



Environmental flow assessments in estuaries and wetlands- Key challenges and approaches

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Training/Workshop on Environmental Flow Assessment-Approaches

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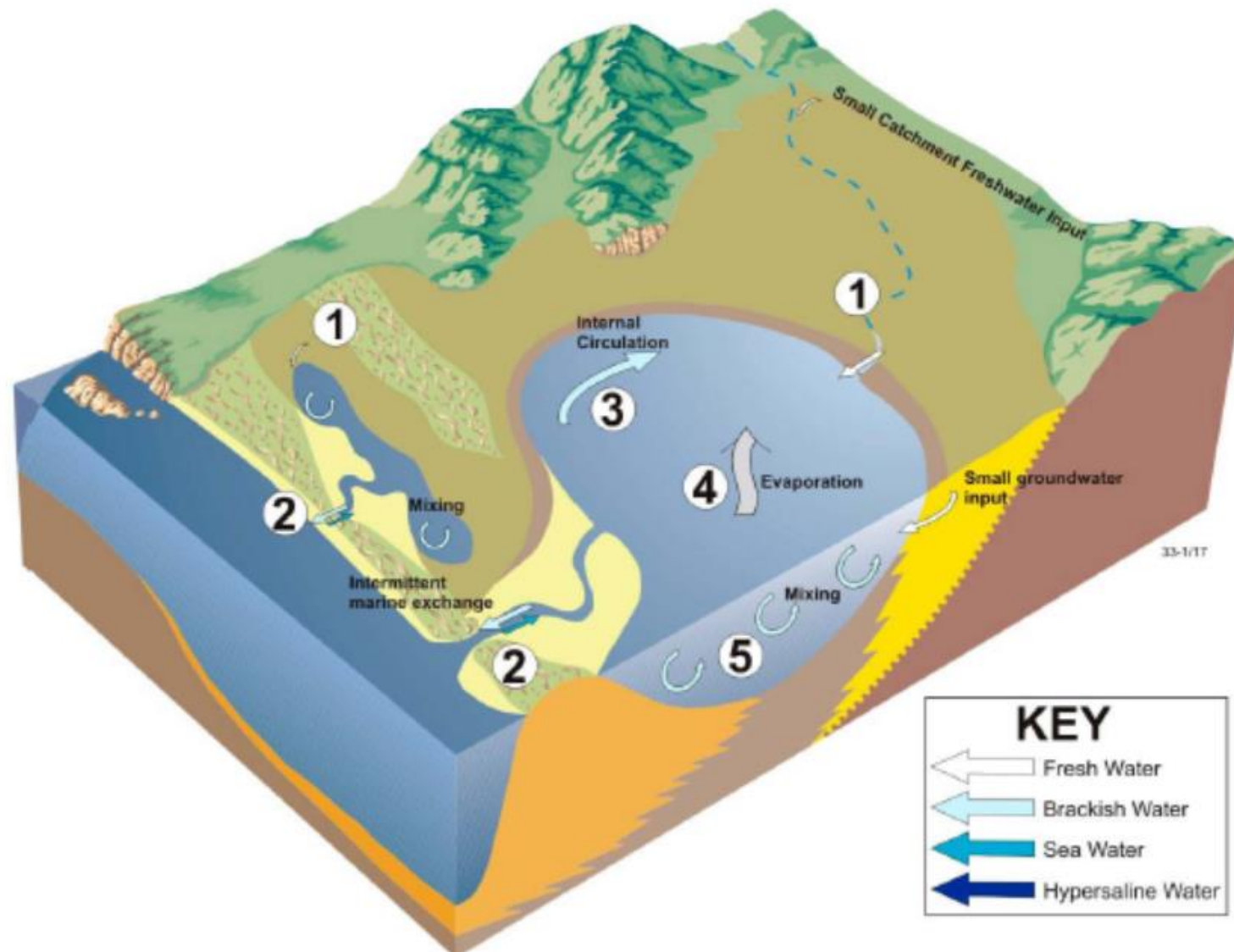


DEFINITION AND CLASSIFICATION

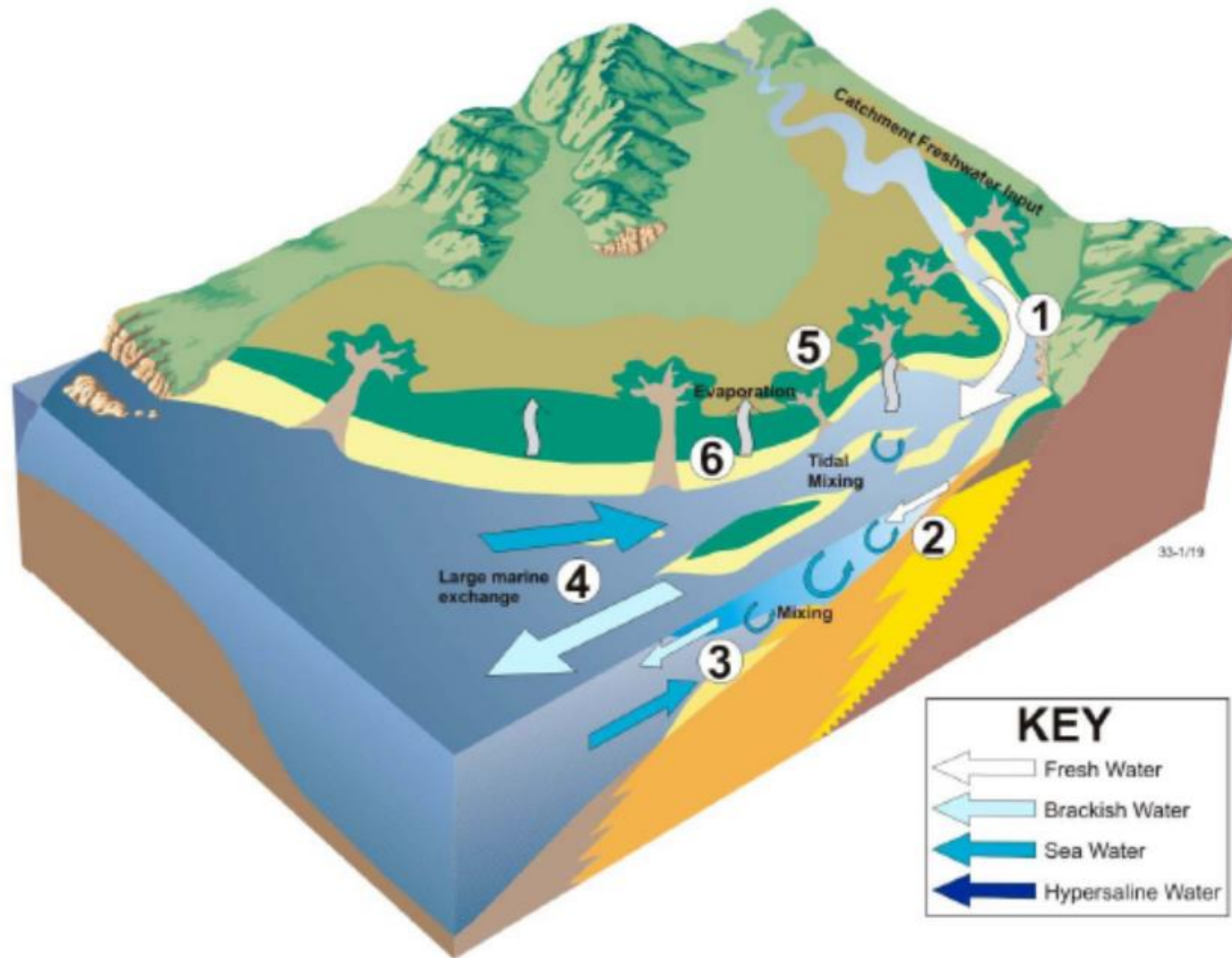
*Estuaries are **semi-enclosed coastal bodies of water** which have a **connection with the open sea** and within which **sea water diluted with freshwater** from land drainage (Pritchard, 1967).*

*Estuaries may be classified in different ways. At the simplest level, there are two types of estuaries—**river mouth estuaries** and **lagoonal estuaries**.*

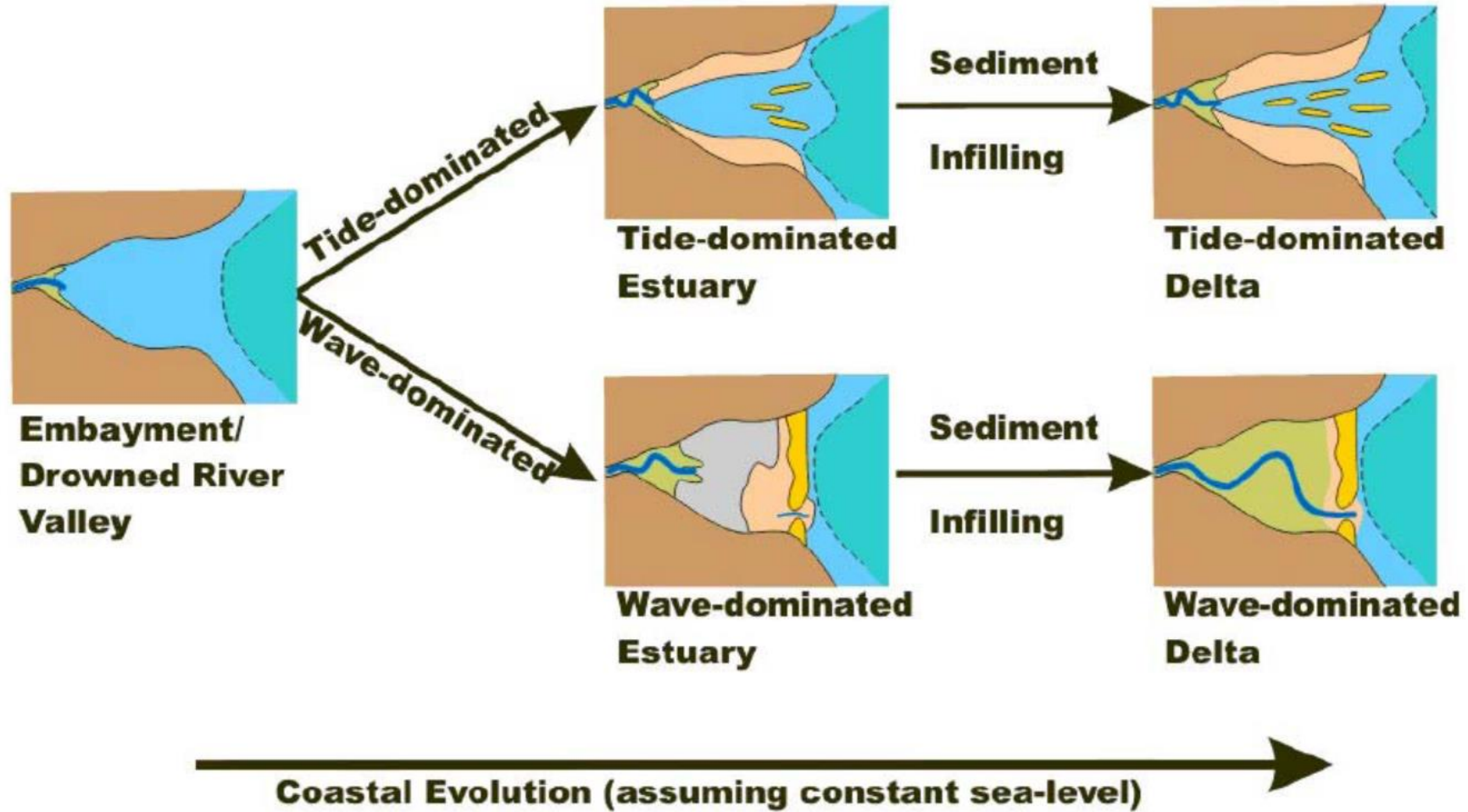
COASTAL LAGOON ESTUARIES



RIVER MOUTH ESTUARIES



DINAMIC SYSTEMS



RELEVANCE OF FRESHWATER FOR ESTUARIES AND COASTAL WETLANDS

Water chemistry, stratification and mixing, water level and habitat structure/diversity, temperature and exchange with the marine environment.

Geomorphological features such as sand bars, channel structure and the opening and closing of the estuary's entrance

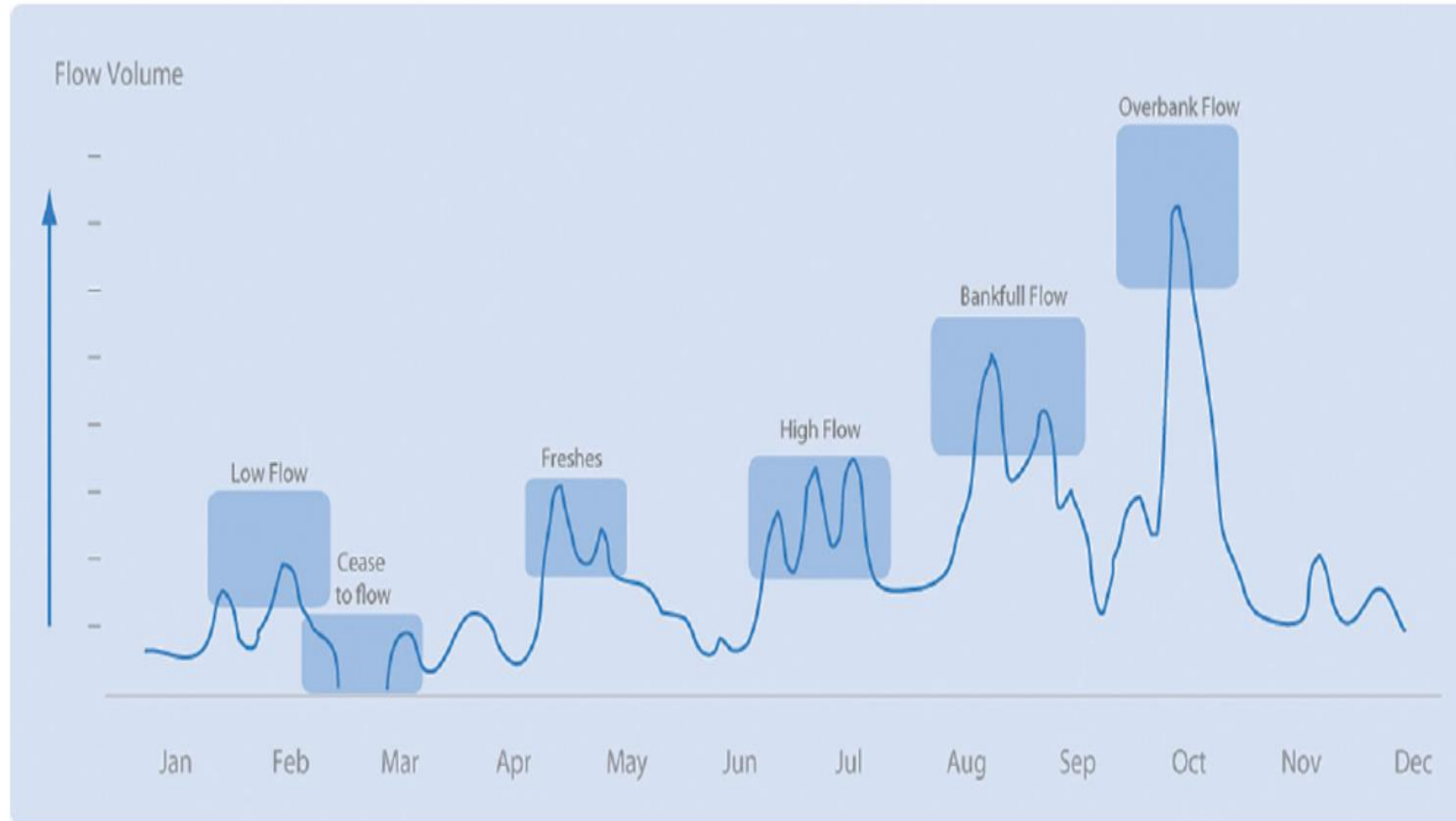
Changes to river hydrology can alter the prevailing physical environment in the estuary with implications for flora and fauna habitat requirements, cues for fish migration, life history processes and recruitment of plants and animals

FRESHWATER MODIFICATION AND ESTUARINE IMPACTS

Peirson et al, 2002

Flow component	Process	
	No.	Nature
Low	1	Increased incidence of hostile water quality conditions at depth
	2	Extended durations of elevated salinity in the upper-middle estuary adversely affecting sensitive fauna
	3	Extended durations of elevated salinity in the upper-middle estuary adversely affecting sensitive flora
	4	Extended durations of elevated salinity in the lower estuary allowing the invasion of marine biota
	5	Extended periods when flow-induced currents cannot suspend eggs or larvae
	6	Extended periods when flow-induced currents cannot transport eggs or larvae
	7	Aggravation of pollution problems
	8	Reduced longitudinal connectivity with upstream river systems
	9	Increased retention times in estuary reaches
	10	Nutrient influxes from density dependent saline surface water -shallow groundwater interactions
	11	Reduced longitudinal connectivity with the downstream marine environment (mouth opening connectivity with marine environment) (low flow and high flow)
Middle-high	9	Diminished frequency of flushing of the estuary bed of fine sediments and organic matter – reducing the quality of physical habitat
	10	Diminished frequency of flushing of organic matter from deep sections of the estuary – reducing water quality
	11	Reduced channel maintenance processes
	12	Reduced inputs of nutrients and organic material
	13	Reduced lateral connectivity and reduced maintenance of ecological processes in water bodies adjacent to the estuary
All	14	Altered variability in salinity structure
	15	Dissipated salinity/chemical gradients used for animal navigation and transport
	16	Decreases in the availability of critical physical habitat features, particularly those components associated with higher velocities

FLOW COMPONENTS



EFLOW METHODS FOR ESTUARIES

Inflow-based methods.

*Inflow-based methods rely on **hydrological analyses** and assume that if the **inflow is maintained then this will maintain estuary** condition and resources as well.*

Resource-based methods

*Resource-based methods focus on organisms and fisheries that are of economic importance. Freshwater inflows are set on the basis of the **requirements of the selected biotic or fisheries resources**, and the goal is to protect the estuary by focusing on key resources.*

Condition-based methods

*In this approach, environmental water requirements are set to maintain **specific physical and habitat conditions** in order to protect the estuarine ecosystem.*

Holistic Ecosystem Methods and Frameworks

*Recent studies have taken a holistic and adaptive approach and are mostly presented as frameworks which provide a **broad strategy for the assessments** of environmental water requirements for estuaries. Methods used in these frameworks are holistic, in that they consider **the entire ecosystem** and include multi-disciplinary teams and stakeholders.*

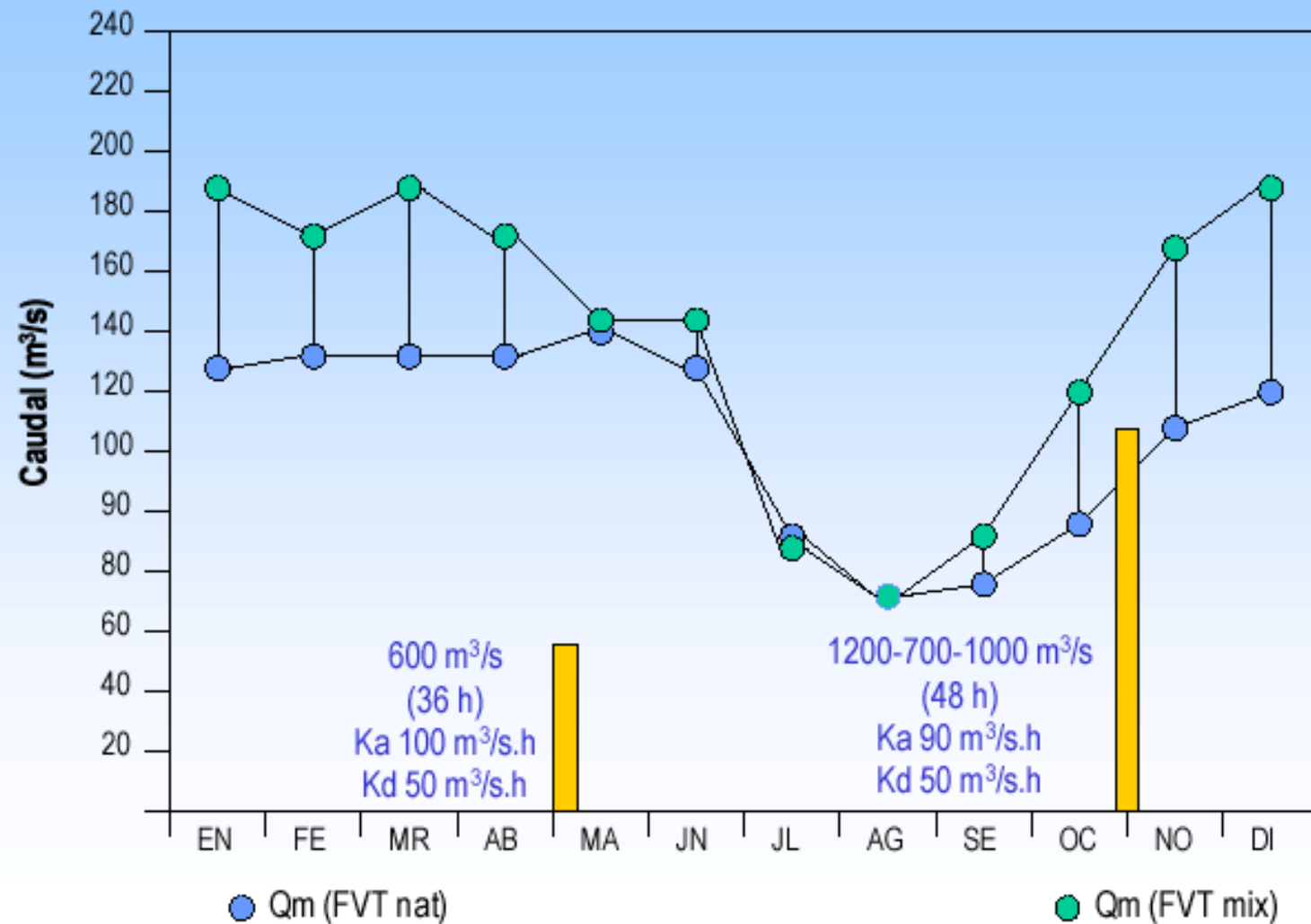
EBRO RIVER







Régimen de Caudales Ambientales Propuesto



HYDROLOGICAL APPROACH





NEED FOR A MORE HOLISTIC APPROACH

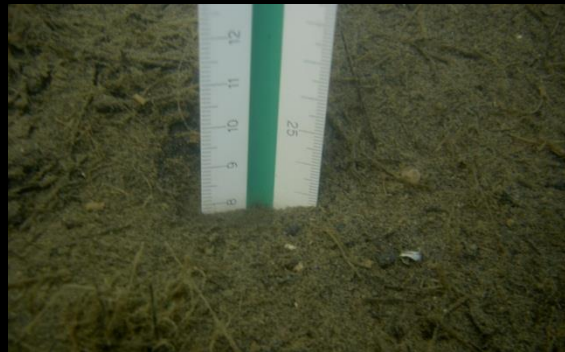
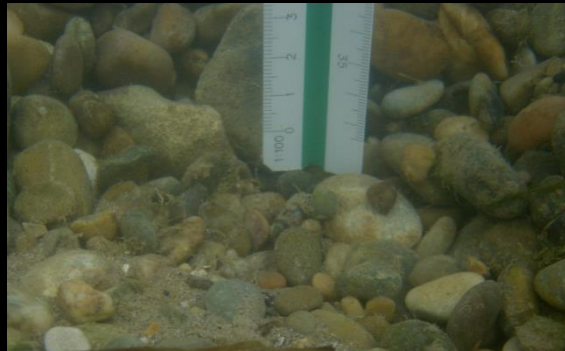


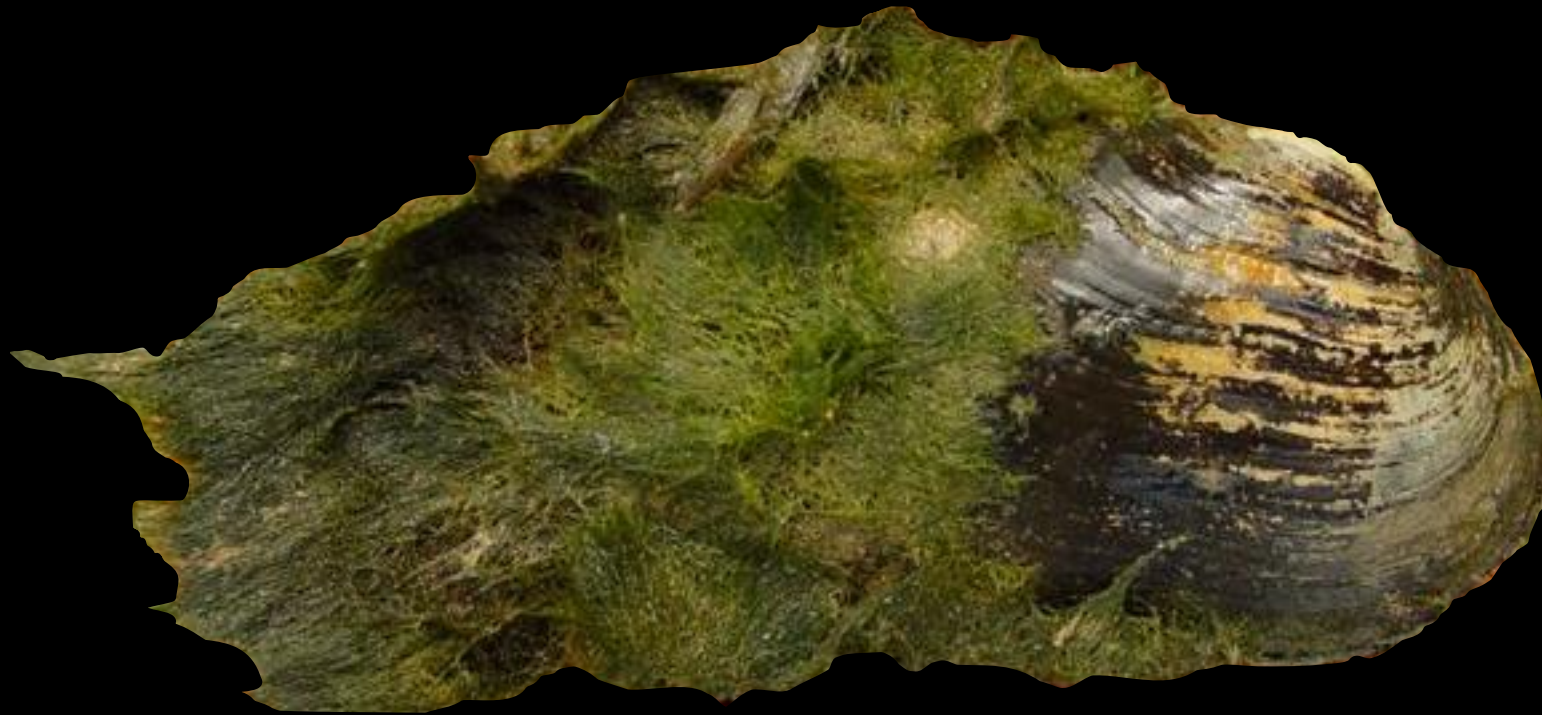
PROBLEMS









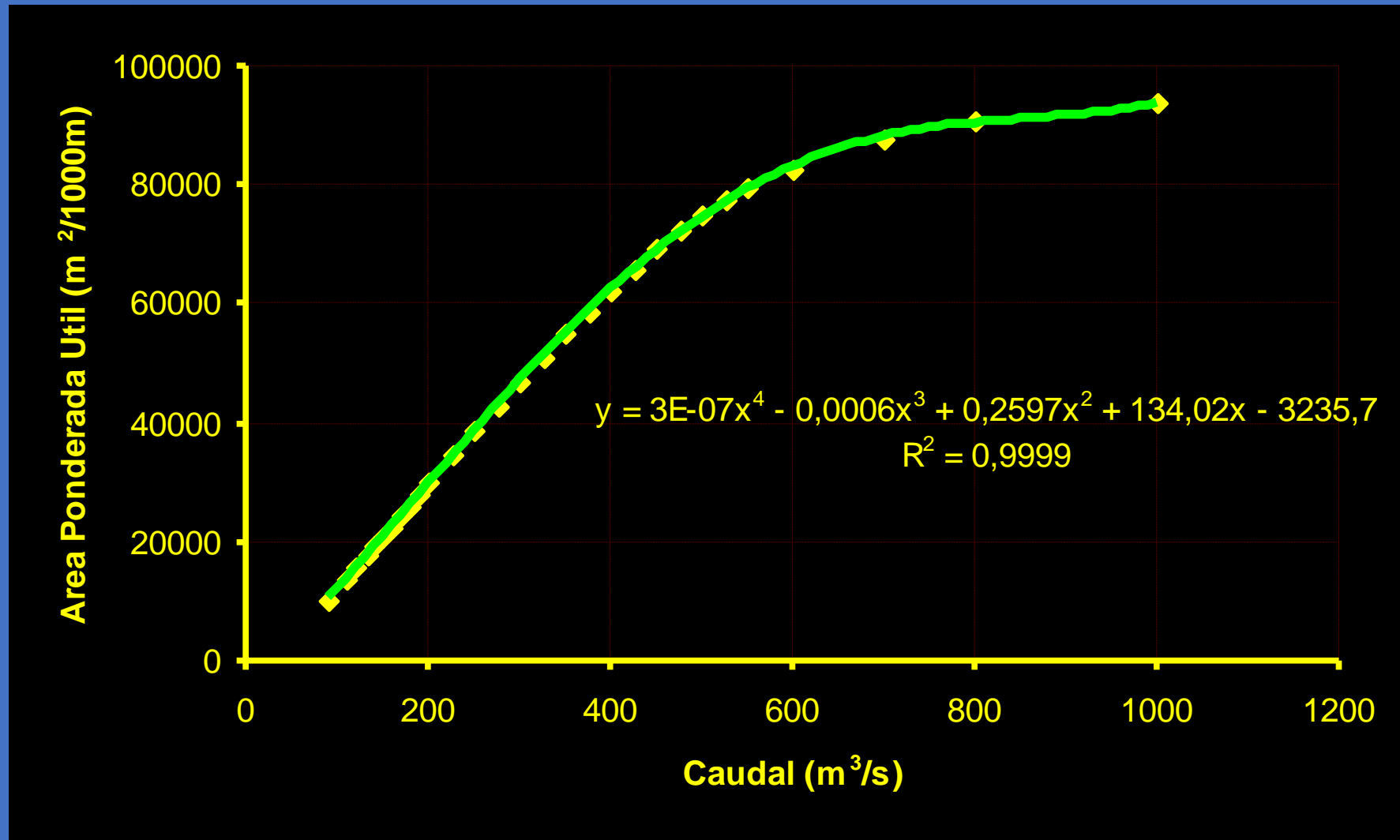


Margaritifera auricularia in standing waters

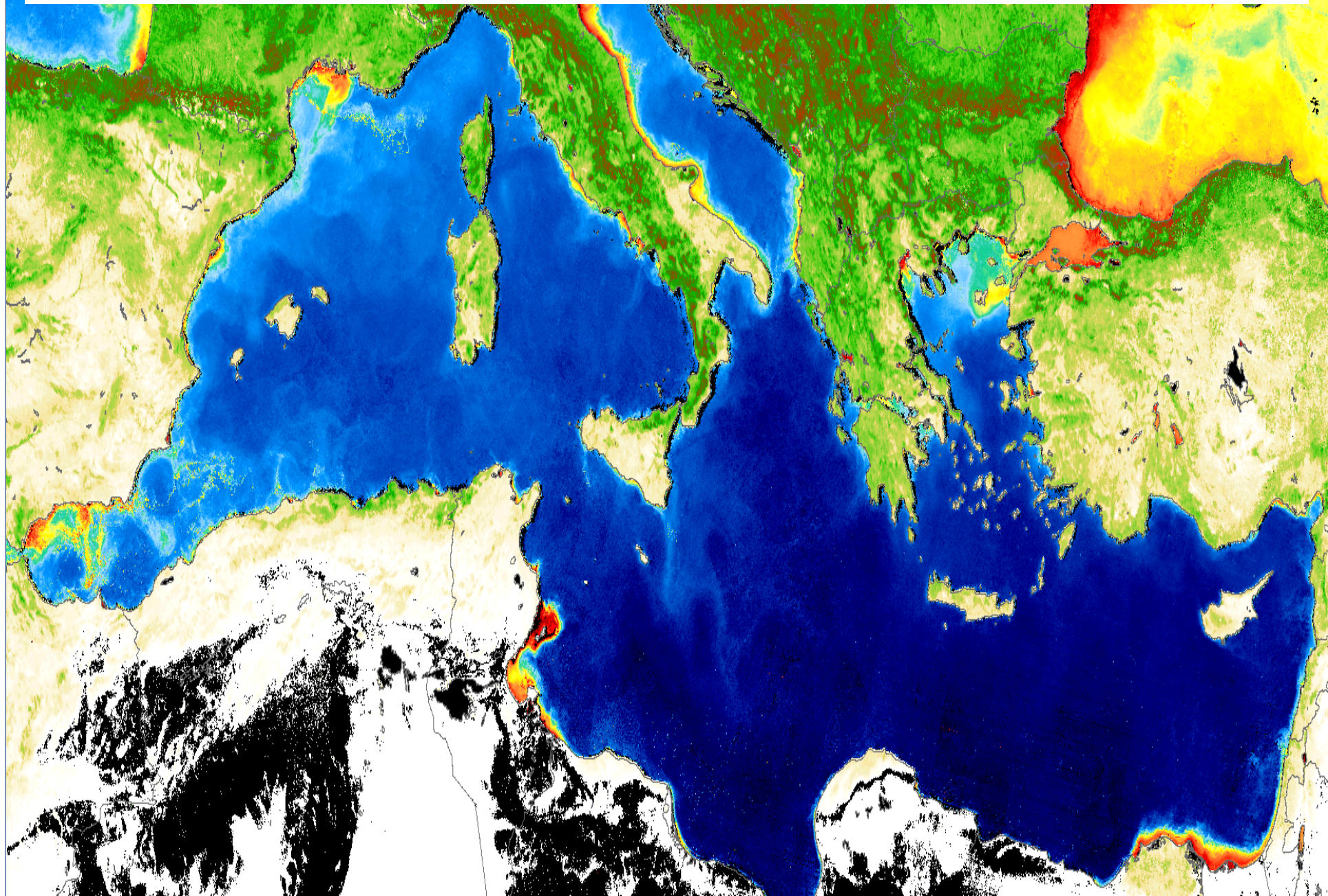
ALOSA FALLAX

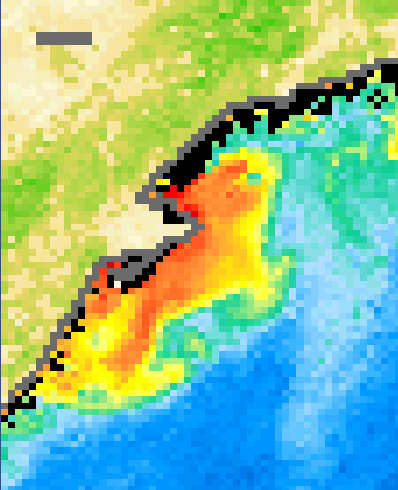


SPAWNING SUITABILITY HABITAT

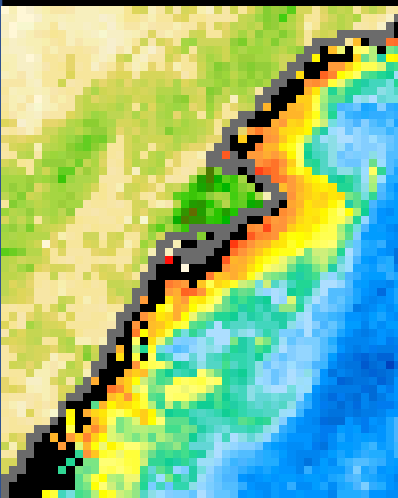


SeaWiFS image color analysis of photosynthetic pigments



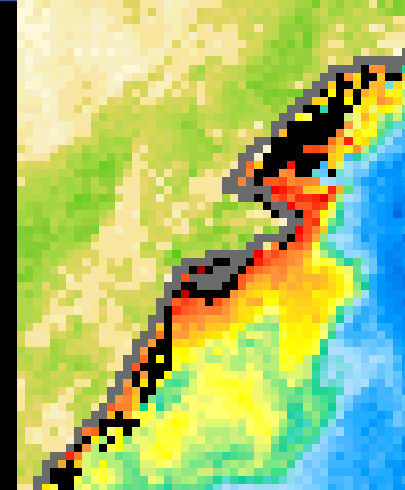
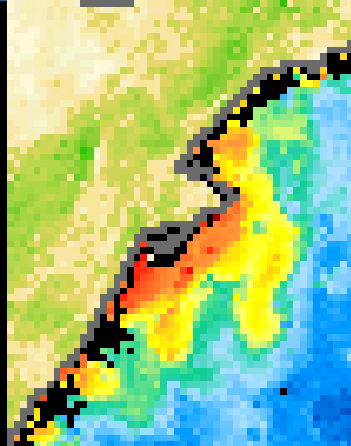


750 m³/s



175 m³/s

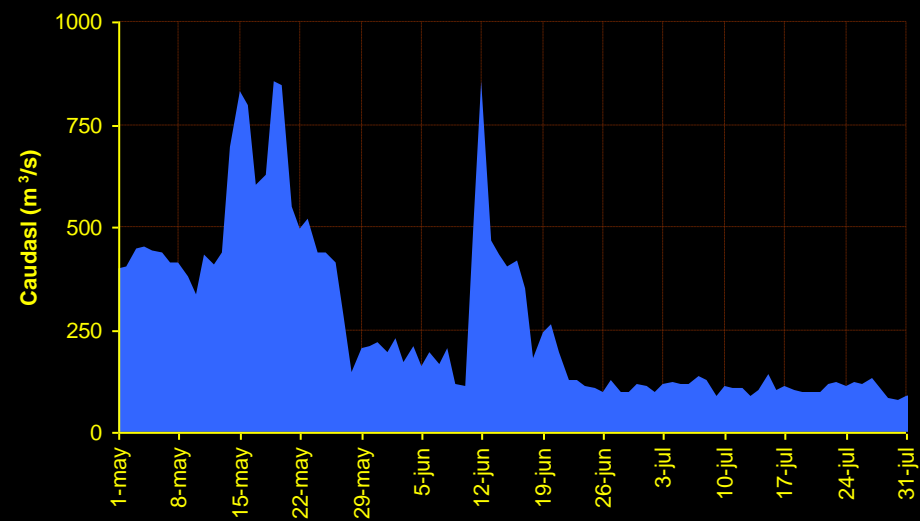
240 m³/s



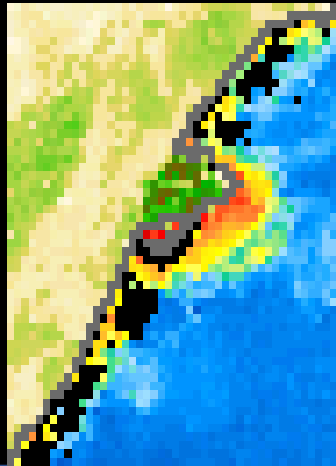
500 m³/s



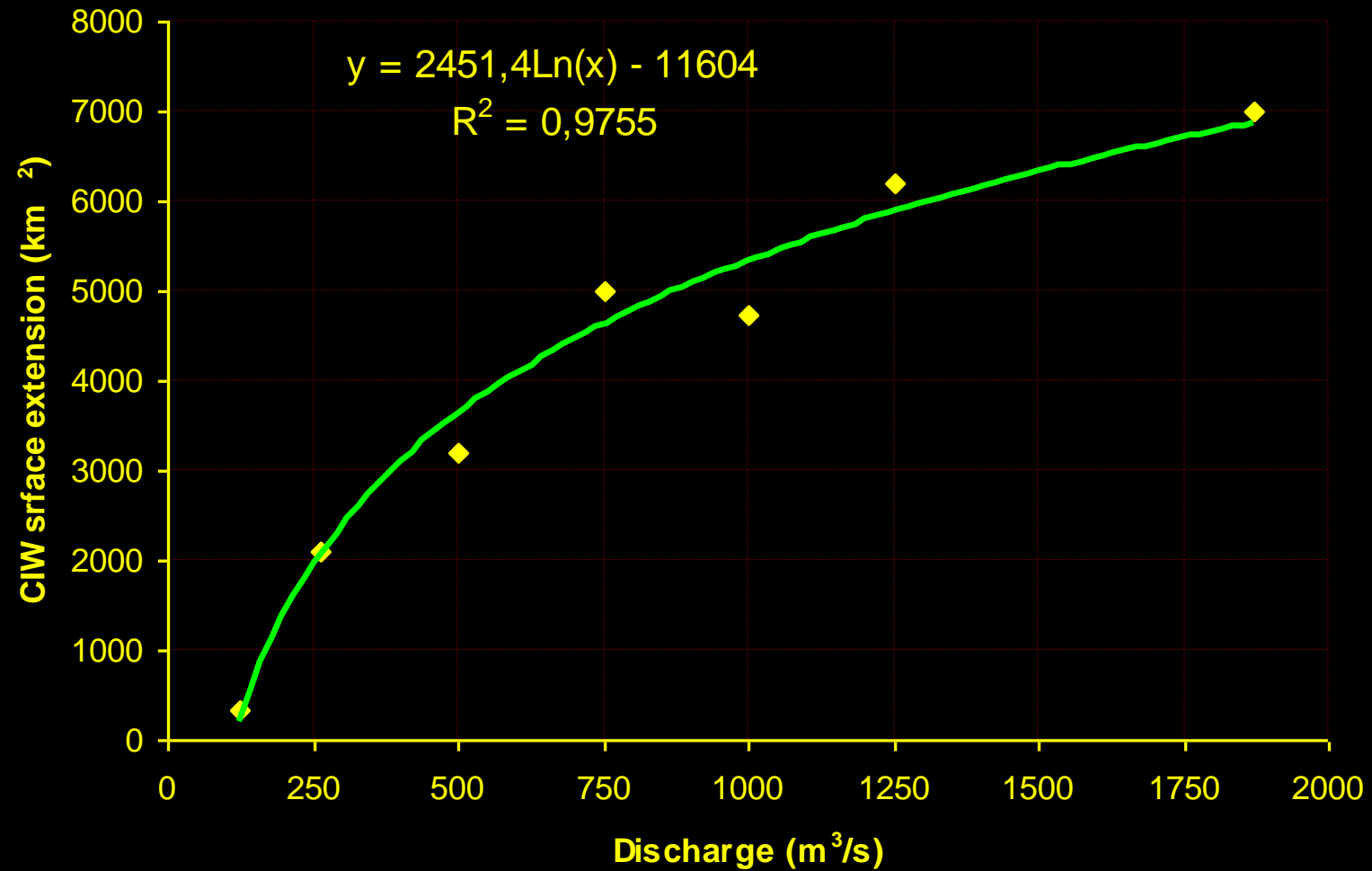
100 m³/s



110 m³/s



RIVER FLOW *vr* SEA PLUME IN THE EBRO RIVER



VALUATION OF SCENARIOS

	NATURAL	PROPUESTA CSTE		PROPUESTA PHE		PROPUESTA PHE	
	Escenario 1	Escenario 2		Escenario 3		Escenario 4	
			%		%		%
<i>Potamogeton pectinatus</i>	↕	↔	↕	↕		↕	
<i>Margaritifera auricularia</i>	↕	↔	↕	↕		↕	
<i>Alosa falax</i>	79410	43032	54	12206	15	17989	23
Sedimentos	911	168	18	35	4	45	5
Productividad marina	3500	2400	69	300	9	500	14

FUENTE DE PIEDRA SALT LAKE

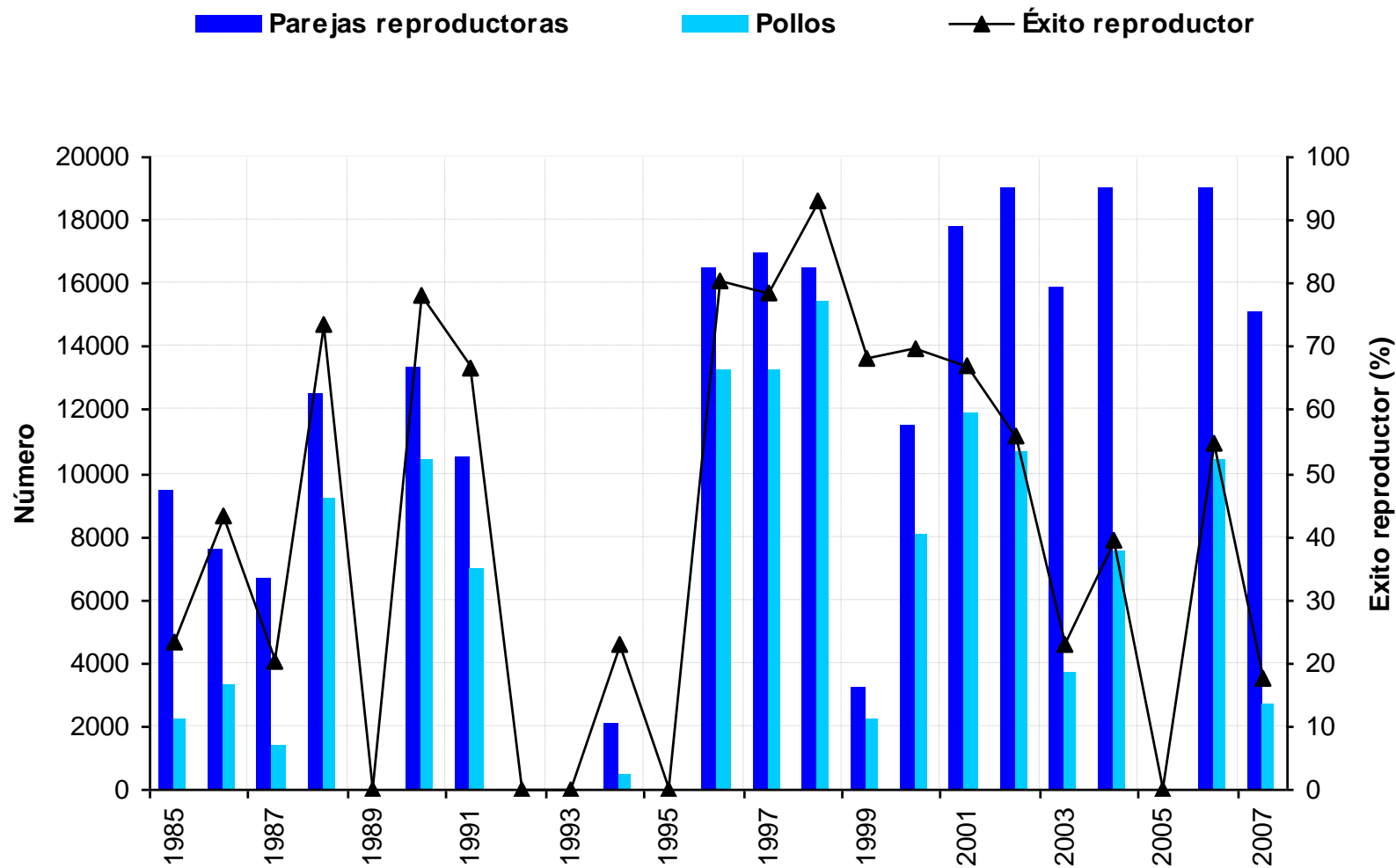




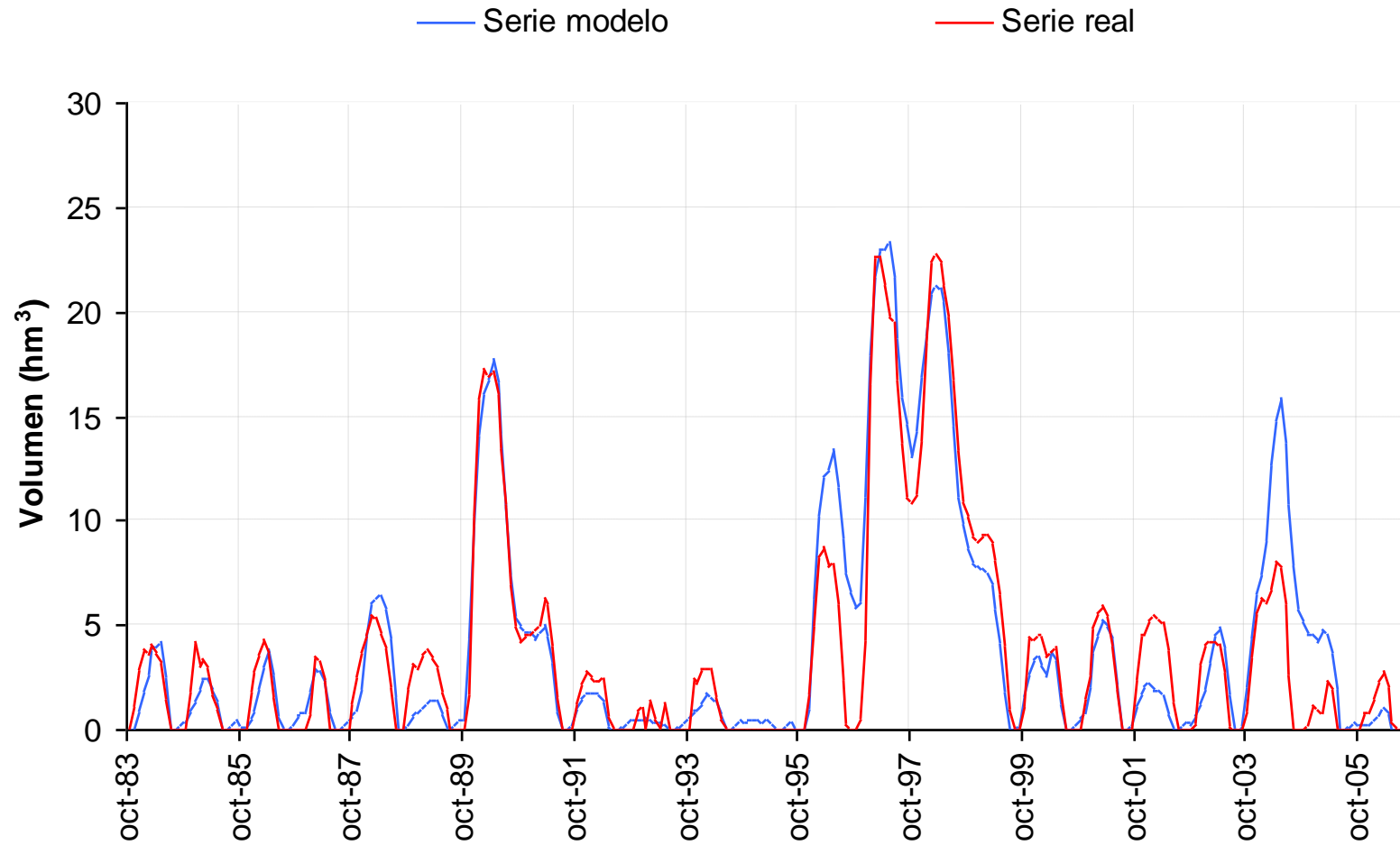




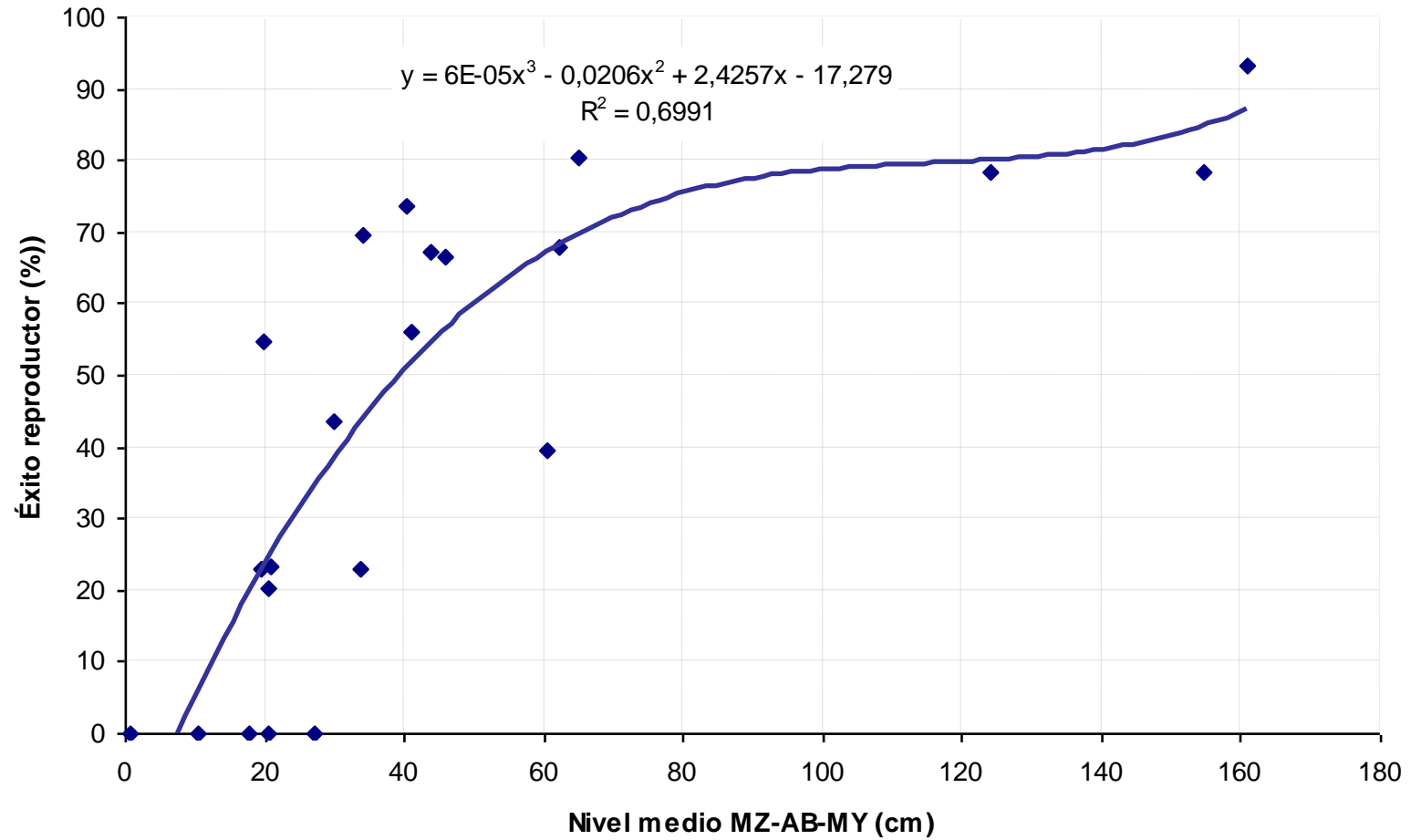
BIOLOGICAL INFORMATION



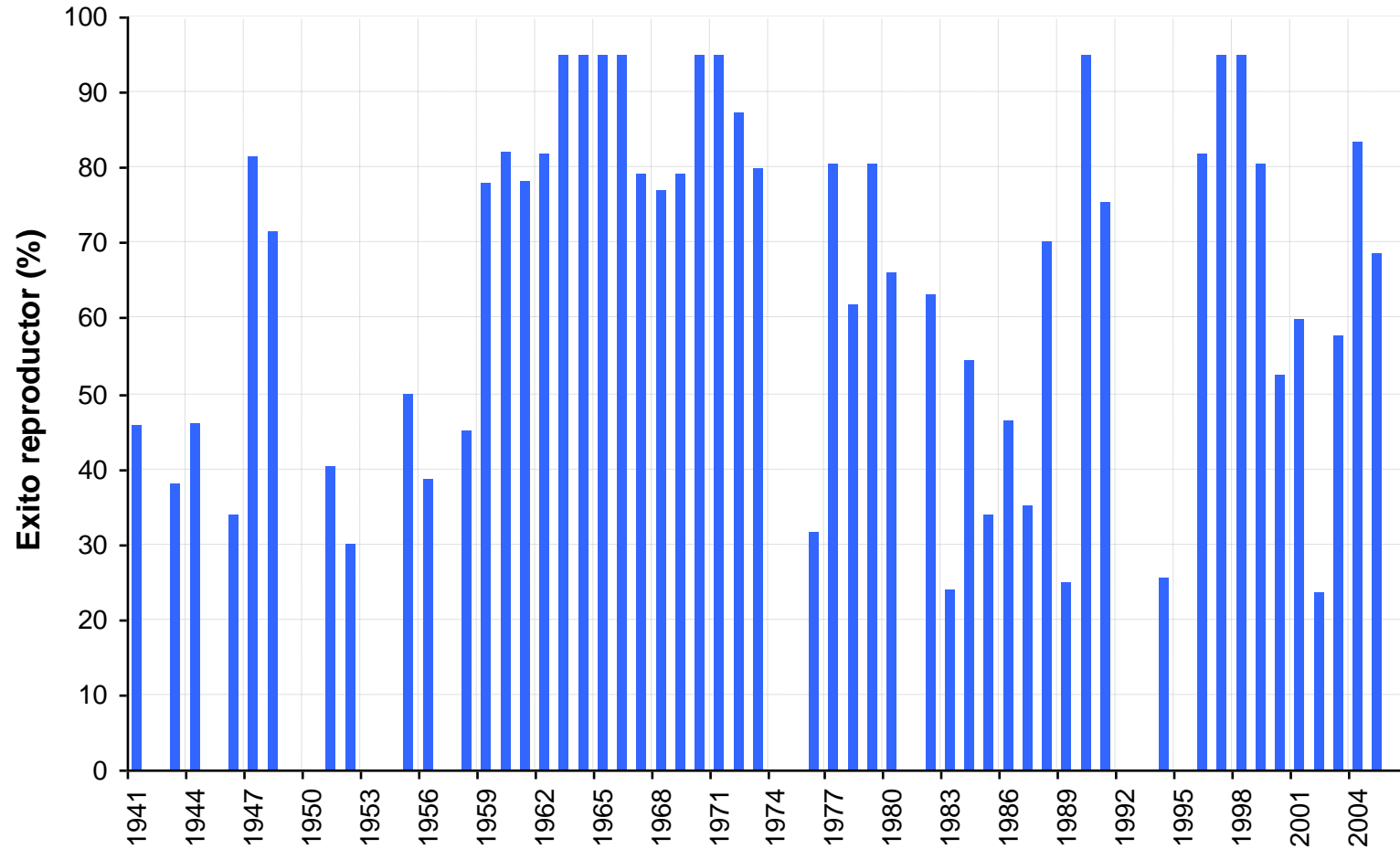
HYDROLOGICAL MODELLING



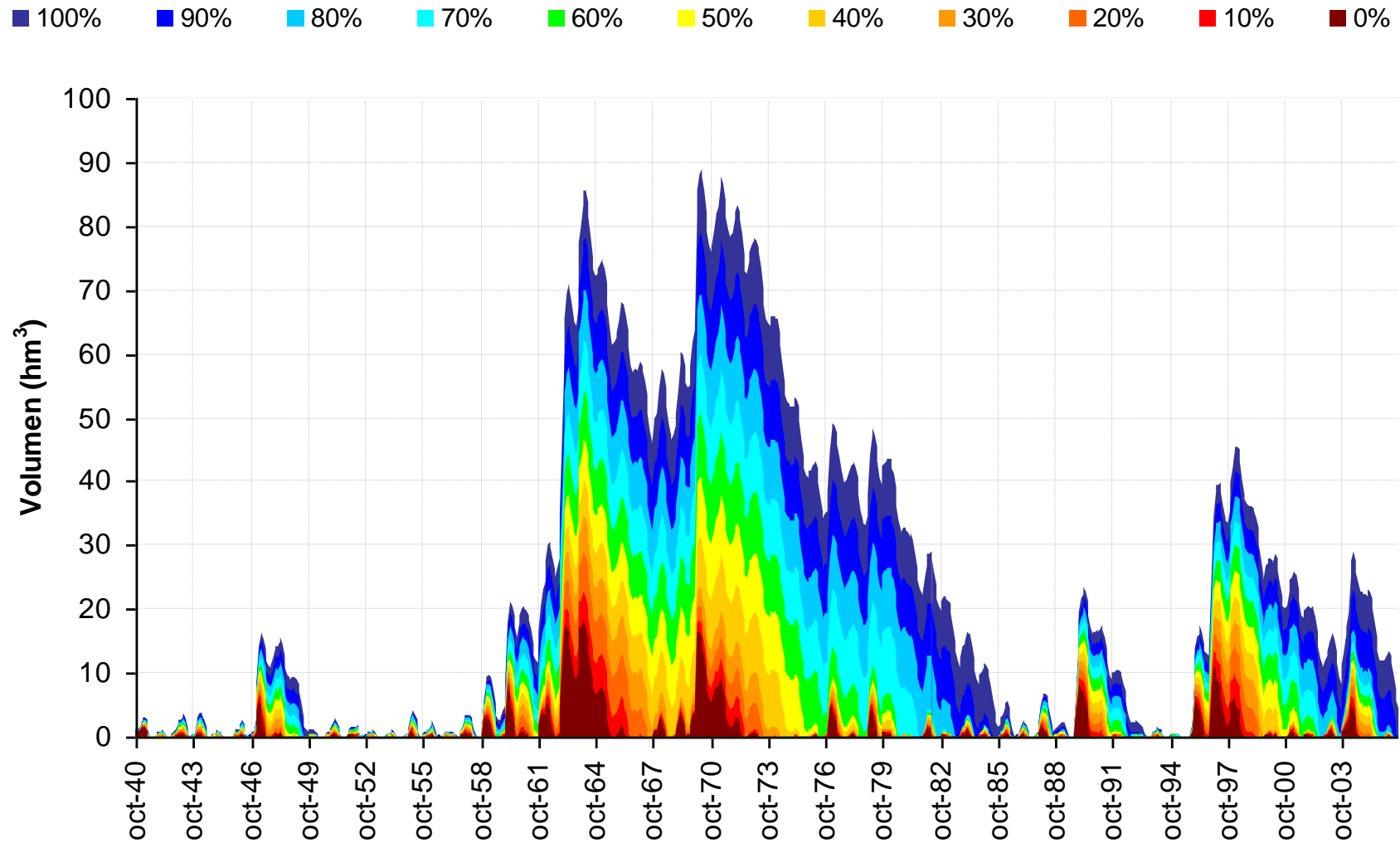
HYDROLOGY VS BIOLOGY



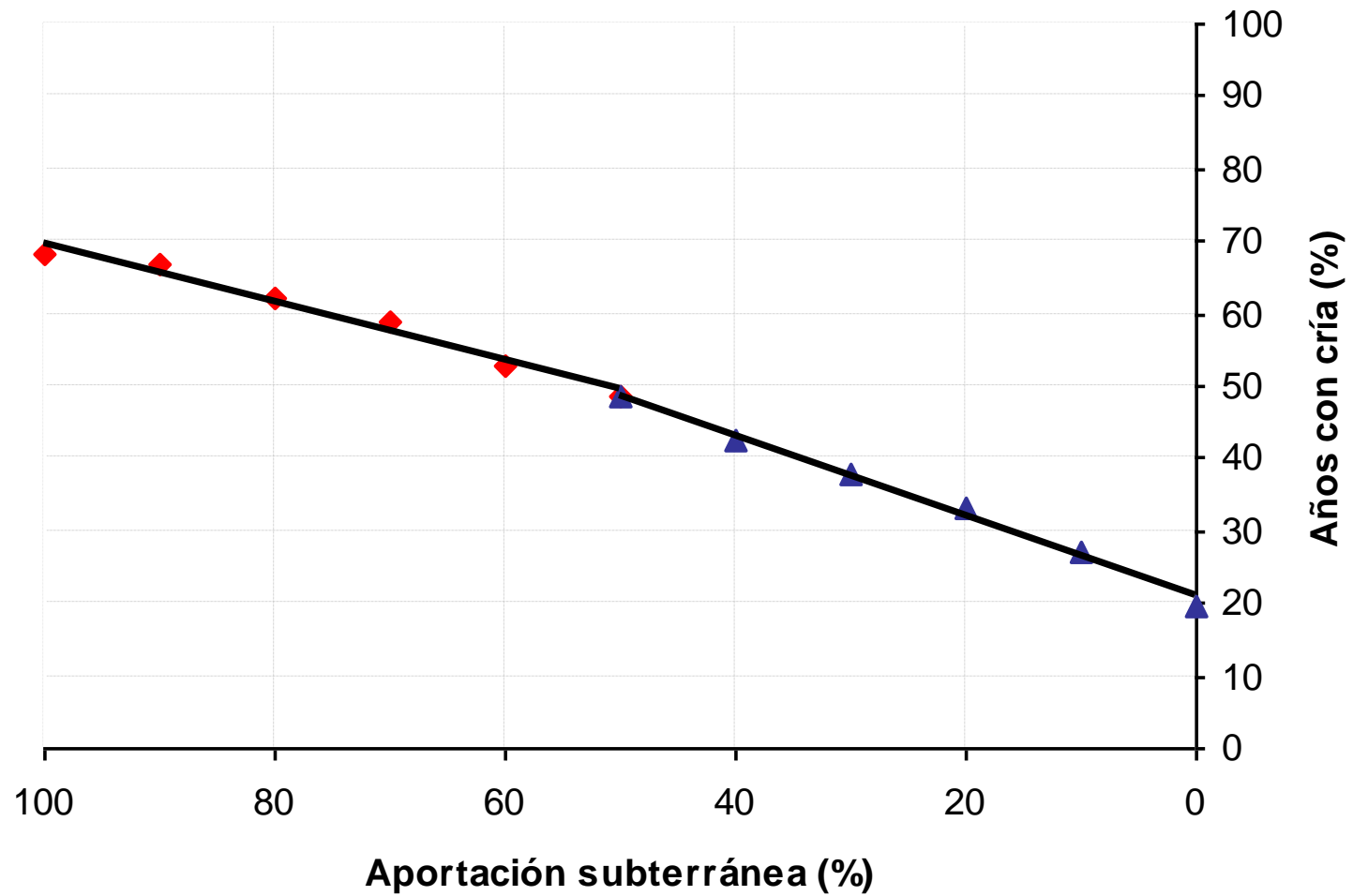
THEORETHICAL BREEDING HIT



MODELLING SCENARIOS



A PROPER TOOL TO TAKE DECISION



SAN PEDRO RIVER

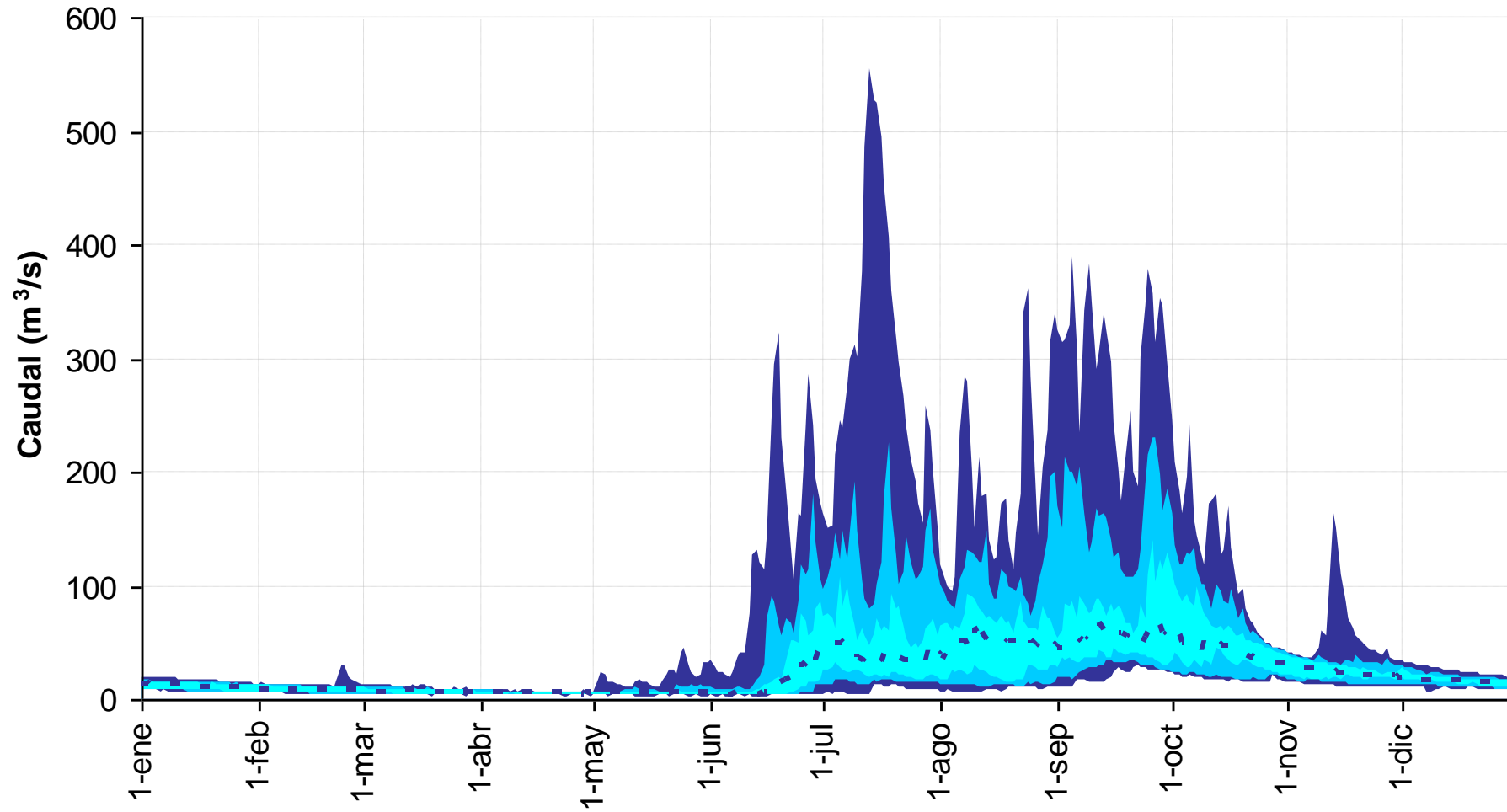




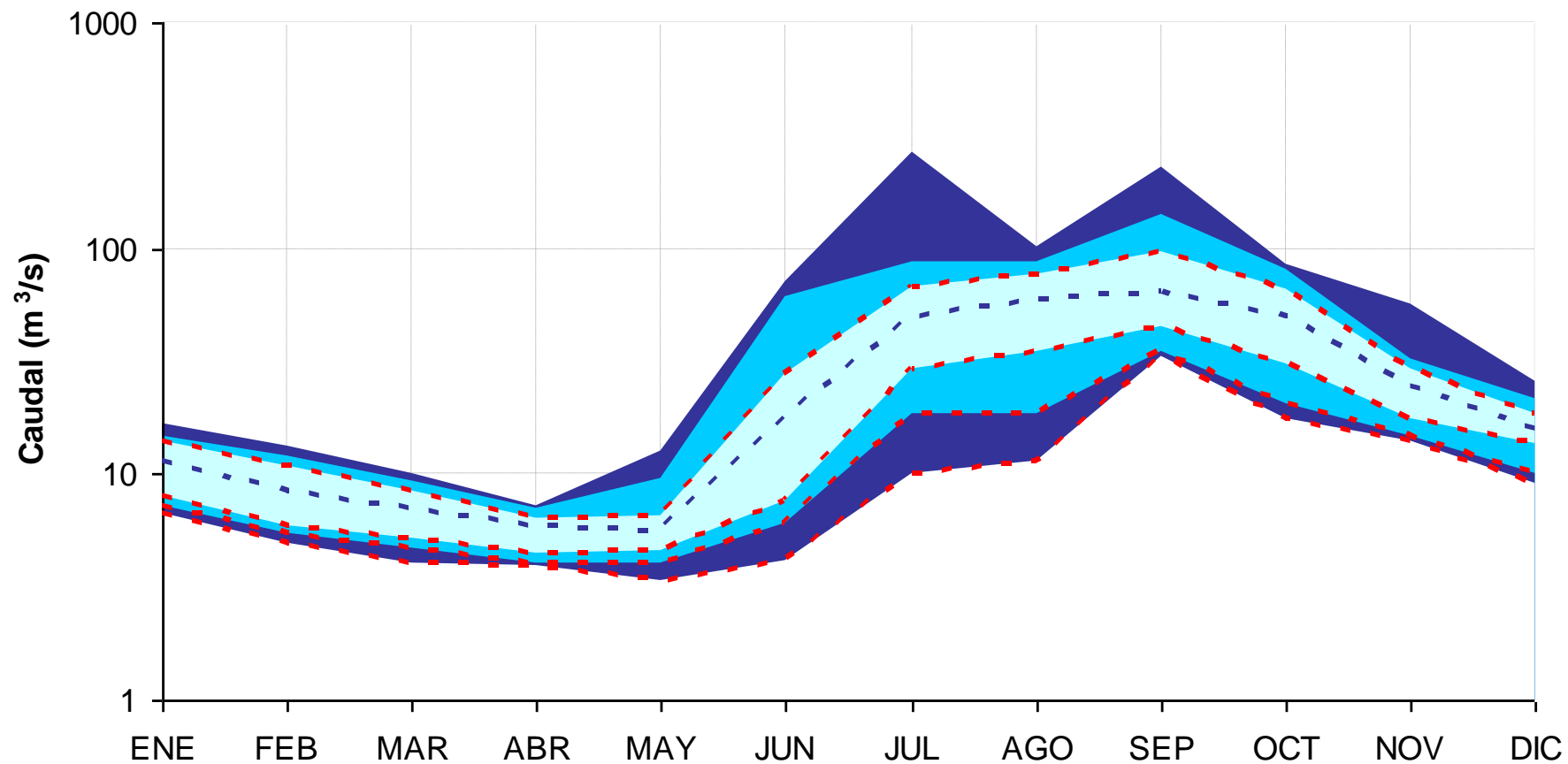




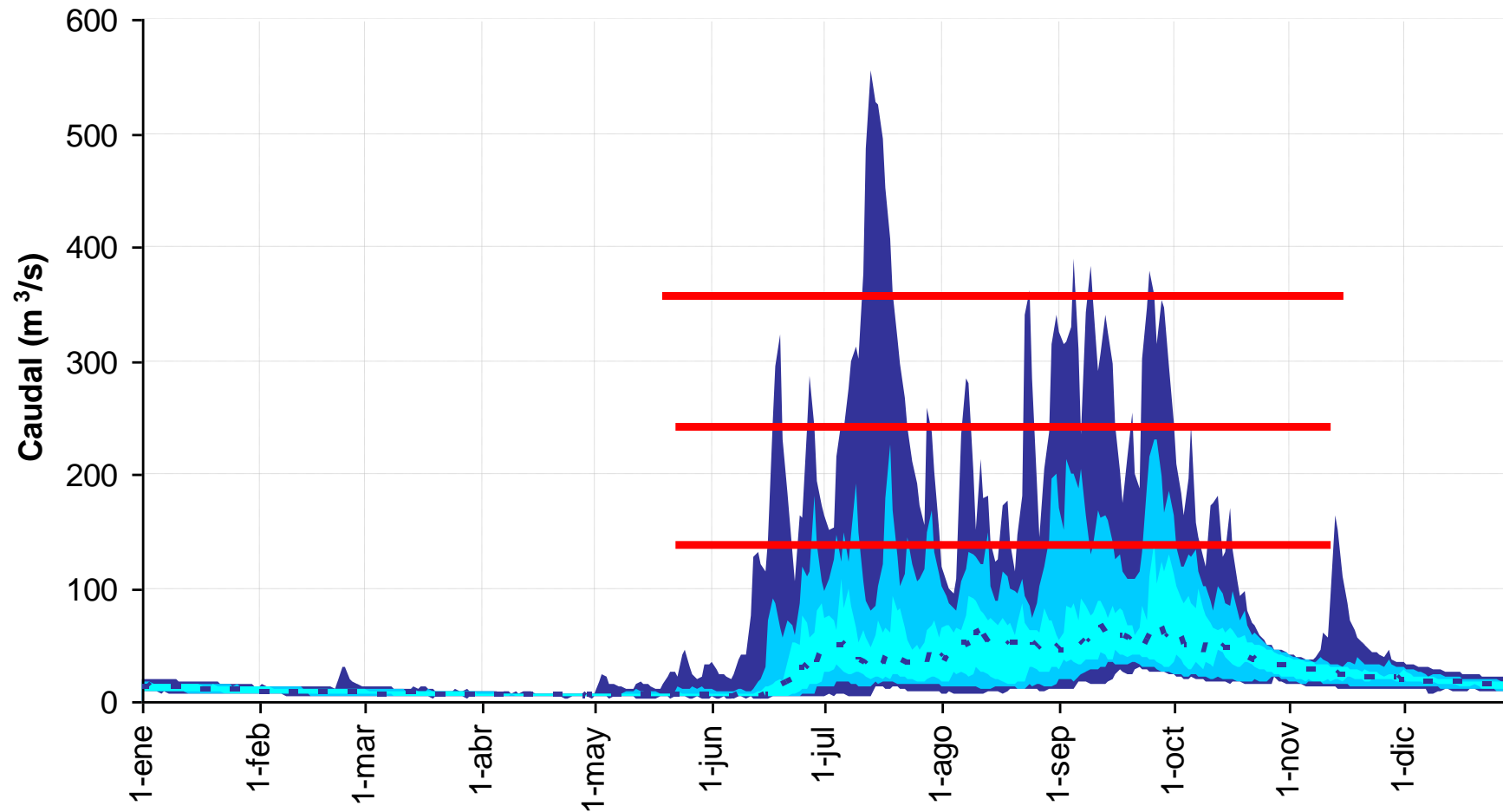
NATURAL FLOW DAILY VAUES



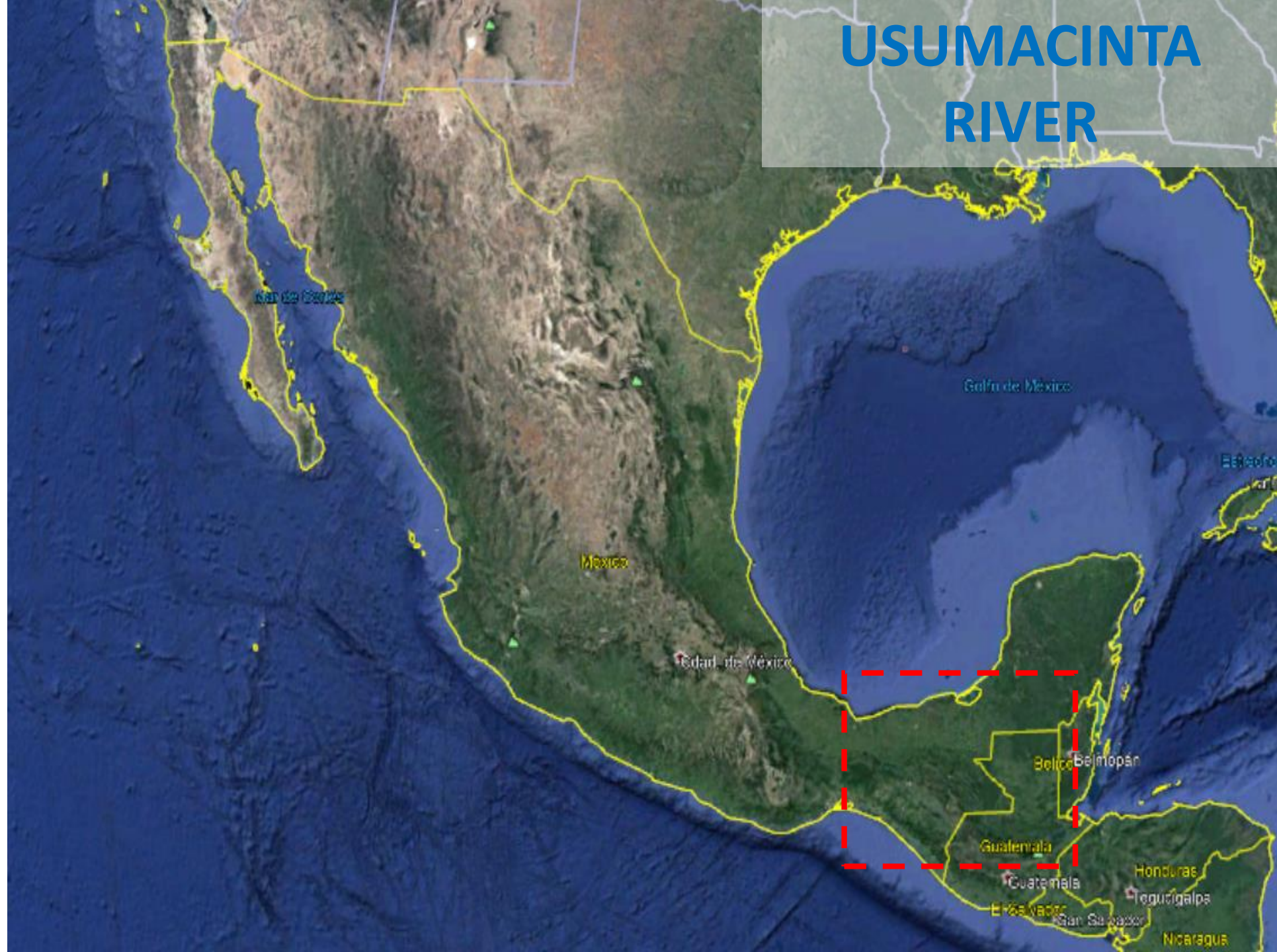
NATURAL FLOW MONTHLY VALUES



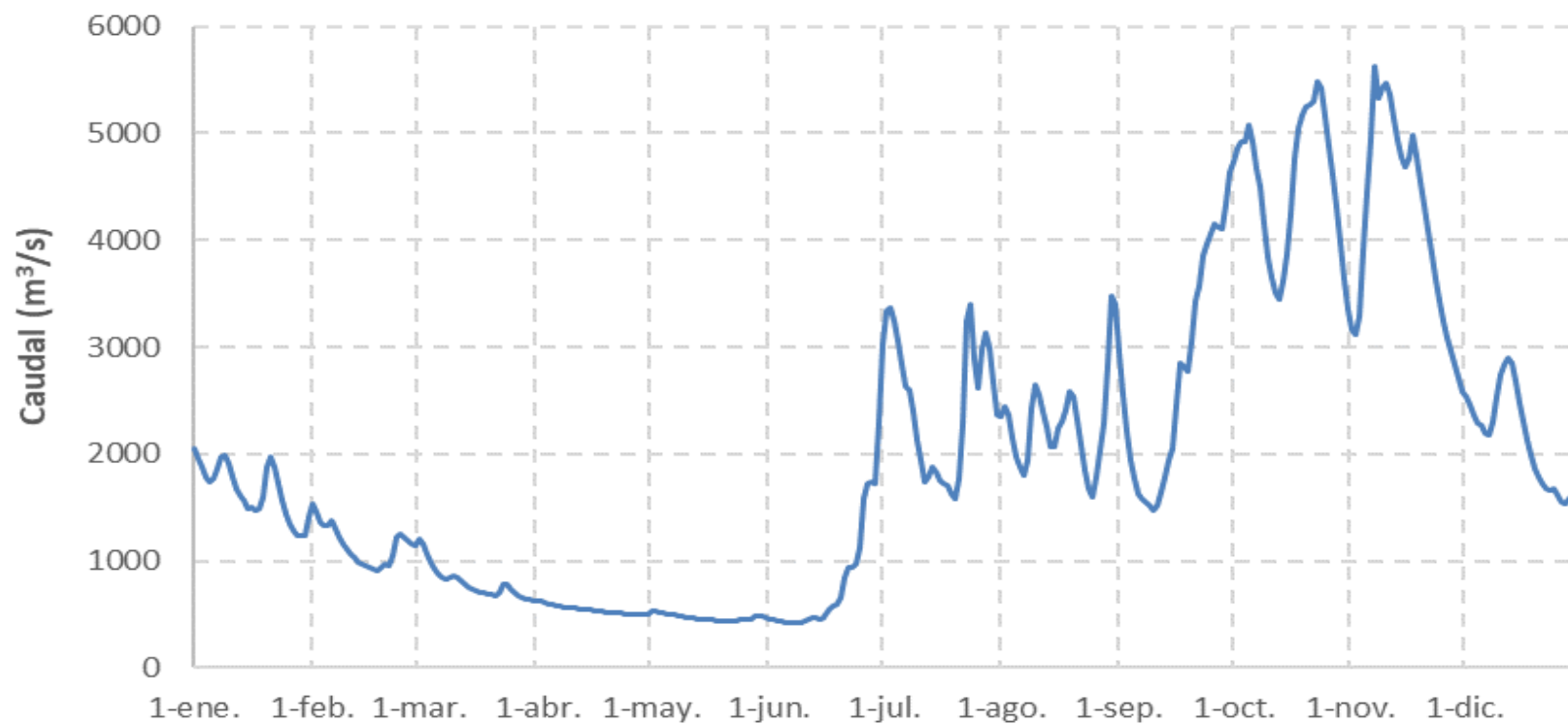
FLOOD REGIME



USUMACINTA RIVER



DAILY DISCHARGE



1965

62580 hm^3









FISH SPECIES COMPOSITION



Zona				Z1	Z2	Z3		
Especies (31)	Nombre común	Importancia	Grupo trofico	LL (12)	T (8)	LL (11)	T (17)	LL (19)
<i>*Ariopsis felis</i> (LC-IUCN)	Curuco		Carnivoro	R	R		D	
<i>Atractosteus tropicus</i>	Pejelagarto	Comercial	Carnivoro	R				
<i>*Bagre marinus</i> (LC-IUCN)	Bagre	Comercial	Carnivoro					R
<i>*Bairdiella chrysoura</i> (LC-IUCN)	Ronco amarillo		Carnivoro				A	
<i>Centropomus parallelus</i> (LC-IUCN)	Chucumite	Comercial	Carnivoro				R	
<i>Centropomus undecimalis</i> (LC-IUCN)	Robalo blanco	Comercial	Carnivoro				R	R
<i>Cribroheros robertsoni</i>	Pez azul	Comercial	Carnivoro			R		
<i>*Ctenogobius claytonii</i> VU (IUCN)	Gobio mexicano		Omnivoro				R	
<i>Ctenopharyngodon idella</i>	Carpa herbívora	Comercial	Herbívoro	R	F	R	R	R
<i>*Dormitator maculatus</i> (LC-IUCN)	Topen	Comercial	Herbívoro					D
<i>*Dorosoma anale</i> (LC-IUCN)	Arenga		Carnivoro	R	F	R	D	R
<i>*Dorosoma petenense</i> (LC-IUCN)	Arenga		Carnivoro		D	A		
<i>*Eleotris pisonis</i> (LC-IUCN)	Guavina		Carnivoro				R	
<i>*Elops saurus</i> (LC-IUCN)	Macabíl		Carnivoro				R	
<i>*Eugerres mexicanus</i> (LC-IUCN)	Pichincha		Omnivoro	D				
<i>*Guavina guavina</i> (LC-IUCN)	Guavina		Carnivoro					R
<i>*Ictalurus furcatus</i> (LC-IUCN)	bobo liso	Comercial	Carnivoro					D
<i>*Mayaheros urophthalmus</i> (P-NOM 059)	Castarrica	Comercial	Detritívoro	R	D	D		F
<i>*Megalops atlanticus</i> (VU-IUCN)	Sabalo	Comercial	Carnivoro	R			D	D
<i>*Microphis brachyurus</i> (LC-IUCN)	Pez pipa		Carnivoro				R	R
<i>*Mugil cephalus</i> (LC-IUCN)	Lisa	Comercial	Carnivoro				F	R
<i>Oreochromis aureus</i>	Tilapia	Comercial	Detritívoro					R
<i>Oreochromis niloticus</i>	Tilapia	Comercial	Detritívoro					R
<i>Oscara heterospila</i>	Mojarra de montecristo	Comercial	Omnivoro	R		R	F	R
<i>Petenia splendida</i>	Tenhuayaca	Comercial	Carnivoro	D	R	R		R
<i>Pterygoplichtys disjunctivus</i>	pez diablo		Detritívoro	D	R	F	D	A
<i>Pterygoplichtys pardalis</i>	pez diablo		Detritívoro	D	A	F	D	A
<i>*Rhamdia guatemalensis</i> (Pr-NOM 059)	Juil		Carnivoro	R			F	D
<i>Rocio octofasciata</i>	Mojarra	Comercial	Carnivoro			R		
<i>Trichromis salvini</i>	mojarra de Santa Isabel	Comercial	Omnivoro			R		R
<i>*Trinectes maculatus</i> (LC-IUCN)	Lenguado		Carnivoro				R	

Jerarquización de especies

Dominante = D

Abundante = A

Frecuente = F

Rara = R

Temporadas:

Transición= T

Lluvia= LL

55 especies

20 sp en protección

* sp en estatus de conservación

Comerciales

17

6

3

7

6

13

Migratorias

4

1

1

1

3

2

sp. Estuarino-marino

6

0

0

0

4

3

CONSERVATION OBJECTIVES

FAUNA

Centropomus undecimalis (robalo blanco)

Centropomus parallelus (chucumite)

Megalops atlanticus (sábalo)

Atractosteus tropicus (pejelagarto)

**Potamarius nelsoni* (bagre lacandón)

**Rhamdia guatemalensis* (juil)

**Eugerres mexicanus* (mojarra blanca)

Crocodyllus moreletii (cocodrilo de pantano)

Dermatemys mawii (tortuga blanca)

Trichechus manatus (manatí)

Lontra longicaudis (nutria de río)

Alouatta pigra (mono aullador)

Amazona albifrons (Loro frente blanca)

Ara macao (Guacamaya)



FLORA

Haematoxylum campechianum (tinto)

Rhizophora mangle (mangle rojo)

Avicennia germinans (mangle negro)

Laguncularia racemosa (mangle blanco)

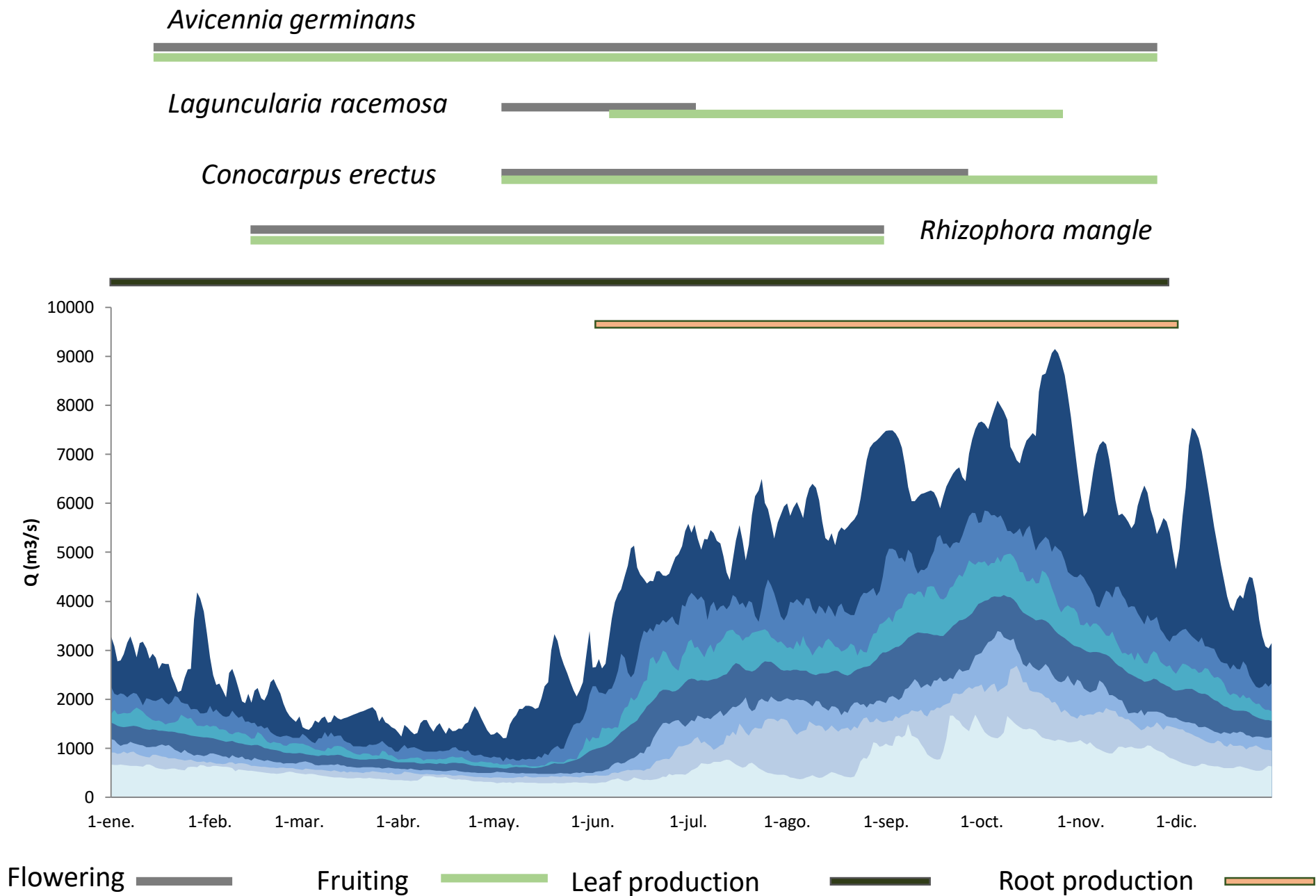
Conocarpus erectus (mangle botoncillo)

Pachira aquatica (zapote de agua)

Annona glabra (anona)



HYDROECOLOGICAL MODEL OF THE USUMACINTA RIVER





Food resources for *Alouatta pigra* and *Trichechus manatus*



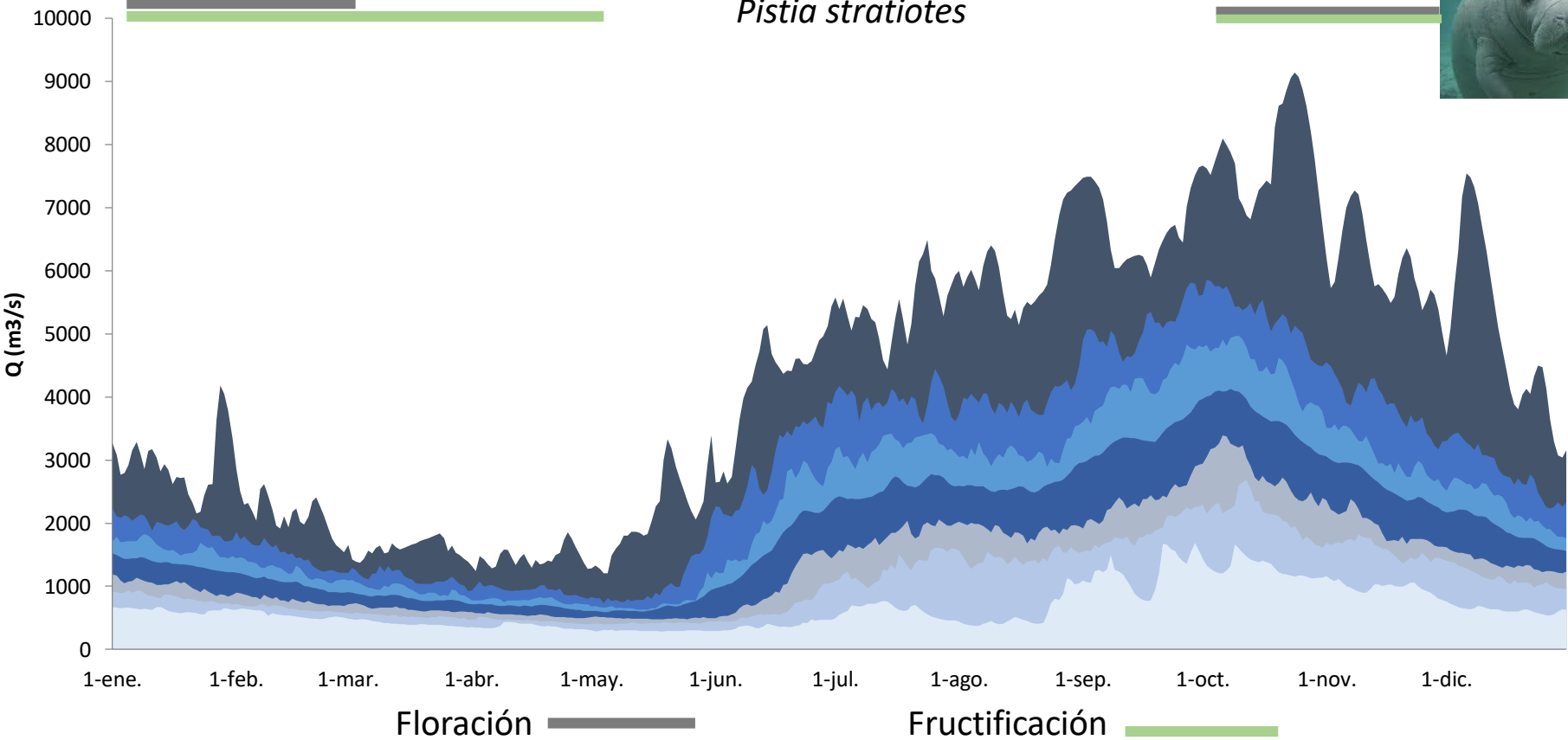
Brosimum alicastrum

Pithecellobium lanceolatum

Spondias radlkoferi

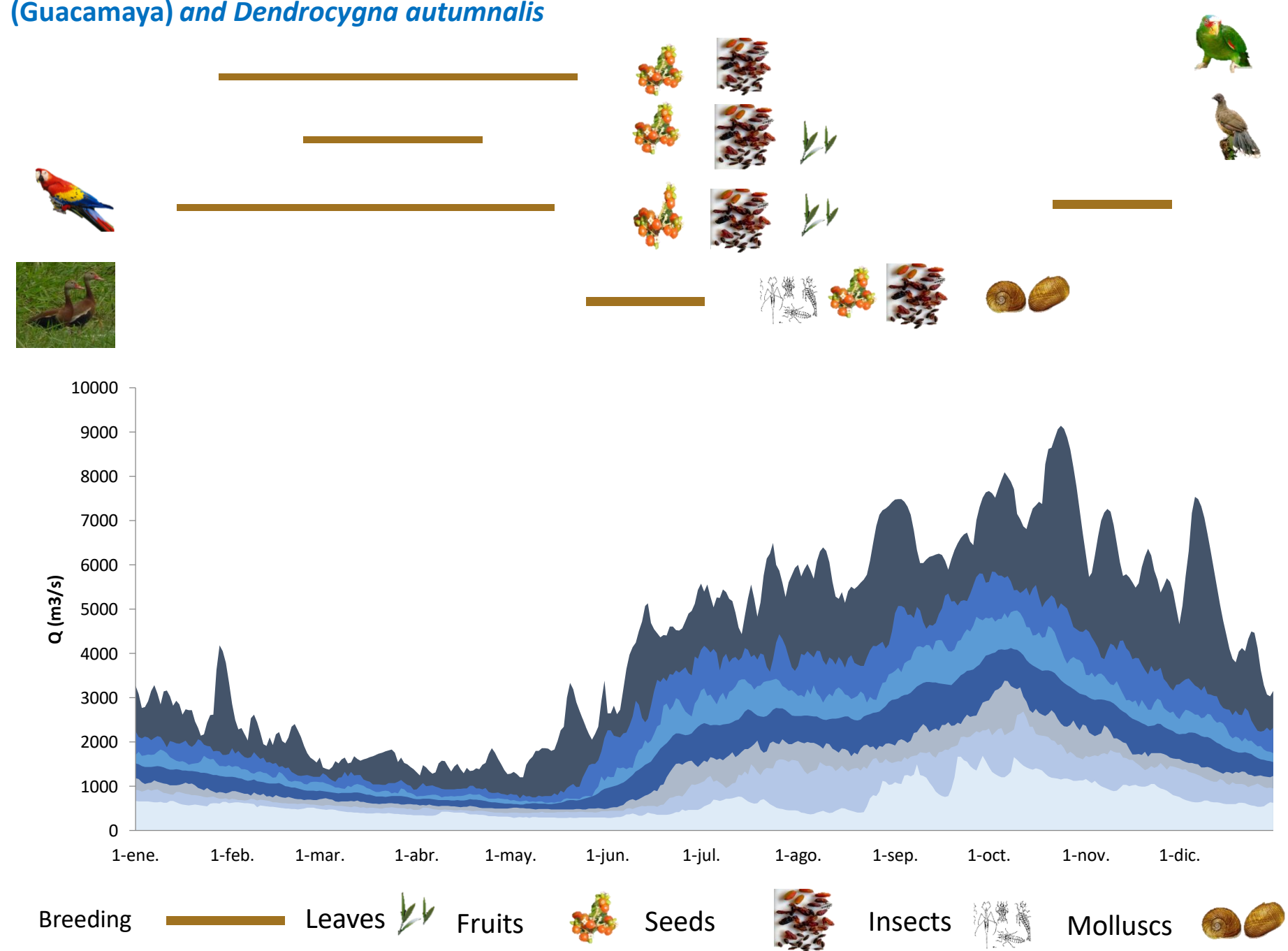
Eichhornia crassipes

Pistia stratiotes

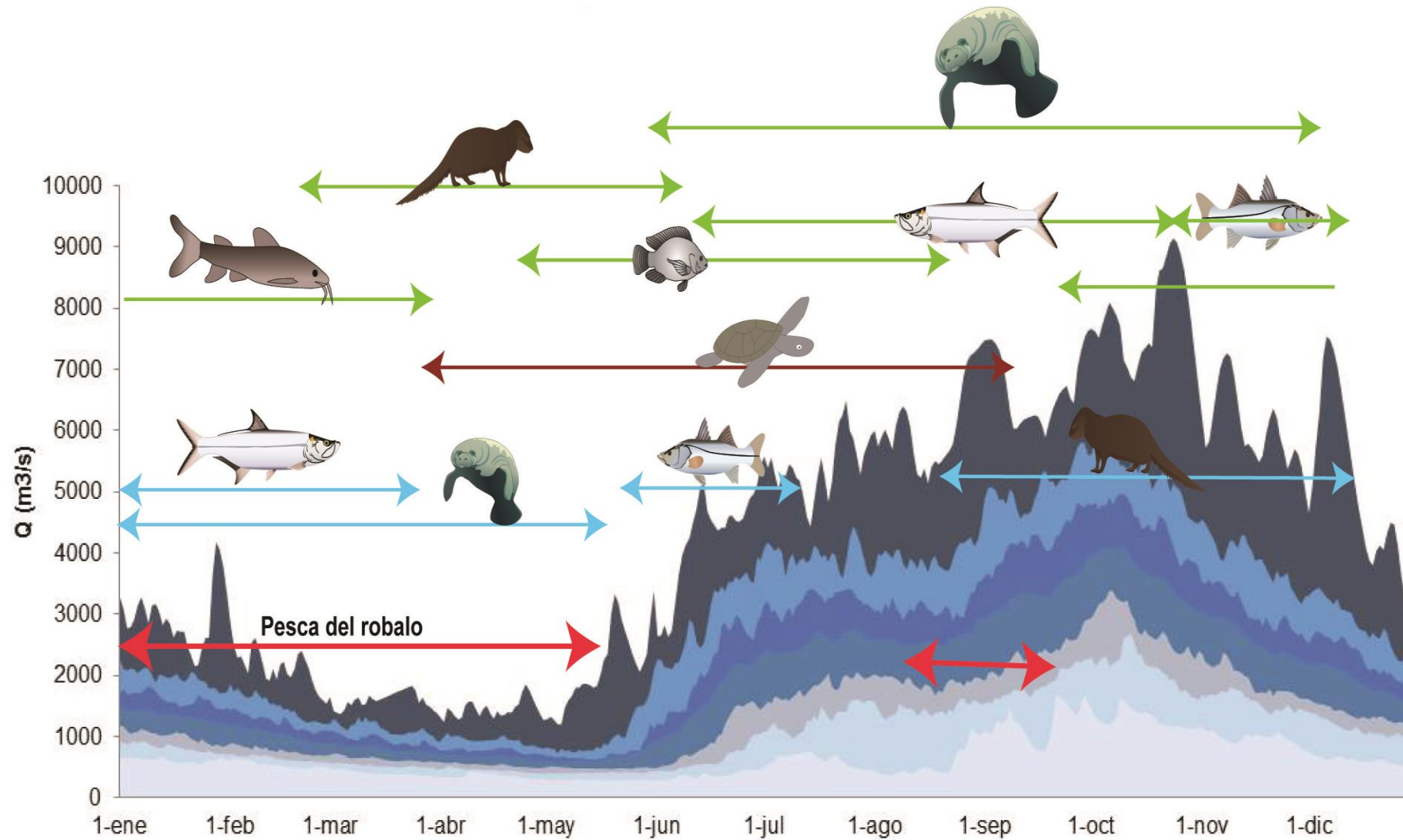




Food resources for *Amazona albifrons* (Loro frente blanca), *Ortalis vetula* (Chachalaca), *Ara macao* (Guacamaya) and *Dendrocygna autumnalis*

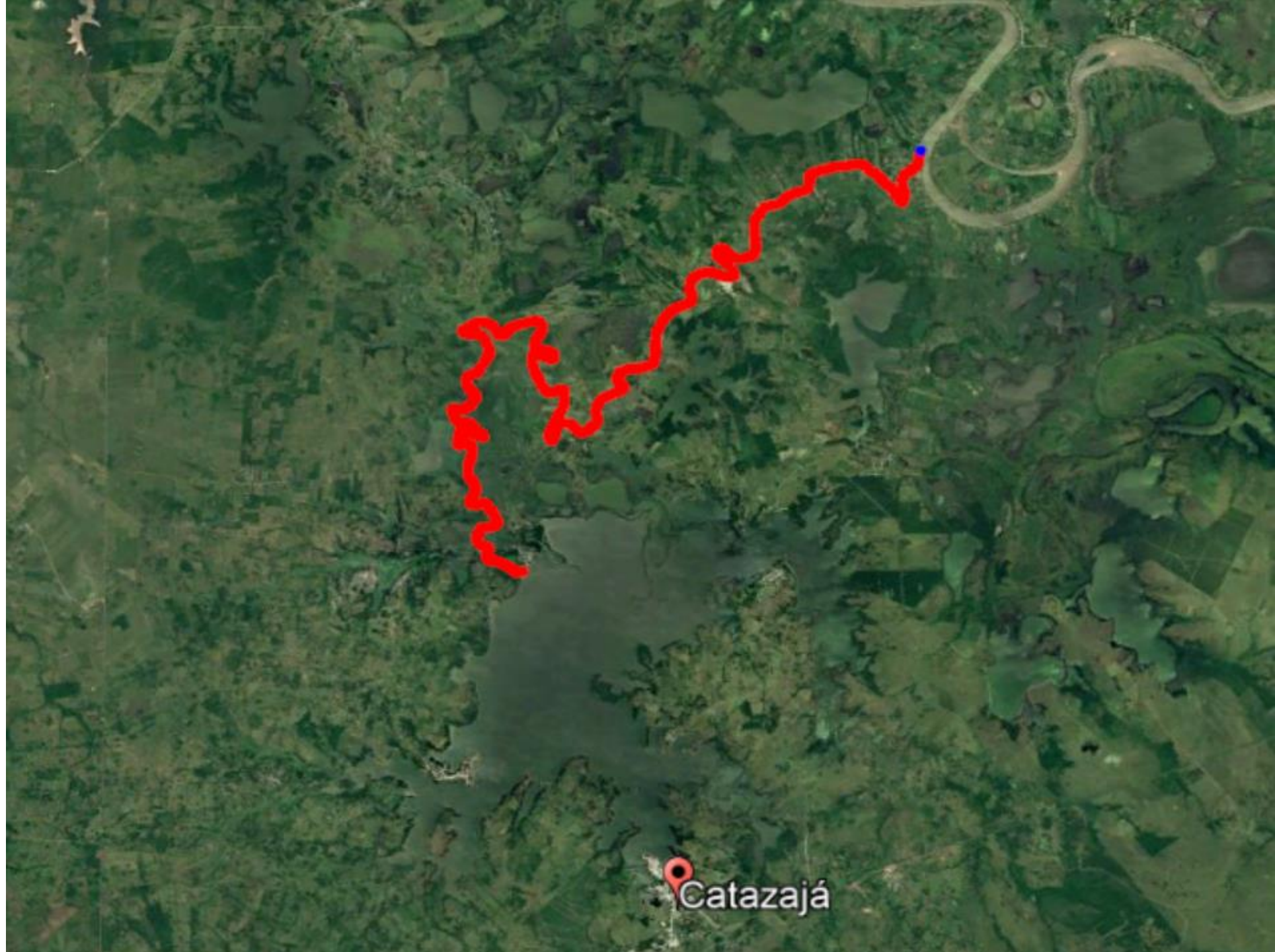


HYDROECOLOGICAL MODEL OF THE USUMACINTA RIVER





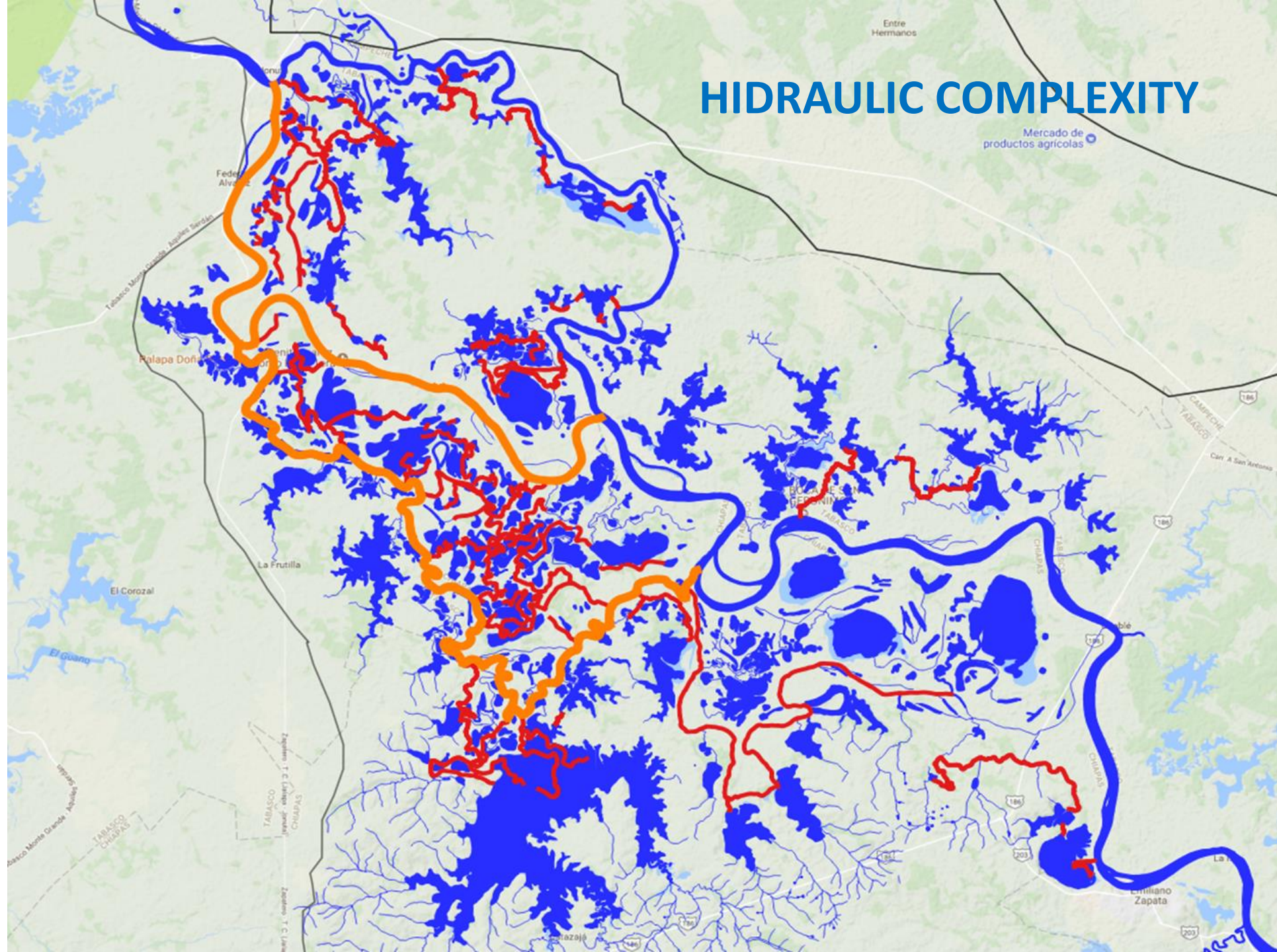
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HIDRAULIC COMPLEXITY



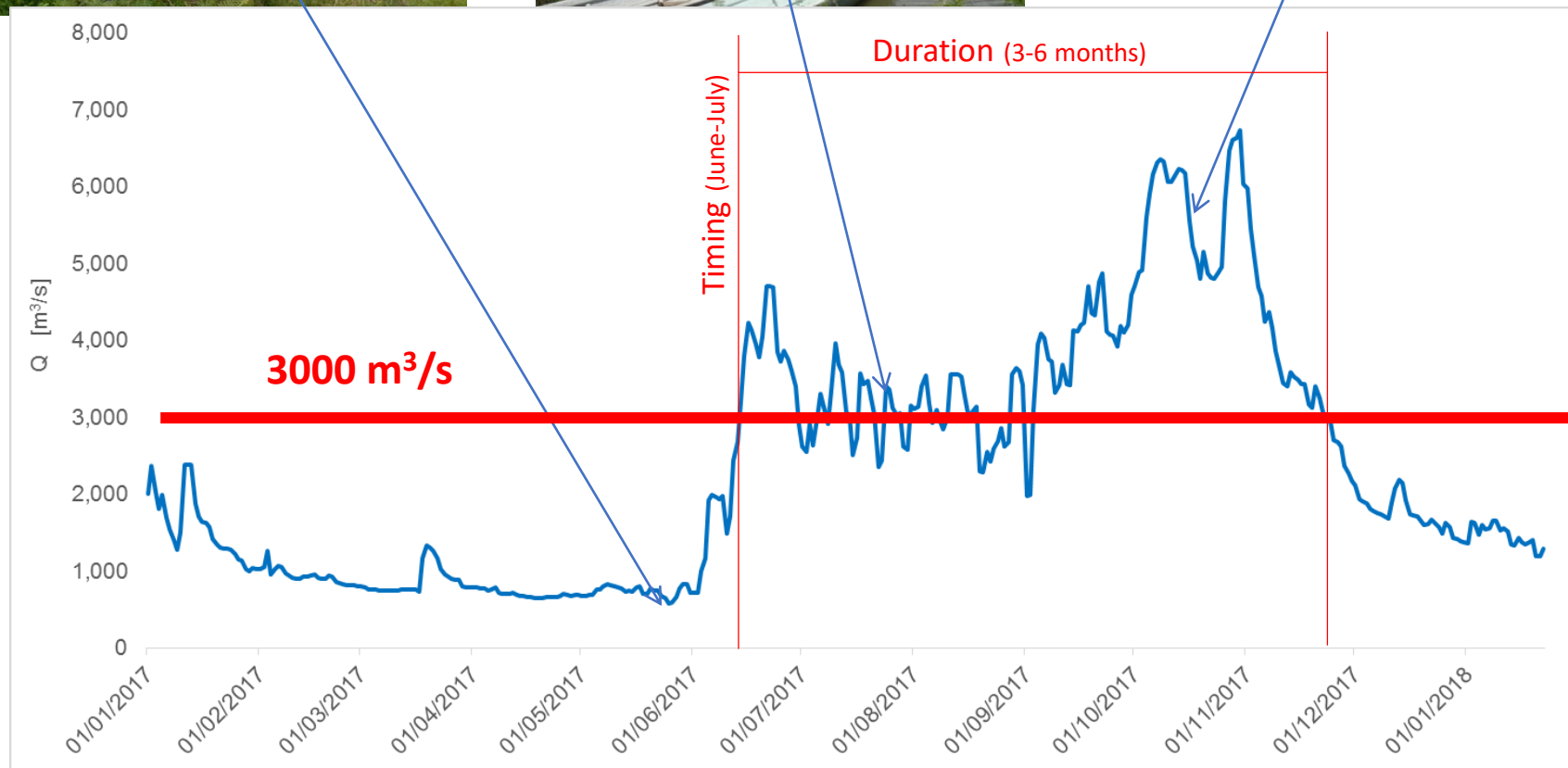
JUNE 2017



AUGUST 2017

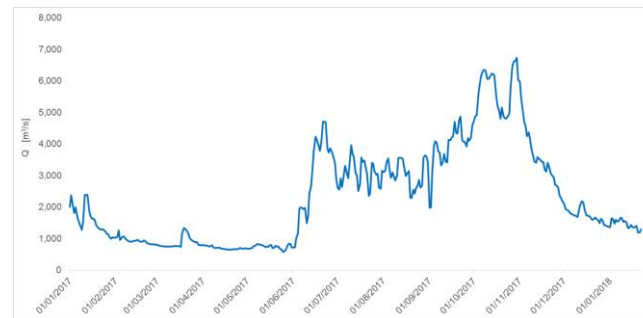
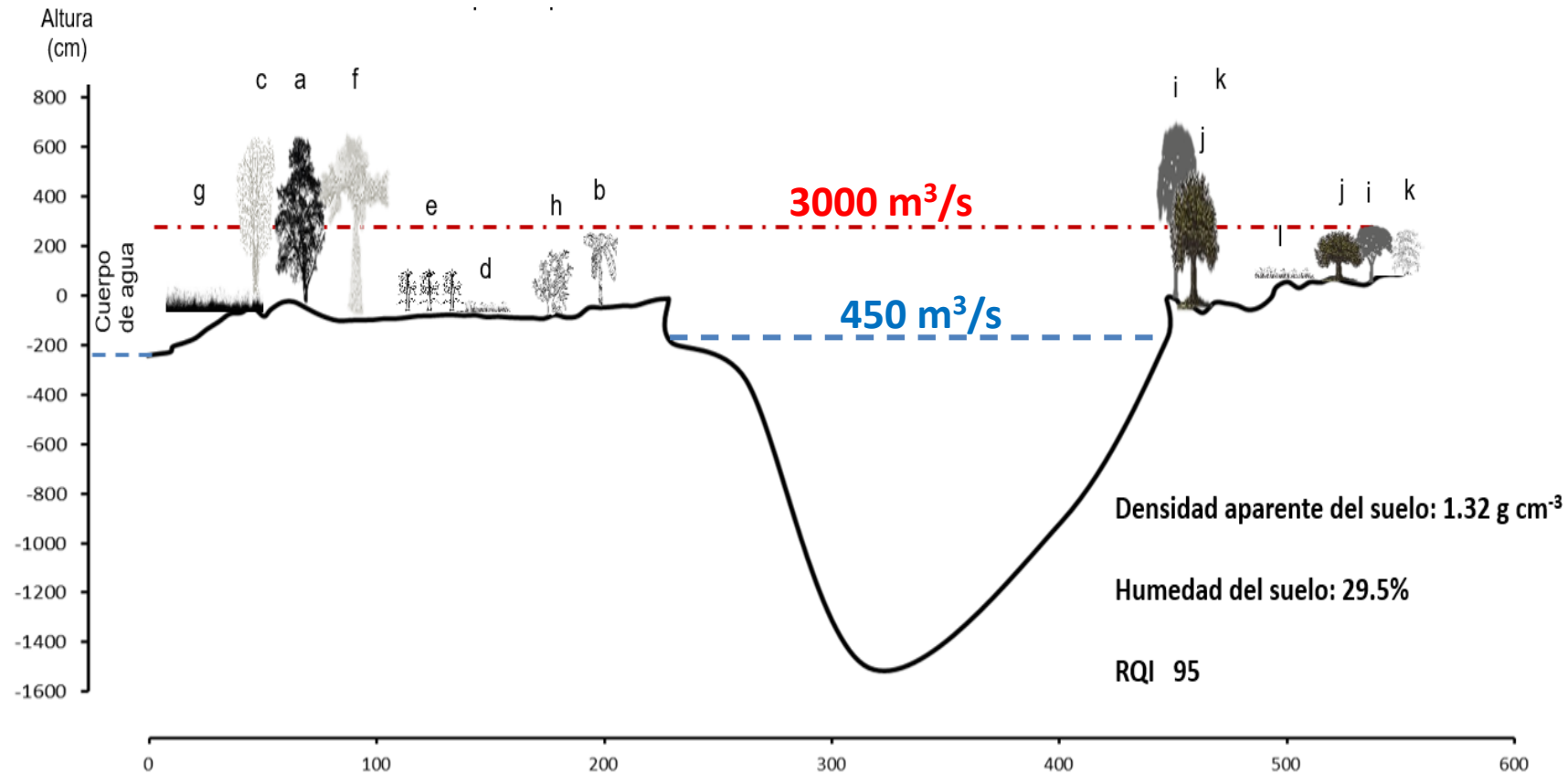


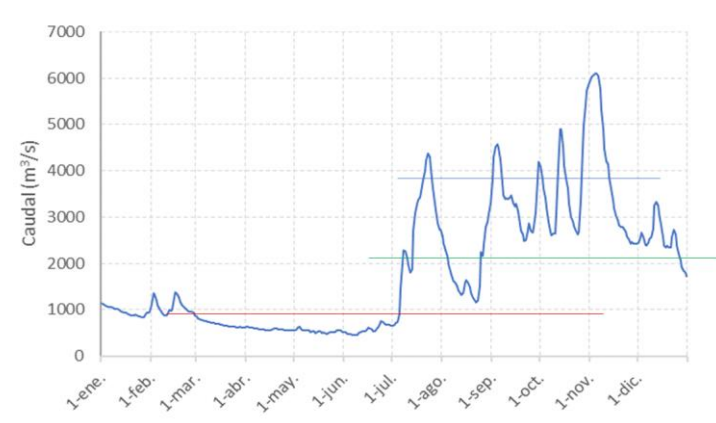
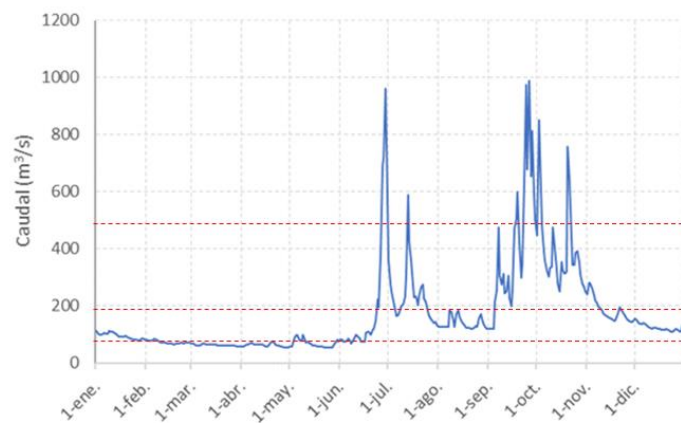
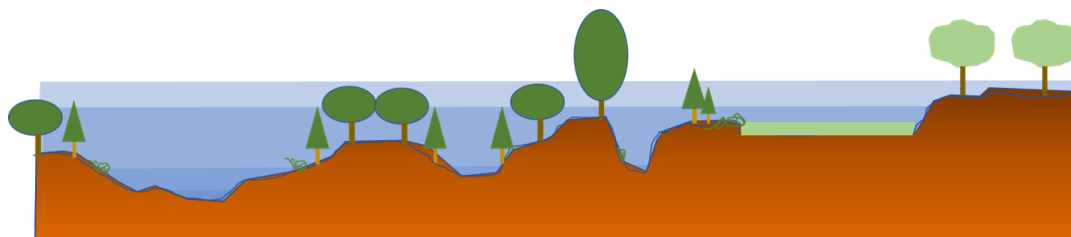
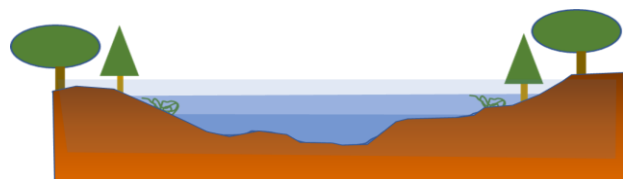
OCTOBER 2017





VEGETATION vs DISCHARGE

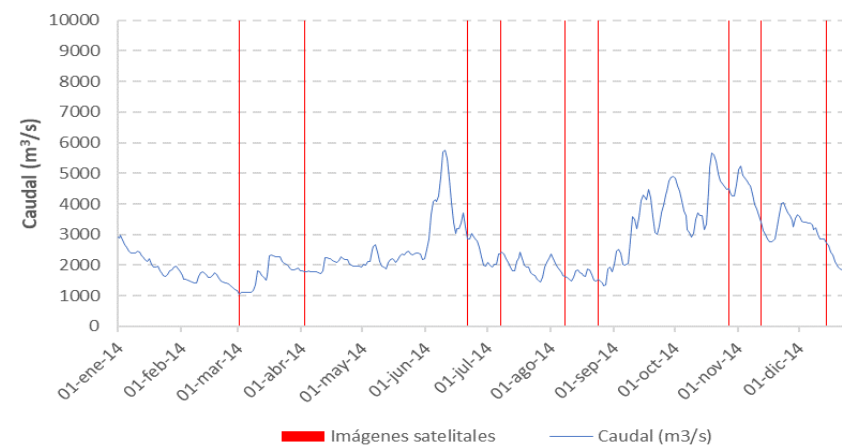
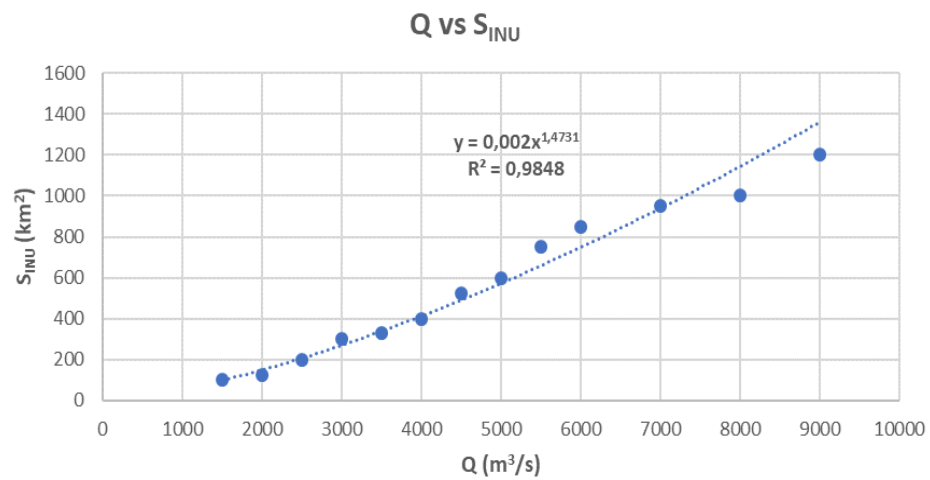
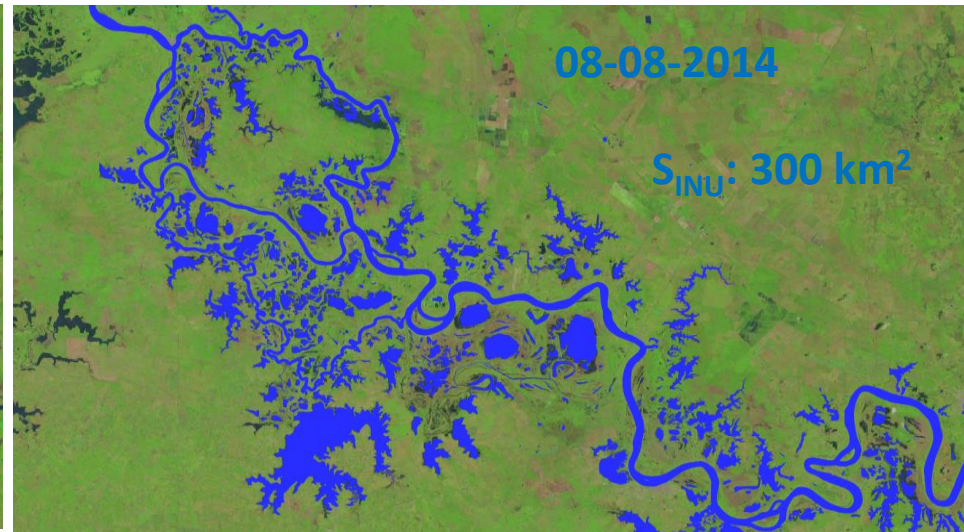
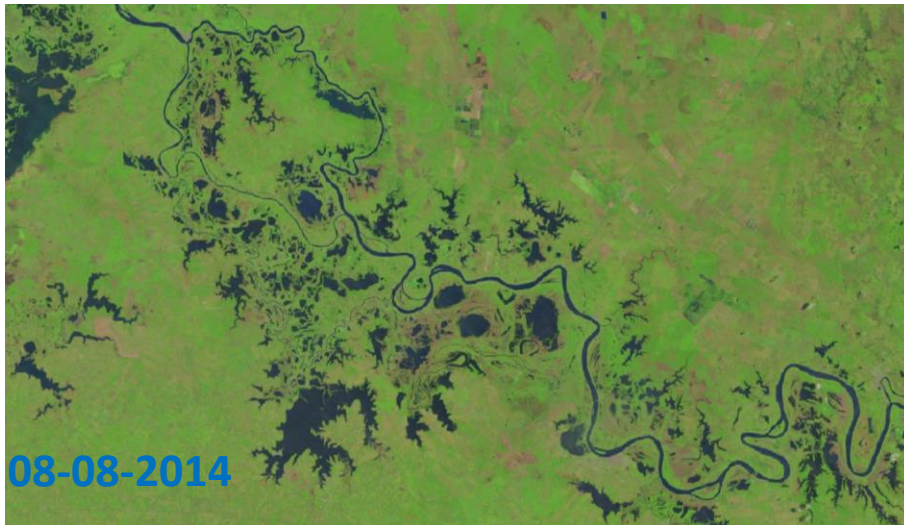




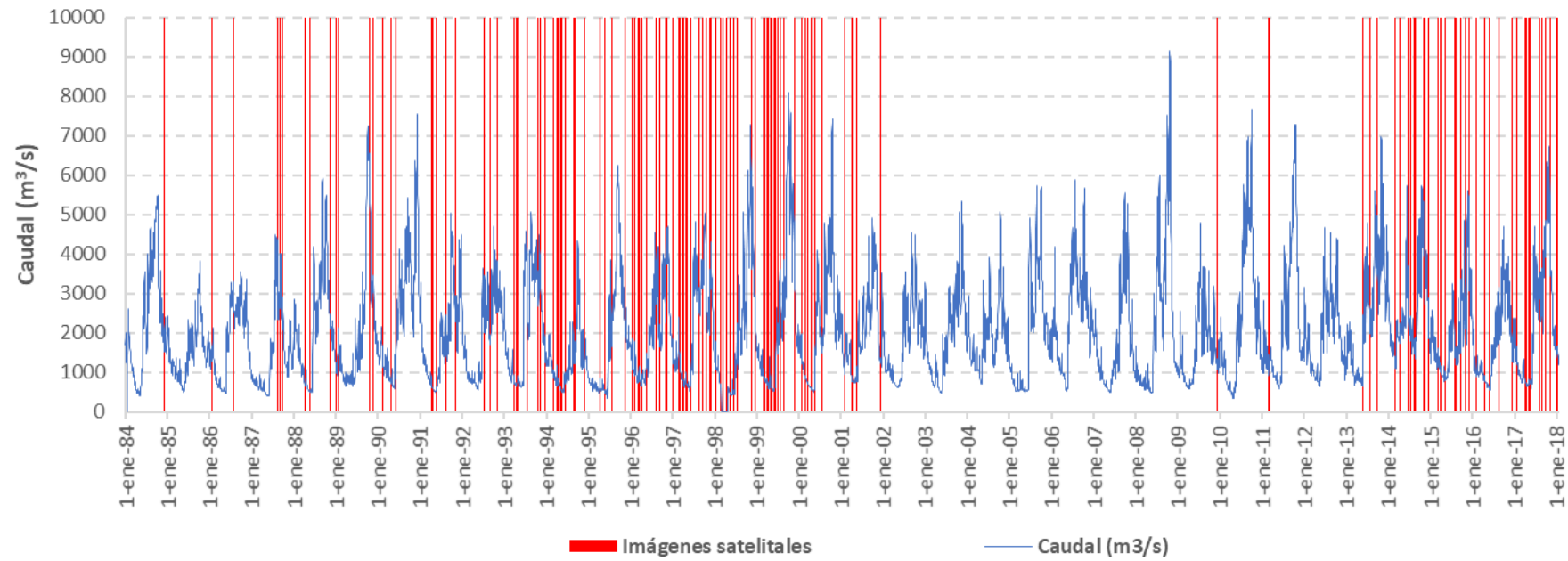
HOW TO DEAL THIS COMPLEXITY OF THE SYSTEM?



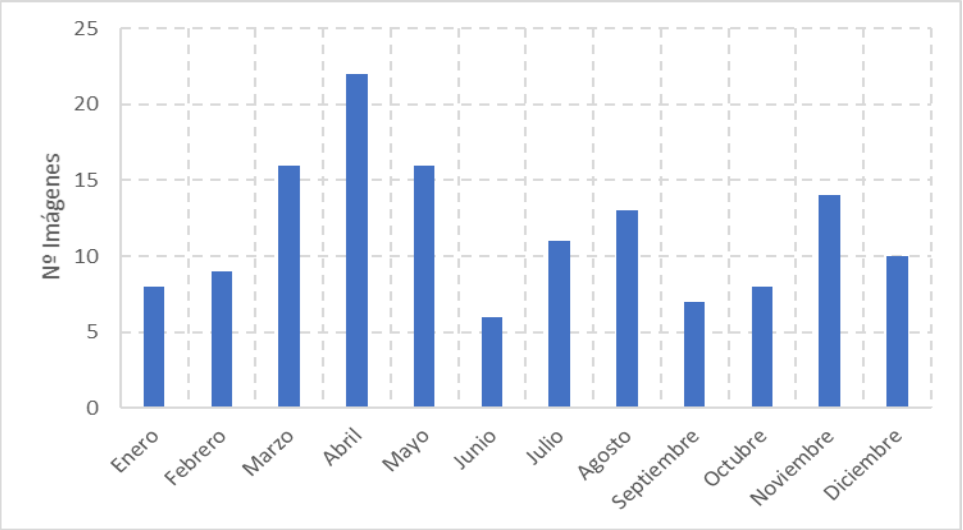
FLOODED AREA vs DISCHARGE

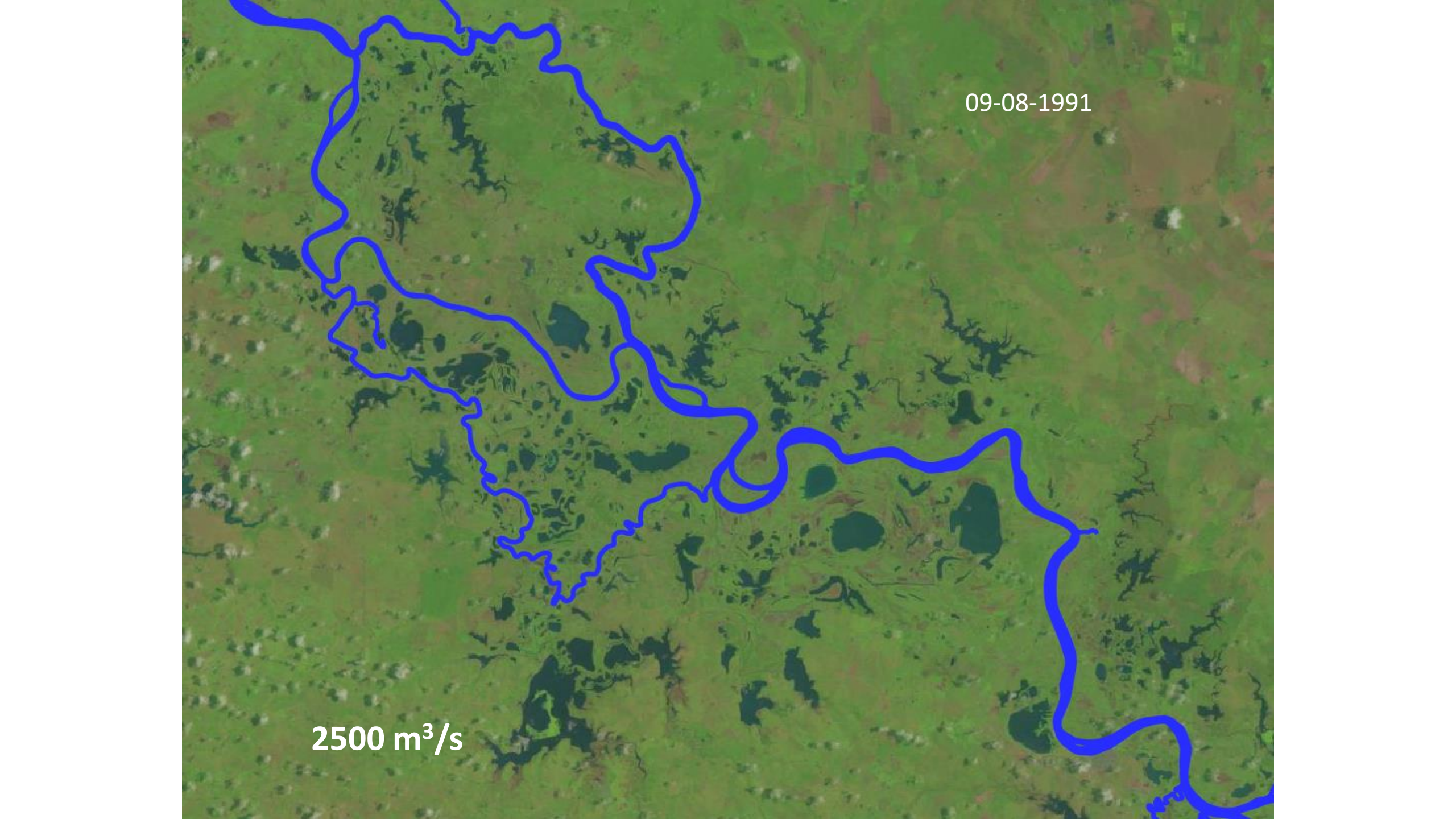


ANALYSIS OF SATELLITE IMAGES



140 LANDSAT IMAGES



A satellite image of a landscape with a river network. A thick blue line traces a path through the network, starting from the top left and moving towards the bottom right. The landscape is a mix of green and brown, with numerous small, dark, irregular shapes scattered throughout, likely representing water bodies or wetlands. The blue line follows a major channel that branches out in several places.

09-08-1991

2500 m³/s

A satellite map of a river network, likely in a forested area. The map shows a complex network of dark, winding lines representing rivers and streams. A prominent blue line traces a specific path through the network, starting from the top left and moving towards the bottom right. The background is a mosaic of green and brown patches, indicating different land cover types. The date '26-07-1986' is printed in the upper right, and the flow rate '3500 m³/s' is printed in the lower left.

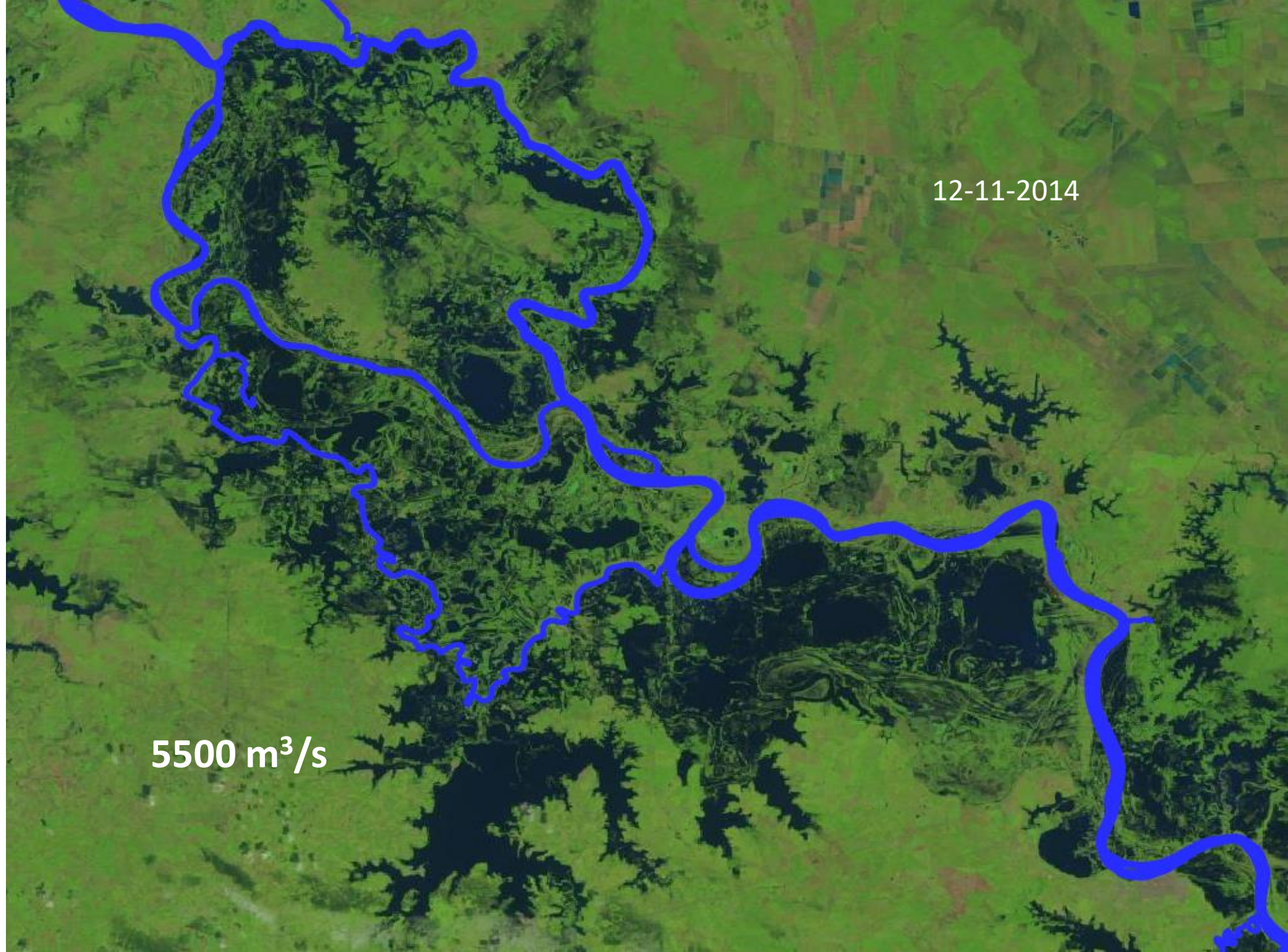
26-07-1986

3500 m³/s



13-07-1993

4000 m³/s



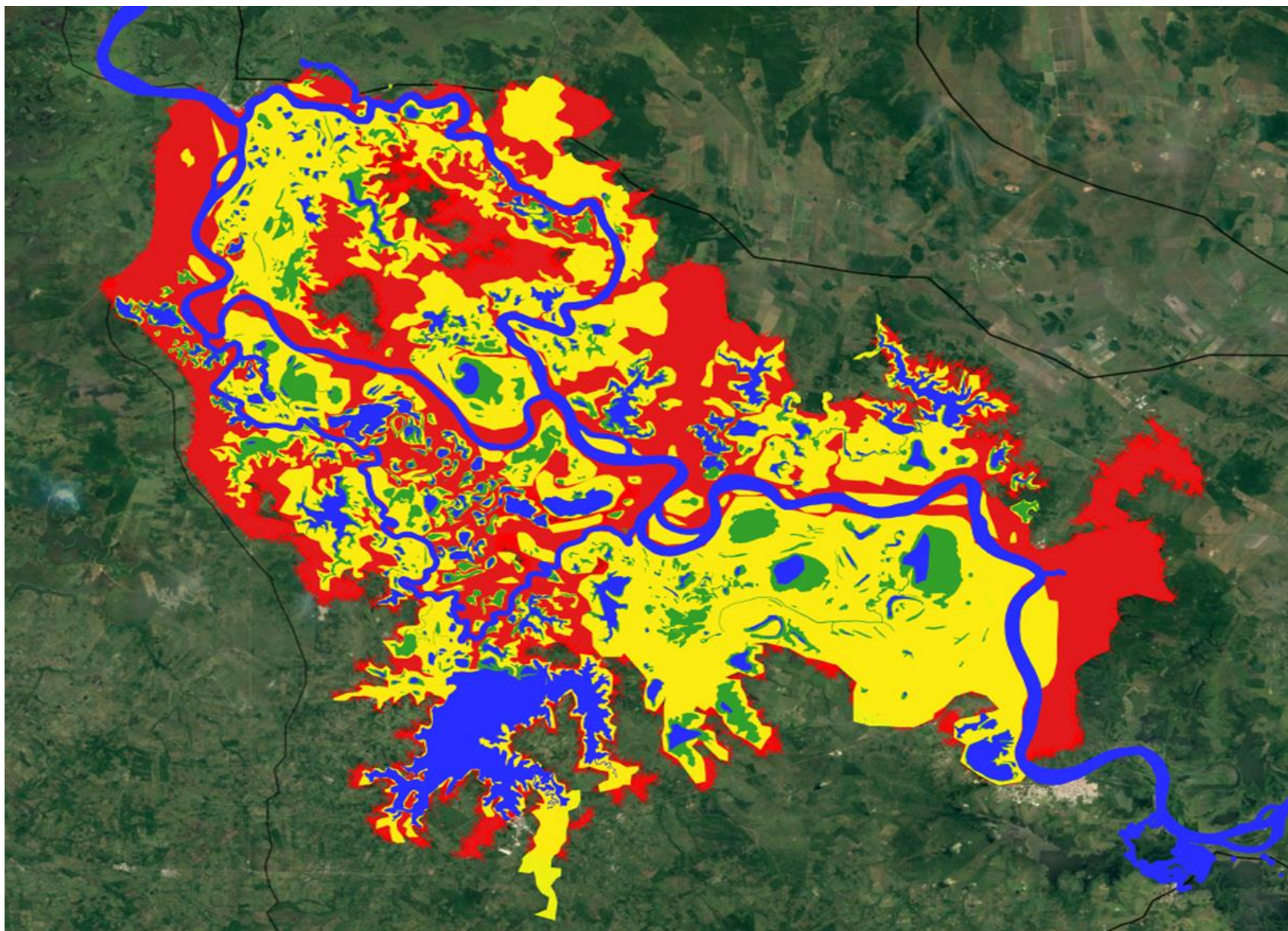
12-11-2014

5500 m³/s

An aerial photograph of a forested landscape. A thick blue line traces a winding path or river through the dense green forest. The path starts from the top left, moves towards the center, and then continues towards the bottom right. The forest is composed of various shades of green, indicating different types of vegetation. The blue line is prominent against the natural colors of the landscape.

14-10-1989

6500 m³/s



DISCHARGE vs FLOODED AREA

