



长江委“创新创效创优”竞赛现场展示

# 高坝大库深水水温水质水生态同步监测 技术研发与应用

长江水利委员会水文局

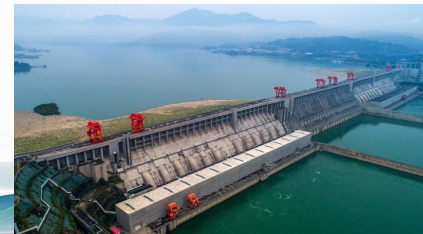
团队成员：左新宇、文首鑫、柯腾、唐鸿琴、任树清、徐鹏、程帅、蒋韵秋、黄蕙

汇报人：左新宇

长江水利委员会水文局

- 一 项目背景
- 二 创意内容
- 三 实施成效
- 四 可推广性

# 一、项目背景



➤ 经济社会的可持续发展依赖于水和生态系统的安全

➤ 长江上游地区

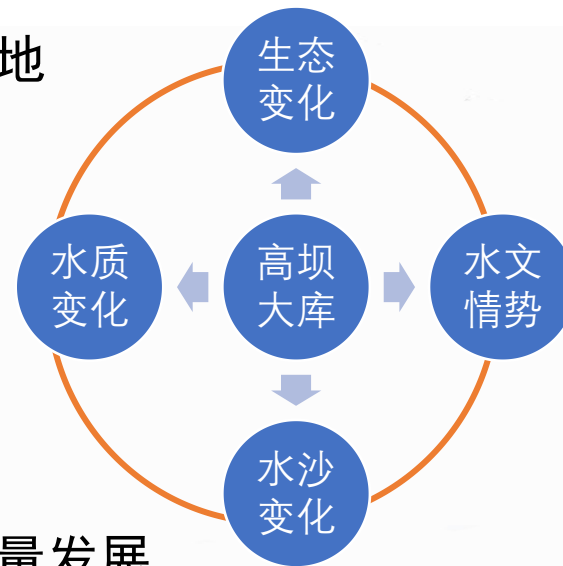
——水电能源供给、水资源配置、防洪安全保障的战略基地

——分布了众多举世瞩目的高坝大库

——显著的综合效益、深远的环境影响

如何更好发挥其有利效应，减缓不利影响？

支撑水库的开发、保护和利用，促进长江经济带绿色高质量发展



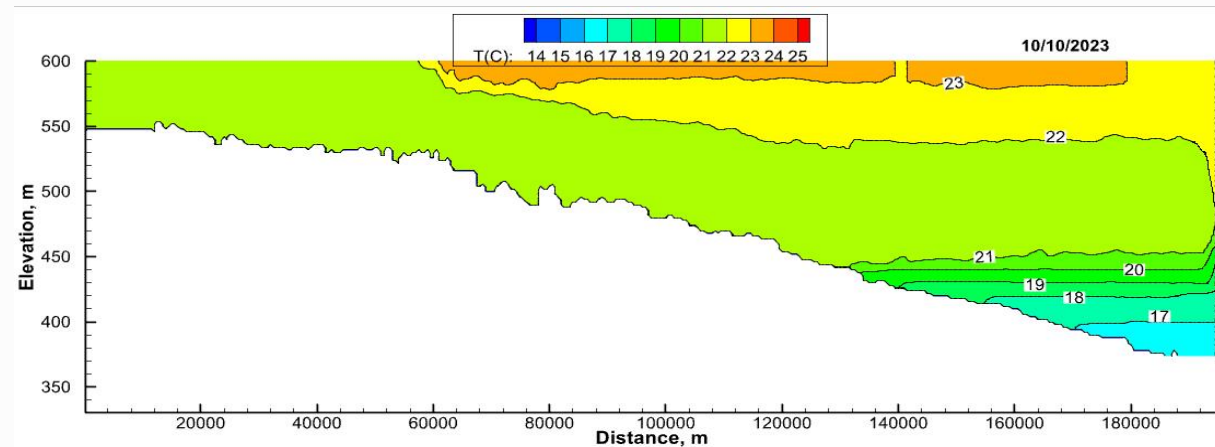
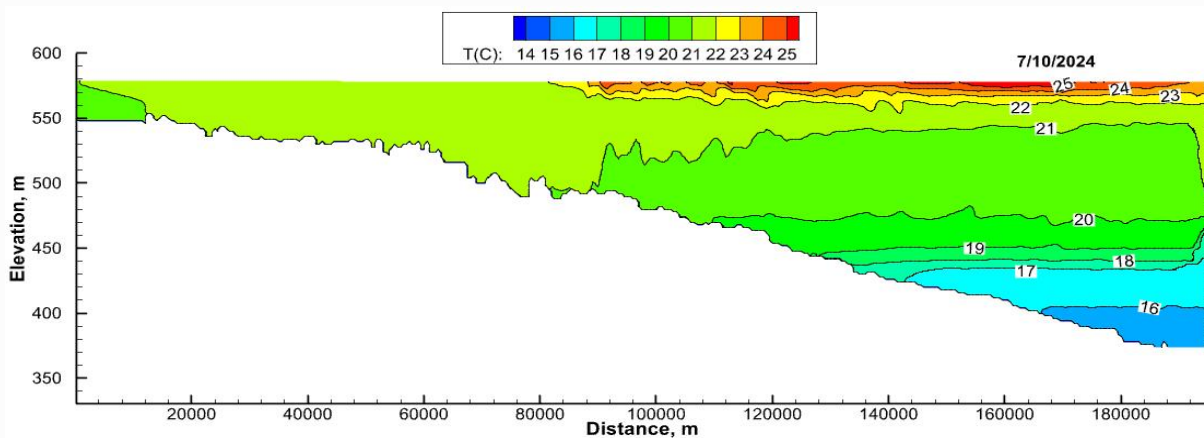
# 一、项目背景

如何更好发挥其有利效应，减缓不利影响？

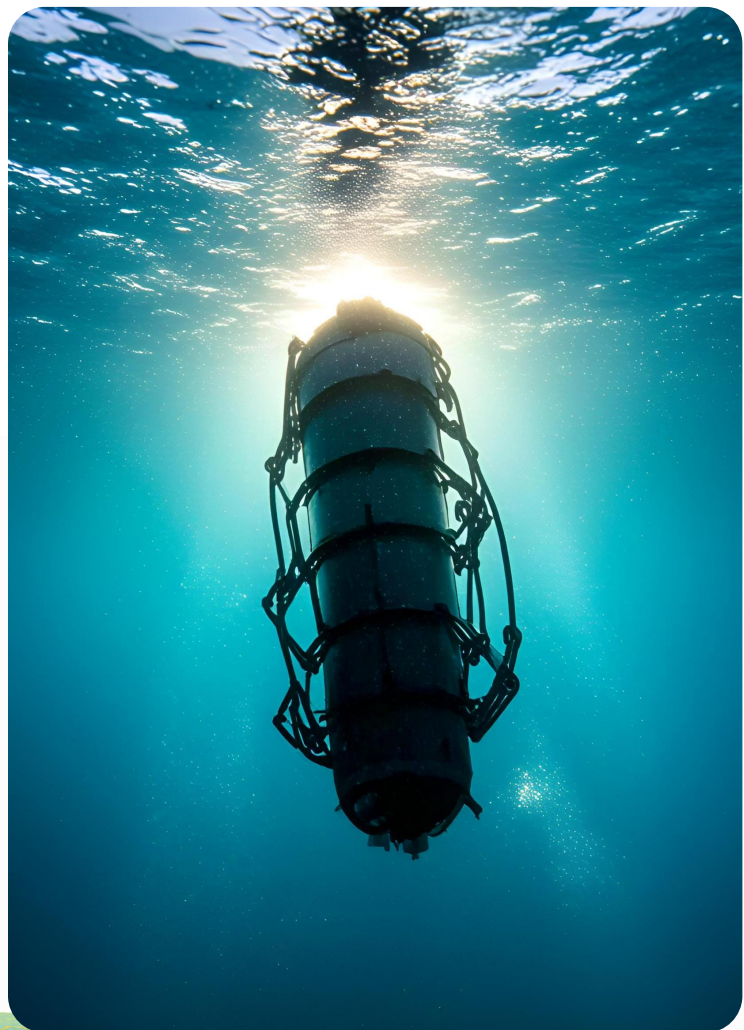
监测研究——熟悉掌握其规律——开发保护利用

现状问题之一：

高坝大库——上百米水深的条件下——水温、水质、水生态常呈现分层状态



# 一、项目背景



## 高坝大库深水监测——多重技术困难

### 1、深水区难以到达，深度难以知晓和控制，采样精度不够

上百米的深水区难以到达，采样器到达的**深度难以准确控制**，**常靠估计**，传统采水器难以避免采样器与外界水体的**多次交换**，水样采集的有效性不足

### 2、监测数据碎片化，多团队、不同时段监测，数据不同步

不同参数通常由不同团队，在不同时间，分别测量，数据**时空不同步**，不同团队仪器直接**可比性不足**，**难以揭示其内在关联机制**

### 3、受效率与成本限制，难实现长期连续监测

传统监测**效率较低**：耗时较长、人力、物力成本高，且**难以实现高频、长期、连续的监测**

# 二、创意内容

## 深水水温水质水生态同步监测技术

深水区  
采样

### 智能触发式采样系统

应用场景1：到达指定深度后，进行水样采集

应用场景2：水样采集同时进行水深测量

数据  
碎片化

### 深水原位同步观测方案

应用场景1：同一深度多参数同步自动监测

应用场景2：不同深度的多参数时空同步监测

数据  
单一化

### 多维度立体监测布局

一次监测 多维数据：

深水水温测定仪+深水型水质多参数仪+鱼探仪声呐设备+水质自动分析仪

1、智能触发式采样系统，预设深度，在指定深度进行水样采集，并且采样过程中同时实现水温、水深等数据同步监测记录

2、将多个传感器，连接成监测链，实现不同深度、多个参数的同步监测；

3、采用多种类型（光电、声呐、生化等）设备协同观测，同时收集深度、水温、水质、生态等多维立体数据

4、改进了一些设备，提高工作效率和安全保障

# 二、创意内容

## 关键技术成果——已取得3个专利，1个软件著作权

促进技术实现，提升仪器安全、测量效率和数据精度和稳定性等

一种水质自动采样器  
(专利号：ZL202421559720.7)

一种可分段取样的水样采样装置  
(专利号：ZL202323010252.6)

一种船用鱼探仪换能器支架  
(专利号：ZL202323447600.6)

地表水水资源质量评价软件  
(软著登字第12155480号)



## 二、创意内容

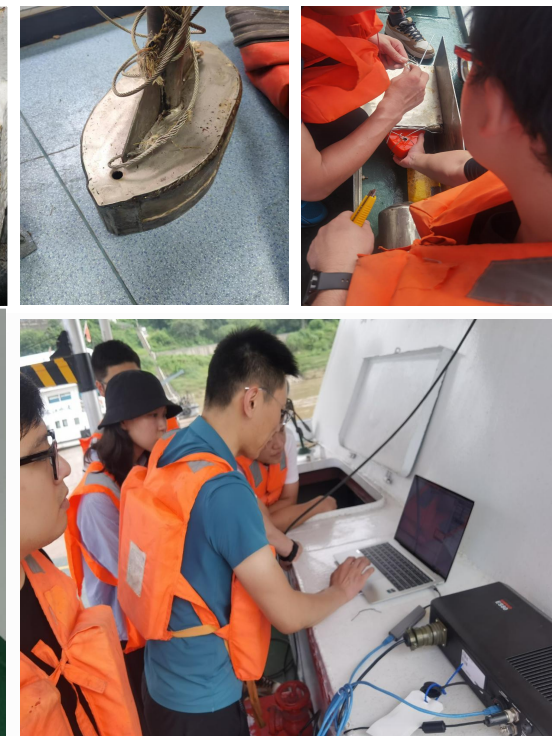
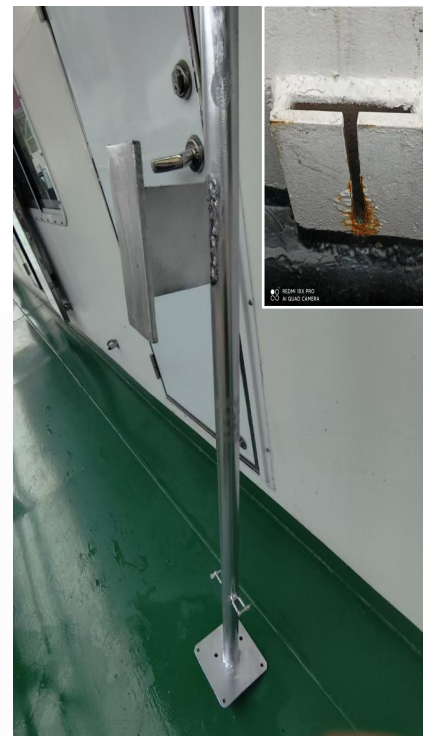
### 现场监测实践照片



乌东德库区  
深水水温水质耦合监测



向家坝库区  
深水水温、水质同步观测



乌东德库区  
水质、水生态同步监测

# 三、实施成效

### 经济和社会效益——近3年超1500万；为高坝大库环境保护和生态调度决策提供技术支持

1. 2025-2029年度金沙江下游流域地表水水质监测技术服务合同 (乌东德)
2. 2025-2029年度金沙江下游流域地表水水质监测技术服务合同 (白鹤滩)
3. 观音岩水电站水质、水温及污水监测项目合同
4. 金沙江下游水电开发水文泥沙情势回顾评价及水环境补充监测合同 (乌东德、白鹤滩、溪洛渡、向家坝)

合同编号:

长江水资源保护科学研究所  
业务委托合同

合同名称: 金沙江下游水电开发水文泥沙情势回顾评价及水环境补充监测

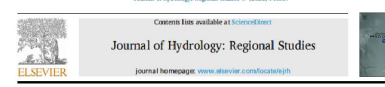
委托方(甲方): 长江水资源保护科学研究所

受托方(乙方): 长江水利委员会水文局长江上游水文水资源勘测局

签订时间: 2025年4月

签订地点: 湖北省武汉市

有效期限: 自合同签订之日起至 2027年12月31日止



**Journal of Hydrology: Regional Studies**  
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**Macroscopic hydro-thermal processes in a large channel-type reservoir**  
Lidi Shi<sup>a</sup>, Jian Sun<sup>a,\*</sup>, Binliang Lin<sup>a</sup>, Khosro Morovati<sup>a</sup>, Zhaowei Liu<sup>a</sup>, Xinyu Zuo<sup>b</sup>

**ABSTRACT**  
Study region: This study was conducted in Xiangjiahe Reservoir, located in the Jinsha River, China's Upper reach of the Yangtze River.  
Study focus: Large channel-type reservoirs are characterized by significant runoff, deep water, and narrow-to-wide channel shape, creating unique hydrological and thermodynamic conditions for their eco-environmental systems. However, the hydro-thermal processes of this type reservoir are not fully known. A large interdisciplinary research was selected to investigate the macroscopic processes through a field survey and employing a three-dimensional (3D) hydro-thermodynamic model.  
New hydrological insights for the region: The research experienced a seasonal varying thermal stratification with a vertical temperature difference of 6–10 °C. Meanwhile a warm flow pattern was detected, consisting of an upper-layer warm water flow and a lower-layer circulation, which was very different from the lake's stratification pattern. When the reservoir was stratified, the inflow warm water on the thermocline could produce a flow effect, promoting vertical mixing and further contributing to hypolimnetic deoxygenation. The observed temperature's warm flow decrease during the non-stratification period, with the non-dam age being ~20 days. The lag effect of the flow-type circulation resulted the cold water in the hypolimnion during the stratification period, and the water age reached 113 days. The presented varying flow pattern and transport timescale have essential effects on the eco-environmental system, providing potential insights into managing water quality and aquatic environment in reservoirs.

**1. Introduction**  
Reservoirs play an essential role in flood control, water supply, and power production when a reservoir is built in a river, the thermodynamic conditions are commonly altered by increasing the water depth, slowing the water flow, and extending residence time (Lin et al., 2020a, 2020b; Morovati et al., 2022). Thus, vertical thermal stratification frequently occurs. The stratified water column is portrayed as a region of sharply varying temperature (thermalization), delineating an upper isothermal region (epilimnion) from a relatively stable deeper region (hypolimnion) (Hilborn et al., 2018). The vertical water column partition significantly affects the reservoir's entire aquatic ecology, including water quality, carbon fixation, nutrient, and phytoplankton dynamics (Sun et al., 2019). For example, due to the stratification, the surface-bottom connectivity is suppressed, giving rise to a nutrient-rich but colder hypolimnion

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**Combined effects of climatic change and hydrological conditions on thermal regimes in a deep channel-type reservoir**

Lidi Shi<sup>a</sup>, Khosro Morovati<sup>a</sup>, Jian Sun<sup>a</sup>, Binliang Lin<sup>a</sup>, Xinyu Zuo<sup>b</sup>

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**Abstract** The thermal regime in large reservoirs plays a significant role in the water quality and ecosystem succession; however, little is known about the impacts of regional climate change and hydrological conditions on a sizeable stratified reservoir with strong inflow conditions, i.e., the Xiangjiahe Reservoir. Using measured data from 2014 to 2018, the monthly and seasonal variations of the water temperature, thermal stability, and their influencing factors were addressed by using empirical models. The results showed substantial variability and seasonality in the reservoir water temperature, which correlated highly with the air temperature, inflow water temperature, and discharge. Correspondingly, there was a seasonal varying thermal stratification in the reservoir's yearly cycle, with its duration being up to 4–5 months, the maximum surface-bottom water temperature difference being up to 7–10 °C. There were significant positive correlations between Schmidt's stability index of the thermal structure and inflow-reservoir temperature difference and the surface-bottom temperature differences, while negative correlations with large discharge. Moreover, the inflow tends to influence thermal stability by retaining hypolimnetic cold water, with its maximum bottom hypoxia residence time being up to 4 months. Research findings indicated that climate warming in the recent 30 years (1988–2017) would cause a 0.21 °C/decade and 0.153 km<sup>3</sup>/decade increase in reservoir surface water temperature and Schmidt's stability index, respectively. Among these variations, the inflow temperature increase caused by climate change accounted for the largest proportion, i.e., 0.16 °C/decade and 0.115 km<sup>3</sup>/decade. Therefore, climate warming significantly affected the thermal regimes in this large reservoir, and the inflow water temperature increase due to warm air was the main factor altering the reservoir's thermal structure. Findings from the present study provide a fresh perspective on how to best optimize the deep channel-type reservoir's water quality in the face of anticipated climatic change.

**Keywords** Deep channel-type reservoirs · Thermal regimes · Climate change · Empirical models

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**Evaluation of genetic diversity and population structure in *Leptobotia microphthalmia* Fu & Ye, 1983 (Cypriniformes, Cobitidae)**

Dongqi Liu<sup>1</sup>, Shining Zhang<sup>2</sup>, Xinyu Zuo<sup>2</sup>, Yi Zheng<sup>1</sup>, Jing Li<sup>1</sup>

**Abstract** This paper reports the first account about dynamic changes on genetic diversity and population structure of *Leptobotia microphthalmia* in the Tangga River drainage due to dam construction. The genetic diversity and population structure of native populations of *L. microphthalmia* collected in 2010 and 2020 were estimated using 12 nuclear microsatellite markers. Reduction of genetic diversity between 2010 and 2020 was not significant in a paired *F*-test ( $p > 0.05$ ), but population structure of *L. microphthalmia* had a tendency to change the genetic differentiation (*F*<sub>ST</sub>) among the first populations collected in 2010 were all significant ( $p < 0.05$ ). However, differentiation (*F*<sub>ST</sub>) among some populations collected in 2020 were significant ( $p < 0.05$ ), which indicated the population structure of *L. microphthalmia* was changing. Correlation analysis indicated that negative correlations between the genetic diversity and geographical distances among populations were significant for seven populations collected at 2020 ( $r = -0.819, p < 0.039$ ), which means that populations of *L. microphthalmia* in high elevation regions were more valuable than those in low elevation regions. Finally, some suggestions for conservation and restoration are proposed, such as artificial propagation, to prevent the further reduction of genetic diversity and population structure.

**Keywords** Conservation biology, fish ecology, microsatellites, restoration

\* These authors contributed equally to this work.

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应用证明	
应用成果名称	一种船用鱼探仪换能器支架
应用单位名称	中国三峡建工(集团)有限公司
通讯地址	四川省成都市高新区天泰路368号三峡大厦A座
应用起止时间	2023年3月至今
应用情况	金沙江下游流域自上而下规划建设了乌东德、白鹤滩、溪洛渡、向家坝4个大型梯级水电站。为监测评价四个梯级水电站建成后水生态环境的变化,在乌东德库区的库尾干支流开展了库尾生态监测试验运行服务等多项生态监测研究工作。该成果装置在乌库尾生态环境监测试验站鱼探仪设备安装和稳定测量工作中,有效的解决金沙江急流水流中鱼探仪相关设备的安装固定和稳定测量问题,为关键作用,改善了工作质量,提高了工作效率,有效支撑了鱼类资源调查监测、增殖放流效果评估等工作,具有显著的经济和效益。





# 四、可推广性

### ➤ 深水“水温-水质-水生态”同步监测解决方案

方法、技术、应用多重创新

技术先进，实用性强

### ➤ 可应用于各个大中型水库、甚至海洋的水温水质水生态监测与评估

### ➤ 已有应用：乌东德、白鹤滩、溪洛渡、向家坝、观音岩电站开展了广泛监测应用；

### ➤ 通过技术培训推广到四川、云南、重庆等周边省份

### ➤ 获得一些兄弟单位，包括高校的合作应用



# 四、可推广性

高坝大库深水水温水质水生态同步监测技术解决方案

是“天空地水工”一体化立体感知系统的一部分

实用性强、应用前景广阔

聚焦水灾害、水资源、水生态、水环境问题

统筹水灾害、水资源、水生态、水环境治理

适度超前谋划构建现代化水利基础设施体系

加快构建“天空地水工”一体化立体感知系统

助力长江大保护

长江经济带绿色高质量发展

复苏河湖生态环境



数字孪生水利建设



“天空地水工”一体化立体感知系统

# Thanks

汇报完毕！ 敬请批评指正！

