Table 3 Biomarkers of marine toxic pollutants

Organism	Biomarker/ Bioindicator	Type of pollutant	References
Mussel	Alterations in the lysosomal enzyme -lipofuscin	Environmental Stress	Raftopoulou and Dimitriadis, 2012
Marine bivalves	Lysosomal membrane stability-cellular	Thermal stress	Dimitriadis *et al.,* 2011
Marine snail (*Cronia contracta*)	Seasonal variation in Acetylcholinesterase activity Acetylcholinesterase inhibition	Neurotoxic substances toxic heavy metals (Pb, Cd, and Cu) and petroleum hydrocarbons	Sarkar, 2006
Phytoplankton (*Chaetoceros tenuissimus*)	Affect growth	Cd	Sarkar, 2006
Fishes (*Callionymus lyra, Limanda limanda, Serranus sp., Mullus barbatus*) and Mussels (*Dreissena polymorpha*)	The induction of the biotransformation enzyme, cytochrome P4501Auction	dioxins, furans, PCBs and PAHs.	Sarkar *et al.,* 2006
Shark (*Schroederichthys chilensis*)	The increase of ethoxyresorufin dealkylation (EROD)	PAH	Fuentes-Rios *et al.,* 2005
Mussels (*Mytilus Galloprovincialis*)	DNA integrity	Genotoxic agents	Pisoni *et al.,* (2004)
Sea star (*Asterias rubens*)	DNA integrity	Persistent pollutants	Everaarts and Sarkar (1996)
Fish	Inhibition of Cholinesterase activity	Organophosphorus Pesticide	Matozzo et al. 2005; De la TorreFernando *et al.,* 2005.
Oyster (*Crassostrea virginica*)	Metallothionein induction	toxic metals	Roesijadi *et al.,*1997
Mussel (*M. edulis*)	Metallothionein induction	toxic metals	Leinio and Lehtonen, 2005
Mussel (*M. galloprovincialis*)	Metallothionein induction	toxic metals	Mourgaud *et al*., 2002; Raspor *et al*., 2004.
Marine birds	The resultant levels of contaminants in their tissues	pesticides, chlorinated hydrocarbons, metals and PAH	Burger *et al*.,2004
Lichen Unicellular alga (*T.erici*)	Increased synthesis of PCs, synthesis of PCs with longer (more stable) chains, up to PC5	Cd	Backor *et al.,*2007

Organism	Biomarker/ Bioindicator	Type of pollutant	References
Transgenic Microalgae (*C. reinhardtii*)	Expression of P5CS gene, Higher free-Proline levels than wild-type cells, grew to higher densities than wild-type cells, sequestered four times more Cd per cell than wild-type cultures.	Cd	Siripornadulisl *et al.,* 2002
Lichen alga (*T.erici*)	Accumulation of free Proline	Cu stress	Backor *et al.,*2004

Algae (*C.reinhardtii*)	Expression of HSP 70 genes (involved with a chloroplast-localized chaperone) and several SHSP.	Heavy metal	Schroda *et al.,*1999,
Alga (*T.erici*)	Expression of HSP 70	Short term Exposure to excess Cd and Cu	Backor *et al.,*2006
Marine micro algae (*Fucus serratus*)	Expression of HSP 70	Cd stress	Ireland *et al.,*2004
Red algae (*Meristiella gelidium*)	Increased production of brominated halocarbons	H_2O_2	Collen *et al.,*1994
Algae (*C. reinhardtii*)	Formation of more granulous and less- dense Stroma, severely inhibiting essential chloroplast processes such as photosynthesis	Selenium toxicity	Morlon *et al.,* 2005
Shark (*Schroederichthhys chilensis*)	Increase of ethoxyresorufin dealkylation (EROD activity)	PAH	Fuentes-Rios *et al.,* 2005
Oyster (*Crassostrea virginica*)	Induction of MTs	Toxic metals	Roesijadi *et al.,* 1997
Mussel (*M. galloprovincialis, Mullus barbatus*)	Induction of MTs	Toxic metals	Petrovic *et al.,* 2001,