

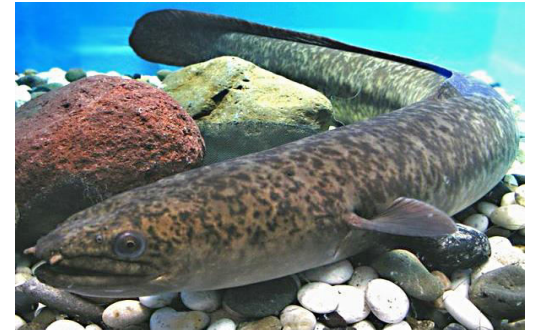
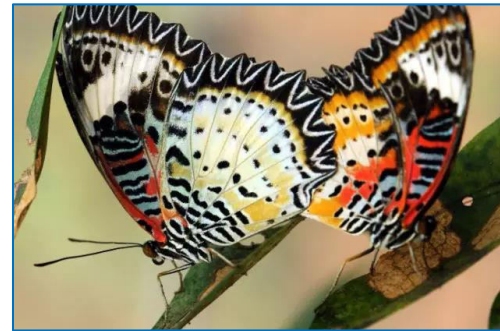


海南中部山区南渡江流域水生生物综合评价

Comprehensive evaluation of aquatic organisms in the Nandu River Basin of the central mountain area, Hainan Island



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outline

01

Background

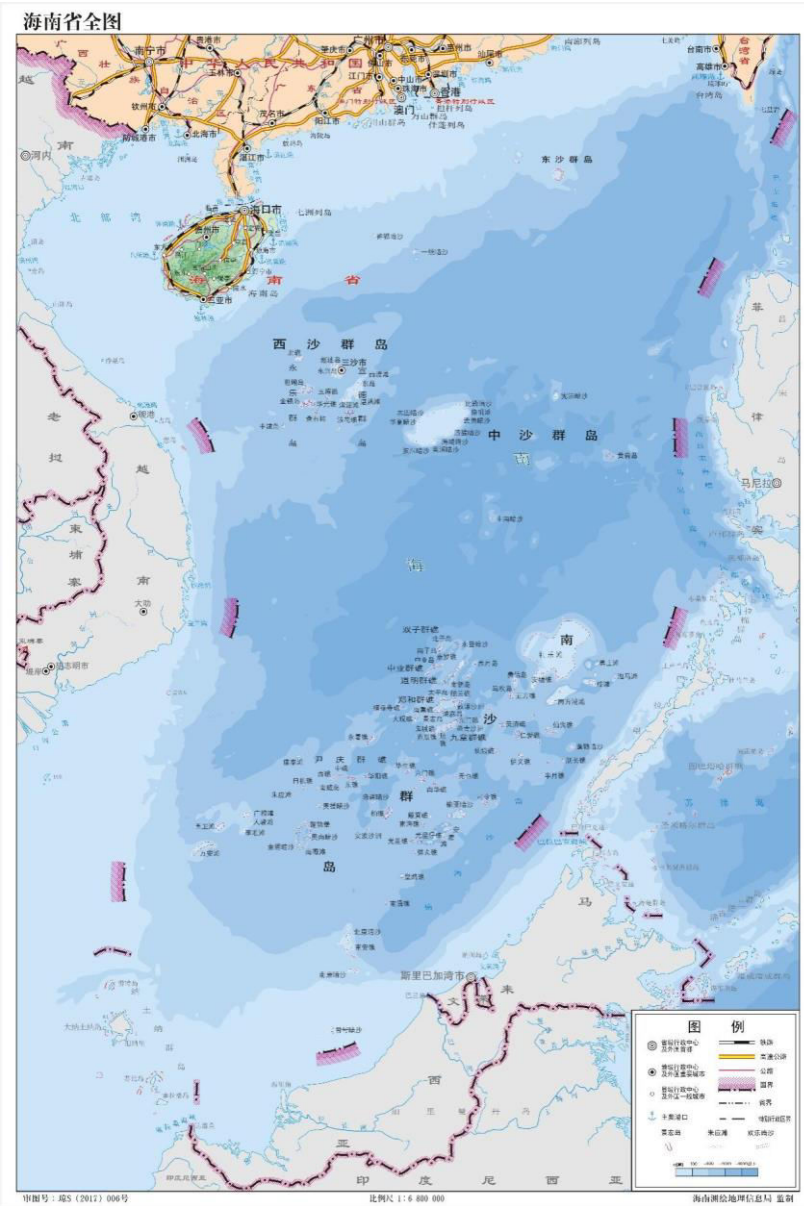
02

Methods

03

Results

Background

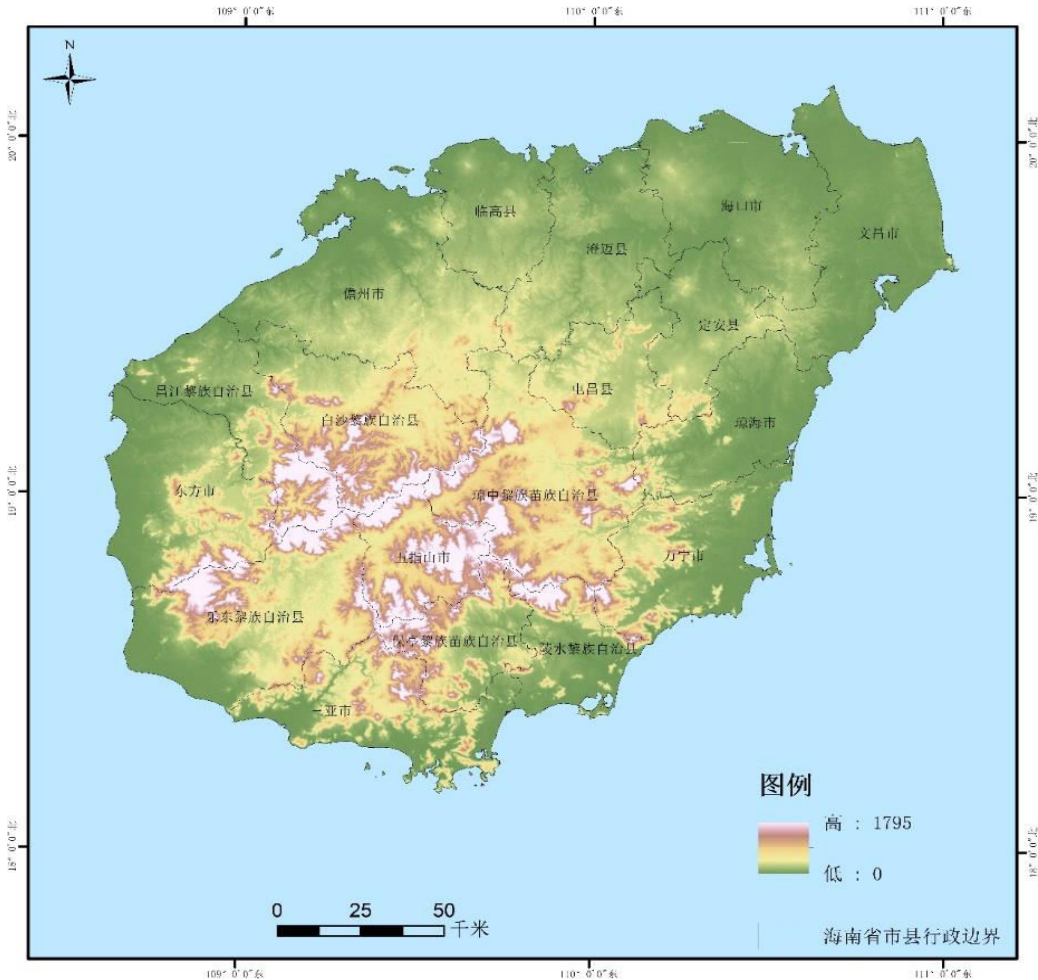


Hainan Island

the second largest island of China

Its ecosystem is relatively unique, and its ecological status is very important.

Background



海南岛地形图

Topographic Map of Hainan Island

□地势为中部高四周低，中间高耸，向外围逐级下降，由山地、丘陵、台地、平原构成环形层状地貌，梯级结构明显。

The terrain is high in the middle and low in the surrounding areas.

□海南岛比较大的河流大都发源于中部山区，组成辐射状水系

So the larger rivers of Hainan Island basically originate from the central mountainous areas.

Background



- 南渡江是海南岛最长的河流，河流全长335km，是海南岛三大河流之一，流域面积超过7000km²，涉及8个市县。另外两条分别是昌化江和万泉河。
- The Nandu River is the longest river in Hainan Island, 335 kilometers in total length, The watershed area exceeds 7000km², Involves 8 cities and counties.

Background



The source of the Nandu River



Middle reaches of the Nandu River



The estuary of the Nandu River

研究目标

Research

Objectives

- 确立南渡江水生生物评价方法，评价南渡江流域多尺度（水体-县域-流域尺度）水生生态系统健康情况。
- Establish the methods for aquatic organisms evaluation in the Nandu River, and evaluate the health of aquatic ecosystems of the Nandu River Basin at the multi-scale (**water body-county-watershed scales**).

outline

01

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Methods



The Nandu River Range

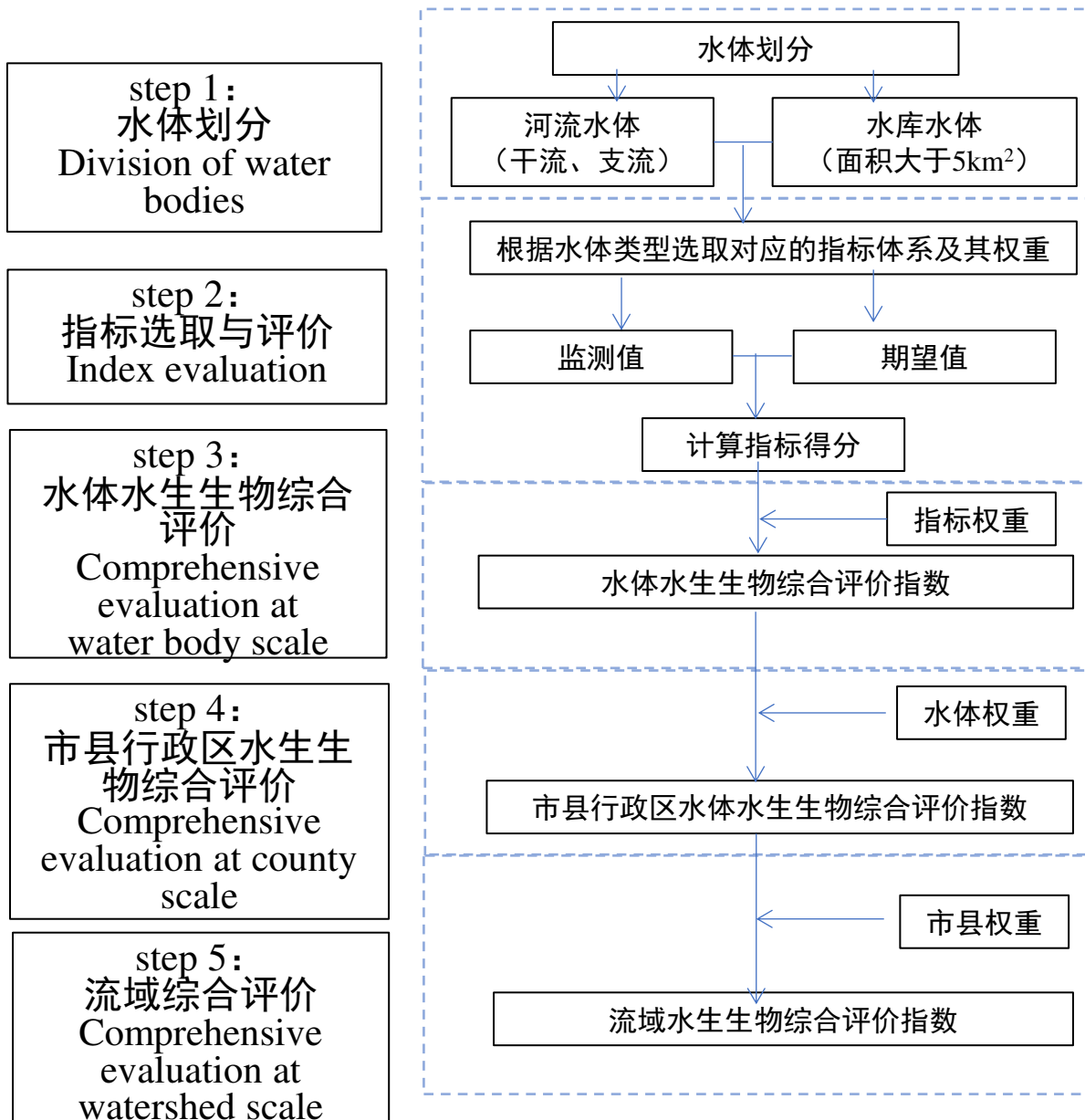
建立流域水生生物评价方法

**Establishing the evaluation framework
for aquatic organisms in river basins**

指标数据获取：现场调查、遥感解译

**Get data: field investigation and
remote sensing interpretation**

Evaluation Framework



➤ **评价水体划分:** 将南渡江流域水体分为河流水体和水库水体, 列出水体清单。

Division of water bodies: Divide the water bodies in the Nandu River Basin into river water bodies and reservoir water bodies.

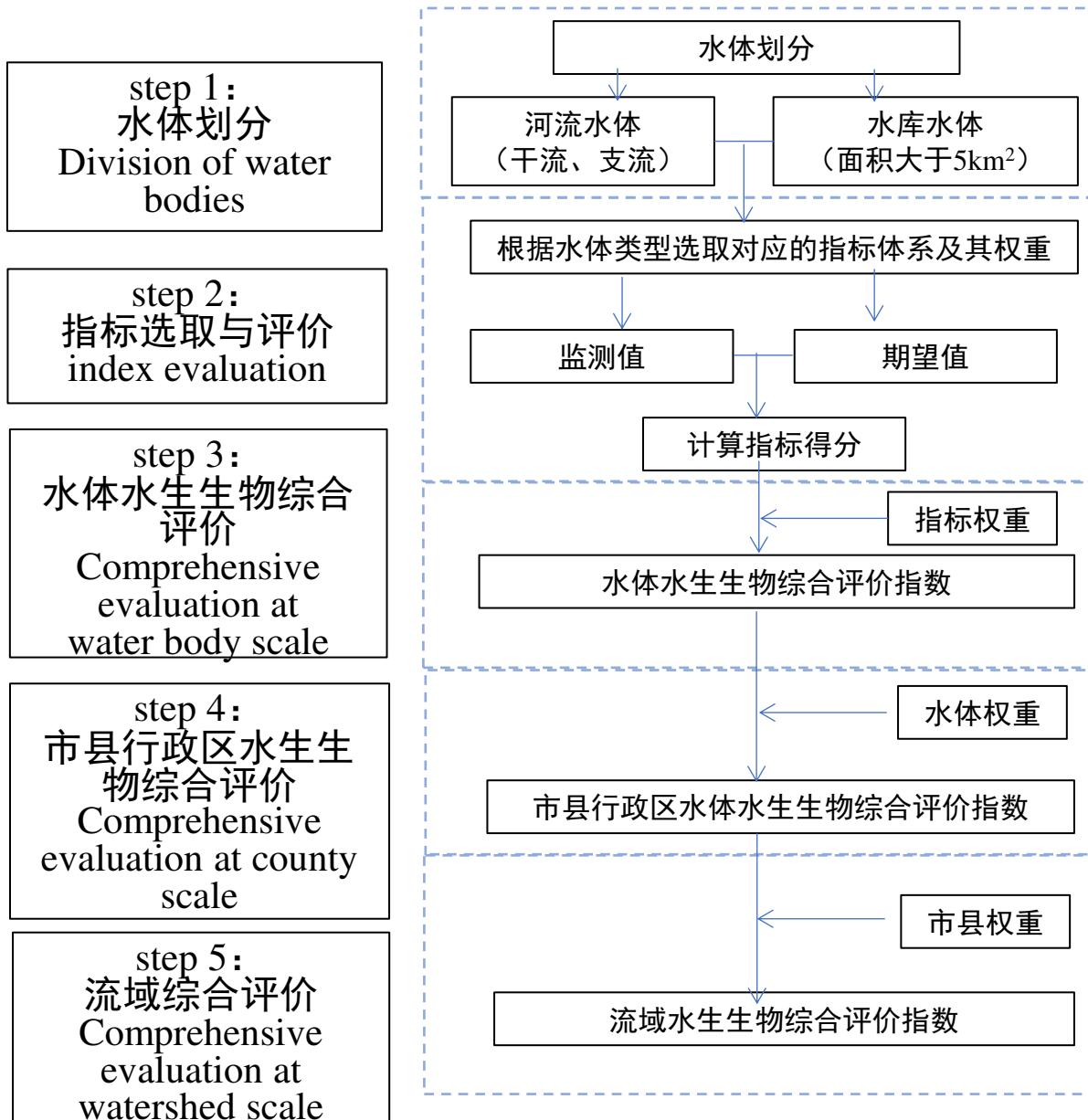
➤ **指标选取与评价:** 选取评价水体对应的指标体系与权重, 通过**监测值与评价期望值**, 计算得到指标得分。

Index evaluation: Determine indicators and weights, determine monitoring values and expected value.

➤ **水体水生生物综合评价:** 各评价指标得分乘以指标权重, 加权求和得到**水体水生生物综合评价指数**。

Comprehensive evaluation aquatic organisms at water body scale.

Evaluation Framework



➤ **市县行政区水体水生生物综合评价**：根据河流水体和水库水体生态综合评价指数和各水体权重，得到流域内**市县行政区水体水生生物综合评价指数**。

Comprehensive evaluation aquatic organisms at county scale

➤ **流域水生生物综合评价**：根据各市县行政区水生生物综合评价指数和各市县权重，得到三大流域各自的水生生物综合评价指数。

Comprehensive evaluation aquatic organisms at watershed scale

单指标评价
Single indicator
evaluation



水体综合评价
Evaluation of at
water body scale



区域综合评价
Evaluation at
county scale



流域综合评价
Evaluation at
watershed scale

指标筛选
原则

Principles of
index
screening

01

针对性：以流域主要的水生态环境问题为导向，可作为水生态系统变化的晴雨表。

Targeting the ecological and environmental problems

02

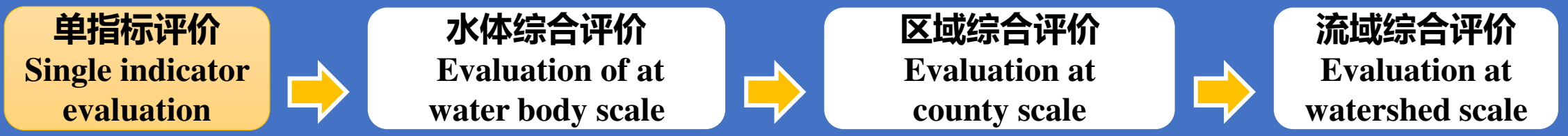
可操作性：方法成熟、易获取、成本低、有改进空间。

Can be obtained easily

03

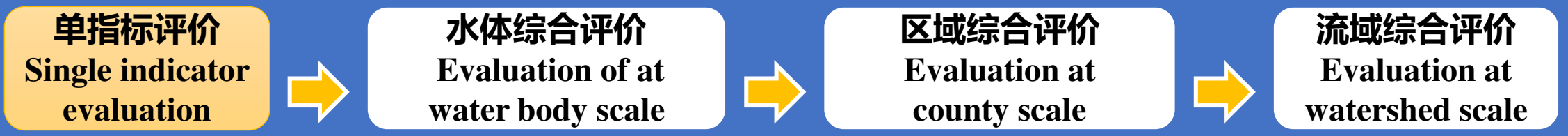
差异性：体现流域内河流和水库生态系统的差异性。

Reflect the ecosystem differences



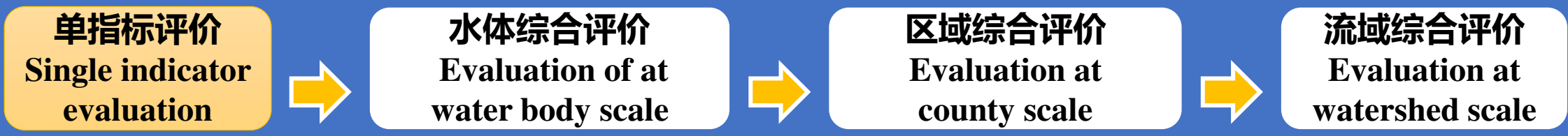
不同类型
河流评价
指标体系
与权重
Different
types of
rivers

序号	水体类型 Types	评价指标Evaluating Indicator	指标权重 Indicator Weight	数据来源 Data Sources
Type I	有重点保护水生生物的河流 Rivers with protecting aquatic organisms	鱼类物种数 Number of fish species	1/7	调查数据 Field Investigation
		浮游植物Shannon-Wiener 多样性指数 Shannon-Wiener Diversity Index of Phytoplankton	1/7	
		着生藻类硅藻属指数 Attached algae index	1/7	
		小型枝角类相对丰度 Relative abundance of small zooplankton	1/7	
		大型底栖无脊椎动物完整性指数B-IBI	1/7	
		重点保护水生生物物种数 Number of protected aquatic species	1/7	
		外来物种入侵度 Invasion degree of alien species	1/7	



不同类型
河流评价
指标体系
与权重
Different
types of
rivers

序号	水体类型 Types	评价指标Evaluating Indicator	指标权重 Indicator Weight	数据来源 Data Sources
Type II	没有重点保护水生生物的河流水体 Rivers without protecting aquatic organisms	鱼类物种数 Number of fish species	1/6	调查数据 Field Investigation
		浮游植物Shannon-Wiener 多样性指数 Shannon-Wiener Diversity Index of Phytoplankton	1/6	
		着生藻类硅藻属指数 Attached algae index	1/6	
		小型枝角类相对丰度 Relative abundance of small zooplankton	1/6	
		大型底栖无脊椎动物完整性指数 B-IBI	1/6	
		外来物种入侵度 Invasion degree of alien species	1/6	



水库评价指标
体系与权重
Reservoir
water bodies

评价指标Evaluating Indicator	指标权重Indicator Weight	数据来源 Data Sources
鱼类物种数 Number of fish species	1/5	现场调查、遥感解译 Get data: field investigation and remote sensing interpretation
浮游植物Shannon-Wiener 多样性指数 Shannon Wiener Diversity Index of Phytoplankton	1/5	
最大水华面积比例 Proportion of maximum water bloom area	1/5	
小型枝角类相对丰度 Relative abundance of small zooplankton	1/5	
外来物种入侵度 Invasion degree of alien species	1/5	

单指标评价
Single indicator
evaluation



水体综合评价
Evaluation at
water body scale



区域综合评价
Evaluation at
county scale



流域综合评价
Evaluation at
watershed scale

评价期望值确定 Determination the expected value

评价期望值：指某水体评价指标曾经达到或者可能达到的较好状态值。

Expected Value: Historical good value or possible good values

方法1
Method 1

根据有权威记录的历史较好状态值确定
Historical good status values

方法2
Method 2

根据监测调查结果，运用统计学方法确定（95%分位数）
The 95% percentile based on monitoring survey results

单指标评价
Single indicator
evaluation



水体综合评价
Evaluation at
water body scale



区域综合评价
Evaluation at
county scale



流域综合评价
Evaluation at
watershed scale

期望值
Expected
Value

序号	指标Evaluating Indicator	期望值Expected Value		期望值计算说明
		河流River	水库Reservoir	
1	鱼类物种数Number of fish species	87	87	根据南渡江土著鱼类历史名录
2	浮游植物Shannon-Wiener 多样性指数Shannon Wiener Diversity Index of Phytoplankton	2.708	2.698	95%分位数
3	最大水华面积比例 Proportion of maximum water bloom area	-	0%	历史值
4	着生藻类硅藻属指数 Attached algae index	9	-	95%分位数
5	小型枝角类相对丰度Relative abundance of small zooplankton	1.000	0.550	95%分位数
6	大型底栖无脊椎动物生物完整性指数B-IBI	2.618	2.110	95%分位数
7	重要水生生物物种数Number of protected aquatic species	1	-	根据南渡江土著鱼类历史名录
8	外来物种入侵度Invasion degree of alien species	0.033	-	根据南渡江土著鱼类历史名录

单指标评价
Single indicator
evaluation



水体综合评价
Evaluation at
water body scale



区域综合评价
Evaluation at
county scale



流域综合评价
Evaluation at
watershed scale

➤ 正向指标得分

正向指标评价得分 =

$$\frac{\text{监测值}}{\text{期望值}} \times 100$$

Positive indicator evaluation score =

$$\frac{\text{Monitor Value}}{\text{Expected Value}} \times 100$$

➤ 负向指标得分

负向指标评价得分 =

$$\frac{\text{最大值-监测值}}{\text{最大值-期望值}} \times 100$$

Negative indicator evaluation score =

$$\frac{\text{Maximum value-Monitor Value}}{\text{Maximum value-Expected Value}} \times 100$$

单指标评价
Single indicator
evaluation



水体综合评价
Evaluation at
water body scale



区域综合评价
Evaluation at
county scale



流域综合评价
Evaluation at
watershed scale

河流水体水生生物评价指数
Evaluation index of aquatic organisms in
river water bodies

水库水体水生生物评价指数
Evaluation index of aquatic organisms in
reservoir water bodies

$$ES_{R1} = (SF_R + PHS_R + GI_R + SZ_R + IBI_R + SK_R + AS_R) / 7$$

式中:

ES_{R1} ——类型 1 河流水生生物评价指数;

SF_R ——鱼类物种数得分;

PHS_R ——浮游植物 Shannon-Wiener 多样性指数得分;

GI_R ——着生藻类硅藻属指数得分;

SZ_R ——小型枝角类相对丰度得分;

IBI_R ——大型底栖动物完整性指数得分;

SK_R ——重要水生生物物种数得分;

AS_R ——外来物种入侵度得分。

$$ES_{R2} = (SF_R + PHS_R + GI_R + SZ_R + IBI_R + AS_R) / 6$$

式中:

ES_{R2} ——类型 2 河流水生生物评价指数;

SF_R ——鱼类物种数得分;

PHS_R ——浮游植物 Shannon-Wiener 多样性指数得分;

GI_R ——着生藻类硅藻属指数得分;

SZ_R ——小型枝角类相对丰度得分;

IBI_R ——大型底栖动物完整性指数得分;

AS_R ——外来物种入侵度得分。

$$ES_K = (SF_K + PHS_K + SA + SZ_K + AS_K) / 5$$

式中:

ES_K ——水库水生生物评价指数;

SF_K ——鱼类物种数得分;

PHS_K ——浮游植物 Shannon-Wiener 多样性指数得分;

SA ——水华面积比例得分;

SZ_K ——小型枝角类相对丰度得分;

AS_K ——外来物种入侵度得分。

有重点保护水生生物河流水体
River water bodies with
protecting aquatic organisms

没有重点保护水生生物河流水体
Rivers without protecting
aquatic organisms

水库水体
Reservoir water bodies



根据市县行政区内河流（干流、支流）和水库等各水体**水生生物评价指数**和**水体权重**，加权求和得到市县水生态综合评价指数。

According to the aquatic organism evaluation index and water body weight of rivers (main streams, tributaries) and reservoirs of each county, the comprehensive evaluation aquatic organisms of at county scale were obtained by weighted summation.

单指标评价
Single indicator
evaluation



水体综合评价
Evaluation at
water body scale



区域综合评价
Evaluation at
county scale



流域综合评价
Evaluation at
watershed scale

序号	行政区District	河流 River				水库 Reservoir	
		干流名称 Main streams	权重 Weight	支流名称 Tributaries	权重 Weight	水库名称 Reservoir	权重 Weight
1	海口市 HaiKou City	干流 (海口段)	0.5	支流 (海口段)	0.5	——	——
2	儋州市 Danzhou City	——	——	支流 (儋州段)	0.4	松涛水库	0.6
3	定安县 Ding'an County	干流 (安定段)	0.3	支流 (安定段)	0.5	南扶水库	0.2
4	屯昌县 Tunchang County	干流 (屯昌段)	0.3	支流 (屯昌段)	0.7	——	——
5	澄迈县 Chengmai County	干流 (澄迈段)	0.5	支流 (澄迈段)	0.5	——	——
6	临高县 Lingao County	——	——	支流 (临高段)	1	——	——
7	白沙县 Baisha County	干流 (白沙段)	0.5	支流 (白沙段)	0.3	松涛水库	0.2
8	琼中县 Qiongzong County	干流 (琼中段)	0.5	支流 (琼中段)	0.5	——	——

单指标评价
Single indicator
evaluation



水体综合评价
Evaluation at
water body scale



区域综合评价
Evaluation at
county scale



流域综合评价
Evaluation at
watershed scale

南渡江流域各县市权重

Weights of counties and cities in the Nandu River Basin

$$P = \frac{1}{2} \sum_{j=1}^n (PC_j \times a_j) + \frac{1}{2} \sum_{j=1}^n (PC_j \times b_j)$$

式中：

P ——流域水生生物综合指数得分；

PC_j ——流域内第 j 个市（县）指标水生生物综合指数得分；

a_j ——流域内第 j 个市（县）面积权重；

b_j ——流域内第 j 个市（县）功能权重；

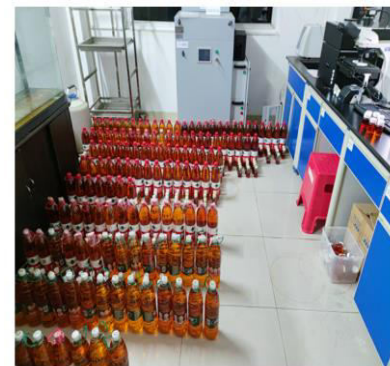
n ——流域内评价考核市（县）数量。

序号	市县名称	流域内国土面积 Land area within the watershed(km ²)	面积权重 Area weight	重要生态空间面积 Important ecological space area(km ²)	功能权重 Functional weight
1	白沙县	1143.88	0.16	899.79	0.53
2	琼中县	466.24	0.07	74.09	0.04
3	儋州市	474.67	0.07	308.90	0.18
4	澄迈县	1569.41	0.22	177.39	0.10
5	屯昌县	1072.79	0.15	56.56	0.03
6	定安县	916.49	0.13	58.22	0.03
7	临高县	291.84	0.04	20.30	0.01
8	海口市	1175.02	0.17	94.52	0.06

Get data: field investigation and remote sensing interpretation

采样时间: 2022年4月 Sample Time: April 2022

类别 Category	调查点位 Number of survey points
浮游植物、浮游动物 Phytoplankton and zooplankton	67
着生藻类 Attached algae	48
水生植物 Aquatic plant	28
鱼类 Fish	11
底栖动物 Zoobenthos	69
水华面积 Water bloom area	2 (松涛水库、南扶水库)



outline

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河流水体 River water bodies

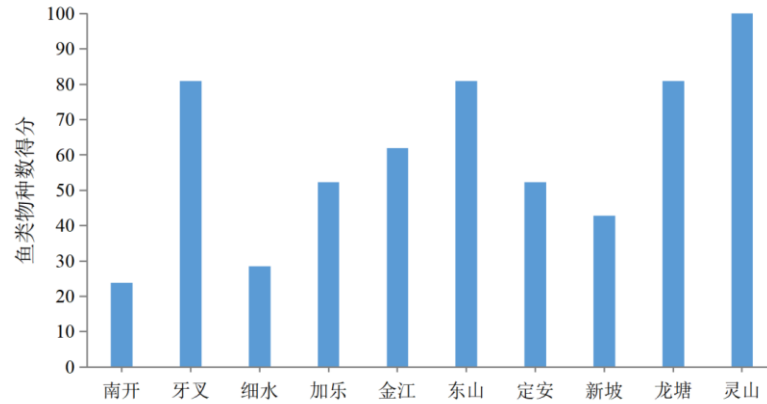
鱼类物种数得分 score of number of fish species

单指标评价
Single indicator
evaluation

水体综合评价
Evaluation at
water body scale

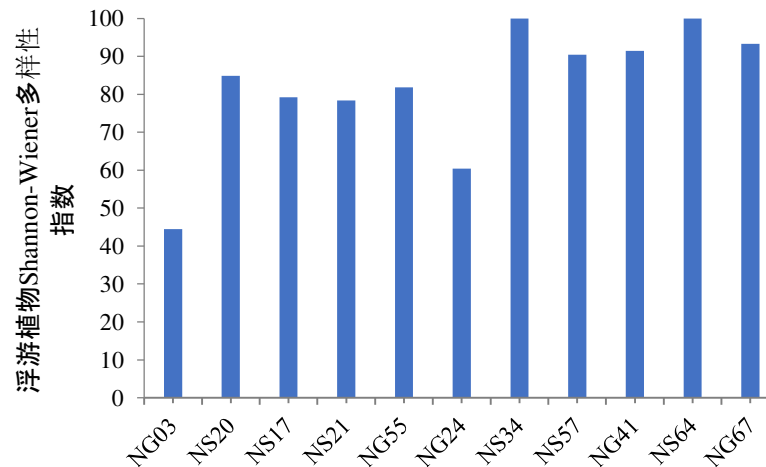
区域综合评价
Evaluation at
county scale

流域综合评价
Evaluation at
watershed scale

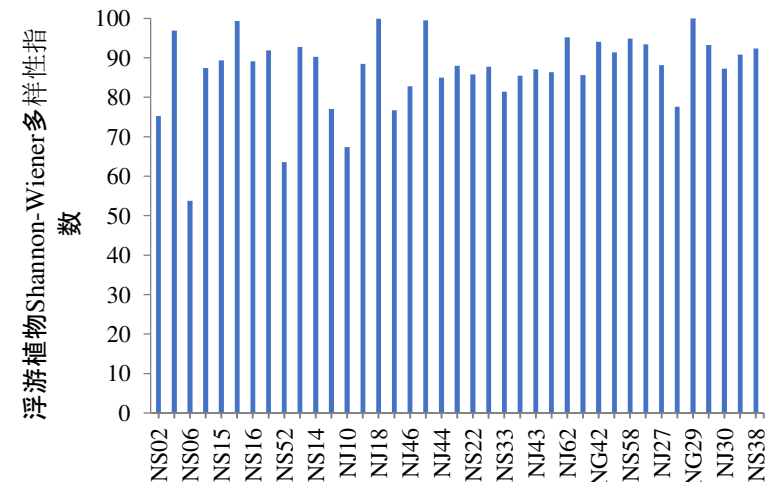


干流: 灵山点位得分最高, 为100分,
支流: 牙叉点位得分最高, 为80.95分

浮游植物Shannon-Wiener 多样性指数得分 score of Shannon Wiener Diversity Index of Phytoplankton



干流平均得分为81.66分
main stream score is 81.66



支流平均得分为87.20分
tributaries score is 87.20

河流水体 River water bodies

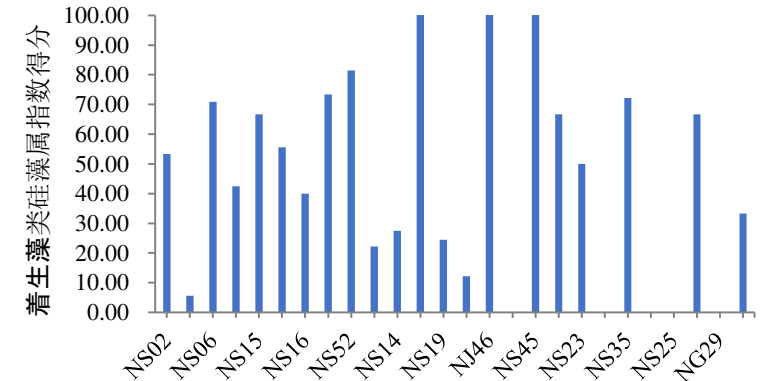
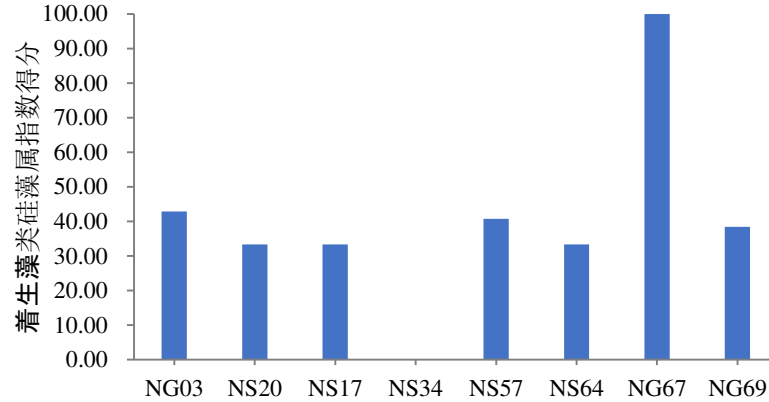
着生藻类硅藻属指数得分 score of attached algae index

单指标评价
Single indicator
evaluation

水体综合评价
Evaluation at
water body scale

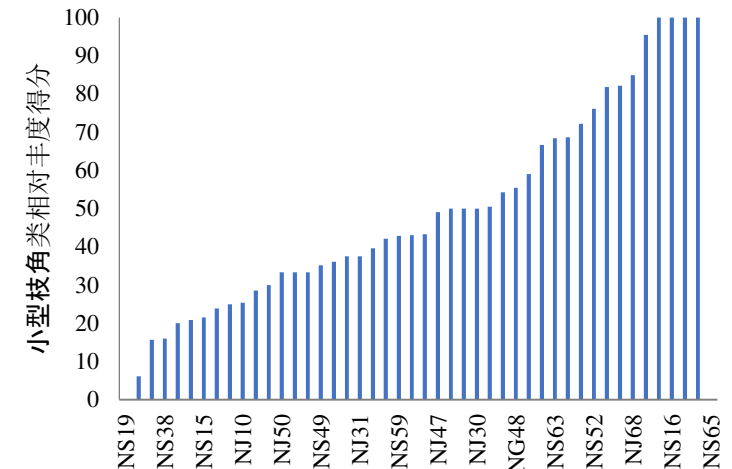
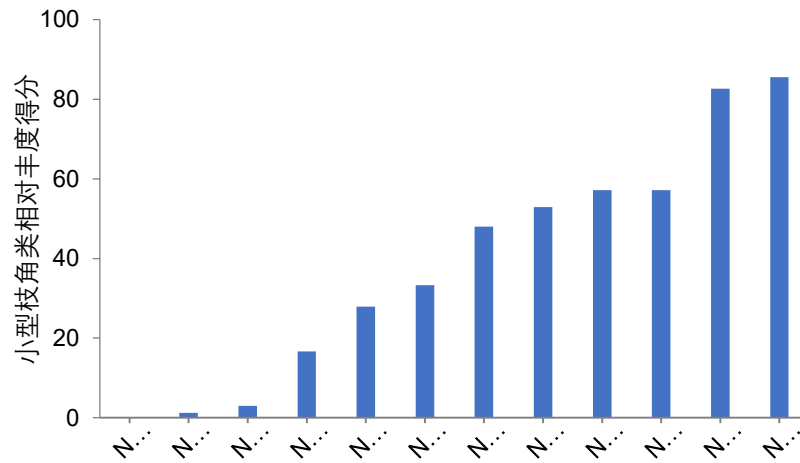
区域综合评价
Evaluation at
county scale

流域综合评价
Evaluation at
watershed scale



干流平均得分为40.26分 main stream score is 40.26 支流平均得分为44.70分 tributaries score is 44.70

小型枝角类相对丰度得分 score of relative abundance of small zooplankton



干流平均得分为38.96分
main stream score is 38.96

支流平均得分为50.11分
tributaries score is 50.11

河流水体 River water bodies

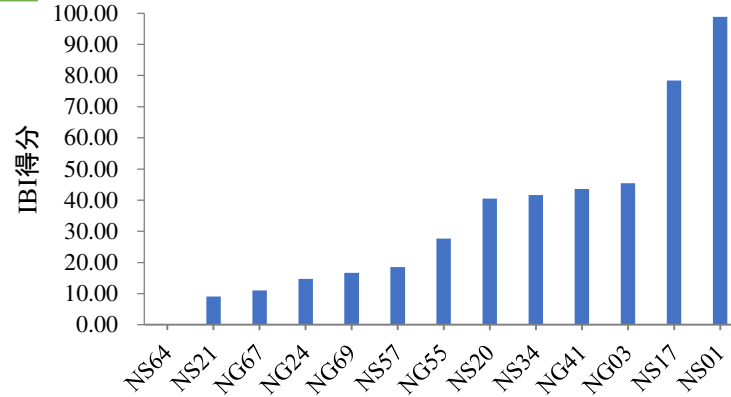
单指标评价
Single indicator
evaluation

水体综合评价
Evaluation at
water body scale

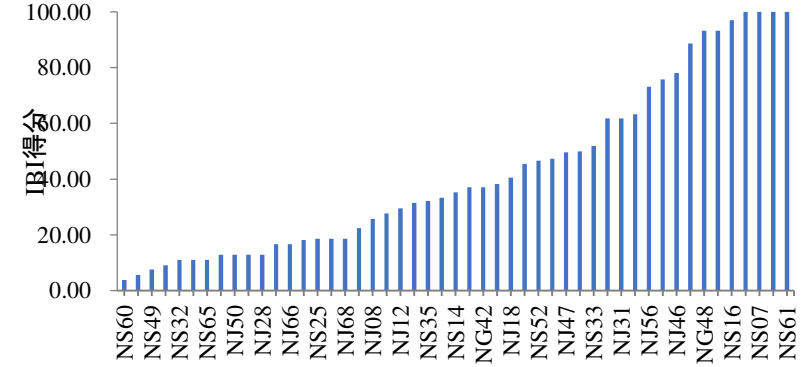
区域综合评价
Evaluation at
county scale

流域综合评价
Evaluation at
watershed scale

大型底栖无脊椎动物生物完整性指数得分 score of I-IBI

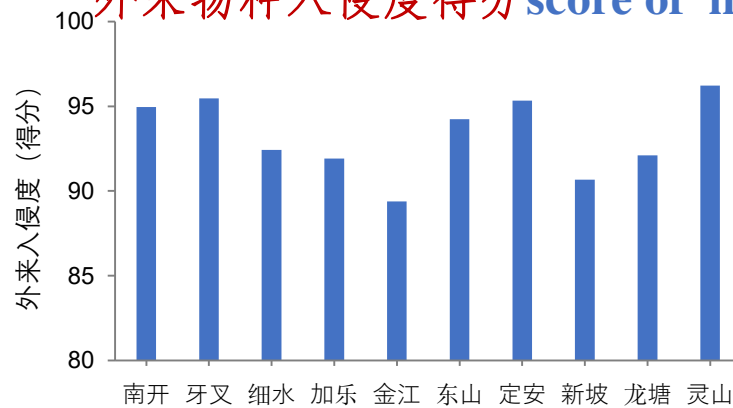


干流平均得分为34.32分
main stream score is 34.32



支流平均得分为42.55分
tributaries score is 42.55

外来物种入侵度得分 score of invasion degree of alien species



干流：灵山点位得分最高，为96.21分，
支流：牙叉点位得分最高，为95.45分。

水库水体 reservoir water bodies

鱼类物种数得分 score of number of fish species

单指标评价
Single indicator
evaluation

水体综合评价
Evaluation at
water body scale

区域综合评价
Evaluation at
county scale

流域综合评价
Evaluation at
watershed scale

序号	市县 District	水库名称 Reservoir	鱼类物种数得分 score of number of fish species
1	儋州市 Danzhou City	松涛水库 SongTao Reservoir	33.33
2	白沙县 Baisha County	松涛水库 SongTao Reservoir	44.44
3	定安县 Ding'an County	南扶水库 Nanfu Reservoir	52.38

- 南扶水库鱼类物种数得分最高
- Nanfu Reservoir has the highest score of number of fish species

水库水体 reservoir water bodies

最大水华面积比例 Proportion of maximum water bloom area

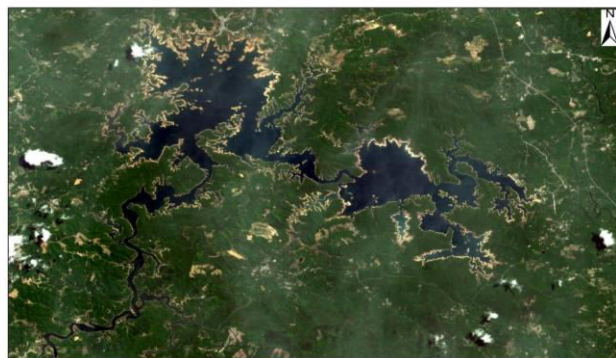
单指标评价
Single indicator
evaluation

水体综合评价
Evaluation at
water body scale

区域综合评价
Evaluation at
county scale

流域综合评价
Evaluation at
watershed scale

2021年7月和11月对松涛水库和南扶水库遥感监测结果显示，两个水库均未发生水华。 No water blooms occurred in SongTao Reservoir and Nanfu Reservoir.



2021年7月松涛水库水华监测影像



2021年11月松涛水库水华监测影像



2021年7月南扶水库水华监测影像

最大水华面积比例均为0%，
该项指标均得100分

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watershed scale

District	Number of fish species	Shannon Wiener Diversity Index of Phytoplankton	Attached algae index	Relative abundance of small zooplankton	B-IBI	Number of protected aquatic species	Invasion degree of alien species	Comprehensive score
HaiKou	71.43	89.68	53.13	37.7	11.55	100	94.95	65.49
Danzhou	—	—	—	—	—	—	—	—
Ding'an	66.66	81.74	100	33.33	27.65	—	92.42	66.97
Tunchang	52.38	78.23	45.92	57.14	9.09	—	96.21	56.50
Chengmai	57.14	84.08	16.67	33.5	35.13	—	91.92	53.07
Lingao	—	—	—	—	—	—	—	—
Baisha	23.81	44.43	42.86	85.53	45.45	—	94.23	56.05
Qiongzong	80.95	79.08	33.33	65.28	78.41	—	90.68	71.29

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District	Number of fish species	Shannon Wiener Diversity Index of Phytoplankton	Attached algae index	Relative abundance of small zooplankton	B-IBI	Invasion degree of alien species	Comprehensive score
HaiKou	71.43	73.75	29.31	55.22	20.38	93.08	57.20
Danzhou	80.95	86.49	70	40.29	40.72	96.21	69.11
Ding'an	66.66	78.77	100	35.09	52.01	95.34	71.31
Tunchang	52.38	86.48	45.93	40.87	41.61	91.92	59.87
Chengmai	57.14	90.83	51.11	45.05	38.49	90.66	62.21
Lingao	57.14	55.97	100	48.85	44.82	89.39	66.03
Baisha	54.76	75.98	54.43	63.6	53.94	93.94	66.11
Qiongzong	80.95	92	36.56	65.28	46.4	92.42	68.94

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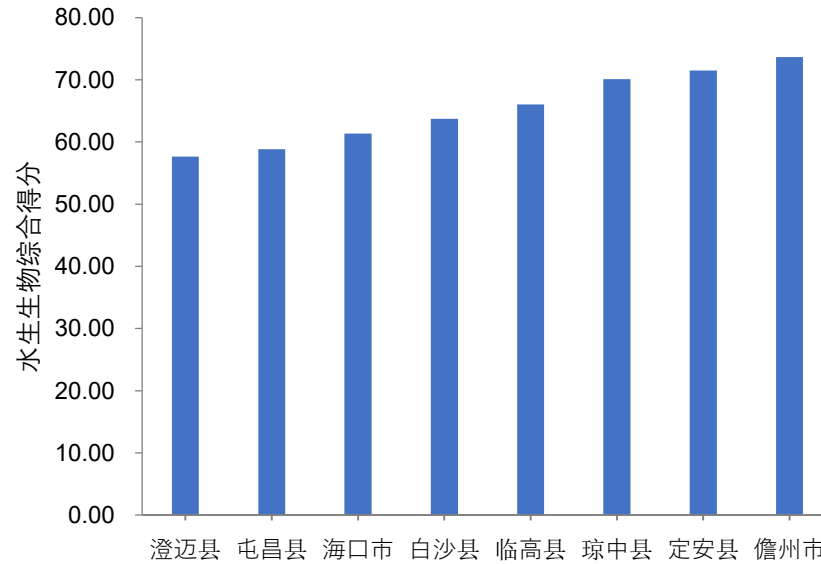
District	Number of fish species	Shannon-Wiener Diversity Index of Phytoplankton	Proportion of maximum water bloom area	Relative abundance of small zooplankton	Invasion degree of alien species	Comprehensive score
HaiKou	—	—	—	—	—	—
Danzhou	33.33	88.93	100	64.82	96.21	76.66
Ding'an	52.38	78.81	100	67.68	95.34	78.84
Tunchang	—	—	—	—	—	—
Chengmai	—	—	—	—	—	—
Lingao	—	—	—	—	—	—
Baisha	44.44	78.74	100	78.74	94.28	79.24
Qiongzong	—	—	—	—	—	—

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儋州市水生生物综合评价得分最高，为73.64分，澄迈县、屯昌县、海口市、白沙县得分相对较低。

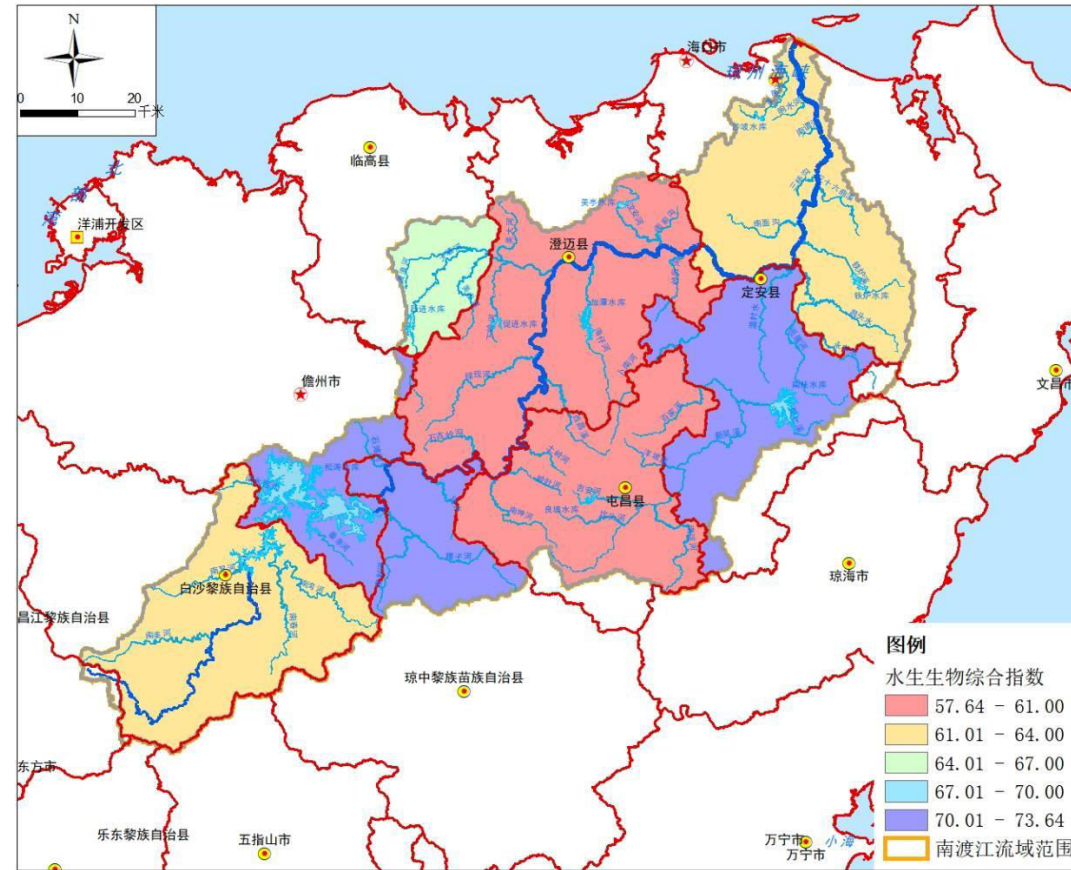
Danzhou City has the highest comprehensive evaluation score for aquatic organisms, with a score of 73.64, Chengmai County, Tunchang County, Haikou City, and Baisha County have relatively low scores.

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南渡江流域水生生物综合评价指数为63.99分。

The comprehensive evaluation index of aquatic organisms in the Nandu River Basin is 63.99.

本研究成果来自《海南重点流域生态环境调查评估项目》

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**Thanks very much for your
attention!**

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