ANNEX I

THE MAIN REPRODUCTIVE GUILDS OF FISH (AFTER BALON, 1975) AND THEIR RESPONSES OF TO CHANGES IN FLOW REGIME AND THE FORM OF THE ENVIRONMENT

GUILD	DEFINITION	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Open substratum spawners			
Pelagophils	Floating eggs	*Ctenopoma; Lates; Salminus;* some pimelodid catfishes; *Stolothrissa tanganyicae*	Changes to flow regimes may result in eggs and larvae in the drift in rivers being delayed in impoundments or carried past desirable nursery areas so die
Litho-pelagophils	Eggs laid on bottom but later become buoyant	*Prochilodus;* many migratory cyprinids	
Lithophils	Eggs deposited in rocks or gravel	Many cyprinid and characin species	Choking, desiccation or overly deep submergence of gravel substrates may render them unusable to the fish
Phyto-lithophils	Eggs deposited on plants, gravels, stones or other substrates	Many cyprinid species	Resistant to most environmental changes
Phytophils	Scatter eggs that adhere to submerged plants	Many cyprinid, characin and siluroid species	Generally resistant but can be affected by changes that affect distribution and abundance of submerged and emergent plants.
Psammophils	Deposit eggs on sandy bottoms	Many migratory cyprinid and characin species	Generally resistant but susceptible to excessive sedimentation

GUILD	DEFINITION	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Brood hiders			
Lithophils	Hide eggs in gravel	Many salmonid species	Choking, desiccation or overly deep submergence of gravel substrates may render them unusable to the fish
Speleophils	Restricted to cave dwelling species		
Ostracophils	Hide eggs in mussels or crabs where they are parasitic	*Rhodeus sericeus*	Susceptible to sedimentation, dredging and other alterations of the bottom that affect mussel abundance
Xerophils	Annual fish with dormant eggs	Annual cyprinodonts e.g. *Nothobranchius*	Eliminated by seasonal wetland management for agriculture
Guarders			
Lithophils	Attach eggs to rocks – males guard eggs	*Loricaria parva, L. macrops;*	Choking, desiccation or overly deep submergence of gravel substrates may render them unusable to the fish
Phytophils	Attach eggs to submerged palnts and guard them often by fanning	*Polypterus* sp.	Generally resistant but can be affected by changes that affect distribution and abundance of submerged and emergent plants.
Aerophils	Attach eggs to overhanging riparian vegetation and splash them	*Copiena arnoldi*	Vulnerable to removal of riparian vegetation

GUILD	DEFINITION	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Pelagophils	Floating eggs guarded by parents	Some *ophicephalids and Anabas* sp.	
Nest spawners			
Lithophils	Eggs attached to prepared areas of rock or gravel	*Aequidens* and many other cichlids, some characins e.g. *Leporinus* sp.	Choking, desiccation or overly deep submergence of gravel substrates may render them unusable to the fish
Phytophils	Construct nests of vegetation on floodplain or inn marginal vegetation	*Clarias batrachus; Gymnarchus niloticus*	Vulnerable to floodplain reclamation and desiccation and to elimination of marginal vegetation.
Psammophils	Shallow nests in sand usually in shallow waters of floodplain lagoons, lakes and reservoirs	Some cichlids e.g. *Tilapia zillii*	Vulnerable to rapid changes in water level
Asprophils	Floating bubble or froth nests usually on floodplains	*Hepsetus odoe; Hoplosternus;* some anabantids	Vulnerable to floodplain reclamation and desiccation and to elimination of marginal vegetation

GUILD	DEFINITION	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Speleophils	Deposit eggs in cleared holes or crevices in rocks usually at lake margins	Rock living cichlids	Vulnerable to rapid changes in lake or reservoir level
Polyphils	Build nests with anything anywhere	*Notopterus chitala*	Generally resistant
Ariadnophils	Build nests out of viscous secretions	*Gasterosteus aculeatus*	
Bearers – external			
Transfer brooders	Fish which carry their eggs before depositing them	*Callichthys; Corydoras*	Generally resistant during carrying phase but many species build nest or leks for courtship that are vulnerable to rapid changes in water level
Mouth brooders	Carry eggs in mouth	Many cichlids; *Osteoglossum*	
Skin brooders	Eggs carried on special skin on ventral surfaces	*Loricaria; Bunocephalus;* some other latin American catfishes	
Pouch brooders	Skin structures modified to form a pouch	*Loricaria vetula;* and *L. anus*	

GUILD	DEFINITION	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Bearers – internal			
Ovi viviparous	Internal fertilization – eggs expelled afterwards	*Pantodon buccholzi*	Generally resistant
Ovoviviparous	Eggs incubate in body cavity: nutrition by yolk	*Potomotrygon*	
Viviparous	Eggs incubate in body cavity: nutrition by absorptive organs	Poeciliidae	

ANNEX II

THE MAIN FEEDING GUILDS OF FISH (AFTER WELCOMME, 2001) AND THEIR RESPONSES OF TO CHANGES IN FLOW REGIME AND THE FORM OF THE ENVIRONMENT

CATEGORY	FOOD ITEMS	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Bottom feeders			
Mud feeders	Finely divided silt and attached organic molecules	*Prochilodus*, *Citharinus*, *Phractolaemus Pterigoplichthys*	May react negatively to changes in the nature of the silt deposited on floodplains as a result of changes in basin forestation and agriculture
Detritus feeders	Coarse decaying plant and animal matter, small crustacea, fungi, diatoms and other microorganisms	Many cyprinids, e.g. *Cyprinus carpo*, *Labeo* sp.,Siluroids, e.g. *Clarias bathupogon*, *Plecostomus* Catastomids	Usually resistant to change except for scouring of detrital deposits by strong currents
Herbivores			
Phytoplankton filterers	Filter floating or decanted phytoplankton from the water column, usually diatoms and green algae, more rarely blue-greens	Cichlids, e.g. *Oreochromis niloticus*, several pelagic haplochromine species	May respond negatively to changes in water quality (Eutrophication) that change the composition of the plankton
Phytoplankton grazers	Graze over rocks and plants for attached algae and fungi, and associated “Aufwuchs” communities (rotifers, micro-crustacea and other micro-organisms)	Many cyprinids, cichlids, siluroids, catastomids	Respond negatively to changes in shoreline in lakes and to silting and desiccation of rocky substrates in rivers

CATEGORY	FOOD ITEMS	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Higher plant feeders	Graze and eat higher plants	*Tilapia zillii, Ctenopharyngodon, Leporinus maculatus, Cichlasoma, Distichodus*	Generally resistant
Fruit, seed and nut eaters	Penetrate flooded forest and floodplains to eat seeds, falling fruit, etc.	*Colossoma bidens, Puntius, Leptobarbus, Brycinus*	Negatively affected by removal of riparian forests although some species appear able to shift their diet as a response to disafforestation
Omnivores			
Omnivores	Unspecialized feeders that eat insects, zooplankton, detritus, plant matter according to abundance	Many species, even highly specialized forms will occasionally eat other foods when their main food item is scarce	Generally resistant
Micro-predators			
Zooplankton feeders	Pelagic species feeding on zooplankton	*Limnothrissa miodon, Rasrtineobola argentaeus, Astyanax, Hypopthalmus*	May respond negatively to changes in water quality (Eutrophication) that change the composition of the plankton
Insectivores	• Surface feeders taking insects falling on surface of water • Bottom feeders feeding over rock, mud or sandy bottoms	*Toxotes chatareus*, pelagic haplochromine cichlids Many species, characins, cyprinids, siluroids, cichlids, *Synodontis*,	Negatively affected by removal of riparian forests and vegetation Susceptible to changes in nature of bottom through silting, dredging or engineering works

CATEGORY	FOOD ITEMS	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Meso-predators			
Crustacean and large insect feeders	Feed on large bottom living arthropods	Young of many fish-eating predators, Siluroids, *Schilbe*	Susceptible to deoxygenation of deeper waters caused by eutrophication
Molluscivores	• Pickers – remove bivalve and gastropods from their shells with special pick like teeth • Crushers – crush whole gasteropods	Haplochromine cichlids *Astatoreochromis*, Siluroids, haplochromiNe cishlids	Susceptible to conditions that change the distribution and abundance of molluscs
Macro-predators			
Fish eaters	• Lurking predators, hide in vegetation or adopt disguise • Pursuing predators, rapidly pursue prey	*Esox, Channa,* *Salminus, Lates, Hoplias, Hepsetus odoe*	Depend largely on abundance of prey species and are susceptible to conditions
Commensals			
Cleaner fish	Species feeding on insect and other surface and gill parasites in freshwaters found especially in highly evolved species flocks	Haplochromine species from lakes Victoria, Malawi and Tanganyika	

CATEGORY	FOOD ITEMS	REPRESENTATIVE SPECIES	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM
Parasites			
Fin nippers	Some fin nippers are found in most fish assemblages in the tropics. They tend to be lurking predators that creep up on other fish to remove part of their fins	*Phago, Serasalmus*	
Flesh biters	Predators that bite lumps out of prey species. Thes are often relatively small fishes	Piranhas	
Scale and mucus eaters	Scale eaters have similar behaviour to fin nippers but have special dentition that enables them to rasp scales from the caudal peduncle or mucus from the body	Specialized individuals in cichlid species flocks	
Egg robbers	Species that prey especially on mouth brooding cichlids, persuading the brooding fish to surrender her brood	Specialized individuals in cichlid species flocks	
Blood suckers	Small species that attach themselves to the gills of other species to suck blood	Candiru	

ANNEX III

THE MAIN ECOLOGICAL GUILDS OF FISH IN RIVERS AND THEIR RESPONSES OF TO CHANGES IN FLOW REGIME AND THE FORM OF THE ENVIRONMENT (FROM WELCOMME, WINEMILLER AND COWX, 2006)

ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
HIGHLAND STREAM GUILDS • Rheophilic, main channel residents • Inhabit torrent and rapids areas			
Riffle guild	• Inhabit rapids and rocky areas • Generally small size and equipped with suckers or spines, may also have elongated or flattened forms • Generally lithophilic with extended breeding seasons depositing their eggs among gravel and rocks • Generally insectivorous or specialists such as algal scrapers or filter feeders	• Sensitive to catastrophic and habitat flows (see Welcomme and Halls 2004) • Damaged by disturbances to pool-riffle structure, such as seasonal desiccation or increases in sediment load that choke the interstitial spaces • Damaged by wash-out or submergence of gravel reaches • Species can be restored by rehabilitation of rapids and the pool-riffle structure • Species have fairly well defined flow requirements	*Chiloglanis, Garra, Phractura* (Africa), *Botia* and balitorinids (Asia); loaches and sculpins (Europe); *Percina, Etheostoma* (N. America); *Characidium, Parodon,* and *Trichomycterus* (S. America)

ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Pool guild	• Inhabit pools, often very micro-habitat specific • More limnophilic in habit • Some species inhabit slack regions of back eddies where there is emergent and floating vegetation. • Other species inhabit the deeper waters • Tend to feeding on the drift dislodged from the riffles or on insects falling into the river • Either lithophilic, breeding in the riffles, or phytophilic, attaching their eggs to vegetation	• Disturbed by changes to the flow regime that desiccate the pools or leave them for long periods without flow • Changes in water level can disturb habitat structure. • Generally rely on delicate balance of pool-riffle structure of the Highland stream and respond negatively to any influence that changes this balance	Many small cyprinids, characins, salmonids, *Schizothorax* (Asia), catfishes and loaches
LOWLAND RIVER (POTAMONIC) GUILDS			
LENTIC GUILDS • Floodplain residents move little between floodplain pools, swamps and inundated floodplain • Repeat breeders with specialized reproductive behaviour • Predominantly polyphils, nest builders, parental carers or live bearers • Generally resistant to low dissolved oxygen			

ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Plesiopotamonic guild	• Tolerant of low dissolved oxygen tensions only • May be lateral migrants moving from river margins, de-oxygenated backwaters and floodplain water-bodies onto floodplain	• Sensitive to the drawdown phase of the hydrological cycle. Sensitive also to the amplitude of flooding that regulates connectivity to the river and extent of inundated floodplain • Tend to disappear when floodplain disconnected and desiccated through poldering and levee construction • May increase in number in shallow, isolated wetlands, rice-fields and drainage ditches	*Polypterus, Oreochromis mossambicus* (Africa); many small characins, cyprinids, catfishes and cichlids (Asia); *Tinca tinca* (Europe); *Astyanax, Markiana* and other characids, *Astronotus ocellatus* and other cichlids, *Rhamdia* and other pimelodids (S. America); *Gambusia affinis, Lepomis humilis, Ameiurus melas* (N. America)
Paleopotamonic guild	• Tolerant of complete anoxia • Usually non-migratory	• Sensitive to the drawdown phase of the hydrological cycle and to risks of desiccation • Persist in residual floodplain water bodies • Principal component of rice field and ditch faunas	*Trichogaster, Ophicephalus* (Asia); *Protopterus, Heterobranchus, Parophicephalus* (Africa); *Clarias, Ctenopoma* (Africa and Asia); *Misgurnus fossilis* (Europe); *Hoplerythrinus, Brachyhypopomus*, *Corydoras*, *Hoplosternum*, *Brachyhypopomus*, *Hypostomus* and other loricariids (Latin America); *Umbra, Lepisosteus* (N. America)

ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Annual guild	• Inhabit seasonal, isolated, water bodies • Have aestivating eggs with diapause • Complete life cycle in one rainy season	• Sensitive to land reclamation schemes that permanently suppress seasonal water bodies	*Rachovia* and other annual killifishes,
LOTIC GUILDS • Migratory fishes, moving often over long distances with sometimes complex migration patterns • One breeding season a year • Intolerant of low oxygen			
Eupotamonic pelagophilic guild	• Main channel residents not entering floodplain • Longitudinal migrants between a usually downstream feeding site and an upstream breeding one • Predominantly pelagophils • Often have drifting eggs and larvae • May use backwaters or slacks downstream of point bars as nurseries	• Tend to disappear when river dammed to prevent migration • Sensitive to the timing and velocity of flow when these are inappropriate to breeding seasonality • Recruitment success lessened if flow excessive or too slow for the needs of drifting larvae • Sensitive to low temperature discharges from dams • May respond positively to fishpasses	*Lates calcarifer* (barramundi) (Australia); *Salminus maxillosus, Brachyplatystoma* and other pimelodid catfishes (Latin America)*;* Asian major barbs, *Hilsa,* some pangasiid catfishes (South and Southeast Asia)*; Alosa* (Northern Hemisphere); *Polyodon* (North America)

ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Eupotamonic lithophilic guild	• Longitudinal migrants, often anadromous between a usually downstream feeding site and an upstream breeding one • Lithophils and psammophils • Fry may be resident at upstream site for a certain period and may occupy upstream floodplain	• Tend to disappear when river dammed to prevent migration or when timing of flood inappropriate to their breeding seasonality • Sensitive to habitat flows if upstream breeding substrates destroyed or degraded • Sensitive to structure of upstream habitats particularly presence of absence of woody debris • May respond positively to fishpasses	*Salmo salar*, anadromous sturgeons (Acipenseridae) (Europe and N. America); *Onchorhynchus* sp. (Northwestern N. America); *Tor tor* (India)
Eupotamonic phytophilic guild	• Use floodplain for breeding, nursery grounds and feeding of juvenile and adult fish • Longitudinal/lateral migrants between floodplain spawning and feeding areas and main channel refugia • Predominantly phytophils • Usually spawn at floodplain margin or on floodplain; sometimes have semi-pelagic drifting eggs and larvae	• Tend to disappear when river dammed to prevent migration • Damaged when access to floodplain denied to developing fry and juveniles • Influenced by amplitude and duration of flooding	*Alestes, Hydrocynus, Citharinus* (Africa); percichthyids (Australia); many large cyprinids throughout the Paleotropics including *Barbus, Labeo, Catla*; *Leporinus, Colossoma, Piaractus, Prochilodus, Semaprochilodus, Pseudoplatystoma* (S. America); some species of suckers (Catastomidae) and large western minnows (Cyprinidae) (N. America)

ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Parapotamonic (Semi-lotic) guild	• Intermediate between rheophilic and limnophilic habit • Short distance, but often non-obligate migrants • Predominantly lithophils, psamophils, phytophils • Prefer anabranches and backwaters with low or seasonal flows • Use backwaters or slacks downstream of point bars as breeding grounds and nurseries	• Sensitive to river straightening and bank revetments • Sensitive to stress flows and habitat flows needed for flushing the system	Many small cyprinids and characins; *Cyprinus carpio* (wild form), *Rutilus rutilus, Abramis brama* (Europe); *Esox lucius* (Northern Hemisphere)
EURYTOPIC GUILDS • Generalist species with very flexible behaviour • Tolerant of low dissolved oxygen • Repeat breeders • Predominantly phytophils, lithophils, psammophils, but some nesters or parental carers • Short distance migrants (semi-migratory) often with local populations			

ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Eupotamonic benthic guild	• Occupy main channel generally benthic sites • May be tolerant of low dissolved oxygen but not necessarily so	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively to flows that change depositional siltation processes and alter the nature of the bottom	Some *mormyrids*, some *Synodontis;* (Africa)*; Ancistrus, Chaetostoma, Pekoltia, Apteronotus, Sternarchorhynchus, Rhabdolichops* (S. America); *Dorossoma, Ictiobus, Ictalurus* (N. America).
Eupotamonic riparian guild	• Occupy main channel riparian vegetation • Usually tolerant of low dissolved oxygen • May be lateral migrants or semi migratory but often flexible with resident elements	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively by flows and management that changes riparian structure	*Heterotis niloticus* and many *Tilapia* and *Oreochromis* species (Africa); *Cyprinus carpio, Scardinius erythrophthalmus* (Europe); *Apistogramma, Crenicichla, Hemigrammus, Nannostomus, Microglanis*, various small doradid and loricariid catfishes, (S. America); *Fundulus*, some *Lepomis* spp. (N. America).

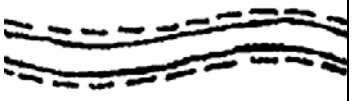
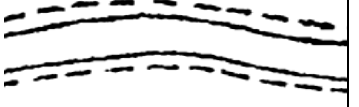
ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
ESTUARINE AND COASTAL LAGOON GUILDS			
Freshwater estuarine guild	• Stenohaline species that inhabit the freshwater component of the estuarine system • Semi-migratory species that move according to salinity and flood strength • Usually breed and feed in freshwater component of system	• Sensitive to changes in flow that affect fresh-salt water balance in the estuarine system • Affected negatively by lowered flows permit greater penetration of saline water • Excessive flows may carry adults and fry into excessively saline environments • Influenced positively by river mouth dams that impound freshwater in the estuary	*Chrysichthys aureus* (Africa); some ariid catfishes (Australia and West Africa); *Theraps maculicauda*, (Central America), *Brachyplatystoma vaillanti* (S. America), *Rutilus rutilus, Abramis brama, Esox lucius* (Baltic and Black Seas)
Brackish water estuarine guild	• Permanent residents of estuary and lagoon system • Euryhaline, able to tolerate both fresh and marine water phases • Usually confined to brackish part of the system	• Influenced negatively by river mouth dams that impound freshwater in the estuary and remove the brackish component	Milkfish *Chanos chanos* (Asia); *Ethmalosa fimbriata, Sarotherodon melanotheron, Chrysichthys nigrodigitatus* (West Africa); *Anableps anableps* (Central America); *Jenynsia multidentata* (S. America); Eleotridae and Mugilidae (global)

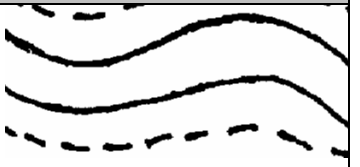
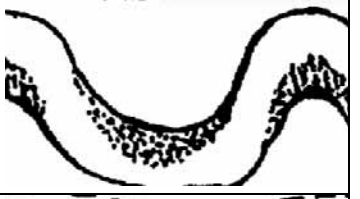
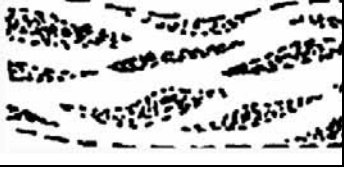
ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Semi-Anadromous estuarine guild	• Stenohaline and euryhaline species • Enter fresh/brackish water system to breed • Enter freshwaters as larvae/juveniles to use the area as a nursery—either obligate or opportunistic	• Stenohaline species may be adversely affected by increased river flows that convert the system to freshwater • Excessive flows may carry adults and fry into excessively saline environments • Influenced negatively by river mouth dams that impound freshwater in the estuary and stop migration into the river	*Hilsa*, Reeves shad many Eleotridae and Gobiidae (global). *Dormitator lebretonis* (West Africa) This guild also includes many crustaceans of economic importance
Amphidromous guild	• Species that enter fresh or brackish waters to feed either as adults or as fry and juveniles	• Euryhaline species • Excessive flows may eject adults and fry from the freshwater system	*Dicentrachus*, *Polynemus*, *Monodactylus* (Asia); This guild also includes many crustaceans of economic importance.
Catadromous guild	• Feed in the freshwater environment, often penetrating far into freshwaters • Breed in the marine environment	• Affected by much the same conditions as affect the eupotamonic guilds and are threatened by interruptions to longitudinal connectivity and by changes to the hydrograph at times critical to migration. They are equally affected by adverse changes to the marine ecosystems	Anguilid eels (Africa); *Anguilla anguilla*. (Europe and N. America) and flounder (*Platichthys flesus* L.)

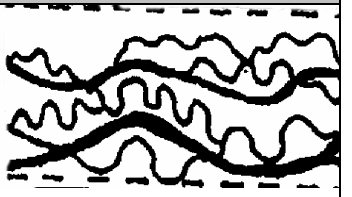
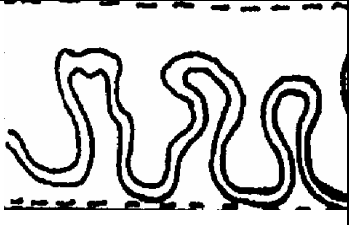
ECOLOGICAL GUILD	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
MARINE GUILDS			
Opportunistic marine fishes	• Enter estuaries opportunistically		Bullsharks (*Carcharinus leucas*), sawfish (*Pristis pectinatus*), many skates and rays, as well as diverse bony fishes

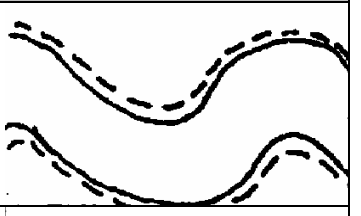
ANNEX IV

SUMMARY OF CRITERIA FOR BROAD-LEVEL CLASSIFICATION OF RIVERS AS DEFINED BY ROSGEN, 1994

Stream type	General description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features	Plan view
Aa +	Very steep, deeply entrenched, debris transport streams.	<1.4	<12	1.0 to 1.1	>0.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with/deep scour pools; waterfalls.	
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	0.04 to 0.10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology.	

Stream type	General description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features	Plan view
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>l.2	0.02 to 0.039	Moderate relief. Colluvial deposition and/or residual soils, Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate with occasional pools	
C	Low gradient, meandering, point-bar, > 2.2 riffle/pool, alluvial channels with broad floodplains.	>2.2	>12	>1.4	<0.02	Broad valleys with terraces, in association with floodplains, alluvial soils, Slightly entrenched with well-defined meandering channel, Riffle-pool bed morphology.	
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<0.04	Broad valleys with alluvial and colluvial fans Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply.	

Stream type	General description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features	Plan view
DA	Anastomosing (multiple channels) narrow and deep with expansive well vegetated Upturn and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks.	>4.0	<40	variable	0.005	Broad, low-gradient valleys with line alluvium and/ or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition with well-vegetated bars that arc laterally stable with broad wetland floodplains.	
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>l.5	<0.02	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well vegetated banks. Riffle-pool morphology with very low width/depth ratio.	

Stream type	General description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features	Plan view
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.4	<0.02	Entrenched in highly weathered material, Gentle gradients, with a high WID ratio, Meandering, laterally unstable with high bank-erosion rates, Riffle-pool morphology.	
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<l.4	< 12	> 1.2	0.02 to 0.039	Gulley, step-pool morphology with moderate slopes and low W(D ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials; i.e. fans or deltas. Unstable, with grade control problems and high bank erosion rates.	

ANNEX V

SOME HABITATS OF RIVER SYSTEMS

HABITAT	SIGNIFICANCE
MONTANE STREAMS ZONE (see Rosgen, 1994)	
Rapids steps and waterfalls Plunge pools	Not generally colonized by many species although some specialized rapids fauna do occur. Highly fragmented populations
HIGHLAND STREAM ZONE (see Rosgen, 1994)	
Usually divided into an alternation of pools and rocky riffles Pools may be open or shaded by forest	Two main groups of inhabitants a) Resident species b) Visitors, usually lithophilic species for breeding.
Pools [in extreme conditions may become isolated and deoxygenated] *Bottom substrate* Mud Sand Leaf litter (Detritus) *Vegetation type* Floating vegetation - floating riparian vegetation and lily pads Submersed vegetation Emergent vegetation	
Riffles A variety of habitats on rocks, on epilithic plants and in interstices of the rock/cobble/gravel	Resident populations of mainly small species often highly specialized to particular types of sub-habitat. Species show a high degree of endemism as individual streams are isolated one for the other.

HABITAT	SIGNIFICANCE
	Resident species highly adapted to rapids, living either on rock surfaces, associated with plants or in the interstices of the gravel and cobbles. Migratory, lithophilic species move upstream from the Potamon or the sea mainly to spawn in various types of gravel or in the interstices of the cobbles.
Fallen tree trunks and other large woody debris	A number of species use large woody debris for refuge, particularly in the dry season.
LOWLAND RIVER ZONE	
CHANNELS Channels include main channels and active anabranches in braided systems. Features include: **Meanders and islands** Meanders produce a regular sequence of habitats of varying depth and bottom type with slow or fast current and open or shaded by riparian forest. Many of the same features are associated with islands especially in braided channels	The potamonic zone is populated by a large number of species that often move considerable distances between habitats during the years hydrological cycle. Channels provide a) habitats for a group of main channel specialist species b) pathways for migrant species c) refuge from inclement conditions as the floodplain dries during low water episodes

HABITAT	SIGNIFICANCE
Slacks waters behind point bars	Significant as nursery and shelter sites for small species and juvenile fish.
Sheltered deeps under undercut banks	Refuge and resting sites for larger fish.
Shallows with no current or slight current	Inhabited by a number of species particularly as nursery areas for juveniles. Used for nest building by cichlid and other species.
Mud bottom Sand bottom Leaf litter bottom	A number of specialist main channel residents live entirely in the main channel and are usually selective for bottom substrate. For example detritivore species are attracted to leaf litter and benthic feeders to mud and sand.
Channel deeps	Major refuge sites for large individuals and species especially during low water.
Floating littoral vegetation	Major refuge habitat during dry season for a large number of small species.
Emergent vegetation in slack pools at low water	Specialist faunas of small species.
Backwaters connected to channels Sometimes fully open to main channels but with many of the characteristics of lagoons or lakes, May be:	Backwaters serve as: Habitat for some species Refuge from strong floods for many species Nursery habitat for many species and may in part substitute for floodplain.
Connection regime	
Connected permanently – maybe lotic when only connected at lower end or seasonally lentic when intermittently connected at both ends	The resident species depend on the micro-habitat composition and vary according to connection regime, bottom type, vegetations, shading etc.
Connected intermittently	The degree of shelter and nursery habitat is conditioned mainly by connection regime.

HABITAT	SIGNIFICANCE
Shading	
Shaded – clear or with large woody debris	
Open with deep water	
Bottom type	Sand bottoms used as spawning substrate by psammophilic species and for nest building by parental guarders.
Mud bottom	
Sand bottom	
Vegetation type	
Floating vegetation mats	Vegetation used as spawning substrate by many phytophilic species. Also epiphyton on the stems of plants serves as food.
Submersed vegetation	
Emergent vegetation	
Floating leafed vegetation	
FLOODPLAINS	A major habitat for many species during the floods that serves as spawning site and nursery for young fish, and shelter and feeding area for adults.
Flooded grassland	The main habitat for spawning by phytophilous species and their fry. Also occupied by floodplain species that move from their permanent habitats in floodplain pools to spawn and feed.
Floating meadows	
Open water	
Littoral fringes at limits of advancing or retreating water	
Rice fields and other flood agriculture	
Flooded forest	Occupied by a range of specialized species that feed mainly on fruit and seeds falling from the flooded trees.
Dense rain forest	
Gallery or levee woodland	
Acacia and bush scrub	
Lagoons and depressions	Occupied by a range of species specialized for the low dissolved oxygen concentrations often found in smaller-pools.
	Species depend on lagoon size and larger lagoons also occupied by large

HABITAT	SIGNIFICANCE
	migratory species that live in the lagoons during the dry season. Species also depend on the degree of separation of the lagoon form the river and hence the frequency of connection.
Shading Shaded by riparian forest Open	
Open water Mud bottom Sand bottom Leaf litter bottom	Many species that are characteristic of bottom substrate.
Vegetation type Emergent vegetation Floating vegetation Floating leafed vegetation Submersed vegetation	Vegetation attracts many species that are characteristic of vegetation type. It also serves as a substrate for epiphytic food organisms
Floodplain pools Pools that dry out completely Marshy pools – heavily vegetated with little dissolved oxygen Shaded pools – in forested areas	Occupied by even more specialized air-breathing species that also have complex reproductive strategies such as live bearing and nest building that ensure breeding success.
Connecting channels Channels connecting floodplains and their water bodies to the main river. These may be seasonal or permanent	Main pathway between river channel and floodplain features. Heavily occupied by fish migrating to floodplain to spawn on the rising flood and young and adults returning on the falling flood. Also occupied by main channel predators at the falling flood feeding on the returning fish.

HABITAT	SIGNIFICANCE
Flood areas outside main flood area Often seasonal	Occupied mainly by annual species.
LARGE LAKES AND RESERVOIRS – associated with river floodplain system. These systems have complexes of lacustrine habitats	Major habitats with characteristic lacustrine faunas (or adapted river faunas). Some elements may be migratory and rely on the river for breeding.
DOWNSTREAM LARGER WATER BODIES – Sea, larger lakes or coastal lagoons	Major seasonal habitat for diadromous migrants.

ANNEX VI

THE MAIN ECOLOGICAL COMMUNITIES OF FISH IN LAKES AND RESERVOIRS, AND THEIR RESPONSES OF TO CHANGES IN FLOW REGIME AND THE FORM OF THE ENVIRONMENT

ECOLOGICAL COMMUNITY	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Pelagic community	Inhabit surface waters; Usually phyto- or zoo-plankton feeders and predators that feed on them	Largely unaffected by physical changes. May respond negatively to changes in water quality (Eutrophication) that change the composition of the plankton	*Limnothrissa, Stolothrissa, Rastrineobola*
Demersal community	Inhabit bottom waters	Affected by general water quality (Eutrophication) in so far as it affects the level of the anoxic waters below the thermocline	
Rock bottoms	Inhabit deep rocky reefs – usually micro-, meso- and macro-predators		*Mormyrus kannume.* Small cichlid species
Mud and sand bottoms	Inhabit a variety of bottom substrates; usually insectivores and molluscivores		Various haplochromine cichlids *Citharinus, Cyprinus*
Mid-water community	Occupy mid-waters –filter feeding planktonophages, predators	Resistant	*Oreochromis, Lates, Plagioscion, Cichla*
Shore communities			
Submersed and emergent vegetation	Form localized communities around submersed vegetation, lily pads and emergent reed beds	Susceptible to changes to nature and composition of shoreline Susceptible to rapid and	*Lepomis,* small cichlids, cyprinids and characins

ECOLOGICAL COMMUNITY	TYPICAL BEHAVIOUR	REACTION TO CHANGES IN HYDROGRAPH AND FORM OF SYSTEM	REPRESENTATIVE SPECIES
Marginal wetlands	Occupy deoxygenated marginal swamps	exaggerated changes in water level particularly in reservoirs	*Protopterus; Clarias, Hoplias*
Rock shores	Inhabit rock shores with a high degree of endemism in some ancient lakes; include a range of trophic types from algal grazers to predators		Small cichlids, characins, cyprinids and siluroids
Mud and sand shores	Occupy shallow mud and sand shores often to limited depth		Mormyrids; small cichlids; juveniles of several species; favoured nesting and lekking sites for several species
Riverine migrant community	Residents of lakes and reservoirs that migrate up rivers to breed Especially common in reservoirs where elements of the former riverine community continue to exist	Affected negatively by damming and other changes in tributary rivers used for spawning	*Labeo, Barbus, Raiamas, Procilodus, Semaprochilodus, Leporinus*

Many rivers, lakes and other inland waters have been modified and degraded by human activities. Rehabilitation of degraded systems and mitigation of impacts of ongoing stresses are needed to preserve ecosystem services and fisheries and are of a high priority if the aquatic biodiversity of inland waters is to be conserved. A number of technical solutions for rehabilitation and mitigation are available to restore habitat diversity, provide for environmental flows and ensure longitudinal and lateral connectivity within such systems. It is recommended that such methods are applied on a basin-wide scale but it is recognized that more restricted sections of waterbodies may have to be targeted. Planning for rehabilitation projects needs to be carefully conceived with clear objectives of the rehabilitation and selection methods to be used. Selecting appropriate methods for any particular waterbody depends on local, social and economic conditions and priorities. Land tenure, local laws and the interests of other local stakeholders in the resource also need to be incorporated into rehabilitation plans. In international rivers and lakes, rehabilitation plans may need negotiation and cooperation by all riparian states. After execution, rehabilitation projects should be carefully monitored in order to meet the objectives.

ISBN 978-92-5-106002-5 ISSN 1020-5292

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TC/M/I0182E/1/05.08/2000