

PDG 2023 Section 6 - Fish and Fisheries



Fish Ecology and Fisheries

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Fish and Fisheries – outline

- PDG Objectives
- Outline of risks to fish and fisheries from HPP developments
 - Understanding ecological and fisheries perspectives
 - **Transboundary and cumulative impacts**
- Monitoring requirements during all phases of development
- Mitigation options
- Lessons learnt from previous PNPAs



Section 6.1 : Objectives (174-175)

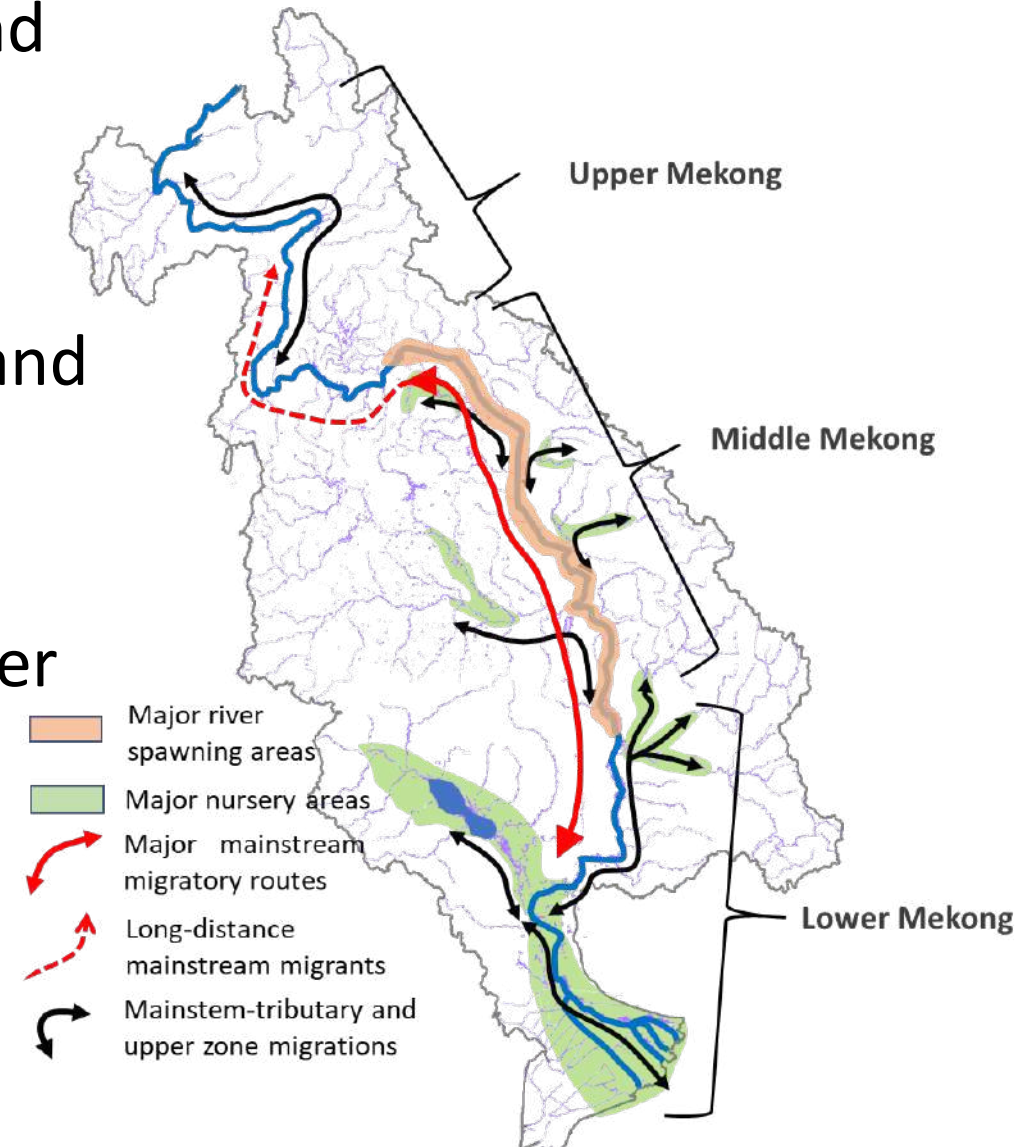
- i. Assess the potential risks to fish and fisheries and OAAs.
- ii. Protect and conserve the 1400 fish species reported from the LMB.
- iii. Minimise the impact of dam construction and operation on upstream migration of fish species.
- iv. Minimise the impact of dam construction and operation on downstream movement of fish species.
- v. Minimise fish and fisheries impacts arising from changes downstream of the reservoir and in impoundment upstream.
- vi. Provide options to mitigate impact of HPP dams on local and transboundary fish and fisheries, and other aquatic organisms.

Fish and Fisheries – major areas addressed in PDG

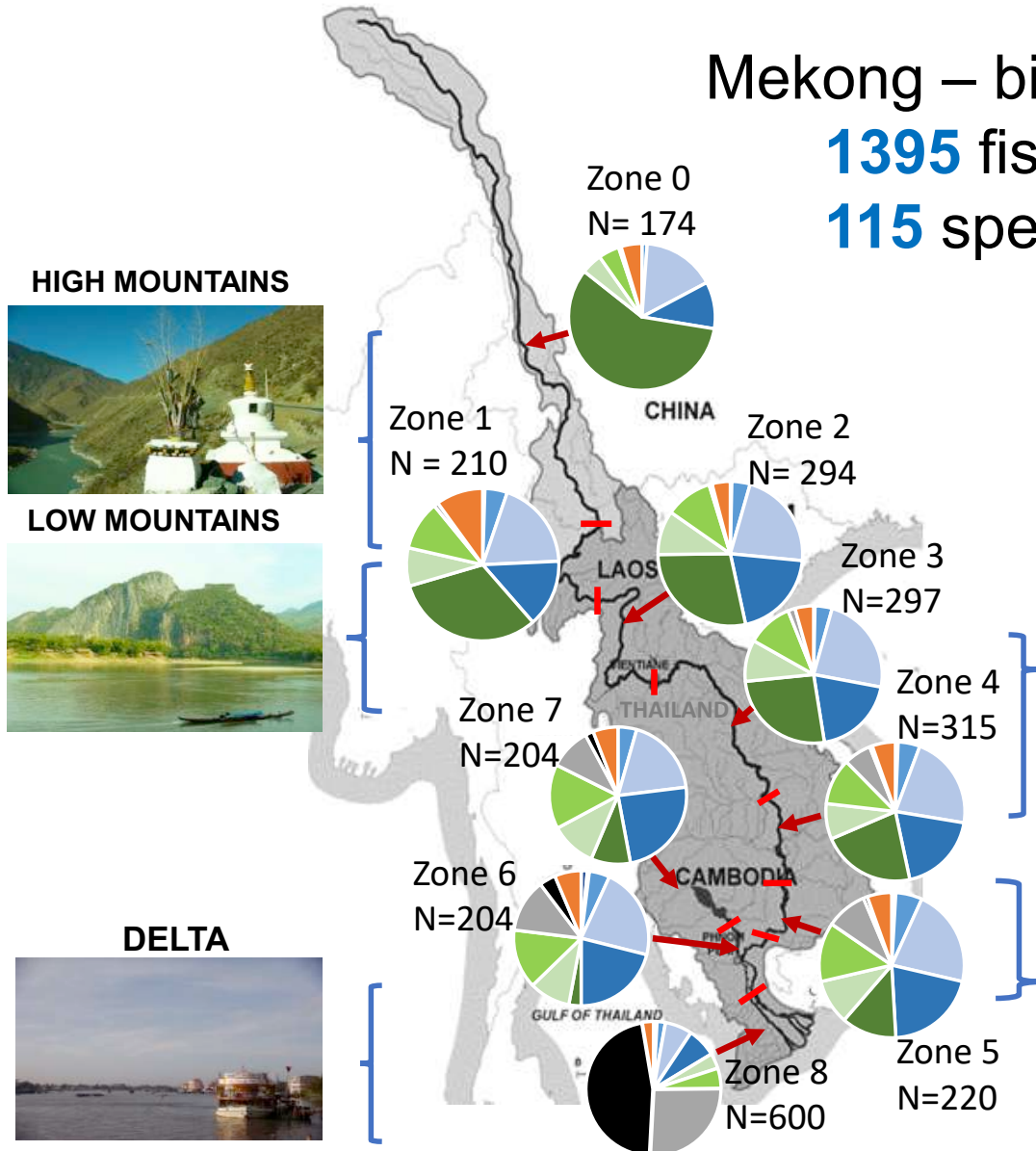
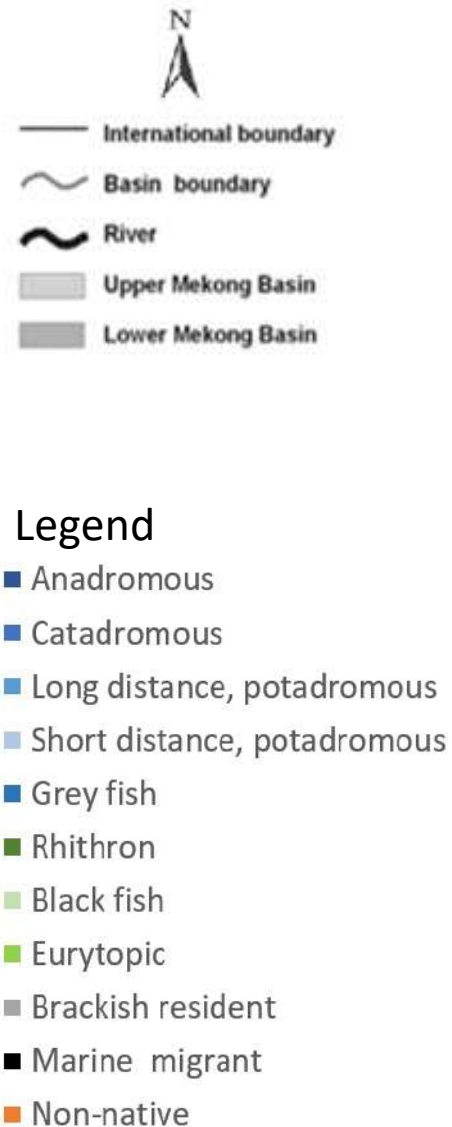
- Greater links to ecological perspectives of fish and fisheries to help governments/developers
- Outline of risks to fish and fisheries from HPP developments
- Updating specific guidance on passage design – upstream and downstream passage (addressed in separate presentation)
- More guidance on alternative mitigation options
- Better guidance on monitoring during all phases of development
- Transboundary and cumulative impacts addressed elsewhere in PDG

Section 6.2 & 6.3 – Ecological perspectives

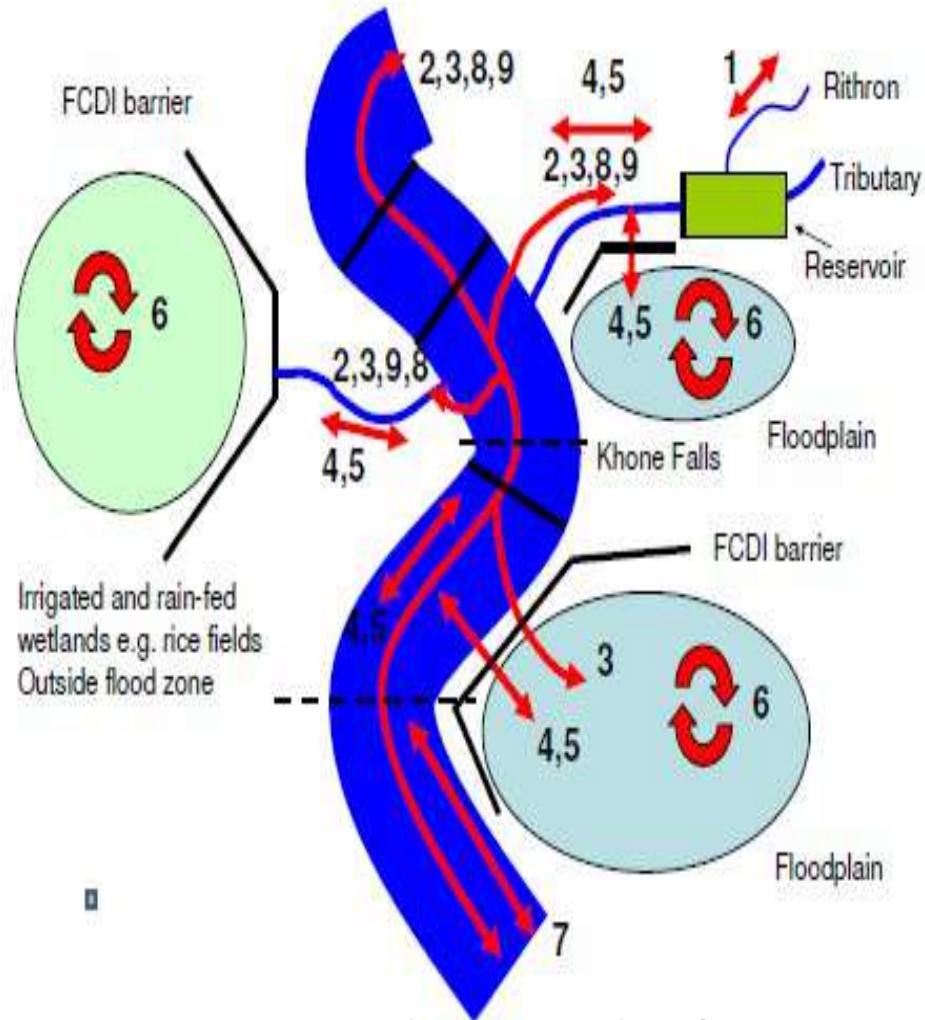
- Great links to ecological perspectives of fish and fisheries to help governments/developers
 - Habitats, ecology and fisheries
 - Clearer overview of migration patterns and transboundary links
 - Links to fish guild approach including species examples and risks of hydropower
 - Hydrology (flow or discharge)
 - Hydraulics (e.g. water velocity in impoundment)



Fish species diversity in the Mekong River

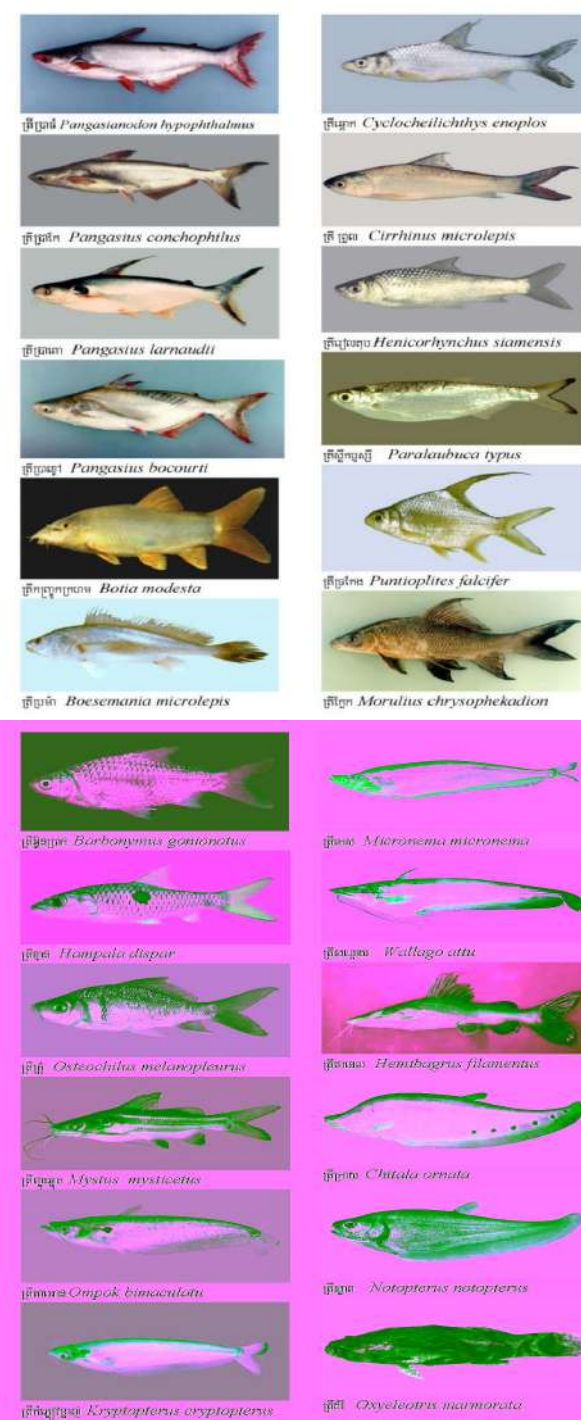


Fish Guild structure



Use MRC Fish species list for categorization and explanation
Council Study:MRC 2015, 2017)

- (1) Rithron resident;
- (2) Migratory main channel (& tributaries) resident guild- **long-distance whitefish**
- (3) Migratory main channel (& tributaries) spawner guild- **short distance whitefish**
- (4) Floodplain spawner guild- **Greyfish;**
- (5) Generalist guild;
- (6) Floodplain resident guild- **Blackfish;**
- (7) Estuarine amphidromous guild;
- (8) Anadromous guild;
- (9) Catadromous guild;
- (10) Marine visitor guild (enter estuaries opportunistically)
- (11) **Non natives**

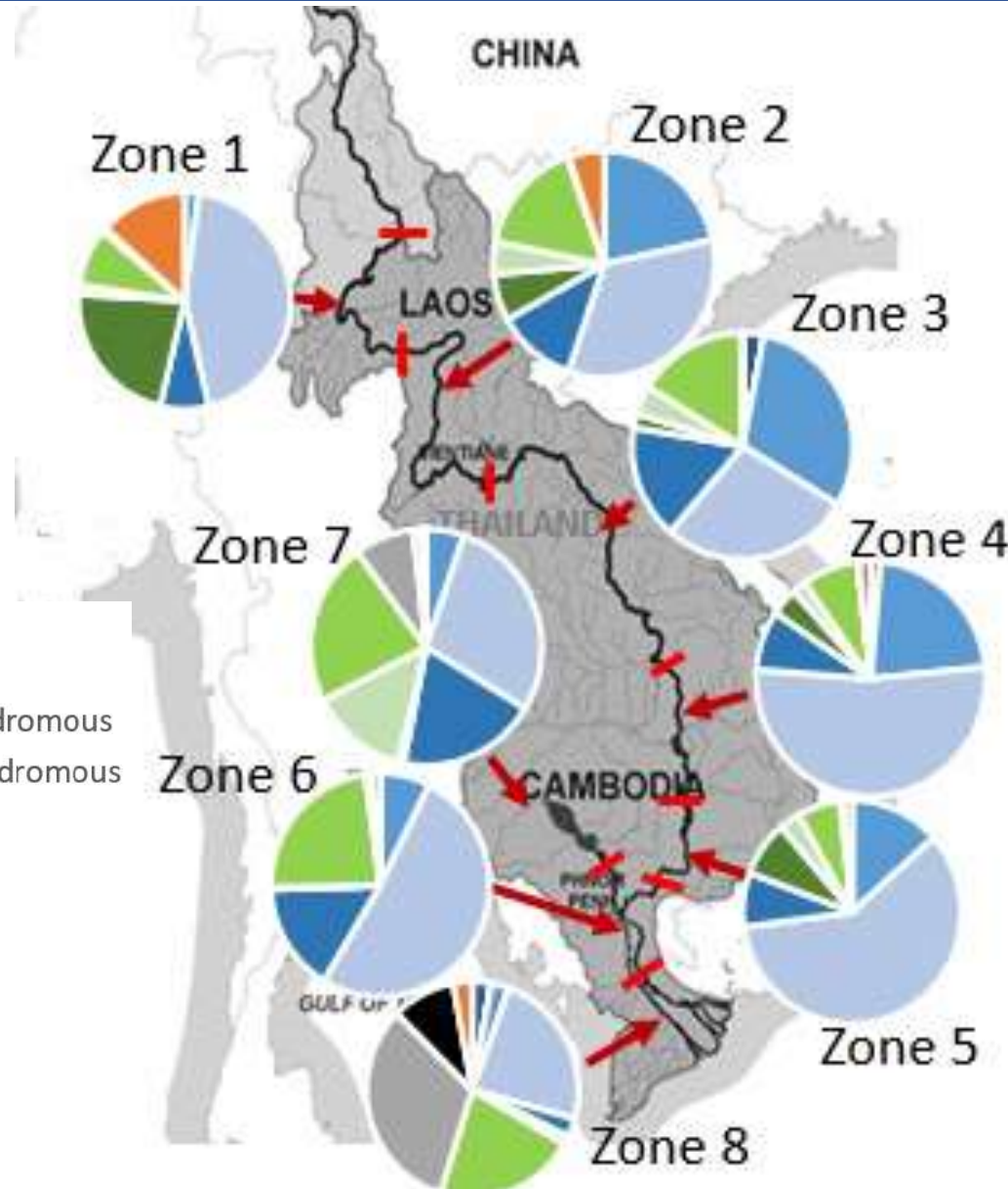


Fisheries of the Lower Mekong Basin



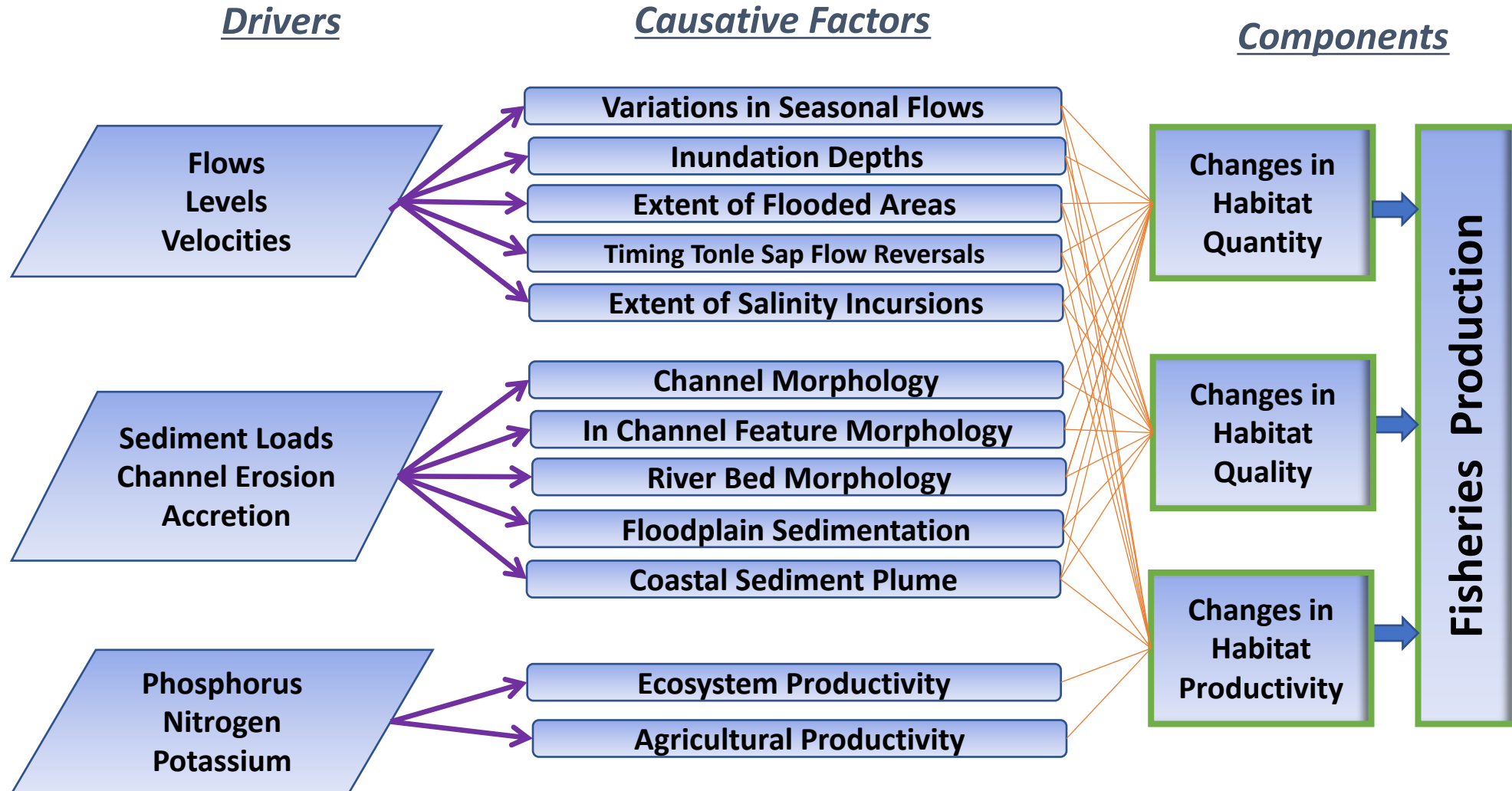
- ⇒ 200+ fish species in catch ; 30+ of high commercial importance
- ⇒ Catch estimated between 1.5-1.7 million tonnes
- ⇒ Total market value **US\$7.0 billion** per year
- ⇒ Per capita consumption ~46 kg/cap/year
- ⇒ **> 50% of total animal protein intake** in LMB from fish (world intake **16%**)
- ⇒ **Fish production dependent on fish migration** (all seasons of year) and **extent of flooding**

Mekong Fisheries catch by guilds

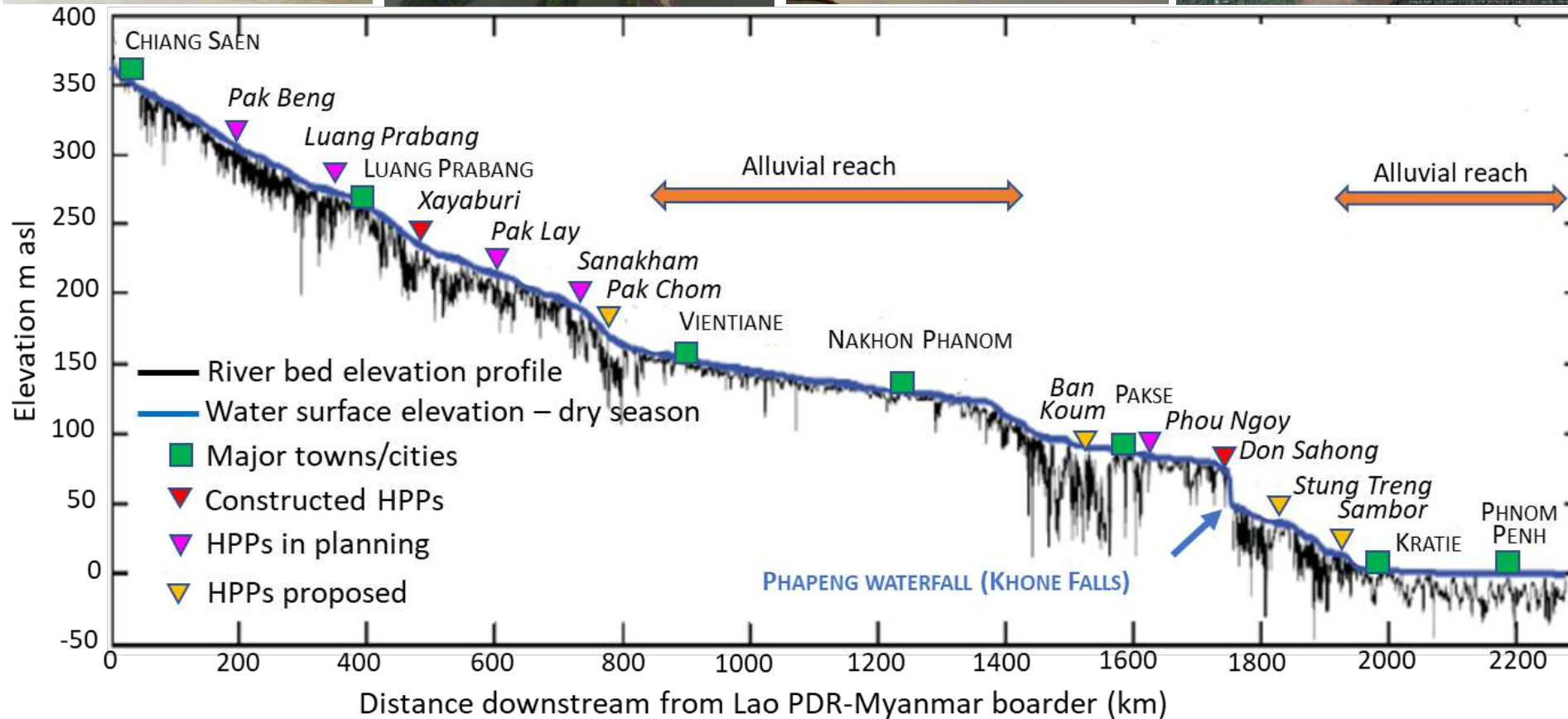


- ⇒ Catch dominated by potadromous migratory whitefish in all regions,
- ⇒ Rhithron species important in Zones 1 & 2
- ⇒ Grey fish important in alluvial floodplain areas
- ⇒ Brackish resident and marine visitors important in Zone 8
- ⇒ **Fish production dependent on fish migration (all seasons of year) and extent of flooding**

Drivers of fisheries in the Mekong

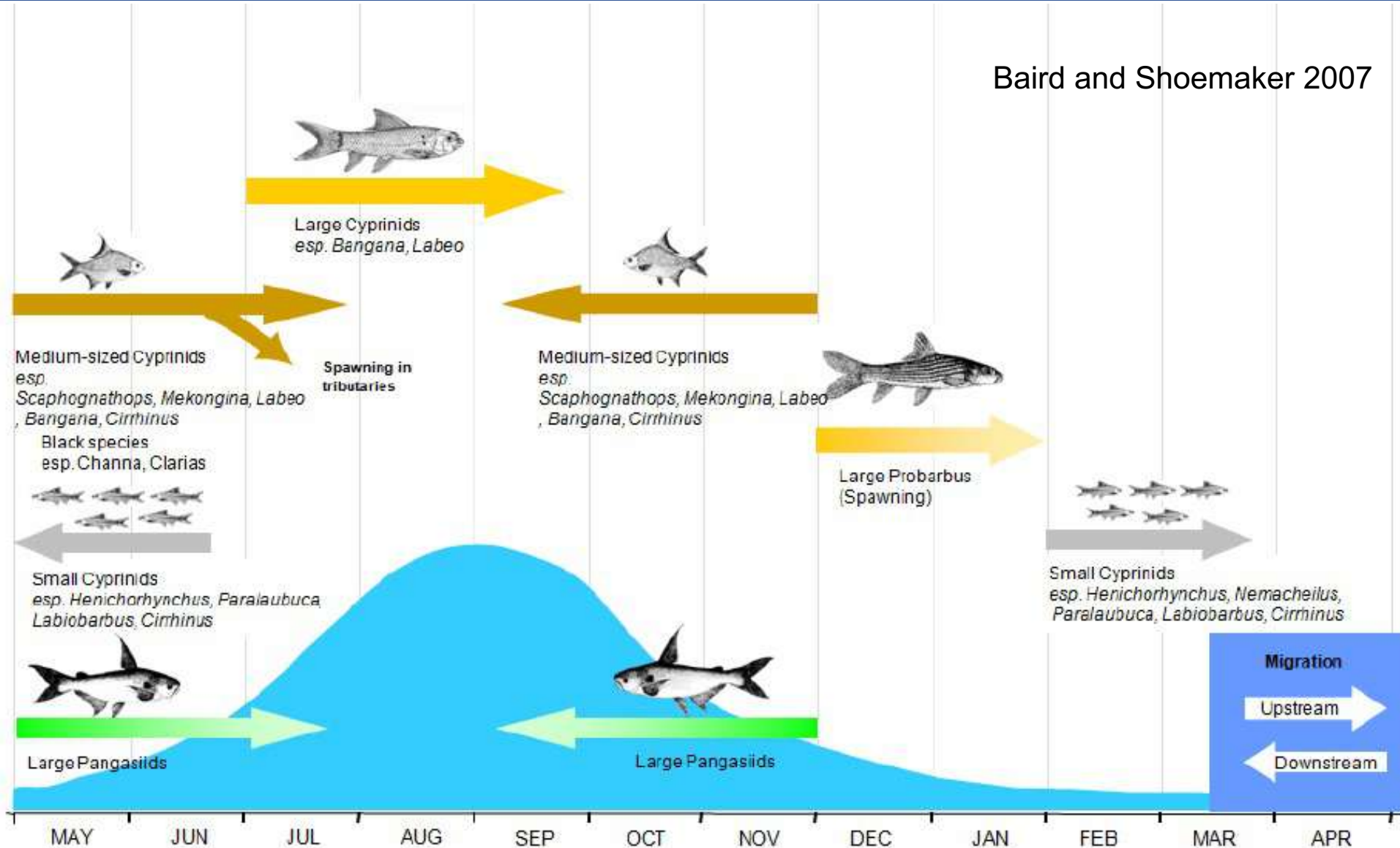


Topographical characteristic driving fisheries

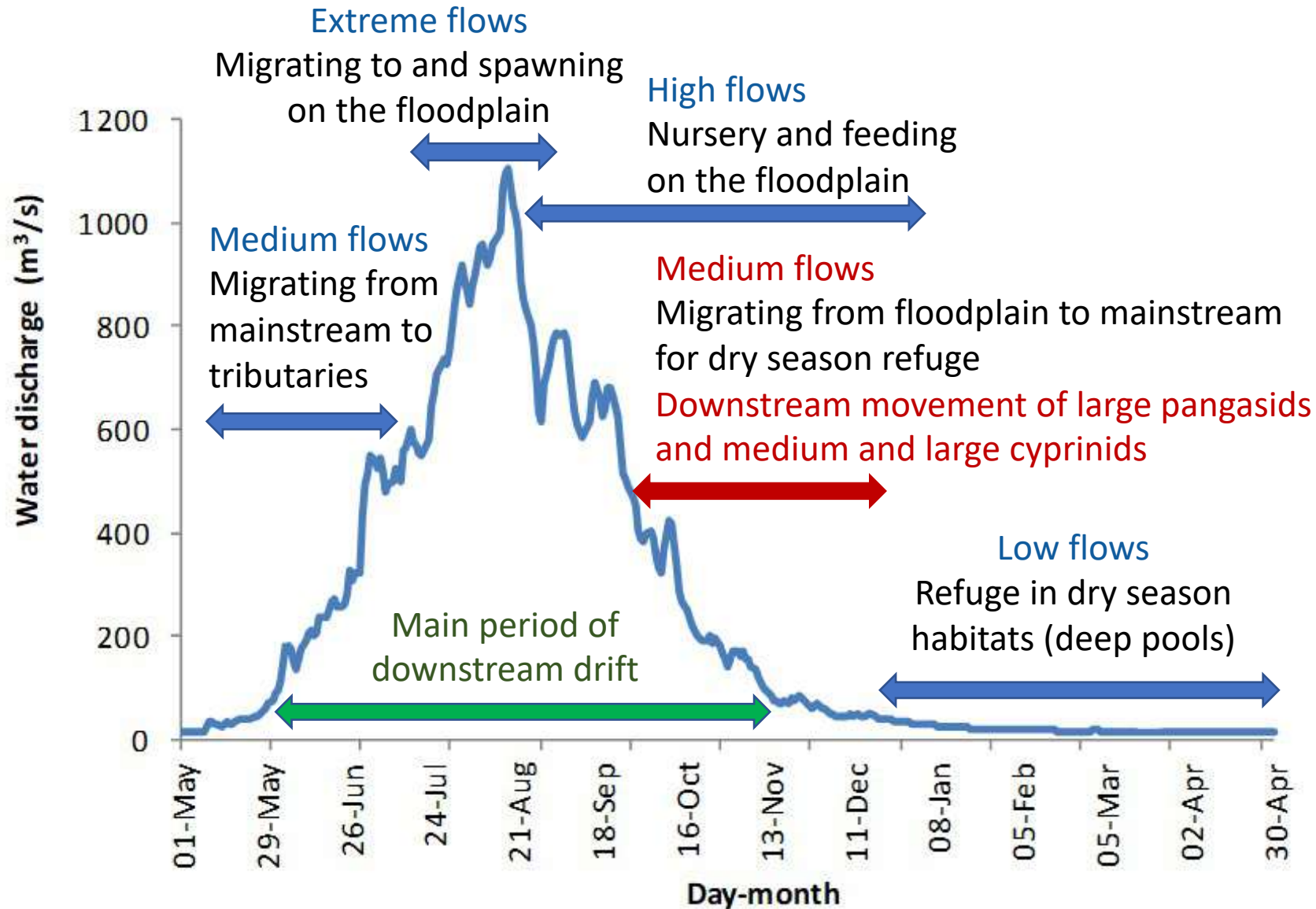


Spawning migrations (all year round)

Baird and Shoemaker 2007



Linking fisheries and the hydrological cycle

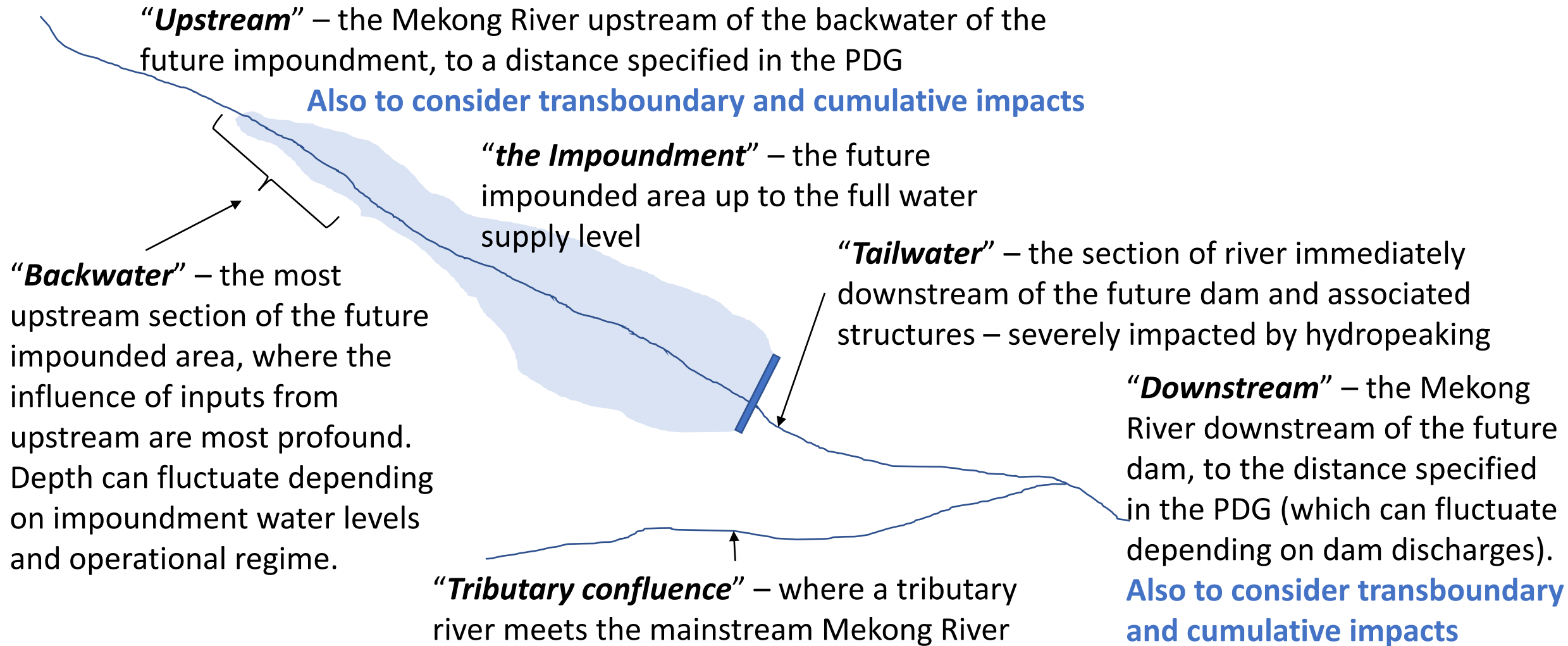


Section 6.2 : Risks (176-185)

- Major impacts on fish populations likely, including loss of some species and major declines in fisheries, with impacts on food security, nutrition, livelihoods, biodiversity and ecosystem resilience.
- Risks are from:
 - **Direct barrier effects on fish and fisheries**
 - **Mortality at hydropower reservoirs**
 - **Upstream impacts of dam on fish and fisheries**
 - **Downstream impacts on fish and fisheries**
 - **Transboundary impacts**

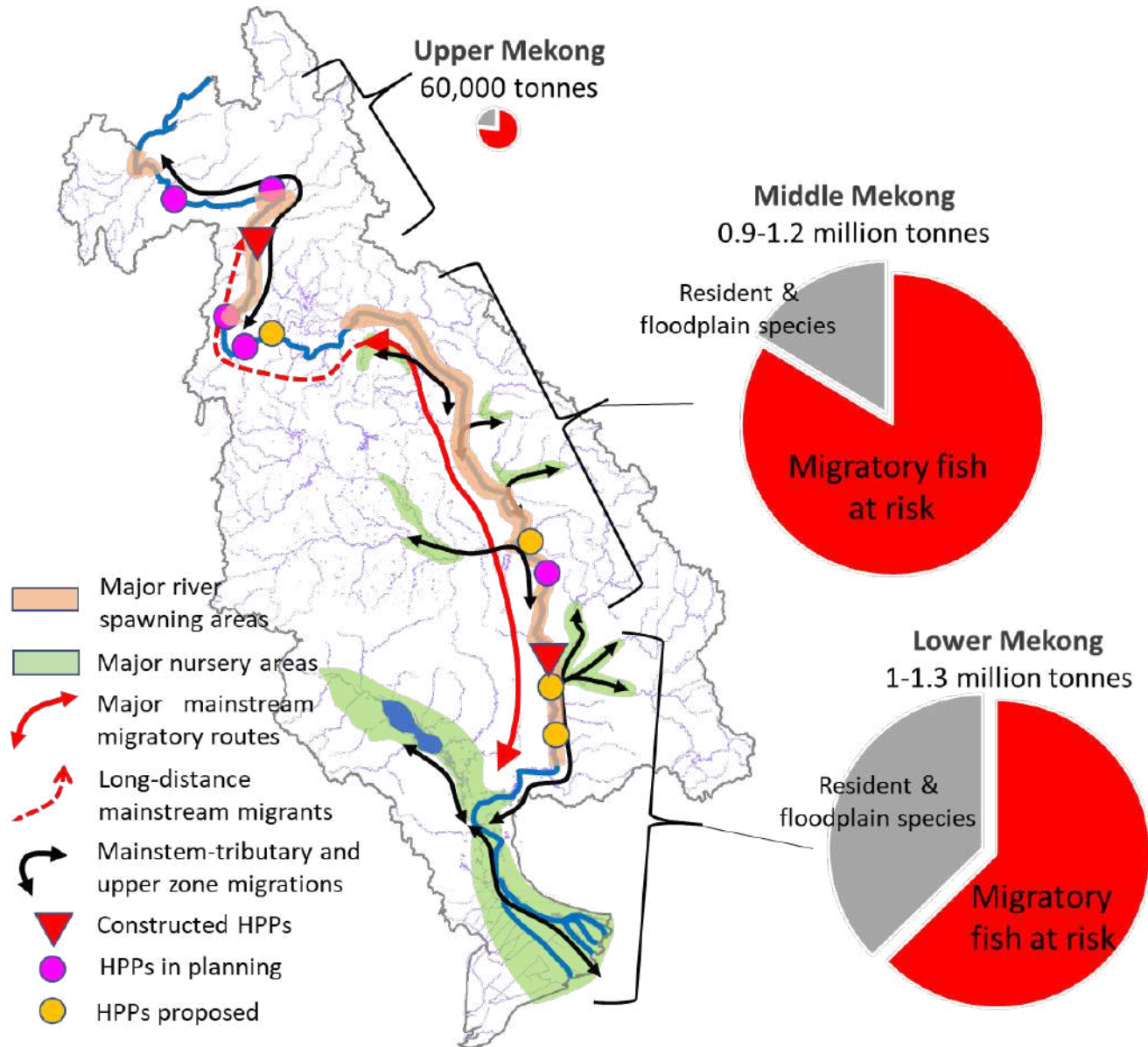


Section 6.2: Risks



Main risks: Barrier effects; mortality in turbines; transformation of upstream to lake; downstream flow regulation

Fish and fisheries at risk from mainstem hydropower



- ⇒ Many species at risk from loss of habitat (flooding) or disruption of migratory pathways
- ⇒ Some species susceptible to extirpation (locally and globally)
- ⇒ Considerable proportion (40-50%) of capture fisheries lost if all mainstem dams constructed (Council Study)
(Note CS does not account for tributary dams)
- ⇒ Alteration of fish community composition and proliferation of non-native species

Direct barrier effects on fish and fisheries

Disruption to longitudinal connectivity

- Interrupts upstream migratory pathways
 - Hydraulic conditions around dam act as barrier to migration
 - Downstream depleted reach barrier to migration
- Disruption of downstream passage – adults, eggs and larval stages
- Reduction in species diversity and abundance, particularly long-distance migrating species, e.g. catfishes
- Potential loss of access to spawning grounds

Problems due to:

- Limited upstream passage over dams
- Limited downstream passage over dams, especially for larval stages
- Reduced flow through impoundment
- Passage through turbines



Mortality at hydropower dams

Mechanical damage in turbines & sluices

- Injury to and mortality of eggs, larvae, juveniles and adult fish that pass through the turbines
- Cause: extreme and rapid pressure fluctuations rupture swim bladders, turbulence, grinding, strike by the runner blades, cavitation and shear stress
- Mortality rates vary depending on turbine type [up to 100%]
Misconception mortality low, even in “fish friendly” turbines
- Differential mortality depending on fish size, shape and behaviour. **Note - mortality may be delayed**



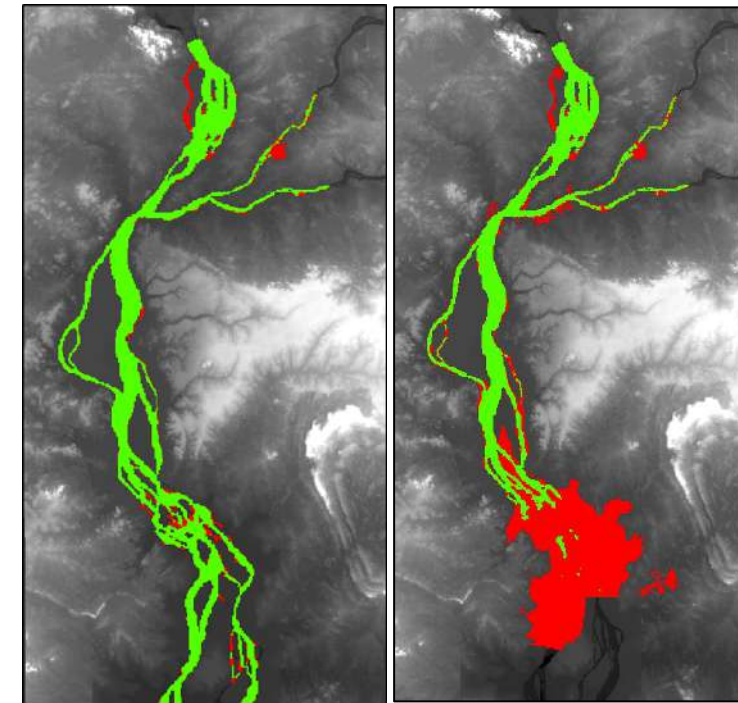
Upstream impacts of HPP on fish and fisheries

- Rapid change from riverine to lacustrine environment
- Flooding of key spawning habitat for many species and drowning of habitat for riverine species
- Reduced flow through impoundment acts as egg and larval sink – minimum threshold velocity > 0.3 m/s
- Reservoir later dominated by lacustrine species and non-native can exploit new habitat
- Fisheries productivity related to drawdown and clearance of impounded area – but rarely achieves pre-impoundment levels

Sambor - Q17000

No Dam

45.5 m dam

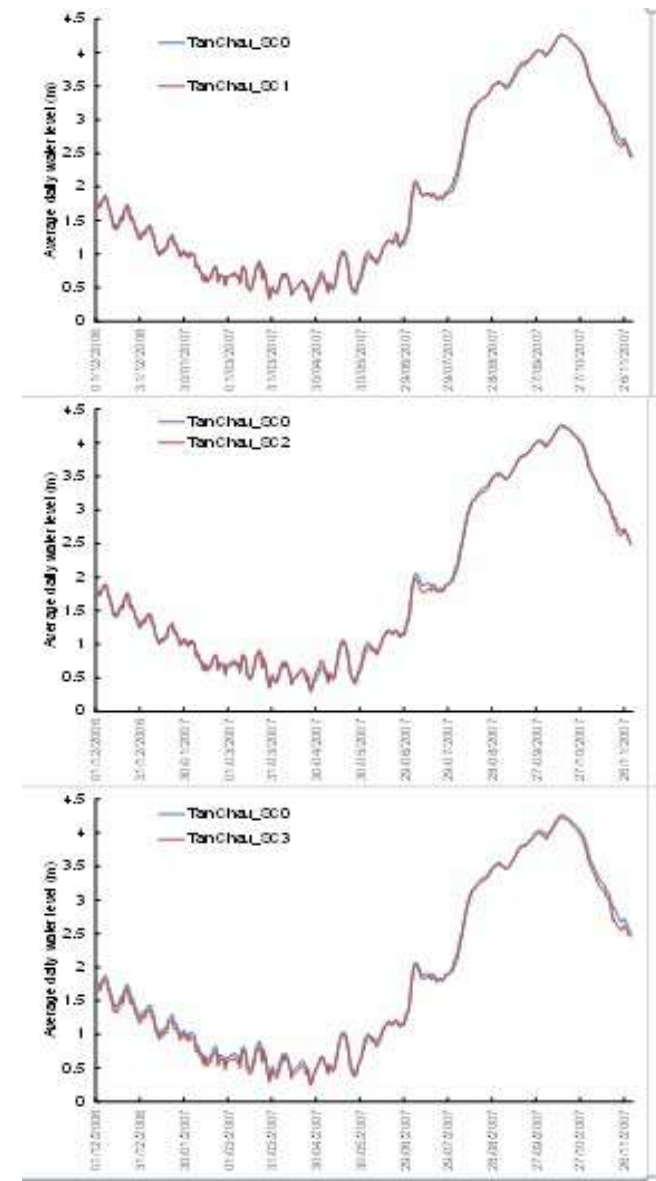


 $\geq$ threshold
velocity
of 0.3 m/s

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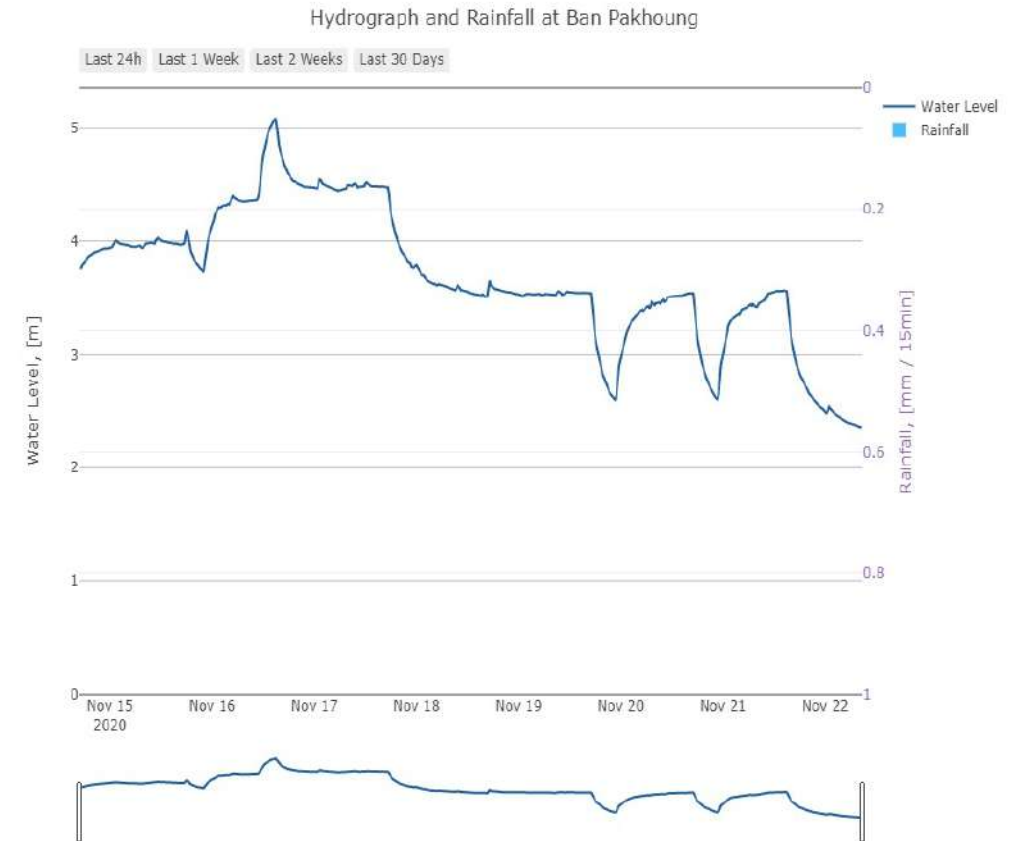
Downstream impacts of HPP on fish and fisheries

- Run of river HPPs - flows similar to current situation = marginal loss of fish production
- Possible impact of onset and offset and duration of flood pulse on fisheries
- No significant changes in wetted areas of different habitat types



Downstream impacts of HPP on fish and fisheries

- Run of river HPPs - flows similar to current situation = marginal loss of fish production
- Possible impact of onset and offset and duration of flood pulse on fisheries
- No significant changes in wetted areas of different habitat types
- Biggest potential impact is hydropeaking: Impact extends considerable distance downstream
note developer's argue RoR with no peaking
- 70% reduction in sediment delivery to delta

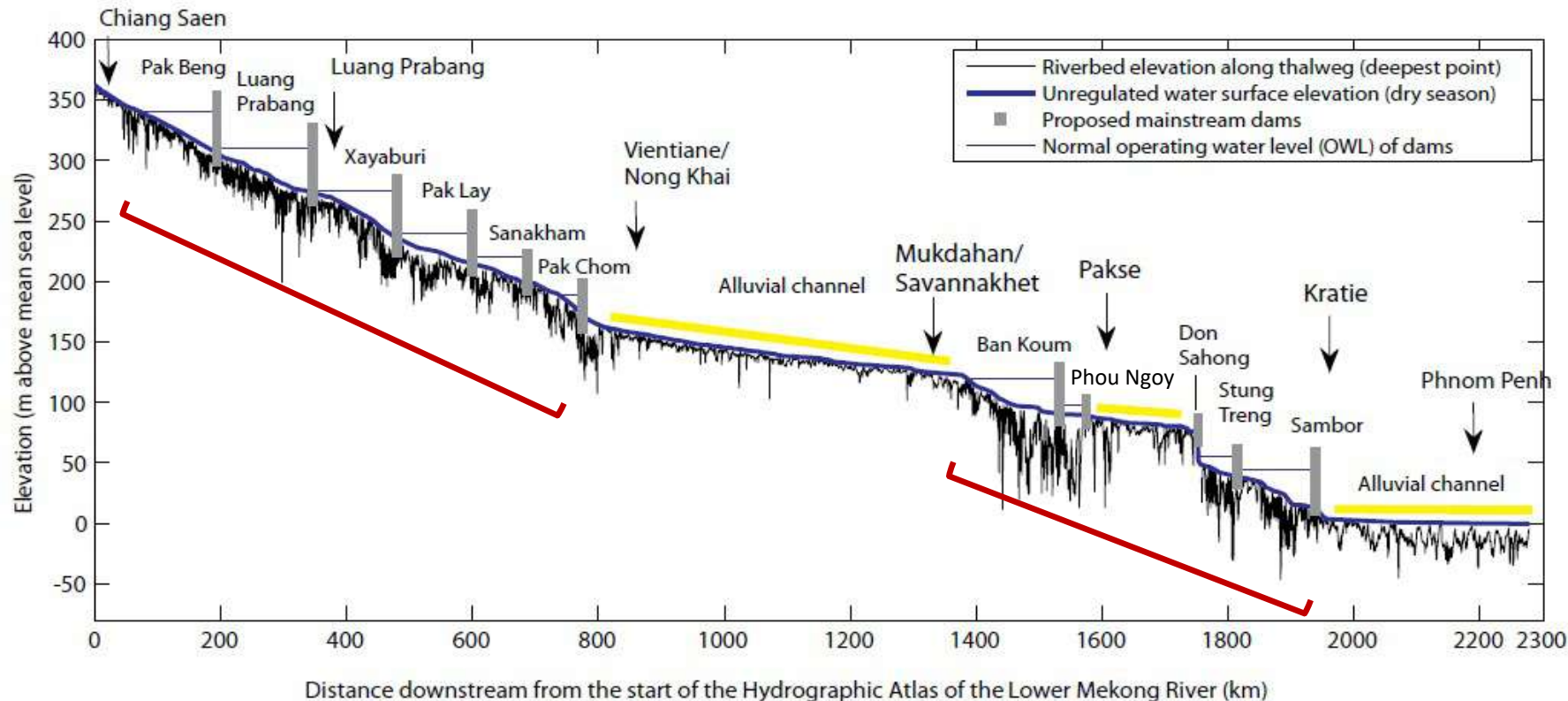


Impact of dams on livelihoods (reservoir and downstream)

Reservoir	Downstream
• Changing life style and occupation in resettle villages	• Changing life style and occupation
• Loss of agriculture land and forest plantations	• Loss of river bank gardens and riparian vegetation
• Limited access to agriculture land and fishing areas both in wet and dry season	• Difficult to catch fish in the dry season
• Unfamiliar with the new fishing equipment and methods	• Loss of fishing gears due to strong water flow
• Loss of cultural identities	• Many people have to go outside villages for cash and food
	• Cannot use water for drinking and washing



Cumulative impacts

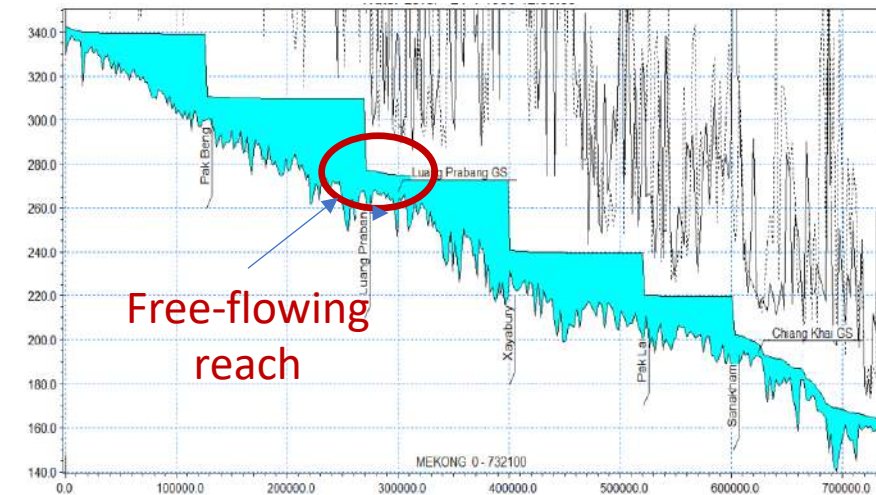


Upper and lower cascades transform river into series of impoundments

Cumulative impact of multiple consecutive barriers

- Upper cascade: only 25 km of free-flowing river above headwaters of Xayaburi remain
- Complete drowning out of deep pools
- Loss of critical spawning and nursery habitats for migratory and rhithron fish species
- Disconnection of tributaries , but also tributary dams

Cumulative impacts

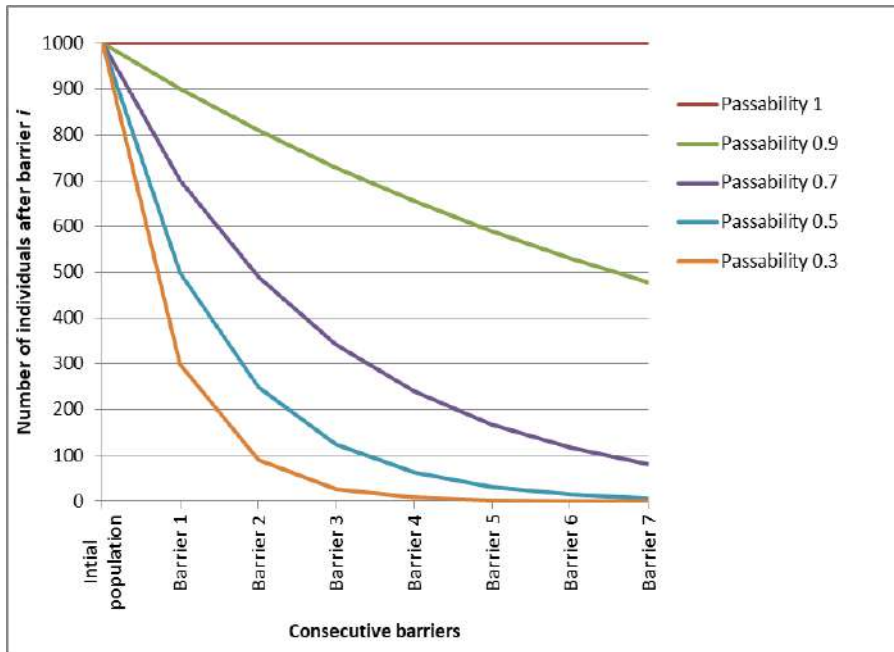


- Longitudinal profile of the upper Lao cascade of HPPs.
- Upper blue polygon illustrates the water surface after construction of all five dams
 - Lower outline of blue polygon illustrates thalweg and distribution of deep pools
- (Source: ISH 306).

Loss of critical spawning habitat questions value of installing fish passage facilities

Endorsed by impact of cumulative impact of multiple consecutive barriers on fish passability rate.

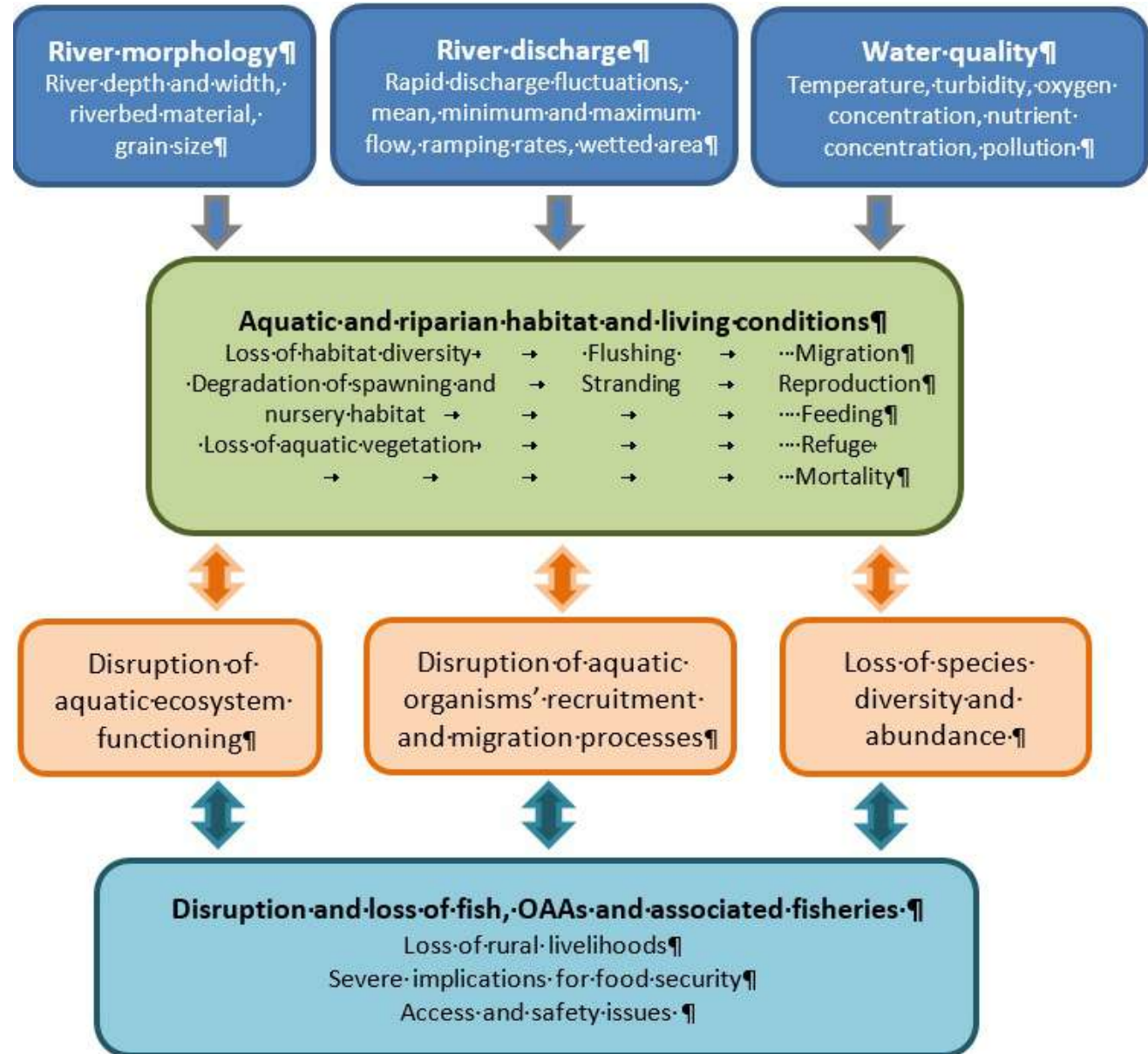
Note graphic does not account for loss of downstream migration and mortality



Transboundary impacts

Potential effects of rapid flow and water level fluctuations and reduction of sediment on aquatic ecosystem functioning and implications for ecosystem services from fisheries and aquatic biota

- Disruption of flows and fish migration triggers
- Reduction in nutrient delivery and primary productivity
- Collapse in fisheries and loss of potadromous white fishes



Section 6.4 – Specific Design Guidance (191-240)

- **Specific Design Guidance** sub-section
 - Divided into: 1) Habitats, and 2) Fish Passage
 - ***Habitats section*** (#194-198) aimed at **planning** (e.g. site selection, dam height) as well as **mitigation**
 - Examples:
 - a cascade of dams (back to back pools) will remove spawning habitat of many riverine species
 - Leaving *flowing water* (10-200 km) between dams could preserve some short-distance migratory fish



Section 6.4 – Specific Design Guidance – Fish Passage(191-240)

Fish Passage:

1. ***Definition of 95% passage*** (#199-202)
2. ***Biological and hydrological criteria for design*** (#203-205)
3. ***Fishpass Design*** – upstream and downstream criteria (#206-235)
4. ***Fish Passage Operation*** (#236-238)

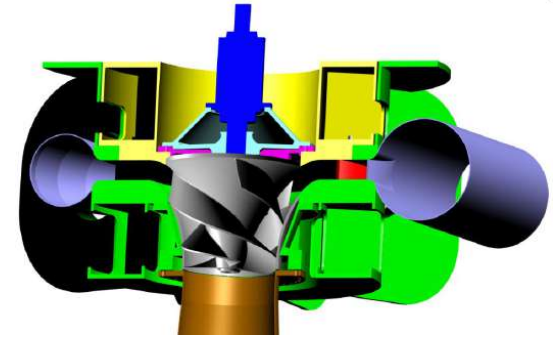
See separate presentation on fish passage



Section 6.4 –Design Guidance – mitigation measures (#240)

Mitigation measures to ameliorate likely impacts focus on:

- Location of dam and operational strategies including intake and outfall locations
- fish passage facilities – **upstream and downstream**
- *'Friendly'* turbine design (recognition that only effective way to improve survival is to direct the fish away from the intakes – screens and bypass channels)
- Replacement of lost fisheries – **aquaculture and stocking**



Nam Ngum, Lao PDR

Summary of issues over typical measures

- ⇒ Technical fish passes not optimal design for Mekong fishes
- ⇒ Design ineffective for diversity of fishes and small fishes
- ⇒ Reservoirs acts as hydrodynamic barrier



Summary of issues over typical measures – fish passage

- ⇒ Technical fish passes not optimal design for Mekong fishes
- ⇒ Design ineffective for diversity of fishes and small fishes
- ⇒ Reservoirs acts as hydrodynamic barrier

Fish passes/fishways effectiveness depends on:

- Fish species in question, water head, design & size of river
- Permanently functional – **allocation of flows for bypass channels**
- Positioning of the entrance
- Provision of sufficient attraction flows around in-take and outfall locations,
- Adapted to the swimming capacities of the fish

PROBLEM: Downstream migration, especially larval stages



Summary of issues over typical measures – downstream passage

- ⇒ Technical fish passes not optimal design for Mekong fishes
- ⇒ Design ineffective for diversity of fishes and small fishes
- ⇒ Reservoirs acts as hydrodynamic barrier
- ⇒ No evidence to support turbines being fish-friendly
- ⇒ Downstream facilities inappropriate - spillway will cause injuries and mortalities of fish

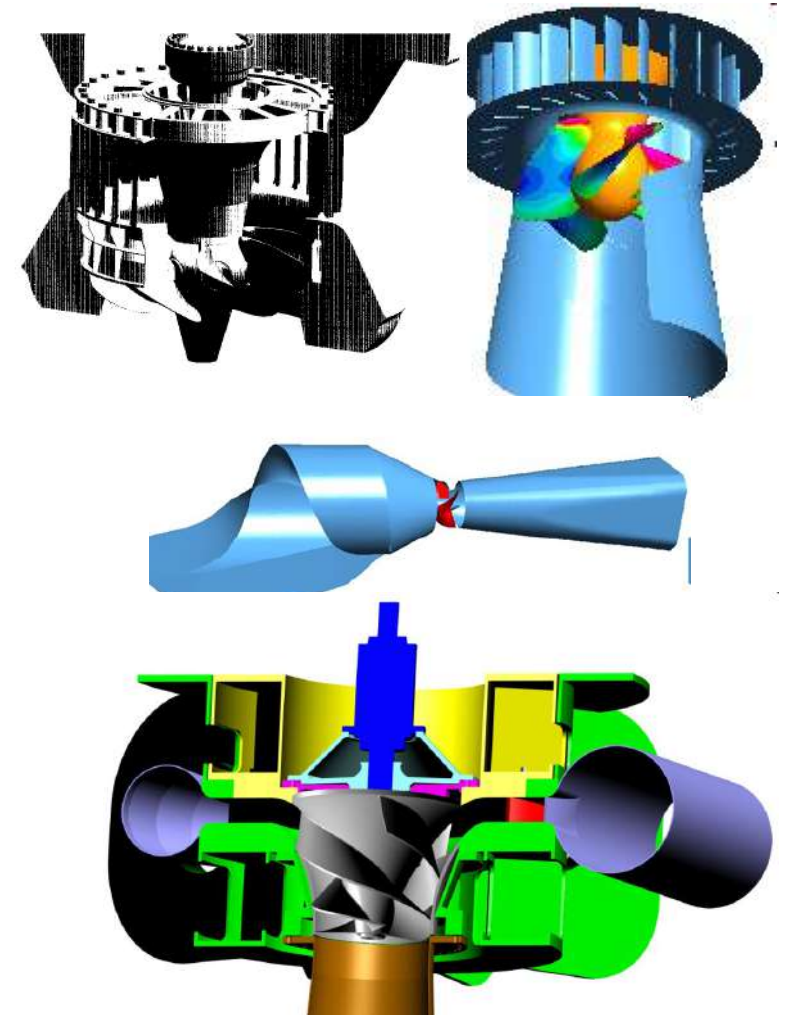


Summary of issues over typical measures – Turbine design

Various turbine designs aimed at reducing impact

- Improved turbine design resulted in **only marginal reductions** in fish mortality,
- Concerns remain regarding leading edge strike, cavitation, pressure effects

Recognition that only effective way to improve survival is to direct the fish away from the intakes – screens and bypass channels



Summary of issues over typical measures – aquaculture & stocking

- ⇒ Technical fish passes not optimal design for Mekong fishes
- ⇒ Design ineffective for diversity of fishes and small fishes
- ⇒ Reservoirs acts as hydrodynamic barrier
- ⇒ No evidence to support turbines being fish-friendly
- ⇒ Downstream facilities inappropriate - spillway will cause injuries & mortality of fish
- ⇒ Aquaculture and stocking not a replacement for lost fisheries yield but supplementation

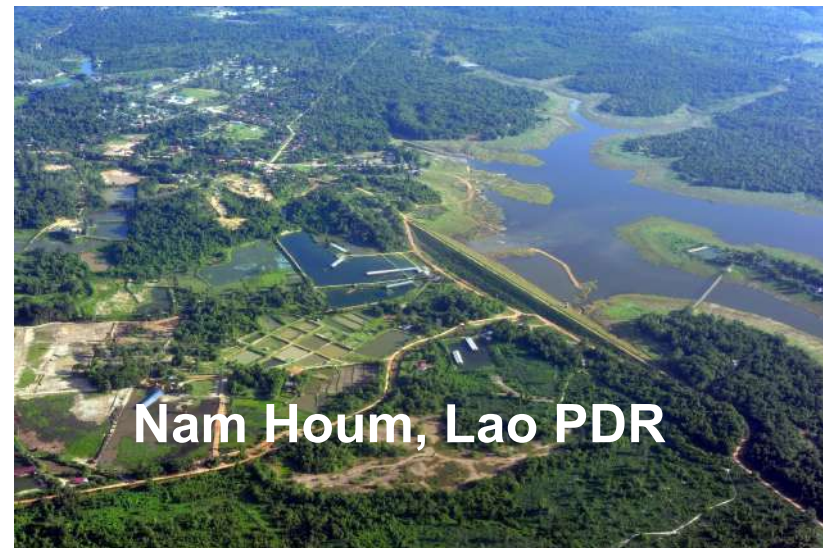


Mitigation measures – aquaculture and stocking

Aquaculture not compensation for lost fish productivity

- Local fishers no experience in fish farming
- No capital to invest in infrastructure (opens opportunity for entrepreneurs)
- Recurrent costs of seed and feeding
- Introduction of alien species (tilapias and carps)

Stocking does not replace lost fish productivity



Section 6.4 – Design Guidance: alternative mitigation measures

- PDG acknowledges that fish passage may not maintain fish populations (e.g. in a cascade of dams where *flowing water* spawning habitats are lost).
- Options for mitigation generally related to :

- Aquaculture and stocking of fisheries

But should consider alternatives

- Environmental flows

- Offsetting: e.g. fishways on wetlands to reconnect nursery areas with river habitats

- Alternative livelihoods strategies



Section 6.5 – Monitoring (241-248)

- PDG contains details of monitoring objectives and methods for governments/developers
- Monitoring should provide baseline status before PNPCA submitted
- **Focus on informing decisions: for design, operations, mitigation and compensation**
- Outputs of monitoring should be made publicly available, to ensure transparency
- Monitoring programme should be funded by the developer
- Fishways should be modified if necessary based on monitoring feedback

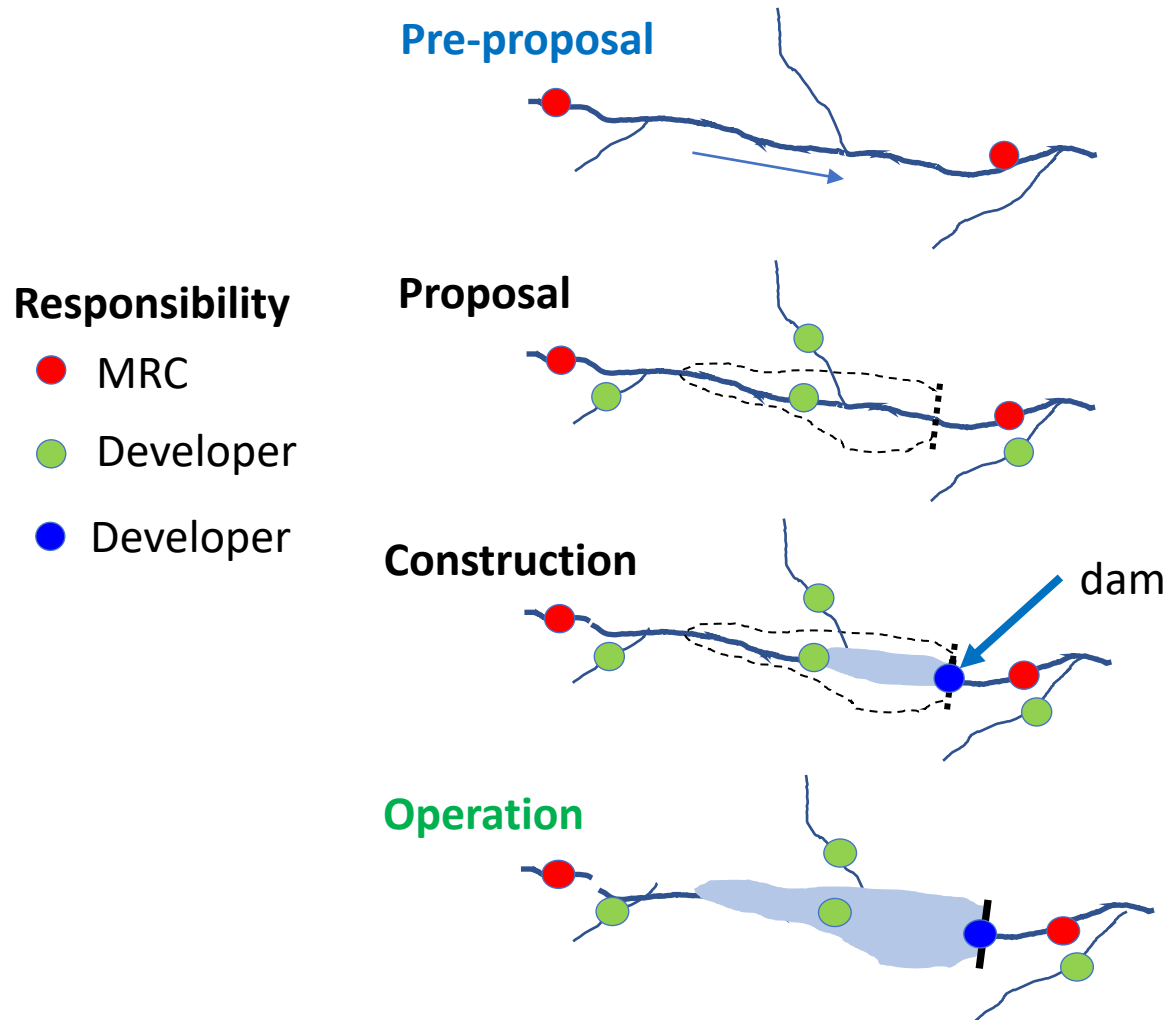
Section 6.5 – Monitoring methodologies

Monitoring activities should include:

- Fish catch monitoring assessing ecology, distribution and diversity
- Fish catch monitoring assessing catch composition and CPUE
- Quantify economically important fisheries
- Household and market surveys
- Independent studies to assess efficacy of fish pass design
 - i) assessing fish approaching the dam/fishpass and locating the entrance - *attraction efficiency*;
 - ii) assessing fish passing through the dam and impoundment, via fishways spillways or turbines - *passage efficiency*.

Section 6.5 – Monitoring methodologies – JEM standard

JEM monitoring strategy in relation to HPPs



Pre project screening of proposal to establish baseline conditions

Use MRC FADM and agency data plus new developer data – **multi-year studies**

Upstream/downstream river monitoring.
Number of downstream sites depends on the nature of the river downstream (e.g. size and location of tributaries).

Frequency of sampling **follows JEM protocols**

Upstream/downstream river monitoring same as proposal/construction phases following JEM.
Tracking and tagging studies for fish passage

Section 6.5 – Monitoring methodologies – JEM methods

Method	Outputs
Artisanal fishery catches	Species presence and absence data, relative abundance (CPUE), size distribution of fish in catch
Gill nets	Species presence and absence, and relative abundance (CPUE): Length based data
Household and market surveys	Catch diversity, importance to food security and livelihoods
Egg and larval surveys	Conical nets to determine distribution, timing and relative abundance of eggs & larvae
Tagging and tracking	Enables fish migration and movement patterns Assessment of proportion of fish passing physical obstructions Enable assessment of fish passage efficiency
Seine nets for adults Micromesh nets for juveniles and benthic species	Species presence and absence, and relative abundance (CPUE): Length based data can be collated Micromesh nets suitable for juveniles and benthic species
Electric fishing	Enables fishing in difficult habitats not accessible to other gears, rocky shores, submerged woodland and vegetation Can give general biomass estimates
Sonar imagery (Didson/Aris)	Relative abundance of fish numbers passing image zone

Lessons learnt from previous PNPAs- General

- Considerable information provided by the developer in multiple volumes
 - **Information fragmented**, repetitive and inconsistent
 - **Information often outdated** and inappropriate to assess the potential impact of designated HPP on fisheries and aquatic ecology, including socioeconomic aspects.
- Documents submitted provide **limited information** to support the prior consultation process with respect to Fish Passage and Fisheries Ecology
- Information **inadequate to establish baseline conditions** against which to measure potential impacts on fisheries and design appropriate mitigation measures

Lessons learnt from previous PNPAs- Fishery monitoring

- Quality of field surveys to provide baseline information for PC and identifying mitigation measures generally weak and much is out of date (need to be in last 3 years)
- Intensity, coverage and methods used **do not follow FADM or more recent JEM guidance**
 - Need to provide information on **fish abundance and diversity, migration guilds** of long-lived and short-lived species, the **scale of fisheries** in the **affected region**
- Developers propose **monitoring programmes** for fish and fisheries during the construction and operational phases but **details of the methodologies generally lacking and budgets modest at best.**

Lessons learnt from previous PNPAs- Fish passage

- Fish passage solutions, as submitted, usually will **not provide sufficient upstream or downstream migration** to sustain migratory fish populations; and these will severely decline.
- **Details of fishway design basic** and do not provide detailed hydraulic modelling
- Very **limited information on downstream fish passage**, especially larval and juvenile life stages
- **Monitoring programme** for the efficacy of fish passage usually not provided
- **Costs** for the construction not provided, and **no contingency funds** for fishway modification are suggested if remedial action required.

Lessons learnt from previous PNPCAs- impact assessment

- **Cumulative and transboundary fisheries mostly related to immediate downstream reach** – developers consider risk and impact assessment outside their remit
- **Disruption to fish migration and reproductive capacity**, and reduction in sediments and associated nutrient dynamics, on **fisheries downstream** need to be evaluated
- Details of **quantitative fisheries impact assessment at regional scale** need to be provided to design effective fisheries mitigation measures
- **Exploitation of other aquatic animals (OAAs)** not considered in environmental assessments
- **Data and information from other studies and prior consultation processes** should be used to further inform the monitoring, as well as the designs of the fish passage facilities.



Thank you

