ENVIRONMENTAL RESTORATION OF THE LOWER EBRO RIVER AND ITS DELTA (CATALONIA, SPAIN)

Nuno Caiola and Carles Ibáñez

IRTA Aquatic Ecosystems

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Summary

1. Recent changes in the ecological processes of the lower Ebro River (*A novel ecosystem*)
2. Effects on the biological communities
3. Possible management solutions, but…
4. Flix toxic wastes
5. Restoration actions and Environmental Indicators network
Ebro basin
Lower Ebro aquatic systems

- The Ebro is the largest river in Spain (85,000 km² of watershed).
- Large reservoirs (Mequinensa and Ribaroja) built in the 60's (up to 200 in the Ebro basin).
- Decreasing river flow due to intensive water uses (irrigation), from 600 m³/s to 300 m³/s.
- Flood plain occupation due to agriculture and margin erosion due to sediment deficit.
- High biodiversity (fish, invertebrates) endangered by invasive species.
- The Ebro delta is the second most important wetland in Spain, with 10,000 Ha of protected habitats and 20,000 Ha of rice fields.
- The last part of the river is a salt wedge estuary (tidal range of 20 cm).
Humanized River

Altered regime
Regulation ↑
Flow ↓
Sediments ↓
Phytoplankton ↑
Macrophytes ↓
Rip. Veg. ↓

1960s

Natural River

Natural regime
River flow ↑

Sediments ↑
Phytoplankton ↓
Macrophytes ↓
Rip. Veg. ↑

Early 20th Century

Deficient water treatment
Eutrophication ↑

Improved water treatment
Eutrophication ↓

Mid 1990s

Altered regime
Regulation ↑↑
Flow ↓↓
Sediments ↓
Phytoplankton ↓
Macrophytes ↑↑
Rip. Veg. ↓
A NOVEL ECOSYSTEM?

New conditions: low P, low discharge, low sediment concentration and alien species

Potamogeton pectinatus  Simulium erythrocephalum  Dreissena polymorpha

Silurus glanis
Hypothesis

- Decrease eutrophication
- Zebra Mussel filtration
- Increase Water transparency
- Decrease sediments
- Delta regression
- Increase Macrophyte coverage
- Decrease flows
- Suitable habitat for invasive species
Dissolved P And N

Phosphates (mg/L)

Year

1987-1995
1996-2004

Ascó
Tortosa

Site

Nitrates (mg/L)

Year

1987-1995
1996-2004

Ascó
Tortosa

Site
Chlorophyll trends
**Chlorophyll versus Phosphorus**

\[ Y = 1.00658923 + 40.3340768 X \]

\[ r^2 = 0.7825 \]
### Relationship between chlorophyll and environmental descriptors

<table>
<thead>
<tr>
<th>Model parameter</th>
<th>Annual model</th>
<th>$N = 25$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>$SP$</td>
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<tr>
<td>Intercept</td>
<td>-3.777</td>
<td>2.472</td>
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<tr>
<td>Period</td>
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<td>0.037</td>
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<tr>
<td>Mean flow $(m^3/s)$</td>
<td>-0.215</td>
<td>0.008</td>
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<tr>
<td>SRP $(\mu g/L)$</td>
<td>0.961</td>
<td>0.989</td>
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<tr>
<td>N-NO$_3$ $(\mu g/L)$</td>
<td>1.629</td>
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<tr>
<td>N-NO$_2$ $(\mu g/L)$</td>
<td>0.796</td>
<td>0.023</td>
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<td>N-NH$_4$ $(\mu g/L)$</td>
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<td>0.373</td>
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<td>TOC $(\mu g/L)$</td>
<td>1.067</td>
<td>0.301</td>
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<td>Silicate $(\mu g/L)$</td>
<td>0.505</td>
<td>0.145</td>
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<td>TSS $(mg/L)$</td>
<td>0.529</td>
<td>0.787</td>
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<tr>
<td>Water $T\degree$ $(^\circ C)$</td>
<td>1.655</td>
<td>0.047</td>
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<td>Cond. $(\mu S/cm \cdot 20\degree C)$</td>
<td>-1.147</td>
<td>0.289</td>
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<td>Zebra mussel $(ind \cdot m^{-2})$</td>
<td>-0.073</td>
<td>0.071</td>
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**Regime shift from phytoplankton to macrophyte dominance in a large river: Top-down versus bottom-up effects**

Carles Ibáñez $^{a,*}$, Carles Alcaraz $^{a}$, Nuno Caiola $^{a}$, Albert Rovira $^{a}$, Rosa Trobajo $^{a}$, Miguel Alonso $^{b}$, Concha Duran $^{c}$, Pere J. Jiménez $^{d}$, Antoni Munné $^{e}$, Narcís Prat $^{f}$
River discharge and sediment load changes

<table>
<thead>
<tr>
<th>Year</th>
<th>Impoundment capacity (Km³)</th>
<th>Sediment yield (milions t/a)</th>
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<td>1877</td>
<td>0</td>
<td>30</td>
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<td>1964</td>
<td>3.45</td>
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<td>Vericat &amp; Batalla (2006)</td>
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</table>
Monitoring the effects of floods on submerged macrophytes in a large river

Carles Ibáñez a, Nuno Caiola a, Albert Rovira a, Montserrat Real b
The Spanish and Catalan administrations know that the Ebro River flows is a key issue.

<table>
<thead>
<tr>
<th>Proposal code</th>
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<th>Hydrological method</th>
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Biological validation of “environmental” flows

Ecological Indicators 45 (2014) 598–604

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Ecological Indicators

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

Effects of flow regulation on the establishment of alien fish species: A community structure approach to biological validation of environmental flows

Nuno Caiola\textsuperscript{a,*}, Carles Ibáñez\textsuperscript{a}, Joan Verdú\textsuperscript{b}, Antoni Munnè\textsuperscript{b}
Conclusions and Management Options

1. Maintain the management criteria regarding nutrient load.

2. Establish an *environmental* flows regime in order to recover the good ecological status in the lower Ebro River.

3. Mobilize the trapped sediments in the dams to restore the sediment load.
Environmental flows proposal

Cabal (m$^3$/s)

- Anys humits
- Anys mitjans
- Anys secs
flushing general proceedings:

Flushing general proceedings:

Flushing general proceedings:

Flushing general proceedings:

Sediment conc. maintenance flushing (peak value > 100 g/L)

Sediment conc. channel formation

Water Level at Dam

Preliminary Drawdown

Erosion

Refill

Final Drawdown

From: Morris & Fan (1998)
Flushning Procedures in the lower Ebro river

1) E. Mequinensa

2) Water level

3) E. Riba-Roja

4) E. Flix

*Water*  
*Sediment*  
*Sediment*

Graphs show variations in water levels and sediment over time.
Flix Dam

1. Approximately $3 \times 10^5$ tons of contaminated sediments

2. Sediments are mobilized with flows above 400 m$^3$/s

3. Moreover, contaminants such as heavy metals are probably in the trophic network, downriver the chlor-alkali plant
How to solve the problem

1. Accept and face it
2. Political will
3. Budget

1. Spanish government paid for studies
2. Restoration actions - 200 M EUR (260 M USD)
3. Environmental Monitoring Network
Decontamination

Riparian vegetation restoration

Green filters

Island restoration
Monitoring network

• 161 automatic stations to measure:
  Water quality
  Flow regime
  Sediment transportation
  Subsidence

• 57 manual stations:
  WFD biological indicators
  Bioaccumulation
  Etc…
Thanks for your attention!