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CONFERENCE PROCEEDINGS

BHUTAN

2019

Fisheries Conservation FOUNDATION

THE FIRST INTERNATIONAL MAHSEER CONFERENCE PROCEEDINGS

Cover photo: Golden Mahseer, artwork by © Joseph Tomelleri.
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THE FIRST INTERNATIONAL MAHSEER CONFERENCE

December 2-9, 2018
Paro, Bhutan

Jointly Hosted by:

Bhutan Ministry of Agriculture and Forests
World Wildlife Fund – Bhutan
Fisheries Conservation Foundation - USA

International Mahseer Conference Organizers:

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Zachery D. Zbinden, University of Arkansas

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Executive Summary

The International Mahseer Conference (IMC) was held December 2-9, 2018 at the Zhiwa Ling Heritage Hotel in Paro, Bhutan. The Conference was hosted jointly by the Ministry of Agriculture and Forests (MoAF), the World Wildlife Fund – Bhutan (WWF-Bhutan), and the Fisheries Conservation Foundation (FCF). It was organized by a Conference Organizing Team (COT) that had multiple members from all three host institutions. Over 110 participants from eleven countries and four continents attended the conference. The focus of the conference was on Mahseer biology, conservation, and management, but global experts also spoke on river connectivity, water security, recreational fishing, fish passage, and hydropower issues.

On Sunday, December 2nd, conference participants registered and convened at an evening reception. The IMC began formally on Monday, December 3rd, with the arrival of the Chief Guest, the Honorable Lyonpo Yeshey Penjor (Minister, MoAF). On completion of the Marchang, representatives from the conference hosts provided welcoming remarks: Dechen Dorji (WWF-Bhutan), Michael Philipp (FCF), and Dasho Rinzin Dorji, (Secretary, MoAF). Lyonpo Yeshey Penjor provided the Chief Guest address highlighting the value of science-based solutions and action plans coming out of international scientific conferences such as the IMC. Dr. David Philipp (FCF) followed this address by unveiling the first scientific illustration of a Golden Mahseer (provided by artist Joseph Tomelleri). This illustration was based upon photographs and measurements collected from a Golden Mahseer within Bhutan. The original artwork had been presented to His Majesty the King prior to the conference. The opening session ended with a plenary talk highlighting the significant achievements of Bhutan's Mahseer Research and Conservation Project.

The formal scientific program was organized into four sessions:

- **Biology of Mahseer**
- **Threats to and Mitigation Options for Mahseer**
- **Conservation of Mahseer and River Ecosystems**
- **Management and Recreational Fishing**

These sessions included one Plenary address, six keynote addresses, 26 oral and 19 poster presentations. On Thursday most international participants enjoyed an all-day field trip to the National Research Centre for Riverine and Lake Fisheries (NRCR&LF) in Haa. To broaden and extend key conference topics, a Roundtable Workshop was held on Friday, December 6, that consisted of three morning and three afternoon facilitated breakout sessions followed by plenary discussions of their findings and recommendations.

Four key messages emerged from the technical sessions.

First, it is clear that the **basic biology and taxonomy of Mahseer** species remain unclear. Conservation programs would be more effective if data were available on migration patterns, reproductive behaviors, abundance, recruitment, and impacts of habitat alteration (among others).

Second, wild Mahseer are impacted by many pressures. **Indiscriminant hatchery stocking, illegal harvest, and altered or destroyed habitat have threatened or extirpated native Mahseer** populations throughout the region. Several presentations highlighted the substantial harm done by indiscriminant stocking of hatchery-reared Mahseer being used as a potential management option.

Third, **effective measures to mitigate impacts of hydropower on Mahseer are still relatively unknown**. Clearly, hatcheries are not an answer, and fish passage methodology that is effective for Mahseer have yet to be developed.

Finally, **Native Fish Conservation Areas were deemed highly effective in developing long-term sustainable community conservation. They effectively link the economic resources provided by recreational anglers (especially high-end fly-fishers) with the needs of local communities**.

It was evident that programs addressing education and outreach at the local community level were significant drivers for raising public awareness of the need for strategic conservation efforts in Bhutan and the region.

Collectively, building upon the science presented during the formal sessions, the Roundtable Workshop developed a series of specific recommendations for Bhutan and the region in general. The following were deemed of highest priority for subsequent implementation:

1. An important **first step would be to delineate Mahseer waters from Trout waters, then develop separate, species-based regulations for each** to ensure their sustainability. Delineating waters should be based on the elevational difference separating the species, i.e., Mahseer exist in Bhutanese rivers at an elevation of 1000m and below.

2. **Curb illegal harvest by developing Community-based Conservation Programs** in Bhutan and across the region. These programs would be based on a Recreational Fishing Program for Mahseer that is non-consumptive (i.e., totally catch-and-release and, therefore, sustainable). This approach has effective and transparent mechanisms that would generate revenues to enhance the livelihoods of local residents as well as to ensure the conservation of Mahseer for future generations.

3. **Develop a National Fish Stocking Policy (NFSP)** and Hatchery Culture Guidelines (HCG). These would include regulations that eliminate the introduction of non-native species by the general public, including those done for religious reasons. **In addition, all hatchery culture and stocking programs** (i.e., new and proposed) **should be suspended** until the requirements outlined in the NFSP document are met.

4. **Improve the process that grants permits and regulates** the location, construction, and operation of technologies that are deemed environmentally negative (e.g., hydropower, rock crushing, road construction, sand and gravel mining, etc.) and require these technologies to complete a **legitimate Environmental Impact Statement (EIS).** This would also entail a review of the projects during construction and subsequent operation to ensure compliance.

5. Regional governments must make a commitment to **reorganize Natural Resource Management and Conservation governance** in such a way that responsibilities are allocated in a sound and logical manner. Within Bhutan specifically, the MoAF should review the existing institutions and their mandates and formulate alternatives that would be more effective and efficient in the coordination and management of aquatic natural resources.

6. **Establish nationwide outreach/education programs** that explain the importance of Mahseer and other native fishes within large river ecosystems, the benefits of establishing Community-Based Conservation Programs based on recreational fishing activities, as well as the need for curtailing illegal harvest of fish and for balancing human development against environmental sustainability.

7. With the overwhelming realization that there is a tremendous lack of relevant scientific data, each political jurisdiction responsible for managing aquatic natural resources needs to **develop a five-year Research Agenda** that lays out how they plan **to address the key information gaps questions below:**

a. How much illegal fishing is occurring, where does it occur and by whom?
b. What key habitats are needed for reproduction and the various life stages of Mahseer?
c. Where do Mahseer migrate for reproduction and overwintering; any trans-boundary movements?
d. What factors contribute to human impacts on fish passage, and how best can they be mitigated?
e. What genetic variation exists within and among Mahseer species; what is their correct taxonomy?
f. How and why are non-native aquatic organisms being introduced; how best to control that?
g. How will climate change impact Mahseer and the large river ecosystems on which they depend?

The IMC participants repeatedly reinforced the highly productive nature of the conference in developing a positive future for Mahseer. They enthusiastically expressed their appreciation for Bhutanese hospitality and were impressed with Bhutan's commitments to conservation from all levels of government. In fact, IMC participants agreed to pursue (1) the production of a Bhutan Declaration outlining key steps to be taken in the near future [a draft version is being finalized] and (2) to organize a follow-up conference in less than two years to assess progress and expand participation. In this regard, an IMC2 is tentatively planned for Spring 2020 in Chiang Mai, Thailand.

Conference Prospectus

Scope and Objective:

A healthy river ecosystem begins with a healthy watershed. From a river's headwaters to the sea, what happens on adjacent lands plays an important role in determining the health of that river's habitats and food webs. Understanding this connection between water and land is imperative not only for developing sound conservation strategies for managing rivers but also for identifying those components of the ecosystem that are needed to support Mahseer. As a migratory species, the more we know about how Mahseer are impacted by development, the better we can work for their long-term survival.

There is still much to learn about Mahseer, including their migration patterns, reproductive behaviors, juvenile survival, critical habitats, and how human activities impact them. Many populations of Mahseer are threatened throughout their range, and the more we know about what impacts their life history, the better we can establish conservation measures to ensure that native populations are here for future generations.

The International Mahseer Conference will bring together people that work on Mahseer biology, fish conservation, rivers and their development, recreational fishing, fisheries management, and general conservation to meet and share the latest research findings, management concerns, potential solutions and conservation strategies.

The conference will be organized into the four themes and feature both invited and contributed presentations about Mahseer species across their range.

- Biology
- Threats and Mitigation
- Conservation
- Management and Recreational Fishing

Expected Outcomes:

The conference will provide a forum for scientists to share their information and ideas on how best to manage and conserve Mahseer and the rivers they inhabit. The conference will also produce a Proceedings that will have following components:

- Future research agendas
- Recommended strategies for Conservation and Management of Mahseer
- Recommended actions to build capacity in Bhutan
- Collaborative partnerships

INTERNATIONAL MAHSEER CONFERENCE SCIENTIFIC PROGRAM

Sunday 02 December

18:00 Opening Reception

Monday Morning 03 December

8:00 – 9:00 Registration Table Open
8:30 Buses pick up participants from respective hotels

CONFERENCE OPENING

Master of Ceremonies: Sonam Yangchen, Department of Livestock, Ministry of Agriculture and Forests

09:15 Arrival of Participants and Guests
09:30 Arrival of Chief Guest
9:35 Marchang, Dasho Rinzin Dorji, Secretary, Ministry of Agriculture and Forests
Welcome Addresses by Conference Hosts:

- Dasho Rinzin Dorji, Secretary, Ministry of Agriculture and Forests
- Mr. Michael Philipp, IMC Co-Chair, Fisheries Conservation Foundation
- Mr. Dechen Dorji, Country Representative, WWF Bhutan
- Keynote Address: Chief Guest, Minister of Ministry of Agriculture and Forests
- Launching of 2018 Living Planet Report, WWF Bhutan
- Launching of Fisheries Website, Department of Livestock
- Acknowledgments and Gifts to Chief Guest, Dignitaries and supporters, David Philipp
- Seating of Chief Guest for plenary presentation
- Plenary Presentation: Developing Bhutan's Con servation Strategy for the Golden Mahseer, Karma Wangchuk (MoAF), Julie Claussen (FCF) and Dr. David Philipp, Fisheries Conservation Foundation
- Vote of Thanks, Dr. Tashi Samdup, Director General, Department of Livestock, MoAF
- Proceed to poster area for official launch of posters by Chief Guest

11:30 Photo Session and Refreshments
12:30 Lunch

Monday Afternoon 03 December, 2018
Introduction of session and announcements: Julie Claussen, Fisheries Conservation Foundation

SESSION THEME: BIOLOGY OF MAHSEER
Chairperson; Michael Douglas, Professor, University of Arkansas, USA
14:00 KEYNOTE: Mahseers (Tor spp.) of the World Status Review
Presenter: Adrian Pinder, Bournemouth University, Director of Research at Mahseer Trust
14:30 Reproductive Behavior and Response of Sahar (Tor putitora) in Tropical Region of Nepal
Presenter: Jay Dev Bista, Agriculture and Forestry University, Nepal
14:50 Distribution and Status of Mahseer Populations in Pakistan
Presenter: Muhammed Rafique, Pakistan Museum of Natural History
15:10 Distribution status of Golden Mahseer in Uttarakhand India and way forward
Presenter: Bhawna Dhawan, Wildlife Institute of India
15:30 Tea Break

Chairperson: Dr. Tashi Samdup, Director General, Department of Livestock, Bhutan
15:45 Mahseer as a component of Fish Biodiversity in Bhutan
Presenter:
Karma Wangchuk, National Research Centre for Riverine and Lake Fisheries, Bhutan
16:05 A molecular assessment of population connectivity among Golden and Chocolate Mahseer in Bhutanese rivers
Presenter:
Marlis R. Douglas, University of Arkansas
16:25 Technological advances in wildlife telemetry: Insight into real-time behaviour of animals
Presenter:
John Grant, Sigma Eight, Inc
Chairperson Poster Session; Julie Claussen, Fisheries Conservation Foundation
16:45 Poster Presentation Session and Reception, hosted by Bhutan Trust Fund for Environmental Conservation and Druk Green Power Corporation
18:00 Bus transportation to downtown Paro: Dinner on your own at local restaurant.

Tuesday Morning 04 December
Introduction of session and announcements: Julie Claussen, Fisheries Conservation Foundation

SESSION THEME: THREATS TO MAHSEER AND MITIGATION

Chairperson: Dr. Tashi Samdup, Director General, Department of Livestock, Bhutan

9:00 KEYNOTE: All Tor are not the same! Status and challenges for stock enhancement of mahseer in India
Presenter:
Rajeev Raghavan, Kerala University of Fisheries and Ocean Studies

9:30 On the brink: population status of the world's largest and most threatened mahseer
Presenter:
Anoop V.K, Kerala University of Fisheries and Ocean Studies

9:50 Impacts of non-native fish on the ecological security of mahseer species in the Indian Himalayan biodiversity hotspot
Presenter:
Nishikant Gupta, International Centre for Integrated Mountain Development

10:10 Pattern of abundance, habitat, threats and conservation priority of Narmada: The State fish of Madhya Pradesh
Presenter: Shriparna Roy Saxena, Barkatulla University, India

10:30 Ecological flow requirement for Golden Mahseer – estimation based on habitat suitability criteria
Presenter: Jeyaraj Antony Johnson, Wildlife Institute of India

10:50 Tea Break

Chairperson: Dr. Rick Williams, Fisheries Conservation Foundation

11:10 Hydroelectricity and Fish Species- A Combined or Separate Chapter
Presenter:
Mohan Bikram Shrestha, Wildlife Educator

11:30 Potential to apply eDNA technology in the process of assessing and managing cumulative impact of cascading hydropower in the Trishuli River watershed Nepal.
Presenter:
Pablo Cardinale, International Finance Corporation

11:50 Monitoring of impacts of Gulpur hydropower project on populations of Mahseer and other fish species
Presenter:
Ahmad Shoaib, Hagler Bailly Pakistan

12:10 An overview of bioengineering solutions for effective passage or blockage of aquatic organisms
Presenter:
Donald L. Pereira, Senior Fisheries Biologist at HDR

12:30 KEYNOTE: Keeping the Mahseer moving: working together for sustainable river basin management
Presenter:
Leeanne Alonso, Biodiversity Specialist, International Finance Corporation, World Bank

13:00 LUNCH

Tuesday Afternoon 04 December
Introduction of session and announcements: Julie Claussen, Fisheries Conservation Foundation

SESSION THEME: CONSERVATION OF MAHSEER AND RIVER ECOSYSTEMS

Chairperson; Nawang Norbu, Director, Bhutan Ecological Society

14:00 KEYNOTE: Valuing Rivers: How the diverse benefits of healthy rivers underpin economies and ecosystems
Presenter:
Stuart Orr, Leader of WWF Freshwater Team, World Wildlife International, Switzerland

14:30 Mahseer in Thailand and Conservation
Presenter: Apinun Suvarnaraksha, Maejo University

14:50 Multi-stakeholder engagement in the conservation, restoration and management of Golden Mahseer: An initiative in Nayar River Valley, Uttarakhand, India
Presenter:
Saurabh Dewan, National Bureau of Fish Genetic Resources, India

15:10 Grassroots reserves benefit Mahseer-dominated tropical river food webs
Presenter:
Aaron A. Koning, Cornell University

15:30 The multiple roles of Mahseer supporting a diversity of cases for their conservation
Presenter:
Mark Everard, University of West England

15:50 Tea Break

Chairperson: Marlis Douglas, Professor, University of Arkansas, USA

16:10 Experience in Implementation of Biodiversity Action Plan for Protection of Mahseer
Presenter:
Naeem Dar, Director, Fisheries and Wildlife Department, Pakistan

16:30 Conservation planning for Mahseers
Presenter:
Sanjay Molur, Zoo Outreach, IUCN Conservation Planning Specialist Group

16:50 Towards conservation of Mahseers and their habitats in Eastern Ghats, India
Presenter:
Paromita Ray, Wildlife Institute of India

17:10 KEYNOTE: Restoring swimways for fish migration: Lessons from local to global
Presenter:
Arjan Berkhuysen, Managing Director, World Fish Migration Foundation, Netherlands

18:15 Buses leave from Zhiwa Ling for Banquet

Conference Banquet hosted by the Honorable Minister, Ministry of Agriculture and Forests, RGOB

19:00 Transportation will leave from the Zhiwa Ling.

Wednesday Morning 05 December
Introduction of session and announcements: Julie Claussen, Fisheries Conservation Foundation

SESSION THEME: MANAGEMENT AND RECREATIONAL FISHING

Chairperson: Sonam Wangdi, Department of Forests and Park Services, MoAF

9:00 KEYNOTE: In search of responsible and sustainable inland recreational fisheries
Presenter:
Steve Cooke, Canada Research Chair, Carleton University, Canada

9:30 Pioneering Mahseer conservation through Eco-Tourism in South India
Presenter:
Sandeep Chakrabarti, Wildlife Association of South India

9:50 An overview of the Native Fish Conservation Area approach to watershed, fisheries, and aquatic conservation and management: implications for mahseer in Bhutan
Presenter:
Richard N Williams, Fisheries Conservation Foundation

10:10 A Science-Based Model for a Recreational Fishing Program for Mahseer in Bhutan
Presenter:
David Philipp, Fisheries Conservation Foundation

10:30 Tea Break

Chairperson: Liane Nowell, Kenauk Institute

10:50 Community Fisheries Programs in Bhutan: Cooperation in Conservation and Management
Presenter:
Singye Tshering, National Research Centre for Riverine and Lake Fisheries, Bhutan

11:10 Perception of stakeholders: challenges and opportunities for Golden Mahseer Tor putitora conservation along Rivers Nayar and Kosi, Uttarakhand; India
Presenter:
Asghar Nawab, World Wide Fund for Nature-India

11:30 Special Recognitions
Presenters:
David Philipp

11:45 Closing Remarks
Kesang Wangchuk, Ministry of Agriculture and Forests and Julie Claussen, FCF

12:00 LUNCH

POSTER PRESENTATIONS

Assessing the efficiency of fishways in Bhutan:
Gopal Prasad Khanal, Singye Tshering, Sangay Norbu, National Research Centre for Riverine and Lake Fisheries

Assessing fish fauna in Bhutan's three major river basins:
Karma Wangchuk, Pema Norbu, Sonam Dorji, Chunglu, National Research Centre for Riverine and Lake Fisheries

Can genetic connectivity in Garra (Cyprininae: Labeonini) serve as a model for fish communities in Trans-Himalayan riverscapes?
Tyler K. Chafin, University of Arkansas

Rheophilic fishes as potential bookmarks for thydrologic alterations of trans-Himalayan riverscapes
Zachery D. Zbinden, University of Arkansas

Is there connectivity among Trans-Himalayan drainages? Snow trout (Schizothorax spp.) (Cyprininae: Schizothoracini) as a test case
Michael Douglas, University of Arkansas

Kenauk as a model for community-based conservation in Bhutan
Liane Nowelll, Doug Harpur, and Mari Hill Harpur, The Kenauk Institute, Dominic Monaco, William Nowell, and Deborah Perzow, Kenauk Nature, Canada

Kenauk Nature as a vacation and fishing destination
Liane Nowelll, Doug Harpur, and Mari Hill Harpur, The Kenauk Institute, Dominic Monaco, William Nowell, and Deborah Perzow, Kenauk Nature, Canada

A model program for training and certifying fishing guides in Bhutan
David Philipp and Rick Williams, Fisheries Conservation Foundation, Jigme Tsuendrup , WWF Bhutan, PatJohnson, Kenauk Nature, Greg Vincent and Jason Franklin, H2O Bone fishing

Illegal fishing and the potential effects on Mahseer
Tshering Dorji and DK Gurung, Department of Forests and Parks, Bhutan

Bhutan's aquaculture program: What we have learned about mahseer
Drukpola, National Research and Development Centre for Aquaculture, Bhutan

How inland fisheries support the UN Sustainable Development Goals
Julie Claussen, Fisheries Conservation Foundation and Monique Perret-Gentil, Venezuela

International Fisheries Section of the American Fisheries Society
Julie Claussen, Fisheries Conservation Foundation and Steven Cooke, Carleton University, Canada

Freshwater conservation in Malaysia
Hafida Bolhen, WWF, Malaysia

Water in Bhutan's Economy: Risks and opportunities for a sustainable future
Sonam Choden, WWF Bhutan and National Environment Commission

Bhutan for Life: A conservation story
WWF Bhutan

Sigma Eight Telemetry Display
John Grant, Haley Mutch, Sigma Eight, Inc, Canada

12:15 Departure for Tiger's Nest Field Trip (pack lunch) *for registered participants

1:30 Departure for Paro Dzong & National Museum Tour *for registered participants

Thursday 06 December
Field trip to National Research Centre for Riverine and Lake Fisheries, Haa, Bhutan

Friday 07 December
Roundtable Workshop, Zhiwa Ling Heritage Conference Room (by invitation)

Chairs: David Philipp and Michael Philipp, Fisheries Conservation Foundation
Format: Group discussions and concurrent focused breakout sessions.
Goal: Develop a set of recommended actions for Bhutan and for the region.
Breakout groups: The breakout groups will work to list and prioritize the specific areas of concern within each topic and develop a set of recommended actions. Each group will have the opportunity to present their ideas to the group at large for further discussion and comment.

Each breakout group will have facilitators and recorders to lead the activity.

Morning Topics
Group 1: Threats to Mahseer and Potential Mitigation Options
Facilitators: Rajeev Raghavan and Jigme Tsuendrup

Group 2: A Research Agenda for Mahseer Conservation and Management
Facilitators: Marlis Douglas and Kesang Wangchuk

Group 3: Potential Community Conservation Activities

Facilitators: Steve Cooke and Sonam Choden

Lunch at Zhiwa Ling

Afternoon Topics

Group 4: A National Fish Stocking Policy and Hatchery Protocols and Guidelines

Facilitators: Rick Williams and Singye Tshering

Group 5: Capacity Building in Bhutan for Aquatic Management and Conservation

Facilitators: Julie Claussen and Karma Wangchuk

Group 6: A Recreational Fishing Program for Mahseer in Bhutan

Facilitators: Dave Philipp and Sonam Wangdi

Reception and Dinner

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News Release

INTERNATIONAL MAHSEER CONFERENCE 2018

December 2, 2018, Paro, Bhutan

The Ministry of Agriculture and Forests (MoAF), in collaboration with the World Wildlife Foundation (WWF) and Fishery Conservation Foundation (FCF), is hosting the first ever International Mahseer Conference (IMC) in Bhutan from 2-8 December, 2018, at Zhiwa Ling Hotel, Paro. Mahseer is a critically endangered species of fish in the Himalayan region. The conference is putting Bhutan on the international stage as a leader in science-based management of its rivers, protecting aquatic biodiversity and using Mahseer as a focal aquatic species. The conference aims to bring scientists and resource managers together to share information on mahseer; draw roadmap for mahseer conservation; and highlight Bhutan's collaborative mahseer research programs with international institutions.

The conference has international participants from five continents of United States of America, South America, Australia, Europe and Asia. The conference is the first international gathering engaging stakeholders interested and involved in mahseer, including renowned fisheries scientists, managers, culturists, policy-makers, eco-tourism specialists, large river conservationists, who are concerned with the long-term sustainable management of mahseer.

The conference meeting is divided strategically into four major technical sessions starting from fish biology to recreational fishing. The important points of technical sessions are discussed further in the round-table workshop where policy makers and scientists make important scientific and policy decisions on mahseer. The conference ends with the field trips to National Research Center for Riverine and Lake Fisheries in Haa and Punatsangchu sites in Punakha-Wangdue valley.

The organizing sponsors of the conference are MoAF, FCF and WWF. These organizers are sharing responsibilities defined in the conference Memorandum of Understanding. Other conference sponsors are: Bhutan Trust Fund for Environmental Conservation-Bhutan, Druk Green Power Corporation-Bhutan, The International Section of the American Fisheries Society, The World Council of Fisheries Societies, UN-FAO Inland Fisheries Consortium, Indian Society of Fisheries Professionals, Zoological Society of Pakistan, The Mahseer Conservancy, The Mahseer Trust, Migratory Fish Platform, Recreational angling companies, Universities, etc. The main intent of hosting the conference is also to advertise Bhutan as a renowned destination for high-end tourists and to promote local economies of Bhutan.

Conference website: http://mahseerconference.org

Officials to be contacted for more information: Dr. Kesang Wangchuk ph: 17820119
Mr. Singye Tshering ph: 17584606

Plenary Session Summary

Developing Bhutan's Conservation Strategy for the Golden Mahseer

Karma Wanchuk[1], Julie Claussen[2], David Philipp[2], Jigme Tsuendrup[3], DK Gurung[1], Tshering Dorji[1], Sonam Drukpa[3]

The Mahseer Conservation and Development Project was officially launched in March 2015 and is being conducted via a partnership between the Fisheries Conservation Foundation, World Wildlife Fund – Bhutan, and the Bhutan Ministry of Agriculture and Forests. This project focuses on four major Research Questions, each of which is being addressed through an ongoing radio telemetry study on the Manas River System (MangdeChu and DangmeChu). The following are the findings of the study to date as they relate to each of the four research questions, including implications of those findings to future Mahseer Conservation needs and potential threats that Mahseer may face in the future. The study included radio telemetry assessments of both Golden Mahseer (Tor putitora) and Chocolate Mahseer (Neolissochilus hexagonolepsis). Where findings are reported for "Mahseer", those findings pertain to both species; findings pertaining to only one species are specified as such. Note: Although some of the findings reported below may be specific for the Manas System, many are likely similar across all watersheds within Bhutan.

Research Question #1: What are Mahseer movement patterns throughout the year?
Finding: Adult Mahseer swim continuously throughout the day and night, often in shallow water along the shoreline.

Implications:

- Illegal land-based fishing for Mahseer, such as cast netting, trapping, gill netting, using lines with baited hooks, etc., can be quite successful and likely supports substantial unreported artisanal fisheries in many areas. Evidence of very extensive illegal fishing is pervasive throughout the basin.
- Illegal harvest rates are likely very high in some areas and could possibly fuel a substantial human-induced mortality of Mahseer in those areas. Our tagging study suggests that more than 50% of our tagged fish may have been illegally harvested during the four years 2015-18.

Finding: Adult Mahseer have a consistent pattern of seasonal movements; overwintering from November to mid-February in the very southern reaches of the watershed in the Manas River, with less than 10% of tagged fish crossing into India in the Manas River system. As the water warms in the spring, Mahseer begin migrating upstream, with some individuals moving as soon as early February. Fish travel long distances quickly (up to 40 kilometers in a single day) and take up positions near the mouths of small tributaries where they wait for the water level in the main river to rise during the monsoonal rains (June-September). When the water levels in the tributaries also rise (June- September), adult Mahseer swim up the tributaries to spawn, perhaps only for short periods and perhaps multiple times during a summer. As water levels and temperatures drop (October-late November), the adult Mahseer slowly migrate downstream, back to their overwintering habitat near the Indian border. The ongoing research priorities are to gather more information on tributary timing and use.

Implications:

- Because the seasonal migration pattern of adult Mahseer is an important component of their life history, alterations to the river system that block fish passage would have quite negative consequences for their populations. How adaptable Mahseer are to significant changes to their.

- Successful fish passage methodology for Mahseer has not yet been developed. A large challenge is that fish passage for Mahseer migrations needs to provide both a mechanism for adults to pass a barrier moving upstream in the spring as well as a mechanism for both adults and juveniles to pass that same barrier moving downstream in the fall.
- The construction phase of major projects that add substantial silt loads to rivers (e.g., sand extraction, roads, bridges, and dams) would also likely hinder Mahseer migration because Mahseer seek out clear water to hold during their upstream movements. Siltation in the tributaries would also have severe impacts on the survival of fish eggs and food availability for juveniles.

Research Question #2: When and where do Mahaseer spawn, and how far do they migrate?
Finding: In the Manas watershed, after they mature, Mahseer migrate up the MangdeChu and DangmeChu to an elevation of 800-1000 m, with indications that this is a yearly event. Figure 1 illustrates the river stretches from the border of Bhutan up to 1000 m elevation, showing the likely range of river stretches for all sizable waters in Bhutan to be used by migrating Mahseer. Tagged fish have been detected moving past our farthest receivers; i.e., past receivers at Berti and the DakpaiChu on the MangdeChu; past our receiver at the mouth of the Sherichu; up to our receiver at the KuriChu dam.

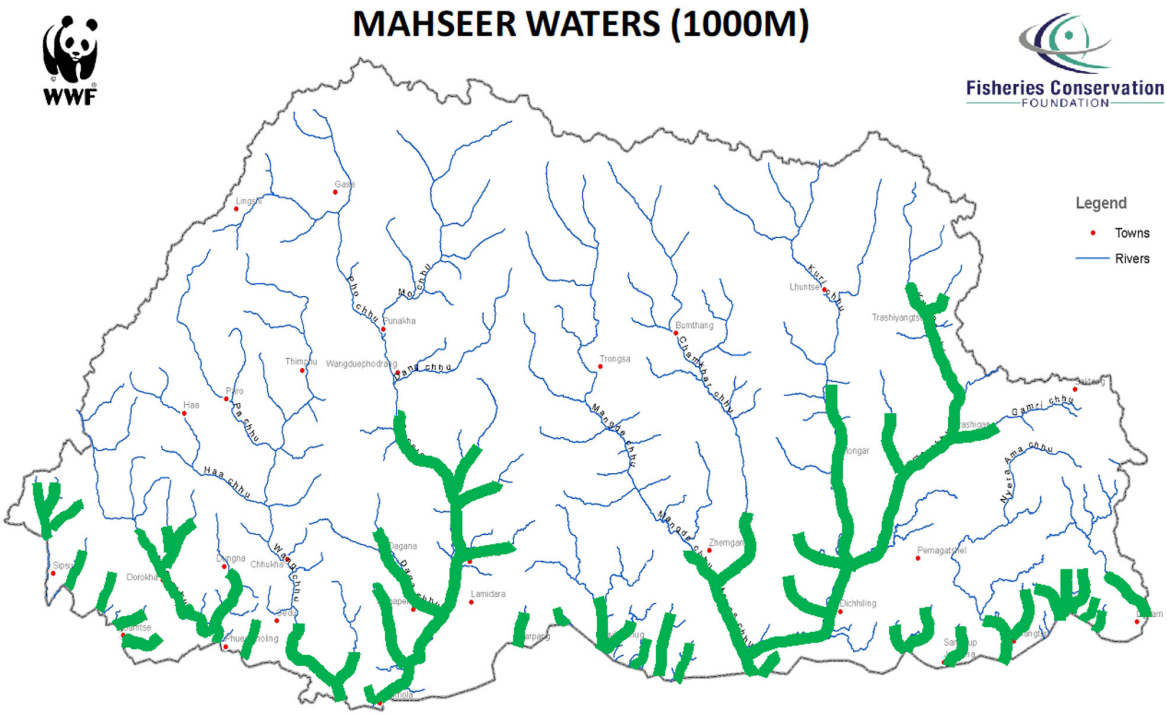

Figure 1. Mahseer Waters in Bhutan. The green areas indicate areas of rivers below 1000 m elevation, i.e., areas that likely support Mahseer populations.

Mahseer spawn in side tributaries of various sizes within the Manas watershed. As a result, some Mahseer migrate only a few miles to their spawning streams, whereas others migrate much farther, up to 100+ km upstream every year to spawn. Larger tributaries (e.g., ChamkharChu and KuriChu) may support some actual spawning, but more likely serve as a corridor for access to side tributaries that contain significant spawning habitat.

Approximately 60% of all tagged Mahseer in the study migrated up the DangmeChu and 40% migrated up the MangdeChu. Of those fish that migrated up the MangdeChu, approximately one-third left the MangdeChu and moved up one of its main tributaries, the ChamkharChu, most likely to spawn in smaller tributaries upstream from the confluence, indicating this is a key corridor for reproduction. Local villagers have confirmed observing Mahseer in these upper side tributaries of the ChamkharChu.

Implications:

- Barriers to passage at points lower (downstream) on the river system will undoubtedly have a greater impact on migrating fish than barriers located at higher elevations. Barriers positioned above 1000 m elevation would have little if any impact on Mahseer migration.
- The mouths of tributaries serve as key Mahseer habitat and are extremely important areas to protect from both alteration and illegal fishing activities.
- Barriers to migration that are located at the confluences of the larger tributaries (e.g., ChamkharChu and KuriChu) would have clear negative impacts because they would block migrations eliminating all of the spawning tributaries upstream from successful Mahseer production.
- When an adult Mahseer is prohibited from reaching its intended spawning tributary, how it responds is unknown. It could simply wait below that blockage every year, never reproducing successfully again; it could move to a near neighbor tributary and attempt to spawn there; or it might take a totally different path to try to find other good spawning habitat. Each of these potential scenarios has very different long-term consequences for Mahseer year class production. The fact that adult Mahseer still swim all the way to the KuriChu Dam (after 15 years of dam operations) indicate the first scenario may be the most likely.

Finding: Mahseer can spawn at any time during the monsoon season (June-September), but only if the main river and tributary reach appropriate water levels for spawning. If that level is reached multiple times, Mahseer may spawn there more than once in a single year. In the Manas system, there are two sub-populations of mahseer for each species; one group that consistently migrates up the DangmeChu to spawn, and the other that consistently migrates up the MangdeChu to spawn. No fish have been observed to switch rivers within a spawning season or among years. Abundance of juvenile Mahseer in the various tributaries is greatly skewed toward the smaller Chocolate Mahseer (maybe as high as 50-100:1 Chocolate:Golden Mahseer). Preliminary surveys for the occurrence of Mahseer juveniles in tributaries, however, has shown that Golden Mahseer juveniles are more difficult to sample using standard methods, and in some instances their presence was only confirmed using underwater video. Preliminary genetic analyses using NextGen sequencing of nuclear DNA (Drs. Michael and Marlis Douglas, University of Arkansas, personal communication) suggest that adult Mahseer return to their natal rivers to spawn. The fact that offspring remain for up to a year in the stream where they were spawned provides the necessary time during the appropriate life history stage for the needed imprinting to occur.

Implications:

- Together, the Sunkosh (PunatsangChu) and Manas (MangdeChu and DangmeChu, and their major tributaries) River systems represent a majority of the usable Mahseer waters in all of Bhutan. As a result, barriers to fish passage on these two systems have the potential for the greatest population level impacts.
- Mahseer appear to be river specific in their migrations, indicating that the subpopulations in these two systems have acquired behavioral and or physiological adaptations to each river. As a result, the use of hatchery stocking programs for mitigation would have quite damaging consequences for the behavior and the relative fitness of those populations.

- It is likely that adult Mahseer home back to their natal tributaries for spawning, which is supported by the genetic analysis. Imprinting mechanisms typically occur in juvenile fish while they grow in their natal tributaries. Because hatchery-reared fish are not raised in or exposed to the water of their natal streams, they would be absolutely unable to locate those home streams. It is unclear if or how hatchery-reared fish would find any tributaries suitable for spawning.
- Abundance differences between the two Mahseer species indicate that populations of Golden Mahseer are at a greater risk than populations of Chocolate Mahseer to be negatively impacted by barriers to their migration/spawning activities.

Research Question #3: How do Mahseer respond to high water during the monsoon season?

Finding: Adult Mahseer begin to move upstream in the major rivers before the water levels rise from the monsoonal rains. They seem to seek out temperature refuges in or near the mouth of tributaries, especially where there is clear water. We have yet to determine if they only stage at tributaries where they spawn or sometimes just hold at those areas before continuing upstream to their own spawning stream. Mahseer do not usually return downstream until the water levels drop after the monsoonal rains stop.

Implications:
- Hydropower or bridge construction phases that severely alter the hydrology of the river (e.g., river diversions, habitat alteration) could have negative impacts at the population level.
- Project construction activities on the banks that cause silt and larger debris to enter the river may also have substantial negative effects.

Research Question #4: Do Mahseer move into India, where they are potentially harvested?

Finding: Of the 107 tagged Mahseer, very few (n=6) have been found to swim into India during their post spawning migration downstream. Of the six Mahseer that did swim past our last receiver and into India, half were observed to return.

Implications:
- At least in the Manas System, few Mahseer venture into India for overwintering. This could be due to the large changes in habitat and water temperature as the river moves into India. It could also be due to harvest levels over time that eliminated the behavior of long distance migrators.
- Other river systems in Bhutan, however, may hold Mahseer populations that migrate in large numbers and/or farther into India, thereby putting them at greater risk of human-induced mortality as a result.

Final Statement: Compared to other countries, Bhutan may have one of the last healthy, pure wild populations of Golden Mahseer remaining in the world. The fact that we have not recaptured any of our tagged fish suggests that there are good numbers of Mahseer within the Manas population. There are, however, no historical data to determine if Mahseer numbers were once much higher. What is evident is that there are a number of pressures on the river ecosystems of Bhutan that can affect Mahseer migration, spawning, and juvenile survival, and if not managed carefully, these fish could become truly endangered.

1. Bhutan Ministry of Agriculture and Forests
2. Fisheries Conservation Foundation
3. World Wildlife Fund - Bhutan

Summary of IMC Session Themes

Session I: Biology of Mahser

This session explored topics on Mahseer taxonomy, life history, habitat needs, and population structure. Keynote speaker Adrian Pinder (Mahseer Trust) began this session with a taxonomic overview on what is currently known about the 16 species of Tor that have currently been described, although a number of new species descriptions are expected across the region. All species of Tor are listed as threatened, severely endangered, or as data deficient within their ranges. Because of the past patchwork approach by numbers of different people working on these fish over the years with little coordination, considerable taxonomic confusion exists with regard to the many Mahseer species across their range. Much of the confusion is attributable to the past use of old school morphometric and meristic characters. This confusion was viewed as a major impediment to Mahseer conservation efforts, with uninformed hatchery stocking programs being exposed as a major potential threat across the range and a major actual current threat in many parts of India. Although a suite of new, powerful genetic analyses are being applied for certain species in certain geographic areas, a coordinated range-wide project that systematically revisits the taxonomy and phylogenetic relationships among all of the species within this group of fishes was deemed critically important. Beyond species level taxonomy, the need for determining population structure and connectivity was shown to be important for protecting the true biodiversity of this group. In fact, preliminary comparisons of populations within Bhutan have indicated that there is high level of genetic diversity, with distinct differences detected among populations from different major river systems in the country.

Although the assessment of habitat needs for Mahseer, including flow, depth, and substrate composition have been studied to some extent in Pakistan, there was a general consensus that much work has yet to be done to understand both habitat and diet requirements for each life history stage. Several areas lacking solid information were identified, including larval and juvenile dispersal patterns, recruitment mechanisms, distribution and range, age of maturity and longevity, and migration patterns. Stakeholders must meet the challenges to address these knowledge gaps by executing appropriate and effective research studies. A major point within the session was that to conserve biodiversity, we must first understand it. Unfortunately, however, we are rapidly losing the ability to address our knowledge deficiencies regarding Mahseer biology because of the increasing population fragmentation from diversions, dams, and irrigation that impact flow regimes and continuity of rivers, as well as the impacts from pollution, invasive species, and unsustainable fishing practices, including unchecked illegal fishing. It became clear that the conservation of Mahseer into the future depends upon controlling human impacts, not only ones that are recognized as clearly detrimental such as dam construction, but also ones that are mistakenly recognized as helpful, such as stocking hatchery reared Mahseer to "bolster" natural populations, a practice that has been shown globally across many fish species to be quite harmful to the wild populations they are supposedly helping.

Session 2: Threats to Mahseer & Mitigation

This session explored the various threats that impact Mahseer populations, including hydropower, illegal fishing, exploitation, habitat degradation, and hatcheries/stocking. The opening Keynote speaker, Rajeev Raghavan (Kerala University of Fisheries and Ocean Studies), addressed the need to protect native populations of Mahseer and damage caused by the lack of scientific oversight of hatchery stocking programs. Existing stocking programs should be research-driven and based on ecological and genetic evidence. Most if not all countries need policies and guidelines for

the assessing the benefits of proposed hatchery supplementation of native stocks, because these efforts often do more harm than good and lack well-defined objectives or methods for evaluation.

There was an overall consensus among participants that hatcheries are not the answer for mitigating population declines due to hydropower or other avenues of habitat degradation. There was consensus that until National Fish Stocking Policies were developed and data regarding the genetic relationships among populations and species are understood, all hatchery-stocking programs should be put on hold.

Hydropower was identified as one of the greatest threats to the long-term viability of Mahseer populations, and it was agreed that there was essentially no reliable scientific information on how individual Mahseer will respond when migratory routes to their natal tributaries are blocked. Although fish passage is often put forward as a viable mitigating solution, serious biological challenges exist to developing a successful fish passage system, and so far, there is no fish passage system designed specifically to meet the needs for upstream and downstream migrations of Mahseer. Even though fish ladders are being planned and even some already implemented, little work has been done to determine if they actually work or not. Furthermore, all efforts have focused on upstream migration, with downstream passage being often ignored; not a viable approach for fish that are iteroparous. Speakers agreed there was a need to establish transparent collaborative relationships to address fish passage for Himalayan species. Using the new technology of detecting species via Environmental DNA (E-DNA), there is great potential for measuring the status or decline of Mahseer populations. Identifying critical Mahseer spawning and/or nursery areas using E-DNA could assist in the site placement for hydropower projects, especially in identifying key spawning sites that should be protected.

Environmental flow (e-flow) assessment work was also presented. Interpreting the results and then applying the results to species-wide conservation efforts is complicated because multiple habitats are used by the various different life history stages and in their migration routes. Work has been underway to develop a habitat suitability curve that can assist in protecting Mahseer in future hydropower planning. It was also made clear that the linkage of forest ecology to river biodiversity is important in understanding Mahseer habitat needs. Ignoring these linkages poses a threat to healthy fish populations and undermines progressive conservation efforts.

The closing keynote talk was presented by Leanne Alonso (International Finance Corporation), who discussed the benefits and complications of using a holistic approach for sustainable river management alongside hydropower projects. If wild Mahseer populations are to survive in the face of these growing threats, we must directly communicate our scientific findings and actionable recommendations to policy-makers. Together, the lack of biological understanding and the paucity of human capital needed to generate that understanding, represent the big picture issues needed to be solved for Mahseer conservation to succeed across the region.

Session 3: Conservation of Mahseer and River Ecosystems

This session explored the topics associated with biodiversity, ecosystem connectivity, education, and policy. The opening keynote speaker, Stuart Orr (WWF International), outlined the difficulties in uncovering the hidden values derived from freshwater systems. He stressed the need to collect data on the value of our rivers and to communicate this value to a wider audience, thereby forwarding an agenda promoting the protection of both river and water quality. Rather than taking a people versus nature approach, conservation professionals need to educate stakeholders on the associated risks and costs to societies and economies when river ecosystems are severely damaged. These ideals reoccurred throughout this session along with recognizing the need to link our conserva-

tion agendas with human needs and then to look for solutions that address both. Although research programs are exploring the aquatic biodiversity in key hotspots, it was agreed that we are losing freshwater wildlife before they are even described.

It was reiterated that there are many serious threats beyond hydropower, such as sand mining, land development, and deforestation that are not often recognized as having long-term consequences on rivers and streams. These impacts, coupled with the lack of understanding of food webs and ecosystem function, could be severely negatively impacting aquatic life and the human communities that rely on fish for food and income.

Many different types of programs have had successes in developing solutions to addressing the protection of freshwater biodiversity. Training and hiring locals to collect data and patrol areas have reduced illegal fishing activities. Community-based approaches with conservation zones, small no fishing reserves, and even a Mahseer National Park were shown to have positive impacts for protecting Mahseer and river biodiversity in general. This session closed with keynote speaker Arjan Berkhuysen (World Fish Migration Foundation) who talked about World Fish Migration Day and the foundation's efforts to promote the importance of migratory fish with a "source to sea" approach for conservation. The success of this bi-annual campaign is growing and has become a key education event for the public and stakeholders to learn about the threats facing Mahseer and other migratory fish. One of the clear take home messages from this session was that fisheries scientists need to take a larger role in communicating the importance of rivers, fish, and Mahseer to the public.

Session 4: Management & Recreational Fishing

The final session of the International Mahseer Conference focused on management and recreational fishing. Steve Cooke (Carleton University) opened this session with his keynote presentation on the significant social, cultural, and economic values that recreational fisheries generate. Many presenters stressed that Mahseer are a highly valued species among anglers around the world, and that interest in angling could and should generate interest in conservation as well as the funds to support it. It was also stressed that high-end recreational anglers are unlikely to be interested in fishing for Mahseer in a population into which hatchery-raised Mahseer are being stocked or even have been stocked in the past. A successful fisheries management program should have a science-based approach that emphasizes and demands the use of sustainable practices, such as catch-and-release only, best handling practices, controlled angling pressure, as well as a permitting process that reflects the high value of Mahseer. A model recreational fishing program for Bhutan was presented that illustrated a potential revenue generation system that included money for conservation and for community betterment, as well as for initiating sampling programs for monitoring the fished populations.

As was stressed in other sessions, effective conservation comes from involving the community. Community-based conservation is the best way to instill a conservation ethic among native peoples by showing them the value of a healthy river. Recreational community-based angling programs for responsible, licensed hook-and-line fishing provide an income alternative that can reduce illegal fishing. In addition, these programs can increase enforcement and educate locals on the importance of conserving Mahseer, i.e., demonstrating that a live fish is more valuable to the community that a dead one. The concept of establishing Native Fish Conservation Areas (NFCA) with a watershed-scale approach that involved all stake-holders, including communities, has been shown elsewhere in the world to be a successful approach for both recreational fisheries and protection of native fish biodiversity. Although well-managed recreational fisheries were shown to be able to meet both the economic needs of the community and biological needs of conservation, it was also stated that they need to be well-designed and planned for long-term health of Mahseer populations over short-term economic gains.

Synopses of Roundtable Discussions

THREATS TO MAHSEER AND POTENTIAL MITIGATION OPTIONS

Facilitators: Rajeev Raghavan (KUFOS) and Jigme Tsuendrup (WWF) + 14 Participants

Charge: List the major threats to Mahseer in Bhutan and the region.
Assess the relative levels of each threat.
Identify potential mitigation options for each priority threat.
Identify the pros and cons of each potential mitigation option.
Develop a set of recommended actions for Bhutan and for the Region.

Overarching Issues:

- General biological information concerning Mahseer (e.g., taxonomy, physiology, life history, population status, etc.) is extraordinarily lacking across Bhutan and the region.
- There is also a pervasive lack of understanding with regard to incorporating general ecological and evolutionary principles into the management and conservation of wild populations of fish, rather than using agricultural and husbandry approaches.
- A lack of awareness is apparent across the region not only among the lay public but society in general, to include the government, including those responsible for conserving natural resources, with the result that Mahseer populations (and large river ecosystems in general) are threatened by environmental degradation.

With some notable exceptions such as Bhutan, the region lacks not only governmental protection for the environment, but also recognition of the need to do so.

Threats to Mahseer (and levels of those threats) in Bhutan and the Region:

1. **Blocking Fish Passage (via hydroelectric projects):** Dams that cut off upstream migration of Mahseer to spawning tributaries could seriously decrease reproductive success, leading to a reduction in annual recruitment and possible extirpation of local populations. [Threat is high in Bhutan and across the region].
2. **Habitat Loss (due to human development but excluding hydropower):** Serious threats to not only Mahseer, but also to large river ecosystems in general are posed by the following: Increased sedimentation via road and bridge construction, sand and boulder mining, rock crushing, removal of riparian vegetation, water diversions (to include irrigation), and encroachment by farms and villages. [Threat is low/medium in Bhutan, high across the region].
3. **Overfishing (either illegal as in Bhutan or legalized overfishing across the region):** Increased harvest, especially with destructive methods such as poisons, explosives, electricity, etc., has greatly reduced number and sizes of adult Mahseer across the entire range. The end result is that many populations are critically endangered, or even extirpated. [Threat is medium/high in Bhutan, high across the region].
4. **Irresponsible Stocking of Hatchery-Reared Fish**: Across the region, there is a failure by government institutions to apply basic genetic, evolutionary, and ecological principles to fisheries management and aquaculture. Instead, hatchery-reared fish are stocked into the wild native populations. Unfortunately, this practice is, and will continue to be widespread, resulting in long-term damage to wild Mahseer populations, to include extirpation of entire species.

When hatchery-produced fish are introduced into a wild population, the wild population is exposed to the following genetic, ecological, and demographic risks.

Genetic Risks:

A. Domestication Selection:

The unintentional selection for traits that are advantageous in a hatchery environment, but are a detriment in the wild is pervasive in hatcheries.. Interbreeding between hatchery-produced and wild fish produces offspring that lack necessary adaptations to the natural environment.

B. Inbreeding Depression:

All too often the effective number of adults (the broodstock) is small in hatchery breeding programs, resulting in huge numbers of very closely related juveniles being released into the wild. If these fish mature and spawn together in the wild, their offspring will suffer from inbreeding depression, i.e., decreased fitness that results from the unmasking of deleterious recessive genes. This is compounded if broodstock arise from fish produced in the hatchery, rather than from wild spawned individuals.

C. Outbreeding Depression:

In the wild, different populations of a species diverge through natural section, becoming adapted to their local environments. When these populations are mixed in the hatchery by cross-breeding parents from different populations, the resulting offspring suffer from outbreeding depression, i.e., decreased local adaptation and fitness in the local population, thereby increasing its vulnerability to various impacts and to potential extinction."

Ecological Risks:

A. Competition:

Juvenile hatchery fish stocked in the wild will compete for resources and space with naturally produced juveniles, resulting in elevated mortality among wild juveniles. Such competition could be particularly acute when the abundance of hatchery fish is disproportionately large compared to the abundance of the natural population.

B. Predation:

As is often the case in hatchery feeding programs, hatchery-produced juveniles are larger than naturally spawned fish. This promotes elevated predation by stocked fish on wild individuals.

C. Disease:

Transmission of diseases between species or populations in a hatchery also promotes its introduction and/or spread of in wild populations, and this can have disastrous consequences.

Demographic Risks:

A. Survival:

When naturally spawned fish compete with or are predated on by hatchery fish, their survival decreases, often substantially. As a result, the hatchery stocked fish fail to augment the year-class of wild fish. Instead, wild spawned fish are replaced by hatchery produced ones. Thus the stocking of hatchery produced Golden Mahseer into a wild year-class will result in a cost to the population rather than a benefit.

B. Reproductive Success:
The mating strategy of hatchery fish differs greatly from that of wild fish. The latter select breeding partners based on a complex set of mate preference traits. In hatcheries, however, spawning pairs are chosen by humans. When hatchery fish reproduce in the wild (among themselves or with wild individuals) their offspring often have lower fitness than wild offspring, and will suffer from some combination of inbreeding depression, outbreeding depression, or domestication. As a result, the inherent fitness of the wild population decreases.

Although supplemental stocking programs are assumed to increase the abundance of wild populations, they instead do just the opposite. In fact, the number of documented instances where supplemental stocking has increased natural reproduction levels is extremely low, even non-existent. [Threat is medium/high in Bhutan, high across the region].

5. **Introduction of Non-native Species**: Again, a lack of understanding with regard to Mahseer taxonomy and the impacts that result from introducing non-native species is apparent within the fisheries management/aquaculture community. As a result, the stocking of fish outside their native ranges is threatening native Mahseer species with extirpation. [Threat is medium/high in Bhutan, high across the region].
6. **Climate Change**: A series of negative impacts are being forced onto many aquatic species across the globe due to ongoing climate change, and Mahseer are no exception. In fact, their life histories are more susceptible to the predicted impacts of climate change, in that they rely on a seasonal and glacial melt-driven monsoonal hydrograph for reproduction. [Threat (long-term) is high in Bhutan and across the region].
7. **Poor Management Through Ineffective Governance**: Unfortunately, the management of aquatic species falls short of what is needed in Bhutan and across the region, the management of aquatic species falls woefully short of what is needed. Natural resource management agencies lack the both the appropriate levels of concern (and urgency) that is needed to combat climate change. They also lack knowledge of ecological principles and examples of failed management approaches to managing migratory fish and river systems from across the world. This issue stems both from a systemic shortage of talent and as well as an ineffective institutional structure. [Threat is medium in Bhutan, high across the region].

Possible Mitigation/Corrective Options:

1. Blocking Fish Passage (via hydroelectric projects) – Mitigation Options:

a. The first option usually considered for Mahseer in Bhutan (and across the region) is to build hatcheries that provide juvenile Mahseer to promote reproduction lost due to the loss of adult migration to spawning tributaries. It seems intuitive that by simply stocking more artificially produced juveniles into a wild population, more mature adults will emerge in the river. That logic, however, assumes that the artificially produced hatchery fish are equal in all respects to those naturally spawned fish, even though by definition they are not. In the wild, individuals that survive are the product of natural adaptations to a specific environment. Alternatively, in a hatchery, individuals easily survive because they are reared in a non-competitive environment, without a need to forage for food, so mortality rates drop. When hatchery-produced fish are introduced into a wild population, the wild population is exposed to the various genetic, ecological, and demographic risks outlined above. There is a growing body of scientific literature that documents the general failure of a hatchery-based management approach, and the negative impacts it has had on an array of wild fish species. [This is a terrible option, everywhere].

b. A second option to build fish passages has been attempted for several dams that impact Mahseer populations. Unfortunately, these fish passages are designed for Atlantic Salmon, a fish that jumps over small barriers. Mahseer do not do so, but instead, power swim past them. Thus, fish passages

fail. In addition, run-of-the-river dams - currently under construction in Bhutan (e.g., PHP I, PHP II, and MHP) block such a long passage (10-20km), that fish passage structures are technically impossible. [This option is unworkable until proper technology is developed].

c. The third and only viable option to date is alternative design (i.e., no run-of-the-river dams) coupled with alternative locations (e.g., for Bhutan, construction at elevations above 1000 m, the upper limit of the Mahseer range). [This option is reasonable, but must be applied very early in the planning process].

2. Habitat Loss (via human development activities that exclude hydropower):

a. Again, the first option that usually comes up for consideration across the region is to build hatcheries. [This is a terrible option at any location].
b. The only legitimate option is to develop ecologically sound regulations (e.g., effective setback minimums for road building, gravel crushing, cattle grazing, etc.), as well as an effective enforcement mechanism to guarantee compliance. [This option requires both governmental will and societal acceptance and is a justification for developing community-based conservation programs in Bhutan and the region].

3. Overfishing:

a. Again, the first option for consideration across the region is to build hatcheries. [Again, this is a terrible option at any location].
b. The only legitimate option is to develop a set of fishing regulations that promote a sustainable fishery. To succeed, an effective enforcement mechanism must be in place to guarantee compliance. Given the de-centralized nature of fishing (legal and illegal) in rural areas, the best option is to develop a community-based conservation program, wherein local communities police themselves. [Again, this requires both governmental will and societal acceptance].

4. Irresponsible Stocking of Hatchery-Reared Fish:

a. Every jurisdiction in the region (much less across the globe) must develop and apply a National Fish Stocking Policy (i.e., a decision-tree that determines whether a proposed stocking is justified, i.e., with benefits that clearly outweigh short- and long-term costs). [This option is easy to develop and implement – but requires government action].
b. Fish Hatchery Culture Guidelines must list the technical methodologies necessary so as to avoid genetic, ecological, and demographic threats outlined previously (e.g., number of brood stock used, use of single-pair matings, equal family sizes, etc.). [This option is also easy to develop, although implementation may require logistics that affect the cost-benefit ratio – this also takes government implementation and funding].

5. Introduction of Non-native Species:

a. Every jurisdiction in the region (much less across the globe) must develop (and demand application of) a National Fish Stocking Policy (i.e., a decision-tree that determines if a proposed stocking is justified (i.e., benefits clearly outweigh short- and long-term costs). The success of this Policy depends upon the accuracy of taxonomic descriptions that, for the Mahseer, are not very robust at all. Again, there is a large body of scientific literature on the damaging effects of introduced non-native species. [This option is easy to develop and implement but requires government action].
b. Culture programs that pass the National Fish Stocking Policy decision-tree must also meet a set of Fish Hatchery Culture Guidelines. These describe technical standards necessary to avoid the genetic, ecological, and demographic threats previously outlined (e.g., manipulations to produce sterile individuals and/or containment regulations). [This option is easy to develop, although implementation may require logistics that may affect the cost-benefit ratio of the proposed activity – again, requiring government action and funding].

6. Climate Change:

Unfortunately, few mitigation options are available with regard to climate change for fisheries management jurisdictions across the region. In addition, deflecting the climate change trajectory at a global scale will require societal action. Research might provide insights as to what might be needed to mitigated in the short-term, particularly with regard to water temperature, dissolved oxygen, water chemistry, flow volumes, etc. [This option is critical but requires government commitment and funding].

7. Poor Management Through Ineffective Governance:

a. The first option to improve the management of aquatic systems is to promote human capacity, which can be done by emphasizing the education, training, and hiring of aquatic scientists. A serious lack of highly qualified individuals is apparent in Bhutan and across the region. Here, governments must invest in the future of their rivers by building human capital in this area. [This option is critical and straightforward, but requires government commitment and funding].
b. The second option is to develop a better organizational structure within the government (or any group involved with natural resource management) so as to improve the management of aquatic systems. Often, management responsibilities are spread across multiple entities that, in many cases, do not communicate among themselves, or worse, compete against one another. In both cases the resource (and the personnel) suffer. [This option is critical and straightforward. It should go hand-in-hand with that immediately above, with government commitment and funding required].

Recommendations for Bhutan and the Region:

1. Develop a National Fish Stocking Policy (NFSP) and Hatchery Culture Guidelines (HCG), to include regulations that eliminate the introduction of non-native species by the general public. This would also include religious reasons.

2. Suspend all current hatchery culture and stocking programs pending review, i.e., until proposals can be justified according to format/requirements outlined in the NFSP document.
3. Prohibit new hatchery culture and stocking programs, until proposals can be justified according to format/requirements outlined in the NFSP document.
4. Develop appropriate fish passage technology that actually works for Mahseer, then install them during future dam construction, or retrofit dams currently operating.
5. Develop a planning system for hydroelectric projects that demands legitimate Environmental Impact Statements (EIS) to assess alternative locations and construction options.
6. Review and modify (if needed) the regulations and permit application processes that govern location, construction, and operations of environmentally negative actions (e.g., rock crushing, sand mining, gravel mining, road construction, etc.). Review existing operations to assess compliance.
7. Develop and implement effective community-based conservation programs. To be effective, these would require a high-end catch and release fishing program that generates substantial revenues for both a Community Action Fund and a Mahseer Conservation Fund. This activity should be combined with a national education/outreach program to serve as explanation for these actions.
8. Develop a plan to predict impending impacts of climate change to large river ecosystems, and initiate research to fill critical information gaps.
9. Develop a review of the government institutions that collectively have responsibility for Mahseer management and conservation. Design the best (new) organizational arrangement(s) to maximize efficiency and effectiveness.

NATIONAL FISH STOCKING POLICY AND HATCHERY CULTURE GUIDELINES

Facilitators: Michael E. Douglas (Univ. Arkansas) & Singye Tshering (MoAF)
+10 Participants

Charge

1. Describe the issues involved with Stocking and Hatcheries;
2. Define the various types of fish stocking activities and their objectives;
3. Outline a plan for developing a National Fish Stocking Policy;
4. Outline a plan for establishing guidelines for Hatchery Culture;
5. Provide a recommended strategy for action.

Background

When fish populations decline, one strategy most often proposed as mitigation is to build a fish hatchery as a means of supplementing the wild population(s). Although such a strategy is benign in its premise, its implementation has produced many negative and permanent ecological repercussions as a result. This is particularly true with regard to Asian rivers, where Golden Mahseer is a specific example. In Bhutan, hatchery-reared Golden Mahseer is proposed as a potential tool to either restore or supplement populations negatively impacted by hydropower and other riverine disturbances

The long-term objective of artificial stocking is to augment (or renew) the natural population with the ultimate goal of increasing or re-establishing the number of adults. This premise assumes, however, that fish artificially produced in a hatchery are equal in all respects to those naturally spawned. This premise has been proven again and again to be false. In the natural environment, adults that survive have done so by successfully evolving adaptations to their environment. These, in turn, are then passed on to their progeny.

Alternatively, in a hatchery environment where mortality rates are low, maladapted individuals survive easily because they are reared in a non-competitive environment where abundant food is available and competition is minimized. Reproduction itself is accomplished artificially by expressing gametes from adults selected by humans a priori in a raceway. As a result of this artificial propagation, deleterious mutations are not only retained in the hatchery population, but subsequently passed along via stocking or augmentation to natural populations.

Consequently, when hatchery-produced fish are introduced into a wild population, a variety of non-exclusive ecological, demographic, and genetic consequences emerge. We list several of these below:

A. Ecological Risks:

1. Accelerated Competition:

Juvenile hatchery fish will compete with naturally produced juveniles for finite food resources and limited space. This, in turn, will promote elevated mortality rates among wild juveniles, which is particularly acute when hatchery fish are stocked in numbers disproportionately large when compared to those of the natural population.

2. Elevated Predation:

As a result of supplemental feeding programs in the hatchery, the supplemented juveniles will often be much larger than naturally spawned fish. This produces a disadvantage for the natives in that they will be easily selected as targets for predation given their smaller size. This will obviously diminish the survival rate of naturally spawned juveniles.

3. Disease:

The introduction and/or spread of diseases from hatchery to wild populations is a common occurrence that can have disastrous consequences. This is because hatchery fish have been reared in an environment where close association is promoted and thus contagion is optimized. These fish have often developed a level of resistance to these issues that is not present in the natural environment, and which predisposes native fishes to extermination.

B. Demographic Issues:

1. Low Survival:

When there are competition and/or predation issues promoted by hatchery fish, the end result is a decrease in the numbers of naturally spawned fish (in some cases substantial numbers). As a result, the year-class of wild fish fails to be augmented with hatchery-produced fish, but instead is simply replaced by wild spawned fish. The end-result? Stocking of hatchery-produced Golden Mahseer into a year-class will result in a demographic cost to the population, rather than a benefit.

2. Diminished Reproductive Success:

Wild fish select breeding partners based on a complex set of mate-preference traits. In hatcheries, spawning pairs are chosen by humans. Offspring of hatchery fish that reproduce in the wild often have lower fitness than naturally occurring wild offspring. They consequently suffer from some combination of inbreeding or outbreeding depression, or selection for domesticated traits provided in the hatchery. As a result, they depress the fitness of the wild population by producing offspring that are markedly suboptimal, when compared to those produced by natural populations.

C. Genetic Problems:

1. Domestication:

This results from the unintentional selection of traits that are advantageous in a hatchery environment, but detriment in the wild. Being habituated to the presence of humans is one aspect. Other examples include the evolution of smaller fins, smaller and more numerous eggs, and loss of predator avoidance behaviors, all traits that are deleterious in the wild. These deleterious adaptations will be retained in the next generation by the interbreeding of hatchery and wild fish.

2. Inbreeding Depression:

The effective number of adults used for breeding in a hatchery (i.e., the broodstock) is often small, yet with large numbers of siblings being produced in the hatchery, and ultimately released into the wild. When these fish spawn together in the wild, their offspring suffer inbreeding depression, i.e., a decrease in fitness that results from the positive assortment of deleterious recessive genes. This is compounded when hatcheries use self-contained broodstock rather than wild-spawned individuals.

A Synthesis:

Results from the Golden Mahseer telemetry study, coupled with ongoing genomic analyses, indicate that Mahseer seemingly return annually to spawn in their natal streams. This life history characteristic (common among migratory fish such as Salmon) requires that Mahseer imprint on these streams as they develop into juveniles. At some point in their life history, they then migrate down from the smaller spawning tributaries into larger streams, eventually into mainstem rivers. Mahseer produced in a hatchery do not have the opportunity to imprint on a natural stream, much less the one within which their parents reproduced. Once hatchery-reared fish are released into the wild, their eventual spawning behavior is open to conjecture, to include not spawning at all given a dearth of reproductive cues that originated in a hatchery environment. If they do spawn, it would almost certainly be in a stream with environmental characteristics for which they are not adapted. If spawning were successful, their maladapted genes would be introduced into the resident natural population, and the resulting offspring would most assuredly depress the fitness of that population.

Although supplemental stocking seems like an easy solution to a complex problem, voluminous data from numerous studies suggest the outcome is just the opposite. For example, studies that demonstrate an increase in natural reproduction due to supplemental stocking are remarkably few. More often, a decrease in the fitness of local populations is documented, but in some cases an entire species is lost due to inappropriate and human-induced hybridization events. More specifically, numerous scientific references document the occurrence of these negative outcomes in populations of Mahseer within India.

Conclusions from the Roundtable Discussion on Hatcheries:

A. Overview

1. Individuals or groups should not be blamed for previous stocking activities. These were administered before the negative aspects of hatchery-implemented stocking were widely known.
2. Any proposal for new stocking activity should be initially DECLINED. Subsequent justification must demonstrate that it meets the new criteria. It will then be subjected to scientific peer review by a multi-disciplinary panel.
3. Any proposed stocking decisions/actions must follow IUCN Guidelines for "Reintroductions and other Conservation Translocations. <https://portals.iucn.org/library/efiles/documents/2013-009.pdf>

B. Potential Fish Stocking Categories and Their Proposed Objectives

1. **Conservation:** To protect fish populations or entire species by increasing the number of adults in the waterbody. This is aimed (erroneously) at augmenting natural recruitment and promoting the reproduction and survival of the species.
2. **Food:** To increase the abundance of fish harvestable for food. This would be accomplished by simply increasing the number of fish in a waterbody without the expectation of reproduction.
3. **Recreation:** To increase the number of fish available for recreational fishing. This would involve a "catch-and-harvest," or more appropriately, "catch-and-release" scenario.
4. **Aesthetics:** To add fish to a waterbody simply for human viewing pleasure, or as a means to remove pest organism (e.g., algae, aquatic vegetation).
5. **Religion:** To release fish into the wild as potential means of gaining religious favor.

Components of a National Fish Stocking Policy

1. A formal proposal process must be implemented for any new stocking activity (ongoing or proposed). This must include the following information:
   a. Objective of the stocking.
   b. Details on the location of the stocking, complete with a site assessment.
   c. Which population will be used for stocking (e.g., species/ source).
   d. Methodologies employed (e.g., numbers/ sizes/ dates/ locations/ etc.).
   e. Proposed benefits.
   f. Potential negative aspects.
   g. Alternatives to stocking.

2. A decision tree must be provided that would assess whether or not the rationale for stocking is justified. Separate criteria will be employed to evaluate native versus non-native stocking proposals.

3. A mechanism for monitoring and evaluation must be provided so as to determine:
   a. Success in meeting objectives (above), as well as a cost diagnosis;
   b. Conservation impacts of the proposed stocking.

A Methodology for Hatchery Culture Guidelines

1. The committee that develops a National Fish Stocking Policy should also be charged with developing a Hatchery Culture Guidelines document.
2. This document would employ a framework similar to that already developed for Pacific Salmon.
3. The guidelines would include details on how to minimize the numerous hatchery issues previously acknowledged above (e.g., ecological, genetic, and demographic). It should be drafted so as to highlight the conservation issues and logistical constraints currently facing Bhutan.

Recommended Strategy

1. The Ministry of Agriculture and Forestry (MoAF) should immediately convene a scientific committee to guide the process of developing a National Fish Stocky Policy. This committee should include outside fisheries management and conservation genomic experts, as well as hatchery personnel from the National Research Center for Riverine and Lake Fisheries (NRCRLF; Haa) and the National Research and Development Center for Aquaculture (NR&DCA; Gelephu).
2. The committee should actively develop a formal National Fish Stocking Policy that would include the components listed above, as well as develop a set of Hatchery Culture Guidelines.
3. All stocking activities (both ongoing and proposed) would be reviewed. A proposal (as outlined above) must be submitted to the committee for evaluation with regards to a decision tree process. Only accepted proposals would be considered for potential stocking activity.

ESTABLISHING/ENHANCING COMMUNITY-BASED CONSERVATION

Facilitators: Steven Cooke (Carleton U) and Sonam Choden (WWF) + 17 Participants

Charge:
1. Define Community-Based Conservation (CBC) and identify benefits;
2. Describe the overall issue for Bhutan and the region and the need for CBC;
3. List ongoing and potential CBC opportunities for Mahseer and large rivers in general;
4. Recommend a strategy for implementing priority opportunities for Bhutan and the region.

Definition: Community-Based Conservation (CBC) in the context of the IMC is defined as a programmatic concept for the management and conservation of natural resources wherein governments work with reside local communities to devise and implement sustainable resource usage that provide not only protection for Mahseer (and large river ecosystems in general), but also benefits to the livelihoods of the local residents and their communities. Definition: Community-Based Conservation (CBC) in the context of the IMC is defined as a programmatic concept for the management and conservation of natural resources wherein governments work with reside local communities to devise and implement sustainable resource usage that provide not only protection for Mahseer (and large river ecosystems in general), but also benefits to the livelihoods of the local residents and their communities.

Benefits:
1. Economic improvement. Encourages the development of revenue-generating alternatives to direct harvest and consumption as well as establish a system of governance that transparently and equitably distributes those revenues for positive gains.
2. Ecosystem stability. Provides resource security over the long-term for local communities.
3. Social benefits. These include improved community facilities, services, and upstream/downstream interactions; enhanced local political involvement; expanded local entrepreneurial opportunities; improved education through program-driven outreach efforts that focus on healthy Mahseer populations and the value of healthy rivers.

Issue:
Illegal fishing was identified by the IMC as the most significant short-term threat to native Mahseer populations in Bhutan, and a significant threat across the entire region. As such, it is composed of two types. The first is illegal sustenance fishing by local residents using gill nets, cast nets, static hook and line rigs, baskets, weirs, electricity, explosives and even chemical poisons. Physical evidence coupled with discussions with local residents strongly suggests these activities are rampant throughout the southern Bhutan and represent a substantial source of mortality. This is likely fueled by the myth that many, if not all Mahseer in Bhutan migrate during winter downstream into India,

where they are harvested in huge numbers and sold back to Bhutanese as food. That myth is used to justify illegal harvest of Mahseer in Bhutan. Why allow India to harvest Bhutanese fish then be forced to purchase them for food when Bhutanese can harvest them instead and retain the money?

The second type of illegal fishing is uncontrolled and unmonitored recreational fishing wherein local and/or foreign anglers are granted permits to fish for trout in waters of southern Bhutan where no trout exist. Fishing for Mahseer is illegal yet these anglers use trout permits to target both Golden and Chocolate Mahseer. This negatively impacts Mahseer reproduction.

Need:
Bhutan must develop a Community-Based Conservation ethic and culture of stewardship, wherein residents along the rivers, and indeed throughout the country, understand the value of healthy fish populations to not only the river/stream ecosystems, but for the whole of society. That understanding should be facilitated by the fact that the Golden Mahseer is the Sernya, one of the eight auspicious symbols of Buddhism. People must understand that a live fish in the river is worth more to society one served for dinner.

Potential CBC Opportunities:

1. Develop alternative livelihoods based around eco-tourism as a non-consumptive use of the fish in the river. This can be done by developing recreational fishing, birding, kayaking/rafting, local cultural interchange, home-stays, camping, and restaurants.
2. Employ additional protein production via aquaponics, aquaculture, other traditional farming.
3. Improved opportunities for micro-financing and private sector investment.

Recommended Strategy for Action: The following are the priority strategies proposed by participants to address the three opportunities listed above:

1. **Alternative livelihoods**: Generate a Recreational Fishing Program for Mahseer that is non-consumptive (i.e., totally catch-and-release and, therefore, sustainable). It would have effective and transparent mechanisms to generate revenues that enhance the livelihoods of the local residents and ensure the conservation of Mahseer for future generations. Such a fishery could easily also facilitate additional recreational/ecotourism activities that would generate more revenues for the local communities. This would also improve employment opportunities and help to curb rural-to-urban migration of residents. [See Roundtable Discussion #6 for additional discussion].

2. **Additional protein production:** This approach should be coordinated by MoAF, and should include some combination of intensive aquaculture or aquaponics using native species as a substitute for domesticated animal protein.

3. Because both 1 and 2 above will increase the potential for entrepreneurial opportunities in the areas of southern Bhutan where Mahseer are located, it will be important promote those opportunities for local residents rather than established businesses in Thimphu or elsewhere.

4. A nationwide outreach/education program that explains the need for change. The CBC plan must be developed and delivered to impacted communities, as well as across Bhutan. It must include the involvement of local leaders (including religious institutions) so as to fulfill outreach activities.

Challenges that must be considered:

1. Developing laws and regulations related to recreational fishing:
   - Create new policies and regulations related to Mahseer/capture fisheries.
   - Review enforcement of current/future laws, regulations, and penalties.
   - Promote community-based enforcement and river patrolling strategies.
   - Educate the public on the new process and why it is important.

2. Establishing community-based governance mechanisms:
   - Create transparent and fair financial management institutions.
   - Develop an effective community-based project decision-making mechanism.

3. Delivering public education and outreach programs on large rivers and endangered species.
4. Ensuring that monitoring/assessment/compliance are community-based.
5. Promoting an integrated approach with regional/global partnerships.
6. Fostering an effective and strategic Environmental Assessment and Planning process.
7. Providing ongoing resource valuation, cash flow, and benefit analysis.
8. Building capacity to deliver on the ground habitat conservation.
9. Evaluating programmatic impacts on the resource and the communities involved.

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BUILDING A RESEARCH AGENDA FOR BHUTAN AND THE REGION

Facilitators: Marlis Douglas (U Arkansas) and Kesang Wangchuk (MoAF) + 14 Participants

Charge:

1. List the key research topics to advance Mahseer management and conservation.
2. Identify information needed to better manage and conserve Mahseer.
3. Prioritize these needs for Bhutan and for the region.
4. Propose a five-year research agenda for Bhutan to address each key information need.
5. Provide a five-year research agenda for the region that addresses each key need.

General Principles:

1. Although some information needs require applied approaches, their feasibility rests upon the ecology and evolution of the species. These data for Mahseer are unavailable across the region.
2. Because applied questions are often complex, an interdisciplinary approach is required. Collaborative efforts that bring together researchers with different interests and expertise are often the most cost-effective means to address these needs.
3. Communication among disciplines and stakeholders (e.g., the IMC) is essential to quickly advance the agenda. Communication not only includes activities such as conferences and symposia, but also the development of a centralized and coordinated database that is freely shared and accessible by researchers.
4. Building capacity across all of Asia is sorely needed, and every effort must be made to help build local knowledge and technical expertise.
5. Research, like management, must be adaptive in nature, i.e., scientists must be willing to modify approaches and protocols as new information becomes available. This requires flexibility with regards to policy, strategic planning and implementation.

Threats to Mahseer in Bhutan and the Region (non-prioritized and taken from RT #1 Results):

1. Over-fishing, both legal (regional) and illegal (Bhutan).
2. Blocking fish passage via hydroelectric projects.
3. Loss and fragmentation of habitat due to anthropogenic activities.
4. A lack of basic data on life history and ecology.
5. Indiscriminate and unregulated stocking of hatchery-reared fish
6. Introduction of non-native species.
7. Climate change impacts.
8. Ineffective management and governance.

Prioritized Information Needs for Bhutan and the Region (excluding General Biology):

1. How much illegal fishing is occurring, where does it occur, who is responsible, and how best can it be reduced if not eliminated?
2. What are the basic habitat needs for reproduction and early life history of Mahseer? Are these habitats interconnected to allow movement among them? How does anthropogenic activities (including hydro-power dam construction) impact these habitats?
3. What factors [e.g., dam location and type (i.e., run-of-the-river versus traditional reservoir dam), duration of construction] contribute to the impacts of hydropower on fish passage? How best can those impacts be mitigated?
4. How do other anthropogenic developments (e.g., sand mining, sedimentation from road/bridge construction, pollution from communities and industry) impact Mahseer? How best can these be mitigated?

5. What fish are cultured in hatcheries within Bhutan and the region? Where (and why) are they stocked? How does this impact native populations and species? What guidelines should be developed? What is the level of genetic variation within and among Mahseer species? Do we understand the correct taxonomy?
6. Which non-native species are being introduced, why, and what are their impacts on Mahseer? How best to eliminate introductions?
7. At what level will climate change impact native Mahseer?
8. Is the current fisheries management structure working in Bhutan and the region? Can it be improved?

Five-Year Research Agenda for Bhutan:

1. Rangers from DoFPS must assess the degree to which illegal harvest of Mahseer (and other fishes) is occurring, and where. This would be a multi-pronged approach that includes some combination of the following:
   a. A standardized survey along waterways to quantify evidence of illegal fishing (i.e., counting gill nets, hook and lines, baskets, floats, etc.). This would occur periodically and would serve to establish baseline data.
   b. The use of camera traps at certain locations where illegal fishing is rampant so as to assess the extent of illegal fishing, when it occurs, by how many people, and with what level of success.
   c. Improve enforcement of the laws by rangers and assess how well it functions.

2. Estimate the percentage of adult Mahseer that enter India from each of the major river systems in Bhutan.
3. Determine migration patterns (spawning-to-overwintering) in the PunatsangChu, and assess methods to mitigate potential dam construction.
4. Complete the ongoing population genetic analyses of Golden and Chocolate Mahseer in Bhutanese rivers. This will clarify stock structure for these species to serve as a guideline for the National Stocking Policy for Bhutan. These data will inform a broader regional study on the taxonomy of Mahseer (i.e., Tor, Neolissochilus, Nazitor).
5. Conduct a review of all hatchery-rearing programs to determine which non-native species are being cultured and if it is justified. Could non-native species either be eliminated, or instead replaced by a similar native species?
6. Initiate laboratory-based studies on Mahseer that related to climate change impacts (e.g., thermal tolerance, oxygen requirements, limitations in elevation).
6. Form a working group to identify the extent of Bhutan's fisheries management and how it might be improved.

Five-Year Research Agenda for the Region:

1. Initiate a region-wide collaborative genetic study involving research and management groups from all countries containing native Mahseer. This would require coordination of various laboratories so as to establish standardized analytical procedures and databases. These data are critically needed to correct the ongoing intentional/unintentional mixing of stocks, and even species.
2. Conduct a review of all hatchery-rearing programs to determine which non-native species are being cultured and if it is justified. Could non-native species either be eliminated, or instead replaced by a similar native species.
3. Each country should assess the population status of Mahseer and determine if overall exploitation rates (legal and illegal) are sustainable. If not, then how can they be curbed without the stocking of hatchery-reared fish?
4. Countries should determine the migration patterns (spawning to overwintering) of Mahseer in their rivers, and assess how to mitigate the construction of dams.

5. Initiate laboratory-based studies on Mahseer that related to climate change impacts (e.g., thermal tolerance, oxygen requirements, limitations in elevation).
6. Form a regional working group to identify fisheries management across the region. How can it be improved, and which trans-boundary issues are apparent?
7. Determine how data can become accessible and shared by various governments, NGOs, and research groups.

BUILDING CAPACITY FOR CONSERVATION AND MANAGEMENT

Facilitators: Julie Claussen (FCF) and Karma Wangchuk (MoAF) + 16 Participants

Charge:

1. Define Management and Conservation
2. List the important Aquatic Management and Conservation (AMC) program areas for Bhutan. Identify the roles that the various Ministries, agencies, NGOs play in each of these areas. Prioritize which of these AMC areas are the most in need of capacity building.
3. Assess both current inefficiencies and real capital needs for each high priority area.
4. Develop a set of recommended actions (internal and external) to improve Bhutan's AMC Capacity.

Defining Conservation and Management:

Bhutanese definitions focused on the management of people and the rules and regulations pertaining to fisheries. Biologists external to Bhutan considered resource management, such as sampling fish populations, assessing habitat, protecting ecological integrity through wise use, conserving native species, and planning for future generations. This distinction was important because it showed how perceptions as well as levels of formal training differed when fisheries management was evaluated in Bhutan.

Overarching Issues:

1. Bhutan's strength in conservation and management has been focused on forests and terrestrial wildlife. Aquatic ecosystems have mostly been viewed as sources of water for consumption, agriculture, and as a basis for hydropower. Relatively little attention has been given to the research, conservation, and management of aquatic resources.
2. Conservation of Golden Mahseer as a Schedule One species has mainly employed hatchery production and supplemental stocking. Other fisheries management plans are not apparent.
3. A serious lack of human capacity (i.e., trained personnel) is apparent in Bhutan (and for the most part, the region).
4. Responsibilities for AMC are spread widely over a number of agencies/institutions, and this yields much confusion and little coordination with regard to responsibilities.

Many environmental plans within proposed projects do not consider the impacts on fish populations, or rivers in general. In fact, in many of the existing Environmental Impact Statement (EIS) documents fish are not even mentioned, even though they are directly impacted, e.g., by construction of a hydroelectric dam or a rock crushing station on the river bank. This is an important aspect in that fish and aquatic species serve as indicators of water quality and ecosystem integrity.

Important program areas for Aquatic Management and Conservation (AMC):

The following is a list of AMC program areas and the responsible institution:
Community based fishing programs: Department of Livestock
Fishing regulations and enforcement: Department of Forests and Park Services
Fish and Fauna assessment: Department of Livestock
Ecotourism: Tourism Council of Bhutan/Department of Forests and Park Services
National Biodiversity Action Plan: National Biodiversity Center
Biodiversity Bill of Bhutan: National Biodiversity Center
Livestock Act and Rules: Department of Livestock
Water Act and Regulations: National Environment Centre
National Environment Act: National Environment Centre
Bhutan Water Policy: National Environment Centre

Needs for Capacity Building:
General Statement: There is a severe lack of fish biologists, river ecologists, aquatic conservation scientists, or fisheries managers in Bhutan across the board. Although consultants and partnerships have been brought in from outside the country, they are not effective in developing and implementing adequate fisheries management programs, much less assess mitigation strategies (such as the potential use of fish passage in hydropower).

Unfortunately, without substantially more basic information on the biology and life history of fishes within Bhutan, constructing sustainable conservation and management plans will remain unachievable. The current lack of biological knowledge on fish and aquatic resources in general continues to promote the approval of inadequate (or purposefully misleading) assessments on development. In addition, Bhutan currently has limited ability to assess if development activities have negatively impacted fish populations.

It was also agreed that the various responsible institutions listed above do not communicate with one other, especially with regard to management and conservation of Mahseer. For example, the Mahseer Conservation Project has made significant progress in understanding the yearly migration patterns of Golden and Chocolate Mahseer. Although several institutions that address regulations on water or river habitat are unaware not only of those findings, but also how planning decisions can impact Bhutan's fish populations. Another example was the lack of knowledge about Bhutan's Community Fisheries Program, managed by the National Research Centre for Riverine & Lake Fisheries (NRCR&LF-Haa). This, despite the fact that these communities are heavily impacted by development activities such as road building, rock crushing, sand mining, and hydropower development.

It was recognized that the focus on fisheries in Bhutan has been from an agricultural standpoint, with much attention and resources provided to fish culture. A lack of knowledge regarding wild fisheries and solutions for conservation outside of hatcheries must be addressed.

Building Human Capacity:
Participants reported that although an untapped pool of people existed within and outside the various responsible institutions, a lack of educational training remains a major concern, particularly with regard to comprehensive and strategic planning for river conservation and fish protection. The following are suggestions on how to increase fisheries capacity:

- Develop educational programs, short courses and modules. These are designed specifically to upgrade the human capacity within each responsible institution, and would span a series of topics: aquatic ecosystems, fish, and fisheries, for example. This would initially involve outside experts to provide those courses.
- Promote the acquisition of educational experience (degrees) for Bhutanese. This would occur outside or Bhutan and, for the most part, external to the region as a whole.
- Require education and training on AMC, for all DoFPS and DoL staff.
- Raise the profile of aquatic life, river habitat, and the land-water connection within the government across the general public. This would occur through targeted messaging.

Building Institutional Capacity:

- Devise a method to bring together relevant institutions and stakeholders so there is buy-in from all sectors on any conservation or management plan.
- Engage with religious institutions and connect cultural and spiritual beliefs with conservation goals.
- Develop citizen science programs for local communities to assist with observations, collecting information, safeguarding habitat, and protecting Mahseer from illegal fishing.

- Re-allocate responsibility and personnel (where needed) among all the various institutions currently responsible for AMC tasks into a smaller and more logical grouping that acts effectively and efficiently, eliminating communication problems.

Recommendations for Bhutan:

General statement:
It is difficult to manage and conserve Mahseer as well as aquatic biodiversity without a single governing body with uniform goals. The overwhelming opinion from participants was that Bhutan must create a central coordinating body to oversee fish and their aquatic habitats (to include research, management, and conservation). This entity should have the capacity and power to assess needs, conduct research, and address conservation planning (such as protection of critical habitats). It would coordinate all activities dealing with AMC or any matter that affects fish or their habitats. In addition, this body would work to raise the level of awareness concerning fish and other aquatic resources to match that of Bhutan's terrestrial wildlife. This would make the Golden Mahseer as recognizable in Bhutan as the tiger.

Specific Recommendations:
1. The Royal Government of Bhutan (RGoB) should reorganize government in a sound and logical way to designate responsibilities for Natural Resource Management and Conservation.
2. The MoAF should: Conduct a retreat with representatives from and all institutions responsible for AMC areas (see list above), to identify the existing structural organization chart as it exists today, then formulates various alternatives. These could potentially include:
3. Adjust the mission/scope of the current MoAF by renaming it as the Ministry of Agriculture and Natural Resources (or even splitting it into two Ministries).
4. Under the Division (or Ministry) of Agriculture, there could be Three Departments: Livestock, Crops, and Aquaculture.
5. Under the Division (or Ministry) of Natural Resources, there could be Four Departments: Forestry, Wildlife, Fisheries, and Parks.
6. Human and Physical resources (facilities) could then be reallocated among the new groups.
7. At least some responsibilities (and possibly personnel) from other institutions could be reallocated to one of the various groups within the new MoNR.

The reorganization would streamline the government by increasing efficiency and effectiveness, without creating more bureaucracy and complexity, or requiring additional human capacity.

A RECREATIONAL FISHING PROGRAM FOR MAHSEER IN BHUTAN

Facilitators: David Philipp (FCF) and Sonam Wangdi (DoFPS, MoAF) + 17 Participants

Charge:
1. Describe the overall issue and need for Bhutan.
2. Describe the desired outcome of a Recreational Fishing Program and list its components;
3. Assess the hypothetical model presented during the IMC and propose needed changes;
4. Recommend a strategy for implementing such a program for Bhutan and the region.

Issue: Illegal fishing, which was identified by the IMC participants to be the most significant short-term threat to native Mahseer populations in Bhutan, is composed of two types: The first is illegal sustenance fishing by local residents using gill nets, cast nets, static hook and line rigs, baskets, weirs, electricity, explosives, and even chemical poisons. Physical evidence coupled with discussions with local residents strongly suggests these activities are rampant throughout southern Bhutan and represent a source of substantial (and unsustainable) Mahseer mortality. This behavior is likely fueled by the myth that many,

if not all Mahseer in Bhutan migrate downstream into India during winter where they are harvested in huge numbers and then sold back to Bhutan as food. This has justified illegal) harvest of Mahseer in Bhutan, i.e., why be forced to buy fish for food when Bhutanese can save money by killing them first? However, radio telemetry data have shown that very few Mahseer leave Bhutan and swim into India.

The second type of illegal fishing is uncontrolled and unmonitored recreational fishing wherein local and/or foreign anglers are granted permits to fish for trout. However, no trout exist in southern Bhutan because the waters are too warm for their survival. Anglers use these permits instead to target both Golden and Chocolate Mahseer. Whether Mahseer so caught are released or harvested is unknown, but it certainly adds to human-based mortality and negatively impacts Mahseer reproduction.

Need:
Bhutan must develop a Community-Based Conservation ethic wherein residents along the rivers, and indeed citizens throughout the country, understand the value of healthy fish populations not only for river/stream ecosystems, but also for society as a whole. This should be facilitated by the fact that the Golden Mahseer is the Sernya, one of the eight auspicious symbols of Buddhism. People must understand that a living fish in the river is worth more to society than a dead one on a plate. [See Roundtable Discussion #3 for a detailed coverage of Community-Based Conservation]. The development and implementation of a Recreational Fishing Program for Mahseer is a necessary cornerstone for success in that area.

Desired Outcome:
A Recreational Fishing Program in Bhutan should be the cornerstone of a community-based conservation program that ensures the sustainability of Mahseer in Bhutan and enhances the livelihoods of residents in watershed communities. It will only succeed if the following objectives are met:

- Provide new recreational opportunities for Bhutanese;
- Increase Bhutan's ecotourism sector;
- Generate revenue to help fund Mahseer (large river) conservation actions;
- Yield funds to support the livelihoods of the watershed's rural residents.

Important Components:
A Recreational Fishing Program in Bhutan should have the following components:

- Regulations that describe geographic boundaries, seasonal closures, needed permits, access restrictions, equipment and technique requirements;
- A pricing structure, with a description of how proposed revenues would be allocated and used;
- Reporting requirements (i.e., how required data are reported and to whom);
- Human capacity (e.g., fishing guides, permits, and scheduling controls);
- A plan for initial implementation and subsequent evaluation/modification.

Assessment of the Recreational Fishing Model:
There was considerable discussion with excellent details provided by all participants, to include an expansion of the model specific for the PunatsangChuu, in recognition of ongoing pilot fishing trips in that drainage.

Recommended Strategy for Action:

1. An important first step in establishing a legitimate Recreational Fishery for Mahseer is to immediately separate Mahseer waters from Trout waters, and to develop separate, species-based regulations to ensure sustainability of each fishery. This should be based on the elevational difference that exist between their respective habitats. i.e., Mahseer found at or below 1000m elevation (See Appendix A for a detailed map).

2. Develop a Recreational Fishing Program for Mahseer that is non-consumptive (i.e., totally catch-and-release and, therefore, sustainable). It would contain effective and transparent mechanisms that generate revenues to enhance the livelihoods of the local residents and ensure the conservation of Mahseer for future generations of Bhutanese.

"See Appendix B for a detailed Model that outlines an approach based on a geographically tiered fishery for Bhutanese and foreign anglers. These revenues will fund a Community Economic Fund and a Mahseer Conservation Fund."

3. The separation of Mahseer versus Trout waters, which should happen as soon as possible. MoAF should then develop and deliver to all of the communities within the watershed, an educational campaign that explains the following: What the Recreational Fishing Program would encompass, how it will benefit local communities, how they can get involved in the program, why illegal fishing will hurt the fishery and hence their livelihoods, and in general, how the Community-Based Conservation Program will work.

Appendix A

Legal Delineation of Mahseer vs Trout Waters for Management in Bhutan

Although public recreational fishing is allowed in Bhutan, angling for Mahseer is not, with the exception being scientific activities or specially permitted groups. Confusion in the current regulations and permitting process, however, allows Mahseer to be exploited. For example, individual anglers obtain permits to fish, which, according to regulations, is limited to trout. These permits, however, are provided to individuals who angle in waters of southern Bhutan, many miles from where brown trout exist. The only legitimate target species for recreational fishing in the southern areas of Bhutan are the two Mahseer species. As a result, a number of Bhutan's southern rivers are fished illegally, putting at great risk the establishment of a catch-and release fishery. We recommend that fishing regulations for Bhutan be quickly amended to delineate all waters of Bhutan as either Mahseer waters (defined as rivers and tributaries at or below 1000m in elevation), or Trout waters (rivers and tributaries above 1000m elevation).

Potential Mahseer Waters (under 1000m)

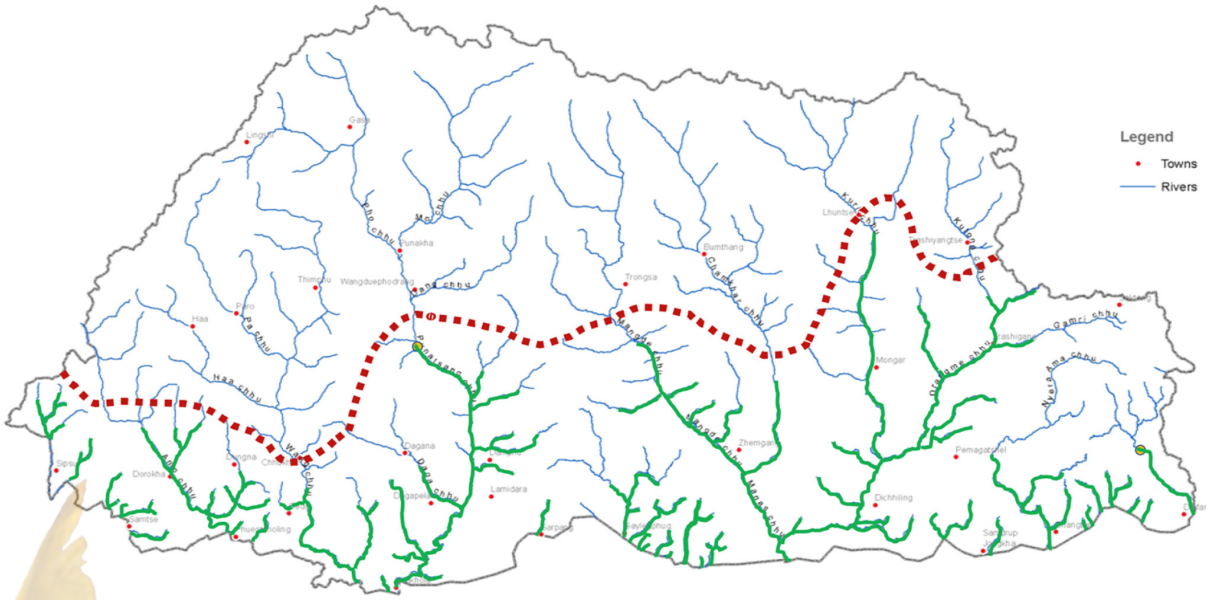

Figure 1. Mahseer Waters in Bhutan. The green lines indicate the parts of rivers that are below 1000 m elevation, areas that likely support Mahseer populations. The dotted line indicates where fishing regulations delineate between Mahseer waters to the south and Trout waters to the north of the line

After such delineation goes into effect, current regulations could still hold for Trout waters, but no fishing would be allowed in Mahseer waters until appropriate regulations are established. This, in turn, requires development of the program proposed below.

Appendix B

A Model for a Recreational Fishing Program for Mahseer in Bhutan January 2019

Prepared by David Philipp, Julie Claussen and Rick Williams, Fisheries Conservation Foundation (with input from Steven Cooke, Jeff Koppelman, Bryant Dunn and the Recreational Fishing Roundtable at the 2018 International Mahseer Conference).

Herein, we propose a recreational fishery model for Mahseer in Bhutan (both Golden Mahseer, Tor putitora, and Chocolate Mahseer, Neolissochilus hexagonolepsis) based on our following experience: Radio-tracking Mahseer in the Manas watershed, angling Mahseer to obtain fish for that study (over 500 Mahseer captured since March 2015), outfitting recreational fishing trips (some in Bhutan for Mahseer), and working with recreational fisheries programs around the globe. Specific details, especially those pertaining to the financial aspects, could certainly be altered if it provides a better fit with Bhutan's goals.

Our model assumes a recreational catch-and-release angling program for Mahseer in Bhutan that will achieve the following objectives:

- Provide new recreational opportunities for Bhutanese;
- Increase Bhutan's ecotourism sector;
- Generate revenue that will fund Mahseer conservation;
- Yield revenue to support the livelihoods of the watershed's rural residents;
- Develop community-based Mahseer conservation practices and ethics;
- Ensure the sustainability of Mahseer in Bhutan for future generations.

We recommend the model be initiated as a pilot program and limited to the Manas watershed (where data are provided from the Mahseer telemetry research project), and the lower Punatsang Chu watershed (where well-organized trips have already occurred). Expansion to other watersheds should proceed only after a successful evaluation over a period of time.

This pilot program defines three zones within Mahseer waters of the Manas watershed (Figure 2) and two zones of Mahseer waters within the Punatsang Chu watershed (Figure 3). Both differ with regard to regulations and cost structure. This was done to strike a balance between the need for high-cost angling with very restrictive access to generate conservation revenues versus affordable access for Bhutanese anglers. This multi-zone strategy has been successful globally.

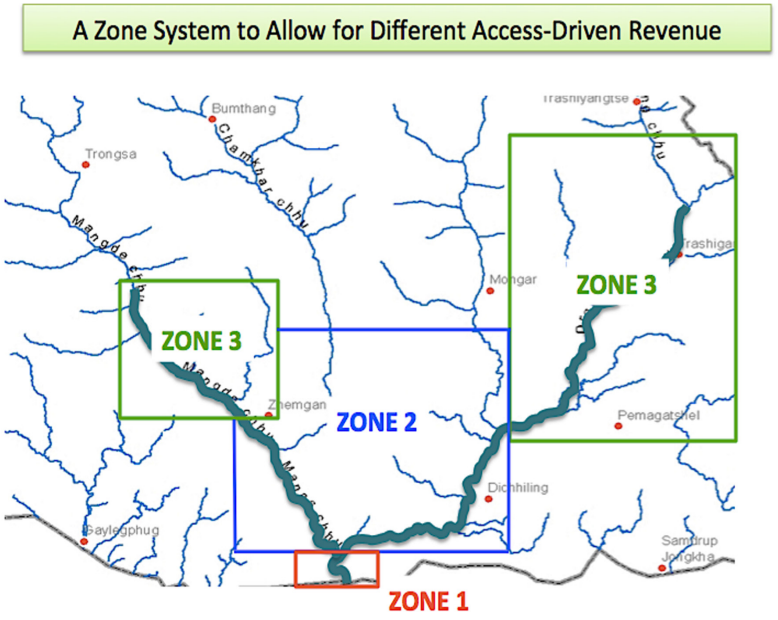

Figure 2. Zone System for the Manas Recreational Fishing Program. Three different zones are delineated by the different colored boxes shown below. Regulations and costs vary between zones – see text below

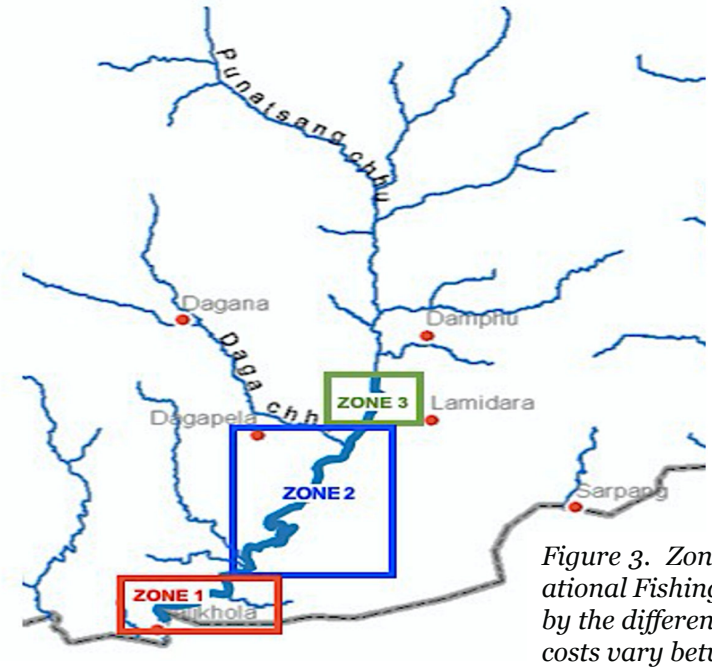

Figure 3. Zone System for the Lower Punatsang Chu Recreational Fishing Program. Two different zones are delineated by the different colored boxes shown below. Regulations and costs vary between zones – see text below.

Some regulations are universal across all three zones:

The recreational fishing season in Mahseer waters is October 1 – May 15 from sunrise to sunset.
All anglers must possess a valid Bhutan Fishing Permit.
All anglers must possess a valid Mahseer Stamp.
All anglers must pay the daily Mahseer Conservation Support Levy specific to the area fished.
All anglers must pay the daily Community Economic Support Levy specific to the area fished.
All anglers must arrange and have documentation for necessary guides and permits.
Fishing is via rod and reel and is catch-and-release only; intentional snagging is prohibited.
All anglers must have a certified fishing guide with them while fishing (see below).

Fly-fishing is defined as using traditional fly-fishing equipment, with only flies that have one barbless single or treble hook.

Spin-fishing is defined as using traditional spin-fishing equipment with only artificial lures (no live or dead bait) that contain one barbless single or treble hook.

All hooked fish must be landed using a landing net or cradle. Best handling practices for recreational fishing are required, to include immediate release of the fish back into the river.

Other regulations vary depending upon the angling zone:

Zone 1: Restricted to fly-fishing only with access permitted only by raft, but rafters can fish from the shore.
Zone 2: Restricted to fly-fishing only with access permitted by raft everywhere, but access on foot is restricted to a few designated areas.
Zone 3: Restricted to fly-fishing and/or spin-fishing, with access permitted by raft and/or by foot only at designated areas.

There would be different access requirements for angling in the different zones:

- In all zones, rafting must be facilitated through a certified rafting company.
- In all zones, a trained fishing guide is required for each fishing raft (this can also be the boatman if certified as a fishing guide). Cargo-only rafts would not require a fishing guide.
- In Zone 3, walk-in angler(s) (up to four per group) require a fishing guide.

Fishing Guides would be certified and trained in trail safety, first-aid, fishing regulations, best fish handling practices, customer relations, and angling support. Guides are also responsible for filing an activity report for each trip (e.g., time fished, number, sizes, and locations of fishes caught).

The following are suggested costs (US$) for angling:

The following are suggested costs (US$) for angling:

Angling Permit

Foreign Angler	1 Day	$30	Bhutanese Angler	1 Day	$15
	7 Days	$70		7 Days	$35
	1 Year	$100		1 Year	$50

Mahseer Stamp

Foreign Angler	1 Year	$100	Bhutanese Angler	1 Year	$50

Mahseer Conservation Support Levy

Foreign Angler	Zone 1	$500/Day	Bhutanese Angler	Zone 1	$250/Day
	Zone 2	$250/Day		Zone 2	$125/Day
	Zone 3	$50/Day		Zone 3	$25/Day

Community Economic Support Levy

Foreign Angler	Zone 1	$500/Day	Bhutanese Angler	Zone 1	$250/Day
	Zone 2	$250/Day		Zone 2	$125/Day
	Zone 3	$50/Day		Zone 3	$25/Day

The following table provides examples of the PER ANGLER costs for one hypoyhetical high-end flyfishing* trip for foreigmers and one hypothetical walk-in** spinfishing for Bhutanese:

	FOREIGN ANGLER TRIP		BHUTANESE ANGLER TRIP	
	Six Day Guided Raft Fishing Trip – four foreign anglers*		**Two Day Guided Walk-in Fishing Trip – four Bhutanese anglers****	
Angling Permit	7 days	$70	7 days	$35
Mahseer Stamp	1 per angler	$100	1 per angler	$25
Conservation Levy	4 days in Zone 2; 2 days in Zone 1	$2000	2 days in Zone 3	$50
Community Levy	4 days in Zone 2; 2 days in Zone 1	$2000	2 days in Zone 3	$40
Rafting / Fishing Guides	1/4 cost @ $400/day	$600	¼ of 2 days @ $50/day	$200
Lodging at start/end	2 days	$300	2 days @ $100/day	$40
Camping/Meals on river	6 days	$600	2 days	$10
Transportation - River sites	4 times	$200		
TOTAL		**$5870**		**$400**

Not included: Travel to Bhutan and to/from Fishing Sites

**Example is for a Six Day Guided Raft Fishing Trip – four foreign anglers:*
Two Days on MangdeChu (Pantang thru Manas Takeout)
Four Days on DangmeChu (Yangmari thru Manas Takeout)

Angling = two days in Zone 1 / four days in Zone
***Example is for a Two Day Guided Walk-in Fishing Trip – four Bhutanese anglers:*
Two Days on MangdeChu (Tingtibi and below)
Angling = two days in Zone 3.

The following table provides estimates for revenue generation for a series of both typical high-end fly-fishing* trips for foreigners, and typical walk-in** trips for Bhutanese, during a hypothetical three-year pilot program, that limited the angling traffic on the rivers each year as follows:

- Year 1: Three raft trips (max of four foreign anglers each – four days each); five walk-in groups (four Bhutanese anglers each - two days each).
- Year 2: Six raft trips (max of four foreign anglers each – four days each); ten walk-in groups (four Bhutanese anglers each - two days each).
- Year 3: Twelve raft trips (max of four foreign anglers each – four days each); twenty walk-in groups (four Bhutanese anglers each - two days each).

Pilot Study Revenues: Based on the proposed rafting and walk-in limits, and assuming that all trips (above) were completely filled, the following table shows the expected gross revenues for each of the three years of the pilot:

Rafting Trips:

Category	Year 1	Year 2	Year 3	Beneficiary
Angling Permits	$840	$1,680	$3,360	RGOB
Mahseer Stamps	$1,200	$2,400	$4,800	RGOB
Conservation Levy	$24,000	$48,000	$96,000	Conservation Fund
Community Levy	$24,000	$48,000	$96,000	Community Fund
Rafting Costs	$7,200	$14,400	$28,800	Rafting Guides
Camping/Meals	$7,200	$14,400	$28,800	Local Groups
Hotel	$3,600	$7,200	$14,400	Local Hotels
Transport	$2,400	$4,800	$9,600	Local Companies
TOTAL	**$70,440**	**$140,880**	**$281,760**	
THREE YEAR TOTAL			**$493,080**	

Walk-in Trips:

Category	Year 1	Year 2	Year 3	Beneficiary
Angling Permits	$700	$1,400	$2,800	RGOB
Mahseer Stamps	$500	$1,000	$2,000	RGOB
Conservation Levy	$1,000	$2,000	$4,000	Conservation Fund
Community Levy	$1,000	$2,000	$4,000	Community Fund
Walk-In Costs	$800	$1,600	$3,200	Trail Guides
Hotel	$4,000	$8,000	$16,000	Local Hotels
TOTAL	**$8,000**	**$16,000**	**$132,000**	
THREE YEAR TOTAL			**$56,000**	

Over the three hypotical years, the total revenue by catrgory for rafting and walk-in trips combined would be:

Category	Walk-in	Rafting	Total Years 1-3	Beneficiary
Angling Permits	$4,900	$5,880	$10,780	RGOB
Mahseer Stamps	$3,500	$8,400	$11,900	RGOB
Conservation Levy	$7,000	$168,000	$175,000	Conservation Fund
Community Levy	$7,000	$168,000	$175,000	Community Fund
Rafting Guides	$0	$50,400	$50,400	Rafting Guides
Trail Guides	$5,600	$0	$5,600	Trail Guides
Camping/Meals	$0	$50,400	$50,400	Local Groups
Hotel	$2,8000	$25,200	$53,200	Local Hotels
Transport	$0	$16,800	$16,800	Local Companies
TOTAL	**$56,000**	**$493,080**	**$549,080**	
THREE YEAR TOTAL			**$549,080**	

Additional Programmatic Needs:
For this program to be implemented,the following would need to be met:

- On-line payment system for Permits, Stamps, Levy Fees; this is critical for walk-in anglers, but all permits, fees, and levies for high end raft trips would likely be paid by tour operators.
- Conservation Fund governance system; a fair system in which all stakeholders have input is critical.
- Community Fund governance system; a fair system in which all stakeholders have input is critical.
- Trip Registration System/Calendar that limits number of anglers per day per zone; user conflicts must be minimized, i.e., rafting trips planning to angle at a certain confluence should never find others there.
- Organization/maintenance plan for camping sites/meals
- Fishing Guide training and certification
- Trial angler groups run through the pilot program to provide feedback
- Marketing plan for potential anglers; this would have to involve several components of the government.
- Fixing porous angling regulations; specifically, delineate Mahseer vs Trout waters and institute detailed regulations to control Mahseer angling in Bhutan.
- Developing a National Fish Stocking Program that corrects the current pervasive perceptions re the need for and benefits from stocking hatchery-reared fish.
- Community Outreach and Education Plan promoting the angling and conservation strategy
- Resource Management Plan that incorporates Mahseer population monitoring and creel results

We believe such a recreational fishing program would accomplish the outlined objectives and be successful as long as the health of the fish and fishery is a priority. The expectations of the anglers would need to be managed; i.e., fly-fishing for Mahseer is quite difficult (especially in Bhutan), and only advanced anglers would have the skill and patience to be successful in landing a large Golden Mahseer. For many experienced anglers, the reward would easily be worth the risk and expense. In addition, recreational fishing for Mahseer in Bhutan is executed in very difficult terrain. As a result, the quality of fishing guides, their knowledge of the river and how to successfully fish for Mahseer, as well as their ability to meet the health and safety needs of anglers, will be a key to the success of this program.

There are a number of anglers around the globe willing to pay the suggested fees for the privilege to fish for wild Mahseer in an exclusive area. Most fly-fishing anglers would also be attracted to the community-based conservation ethic as promoted within the goals of their program. The success of developing such a community-based conservation ethic will depend on a significant portion of the revenues being used to improving the watershed communities. If these revenues are invested in businesses outside of the watershed, then illegal fishing would increase.

Resources
Selected Publications on Recreational Fishing as a Conservation Action

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Cooke, S. J., Z. Hogan, P. Butcher, M. Stokesbury, R. Raghavan, A. Gallagher. 2014. **Angling for endangered fish: conservation problem or conservation action?** Fish and Fisheries, 17 (1), 249-265.

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Williams, J.E., R. N. Williams, R. F. Thurow, L. Elwell, D. P. Philipp, F. A. Harris, J. L. Kershner, P. J. Martinez, D. Miller, G. H. Reeves, C. A. Frissell, and J. R. Sedell. 2011. **Native Fish Conservation Areas: A Vision for Large-Scale Conservation of Native Fish Communities.** Fisheries 36 (6): 267-277).

Declaration of the International Mahseer Conference 2018, Paro Bhutan

Conserving Mahseer for the benefit of people and nature across Asia

This declaration, proclaimed at the First International Mahseer Conference held in Paro, Bhutan December 2-8, 2018, (http://mahseerconference.org/), presents findings and recommendations to address the urgent need to protect Mahseer, an iconic group of fish species that inhabit South and Southeast Asian rivers.

The State of Mahseer Conservation

Mahseer are an iconic group of migratory fishes that play a key role in the social, cultural, and economic well-being of communities across the region. Mahseer populations require healthy freshwater ecosystems, yet river systems across the region are under a number of substantial threats. In fact, most species of Mahseer are assessed as threatened on the IUCN Red List. To protect Mahseer populations, effective conservation strategies must address the current threats that are depleting their numbers. To accomplish that goal, management actions need to take an ecosystem approach with trans-boundary cooperation that includes many different stakeholders engaging a diversity of policy sectors. The effective conservation of Mahseer not only helps to safeguard social and cultural heritage across the region, but also helps to protect the ecological functioning of Asia's rivers, thereby supporting human health, livelihoods, food security, and general well-being. The wider societal benefits of Mahseer conservation can therefore be linked to a number of the 17 United Nations Sustainability Development Goals (SDGs), noted by SDG number below.

Findings and Recommended Actions

Regulating Fishing to Conserve Native Fishes [SDG 2,8,12,15]

Problem: Over-fishing through the use of legal means or illegal practices is rampant throughout the region. The use of destructive methods such as poisons, explosives, electricity, gill nets, and traps that focus on large mature adults is rampant and represents the greatest immediate threat to many Mahseer populations.

Recommendation: Each country should enable regulations to prevent over-fishing and eliminate illegal fishing by increasing enforcement effectiveness. To accomplish that goal it is vital to establish a society-wide conservation ethic by implementing community-based conservation programmes that can benefit both the fishery and local people. A critical component of such an effort will be widespread and locally tailored public education actions to explain the need for and benefits from conservation actions

Keeping Rivers Free Flowing [SDG 2,6,7,9,12,13,15]

Problem: Dams create blockages that impede the movement of migratory fish and represent a long-term threat to Mahseer and other fishes. These obstructions also have significant implications for the livelihoods of fishers as well as for food security across the region. Dams also change river food webs and block the flow of sediments crucial for the habitat and productivity of downstream lands and the stability and resilience of deltas.

Recommendation: When considering new energy generation projects, governments should evaluate all renewable energy options and choose the best low-carbon, low-cost and low-impact strategy. Where economic and energy planning deem hydropower or other dam projects necessary, their negative impact on communities, rivers, and biodiversity should be mitigated through better siting decisions during the

planning phase, by using fish-friendly practices during construction, by installing effective fish passage technology (both upstream and downstream), and by using dam operational schedules that provide appropriate downstream hydrological regimes, including sufficient environmental flows for people and nature. Furthermore, hatchery-based supplemental stocking programmes should never be considered a viable mitigation strategy, because they harm rather than augment wild populations.

Protecting Critical Habitat for Native Fishes [SDG 1,2,3,4,6,7,9,11,12,15]

Problem: Human-induced activities, such as water abstraction, deforestation, sand and boulder mining, gravel crushing, road and bridge construction, impoundments, and chemical pollution from agriculture, industry, and human waste, have widespread negative impacts on Mahseer and the rivers systems on which they depend.

Recommendation: Governments need to develop and enforce stricter environmental criteria for permitting human activities that impact rivers, thereby also protecting the many human services and ecological benefits that rivers provide. Both government and non-governmental organizations should work to establish programs to educate stakeholders and the public not only about the impacts of human expansion and development on river ecosystems, but also about alternative sustainable practices for development.

Instituting Responsible Fish Stocking Policies [SDG 2,12,15]

Problem: Native wild fish populations have unique genetic and life history attributes among river systems. Restocking wild populations using hatchery-reared fish is harmful to those wild populations and not, as is too often assumed, a means of mitigation for destructive activities (e.g., hydropower, overfishing, and/or pollution). Current management and conservation strategies for Mahseer are often ineffective because they are based on agricultural practices rather than ecological and evolutionary principles.

Recommendation: A National Fish Stocking Policy based on the best available international science and experience must be developed before any stocking is allowed to proceed. Such policies must provide criteria to be met before any and all proposals to stock any fish (native and non-native species) were to be considered. To facilitate the success of that approach, scientists, conservation organisations, and management agencies across the range of all Mahseer species should share data openly, coordinate genetic information, cooperate on joint research projects, and join together to share best practices.

Filling in the Gaps in our Biological Information [SDG 4,15]

Problem: There is a substantial lack of basic biological data concerning Mahseer fishes across their ranges. This deficit of information greatly impedes successful conservation efforts and facilitates continued population declines. Governments need to invest in both basic and applied research to ensure the long-term survival of Mahseer populations through improved management practices.

Recommendation: To ensure the long-term survival of Mahseer across the region, governments need to invest in basic and applied research that fills in these information gaps, including clarifying the taxonomy of local Mahseer species, identifying key habitats required for their various life history stages, and documenting the diversity of beneficial services that they provide for people. There should be a coordinated effort to standardize methods and share knowledge across the range of Mahseer.

Bracing for Climate Change [SDG 2,7,13,15]

Problem: The impacts of climate change will continue to accrue throughout the region, amplifying the issues facing Mahseer and river systems in general. Protecting Mahseer habitats supports the resilience of communities, economies, food security and livelihoods. Ensuring rivers are free-flowing guarantees sediments can replenish deltas, which are on the front lines of climate adaptation, are home to significant human populations, drive the GDP, and are vital for rice and other food production.

Recommendation: Scientists, conservation organizations, and governments throughout the region should work together to address the uncertain impacts of climate change on Mahseer populations and their habitats. Governments need to view river systems as dynamic and connected, planning according to the new climate reality rather than assuming past norms.

Recognizing the True Values of Our Large River Ecosystems [SDGs 1,2,6,7,8,11,12,15,16,17]
Problem: Rivers provide a broad set of services that deliver immense benefits to people, economies, and nature, far exceeding the value of the water they carry. Far too often, however, these broader benefits are not understood, recognized, or valued until problems emerge from a river's neglect. Recognition of these societal benefits needs to inform sustainable river management.

Recommendation: Governments must greatly improve their measurement of the ecological services provided by rivers, basing them on a rigorous understanding not just of the hydrological and biological processes of rivers, but also of our societal and economic dependence on rivers. Various methods are emerging that improve our valuation methods for water and rivers, with particularly rapid progress having been made in quantifying ecosystem services with the recognition that all of these benefits are integrally interconnected. Making decisions and ensuring that progress is durable require effective water management institutions and governance, with roles in that process for government, financial institutions, and the private sector.

International Mahseer Conference Abstracts and Presentation Summaries

Presentation summaries were recorded by the conference rapporteurs:
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KEYNOTE ABSTRACTS

Mahseers (Tor spp.) of the World Status Review

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Abstract:
We are living in a changing world, where rapidly increasing anthropogenic interferences are impacting both directly (e.g. pollution, habitat destruction, harvest etc.) and indirectly (e.g. climate change) on the health of aquatic ecosystems across the globe. With a biogeographic range extending across the fast flowing rivers of South and Southeast Asia, the 'mahseers' represent an iconic group of fishes which are now facing unprecedented population pressures. Despite their large size, attractive appearance and cultural/recreational importance, taxonomic clarity and population distribution knowledge across the genus Tor remain severely limited, with fundamental aspects of biology and autecology still unknown for many species. With interest rapidly growing across stakeholder groups (e.g. scientists, conservationists, recreational anglers, land and water resource managers) to conserve this group of iconic fishes, there is an immediate urgency to provide the scientific community, stakeholders and policy makers with standard points of reference to benchmark the current state of knowledge pertaining to the genus Tor. Based on a multidisciplinary approach incorporating examination of type specimens, original descriptions, historic photographs and morphological/genetic analysis, this paper resets the knowledge base pertaining to the genus Tor in presenting a current list of valid species, their distributions, population status and revised IUCN Red List assessment status. In highlighting the many evidence gaps still required to resolve remaining uncertainties, the authors also hope to invite and stimulate further study to challenge and build on the current evidence base, to effect the conservation of mahseer into the future.

Presentation Summaries:

Summary 1:

What do we know and not know about Tor? Topics were taxanomic review of mahseer, the problems facing populations of mahseer, and knowledge gaps hindering conservation.

Major Points:

- Major threats to mahseer: Pollution, invasive species, river fragmentation, changing riverscapes/ flow regimes, unsustainable fishing (e.g. dynamite fishing).
- Conservation challenge: "Knowledge is power". Need to identify knowledge gaps, and execute appropriate research methods and biodiversity assessments. Need to shift research objectives from aquaculture.
- Taxonomic confusion, uncertainty, and ambiguity are a problem. In order to conserve biodiversity, we must first understand it. To resolve these issues, an IUCN workshop was held which came to a consensus of 16 species of Tor. New species descriptions will come soon.

Discussion:

1st question asked if stocked bluefin mahseer in India hybridize with other Tor. Dr. Pinder responded that the original stocks may in fact be of hybrid origin, making it difficult to tell if we are seeing hybridization in nature.

2nd question asked about the current status of the stocking program in India. Adrian responded that he met with the hatchery which agreed to stop stocking bluefin mahseer. However, other hatcheries have established stocks and continue to stock them, thus necessitating a nation-wide effort.

Summary 2:

We must overcome the knowledge gaps, especially taxonomic confusion, to properly conserve Mahseer.

Major Points:

- Population threats: pollution, river fragmentation, changing riverscapes, water abstraction, unsustainable fishing
- Knowledge gaps: ecology, species distributions, taxonomic confusion, population threats, population trends
- 16 species of Tor assessed—new species expected
- All species are near threatened, worse, or date deficient
- More ecological information is needed

In Search of Responsible and Sustainable Inland Recreational Fisheries

Steve Cooke, Canada Research Chair, Carleton University, Canada

Abstract:

Recreational fisheries operate around the globe, engaging 220 million participants and includes a wide variety of freshwater and marine gamefish species. People fish for a variety of reasons; from catch-and-release angling to harvest-oriented catches, however, the value of recreational fisheries is often ignored and largely overlooked. There are numersous examples of recreational fisheries that are well-managed and where fisheries managers, anglers, the angling industry engage in responsible behaviours that contribute to long-term sustainability of fish populations and the sector. Natural resource management agencies need to fully adopt and implement evidence-based management for conservation and recreational fisheries management.

Presentation Summaries:

Summary 1:

The focus was on what we can do to promote sustainable and responsible fisheries, with a major point being that this must happen via changing angler behaviors and values. “Conservation is about people”.

Major Points:

- Generally, we don’t think of recreational fishing as a major impact compared to commercial, but it certainly can be. ‘Combat fishing’, high density fishing, competing with indigenous needs, fishery-induced evolution. Clearly a need to be “responsible” and “sustainable”.
- Ten commandments to Responsible and Sustainable fishing in a ‘good Anthropocene’. Things individuals, managers, and policymakers can do.
- Managing for ‘maximum sustainable yield’ disregards the motivations of recreational fisherman
- Ecotourism a powerful movement to tap into.
- Catch and release: What can we do to minimize injury? Handle the fish better; less damaging gear; angler experience.
- Deep hooking the biggest problem. Lure type & size (no live bait, small = deeper); Fishing method (passive = deeper); experience (novice = deeper); hook type (circle hooks = better).
- Higher water temps = higher mortality. Regulations should keep this in mind and maybe should make seasonal regulations.
- C&R of mahseer - Take home message: They’re robust. Barbless J hook the best, barbed treble the worst. Live bait has the postential to increase mortality.
- How to make a fishery sustainable? Need to consider population sizes, demographics, life history.
- Need to communicate guidelines with fisherman and make sure they absorb them! Fishing guides, ‘celebrity’ fisherman, and outfitters can play a role. Conservation is about people.

Discussion:

The first question asked about criteria to decide which stocks are suitable for recreational or sustainable recreational fishing. He also commented that mahseer have low fecundity. Dr. Cooke said more data is needed to develop a reliable model of C&R or fishing impacts for mahseer. We need to get those data to better inform fisheries. We need basic life history and population biology information.

Summary 2:

Responsible and Sustainable recreation fisheries rely on modifying human behavior and using science to identify best practices.

Major Points:

- Recreational fisheries hold significant social, cultural, and economic value and can generate many benefits
- Maximizing MSY is rarely the management objective of Responsible and Sustainable recreational fisheries
- Angler behavior, air exposure, handling, when and what to fish for
- Gear choice
- Angler experience and knowledge
- Minimize deep hooking
- Avoid fishing at warmer temperature
- Blue-finned mahseer are robust and resilient when caught
- Golden mahseer mortality may be around 3%
- Need population estimates for mahseer
- Key: Identifying best practices & sharing effectively

Q: Any criteria to decide if a stock can sustain a recreational fishery?
A: We need to know more, and hatchery data is not optimal for assessing natural stocks.

Keeping the Mahseer Moving: Working Together for Sustainable River Basin Management
Leanne Alonso, Biodiversity Specialist, International Finance Corporation, World Bank Group

Abstract:
The Golden Mahseer (Tor putitora) and other mahseer species are flagship species across the Himalayas and India. Despite their economic, cultural and biological importance, they are threatened throughout their range. T. putitora is categorized as Endangered on the IUCN Red List, while Tor tor is Data Deficient and Tor remadevii is Critically Endangered. The threats to these species are diverse but all stem from the same source: human activities that lead to changes in the aquatic ecosystem or have direct impacts on the mahseer. The wide range of threats discussed in this session, including non-native fish, stocking, hydropower and other water diversion projects, and cumulative impacts of development requires innovative mitigation actions to reduce these threats. Mitigation such as adequate ecological flow, fish passage, environmental flow scenario assessment, and monitoring of fish migration and populations. These threats are complicated and cannot be addressed by any one group or stakeholder alone. The International Finance Corporation (IFC) has been exploring a wide range of approaches to minimize impacts of hydropower to the Golden Mahseer and other migratory fish in Nepal and Pakistan. These approaches require collaboration between developers, governments, NGOs, scientists and communities. A discussion of the contribution of each of these stakeholders will be held with session participants. Examples from IFC and other projects will be provided to illustrate the possibilities and challenges of mitigating these threats and to highlight the role that each of us can play to achieve a sustainable outcome for the mahseer.

Presentation Summaries:
Summary 1:
Dr. Alonso presented on how IFC is working to mitigate threats to mahseer through investments and advisory services.

Major Points:
- One major project is the Gulpur HPP in the Jhelum-Poonch basin in Pakistan, where migratory paths are already impacted by existing reservoirs. Dr. Alonso noted the concern of creating two mahseer populations divided by the dam which both supposedly have tributaries for spawning. I'm unclear on how the migratory life history of mahseer is disrupted- tracking studies would be valuable, which Dr. Alonso noted.
- There are many other proposed hydropower projects, which are required to follow their own biodiversity action plans.
- Another major project is the Trishuli basin in Nepal, where there are a total of 23 planned projects in that watershed. The IFC project is designing a fish ladder with Schizothorax in mind, and they are trying to work with the other projects to build fish ladders. She noted that the system proposed in Trishuli will only cost ~$150,000.
- In Nepal, HPP must either build a fish hatchery or fish ladder, but no evaluation of if the fish ladders work! Which species actually use it? The Andhi Khola fish ladder was designed for chocolate mahseer (Neolissochilus hexagonolepis), although it is unknown if they actually use it.
- Bhutan: Dangmechhu and Kirichhu have fish passages, although Punatsangchhu lacks one. Monitoring is in progress by NRCR&LF (DoL) staff to determine effectiveness.

Discussion:

» Dr. David Philipp brought up the issue of the Gulpur system splitting a migratory population, and that fish may be required to develop new life histories. This is an important point because we don't currently know how individual mahseer respond when migratory routes to their natal tributaries is blocked. Do they find new sites?

» Steve Cooke cautioned that IFC may be overselling claims of a "net gain" or success of biodiversity -action plans. Continued discussion was over the overall cost of projects versus the environmental cost. An important point was that environmental costs are essentially a "rounding error" in the broad sense of the budgets for these major projects.

Summary 2:

- Funding agencies like IFC, who fund hydropower projects across the world, try to demonstrate their clients/projects will avoid and mitigate impacts to ecosystems
- Projects attempt to show a net increase in biodiversity and to Mahseer populations post project completion
- Taking a holistic approach to mitigate impacts across watersheds

Discussion:

Q: Will mahseer population divided into two by a dam be able to adapt to new life history strategies?
A: We do not know

Comments:

- The holistic approach is good, but there may be an overstatement of net gain in diversity and the ability for Mahseer to adapt.
- Dealing with the devil can get a lot of conservation funds

Valuing Rivers: How the Diverse Benefits of Healthy Rivers Underpin Economies and Ecosystems
Stuart Orr, Leader of WWF Freshwater Team, World Wildlife International, Switzerland

Valuing Rivers: Saving the Golden Mahseer…and so much more
Stuart Orr, World Wildlife Fund International

Traditionally, rivers have been valued primarily as water sources to drive the economic engines of irrigation and hydropower. But along with ensuring the survival of the Golden Mahseer and other freshwater biodiversity, healthy rivers also provide a broader set of services that deliver immense benefits to communities, companies and countries – benefits that underpin economies and sustainable development. Yet far too often, these 'hidden' values are not understood, recognized or valued and so are not a priority for river management – until clear problems emerge from their neglect. Decision makers continue to overlook values such as flood-risk reduction, sediment delivery that keeps deltas from sinking and shrinking, and thriving freshwater fish stocks.

This short-sighted approach has proven costly across the globe and will result in even greater biodiversity and economic losses in the future. Already, 19 per cent of global GDP comes from watersheds with high or very high-water risk, while most of the world's great deltas – including the Ganges, Indus, Mekong and Yangtze – are sinking and shrinking.

With rivers under growing pressure from dam development, climate change and soaring demand for water to irrigate farms and fuel hydropower plants, there is an urgent need for societies to properly measure, value and promote rivers' diverse benefits – to ensure that the best overall decisions are taken and that progress is sustainable.

Healthy rivers provide benefits that are part of the solution to a range of our most pressing problems. We have ignored and neglected these critical values for far too long. It is time for a 'new deal' for the world's rivers.

Presentation Summaries:

Summary 1:

Mr. Orr gave a '30,000 foot' view of the issues facing management of freshwater biodiversity. A major topic was on how we uncover the hidden values derived from freshwater systems, and how we can try to link our agenda within the context of other interests competing for freshwater resources- hydropower, mining, land development, financial institutions

Major Points:

- WWF International freshwater program focuses on system-level as well as species-specific management.
- A major issue is that a lot of freshwater diversity is hidden. High endemism due to habitat isolation and specialization, many poorly known or undescribed species. "We are losing wildlife before it is defined"
- How to uncover the hidden values of freshwater systems? Food production, livelihood, fisheries, flood mitigation, biodiversity.
- Sand mining a much larger issue than is generally appreciated. Up to 50 billion tons per year, and increasing. Need to convey issues and risks in a way which appeal more widely. How do we get the message out? Need to focus on incentives which influence decision-making
- Issues stemming from the use and abuse of freshwater resources by the private sector can be extremely expensive to the public.
- "We need to be energy specialists, not just mahseer specialists"
- Major focus on making our ideas "bank-able", or communicating them in terms of the associated risks and costs (to people and economies) in order to get the attention of financial powers. It is not enough to communicate with other ecologists and conservationists, major need to put into a broader context.

Discussion:

» Dr. Everard started off the discussion started on the topic of water value- if a dollar is loaned, can we get it back "without blood". Mr. Orr responded that he believes that if we can bring our work into bankable ideas, make them of interest to a broad set of investors and communicate the other values and risks. He noted that the onus is on us to get smarter about talking about what we want, and what we see as important in managing freshwater system.

» Julie Claussen asked whether or not these issues being identified (esp. with sand mining) in the conservation community are getting traction on the business side. Mr. Orr replied that WWF is talking with financial institutions, and he believes pressures are coming and that people in the broader sense are beginning to wake up to the issue.

Summary 2:

We must collect data on the value of our rivers & communicate this value to a wider audience to forward an agenda promoting river/water quality.

Major Points:

- System-scale planning and management of river ecosystems and river species
- Freshwater ecosystems contain an incredible amount of diversity in such a small amount of total global habitat
- These systems are under increasing threat on multiple fronts
- Linked to a theme of "Valuing Water"

- Hidden values of freshwater systems: Food, livelihoods, flood mitigation, fisheries, biodiversity
- Sand mining may be a much larger issue for freshwater ecosystems than we know
- How much will it cost to replace what we are destroying: economics for water and rivers
- Estimating total economic value of rivers and water—risks and opportunities
- Water issues = risk for businesses…how to engage this sector to create mutually beneficial outcomes
- What is the appropriate energy mix to grow an economy?
- "We need to be energy specialists, not just Mahseer specialists"

Discussion:
Q: What is the status of catfish in the Mekong River?
A: There is an opportunity to turn protection into bankable opportunities, but we must be careful about how to approach financial institutions. Its not about ecology, but return on investment.

Q: Are issues with sand mining effecting practices at all?
A: Vietnam villages are being swept away due to sand mining. Blockchain could be used to trace this somehow?

All Tor are not the same! Status and Challenges for Stock Enhancement of Mahseer in India
Rajeev Raghavan, Kerala University, Mahseer Trust & IUCN Freshwater Fish Specialist Group

Abstract:
Stock enhancement, the release of hatchery-produced fish into the wild, has been widely regarded as the ultimate and immediate solution to declining fish populations. They have been used as a popular conservation tool in both freshwater and marine realms in both the developing and the developed world. Despite the worldwide expansion of stock enhancement programs, its outcome and impacts remain poorly understood. Mahseer comprise a major group of freshwater fish subjected to stock enhancement programs across India, having been introduced to various biogeographic zones. Considered as the biggest conservation effort for any group of freshwater fish in India, hatchery-assisted stocking of mahseer, often from few founder populations has resulted in the movement of fry and fingerlings to both within, and outside the native range of the various species involved. Artificial propagation and stocking, for example, has resulted in expansion of distribution range of some species (Tor khudree and T. tor) and resulted in the extirpation of others (endemic species such as T. remadevii). Despite published evidence on the conservation issues associated with unregulated stocking, various species of mahseer (within Tor and Neolissochilus) continue to be artificially bred and moved across the country, increasing risks to endemic species with a restricted range. My presentation aims to highlight the issue of misinformed stocking of mahseers in India, raise urgent awareness of the impacts of past and present stock enhancement activities within the context of both conservation and sport fisheries, and discuss the need for improved captive breeding and stocking programs in the backdrop of 'taxonomic uncertainties' and 'precautionary principle' and following the framework of the 'IUCN guidelines for ex-situ conservation and reintroduction'.

Presentation Summaries:
Summary 1:
Dr. Raghavan discussed knowledge gaps and issues associated with hatchery and stocking practices in mahseer. He summarized problems stemming from unscientific stocking practices and calls for research-driven stocking practices informed by ecological and genetic evidence, which should inform new guidelines for a responsible hatchery and stocking program.

Major Points:

- Knowledge gaps: How many species, what are their distributions? Are populations declining: quantitative versus anecdotal evidence? What are the ecological requirements? Impacts of threats?
- Rajasthan hatchery-produced hybrids have shown some hybrid vigor. These "Frankenstein mahseer" have no records of intentional release, but it is possible they have been stocked (accidentally or otherwise).
- Many years of haphazard and unscientific stocking are of major concern. From 1970s-2000 there were >7 million fingerlings stocked of T. khudree and "T. mussallah" (T. remadevii?), both within and outside their native ranges. T. khudree may have been stocked as far as the Mekong basin.
- Between 1995-2001, the hatchery also produced T. putitora (Golden), but with zero records of where these fish have gone! However, some putative T. c.f. putitora were collected in south-central India, well outside of the native range of the species, suggesting these may have originated from hatchery stock. Genetic studies suggest that the broodstock originated from western Himalayan T. putitora
- Roadmap for mahseer stocking: Established (e.g. IUCN guidelines), good understanding of native distributions, population management units, immigration, and stocking records; and completely re-establish all broodstocks using scientific practices (e.g. removing hybrids, and maintaining records of broodstocks). We also must identify management units which should be maintained as separate broodstocks.
- Lessons for countries which are not yet impacted (too much…) by irresponsible stocking (i.e. Bhutan): "Say NO" to stocking hatchery-reared fish.
- Dr. Raghavan notes that a very important contribution of the Paro Conference could be for members and member organizations to deliver a statement on responsible practices for mahseer.

Discussion:

» Dr. David Philipp asked if any countries stocking mahseer have official stocking policies. Dr. Raghavan responded that most countries have NO policy. Dr. Philipp noted that this is an important opportunity for Bhutan to be a model eader and develop policy for responsible practices.

» The next question was about the knowledge gaps in mahseer, with a general gist that we must do a better job of communicating species-specific research to the broader mahseer research and conservation community. An important function of the IMC establishes a forum for this.

Summary 2:

Stocking of mahseer in India has been carried out without considering the impacts on the native population. Stocking needs to be halted.

Major Points:

- Hatchery supplementation of native stocks often has negative effects
- Mahseer knowledge gaps: how many species, & what are their distributions? Are populations declining? What are ecological requirements? Impacts of specific threats?
- General consensus: most mahseer species in South Asia are in decline
- Hatcheries in India rear large numbers of fingerlings from all four species there
- Fish have been stocked widely across India & outside of their native ranges
- Golden Mahseer and Tor tor ranges have been extended because of stocking
- Authors are working on a global mahseer phylogeny
- Genetic evidence suggests at least two populations of Golden Mahseer in NE & NW India
- Failures: no evaluation of outcomes, no long-term impacts, recipient ecosystems are degraded, potential hybridization not understood.
- Fewer & regulated hatcheries could provide "common sense" stocking
- Need to understand distinct genetic stocks & levels of hybridization
- Eliminate all broodstock & juveniles held in hatcheries & captive breeding facilities

- Bhutan should avoid Indian influence in stocking programs
- Call for Paro Declaration: a position statement on mahseer stocking & introduction

Discussion:
Q: How many countries have a national mahseer stocking policy?
A: Unsure
Comment: Bhutan could be a world leader in creating a national stocking policy

Restoring Swimways for Fish Migration: Lessons from Local to Global
Arjan Berkhuysen, Managing Director, World Fish Migration Foundation, Groningen, Netherlands

Co-Author: Herman Wanningen, World Fish Migration Foundation, herman@fishmigration.org

Abstract:
Around the world, researchers, managers and governments have been working for many years to improve the situation for migratory fish by developing fishways, removing dam, rehabilitating rivers and exploring other solutions. However, the continued deterioration in fish populations demonstrates the need for more optimized approaches within the policy cycle and for ongoing refinement. During this presentation we will explore how developing strong fish migration visions, together with good cooperation's, communications, subsidy coordination and knowledge exchange from local to global level can lead to effective implementation of solutions. Lessons learnt from projects such as the World Fish Migration Day, From Sea To Source Vision, Dam Removal movement in Europe and Fish Migration River project, will be shared. Recently the World Fish Migration Foundation launched a new international book on Fish Passage experiences, called "From Sea To Source 2.0". This book provides a practical guidance to tackle river connectivity worldwide. There are over a million obstacles in European rivers alone. More and more rivers are now opened up again to improve fish stocks, of for example salmon, sturgeon and eel. "From sea to source 2.0" is a unique collaboration of over 100 international fisheries professionals from the fish passage network. It is supported by river managers, angling associations, governments, research institutes and NGOs including WWF and the Nature Conservancy. The book is full of inspiring stories, hard lessons learned and great successes from nearly every continent on the planet.

Presentation Summaries:
Summary 1:
Focus on issues facing fish migration globally: awareness, scale of research (knowledge gaps), dam building in the developing world, and how the World Fish Migration Foundation is trying to help. "Happy fish, Happy people"

Major Points:
- "With current knowledge we would have done it completely differently"- the general feeling of dam engineers
- Fish Migration Days- celebration to create awareness of the importance free-flowing rivers. ~50 million people reached
- Major issue that studies are often very local. Need to study from "source to sea". This presents obvious logistical and financial difficulties.
- Major goal is to map the major "fishways" of the world (e.g. as in flyways for birds)
- A really important takeaway here is that we as fish scientists need to take a larger part in communicating issues with the public, as this can ultimately propogate upward to policy. We need to cultivate value in the public.

Summary 2:
Outreach at a global level will help increase the number of advocates for migratory fish.
Advocates for migratory fish include: local stakeholders, anglers, scientists, science communicators, and financiers. Scientists help inform the science communicators who are perhaps better equipped than scientists to increase the general pool of advocates via social media and messaging, and, in addition, these communicators understand how best to bring financiers into the fold.

- Outreach: World Fish Migration Day—a celebration of fish migration
- Studies of fish migration are often focused locally
- Because networks are site specific a global consensus could be informative
- Outreach combined with a connected network of interested participants

CONFERENCE ABSTRACTS

Reproductive Behavior and Spawning Response of Sahar, Tor putitora, in Tropical Region of Nepal

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Abstract:
Mahseer (Tor putitora) also known as Sahar in Nepal, is a high value indigenous riverine species which is declining in its natural habitat and has been declared an endangered species in Nepal. Limited seed production using natural propagation has restricted its expansion in culture as well as rehabilitation in natural waters. Sahar is an intermittent in spawning behavior, can breed twice or more than that in a year. Maturation time of this species is much shorter then carps and can get over maturity within a short period in natural spawning. It is long migratory during spawning season when river and rivulets are full of flood. We achieved success in artificial propagation of sahar using synthetic hormone. The breeding program was conducted at the Agriculture and Forestry University (AFU), Rampur, Chitwan and the Center for Aquaculture Research and Production (CARP), Kathar, Chitwan, Nepal during February to April 2017. One hundred male (0.4-1.5 kg) and sixty-five female (0.75-2.5 kg) brood fish were reared in 500 m2 earthen ponds at 1000 kg/ha. Fish were fed with 35% crude protein feed at 3% of body weight per day. Maturity was observed in two days interval by sampling fish and testing softness of the abdomen. Female broodfish with a soft and extended abdomen were injected with synthetic hormone (Ovulin) at 0.5 mL/kg body weight. Males did not receive any hormone. After 24-26 hours of injection, ova from injected females were obtained by simple hand stripping and fertilized with milt collected from males. The fertilized eggs were incubated in Atkin hatching trays. A total of 16 females were induced to spawn, and they produced 1630-3552 eggs per kg body weight. Egg fertilization, hatching and larval survival rates were 90-97, 75-80 and 70-75, respectively. This study demonstrated that mass seed production and larval rearing of sahar is possible in the tropical region of Nepal using induced breeding. When using natural spawning, a high frequency of females is not taken until they are overly mature, even with daily evaluation of maturity. Induced spawning reduces the number of over-matured females by synchronizing the stripping time of injected brood fish.

Key Words: Endangered, Migratory, Maturation time, Intermittent, Induced spawning

Presentation Summaries:

Summary 1:

Research objectives were to determine breeding habits of Tor in Nepal, with the goal of developing propagation methods for aquaculture. They found that induced spawning was an effective method.

Major Points:

- Breeding season in tropics was found to be the same as at higher elevations.
- Hormone-induced spawning was successful, with relatively high egg output and hatching rates as compared to natural spawning.
- Males reach maturity earlier than females (at 1 vs 3+ years), and 2 spawns per year can be seen in hatchery

Discussion:

» First question asked if maturity in the wild varies from that seen in the hatchery. Discussion followed that growth rate is similar although varies in the wild between more and less tropical regions.

» Discussion continued regarding the source of broodstocks. Initial broodstocks were established by collecting spawn in the wild, with individuals released. The impact of this on genetic diversity within the hatchery was not discussed due to time constraints.

» Responsible hatchery actions and the need for science-based guidelines for their use was a topic that continued to come up in discussions throughout the conference.

Summary 2:

Hatcheries can create fingerlings successfully.

- Tor putitora & Tor tor in reported in Nepal
- Important fish resource (aquaculture)
- 85% of aquaculture in tropical regions
- Objectives: to determine breeding performance, breeding season
- Reared broods of Tor in cement pond using standardized methods
- Breed twice per year spring & autumn in pond condition
- In natural waters fish spawn during monsoon

Discussion:

Q: Males maturing at small size in experimental hatchery, what size is required for successful stocking in nature?

Q: Is hatchery supplementation worth the effort? (Suggested it may be a waste of money)
A: Yes, because breeding is easy

Distribution and Status of Mahseer Populations in Pakistan

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Abstract:
Mahseer was originally widely distributed in the Indus Basin in Pakistan and occurred in its migratory range extending from the Kabul River and its tributaries in the Hindukush Range in the west to Sutlej River in the Himalayan Range towards the east. Its principle breeding and feeding areas lay in the mountain streams that provide ideal sequences of riffles and pools in single or multi-channels configuration. In the winter, the migratory range of the fish extended as much as 500 km into the plains in the Indus Basin where it was found as far downstream in the Indus River at the city of Multan. Geologic changes first resulted in diversion rivers in Punjab that used to flow into the Ganges Basin towards the Indus Basin thus segmenting the habitat of Mahseer in the Himalayas, and later in the separation of Hingol River in Baluchistan from the Indus Basin where a healthy population of Mahseer is still found. Finally, in the last century, construction of irrigation barrages in Indus plains and storage dams in the mountains have resulted in drastic modifications in continuity and flows, resulting in at least 13 populations of Mahseer that have been separated with varying degrees of genetic isolation. A framework has been developed for a strategic assessment of the impact on habitats and degradation that has resulted from imposed modifications in flows and continuity, present threats to habitat form economic activities such as unregulated fishing and sediment mining, and expected impacts on habitats from future developments. This framework can provide guidance to biodiversity managers for development of strategies and plans to rehabilitate populations of Mahseer and other migratory fish.

Presentation Summaries:
Summary 1:
Habitats were scored on the basis of geomorphology, water quality, human pressures, and connectivity in order to find the habitat components determining population status and connectivity. This work is still in a preliminary stage, and unfortunately time ran out before discussion of results.

Major Points
- Similar to elsewhere, human impacts are very apparent- diversions, damming, and irrigation in particular have caused drastic impacts on flow regimes and continuity of rivers. As a result, populations today are fragmented.
- The next step is validation of this framework- does it explain patterns of abundance? What habitat components show the greatest effect?

Summary 2:
Serious population fragmentation of Mahseer populations in Pakistan have led to a framework for assessing habitat quality for mahseer across the country that may be employed across the range.

- 14 distinct populations of Mahseer in Pakistan
- Fragmentation is serious concern here resulting from dams in mountain regions
- Framework for habitat assessment: scored habitats where populations occur using geomorphology, water quality, management & pressures, & connectivity of habitat
- Poonch river is a good example of quality habitat conditions

Distribution Status of Golden Mahseer, Tor putitora, in Uttarakhand India and Way Forward

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Abstract:
The golden mahseer, Tor putitora (Hamilton, 1822) is distributed along foot hills of the Himalaya and in Uttarakhand state; this species has its distribution range from 300m to 1500m altitude. Historically, it was distributed from west, Alakhnanda- Bhagirathi river system to river Kali in the east, along the border of Nepal. A migratory species, Golden mahseer, used to migrate from lower reaches of Ganga to the upper reaches of its tributaries for spawning. But presently, the river habitat have been drastically modified and fragmented because of construction of hydro-power dams/barrages built downstream to upper reaches of Himalayan river systems. Due to these barrier effects, breeding and spawning grounds of golden mahseer habitats have considerably lost. Even, fish population of Saryu and Kali River may suffer in the coming years due to the proposed Pancheswar dam. Currently, the fragmented population of golden mahseer occurs from Rishikesh to Srinagar in Alkahnanda River; upto Koteshwar dam in Bhagirathi River to Tehri dam till Maneri hydro power plant and in tributaries of River Ramganga (Kohlu, Kosi and Khoh). Hence, it is necessary to protect these river systems and this majestic fish species from extinction. To conserve and restore this species, we need to understand its habitat, migratory pattern and spawning biology. For this, a study is being initiated by Wildlife Institute of India and WWF-India in collaboration with Uttarakhand Forest Department to understand the abundance, movement, migration and spawning grounds of golden mahseer in apprehension to the present scenario using Radio Telemetry techniques.

Presentation Summaries:

Summary 1:
Habitat characteristics were categorized for sites containing mahseer, in order to habitat preferences and usage of Tor putitora in Uttarakhand. Preliminary results show associations of flow, depth, and substrate composition with mahseer presence.

Major Points:

- Once again indiscriminate fishing, over exploitation, and habitat degradation/ fragmentation form the primary threads to Tor. Existing and planned dams are also of major concern with regards to inhibiting migratory pathways.
- Mahseer were found generally to use habitat with small boulders, cobblestone, and sand. Habitat preferences were shown for.
- The next step is to examine food preferences via gut content analysis, and to better inventory habitat utilization during different seasons using radio telemetry.

Discussion:

» The first question asked about the specificity of sampling methods for juveniles specifically, and if habitat preferences differed between juveniles and adults. This is of particular importance given the migratory life history of this species. Response was that juveniles were not sampled (although observed in some cases). Discussion followed that the potential impact of planned hydropower projects should be examined.
» The next question was of how we account for human harvest pressures in making density estimates. No resolution was found.

» Dr. David Philipp asked about the proposed protocol for radio telemetry. Answer: Tracking will be performed manually. Discussion continued on the exact method for telemetry, specifically on what sort of tags are used and how they will be attached. A major point was that external tagging would not likely be effective for mahseer. The ongoing telemetry work in Bhutan provides an excellent model for studies such as this going forward.

Summary 2:
More knowledge about the distribution, migration patterns, and ecology is necessary for conservation of Mahseer.

- Typical pattern of upstream migration for spawning—incorporate in management?
- Usual threats mentioned in previous talks.
- Assessed habitat to determine preferences of Mahseer.

Discussion:
Q: Juveniles hard to catch? What habitat do they prefer?
A: We do not catch juveniles

Q: How to control for habitat management differences?
A: Will consider, but had not previously

Q: Will radio tracking be done manually?
A: Yes

Q: Is tagging external? Radio tags outside fish? MAJOR ISSUE
A: Yes, attached with straps
Comment: Tags should be internal—better for the fish

Mahseer as a component of Fish Biodiversity in Bhutan
Presenting Author:
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Co-Authors:
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Abstract:
Bhutan is endowed with rich natural water bodies in the form of rivers, streams and lakes that display a rich diversity of aquatic life. Bhutan's rich water resources are being used for many development activities ranging from fish production to hydropower. To ensure that aquatic resources are being utilized sustainably, it is important that management plans be developed based on sound scientific data. Because there currently is no comprehensive database on the fishery resources of Bhutan, it is imperative that such a database be developed. The National Research Centre for Riverine & Lake Fisheries in this regard is in the process of assessing fish fauna both in terms of species composition and distribution in Bhutan major river systems.
Study in the western part of Bhutan has already been completed with 104 species of fish in total listed. Assessment of fish fauna in the remaining parts of the country (central and eastern) is currently on-going. The study when completed will provide a baseline information for Species Account in each river systems of Bhutan, which will then provide a basis for fishery specific management and conservation needs to be in place.

Presentation Summaries:

Summary 1:

Karma described the work of the Bhutan DoL fisheries research centre in Haa to catalogue, describe, and survey the fish biodiversity of Bhutan. This work has thus far culminated in a published field guide to the fishes of the western drainages, with the eastern drainages nearing completion. This comprises the first ever biodiversity database for ichthyofauna of Bhutan.

Major Points:

- Establishing conservation policy requires a 'biodiversity baseline': What species are there? Where do they live? Only after studying their biology and preferences can we build effective management plans.
- A major component has been capacity building: Sampling started with self-made electroshockers manufactured from a motorcycle battery and mosquito nets in the place of seines. Equipment and techniques have evolved through time.
- Incredibly thorough sampling. >104 species found in west, 18 new found in east so far.
- Not sampling mahseer doesn't mean they aren't there; complementary sampling techniques are necessary. They are working on pioneering new techniques such as sampling DNA directly from the water to identify presence or absence of mahseer.

Discussion:

» The first question asked if sampling was constrained to low water seasons. Karma responded that sampling extended across all seasons except monsoon, which is infeasible.

» Further discussion questions the habitat use of golden mahseer juveniles- do they remain in small streams or large rivers? In India, they found that juveniles tend to stay in fairly small tributaries. One individual also commented that fry can be found commonly near the spawning site- this points out another aspect of research which is needed, which is to examine larval and juvenile dispersal and how this contributes to population structure in golden mahseer. As Karma noted, sampling juveniles is difficult especially with some sampling methods. A potential role for eDNA sampling as a solution was brought up during the presentation although there was not time to explore this in discussion.

Summary 2:

Bhutan is working on fish biodiversity sampling across the country to provide baseline data for fisheries conservation.

- Baseline information required for successful conservation efforts.
- Collections made at over 200 sampling stations spanning all major river basins.
- 122 species collected (18 additions to previous species list)
- Sampling is very challenging given the terrain & stream substrate.
- Juvenile Mahseer are difficult to collect.
- Using a combination of sampling methods in order to maximize detection will increase the resolution of Mahseer distribution estimates, & can be utilized to reveal more about their ecology

Discussion:

Q: Sampling season?
A: We sample three seasons & exclude monsoons (due to danger)

Q: Have you tried sampling smaller streams for Mahseer?
A: Good comment, will consider
Comment: Yes, juveniles will be in the small tributaries for up to 1 year after hatch

Riverscape genetics defines population connectivity in Golden (Tor putitora) and Chocolate mahseer (Neolissochilus hexagonolepis) (Cyprininae: Torini) in Bhutan

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Abstract:
The landscape of Bhutan is defined by elevational gradients that promote vulnerability to climate change. To preserve terrestrial biodiversity, Bhutan is constitutionally committed to conserving >60% of its land as protected areas. However, its aquatic biodiversity is poorly understood and the conservation status of native fishes virtually unknown. One charismatic species, the Golden Mahseer (Tor putitora) has gained attention as a result of potential hydropower threats. A recent telemetry study of adult movement patterns suggests extensive migrations to spawning habitats in tributaries. The present study extends telemetry findings by collecting genetic data on Golden Mahseer and contrasting it against data gathered for Chocolate Mahseer (Neolissochilus hexagonolepis). We defined fine-scale population structure using a genomic approach (ddRADseq: double-digest Restriction Associated DNA sequencing) with variation assayed at over 40,000 nuclear loci (SNPs: single-nucleotide-polymorphisms). Initial results indicate population connectivity is defined by riverscape characteristics, including drainage patterns and stream-networks. Analysis of juveniles from tributaries suggests a population structure defined by localized reproduction. These results promote management decisions aimed at long-term conservation of native fishes in general. They also provide a baseline from which to gauge economic development of aquatic resources that will benefit the Bhutanese people without jeopardizing aquatic biodiversity.

Presentation Summaries:

Summary 1:
Marlis described work using genetic data to examine population connectivity in golden and chocolate mahseer. Differentiated genetic stocks were found in chocolate mahseer following an east-west divide across Bhutanese drainages. Work is ongoing for golden mahseer.

Major Points:

- Genetics data can be used to test and corroborate conclusions found via other methods such as radio telemetry.
- Major question: Do we have different genetic stocks of Mahseer in Bhutan? Do fish disperse between different drainages?

- Golden mahseer rare. To satisfy need for large sample sizes, we consider chocolate mahseer as a surrogate while additional Goldens can be sampled.
- Some population structure was found generally following an east-west divide: Manas tributaries vs. Wangchhu/Amocchu/Punatsangchhu. This seems to be continuous and weakly driven by stream distance, suggesting that dispersal is relatively high over the long-term.

Discussion:

» The first question asked about implications for stocking. Dr. Marlis responded that we should be careful until we better understand potential adaptive differences between populations. "Hatcheries seem like a good solution until they aren't a good solution"- essentially, hatcheries are not a 'silver bullet' solution, we can harm natural populations by making uninformed stocking decisions resulting from domestication in the hatchery or mixing distinct stocks. This was a recurring theme in discussion throughout the conference.

» The next question asked about the potential connectivity- today, this is disrupted by dams and other issues. Marlis responded that genetic differences accumulate over thousands of years, but that further inquiry in India would be fruitful. She noted that the telemetry study presented by Dr. Philipp showed low levels of dispersal out of Bhutan, suggesting a strong possibility for adaptive differences between Bhutanese and Indian Mahseer.

» The next question asked about dispersal and gene flow, and Marlis noted that this is an evolutionary process, and very little dispersal over many thousands of years can still maintain genetic connectivity. This emphasizes the distinction between the contemporary timescale at which telemetry works, and the historical patterns which population genetic methods examine.

Summary 2:

Understanding where distinct stocks of Mahseer occur is paramount to their conservation.

- Genetic analyses can be used to determine population structure & connectivity.
- Are there distinct stocks of Mahseer?
- Do Mahseer migrate among populations?
- 2 populations of Golden Mahseer.
- 3 populations of Chocolate Mahseer.
- Much genetic diversity found .
- Isolation by distance is influenced by stream distance & landscape features

Discussion:

Q: What does this mean for stocking?
A: These methods can be used to measure a baseline of genetic diversity to determine effects of stocking

Q: Are Mahseer in India genetically distinct from Bhutanese?
A: I expect them to be different due to limited connection & different habitat

Technological advances in wildlife telemetry: Insight into real-time behaviour of animals

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Abstract:

Most radio telemetry studies currently require researchers to physically visit receivers to collect observational data. Receivers in remote, hard to access areas will have long times between visits, risking unreliable data (unknown power outages, antennas blown down, etc.), and site visits are often expensive. A new system has been developed that integrates multiple device connections to the internet and

records the data to a centralized database in real-time. This system, called the Multi-protocol Integrated Telemetry Acquisition System (MITAS), allows for near instant receiver status checks, real-time analysis of the observations made by the receivers, and resource savings for obtaining data. In this experiment, Sigma Eight Inc. receivers (model Orion) were placed on either a wired network, or wireless cellular network connection in Aurora, Ontario, Canada and transmitted data to a MITAS server located in Sydney, Australia. There was over 99.68% transmission efficiency from the receiver to the database, using a 30Mbps connection for the wired receivers, and a LTE connection for the wireless receivers.

Presentation Summaries:

Summary 1:

John works with Sigma Eight Inc., which produces equipment for radio telemetry. He contrasted technologies for telemetry and how these can be useful in a scientific context.

Major Points:

- Data collection must be controlled and standardized so as to minimize bias.
- GPS is high accuracy, but expensive and requiring large batteries. Acoustic methods are cheap, but very limited in where it can be applicable (e.g. in a river it would be ineffective). VHF/Radio is the most cost-effective, and can be used in water as long as it isn't overly deep or saltwater.
- Sigma Eight has developed a system called MIDAS which automates more of the process, and solving issues due to manual collection from receiver stations although dependent on an internet connection and thus limited in remote areas.

Discussion:

» This first question asked about limitations of the system: How far can the transmitter be from the receiver? How deep can the water be? The answer is essentially "It depends", since multiple factors such as interference and conductivity of the environment will cause variation.

» Continued discussion asked about the efficiency of the internet-connected receivers. This would depend on local internet connection, however in cases of outages the receivers will store data locally. Applicability to remote areas of Bhutan and Nepal would depend on the internet connection as well.

» Julie Claussen asked about the usage of this system in terrestrial systems. John responded that the setup of the system would be the same with terrestrial animals, although the range (distance from receiver to transmitter) can be much longer (>3km potentially). Dr. Philipp noted that even with deep water, distances can even be 0.5-1km as long as there is a line-of-sight transmission pathway, based on observations made in the Bhutan telemetry study.

» Discussion continued to the issues of the topography of countries such as Bhutan and other mountainous areas. John mentions that it is possible to "daisy chain" an internet signal from areas which do have signal, or using satellite. Cell signal could also be a possibility?

Summary 2:

Radio tagging is a cheap and effective means of tagging aquatic and terrestrial wildlife.

- Comparison of tracking technologies: GPS, Acoustic, VHF (radio)
- VHF is cheapest & easiest, but resolution is low

Discussion:

Q: Limit on distance between transmitter & receiver?
A: Depends largely on conductivity & interference. To solve you can calibrate.

Q: Has this technology been used in Himalayan countries?
A: Requires good internet connection

Q: How about terrestrial organisms?
A: Works well regardless of animal, & transmitters/receivers can be setup to track both at the same time.
Comment: In Bhutan the technology is working well.

On the Brink: Population Status of the World's Largest and Most Threatened Mahseer
Presenting Author:
Anoop V.K, Kerala University of Fisheries and Ocean Studies

Abstract:
Of the 16 valid species of Tor mahseer occurring in the freshwaters of Asia, the hump-backed mahseer, Tor remadevii, growing to sizes >54 kg is one of the rarest and the only Tor assessed as 'Critically Endangered' on the IUCN Red List. The hump-backed mahseer is endemic to the River Cauvery and its tributaries in South India. Though known in both scientific and popular literature since the 1920s, as the 'hump-backed mahseer' and 'Tor musullah', the exact identity and nomenclature of the species was cleared only recently (2018), leading to a comprehensive range-wide survey to understand microlevel distribution, population status/trends and threats. Despite being common in the Cauvery Wildlife Sanctuary until the mid 2000's, surveys have only been able to confirm the current presence of the species in Moyar, Pambar and Bhavani tributaries of the Cauvery, with small numbers also present in the main stem of the upper Cauvery flowing through Kodagu. Potential yet limited presence of T. remadevii in the Kabini (a major tributary of Cauvery) is pending confirmation from genetic studies. At all confirmed sites, abundance is extremely low dominated by juveniles with records of adult fish rare. Local knowledge reveals that both number and size of individuals have declined over last few decades. In the last remaining sites of occurrence, T. remadevii is facing an array of stressors including indiscriminate fishing, habitat loss, pollution and alien species. We provide a site-based status overview of the most threatened mahseer species to inform conservation action and policy.

Presentation Summaries:
Summary 1:
Mr. Anoop summarized status of humpbacked mahseer (T. remadevii) and the result of novel field surveys, and examined anthropogenic threats to extant populations. T. remadevii was found to be highly impacted throughout much of their native range, with much critical habitats in the Moyar, Bhavani, and Kabini rivers being outside of protected areas.

Major Points:
- Major threats for T. remadavii are once again illegal fishing and habitat degradation due to damming, which causes migratory barriers and sedimentation. Introduced species, pollution, and non-discriminate fishing practices (e.g. gill nets) are also major issues.
- Field surveys have shown distributional overlap and co-occurrence with bluefin mahseer. Given the critically endangered status of humpbacked mahseer (and associated low effective population sizes), I wonder if genetic erosion by hybridization with bluefin could be a conservation issue?
- Mr. Anoop showed two videos of locals collecting migrating fish in narrow rapids, inside a protected area. This was strong imagery demonstrating the conflict between community needs (i.e. fish as a protein source) versus conservation objectives. This unfortunately seems to be a ubiquitous issue for mahseer, in Bhutan as well. This also echoes the message that regulation and enforcement without community incentive won't work.

Summary 2:
Humpback mahseer populations are declining where they occur in India, but populations still persist. Severe pressures from humans threaten the existence of this species.

- Humpback mahseer, Tor remadevii—most threated species of Tor
- Species was validated in 2018, otherwise little scientific interest for 150 years
- Aims: population status, distribution, threats, conservation strategies
- Size of fish may be in decline
- Humpback feed on fruits from riparian zone
- Threats: Illegal fishing & dam sedimentation; pollution & exotic species

There was no time for questions.

Impacts of Non-Native Fish on the Ecological Security of Mahseer Species in the Indian Himalayan Biodiversity Hotspot
Presenting Author:
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Abstract:
Mahseer fish species are critical components of locally-adapted freshwater food webs, serve important roles as a nutrition source (a provisioning ecosystem service), and provide cultural values across the Indian Himalayan biodiversity hotspot. Associated fisheries along Himalayan mid-hill and foothill river stretches, including in the Shivalik Hills and parts of the Terai (region between the lower foothills of the Himalayas and the plains), provide livelihood security for millions of people. Diverse anthropogenic stressors, compounded by changing climatic variables (e.g. temperature and rainfall), have significantly depleted native mahseer fish populations over recent decades resulting in them now being considered locally vulnerable or endangered. Numerous hydropower projects have fragmented mahseer populations, impairing genetic exchange, obstructing migratory paths of species and changing the structure and functioning of riverine habitats, especially of formerly fast-flowing rivers. In-depth literature survey, focus group discussions and semi-structured interviews have revealed that the current increasing spread of non-native fish species compounds these threats to native mahseer species and overall freshwater ecology. The need for better understanding of the distribution, habitat requirement and movement behavior of non-native fish species is therefore essential to manage growing threats towards mahseer in the region.

Major Points:
- It is important to consider the social and cultural importance of mahseer when designing conservation policy, in addition to the ecological significance. People catch mahseer for food and sale in the fish market. What will be the impact on local livelihoods moving forward?
- “Do we need a legal umbrella protecting these species?” An additional question is whether or not such protections would be effective, and what the social impacts/conflicts are.
- By 2050 we expect warming, greater monsoon, higher precipitation, and losses in glacial mass. What will be the impacts for mahseer?
- Common carp, brown trout, rainbow trout, mirror carp, silver carp, grass carp, and crucian carp are all considered to be impactful as invasive species. Of note, aquaculture of these species as a food source is ongoing. Issues are predation (esp. on mahseer eggs/fry) and competition for similar resources.

- How to move forward? State Action Plans on Climate Changes do not consider mahseer. The need is to directly communicate needs and actionable policies to decision makers, in the appropriate language.
- Otters are a major conservation focus- how important is mahseer for otters? Can we link biodiversity protections across species or communities?

Discussion:

» Discussion kicked off with how we can get policy makers and religious leaders on board. Dr. Gupta emphasized the need to communicate directly and in lay terms why mahseer (and other species) are important and what the benefits of protections are.

» Dr. Marlis Douglas asked what sort of issues may be presented by increased monsoon under a warming climate. She noted that an important issue is environmental cues associated with flow changes (e.g. to trigger migration). Dr. Gupta agreed that mahseer migrate to tributaries pre-monsoon and return after, and that environmental cues such as temperature and flow can certainly impact migratory patterns. Discussion returned to this topic later, that silt load in the water, as well as water level, are likely important cues for migration and spawning. These are already being disturbed, indicating a need to investigate how populations are responding today.

» Dr. Steve Cook asked how we can balance between the need for immediate short-term change, while also making long-term plans. i.e. if we focus on long-term, we may lose the mahseer in the meantime. Dr. Gupta noted that he tries to communicate a mixture of both perspectives, as they are inextricably linked. We need to deal with current issues such as mining and damming, while keeping a long-term vision in mind. Discussion continued on the broader issue of communicating what we are doing, what works and doesn't work, and collaboratively moving forward. Dr. Gupta echoed the issue of communication and distribution of ideas among workers of the field. He was also asked about communication with the public, via traditional and social media.

Summary 2:

Mahseer in India are impacted by the typical stressors mentioned elsewhere, but also a stocking program of non-native species.

- High demand for mahseer leads to over-exploitation
- Legal protection for mahseer should be considered
- Knowledge gaps reduce the effectiveness of conservation efforts
- Changing climate may exacerbate the issues Mahseer are facing
- Many exotic fish species may have negative impacts on Mahseer due to competition for food and habitat, and predation (e.g. common carp)
- Mahseer are prey for many otter species which also require protection (Linking conservation of species together)

Discussion:

Q: Is stocking [of non-natives] a continuous process?
A: We have not looked at the stocking process, just current distribution on non-natives.

Q: How will more erratic monsoons effect homing cues of mahseer?
A: Need to understand via telemetry weather increased monsoon size may delay or otherwise impact migration to spawning grounds

Q: How to balance immediate threats with long-term vision?
A: Best to be a mixture of both.

Pattern of Abundance, Habitat, Threats and Conservation Priority of Narmada Mahseer (Tor tor): The State Fish of Madhya Pradesh

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Conservation of Narmada mahseer (Tor tor. Ham.), the state fish of Madhya Pradesh province of India is emerging as a new challenge for biodiversity managers. Construction of a series of dams on many rivers in the state, in recent times is one the known major threats to the lotic breeding grounds of this flagship freshwater fish of Narmada and many other river systems in Madhya Pradesh. There remain significant gaps in the existing knowledge on pattern of abundance, distribution, stock, habitats and prioritization of important spawning grounds of Narmada mahseer in recent times. Several studies have indicated declining trend of Narmada mahseer owing to the indiscriminate fishing of broodstock and juveniles, fast degradation and fragmentation of habitat and other anthropogenic pressures. Alarming decline in population of of Narmada mahseer (25-30 % to roughly 3%) has been reported by different authors. Considerable alteration of substrate, sediment load and flow are considered to be the main reason for the decline of Narmada mahseer. Since mahseer (T. tor) has been declared as state fish of Madhya Pradesh, it is recommended to ensure that the habitat, spawning and migratory requirements of mahseer are fulfilled. This paper presents field observation based information on current pattern of abundance, distribution, habitat, ecology, biology, threats, conservation priority of Tor tor in river Narmada, identifies research gaps and advocates innovative strategies for their sustainable utilization and management. Protection of remaining suitable habitat in pristine forested zones of Madhya Pradesh is a ray of hope for bringing back the glory of this so called 'Tiger of Freshwater'. This paper suggests a reverse hierarchy of fish-freshwater-forests (3F) connection and evaluates potential role of foresters in conservation of Mahseer in dense forested watersheds of Madhya Pradesh. This paper recommends on the basis of field experience in Barwaha forest division, that field foresters can play a significant role in identification and mapping of mahseer habitat in forested zones, protection of identified habitat, monitoring of changes in Mahseer occurrence pattern, tracking of Mahseer migration pattern, species restoration in wild through in-situ conservation, conservation breeding and ranching and community based ecotourism including fish watching, angling and release.
In addition to studies of habitat and population dynamics of Narmada mahseer, the paper is also reporting an initial process of institutionalization towards mahseer conservation in India through a pan-Indian informal group of mahseer lovers, ie, Fans of Indian Mahseer (FIM) and outlines a unique MIRACLE (acronym) strategy for mahseer conservation which includes mapping of habitat, involving people, research and data collection, advocacy for policy and legal framework, conservation measures, livelihoods connections and extension and training of frontline foresters.

Presentation Summaries:

Summary 1:

Dr. Saxena summarized the different strategies taken for promoting management of T. tor in India, and detailed a framework for outreach, research, and ultimately policy making.

Major Points:

- Surveys show T. tor of all life stages are captured in forested streams. As such, foresters play a vital role in mahseer management. "If you have good forests, you have good streams".

- Dr. Saxena promoted a "MIRACLE" strategy of Mapping habitat; Involving people (outreach); Research and data collection; Advocacy (for policy); Conservation; Livelihood (community/social impacts); and Extension (training/ capacity building).
- She is currently working with foresters to develop an atlas of mahseer in forested streams, and outreach activities to promote awareness and to involve policymakers.
- Both ex situ and in situ propagation strategies have been attempted. In-river propagation produced >10,000 fry. I wonder what the effects of different propagation methods are re: imprinting of fry for migratory behaviors as adults?

Discussion:

» The discussion was of limited time, but focusing on the issue of pressures of individuals and policymakers promoting hatcheries and stocking (esp. of non-natives), which contrast with ecologically-sensible policies.

Summary 2:

The author presented the MIRACLE framework for conservation of Mahseer.

- 76% decline of Narmada Mahseer over the last half century
- MIRACLE strategy for conservation
- M: Mapping of Habitat
- I: Involving people & Outreach activities
- R: Research
- A: Advocacy for policy & legal framework
- C: Conservation measures/management/regulation
- L: Livelihood connections of fisherman with Mahseer conservation
- E: Extension and Training: customized training for forest staff (capacity building)

Ecological Flow Requirement for Golden Mahseer (Tor putitora) – Estimation Based on Habitat Suitability Criteria

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Abstract:

Golden mahseer is one of the largest freshwater fish, inhabits in streams and rivers of Himalaya. The population of golden mahseer is declining all over its distribution range, due to river valley modifications, flow reduction, and habitat loss. One of the challenges in conserving this species is ensuring adequate flow for meeting the biological requirement of species. Often flow estimation procedures for hydrological alternation are either arbitrarily or based on expert opinion. Most of the time, the suggested flow are inadequate for species to meet their life history traits. Therefore, a method that incorporates species habitat suitability criteria would yield better e-flow estimate than any other approach. In this context, we have estimated ecological flow requirement for golden mahseer based on their microhabitat requirement. In this method, we have generated depth, flow and substrate suitability curve for golden mahseer based on species use recorded in Kosi river in Uttarakhand state. The generated habitat suitability curves were fitted into the cross-sectional data (depth and flow) of the Kosi river in the Physical Habitat Simulation Model (PHABSIM). The model was simulated to generate weighted usable area (WUA) for golden mahseer at different flow discharge scenario. The WUA generated in the model was

plotted against different flow discharge to detect the inflection point of the curve. The inflection point of the curve against given discharge was considered as ecological flow requirement for golden mahseer.

Presentation Summaries:

Summary 1:

Dr. Johnson reviews the e-flow (environmental/ecological flow) concept and uses habitat simulation models to characterize e-flow requirements for T. putitora. He applied habitat simulation models to generate a habitat suitability curve for T. putitora and determined the required flow based on their use/ preferences.

Major Points:

- Can fish ladders be effective in Himalayan systems? Dr. Johnson notes that, while effective for salmonids, cyprinids (to include mahseer) require natural passages.
- Before 2012, these was no "e-flow" (environmental flow) consideration in India. (Note that in this context, "environmental flow" is referring to discharge, timing and amount of water flow, flow regimes, 'mean seasonal flow').
- Many methods to quantify environmental flow, but site- and time- specific biases. These could be directly from flow data over time, or derived from relationships of width/depth and flow rates, via more complicated simulation models of more specific habitat requirements of biota. An 'holistic' method can also be used which considers basin-wide biotic/abiotic components, connectivity, and social components.
- Essentially what he does is make observations of mahseer habitat use in a reach (i.e. depth/ flow where seen in snorkeling surveys) to develop a habitat suitability curve. This can then be applied with high resolution depth and velocity data for other reaches to determine how much preferred habitat is available. But how many observations were used? How many are needed to be robust?
- PHABSIM models revealed depth and velocity preferences, with required flow being 52% of the flow during the 'lean' (low flow) season (=140 cum/s)

Discussion:

» Dr. Johnson was asked how these models apply to monsoon-dominated systems, as they are generally applied to temperate systems. He replied that the presented work is preliminary and that further validation is in progress. This is a salient point, as we know that mahseer intentionally seek different habitats during spawning season (which overlaps with the monsoon) and thus the characteristics defining their habitat use change

Summary 2:

Eflow may be used to assess the amount of viable habitat for Mahseer over variable flow regimes.

- Hydro-dams: barrier effects, loss of breeding habitat
- Are fish ladders effective for overcoming barriers? (Perhaps not)
- Hydro-dams: reduction of water flow—dry zones below rivers
- Environmental flow—flows that are released into a river system to maintain ecological integrity
- Steps for eflow analysis: Measure habitat frequency at cross-sections of streams; then measure habitat suitability curves for each species; finally determine the suitability of a stream reach for a particular species
- Use simulation to predict how variation in flow will affect how much habitat will be available

Discussion:

Q: How will seasonal effects (monsoon) affect this method?

A: Must study multiple seasons

Hydroelectricity and Fish Species- A Combined or Separate Chapter

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Abstract:
Development and nature conservation have always been a flip side. The development of infrastructure fulfilling the necessities of mankind have degraded natural habitat posing threat to species toward extinction. In past few decades, many areas have also been subject to significant ecological change owing to demographic, land use change, soil spoil and unsustainable extraction and dredging, construction of dams for hydropower and irrigation and development of road connectivity. Fish species is no exception threatened by these activities. Primarily, hydropower installation and damming of water tailored with construction materials extraction from the river bear severe threat of extinction of the fresh water fishes. As with the numerous rivers in Nepal, hydropower development has been raised. Majority of the rivers with feasible of hydropower production have provided approval for electricity production. Trishuli, Gandaki, Mahakali, Karnali and Koshi are the major rivers with higher production capacity. These rivers too bear globally threatened Mahseer species such as; Neolissochilus hexagonolepis, Tor chelyonides, Tor putitora and Tor tor. Series of hydropower plants is under construction and is in progress in the river course unconcerned to required minimum distance between two hydropower plants. This has posed the severely hindered fish migration; has fragmented aquatic habitat isolating fish population, hindered fish migration, degraded spawning sites and finally decimated species and population. Neither there is definite minimum distance between two hydropower plants state in the rules and regulation in Nepal nor developers are concerned about the effect to fish. Through baseline studies and monitoring visit of several hydropower plants, it is found that fish conservation has major obstacle for developers and is the least prioritized agenda. This have been posing the threat to survival of fish species in their natural habitat.

Keywords: Hydropower, Infrastructure, Mahseer, Threats, Nepal

Presentation Summaries:

Summary 1:
Mr. Shrestha discussed the linkage versus independence of hydropower and fish conservation issues, and the status of hydropower in Nepal.

Major Points:

- Mr. Shrestha showed data on number of hydropower licenses issues and applied for. (See powerpoint for details)

Discussion:

» Discussion centered around whether or not we can coordinate a 'pan-regional' perspective. Mr. Shrestha responded that the Nepalese government is taking many applications but not necessarily considering all relevant criteria in granting licenses.

Summary 2:
Dams pose a threat to Mahseer and other species.

- Nepal has many rivers and high hydropower potential; therefore, many dams are being built and planned there
- Much Mahseer habitat is being affected

Discussion:
Q: What is going to happen to all these waterways, because this happens in India as well.
A: Important question.

Q: Is there an attempt to create a regional plan for hydropower?
A: Nepal needs the hydropower, but should consider some regulation

Potential to Apply eDNA Technology in the Process of Assessing and Managing Cumulative Impact of Cascading Hydropower in the Trishuli River Watershed Nepal.

Presenting Author:
Pablo Cardinale, International Finance Corporation

Co-Authors:
Kate Lazarus, International Finance Corporation
Leeanne Alonso, International Finance Corporation
Yash Arora, International Finance Corporation
Ashok Baniya, NWEDC
Adarsh Man Sherchan, CMDN
Dibesh Karmacharya, CMDN –

Abstract:
Nepal needs hydropower development to grow its economy with a domestic and cost-effective source of energy. However, if not assessed and managed properly, hydropower projects have the potential to create long term, diverse, and significant adverse environmental and social impacts. In the case of the Trishuli River, the river basin has already been impacted by five projects in operation and dozens under various stages of planning and construction. Despite all these projects being subjected to individual ESIAs, they have not considered the potential for cumulative impacts from their combined activities. The Nepal Water and Energy Development Co. Ltd (NWEDC) and the International Finance Corporation (IFC) are co-developing the Upper Trishuli-1 216 MW HPP (UT1). In compliance with good international practice and IFC Performance Standards on Environmental and Social Sustainability[1], over the past three years the NWEDC-IFC consortium has been leading a Cumulative Impacts Assessment and Management (CIA) process not only to ensure that most significant potential cumulative impacts and risks are identified, but also to foster the creation of a multi-stake holder collaborative platform to coordinate environmental and social impacts and risks monitoring and management, comprehensive data sharing & permanent stakeholder communication, and a governance system to define trade-off in decision making and relevant adaptive management triggers. This CIA effort involved the Center for Molecular Dynamics Nepal (CMDN) to explore the use of eDNA to define existing aquatic biodiversity baseline condition, assess potential impacts of multiple cascading hydropower development in the Trishuli River, and their impact on longitudinal connectivity and habitat availability for key indicator species. This paper presents the preliminary eDNA results for Tor putitora‘s presence along selected sites in the Trishuli River currently or expected to be impacted by cascading hydropower, describes the genetic markers / methodology used, and suggests a mid-to-long term monitoring eDNA methodology to be used at the watershed level to assess the effectiveness of the measures implemented / proposed to mitigated potential cumulative impacts over this endangered species in the Trishuli River.

Presentation Summaries:
Summary 1:
Mr. Cardinale talked about the environmental and social criteria IFC used before funding infrastructure projects, and how eDNA is being combined with other methods of sampling in order to assess fit of environmental criteria for sites of planned hydropower projects in Nepal.

Major Points:

- IFC is the biggest private-sector financier in the world, thus has large interests in major infrastructure projects such as hydropower. IFC investments such comply with IFC environmental performance and social sustainability standards. E.g. social and environmental impacts of projects and how to manage, labor and working conditions, cultural impacts (e.g. on indigenous peoples or local heritage).
- A major performance standard for ICF investments is that natural habitats to not see net loss, or that critical habitats see net gain.
- Currently over 30 hydropower projects planned in Nepal (Tirsuli drainage), with 6 in progress and IFC financial backing requested for 3 projects.
- E-flow surveys were performed, and currently collaborating with Center for Molecular Dynamics in Nepal to develop eDNA sampling. Comparison of eDNA to traditional sampling shows greater number of species observed via eDNA.
- Relative abundances were estimated from the eDNA data (although I don't know how robust these estimates are…maybe more indicative of relative biomass??)
- A major question remaining is false positives: If we sample "T. putitora" is it really T. putitora DNA? Can we develop better species-specific markers?
- Can eDNA be used to estimate relative abundance? Can eDNA be used for long-term monitoring, and pick up changed in relative abundance?

Discussion:

» Dr. Marlis Douglas noted that there are nuances to marker development and that is important to better survey the literature and available resources before starting a project. She also questioned the applicability for estimated relative abundance and how comparable these estimates are among sites. Mr. Cardinale noted that these are questions their molecular collaborators are trying to figure out. Dr. Douglas noted that size of individuals will determine amount of DNA shed to environment, which means that estimating relative abundance is not a simple thing, and that amount of DNA in a sample per species is NOT the sample as relative proportion of that species in the environment. This is a very important point for us to consider in trying to interpret the results of eDNA surveys.

Summary 2:

eDNA increases the number of species detected in biodiversity monitoring program.

- Efforts underway to assess regional hydropower threat to ecosystems and use this to inform conservation
- One of the eight performance standards for international finance includes an assessment of biodiversity conservation and sustainability impacts of projects
- "Cumulative Impacts of Cascading hydropower"
- IFC (whom the author represents) provides financial backing for hydropower projects in Nepal
- Conducted field sampling to measure eFlow and fish communities using a variety of methods
- In addition, water is filtered at field sites to assess eDNA efficacy for contributing to biodiversity sampling
- More fish show up in the eDNA sampling
- The author mentioned issue with Tor putitora markers and with estimating relative abundance with eDNA, but this may have been misinformation (unintentional)

Discussion:

Q: Are you able to measure relative abundance at each site with eDNA?
A: We need more research, but we are currently attempting to measure eDNA research.

Monitoring of Impacts of Gulpur Hydropower Project on Populations of Mahseer and Other Fish Species

Presenting Author:
Ahmad Shoaib, Hagler Bailly Pakistan (Pvt) Ltd., Islamabad, AShoaib@haglerbailly.com.pk

Abstract:
The 100 MW Gulpur Hydropower Project is being constructed on the Poonch River in the Pakistan Administered Kashmir and is expected to start operation by mid-2019. The Poonch River provides a highly suitable habitat for the Golden Mahaseer Tor putitora. The full length of 104 km and associated tributaries were notified as a national park by the government in 2010. In addition to Golden Mahaseer, there are at least 35 species of fish in the river including the Critically Endangered Kashmir Catfish Glyptothorax kashmirensis and a number of migratory and restricted range species. The permission for construction of the project was given by the government that the project will achieve Net Gain in biodiversity consistent with the requirements of IFC Performance Standard 6 for projects falling Critical Habitat. A Biodiversity Action Plan inclusive of a Monitoring and Evaluation Plan was prepared for monitoring of the impacts of the project on aquatic biodiversity, and the outcome of actions for in-situ protection of the fish to achieve the Net Gain in biodiversity. Seasonal surveys following a defined protocol were initiated prior to construction of the project and the coffer dam that has created a barrier to fish migration, and have continued since. Results of monitoring show relatively higher increase in fish populations of most of the species upstream of the dam including the Mahaseer, while downstream the population of Mahaseer has remained stable. The results are largely consistent with the predictions of impacts made using the DRIFT DSS as a part of the project ESIA, and show that the impact of the barrier created by the cofferdam has been offset by the conservation program put in place. A special aspect which has been studied is the impact on fish populations of temporary diversion tunnels that allow fish to move downstream only. A separation has occurred in the populations of migratory fish, where species that prefer warmer water have accumulated downstream of the dam, while those that prefer cooler water have survived largely upstream of the dam.

Presentation Summaries:

Summary 1:

Mr. Shoaib showed results of surveying during construction of the Gulpur HPP.

Major Points:

- Gulpur Hydropower Project is a major dam currently in construction on the Poonch River in Pakistan, expected completion 2019. This is impactful because the river and associated tributaries comprise a national park and are habitat for golden mahseer (endangered) and Glyptothorax kashmirensis (critically endangered).
- A Biodiversity Action Plan including monitoring and evaluation was established in order to meet criteria of a “net habitat gain” for the project. Surveys began in 2015 prior to construction in order to establish a baseline. Construction began in 2016. Active (electrofishing and cast net) and passive (gill net and fyke net traps) sampling methods were used, although methods were not standardized across all surveys.
- Mr. Shoaib noted an overall increase in fish captured from 2016-2018 spring, summer, and winter surveys but it is unclear how this is supposed to translate to some meaningful change in diversity and whether or not this can be explained by change in sampling effort/ methods. Species composition, relative abundance? What has happened to the community?
- It is not clear how the presented results contribute to any form of conclusions re: the aforementioned BAP and quantifying net habitat change.

Summary 2:
A study backed by financiers is being used to suggest dams increase biodiversity.
Major Points:

- The condition for construction of a dam on the Poonch river was to establish a net gain in biodiversity.
- Developed a Biodiversity Action Plan to monitor wildlife.
- The data presented suggest biodiversity has increased following the construction of the dam. It is unclear how this was achieved.
- I would caution the interpretation of these data, because the sampling schedule was skewed towards methods that were less effective at collecting species earlier in the sampling schedule, while being skewed towards more effective methods later in the schedule. This bias could have been the cause of the "increase" in diversity.
- Another issue here is that number of species could increase, but the community could completely change. We have to decide if that is OK.

There was no time for questions.

An overview of bioengineering solutions for effective passage or blockage of aquatic organisms

Presenting Author:
Donald L. Pereira, Senior Fisheries Biologist at HDR

Co-Author:
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Abstract:
Many communities of aquatic organisms require a high degree of connectivity in order for individual species to access key habitats during all phases of their life history. Throughout the globe, humans have erected numerous barriers in riverine environments, for purposes including hydroelectric generation, irrigation, navigation, flood mitigation, aquaculture, control of unwanted or invasive species, etc. This presentation will provide a broad overview of some of the bioenegineering solutions available today that provide both upstream and downstream passage of desirable species, as well as blocking the movement of invasive species. These solutions are inherently complex and almost always require a detailed understanding of the target organisms ecology, including behavior and detailed life history dynamics, as well as the physical and operational environment within which a passage or barrier strategy is to be implemented. We will also describe some of the leading challenges and lessons learned in the design and implementation of effective fish passage and barrier systems.

Presentation Summaries:
Summary 1:
Dr. Pereira provided a survey of bioengineering approaches to fish passage and the financial and biological challenges to their implementation. A major point was made that what works in one place with one species cannot be applied unilaterally elsewhere (i.e. context matters!).

Major Points:

- Dr. Pereira described the variety of ways fish passages are engineered and the different challenged faced in upstream and downstream passage (see slides for details). A major issue is upfront cost and maintenance cost of different methods. Problems are also site-specific, and require consideration of the specific biology of the fish. Application of fish ladders to fish which are behaviorally excluded is a perfect example. "Biomechanics" critical.

- Fish don't survive traditional turbines. Some new developments for safer turbines.
- Need to establish transparent collaborative relationships. Better to do things right the first time, because retrofitting alternate methods may not be possible or financially realistic.
- Fish passage costs can be >$100M (!)

Summary 2:
Fishways could potentially mitigate issues dams create for fish migration and passage, however these solutions are expensive, and their efficacy has yet to be fully understood.

- There are multiple ways to move fish upstream and downstream past blockades such as dams.
- Fish passage solutions are site specific and depends on the fish which need to pass and their characteristics.
- Must gather information to assess the feasibility and design of these systems to determine if they are working to allow fish passage.

There was no time for questions.

Mahseer in Thailand and Conservation
Presenting Author:
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Abstract:
The Neolissochilus group found in Thailand can be divided into two groups i.e. the first group with dorsal rays 8-9½ and body depth 2.6-3.6 times SL. This group can be divided into two main groups 1) small eye 1.5-2.4 times HL (Neolissochilus subterraneus and Neolissochilus paucisquamatus) and 2) moderate eye 2.5-2.9 times HL (Neolissochilus soroides (no lateral stripe, eye diameter with 2.6-2.9 times HL, 21-27 lateral lines scales and iii-iv, 9-9½ dorsal fin rays), Neolissochilus vittatus (with lateral stripe, 23-25 lateral lines scales and iii-iv, 8-8½ dorsal fin rays), Neolissochilus sumatranus (thick lip with fleshy lobe on lower lip to chin, lateral stripe absent) and Neolissochilus stracheyi (normal lip without fleshy lobe on lower lip to chin, lateral stripe present). And the second group had dorsal rays 10-10½ i.e. Neolissocheilus sp. The conservation status, it should be protected them from monoculture of commercial agriculture in the mountainous area.

Presentation Summaries:
Summary 1:
Dr. Suvarnaraksha provided a survey of the mahseer species found in Thailand, including dichotomous keys, distributions, and life history information for each species, and issues facing their conservation

Major Points:
- 6 species of Neolissochilus in Thailand. Dr. Suvarnaraksha provided a dichotomous key and distribution maps of Neolissochilus of Thailand- see slides for detail.
- Extensive deforestation in Thailand a major issue, due to increased erosion and sedimentation. Introduction of alien species is also a major concern.
- Conservation has relied on a community-based approach. Local people have been taught to identify and propagate species, and protect their own local reserves of river.
- "ECONECO": Linking economy and ecology

Summary 2:
Outlook for Neolissochilus conservation in Thailand

- Ffish.asia
- Four genera of Mahseer in Thailand
- Many species of Neolissochilus in SE Asia
- Feeding behavior, sexual differences, food preferences were glossed over
- Teaching community to identify and appreciate diversity is important outreach practice
- Overall conservation strategy:
    1. Outreach
    2. Teaching locals to breed fish themselves
    3. Reservations (no harvest areas/preserves)
    4. Re-habitat
    5. Restocking (must know community composition first)
    6. Prevent introductions of alien species
- ECONECO = Economy + Ecology

There was no time for questions.

Multi-stakeholder Engagement in the Conservation, Restoration and Management of Golden Mahseer: An Initiative in Nayar River Valley, Uttarakhand, India

Presenting Author:
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Abstract:
Conservation of Golden mahseer in the upper stretch of River Ganga is a serious concern owing to massive habitat fragmentation and indiscriminate fishing of brooders. A major challenge is bringing together all local stakeholders and reconciling differing social and ecological issues. With financial support under 'Conservation Leadership Programme', we initiated community-based approach towards management of mahseer stock, so as to build long-term and inclusive conservation strategy for critical breeding grounds in Nayar River valley. We made an attempt to identify all major stakeholders from regulatory authorities, to individuals or groups working in the region and identified their interests and concerns through structured interviews, questionnaires and secondary data. We also mapped social status and economic interests of fishermen communities in three villages along Nayar River to develop an understanding of potential areas of conflict, synergies and ways to reconcile their interests with our long-term conservation goals. Several discussions were held with state regulatory authorities to build consensus on providing alternative means of livelihood for local communities, as well as involving them in future decision-making. We observed number of challenges in fostering community involvement, stimulating government and managing conflict between them. Behaviour change in fishermen community is particularly difficult due to their socio-economic interest associated with fishing culture. However, building trust and economic empowerment through alternative avocations could be critical

components in engaging the community. State regulatory authorities working as advocacy organizations often make it difficult to gain community trust. There is need to strategise whether advocacy or facilitation is most needed.

Presentation Summaries:

Summary 1:

Mr. Dewan discussed community interests in conservation and management. The primary point was that harsh regulation without considering local attitudes and motivations is destined to fail.

Major Points:

- "Managing fisheries is managing people" Hillborn, 2007- The point being, that the interests of people need to be at the heart of our fisheries management policy.
- Trying to regulate fishing in these areas is not possible. Illegal fishing and fishing using destructive practices is prominent, villagers listen to local leaders (head of village, elders) and not government regulation. "People respond to regulation in surprising ways…It is important to understand their motivations".
- People with unstable incomes cannot afford to stop hunting or fishing. How to replace that value which they are taking from the river? One strategy Mr. Dewan's department took was to hire and train locals for data collection, which provides an alternate source of income while also educating the local community on the other values of the river. They were involved in patrols to help enforce a "no fishing" season. If we can find a way for their people to harvest sustainable value from the river, they can be our "best protectors".
- Other initiatives they plan to try: Selling fishes to communities to rear for protein; subsidies for building ponds; encouraging tourism to replace income.

Discussion:

The first question was a comment to further emphasize that if we remove fishing as a local source of income, we need to provide a better livelihood.

Summary 2:

The people in small villages that use illegal fishing as a source of income can be converted into important conservation partners.

Major Points:

- Conservation is really about people and protecting relevant resources to ensure our continued health.
- Leaders, commoners, destructors, regulators = categories of people in villages next to Mahseer streams.
- Trying to change the values of each group in ways the create desired outcome of protecting Mahseer
- Illegal fishermen can support themselves by selling Mahseer.
- Listen and do not come off as arrogant if you wish to influence local ideas about conservation.
- Behavior will change once people understand the value to the change and once barriers to change are removed.
- Pay locals to gather data so they do not have to rely on illegal hunting and fishing.
- These efforts are happening downstream of a dam; however, upstream commercial fishermen are heavily impacting Mahseer populations in the 50 km long lake.

Discussion:

Comment: We must replace illegal fishing benefits with something else valuable.

Grassroots Reserves Benefit Mahseer-Dominated Tropical River Food Webs

Presenting Author:
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Co-Author:
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Abstract:
Intensive harvest has resulted in significant declines in biodiversity, abundance, and biomass of fisheries worldwide. No-take reserves have become critical components of marine ecosystem-based fishery management, yet the potential translation of spatial protection to river systems has not been fully realized. Several features of marine reserves have been found to predict reserve success regarding increasing fish diversity, density, and biomass relative to fished areas beyond reserve boundaries. These features include reserve size, age, enforcement, and isolation. Using a network of 23 community-based riverine reserves located in the Mae Ngao River, a Salween River tributary in Thailand, we test the potential for these same features derived from the marine reserve literature, as well as the network properties of our study river, to benefit riverine fish communities dominated by Tor and Neolissochilus species. We find riverine reserves have strong positive impacts on overall fish richness, density, and biomass, with particularly strong effects on Mahseer. However, different reserve features were found to predict each conservation outcome (richness, density, and biomass). Additionally, we found that the dominant predictors of reserve success varied further when we considered fish assemblages based on functional traits. The effectiveness of small, community-initiated reserves offers a new, transferable model for protecting entire food webs and augmenting fishery yields in biodiverse tropical rivers. Yet, the complexity of the responses to reserve protection strongly suggest that networks of reserves composed of independently designed reserves having specific conservation targets will likely be required to achieve the full conservation potential of riverine reserves.

Presentation Summaries:

Summary 1:

Dr. Koning focused on grassroots (small, community-regulated) reserves, and on what predicts reserve success. He found that these small reserves had an overwhelming effect on local biomass and density, and that enforcement, size, placement in the stream, and distance to other reserves and villages all impact success of the reserve.

Major Points:

- "Grassroots" (small, community-regulated) reserves are common throughout southeast Asia. These are independently enforced and created. Average size ~600m.
- Marine fisheries have moved from evaluations and regulations focused on individual stocks to more ecosystem-based management. Creating reserves which protect ecosystems, even small, can have large spillover effects to areas outside the reserves. However, these ideas haven't been applied broadly to freshwaters.
- Examining success was via transects of reserve and non-reserve areas measuring richness, density, and biomass. On average, ~2 more species found on reserve vs. immediately outside (~150m apart), ~3x higher density, ~25x higher biomass (!).
- What predicts which reserves work better than others? Enforcement, age, size, and isolation from other reserves?
- River size of reserve predicts species richness, but important to consider greater endemicity in headwater streams. Enforcement and age predict richness of small fish. Distance to village predicts density response- the further from a village, the more likely to be fished illegally.
- Results show that these reserves can be very successful, and that this community-based approach could serve as a model for other areas which rely on freshwater fish harvest.

Summary 2:
Reserves can be utilized in tandem with local villages to maximize conservation benefit.

- Ecosystem based management as a better means of conservation.
- How can we quantify riverine reserve success?
- What factors predict riverine reserve success?
- Reserves have more species, density of individuals, and biomass.
- Important factors for success include: size, isolation, and age of the reserve.

There was no time for questions.

The Multiple Roles of Mahseer Supporting a Diversity of Cases for their Conservation

Presenting Author:
Dr. Mark Everard, University of West England, Bristol, mark.everard@uwe.ac.uk

Abstract:
Mahseer fishes across their South and South-eastern Asian range serve many functions within their host aquatic ecosystems, providing a range of human benefits. In terms of provisioning ecosystem services, mahseer fishes serve as a valued source of food as well as ornamental and genetic resources. These fishes also play key roles in the functioning of aquatic ecosystems, including as higher-level predators that, through their migratory behaviour, also redistribute nutrients in river systems whilst also grazing on snails and other potential disease vectors. Mahseer are imputed with cultural and spiritual meanings by many communities, inspiring art in various forms, and serving as a highly valued attraction for recreational angling and ecotourism. Mahseer are of inherent value but, indissoluble from the vitality of the freshwater ecosystems that support them, serve invaluable additional roles as indicators of the health of aquatic environments and the many services they provide to humanity. This breadth of values underlines the multiple reasons for prioritising conservation of mahseer and the protection or restoration the habitats that currently support, or formerly supported, these iconic fishes.

Presentation Summaries:
Summary 1:
Dr. Everard gave a thought-provoking appeal to fundamentally shift the way we think about conservation and why we do it.

Major Points:
- He caught mahseer with mangoes!
- Opposing conservation philosophies: “People versus nature” as opposed to “co-dependence”. The former philosophy is a losing battle.
- Need to think of nature as a part of infrastructure. Traditional infrastructure as a conduit to “natural infrastructure”.
- Neoclassical markets put a monetary value on ecosystem components, but the values are much greater. What are the values of mahseer rivers? The costs of a dam are much greater than the financial cost/benefit ratios imply- erosion of deltas, disruption of flows, etc.
- “Ecosystem services” approach- value the services and not just the products of nature. How do we mainstream the plural values of nature into societal valuation? Need to go beyond altruistic concern- we protect the ecosystem because it delivers us value that we need.
- Why protect mahseer? “Because rivers need fish and people need rivers”.

Summary 2:
Fish and rivers have a plurality of values to humans and protecting this value makes good long-term economic sense.

- Changing the public perception of conservation.
    1. People versus nature is not good for outcomes
    2. Co-dependence as a message could prove more successful
- Anthropogenic infrastructure is just a means to utilize natural infrastructure.
- These two infrastructures are often out of sync or harmony.
- Value of fish: food, pet trade, other utilities, pest control, nutrient recycling, angling economy, spiritual value, counter-terrorism, art/beauty, inherent values.
- Value of rivers: costs if degraded, floodplains/deltas which lead to agriculture and grazing.
- We can't put a price on nature, but we can attempt to value ecosystems.
- Once we understand the value, it should follow that conservation makes long-term economic sense

There was no time for questions.

Conservation Planning for Mahseers
Presenting Author:
Sanjay Molur, Zoo Outreach, IUCN Conversation Planning Specialist Group, sanjay@zooreach.org

Presentation Summaries:
Summary 1:
Mr. Molur focused primarily on the role for translocation of mahseer as a conservation strategy.

Major Points:
- Mahseer translocation thus far has been for non-conservation purposes- accidental, commercial, recreational, etc. Conservation-centric purposes can be population reinforcement or reintroduction or assisted colonization (or migration), and must be evidence-based.
- Is translocation a viable option?
- Vortex models.

Discussion:
Discussion was short but centered around the issues of non-scientifically understood translocations.

Summary 2:
A proper population modelling analysis can be used for conservation planning and to defend river systems from projects such as hydropower

Major Points:
- Translocations of Mahseer are rarely—if ever—in the name of conservation, but instead are either accidental, or for welfare, commercial, recreation, pseudo-scientific reasons.
- As a result, translocation typically has a negative impact/result.
- Translocation for conservation purposes should be studied for benefits/risks.
- Vortex Models & Population & Habitat Viability Analysis: explaining birth, death, immigration, & emigration (population dynamics) via various pertinent factors.
    1. Life history characters (e.g. reproductive traits)
    2. Human impacts
    3. Chance events

- Even with incomplete data, relative predictions and advice can be given

Discussion:
Comment: translocation is not just about rearing and releasing.

Towards Conservation of Mahseers and their Habitats in Eastern Ghats, India
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Abstract:
Eastern Ghats is a 1450-km long discontinuous chain of mountains along the eastern coast of India. Despite its importance in the biogeography and maintenance of freshwater fish diversity in Peninsular India, little information is available from this landscape. Distribution and habitat preference of Tor sp. was assessed in the hill streams of Eastern Ghats in Papikonda National Park, India from December 2017 to April 2018. Fish sampling was carried out in 12 streams; at each stream 100-m stretch was selected and different habitat type was sampled using cast nets, drag nets and block nets. Apart from the main river channel in the national park, the species was recorded from two large streams in the study area. Preliminary analysis indicates the species' preference for relatively deeper pools (above 39 cm) with moderate water flow (0.093-0.279 m/s). Results also indicate widespread habitat degradation of hill streams and a change in distribution of the Tor sp. in comparison to a previous study conducted in 2013. Apart from the potential impacts of river regulation, threats such as diversion of streams for farm irrigation and usage of poisons were also observed during the study period. One of the main objectives of the current project is to improve conservation of the threatened fish species in Eastern Ghats by raising awareness and building capacity of key stakeholders. In this regard, a training program on stream monitoring had been organized for local researchers in April, 2018 along with outreach campaigns for the local fishing community.

Presentation Summaries:
Summary 1:
The focus was on building a research program to understand the biodiversity and impacts in the drainages of the Eastern Ghats

Major Points:
- Eastern Ghats are a highly discontinuous range, with rivers within highly dammed and impacted by other industry.
- Tor juveniles were primarily found in higher order streams with moderate flow and deeper pools, with a preference for bedrock.
- Poisoning by locals is common, with individuals releasing ~1kg of bleach in streams after the monsoon. Presumably as a method of harvesting fish.
- Promoting research: A workshop on stream ecology was done, to promote capacity in university students. Local ichthyologist meet-up.

Discussion:
One question asked if she planned to compare biodiversity in the Western Ghats. Ms. Ray noted that this work is ongoing but a lot of data collection is still needed.

Summary 2:
Baseline data is critical for Mahseer conservation.

Major Points:
- Court order demanded a survey prior to the construction of a large dam in India.
- PHABSIM= Physical Habitat Simulation Model.
- At least 4 threatened or endangered species encountered in the area that would be inundated by the dam, including Tor sp.
- Juvenile Mahseer found in tributary streams
    1. Prefer moderate flow and deeper pools and bedrock substrate
- Threats include poisoning, water abstraction, exotic introductions, etc. .
- Importance of stakeholder-based planning and outreach (capacity building).
- Future hopes to resolve taxonomic issues & further study habitat association.

Discussion:
Comment: Eastern & Western Ghats are approximately the same age

Q: Do you plan to compare your biodiversity data of the two regions
A: Absolutely plan to.

Pioneering Mahseer Conservation through Eco-Tourism in South India
Presenting Author:
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Abstract:
The wildlife Association of South India (WASI) has been engaged in Mahseer conservation in the Cauvery River in South India for the past 45 years. This not for profit organization leased a stretch of the river from the State Forest Department, recruited guards and fishing guides from the local community to protect the Mahseer. Several ex-poachers were offered legitimate employment and rehabilitated as guards and guides. The credo of 'catch & release' recreational angling was strictly followed,as were best fish handling practices, and the revenue generated from camping and fishing license fee, paid for the salaries. This Eco-Tourism model was pioneered by WASI and later adopted by the State run Eco-Tourism organization and scaled up (albeit for commercial reasons) to make a 40 km stretch of the Cauvery a Mecca for National and International anglers. Poor rainfall resulting in reduced water flow, depleting dissolved oxygen and other habitat impacting developments in recent years have adversely impacted the population of mahseer, in particular the "hump backed". The cessation of recreational angling has cut the flow of angling funds for mahseer conservation. A successful Eco –Tourism based conservation model has come to a standstill. WASI offers to share their experience with any organization willing to adopt this Eco-Tourism model for conservation.

Presentation Summaries:
Summary 1:
Focus was on actions taken by the Wildlife Association of South India to act as steward of the Cauvery river

Major Points:
- "Whose river is it anyway?" A major problem in India that there is no particular entity that acts as custodian of the river. Forestry cares about forests, Irrigation dept. focuses on supplying water. Who focuses on the river ecosystem?
- Tragedy of the Commons.
- WASI established guidelines and began enforcement.
- Awareness spreading.
- Recreational fishing as an important part of community-based regulations. Anglers "eyes and ears" of river.

Summary 2:
A three-pronged approach to conserving Mahseer

- In India, no department of state is concerned with river ecosystems.
- Good conservation comes from involving the community, reducing illegal activity, & spreading awareness.
- "A Mahseer in the river is worth its weight in gold".
- Focus on catch and release angling

There was no time for questions.

An Overview of the Native Fish Conservation Area Approach to Watershed, Fisheries, and Aquatic Conservation and Management: Implications for Mahseer in Bhutan
Presenting Author:
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Abstract:
Native Fish Conservation Areas (NFCA) are watersheds where management primarily emphasizes conservation and restoration of native fish and other aquatic species, and their habitats, while also managing compatible recreational and commercial uses. The goal of Native Fish Conservation Areas is to sustain the integrity of key aquatic habitats in order to maintain long-term persistence of native aquatic species. NFCAs also provide a mechanism for a collaborative and coordinated approach among multiple partners at a watershed level to accomplish the conservation of aquatic resources. This approach incorporates the knowledge and talents of technical and non-technical partners to accomplish conservation on waters flowing across public and private lands. A global system of highly visible NFCAs will increase the awareness of native fishes among the public and help communicate the importance of conserving native aquatic communities. Examples of established Native Fish Conservation Areas in the Little Tennessee River in the eastern U. S. and across Texas in the southwestern United States in North America will be discussed. The potential benefits of using an NFCA watershed approach to inform management of mahseer in Bhutan will be discussed.

Presentation Summaries:

Summary 1:

An overview of the Native Fish Conservation Area watershed-scale approach to fisheries conservation and its applicability in Bhutan.

Major Points:

- NFCA's are watershed-scale (4th code HUC) with a management emphasis on conservation and long-term recovery and persistence of fishes. An "insurance policy" against local extirpations.
- Maintain natural processes; include diverse habitats; support all life history stages. Designate by considering local diversity and importance of habitat.
- Local stewardship is critical.
- Little Tennessee River in USA was the first official NFCA.
- Could an NFCA approach work in Bhutan? Natal fidelity, genetic stocks, demonstrate a need for designating watersheds for protection. "Wild and Scenic River status". This can also be an important component of ecotourism.

Discussion:

1st question asked is NFCA's management units are large enough to encompass mahseer migratory routes, since watershed and biological boundaries do not follow state and political boundaries- the big implication here being that NFCA's in Bhutan cannot regulate activity downstream in India. Rick noted that data suggests they don't range much into India.

Summary 2:

Native Fish Conservation areas are watershed-scale areas where management conserves native fish population.

Major Points:

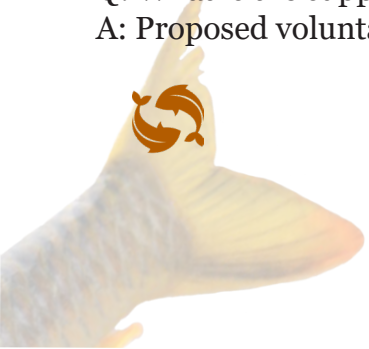
- Critical elements of NFCA:
    1. Maintain natural processes within NFCA
    2. Include habitats for diverse life histories and all life stages
    3. Support long-term population persistence
    4. Continue in perpetuity
- Regional based management focuses not just on the highest diversity sites in a watershed, but the entire drainage, which encompasses even the low diversity sites that have high beta-diversity and often some endemics.
- Potential for NFCAs for fish conservation in Bhutan?

Discussion:

Comment: If NFCA was used in Bhutan the boundary would have to extend up to the India border, but would not contain the entire watershed.

» What about a partnership between Bhutan & India to include the Brahmaputra basin? "Fish without borders"

Q: What is the supporting structure for NFCA?
A: Proposed voluntary regulation/partnership/management



A Science-Based Model for a Recreational Fishing Program for Mahseer in Bhutan

Presenting Author:
David Philipp, Fisheries Conservation Foundation

Co-Author:
Julie Claussen, Fisheries Conservation Foundation

We propose a model for establishing a recreational fishery in Bhutan for Mahseer (both Golden Mahseer, Tor putitora, and Chocolate Mahseer, Neolissochilus hexagonolepsis). This model, which represents just one possible scenario, is designed to promote community-based conservation activities through the formal development of both a Mahseer Conservation Fund and a Community Economic Assistance Fund. Those funds would be fueled through levies on anglers fishing for Mahseer in Bhutan's Waters. Those levies would use a tiered costing approach based upon the geographic area of the river(s) being fished and whether the angler had Bhutanese or foreign citizenship. We also recommend a set of regulations for managing the angling and propose a plan for implementing a pilot project to assess and fine tune such a program.

Presentation Summaries:

Summary 1:

A model is provided for establishing a high-end recreational fishery in Bhutan with proposed regulations and community investment

Major Points:

- Very important to manage angler expectations. We want anglers coming away thrilled.
- Illegal harvest of course a massive issue in Bhutan. How to mitigate? Community-based conservation, by initiating high-end catch-and-release angling.
- "Make live fish in the river more valuable than food".
- To decrease illegal recreational fishing, we need to delineate mahseer vs. trout streams. Different permits for different areas.
- A model program: Institute a zone system with different regulations. Some regulations universal across zones: Close season covering the monsoon (spawning time + dangerous), need fishing license + mahseer stamp, community support levies, permits, rod & reel and C&R, safe gear (barbless, etc), no live bait, fish landed with net, safe handling. Zone specific regulations: fly fishing only in some areas, access restrictions depending on area (e.g. rafting vs. on shore); fly vs. spin-fishing in some areas.
- Costs? Should be higher for foreign vs. Bhutanese anglers. Very expensive levies- $1000 per day in the highest density zone for foreign anglers! Permit money to government, community and conservation levies, income for raftering company and guides, hotels. Exclusive- but great for the community.
- Needs: trained guides, certified rafters, trained trail guides. Guides need training in safety, record keeping, best handling practices, etc.
- Need to be careful about monitoring pressure: Start slow. Few trips per year at first. These prices are high- but they can be met if the fishing is as good as its supposed to be. Start monitoring programs so we know what's happening to the population!

Discussion:

» 1st comment noted that Bhutan is newest to recreational fishing and in a position to be a leader in this region, because it can learn from models which work well and models that don't work well. Incredibly important to get this right from the beginning, and develop around the model presented.

» It's easier to start out right than to fix things once they're screwed up! Learn from the mistakes of other countries like the US.

Summary 2:
A properly managed Mahseer fishery in Bhutan will be good for the people & the fish.

Major Points:
- Managing angler expectations is key to recreational fisheries.
- We need to regulate recreational fishing because so much illegal harvest is happening.
- Must establish community-based conservation = increase enforcement and educate.
- A live fish is more valuable to the people.
- Delineate parts of the river where mahseer are vs. where only trout occur = 2 separate management and regulatory areas.
- Provide opportunities for Bhutanese, increase eco-tourism, generate revenue to fund Mahseer conservation, generate revenue for local economies.
- Regulations & fees associated with fishing permits vary depending on zones.
- Controlling pressure & usage rates over time

Discussion:
Comment: Bhutan can be a world leader in recreational fishing by incorporating well developed models for recreational fisheries. It is important to get this right.

Q: Can there be a monitoring program to continuously assess stocks?
A: Absolutely, angler trips will be a form of this, and the funds provided will help fund conservation

Community Fisheries Programs in Bhutan: Cooperation in Conservation and Management

Presenting Author:
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Abstract:
Bhutan is endowed with rich natural water bodies, which are being used for many developmental purposes such as hydroelectric project, irrigation, stone and sand quarry etc. In addition, many communities along Bhutan's rivers have relied on fisheries, even though fishing for consumption is not legal in Bhutan. Through the development of community fishery programs at select locations, nutritional sources can be secured and socioeconomic enhancement through sale of fresh fish be established for riverside villages. By instituting a sustainable mode of fish harvest practice, coupled with training on the stewardship of river resources, community fishery program can curtail destructive fishing practices and ensure that fish biodiversity is protected. Community based fisheries management programs can therefore, bring about immense benefits both in terms of income generation, nutrition, and conservation.

Presentation Summaries:
Summary 1:
Overview of issues facing fisheries in Bhutan and establishment of Community Based Fisheries Management practices

Major Points:

- Warm (carp) and cold (rainbow trout) aquaculture. >12 metric tons of fish in 2017, to satisfy increasing demand for fish.
- Vast majority of fishing is subsistence.
- Community Based Fisheries Management: community collaboration and local participation, localized. 7 CBFM programs established currently in Bhutan.
- Stakeholders meeting- government, agencies, community, National Environment Commission, NRCR&LF.
- Fishing community generally known more about their local fishery than agency staff. Foster sense of ownership

Discussion:

» 1st question was about how to protect from invasive species, given hatchery practices and high number of invasive species south in India.
» 2nd question asked if communities are increasing in size, and how will increased population growth (of people) going to add pressures? There was no time for answering.

Summary 2:

- Fisheries in Bhutan are based largely around subsistence aquaculture.
- Demand for fish is increasing.
- Community Based Fisheries Management (CBFM).
- Many CBFM regions established in Bhutan.
- Key part of this process is a meeting with all relevant stakeholders, which is used to inform the establishment of a management plan.
- Benefits of CBFM:
    1. Efficacy
    2. Sense of ownership
    3. Enhanced livelihood

Discussion:

Q: Are the communities increasing in size, and could the goals of the CBFM buckle under the pressure of increased populations?
A: Fisheries Program is very new. Fisheries provides the science, not the enforcement. Also, the people of Bhutan work well together because the population is small, and they know one another better.

Perception of stakeholders: challenges and opportunities for Golden Mahseer, Tor putitora, conservation along Rivers Nayar and Kosi, Uttarakhand

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Golden Mahseer Tor putitora a large cyprinid inhabits foothills of the Himalayan rivers. Over the years owing to anthropogenic discontinuities freshwater habitat have degraded leading to loss in species assemblage and population decline. Interviews were conducted in December 2017 and May 2018 along Rivers Nayar and Kosi respectively. Questions were designed to map human-wildlife interactions to identify areas of conflict and positive association. There were 38 and 75 respondents along River Nayar

and Kosi respectively. In most cases respondents were aware of the endangered conservation status and the distribution of Golden Mahseer. Fishermen at both survey sites solely depend on fish catch and for almost 50% of them, their entire family is dependent on it. Fishing is practiced illegally along River Nayar while along River Kosi the Forest Department sanctions license on annual basis. Fish catch ranges 2-5kg/day and during monsoon fishing becomes intensive. Generally, cast nets, line nets and hinges are used to fish while few fishermen also resort to dynamiting and use of bleaching powder. Golden Mahseer is considered a delicacy and being in high demand in local hotels is sold at Rs. 150-300/kg. Recognizing the urgent need to protect Golden Mahseer habitat, WWF-India in collaboration with diverse stakeholders in Uttarakhand state has initiated ecological studies and sensitization programmes for mobilizing community participation. An atlas as a single comprehensive reference point for information on Golden Mahseer conservation will be devised and propagated to focus on critical habitats and assist in advocacy campaigns enhancing legal protection for the species.

Presentation Summaries:

Summary 1:

Stakeholder perceptions from surveys along stretches of the Nayar-Ganga and Kosi Rivers in Uttarakhand, India. The common issue was reiterated that fishing is a primary income source for many people, creating conflict between community and conservation agendas.

Major Points:

- Proposed actions: Mapping critical habitat, radio tagging mahseer to determine habitat use, assessing current distribution and population/stock status.
- Focusing on stretches of the Nayar-Ganga complex and Kosi River.
- Fishing has been a traditional occupation here. Forest dep.t granting permits and licenses since 1938. Much of fishing is illegal but sole source of income for many families.
- Fishing community generally responsive to conservation efforts, but needing some form of economic incentive to replace fishing income.

Discussion:

» 1st question asked about response from policymakers. Dr. Nawab responded that responses have generally been positive in forestry departments.

Summary 2:

Major Points:

- Key Recommendations:
    1. Research & Monitoring
    2. Policy Initiatives
    3. Awareness & Capacity Building
- Golden Mahseer was proposed the National Fish of India.
- Perhaps such a proposal could be made by this first IMC.
- Fishing is often a traditional occupation.
- Providing alternatives to illegal fishing (economic & food) is paramount to successful mitigation.

Discussion:

Q: What response do you get from policymakers?

A: Policymakers/government seem to appreciate the efforts being undertaken.

POSTER ABSTRACTS

Assessing the Efficiency of Fishways in Bhutan

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Abstract:
Endowed with rich perennial water resources, Bhutan has an estimated hydropower potential of 30,000 MW of which 23,760 MW is accessed to be technically feasible from 70 run-of-the-river and 6 reservoir scheme hydropower projects. Bhutan's water reserves, besides being used for generating electricity, are also home to many native fish species that will be impacted by the construction of the hydroelectric dams, either through displacement and loss of habitat for resident species or through obstruction of spawning movement for migratory species.
In the wake of the evident impacts of dams on the native fish population, the Water Regulation of Bhutan (2014) stipulate maintaining a minimum environmental flow of 30% of the lean flow (e-flow) for all hydroelectric projects. In addition to this, it also requires dams to incorporate fishway or other facilities to facilitate the movement of migratory fish.
Till date, only 2 hydropower projects in Bhutan have fishways incorporated in their dams, namely the Kurichhu HHP and Dagachhu HHP. However, the effectiveness of these fishways is yet to be evaluated. The National Research Centre for Riverine & Lake Fisheries (NRCR&LF) under DoL is therefore conducting a study to assess the effectiveness of these fishways with the aim to improve (for future projects) and improvise modifications on the existing structures.

Illegal Fishing and the Potential Effects on Mahseer

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Illegal fishing is just one of the current threats that Mahseer face, including the loss of habitat due to hydropower development, the degradation of habitat due to road building or sand mining, or other anthropogenic effects. Illegal fish harvesting is expected to increase with expanding populations and improved road access to more remote areas of the country. Mahseer are vulnerable to illegal land-based fishing, such as cast netting, basket trapping, gill netting, and single or multiple lines with baited hooks. These methods can be quite successful and support substantial, unreported artisanal fisheries in many areas. Evidence of illegal fishing appears to be pervasive throughout Bhutan. Illegal harvest is not reported, and can adversely impact how to best conserve and manage fish populations. In addition, Bhutan is just beginning to recognize the level of fish biodiversity within its streams and rivers and much of the basic biology and life history is unknown. Some fish species will likely be more vulnerable to illegal harvest and could potentially be severely impacted. First documenting the extent of illegal fishing and the level harvest, and then designing solutions, will be important steps for mahseer conservation and management plans.

A Strategy for Training and Certifying Fishing Guides in Bhutan

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Abstract:
Because catch-and-release recreational fisheries have been shown to be successful drivers of community-based fisheries conservation programs in many remote areas around the world, Bhutan and other countries in Southern Asia should consider establishing such a program for Mahseer. Before such a recreational fishery can be established, however, a certain level of programmatic and logistical infrastructure must be developed, including fishing regulations, travel procedures, accommodations, and guiding. There are currently no certified fishing guides in Bhutan and very few people experienced in fishing, much less fly fishing, for Mahseer, and this lack of trained personnel could prove to be a major impediment to successfully launching such a fishery. We outline a model process for addressing that need in Bhutan, one that includes establishing the training criteria for several tiers of guides (e.g., senior fishing guide, junior fishing guide, and trail guide), as well as the skills needed for each tier (e.g., safety, angling equipment, client relations, and best handling practices, as well as knowledge of the rivers, angling techniques, regulations, and data collection). The key to efficient development of a local cadre of guides will be to train and certify a small core of Bhutanese that are already familiar with Mahseer angling and let those individuals implement an in-country training program for the rest of the country.

DNA Barcoding the Himalayan Torrent Ichthyofauna of Bhutan

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Abstract:
Morphologies and behaviors of rheophilic fishes have been shaped over evolutionary time by fast flowing waters and rocky substrates. These have also promoted their ability to withstand violently shifting substrates and downstream displacements. Yet the 'soft' hydrologic barriers (i.e., slow water reaches) effectively separating rapids can promote diversity not only across drainages but within as well. To gauge the potential for new species within these specialized habitats, we evaluated 98 loach (Cobitoidea)

and 38 catfish (Siluriformes) collected in mid- and headwater streams of Bhutan. We did so by first sequencing a mitochondrial gene (COI), then using NCBI BLAST to assess if species-identity resides within GenBank. For loach, 94% of individuals (N=92) were taxonomically identified, representing 10 species and 8 genera. For catfish, 80% were so identified (N=30), representing 8 species and 6 genera. However, many of our specimens could not be so identified (loach=6%; catfish=18%). This underscores potential issues with GenBank, such as the mis-identification of sequences previously-submitted, as well as the incomplete nature of the database. DNA barcoding is an effective means of identifying Himalayan loach and catfish but will be more functional as a biodiversity tool once additional sequences of Himalayan species are added.

Is there connectivity among Trans-Himalayan drainages? Snowtrout (Schizothorax spp.) (Cyprininae: Schizothoracini) as a test case

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Abstract:
Global biodiversity hotspots represent remote, tectonically active areas that have undergone significant geologic and climatic change. One such region, the Himalayan Mountains, was created by the gradual collision of the Indian plate with the Eurasian landmass. Drainages then downcut southward as the Tibetan Plateau uplifted, allowing fossil-poor aquatic taxa to disseminate and diversify. This riverine evolution provides a biogeographic template upon which phylogeographic relationships of Himalayan fishes can be superimposed. Here, we sequenced 1,140 base pair of mitochondrial (mt)DNA cytohrome-b (cytb) for five Schizothorax species (N=155) endemic to the Central Himalayas [i.e., Nepal (N=85) and Bhutan (N=70)]. We placed these data in context by acquiring an additional 110 GenBank sequences from trans-Himalayan and central Asian rivers, as well as 2 outgroups. Our data were evaluated using a maximum likelihood (ML) approach, with results indicating that Schizothorax is much more diverse across basins than within, suggesting the presence of undiagnosed diversity. We also found species to be paraphyletic in the tree, reflecting either potential misdiagnoses in the field or unidentified cryptic species. Schizothorax in Bhutan is represented by two distinct clades that seemingly have affinities with Tibet and Nepal, respectively, indicating a previous Pleistocene stream connectivity that is now disrupted.

Kenauk as a Model for Community Based Conservation in Bhutan.

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Abstract.
On the property of Kenauk in Montebello, QC, Canada co-exist two mutually beneficial companies; Kenauk Nature and the Kenauk Institute. Kenauk Nature is an outfitter widely renowned as a fishing and eco-tourism destination while the Kenauk Institute is a research and education organization that promotes conservation through science. Using Kenauk as a model, we would like to demonstrate how recreational fishing can drive community based conservation which creates a feedback loop of sustainably managed fish populations, a successful long-term fishing industry and unique experiences for visiting anglers. Research through an organization like the Kenauk Institute can generate the information needed to inject science into conservation and benefit local recreational fishing through informed management recommendations.

Artificial breeding of the endangered Golden Mahaseer, Tor putitora, at National Research and Development Centre for Aquaculture in Gelephu

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Abstract:
In order to replenish the future populace of critically endangered species in the depleted water bodies of Bhutan, National Research and Development Centre for Aquaculture (NR&DCA), Gelephu has conducted trial to artificially breed Golden Mahaseer in captivity from February, 2013 till date. 345 males of 0.6 kg to 1.87 kg and 343 females of 1.04 kg to 2.6 kg brood fish were reared inside the earthen pond. Breeder were provided with formulated fish feed along with the mixture of muster oil cake and rice bran at 2 % body weight per day. Chicken offal was provided twice a week to observe if there is improvement in their gonadal maturity. Maturity was observed by sampling fish and applying gentle pressure to the abdomen to express gonad and milt twice a week during February to April and September to December in a year. First eggs were successfully striped and incubated in February to April, 2013. Till date, NR&DCA, Gelephu has striped 147 females and 294 males producing more than 20000 viable fingerlings which are currently under successful rearing at NR&DCA, Gelephu. This breeding trial was first rudimentary breakthrough in the history of aquaculture and fisheries in Bhutan and trial demonstrated that natural breeding and fry/fingerling rearing is possible in the Sarpang region of Bhutan. However, further studies should be conducted to assure its possibilities to propagate under induced conditions and improved technology for mass seed production are needed in the future studies.

A genetic survey of the genus Garra (Cyprinidae: Labeoninae) in Western Bhutan

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Abstract:
Widespread and ecologically-conspicuous species often span both spatial and temporal environmental gradients and are thus good models from which to gauge the demographic impacts of climate and geography. The latter, in turn, have deposited genetic signatures within populations, and their evaluation can clarify broader biogeographic patterns and also the processes involved in creating and maintaining biodiversity. Here, we evaluated several such species found within a primarily rheophilic genus (Garra) that spans ~110 Asian and ~30 African species. We focused specifically within the drainages of Bhutan where Garra is speciose, and as such represents an excellent model with which to examine Himalayan phylogeography. To this end, we sequenced 661 bases of the mitochondrial (mtDNA) COI gene for 314 individuals and placed these within a broader phylogenetic context by employing 1,457 broadly-distributed individuals from GenBank. We found considerable within-species diversity, with strong evidence of both cryptic and novel lineages, each requiring formal description. We also noted polyphyly and a need for revision. To conserve biodiversity, it is imperative to first delineate constituent elements. The phylogenetic approach presented herein is an effective framework not only to benchmark Garra, but also the broader trans-Himalayan fish community.

How Inland Fisheries Support the UN Sustainable Development Goals
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The fish and fisheries that are in all freshwater bodies including lakes, rivers, streams, wetlands, and reservoirs and considered a part of inland fisheries. These fisheries are an important source of employment, provide food and nutritional security, offer many sources of recreation, and are a key component in cultural values. They are especially significant in vulnerable communities in high poverty regions around the globe. It is estimated that globally, more than 57 million people are reliant on inland fisheries in some capacity for their employment. Millions more rely on freshwater fisheries for a main source of their food and nutrition. Despite their importance, inland fisheries are often an "invisible" resource due to the current lack of information and reporting or recognized economic value. The InFish Network is an international collaboration of government entities, universities, independent researchers, and non-governmental organizations, that are working to raise awareness and increase the profile on the importance of inland fisheries in the success of achieving the UN Sustainable Development Goals.

Water in Bhutan's Economy: Risks and opportunities for a sustainable future
Presenting Author:
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Kenauk Nature as a Vacation and Fishing Destination
Liane Nowell, The Kenauk Institute

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WWF Malaysia: Freshwater Conservation

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Bhutan for Life: A Conservation Story

Presenting Authors:
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International Fisheries Section of the American Fisheries Society

Presenting Authors:
Julie Claussen, Fisheries Conservation Foundation
Steven Cooke, Carleton University, Canada

Sigma Eight Telemetry Display

Presenting Authors:
John Grant, Sigma Eight, Inc, Canada
Haley Mutch, Sigma Eight, Inc, Canada

About the IMC Keynote speakers

Dr. Leeanne E. Alonso
Biodiversity Specialist, International Finance Corporation, World Bank Group

Dr. Leeanne E. Alonso is a Biodiversity Consultant to the International Finance Corporation (IFC), the private lending arm of the World Bank, where she advises private sector companies on mitigation of impacts of their development projects on the natural environment. She works on hydropower projects in Asia and Africa, particularly with the Mahseer in Pakistan and Nepal, where she and her IFC Hydro Advisory colleagues are approaching biodiversity management at a basin-wide scale in order to bring together private sector developers, government, NGOs and international lenders to reduce cumulative impacts. Leeanne has a PhD in Biology from Harvard University and over 25 years of experience working in the biodiversity conservation field, particularly in the tropics. As the Director of the Rapid Assessment Program (RAP) at Conservation International from 1998–2011, and Director of Global Wildlife Conservation's Global Biodiversity Exploration Program from 2012–2015, Leeanne has coordinated and led more than 45 biodiversity field surveys around the world in terrestrial and freshwater habitats. While her background is in terrestrial ecology (in particular, ants), Leeanne is expanding her knowledge of fish migration, fish passages and fish monitoring so that she can guide IFC hydropower clients toward better management of their impacts on aquatic ecosystems.

Dr. Rajeev Raghavan
Kerala University of Fisheries and Ocean Studies (Kochi, India) & IUCN Freshwater Fish Specialist Group

Rajeev Raghavan is an Assistant Professor at the Department of Fisheries Resource Management, Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, India. Over the last 15 years, Rajeev has been involved in interdisciplinary research that generates information for conservation decision making in tropical aquatic ecosystems, with particular focus on the Western Ghats Biodiversity Hotspot. His work cuts across multiple disciplines from taxonomy to evolutionary biogeography, inland fisheries management and conservation policies, and ranges from local to global scales. Closely involved with the work of the IUCN's Species Survival Commission (IUCN-SSC), Rajeev wears multiple hats, including that of the "South Asia Coordinator" of the IUCN-Freshwater Fish Specialist Group and IUCNs "Freshwater Fish Red List Authority Coordinator" for the regions of Southern, Northern, Eastern Asia and Oceania. In addition, he is also a member of the IUCN SSC/WCPA Joint Task Force on Biodiversity and Protected Areas, the WCPA-Freshwater Specialist Group, and the IUCN Conservation Planning Specialist Group. Rajeev has over 125 publications in peer-reviewed literature, several of them on mahseer conservation.

Dr. Steven Cooke
Professor of Fish Ecology and Conservation Physiology and Canada Research Chair, Institute of Environmental Science and Department of Biology, Carleton University (Canada)

Dr. Steven J. Cooke's research covers many disciplines in the areas of fish ecology, physiology, and behaviour, as well as research in human dimensions, knowledge mobilization, and policy. In 2015, he founded the Canadian Centre for Evidence-Based Conservation, which synthesizes information for policy makers. His research findings (600+ peer-reviewed publications) have ranged from fish passage solutions and habitat restoration activities, to addressing issues related to fish and turtle bycatch and innovations in recreational fisheries management. He has worked diligently to raise the profile of inland fish and fisheries to resource development globally. Steve's hard work in creative approaches in science and his ability to engage in partnership research has been recognized with several awards, including the Roderick Haig-Brown Award, the Latornell Leadership Award, NSERC E.W.R. Steacie Award (given to the top six under-40 Canadian scientists), and elected into the College of the Royal Society of Canada. Steve is an active member of the American Fisheries Society and is currently serving as President of the International Fisheries Section.

Adrian C. Pinder
Bournemouth University (UK) and Director of Research at Mahseer Trust

Adrian Pinder is a UK-based fisheries scientist with a career extending over 30 years. During this period, he has spent 20 years under the employment of the UK Government's Centre for Ecology and Hydrology, prior to joining Bournemouth University where he currently heads "BU Global Environmental Solutions (BUG)," a research consultancy specializing in fishery investigations and the development of sustainable environmental solutions throughout the UK and abroad.

It was a lifelong passion for angling that first led Adrian to South India's River Cauvery in search of the mighty hump-backed mahseer, a legendary fish that had been luring him to the subcontinent since first seeing pictures of this fish as a young boy. Since returning from his first trip in 2010, Adrian has served in a voluntary capacity as a Director and Trustee of the Mahseer Trust, an NGO he established to coordinate an international scientific effort to conserve some of South and Southeast Asia's most threatened fish species. On behalf of the Mahseer Trust and Bournemouth University, Adrian has traveled throughout India and hosted a number of international conferences and workshops. He has published extensively on a range of studies, from resolving the taxonomy of the genus Tor, to the utility of angler data to define population trends, to the imminent extinction threat to South India's hump-backed mahseer.

Stuart Orr
Leader of WWF Freshwater Team, World Wildlife International, Switzerland

Stuart Orr is the Leader of WWF's Freshwater Practice, driving the freshwater strategy of the world's largest independent conservation organization. A global authority on water stewardship, Stuart has spent the past decade devising and testing innovative approaches to freshwater conservation at WWF by engaging business and finance, and focusing on emerging themes such as the water-food-energy nexus, economic incentives and water-related risk. He has written numerous scientific papers and mainstream publications on issues ranging from corporate water governance to fish protein in the Mekong. Stuart has also sat on various advisory panels and boards, including the World Economic Forum's Water Security Council and the IFC's Infrastructure & Natural Resources Advisory Steering Committee.

Arjan Berkhuysen
Managing Director, World Fish Migration Foundation, Groningen, Netherlands

Arjan is passionate about people and nature. He believes man is part of nature, and he likes to work toward a future where man and nature coincide. Arjan has worked as head of the water programme of WWF Netherlands, where he focused on restoration and protection of estuaries worldwide. He has worked in the Netherlands restoring natural dynamics in the delta to bring back the sturgeon in the Netherlands. Arjan has served as director of the Waddenvereniging, a Dutch NGO protecting the UNESCO World heritage Waddensea. Together with the local population, the Waddenvereniging managed to stop gas exploration plans in the area, and Arjan successfully lobbied for changing the governance of the area. Arjan is particularly proud to have started the innovative Fish Migration River Project on the lower Rhine, with the goal of restoring the great and crucial Rhine Swimway routes. This project made him so enthusiastic on the issue of fish migration that he did not hesitate when he was asked to work for the World Fish Migration Foundation, where he now serves as Managing Director.

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Michael Philipp
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12

Number of countries across four continents that participated in the conference.

26

Number of presentations at the International Mahseer Conference on: Biology of Mahseer, Threats and Mitigation, Conservation of River Ecosystems, and Recreational Fishing.

6

Number of roundtable workshops that were held to formulate recommendations on specific topics related to Mahseer conservation and management.

7

Recommendations in the Declaration stating future actions needed to conserve Mahseer and the Large river ecosystems upon which they depend.

Working to sustain the natural world for people and wildlife

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