



BDP2: FISHERIES ASSESSMENT METHODOLOGY

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Purpose

- Overview of proposed methodology to assess likely outcomes of the development scenarios on future yields of fish and OAA in the LMB.





Resource Scope

- Wild capture fish and...
- OAA (e.g. frogs, crabs, small shrimp).
- Excludes potential national development plans for the aquaculture sector (not included in development scenarios).
- But autonomous aquaculture development in reservoirs assumed.
- Excludes unplanned or unspecified mitigation measures (e.g. fish pass facilities in flood control embankments).



Spatial Scope

- **“All aquatic fish habitats where changes to yield would be expected as a result of the diminished access to these habitats or arising from changes to hydrological conditions within them due to development activities”.**



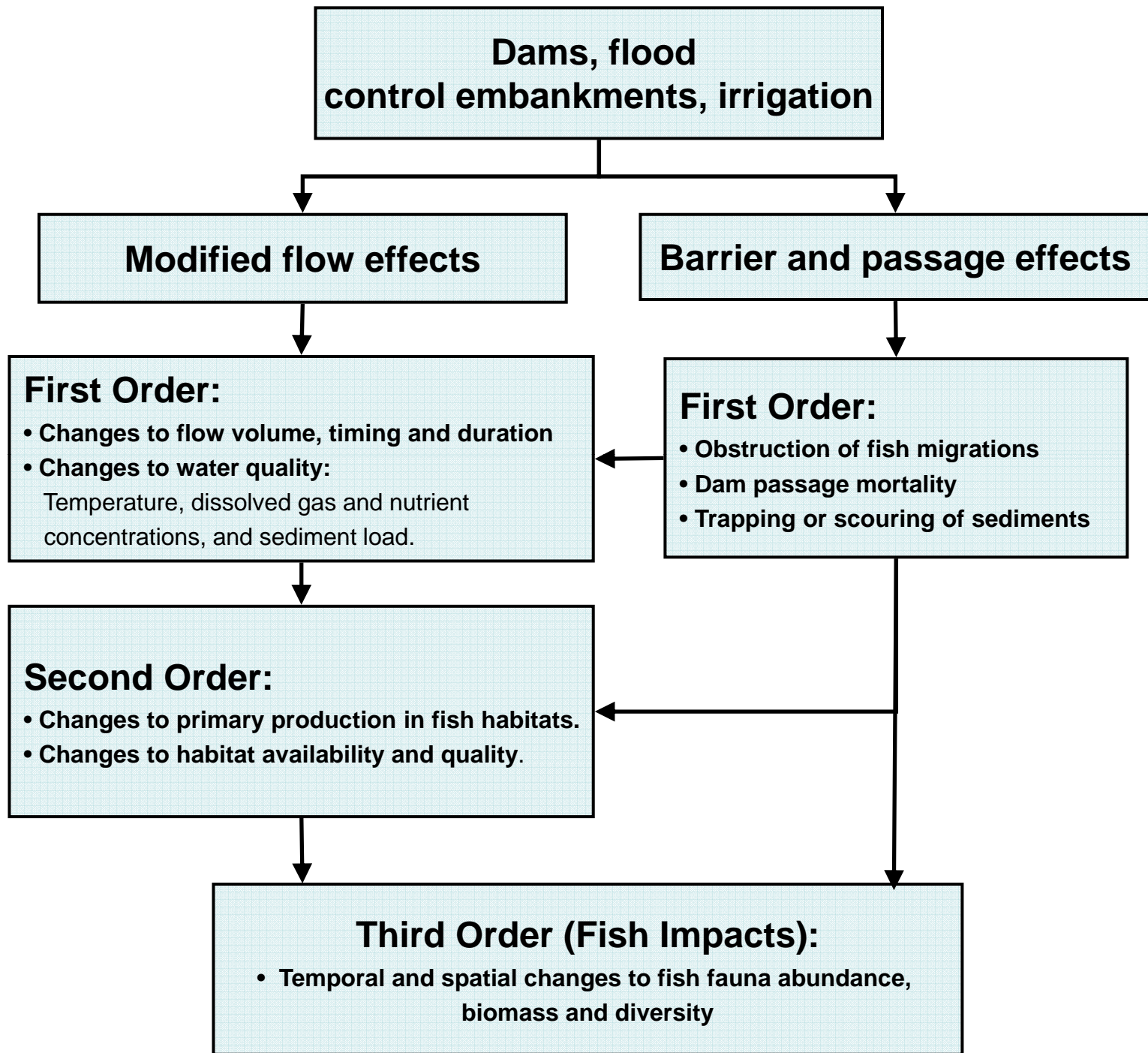
Development Scope

- **Three major development themes are included:**
 - 1. Hydropower**
 - 2. Irrigation (& other abstractions)**
 - 3. Flood Control (overlaps irrigation)**



Development Pressures

- **How do dams, flood control embankments and irrigation projects affect fish yields?**



Mainstream and Tributary Dam Impacts

 - Quantified impacts

Dams	1 st and 2 nd Order Impacts
Barrier and passage effects	Obstruction of fish migrations and passage mortality (if applicable).
	Interruption of downstream sediment transport.
	Formation of reservoirs in tributaries upstream of dams.
Modified flow effects: Upstream / reservoirs	Increased flooded area.
	Increased dry season water levels
	Decreased flow velocity.
	Increased sediment deposition due to low flow conditions.
	Rapid (short-term) fluctuations in water levels (hydropeaking)
	Stabilized water levels (no flood pulse).
	Vertical stratification of the water column.
	Increased water depth.
	Changes to water temperature.
Modified flow effects: Downstream	Diminished and delayed floodplain inundation
	Increased dry season water levels
	Diminished and delayed flows (discharge) in channel.
	Reduced sediment transport downstream.
	Rapid (short-term) fluctuations in water levels (hydropeaking).
	Changes to salinity in delta regions.
	Release of deep cold, nutrient-rich but often anoxic waters.
	Release of gas super-saturated water.

Flood Control Project Impacts

 - Quantified impacts

<p>Flood control schemes (FCDI Inside flood zone)</p>	<p>1st and 2nd Order Impacts</p>
<p>Barrier and passage effects</p>	<p>Obstruction of fish migrations between floodplain and main channel.</p>
	<p>Interruption of sediment transport to floodplains.</p>
	<p>Passage mortality via pumps for irrigation and flood control.</p>
<p>Modified flow effects:</p>	<p>Diminished and delayed flooding inside poldered areas</p>
	<p>Increases to river discharge as flow is constrained to main channel.</p>
	<p>Increased use of pesticides and fertilizers for HYV's of crops.</p>

Irrigation Project Impacts

 - Quantified impacts

Irrigation Projects (Outside of flood zone)	<p style="text-align: center;">1st and 2nd Order Impacts</p>
Barrier and passage effects	<p>Obstruction of fish migrations between project and river system.</p>
	<p>Passage mortality via pumps for irrigation.</p>
Modified flow effects:	<p>Increased area of 'ricefield landscape' i.e. small ponds, reservoirs, and surrounding ricefields forming the irrigation project.</p>
	<p>Downstream reductions to flow by irrigation abstractions or diversions from channels WITHIN the floodzone or connected to the river system.</p>
	<p>Increased use of pesticides and fertilizers</p>



Quantifiable Impacts

LOSSES:

1. Barrier impacts of dams and flood control embankments.
2. Flood modification impacts in the flood zone arising from water storage above dams and abstractions for irrigation (& water supply).

GAINS / COMPENSATION:

3. Reservoir fisheries above tributary dams.
4. Irrigation projects.



Other Impacts: qualitative assessment

- **Qualitative assessments will be undertaken to highlight the likely scale and direction of the remaining 1st and 2nd order impacts of fish yields.**



Assessment Methodology

- **OUTLINE OF QUANTITATIVE ASSESSMENT METHODOLOGY:**
 1. **Barrier impacts of dams & flood control projects**
 2. **Reservoir fisheries**
 3. **Modified (flow) flood impacts**
 4. **Irrigation project impacts**

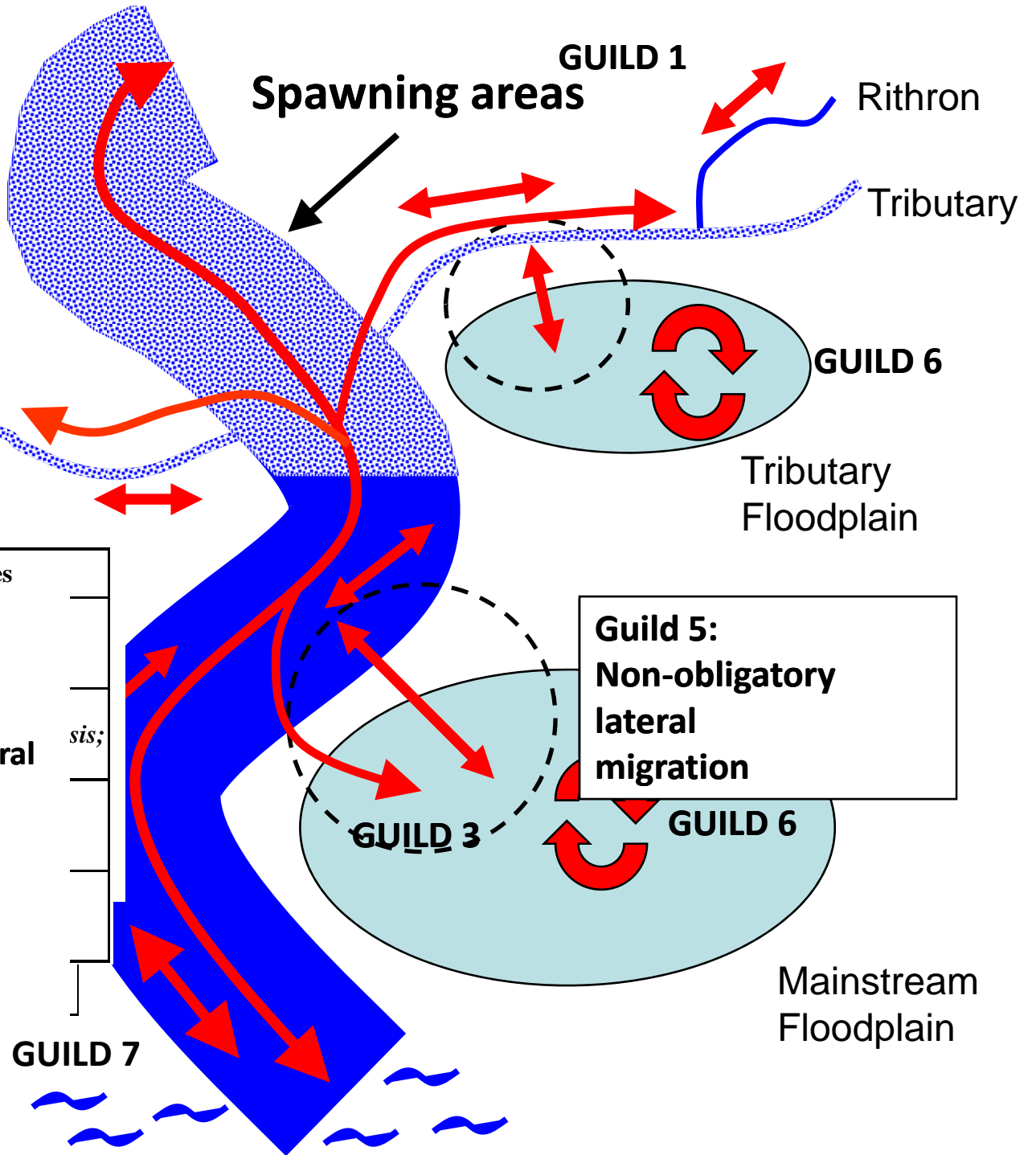
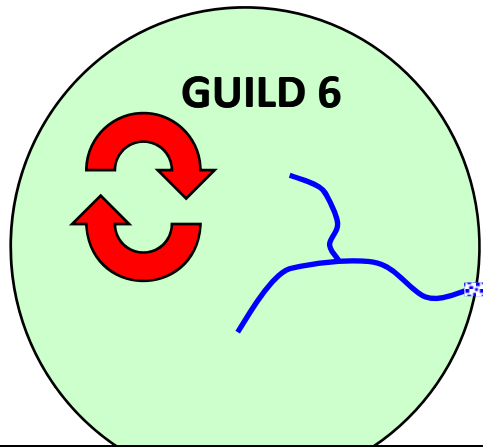


1. Barrier Impacts: Dams and Flood Control Embankments

Impacts will vary among species depending upon:

- Scale of their migrations.
- Type of migrations (longitudinal / lateral).
- Tolerance to environmental conditions and behavioural flexibility (adaptability).
- We can approximately group species into 9 'guilds' according to these characteristics as follows...

GUILDS 1, 6, 7, 9
GUILDS 2, 3, 5, 8



Guild	Name	Examples
		Species resident in the rithron, estuary and floodplains.
		No significant longitudinal or lateral migrations.
		Barrier impacts low.

Guild 5:
Non-obligatory lateral migration

GUILD 7

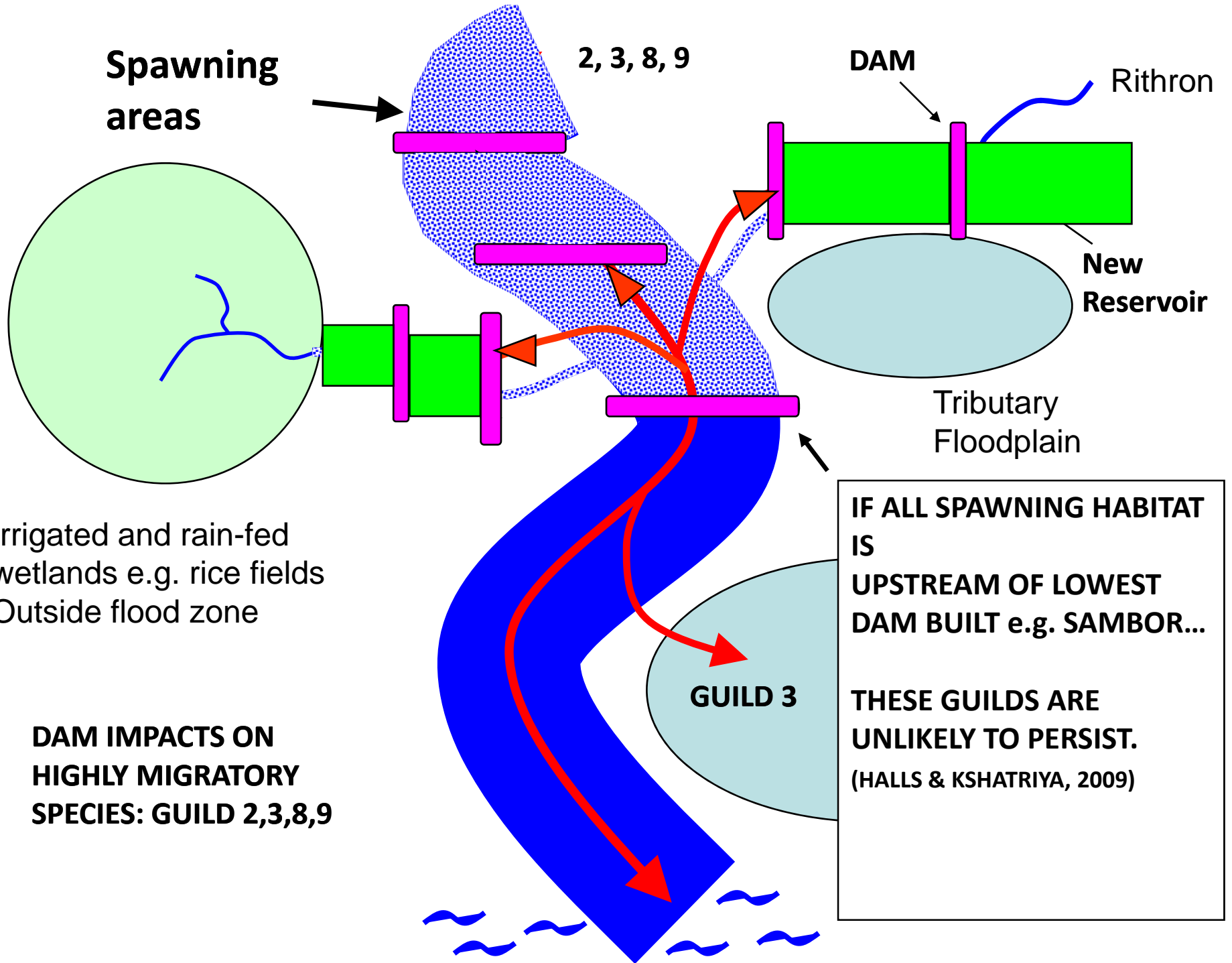
Mainstream Floodplain



Assessment Methodology

**ESTIMATING IMPACTS OF DAMS ON
YIELDS OF HIGHLY MIGRATORY
SPECIES:**

GUILDS 2,3,8,9.



Spawning areas

2, 3, 8, 9

DAM

Rithron

New Reservoir

Tributary Floodplain

Irrigated and rain-fed wetlands e.g. rice fields
Outside flood zone

DAM IMPACTS ON HIGHLY MIGRATORY SPECIES: GUILD 2,3,8,9

GUILD 3

IF ALL SPAWNING HABITAT IS UPSTREAM OF LOWEST DAM BUILT e.g. SAMBOR... THESE GUILDS ARE UNLIKELY TO PERSIST. (HALLS & KSHATRIYA, 2009)



Barrier Impacts of Dams

$$\text{New Yield}_{2,3,8,9} = \text{Baseline Yield}_{2,3,8,9} \times \left[\frac{\text{Remaining Channel Area}}{\text{Baseline Channel Area}} \right]$$

Where channel area is the sum of the main channel and tributary area measured:

- (i) Below the lowest mainstream dam e.g. Pak Chom (assumes spawning habitat throughout system) or
- (ii) between the lowest mainstream dam and the location of the Sambor dam (assumes all spawning habitat above Sambor) or

Other assumptions about spawning habitat distribution? Results of 'Ichthyoplankton survey'

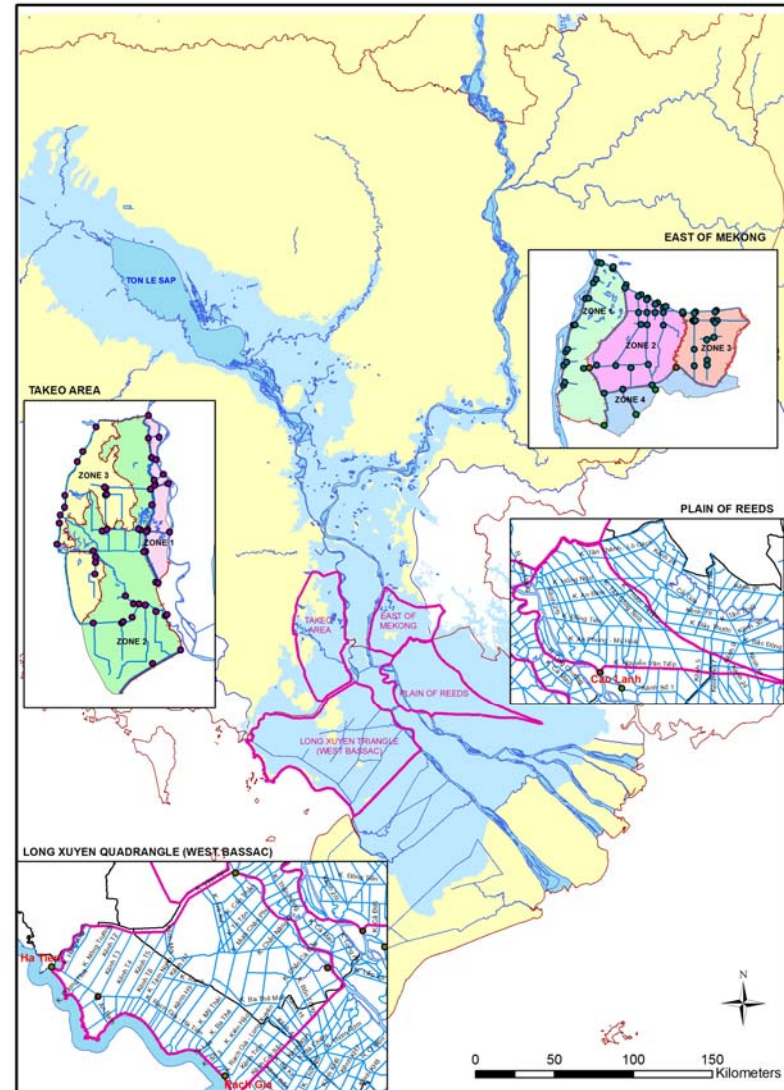


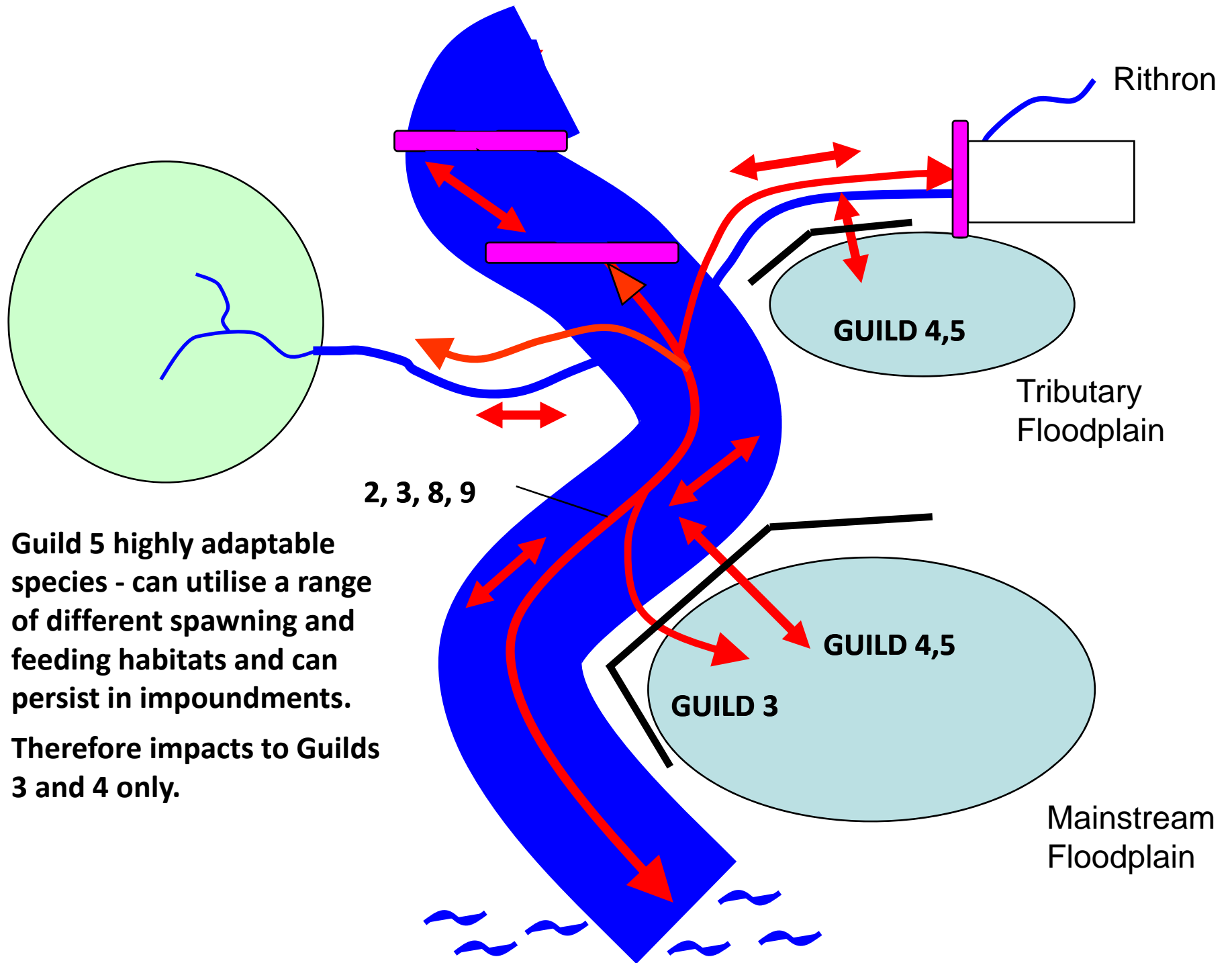
Barrier Impacts of Flood Control Embankments



- A number of new flood control projects are planned for the basin.
- The most significant are included in Scenario 7: 'Mekong Delta Flood Management Scenario'.
- Provide early (no flooding until 1st August) or full flood protection and regulation using embankments, pumps and regulators.
- Combined, the 4 projects control flooding and salinity over 4,600 km² of floodplain inside the flood zone.
- These projects have the potential to have both barrier and modified flow (flood-pulse) impacts on fisheries.

MEKONG DELTA





Guild 5 highly adaptable species - can utilise a range of different spawning and feeding habitats and can persist in impoundments. Therefore impacts to Guilds 3 and 4 only.

2, 3, 8, 9

GUILD 4,5

Tributary Floodplain

GUILD 4,5

GUILD 3

Mainstream Floodplain

Rithron



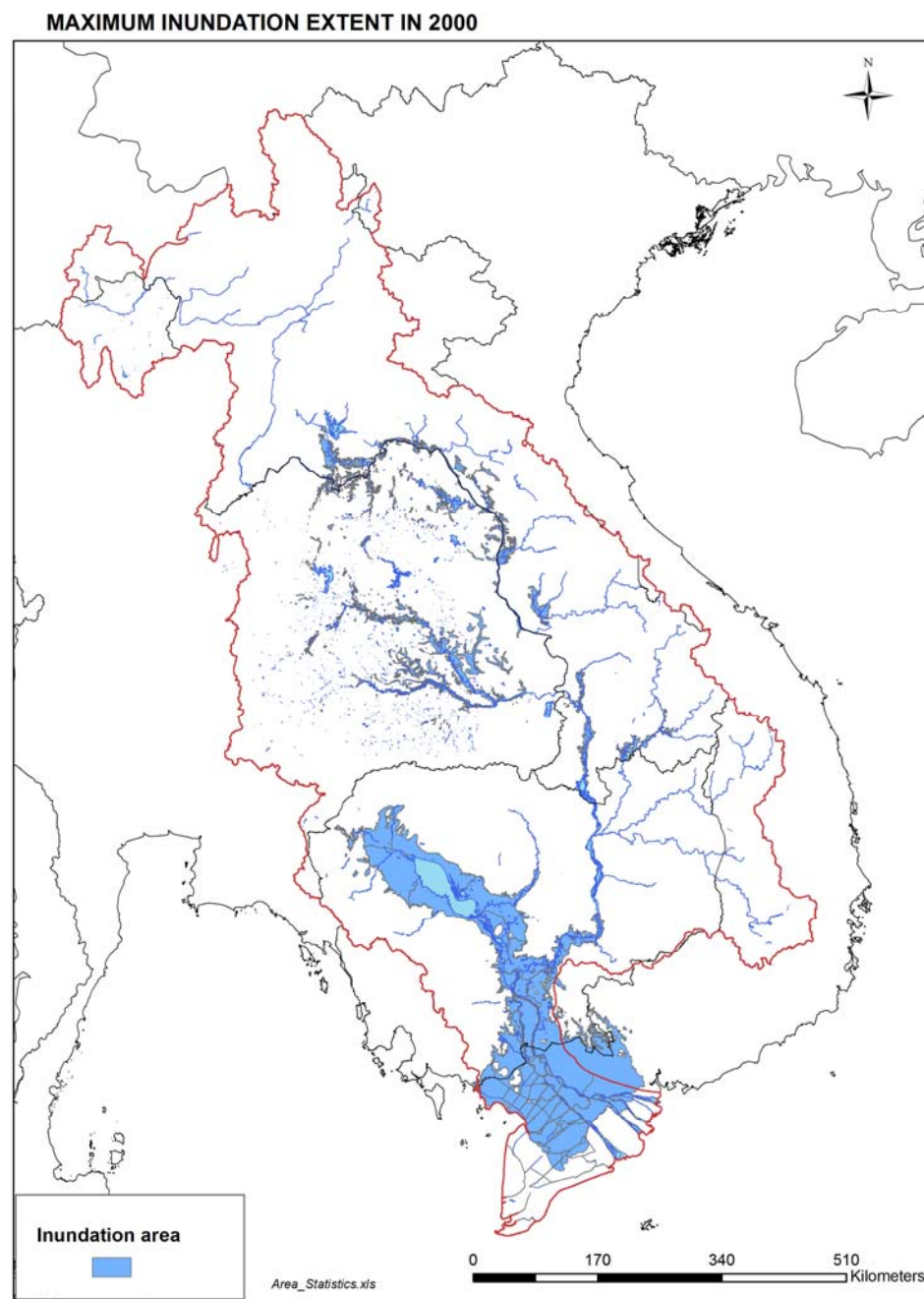
Barrier Impacts of Flood Control Embankments

$$\text{New Yield}_{3,4} = \text{Baseline Yield}_{3,4} \times \left[\frac{\text{Unprotected Floodplain Area}}{\text{Baseline Floodplain Area}} \right]$$

After accounting for barrier impacts of dams.

3. Modified Flow Impacts

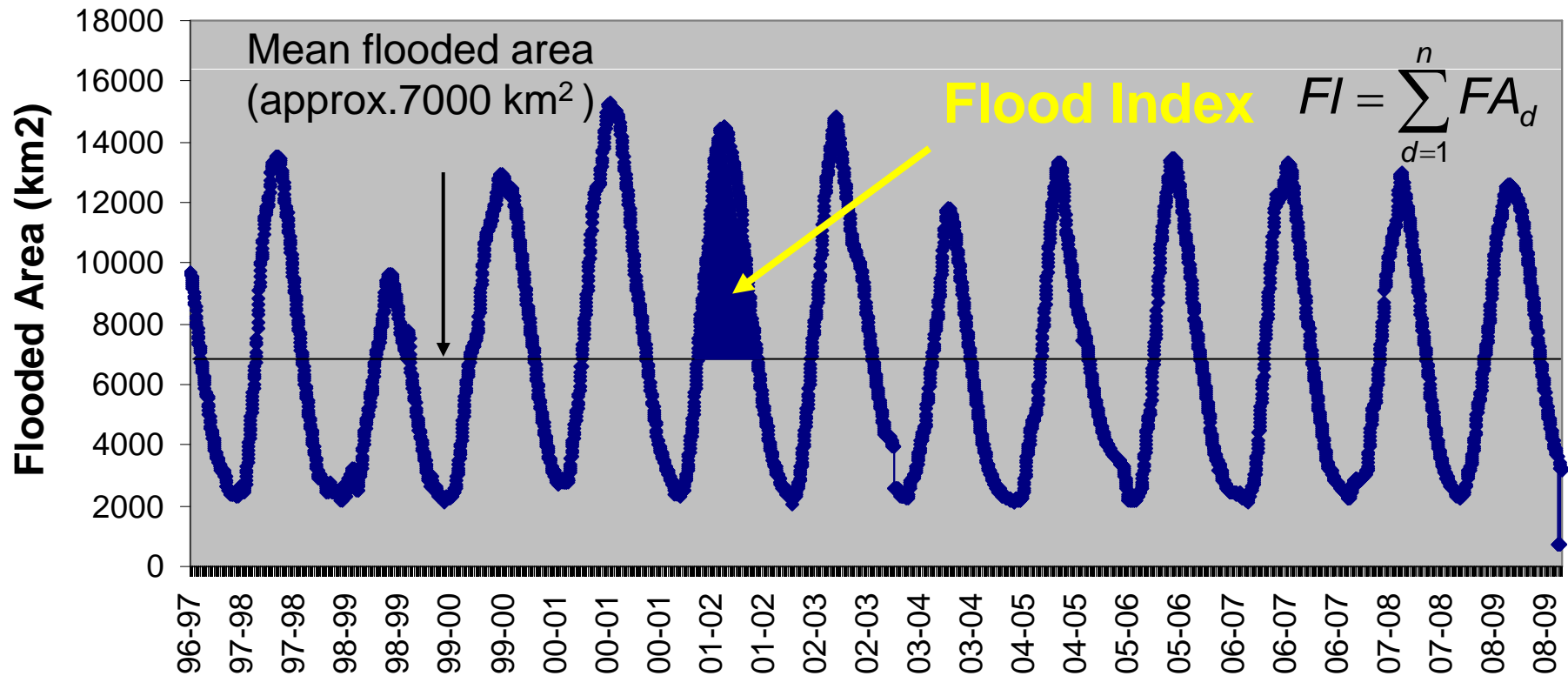
- Estimated from changes to aquatic habitat availability in the flood zone...
- Described by the Flood Index (FI) – a measure of the extent and duration of flooding.
- All species hypothesised to be affected due to flood influence on primary and secondary production, and trophic (food chain) effects.





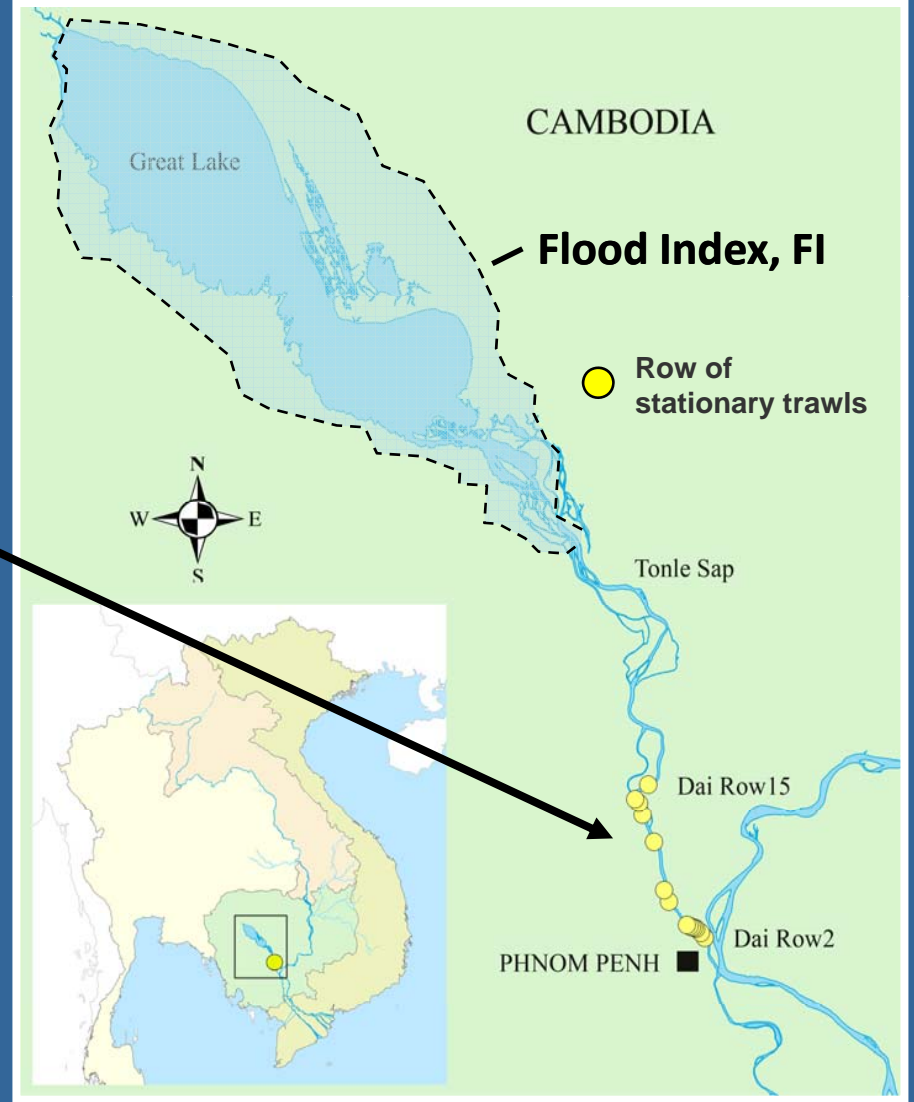
Modified Flow Impacts

TS-GL daily flooded area estimates





Modified Flow Impacts

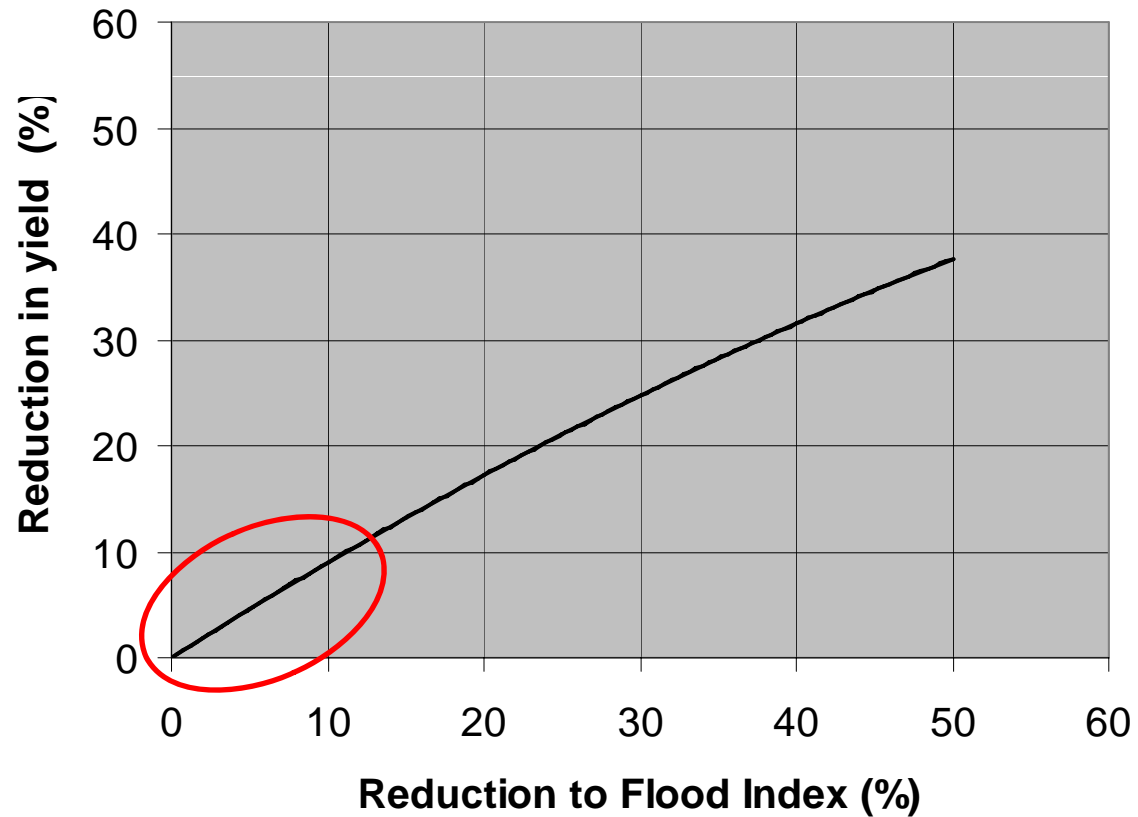




Modified Flow (Flood) Impacts

Predicted reduction in fish yield in response to reductions to the mean flood index

$$y = -0.0035x^2 + 0.9292x + 0.0515$$





Modified Flow (Flood) Impacts

- For each country, model applied to the yield of each guild weighted by the flooded area over which changes to the flood index occur to estimate the new yield of each guild.

(After accounting losses due to the barrier effects).

- [Note: The flooded area excludes the area of the flooded zone lost to reservoirs, areas upstream of reservoirs that are no longer influenced by the flood pulse, and areas within FCDI or flood control schemes which will have their own unique flood indices.]



4. Irrigation Project Impacts and Compensation

- Expansion of the irrigation projects will impact on fish yields in the flood zone by depriving them of water (flood modification).
- These already included in flood modification impacts.
- Losses may be partially compensated by additional catches of blackfish (Guild 6) from the irrigated rice fields and irrigation reservoirs.
- These 'gains' estimated as the product of the additional irrigation project area and the mid-range of the areal yield estimate i.e. 75 kg/ha.

Thank you



Clown Featherback
(Chitala ornata)



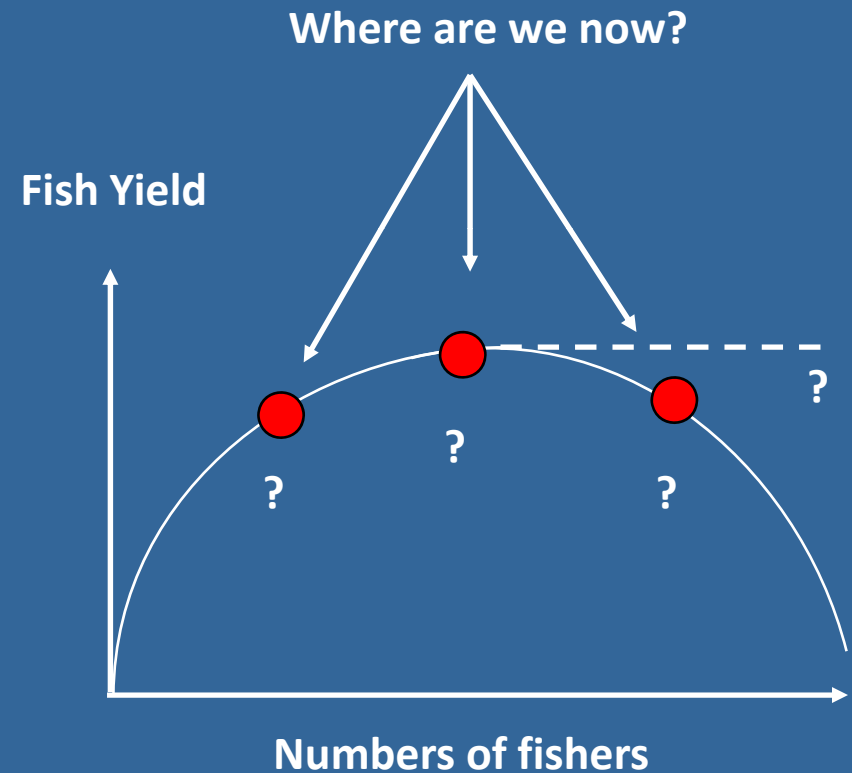
Other Impacts

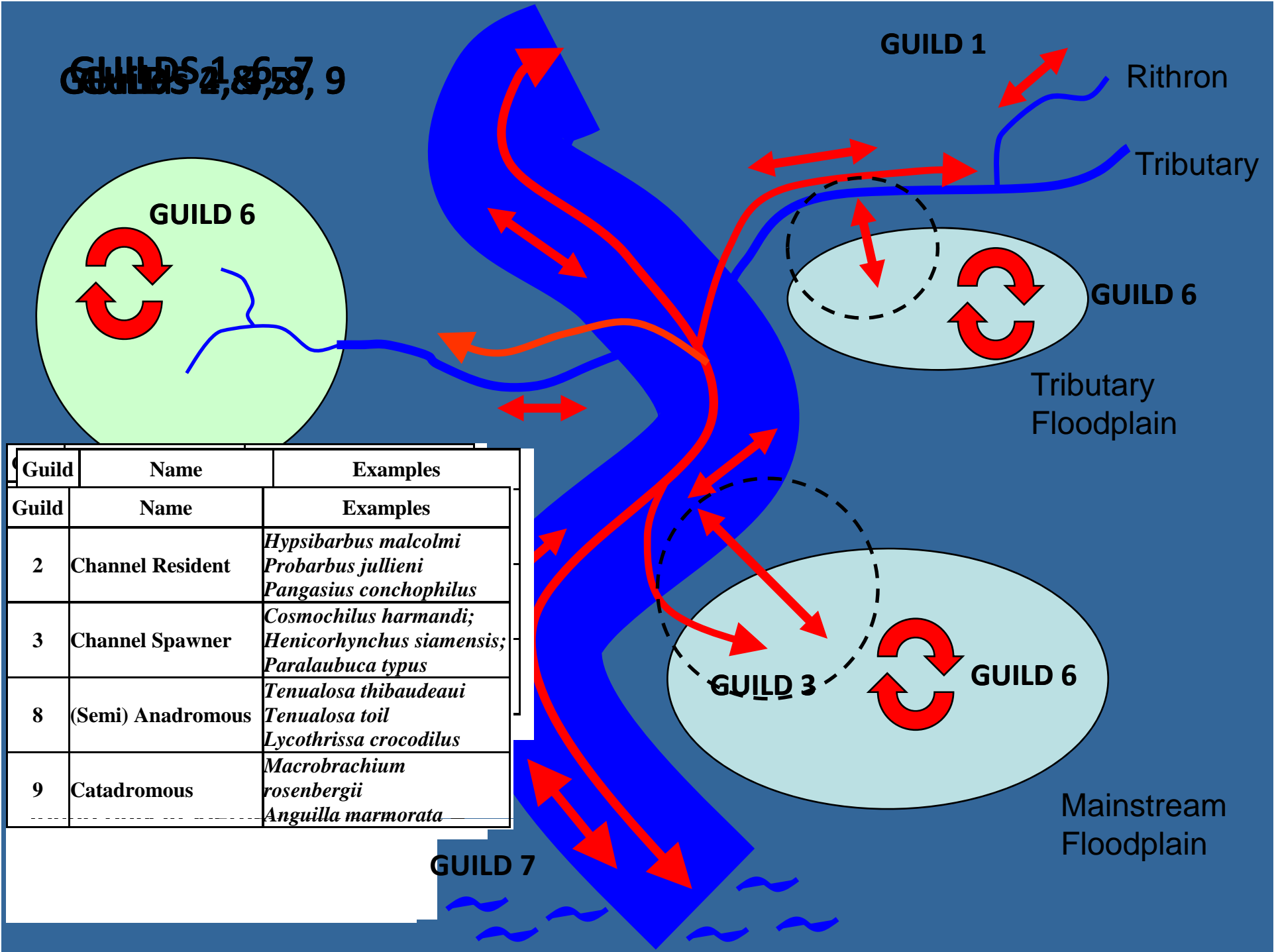


- **Changes to sediment input (may)**
 - Affect overall system productivity (including fish)
 - Degrade important fish habitats e.g. deep pool refuges and spawning sites/beds.
- **Changes to flow and depth near dams (may):**
 - Affect passive downstream drift of fish larvae.
 - Affect flow related migration/spawning cues.
 - Drown / degrade spawning substrates/habitats.
- **Hydro-peaking - rapid changes to water levels changes in the main channel (2-3 m in 24 hours)**
 - Affect migration/spawning cues
 - Strand eggs, larvae and adult fish.

Population Growth

- Population growth is not included...
- Future fish yield is assumed to be unaffected by the growing basin population (potential fishing pressure) because:
- Management may effectively control growing fishing pressure.
- Alternative livelihoods opportunities may grow.
- Uncertainty surrounding existing levels of exploitation.





GUILDS 1, 6, 7, 9
GUILDS 2, 3, 5, 8

GUILD 1

Rithron

Tributary

GUILD 6

GUILD 6

Tributary
Floodplain

Guild	Name	Examples
2	Channel Resident	<i>Hypsibarbus malcolmi</i> <i>Probarbus jullieni</i> <i>Pangasius conchophilus</i>
3	Channel Spawner	<i>Cosmochilus harmandi</i> ; <i>Henicorhynchus siamensis</i> ; <i>Paralaubuca typus</i>
8	(Semi) Anadromous	<i>Tenualosa thibaudeaui</i> <i>Tenualosa toil</i> <i>Lycotrhissa crocodilus</i>
9	Catadromous	<i>Macrobrachium rosenbergii</i> <i>Anguilla marmorata</i>

GUILD 3

GUILD 6

Mainstream
Floodplain

GUILD 7

Number of Tributary Dams

