water

Fish Community Responses to Human-Induced Stresses in the Lower Mekong Basin

Vanna Nuon [1,2,*], Sovan Lek [3,4], Peng Bun Ngor [4,5], Nam So [1,4], and Gaël Grenouillet [3,6]

[1] Mekong River Commission Secretariat, P.O. Box 6101, 184 Fa Ngoum Road, Unit 18, Vientiane 01000, Laos; sonam@mrcmekong.org
[2] Cambodia National Mekong Committee, No. 576, National Road No. 2, Sangkat Chak Angre Krom, Khan Meanchey, Phnom Penh 12300, Cambodia
[3] Laboratoire Evolution et Diversité Biologique, UMR5174, Université de Toulouse III Paul Sabatier, CNRS, IRD, Toulouse 31062, France; sovan.lek@univ-tlse3.fr (S.L.); gael.grenouillet@univ-tlse3.fr (G.G.)
[4] Inland Fisheries Research and Development Institute, Fisheries Administration, No. 186, Preah Norodom Blvd., P.O. Box 582, Phnom Penh 12300, Cambodia; pengbun.ngor@gmail.com
[5] Wonders of the Mekong Project, c/o Inland Fisheries Research and Development Institute, Fisheries Administration, No. 186, Preah Norodom Blvd., P.O. Box 582, Phnom Penh 12300, Cambodia
[6] Institut Universitaire de France, 75231 Paris, France
* Correspondence: vannanuon88@gmail.com

Figure S1. Sampling effort at 25 sites from 2007 to 2018. The black squares represent the sampling years for each site, and the small dots indicate the missing data.

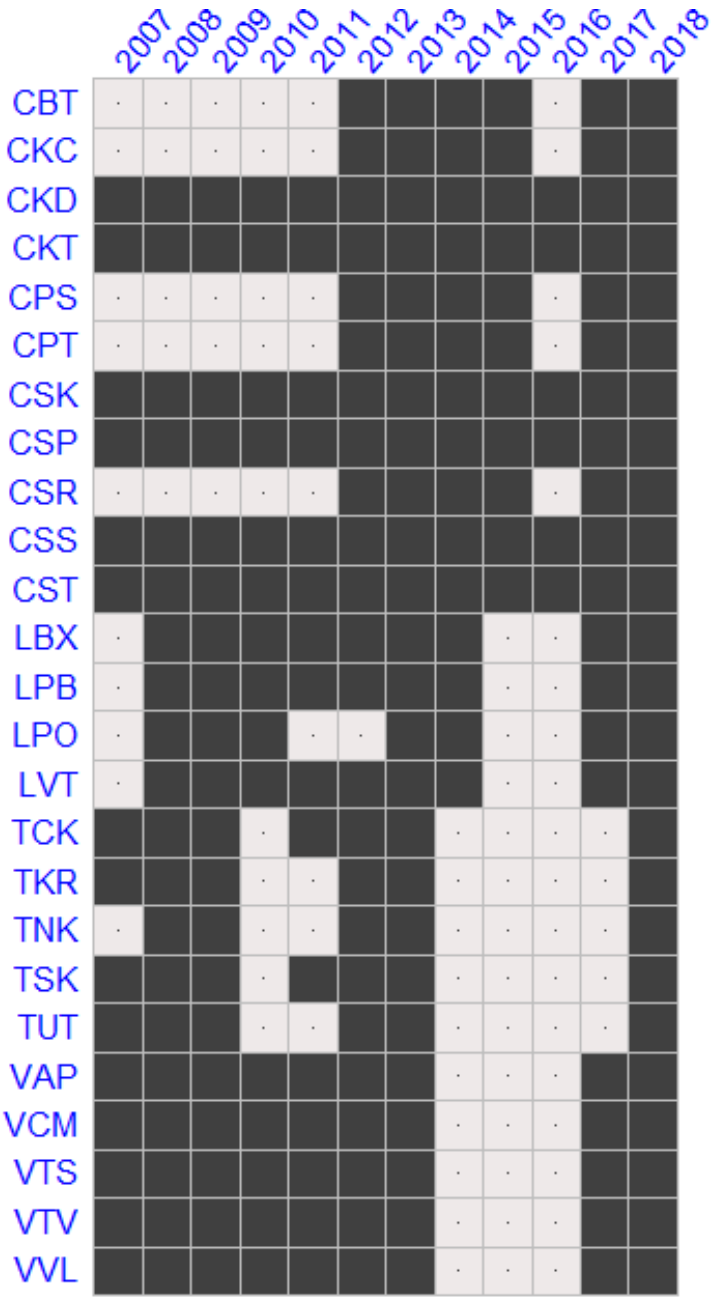
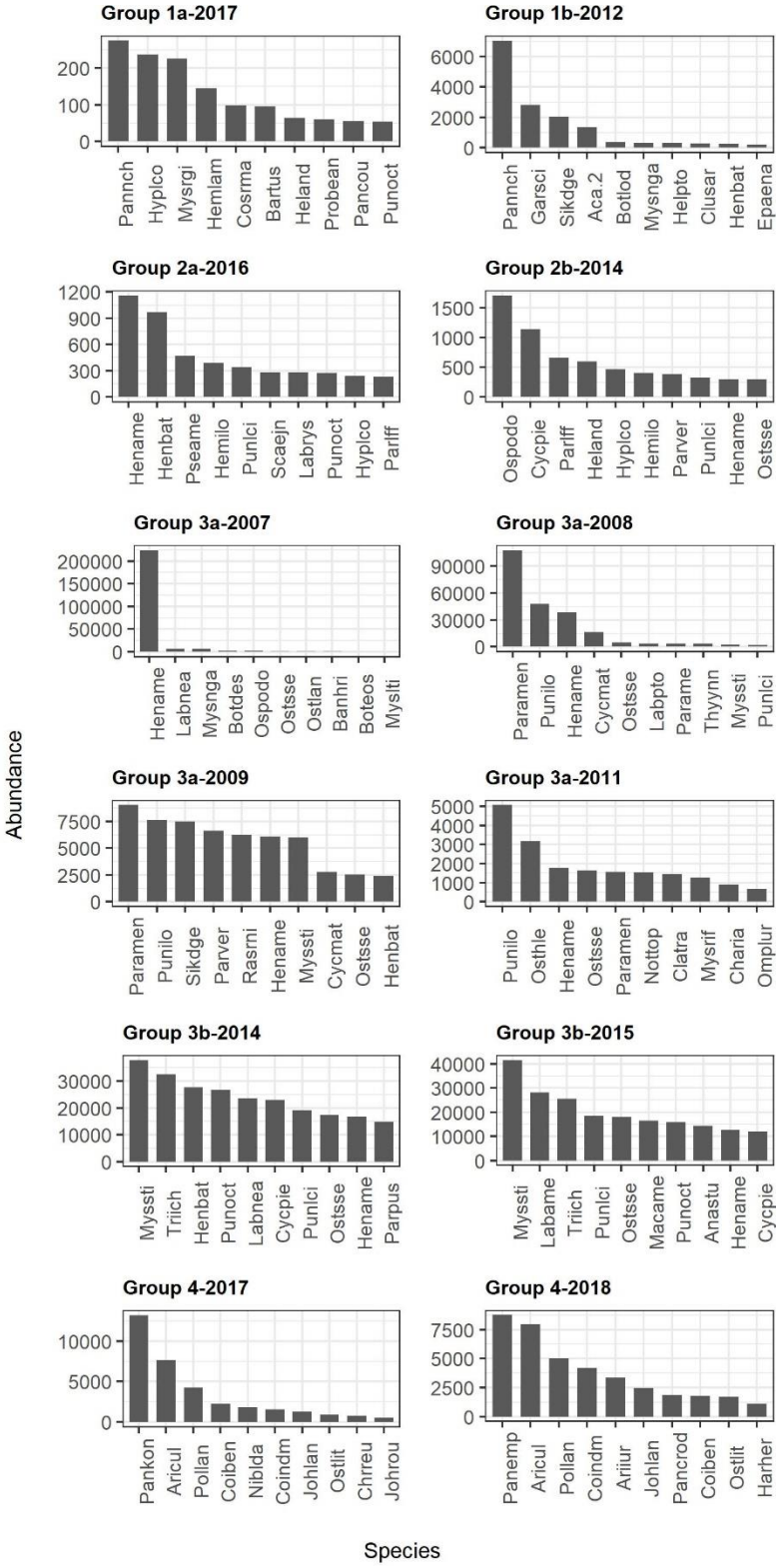


Figure S2. Top ten dominant species for years with a significant LCBD index. The abbreviations of the species names are indicated in the table right after the graph. The abbreviations of guild are defined in Table S3.



Abbreviation	Species name	Guild	Abbreviation	Species name	Guild
Aca.2	*Acanthopsis sp.2*	G3	Macame	*Macrognathus siamensis*	G6
Anastu	*Anabas testudineus*	G6	Mysrgi	*Mystacoleucus marginatus*	G1
Aricul	*Arius maculatus*	G7	Mysrif	*Mystus atrifasciatus*	G4
Ariiur	*Arius sciurus*	G7	Myslti	*Mystus multiradiatus*	G4
Banhri	*Bangana behri*	G3	Mysnga	*Mystus singaringan*	G4
Bartus	*Barbonymus altus*	G4	Nottop	*Notopterus notopterus*	G5
Boteos	*Botia eos*	G3	Omplur	*Ompok siluroides*	G4
Botlod	*Botia helodes*	G3	Ospodo	*Osphronemus exodon*	G1
Botdes	*Botia modesta*	G3	Ostsse	*Osteochilus hasselti*	G5
Charia	*Channa striata*	G6	Ostlan	*Osteochilus melanopleura*	G3
Chrreu	*Chrysochir aureus*	G10	Osthle	*Osteochilus schlegeli*	G3
Clatra	*Clarias batrachus*	G6	Ostlit	*Osteogeneiosus militaris*	G7
Clusa	*Clupeichthys aesarnensis*	G3	Pancou	*Pangasius bocourti*	G2
Coiben	*Coilia rebentischii*	G10	Panemp	*Pangasius krempfi*	G8
Cosrma	*Cosmochilus harmandi*	G2	Pankon	*Pangasius mekongensis*	G2
Cycmat	*Cyclocheilichthys armatus*	G4	Pancrod	*Panna microdon*	G10
Cycpie	*Cyclocheilichthys tapiensis*	G4	Paramen	*Parachela siamensis*	G4
Epaena	*Epalzeorhynchos frenatum*	G1	Parver	*Paralaubuca riveroi*	G4
Garsci	*Garra fasciacauda*	G1	Parpus	*Paralaubuca typus*	G4
Harher	*Harpadon nehereus*	G10	Paramen	*Parambassis siamensis*	G5
Helpto	*Helicophagus leptorhynchus*	G3	Parlff	*Parambassis wolffi*	G4
Heland	*Helicophagus waandersii*	G3	Pollan	*Polynemus melanochir*	G7
Hemlam	*Hemibagrus filamentus*	G3	Probean	*Probarbus labeaminor*	G2
Hemilo	*Hemibagrus spilopterus*	G3	Pseame	*Pseudomystus siamensis*	G3
Henbat	*Henicorhynchus lobatus*	G5	Punlci	*Puntioplites falcifer*	G3
Hename	*Henicorhynchus siamensis*	G5	Punoct	*Puntioplites proctozysron*	G3
Hyplco	*Hypsibarbus malcolmi*	G3	Punilo	*Puntius spilopterus*	G4
Johlan	*Johnius belangerii*	G10	Rasrni	*Rasbora tornieri*	G4
Johrou	*Johnius carouna*	G10	Scaejn	*Scaphognathops stejnegeri*	G3
Labrys	*Labeo chrysophekadion*	G3	Sikdge	*Sikukia gudgeri*	G4
Labpto	*Labiobarbus kuhli*	G5	Thyynn	*Thynnichthys thynnoides*	G4
Labnea	*Labiobarbus lineata*	G5	Triich	*Trichogaster trichopterus*	G6
Labame	*Labiobarbus siamensis*	G5			

Figure S3. Fish relative abundance categorized by fish-bodied size per group. Yearly relative fish abundance data were clustered by SOM groups and then categorized by fish-bodied size: small size (≤25 cm), medium size (26–60 cm), large size (61–99 cm) and giant size (≥100 cm).

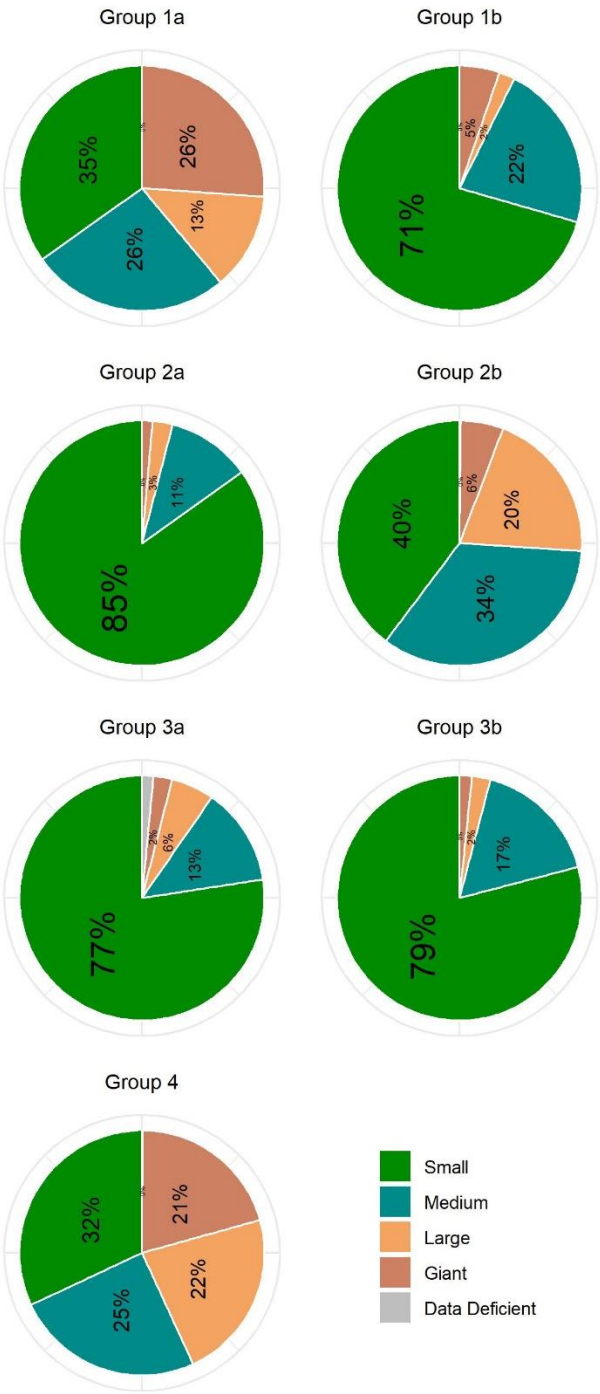
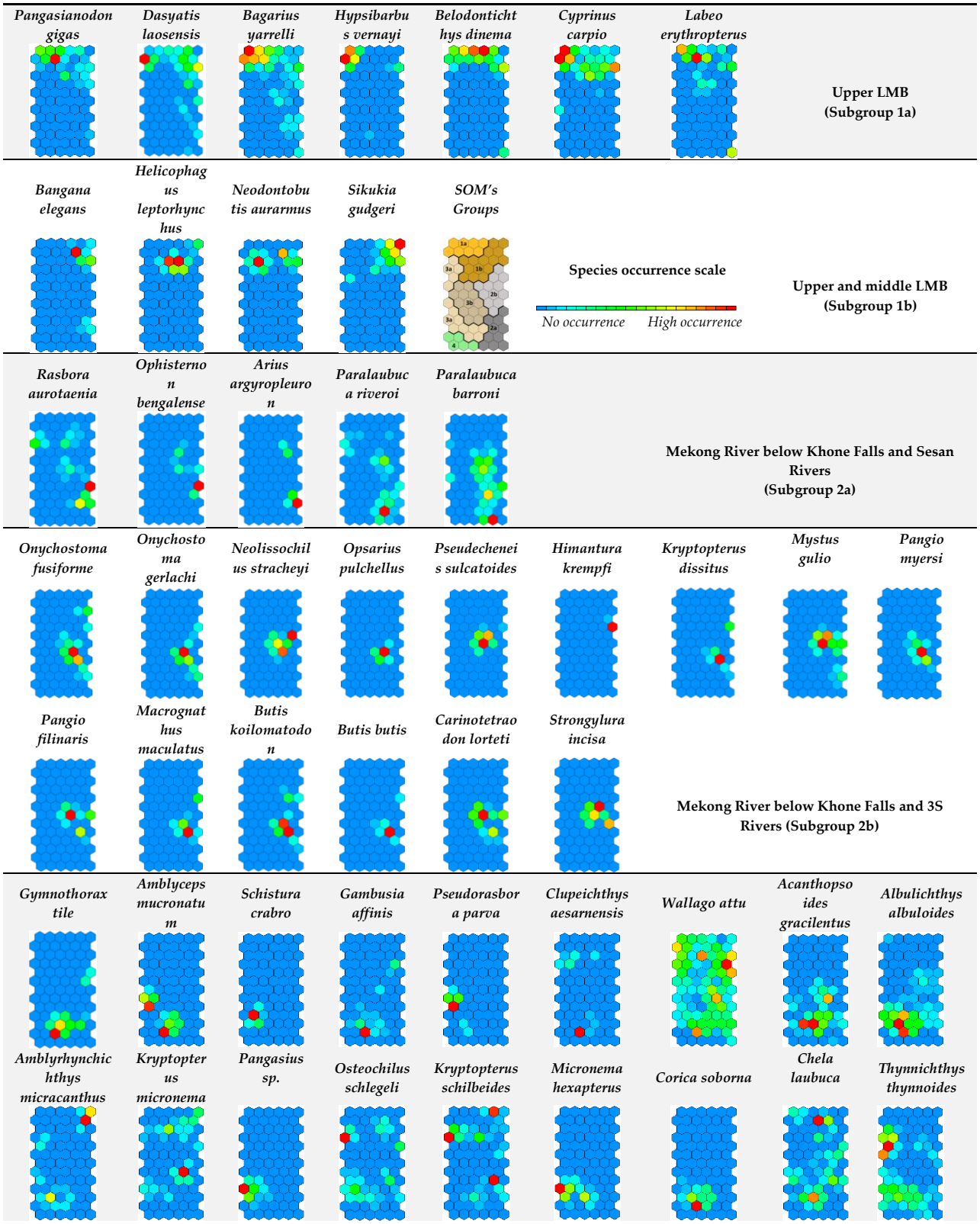
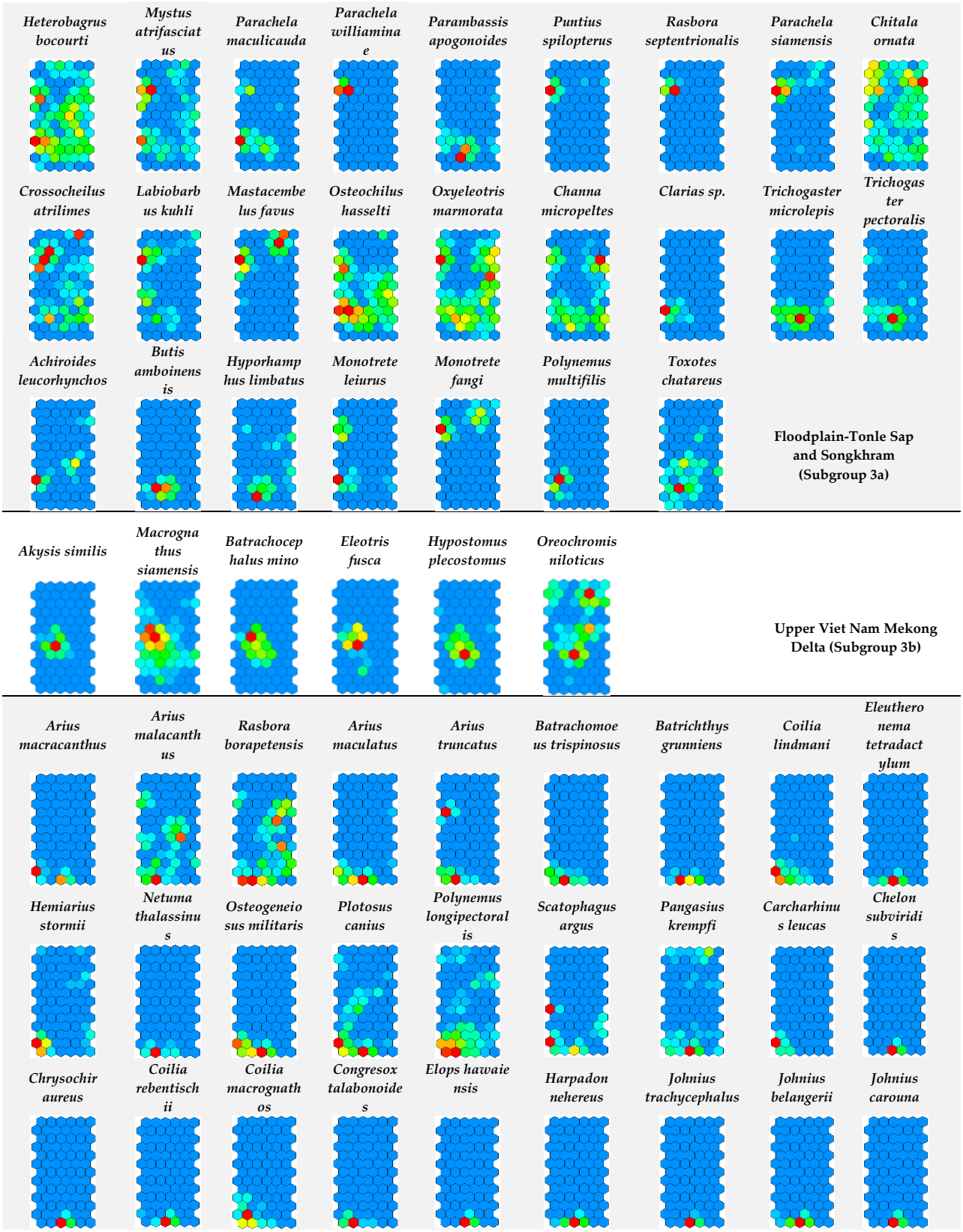


Figure S4. Distribution patterns of 119 indicator fish species on the SOM map.




Heterobagrus bocourti
Mystus atrifasciatus
Parachela maculicauda
Parachela williaminae
Parambassis apogonoides
Puntius spilopterus
Rasbora septentrionalis
Parachela siamensis
Chitala ornata
Crossocheilus atrilimes
Labiobarbus kuhli
Mastacembelus favus
Osteochilus hasselti
Oxyeleotris marmorata
Channa micropeltes
Clarias sp.
Trichogaster microlepis
Trichogaster pectoralis
Achiroides leucorhynchos
Butis amboinensis
Hyporhamphus limbatus
Monotrete leiurus
Monotrete fangi
Polynemus multifilis
Toxotes chatareus
Floodplain-Tonle Sap and Songkhram (Subgroup 3a)
Akysis similis
Macrognathus siamensis
Batrachocephalus mino
Eleotris fusca
Hypostomus plecostomus
Oreochromis niloticus
Upper Viet Nam Mekong Delta (Subgroup 3b)
Arius macracanthus
Arius malacanthus
Rasbora borapetensis
Arius maculatus
Arius truncatus
Batrachomoeus trispinosus
Batrichthys grunniens
Coilia lindmani
Eleutheronema tetradactylum
Hemiarius stormii
Netuma thalassinus
Osteogeneiosus militaris
Plotosus canius
Polynemus longipectoralis
Scatophagus argus
Pangasius krempfi
Carcharhinus leucas
Chelon subviridis
Chrysochir aureus
Coilia rebentischii
Coilia macrognathos
Congresox talabonoides
Elops hawaiensis
Harpadon nehereus
Johnius trachycephalus
Johnius belangerii
Johnius carouna

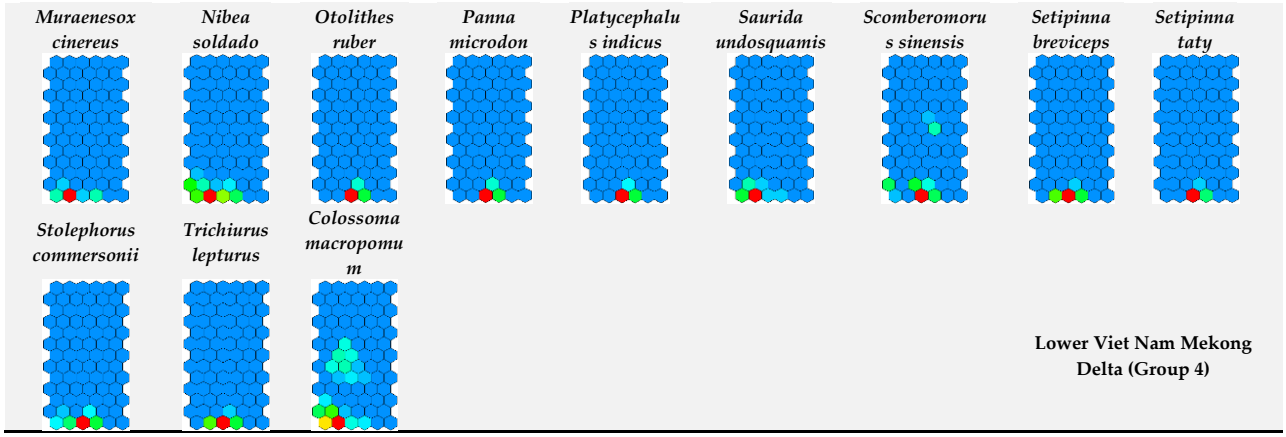

Muraenesox cinereus
Nibea soldado
Otolithes ruber
Panna microdon
Platycephalus indicus
Saurida undosquamis
Scomberomorus sinensis
Setipinna breviceps
Setipinna taty
Stolephorus commersonii
Trichiurus lepturus
Colossoma macropomum
Lower Viet Nam Mekong Delta (Group 4)

Table S1. Fish species in their ecologically distinct groups (Source: Mekong River Commission [1]).

Fish Guilds	Description
Rhithron residents	Resident in rapids torrents, rocky areas and pools in the rhithron
Main-channel residents or long-distance white fishes	• Long distance migrants spawning in the main channel (sometimes in upper zone of the Mekong). Feeding habitat of upstream of adult in the main channel. • May migrate to refuges (deep pools) in the main channel during the dry season. • Pelagophilic members have drifting pelagic eggs or larval stages and return to adult habitats using backwaters and slacks as nurseries. • Adults do not enter floodplains and may be piscivorous.
Main-channel spawners or short-distance white fishes	• Spawn in the main channel, tributaries or margins upstream of floodplain feeding and nursery habitat often with pelagic eggs or larval stages. • Adults and drifting larvae return to floodplains to feed. • May migrate to refuges (deep pools) in the main channel during the dry season.
Floodplain spawners or grey fishes	• Migrates from floodplain feeding and spawning habitat to refuges (deep pools) in the main channel during the dry season. • Spawning occurs on the floodplain and main channel used as refuge during dry season.
Eurytopic or generalist fishes	• Limited non-critical migrations in mainstream. • Highly adaptable, mobile and static elements in their genome make them highly adaptable to habitat modification.
Floodplain residents or black fishes	• Limited migrations between floodplains, pools, river margins, swamps, and inundated floodplains. • Tolerant to low oxygen concentrations or complete anoxia.
Estuarine residents	Limited migrations within the estuary in response to daily and seasonal variations in salinity
Anadromous fishes	• Enters fresh/brackish waters to breed. • Enters freshwaters as larvae/juveniles to use the area as a nursery, either obligate or opportunistic.
Catadromous fishes	• Reproduction, early feeding, and growth at sea. • Juvenile or sub-adult migration to freshwater habitat, often penetrating far upstream.
Marine visitors	Enters estuaries opportunistically
Non-native fishes	It is an introduced species or alien species.

Table S2. Beta diversity, LCBD indices per year and *p*-values (after 999 random permutations) of SOM group and subgroups. The LCBD indices for each group and subgroup are relative values summing to 1; LCBD indices that have *p*-values ≤0.05 are indicated in bold.

(Sub)groups	Beta Diversity	LCBD											
		2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Group 1a	**0.22**	–	0.10	0.06	0.09	0.07	0.07	0.07	0.08	–	–	**0.46**	–
P-values		–	0.552	0.993	0.717	0.94	0.968	0.979	0.9	–	–	**0.001**	–
Group 1b	**0.53**	0.10	0.08	0.07	–	0.11	**0.15**	0.12	0.13	–	0.13	0.07	0.05
P-values		0.474	0.896	0.898	–	0.396	**0.03**	0.181	0.078	–	0.095	0.959	1
Group 2a	**0.24**	0.07	0.08	0.08	0.10	0.04	0.08	0.05	0.10	0.13	**0.25**	–	–
P-values		0.626	0.555	0.548	0.345	0.983	0.627	0.945	0.424	0.212	**0.004**	–	–
Group 2b	**0.19**	0.07	0.09	0.08	0.06	0.08	0.08	0.07	**0.14**	0.07	0.07	0.08	0.10
P-values		0.805	0.295	0.526	0.958	0.489	0.527	0.839	**0.001**	0.939	0.821	0.403	0.135
Group 3a	**0.45**	**0.17**	**0.15**	**0.13**	–	**0.16**	0.06	0.04	0.06	0.06	–	0.08	0.08
P-values		**0.001**	**0.016**	**0.043**	–	**0.001**	0.995	1	0.994	1	–	0.878	0.799
Group 3b	**0.19**	0.08	0.06	0.06	0.07	0.04	0.05	0.05	**0.21**	**0.17**	–	0.10	0.11
P-values		0.585	0.87	0.963	0.794	0.996	0.987	0.999	**0.001**	**0.001**	–	0.383	0.199
Group 4	**0.33**	0.16	0.05	0.04	0.04	0.04	0.06	0.08	–	–	–	**0.27**	**0.26**
P-values		0.098	0.888	0.984	0.993	0.994	0.923	0.803	–	–	–	**0.002**	**0.004**

Table S3. Indicator species identified for each SOM group in the LMB: G1 = rhithron residents; G2 = long-distant white fishes; G3 = short-distant white fishes; G4 = grey fishes; G5 = generalist fishes; G6 = black fishes; G7 = estuarine residents; G8 = anadromous fishes; G9 = catadromous fishes; G10 = marine visitors; G11 = non-native fishes.

(Sub)group	Indicator Species	Indicator Value	Significant Level	Guild
1a	*Bagarius yarrelli*	0.908	***	G1
	Belodontichthys dinema	0.865	***	G11
	Cyprinus carpio	0.793	***	G11
	Hypsibarbus vernayi	0.693	***	G3
	Labeo erythropterus	0.521	***	G11
	Pangasianodon gigas	0.485	***	G2
	Dasyatis laosensis	0.466	**	G3
1b	*Bangana elegans*	0.295	*	G3
	Helicophagus leptorhynchus	0.600	***	G3
	Neodontobutis aurarmus	0.289	*	G4
	Sikukia gudgeri	0.698	***	G4
2a	*Plicofollis argyropleuron*	0.311	*	G7
	Ophisternon bengalense	0.408	**	G7
	Paralaubuca barroni	0.699	***	G4
	Paralaubuca riveroi	0.830	***	G4
	Rasbora aurotaenia	0.487	**	G4
2b	*Butis koilomatodon*	0.415	**	G7
	Butis butis	0.362	**	G7
	Carinotetraodon lorteti	0.274	*	G7
	Himantura krempfi	0.274	*	G3
	Kryptopterus dissitus	0.415	**	G3
	Macrognathus maculatus	0.343	*	G6
	Mystus gulio	0.462	**	G4
	Neolissochilus stracheyi	0.316	**	G1
	Onychostoma gerlachi	0.379	*	G1
	Onychostoma fusiforme	0.502	**	G1
	Opsarius pulchellus	0.274	*	G1
	Pangio myersi	0.316	*	G4
	Pangio filinaris	0.274	*	G4
	Pseudecheneis sulcatoides	0.274	*	G1
	Strongylura incisa	0.274	*	G10
3a	*Acanthopsoides gracilentus*	0.376	*	G3
	Achiroides leucorhynchos	0.369	*	G7
	Albulichthys albuloides	0.739	***	G3
	Amblyrhynchichthys micracanthus	0.407	*	G3
	Amblyceps mucronatum	0.345	**	G1
	Butis amboinensis	0.345	**	G7
	Channa micropeltes	0.862	***	G6
	Chela laubuca	0.507	*	G4
	Chitala ornata	0.823	***	G5
	Clarias sp.	0.488	***	G6
	Clupeichthys aesarnensis	0.436	*	G3
	Corica soborna	0.408	***	G3
	Crossocheilus atrilimes	0.571	***	G5
	Gambusia affinis	0.435	**	G11

	Gymnothorax tile	0.436	**	G10
	Heterobagrus bocourti	0.901	***	G4
	Hyporhamphus limbatus	0.487	**	G7
	Kryptopterus micronema	0.683	***	G3
	Kryptopterus schilbeides	0.428	*	G3
	Labiobarbus kuhli	0.615	***	G5
	Mastacembelus favus	0.334	*	G5
	Micronema hexapterus	0.463	***	G3
	Monotrete leiurus	0.488	***	G7
	Monotrete fangi	0.331	*	G7
	Mystus atrifasciatus	0.828	***	G4
	Osteochilus schlegeli	0.623	***	G3
	Osteochilus hasselti	0.942	***	G5
	Oxyeleotris marmorata	0.919	***	G5
	Pangasius sp.	0.552	**	G3
	Parachela siamensis	0.571	***	G4
	Parachela maculicauda	0.613	***	G4
	Parachela williaminae	0.378	**	G4
	Parambassis apogonoides	0.488	**	G4
	Polynemus multifilis	0.309	*	G7
	Pseudorasbora parva	0.345	*	G11
	Puntius spilopterus	0.488	**	G4
	Rasbora septentrionalis	0.344	*	G4
	Schistura crabro	0.267	*	G1
	Thynnichthys thynnoides	0.914	***	G4
	Toxotes chatareus	0.417	*	G7
	Trichogaster microlepis	0.883	***	G6
	Trichogaster pectoralis	0.844	***	G6
	Wallago attu	0.883	***	G3
3b	*Akysis similis*	0.385	**	G3
	Batrachocephalus mino	0.333	**	G7
	Eleotris fusca	0.365	*	G7
	Hypostomus plecostomus	0.921	***	G3
	Macrognathus siamensis	0.907	***	G6
	Oreochromis niloticus	0.732	***	G11
4	*Arius macracanthus*	0.333	*	Data Deficient
	Arius maculatus	0.998	***	G7
	Arius malacanthus	0.347	*	G7
	Arius truncatus	0.401	**	G7
	Batrachomoeus trispinosus	0.816	***	G7
	Batrichthys grunniens	0.408	***	G7
	Carcharhinus leucas	0.471	***	G10
	Chelon subviridis	0.408	***	G10
	Chrysochir aureus	0.333	**	G10
	Coilia rebentischii	0.524	***	G10
	Coilia macrognathos	0.832	***	G10
	Coilia lindmani	0.865	***	G7
	Colossoma macropomum	0.804	***	G11
	Congresox talabonoides	0.333	**	G10
	Eleutheronema tetradactylum	0.707	***	G7
	Elops hawaiensis	0.333	**	G10
	Harpadon nehereus	0.707	***	G10

Hemiarius stormii	0.875	***	G7
Johnius trachycephalus	0.333	**	G10
Johnius belangerii	0.667	***	G10
Johnius carouna	0.333	**	G10
Muraenesox cinereus	0.471	***	G10
Netuma thalassinus	0.744	***	G7
Nibea soldado	0.913	***	G10
Osteogeneiosus militaris	1.000	***	G7
Otolithes ruber	0.333	**	G10
Panna microdon	0.527	***	G10
Pangasius krempfi	0.906	***	G8
Platycephalus indicus	0.408	***	G10
Plotosus canius	0.886	***	G7
Polynemus longipectoralis	0.770	***	G7
Rasbora borapetensis	0.478	*	G4
Saurida undosquamis	0.333	**	G10
Scatophagus argus	0.562	***	G7
Scomberomorus sinensis	0.561	***	G10
Setipinna breviceps	0.408	***	G10
Setipinna taty	0.333	**	G10
Stolephorus commersonii	0.333	**	G10
Trichiurus lepturus	0.333	**	G10

* Significance ($P \leq 0.05$); ** Significance ($P \leq 0.01$); *** Significance ($P \leq 0.001$)

References

1. Mekong River Commission. *The Council Study: The Study on Sustainable Management and Development of the Mekong River, including Impacts of Mainstream Hydropower Projects. Biological Resource Assessment Final Technical Report Series. Volume 1: Specialists' Report*; Mekong River Commission Secretariat: Vientiane, Lao PDR, 2017; Volume 1.

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