长江江豚保护及智能监测技术进展

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2025年8月

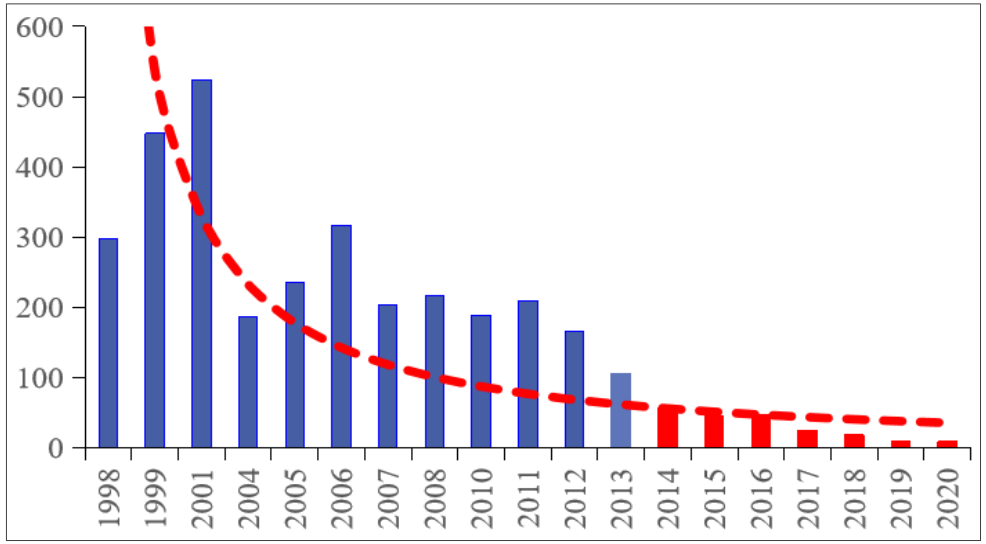
长江 世界第三大河，流经唯一国度的世界最长河流

- 生命之河
- 母亲河
- 两种鲸类
- 黄金水道

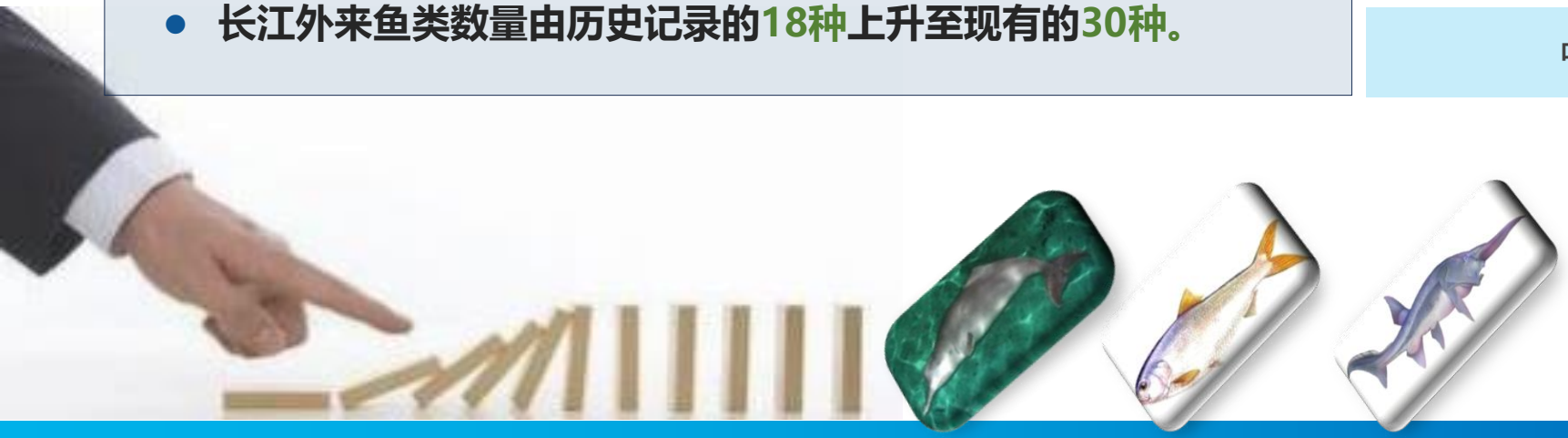
长江生物多样性快速衰退

长江生物多样性保护仍然面临严峻挑战

- 白鳖豚、白鲟、鲥鱼功能性灭绝。
- 中华鲟极度濒危，自2017年以来自然繁殖活动中断，每年洄游至葛洲坝的繁殖个体仅约10余尾。
- 2019-2022年长江调查到约323种鱼类，有135种（约占1/3）历史分布鱼类没有被采集到。
- 长江外来鱼类数量由历史记录的18种上升至现有的30种。



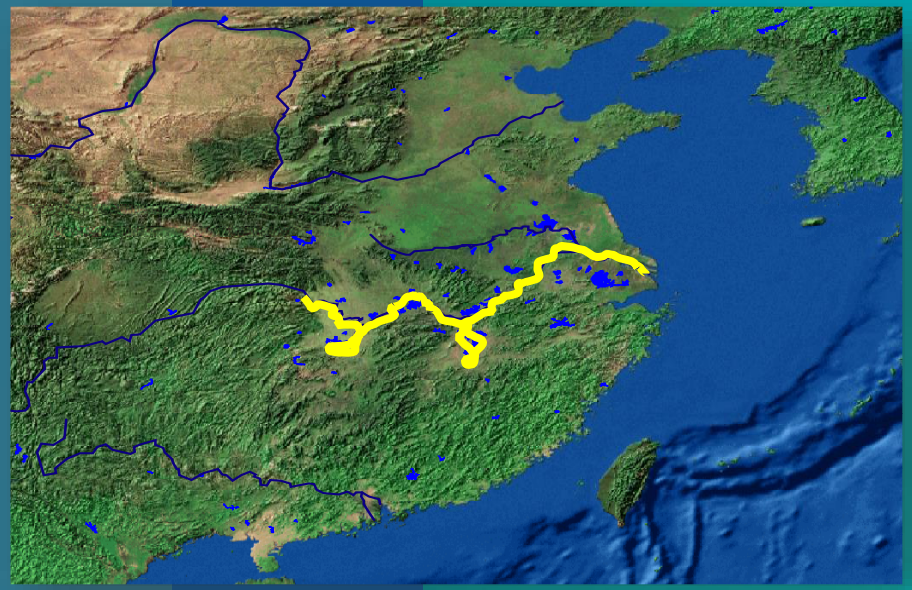
中华鲟繁殖群体数量(尾)



最后一个倒下的是谁?

Who will be the next?

长江江豚 *Neophocaena asiaeorientalis asiaeorientalis*

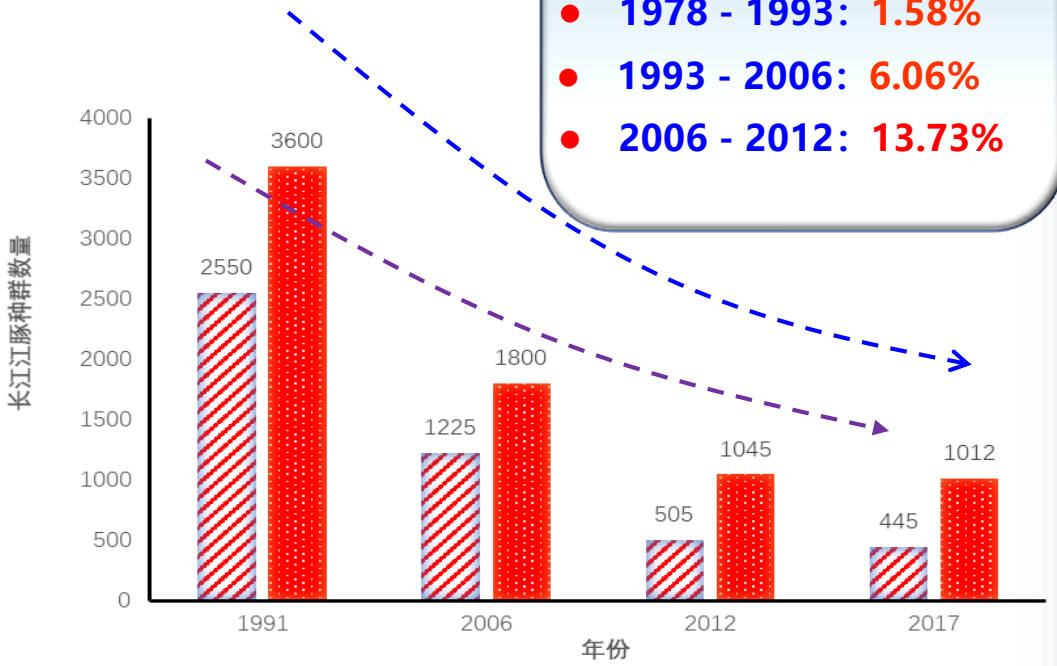


长江江豚分布

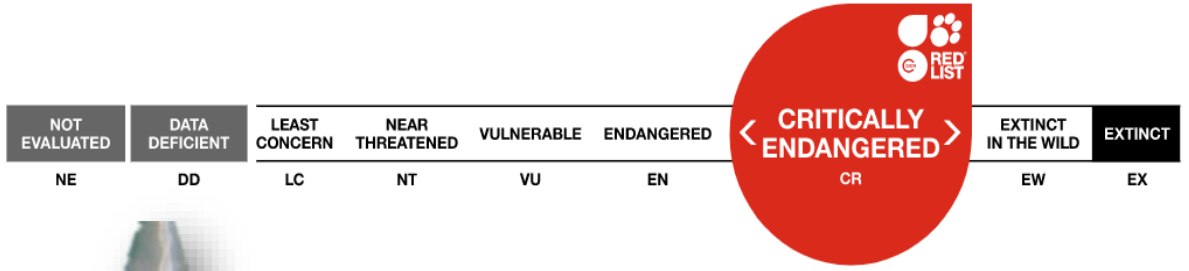
长江江豚自然种群数量急剧下降

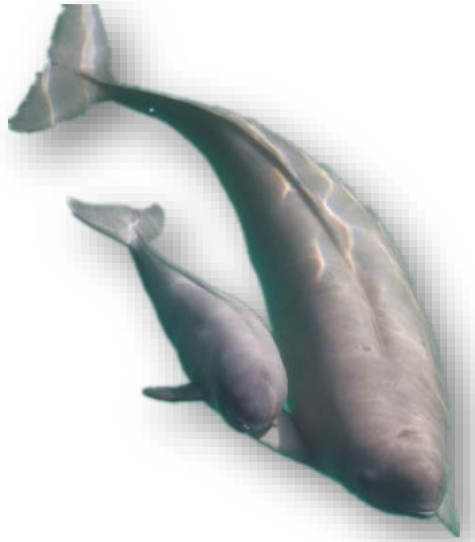
年下降速率:

- 1978 - 1993: 1.58%
- 1993 - 2006: 6.06%
- 2006 - 2012: 13.73%



长江江豚的数量变化趋势（1991-2017）





CR!

极度濒危！

长江江豚自然种群数量急剧下降

主要威胁

栖息地退化

非法和过度渔业捕捞

繁忙航运

水污染

采砂

目标与保护策略

短期目标
[减缓数量下降速率]

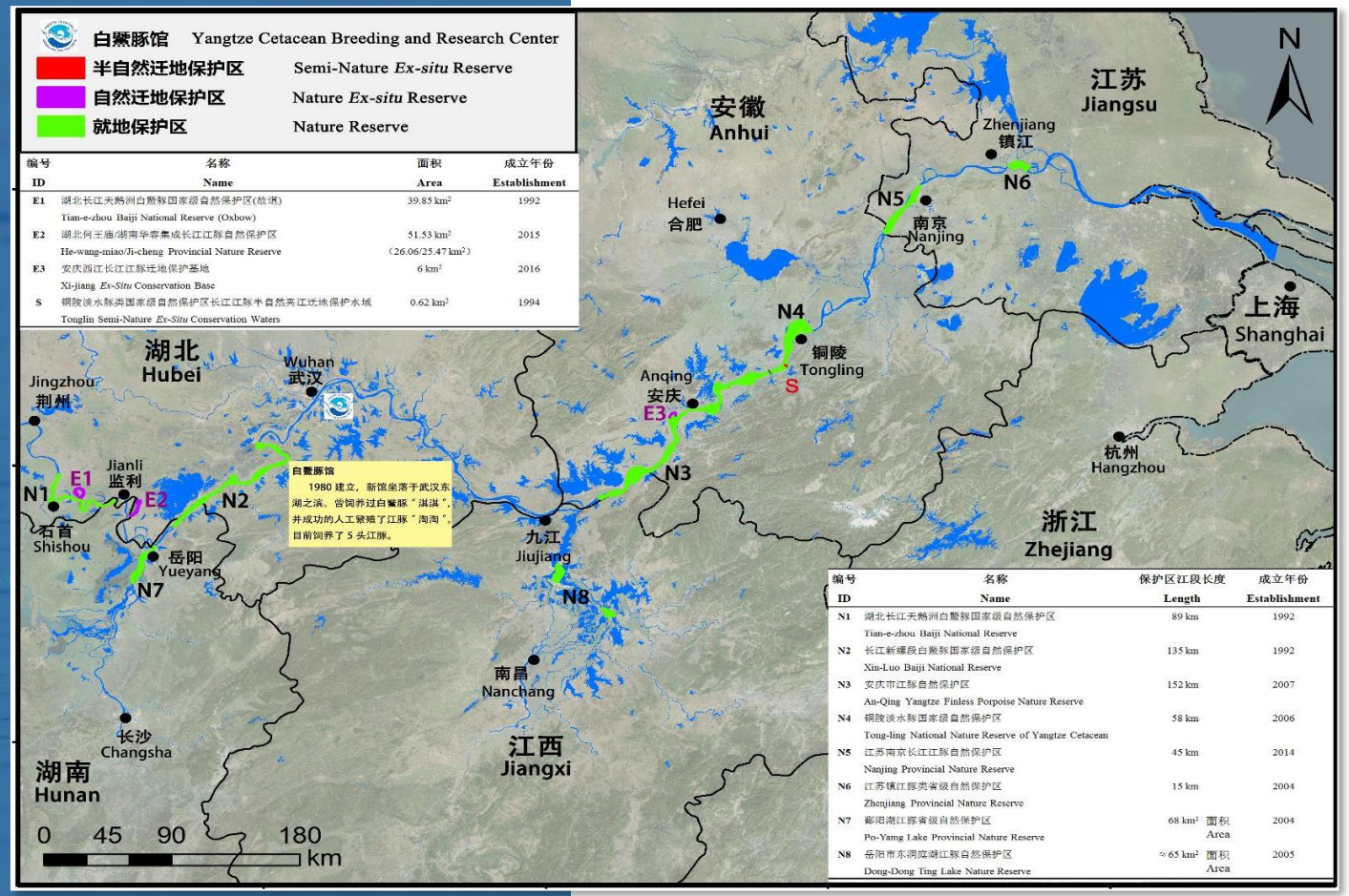
最终目标
[长江江豚兴盛繁衍]

- 自然迁地保护
  - 保种种群
- 就地保护
  - 根本措施
- 人工圈养繁殖与研究
  - 科技支撑和公众教育

就地保护

建立了8个自然保护区

- 定期监测种群丰度和生境
- 系统提高保护区管理能力
- 针对性地修复和恢复自然生境
- 提高保护区管理水平
- 建立更多就地保护区



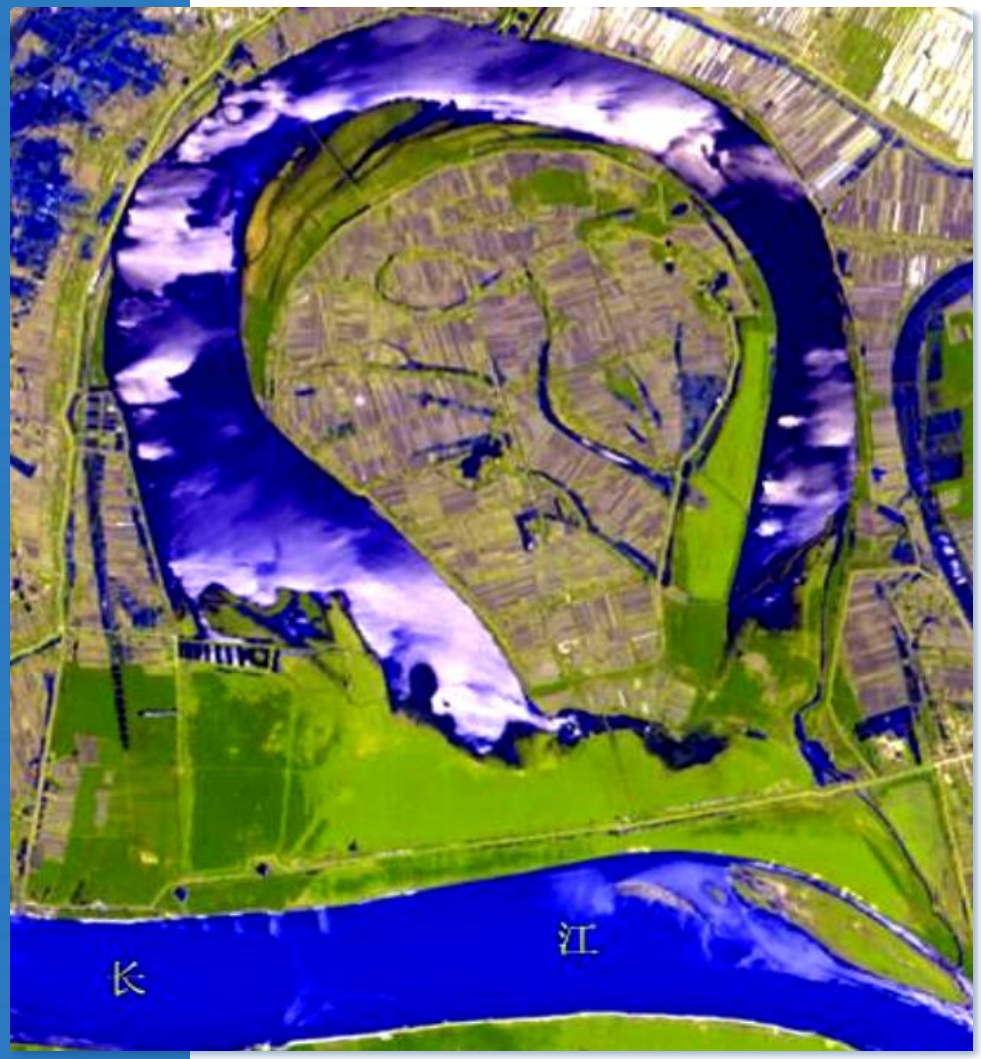
编号 ID	名称 Name	面积 Area	成立年份 Establishment
E1	湖北长江天鹅洲白鳍豚国家级自然保护区(故道) Tian-e-zhou Baiji National Reserve (Oxbow)	39.85 km²	1992
E2	湖北何王庙/湖南华容集成长江江豚自然保护区 He-wang-miao/Ji-cheng Provincial Nature Reserve	51.53 km² (26.06/25.47 km²)	2015
E3	安庆西江长江江豚迁地保护基地 Xi-jiang *Ex-Situ* Conservation Base	6 km²	2016
S	铜陵淡水豚类国家级自然保护区长江江豚半自然夹江迁地保护水域 Tonglin Semi-Nature *Ex-Situ* Conservation Waters	0.62 km²	1994

编号 ID	名称 Name	保护区江段长度 Length	成立年份 Establishment
N1	湖北长江天鹅洲白鳍豚国家级自然保护区 Tian-e-zhou Baiji National Reserve	89 km	1992
N2	长江新螺段白鳍豚国家级自然保护区 Xin-Luo Baiji National Reserve	135 km	1992
N3	安庆市江豚自然保护区 An-Qing Yangtze Finless Porpoise Nature Reserve	152 km	2007
N4	铜陵淡水豚国家级自然保护区 Tong-ling National Nature Reserve of Yangtze Cetacean	58 km	2006
N5	江苏南京长江江豚自然保护区 Nanjing Provincial Nature Reserve	45 km	2014
N6	江苏镇江豚类省级自然保护区 Zhenjiang Provincial Nature Reserve	15 km	2004
N7	鄱阳湖江豚省级自然保护区 Po-Yang Lake Provincial Nature Reserve	68 km² 面积 Area	2004
N8	岳阳市东洞庭湖江豚自然保护区 Dong-Dong Ting Lake Nature Reserve	≈ 65 km² 面积 Area	2005

白鳍豚馆 YANGTZE CETACEAN Breeding and Research Center

迁地保护

建立了3个自然和1个半自然的迁地种群，共有约150头江豚，每年出生10头以上



天鹅洲故道卫星图像

迁地保护

2015年3月

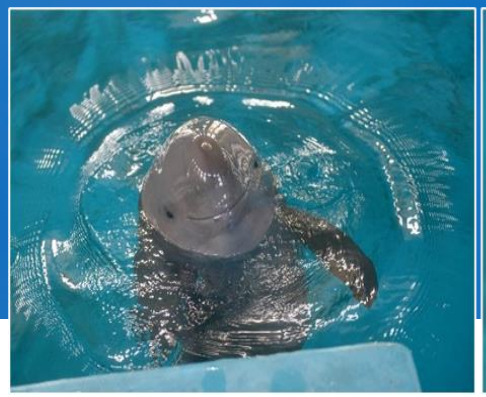
第一批长江江豚被引入何王庙/集成故道迁地保护水域

共27头江豚被迁移到何王庙/集成故道中，自2016年以来，开始有小江豚出生，目前数量已经接近40头。

2019年11月

国际鲸类专家参观何王庙/集成故道

人工饲养繁殖与研究—白鳖豚馆



淘淘：雄性
2005年7月5日出生

E波：雄性
2018年6月2日出生

汉宝：雄性
2020年6月3日出生，
淘淘的儿子

F9c22：雌性
2022年6月27日生，
淘淘的女儿

F9c24：雄性
2024年6月9日生，
淘淘的儿子

白鳖豚馆
YANGTZE CETACEAN
Breeding and Research Center

唯一人工环境下长江江豚繁育群体，并实现二代江豚繁殖成功

白鳖豚馆
YANGTZE CETACEAN
Breeding and Research Center

短期目标的实现

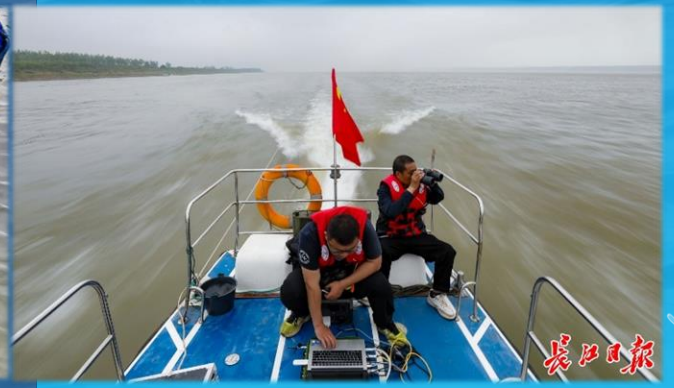
2017年考察，估计长江江豚数量为1012头，与2012年没有显著差异，加速下降的趋势得以遏制。

2022年，数量增加到1249！

长江江豚自然种群历史性的首次实现了止跌回升。

迁地保护江豚的野化放归

- 对4头迁地保护江豚开展了野化适应性训练，2023年成功实施了**迁地保护江豚首次放归长江干流**
- 经过6个月的监测，发现其较好的融入了野外群体，行为模式正常，处在安全状态
- 将推动江豚野化放归的规范化、规模化
- 促进我国三十多年江豚迁地保护工作完成最后一环，**实现迁地保护与就地保护的有机融合**



白鳍豚馆 YANGTZE CETACEAN Breeding and Research Center

全民参与保护，关爱江豚生存

白鳍豚馆
YANGTZE CETACEAN
Breeding and Research Center

与豚携游、与黄鹤楼同框：人与自然和谐的典型样板

图片来源：云上宜昌

首度揭秘：江豚常来武汉，为何你难以遇见？

武汉发布 >

武汉市政府新闻办官方澎湃号

该领域的影响

《科学》
《自然》
报 道

water has heaped strain on seismic faults. The rising waters have also uprooted more than 1 million people and submerged entire communities. Another 4 million of the 16 million people living in the reservoir area may have to be relocated in coming years, officials revealed last fall.

In China, public debate about the dam's dark side is muted. But for scientists, the myriad effects of Three Gorges are fair game. The government has sanctioned an ambitious program to monitor the Yangtze and the Three Gorges reservoir area, which at 58,000 square kilometers is bigger than Switzerland. "We're studying the changing landscape," says Wu Bingfang, whose team at CAS's Institute of Remote Sensing Applications (IRSA) in Beijing is using satellite imagery to follow how the dam impacts its surroundings. They also intend to estimate how much methane and other greenhouse gases the reservoir

fragile condition has been posted to a CTGPC-run Web site, www.tgenviron.org. The findings are expected to guide priorities of a $7.3 billion monitoring and mitigation program over the next 12 years.

"Humanity deserves the opportunity to learn some lessons from this engineering exercise," says Chen Jiquan, a landscape ecologist at the University of Toledo in Ohio. In 2000, Chen led a 12-person delegation from the Society for Conservation Biology to China to assess Three Gorges. The

colossal project's mixed legacy. "Researchers want to tell the truth," says Wu.

A fading pulse

In the 1930s, engineers identified the picturesque Three Gorges region straddling Hubei and Sichuan provinces as an ideal spot for a dam to dwarf all others. The original idea was to tame the Yangtze's periodic floods, but planning sputtered until the early 1980s, when China's energy needs grew more intense. "They thought this large dam would solve a lot of problems," says Chen. Then-Premier Li Peng, a water engineer by training, pushed hard for Three Gorges, and in 1984 CAS began an environmental impact assessment. After weighing the pros and cons, the 8-year-long review gave Three Gorges the thumbs-up. Construction started in 2003—to the dismay of many scientists. "I felt there were serious problems. My opinion was to wait 20 or 30 years," says Niu.

In May 2006, some 26,000 workers completed a Great Wall for the Yangtze: a concrete

Well bred. A female jiangzhu and her two babies at IHB.

CREDIT: COURTESY OF WANG DING

Published by AAAS

《科学》(2008)

成功繁殖

—— 中科院水生所的一只雌性江豚与她的两个孩子

Fading pulse. IHB keeps a few finless porpoises in captivity, but a 10-year ban on Yangtze fishing may be their only hope of survival in the wild, argues Wang Ding.

CONSERVATION BIOLOGY

Last Stand on the Yangtze

SHISHOU, CHINA—A hundred meters or so off the bow of our motorboat, a dark shape breaks the surface and quickly vanishes. Was it a trick of the light? Heavy rains have washed nutrients into the lake, turning the usually clearer waters emerald green. A few minutes pass, then ecologist Xie Songguang, perched like a coxswain, points off starboard and cries: "Over there!" The earlier sighting was no mirage: Two more glistening humps

Yangtze fishing communities have already begun to forget that these creatures even existed, Samuel Turvey of the Institute of Zoology in London and colleagues report in the June issue of *Conservation Biology*. "I was extremely surprised that local 'co… nity memory' of the Yangtze megafa… being lost so rapidly," Turvey says.

Researchers hope to make a last-ditch effort to stabilize the Yangtze ecosystem and

was too late for the *baiji*. Yangtze surveys charted a decline from 11 sightings in 1997 to two in 1999. Then in 2002, Qiqi died of old age, apparently. That was the last *baiji* Chen and other scientists laid eyes on. In 2006, not a single *baiji* was spotted in an exhaustive survey, making it the first human-caused extinction of a cetacean (*Science*, 22 December 2006, p. 1860).

Several measures may avert a similar fate for the Yangtze porpoise. More sanctuaries could help, for starters. The porpoises reproduce readily in Tian-E-Zhou: In 2008, all five mature females there gave birth. But small reserves can become a death trap. In early 2008, unprecedented in recent memory, much of Tian-E-Zhou's surface froze over for … porpoi… …ing … …nt fem… …ed … …er, all t… …ve … died," says IHB's Hao Yuhang.

Food supply is another constant worry.

《科学》(2010)

NATURE | NEWS

Yangtze finless porpoises in peril

Survey finds that the freshwater mammal is in serious decline.

Jane Qiu

24 December 2012

Fishing, pollution and other human activities along the Yangtze River in China are driving yet another species of freshwater cetacean to the brink of extinction. That is the conclusion of a six-week survey of the river's middle and lower stretches by the Chinese Academy of Sciences' Institute of Hydrobiology (IHB) in Wuhan and the conservation group WWF in China.

The final results of the survey will be announced in March. But the preliminary findings are worrying: the survey team spotted fewer than half of the Yangtze finless porpoises (*Neophocaena phocaenoides asiaeorientalis*) that were seen during a similar expedition in 2006, which found 1,225 living in the river[1].

"This is really bad news," says Wang Ding, an ecologist at the IHB who is the survey's chief scientist. "The finless porpoises are doing much worse than previously thought along the Yangtze mainstream."

Peter Parks/Getty

The Yangtze finless porpoise is in decline in the … …t estim… …gered.

The Yangtze finless porpoise is one of the world's few remaining freshwater cetaceans. It is found only in the Yangtze, as well as in two adjoining lakes, called Poyang and Dongting. Scientists hope that the porpoises can avoid the same fate as the Yangtze river dolphin, or baiji (*Lipotes vexillifer*), which was declared effectively extinct after the 2006 survey.

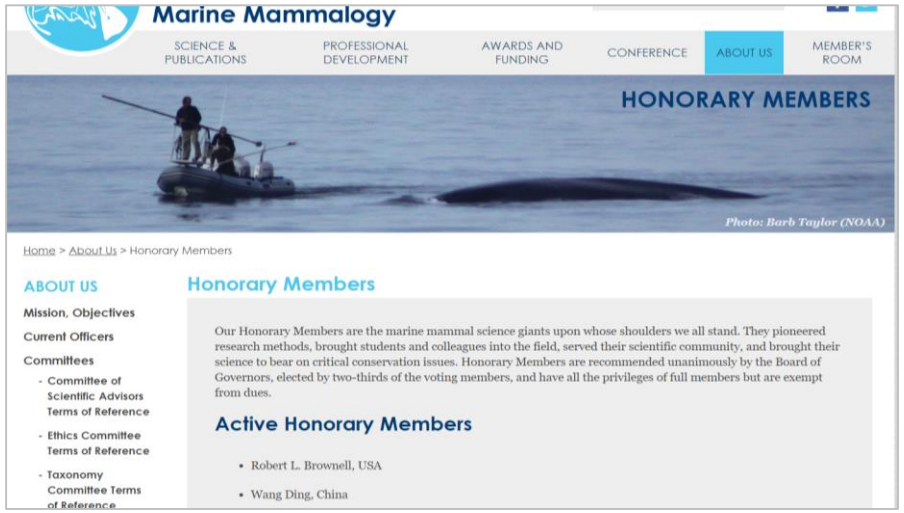
Endangered ecosystem

The latest survey also found that a population of about 450 porpoises in Poyang Lake has been stable for the past six years. But only 90 of the animals remained in Dongting Lake, a decline of 40% since 2006. This means that there is a total of only around … finless porpoises in the Yangtze River basin — making them even rarer than giant pandas in the wild.

《自然》(2012)

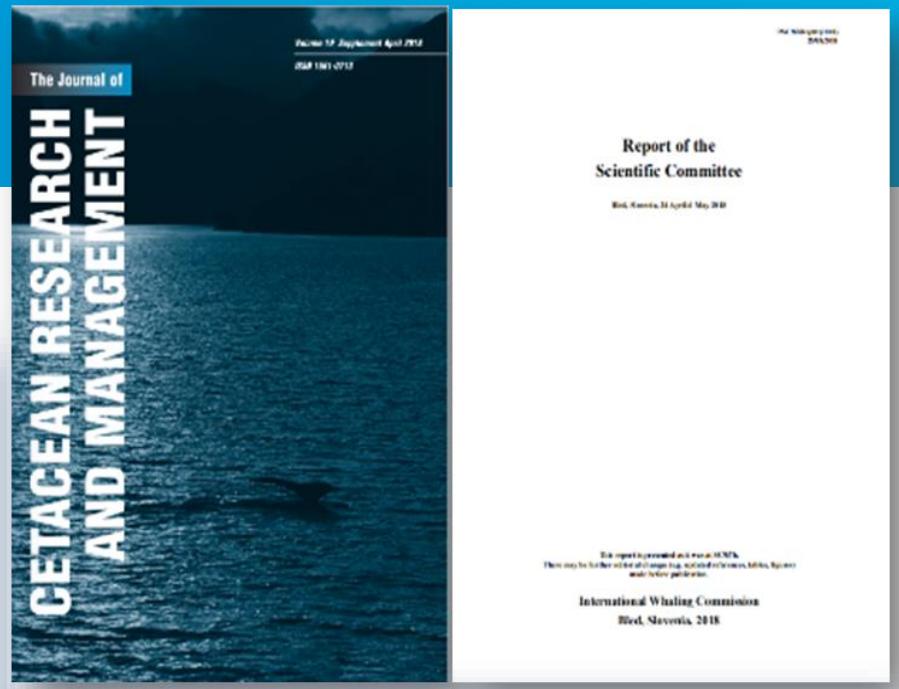
该领域的影响

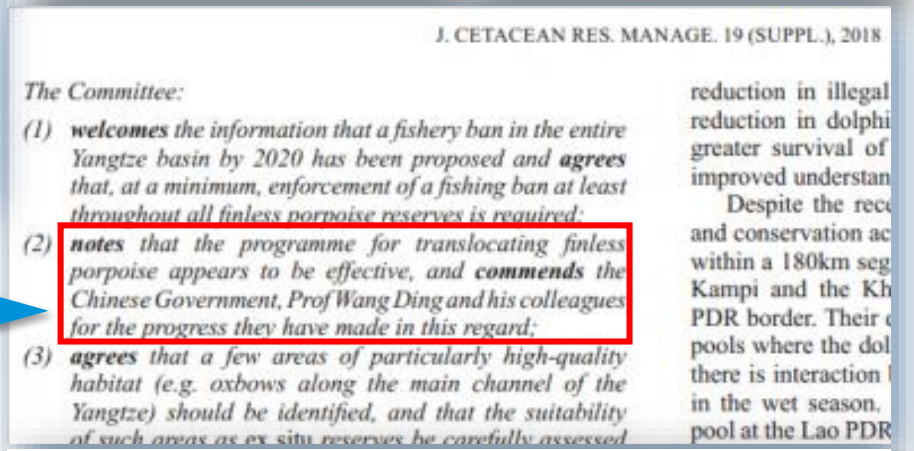
鲸类物种迁地保护的首个成功范例



王丁 当选

SMM “荣誉会员”




J. CETACEAN RES. MANAGE. 19 (SUPPL.), 2018

The Committee:

(1) ***welcomes*** *the information that a fishery ban in the entire Yangtze basin by 2020 has been proposed and* ***agrees*** *that, at a minimum, enforcement of a fishing ban at least throughout all finless porpoise reserves is required;*

(2) ***notes*** *that the programme for translocating finless porpoise appears to be effective, and* ***commends*** *the Chinese Government, Prof Wang Ding and his colleagues for the progress they have made in this regard;*

(3) ***agrees*** *that a few areas of particularly high-quality habitat (e.g. oxbows along the main channel of the Yangtze) should be identified, and that the suitability of such areas as ex situ reserves be carefully assessed*

reduction in illegal
reduction in dolphi
greater survival of
improved understan
Despite the rec
and conservation ac
within a 180km seg
Kampi and the Kh
PDR border. Their
pools where the dol
there is interaction
in the wet season.
pool at the Lao PDR

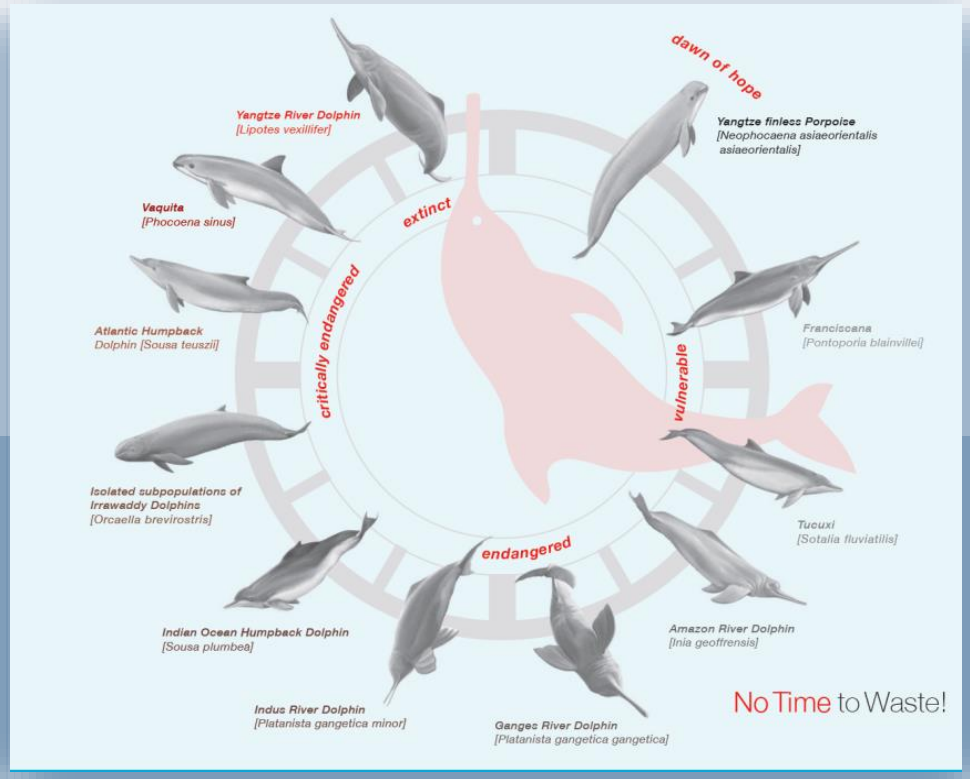
2017 IWC SC 报告

长江江豚的迁地保护被证明是有效的，

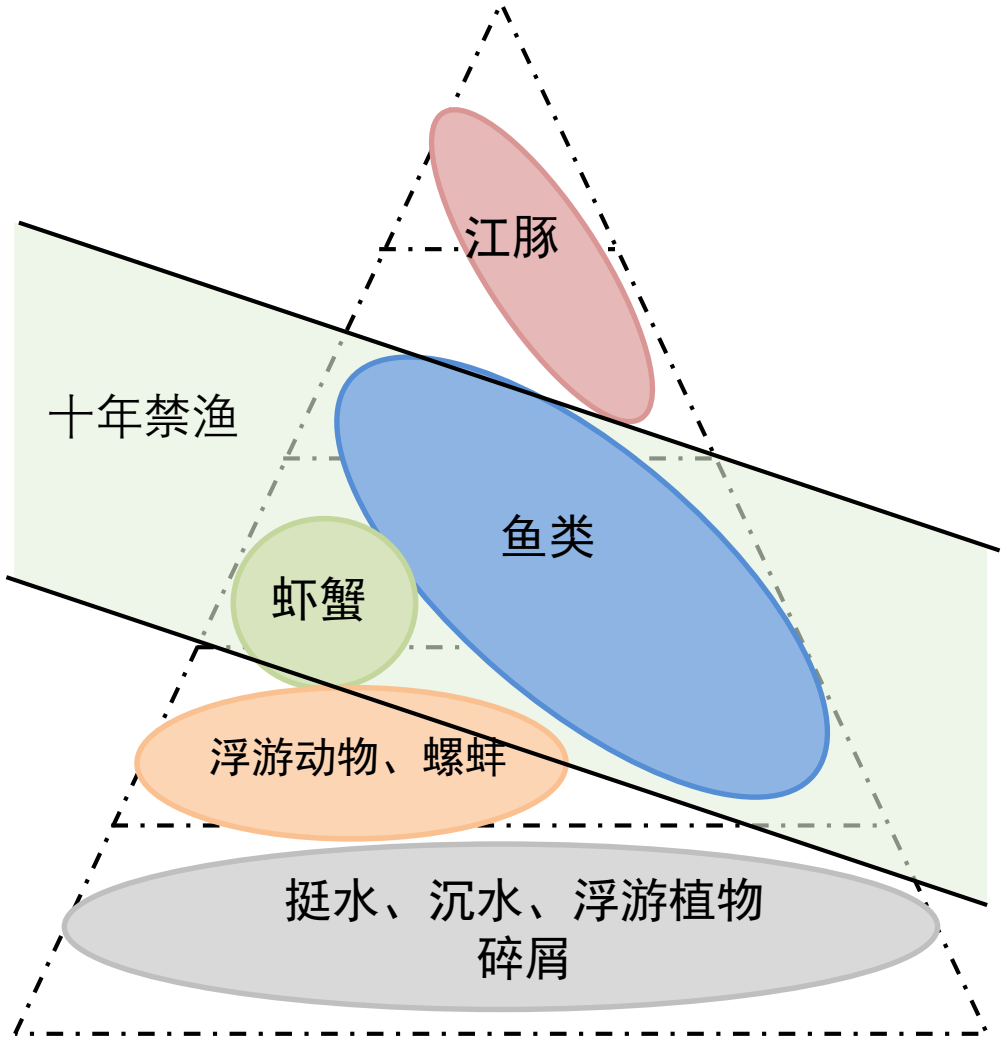
祝贺中国政府、王丁教授和他的团队取得的成功。

该领域的影响

IUCN和SMM 将长江江豚综合保护实践作为范例，供其他国家濒危小型鲸类的保护借鉴参考



长江江豚还面临多种人类活动及气候变化等威胁



- 十年禁渔极大程度上消除了非法及过度捕捞的影响，已经在一定程度上促进了长江江豚等水生生物恢复，但对其它威胁的管控有限
  - 小型鱼类资源恢复缓慢
  - 航运高速发展
  - 种群后代呈现雄性性别偏移
  - 极端气候事件频繁发生
  - 河漫滩生境持续衰退……
- 精准监测人类活动和基于种群动态的协同管理已成为支撑江豚持续恢复的核心需求

传统上应用的是基于可见光的鲸类监测技术

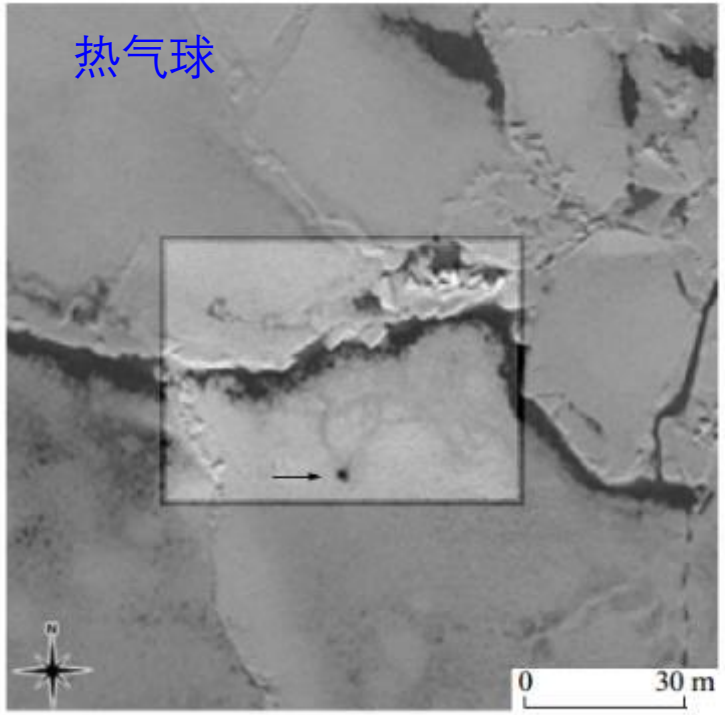


Fig. 5. Tracks and a hole (arrow).

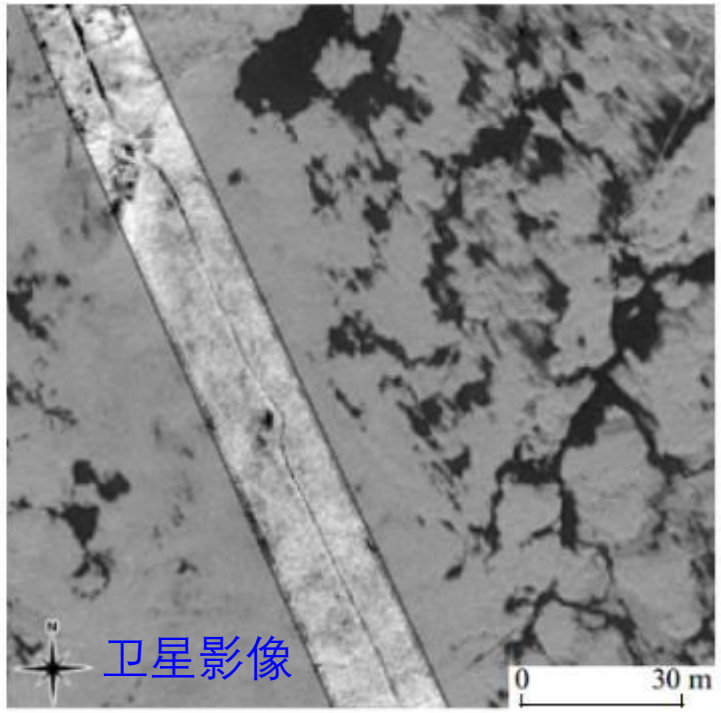
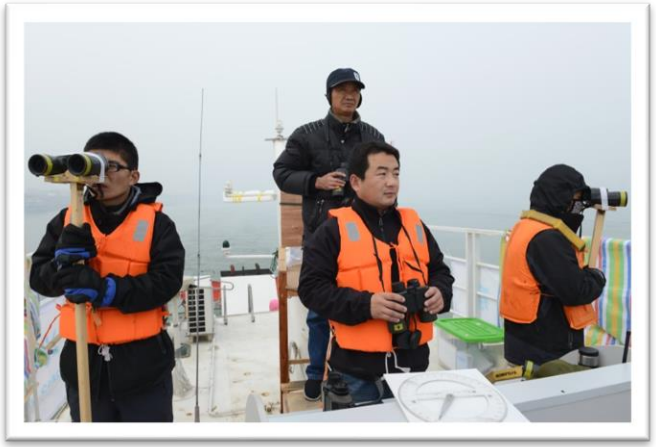


Fig. 6. Potential trace of a polar bear (highlighted line).



受光线、天气及观察者技术能力等影响大，一般人员很难执行

虽然可见鲸类出水呼吸，但~95%以上时间生活在水下

近年来手持设备和无人机等技术应用于长江江豚监测

渔政天网系统

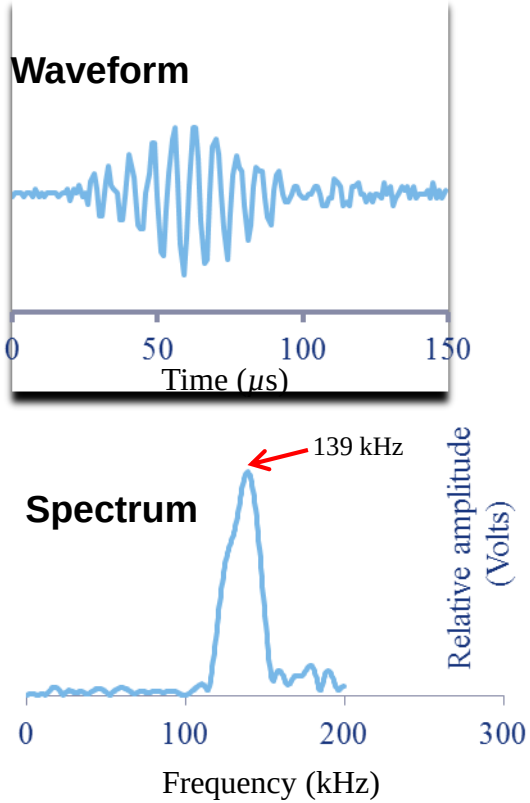
无人机

缺乏对目标的节律识别，拍到江豚存在偶然性，且监测范围有限

新的监测手段：利用小型齿鲸独特的生物声呐系统特征

通过颚隆发声

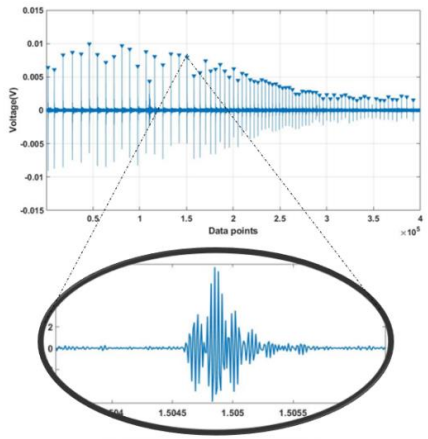
通过下颚接收回声



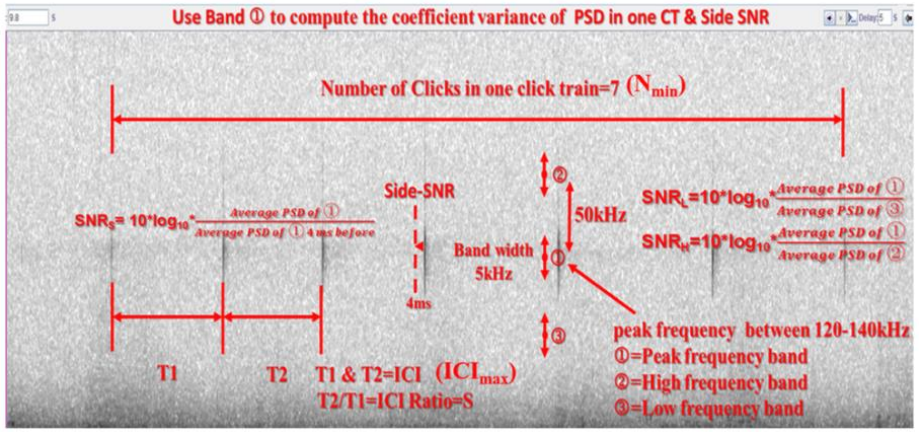
长江江豚通常发出高频窄带的声呐信号，声信号之间的平均时间间隔为6.4s

Li et al., JASA, 2005a; Fang et al., JASA, 2015

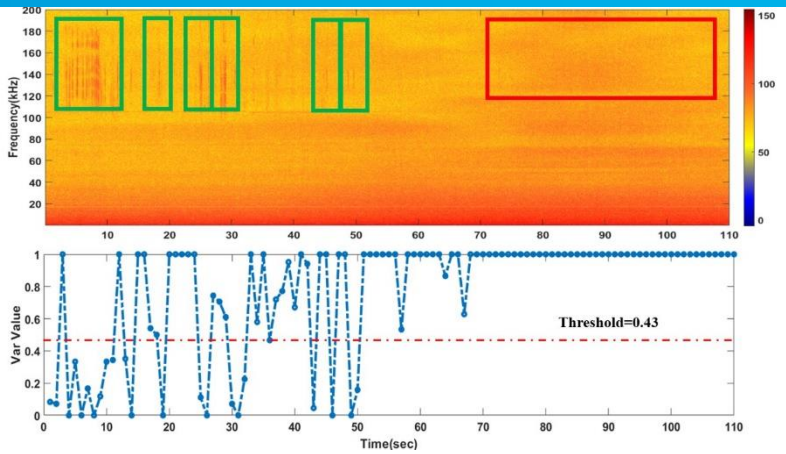
自主开发长江江豚声学自动识别算法



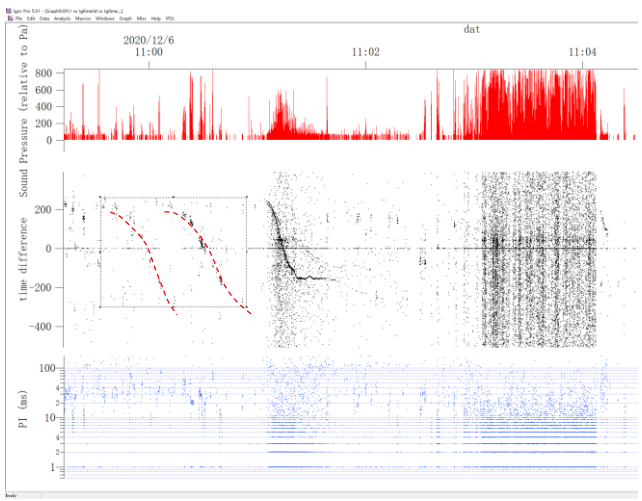
标记脉冲的峰值频率

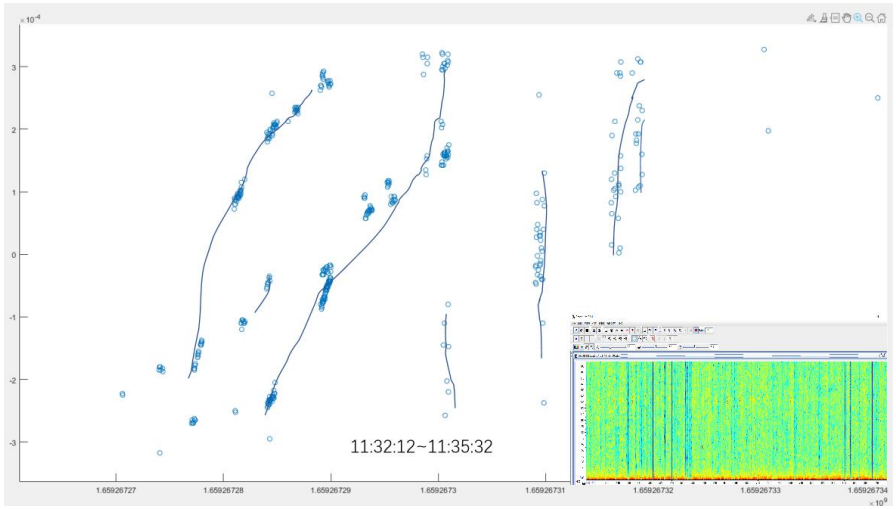


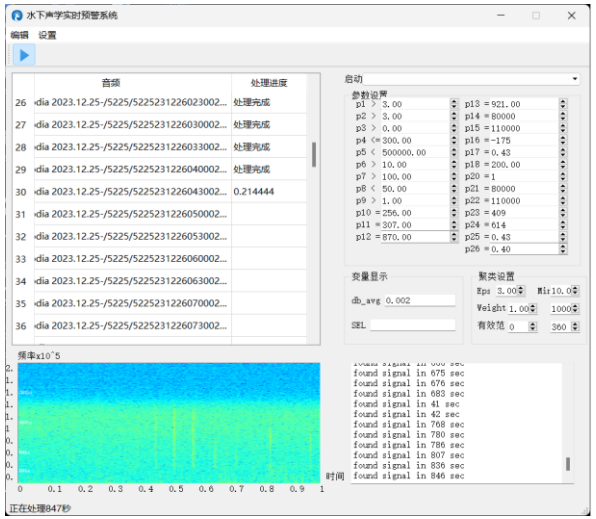
长江江豚回声定位信号自动检测算法的7项参数



有效的将含长江江豚信号的时间点提取并实时回传
(绿框处为长江江豚脉冲串，红框处为船舶高频噪音)



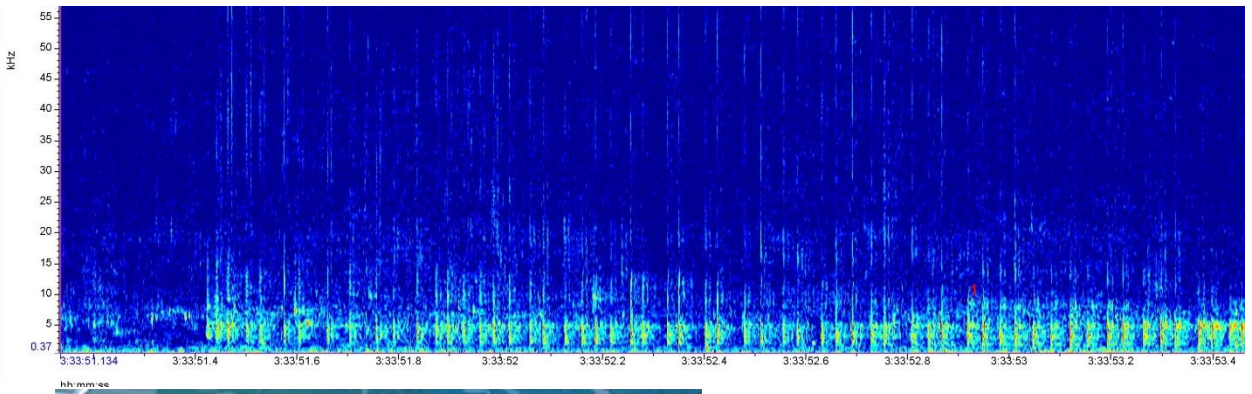




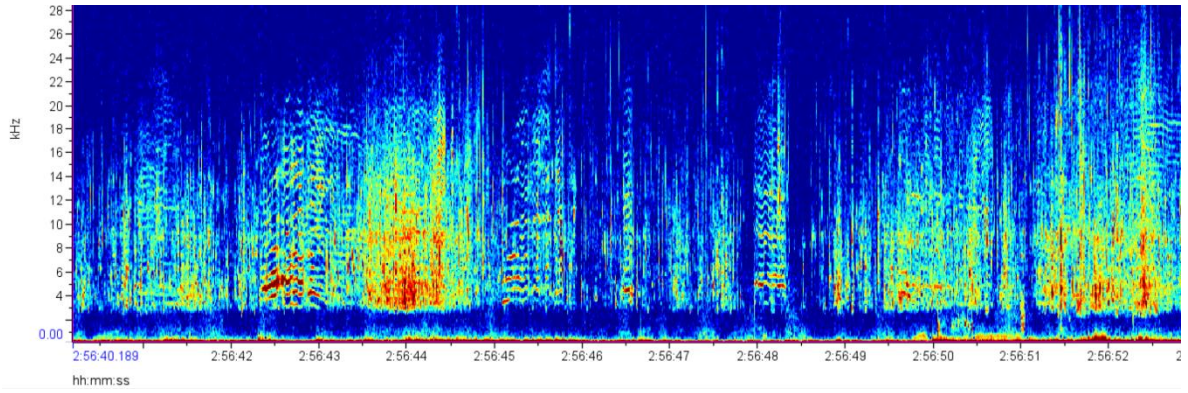
使用自主开发的DolphinWave软件自动识别长江江豚回声定位信号（识别率超过99%），并根据声学轨迹进行群体数量估计，利用GPS进行定位。

可利用声信号特征来识别幼年和成年长江江豚

- 新生幼豚自分娩至约112天内发出低频信号，峰值频率主要集中在2khz~8khz
- 成年江豚会发出多种类型的声信号，但主要是高频信号， 峰值频率主要集中在120khz~160khz



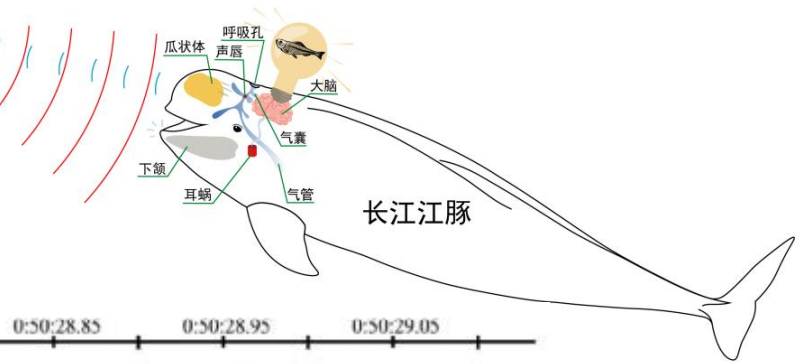
新生幼豚

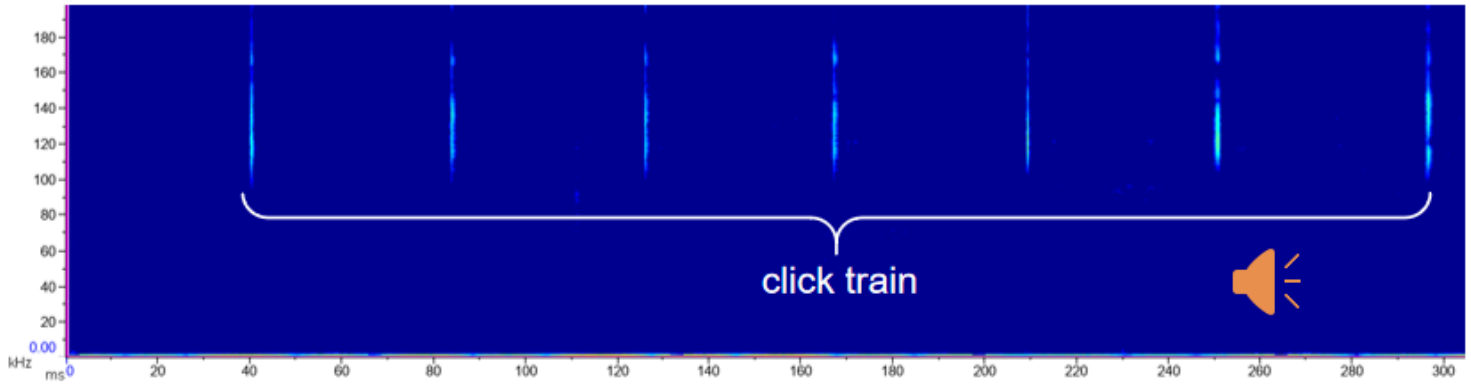


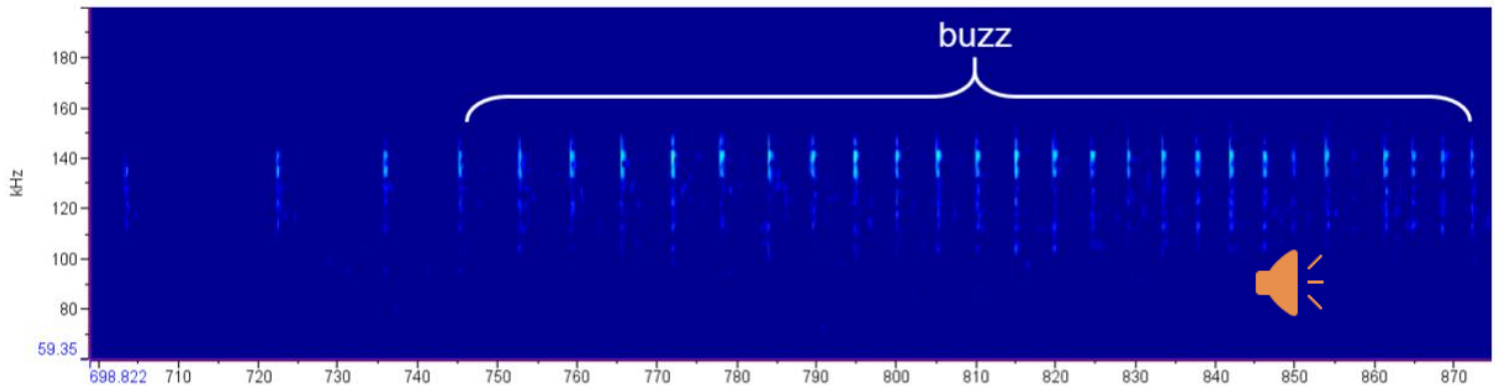
成年江豚

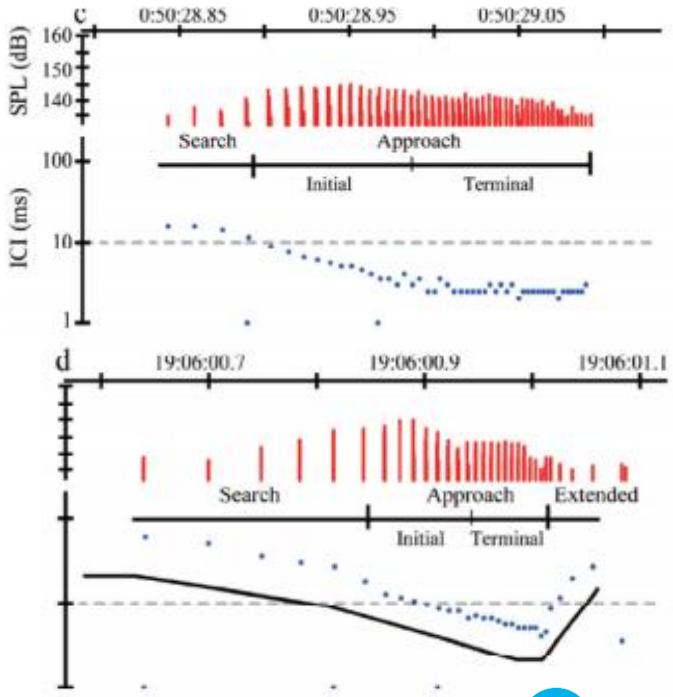
江豚发出特异性的嗡叫声可指征捕食行为

长江江豚的回声定位（click train）脉冲间间隔（ICI）一般在20~80ms，而在其搜捕猎物的过程中，会发出一系列ICI小于10ms的脉冲串，也被称为嗡叫声（buzz），其作用是精准捕捉猎物的空间变化。通常将buzz视为长江江豚的捕食尝试的声学指示。

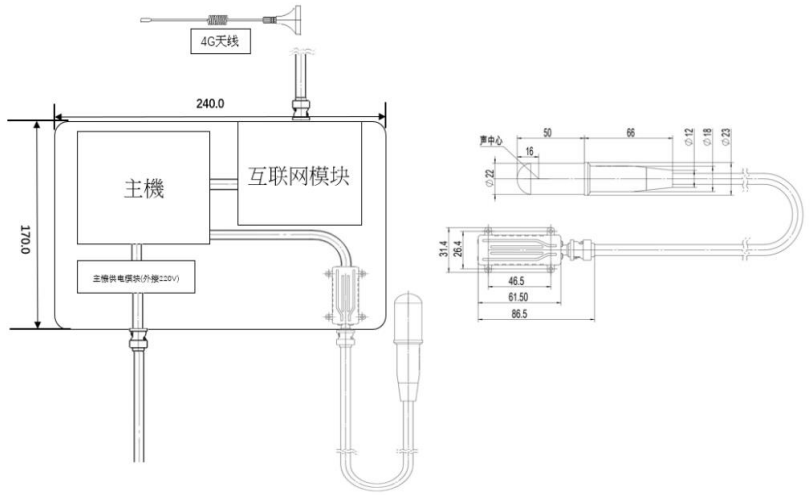








研制了全球首个小型齿鲸实时被动声学监测设备



基于这些研究，我们研制了全球首套针对小型齿鲸的实时被动声学监测设备。一个是含有2个水听器的拖曳式监测设备，适用于开展大范围的种群监测，可以获得种群数量和分布的信息。另一个是含有4个水听器的定点监测设备，适用于对重点水域开展长期监测，能够获得种群数量、幼豚比例、栖息地利用格局、行为模式等信息，特别是迁移行为的监测。其中，1个水听器兼顾低频，可以监测评估水下噪声对江豚的影响，支撑管理工作。

数量、分布

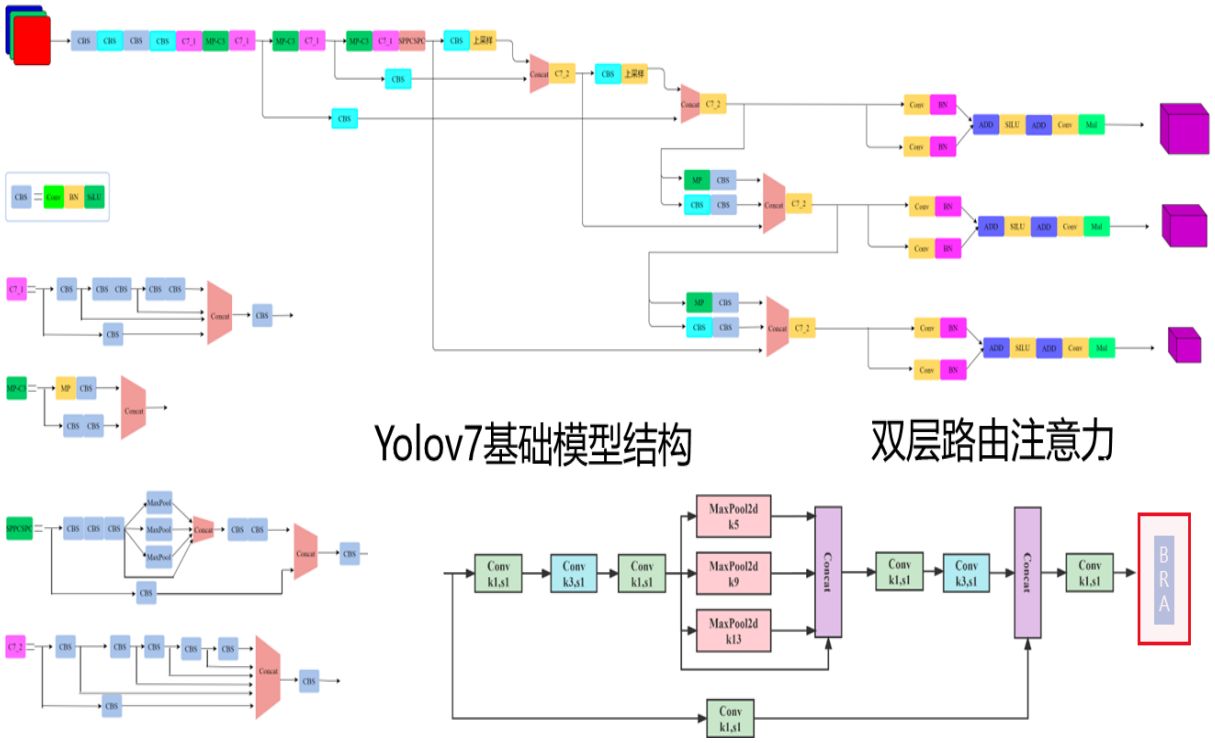
数量、栖息地利用特征、迁移行为

拖曳双通道阵列
RPCD-A2
针对大范围种群调查

定点四通道阵列
RPCD-A4
针对热点水域长期监测

自主开发长江江豚出水影像自动识别算法

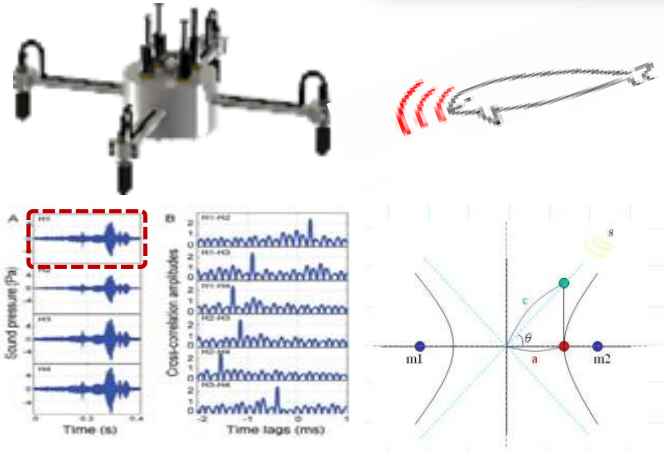
- 构建了包含出水行为特征的图片库，研发识别算法，**准确率约90%**



声学探测可以获得江豚种群的信息，但是如果能同时看到影像，那就更好了，毕竟眼见为实。我们又开发了基于影像的江豚出水行为识别算法。构建了江豚出水特征图片库，目前的识别准确率超过90%。

建立了声光融合的长江江豚实时智能监测技术

声学感知



4通道声信号监测

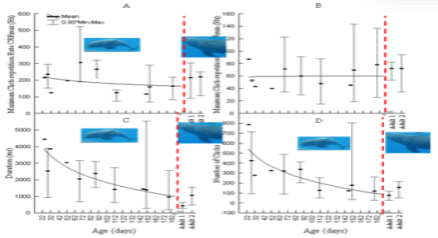
↓

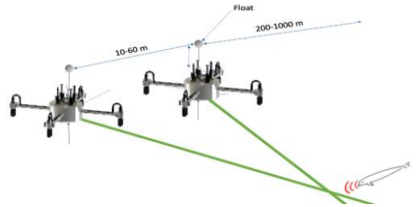
江豚声信号提取
巴特沃斯滤波器

↓

江豚声源识别
(TDOA)获取二维空间发声方位角

声学识别





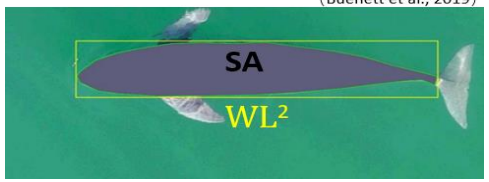
幼年与成年江豚识别
成豚：120-160kHz
幼豚：2-8kHz

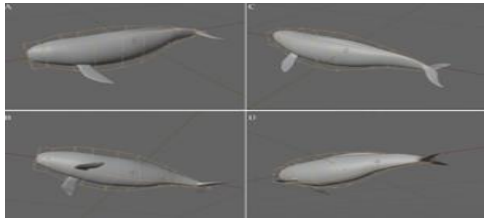
↓

江豚水下位置计算
DBSCAN聚类算法获取江豚角度与位置

健康评价

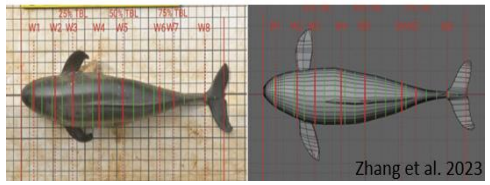
BAI=体表面积/对应体长²×100%
(Buenett et al., 2019)



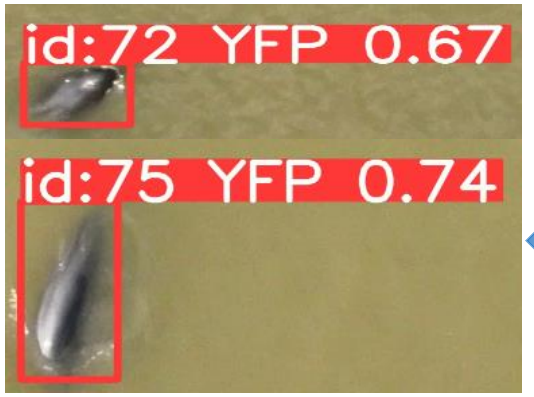


年龄结构及营养评价
使用 Blender 3D软件构建江豚3D模型

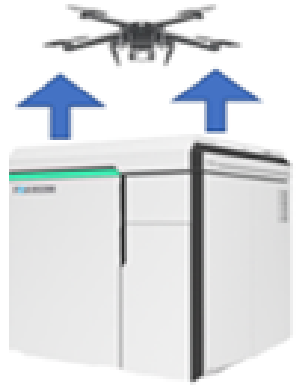
BMI=体重/体长²×100%；体脂厚度等生理参数



视频识别



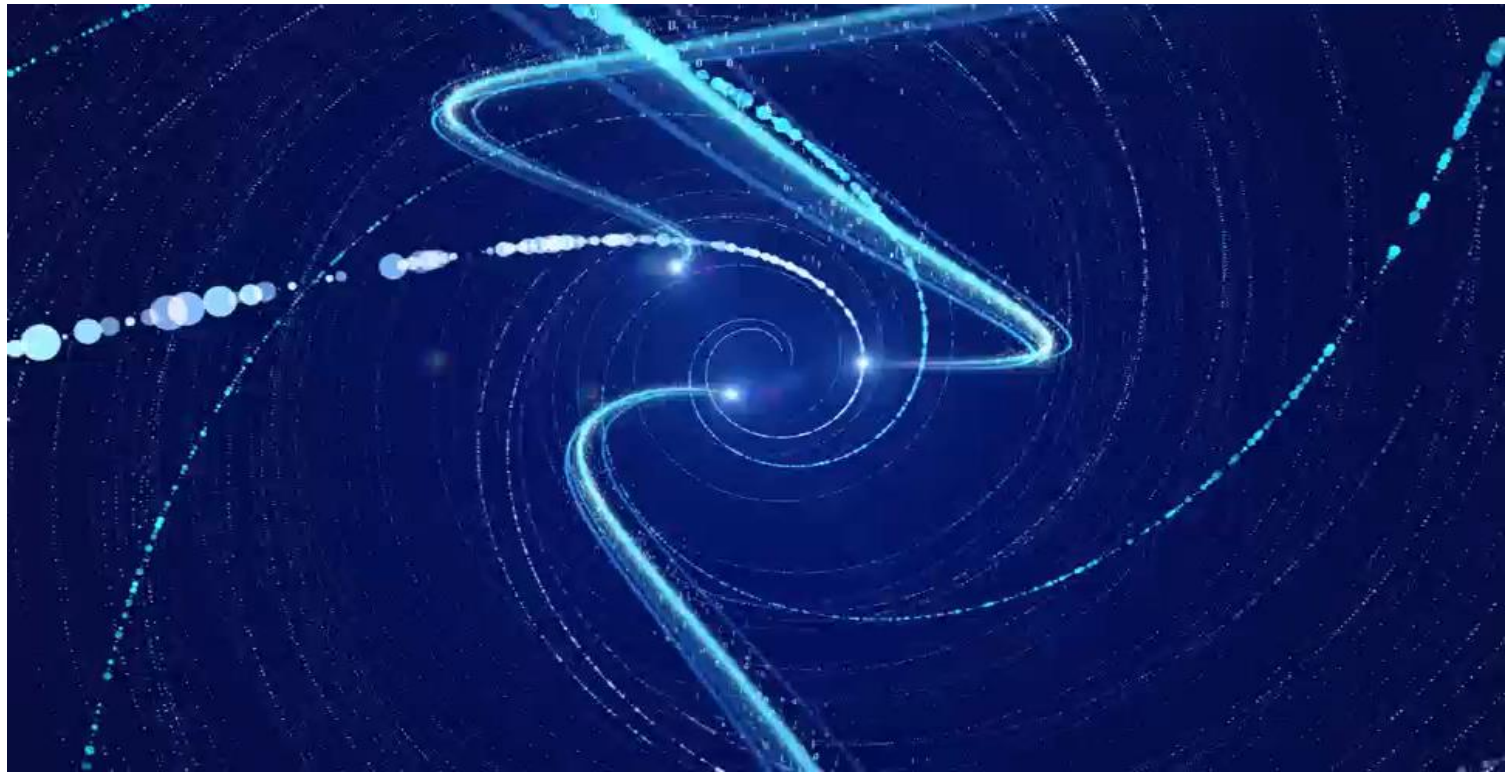
BOT-Sort追踪



实时被动声学监测技术应用：长江江豚生态科学考察

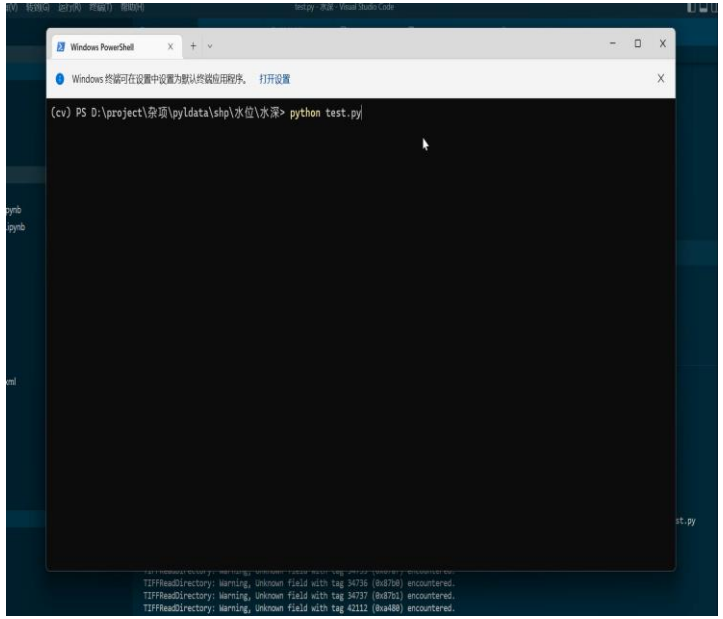
这些技术和设备得到了较好的应用。例如，在2022年全范围长江江豚种群生态科学考察过程中，我们使用实时声学监测设备，显著提高了江豚观察效率。考察时设备拖曳在船尾，监测到江豚声信号实时提醒，并自动记录位置和群体数量。传统的考察，需要人员时时刻刻紧盯江面，容易受到天气和人员能力及状态等影响，这个系统可以在江豚出现时，给出预警并提示江豚群体位置，便于结合目视观察确定个体数量。此外，设备本身也会根据声源的轨迹跟踪，识别个体数量。这个技术有望使江豚的监测场景发生根本性变革，将来考察可能是这样的：科考队员在船舱里喝着茶或者咖啡，待设备提醒后再细致观察，就能完成精准的种群监测。

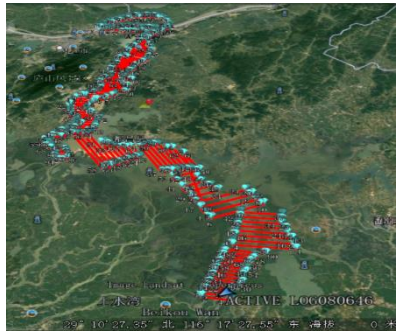
声光融合监测技术应用：南京长江江豚保护区智慧监测管理系统



此外，我们还推动了管理部门管理能力和水平的提升。应用我们研发的声光融合的监测技术，在南京保护区构建了智慧监测预警管理系统，实现了天空-水面-水下的立体监测。系统监测获得的江豚影像，具有很好的传播性，可以很好的用于宣教。

声光融合监测技术应用：鄱阳湖长江江豚智慧监测预警管理系统





- 研发江豚栖息地选择和风险预警模型，每天根据水位等信息模拟江豚分布及高风险区
- 自动生成巡护线路，指导船基巡护
- 还可利用长航时无人机自动巡护
- 实时识别江豚和有害人类活动，及时管理

针对像鄱阳湖这样较大范围的监测和管理需求，我们又研发了一个自动监测预警管理系统。我们首先根据研究构建了鄱阳湖江豚的栖息地选择模型，结合水文、水底地形和人类活动等信息，开发了高风险水域识别和预警算法，每一天这个系统会自动运行，根据获取的数据自动模拟鄱阳湖的水面状况、江豚分布和高风险水域，并根据监测和管理目标自动生成巡护线路，发给每个区域相应的管理人员，他们可以选择按照这些线路开船进行拖曳声学设备巡护，也可以应用无人机自动开展巡护。巡护的数据实时回传和识别，既包括江豚也包括对各种人类活动的识别，可以及时预警相关风险，发出管理提示，防患于未然。

谢谢关注！

保护长江最美微笑，助力建设美丽中国!

鄱阳湖江豚，余会功拍摄