

工學碩士 學位論文

**Analysis of Polycyclic Aromatic Hydrocarbons
(PAHs)
in Marine Organisms and Sediments
from the intertidal zone of Yellow Sea, Korea.**

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**The High Performance Liquid Chromatography (HPLC)
Analysis of Polycyclic Aromatic Hydrocarbons (PAHs)
in Marine Organisms and sediments
from the Intertidal Zone of Yellow Sea, Korea**

by Jong- young, Choi

**The School of Civil and Environmental Engineering
Graduate School of Korea Maritime University**

Abstract

Polycyclic Aromatic Hydrocarbons (PAHs) are ubiquitous environmental pollutant. Because of the high toxicity of some polycyclic compounds, such as benzo(a)pyrenes, the determine of their level in sediment and marine organisms was target of several papers.

The basic purpose of this study is reporting preliminary data on sediment, and marine organisms from the intertidal zone of West Sea. And our results of study compared with present studies results from intertidal zone of East sea and South Sea. PAHs are determined using by High Performance Liquid Chromatography (HPLC)in sediment, green larver (*Ascidian*), and Oyster (*Ruditapes Philippinarum*) of intertidal zone of West Sea. Sixteen PAHs compounds were identified, including carcinogenic compouds.

PAHs in samples (sediment, green larver and oyster) were extracted and analyzed. 20g of each organisms (wet weight) and sediment (dry weight) was

taken to be analyzed. These samples were Soxhlet-extracted and, then saponified by refluxing and then the PAHs were identified and quantified by HPLC.

Total PAHs in sediments from intertidal zone of West Sea ranged from 0.0077 to 1.6593 ppb (ng/g) (mean value, 0.4856 ± 0.5273 ppb), in green larver ranged from 0.1490 to 1.1376 ppb (mean value, 0.4978 ± 0.5539 ppb), in oyster ranged from 0.1675 to 2.8248 ppb (mean value, 0.9618 ± 0.7441 ppb).

Our study area more polluted from intertidal zone of East Sea (Uljin, Youngdok, Kori), but, unpolluted from intertidal zone of South Sea (Kyoungyang, Pusan, Massan, Hadong).

The mean value of ratio of 3-rings to 4-rings of sediments, green larver, and oyster was 0.5670 ± 0.2230 (ranged between 0.000 and 3.657), 3.55 ± 1.5657 (ranged between 0.092 and 6.138) and 0.4872 ± 0.2829 (ranged between 0.3872 and 1.9496).

Compared with present other studies, we concluded that the PAHs level in intertidal zone of West Sea appeared to be comparatively low.

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가 가 . 가
가

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가

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, , ,

20

가 0.08 0.4 % 1.7 8.8

(National Academy of Science, 1975 :

1985).

(oil slick)

,

,

,

,

(Emulsion)

,

70 80 %

가

(tar ball)

,

,

가

.

50 90%

‘Chocolate mousse’

가 가

(Payne and Phillips, 1985).

가 가 100
food chain 가

가
75% ,
25% ,
가
가
가 가

가

6

가
가
addition reaction
가
가

(Polycyclic Aromatic Hydrocarbons ; PAHs)

가

가

PAHs (anthropogenic) (natural source)

가
(Elisabeth, 1993).
(,)

PAHs , BILGE BALLAST , 가
(Rainio and Biscaya, 1994).

Gas Chromatography (GC)
High Performance Liquid Chromatography (HPLC)
(Polycyclic Aromatic Hydrocarbons : PAHs) 가

HPLC

(Oyster) PAHs
(Oyster)
, PAHs PAHs

(Boehm and Quinn, 1976 ; Clarck and Finley, 1975 ; Dun and Stich, 1975 ;
Fassato and Siviero, 1974 ; Hansen *et. al.*, 1978 ; Lee., 1977 ; Mix and Schaffer,
1979 ; Niff *et. al.*, 1976 ; Stegeman and Teal, 1973).

PAHs
가 가 가

가

가 , 가
(United States Environmental
Protection Agency, 1997).
가
가
PAHs 가
가
PAHs ,
, monitoring

- 1.

44m

(,1990)

가 ,

Fig. 1, 2,

3, 4, 5, 6, 7

가

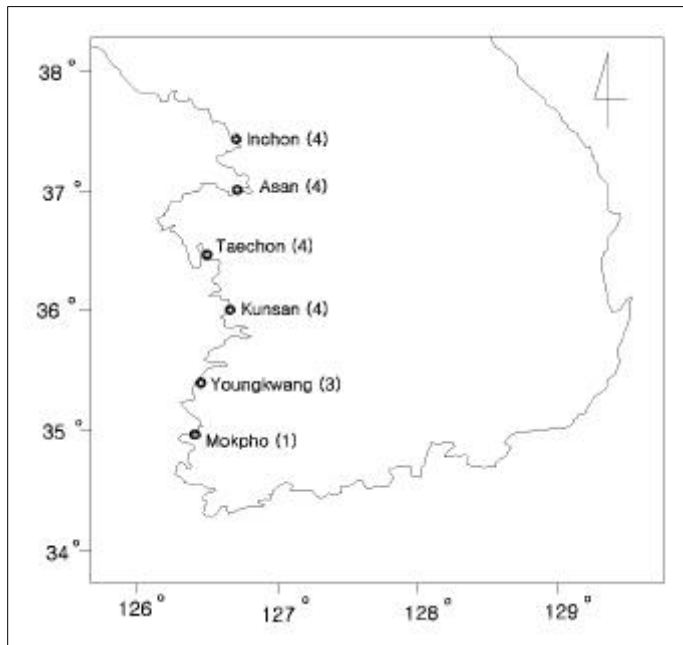


Fig. 1. Study Area

Fig. 2.

가

11

가

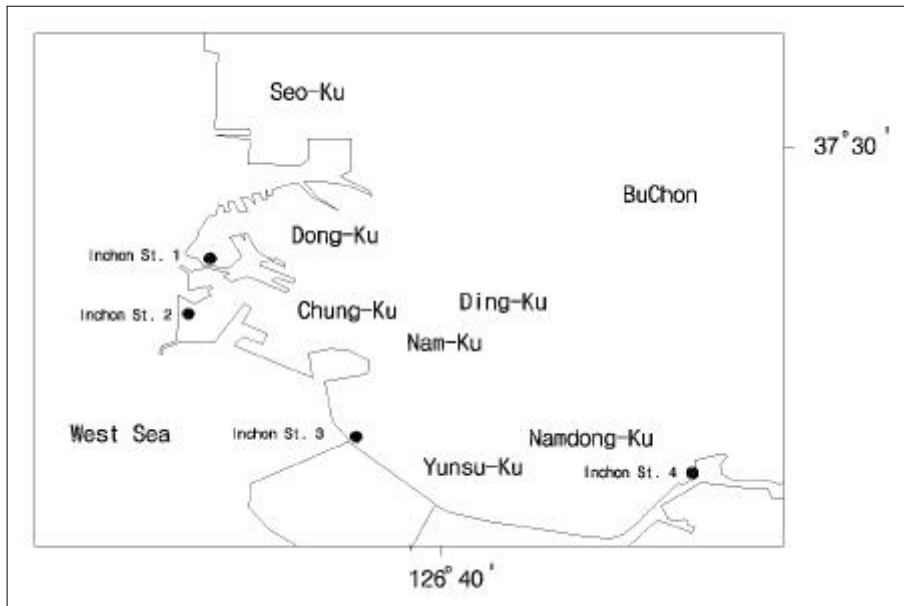


Fig. 2. Location of sampling sites in Incheon Harbor (1999. 7.)

4

1

3

2

LNG

4

가

1 , 가
 2 2 가
 가 ,
 가 가
 가 3 4
 3 4

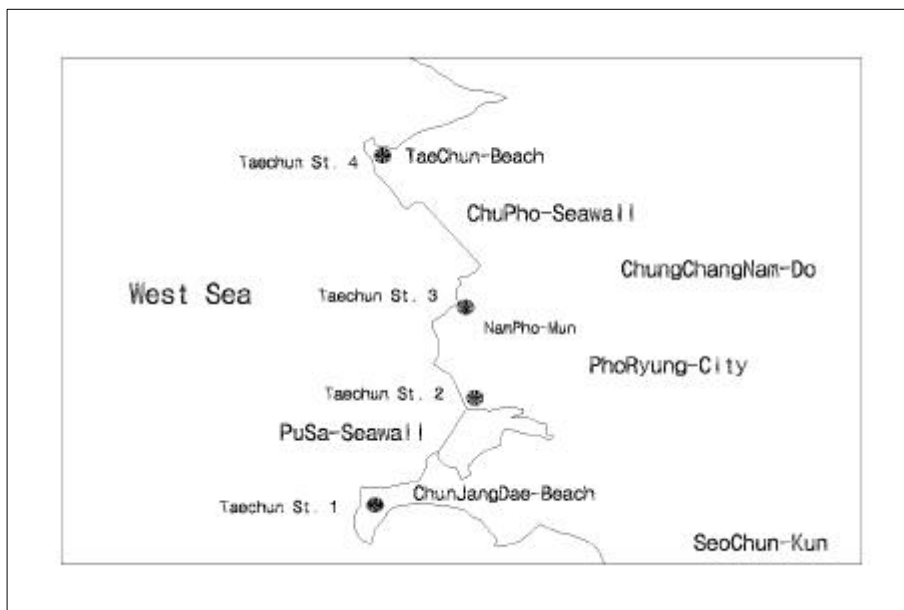


Fig. 4. Location of sampling sites in Taechon (1999. 7.)

Fig. 4

1

2

3

4

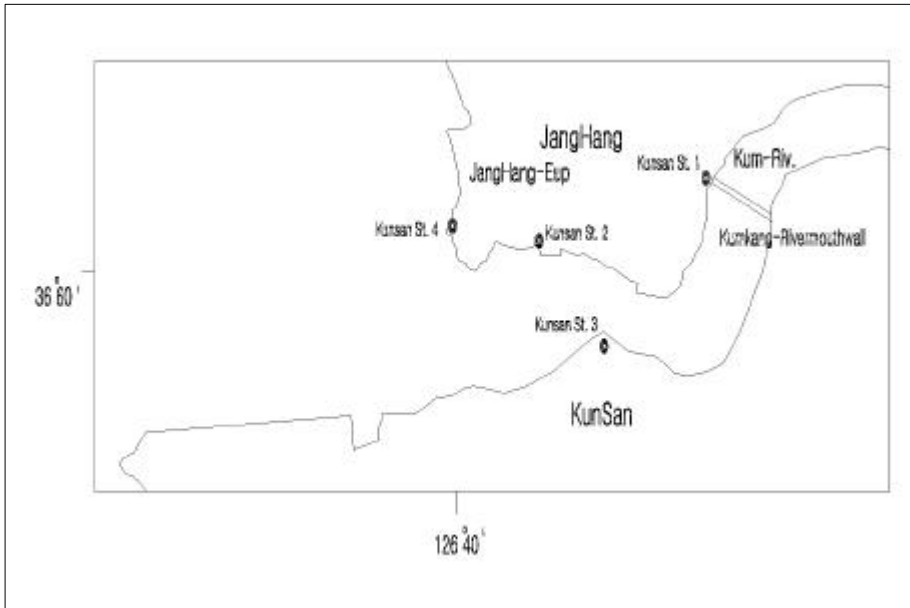


Fig. 5. Location of sampling sites in Kunsan Harbor (1999. 7.)

Fig. 5

가

1994

(, 1996)

1.16 2.71 mg/

, 8

2

가

1

2

가

3

LG

4

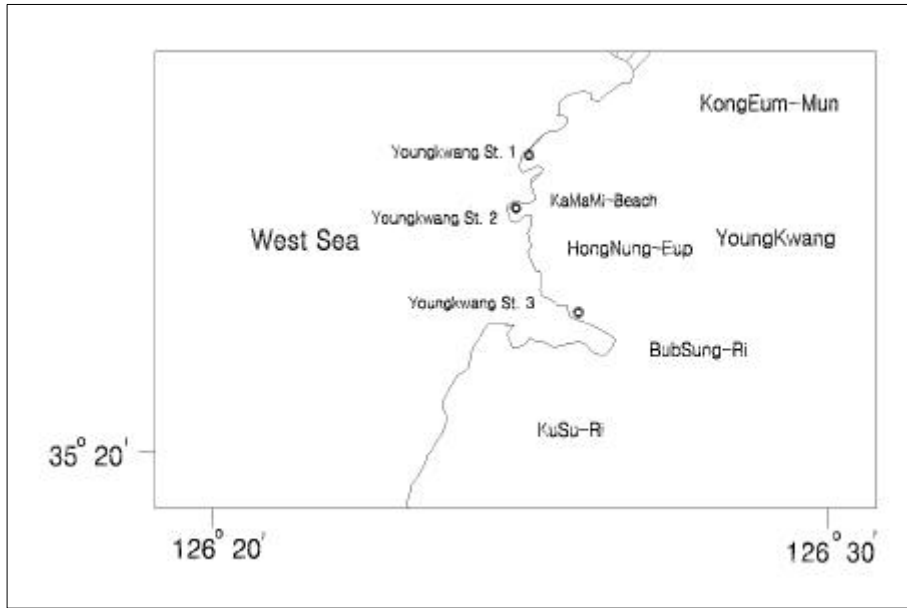


Fig. 6. Location of sampling sites in Youngkwang (1999. 7.)

Fig. 6.

가

가

1

2 가

3

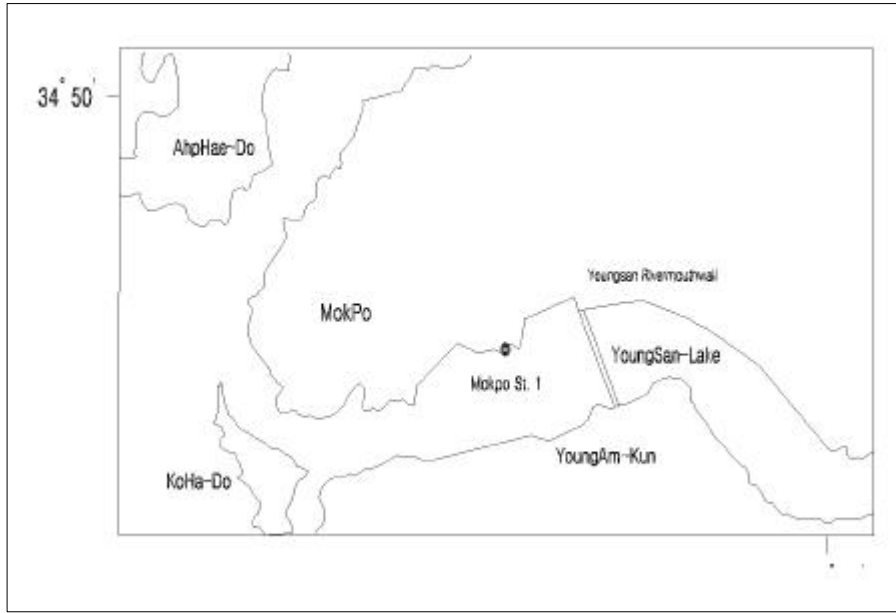


Fig. 7. Location of samplig sites in Mokpo Harbor (1999. 7.)

1897

4

4

5

3

2

가 ,
가

Fig. 7

- 50

- 2.

- 2- 1.

HPLC PAHs

12

PAHs
sample 20g Thimble Filter
, 560

가 (Smith et al., 1987). n-hexane, Ethyl Ether,
Aceton, Petroleum Ether 25Mℓ, 10Mℓ, 75Mℓ, 90Mℓ
Soxhlet system 6 (60) 가
(Rainio et al., 1986).
solvent Rotary Evaporator 40

refluxing Methanol 50Mℓ 3 90 refluxing
Potassium Hydroxide 7g
PAHs
가 sample
PAHs

Natusch and Tomkins (1978)
Cyclohexane 50Mℓ
Cyclohexane (Le,
et. al., 1978). 3 cyclohexane
DMSO 50Mℓ 3
DMSO cyclohexane
cyclohexane 50 Mℓ 3
(Smith et al., 1984; Smith et al., 1987). , cyclohexane
DMSO (Natusch and Tomkins,
1978).

Cyclohexane
Evaporator 40 Ml 가
3Ml

PAHs
1Ml
syringe filter (pore 0.2µm)

Rotary
1
filtering

PAHs

(Lee *et. al.*, 1978; Tjessem and Palmork, 1984; Berthou *et. al.*, 1985; Ducreux *et. al.*, 1986).

2- 2- 2. HPLC

PAH HPLC(High Performance Liquid Chromatography)
GC(Gas Chromatography)
Fluorescence Detector UV/VIS Detector 가 HPLC GC
Mass Spectrometry HPLC (mobile
phase) (treating system), pumping system, (sample injection
system), HPLC , Detectors 5
PAHs HPLC (Linear Instrument co.) ,
controller (Linear Instrument Model S-2000) Binary Solvent
Delivery System (Linear Instrument Model S-1100), Low Pressure Gradient
Mixer(Linear Instrument S-8110) UV(Linear
Instrument UVis 200) Fluorescence detector (Linear Instrument Model LC304)
Data (Hewlett Packard
Model Vectra-VL2) 가 Peak-3 sample
software (Peaksimple Serial Data Program ; SRI Model 202)
column LUNA 5u C18(2) column (4.6 mm x 250mm, 5µm
particle size, Phenomenex co.) 0.25Ml Syringe

(standard sample solution : Polynuclear
Aromatic Hydrocarbons Mixure for EPA 610, Sigma- Chemical co.)

PAHs

System) , Acetonitril flow rate 0.8ml/min
 , 0.5 bar 가 ,
 HPLC
 가 Automatic Gradient Controller (Linear Instruments Model S-2000) Automatic Gradient Controller 가
 가 , PAHs가
 : 50 (V/V) Solvent A가 Acetonitril H₂O가 50
 Solvent B 가 5
 Solvent B (Acetonitril : H₂O , 50:50 V/V)가 90% Solvent A가 10%
 . Solvent A 가
 60 Solvent A가 100

Table. 1 Binary gradient solvent program employed in the study

Time (min)	Solvent A	Solvent B
	Acetonitril (%) <i>CH₃CN</i>	Distilled Water (%) <i>H₂O</i> : <i>CH₃CN</i> (50 : 50, V/V)
0	0	100
10	10	90
20	30	70
30	50	50
40	60	40
50	70	30
55	90	10
60	100	0

UV/VIS Detector 270 nm Fluorescence Detector
 254 nm PAHs . UV/VIS Detector
 Fluorescence peak HPLC 가
 Peak-3 sample Serial Data System . HPLC
 (retention time : Rt)

Napthalene (NPTHL) 가 Acenaphthylene
 (ANCPL), Acenaphthene (ACNPN), Fluorene (FLURN), Phenanthrene (PHEN),
 Anthracene (ANTHR), Fluoranthene (FLRTH), Pyrene (PYR),
 Benzo(a)anthracene (BaA), Chrysene (CHRY), Benzo(b)fluoranthene (BbF),
 Benzo(f)Fluoranthene (BkF), Benz(a)pyrene (BaP), Dibenz(a,h)-anthracene
 (DahA), Benzo(g,h,i)perylene (BghiP), Indeno(1,2,3-cd)pyrene (I123cdP)
 16가 (Menzie *et. al.*, 1992).

(retention time : Rt) 2 . ,

Fig. 8 .

PAHs .

PAHs .

PAHs (isomer) PAHs(Alkylated PAHs)

.(Back, 1991).

, PAHs Acetonitril .

Table. 2. The chemical properties and retention times of selected 16 PAHs (Rt)

No.	COMPOUND (ABBREV)	Alternative Name	Formular (MW)	Rt (min)*
1	Naphthalene (NPTHL)		C 10 H 8 (128)	16.11
2	Acenaphthylene (ANCPL)		C 13 H 10 (168)	18.23
3	Acenaphthene (ACNPN)		C 14 H 10 (154)	21.73
4	Fluorene (FLURN)		C 14 H 10 (166)	23.50
5	Phenanthrene (PHEN)		C 14 H 10 (178)	24.82
6	Anthracene (ANTHR)		C 14 H 10 (178)	24.97
7	Fluoranthene (FLRTH)		C 16 H 10 (202)	27.97
8	Pyrene (PYR)		C 16 H 10 (202)	29.59
9	Benzo(a)anthracene (BaA)	1,2 Benzanthracene	C 18 H 12 (228)	31.98
10	Chrysene (CHRY)		C 18 H 12 (228)	34.82
11	Benzo(b)fluoranthene (BbF)	3,4 Benzfluoranthene	C 20 H 12 (252)	35.57
12	Benzo(f)Fluoranthene (BkF)	11,12 BenzoFluoranthene	C 20 H 12 (252)	43.80
13	Benz(a)pyrene (BaP)	3,4 Benzpyrene	C 20 H 12 (252)	45.43
14	Dibenz(a,h) anthracene (DahA)	1,2,5,6 Dibenzanthracene	C 22 H 14 (278)	51.16
15	Benzo(g,h,i)perylene (BghiP)	1,12 benzperylene	C 22 H 12 (276)	52.60
16	Indeno(1,2,3- cd)pyrene (I 123cd P)	o- Phenyleneperylene	C 22 H 12 (276)	55.23

* : HPLC PAH UV/VIS Detector (retention time)

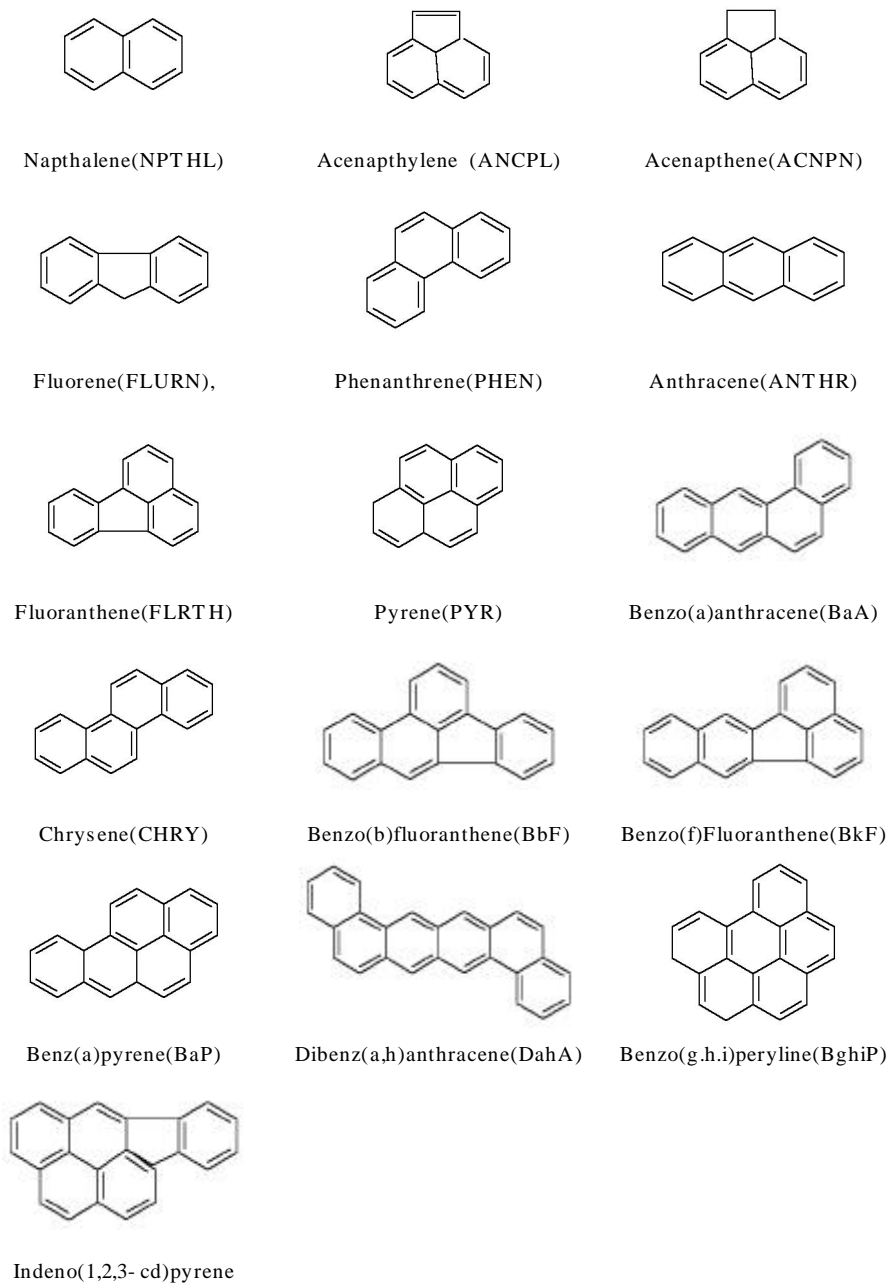


Fig. 8. The molecular structures of 16 PAHs analyzed

- 1. PAHs

1 1.2872 ppb 가 , 가
 3 0.0077 ppb .
 1 0.1740 ppb , 1 0.1490 ppb, 3
 1.3176 ppb , 1 0.3505 ppb .
 2 2.8248 ppb 가 , 4 0.2870
 ppb 가 .

0.0002 0.4628
 ppb (Table 3), 0.0010 1.0787 ppb (Table.
 4) , 0.0001 0.9285 ppb
 (Table. 5).

가 ,
 1 3
 1.2872 ppb, 1.6593 ppb 가

가
 PAHs PAHs
 16 가
 PAHs (carcinogenic) 가 BkF, BaP,
 DahA, BghiP, I123-cdP . PAHs

(Table. 6, Fig. 12, 13, 15, 17).

PAHs						가
	,	가		.		
		PAHs	1,	2,	3	0.4448 ppb, 0.1438
ppb, 0.1112		ppb				
	.			,	2,	4
ppb, 0.0105		ppb				0.0052
	.					
		PAHs			3	1.3176 ppb
PAHs	가	가	,		0.4511 ppb	가
	.			PAHs		1
0.0090 ppb,	3	0.1380 ppb	,	1		0.0922 ppb
,		0.0444 ppb	.			
	,	1	2	1.6822ppb,	2.8248 ppb	가
	,			0.2870 ppb	가	.
,	1	2		0.5485 ppb,	1.1680 ppb	가
,	2	0.0562 ppb	가			.

Table. 6. Relative concentration of Carcinogenic PAH component in Total PAHs

unit : ppb

	Carcinogenic PAHs			Total PAHs		
	Sediment	Green Larver	Oyster	Sediment	Green Larver	Oyster
Inchon 1	0.4448		0.5485	1.2872		1.6822
Inchon 2	0.0400		1.1680	0.0953		2.8248
Inchon 3	0.1438		0.0354	1.6593		0.1675
Inchon 4	0.1112			0.2542		
Asan 1	0.0744			0.4731		
Asan 2	0.0213		0.3177	0.0666		0.8286
Asan 3	0.0077		1.0039	0.0440		0.7003
Asan 4	0.0358			0.0820		
Taechon 1	0.0000	0.0922	0.2771	0.1148	0.1740	0.6123
Taechon 2	0.0052		0.1913	0.0110		0.4585
Taechon 3	0.0000			0.0077		
Taechon 4	0.0105		0.2121	0.1232		0.2870
Youngkwang 1	0.3167	0.0090	0.5256	1.1603	0.1490	1.0903
Youngkwang 2	0.2811		0.0562	0.8728		0.4363
Youngkwang 3	0.0733	0.1380	0.1835	0.2453	1.3176	1.4710
Kunsan 1	0.1471			0.4366		
Kunsan 2	0.0054			0.1625		
Kunsan 3	0.0017			1.2566		
Kunsan 4	0.0024			1.1052		
Mokpo 1	0.0232	0.0444	0.1211	0.2552	0.3505	0.9828

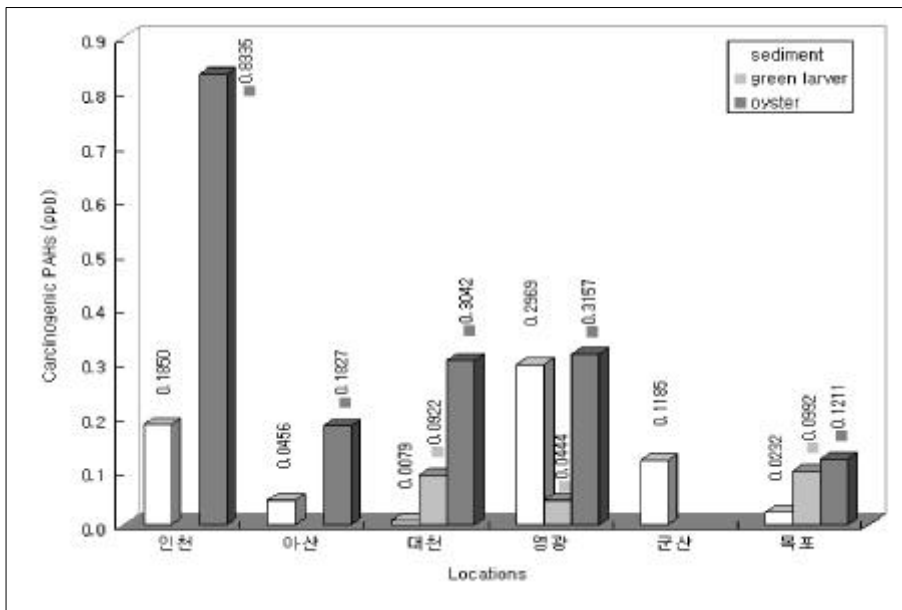


Fig. 11. Total Concentration of 16 PAHs analyzed by uv/vis detector

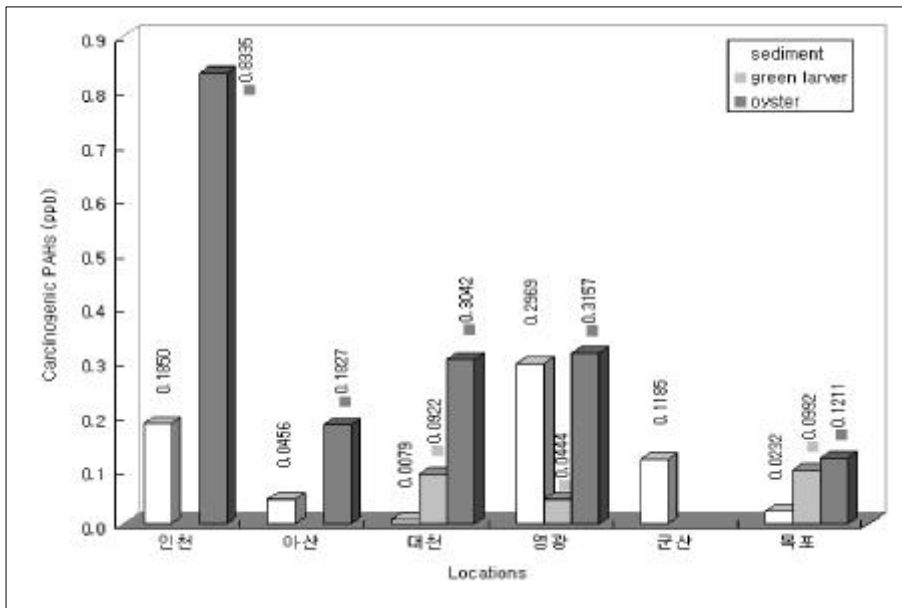


Fig. 12. The distribution of Carcinogenic PAHs analyzed by uv/vis detector

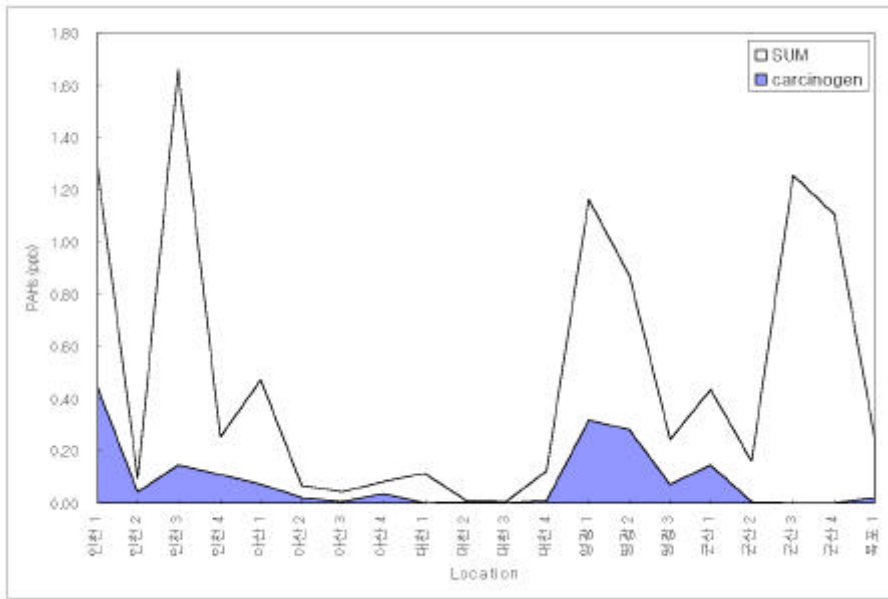


Fig. 13. Relative comparison Carcinogenic PAHs in sediment with total PAHs

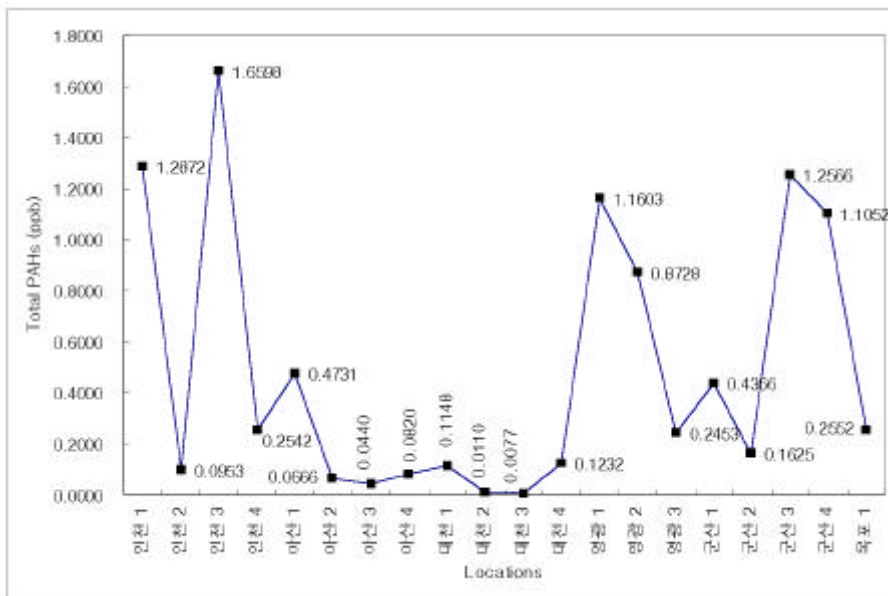


Fig. 14. The distribution of Total PAHs from Sediment at each site

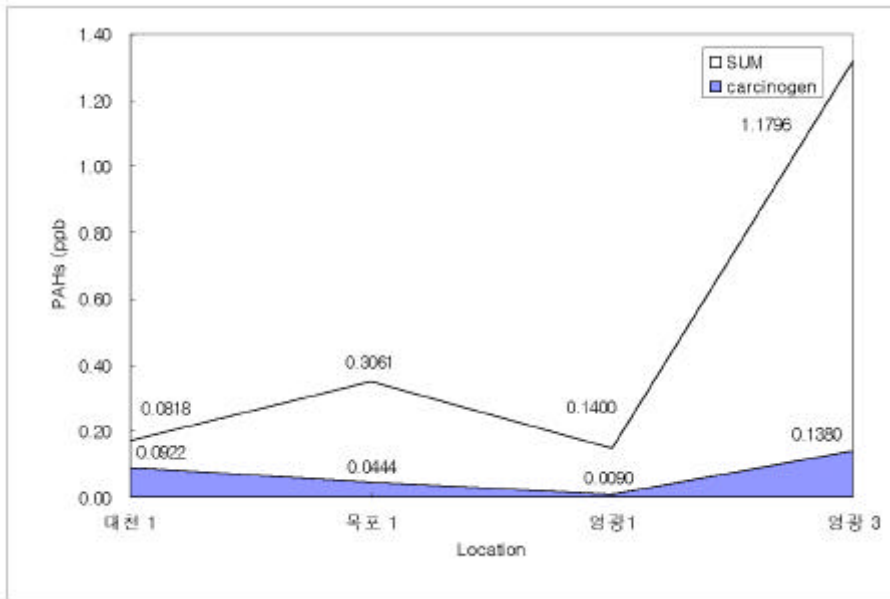


Fig. 15. Relative comparison Carcinogenic PAHs from seaweed with Total PAHs

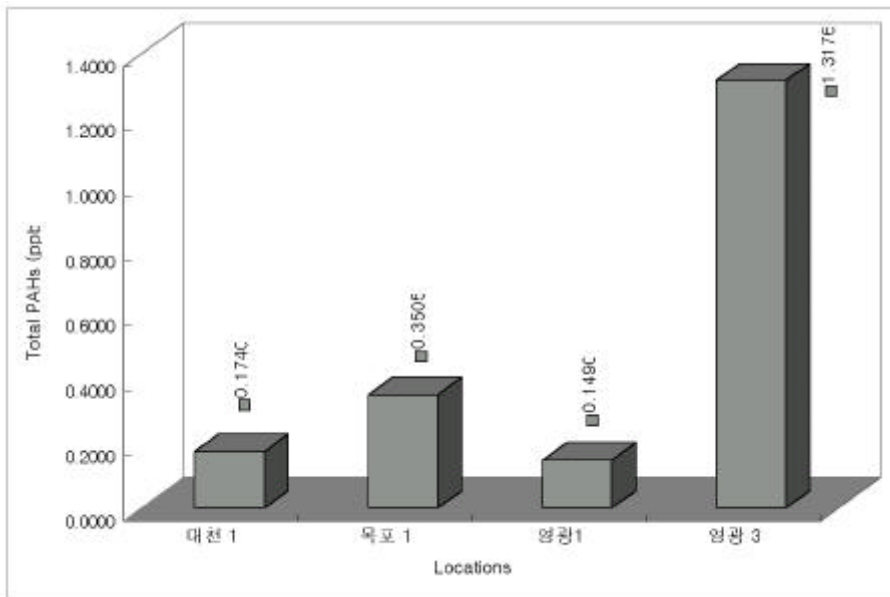


Fig. 16. The distribution of Total PAHs from Seaweeds at each site

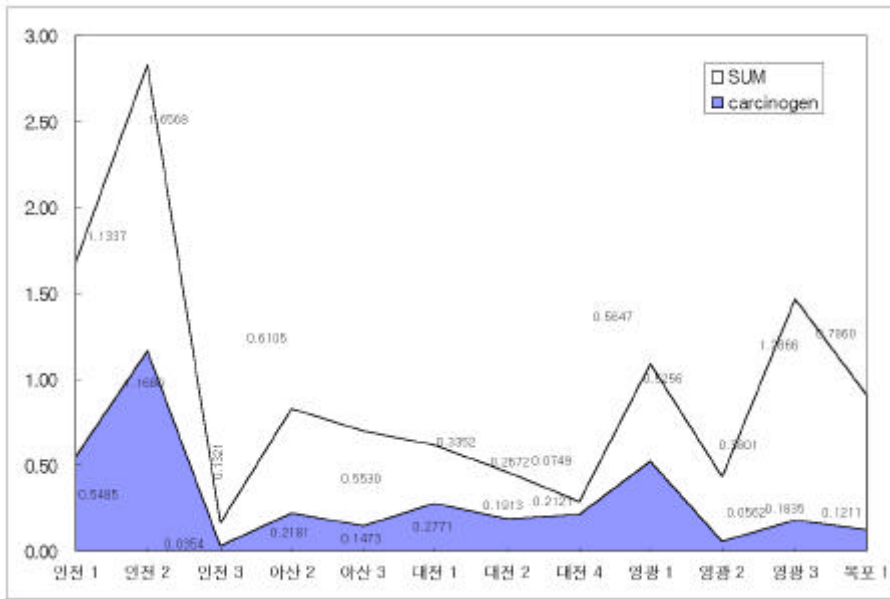


Fig. 17. Relative comparison Carcinogenic PAHs in shellfish with total PAHs

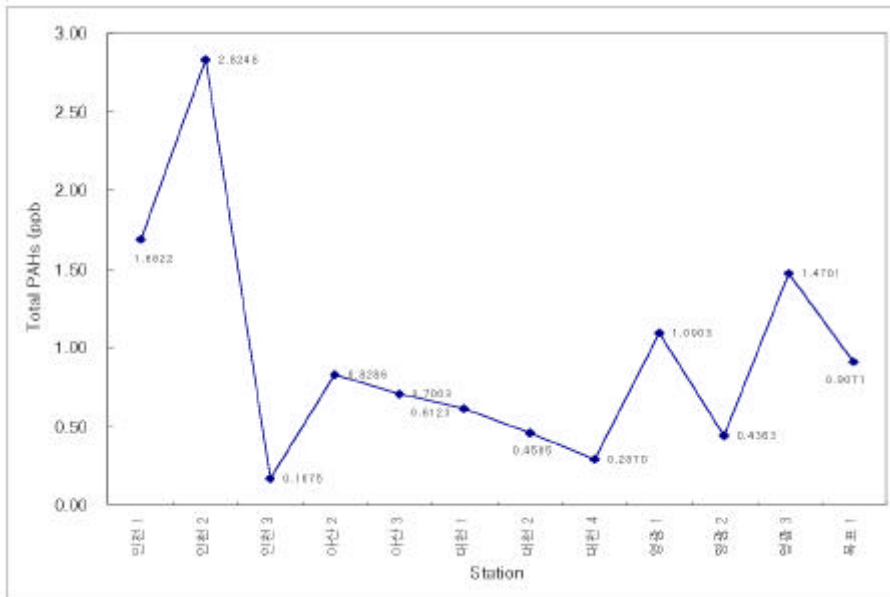


Fig. 18. The distribution of Total PAHs from shellfish at each site

- 2. PAHs PAHs

2 3 가 PAHs

3 5 가 PAHs (Boehm and Farrington, 1984). PAHs

가 sediment trap flux (Elisabeth *et. al.*, 1993). Bruce *et. al.* PAHs PAHs PAHs . Bruce Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthrcene

PAHs PAHs PAHs PAHs PAHs 가

Table. 7. PAHs (3) PAHs (4) PAHs PAHs (Fig.18.). 1 PAHs PAHs가 100% PAHs 100% 가 PAHs PAHs PAHs PAHs가

PAHs 1, 1, 3
 PAHs PAHs
 1 4
 PAHs 1
 PAHs 90% 가
 PAHs PAHs
 1 PAHs
 가 가
 PAHs
 PAHs
 1 3 PAHs
 PAHs
 가
 , , ,
 ,
 , PAHs
 PAHs 가
 , 가

Table. 7. 3 ring PAHs vs. 4 ring PAHs ratio at each site (unit : %)

Sites	3 rings PAHs			4 rings PAHs		
	Sediment	Green Larver	Oyster	Sediment	Green Larver	Oyster
Inchon 1	35.56		10.97	64.44		89.03
Inchon 2	43.13		36.72	56.87		63.28
Inchon 3	76.14		69.84	23.86		30.16
Inchon 4	31.55			68.45		
Asan 1	45.50			56.50		
Asan 2	3.30		46.64	96.70		53.36
Asan 3	25.00		72.24	75.00		27.76
Asan 4	22.93			77.07		
Taecheon 1	100.00	8.39	49.67	0.00	91.61	50.33
Taecheon 2	31.82		48.33	68.18		51.67
Taecheon 3	38.96			61.04		
Taecheon 4	22.08		15.92	77.92		84.08
Youngkwang 1	66.66	65.77	47.95	33.34	34.23	52.05
Youngkwang 2	38.15		71.75	61.65		28.25
Youngkwang 3	1.75	86.49	64.71	98.25	13.51	35.29
Kunsan 1	49.02			50.98		
Kunsan 2	59.38			40.62		
Kunsan 3	0.23			99.77		
Kunsan 4	4.92			95.08		
Mokpo 1	78.53	85.99	48.48	21.47	14.01	51.52

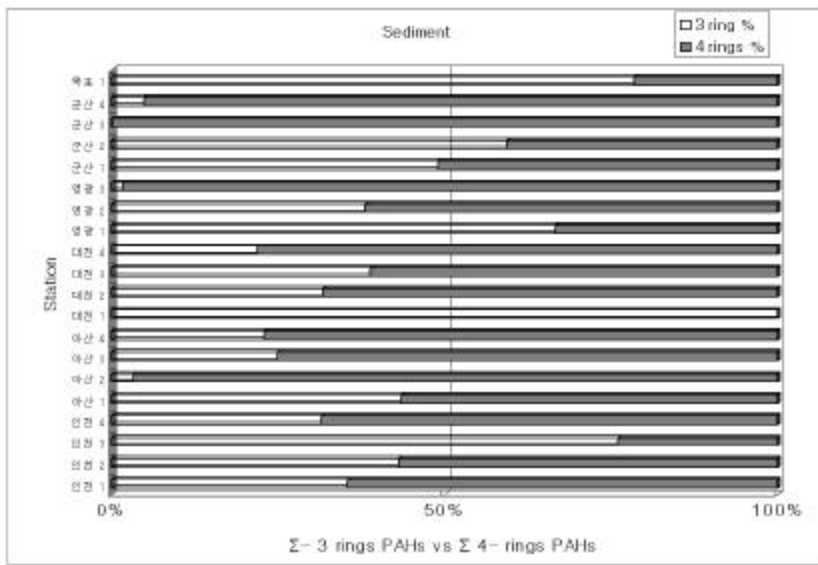


Fig. 19. 3 rings PAHs vs. 4 rings PAHs ratio from sediment at each sites

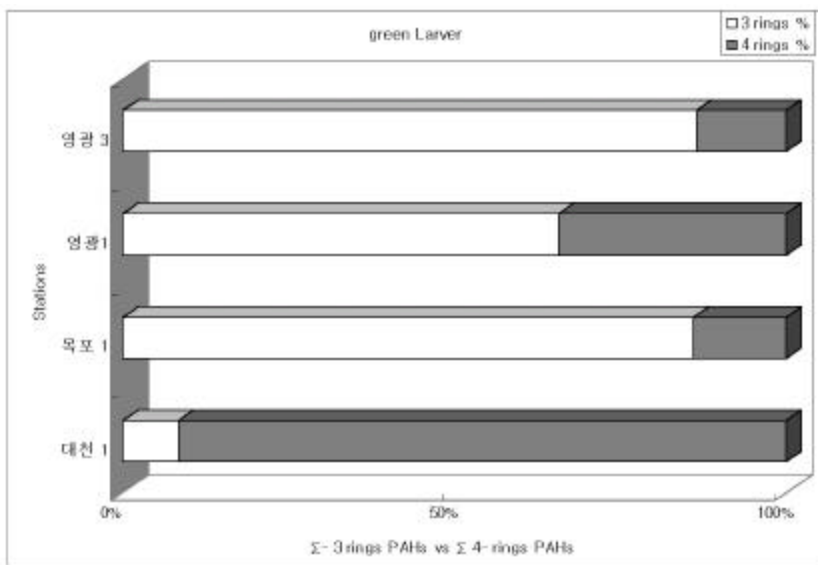


Fig. 20. 3 rings PAHs vs. 4 rings PAHs ratio from seaweeds at each sites

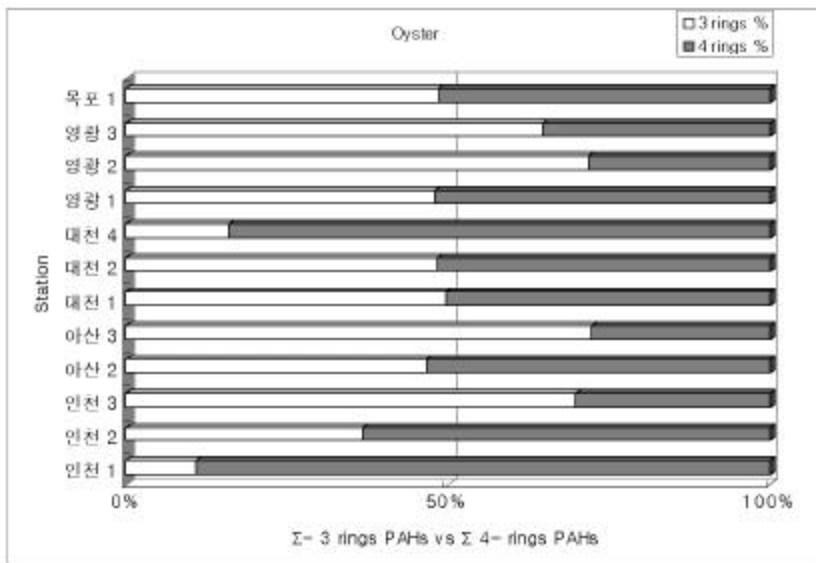


Fig. 21. 3 rings PAHs vs. 4 rings PAHs ratio from shellfish at each sites

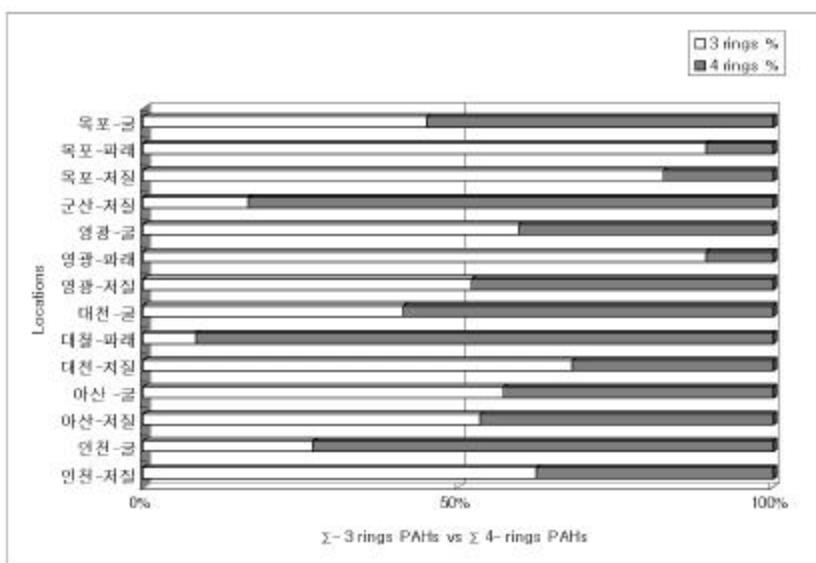


Fig. 22. Relative comparison 3 rings PAHs with 4 rings PAHs ratio

- 3.

- 3- 1.

가

11

1 LNG

2

3

4

1 NACPN,
FLRTH, BkF 0.3187 ppb, 0.2991 ppb, 0.2120 ppb
가

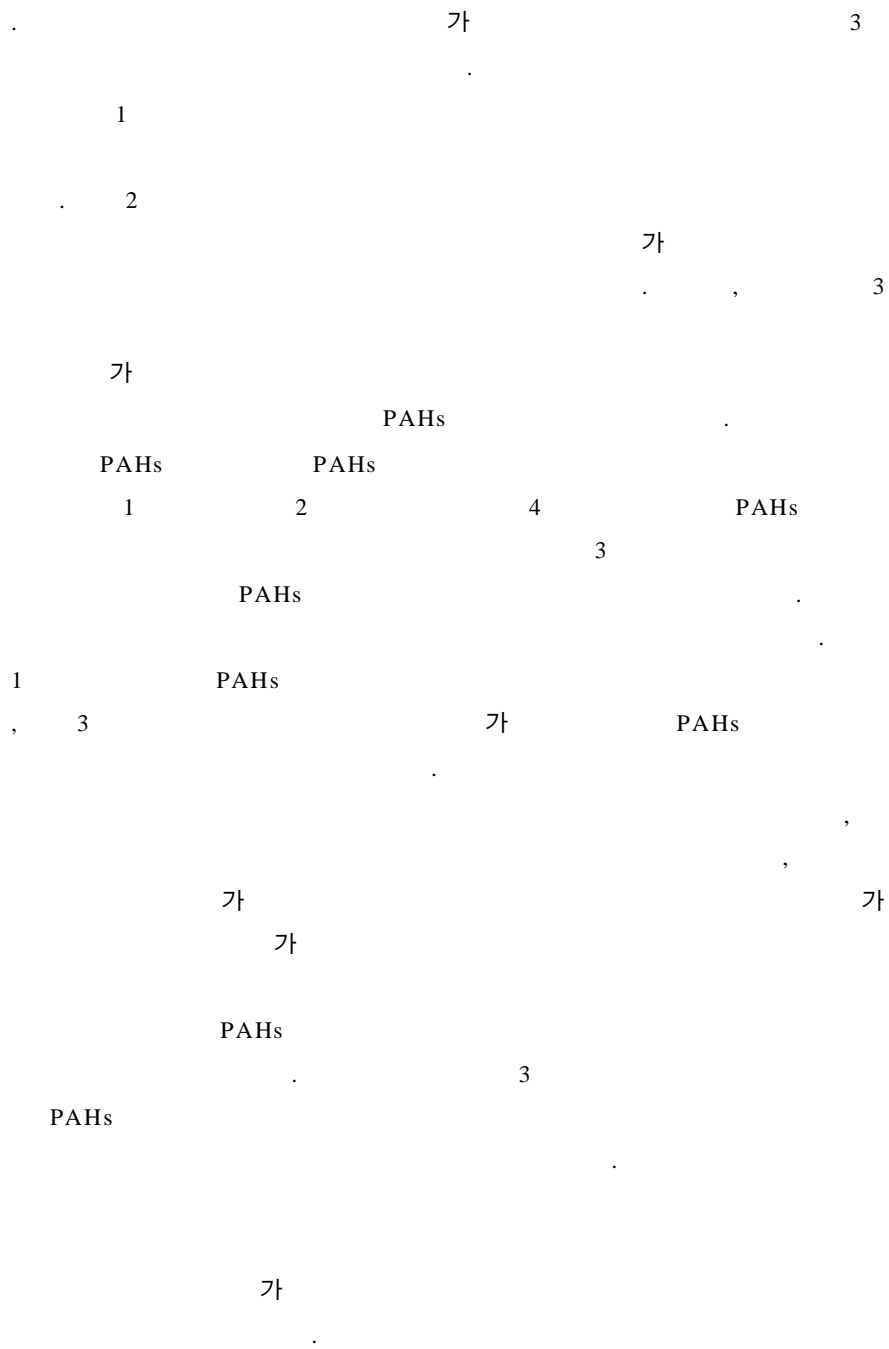
2 PAHs NAPTL, NACPL, FLURN 0.4628 ppb, 0.4036
ppb, 0.2701 ppb 4 2 가

가

PAHs

1 FLRTH가 0.9285 ppb 가

2 PAHs ANCPL PAHs BbF, BkF
가 0.5473 ppb, 0.6075 ppb, 0.9405 ppb



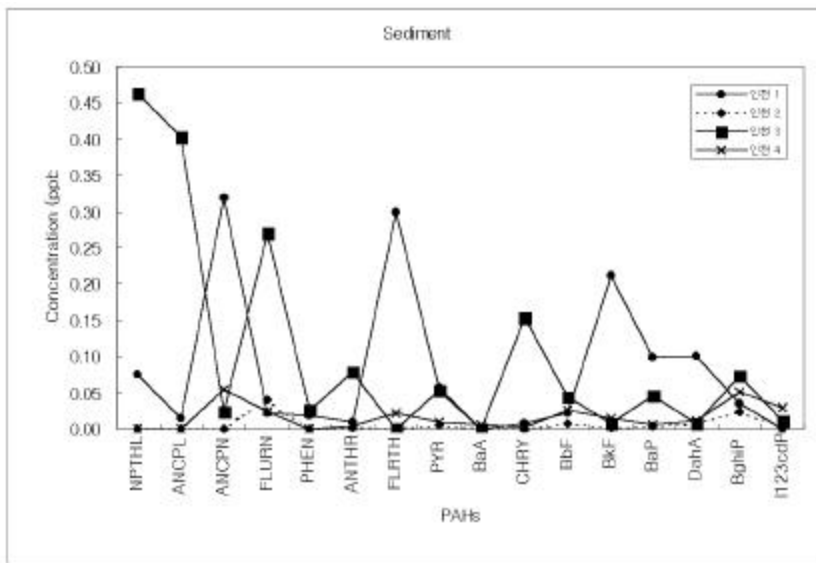


Fig. 23. The distribution of each PAHs in sediments from the Incheon Harbor

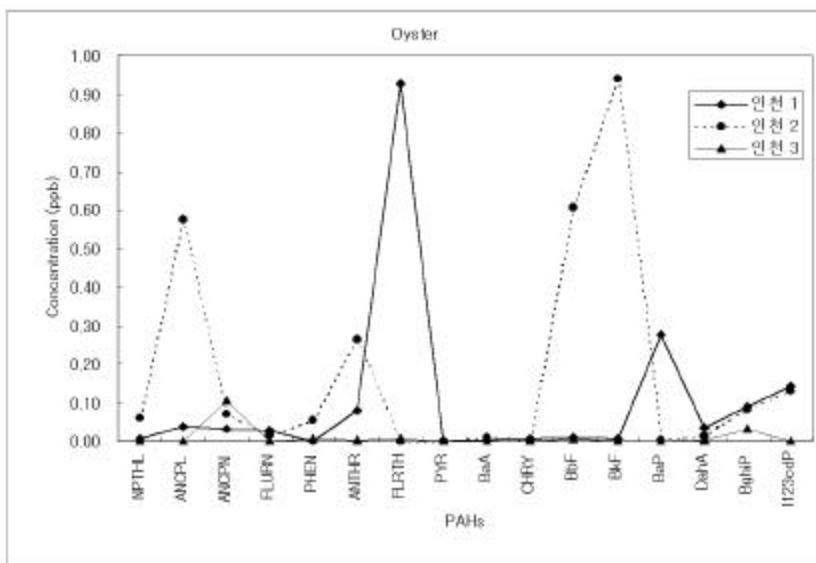


Fig. 24. The distribution of each PAHs in oyster from the Incheon Harbor

- 3- 2.

가
 가 (, 1994). 가
 가 가 가
 가 가
 가 가
 가 가
 가
 가
 1 PYR 0.0873 ppb 가
 , CHRY, BbF, BkF
 2 FLRTH가 0.0414 bbp
 가
 3 4 가
 FLRTH 가
 3
 2 가 FLRTH 가
 0.0234 ppb 4
 PHEN
 BbF가 0.0188 ppb, 0.0182 ppb
 2 ANCPN 0.3222 ppb
 가 , FLRTH, BbF, BghP, I123-αP

0.1172 ppb, 0.0980 ppb, 0.0818 ppb, 0.0940 ppb

3

PAHs ANCPN FLRTH 0.2567 ppb, 0.1170 ppb
ANCPN

FLRTH

PAHs

PAHs

1

PAHs

2, 3, 4

PAHs

PAHs

LNG

가

가

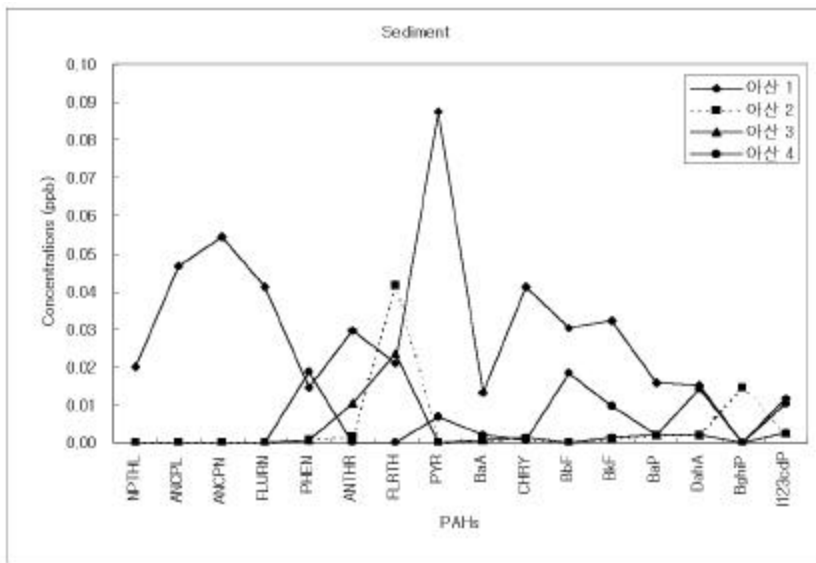


Fig. 25. The distribution each PAHs in sediment from the Asan Bay

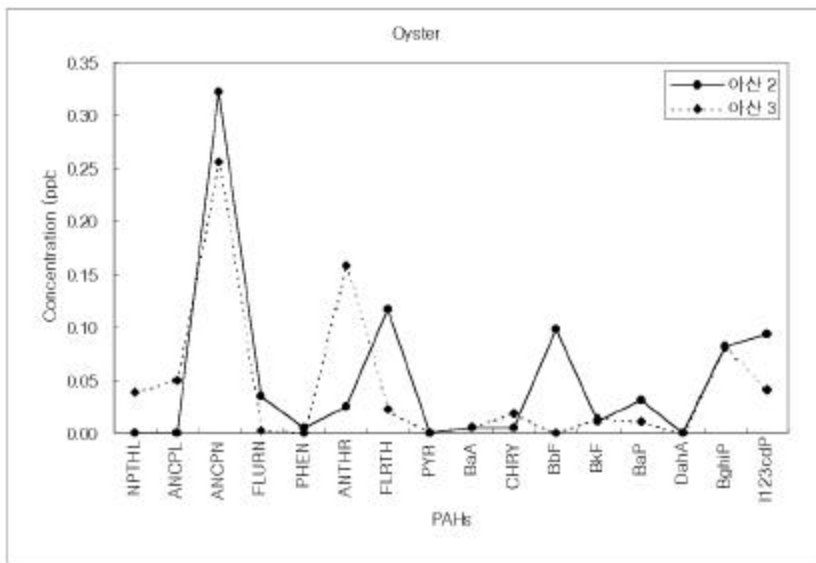


Fig. 26. The distribution of each PAHs in green larver from the Asan Bay

가

가

16가 PAHs

가 1 ANCPL 0.1148 ppb

2, 3, 4 0.01 ppb

1 ANCPL

2 ANTHR BbF

0.0035 ppb, 0.0023 ppb

3 ANCPN 가

ANCPL FLRTH가 0.003

ppb, 0.0047 ppb

4 FLRTH가 0.0649 ppb

0.005 ppb

16가 PAHs 가 0.1740 ppb

BbF BghiP가 0.0564 ppb,

0.0590 ppb , NPThL, ANCPL,

ANCPL, PYR, DahA

1, 2, 4 16가

PAHs 가 0.6123 ppb, 0.4585 ppb, 0.2870 ppb

1 ANCPL,

ANTHR, FLURN, PHEN, BkF, DahA 0.0784 ppb, 0.0797 ppb,

0.0599 ppb, 0.0724 ppb, 0.1142 ppb, 0.0119ppb

2 ANCPL, ANTHR,

BkF, DahA 0.0825 ppb, 0.0832 ppb, 0.0798 ppb, 0.0999 ppb

4 BghiP 0.1892

PAHs PAHs PAHs
2, 3, 4 4

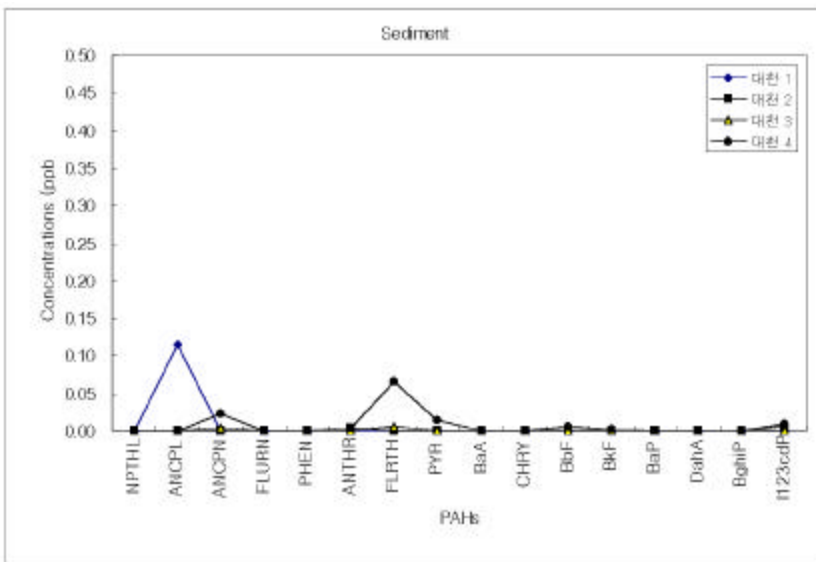


Fig. 27. The distribution of each PAHs in sediment from the Taechon

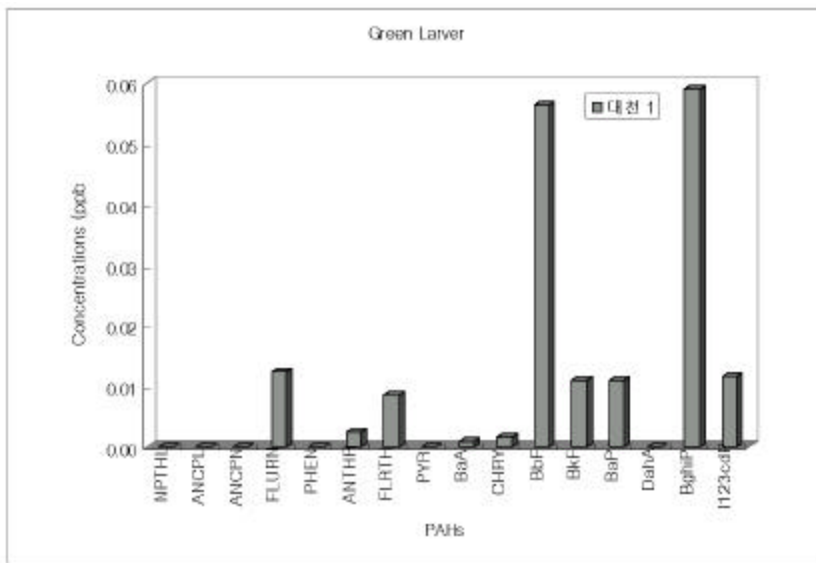


Fig. 28. The distribution of each PAHs in green larver from the Taechon

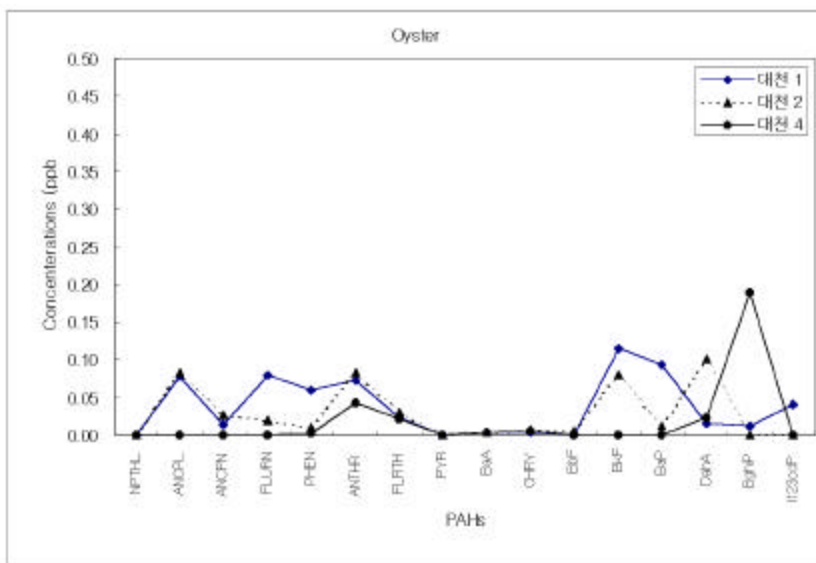


Fig. 29. The Concentration of individual PAHs in oysters from the Taechon

- 3- 4.

가

16가 PAHs 가 1,
 2, 3 1.1603 ppb, 0.8728 ppb, 0.2453 ppb
 1, 3 0.1409 ppb, 1.3176 ppb
 1, 2, 3 1.0903 ppb, 0.4363 ppb, 1.4710 ppb

가

1 NPTHL, ANTHR, BkF가 0.1334 ppb, 0.4600 ppb, 0.3030
 ppb , 2 PYR 0.2060
 ppb 가
 3 2 가 PYR 0.0163 ppb 16가
 가

1

3 ANCPN 1.0787 ppb

1 ANCPN, BghiP, I123-αP가 0.3625
 ppb, 0.2088 ppb, 0.1948 ppb

2 ANCPN 0.0721 ppb

3

ANCPN BbF 가 0.3890 ppb, 0.1030 ppb

ANCPN

PAHs

PAHs

3

PAHs

1

2 PAHs 가
PAHs

PAHs

1 가 ,
3 가 , 1 3
가
2 가 가 1 가

가

가

PAHs

PAHs

가

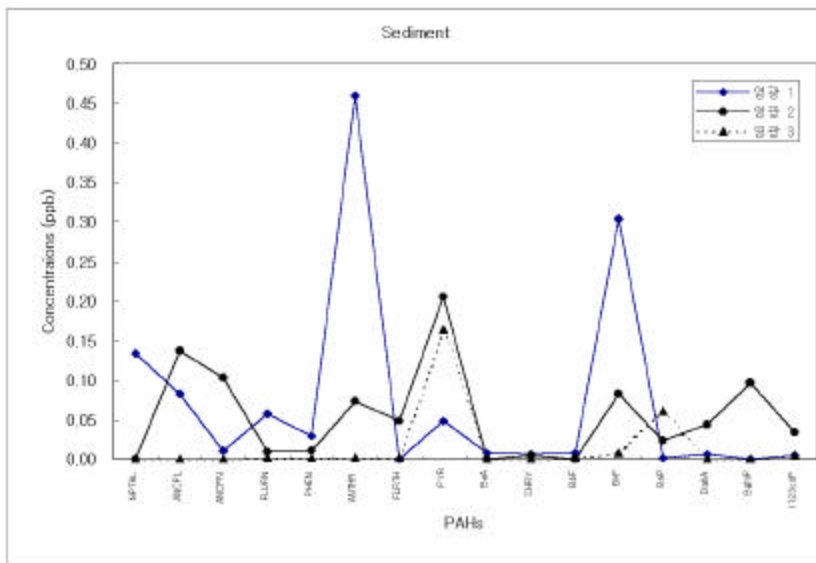


Fig. 30. The distribution of each PAHs in sediment from the Youngkwang

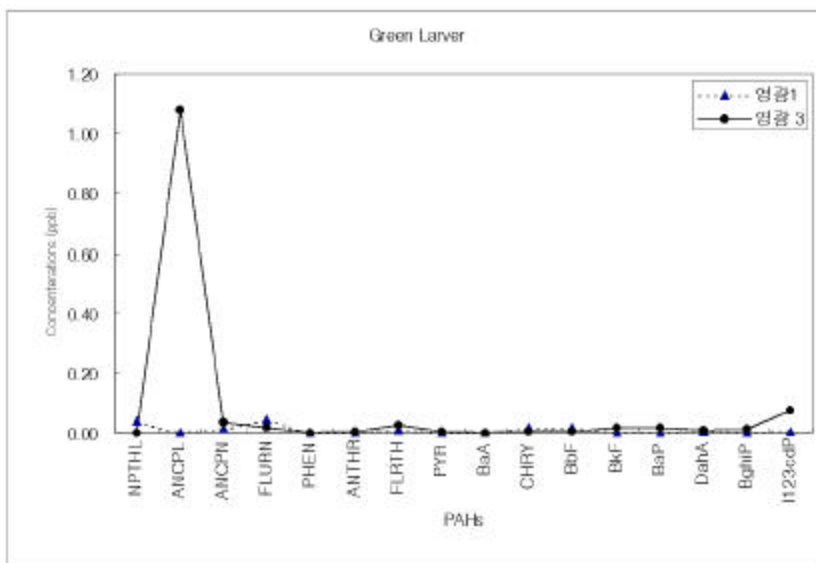


Fig. 31. The distribution of each PAHs in green larver from the Youngkwang

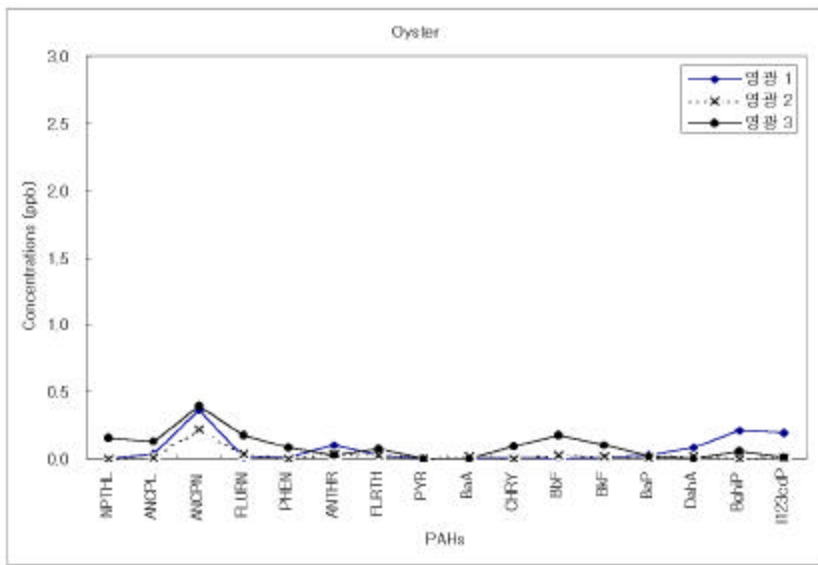


Fig. 32. The distribution of each PAHs in oysters from the Youngkwang

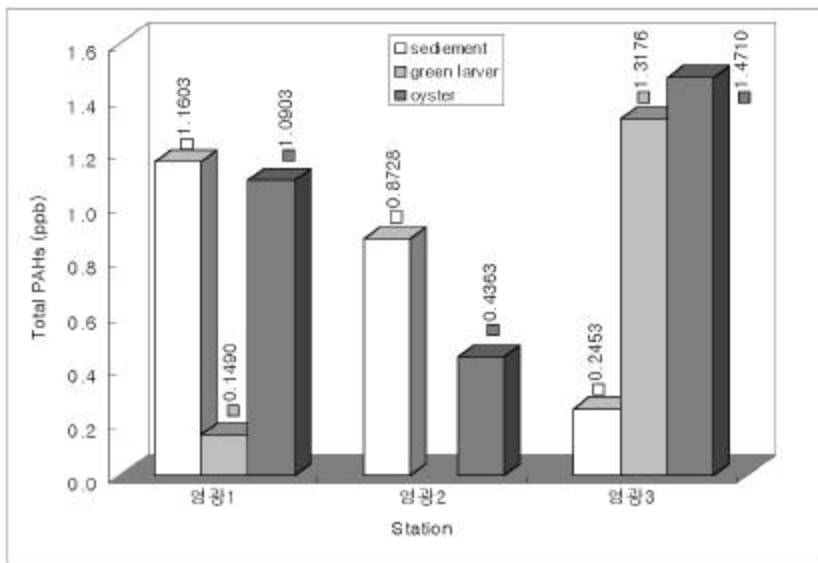


Fig. 33. The comparison of each PAHs component in sediment, green larver and oyster from the Youngkwang

16가 PAHs
1, 2, 3, 4 0.4366 ppb, 0.1625 ppb, 1.2566 ppb, 1.1052 ppb
1
2 1
3 FLRTH 1.2415 ppb
4 3
4 FLRTH 0.8221 ppb

(Fig 29).

PAHs PAHs
1 2 PAHs
3 4
PAHs (Fig.
18).

1
PAHs 가 , 2
PAHs
3 4 FLRTH
16가 PAHs 가 , FLRTH
15가
PAHs
3
4
1

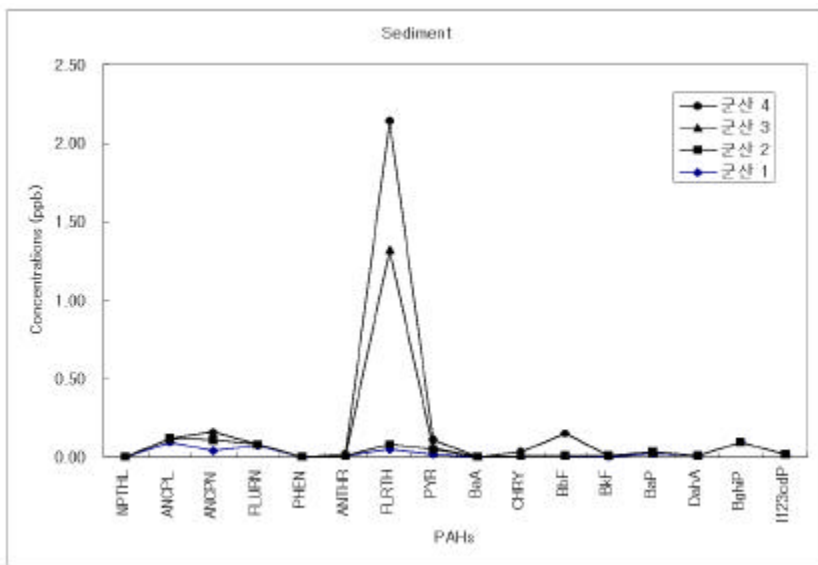


Fig. 34. The distribution of each PAHs in sediment from the Kunsan Bay

- 3- 6.

가

, , ,
 .
 ,
 가 가
 16가 PAHs 0.2552
 ppb
 PAHs ANCPL 0.1701 ppb
 , 15가
 가 16가 PAHs
 0.3505 ppb , , ANCPL 0.2101 ppb 가
 , 15가
 , 16가 PAHs
 0.9828 ppb
 PAHs
 ANCPN 0.2204 ppb , BbF가 0.3171ppb, BkF가 0.1057 ppb
 PAHs PAHs
 PAHs
 , 16가
 PAHs
 PAHs
 가

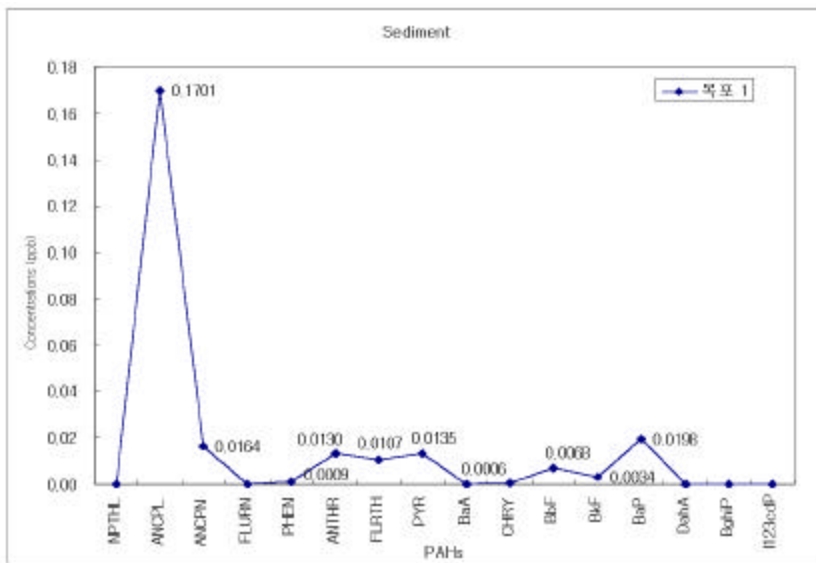


Fig. 35. The distribution of each PAHs in sediment from the Mokpo Harbor

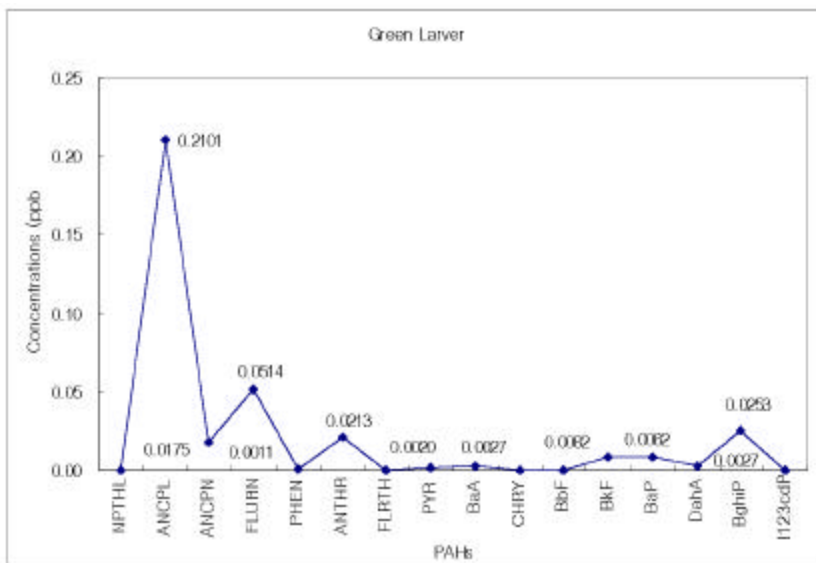


Fig. 36. The distribution of each PAHs in seaweed from the Mokpo Harbor

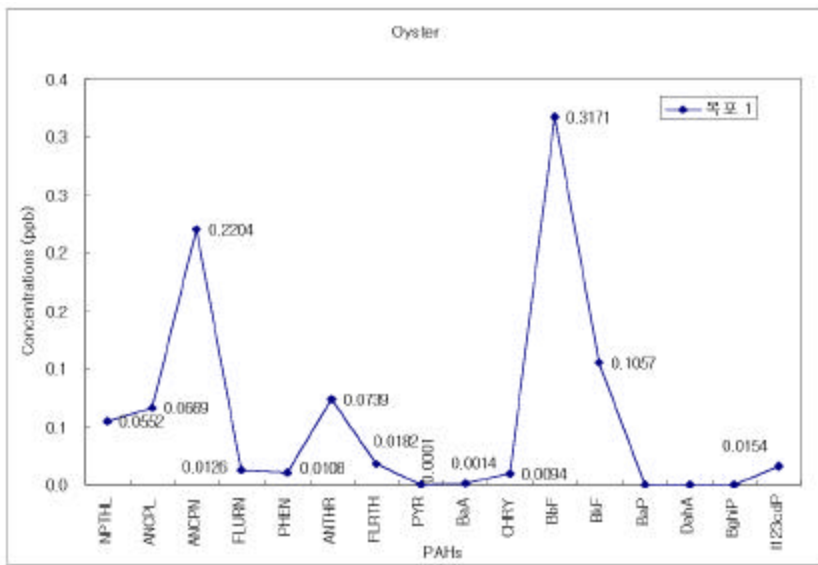


Fig. 37. The distribution of each PAHs in oyster from the Mokpo Harbor

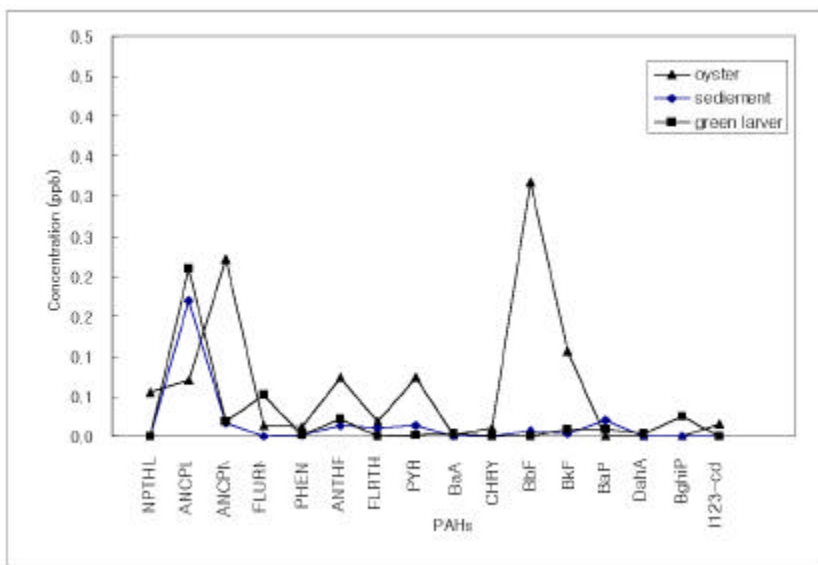


Fig. 38. The comparison of each PAHs component in sediment, green larver and oyster from the Mokpo Harbor

- 4.

(Table 8, 9 10).

16가 PAHs		16가 PAHs	
458.7645	2179.3980 ppb	0.2423 ppb	1.1890 ppb
		0.0071 ppb	0.0010
			0.0132 ppb
PAHs	0.1740	1.3194 ppb	
ppb			0.0026
			0.0194
	377.4059	955.0000 ppb	
			가
	PAHs		가
			가

PAHs

PAHs

PAHs

PAHs가

PAHs

PAHs

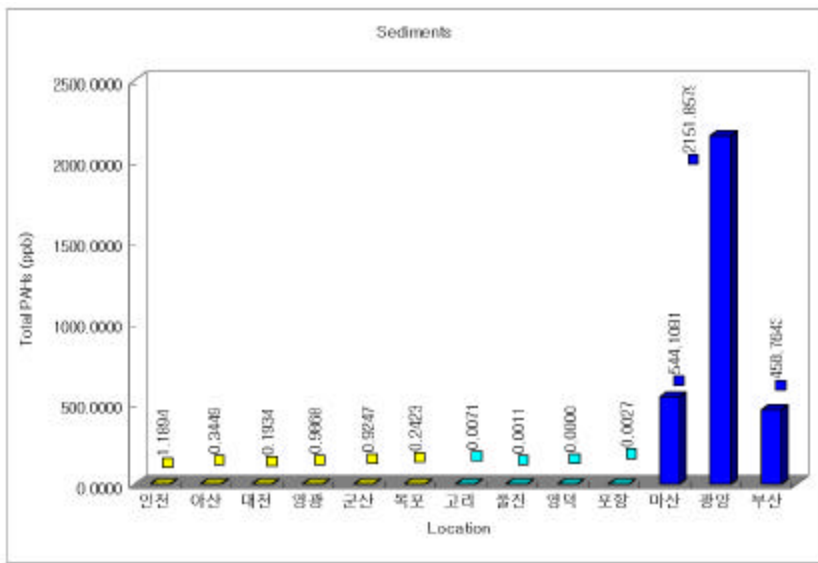


Fig. 39. Total PAHs Yellow Sea with East & Southe Sea from Sediment

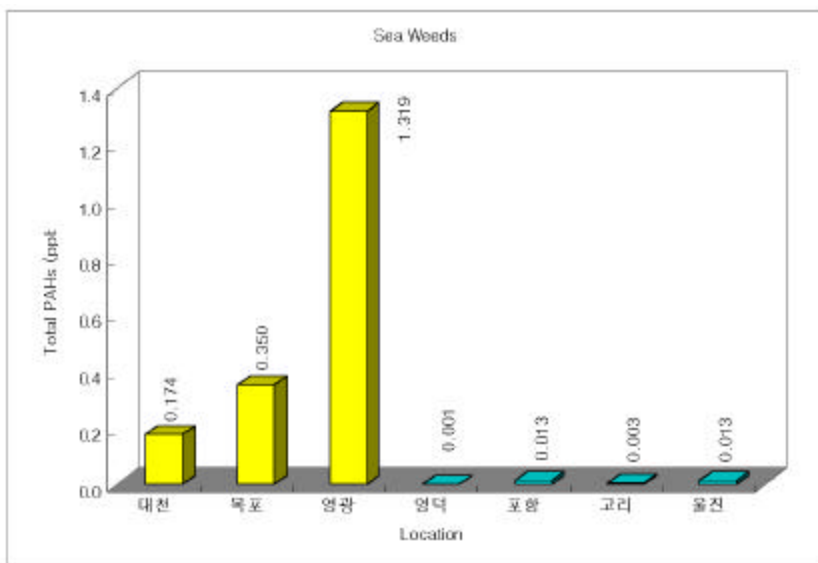


Fig. 40. Total PAHs Yellow Sea with East Sea from seaweeds

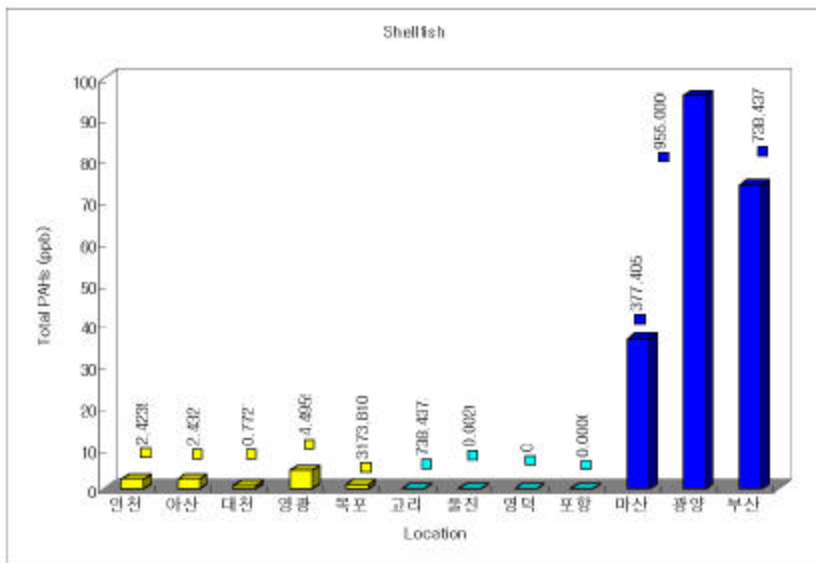


Fig. 41. Total PAHs Yellow Sea with East & South Sea from shellfish

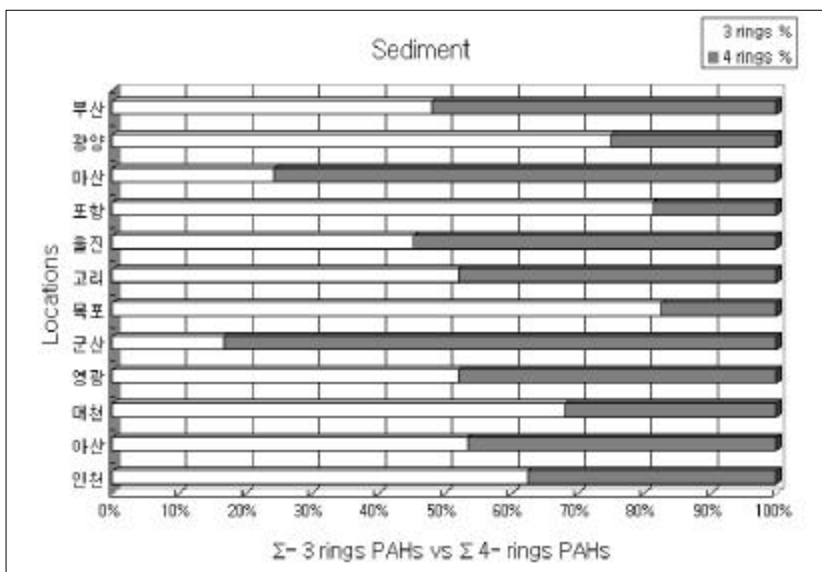


Fig. 42. 3 rings PAHs with 4 rings PAHs ratio from sediment at each site

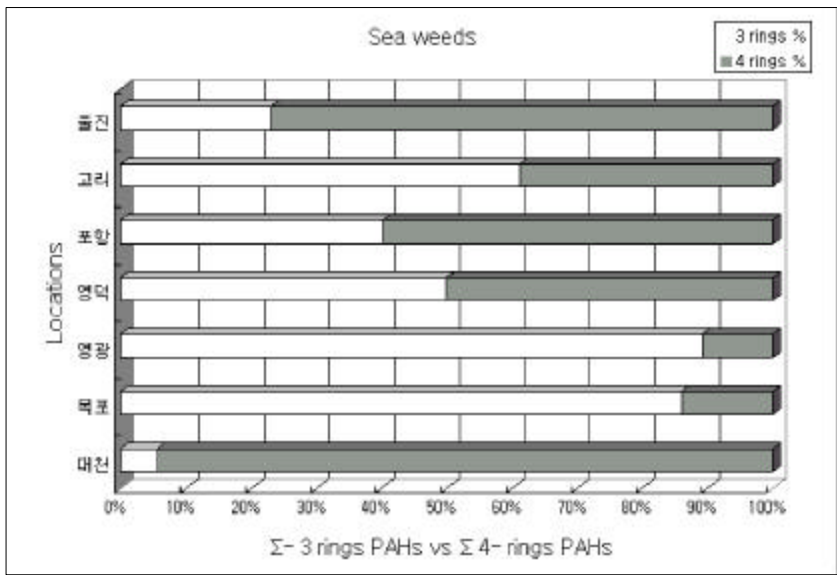


Fig. 43. 3 rings PAHs with 4 rings PAHs ratio from seaweed at each site

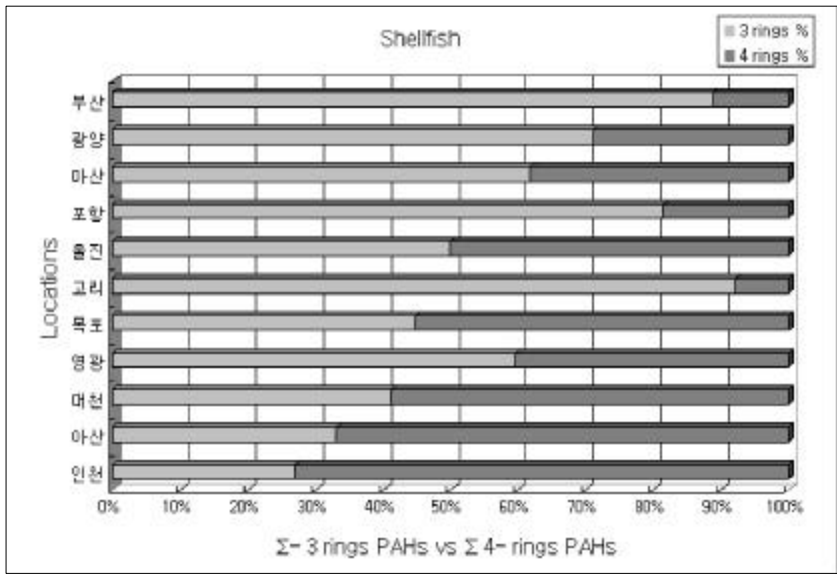


Fig. 44. 3 rings PAHs with 4 rings PAHs ratio from shellfish at each site

1.1890 ppb, 0.3450 ppb, 0.1933 ppb, 0.9868 ppb, 0.9245 ppb, 0.2423 ppb (kim, 1997)

(D. A. Carey & Farrington, 1989) Baltic Sea Order Estuary(G. Kowalewska & Wawrzyniak, 1997) (Hamid & Amina, 1989) 가 44194.14 ppb, 4294.492 ppb, 1.2657 ppb , Humber Plume (Hans & Lisbeth, 1993) 2.1500 ppb 가 (Fig. 38).

PAHs (3 rings PAHs) PAHs(4 rings PAHs) PAHs가 PAHs

et. al., 1983) Lobster 16가 PAHs 898 ppb , New Jersey (Pancirve & Brown, 1997) Oyster() Mussel() 8.8 ppb, 113 ppb , Gulf of Naples 235 ppb , Lanuna Veneta(Fassato et. al., 1979) 83.2 ppb 가 , Baltic Sea PAHs가 (Kit, 1995). PAHs(4 rings PAHs) PAHs(3 rings PAHs) 가

(Fazio, 1970; Pancirvo & Brown, 1977; Joe *et. al.*, 1979; Mix & Schaffer, 1983).

PAHs PAHs가 PAHs가
(Fig. 44).
Lagos Lagoon (E.
A. Ajao and S. O. Fagade, 1990) PAHs 가
11.035 ± 15.147 ppb ,
(Josip and Perica, 1990) 0.48 18.14 ppb
Great Barrier Reef (J. David
Smith *et. al.*, 1985)

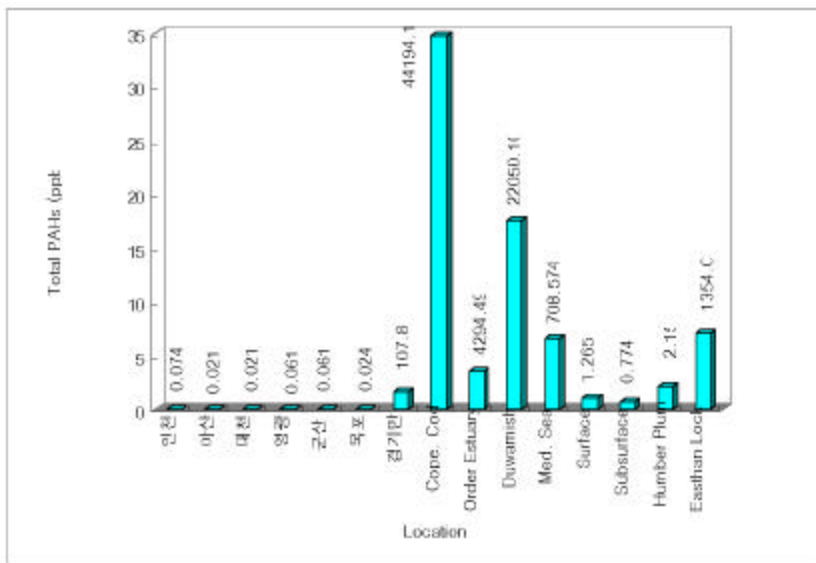


Fig. 45. Comparison of PAHs in this study with Other Country (sediment)
 * Med. Sea : Mediterranean Sea, surface and subsurface : Irque

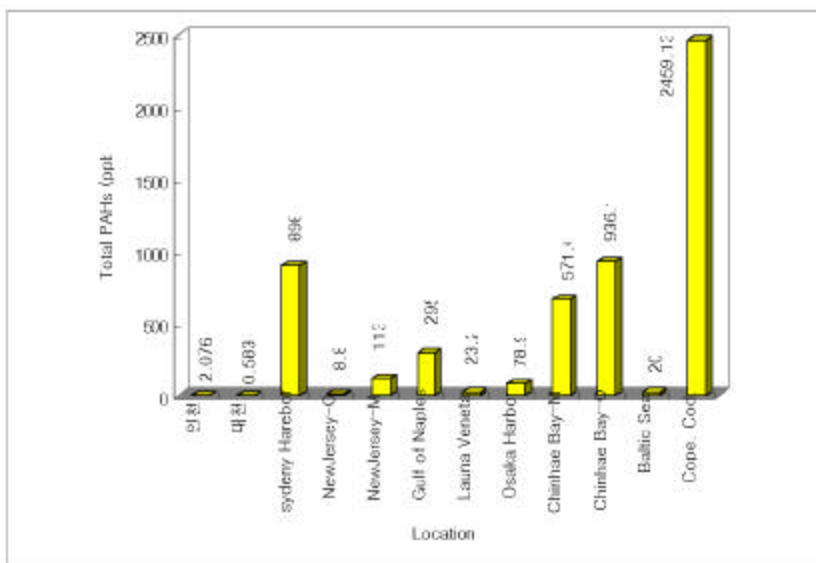


Fig. 46. Comparison of PAHs in this study with Other Country
 (Marine Organisms) * O : Oyster, M : Mussel

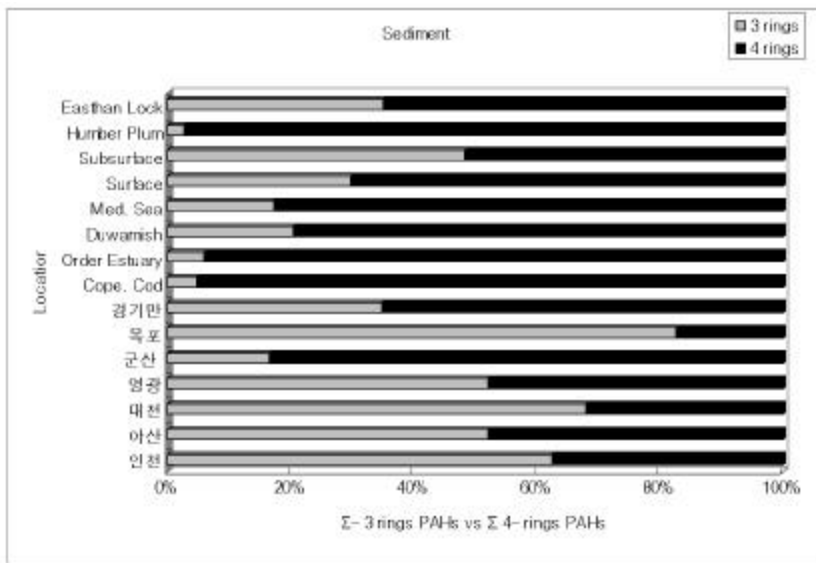


Fig. 47. 3 rings vs. 4 rings (Sediment)
 * Med. Sea : Mediterranean Sea, surface and subsurface : Irque

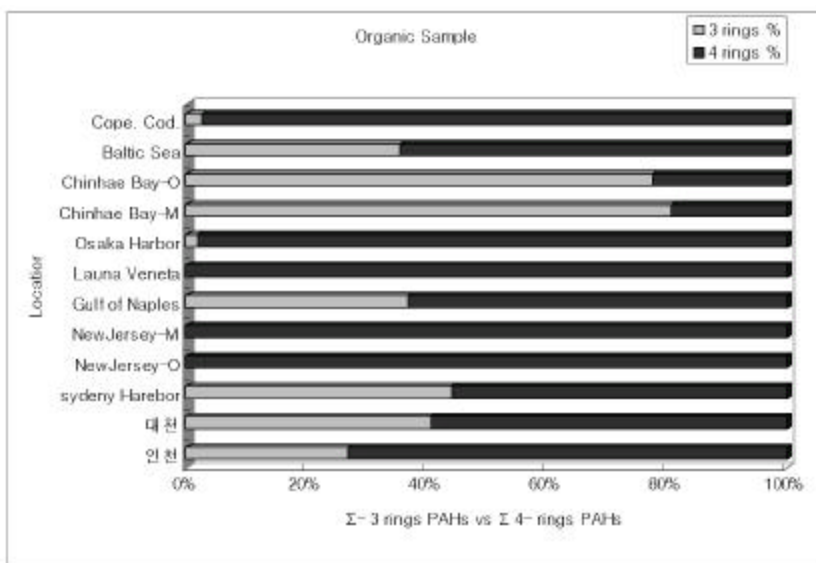


Fig. 48. 3 rings vs. 4 rings (Shellfish)
 * O : Oyster : M : Mussel

- 6.

가

(Lee, 1993).

200

가

가 가 (, 1991).

가 가

가 (, 1990).

fiber, , solvent , plastic

가 , ,

. 1970

, 가

(Shelton, 1971 ; Baker, 1976 ; Moldan *et. al.*, 1976 ; Teal and Howarth, 1984 ; Percy and Wells, 1991).

1920

API (American Petroleum Institute)

가

(Bertha and

Bossert, 1984).

가

(. 1991).

1995

2

23%

(U. S. Energy Information Administration

Annual Energy Review, 1987).

가

(, 1988).

(, 1999).

가 , . 1980

, 1999). 가 (

PAHs

가

PAHs

가

PAHs

PAHs

PAHs가

PAHs

PAHs

가

- , 1999. ;
- (ITOPF, The International Tanker Owners Pollution Federation Ltd)
- . 1988. (BSPG00057-184-4), pp. 292
- , 1990.
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