

# THE ROLE OF INTEGRATED WATER RESOURCES MANAGEMENT IN THE RESTORATION OF MEDITERRANEAN TEMPORARY STREAMS IN THE COSTA BRAVA, CATALONIA, NE SPAIN

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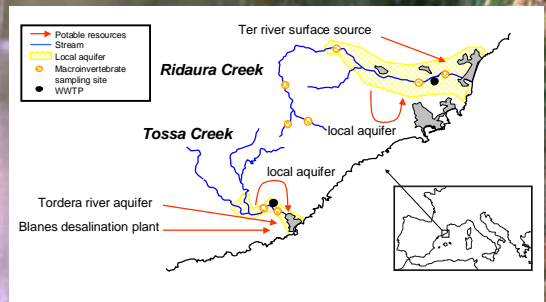
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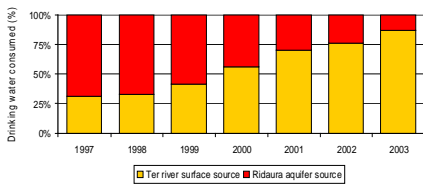
The Costa Brava is the most important touristic destination in north-east Catalonia (resident population, 150,000 inhabitants; maximum estimated occupation, 1,100,000 inhabitants). The urbanistic development of the area, related to touristic activities, began in the decade of 1960, transforming the traditional primary economy into a tertiary economy. Until the decade of 1990, the sole sources of drinking water were the local aquifers, and, as a consequence, the mediterranean kind of streams of the area remained dry throughout most of the year. Changes in the management of resources have led to a certain improvement in the ecological quality of the mediterranean streams in the Costa Brava.



## Improvements in the Ridaura Creek basin

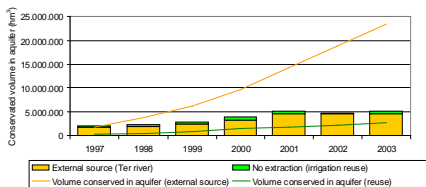
### a) Increased use of external water sources

| Period     | Example year | Ridaura aquifer, % | External sources (Ter river), % |
|------------|--------------|--------------------|---------------------------------|
| Until 1993 | 1990         | 100                | 0                               |
| 1993-2000  | 1997         | 75                 | 25                              |
| From 2001  | 2004         | 20                 | 80                              |



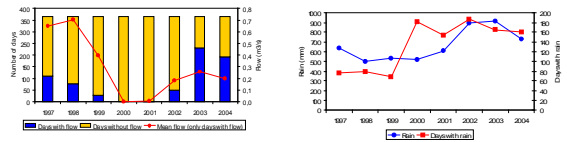
### ® saving of scarce local water resources

### b) Reuse as another tool for groundwater conservation



### ® saving of scarce local water resources

### c) Saving of local water resources



### ® recovery of flow during wet season

d) For total recovery of the water quality between the WWTP and the sea, it is still necessary to improve nutrient removal in treated wastewater. Restoration of riparian vegetation also needed.

Averages of seasonal sampling since 2004 (N=2 for each season except autumn 2005, not yet sampled)

| Parameter              | Winter | Spring | Summer | Autumn |
|------------------------|--------|--------|--------|--------|
| Conductivity, mS/cm    | 0.357  | 0.483  | 0.295  | 0.247  |
| Dissolved oxygen, mg/L | 11.1   | 9.0    | 7.5    | 10.6   |
| Total nitrogen, mg/L   | <1     | <0.3   | ND     | ND     |
| Ammonia, mg/L          | <0.3   | <0.3   | ND     | ND     |
| Nitrate, mg/L          | <0.01  | <0.01  | ND     | ND     |
| Total phosphorus, mg/L | <0     | 2.0    | ND     | ND     |
| BMWP                   | 203    | 198    | 60     | 94     |
| Category BMWP          | I      | I      | II     | I      |
| ASPT                   | 5.5    | 5.7    | 5.1    | 6.7    |
| Taxa number            | 37     | 32     | 12     | 20     |
| Conductivity, mS/cm    | 0.455  | 0.481  | 0.544  | 0.544  |
| Dissolved oxygen, mg/L | 11.5   | 9.4    | 8.7    | 10.9   |
| Total nitrogen, mg/L   | 6.8    | 0.8    | ND     | ND     |
| Ammonia, mg/L          | <0.3   | <0.3   | ND     | ND     |
| Nitrate, mg/L          | 5.3    | 9.7    | ND     | 0.4    |
| Total phosphorus, mg/L | 1.1    | 18     | 4.6    | 5.5    |
| BMWP                   | 142    | 162    | 70     | 70     |
| Category BMWP          | I      | I      | II     | II     |
| ASPT                   | 4.3    | 4.4    | 5.2    | 5.2    |
| Taxa number            | 33     | 37     | 16     | 16     |
| Conductivity, mS/cm    | 0.838  | 0.843  | 1.542  | 1.061  |
| Dissolved oxygen, mg/L | 6.5    | 6.3    | 4.4    | 8.7    |
| Total nitrogen, mg/L   | 6.9    | 23.3   | 38.1   | 11.1   |
| Ammonia, mg/L          | <6.2   | 1.2    | 30.0   | 6.2    |
| Nitrate, mg/L          | 3.6    | 3.3    | 4.2    | 3.5    |
| Total phosphorus, mg/L | 2.0    | <2.7   | 2.7    | 7.0    |
| BMWP                   | 93     | 78     | 31     | 93     |
| Category BMWP          | II     | II     | III    | II     |
| ASPT                   | 3.6    | 3.4    | 2.6    | 4.7    |
| Taxa number            | 26     | 23     | 12     | 20     |

ND: No data available



## Improvements in the Tossa Creek basin

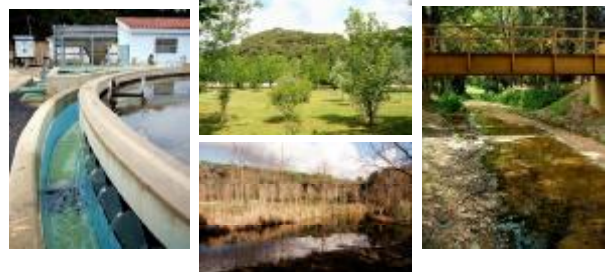
### a) Increased use of external water sources

| Period     | Example year | Tossa aquifer, % | Tordera aquifer, % | Blanes desalination plant, % |
|------------|--------------|------------------|--------------------|------------------------------|
| Until 1980 | 1975         | 100              | 0                  | 0                            |
| 1980-2003  | 1990         | 20               | 80                 | 0                            |
| From 2003  | 2004         | 20               | 52                 | 28                           |



### ® saving of scarce local water resources

b) Active reuse, after advanced wastewater treatment, for environmental enhancement. Transformation of a rubbish tip into an urban park irrigated with reclaimed wastewater. Infiltration from an ornamental, man-made pond maintains a small flow in the stream even in the peak of summer, when the rest of the creek dries out.



### ® recovery of flow all year round downstream of the pond

c) High quality of the water in the stream all year round, even after the recharge point.

Seasonal averages of data available since 2003, calculated from monthly values for physico-chemical parameters and seasonal values for biological parameters

| Stretch  | Parameter  | Winter              | Spring | Summer | Autumn |
|--|--|---------------------|--------|--------|--------|
| Before urban park (no influence of reclaimed wastewater) | Conductivity, mS/cm                              | 0.408               | 0.358  |        | 0.435  |
|  | Dissolved oxygen, mg/L                           | 10.4                | 8.4    |        | 8.8    |
|  | Total nitrogen, mg/L                             | <3.2                | <3.9   |        | <4.2   |
|  | Ammonia, mg/L                                    | <1.0                | <1.2   |        | <2.1   |
|  | Nitrate, mg/L                                    | 1.6                 | 1.8    |        | 1.9    |
|  | Total phosphorus, mg/L                           | 0.7                 | <0.5   |        | 0.8    |
|  | Category BMWP                                    | 97                  | 114    |        | 31     |
|  | ASPT   | 1                   | 1      |        | 1      |
|  | Number of taxa                                   | 4.7                 | 5.2    |        | 3.1    |
|  | After urban park (Soil-filtered reclaimed water) | Conductivity, mS/cm | 0.426  | 0.388  | 0.581  |
| Dissolved oxygen, mg/L                                   |  | 10.6                | 9.0    | 6.3    | 10.9   |
| Total nitrogen, mg/L                                     |  | <3.2                | <4.2   | <4.2   | <3.7   |
| Ammonia, mg/L  |  | <1.2                | <1.3   | <0.8   | <1.7   |
| Nitrate, mg/L  |  | 1.6                 | 1.5    | 2.0    | 1.8    |
| Total phosphorus, mg/L                                   |  | 0.9                 | <0.5   | 0.7    | 0.7    |
| Category BMWP  |  | 108                 | 121    | 85     | 55     |
| ASPT   |  | 1                   | 1      | II     | II     |
| Number of taxa   |  | 5.1                 | 5.2    | 3.5    | 4.4    |
|  |  | 21                  | 24     | 24     | 13     |



### d) Restoration of riparian vegetation

