

## HyMoCARES Case Study ‘Lech and Wertach Rivers’ (Germany)

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### 1. General presentation of the study site(s)

Both study site rivers *Wertach* and *Lech* are originating in the northern Alps near the border between Austria and Germany, and are then running in roughly north direction through Bavaria towards the Danube River. Thereby, the Wertach represents a tributary of the Lech, and joins it in the city center of Augsburg (Fig. 1).



Figure 1: Location of the two study rivers in Germany. In orange, the Wertach River, in red the Lech River. (Graphics: M. Carolli, IGB).

Both rivers originally have been typical pre-Alpine rivers with high sediment load. The seasonal discharge regime is shaped by snow melt in spring. This snowmelt regime may be superimposed by sudden floods which may appear after heavy rains (orographic lift rains) occurring with northerly winds at the northern rim of the Alps.

In both rivers, restoration projects have been conducted in some reaches, which are partially continuing up to date. These two restoration projects ‘Licca liber’ and ‘Wertach Vital’ serve as case studies within the HyMoCARES project (Table 1).

Table 1. Basic information on the study reaches

River	<i>Lech</i>	<i>Wertach</i>
Drainage area (km <sup>2</sup> )*	2350	1441
Location of pilot reaches	From dam '23' until the river joins the Danube River	From dam 'Inningen' until the river joins the Lech River
Length of the study reach (km)	30	14
Active channel width (m)	65	35
Channel slope (m/m)	5,48m/1000m	4,05m/1000m
Planform channel morphology	wandering confined pattern  naturally: braided	single-thread pattern, with local wandering confined style  naturally: transition braided-meandering
Name of restoration project and internet sites	Licca liber	Wertach Vital
Internet sites Wikis	<a href="https://de.wikipedia.org/wiki/Lech">https://de.wikipedia.org/wiki/Lech</a> <a href="http://www.augsburgwiki.de/index.php/AugsburgWiki/Lech">www.augsburgwiki.de/index.php/AugsburgWiki/Lech</a>	<a href="https://de.wikipedia.org/wiki/Wertach">https://de.wikipedia.org/wiki/Wertach</a> <a href="http://www.augsburgwiki.de/index.php/AugsburgWiki/WertachVital">www.augsburgwiki.de/index.php/AugsburgWiki/WertachVital</a>
Restoration website	<a href="http://www.wwa-don.bayern.de/fluesse_seen/massnahmen/liccaliber/index.htm">www.wwa-don.bayern.de/fluesse_seen/massnahmen/liccaliber/index.htm</a>	<a href="http://www.wwa-don.bayern.de/hochwasser/hochwasserschutzprojekte/wertachvital/">www.wwa-don.bayern.de/hochwasser/hochwasserschutzprojekte/wertachvital/</a>

Both rivers have historically been used for extensive fishing, timber rafting and water mills since medieval times. In the 20<sup>th</sup> century they have been straightened for flood protection reasons, with subsequent construction of a series of dams and reservoirs (Fig. 2). For the Lech River, even a huge lake reservoir ("Forggensee") has been built in the area where the river leaves the Alps. The lake is operating as a seasonal water reservoir (high water levels in summer, nearly empty in late winter) in order to feed more smoothly the 31 hydropower plants constructed along the downstream course of the Lech river in the time period from 1903 until recently.

The Wertach River is the so called little sister of the Lech and has experienced similar alterations. Here also the river has lost length and width and the channel slope has increased. However, the many weirs built to stabilize the shortened river channel are not used for hydropower generation.



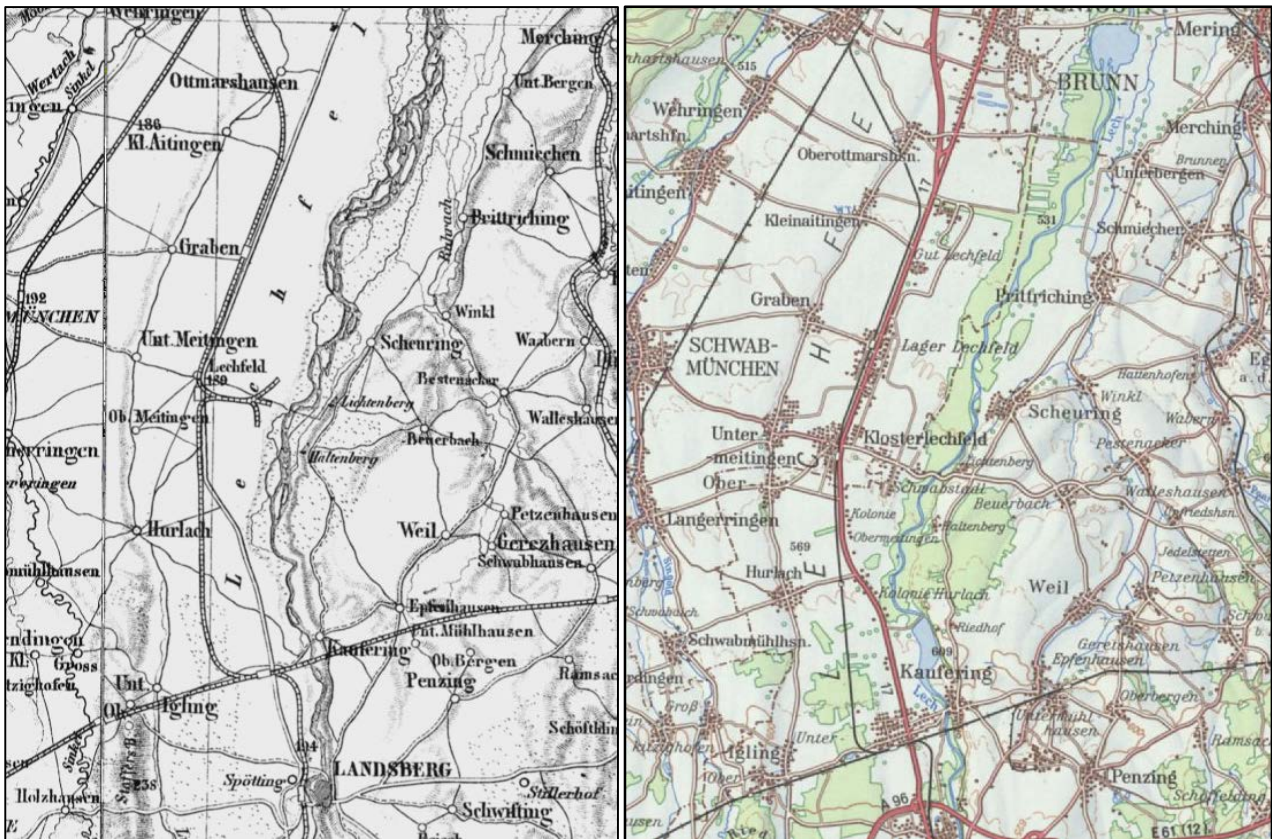


Figure 2: Morphological evolution of the Lech River from 1884 (left) to 1984 (right) (source: Geoportal Bayern <https://geoportal.bayern.de/>)

When rivers were historically channelized, the longitudinal slope of the channel increased, and the width decreased, which resulted in higher flow velocity. Also, the input of new sediment into the river was decreased by artificial bank stabilization, and by the construction of dams in the mainstream river as well as in tributary streams. As a result, both rivers incised their river bed for several decades, and thus lowered their river beds by several meters.

Nowadays incision represents the major management problem at both the Lech and Wertach river, as sediment load that is fully retained in reservoirs (Figure 2). Huge efforts and expenses have been made to artificially stabilize the banks of the incised river channels.

As an unwanted effect of river channelization, the water retention capability of the river channel was lost, so that the flood risk has risen again. Floods with huge damages of several 100 million Euros have occurred.

In addition, the ecological integrity of former river floodplains has been greatly affected by channel incision. Fragmentation of the river by hydropower dams, and hydropowering operation of hydropower plants has resulted in a severe reduction of fish density and diversity. Especially, formerly typical, abundant and economically valuable fish species as Huchen (Danube salmon, *Hucho hucho*) and Grayling (*Thymallus thymallus*) have mostly disappeared.

Therefore, for both rivers multi-targeted restoration projects have been initiated by the water authorities called “WertachVital” and “Licca liber”. Both projects aim to mitigate channel incision, to improve the ecological status of both rivers, and to improve the access to the river for

recreational activities. Both projects accompanied by extensive communication actions with local residents and stakeholders, including the collection of opinions by questionnaires.

## **2. Hydromorphological restoration actions**

### **Lech**

The “Licca liber” project focuses to stabilise and restore the lowermost river section, including the river mouth to the Danube. Our study examines two sections of the river (river-km 17 - 37,3 and river-km 46,95 – 56,7). There, it is attempted to mitigate the severe impacts of past channel straightening, and restore some elements of the Lech’s natural channel morphology. Several measures aim to stop further incision, including large-scale artificial addition of sediment the timing of these measures cannot be specified because no legal process of authorisation has started yet. It is expected that hydromorphological measures will also improve the status of the aquatic biotic communities, which have to be improved in order to reach a “good ecological status” according to the WFD. All restoration measures may only be performed if flood safety is kept at least at the same level as before, or is even improved. In addition, it is aimed to improve accessibility of the river to local residents, and to improve opportunities for leisure time activities on the river. Measures planned in the “Licca liber” project have been presented to the public in many events, and the public was asked to comment them in a survey using an online commenting tool.

According to LfU Bayern the mayor objectives for restoration of Lech river due to its massively altered morphology and flow regulation are to modify hydropiking, improve habitat connectivity by building fish passes at weirs and dams. Another objective is to reduce or remove the massive bank and bed protection i.e. riprap and to install measures to improve habitat quality in the channel profile in connection with selective measures in combination with changes in profile, i.e. gravel bar mobilisation and measures to connect the channel to sediment sources/supply. These measures all have to be realized until the end of the WFD period to achieve the good ecological potential (because Lech and Wertach, too are HMWB) or status, after the year **2021**.

### **Wertach**

Most importantly, the nearby inhabitants of the Wertach river have to be reliably secured from destructive floods. To prevent the river from further erosion, measures have to be taken to reduce shear stress. Construction of a dynamic and continuous river system will help generating a continuous habitat for aquatic fauna and flora.

The „Wertachauen“, as an urban recreation area, will be re-designed in a more natural way, and be accessible for everyone.



Figure 3: Wertach River restoration site (author: Mauro Carolli, IGB).

### 3. Monitoring activities

#### Lech River

The Lech River project (Licca liber) is still under discussion and monitoring activities are not planned by the agencies managing the project. However, the Landesfischereiverband Bayern e.V. (Bavarian Fishery Association) has planned to do subsurface mapping of a sediment introduction and habitat improvement measure related to that.

#### 3.1. General objectives of the monitoring program

#### Lech River

The objective of the monitoring with the echo sounding is to assess habitat variations before/after the restoration project. Echo sounding allows to map the river bathymetry and its variations, which could be used as an input for other tools selected and developed in HyMoCARES.



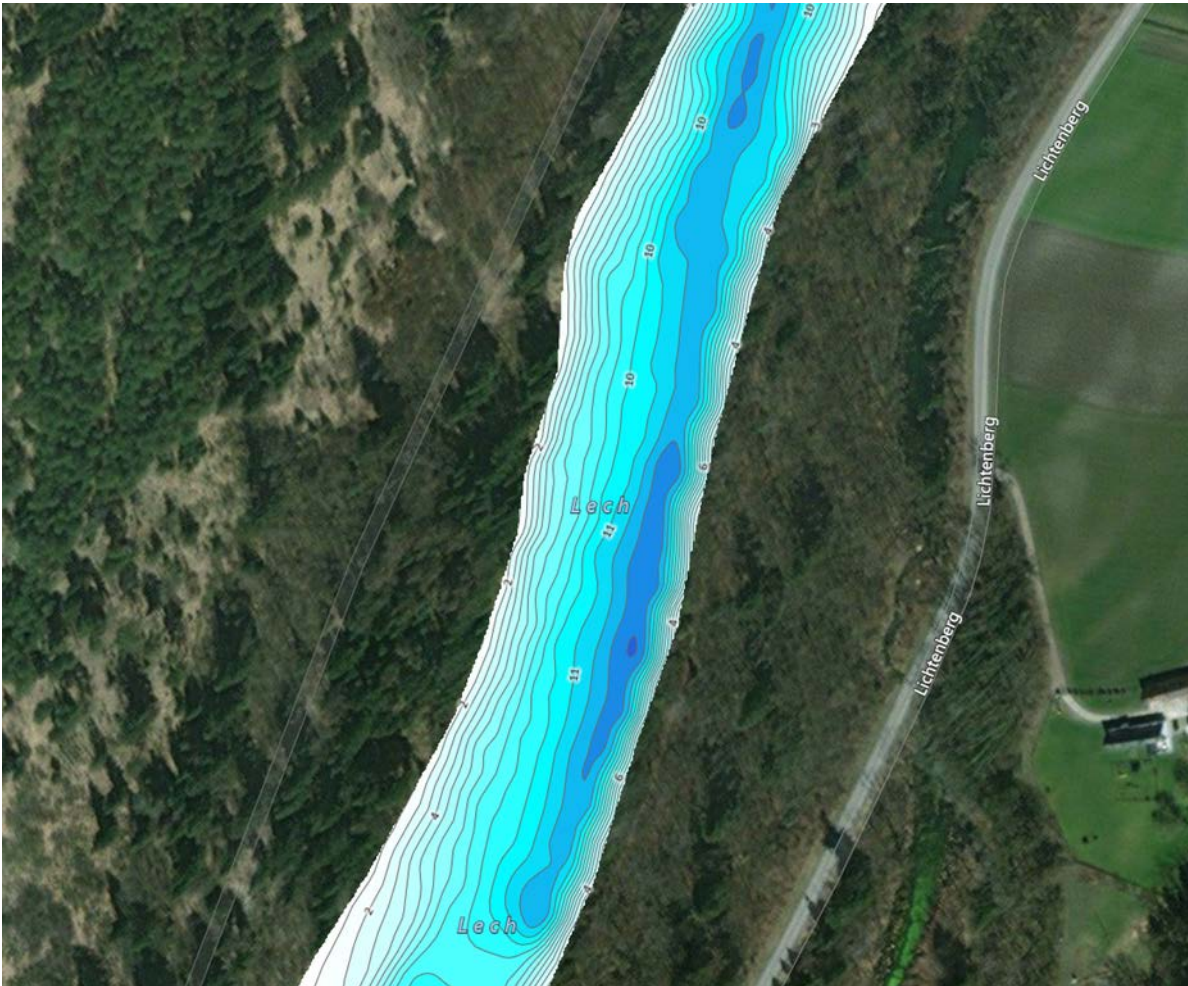


Figure 4: Depth chart (in ft) of the Lech river, near Scheuring, made from echobathymetrics on 21<sup>st</sup> of November before the sediment introduction

### 3.2. Physical monitoring

#### Lech River

Echo sounding is a type of sonar frequently used to collect hydraulic variables in non-shallow rivers. This technique allows to map water depth and substrate at the reach scale in the area where restoration projects will eventually be put in practice. Echo sounding allows to Along with hydraulic variables, the association plans to acquire aerial images by using a drone.

### 3.3. Ecological monitoring

The ecological monitoring activities for Lech and Wertach are done by the LFU Bayern according to the WFD specifications and the request for data concerning all the monitoring activities was sent to the ministry and then delegated to LfU Bayern. The request was accepted and LFV recently received the Data files for Lech and Wertach for water framework directive monitoring and assessment of the ecological and morphological status.

#### 4. Sediment introduction and habitat improvement measure

##### Lech River

The construction works on the Lech river barrage 20 started on November 21<sup>st</sup> and took until November 30<sup>th</sup>. Figure 5 shows nicely the new created oxbow and the amount of excavated sediments that were introduced into the Lech river. This measure is meant to create key habitats for several lifestages of rheophilic fishspecies of the Lech river in this reach. The missing linkage between spawning grounds and follower habitats and structures is one major component that led to the decrease in biodiversity in alpine streams and that has to be restored.



Figure 5: Artificial oxbow near Scheuring on November 30th the introduction of logwood debris and roots will be made soon.