Chapter 11 REGULATION OF TOTAL MAXIMUM DAILY LOADING

1. Introduction

1.1 The outcome and problems of Water Pollution Control Law

The Water Pollution Control Law legislated in 1970 defined Environmental Water Quality Standards (EWQS) as targets of water quality management and regulated effluent quality from industries to comply with the targets. In addition to these regulations, prefectural governments legislated stringent effluent standards.

As shown in previous chapters, quality of waters for the parameters on human health improved remarkably. The quality of river waters for the parameters on living environment also improved as shown in Fig.11-1. However, there have been little improvement in lake water. Percent compliance for estuaries was generally good even at the start of the regulation, whereas little improvement has been noted. As shown in Fig.11-2, large estuaries in Japan like Tokyo Bay, Ise Bay and Seto Inland Sea with intensive industrial activities and high population density in the basin are low in percent compliance. There are still high possibilities of further deterioration in water quality in these estuaries and more efforts to restore these estuaries are necessary.

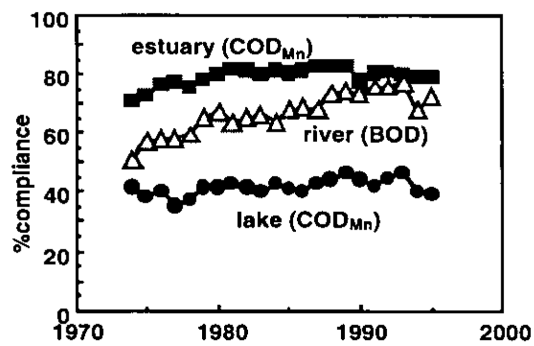

Fig.11-1 Percent compliance of environmental water quality standards.

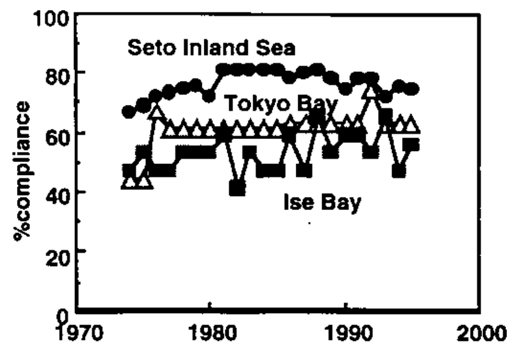

Fig.11-2 Percent compliance of environmental water quality standards for estuaries.

1.2 Limitation of regulations for effluent water quality

The regulations for effluent water quality were effective as shown above, whereas the following legal limitations have been pointed out;

1) Although the decrease in total loading is necessary to comply with the EWQS, loadings from inland area are difficult to control. This is because prefectural stringent effluent standards are legislated by each prefectural government and not necessarily based on water quality in estuaries.
2) The loading from industries decreased significantly by the effluent regulations. However, domestic wastewaters have not been controlled effectively except for sewage effluents and their contribution increased relatively,. Especially, little efforts have been made to control gray waters.
3)The effluent quality regulations could not prevent the increase in total loading associated with the increase in productivity nor the dilution of effluents to comply with the regulation.

1.3 Regulation of total maximum daily loading

Thus the effluent quality was not enough to restore water quality in large-scale closed waters. Regulations for total amount of loadings not only from industrial and domestic sources but also non-point and internal sources are necessary. The regulation of total maximum daily loading

(TMDL) started in 1978 in order to comply with the EWQS as amendments of "Water Pollution Control Law (WPCL)" and "the Law Concerning Special Measures for Conservation of the Environment of Seto Inland Sea".

Prior to the legislation of TMDL, "Tentative Law Concerning Measures for Conservation of Environment in Seto Inland Sea" was legislated in 1973 to conserve environment in Seto Inland Sea. The target of this regulation was to reduce industrial COD loading into Seto Inland Sea down to 1/2 from that of 1972. All the prefectural governments in the basin legislated stringent effluent standards to satisfy with their duties for the reduction. This was the first regulation not based on effluent concentration but based on total loading.

The law recommended other estuaries to have similar regulatory system as Seto Inland Sea. Although some prefectural governments started similar regulations, these are different from the regulation of TMDL in the following aspects;

*only industrial effluents were regulated in most cases,
*regulatory systems are based on stringent effluent quality.

2. Regulatory System of TMDL in Japan

2.1 Basic policy

The purpose of the regulation of TMDL is to reduce total amount of loading into large scale closed water bodies facing with serious pollution. The reduction must be uniform and effective for all the activities in the basin including inland area.

The basic policy for the regulation is as follows;

*(specified basin) all drainage basin for the specified waters. The prime minister formulates basic policy for TMDL to avoid inequality among prefectures,
*(total loading) total amount of loadings to be reduced includes not only those from industries under control by the WPCL but also those without regulation such as domestic wastewater,
*(target of TMDL) should be specified for each source,
*(implementation) all the industries in the specified basin are required to satisfy with the target of TMDL. Also, the regulation of TMDL requires construction and improvement of sewerage system, on-site treatment plants, and small scale industrial wastewater treatment processes, and environmental education,
*(loadings to be regulated) total daily loading by the specified effluents originating mainly from production processes. No regulation for indirect cooling water and rainwater,
*(monitoring) each industry must monitor and file daily loading based on the specified procedure to estimate total daily loading.

It is well known that the regulations of TMDL in terms of sulfur oxides in Air Pollution Control Law and TMDLs in U.S. are called as environmental quality based approach and directly based on environmental quality standards. TMDLs in U.S. define the target of loadings to comply with environmental quality standards. EWQS in Japan is an administrative target to be satisfied. However, it was not necessarily realistic and sufficient scientific understandings and data base was not available to define the target of TMDL directly based on EWQS for waters with concentrated industrial activities and population.

Therefore, the target of TMDL was defined to the realistic and possible limit in the target year taking the increase in loading associated with the development of industrial activities and population growth, developments of wastewater treatment technology and percent service of sewerage systems in the basin into consideration. Also the regulation specified tentative target and period if it seemed difficult to satisfy with the target within the target year. For the implementation of the regulation, the government specified standard methods applicable for various industries to monitor and file total daily loading. A schematic diagram of the regulatory system of TMDL is shown in Fig.11-3.

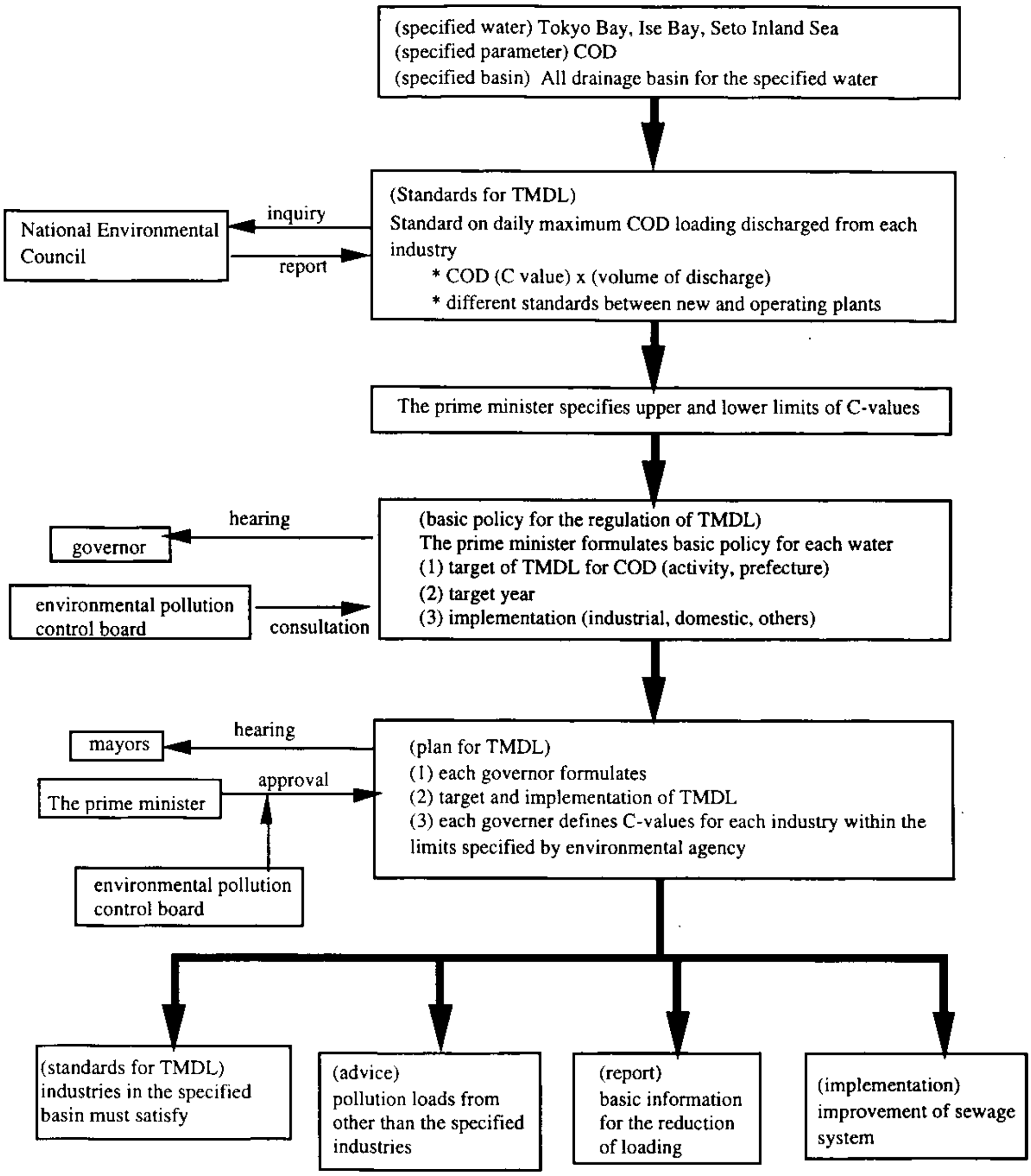

Fig. 11-3 Schematic diagram of the system of the regulation of TMDL

2.2. Specified water, basin,and parameters

The governmental ordinance defines specified water, basin (drainage basin for the water), and parameters (parameters to be regulated) for the regulation of TMDL. Specified water is large polluted enclosed water body with a drainage basin of concentrated human activities with high potential of pollution loadings. Specified basin is the drainage basin of the specified water.

These are as follows at present;

*specified water: Tokyo Bay, Ise Bay, Seto Inland Sea
*specified parameter: COD
*specified basin: all the drainage basins of the specified water in 20 prefectures

2.3 Basic policy for TMDL

The prime minister is responsible for the basic policy for TMDL. The policy for the 1st TMDL in 1979 was based on the following information;

* present loading of COD,
* target and year of TMDL within the possible limit taking the increase in loading associated with the development of industrial activities and population growth, developments of wastewater treatment technology, and percent service of sewerage systems in the basin into consideration,
* target of TMDL for each activity and prefecture.

The regulation of TMDL requires to define the target of the maximum daily loading of COD into the specified water from each activity in each prefecture in the target year. Therefore, Environmental Agency surveyed the amount of generated loadings from all the activities. Loadings are classified into three major categories, i.e. domestic, industrial, and others (livestock, non-points) as shown in Table 11-1.

Table 11-1 Classification of generated loading

	class	category
domestic	point sources	domestic sewage treatment plant night soil treatment plant gappei Jokaso (population 201-500, > population 500) tandoku Jokaso (population 201-500, > population 500)
	non-point sources	gappei Jokaso (< population 201) tandoku Jokaso (< population 201) graywater
industrial	point sources	industrial wastewater treatment plants (> 50 m^3) industrial sewage treatment plant
	non-point sources	small scale industrial wastewater treatment plants (< 50 m^3) small scale industries without regulation
others	point sources	barns wastewater treatment plants for feed lot other wastewater treatment plant
	non-point sources	pasture (cattle, pig, horse) land (forest, paddy field, others) landfill sites for solid wastes

2.4 Plan for TMDL

The governor of each prefecture is responsible for making the plan for TMDL based on the basic policy for TMDL as follows. The plan for the 1st TMDL was issued in 1980.

* target of TMDL for each activity
* measures to implement the target

Although the purpose of the regulation of TMDL is to comply with the EWQS, target of TMDL was defined to the possible limit taking the increase in loading associated with the development of industrial activities and population growth, developments of wastewater treatment technology and percent service of sewerage systems in the basin into consideration. Especially, the regulation requires balanced reduction of loadings between industrial and domestic wastewaters.

Major measures to attain the target of TMDL are as follows;

a) domestic wastewater: reduction of the large loading of domestic wastewater,
*increase in the percent service by public owned sewer system and domestic wastewater treatment system (gappei-Jokaso, sewage system for farming village, community plants)
*advanced treatment processes and improved maintenance
*environmental education to reduce domestic loading

b) industrial wastewater: reduction of loading with equality among industries
*regulation of industrial effluents by the standards for TMDL
*guidances for small scale and non-controlled industries, and increase in the number of industries to be regulated,

c) others: reduction of loadings by controls of non-point sources
*management of livestock wastewaters
*improved system for the control of combine sewer overflow
*management of bottom sediments
*improved aquaculture
*ecosystem management to restore and maintain natural purification capacity

2.5 Standards for TMDL

2.5.1 Basic policy for the Standards for TMDL

The contemporary regulations controlled the concentration of effluents at the point of discharge. The regulation of TMDL, however, controls the maximum allowable daily loading from industries located in the specified basin with daily discharge more than 50 m^3 as follows,

$$L = C \cdot Q \times 10^{-3}$$

where,
L: maximum allowable loading (kg/day)
C: COD value specified by the governor (mg/l)
Q: volume of specified effluent (m^3/day)

The specified effluents are effluents from specified industries by industrial and domestic activities except for waters without pollution load like cooling water. As in the 4th TMDL, the regulation requires more stringent control of loadings from new and expanded plants after 1980. The following is an equation for the 4th TMDL.

$$L = (C_0Q_0 + C_iQ_i + C_jQ_j) \times 10^{-3}$$

where,
L: maximum allowable loading (kg/day)
C_0: COD values for Q_0 specified by governor (mg/l)
C_i: COD values for Q_i specified by governor (mg/l)
C_j: COD values for Q_j specified by governor (mg/l)
Q_0: volume of specified effluent discharge (except for Q_i, Q_j) (m^3/day)
Q_i: volume of specified effluent discharge from new and/or expanded plants in operation between July 1, 1980 and June 30, 1991 (except for Q_j) (m^3/day)
Q_j: volume of specified effluent discharge from new and/or expanded plants in operation after July 1, 1991 (m^3/day)

The above mentioned COD values are called as C-values. Each governor determines C-values for each industrial category based on the allowable upper and lower limits specified by Environmental Agency. Number of industrial categories was 217 in the first TMDL. It increased to 232 in the 4th TMDL.

Table 11-2 Influent and effluent COD (mg/l) and BOD/COD ratio

industry	process / parameter	influent (biological treatment)	influent (biological+coagulation)	average
food	COD	600	680	630
	BOD	990	1190	1060
	BOD/COD	1.65	1.75	1.68
fiber	COD	450	400	390
	BOD	380	381	370
	BOD/COD	0.84	0.95	0.95
paper & pulp	COD	420	460	360
	BOD	370	400	320
	BOD/COD	0.88	0.87	0.89
chemical (organic)	COD	450	780	540
	BOD	860	1060	860
	BOD/COD	1.91	1.36	1.59
domestic	COD	390	520	390
	BOD	500	830	520
	BOD/COD	1.28	1.60	1.33

industry	process / parameter	effluent (biological treatment)	effluent (biological+coagulation)	average
food	COD	17.8	15.2	18.0
	BOD	10.8	10.2	11.9
	BOD/COD	0.61	0.67	0.66
fiber	COD	48.3	37.4	45.3
	BOD	21.7	19.8	25.6
	BOD/COD	0.45	0.53	0.57
paper & pulp	COD	59.3	45.2	47.6
	BOD	27.4	17.9	30.4
	BOD/COD	0.46	0.40	0.64
chemical (organic)	COD	20.8	25.2	24.6
	BOD	11.0	19.7	17.1
	BOD/COD	0.53	0.78	0.69
domestic	COD	13.4	13.0	13.6
	BOD	8.5	7.7	8.7
	BOD/COD	0.63	0.59	0.64

Table 11-3 Median quality of effluents from industries with common and best available wastewater treatment processes

code	industry	median influent COD (mg/l)	effluent COD (mg/l)			
			common process I		best available process II	
			process	median	process	median
2	livestock farming (<1,000 t/day)	1,970	B	75	B+C+F	117
6	dairy products	270	B	19	B+C+F	14
18	soy source, amino acids	483	B	21	B+C+F	15
41	non-alcoholic drinks	240	B	18	B+C+F	14
79	non-bleached chemical pulp	1,140	C+B	50	C+B+F	45
102	phosphorus & nitrogen fertilizer	87	C	12	B+C+F	18
120	plastic products	166	B	26	B+C+F	20
147	oil refinery	87	B	12	B+C+F	9
149	coke oven	4,420	B	23	B+C+F	17
169	stone & gravel	8	C	7	C+F	7
209	sewage	85	B	12	B+C+F	9
213	restaurants	150	B	14	B+C+F	10
221	tandoku Jokaso (>501)	92	B	12	B+C+F	9

B: biological treatment, C: coagulation, F: sand filtration

2.5.2 The upper and Lower limits of C-values

The most common wastewater treatment processes and average effluent concentration are the basis to determine the lower limit (the most stringent) of C-values. C_j values for new and expanded plants are based on the best available technology for COD removal. Governors are responsible to determine C-values within the limits.

Table 11-2 shows average quality of wastewater from industries used to determine the limits of C-values. Influent COD ranged from 400 mg/l to 600 mg/l. Food and organic chemical industries discharged higher COD. Effluent COD from food, organic chemicals and domestic wastewater were around 20 mg/l, whereas those from fiber and paper & pulp industries were relatively high, more than 40 mg/l, with lower percent of removal. This may be due to low BOD/COD ratio and, hence, lower removal of COD by the most common biological treatment processes.

Table 11-3 shows examples of influent COD (50 percentile), the most common available wastewater treatment technologies (process I), the best available technologies (process II) and corresponding effluent COD values (50 percentile) from the surveillance carried out in 1994 for 4th TMDL. The process I for industries with organic discharges was biological treatment. The process II was biological treatments followed by coagulation and sand filtration. However, process I was coagulation and sedimentation and process II was followed by sand filtration for industries like inorganic chemicals, pottery, metal, machinery and electric.

Table 11-4 shows examples of the upper and lower limits of C-values for the 1st and the 4th regulations of TMDL. The 4th specified the lower C-values than the 3rd in 97 categories taking present effluent quality, available treatment technology, reduction of loadings during previous TMDLs and equality among industries into consideration. There were 18 categories with C-values higher than the national minimum effluent regulation (160 mg/l) until the 3rd. They are only 4 in the 4th, i.e. pulp, coal tar, ion exchange and coke oven. There were significant improvements in C-values between the 1st and the 4th for industries with high C-values like pulp, coal tar and coke oven. There are industries like dairy products, however, with little improvement from the 1st to the 4th.

Table 11-4 Examples of lower and upper limits of C values for the first and the fourth TMDL

code	industry	1 st		4 th					
		C_0		C_0		C_i		C_j	
		lower	upper	lower	upper	lower	upper	lower	upper
2	livestock farming (<1,000 t/day)	70	140	70	120	70	100	60	90
6	dairy products	30	60	30	50	30	50	20	40
18	soy source, amino acids	90	120	70	100	70	90	40	80
41	non-alcoholic drinks	20	120	20	60	20	50	20	40
57	fiber (linen)	100	120	90	110	90	110	90	110
79	non-bleached chemical pulp	210	330	140	170	130	170	130	170
102	phosphorus & nitrogen fertilizer	30	120	30	90	30	70	30	60
120	plastic products	30	50	30	50	30	50	30	50
147	oil refinery	20	60	20	50	20	40	20	40
149	coke oven	250	350	180	220	180	200	90	160
169	stone & gravel	20	40	20	40	20	40	20	40
209	sewage	30	110	20	60	20	40	20	40
213	restaurants	-	-	50	70	40	60	30	50

2.6 Monitoring of loading

It is essential for the regulation of TMDL to monitor and file daily loading appropriately by plant owners. The ideal procedure of monitoring is on-line automatic monitoring of loadings. However, it is impossible to monitor COD loading based on the standard method. Therefore, the recommended methods are monitoring both for the volume of effluent and concentration of COD to make the product of them as loading. Although flow meter and automatic monitor of COD are recommended, small industries can adopt simpler methods as shown in Table 11-5.

Table 11-5 Methods allowable (A) for the determination of loading and required frequency

methods \ plants		daily discharge > $400m^3$	daily discharge < $400m^3$	with correlation between flow and COD > $400m^3/d$	with correlation between flow and COD < $400m^3/d$	others (difference
COD mg/l	(1) continuous monitoring both for flow and COD (COD, TOC, TOD, UV monitors and automatic sampler with recorder	A	A	-	-	
	(2) composite sampler + standard manual analysis for COD	allowable if procedure (1) is not applicable nor possible	A	-	-	allowable if procedure (1) is not applicable nor possible
	(3) 3 samplings/day followed by the standard manual analysis	allowable if approved by governor	A	-	-	allowable if approved by governor
	(4) 3 samplings /day followed by quick analysis without automatic sampler and recorder	allowable if approved by governor	A	-	-	allowable if approved by governor
flow Qm^3/d	(1) flow meter with recorder	A	A	A	A	A
	(2) cumulative flow volume recorder	A	A	A	A	A
	(3) Quick analysis like JISK0094-8	allowable if approved by governor	A	-	A	allowable if approved by governor

daily discharge	monitoring frequency
$400m^3$ -	everyday with wastewater discharge
$200m^3$ - $400m^3$	at least once per 7 days of wastewater discharge
$100m^3$ - $200m^3$	at least once per 14 days of wastewater discharge
$50m^3$ - $100m^3$	at least once per 30 days of wastewater discharge

3. History of Basic Policy for TMDL

The 1st regulation of TMDL started in 1979 with the target year of 1984. As shown in Fig.11-4, COD loading decreased in all the specified water. However, improvement of water quality was not as expected and both red-tides and blue-tides were observed (see Figs.11-15 and 11-16 later on). The second and third regulations of TMDL, therefore, were legislated with the target years of 1989 and 1994, respectively.

The 3rd regulation of TMDL started from 1989 with the targets of 12 %, 9 % and 2 % reductions for domestic, industrial and other loadings, respectively until 1994. The targets were 13 %, 8 % and 9 % for Tokyo Bay, Ise Bay and Seto Inland Sea, respectively. The targets for each prefecture were different taking the difference in percent service of sewerage system, the reduction in previous regulations into consideration.

The needs for further improvement of water quality in the specified waters legislated the 4th regulation in 1996 with the target year of 1999. The targets are 8 %, 7 % and 4 % reduction for Tokyo Bay, Ise Bay and Seto Inland Sea, respectively. The targets for activities are 9 % and 3 % respectively for domestic and industrial loadings, whereas the target for other sources is 5 % increase. This is because the loading in the reference year, 1994, was smaller than that of normal years by draught. There will be no increase in the loading based on normal year.

4. Reduction of Total Daily Loading

Fig. 11-4 shows the reduction of total daily loadings into specified waters from the beginning of the 1st to the end of 3rd and the target values for the 4th in 1999. The reduction for domestic sources in Tokyo Bay was significant, whereas that for industrial sources was not enough. Both domestic and industrial sources decreased in Seto Inland Sea. The rate of decrease, however, was small compared to Tokyo Bay. Little improvement was noted in other sources.

Percent contributions of pollution sources into the specified waters in 1984 and 1992 are shown in Fig. 11-5. The contribution of domestic sources was as high as 70 % in Tokyo Bay. Those in Ise Bay and Seto Inland Sea were 53 % and 49 %, respectively. It must be noted that from 65 to 80 % of domestic sources were graywaters.

Implementations of various measures to control domestic wastewater decreased its contribution in 1992. Especially, contributions of graywater decreased significantly in all the waters. Contrarily, the percent contribution of industrial wastewaters increased in Tokyo Bay and Seto Inland Sea.

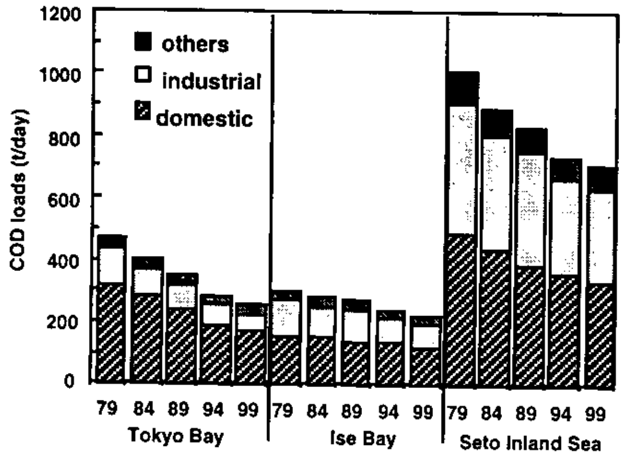

Fig. 11-4 Total daily loadings (1979-1994) and target values for the regulations of TMDL.

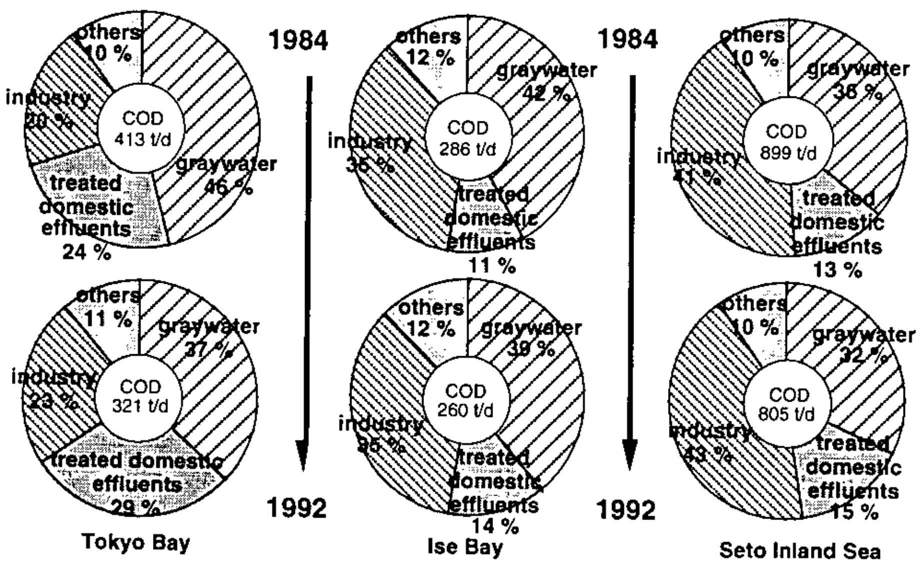

Fig. 11-5 Changes in total daily loadings from 1984 to 1992.

4.1 Reduction of loadings by domestic wastewater

The slight increase in population in the specified basin is shown in Fig. 11-6. Fig. 11-7 shows populations served by each domestic wastewater treatment system. The population served by public owned sewer system increased significantly. Contrary, those who rely on night-soil treatment are decreasing every year. The population using Jokaso is decreasing in Tokyo Bay, whereas that in Seto Inland Sea is constant. The delayed construction of sewer system in Ise Bay increased the population using Jokaso. The population discharging gaywater without treatment is decreasing and the percent contributions are now 25.2 %, 54.6 % and 45.5 % in Tokyo Bay, Ise Bay and Seto Inland Sea, respectively.

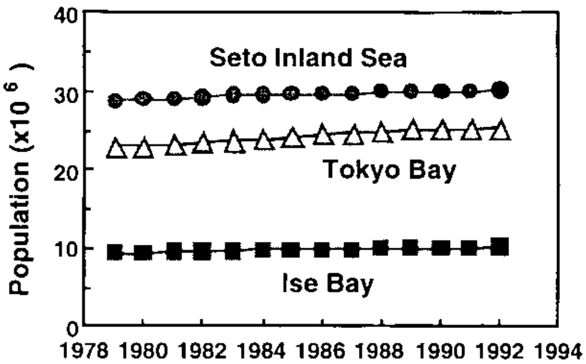

Fig. 11-6 Population growth in the specified basin

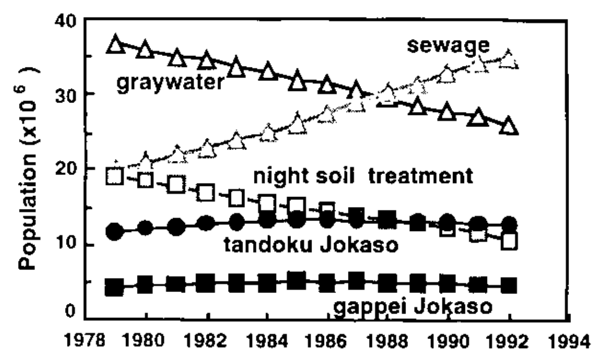

Fig. 11-7 Populations served by each domestic wastewater treatment system

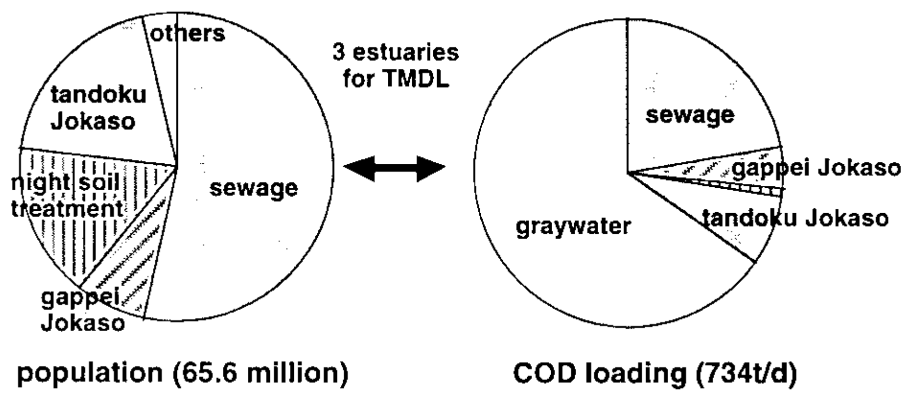

Fig. 11-8 Population vs. treatment systems in the specified basin.

Fig. 11-8 shows percent population served by and percent loading from each treatment system in the specified basins in 1992. The percent population served by sewage and gappei Jokaso was ca. 60.1 %, whereas the corresponding loading was only 27 %. Night soil treatments served 16.5 % of population and discharge less than only 1 % of total loading. However, population using night-soil treatment and Tandoku Jokaso is discharging graywater without treatment and their loading is as large as 65 %. This indicates that the contribution of graywater to the total domestic wastewater loading is remarkably large.

4.2 Reduction of loadings by industrial wastewater

Industries have carried out various measures to reduce pollution loading. They tried to save water, improved production processes and maintenance of treatment plants. Table 11-6 summarizes numbers of renewal and expansion of wastewater treatment plants in specified basin from 1990 to 1993. Most of processes adopted were biological treatment processes such as activated sludge process and processes for the removal of suspended solids like coagulation, sedimentation and sand filtration. Some plants have adopted advanced processes like activated carbon adsorption.

Table 11-7 shows numbers of process improvements for the same period. The numbers indicates that industries carried out not only improvement of treatment processes but also better maintenance, water use and process modification.

Table 11-6 Renewal and expansion of wastewater treatment plants in the specified basin for TMDL

process	number of plants
activated sludge	197
other biological treatment	117
coagulation and precipitation	118
sand filtration	71
oil separation	13
ozonation	4
activated carbon adsorption	50
other advanced treatments	9
other treatment processes	98
total	677

Table 11-7 Improvements of production and wastewater treatment processes in specified area for TMDL

procedure	number of plants
water use	123
production processes	98
maintenance of treatment plants	116
others	37
total	374

Table 11-8 summarizes various measures adopted by each industry to decrease COD loading. Industries which improved wastewater treatment plants are from 5 to 20 %. Coal and oil industries are the highest in the percentage indicating dependency on wastewater treatments rather than process modifications. Table 11-9 shows summary of industrial surveys in 1994 for procedures to improve production processes to decrease loadings. Process improvements seem to be as effective as construction/expansion of wastewater treatment plants.

Table 11-8 Improvements of production processes and renewal/expansion of wastewater treatment processes in the specified basin for TMDL

industry	total number of plants (1992)	number of new and expanded plants	% new & expansion	process improvement	% improved
food	1,253	69	5.5	49	3.9
fiber	589	26	4.4	27	4.6
paper & pulp	220	17	7.7	25	11.4
chemical	603	74	12.3	68	11.3
coal/petroleum	48	9	18.8	5	10.4
steel	204	13	6.4	4	2.0
other industries	5,070	223	4.4	13	2.6
domestic wastewater	-	37	-	-	-
total		468		309	

Table 11-9 Procedures to improve production processes

procedure	
improvement of production processes (742)	- better process management (238) - machine renewal (209) - introduction of automation (157) - others (138)
replace raw materials (97)	- using processed (ex. washed) raw materials (38) - out sourcing of raw material processing (5) - others (54)
replace chemicals (534)	- proper use/application/waste (263) - replace to those without N and P (190) - others (81)
others (411)	- improve product yield (180) - in-process recycling (103) - reuse of wastes (94) - others (34)
separate treatment of concentrated wastes (117)	- incineration (51) - contract as industrial wastes (51) - composting (15)

Compliance for the regulation of TMDL in the specified basins is shown in Table 11-10. Around seven percent of plants could not satisfy with the standards more than 1 day. Reasons for the violations are shown in Table 11-11. Most of the plants had treatment plants but were poor in maintenance and operations. Other reasons were troubles and/or worn-out in treatment plants or increase in flow rate and/or influent concentration by the change in production processes. The failures in TMDL regulation are subjected to the order of the governor to improve treatment plants and not by penalties. Actually, local governments recommended various procedures to satisfy with the standards.

Table 11-10 Compliance for the regulation of TMDL in 3 specified estuaries

	total plants	plants not complied*	(%)
1990	10,669	813	7.6
1991	10,688	743	7.0
1992	10,886	745	6.8

*Plants could not comply with TMDL more than 1 day except for Jokaso (201-500)

Table 11-11 Failure to TMDL in 3 specified estuaries

cause	%
no treatment plants	3.6
old and/or troubled treatment plants	14.6
poor maintenance of treatment plant	40.9
increase in wastewater flow and concentration	15.6
monitoring error, unknown	25.3

Table 11-12 Recommendations by local governments to decrease loading from plants violated TMDL regulation

contents	%	instructions
better maintenance of treatment plants	54	- adjust aeration time - chemical dose based on pH meter - proper pumping time - better operation of coagulation and sedimentation
improvement of treatment plants	25	- replace catalysı - better aeration scheme - install of floating scum skimmer - batch to continuous operatior - install of foam breaker
increase treatment capacity and saving water	8	- install aeration equipment - install pretreatment (sedimentation) - install multi-filter, sand filtration - install oxidation, coagulation-sedimentation processes
others	-	- increase frequency of plant inspection - improve high loading process - inspection and cleaning - prevent rainwater and groundwater inflow - install gappei Jokaso - disposal of high strength wastewater as industrial wastes - replace chemicals and raw materials

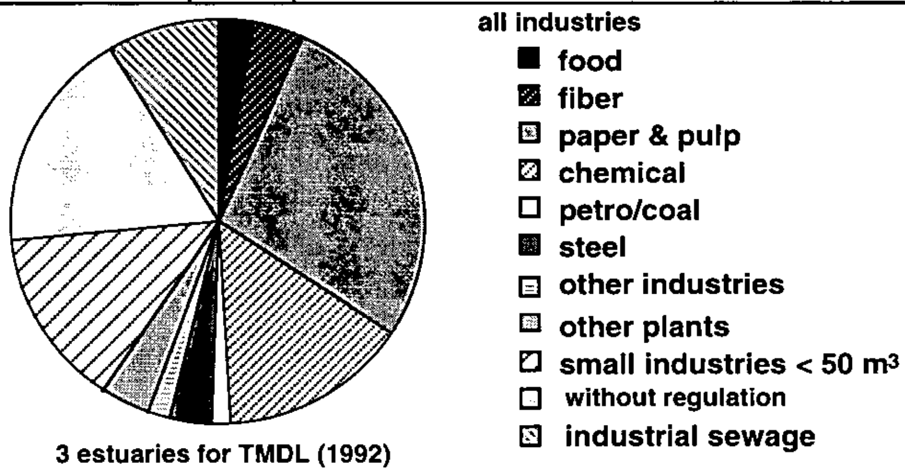

Fig.11-9 Percent contribution of industrial sectors to total COD loading to the specified waters

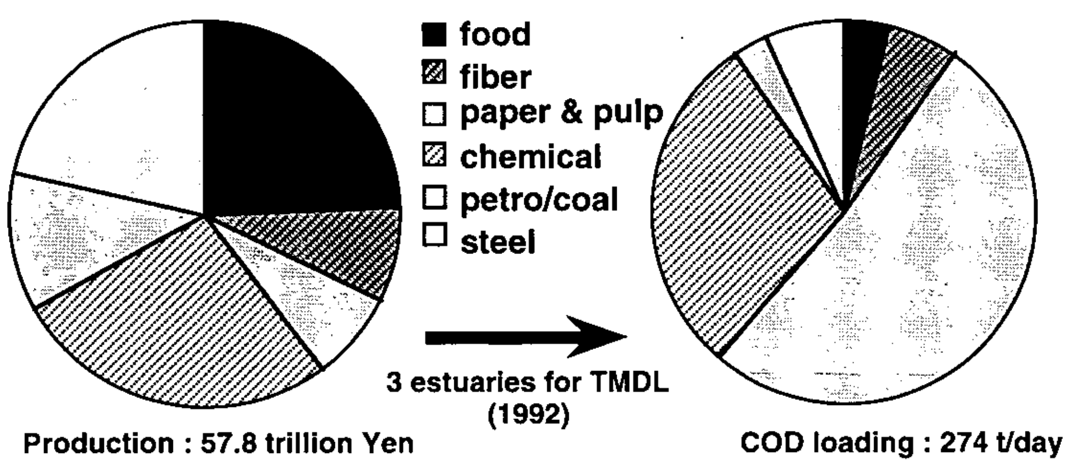

Fig. 11-10 Percent contributions of loadings and productivity for major industries.

Fig.11-9 shows percent contribution of each industrial sector to total COD loading into the specified waters. The largest is paper & pulp industries followed by chemical industries. The percent contribution from small industries with daily discharge less than 50 m3 or without regulation is more than 30 %. Prefectural governments are making efforts to reduce these loadings either by local ordinance or guidelines and manuals.

A comparison between percent contribution of loadings and productivity for major industries is shown in Fig. 11-10. Loadings from paper & pulp industries are relatively high compared to their productivity. Those from food and steel industries are relatively small.

There are industries with relatively higher loadings. However, it must be noted that effluents from industries are not the same quality. Treatability of industrial effluents are significantly different. Some wastewater are still difficult to handle even with the most advanced treatment technology. Also, productivity is not the sole indicator to evaluate loadings. Other factors like economic situations and employment must be taken to evaluate allowable or permissible loadings from industries. C values, therefore, were determined based on all of these factors to secure equality among industries.

It is common that the improvement of treatment facility results in the increase in treatment cost per volume of wastewater. The further decrease in loading, therefore, is not easy for industries that have decreased loading remarkably. Figs. 11-11 shows historical reduction of loading into the specified waters from some industries and sewage works. All the loadings are relative values based on those in 1992.

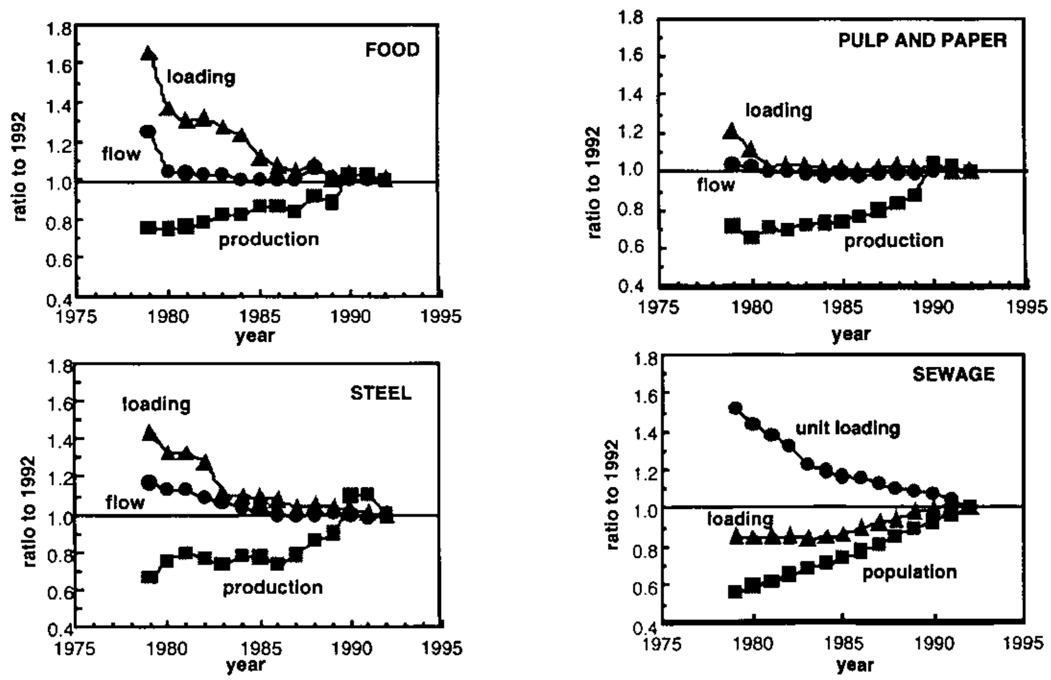

Fig. 11-11 Relative production, volume of discharge and COD loading from food, paper & pulp, steel industries and sewage.

In 1979, food industries discharged 1.7 times as large loadings as that in 1992. Remarkable reduction was noted in the beginning of the 1st TMDL. More than 20 % of water was saved at the same time. However, the rate of decrease is small after that and little decrease is noted after 1987. It must be noted that the loading did not increase in spite of the significant increase in production. The regulation, therefore, seemed to be effective.

Similar trend is also noted in steel industries. Although pulp & paper industries could decrease loading, the percent decrease is small compared to other industries. However, the increase in the production indicates that the loading should have increased remarkably without the regulation. Contrary to industrial circles, loading by sewage increased gradually. This is because percent population served by sewage increased and not because no efforts were made to decrease loading. Actually, per capita loading by sewage decreased remarkably from 1979 to 1992 indicating that wastewater treatment technology has been improved.

Table 11-13 Initial investment and operational costs for wastewater treatment plants

initial investiment	total (10^6 Yen)			per volume (10^6 Yen/m^3)			per sales (10^3 Yen/ 10^6 Yen sales)			per profit (10^3 Yen/ 10^6 Yen profit)		
	C	B	B+C	C	B	B+C	C	B	B+C	C	B	B+C
livestock farm	-	11.8	-	-	119	-	-	112	-	-	-	-
food	-	25.4	32.8	-	256	331	-	11	14	-	309	399
fiber	24.4	32.0	56.3	115	151	267	26	34	60	1,139	1,494	2,632
paper/pulp	22.1	84.1	106.2	12	45	57	9	32	41	1,668	6,350	8,018
inorganic chemical	26.8	-	-	99	-	-	5	-	-	613	-	-
organic chemical	37.6	114.7	152.3	63	193	256	5	14	19	73	223	296
pottery	16.3	-	-	129	-	-	4	-	-	140	-	-
metal/machine /electric	50.5	68.1	101.5	113	152	226	5	7	11	240	323	481
domestic/ others	21.8	28.6	46.2	279	367	464	-	-	-	-	-	-

operational cost*	C:coagulation	B:biological	B+C
livestock farm	-	68	-
food	-	50	67
fiber	60	39	99
paper/pulp	9	19	28
inorganic chemical	37	-	-
organic chemical	37	40	72
pottery	31	-	-
metal/machine/electric	60	46	-
domestic/others	40	44	56

* median costs for electricity and chemicals

Table 11-13 shows initial investment sand operational costs for wastewater treatment plants of industries. Cost of initial investment was estimated from median values of wastewater discharge and the correlation between initial investments and volume of wastewater for corresponding industry. The fact that initial investments per unit volume of wastewater ranged from 12 to 464 thousand Yen indicates large difference among industries and treatment systems. The unit costs for fiber and paper & pulp industries were relatively small. However, their costs per ordinary profit were extremely large.

On the basis of on the above mentioned view point, historical decrease in loadings per unit production is shown in Fig. 11-12. Most industries decreased the loading constantly after the start of the regulation of TMDL. The unit loading decreased down to a half of that in the stating year, 1979. The percent decrease was almost constant and around 4 % per year.

However, the percent decreases in paper & pulp and petroleum/coal industries were only 40 % and 25 %, respectively.

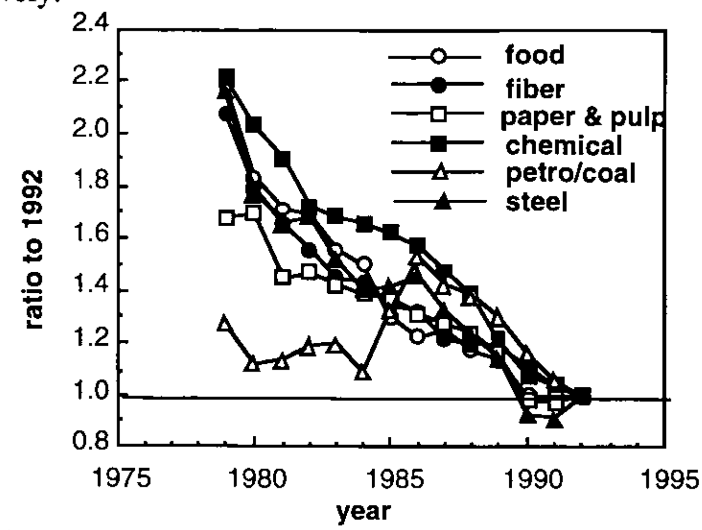

Fig. 11-12 Historical decrease in loadings per unit production

Table 11-14 Difference between target and realized values of 3rd TMDL

	1994	domestic	industrial	others	total
Tokyo Bay	target	203	69	36	308
	realized	197	59	30	286
Ise Bay	target	127	91	33	251
	realized	134	83	29	246
Seto Inland Sea	target	359	321	80	760
	realized	365	309	72	746

5. Effects of the regulation of TMDL on Water Quality

Table 11-14 compares the target of TMDL in the 3rd and the loading attained estimated prior to the 4th regulation. The attained loadings are almost smaller than the targets of TMDL. Therefore, we may regard that the reduction of total loading was successful. The loadings at the end of the 4th TMDL (1999) will be 55 %, 75 % and 71 % of those in the start of the 1st (1979) in Tokyo Bay, Ise Bay and Seto Inland Sea, respectively.

Fig. 11-2 shows the corresponding changes in water quality and outbreaks of blue-tide and red-tide are shown in Figs. 11-13 and 11-14, respectively. The number of the outbreaks of both tides decreased compared to 1980's. However, the percent compliance for EWQS is still low. This can be attributed to eutrophication as mentioned in Chapter 6. The regulations of TMDL in terms of COD could reduce external loading of COD, whereas they do not necessarily control internal production of COD associated with eutrophication. The percent contribution of internal COD production is estimated to range from 30 % to 60 %. Thus, the control of internal production is as important as that of external inputs. Regulation of TMDL not only for COD but also for nitrogen and phosphorus will be urgent needs.

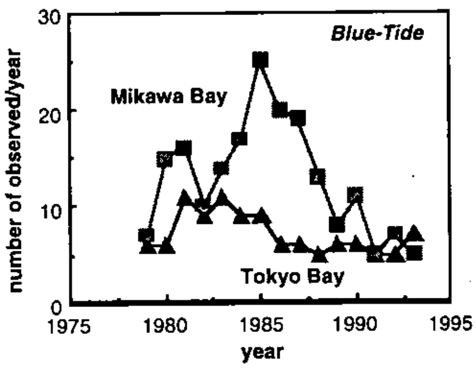

Fig. 11-13 Outbreaks of blue-tide

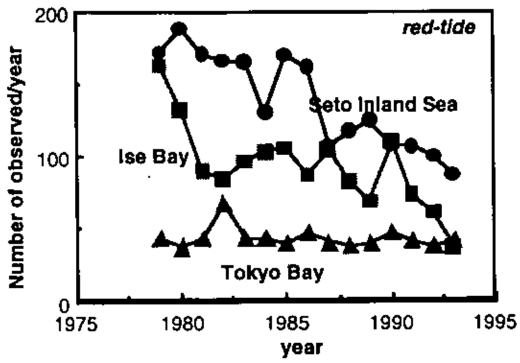

Fig. 11-14 Outbreaks of red-tide