

Conserving Mekong Megafishes: Current Status and Critical Threats in Cambodia

Teresa Campbell ^{1,*}, Kakada Pin ^{2,3}, Peng Bun Ngor ^{3,4} and Zeb Hogan ¹

¹ Department of Biology and Global Water Center, University of Nevada, Reno, Nevada 89557, USA; tcampbs@gmail.com (T.C.); zhogan@unr.edu (Z.H.)

² Centre for Biodiversity Conservation, Royal University of Phnom Penh, Phnom Penh 12156, Cambodia; pin.kakada77@gmail.com

³ Wonders of the Mekong Project, c/o Inland Fisheries Research and Development Institute, Phnom Penh 12300, Cambodia

⁴ Inland Fisheries Research and Development Institute, Fisheries Administration, Phnom Penh 12300, Cambodia; pengbun.ngor@gmail.com

* Correspondence: tcampbs@gmail.com; Tel.: +01-775-682-6066

Received: 2 June 2020; Accepted: 20 June 2020; Published: 25 June 2020

Table of Contents

Supplementary Tables and Figures.....	1
Detailed Local Ecological Knowledge Survey Methods and Recommendations.....	10
Local Ecological Knowledge Questionnaire.....	11

Supplementary Tables and Figures

Table S1. Comparisons of Mekong megafish body sizes (weight in kg) reported by fishers to the maximum body size from FishBase (www.fishbase.org). Except for *Max size from FishBase*, the values presented are the means of fisher responses, with the percent of the maximum body size from FishBase in parentheses. *Max size from fishers* represents the maximum size that fishers knew the species to attain. *Size of largest capture* is the size of the largest specimen ever captured by fishers. *Avg size at present* is what fishers reported to be the current average body size. *Size of last capture* is the body size of the most recent specimen captured by fishers.

Species	Max Size from Fish Base	Max Size from Fishers	Size of Largest Capture	Avg Size at Present	Size of Last Capture
agry	30	3 (11%)	2 (5%)	0.4 (1%)	0.6 (2%)
csia	300	109 (36%)	53 (18%)	8 (3%)	15 (5%)
pgig	350	256 (73%)	207 (59%)	100 (29%)	95 (27%)
psan	300	81 (27%)	68 (23%)	4 (1%)	9 (3%)
pjul	70	34 (49%)	23 (33%)	4 (5%)	4 (5%)
upol	600	166 (28%)	121 (20%)	29 (5%)	31 (5%)
wmic	96	84 (88%)	52 (54%)	6 (6%)	13 (14%)

Table S2. Mekong megafishes' age and length at first maturity. Values taken from FishBase's life history tool (https://www.fishbase.se/report/KeyFactsMatrixList.php?e_code=21). These values are estimates calculated from inputs such as maximum length rather than actual measured traits.

Species	Age at First Maturity (yr)	Length at First Maturity (cm)
agry	9.8	67.5
csia	17.7	141.4
pgig		141.4
psan		141.4
pjul	11.6	76.7
upol		116.1
wmic	9.6	78.4

Table S3. Comparison of fishers' mean dates of last capture with their perceived rankings of megafish population abundance at the time of the survey (June 2018). The mean dates of last capture are the same values shown in Figure 2. *Mbp* = months before present (June 2018). The mean perceived abundances are the same values (in both descriptive and numerical forms) shown in Figure 3 for the mean perceived abundance at the time of the survey.

Species	Mean Last Capture Date (mbp)	Mean Perceived Abundance – June 2018
agry	5.0	Uncommon to rare (2.7)
csia	12.2	Uncommon (2.3)
lstr	19.5	(not enough data)
pgig	95.1	Rare to locally extirpated (3.1)
psan	25.2	Rare (2.9)
pjul	4.5	Uncommon (2.1)
upol	16.3	Uncommon (2.1)
wmic	23.7	Rare (2.9)



Figure S1. Photographs of the megafish species examined in this study. (a) *Aaptosyax grypus*, (b) *Catlocarpio siamensis*, (c) *Luciocyprinus striolatus*, (d) *Pangasianodon gigas*, (e) *Pangasius sanitwongsei*, (f) *Probarbus jullieni*, (g) *Urogymmus polylepis*, (h) *Wallago micropogon*. Photo credits: Peter Cunningham (a), Zeb Hogan (b,d,e-g), FISHBIO (c), Suthep Kritsanavarin (h).

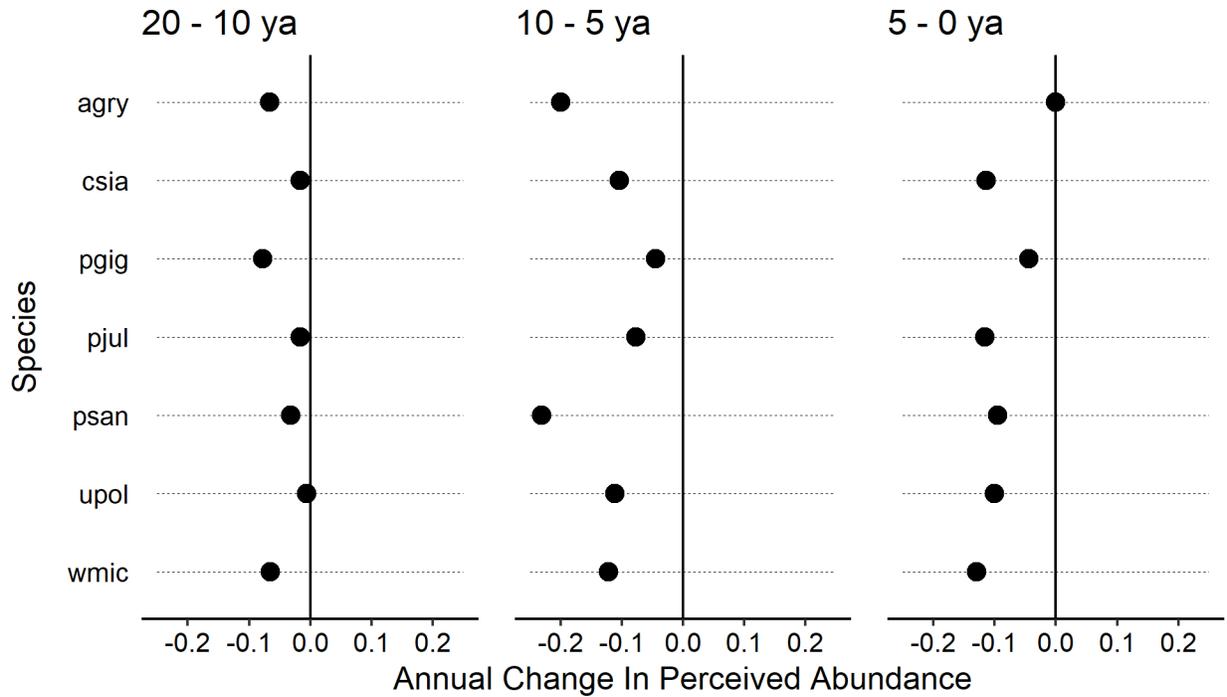


Figure S2. Annual change in perceived abundance of Mekong megafishes in northern Cambodia. Annual change was calculated for three time intervals: 20 to 10 years ago (ya), 10 to five ya, and five to zero ya. Annual change in perceived abundance was calculated by subtracting the mean at the second time period from the mean at the first time period and dividing by the number of years between each time period. Thus, a change with an absolute value of 0.1 between 20 to 10 ya, and a change with an absolute value of 0.2 for the other two time intervals, indicates a change of a full abundance ranking over the whole time interval. Negative values indicate a decrease in body size; zero indicates no change; positive values indicate an increase in body size. Sample sizes for each species are the total numbers of high-quality interviews for the whole study area reported in Table 2.

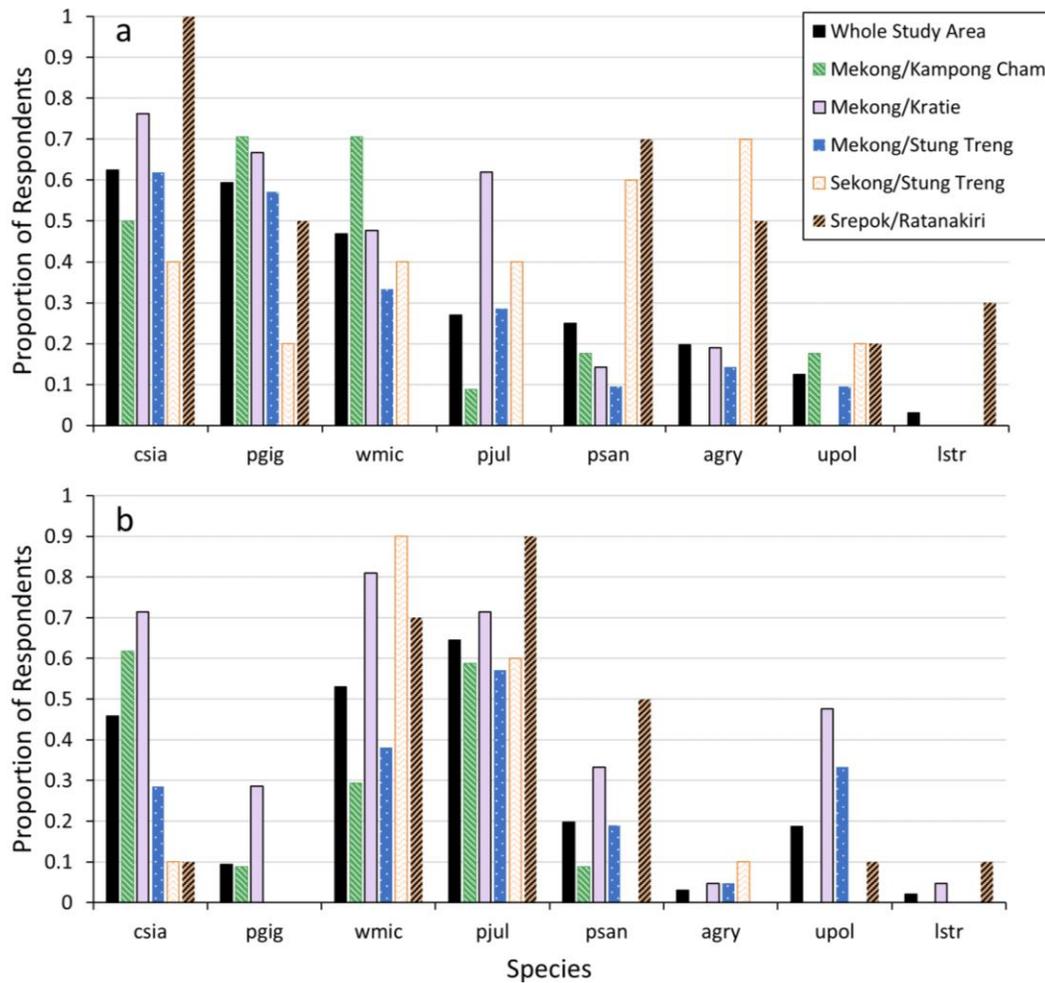


Figure S3. Mekong megafishes identified by local fishers as extirpated or likely to be extirpated in northern Cambodia. These data were generated from the open-ended question: “Do you think any of these species will be extirpated (conveyed to fishers as “lost,” “disappeared,” “never seen,” “no longer existing,” or “gone” from places where they fish)?” **Panel a** shows the proportion of respondents who identified the species as already, or likely to become, extirpated. This proportion is the number of times a species was named in the given river section divided by the total number of fishers interviewed in that river section. Because this question was open-ended, it was not tied to individual species interviews, and therefore did not receive an interview quality rating (see main text for details about the quality ratings). Therefore, to give an idea of the reliability of the information provided in **panel a**, the proportion of respondents who provided a high-quality interview on the individual species was shown in **panel b**; this proportion suggests how well known the species was in that river section, and thus gives an estimate of the reliability of the extirpation risk data in **panel a**. (For example, if zero out of 20 fishers interviewed in a river section provided a high-quality interview on one species, but 18 of them reported the species as extirpated or likely to be extirpated, then it is likely that the fishers were reporting this species as extirpated because they had never personally seen the species rather than because they had true knowledge of its population trend or status. In this example, the species was either truly not there or it was there and these fishers never caught it. See *Aptosyax grypus* in the Sekong and Srepok rivers. On the other hand, if 20 out of 20 fishers interviewed provided high-quality interviews on the species, and all 20 of them identified it as extirpated/becoming extirpated, then this is very strong evidence that the species is not present, or is soon to be extirpated, in that river section. See *Catlocarpio siamensis* in the Mekong River in Kratie.) The sample sizes are the total number of fishers interviewed per river section reported in Table 2.

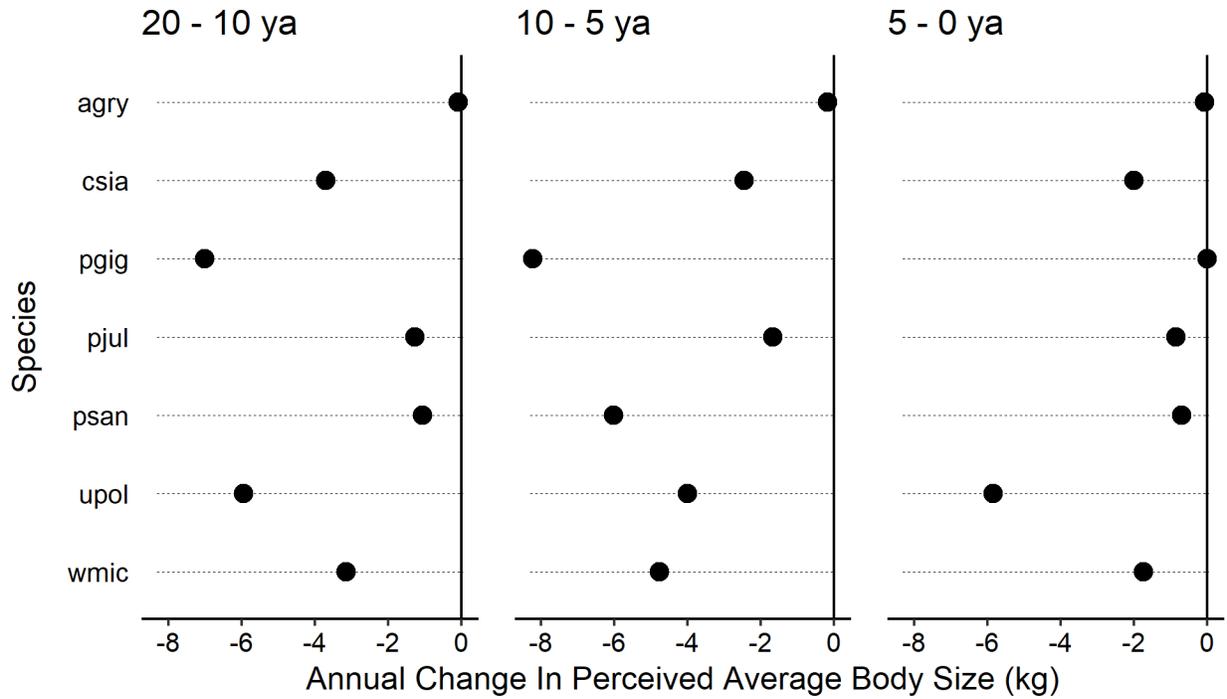


Figure S4. Annual change in perceived average body size of Mekong megafishes. Annual change was calculated for three time intervals: 20 to 10 years ago (ya), 10 to five ya, and five to zero ya. Annual change in perceived average body size was calculated by subtracting the mean at the second time period from the mean at the first time period and dividing by the number of years between each time period. Negative values indicate a decrease in body size; zero indicates no change; positive values indicate an increase. Sample sizes for each species are the total numbers of high-quality interviews for the whole study area reported in Table 2.

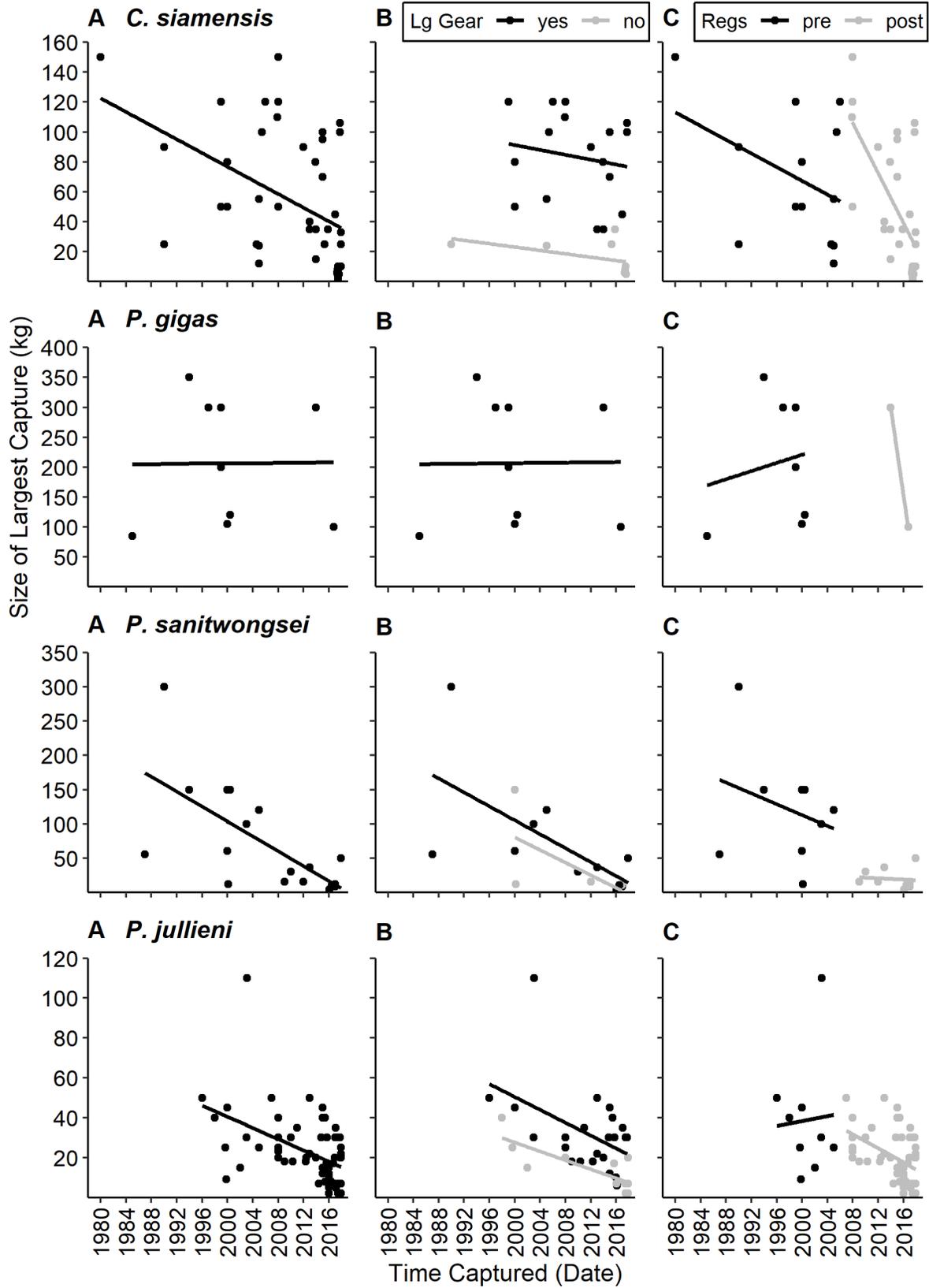


Figure S5. (Continued on next page.)

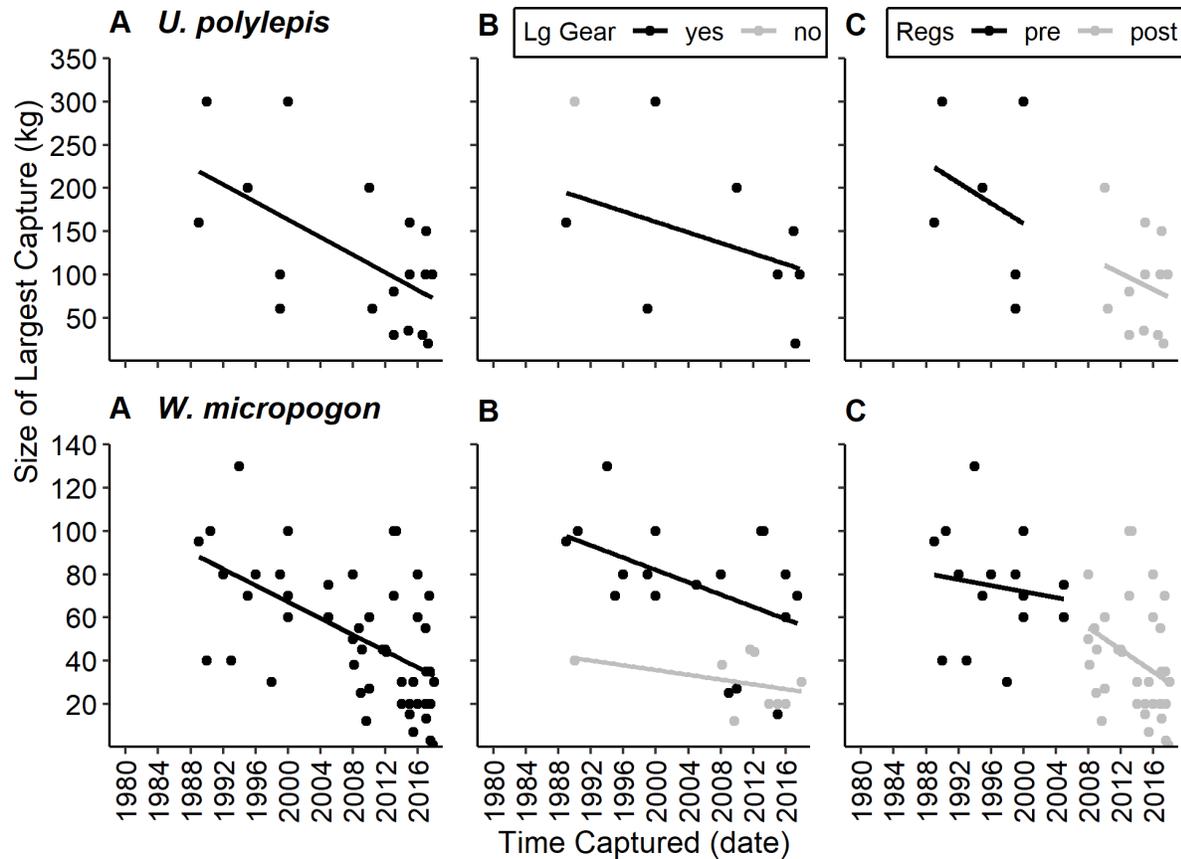


Figure S5 continued. Plots of the size and date of capture of the largest Mekong megafish specimens captured by fishers. Trend lines represent the result of simple linear regression. Column A shows the results from all the data. Column B shows results from dividing the data into two groups: fishers who reported using gears large enough to catch large megafish specimens (black), and fishers who said they did not use large gears (grey). Column C shows results from dividing the data into another two groups: captures that occurred before 2006 when fishing regulations were instituted (black), and captures that occurred after 2006 (grey). Sample sizes for each species are the total numbers of high-quality interviews reported for the whole study area in Table 2. Note different y-axes.

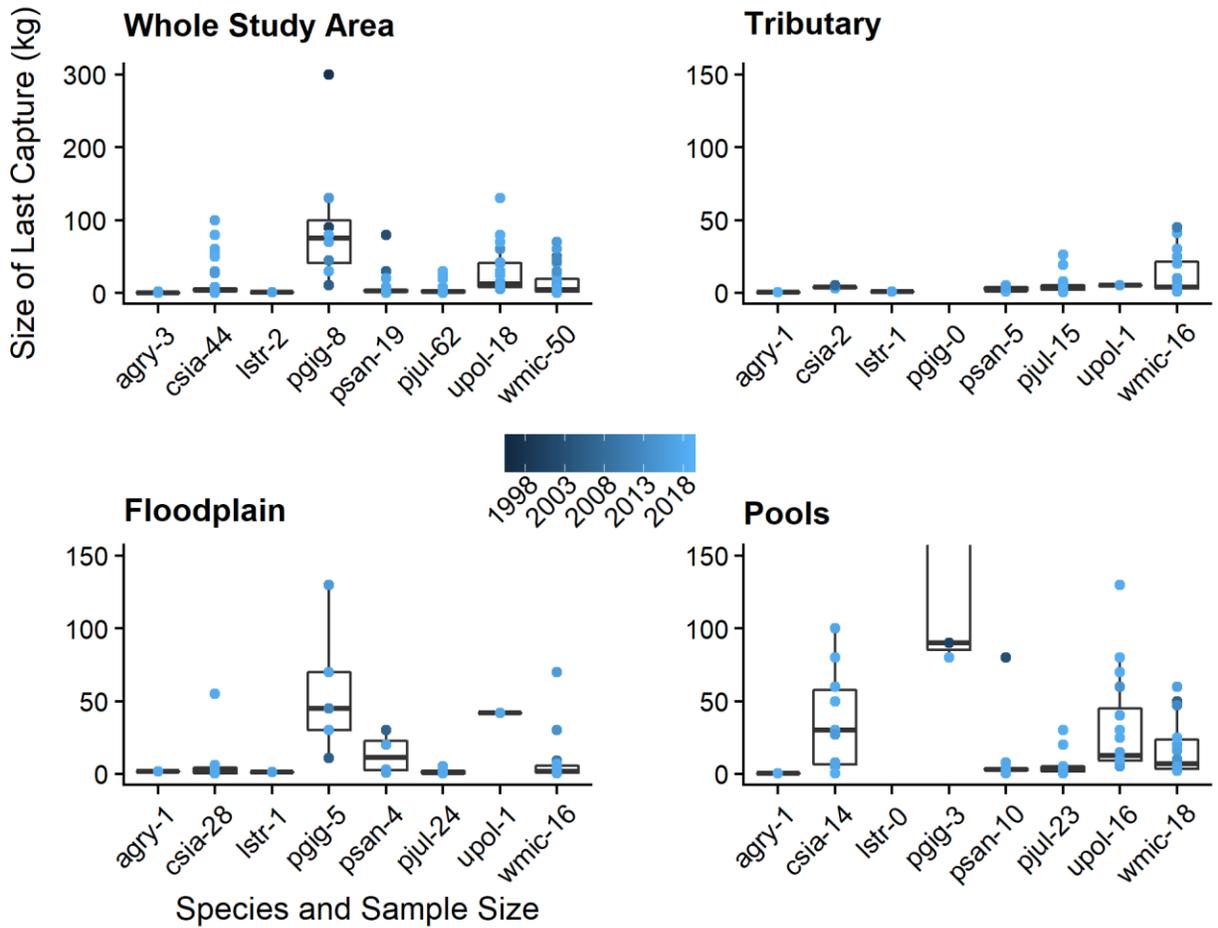


Figure S6. Distributions of body sizes of the most recent Mekong megafish specimens captured by fishers in northern Cambodia. Each point corresponds to a unique capture record, and the blue shading signifies the year in which it was captured (see color scale). Note the different y-axis on the “Whole Study Area” panel. The 300-kg *Pangasianodon gigas* shown in the “Whole Study Area” panel was captured in pools habitat and is out of view in the “Pools” panel. “Whole Study Area” = data from all 12 villages where interviews were conducted; “Floodplain” = data from five villages in river sections that have close connectivity with the floodplain; “Pools” = data from five villages in river sections that have nearby deep pool habitat; “Tributary” = data from two villages on the 3S Rivers, which are tributaries to the Mekong River. The number after the species abbreviation on the x-axis is the sample size – the number of high-quality interviews obtained for that species.

Detailed Local Ecological Knowledge Survey Methods and Recommendations

Several survey trials and scouting trips were conducted in order to find villages with knowledgeable fishers, make contact with village chiefs, and refine the questionnaire and methodology. During these trials, questions that were too difficult for fishers to answer were either re-phrased or eliminated, and the question list was consolidated in order to reduce the amount of interview time. The trials were invaluable for making contact with village chiefs and identifying villages with many knowledgeable fishers. Due to the remote nature of these villages, it was often not possible to contact the chief before the survey team arrived at the village. Therefore, sometimes upon arrival the team would find out that there were no fishers available to interview (perhaps they were out fishing for the day) or that there were no fishers that would be considered experts (see below) in that village. During the trials, the team was able to make contact with the chiefs, explain the project, and find out if there were expert fishers there and when would be a good time to come back to interview them. This greatly facilitated the interview process when the team came back for the full survey.

This process of explaining the project to the chief ahead of time was also invaluable for obtaining more accurate information about the fish because many people in remote villages are suspicious of researchers and government officials – and for good reason. In Cambodia, there are many fisheries laws that are regularly broken. Common violations include: fishing inside conservation zones, electrofishing, and fishing with too large or too small gillnet mesh. In order to protect large-bodied fish, it is illegal under national law to fish with gillnet mesh larger than 15 cm. Additionally, several species of megafishes are illegal to catch, sell, buy, stock, process and transport (except for “under official permission”) due to their endangered status. This list includes several of our study species: *Pangasianodon gigas*, *Catlocarpio siamensis*, *Probarbus jullieni*, and *Wallago micropogon*. However, many fishers continue to practice illegal fishing methods and/or keep restricted species. Reasons for breaking the law include financial benefit (some megafishes are the highest-priced species on the market) and the belief that they must do this in order to support their family. On top of all of this, fishers and law enforcers in Cambodia do not generally have good working relationships. Therefore, when outside people (especially government officials) come to a village asking about large, endangered fishes, fishers have good reason to be concerned that they will get in trouble with the law and possibly be imprisoned.

Taking time with the village chief to carefully explain the intent of the project before conducting the survey allowed the team to convince the chief that we were only interested in the fish populations with the intent of helping preserve them, and that we were not spying on fishers’ activities in order to get them in trouble with the law. Once the chiefs were convinced, they helped convince the rest of the villagers, who look to the chief to protect their interests. During the trials, the survey team also implemented some practices that helped make the chiefs and fishers more comfortable, like providing food, distributing gifts (e.g. fish coloring books and colored pencils for children), and laughing and joking with the villagers. Fishers were also provided five USD for compensation for their time and to foster good will. All of this created a friendlier and more inviting environment that we believe helped to foster more honest conversation about fishing activities and catches of sensitive species.

In addition to these practices, we recommend that researchers hoping to implement similar studies establish relationships with local people who can vouch for them to other villagers. In some villages, one of our team members had a trusted contact who served this purpose; we found that it was easier to talk to the fishers in those villages. We believe that establishing a network of fishers to work with regularly is one of the best ways to obtain information about sensitive species. There is high risk to these people for divulging certain fishing activities, so established relationships and trust between fishers and researchers is critical for these types of local ecological knowledge surveys.

Questionnaire

The following pages contain the English version of the semi-structured questionnaire used for the local ecological knowledge survey. A Khmer translation of this questionnaire was used for the interviews.

Interview Form

Fill out entire form for every interview

Informed consent statement

We are from the University of Nevada, Reno (USA) and the Royal University of Phnom Penh. We have come to study the Mekong River and its important species so we can help protect the environment and fisheries yields. We hope you can provide some information to help us better understand the current status of these species and how they have changed over the years. We are not concerned with enforcing fishing laws; we simply want to find the best information available about the species so we know what the species need to survive. The survey is anonymous and the information you provide will only be used for research and analysis. We will not record your name or disclose any of your personal information to a third party. Your participation is completely voluntary; if you do not wish to participate, we will end the survey now. If you are willing to participate, but do not want to answer any of the questions, we will skip those questions. You can also request to stop the interview at any time.

1. Are you willing to participate in this survey? Yes No
2. Is it okay with you if we record the audio of this interview? Yes No

Date: _____ Start Time: _____ Interviewer: _____

River: _____ Nearby City: _____

Village Name: _____ GPS coordinates: _____

Respondent Experience

Please tell me a little about your experience with the fish.

3. Gender _____ 4. Age _____ 5. Primary Occupation _____ 6. Years Experience _____
7. Years Fishing (if not primary occupation) _____
8. Hours per week fishing? Now? In the past? _____
9. Where do you fish now? In the past? _____

Species-specific questions

Now we will give you some photos of fish to look at. If you don't know the species, that is fine. We will skip it.

*Interviewer Instructions: Show photos of the juvenile and adult for each species. If the respondent does not know the species, mark "No" and skip to the next. If the respondent does know the species, mark "Yes" and fill out a **Species Information Form** for that species. Let the respondent provide all answers about the species, including the name of the species; do not provide answers for the respondent. If they say they know it, but can't think of the name, you can help them with the name. If the target species is commonly confused with other species, don't show photos of the commonly confused species right away. Ask the respondent if the target species is similar to any other species to test their knowledge; then show the photos of the commonly confused species (see Species Information Form).*

1. Wallago leerii Do you know this species? Yes No
2. Aptosyax grypus Do you know this species? Yes No
3. Pangasius krempfi Do you know this species? Yes No
[Commonly confused species: *P. macronema* and *P. mekongensis*.]
4. Pangasius sanitwongsei Do you know this species? Yes No

Interview Form

Fill out entire form for every interview

[Commonly confused species: P. larnaudii.]

5. Pangasianodon gigas Do you know this species? Yes No

[Commonly confused species: Pangasius mekongensis and Pangasianodon hypophthalmus.]

6. Himantura polylepis Do you know this species? Yes No

7. Probarbus jullieni Do you know this species? Yes No

[Commonly confused species: P. labeamajor.]

8. Catlocarpio siamensis Do you know this species? Yes No

9. Luciocyprinus striolatus Do you know this species? Yes No

General Questions

Do you think any species will be extirpated?

What is the biggest threat to these species or to fish in general?

What are the biggest problems or challenges for fishermen right now?

Are there any restrictions on how you catch these species or how many you can harvest?

What gears do you usually use for fishing?

Do you know of any places where lots of electrofishing or dynamite fishing occurs?

Interview End Time: _____

Interview Form

Fill out entire form for every interview

Post-Interview Assessment**Respondent:** Did the respondent appear to be knowledgeable about the species? Why/why not?**Species Assessments:** Rate the quality of the information given for each species by checking the applicable box.

- | | | | | | | | | | |
|-----------------------------|----------|------|--------------------------|------|--------------------------|--------|--------------------------|-----|--------------------------|
| 1. Wallago leerii | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 2. Aptosyax grypus | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 3. Pangasius krempfi | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 4. Pangasius sanitwongsei | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 5. Pangasianodon gigas | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 6. Himantura polylepis | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 7. Probarbus jullieni | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 8. Catlocarpio siamensis | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |
| 9. Luciocyprinus striolatus | Quality: | Poor | <input type="checkbox"/> | Good | <input type="checkbox"/> | Expert | <input type="checkbox"/> | N/A | <input type="checkbox"/> |
| Rationale: | | | | | | | | | |

What information can we use from this interview for further analysis?

Species Information Form

Use this form for known species only. Attach to the Interview Form for each respondent.

Date: _____ Time: _____ Interviewer: _____

Species' scientific name: _____

Questions:

What is its name? _____ Can you describe this fish for us? How big is it? Any unique features?
[If they can't give the name, you can provide it for them to see if they remember.]

Are there any species that are very similar to it? Yes No

How do you tell them apart?

[For species that we know are easily confused with other species, show them the photos of the commonly-confused species and make sure they are referring to the target species.]

Do you have any good stories or information about this species? Any photos of large fish?

What are its habits or migration patterns?

Where do you usually find this fish? What type of habitat do you catch it in?

[If fisherman cannot answer this question, use these examples:]

For example, pool/fast water, deep/shallow water, middle or edge of river, near rocks/trees/etc.

Do you find juveniles and adults here? Juvenile Adult

If not, why do you think you don't find them?

Species Information Form

Use this form for known species only. Attach to the Interview Form for each respondent.

When is this fish most abundant here? Do you catch it a lot at this time? If not, why?

If you could describe the status of this fish through time, would you rate it as 1-common, 2-uncommon, 3-rare, or 4-extinct: 20 ya _____, 10 ya _____, 5 ya _____, present _____

Average body size (kg): 20 ya _____, 10 ya _____, 5 ya _____, present _____

How big was the last one you caught (kg)? What was the date (month + year)? _____

How did you catch it?

How big was the biggest one you ever caught (kg)? _____ Date _____ Location _____

How did you catch it?

Do you ever find it with eggs? When? Do you know anything else about its spawning habits?

If I wanted to catch this fish to take a photo of it or tag it for research, how do you recommend that I do that? Where should I go? Who should I talk to?

What do people usually do with this species when they catch it? Food Sell Release

Cost/kg?