

Trophic importance of benthic microalgae to macrozoobenthos in coastal bay systems in Korea: dual stable C and N isotope analyses

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Appendix 1. Stable isotope ratios (‰) of primary producers, suspended particulate organic matter (POM) and sedimentary organic matter (SOM) collected from southern coastal bays and the adjacent offshore region of the Korean Peninsula. Values with same superscript letters are not significantly different ($p < 0.05$)

	n	$\delta^{13}\text{C}$ (mean \pm SD)	$\delta^{15}\text{N}$ (mean \pm SD)
Kwangyang Bay			
Terrestrial			
Riverine POM	3	$-23.7^{\text{d}} \pm 0.5$	$8.6^{\text{h}} \pm 1.1$
<i>Salix gracilistyla</i> (black pussywillow)	2	$-27.8^{\text{e}} \pm 0.6$	$8.0^{\text{h}} \pm 0.4$
Saltmarsh			
<i>Phragmites australis</i> (common reed)	2	$-28.9^{\text{e}} \pm 0.3$	$6.1^{\text{i}} \pm 0.2$
Algae			
POM	4	$-20.2^{\text{c}} \pm 0.9$	$11.0^{\text{g}} \pm 0.6$
Phytoplankton	4	$-19.8^{\text{c}} \pm 0.9$	$11.1^{\text{g}} \pm 1.1$
Benthic diatoms (benthic microalgae)	5	$-13.7^{\text{b}} \pm 0.7$	$10.8^{\text{g}} \pm 0.7$
<i>Ulva pertusa</i> (macroalgae)	2	-13.8 ± 1.3	14.8 ± 0.4
<i>Enteromorpha compressa</i> (macroalgae)	1	-15.8	13.1
Macroalgae mean	3	$-14.5^{\text{b}} \pm 1.5$	$14.2^{\text{i}} \pm 1.0$
Seagrass			
<i>Zostera marina</i>	2	$-11.5^{\text{a}} \pm 0.1$	$14.1^{\text{i}} \pm 0.1$
SOM	5	$-19.6^{\text{c}} \pm 0.7$	$10.4^{\text{g}} \pm 1.1$
Yoja Bay			
Saltmarsh			
<i>Phragmites australis</i> (common reed)	3	-25.9 ± 0.5	7.3 ± 2.2
Algae			
POM	2	-20.2 ± 1.3	11.0 ± 0.6
Phytoplankton	2	-21.2 ± 0.2	11.3 ± 1.4
Benthic diatoms (benthic microalgae)	5	-14.5 ± 0.6	10.8 ± 1.1
SOM	4	-19.5 ± 1.2	10.4 ± 0.5
Deukryang Bay			
Saltmarsh			
<i>Phragmites australis</i> (common reed)	2	-25.5 ± 0.5	8.6 ± 1.9
Algae			
POM	3	-21.0 ± 1.6	10.8 ± 0.2
Phytoplankton	3	-21.3 ± 1.2	11.7 ± 0.4
Benthic diatoms (benthic microalgae)	6	-14.0 ± 0.9	11.0 ± 0.2
SOM	4	-19.3 ± 1.0	10.6 ± 0.5
Offshore near Koemun Island			
Algae			
POM	2	-20.7 ± 0.1	8.8 ± 1.4
Phytoplankton	4	-20.0 ± 0.5	9.5 ± 0.7

Appendix 2. Stable isotope ratios (‰; mean ± SD, n in parenthesis) of macrozoobenthos collected from the intertidal and subtidal habitats in the 3 study bay systems

Species (common name)	$\delta^{13}\text{C}$		
	Kwangyang Bay	Yoja Bay	Deukryang Bay
Intertidal zone			
Primary consumers			
Suspension feeders, pelagic feeding			
<i>Anrina pectinata</i> (pen shell)			-15.6 (1)
<i>Barbatia virescens obtusoides</i> (ark shell)			-14.2 ± 0.4 (2)
<i>Crassostrea gigas</i> (Pacific oyster)	-17.4 ± 0.2 (2)	-16.4 ± 0.7 (3)	-16.0 ± 0.9 (3)
<i>Cyclina sinensis</i> (Chinese cyclina)	-16.8 ± 0.2 (5)		-16.4 ± 0.8 (3)
<i>Dosinella corrugata</i> (Japanese dosinia)	-15.8 (1)		
<i>Glaucomomya chinensis</i> (bivalve)	-16.9 ± 0.8 (5)		-15.0 ± 0.2 (2)
<i>Lingula anatina</i> (lamp shell)			-15.5 ± 0.6 (2)
<i>Mactra veneriformis</i> (surf clam)	-16.7 ± 0.4 (6)		
<i>Musculus senhausia</i> (Asian mussel)	-16.8 ± 0.8 (3)		
<i>Mya arenaria</i> (soft shell clam)	-15.6 ± 1.3 (7)		
<i>Mytilus galloprovincialis</i> (mussel)	-17.8 ± 1.2 (5)		
<i>Ruditapes philippinarum</i> (Manila clam)	-16.5 ± 0.4 (6)	-17.4 (1)	-16.4 ± 0.1 (2)
<i>Scapharca subcrenata</i> (ark shell)		-17.1 ± 1.1 (5)	
<i>Sinonovacula constricta</i> (razor clam)	-15.1 (1)	-15.6 ± 1.1 (3)	-14.6 ± 0.7 (3)
<i>Solen strictus</i> (razor clam)	-14.4 ± 1.6 (3)		
<i>Tegillarca granosa</i> (bloody clam)		-16.7 ± 0.8 (9)	-14.6 ± 0.4 (7)
Deposit feeders, benthic feeding			
<i>Batillaria multififormis</i> (mud creeper)		-13.5 (1)	-11.5 ± 1.2 (3)
<i>Bullacta exarata</i> (white bubble shell)	-12.7 ± 0.9 (2)		-12.0 (1)
<i>Cirratulus cirratus</i> (cirratulid worm)			-13.3 (1)
<i>Lagis bocki</i> (pectinariid worm)	-12.4 ± 0.3 (2)		
<i>Macoma sector</i> (tellinid clam)			-12.0 ± 0.4 (2)
<i>Sternaspis scutata</i> (sternaspid worm)			-11.7 (1)
<i>Moerella iridescens</i> (tellinid clam)	-12.7 ± 0.2 (5)		-12.9 ± 0.6 (2)
<i>Molpadia volitica</i> (sea cucumber)		-14.0 (1)	
<i>Neanthes japonica</i> (nereid worm)		-13.2 ± 0.6 (2)	-12.4 ± 1.3 (3)
Predators, benthic feeding			
<i>Euspira fortunei</i> (moon shell)	-12.7 ± 0.2 (2)	-13.1 (1)	-10.4 ± 0.3 (3)
<i>Neptunea arthritica cumingii</i> (whelk)		-15.5 ± 0.9 (2)	-15.5 ± 1.0 (2)
<i>Diopatra sugokai</i> (onuphid worm)	-14.0 (1)	-14.7 ± 0.1 (2)	-11.6 (1)
<i>Glycera chirori</i> (bloodworm)	-12.0 (1)		-12.0 ± 0.7 (3)
<i>Glycera decipiens</i> (bloodworm)	-12.8 ± 0.9 (3)		-10.9 (1)
<i>Glycera rouxii</i> (bloodworm)		-13.4	
<i>Glycera subaenea</i> (bloodworm)	-10.6 (1)		
<i>Nephtys</i> sp. (cat worm)	-10.2 (1)		
<i>Reticunassa japonica</i> (nassariid dog welk)	-13.2 (1)		
Omnivores, benthic feeding			
<i>Lumbrineris japonica</i> (nereid worm)	-12.4 (1)	-14.0 (1)	
<i>Ceratonereis erythraensis</i> (nereid worm)		-16.4 (1)	
<i>Perinereis nuntia</i> (nereid worm)		-14.4 (1)	
<i>Alpheus brevicristatus</i> (shrimp)			-10.0 (1)
<i>Metapenaeopsis dalei</i> (shrimp)			-10.2 ± 0.1 (2)
Subtidal zone			
Primary consumers			
Suspension feeders, pelagic feeding			
<i>Artina pectinata</i> (pen shell)			-15.9 (1)
<i>Mya arenaria</i> (soft shell clam)	-16.8 ± 0.6 (2)		-16.5 (1)
<i>Scapharca subcrenata</i> (ark shell)	-15.7 ± 0.6 (2)	-15.9 ± 0.5 (3)	
<i>Tagillarca granosa</i> (bloody clam)		-14.6 (1)	
Deposit feeders, benthic feeding			
<i>Bullacta exarata</i> (white bubble shell)	-14.7 (1)	-15.9 (1)	
<i>Lagis bocki</i> (pectinariid worm)	-14.4 (1)		
<i>Moerella iridescens</i> (tellinid clam)			-14.7 ± 0.9 (3)
<i>Molpadia volitica</i> (sea cucumber)	-12.1 (1)	-13.4 ± 0.4 (3)	-14.9 ± 0.2 (3)
<i>Neanthes japonica</i> (nereid worm)			-15.9 (1)
<i>Nereis pelagica</i> (nereid worm)			-13.6 (1)
<i>Sacella confusa</i> (elongated nut clam)			-16.6 ± 0.1 (2)
<i>Sternaspis scutata</i> (sternaspid worm)	-13.2 (1)	-13.8 (1)	-15.9 (1)
<i>Theora fragilis</i> (semelid bivalve)	-14.1 (1)		-15.5 (1)
<i>Xenophthalmus pinnotheroides</i> (pea crab)	-13.8 (1)		
Predators, benthic feeding			
<i>Diopatra sugokai</i> (onuphid worm)	-15.4 (1)	-14.3 (1)	
<i>Euspira fortunei</i> (moon shell)			-15.2 ± 1.2 (2)
<i>Glycera chirori</i> (bloodworm)	-14.0 ± 1.2 (3)		-14.0 (1)
<i>Glycera decipiens</i> (bloodworm)	-13.4 (1)		
<i>Glycera rouxii</i> (bloodworm)		-12.5 (1)	
<i>Nephtys oligobranchia</i> (nephtyid worm)	-13.8 (1)		
Omnivores, benthic feeding			
<i>Lumbrineris japonica</i> (nereid worm)	-14.5 (1)	-13.1 (1)	
<i>Lumbrineris nipponica</i> (nereid worm)		-13.7 (1)	

Appendix 2 (continued)

Species (common name)	$\delta^{15}\text{N}$		
	Kwangyang Bay	Yoja Bay	Deukryang Bay
Intertidal zone			
Primary consumers			
Suspension feeders, pelagic feeding			
<i>Anrina pectinata</i> (pen shell)			15.1 (1)
<i>Barbatia virescens obtusoides</i> (ark shell)			14.7 ± 0.6 (2)
<i>Crassostrea gigas</i> (Pacific oyster)	14.2 ± 0.1 (2)	14.1 ± 0.9 (3)	14.6 ± 0.4 (3)
<i>Cyclina sinensis</i> (Chinese cyclina)	14.6 ± 0.6 (5)		14.4 ± 0.4 (3)
<i>Dosinella corrugata</i> (Japanese dosinia)	14.4 (1)		
<i>Glaucomomya chinensis</i> (bivalve)	14.0 ± 0.7 (5)		13.7 ± 0.1 (2)
<i>Lingula anatina</i> (lamp shell)			14.4 ± 0.6 (2)
<i>Mactra veneriformis</i> (surf clam)	14.2 ± 0.4 (6)		
<i>Musculus senhausia</i> (Asian mussel)	14.5 ± 0.2 (3)		
<i>Mya arenaria</i> (soft shell clam)	13.9 ± 0.6 (7)		
<i>Mytilus galloprovincialis</i> (mussel)	13.8 ± 0.2 (5)		
<i>Ruditapes philippinarum</i> (Manila clam)	13.6 ± 0.4 (6)	15.4 (1)	13.3 ± 0.4 (2)
<i>Scapharca subcrenata</i> (ark shell)		14.8 ± 0.1 (5)	
<i>Sinonovacula constricta</i> (razor clam)	14.3 (1)	15.1 ± 0.1 (3)	14.2 ± 0.3 (3)
<i>Solen strictus</i> (razor clam)	13.8 ± 1.1 (3)		
<i>Tegillarca granosa</i> (bloody clam)		14.4 ± 0.2 (9)	14.4 ± 0.4 (7)
Deposit feeders, benthic feeding			
<i>Batillaria multiformis</i> (mud creeper)		15.3 (1)	15.4 ± 0.3 (3)
<i>Bullacta exarata</i> (white bubble shell)	13.9 ± 1.3 (2)		14.2 (1)
<i>Cirratulus cirratus</i> (cirratulid worm)			15.1 (1)
<i>Lagis bocki</i> (pectinariid worm)	14.2 ± 0.1 (2)		
<i>Macoma sector</i> (tellinid clam)			15.6 ± 1.5 (2)
<i>Sternaspis scutata</i> (sternaspid worm)			14.9 (1)
<i>Moerella iridescens</i> (tellinid clam)	15.2 ± 0.7 (5)		14.7 ± 0.1 (2)
<i>Molpadia volitica</i> (sea cucumber)		14.9 (1)	
<i>Neanthes japonica</i> (nereid worm)		15.2 ± 0.7 (2)	13.9 ± 0.2 (3)
Predators, benthic feeding			
<i>Euspira fortunei</i> (moon shell)	16.8 ± 0.5 (2)	16.6 (1)	15.8 ± 0.3 (3)
<i>Neptunea arthritica cumingii</i> (whelk)		16.4 ± 0.1 (2)	16.2 ± 0.8 (2)
<i>Diopatra sugokai</i> (onuphid worm)	18.5 (1)	17.4 ± 1.2 (2)	17.0 (1)
<i>Glyera chirori</i> (bloodworm)	17.0 (1)		17.4 ± 1.5 (3)
<i>Glycera decipiens</i> (bloodworm)	18.0 ± 0.5 (3)		16.8 (1)
<i>Glycera rouxii</i> (bloodworm)		18.3 (1)	
<i>Glycera subaenea</i> (bloodworm)	17.0 (1)		
<i>Nephtys</i> sp. (cat worm)	16.6 (1)		
<i>Reticunassa japonica</i> (nassariid dog welk)	16.7 (1)		
Omnivores, benthic feeding			
<i>Lumbrineris japonica</i> (nereid worm)	17.2 (1)	16.9 (1)	
<i>Ceratonereis erythraensis</i> (nereid worm)		17.1 (1)	
<i>Perinereis nuntia</i> (nereid worm)		18.0 (1)	
<i>Alpheus brevicristatus</i> (shrimp)			17.9 (1)
<i>Metapenaeopsis dalei</i> (shrimp)			16.6 ± 0.5 (2)
Subtidal zone			
Primary consumers			
Suspension feeders, pelagic feeding			
<i>Artina pectinata</i> (pen shell)			13.8 (1)
<i>Mya arenaria</i> (soft shell clam)	14.0 ± 0.3 (2)		14.5 (1)
<i>Scapharca subcrenata</i> (ark shell)	14.3 ± 0.4 (2)	14.3 ± 0.3 (3)	
<i>Tagillarca granosa</i> (bloody clam)		15.0 (1)	
Deposit feeders, benthic feeding			
<i>Bullacta exarata</i> (white bubble shell)	14.2 (1)	15.4 (1)	
<i>Lagis bocki</i> (pectinariid worm)	15.8 (1)		
<i>Moerella iridescens</i> (tellinid clam)			13.6 ± 0.4 (3)
<i>Molpadia volitica</i> (sea cucumber)	14.6 (1)	13.6 (1)	14.7 ± 1.1 (3)
<i>Neanthes japonica</i> (nereid worm)			15.2 (1)
<i>Nereis pelagica</i> (nereid worm)			15.3 (1)
<i>Sacella confusa</i> (elongated nut clam)			12.7 ± 0.4 (2)
<i>Sternaspis scutata</i> (sternaspid worm)	14.5 (1)	15.5 (1)	14.6 (1)
<i>Theora fragilis</i> (semelid bivalve)	15.1 (1)		15.0 (1)
<i>Xenophthalmus pinnotheroides</i> (pea crab)	14.5 (1)		
Predators, benthic feeding			
<i>Diopatra sugokai</i> (onuphid worm)	17.5 (1)	17.9 (1)	
<i>Euspira fortunei</i> (moon shell)			17.8 ± 0.7 (2)
<i>Glycera chirori</i> (bloodworm)	17.4 ± 1.2 (3)		17.2 (1)
<i>Glycera decipiens</i> (bloodworm)	17.8 (1)		
<i>Glycera rouxii</i> (bloodworm)		18.5 (1)	
<i>Nephtys oligobranchia</i> (nephtyid worm)	17.1 (1)		
Omnivores, benthic feeding			
<i>Lumbrineris japonica</i> (nereid worm)	17.5 (1)	18.4 (1)	
<i>Lumbrineris nipponica</i> (nereid worm)		18.2 (1)	

Appendix 3. Stable isotope ratios (‰, means ± SD, sample size in parenthesis) of benthic invertebrates collected from offshore sites

Species (common name)	δ ¹³ C	δ ¹⁵ N
Primary consumers		
Suspension feeder, pelagic feeding		
<i>Scapharca subcrenata</i> (ark shell)	-19.1 (1)	12.7 (1)
Deposit feeders, benthic feeding		
<i>Ampelisca</i> sp. (amphipod)	-19.1 (1)	11.2 (1)
<i>Cyathura carinata</i> (isopod)	-20.5 (1)	13.4 (1)
<i>Cirratulus cirratus</i> (cirratulid worm)	-19.1 (1)	14.0 (1)
<i>Moerella iridescens</i> (tellinid clam)	-18.2 (1)	12.1 (1)
<i>Molpadia volitica</i> (sea cucumber)	-16.8 (1)	13.6 (1)
<i>Neanthes japonica</i> (nereid worm)	-17.1 (1)	12.6 (1)
<i>Sternaspis scutata</i> (sternaspid worm)	-18.9 ± 1.0 (2)	14.5 ± 0.1 (2)
<i>Tellinella (Pharaonella) sieboldii</i> (tellinid clam)	-17.9 (1)	11.2 (1)
<i>Xenopthalmus pinnotheroides</i> (pea crab)	-18.0 (1)	12.5 (1)
Species mean ± SD	-18.4 ± 1.1	12.8 ± 1.2
Predators, benthic feeding		
<i>Acrocirrus validus</i> (acrocirrid worm)	-18.4 (1)	17.3 (1)
<i>Arabella iricolor</i> (opal worm)	-17.2 (1)	16.9 (1)
<i>Diopatra bilobata</i> (onuphid worm)	-18.6 (1)	14.5 (1)
<i>Glycera chirori</i> (bloodworm)	-17.9 ± 1.2 (2)	14.7 ± 0.4 (2)
<i>Glycera rouxii</i> (bloodworm)	-16.7 (1)	15.5 (1)
<i>Haploscoloplos elongatus</i> (orbiniid worm)	-18.1 (1)	15.0 (1)
<i>Magelona japonica</i> (magelonid worm)	-19.1 ± 0.1 (2)	13.2 ± 0.3 (2)
<i>Phylo fimbriatus</i> (orbiniid worm)	-18.8 (1)	14.0 (1)
<i>Polyopthalmus pictus</i> (opheliid worm)	-18.8 ± 0.4 (2)	13.6 ± 0.4 (2)
<i>Siphonalia fusoides</i> (whelk)	-16.4 ± 0.2 (2)	15.4 ± 1.3 (2)
Species mean ± SD	-18.0 ± 0.9	15.0 ± 1.3
Omnivores, benthic feeding		
<i>Alpheus brevicristatus</i> (Teppo snapping shrimp)	-17.8 (1)	13.8 (1)
<i>Latretus</i> sp. (shrimp)	-17.0 (1)	14.8 (1)
<i>Lumbrineris japonica</i> (nereid worm)	-18.8 (1)	16.4 (1)
Species mean ± SD	-17.9 ± 0.9	15.0 ± 1.3