Title: Biodiversity Management Policy Unintentionally Boosted Science Research

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Abstract:
Natural resources management policies are critical for biodiversity preservation, yet their socioeconomic implications remain poorly understood. Using the seasonal fishing ban on the Yangtze River since 2003 as a case study, we provide the first causal evidence that such policies can enhance science and innovation by increasing the availability and diversity of research materials. The analysis reveals that the ban spurred higher quality research inquiries about Yangtze River fish. Funded programs doubled and funding amounts more than tripled. Scientific output grew dramatically, with publications more than tripled, citations augmented more than five-fold, and related books, patents, awards, and media coverage all significantly increased. We attribute this increase to enhanced biological research materials (in both quantity and diversity), rather than other attention-based or policy-based channels.

Main Text:

Biodiversity loss stands out as one of the most significant global threats(*1*). Addressing this challenge requires concentrated global efforts and effective management policies. At the 2022 CBD-COP15 meetings in Kunming/Montreal, attendees committed to developing and implementing an effective global biodiversity framework to reverse this loss. However, current policies within the framework focus on direct biodiversity metrics and market-related outcomes and they typically leave out their broader externalities(*2*, *3*). To bridge the gap and inform future policies, we focus on the overlooked spillover effects of management policies of natural resources, especially biodiversity, on scientific research, using the 2003 Yangtze River fishing ban as a case study. We find that this policy not only curbed the decline in the quantity and diversity of Yangtze fish species as originally intended, but also increased funding, publications, and impact of related research.

Biodiversity is essential for providing food, medicine, and ecosystem stability(*3*, *4*), as well as driving scientific advancements(*5*). While the theoretical benefits of preserving biodiversity are widely discussed in policy circles, it lacks empirical evidence on its broader impact(*6*, *7*). To this end, we offer one of the first studies to pin down the causal effect of biodiversity management policies on scientific research, quantify its economic magnitude, and examine each plausible underlying mechanism. While our research centers on fishing ban policies, its findings offer valuable insights for broader biodiversity management strategies.

Freshwater ecosystems are highly vulnerable to biodiversity loss(*8*). As China's longest river and the world's third longest, the Yangtze has long been symbolized as a biodiverse region, with extensive research on its rich fish resources(*9*, *10*). However, overfishing and climate change have severely depleted its fishery resources(*11*, *12*). To restore fishery resources and biodiversity of the Yangtze River, the Chinese government started an annual spring fishing ban in 2003. Existing studies have shown that similar fishing bans or seasonal fishing closures positively impact fish species richness and abundance(*13-15*). The ban was primarily aimed at sustainable development of fishery resources(*16*), not scientific, economic, or political goals. This makes the fishing ban an ideal policy intervention to study the impact of natural resources management policies on scientific research, primarily through its effect on the availability and diversity of biological materials for research purposes.

A growing body of evidence suggests that scientific research at universities and research institutes is of considerable significance to competitiveness and technological progress, and public funding can result in higher research output(*17-19*). Therefore, we focus on research programs funded by the National Natural Science Foundation of China (NSFC), for their two critical advantages in our study.

First, NSFC funding is highly competitive and crucial for scientific inquiries. As the primary sponsor of fundamental scientific research in China(*20*), the NSFC has led

funding for all papers on freshwater fish published by Chinese researchers. Data from China National Knowledge Infrastructure (CNKI) shows that 73.32% of NSFC-funded freshwater fish research papers were published in core journals listed in 'A Guide to the Core Journals of China' by Peking University during our sample period, compared to only 17.85% of unfunded papers. Funding applications are evaluated yearly with standardized assessment criteria, ensuring timeliness and objectivity in funding decisions, making NSFC funding a reliable proxy for research inputs.

Second, although no universal dataset encompasses all fish-related research, NSFC-funded programs (henceforth referred to as "funded programs") contain sufficient information for constructing a comprehensive database on fish research, including funding, publications, and impact. Importantly, the title and introduction of funded programs indicate their relevance to specific fish species. We also obtain information on the published papers generated by these programs, including their citation counts. This data is compiled into a species-year level panel dataset from 1995 to 2014, covering 1,562 fish species, including 320 Yangtze River fish (YRF) and 1,242 non-YRF species. Thus, we observe the annual research funding, publications, and impact for each fish species.

Merging databases containing detailed information on the fish species attributes and funded programs, we first compare the differences in the number of funded programs, total funding amounts, publications per program, and citation counts per paper between YRF and non-YRF before and after the 2003 fishing ban. Using a difference-in-differences (DiD) strategy (Eq. 1 in Methods below), we find a significant surge in scientific inquiry, output, and citations related to YRF following the ban, compared to non-YRF. Specifically, the number of funded programs, funding amounts, associated publications, and citations related to YRF increased by 97%, 230%, 273%, and 458%, respectively, as a result of the ban. The ban also boosted related books, patents, awards, and media coverage, highlighting the broader societal impact.

Next, we explore the potential mechanisms through which the ban affects scientific research: (1) policies (the ban and other ones) aimed at spurring YRF research, (2) increased public attention on YRF, and (3) greater availability of biological research materials due to the ban. Our analysis suggests the evidence is most consistent with the third interpretation that the fishing ban stimulates scientific research by preserving or adding research materials, both in quantity and variety.

This study contributes to our understanding of natural resources management policies and of the drivers of scientific research. While prior studies examine the direct biological and economic consequences of such policies(*21-25*), particularly in fishery resources management(*15*, *26-31*), we are among the first to study their spillover effects on scientific research. In doing so, we help quantify the scientific value of biodiversity, which adds importantly to the seminal studies on the economics of biodiversity and the fundamental values of biodiversity(*32*, *33*). Among them, several theories discuss the

scientific value of biodiversity, but without offering much empirical support(*6*, *7*, *34*). We close this empirical gap using our quasi-natural experiment on the Yangtze River fishing ban. We offer evidence that diverse biology used as a research resource can motivate scientific inquiry and output and improve quality, constituting an important driver for scientific advances(*35*). Our emphasis on the role of research materials complements existing literature that emphasizes researchers (i.e., labor), tools and methods(*35*, *36*), highlighting the critical role of biological materials in scientific discovery, akin to the importance of data availability in many disciplines(*37*, *38*).

Results

Fishing ban and scientific research

Table 1 presents the results from estimating the Difference-in-Differences (DiD) model (Eq. 1 in Methods). Columns 1-4 display the number of funded programs, total funding amount (thousand RMB), average number of papers generated from these programs, and average citations per paper five years post-publication. The statistically significant point estimates reveal that other things being equal, the ban led to an additional increase of 97% in the number of funded YRF programs and a 230% increase in funding amounts for YRF compared to pre-ban levels, and relative to non-YRF programs. Moreover, YRF is also associated with a 273% differential increase in publications and a 458% increase in citations compared to pre-ban levels. The approach for calculating the economic impact is explained below in the Methods section. Robustness checks in table S2, which include additional fixed effects and alternative citation metrics, corroborate these findings. The effects grow over time and easily double when using alternative metrics of research impact and excluding fish species with no funded research.

To address potential concerns that the increase in research funding due to fishing bans might "crowd out" the funding that other programs should have received, we conduct supplementary tests. Indeed, we observe that research on non-YRF also receives greater funding, it is associated with an increase in published papers, and it garners more citations than what the pre-ban trend would project. This is shown in table S3 Panel A and B. We conclude that the ban did not appear to divert funding from non-YRF to YRF programs.

Then, we examine whether fish programs divert funding or talent from other disciplines (see fig. S1). First, we confirm that most fish programs (both YRF and non-YRF programs) are categorized under the Fisheries Science discipline within the Life Sciences field (fig. S1A). Second, we analyze the disciplinary distribution of all fish programs within Life Sciences, categorizing them into Fisheries Science programs and non-Fisheries Science programs. We find that, after the fishing ban, the proportion of fish research conducted by non-Fisheries Science does not increase. This implies that fish programs become more concentrated within Fisheries Science after the YRF ban and they do so without attracting resources away from non-Fisheries Science disciplines (fig. S1B). Third, we investigate whether Life Sciences divert funding from

other fields. Time series graphs for the proportions of programs across eight fields including Life Sciences are in fig. S1C. The shares of Life Sciences programs slightly decrease after the ban, further reinforcing that they do not crowd out programs in other fields. In the end, even if there were any crowding-out as a market outcome, it is unlikely welfare-reducing absent salient market frictions.

We next estimate the event study regressions (outlined in Eq. 2 in Methods) and summarize the results in Fig. 1. The conditional differences in Fig. 1 between YRF and non-YRF funding, publications and citations are small in magnitude and statistically insignificant before the introduction of the fishing ban. This fact validates the critical parallel trends assumption. In Fig. 1, A and B, there is a lag of approximately three years before the impact on funding becomes statistically significant, likely attributable to the time required for the fish populations to recover, proliferate, and then yield more potential research materials. Due to the exponential path of fish reproduction, the magnitude of the effects becomes ever larger over time. In Fig. 1C, the average number of eventual publications increases right after the fishing ban in part because our publication measure includes all future publications from a program funded in any particular year. Note also that these publications are supported by the cumulative increase in fish research materials following the ban. In Fig. 1D, the average citations to the research publications also increase after the fishing ban.

It is important to ascertain whether the fishing ban affects other types of scientific output. We investigate patents, awards, and books related to funded programs and show the fishing ban also leads to an increase in these other types of YRF research outputs. These results are presented in Columns 1-3 of Table 2. Public influence on YRF research also increases following the fishing ban. Here, we use news reports related to fish research to construct the public influence of research each year for each type of fish. More reports typically mean more research activity, as findings are often shared with the public through the media. We classify news reports as “fish research” if they mention a fish species from our catalog and include research-related terms in table S7. The result in Column 4 of Table 2 shows that there was a significant rise in news reports about YRF research compared to non-YRF research after the fishing ban, indicating increased public influence of YRF research post-ban.

Potential explanations

Government research policies concerning YRF programs

One possible explanation for our main finding is that more government policies arise related to, contemporaneous with, or even after, the fishing ban to encourage YRF-related scientific research. To investigate this possibility, we first collect all policy documents in the 1995-2014 period from several major Chinese ministries and conduct a textual analysis to test this mechanism. We segment the documents into words and create a word cloud of the 50 most frequent terms, as shown in Fig. 2A. None of the top words pertain to scientific research, implying that these policies are unlikely to target scientific research directly. Second, the main goal of the fishing ban is to protect

fish resources in the Yangtze River, which could target research focusing on the "Yangtze River" or "fish protection." To test this, we remove funded programs related to the "Yangtze River" and "fish protection" from our sample. The main results, as reported in table S4, remain, further invalidating the alternative channel. Third, following the fishing ban, the NSFC committee might have boosted Yangtze River-related research funding by increasing support for such studies. If this mechanism were in place, the committee would have discussed its support for Yangtze River research through media statements. We collect all news reports from the NSFC official website and tag those related to the Yangtze River by year. We run the regression of Eq. 3. Fig. 2B shows no significant change in the support in these news reports post-ban, ruling out this possible channel. In summary, policies directly increasing support for research on the Yangtze River and its fish species following the fishing ban appear absent and, even if present, cannot be the primary driver for our findings.

Increase in public attention to the fishing ban

Another possible mechanism through which the fishing ban boosts scientific research is increasing attention in both the public and academic circles regarding the fishing ban and YRF. We examine the time trend of attention to this policy using the annual ratio of the number of news reports on the "Yangtze River fishing ban" to the number of news reports on the "Yangtze River." As shown in Fig. 2C, public interest peaks when the ban was implemented in 2003 but decreases afterward, suggesting only a transient surge in attention. However, our baseline regression results show that YRF-related scientific research steadily increases over time. This contrast suggests that the rise in scientific research is unlikely to have been driven by public attention to the fishing ban policy.

Second, we hypothesize that critically-rare fish species — characterized by low population numbers but still with a chance of recovery through conservation efforts— are most likely to capture the attention of researchers among different fish species(*39*). Studying rare species may attract more funding and foster more collaboration opportunities and career advancement. The high academic value and research difficulty of these species often lead to publications in high-impact journals, bringing researchers greater achievement and recognition. Thus, if the mechanism of "heightened researcher attention" were in effect, we expect a surge in research focused on these rarer fish species over others. We classify "rare" fish species as those that are categorized as either "critically endangered (*CR*)," "endangered (*EN*)" or "vulnerable (*VU*)." We estimate a triple-difference model (Eq. 4 in Methods) and summarize the results in Fig. 2D and table S5. Contrary to what this channel would imply, the results reveal that research related to rare fish species does not receive a stronger effect than other fish species after the fishing ban.

Increase in research materials

The third intuitive explanation for our main finding is that the implementation of the fishing ban increased the fish population, thus providing a richer biological resource

base for scientific study. Note that rigorous scientific research often requires extensive and repeated experimentation to get real and accurate conclusions, a process for which an ample supply of research subjects is indispensable(*40-43*). For instance, differential therapeutic effects may arise from varying concentrations of fish oil. High concentrations enhance brain function and address cardiovascular issues, while lower concentrations may contain components increasing cardiovascular risk. Researchers using different amounts of research materials (i.e., fish) may yield divergent conclusions, so the abundance of fish species would be critical for reconciling findings that emerge across different studies(*44*),(*45*).

The ideal approach to evaluating this mechanism would be to examine directly whether the populations of each YRF species increased following the fishing ban. However, there is no official direct observational data on the populations of fish species over time. Therefore, we employ three slightly indirect approaches to disentangle the potential role of research materials.

First, we consider potential heterogeneity in access to research materials. In the early 2000s, China's inter-provincial transport infrastructure was underdeveloped, posing significant obstacles for scientists traveling across provinces for research. Given limited mobility, the scholars near the Yangtze River had an inherent advantage in studying the river's fish species. This proximity reduced the logistical and financial costs associated with research, potentially increasing the productivity of local institutions. As a result, we would expect the fishing ban to have a greater impact on scientific research conducted by institutions within the Yangtze River basin than those outside it due to the differential ease of access to research materials.

Second, we consider the potential heterogeneity in the availability of different types of fishery materials to help us verify this mechanism. Intuitively, the fishing ban would have a less noticeable effect on research related to extinct fish. This is because even the strictest fishing policies cannot bring back extinct fish, thus eliminating the availability of corresponding materials for researchers to study. Consequently, the fishing ban is expected to have a greater impact on research concerning non-extinct fish species than on research of extinct species.

Third, we examine the potential heterogeneity among fish populations in the upstream and non-upstream sections of the Yangtze River. The upstream region harbors approximately 90% of the river basin's hydropower infrastructure. Extensive cascade development and river channelization had resulted in significant habitat fragmentation. Due to these challenging environmental conditions, the recovery effect of the fishing ban on fish populations in the upstream section is likely to have been weaker. Therefore, if the proposed research material mechanism holds, the impact of the fishing ban on research related to fish species in the non-upstream areas of the Yangtze River is more pronounced compared to those in the upstream regions.

For the aforementioned heterogeneity analyses, we construct three variables: (1) whether the institution conducting the research in a funded program is located in a province within the Yangtze River Basin; (2) whether the fish species is extinct; and, (3) whether the fish species is an endemic fish from the upstream of the Yangtze River. We use a triple-difference regression model (listed as Eq. 5, Eq. 6, and Eq. 7 in Methods), interacting each variable with the baseline DiD term. The point estimates of the coefficients and the 95% confidence intervals are presented in Fig. 3. The coefficients in Fig. 3, detailed in table S6, are primarily positive, indicating that the mechanism of increased research materials leads to an increase in scientific research. These heterogeneity results would not arise if the ban had not increased fish species as research materials because neither government policies nor private incentives at the time of the ban specifically targeted researchers in the Yangtze River basin. Additionally, they did not focus on non-extinct or non-upstream fish species.

We also document evidence of the effect of the increased diversity of fish species after the fishing ban on funded programs. First, we describe in Fig. 4A how the reported number of fish species in the Yangtze River declined prior to the ban, but exhibited a gradual increase after the ban, including that for the Hejiang reach, an important part of the Yangtze River. Furthermore, we recorded the natural fishery catch in the Three Gorges Reservoir area of the Yangtze River, which saw a notable increase following the ban. These findings corroborate an increase in fishery resources.

Next, the increase in fish diversity, as seen in Fig. 4a, should also increase research diversity if fish species are used in scientific research. Our analysis provides insights into the yearly patterns in the number of fish species mentioned in funded programs' published papers affiliated with YRF and non-YRF. As shown in Fig. 4B, YRF programs' papers mention more fish species than non-YRF programs' papers following the fishing ban.

Discussion

In this study, we examined the unintended spillover effect on scientific research of a sweeping fishing ban in the Yangtze River since 2003. Utilizing a unique dataset on NSFC programs and corresponding papers and citations from 1995 to 2014, we find evidence that the implementation of the fishing ban significantly increased the activity, output, and quality of scientific research related to fish species in the Yangtze River. The evidence is most consistent with one explanation—the research boost arose from the increase in the availability of biological research materials (and their diversity across species) brought about by the fishing ban. Our findings augment our understanding of the benefits(*46*, *47*) and costs(*48-50*) of biodiversity conservation and of the implications of natural resources management on science in particular.

Our study has several implications. First, effective natural resource management policies, such as a fishing ban, may yield positive externalities on science. Indeed, strengthening biodiversity protection can spur more scientific inquiries, resulting in

greater funding, number of publications, citations, books, patents, awards, and media mentions of related publications and researchers. This finding underscores the idea that sustainability initiatives may facilitate knowledge creation and dissemination. When assessing the benefits and costs of natural resources management policies, we recommend that decision-makers consider its broader effects on research and innovation, because they constitute not only matters of ecological responsibility but also strategic investments in future science and technology. Our estimates may prove useful when forecasting the impacts of similar management policies, such as the 2021 intensification by the Chinese government of the seasonal ban along the Yangtze River to a year-round prohibition for a minimum of ten years. Absent our study, it is difficult to anticipate or quantify how the new initiative can advance quality scientific inquiries and outputs beyond serving as a catalyst for bolstering greater biodiversity and species abundance in the Yangtze River.

Second, our study offers insights concerning the underlying factors driving scientific advancement. In addition to substantial financial investment in research(*20*) and demographic considerations(*36*), accessible, abundant, and diverse research materials are equally important for the development of modern science[8], because they enable researchers to conduct experiments, validate hypotheses, and ultimately advance the frontiers of scientific knowledge.

In closing, we acknowledge certain limitations of our study and suggest future research directions. Our measurement of scientific inquiries focuses on NSFC, arguably the most important funding program in China. However, other research funding and activities exist, which could render our results an understatement of the effects of the fishing ban on scientific research. Moreover, our analyses regarding the effect of the fishing ban on scientific impact can be extended to examine how the research translates into commercial products and technologies with practical applications. Lastly, while fish studies are crucial in biology and ecology, research on other biological groups can be equally informative about the potential effects of conservation and research involving these organisms on allocating research funding and scientific outputs and quality. We encourage future research along these lines.

Methods

Data

Fish species

Data on fish species is merged from four different sources. First, we manually collected all the information about freshwater and freshwater/saltwater fish in China from Cnfishbase(*51*), a comprehensive database of Chinese fish species. This database integrates data from multiple trusted sources, including regional fish monographs, relevant journals and books, and other scientific literature. By synthesizing these diverse inputs, the database Cnfishbase ensures reliability in ichthyological taxonomy through meticulous data verification and comparison. This database includes information about each fish's order, family, species (according to the biological

classification system), and habitat (the descriptive statistics are shown in table S1 Panel C). Second, we determine whether a certain fish is distributed in the river according to the Yangtze River Fish List(*52*). Third, based on China's Red List of Biodiversity (2004), we construct a categorical variable (Threatened Level) indicating seven ranked endangered levels: extinct (*EX*), extinct in the wild (*EW*), critically endangered (*CR*), endangered (*EN*), vulnerable (*VU*), least concern (*LC*), and not evaluated (*NE*). Fourth, we also define whether a fish species is endemic to the upstream of the Yangtze River from the literature(*53*).

Research program funding

Data on all funded programs are retrieved from the NSFC website, which provides information on successful applications. For each program, information is obtained on its unique ID, its affiliated institution, the title of the program, summary and keywords, research field, year of application, amount of grant, and type of fund. We identify programs related to each fish species per year based on whether the species is mentioned in the title, summary, or keywords. We then aggregate the number of programs and funding amounts at the species-year level. Information is obtained from the papers published by these programs and their corresponding citations, which are similarly aggregated at the fish species-year level. Due to data limitations, the quality of the NSFC data after 2014 is not so reliable. Additionally, significant changes in fishing ban policies occurred after 2015. Consequently, our sample period is restricted to the year 2014 and earlier. According to the sub-sample statistics in table S1 Panel B, the total number of funds related to YRF is about 0.11 per year per fish species on average, with a total amount of about 51,240 RMB. The average number of papers generated by YRF-related funded programs is 0.26 and the average citation within five years post-publication for those papers is 0.16.

Model

We begin examining the impact of the fishing ban in the Yangtze River on project funding in the following standard DiD framework. Specifically, we run the following regression:

$$Scientific\,Research_{f,t} = \alpha + \beta_1 YRF_f \times Post_t + \delta_f + \gamma_t + \varepsilon_{f,t} \,(\text{Eq.1}).$$

where f indexes fish species, and t indexes years. The outcomes of interest, denoted $Scientific\,Research_{f,t}$, include four metrics: the number of funded programs, the amount of funding (thousand RMB), publications per fund, and citations per paper related to fish f in year t. YRF_f is a dummy variable that equals one if fish f is included in the list of YRF. $Post_t$ is a dummy variable that equals one for the years in and after 2003, the start year of the fishing ban. The equation also contains controls for fish species and year-fixed effects, δ_f and γ_t. $\varepsilon_{f,t}$ is the error term. The fish species fixed effects, δ_f, which are a set of fish-specific dummy variables, can control for time-invariant confounders specific to each fish, such as the family and habitat. The year fixed effects, γ_t, are a set of dummy variables that account for shocks common to

all fishes in a given year, such as a national policy. We cluster the standard errors at fish order × year level to account for possible correlations in the residual. The coefficient of interest in Eq. 1 is β_1, the estimated impact of the fishing ban on scientific research. We expect the coefficient to be positive, suggesting a greater increase in the scientific research related to YRF.

We also estimate a fully flexible year-by-year specification taking the following form:

$$Scientific\,Research_{f,t} = \alpha + \sum_{\tau \neq 2002} \beta_\tau YRF_f \times Year_\tau + \delta_f + \gamma_t + \varepsilon_{f,t} \quad (\text{Eq.2})$$

In Eq. 2, instead of interacting YRF_f with a post-reform indicator variable, we interact with the treatment variable with each year relative to 2002. The estimated vectors of β_τ reveal the differences between the treated and control groups in each year. If, for example, the fishing ban increased scientific research, then we would expect the estimated β_τ to be constant over time for years before the fishing ban and then to increase as the ban began.

To investigate whether the increase in fund applications is closely related to the increase in Yangtze River-related policy support of the fund's supply side, we evaluate the changes in the probability of news articles from the NSFC website being classified as "Yangtze River research." The specification is set as follows:

$$1\left(News\ on\ Yangtze\ River\ Research\right)_{i,t} = \alpha + \sum_{t=2001}^{2014} \beta_{i,t} Year_t + \varepsilon_{i,t} \quad (\text{Eq.3})$$

where $1\left(News\ on\ Yangtze\ River\ Research\right)_{i,t}$ equals one if the news *i* contains the term "Yangtze River" along with a list of associated research-related terms in table S7, zero otherwise. $Year_t$ equals one in year t and zero otherwise. Each observation is a piece of news from the NSFC website. The coefficient $\beta_{i,t}$ captures the change in NSFC's support on the Yangtze River research year by year.

To test the mechanism that the fishing ban has led to heightened attention from researchers, we run the following regression:

$$\begin{aligned} Scientific\,Research_{f,t} &= \alpha + \beta_1 YRF_f \times Post_t \times Rare_f \\ &+ \beta_2 YRF_f \times Post_t + \beta_3 Rare_f \times Post_t + \delta_f + \gamma_t + \varepsilon_{f,t} \quad (\text{Eq.4}) \end{aligned}$$

where $Rare_f$ equals one if a fish species is classified as vulnerable (*VU*) or endangered (*EN*) or critically endangered (*CR*), according to the threatened level of fish in table S1 Panel C, and zero otherwise.

To provide further evidence to support the claim that the fishing ban has led to an increase in research materials and thus YRF research, we further run the following three regressions:

$$Scientific\ Research_{f,p,t} = \alpha + \beta_1 YRF_f \times Post_t \times YR\ Prov_p + \beta_2 YRF_f \times Post_t + \beta_3 YR\ Prov_p \times Post_t + \beta_4 YRF_f \times YR\ Prov_p + \delta_f + \mu_p + \gamma_t + \varepsilon_{f,p,t} \quad (\text{Eq.5})$$

where $YR\ Prov_p$ represents whether a province is geographically proximate to the Yangtze River basin, including 19 provincial-level administrative units: Qinghai, Tibet, Sichuan, Yunnan, Chongqing, Hubei, Hunan, Jiangxi, Anhui, Jiangsu, Shanghai, Guizhou, Gansu, Shaanxi, Henan, Zhejiang, Guangxi, Guangdong, and Fujian. The interest coefficient in the equation, β_1, is anticipated to display a statistically significant positive effect.

$$Scientific\ Research_{f,t} = \alpha + \beta_1 YRF_f \times Post_t \times Non-Extinct_f + \beta_2 YRF_f \times Post_t + \beta_3 Non-Extinct_f \times Post_t + \delta_f + \gamma_t + \varepsilon_{f,t} \quad (\text{Eq.6})$$

where $Non-Extinct_f$ equals one if a fish species is not classified as extinct (*EX*) or extinct in the wild (*EW*) according to the threatened level of fish in table S1 Panel C, zero otherwise.

$$Scientific\ Research_{f,t} = \alpha + \beta_1 YRF_f \times Post_t \times Non-Upstream_f + \beta_2 YRF_f \times Post_t + \beta_3 Non-Upstream_f \times Post_t + \delta_f + \gamma_t + \varepsilon_{f,t} \quad (\text{Eq.7})$$

where $Non-Upstream_f$ equals one if a fish species is classified as being found in the Yangtze River but not endemic to the upstream of the Yangtze River according to the distribution of fish in table S1 Panel C.

Furthermore, we examine whether the public influence on YRF research has increased following the fishing ban. We utilize news reports related to fish research to construct a measure of the public's impact on research for each type of fish each year. The specification of the event study is set as follows:

$$News\ report\ on\ fish\ research_{f,t} = \alpha + \sum_{\tau=2000}^{2014} \beta_\tau YRF_f \times Year_\tau + \delta_f + \gamma_t + \varepsilon_{f,t} \quad (\text{Eq.8}).$$

where $News\ report\ on\ fish\ research_{f,t}$ equals the number of news related to research on fish *f* in year *t*. A news report is identified as research-related if it includes both the name of a fish species and a set of research-related terms in table S7. The other terms remain unchanged from Eq. 1.

Method for quantifying economic impact

When calculating the economic impact, it is essential to compare the counterfactual scenario with the actual situation. We can simulate the absence of the fishing ban by

setting YRF to zero in Eq.1 following the established protocols(*54*). By doing so, we estimate the overall scientific research outcomes (including the number of funded programs, funding amounts, publications, and citations) related to YRF under the counterfactual scenario where the fishing ban does not exist, other things being equal. Comparing this hypothetical scenario with the actual situation allows us to quantify the increase in scientific research attributed to the fishing ban.

The back-of-the-envelope calculation goes as follows. First, based on the DiD coefficient estimated from Eq.1, we subtract this coefficient from the actual scientific research values for YRF. This provides us with the estimated scientific research values under the counterfactual scenario. We then calculate the difference between the actual and counterfactual situations. By summing up these differences, we obtain the overall impact on scientific research resulting from the ban.

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Supplementary Materials

Supplementary Text

Figs. S1

Tables S1 to S7

Figures and tables

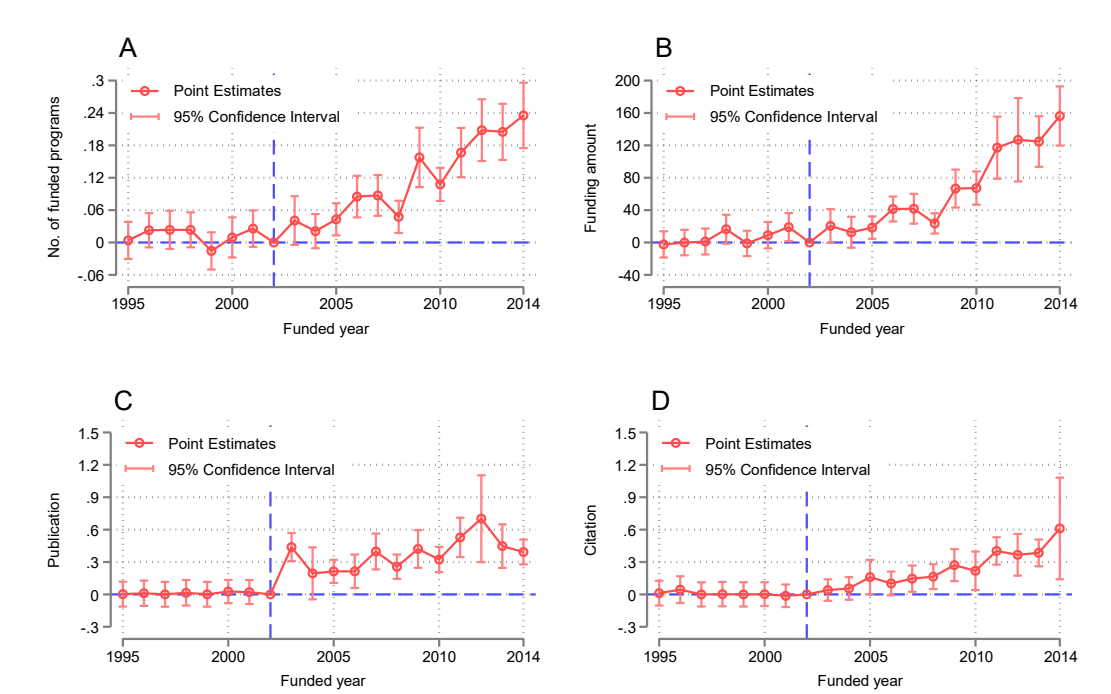


Fig. 1. Effect of fishing regulation on scientific research. This figure illustrates the estimated differences in various metrics between Yangtze River fish species and non-Yangtze River fish species before and after the fishing ban, as calculated using Eq. 2. Specifically, it examines differences in the number of funded programs (**A**), the amount of funding (thousand RMB) (**B**), eventual publications per funded program (**C**), and citations per published paper (**D**). The markers and capped spikes represent the OLS estimators and 95% confidence intervals. The sample period covers from 1995 to 2014. The dashed vertical line indicates the time point one year prior to the initiation of the fishing ban. The regression includes fish species fixed effects and year fixed effects. The standard errors are clustered at the fish order × year level.

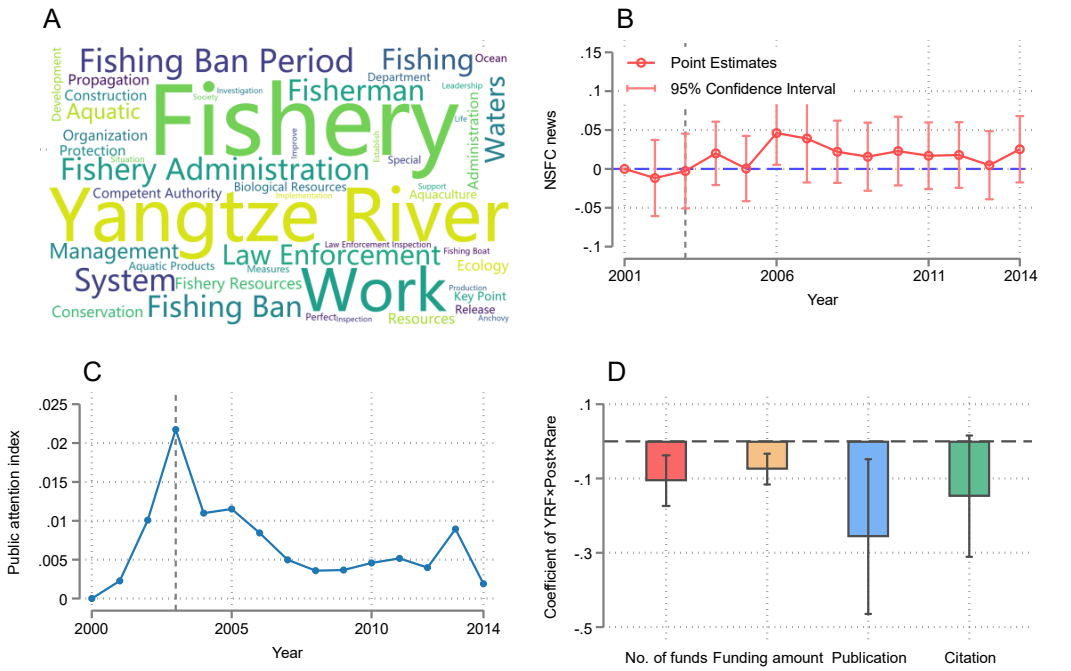


Fig. 2. Direct policy support for YRF scientific research. A, A word cloud of fishing ban policy documents, where the size of the word indicates its frequency of occurrence. We select the top 50 most frequent words. The fishing ban-related policies were collected from the websites of the Ministry of Agriculture, Ministry of Science and Technology, Ministry of Finance, the State Council, Ministry of Ecology and Environment, and the National Development and Reform Commission for "fishing ban" related policy documents. **B,** Changes in support from NSFC towards research on the Yangtze River. This is depicted through the estimated changes in the probability of news articles being classified as "Yangtze River research" news. The classification is based on the occurrence of the term "Yangtze River," along with a list of associated research-related terms in table S7 on the NSFC website. **C,** Change in the public's attention regarding the Yangtze River fishing ban. We calculate the Public Attention Index by dividing the number of news reports mentioning the theme "Yangtze River fishing ban" by the total number of news reports mentioning the "Yangtze River" for that particular year. **D,** Heterogeneous effects of fishing ban on research pertaining to rare fish species. Rare fish species are classified as vulnerable (*VU*) or endangered (*EN*) or critically endangered (*CR*). The dependent variables are the number of funded programs, funding amount (million RMB), publications per fund, and citations per paper. The regression includes fish species fixed effects and year fixed effects. The standard errors are clustered at the fish order × year level.

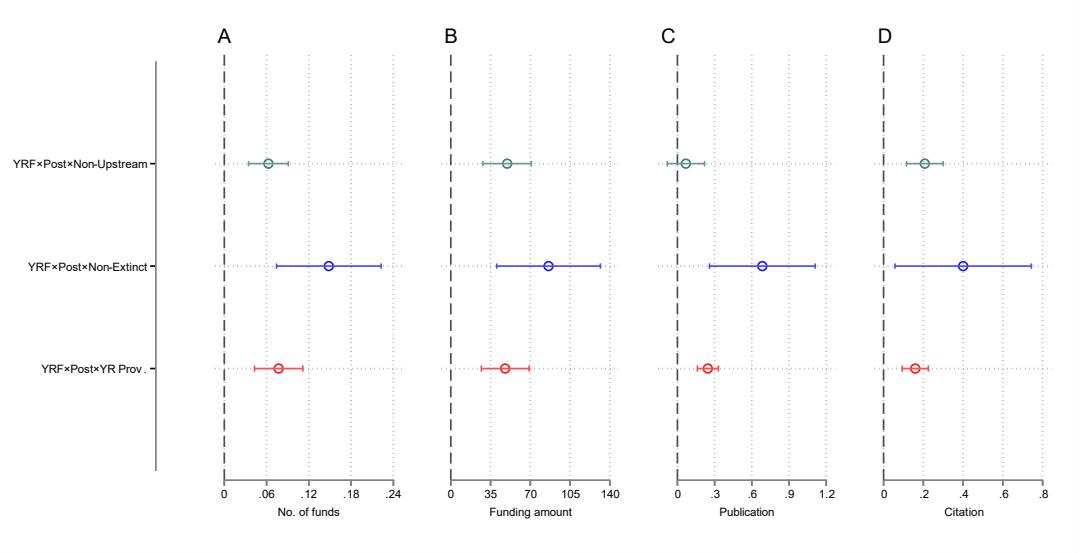
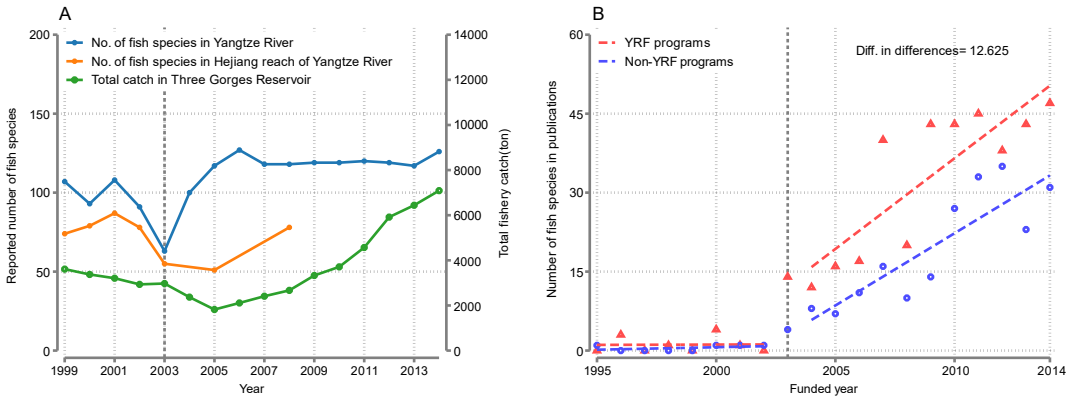


Fig. 3. Increase in biological materials for scientific research. This figure presents the heterogeneity of the impact of fishing regulations on scientific research across different groups. The groups include: (1) Whether the institution to which the fund belongs is located in a province in the Yangtze River Basin, (2) Whether the fish species have become extinct (*EX*) or extinct in the wild (*EW*), and (3) Whether the fish species are endemic to the upstream of the Yangtze River. This figure presents the point estimates and 95% confidence intervals of the effects on the number of funds, funding amount (thousand RMB), publications per fund, and citations per paper. The regression includes fish species fixed effects and year fixed effects. The standard errors are clustered at the fish order × year level.



685

686 **Fig. 4. Increase in biological materials for scientific research. A,** Annual reported number
687 of fish species in the Yangtze River and the Hejiang reach of the Yangtze River. The statistical
688 data is from the *Bulletin on the Ecological and Environmental Monitoring Results of the Three*
689 *Gorges Project* issued by the Ministry of Environmental Protection from 2000 to 2015. The
690 blue and orange solid lines represent the trend in the reported number of fish species in the
691 Yangtze River and the Hejiang reach of the Yangtze River. The green solid line represents the
692 trend in total fishery catch in the Three Gorges Reservoir area. The black vertical dashed line
693 indicates the year when the fishing ban started. Due to the major flood that occurred on the
694 Yangtze River in 1998, we are only displaying data from 1999 onwards. **B,** Number of fish
695 species in the YRF and non-YRF programs' corresponding publications. The red dashed line
696 represents the YRF programs' associated publications, while the blue dashed line represents
697 the non-YRF programs' associated publications. The black dashed vertical line indicates the
698 time when the fishing ban was implemented.

699

Table 1: Effect of fishing regulation on scientific research

	Short-term		Long-term	
	Number of funds	Funding amount	Publication	Citation
	(1)	(2)	(3)	(4)
YRF×Post	0.105***	62.848***	0.368***	0.238***
	(0.018)	(11.503)	(0.034)	(0.038)
Observations	31240	31240	31240	31240
Adjusted R^2	0.521	0.349	0.193	0.163
Species FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Notes: The table presents the Difference-in-Differences (DiD) estimation of the impact of fishing regulations on scientific research outcomes, evaluated from both short-term and long-term perspectives. In the short term, the analysis examines two independent variables: the number of funded programs (Column 1) and the amount of funding (Column 2). From a long-term perspective, the analysis examines publications per fund (Column 3) and citations per paper (Column 4). The sample covers the period from 1995 to 2014. "YRF" is a binary indicator that equals one if a fish species belongs to the Yangtze River. "Post" is a binary indicator that equals one in and after 2003. The regression includes fish species fixed effects and year fixed effects. Standard errors in parentheses are clustered at the fish order × year level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table 2: Effect of fishing regulation on other scientific outputs and public influence

	Patents	Books	Awards	Media Coverage
	(1)	(2)	(3)	(4)
YRF×Post	0.012***	0.003***	0.008***	0.020***
	(0.003)	(0.001)	(0.002)	(0.003)
Observations	31240	31240	31240	23415
Adjusted R^2	0.041	0.050	0.079	0.642
Species FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Notes: This table replaces the dependent variable with other outcomes of the fund, including patents, books, awards (also divided by the number of funds) and news related to fish research. The sample covers the period from 1995 to 2014 for Columns 1-3, and 2000 to 2014 for Column 4. "YRF" is a binary indicator that equals one if a fish species belongs to the Yangtze River. "Post" is a binary indicator that equals one in and after 2003. The regression includes fish species fixed effects and year fixed effects. Standard errors in parentheses are clustered at the fish order × year level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.