

Table S1. List of available sea cucumber mitogenomes.

Family	Species	Accession	Geographical location	Reference / Submitter Institute
Chiridotidae	<i>Chiridota heheva</i>	MW357261	Haima, South China Sea	Sun et al. 2021
	<i>Chiridota</i> sp. SS-2021	MW357262	Manus Basin, Papua New Guinea	
Caudinidae	<i>Acaudina molpdioides</i>	MK05010	Ningde, Fujian province, China	Wang et al., 2019
Cucumariidae	<i>Cercodemas anceps</i>	MW044622	Sanya city, Hainan Province, China	Li et al. 2021
	<i>Colochirus quadrangularis</i>	MT108721	NA	Lingnan Normal University (China)
	<i>Cucumaria miniata</i>	NC005929	NA	Scouras et al. 2004
	<i>Pseudocolochirus violaceus</i>	MT587564	Shenzhen, Guangdong province, China	Wang et al. 2020
	<i>Thyonella gemmata</i>	MZ463652	Coast of Lower Grand Lagoon Bay, Florida	Figuerola et al. 2021
Elpidiidae	<i>Scotoplanes</i>	LC416624 and LC416626	Otsuchi, Iwate, Japan	Takano et al. 2019
	<i>Peniagone</i> sp. YYH-2013	KF915304	Mariana Trench	Second Institute of Oceanography (China)
Holothuriidae	<i>Actinopyga echinites</i>	MN793975	SanYa, HaiNan province, China	Zhong et al. 2020
	<i>Actinopyga lecanora</i>	MW248463	LingShui, HaiNan province, China	Zhong et al. 2021
	<i>Bohadschia argus</i>	OL741685	Qionghai, Hainan Province, China	Ma et al. 2022
	<i>Holothuria edulis</i>	MT084774	NA	Lingnan Normal University (China)
	<i>Holothuria forskali</i>	FN562582	Ferrol, Spain	Perseke et al. 2010
	<i>Holothuria fuscogilva</i>	MZ305460	NA	Institute of Marine Drugs, Guangxi University of Chinese Medicine (China)
	<i>Holothuria glaberrima</i>	NA	Puerto Rico, USA	Medina-Feliciano et al, 2021
	<i>Holothuria hilla</i>	MN163001	Changjiang, Hainan Province, China	Yang et al. 2019
	<i>Holothuria leucospilota</i>	MN276190	Beihai, GuangXi province, China	Zhong et al. 2019
	<i>Holothuria leucospilota</i>	ON584426	Tanjung Sedili Beach, Malaysia	Badrulhisham et al. 2023
	<i>Holothuria (Stauropora) pervicax</i>	MK328500	Jeju Island, Korea	Lee & Shin 2019
	<i>Holothuria (Roweothuria) polii</i>	NC045029	Western coast of Sardinia, Oristano province, Italy	Utzeri et al. 2020
	<i>Holothuria scabra</i>	KP257577	NA	Xia et al. 2016
	<i>Holothuria spinifera</i>	MN816440	NA	Dalian Ocean University (China)
Phyllophoridae	<i>Neocucumis proteus</i>	MZ305458	NA	Institute of Marine Drugs, Guangxi University of Chinese Medicine (China)
	<i>Phyllophorella liuwutiensis</i>	MN198190	NA	Fisheries Research Institute of Fujian Province (China)
	<i>Phyllophorus liuwutiensis</i>	MN198190	Xiamen City, Fujian Province, China	Yang et al. 2020
	<i>Phyrella fragilis</i>	MZ305459	SanYa, HaiNan province, China	Zhong et al. 2021
Psychropotidae	<i>Benthodytes marianensis</i>	MH208310	Mariana Trench	Mu et al. 2018
Stichopodidae	<i>Apostichopus japonicus</i>	NC012616	Oita, Japan and Qingdao, China	Sun et al. 2010
	<i>Isostichopus badiionotus</i>	MZ188901	St. Andrews State Park, Florida	Drake et al. 2021
	<i>Parastichopus californicus</i>	KP398509	Vancouver Island, Canada	Zhang et al. 2016
	<i>Parastichopus nigripunctatus</i>	AB525762	NA	National Research Institute of Fisheries and Environment of Inland Sea (Japan)
	<i>Apostichopus parvimensis</i>	KU168761	NA	BGI Education Center (China)
	<i>Stichopus chloronotus</i>	MW218897	Sanya City, Hainan Province, China	Chen et al. 2021
	<i>Stichopus horrens</i>	HQ000092	Xisha islands, Hainan Province, China	Fan et al. 2011
	<i>Stichopus monotuberculatus</i>	MN276189	Beihai, GuangXi province, China	Zhong et al. 2019
	<i>Stichopus naso</i>	MZ469138	Qionghai, Hainan Province, China	Li et al. 2022

	<i>Stichopus ocellatus</i>	NC062943	Dong Fang, Hainan province, China	Zhong et al. 2022
	<i>Stichopus sp.</i>	HM853683	Weizhou island, Guangxi province, China	Fan et al. 2012
	<i>Thelenota ananas</i>	MW548268	NA	Hainan Provincial Key Laboratory of Tropical Maricultural Technologies, Hainan Academy of Ocean and Fisheries Sciences (China)
Synallactidae	<i>Synallactes</i>	MT559281	Western Pacific Ocean	Liao et al. 2020
Synaptidae	<i>Euapta godeffroyi</i>	LC704718	Nyaung Oo Phee Island, Myanmar	Ogawa et al. 2022

Table S2. List of available sea cucumber genomes and epigenomes and relative BioProject identification number.

Family	Species	BioProject	Reference / Submitter Institute
Genomes			
Chiridotidae	<i>Chiridota heheva</i>	PRJNA752986	Zhang et al. 2022
Holothuriidae	<i>Holothuria glaberrima</i>	PRJNA497079	Medina-Feliciano et al. 2021
	<i>Holothuria scabra</i>	PRJNA542245	Luo et al. 2022
	<i>Actinopyga echinites</i>	PRJNA525093	Iridian Genomes (USA)
	<i>Holothuria glaberrima</i>	PRJNA497079	Iridian Genomes (USA)
	<i>Holothuria leucospilota</i>	PRJNA747844	Chen et al. 2023
	<i>Holothuria tubulosa</i> Gmelin, 1791	PRJNA917268	Kyritsi et al. 2023
Pelagothuriidae	<i>Enypniastes eximia</i>	PRJNA609335	Iridian Genomes (USA)
Phyllophoridae	<i>Pentamera pediparva</i>	PRJNA609338	Iridian Genomes (USA)
Stichopodidae	<i>Apostichopus japonicus</i>	PRJNA335936	Jo et al. 2017
		PRJNA413998	Li et al. 2018
		PRJNA354676	Zhang et al. 2017
		PRJNA812362	Wang et al. 2022
		PRJNA865892	Guo et al. 2023
		SRR22523578	Sun et al. 2023
	<i>Australostichopus mollis</i>	PRJEB10682	Long et al. 2016
	<i>Apostichopus californicus</i>	PRJNA720913	Walla Walla University (USA)
	<i>Apostichopus leukothele</i>	PRJNA525091	Iridian Genomes (USA)
	<i>Apostichopus parvimensis</i>	PRJNA182998	Sea Urchin Genome Sequencing and Analysis Consortium
	<i>Stichopus chloronotus</i>	PRJNA511931	Institute of Oceanology, Chinese Academy of Sciences
	<i>Stichopus horrens</i>	PRJNA551342	Universiti Kebangsaan (Malaysia)
	<i>Stichopus monotuberculatus</i>	PRJNA938157	Zhong et al. 2023
Synallactidae	<i>Paelopatides</i> sp. YAP	GSA: CRA003479	Shao et al. 2022
	<i>Paelopatides confundens</i>	PRJNA596744	Iridian Genomes (USA)
Epigenomes			
Stichopodidae	<i>Apostichopus japonicus</i>	PRJNA643989 - Methylome	Yang et al. 2020
		n.a. - Methylome	Sun et al. 2020
		Data on request - Methylome	Han et al. 2021
		n.a. - ChiPseq	Xu et al. 2022

Table S3. List of sea cucumber transcriptomes with relative accession number and developmental stage.

Family / Species	BioProject / Accession	Developmental stage	Reference / Submitter Institute
Stichopodidae / <i>Apostichopus japonicus</i>	PRJNA412138	blastula	Boyko et al. 2019
		gastrula	
		auricularia larva	
		pentactula larva	
	PRJNA553613	zygote	Li et al. 2018
		4 cells	
		morula	
		blastula	
		early/late gastrula	
		early/mid/late auricularia larva	
		metamorph 1/2/3/4	
		doliolaria larva	
	SRP135833	pentaculata larva	Zhan et al. 2019
		juvenile	
	PRJNA407836	45 dpf	Wang et al. 2018
	PRJNA76487	embryo (4 and 23 hpf)	Du et al. 2012
		larva (30 hpf; 6,8,10 dpf)	
		juvenile (16 and 22 dpf)	
		juvenile (32 and 37 dpf)	
Holothuriidae / <i>Holothuria leucospilota</i>	PRJDB3196	blastula; auricularia larva (2 dpf)	University of Tsukba
		auricularia larva (3 dpf)	
Holothuriidae / <i>Holothuria scabra</i>	PRJNA433757	juvenile	Ordoñez et al., 2021

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