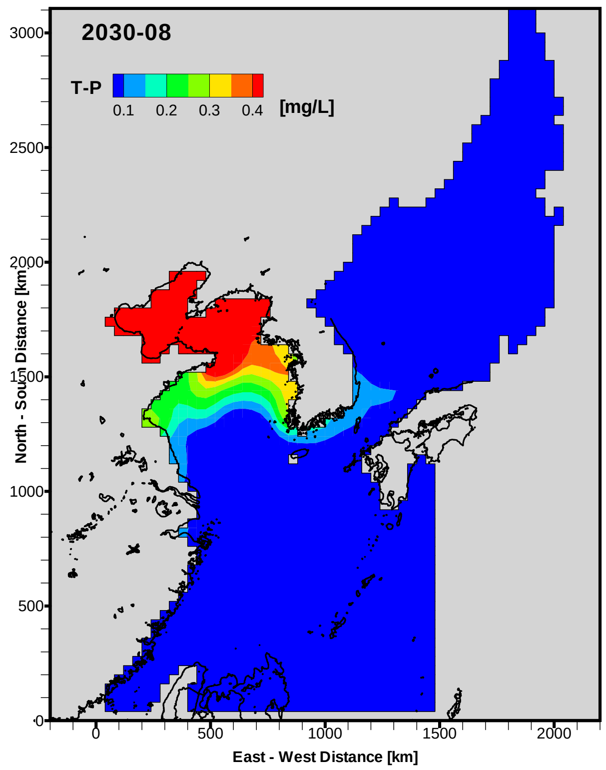
	Winter	Summer
SCENARIO 2		
SCENARIO 2'		

Figure 10(2) Water quality distributions (Scenario 2 and Scenario 2' in 2030, T-P)

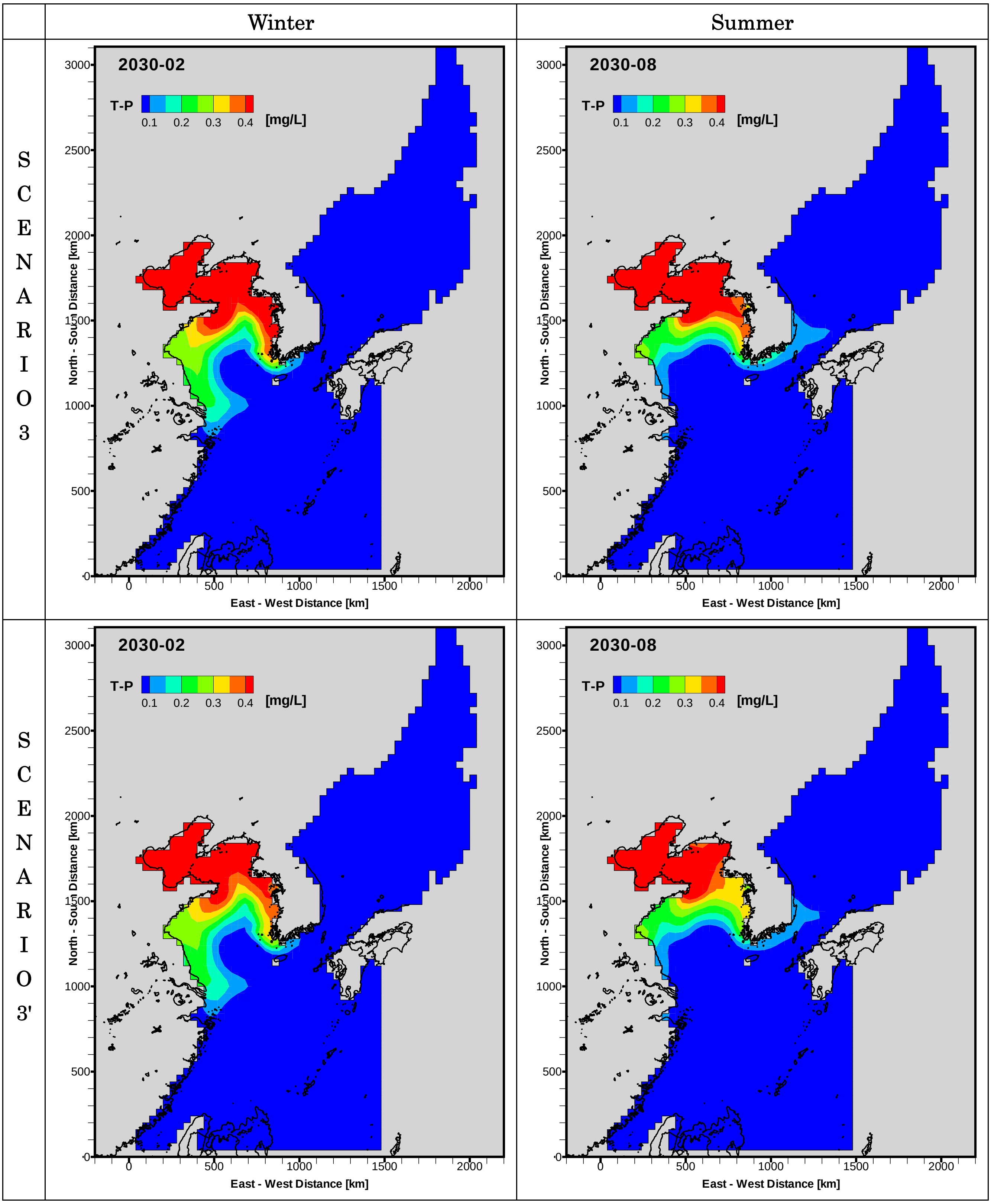


Figure 10(3) Water quality distributions (Scenario 3 and Scenario 3’ in 2030, T-P)