LIMNOLOGÍA

LICENCIATURA EN GESTIÓN AMBIENTAL
CURE/Facultad de Ciencias
UdelaR
Reservorios - Represas – Embalses
goyenola@gmail.com
Maldonado, 2014

CURE
Centro Universitario
de la Región Este

Represa, embalse / Pantano (España) / *Reservoir, dam, impoundment*
RESERVORIOS

Cuerpos de agua construidos o modificados por la actividad humana para propósitos específicos, con el objetivo de proveer un recurso seguro y controlable.

Principales usos:

- Suministro de agua para potabilización
- Suministro para la actividad industrial (enfriamiento, etc.)
- Generación hidroeléctrica
- Riego, cría de ganado
- Regulación de cursos de agua y control de inundaciones
- Recreación, actividades náuticas y otros usos recreacionales
- Disposición de residuos
- Pesquerías comerciales y recreacionales
- Navegación

¡$!

¿UY?

Thornton, J., A. Steel & W. Rast, 1996. Chapter 8. Reservoirs. In Chapman, D. (ed) Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring. 2nd. UNESCO/WHO/UNEP.
http://www.who.int/water_sanitation_health/resourcesquality/wqachapter8.pdf

CURE
Centro Universitario
de la Región Este


OSE, Aguas Corrientes

OSE, Paso Severino


Laguna del Sauce
PROHIBIDO
PASAR
http://www.panoramio.com/photo/41342730?source=wapi&referrer=kh.google.com
2010/09/24 16:33

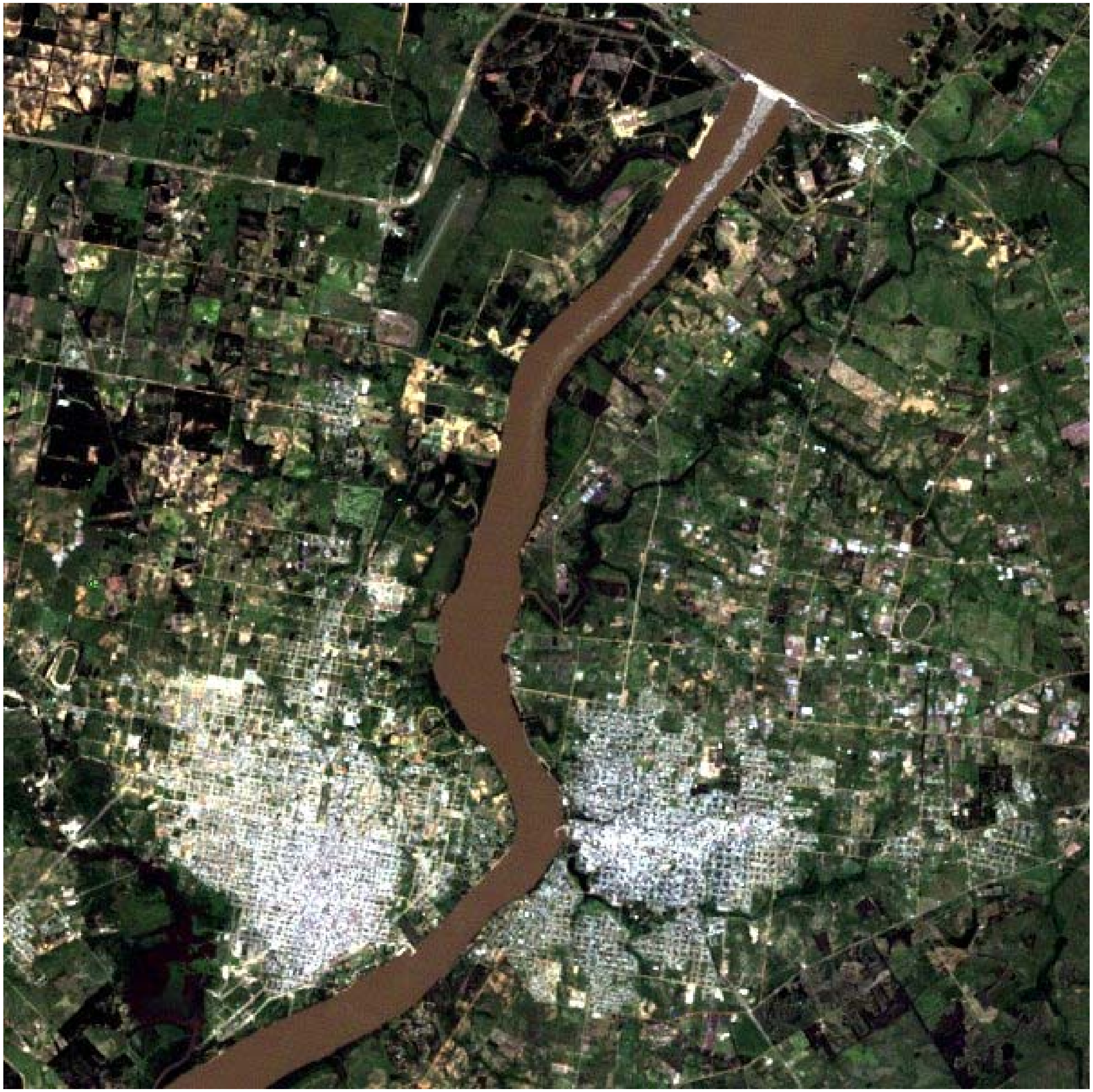

San Francisco (Minas)


San Francisco (Minas)

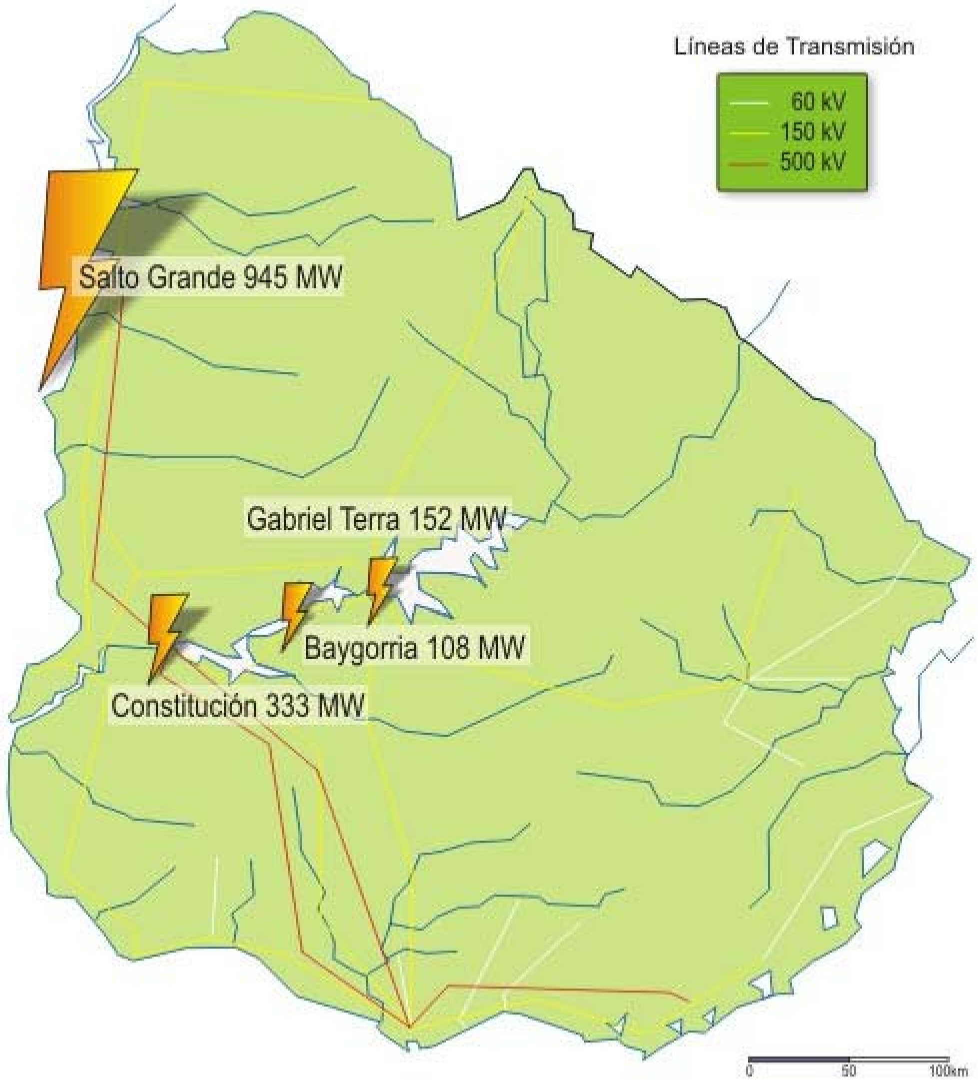
Represa de Cuñapirú (1882)

Salto Grande

CURE
Centro Universitario
de la Región Este



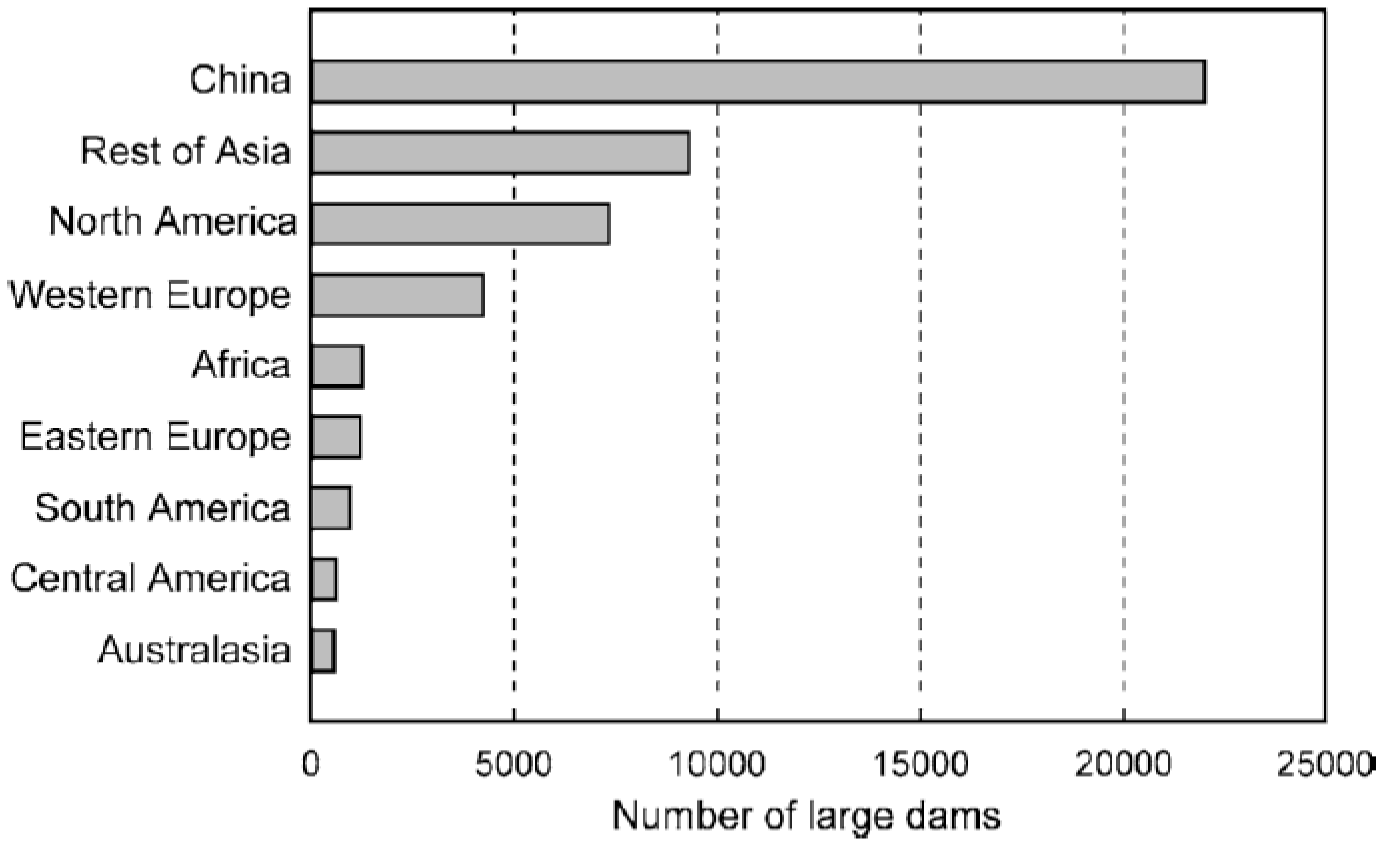
CURE
Centro Universitario
de la Región Este



Centrales Hidroeléctricas
Capacidad Instalada y Líneas de Transmisión

Fuentes: Achkar (2000) y UTE

CURE
Centro Universitario de la Región Este



Allan, J. D. & M. M. Castillo, 2007. Stream Ecology: structure and function of running waters. Springer.

25 per cent of all waters flowing to the oceans have previously been impounded in reservoirs (UNEP, 1991).

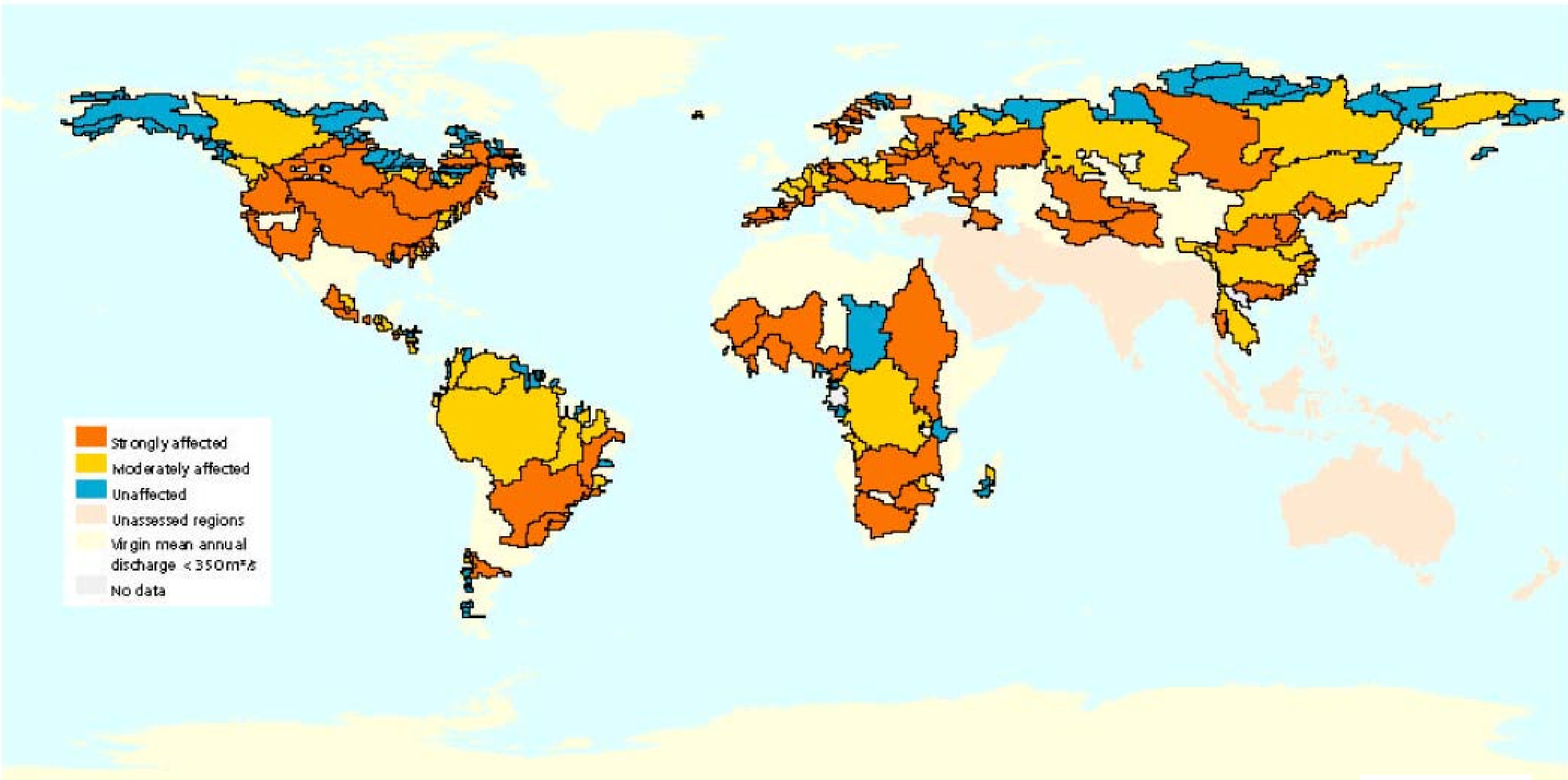
(Thornton et al 1996)

http://www.youtube.com/watch?v=OR5IFcSsaxY#t=12

http://www.youtube.com/watch?v=RPm9LUZDCgg

CURE
Centro Universitario
de la Región Este

Map 1
River Channel Fragmentation and Flow Regulation



Source: Dynesius and Nilsson, 1994 and Nilsson et al., 2000. Watershed boundaries are from Fekete et al., 1999.
Projection: Geographic

América Latina

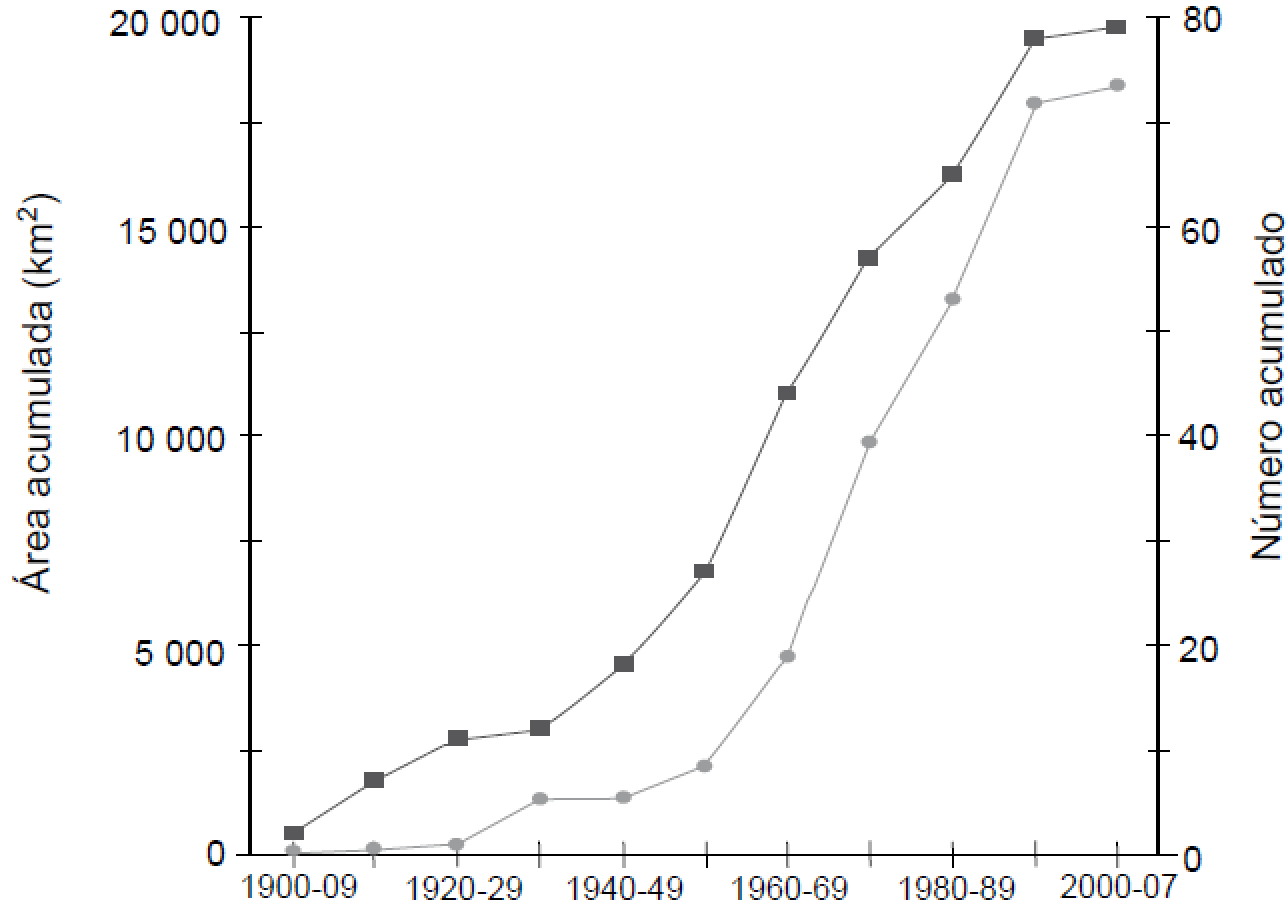
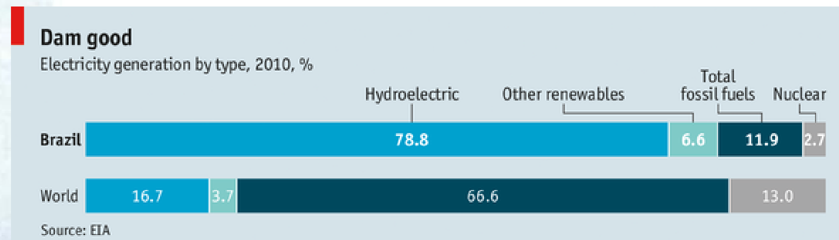


Figura 16.1. Área cubierta por los embalses(■) y número de represas (●) construidas en Brasil (adaptado de Agostinho *et al.*, 2007a).

http://www.faunagua.org/biblioteca/3Cap16.pdf

CURE
Centro Universitario
de la Región Este

Figure 1 – Distribution of the main hydroelectric power plants in Brazil. Notice the concentration in the South and Southeast regions (Kelman et al., 2006).



CURE
Centro Universitario
de la Región Este

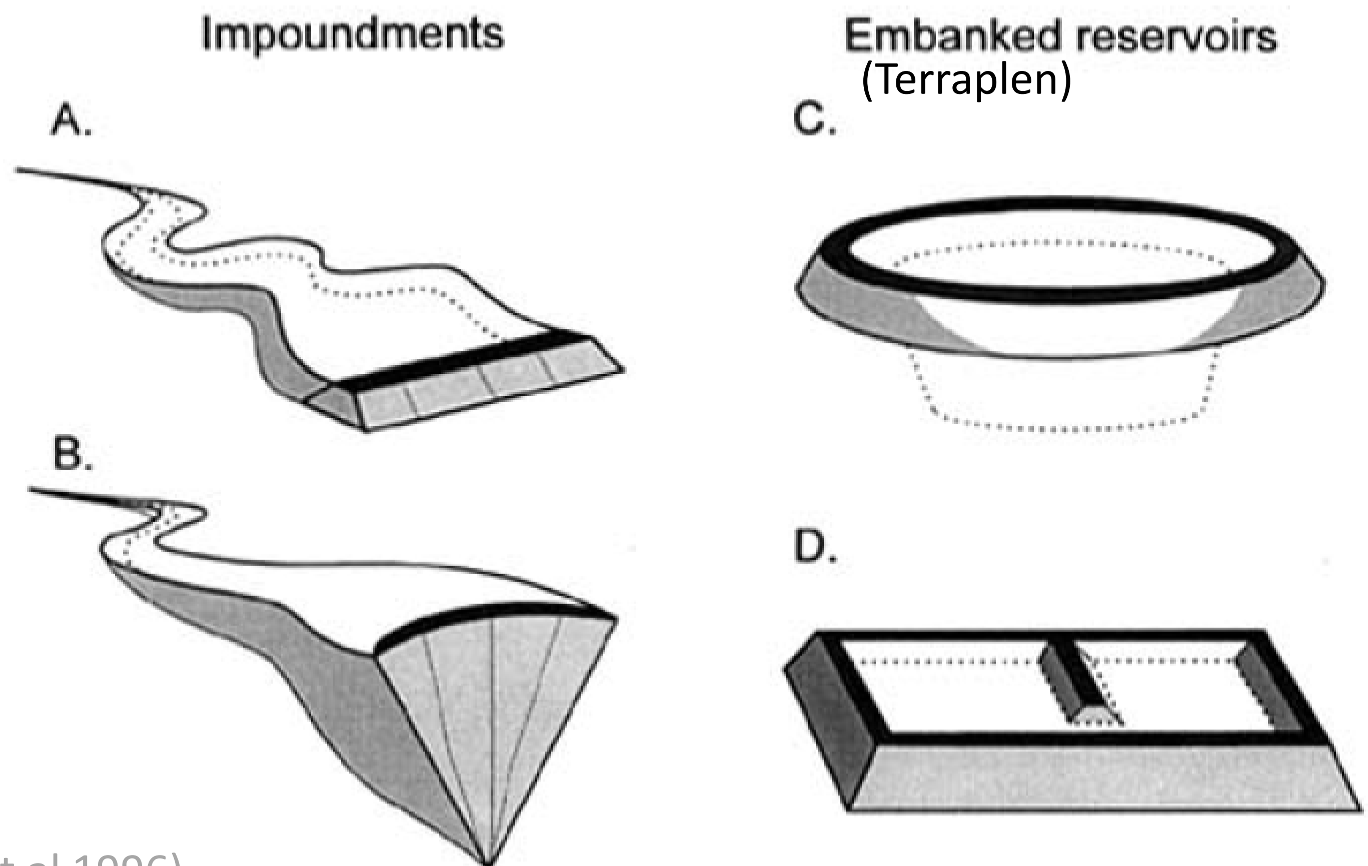
http://www.economist.com/news/americas/21577073-having-spent-heavily-make-worlds-third-biggest-hydroelectric-project-greener-brazil

Hoover Dam (USA)

Centro Universitario de la Región Este

Represa, embalse / Pantano (España) / *Reservoir, dam, impoundment*
RESERVORIOS

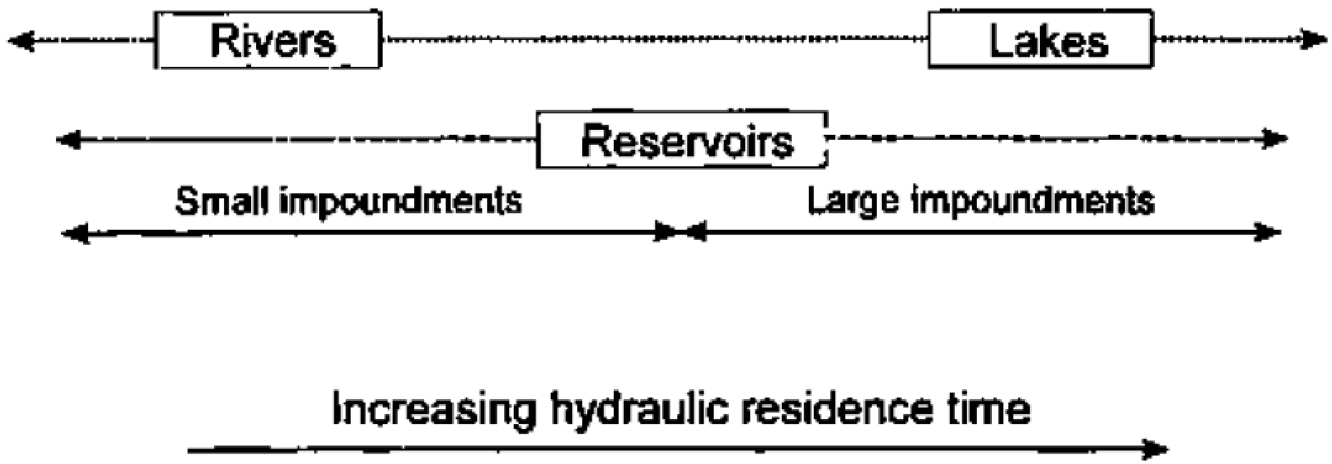
Figure 8.3 Examples of the principal reservoir configurations: A. shallow, ‘U’ shaped; B. deep, ‘V’ shaped; C. deep, regular; D. shallow, regular



(Thornton et al 1996)

Caracterísicas

Figure 8.2 The intermediate position of reservoirs between rivers and natural lakes is determined by their water residence time and degree of riverine influence (Based on Kimmel and Groeger, 1984)



(Thornton et al 1996)

CURE
Centro Universitario
de la Región Este

Table 1.1 Characteristics of reservoirs and glacial lakes[a]

Factor	Characteristic: Reservoir	Characteristic: Glacial lake
Shoreline	Astatic	Stable
Water level	Large, irregular fluctuations	Natural
Flushing rate	High	Low
Thermal stratification	Irregular	Natural regime, dimictic
Ionic composition	Variable	Relatively predictable
Sedimentation rate	High	Low
Turbidity	High	Low
Water release level	Variable	Surface
Organic accumulation	Rapid	Slow
Principal source of nutrients	Allochthonous, then autochthonous	Autochthonous
Growth selection	Rapid (r)	Homeostatic (K)
Immigration-extinction	Rapid	Slow

[a]Modified from Ryder 1978.

(Thornton et al 1996)

Dinámica / zonación

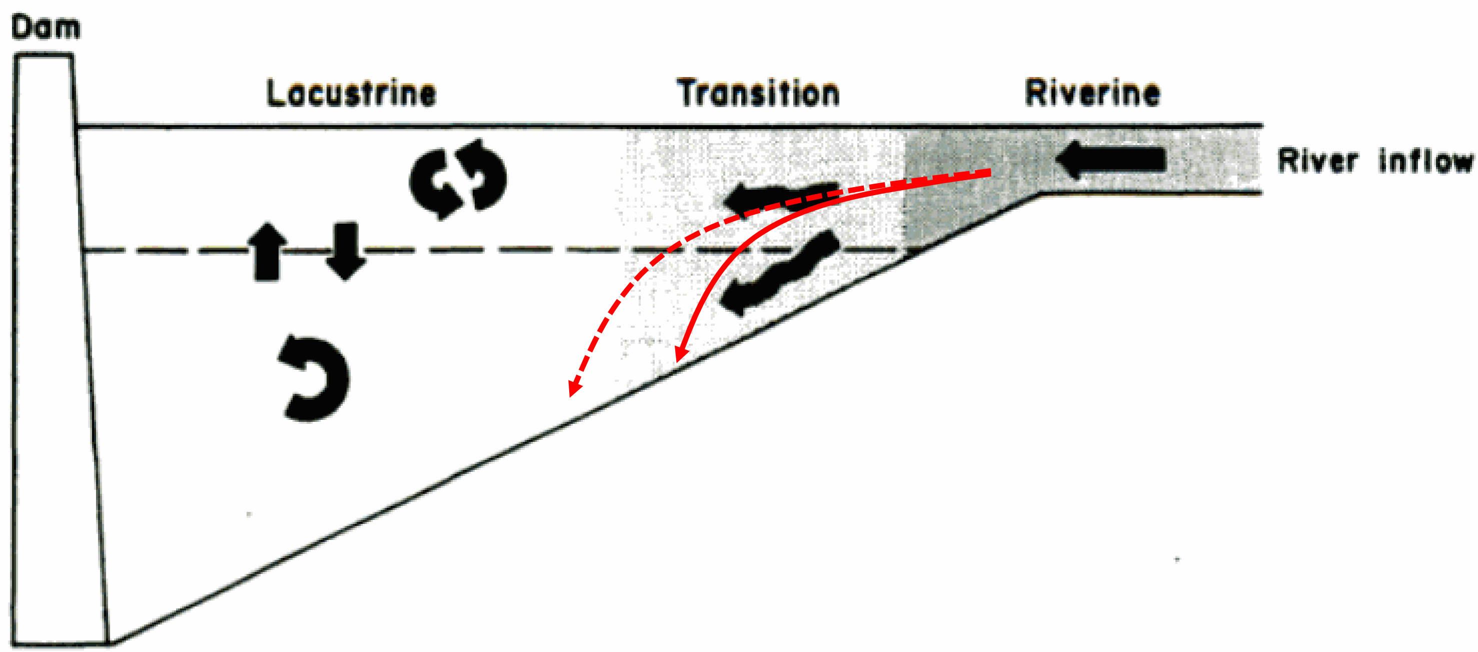
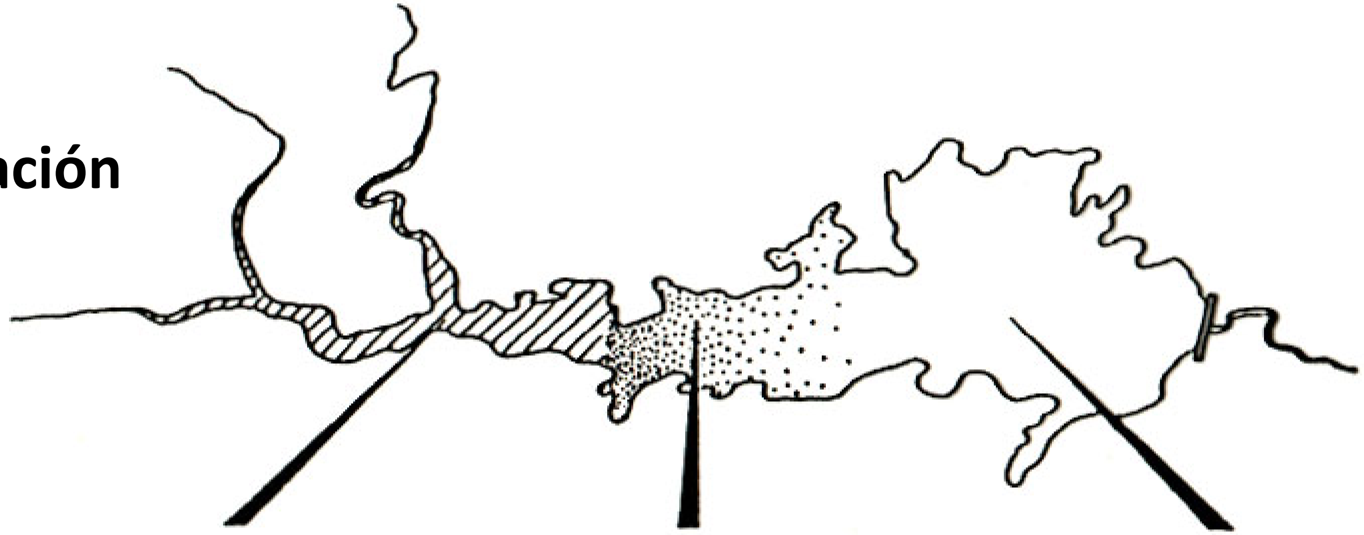


Figure 1.10 Three distinct zones resulting from gradients in reservoirs.

(Thornton et al 1996)

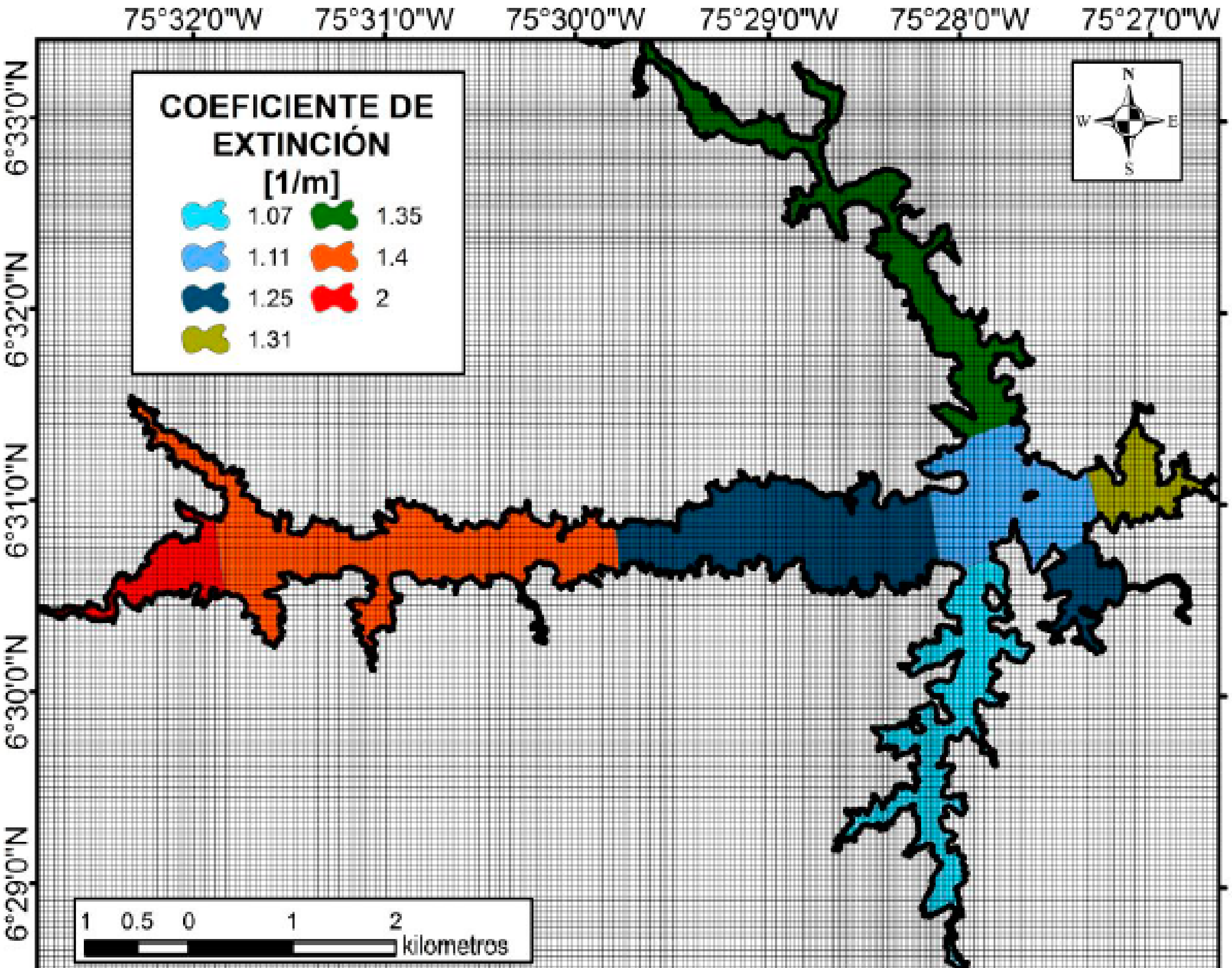
CURE
Centro Universitario
de la Región Este

Zonación



RIVERINE ZONE	TRANSITIONAL ZONE	LACUSTRINE ZONE
• NARROW, CHANNELIZED BASIN	• BROADER, DEEPER BASIN	• BROAD, DEEP, LAKE-LIKE BASIN
• RELATIVELY HIGH FLOW	• REDUCED FLOW	• LITTLE FLOW
• HIGH SUSP. SOLIDS. TURBID, LOW LIGHT AVAIL.	• REDUCED SUSP. SOLIDS, LESS TURBID, LIGHT AVAIL. INCREASED	• REL. CLEAR, LIGHT MORE AVAIL. AT DEPTH, $Z_p > Z_m$
• NUTRIENT SUPPLY BY ADVECTION, REL. HIGH NUTRIENTS	• ADVECTIVE NUTRIENT SUPPLY REDUCED	• NUTRIENT SUPPLY BY INTERNAL RECYCLING, REL. LOW NUTRIENTS
• LIGHT-LIMITED PPR	• PPR/m^3 REL. HIGH	• NUTRIENT-LIMITED PPR
• CELL LOSSES PRIMARILY BY SEDIMENTATION	• CELL LOSSES BY SEDIMENTATION AND GRAZING	• CELL LOSSES PRIMARILY BY GRAZING
• ORGANIC MATTER SUPPLY PRI- ALLOCHTHONOUS, $P < R$	• INTERMEDIATE	• ORGANIC MATTER SUPPLY PRIMARILY AUTOCHTHONOUS, $P > R$
• MORE "EUTROPHIC"	• INTERMEDIATE	• MORE "OLIGOTROPHIC"

(Thornton et al 1996)



CURE
Centro Universitario
de la Región Este

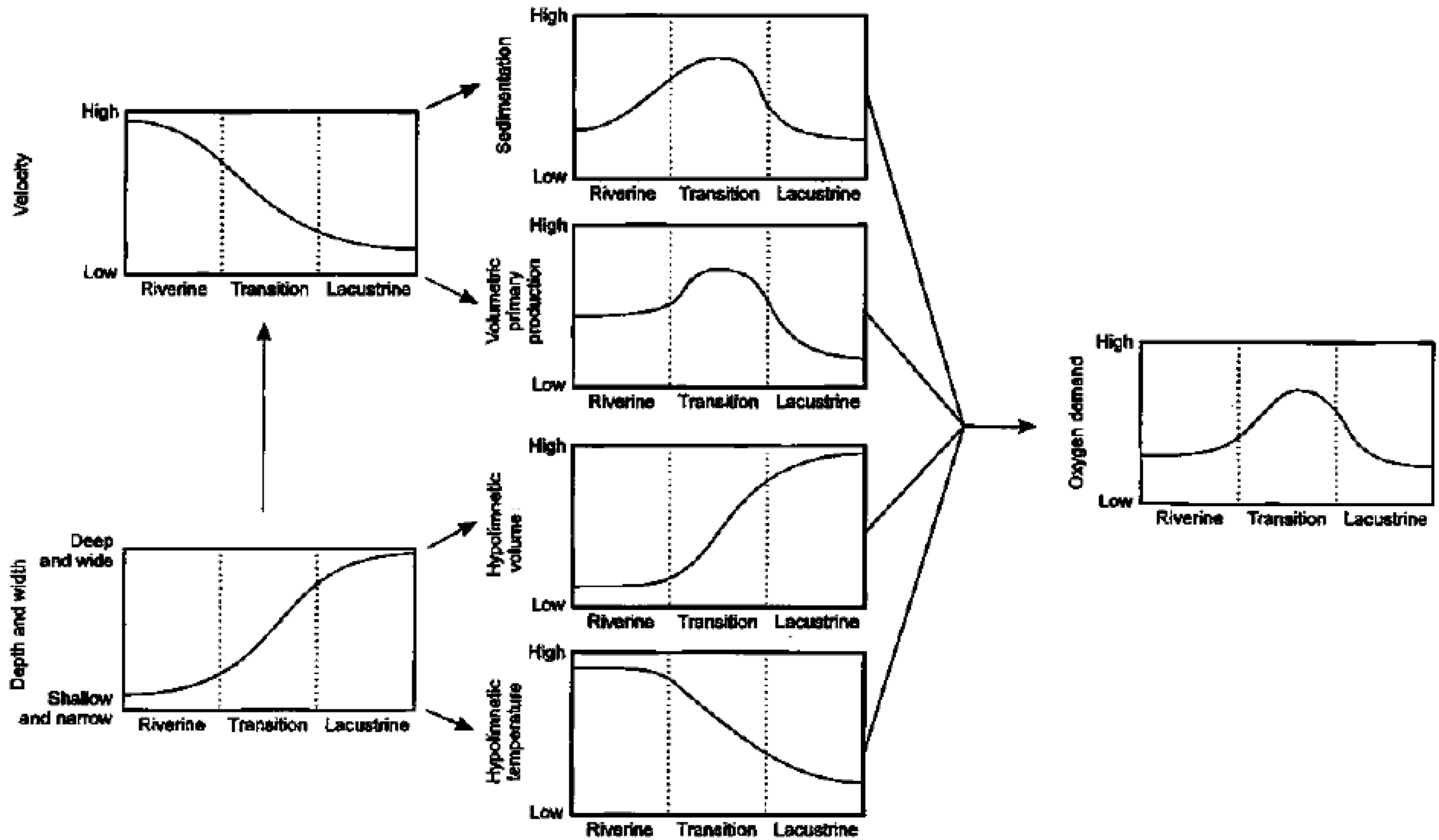
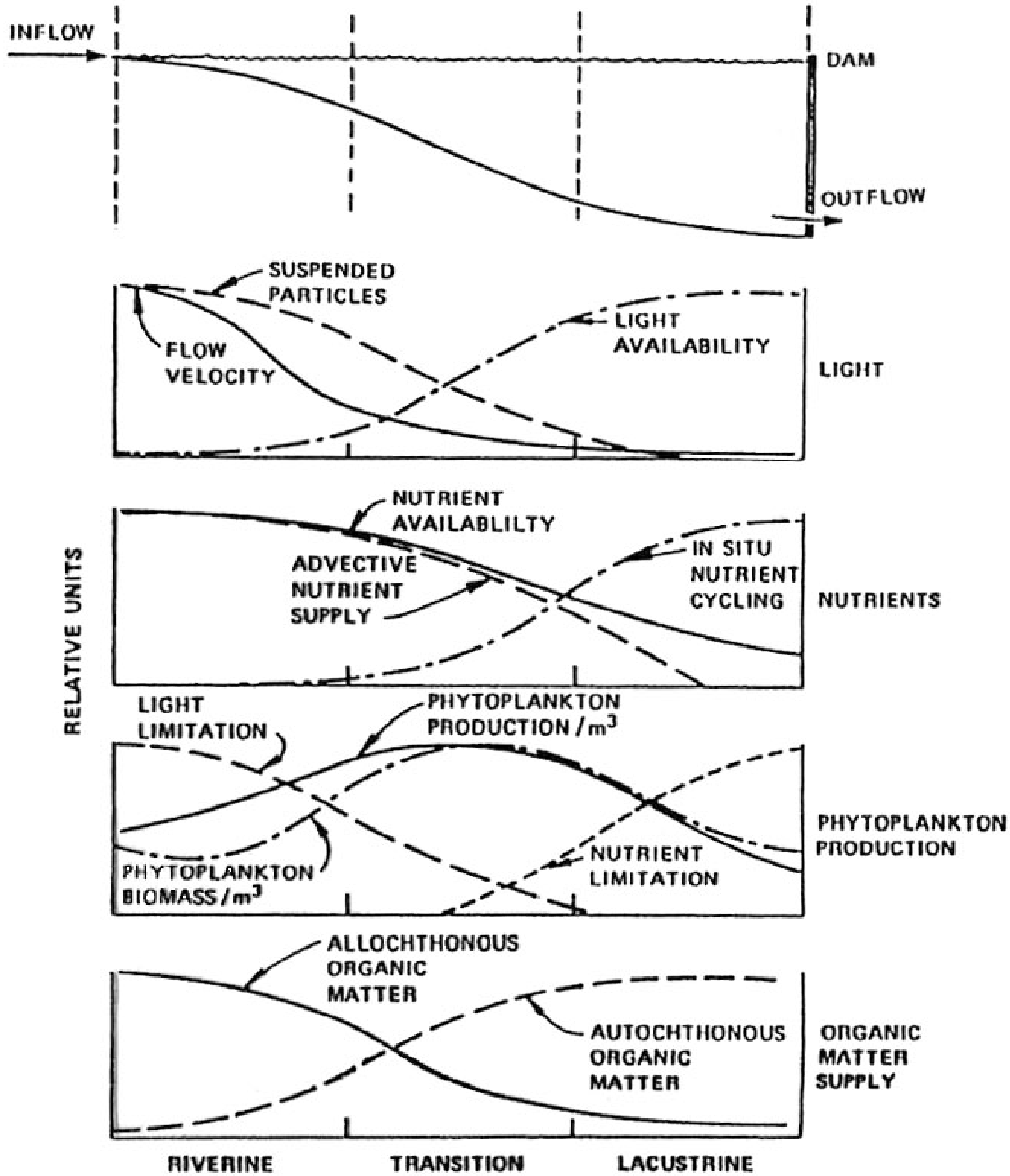


Figure 8.10 Relationship of morphometry, retention time and longitudinal variation in water quality process rates to oxygen demand along the length of a reservoir (see also Figure 8.4) (After Cole and Hannan, 1990) Reproduced by permission of John Wiley & Sons, Inc.

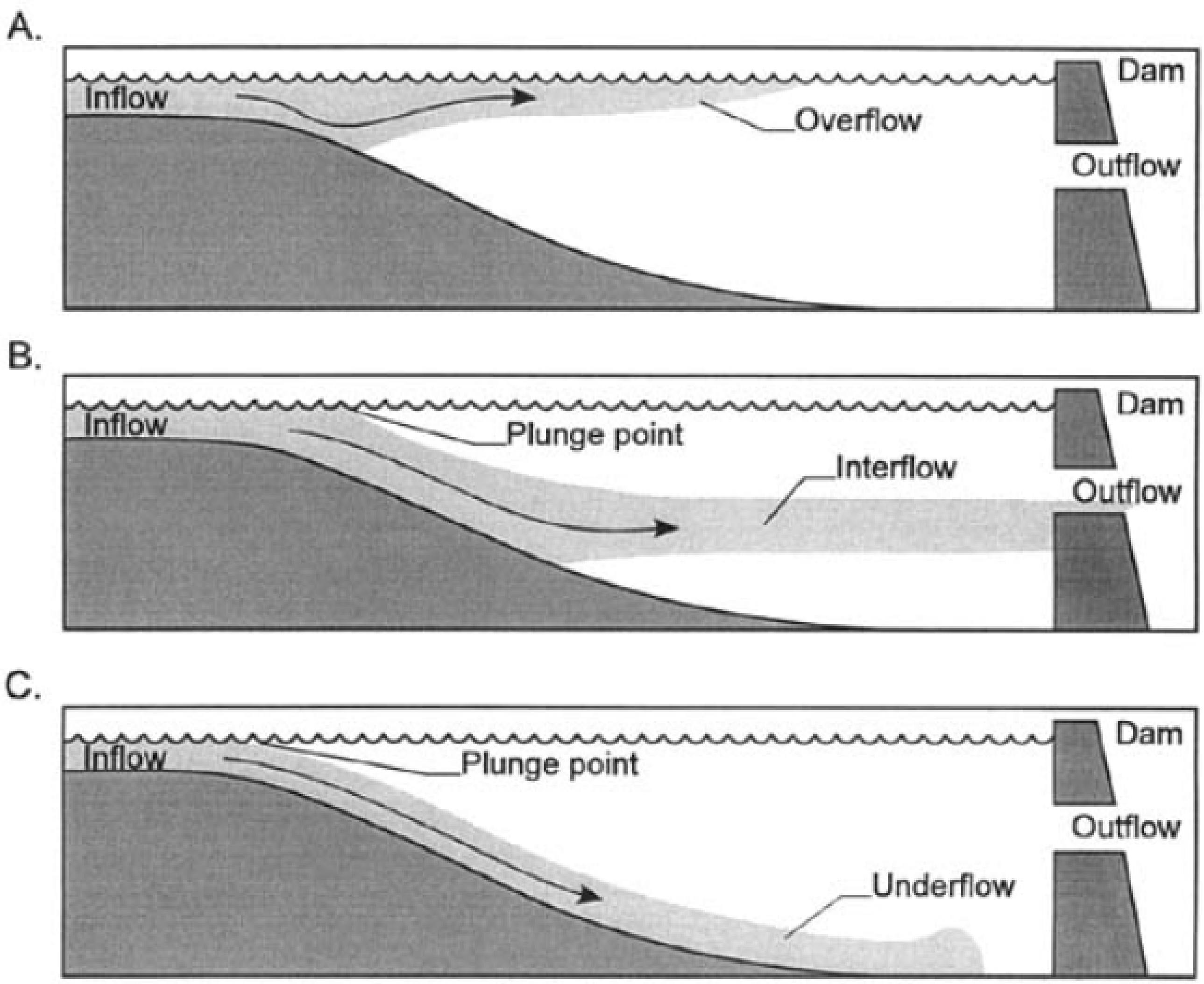
(Thornton et al 1996)

Zonación



(Thornton et al 1996)

CURE
Centro Universitario
de la Región Este



(Thornton et al 1996)

CURE
Centro Universitario
de la Región Este

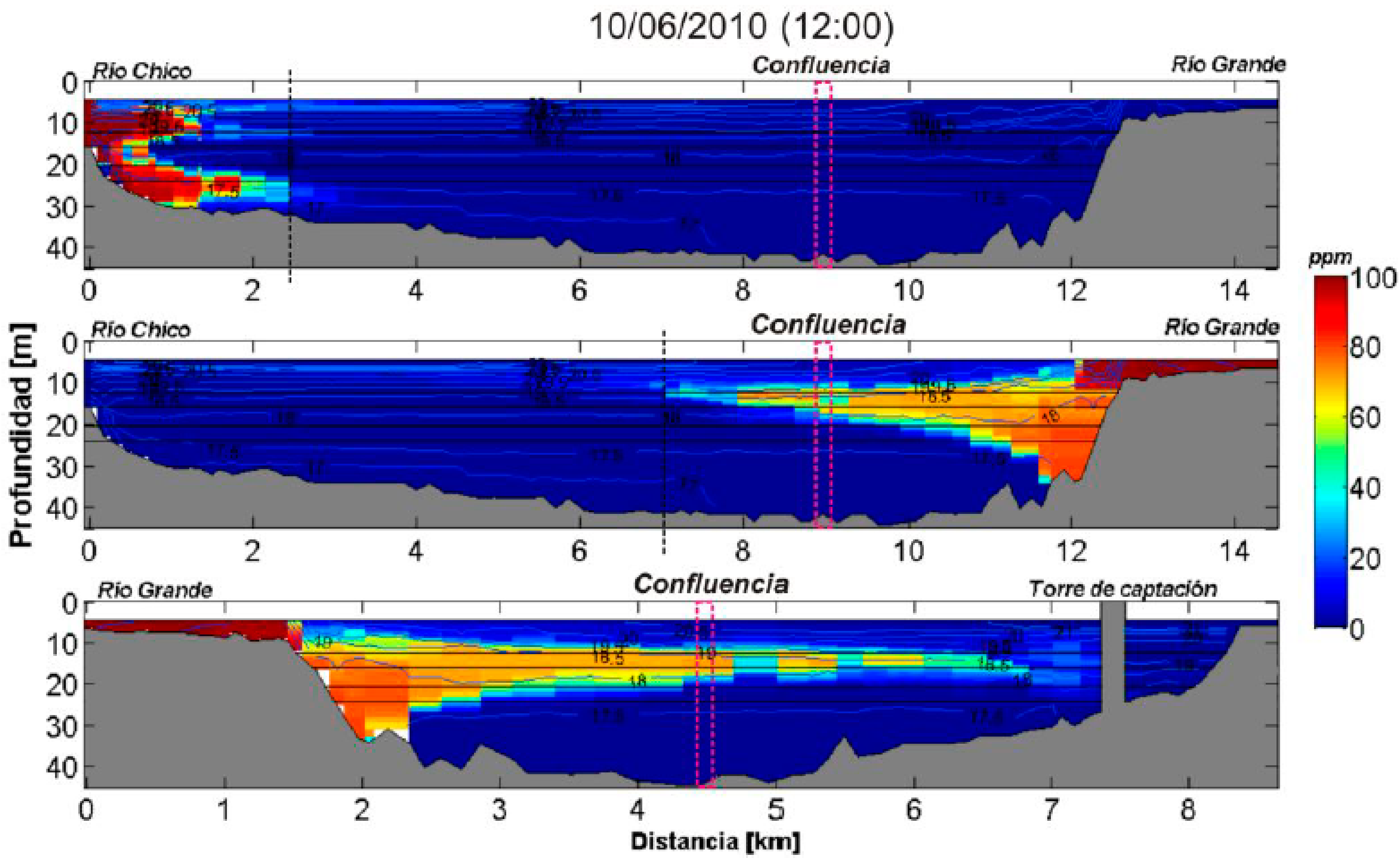
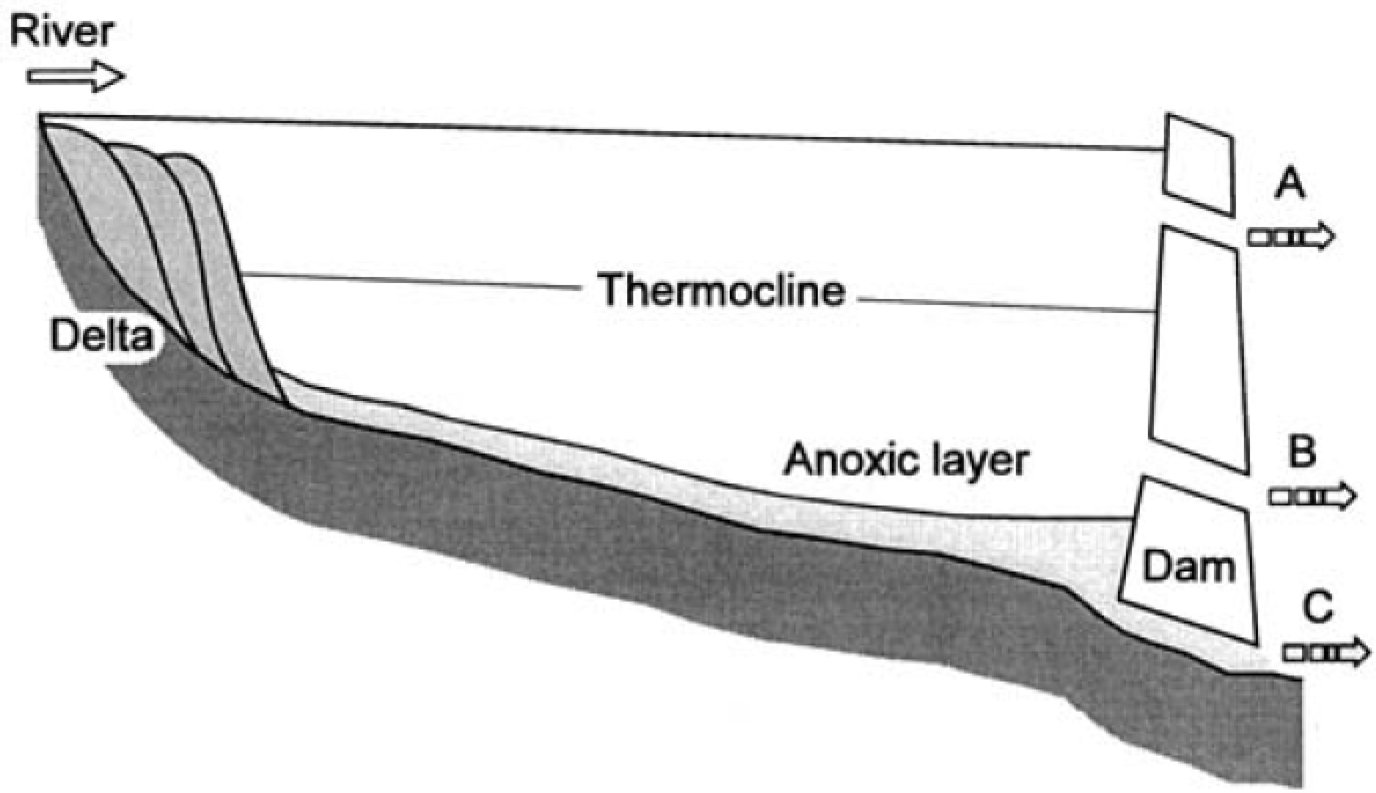


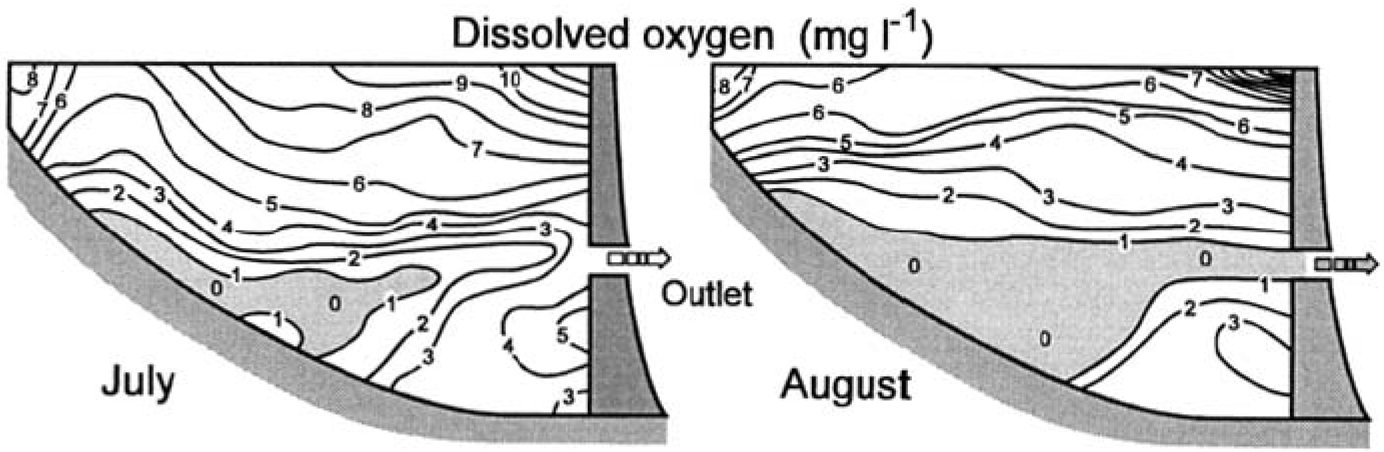
Figura 5-14: Desarrollo de la entrada de las plumas de los ríos Grande y Chico en el embalse Riogrande II - Caso de simulación con el embalse en condición de nivel medio e hidrográfas sincronizadas.



(Thornton et al 1996)

CURE
Centro Universitario
de la Región Este

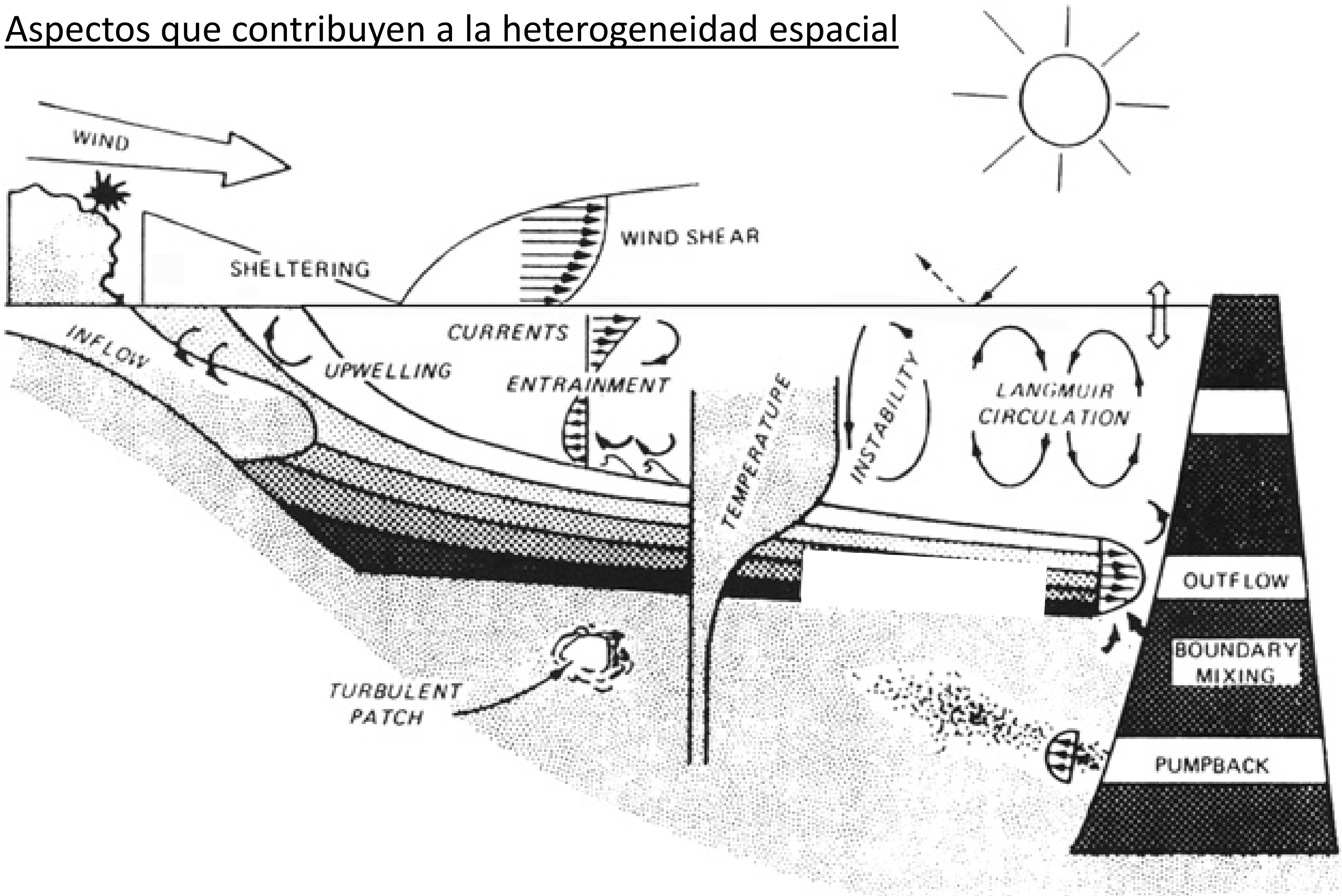
Figure 8.11 An example of modifications in the depth distribution of dissolved oxygen by currents caused by mid-depth water withdrawal (Based on Ebel and Koski, 1968)



(Thornton et al 1996)

CURE
Centro Universitario
de la Región Este

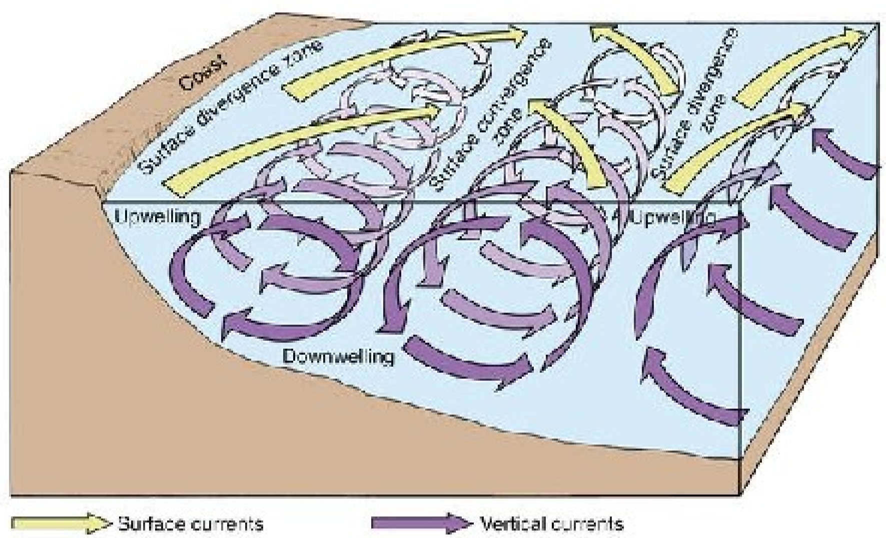
Aspectos que contribuyen a la heterogeneidad espacial



(Thornton et al 1996)

CURE
Centro Universitario de la Región Este

Apunte: Circulación de Langmuir



CURE
Centro Universitario
de la Región Este

¿Cuáles serán los productores primarios predominantes?

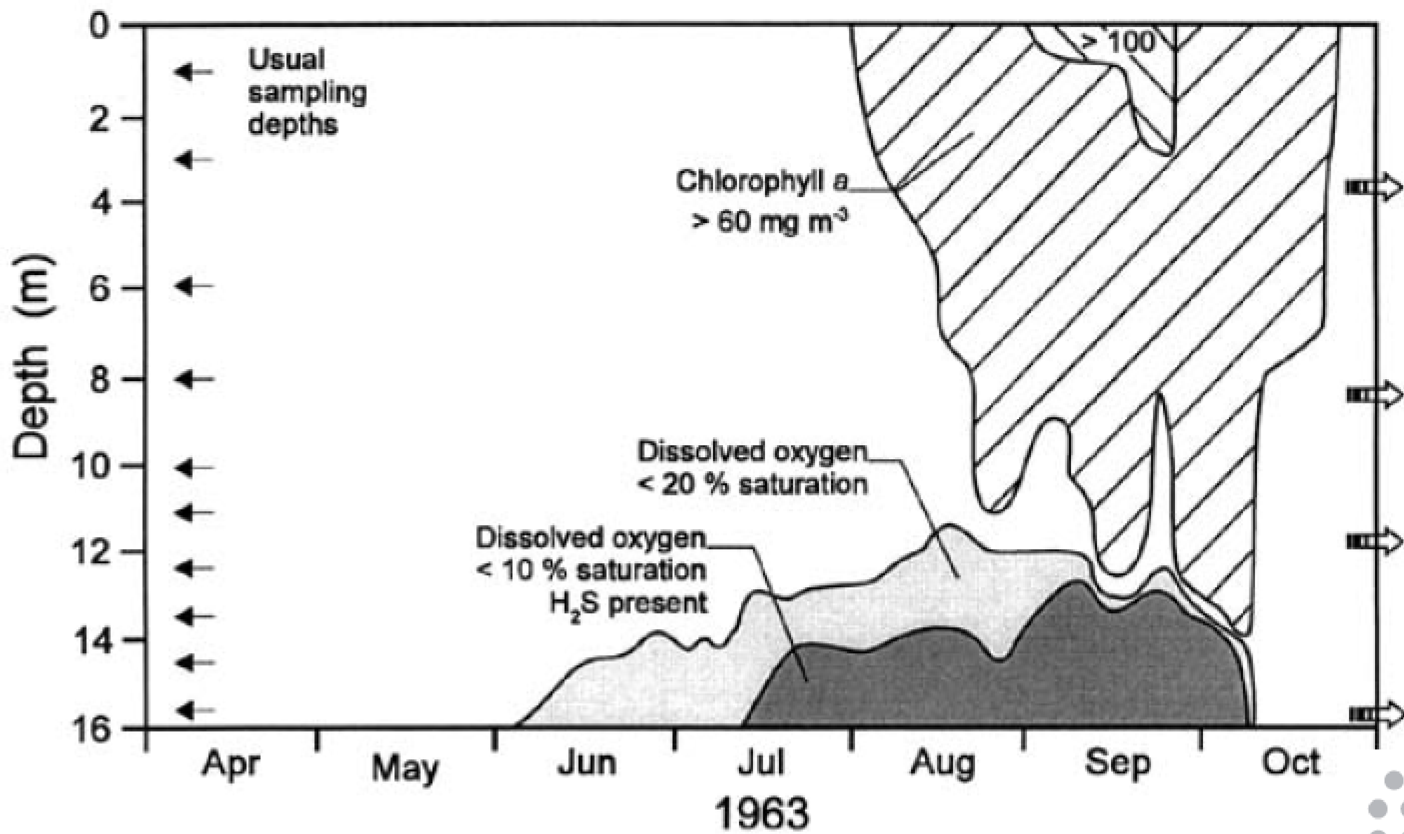
CURE
Centro Universitario
de la Región Este

Lago Rincón del Bonete (2013)

Noticia http://historico.elpais.com.uy/13/03/27/pciuda_705413.asp

CURE
Centro Universitario
de la Región Este

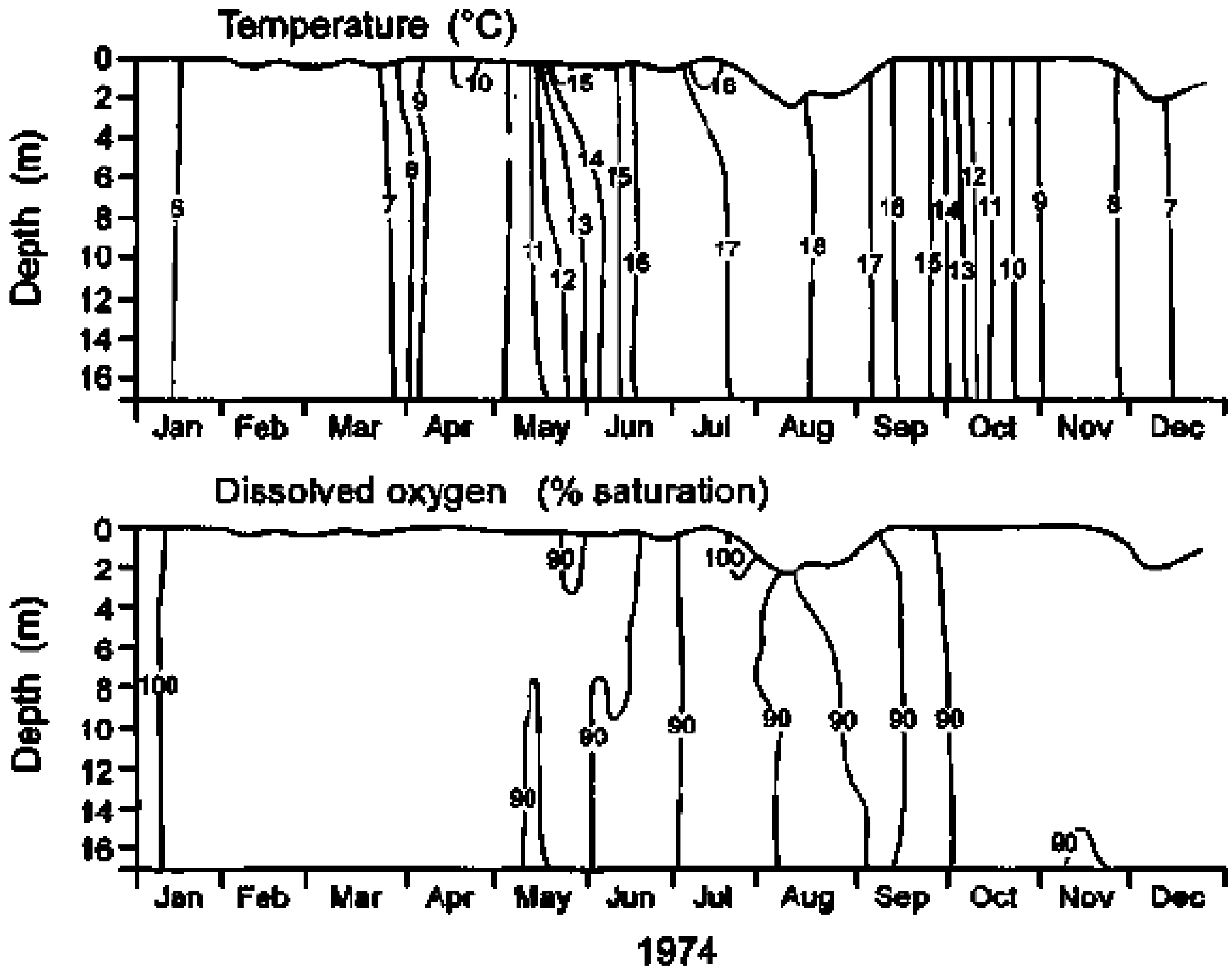
Figure 8.18 Depths distributions of chlorophyll a and dissolved oxygen concentrations in relation to the water withdrawal points in the highly eutrophic King George VI reservoir, UK, during the summer months, prior to the application of any management regime (compare with the managed reservoir in Figure 8.12) (After Steel, 1972)



(Thornton et al 1996)

CURE
Centro Universitario de la Región Este

Figure 8.12 Uniformity in annual temperature and dissolved oxygen depth distributions in Queen Elizabeth II reservoir, UK achieved by jet-mixing in the water column. Compare with an unmanaged situation in a similar reservoir in Figure 8.18.



(Thornton et al 1996)

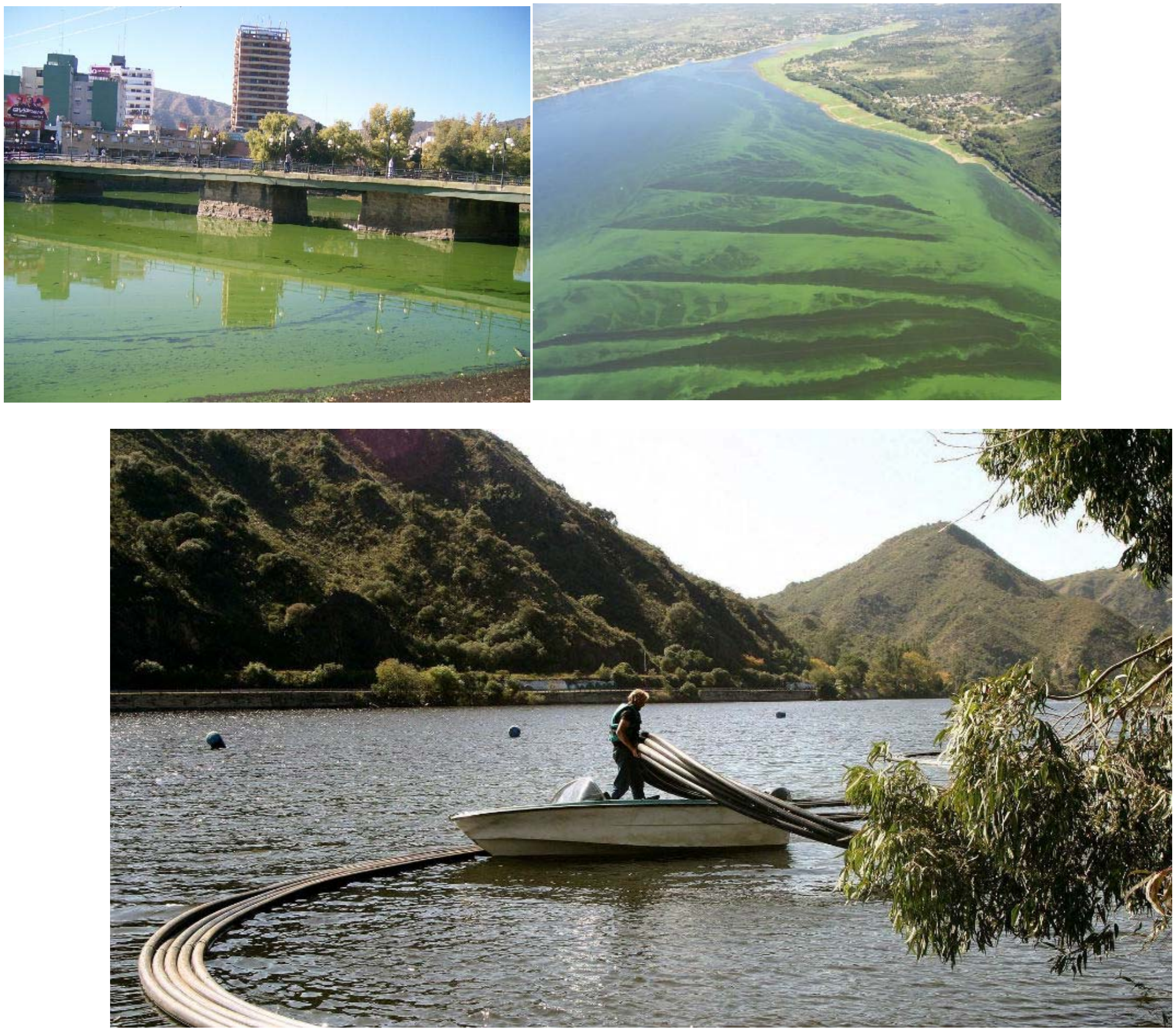


FIG. 40.- Embalse san roque (carlos paz, córdoba, argentina).
Arriba: estado ambiental, intensas floraciones.
http://www.funeat.org.ar/art%c3%adculoscarlosprosperi.html.
Abajo: instalación de sistema de difusores
(http://www.diaadia.com.ar/cordoba/san-roque-menos-verde-difusores).

CURE
Centro Universitario
de la Región Este

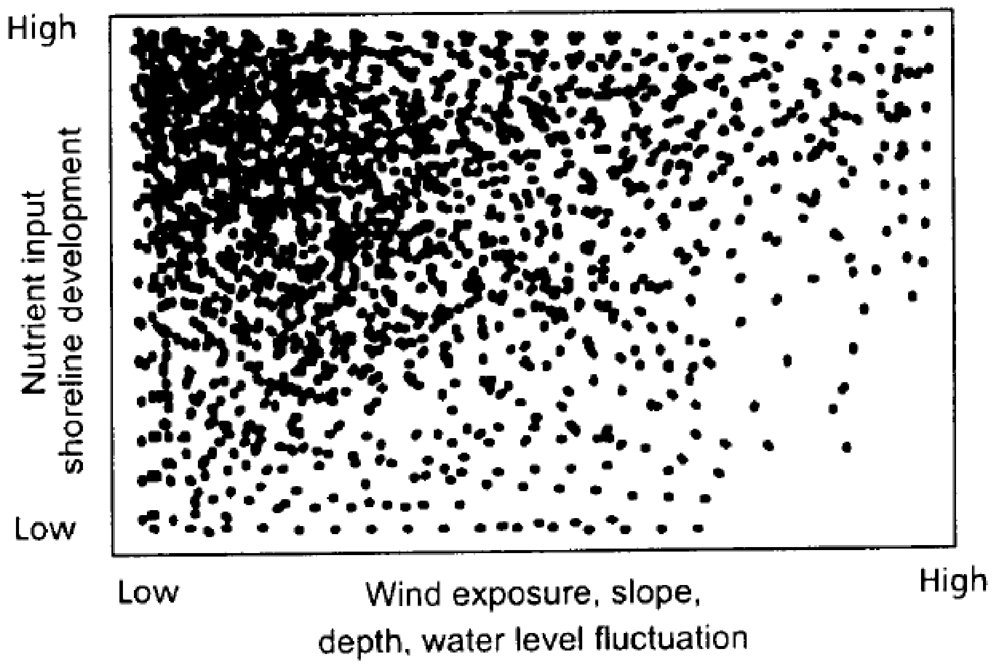
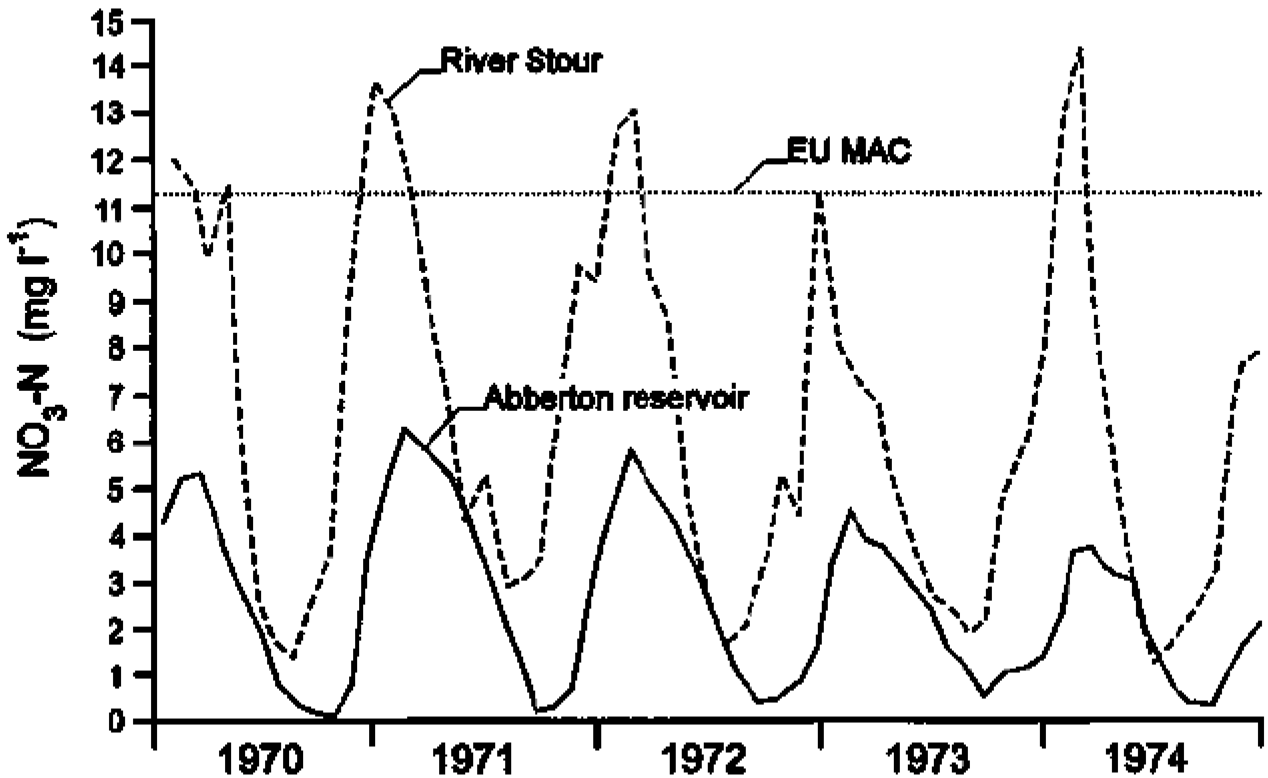


Figure 5 Hypothetical tendency of colonization of aquatic macrophytes in reservoirs. The degree of colonization is directly related with points density (after Thomaz and Bini, 1998b).

(Tundisi & Straskraba 1999)

CURE
Centro Universitario
de la Región Este

Figure 8.17 Annual variation in the nitrate-nitrogen concentrations in the River Stour, UK compared with the concentrations in the waters of the Abberton reservoir which is supplied by the river. De-nitrification in the reservoir helps to reduce the nitrate-nitrogen concentrations to below guideline levels for drinking water. (After Slack, 1977)



(Thornton et al 1996)

CURE
Centro Universitario de la Región Este

San Clemente Dam on the Carmel River after a heavy rainfall (NOAA)

Represa, embalse / Pantano (España) / *Reservoir, dam, impoundment*
RESERVORIOS

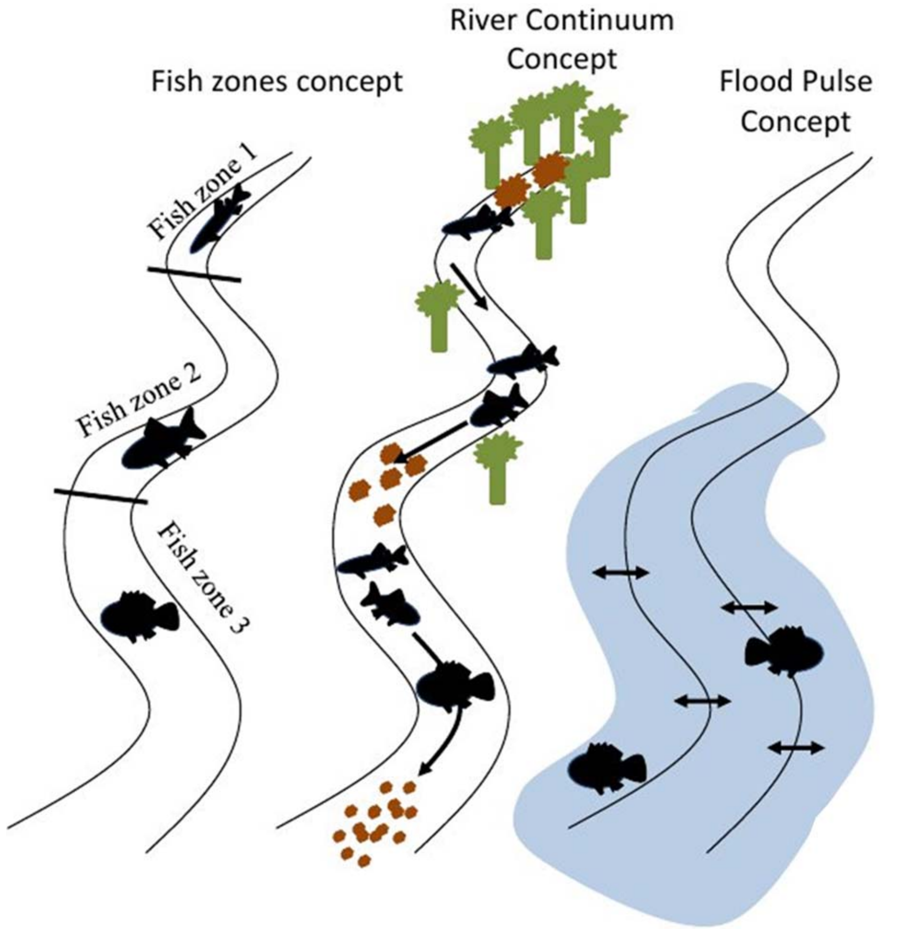
Efectos "colaterales":

Alteración del régimen hidrológico natural:

1. Inundaciones en regiones de aguas arriba
2. Inundan y crean nuevos hábitats
3. Aumentan el volumen de agua evaporada
4. Merma de los caudales circulantes aguas abajo
5. Modificación de las condiciones geomorfológicas del cauce (sedimentación)
6. Alteración de las zonas bajas que perturba el ciclo natural de peces y otros organismos acuáticos (alteración de corredores ecológicos naturales)
7. Alteración de los hábitats y los paisajes fluviales: fragmentación del hábitat
8. Desaparecen tierras cultivables, dificulta la navegación fluvial
9. Modifican la calidad del agua
10. Emiten gases de efecto invernadero
11. Desplazamiento de comunidades enteras
12. Cambios forzados en las actividades de subsistencia

CURE
Centro Universitario
de la Región Este

Presas y funcionamiento de ecosistemas lóticos



…

Discontinuidad seriada

De acuerdo a la hipótesis del continuo las comunidades se organizan espacialmente de acuerdo a la variación de las propiedades físicas y químicas del sistema, en consecuencias las diferentes comunidades también presentan un continuo en algunos de sus atributos o propiedades; la construcción de una represa crea una discontinuidad.

Ej.
P/R ratio ?
Hetrogeneidad ambiental?

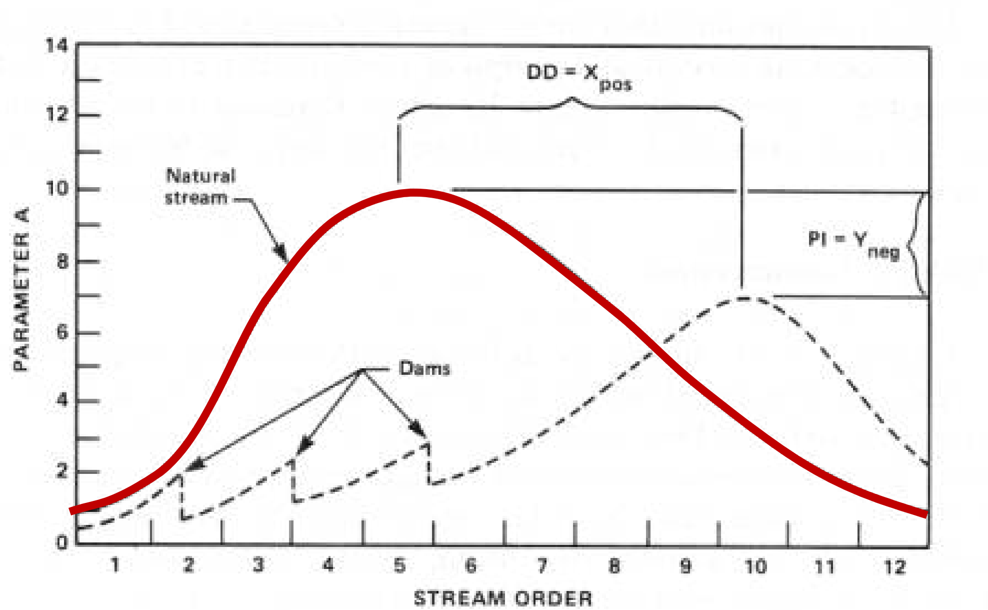


Figure 3. Theoretical framework for conceptualizing the influence of impoundment on ecological parameters in a river system. Discontinuity distance (DD) is the downstream (positive) or upstream (negative) shift of a parameter a given distance (X) due to stream regulation. PI is a measure of the difference in the parameter intensity attributed to stream regulation.

Ward, J. V., 1983. The serial discontinuity concept of lotic ecosystems. In Fontaine, T. D. & S. M. Bartell (eds) *Dynamics of Lotic Ecosystems. Ann Arbor Sci., Ann Arbor, MI, 29-42.*

CURE
Centro Universitario de la Región Este

(NM)

Discontinuidad seriada

Estas condiciones alteradas por la construcción de una presa son reestablecidas aguas abajo, estas generalmente se identifican y se cuantifican en términos de la distancia en que existe una recuperación de las características estudiadas.

Ej.
P/R ratio
Hetrogeneidad ambiental

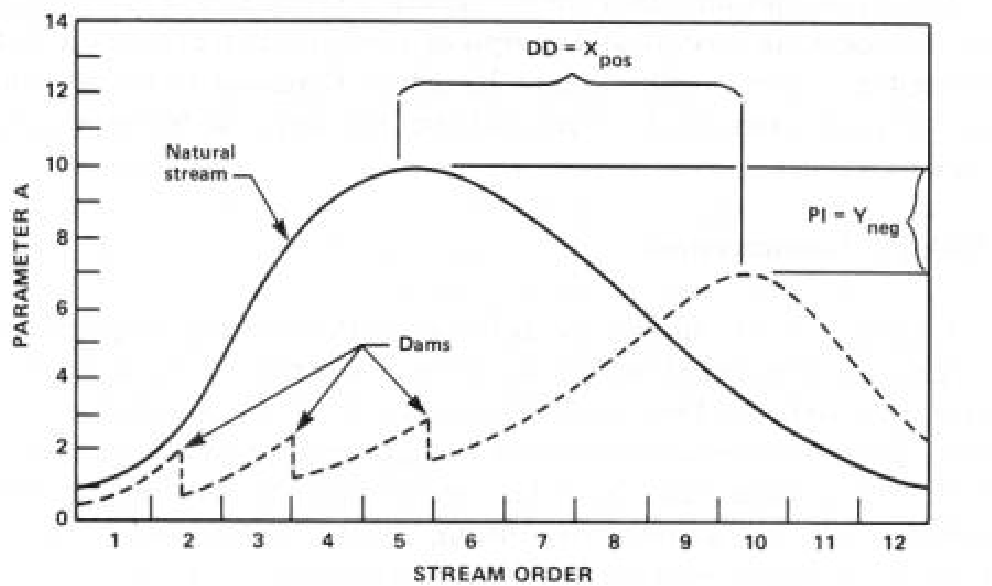


Figure 3. Theoretical framework for conceptualizing the influence of impoundment on ecological parameters in a river system. Discontinuity distance (DD) is the downstream (positive) or upstream (negative) shift of a parameter a given distance (X) due to stream regulation. PI is a measure of the difference in the parameter intensity attributed to stream regulation.

Ward, J. V., 1983. The serial discontinuity concept of lotic ecosystems. In Fontaine, T. D. & S. M. Bartell (eds) *Dynamics of Lotic Ecosystems. Ann Arbor Sci., Ann Arbor, MI, 29-42.*

CURE
Centro Universitario
de la Región Este

(NM)

Discontinuidad seriada

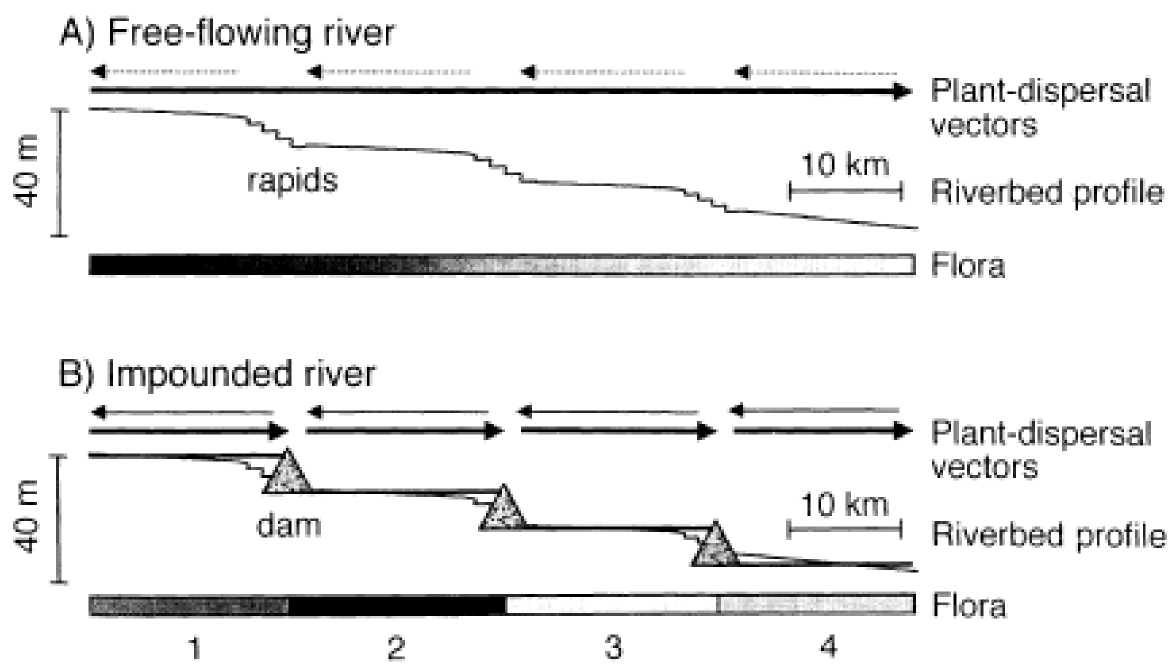
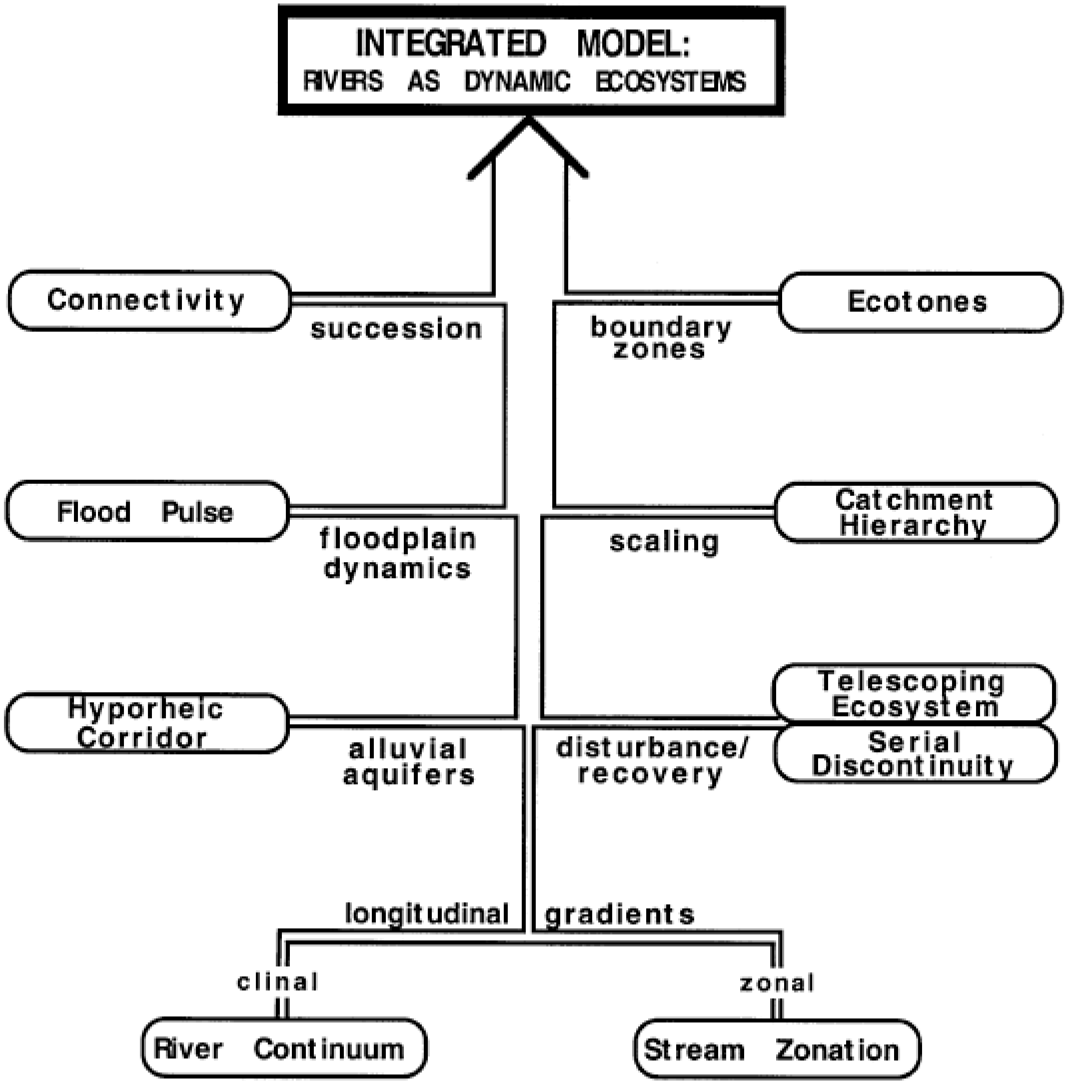


Figure 1-2. Hypothesized relationships between plant-dispersal vectors, riverbed profile, and composition of the riparian flora in free-flowing versus impounded rivers. (A) The flora in the free-flowing river is hypothesized to describe a gradual change downstream, whereas (B) in the regulated river, each impoundment is projected to develop an individual flora (denoted 1–4). (From Jansson et al., 2000a, copyright © Ecological Society of America; reprinted by permission.)

cascaded reservoirs

CURE
Centro Universitario de la Región Este

(NM)



Ward et al 2002

GRANDES REPRESAS Y COMUNIDAD DE PECES

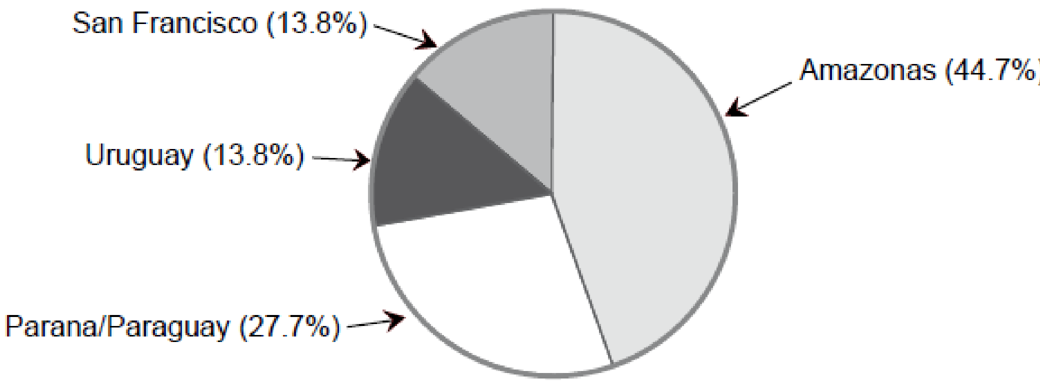


Figura 16.4. Porcentaje de especies migradoras por cuenca (adaptado de Agostinho *et al.*, 2007a)

http://www.faunagua.org/biblioteca/3Cap16.pdf

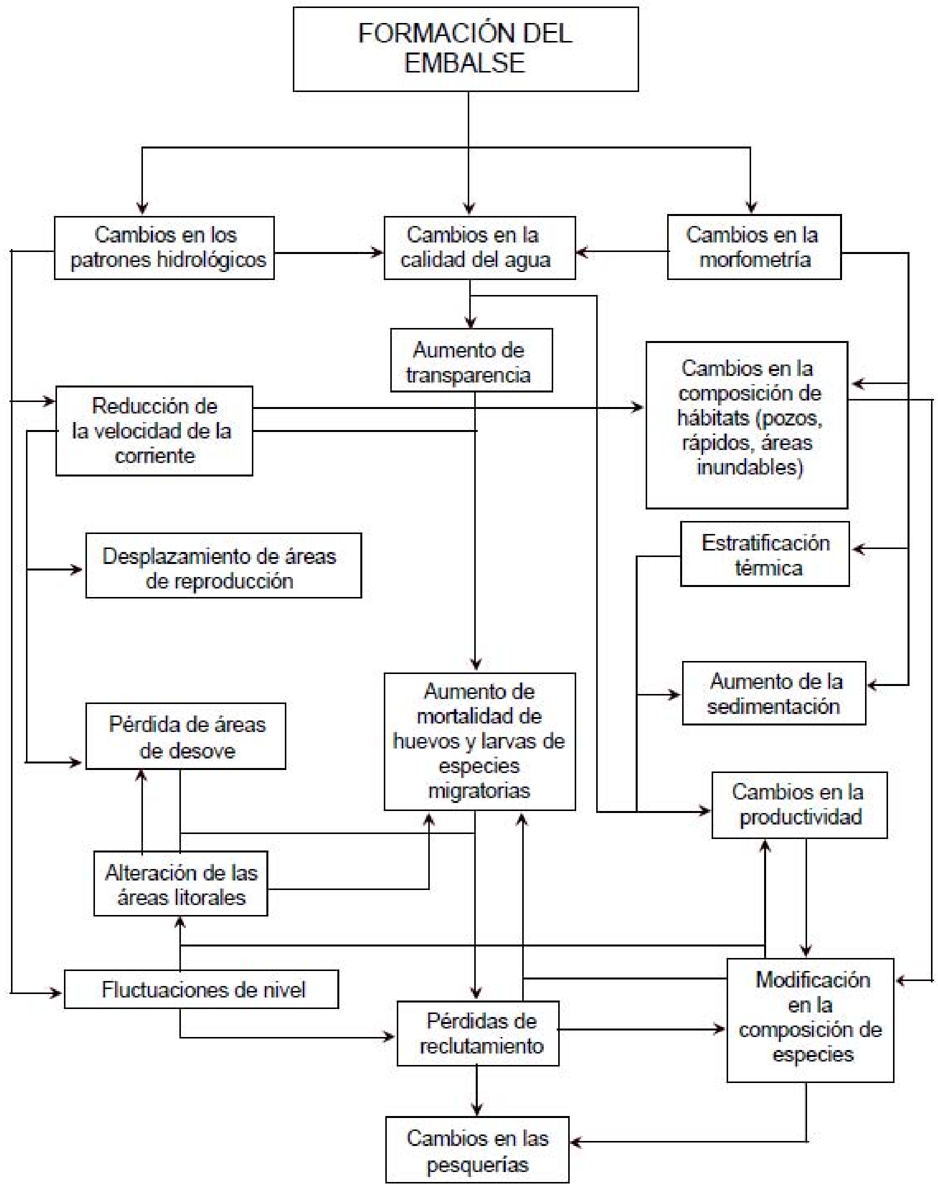


Figura 16.2. Potenciales impactos generados sobre las comunidades de peces aguas arriba de una represa, a partir de cambios en factores ambientales relevantes que ocurren por la construcción de un embalse (Elaboración propia)

http://www.faunagua.org/biblioteca/3Cap16.pdf

CURE
Centro Universitario

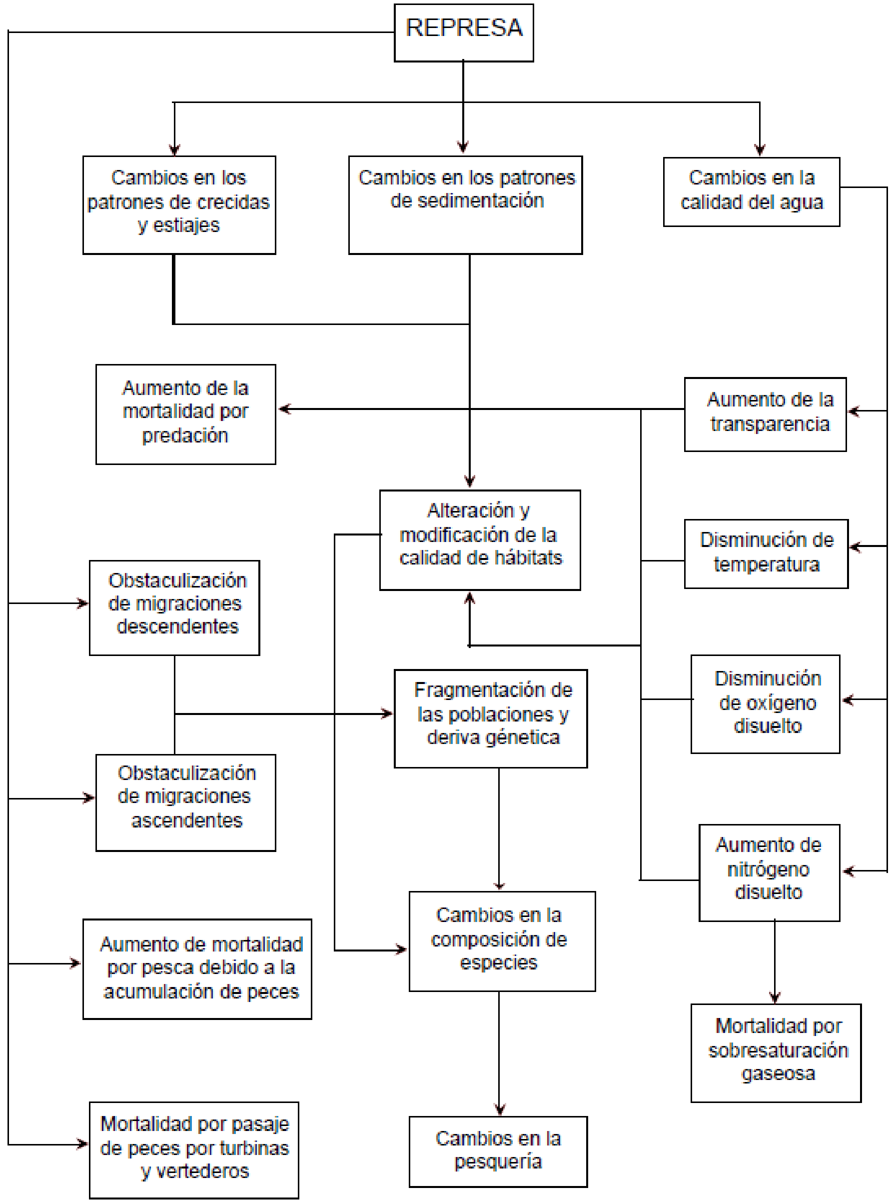


Figura 16.3. Potenciales impactos generados sobre las comunidades de peces aguas abajo de una represa, a partir de cambios en factores ambientales relevantes que ocurren por la construcción de un embalse (Elaboración propia)

http://www.faunagua.org/biblioteca/3Cap16.pdf

CURE
Centro Universitario de la Región Este

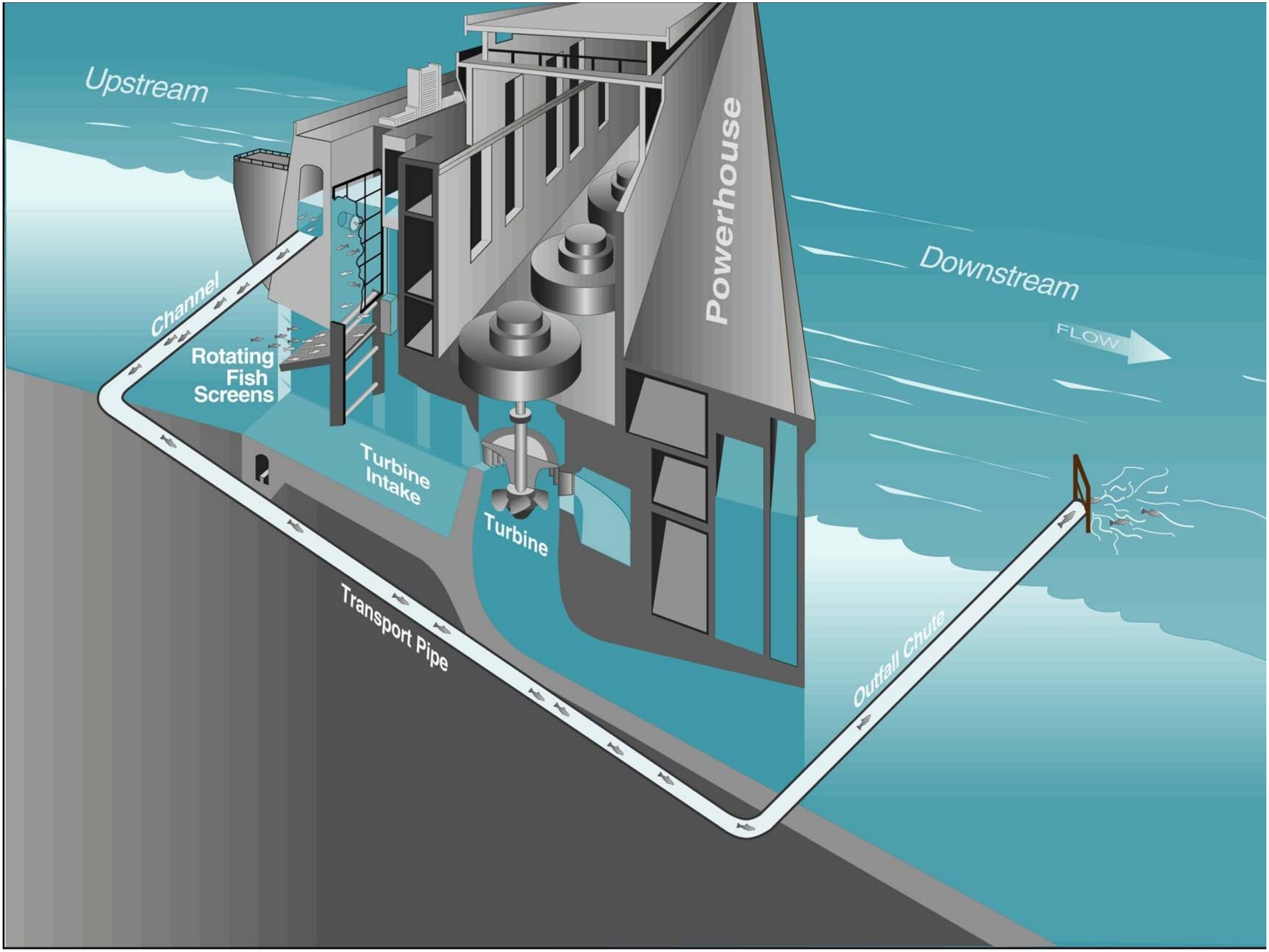
Cuadro 16.3. Comparación de diferentes sistemas de traspaso utilizados en ríos sudamericanos (adaptado de Oldani *et al.*, 2007).

Sistema	**Ventajas**	**Desventajas**	**Ejemplos**
Ranuras verticales ("vertical slots")	Permite operar con diferentes niveles de agua.	Ofrece dificultades de paso para especies de gran porte. Carece de áreas de descanso para los peces.	Represa de Iagarpava (río Grande, Brasi)
Escaleras (escalones-tanques) ("pool and weir")	Apropiadas para represas de baja altura y gran flexibilidad de diseños.	Alta selectividad de especies. Sensible a los cambios de caudal. Poca efectividad para especies de fondo.	Represa de Lajeado (río Tocantins, Brasil) Represa de Salta Morais (río Tijuco, cuenca alta del río Paraná, Brasil)
Ascensores	El costo es independiente de la altura de la represa. Requiere poco espacio para su instalación. Poco sensible a las variaciones de nivel del embalse.	Costo elevado de construcción, operación y manutención. Genera estrés en los peces y mortandad por aglomeración. El número de peces transferidos depende del volumen del ascensor y del tiempo del ciclo.	Represa Engenheiro, Represa Sergio Motta (río Paraná, Brasil) Represa de Funil (río Grande, Brasil) Yacyreta (río Paraná, Argentina-Paraguay) Represa Santa Clara (río Mucuri).
Esclusas ("fish locks")	Diseño flexible que puede ser adaptado a distintos tipos de represas hidroeléctricas.	Baja capacidad de transferencia. El número de peces transferido depende del número de ciclos diarios. Durante la fase del llenado, el flujo de atracción se reduce o se elimina.	Represa de Salto Grande (río Uruguay, Argentina-Uruguay)
Sistemas de by-pass (ríos artificiales)	Alta capacidad de transferencia. Permiten simular las condiciones naturales del río. Amplio espectro de velocidades de agua Utilizables para migraciones descendentes. Proporcionan hábitats para especies residentes.	Requieren de un amplio espacio para su instalación cuando la altura de la represa es considerable debido a su baja pendiente. Susceptible a variaciones del nivel de agua en el reservorío. Riesgo de introducción de especies no-deseadas.	Canal de Piracema, Represa Itaipú, río Paraná (Paraguay-Brasil)

CURE
Centro Universitario
de la Región Este

CURE
Centro Universitario
de la Región Este

CURE
Centro Universitario
de la Región Este

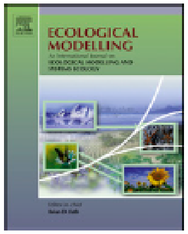

Upstream
Powerhouse
Downstream
FLOW
Channel
Rotating Fish Screens
Turbine Intake
Turbine
Transport Pipe
Outfall Chute

Ecological Modelling 252 (2013) 266–272

Contents lists available at SciVerse ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel



Adapting the operation of two cascaded reservoirs for ecological flow requirement of a de-watered river channel due to diversion-type hydropower stations

Qiuwen Chen[a,b,*], Duan Chen[a,c], Ruonan Li[a], Jinfeng Ma[a], Koen Blanckaert[a]

[a] *RCEES Chinese Academy of Sciences, Shuangqinglu 18, Haidian District, Beijing 100085, China*
[b] *Three Gorges University, Daxue Road, Yichang 443002, China*
[c] *Changjiang River Scientific Research Institute, Jiuwanfang, Hankou District, Wuhan 430010, China*

DOI: 10.1007/s002670010189

Undamming Rivers: A Review of the Ecological Impacts of Dam Removal

ANGELA T. BEDNAREK
Department of Biology
University of Pennsylvania
Philadelphia, Pennsylvania 19104-6018, USA
The Patrick Center for Environmental Research
The Academy of Natural Sciences
1900 Benjamin Franklin Parkway
Philadelphia, Pennsylvania 19103

ABSTRACT / Dam removal continues to garner attention as a potential river restoration tool. The increasing possibility of dam removal through the FERC relicensing process, as well as through federal and state agency actions, makes a critical examination of the ecological benefits and costs essential. This paper reviews the possible ecological impacts of dam removal using various case studies.

Restoration of an unregulated flow regime has resulted in increased biotic diversity through the enhancement of preferred spawning grounds or other habitat. By returning riverine conditions and sediment transport to formerly impounded areas, riffle/pool sequences, gravel, and cobble have reappeared, along with increases in biotic diversity. Fish passage has been another benefit of dam removal. However, the disappearance of the reservoir may also affect certain publicly desirable fisheries.

Short-term ecological impacts of dam removal include an increased sediment load that may cause suffocation and abrasion to various biota and habitats. However, several recorded dam removals have suggested that the increased sediment load caused by removal should be a short-term effect. Preremoval studies for contaminated sediment may be effective at controlling toxic release problems.

Although monitoring and dam removal studies are limited, a continued examination of the possible ecological impacts is important for quantifying the resistance and resilience of aquatic ecosystems. Dam removal, although controversial, is an important alternative for river restoration.

Dams are pervasive features of the world's river systems. There are more than 75,000 dams above 5 ft tall in the United States and 40,000 dams over 50 ft tall worldwide (National Research Council 1992, Dynesius and Nilsson 1994, McCully 1997). Smaller dams (i.e., below 5 ft tall) in the United States likely number in the thousands (American Rivers and NPS 1996). Nearly 80% of the total discharge of large rivers in the northern third of the world is impacted by river regulation (Dynesius and Nilsson 1994). This large number of dams worldwide can be attributed to the variety of services they provide: inexpensive and efficient power generation, effective flood control, navigation, water supply, irrigation, and recreational opportunities.

Nevertheless, the presence of dams is problematic for many aquatic ecosystems. Dams impact ecosystems in a number of ways: altering the natural cycle of flow, transforming the biological and physical characteristics of river channels and floodplains, and fragmenting the continuity of rivers (Petts 1984, Chisolm 1994, Yeager 1994, Ligon and others 1995, Ward and Stanford 1995, Stanford and others 1996, Poff and others 1997). Lateral exchanges of sediment, nutrients, and organisms between aquatic and terrestrial areas may be limited by fewer overbank floods in a dammed river (Junk and others 1989, Naiman and others 1993). Coastal areas may lose valuable habitat and shift biotic composition when they are deprived of sediment because of dammed rivers upstream (DOI 1996). The physical obstruction of both dams and reservoirs impedes and delays the migration of various organisms (Drinkwater and Frank 1994, Staggs and others 1995, Stanford and others 1996). The turbines of a hydropower operation harm fish and other biota as they attempt to pass (Dadswell 1996). The change from a river to a reservoir ecosystem often shifts species composition. Unnatural timing of flow releases for power production and the altered temperatures of those releases can confound emergence or growth cues (Petts 1984).

Recognition of these impacts has led to a search for solutions. For example, in the United States, the Federal Energy Regulatory Commission (FERC) relicensing process for hydropower operations is critically examining the environmental impacts of dams (American Rivers and NPS 1996). FERC issues 30- to 50-year licenses to dams owned by nonfederal entities, such as utility companies, municipalities, and independent

KEY WORDS: Dam removal; Restoration; Mitigation; Flow regime; Sediment; Fish passage

http://www.youtube.com/watch?v=4LxMHmw3Z-U

CURE
Centro Universitario
de la Región Este

Represa, embalse / Pantano (España) / *Reservoir, dam, impoundment*
RESERVORIOS

Bibliografía recomendada

Thornton, J., A. Steel & W. Rast, 1996. Chapter 8. Reservoirs. In Chapman, D. (ed) Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring. 2nd. UNESCO/WHO/UNEP. http://www.who.int/water_sanitation_health/resourcesquality/wqachapter8.pdf

Y disponible en EVA