Marine and Freshwater Research, 2020, **71**, 617–626
https://doi.org/10.1071/MF19055

Supplementary material

Bioaccumulation and health risk assessment of polycyclic aromatic hydrocarbons in oyster (*Crassostrea* sp.) and gastropod (*Cymatium* sp.) species from the Can Gio Coastal Wetland in Vietnam

Luu Thanh Pham[A,B,F], *Thuy Thi Thanh Hoang*[C], *Loan Thi Cam Tu*[C], *Yen Thi Hoang Tran*[B], *Bao Duy Le*[D], *Dong Van Nguyen*[D], *Huy Xuan Do*[E] *and Nam Van Thai*[A]

[A]Ho Chi Minh City University of Technology (HUTECH), 475A Dien Bien Phu Street, Binh Thanh District, Ho Chi Minh City, Vietnam.

[B]Institute of Tropical Biology, Vietnam Academy of Science and Technology (VAST), 85 Tran Quoc Toan Street, District 3, Ho Chi Minh City, Vietnam.

[C]Ho Chi Minh City University of Natural Resources and Environment, 236B Le Van Sy Street, Tan Binh District, Ho Chi Minh City, Vietnam.

[D]University of Science, Vietnam National University Ho Chi Minh City (VNU-HCM), 227 Nguyen Van Cu Street, District 5, Ho Chi Minh, Vietnam.

[E]Institute for Environment and Resources, Vietnam National University, 142 To Hien Thanh Street, District 10, Ho Chi Minh City, Vietnam.

[F]Corresponding author: pt.luu@hutech.edu.vn

Table S1. Average shell length and weight of oyster (*Crassostrea* sp.) collected from the Can Gio Coastal Wetland in Vietnam

Site	Species	Number of individual	Average shell length (cm)	Average weight (g)	Collection day
CG1	*Crassostrea* sp.	12	7.27 ± 2.05	72.61 ± 7.8	01 Sep 2017
			7.04 ± 1.23	55.76 ± 9.1	14 Apr 2018
CG2	*Crassostrea* sp.	12	7.31 ± 0.87	62.34 ± 11.4	01 Sep 2017
			7.24 ± 1.76	58.27 ± 19.3	14 Apr 2018
CG3	*Crassostrea* sp.	13	8.47 ± 0.51	83.48 ± 8.2	01 Sep 2017
			8.92 ± 0.49	69.39 ± 11.7	14 Apr 2018
CG4	*Crassostrea* sp.	12	8.61 ± 0.75	53.51 ± 6.5	01 Sep 2017
			8.57 ± 0.82	61.46 ± 7.6	14 Apr 2018
CG5	*Crassostrea* sp.	14	7.33 ± 1.05	48.75 ± 12.0	01 Sep 2017
			7.2 ± 1.24	53.22 ± 8.1	14 Apr 2018
CG6	*Crassostrea* sp.	12	8.09 ± 1.12	80.73 ± 18.9	01 Sep 2017
			7.97 ± 0.72	63.96 ± 6.2	14 Apr 2018
CG7	*Crassostrea* sp.	12	8.12 ± 1.11	76.88 ± 11.3	01 Sep 2017
			7.8 ± 1.65	45.72 ± 10.4	14 Apr 2018
CG8	*Crassostrea* sp.	13	8.4 ± 0.56	64.03 ± 5.9	01 Sep 2017
			8.56 ± 0.47	63.27 ± 6.8	14 Apr 2018
CG9	*Crassostrea* sp.	12	7.43 ± 1.67	49.31 ± 17.0	01 Sep 2017
			8.38 ± 1.02	58.72 ± 7.9	14 Apr 2018
CG10	*Crassostrea* sp.	12	7.29 ± 2.09	53.65 ± 17.5	01 Sep 2017
			8.13 ± 1.36	59.84 ± 8.3	14 Apr 2018
CG11	*Crassostrea* sp.	12	7.72 ± 1.91	62.32 ± 12.8	01 Sep 2017
			7.31 ± 1.79	71.94 ± 18.4	14 Apr 2018
CG12	*Crassostrea* sp.	13	8.46 ± 0.58	64.13 ± 7.1	01 Sep 2017
			8.24 ± 0.77	52.66 ± 5.3	14 Apr 2018
CG13	*Crassostrea* sp.	12	8.29 ± 0.85	66.47 ± 5.0	01 Sep 2017
			8.13 ± 0.94	52.48 ± 6.4	14 Apr 2018
CG14	*Crassostrea* sp.	14	7.83 ± 1.03	61.84 ± 15.7	01 Sep 2017
			7.68 ± 1.46	59.02 ± 13.2	14 Apr 2018

Table S2. Average shell length and weight of gastropod (*Cymatium* sp.) collected from the Can Gio Coastal Wetland in Vietnam

Site	Species	Number of individual	Average shell length (cm)	Average wet weight/individual (g)	Collection day
CG1	*Cymatium* sp.	30	4.7 ± 0.6	5.7 ± 1.9	01 Sep 2017
			5.1 ± 0.7	6.9 ± 2.2	14 Apr 2018
CG2	*Cymatium* sp.	30	4.0 ± 0.6	5.1 ± 2.0	01 Sep 2017
			5.7 ± 0.5	7.3 ± 1.2	14 Apr 2018
CG3	*Cymatium* sp.	30	5.3 ± 0.4	7.2 ± 1.1	01 Sep 2017
			5.5 ± 0.8	7.5 ± 2.7	14 Apr 2018
CG4	*Cymatium* sp.	30	4.9 ± 0.5	6.4 ± 2.0	01 Sep 2017
			4.7 ± 0.9	6.2 ± 3.4	14 Apr 2018
CG5	*Cymatium* sp.	30	5.8 ± 0.4	8.4 ± 1.8	01 Sep 2017
			5.0 ± 0.8	6.2 ± 2.4	14 Apr 2018
CG6	*Cymatium* sp.	30	4.8 ± 0.9	6.0 ± 2.9	01 Sep 2017
			5.6 ± 0.5	7.7 ± 2.0	14 Apr 2018
CG7	*Cymatium* sp.	30	5.8 ± 0.7	8.3 ± 2.4	01 Sep 2017
			5.1 ± 0.6	7.3 ± 1.9	14 Apr 2018
CG8	*Cymatium* sp.	30	5.5 ± 0.4	7.1 ± 2.1	01 Sep 2017
			5.3 ± 0.5	7.5 ± 1.7	14 Apr 2018
CG9	*Cymatium* sp.	30	5.9 ± 0.8	8.6 ± 3.2	01 Sep 2017
			4.9 ± 0.7	6.8 ± 2.7	14 Apr 2018
CG10	*Cymatium* sp.	30	5.6 ± 0.5	7.5 ± 2.3	01 Sep 2017
			5.2 ± 0.7	6.9 ± 1.6	14 Apr 2018
CG11	*Cymatium* sp.	30	5.4 ± 0.9	7.0 ± 3.1	01 Sep 2017
			5.7 ± 0.5	7.6 ± 1.8	14 Apr 2018
CG12	*Cymatium* sp.	30	6.0 ± 0.6	8.9 ± 2.8	01 Sep 2017
			5.9 ± 0.4	8.3 ± 1.7	14 Apr 2018
CG13	*Cymatium* sp.	30	5.2 ± 1.0	7.3 ± 3.3	01 Sep 2017
			4.9 ± 0.4	6.9 ± 1.6	14 Apr 2018
CG14	*Cymatium* sp.	30	5.5 ± 0.6	7.8 ± 2.2	01 Sep 2017
			5.7 ± 0.5	8.1 ± 1.9	14 Apr 2018

Table S3. The concentration of polycyclic aromatic hydrocarbons (PAHs) in bivalves and gastropods from different regions

Maximum concentration data from wet weight are converted to dry weight basis for comparison using a wet weight/dry weight ratio of 4. NR, not reported

Locations	Region	Species	Number of sampling stations	Analytical method	Number of analysed PAHs	Maximum concentration (ng g^{-1} DW)	References
Baltic Sea	Temperate	*Macoma balthica*	9	HPLC	12	1192	Pikkarainen (2004)
Danish coasts	Temperate	*Mytilus edulis*	26	HPLC	14	444	Granby and Spliid (1995)
Bay of Biscay, Spain	Temperate	*Mytilus galloprovincialis*	4	GC/MD	14	256	Orbea *et al*. (2002)
	Temperate	*Crassostrea* sp.	4	GC-MD	14	872	
Venice Lagoon, Italy	Temperate	*Mytilus galloprovincialis*	10	HRGC-HRMS	15	2434	Moschino *et al.* (2012)
	Temperate	*Ruditapes philippinarum*	8	HRGC-HRMS	18	5335	
Arcachon Bay, France	Temperate	*Mytilus* sp.	7	GC-MS	16	1450	Devier *et al*. (2005)
Mediterranean Spanish coast	Temperate	*Donax trunculus*	14	GC-MS	8	40.36	Bouzas *et al*. (2011)
	Temperate	*Mytilus galloprovincialis*	14	GC-MS	8	36	
Ria Formosa Lagoon, Portugal	Temperate	*Ruditapes philippinarum*	8	HPLC	16	4800	Barreira *et al*. (2007)
Mediterranean coast (France and Spain)	Temperate	*Mytilus galloprovincialis*	23	GC-MS	26	390	Baumard *et al*. (1998)
	Temperate	*Mytilus galloprovincialis*	NR	GC-MS	17	59	
Kristiansand city, southern Norway	Temperate	*Mytilus edulis*	2	NR	16	1060	Schøyen *et al*. (2017)
Ria de Vigo, Spain	Temperate	*Myyilus ga*	8	HPLC-FLD	13	1007	Viñas *et al*. (2012)
Biscay Bay, Spain	Temperate	*Crassostrea* sp.	4	GC-MS	16	1400	Cortazar *et al*. (2008)
Vigo estuary, Spain	Temperate	*Mytilus ga*	1	HPLC-FLD	13	740	Ruiz *et al*. (2011)
Saronikos Gulf, Greece	Sub-tropical	*Mytilus galloprovincialis*	4	HPLC	17	2400	Valavanidis *et al*. (2008)
Abu Qir Bay, Egypt	Sub-tropical	*Mactra corallina*	NR	GC-MSD	18	2830	Khairy *et al*. (2009)
	Sub-tropical	*Tapes decussata*		GC-MSD	18	3880	
Abu Qir Bay, Egypt	Sub-tropical	*Donax trunculus*	19	GC-FID	11	1,137	El Deeb *et al*. (2007)
Pacific Coast, Japan	Sub-tropical	*Ruditapes philippinarum*	7	GC-MS	8	342	Onozato *et al*. (2016)
	Sub-tropical	*Mactra quadrangularis*	7	GC-MS	8	244	

Locations	Region	Species	Number of sampling stations	Analytical method	Number of analysed PAHs	Maximum concentration (ng g^{-1} DW)	References
	Sub-tropical	*Mytilus galloprovincialis*	7	GC-MS	8	351	
Jiaozhou Bay, China	Sub-tropical	*Ruditapes philippinarum*	5	GC-MS	16	939	Ma *et al*. (2009)
Shanghai City, Eastern China	Sub-tropical	*Mytilus edulis*	5	GC-MS	24	3496	Fung *et al*. (2004)
Egyptian Coast Red Sea, Egypt	Sub-tropical	*Brachiodonates* sp.	11	GC-MS	16	4670	El Nemr *et al*. (2004)
San Francisco estuary, USA	Sub-tropical	*Mytilus edulis*	14	GC-MS	25	1093	Oros and Ross (2005)
	Sub-tropical	*Corbicula fluminea*	14	GC-MS	25	720	
	Sub-tropical	*Crassostrea gigas*	14	GC-MS	25	6900	
South-Central and Central Chile	Sub-tropical	*Perumytilus purpuratus*	6	GC-MSD	16	253	Palma-Fleming *et al*. (2004)
Osaka Bay, Japan	Sub-tropical	*Mytilus galloprovincialis*	20	GC-MS	16	361	Ito *et al*. (2015)
Tohoku district, Japan	Sub-tropical	*Mytilus galloprovincialis*	64	GC-MS	18	560	Tanaka and Onduka (2010)
Atlantic Ocean, USA	Sub-tropical	*C. virginica*	9	GC–SIM	7	135	Senthil Kumar et *al*. (2008)
Can Gio coastal wetland, Vietnam	Tropical	*Crassostrea* sp.	14	HPLC-FD	16	260	Present study
	Tropical	*Cymatium* sp.	14	HPLC-FD	16	96	Present study
Halong Bay, Vietnam	Tropical	Clam	NR	GC-FID	8	275	Thuy *et al*. (2018)
Quangninh & Haiphong provinces, Vietnam	Tropical	*Meretrix* sp.	NR	GC-FID	8	246	
Ilha Grande Bay, Brazil	Tropical	*Perna perna*	6	GC-MS	8	17.7	Yoshimine and Carreira (2012)
Sao Sebastiao, Brazil	Tropical	*Perna viridis*	7	GC-MS	16	1630	Pereira *et al*. (2007)
Straits of Johore, Singapore	Tropical	*Perna viridis*	2	NR	18	244	Yap *et al*. (2012)
Vietnam coastal zone	Tropical	*Perna viridis*	5	GC-MS	19	110	Isobe *et al*. (2007)
Terminos Lagoon, Mexico	Tropical	*Crassostrea virginica*	5	GC-MS	8	1832	Noreña-Barroso *et al*. (1999)
Caribbean Sea, Venezuela	Tropical	*Isognomon alatus*	10	GC-MS	6	24	Jaffé *et al*. (1998)
Brazilian Estuarine	Tropical	*Crassostrea rhizophorae*	8	GC-MS	16	584	Torres *et al*. (2012)

Locations	Region	Species	Number of sampling stations	Analytical method	Number of analysed PAHs	Maximum concentration (ng g^{-1} DW)	References
Malaysia coast	Tropical	*Perna viridis*	7	GC-MS	18	2060	Shahbazi *et al*. (2010)
Pearl River Estuary, Guangdong, China	Tropical	Shell fish	16	GC-FDI	15	1040	Wei *et al*. (2006)
Eastern Guangdong coast, China	Tropical	*Crassostrea rivularis*	7	GC-MS	15	1178	Yu *et al*. (2016)
Minjiang River Mouth, China	Tropical	*Perna viridis*	2	GC-MS	24	527	Fung *et al*. (2004)
Jiulongjiang River Mouth, China	Tropical	*Perna viridis*	2	GC-MS	24	1353	

Table S4. Regulation limits for polycyclic aromatic hydrocarbons (PAHs) from different countries and organisations

US Food and Drug Administration (US FDA) levels of concern (LOC) consumption rates for shrimp and crab (13 g day^{-1}), oysters (12 g day^{-1}) and finfish (49 g day^{-1}) (data from US Food and Drug Administration 2010). China's maximum levels for contaminants in foods data are from Ministry of Health of China (2012). European Union (EU) Commission regulation of maximum levels for PAHs in foodstuffs data are from European Commission (2011). Environmental Assessment Criteria (EAC) data are from Webster *et al*. (2009).

Chemical	China's maximum levels for contaminants in food (μg kg^{-1})	EU Commission regulation of maximum levels for PAHs in foodstuffs (μg kg^{-1})	EAC (μg kg^{-1} DW)	US FDA LOC (ppm)		
				Shrimp and crabs	Oysters	Finfish
Naphthalene			340	123	133	32.7
Fluorene				246	267	65.3
Phenanthrene			1700	1846	2000	490
Anthracene			290	1846	2000	490
Fluoranthene			110	246	267	65.3
Pyrene			100	185	200	49
Chrysene				132	143	35
Benzo[k]fluoranthene			260	13.2	14.3	3.5
Benzo(b)fluoranthene				1.32	1.43	0.35
Benzo[a]anthracene			80	1.32	1.43	0.35
Benzo[a]pyrene	5	6	600	0.132	0.143	0.035
Benzo[ghi]perylene			100			
Indeno(1,2,3-cd)pyrene				1.32	1.43	0.35
Dibenz(a,h)anthracene				0.132	0.143	0.035
Sum of benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene and chrysene		35				

References

Barreira, L. S., Mudge, S. M., and Bebianno, M. J. (2007). Polycyclic aromatic hydro carbons in clams *Ruditapes decussatus* (Linnaeus, 1758). *Journal of Environmental Monitoring* **9**, 187–198. doi:10.1039/b614919g

Baumard, P., Budzinski, H., and Garrigues, P. (1998). Polycyclic aromatic hydrocarbons in sediments and mussels of the western Mediterranean Sea. *Environmental Toxicology and Chemistry* **17**, 765–776. doi:10.1002/etc.5620170501

Bouzas, B. A., Aguado, D., Martí, N., Pastor, J. M., Herráez, R., and Campins, P. (2011). Alkylphenols and polycyclic aromatic hydrocarbons in east-ern Mediterranean Spanish coastal marine bivalves. *Environmental Monitoring and Assessment* **176**, 169–181. doi:10.1007/s10661-010-1574-5

Cortazar, E., Bartolomé, L., Arrasate, S., Usobiaga, A., Raposo, J., Zuloaga, O., and Etxebarria, N. (2008). Distribution and bioaccumulation of PAHs in the UNESCO protected natural reserve of Urdaibai, Bay of Biscay. *Chemosphere* **72**, 1467–1474. doi:10.1016/j.chemosphere.2008.05.006

Devier, M.-H., Augagneur, S., Budzinski, H., Le Menach, K., Mora, P., Narbonne, J.-F., and Garrigues, P. (2005). One-year monitoring survey of organic compounds (PAHs, PCBs, TBT), heavy metals and biomarkers in blue mussels from the Arcachon Bay, France. *Journal of Environmental Monitoring* **7**(3), 224–240. doi:10.1039/b409577d

El Deeb, K. Z., Said, T. O., El Naggar, M. H., and Shreadah, M. A. (2007). Distribution and sources of aliphatic and polycyclic aromatic hydrocarbons in surface se diments, fish and bivalve s of Abu Qir Bay (Egyptian Mediterranean Sea). *Bulletin of Environmental Contamination and Toxicology* **78**, 373–379. doi:10.1007/s00128-007-9173-z

El Nemr, A., Sikaily, E. L., Khaled, A., Said, T. O., and Abd-Alla, A. M. A. (2004). Determination of hydrocarbons in mussels from the Egyptian Red Sea coast. *Environmental Monitoring and Assessment* **96**, 251–261. doi:10.1023/B:EMAS.0000031731.88863.25

European Commission (2011). Commission Regulation (EU) No 835/2011 of 19 August 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for polycyclic aromatic hydrocarbons in foodstuffs. *Official Journal of the European Union* **215**, 4–8.

Fung, C. N., Lam, J. C. W., Zheng, G. J., Connell, D. W., Monirith, I., Tanabe, S., Richardson, B. J., and Lam, P. K. S. (2004). Mussel-based monitoring of trace metal and organic contaminants along the east coast of China using *Perna viridis* and *Mytilus edulis. Environmental Pollution* **127**, 203–216. doi:10.1016/j.envpol.2003.08.007

Granby, K., and Spliid, N. H. (1995). Hydrocarbon and organochlorines in com-mon mussels from the Kattegat and the belts and their relation to condition indices. *Marine Pollution Bulletin* **30**, 74–82. doi:10.1016/0025-326X(94)00104-H

Isobe, T., Takada, H., Kanai, M., Tsutsumi, S., Isobe, K. O., Boonyatumanond, R., and Zakaria, M. P. (2007). Distribution of polycyclic aromatic hydrocarbons (PAHS) and phenolic endocrine disrupting chemicals in

South and Southeast Asian mussels. *Environmental Monitoring and Assessment* **135**(1–3), 423–440. doi:10.1007/s10661-007-9661-y

Ito, K., Uno, S., Tanaka, H., Miki, S., Kokushi, E., Yamamoto, M., Koyama, J., and Añasco, N. C. (2015). Distribution of parent and alkylated PAHs in bivalves collected from Osaka Bay, Japan. *Japanese Journal of Environmental Toxicology* **18**(2), 11–24 10.11403/jset.18.11.

Jaffé, R., Leal, I., Alvarado, J., Gardinali, P. R., and Sericano, J. L. (1998). Baseline study on the levels of organic pollutants and heavy metals in bivalves from the Morrocoy National Park, Venezuela. *Marine Pollution Bulletin* **36**, 925–929. doi:10.1016/S0025-326X(98)00090-3

Khairy, M. A., Kolb, M., Mostafa, A. R., El-Fiky, A., and Bahadir, M. (2009). Risk assessment of polycyclic aromatic hydrocarbons in a Mediterranean semi-enclosed basin affected by human activities (Abu Qir Bay, Egypt). *Journal of Hazardous Materials* **170**(1), 389–397. doi:10.1016/j.jhazmat.2009.04.084

Ma, H., Qian, S., and Xuchen, W. (2009). Accumulation of petroleum hydrocarbons and heavy metals in clams (*Ruditapes p hilippinarum*) in Jiaozhou Bay, China. *Chinese Journal of Oceanology and Limnology* **27**, 887–897. doi:10.1007/s00343-009-9223-y

Ministry of Health of China (2012). Maximum levels of contaminants in foods. (GB2762–2012). pp. 1–15.

Moschino, V., Delaney, E., and Da Ros, L. (2012). Assessing the significance of *Ruditapes philippinarum* as a sentinel for sediment pollution: bioaccumulation and biomarker response. *Environmental Pollution* **171**, 52–60. doi:10.1016/j.envpol.2012.07.024

Noreña-Barroso, E., Gold-Bouchot, G., Zapata-Perea, O., and Sericano, J. K. (1999). Polynuclear arom atic hydroc arbons in American oysters *Crassostrea virginica* from the Terminos lagoon, Campeche, Mexico. *Marine Pollution Bulletin* **38**, 637–645. doi:10.1016/S0025-326X(98)00165-9

Onozato, M., Nishigaki, A., and Okoshi, K. (2016). Polycyclic aromatic hydrocarbons in sediments and bivalves on the Pacific Coast of Japan: influence of tsunami and fire. *PLoS One* **11**(5), e0156447. doi:10.1371/journal.pone.0156447

Orbea, A., Ortiz-Zarragoitia, M., Solé, M., Porte, C., and Cajaraville, M. P. (2002). Antioxidant enzymes and peroxisome proliferation in relation to contaminant body burdens of PAHs and PCBs in bivalve molluscs, crabs and fish from the Urdaibai and Plentzia estuaries (Bay of Biscay). *Aquatic Toxicology* **58**, 75–98. doi:10.1016/S0166-445X(01)00226-0

Oros, D. R., and Ross, J. R. M. (2005). Polycyclic aromatic hydrocarbons in bivalves from the San Francisco estuary: spatial distributions, temporal trends, and sources (1993–2001). *Marine Environmental Research* **60**(4), 466–488. doi:10.1016/j.marenvres.2005.02.001

Palma-Fleming, H., Adalberto, J. A. P., and Gutierrez, E. (2004). Polycyclic aromatic hydrocarbons in sediments and mussels of Corral Bay, south central Chile. *Journal of Environmental Monitoring* **6**(3), 229–233. doi:10.1039/b307018b

Pereira, C. D. S., de Souza Abessa, D. M., Bainy, A. C. D., Zaroni, L. P., Gasparro, M. R., Bicego, M. C., Taniguchi, S., Furley, T. H., and De Sousa, E. C. P. M. (2007). Integrated assessment of multilevel biomarker

responses and chemical analysis in mussels from São Sebastião, São Paulo, Brazil. *Environmental Toxicology and Chemistry* **26**, 462–469. doi:10.1897/06-266R.1

Pikkarainen, A. L. (2004). Polycyclic aromatic hydrocarbons in Baltic Sea bivalves. *Polycyclic Aromatic Compounds* **24**(4–5), 681–695. doi:10.1080/10406630490472310

Ruiz, Y., Suarez, P., Alonso, A., Longo, E., Villaverde, A., and San Juan, F. (2011). Environmental quality of mussel farms in the Vigo Estuary: pollution by PAHs, origin and effects on reproduction. *Environmental Pollution* **159**, 250–265. doi:10.1016/j.envpol.2010.08.031

Schøyen, M., Allan, I. J., Ruus, A., Håvardstun, J., Hjermann, D. Ø., and Beyer, J. (2017). Comparison of caged and native blue mussels (*Mytilus edulis* spp.) for environmental monitoring of PAH, PCB and trace metals. *Marine Environmental Research* **130**, 221–232. doi:10.1016/j.marenvres.2017.07.025

Senthil Kumar, K., Sajwan, K. S., Richardson, J. P., and Kannan, K. (2008). Contamination profiles of heavy metals, organochlorine pesticides, polycyclic aromatic hydrocarbons and alkylphenols in sediment and oyster collected from marsh/estuarine Savannah GA, USA. *Marine Pollution Bulletin* **56**, 136–149. doi:10.1016/j.marpolbul.2007.08.011

Shahbazi, A., Zakaria, M. P., Yap, C. K., Surif, S., Bakhtiari, A. R., Chandru, K., Bahry, P. S., and Sakari, M. (2010). Spatial distribution and sources of polycyclic aromatic hydrocarbons (PAHs) in green mussels (*Perna viridis*) from coastal areas of Peninsular Malaysia: implications for source identification of perylene. *International Journal of Environmental Analytical Chemistry* **90**, 14–30. doi:10.1080/03067310902913000

Tanaka, H., and Onduka, T. (2010). Background levels of PAHs in the coastal waters of Japan based on residual concentrations of bivalves. *Journal of Environmental Chemical Engineering* **20**, 137–148. doi:10.5985/jec.20.137

Thuy, H. T. T., Loan, T. T. C., and Phuong, T. H. (2018). The potential accumulation of polycyclic aromatic hydrocarbons in phytoplankton and bivalves in Can Gio coastal wetland, Vietnam. *Environmental Science and Pollution Research International* **25**(18), 17240–17249. doi:10.1007/s11356-018-2249-y

Torres, R. J., Cesar, A., Pereira, C. D., Choueri, R. B., Abessa, D., and Do Nascimento, M. R. (2012). Bioaccumulation of polycyclic aromatic hydrocarbons and mercury in oysters (*Crassostrea rhizophorae*) from two Brazilian Estuarine zones. *International Journal of Oceanography* **2012**, 838320. doi:10.1155/2012/838320

US Food and Drug Administration (2010). Protocol for interpretation and use of sensory testing and analytical chemistry results for re-opening oil-impacted areas closed to seafood harvesting due to the Deepwater Horizon oil spill. (US FDA.) Available at https://www.fda.gov/food/food-safety-during-emergencies/protocol-interpretation-and-use-sensory-testing-and-analytical-chemistry-results-re-opening-oil [Verified 10 August 2019].

Valavanidis, A., Vlachogianni, T., Triantafillaki, S., Dassenakis, M., Androutsos, F., and Scoullos, M. (2008). Polycyclic aromatic hydrocarbons in surface seawater and in indigenous mussels (*Mytilus galloprovincialis*) from coastal areas of the Saronikos Gulf (Greece). *Estuarine, Coastal and Shelf Science* **79**, 733–739. doi:10.1016/j.ecss.2008.06.018

Viñas, L., Franco, A., Blanco, X., Bargiela, J., Soriano, J. A., Perez-Fernandez, B., and Jose Gonzalez, J. (2012). Temporal and spatial changes of PAH concentrations *in Mytilus galloprovincialis* from Ria de Vigo (NW Spain). *Environmental Science and Pollution Research International* **19**, 529–539. doi:10.1007/s11356-011-0584-3

Webster, L., Fryer, R., Davies, I. M., Roose, P., and Moffat, C. F. (2009). A proposal for the assessment criteria to be used for the assessment of monitoring data for the concentration of hazardous substances in marine sediments and biota in the context of the OSPAR QSR. Fisheries Research Services Collaborative Report number 02/09.

Wei, S., Lau, R. K. F., Fung, C. N., Zheng, G. J., Lam, J. C. W., Connell, D. W., Fang, Z., Richardson, B. J., and Lam, P. K. S. (2006). Trace organic contamination in biota collected from the Pearl River Estuary, China: a preliminary risk assessment. *Marine Pollution Bulletin* **52**, 1682–1694. doi:10.1016/j.marpolbul.2006.06.009

Yap, C., Shahbazi, A., and Zakaria, M. (2012). Concentrations of heavy metals (Cu, Cd, Zn and Ni) and PAHs in Perna viridis collected from seaport and non-seaport waters in the straits of Johore. *Bulletin of Environmental Contamination and Toxicology* **89**, 1205–1210. doi:10.1007/s00128-012-0838-x

Yoshimine, R. V., and Carreira, R. S. (2012). PAHs in cultured mussels *Perna perna* from a southeastern Brazilian bay. *Journal of the Brazilian Chemical Society* **23**, 1429–1436. doi:10.1590/S0103-50532012005000003

Yu, Z. L., Lin, Q., Gu, Y. G., Ke, C. L., and Sun, R. X. (2016). Spatial–temporal trend and health implications of polycyclic aromatic hydrocarbons (PAHs) in resident oysters, South China Sea: a case study of Eastern Guangdong coast. *Marine Pollution Bulletin* **110**(1), 203–211. doi:10.1016/j.marpolbul.2016.06.061