ASSESSING TO PLAN: NEXT STEPS TOWARDS CONSERVATION ACTION FOR THREATENED FISHES OF THE SUNDA REGION

IUCN SSC Species Survival Commission

CONSERVATION PLANNING SPECIALIST GROUP
Changing the Future for Wildlife

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Cover photo © Zahar A. Zakaria: *Paedocypris micromegethes*

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EXECUTIVE SUMMARY

In January 2019, the Freshwater Biodiversity Unit, IUCN Global Species Programme held a workshop to review global assessments for 400 species of freshwater fishes native to the Sunda region, for inclusion on the IUCN Red List of Threatened Species ™.

As part of this initiative, the IUCN SSC Conservation Planning Specialist Group (CPSG) facilitated a pilot trial of the Assess to Plan (A2P) process. The A2P sessions involved an additional review of the Threats and Conservation Actions information contained within the draft Red List assessments for threatened species, which was carried out by the assessors and an additional group of conservationists from the region. The purpose of this additional review was to identify the next steps towards conservation action for all species categorised as threatened.

During the workshop, Red List assessments were reviewed for 400 species, of which 122 species were categorised as threatened (Critically Endangered, Endangered or Vulnerable). Of these, 11 species are endemic to Sulawesi, 30 to Sumatra, 45 to Borneo and 18 to Peninsular Malaysia. A further 18 of the 122 threatened species occur at multiple locations throughout the Sunda region.

Assess to Plan (A2P) discussions revealed that for those taxa categorised as threatened, major challenges are peat swamp conversion, invasive species and overharvesting for the ornamental fish trade.

With so little of this habitat remaining, supporting individuals, organisations or initiatives concerned with protecting or where possible restoring peat swamp forests was considered critical. No feasible remedial action was identified to address the threat of invasive species and recommendations focused instead on attempting to increase the resilience of native threatened fishes by improving water and habitat quality, and in some cases by supplementing stocks of threatened species from aquaculture. Establishing the feasibility of supportive breeding was amongst the recommendations for species threatened by trade and genome banking was recommended for all threatened taxa. Eight species were assessed as Critically Endangered: Possibly Extinct. The immediate next step for these species is to establish whether they are extant, through surveys.

This workshop was the first trial of the Assess to Plan process and much was learned about how best to present information, support planning discussions and capture findings efficiently. Due to the experimental nature of this first workshop and to constraints on time, some areas and species received more attention than others and this is reflected in the structure of the report. We envisage more uniform treatment and reporting in subsequent A2P projects.

Subsequent to the completion of the workshop, Shoal (with support from WRS, IUCN SSC ASAP, Global Environment Centre and Monash University Malaysia and in partnership with the Parosphromenus Project) facilitated a meeting to develop an action plan for peat swamp fishes in Malaysia. A new working group, established at the workshop, are now developing projects and actions to take the priorities identified forward. This work will be extended to include Indonesia. Furthermore, IUCN SSC ASAP, WRS and Shoal are working to identify priority actions for all ASAP fishes (species listed as Critically Endangered on the IUCN Red List of Threatened Species and found in South-east Asia), to be completed by early 2021.

Full details of the A2P conservation action planning process and next steps for threatened fishes of the Sunda region are presented in the following pages.

1. INTRODUCTION

1.1 THE IMPORTANCE OF FRESHWATER ECOSYSTEMS

Freshwater ecosystems are estimated to cover just 0.8% of the Earth's surface yet provide a range of aquatic habitats essential to the survival of up to 12% of all known species. These ecosystems—rivers and their floodplains, streams, lakes, springs, marshes, bogs, fens, swamps, and peatlands to name a few— host more than 50% of all fish species (Acreman et. al., 2019; Fricke, Eschmeyer, & van der Laan, 2019; Mittermeier et al., 2010; WWF 2018).

However, these freshwater systems are now among the most threatened habitats in the world, due to a range of complex and multi-dimensional factors including human development, land-use change, creation of dams, water-diversion and drainage systems, unsustainable water extraction, logging, agriculture, pollution, overfishing, invasive species, disease, poor management and climate change (WWF 2020; WWF 2018, IPBES 2019).

Current wetland loss is estimated to be three times faster than forest loss with as much as 87% lost globally in the last 300 years, and fewer than 70 of the world's 177 longest rivers remain free of man-made obstructions (IPBES 2018; WWF 2018; IUCN 2020*a*).

Freshwater biodiversity is declining rapidly at the global scale with the Living Planet Index (LPI) for freshwater populations having fallen 84% since 1970 (equivalent to 4% per year); more than double the rate of species declines found in marine and terrestrial ecosystems (WWF 2018; IUCN 2020*a*; IPBES 2019).

Approximately 30% of the ~9,659 freshwater fish species assessed for the IUCN Red List of Threatened Species™ are considered threatened with extinction, and approximately 1% are already Extinct (EX) or Extinct in the Wild (EW) (as of 2020-1 version of the Red List; IUCN 2020*b*). Despite the importance of this rich biodiversity and known rapid declines in their populations across the planet, freshwater species are generally not considered a conservation priority (ASAP, 2019).

1.2 FRESHWATER FISHES OF THE SUNDA REGION.

"Freshwater fishes" are species that live all, or a critical part of their lives in either inland freshwaters or brackish estuaries. This definition includes all "primary" (salt intolerant or stenohaline) freshwater fishes; all "secondary" (salt tolerant or euryhaline) freshwater fishes, e.g. salmon, eels, some rays and sawfish; and some estuarine fish (IUCN FFSG, 2015).

Considering the small proportion of the Earth's surface that freshwater systems occupy, they house a disproportionately high fraction of the global fish diversity (more than 50 %, >15,000 freshwater fish species) (Froese and Pauly, 2019; Carrizo *et al.,* 2013; IUCN FFSG 2015, Tedesco *et al.,* 2017).

The Sunda region is a biogeographical region of Southeastern Asia, including Peninsular Malaysia on the Asian mainland as well as the large islands of Borneo, Sumatra, Sulawesi and their surrounding small islands.

The freshwater fish fauna of this region is exceptionally diverse, with over 1,000 species recognised, a high degree of endemism and new species regularly being described. However, relatively little is known about freshwater fishes of the region, in comparison to terrestrial and marine biodiversity. Available information on species' population trends, distribution and conservation status has been

extremely limited. Many of the freshwater fish species from Southeast Asia that have been assessed for the IUCN Red List, have been listed as Data Deficient and many other species have never had their conservation status assessed (ASAP 2019).

Considering the multitude of threats facing freshwater ecosystems and biodiversity in the region, there is a real concern that many freshwater fish species needing conservation attention are falling through the gaps, with the increasing possibility of species going extinct (ASAP 2019).

2. THE IUCN RED LIST OF THREATENED SPECIES

The IUCN Red List is a critical indicator of the health of the world's biodiversity. It is widely recognised as the most comprehensive, scientifically based source of information on the global status of fungi, plant and animal species. IUCN Red List Categories and Criteria are applied to individual species assessments to determine their relative risk of extinction. Threatened species are those listed as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU). Classification of species into the threatened categories applies a set of five quantitative criteria based on biological factors related to extinction risk, including rate of population decline, population size, area of geographic distribution and degree of population and distribution fragmentation.

In addition to information on abundance, distribution and population trends, the IUCN Red List assessment process includes identification of the threats posed to species, requiring assessors to attribute those that have contributed to the IUCN category assigned and encouraging them to indicate those having the highest impact. Further, the assessment process collects information on conservation actions in place and on what further conservation actions or research is thought to be needed.

Species that are either close to meeting the threatened thresholds or would be threatened were it not for ongoing conservation programmes are classified as Near Threatened (NT). Taxa evaluated as having a low risk of extinction are classified as Least Concern (LC). Also highlighted within the IUCN Red List are taxa that cannot be evaluated due to inadequate information to make a direct or indirect assessment of risk of extinction based on distribution and/or population status and are therefore assessed as Data Deficient (DD). This category does not necessarily mean that a species is *not* threatened, only that the risk of extinction cannot be assessed with the information available (IUCN 2012).

3. MULTI-SPECIES CONSERVATION ACTION PLANNING

IUCN's Species Survival Commission (SSC) has adopted an 'Assess – Plan – Act cycle' and a goal that 'every species that needs conservation attention is covered by an effective plan of action'. However, with more than a quarter of all species on the IUCN Red List assessed as threatened with extinction, there are too many species to address with single-species conservation planning.

As the planning arm of the IUCN SSC, the Conservation Planning Specialist Group (CPSG) is committed to enabling the rapid progression of threatened species from assessing, through conservation planning, and into effective action.

Species conservation action planning considers not only what action is needed but how it will be done, when, by whom and with what resources. Once these have been agreed among stakeholders, prospects for species can be expected to improve.

Species conservation action planning often benefits from a stakeholder inclusive environment in which species specialists collaborate with government agencies, relevant conservation NGOs, community groups, and the private sector, to establish a way forward that all groups can support and, ideally, benefit from.

These stakeholder-inclusive projects are resource intensive. Given the large number of species that need conservation attention through planning, it would be more efficient if each action planning process or event could address adequately the needs of multiple species. This is achievable for groups whose conservation needs overlap significantly, such as those sharing the same threatened environment or those targeted by threats that are taxon rather than site-specific, such as disease or over-harvesting for trade.

For a given large group of taxa, the information on threats and conservation actions needed contained in the Red List database is a valuable source of information for creating these multi-species planning groups and for identifying the next steps to conservation action both for these groups and for any "orphan" species that sit outside them. Therefore, it is important that this information is the best reflection of the expert knowledge available to the Red List assessment process.

Currently, species assessors use the published literature and personal knowledge to identify and prioritise threats to each species and to infer from this the conservation actions needed. Information is entered by ticking one or more of the boxes provided against two separate, standardised lists: one of threats, one of conservation actions needed. An accompanying text file (assessment documentation) is used to provide specific detail. Assessors may be responsible for one or more species within a wider Red Listing project.

The complexity of these two data classification standards, the need for a level of subjectivity in their use and the differences between assessors in their knowledge or experience, *can* result in the inconsistent application of these standards across species subject to the same circumstances. Such inconsistencies can be found both between entries done by different assessors and between entries done by the same assessor but at different times. As a result, what is one common threat may appear to be several different ones acting on different species, and different conclusions may be drawn about the kinds of action needed for species subject to the same threats, at the same site, depending on which species account is being viewed.

3.1 THE ASSESS TO PLAN (A2P) PROJECT

Red-List workshops potentially provide an opportunity for assessors to discuss and fix these inconsistencies, but in practice time is always short, and priority must be given to other sections of the Red List information that impact more directly on Red List category determination.

The "Assessing to Plan" process was formulated as an intermediate step between Red List Assessments and stakeholder inclusive action planning. It is designed to:

- be integrated into a Red List workshop
- support assessors and other experts present to view available Red List information on threats and on conservation actions needed across geographically clustered groups of threatened (Critically Endangered, Endangered or Vulnerable) species simultaneously, with a view to:

- enhancing the consistency and quantity of information on threats;
- enhancing the consistency and relevance of recommended conservation actions;
- generating additional information, insights and recommendations to move the group of species assessed into the conservation action planning realm.

The A2P process is necessarily more subjective and context-specific than the Red List process, which is objective and governed by universal standards. The A2P process uses the best information available within structured but creative discussions with experts and other stakeholders. It considers what needs to be done to conserve targeted species, focusing on what it might be possible for people to achieve given the political, economic and social contexts in which conservation must operate.

3.2 ASSESS TO PLAN (A2P) OUTPUTS

There are two primary outputs of the Assessing to Plan process. The first is more consistent and complete information on threats and conservation actions needed, for the group of species assessed as threatened by the Red List workshop. The second is a preliminary grouping of species with, for each group, recommendations for next steps in their conservation along with who will take those steps.

4. WORKSHOP SCOPE AND PROCESS

4.1 SCOPE OF WORKSHOP

The Freshwater Biodiversity Unit (FBU), IUCN Global Species Programme, with support from the Toyota Motor Corporation, is undertaking an initiative which aims to make significant progress towards completing a globally comprehensive assessment of freshwater fishes by 2021 (IUCN, 2020). In January 2019, the IUCN FBU held a combined IUCN Red List Review and Assess to Plan (A2P) workshop for freshwater fishes of the Sunda region, as part of this Global Freshwater Fish Assessment, in collaboration with IUCN SSC Asian Species Action Partnership and supported by Wildlife Reserves Singapore. The workshop took place over a total of five days, involving 19 participants, five Red List facilitators and two Assess to Plan facilitators. A list of all workshop participants is provided in Appendix I.

A total of 1,069 species of freshwater fishes are being assessed from the Sunda region. The aim of the workshop was to review draft assessments for 400 of these species, prior to their publication on the IUCN Red List of Threatened Species ™. A list of the 400 species for which assessments were reviewed during the workshop is presented in Appendix II.

The first (experimental) application of the Assess to Plan (A2P) process was incorporated into this workshop and CPSG worked in close partnership with the IUCN FBU to implement this additional planning component.

4.2 IUCN RED LIST ASSESSMENT REVIEW PROCESS

Prior to the workshop, an assessor(s) was identified for each species, based on their expertise, and contracted as a consultant(s) to complete a draft IUCN Red List assessment for each species that had been assigned to them.

During the workshop, participants worked in groups to peer-review and finalise these draft assessments, prior to submission to the Red List Unit, IUCN Global Species Programme. Species assessments were divided into five working sets, based on taxonomy (Table 1) and workshop participants divided into five groups (each group with an IUCN Red List facilitator) based on their

expertise. Within each working set, species were also allocated to one of five geographic sets, based on their global distribution. These geographic areas were Sulawesi, Sumatra, Borneo, Peninsular Malaysia and 'Sunda region-wide' for species with a distribution across more than one area within the Sunda region. Movement of experts between working groups was encouraged, to ensure each participant was able to contribute to and review assessments for the species within their taxonomic and geographic areas of expertise.

Group participants worked together to review each species assessment and confirm they agreed that the correct IUCN Red List Category and Criteria had been applied. This was carried out through facilitated review of the assessment documentation and verification that the correct Red List category and criteria had been applied. Experts had the opportunity to provide and discuss any additional information that was made available during the workshop, incorporating this new information into the assessment documentation and adjusting the Red List category, if applicable. All final draft assessment reviews were completed by group consensus and experts involved were listed as reviewers on the final draft assessment

Each group worked through their species assessment reviews following the same geographic order (all Sulawesi species first, followed by Sumatra, Borneo, Peninsular Malaysia and then Sunda region-wide). Within each geographic location, assessments with provisional threatened category assessments (Critically Endangered, Endangered, Vulnerable) were reviewed first, followed by species with provisional Near Threatened, Data Deficient and then Least Concern categories.

Post workshop, all draft assessments underwent a final pre-submission review, carried out by the IUCN FBU. Any outstanding queries were followed up with experts for resolution and then assessments were submitted to the Red List Unit for publication on the IUCN Red List.

Table 1. Taxonomic working sets for Red List review groups[1]

Working set	Number of species
1. Akysidae, Bagridae, Clariidae, Siluridae	74
2. Balitoridae, Cobitidae, Cyprinidae, Gastromyzontidae, Mastacembelidae	144
3. Eleotridae, Gobiidae, Rhyacichthyidae	63
4. Osphronemidae	99
5. Adrianichthyidae, Zenarchopteridae	20
Total number of species	**400**

4.3 ASSESS TO PLAN (A2P) PROCESS

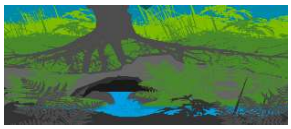
A2P matrices were created for the species assessed as threatened within each of the five Sunda geographic regions (Sulawesi, Borneo, Sumatra, Peninsular Malaysia and Sunda region-wide. See attached Appendices 3.1 – 3.5). Each matrix provided an overview of the threats, conservation actions needed and conservation actions in place, as selected within the coded sections of each species' Red List assessment, by the Red List assessors. Within each matrix, species were ordered by their level of endemicity within the region (those species with the most restricted distribution listed first moving up to species that may occur through the region listed last).

A2P sessions were held for each of the five Sunda regions. For each region, workshop participants with expertise on species, threat process and/or conservation actions in place on the ground in that region joined the A2P session. The A2P matrix allowed experts to view the threats and conservation actions

[1] *The Family names Gastromyzontidae and Zenarchopteridae used in this report are correct, however currently deviate from the taxonomy published on the current IUCN Red List (2020-1).*

needed across all threatened species within that region simultaneously and several inconsistencies in the Red List coding were identified. Following discussion and agreement with the relevant Red List assessors, changes to the coding within assessments were recommended and were highlighted within the A2P matrix. The A2P working group then assigned each of the species threatened to one (or more) of five A2P 'buckets' (site, habitat, threat, single species and intensive care), depending on their most critical conservation action planning needs. The five A2P conservation planning buckets for threatened species and a summary description for each are presented in Table 2.

Table 2. Summary of the five A2P conservation planning buckets for threatened species.

A2P conservation planning bucket	Description
Site directed action planning 	• species inhabiting a defined area and subject to multiple localised threats linked to that area (e.g. species affected by disturbance, pollution and other impacts from specific development projects at a particular site).
Habitat directed action planning 	• species dependent on the same, specific habitat type which is subject to a common threat or set of threats (the specific habitat type could occur at multiple sites).
Threat directed action planning 	• groups of species targeted by a common threat that is not anchored to a site or sites, but which travels with the species (e.g. species targeted for traditional medicine or international trade; species affected by a disease pandemic such as chytrid fungus).
Single or multi - species recovery action planning 	• outlier species whose conservation needs do not overlap well with those of other species and therefore require a unique set of actions, or high-profile species whose needs overlap well with many others can provide an effective umbrella for planning.
Intensive care action planning 	• species for which *in situ* conservation alone is considered unlikely to prevent extinction within the time available and planning for potential intensive species management of some form may be also be required (could include actions such as small population management or translocation, genome banking, intensive management in the wild, *ex situ* management etc).

Within each A2P bucket, species groups were created by identifying species that overlap in terms of the conservation actions needed, that can be addressed by the same conservation agencies. For example, 25 species could be allocated to the A2P 'site' bucket. Within that, 17 of the 25 species occur at 'Site A' and eight occur at 'Site B'. Conservation planning for multi-species can be co-ordinated at this site level, however conservation planning actions and relevant stakeholders are likely to differ *between* sites A and B. Hence in this example, there are two *'species groups'* within the A2P 'site' bucket. Similarly, 12 species could be allocated to the A2P 'threat' bucket. Five of these species could require conservation planning around international trade as the major threat, whereas seven of these species could require conservation planning around a specific disease as the major threat. Therefore, there are also two 'species groups' within this A2P 'threat' bucket (Figure 1).

Figure 1. Example of species *'groups'* housed within A2P threatened species 'buckets'. Species *groups* house species expected to respond positively to the same set of conservation actions *and* whose conservation can be addressed by the same constituency of conservation actors or agencies.

A2P conservation planning sessions were held for each of the threatened species groups identified during the workshop. Discussions were held with species experts to identify the planning or conservation actions required and the key collaborators and stakeholders potentially involved in taking the next steps for each group.

The aim of A2P discussions was that by the end of the workshop, all species considered during the A2P process would be assigned to at least one multi-species group, with each group assigned conservation action or further planning recommendations, and a workshop participant who would lead on taking these actions forward, post workshop.

5. RESULTS OF THE 2019 ASSESS TO PLAN (A2P) PROJECT FOR FRESHWATER FISHES OF THE SUNDA REGION.

The outputs of the 2019 Sunda Fish Assessing to Plan working group discussions are provided, organised into the following sections:

Geographic boundary	Number of threatened species considered
Indonesia	
Sulawesi	11
Sumatra	30
Indonesia/Malaysia	
Borneo	45
Malaysia	
Peninsular Malaysia	18
Sunda region-wide	18
Total number of threatened species	122

5.1 SULAWESI

Contributors: Mike Baltzer, Nerissa Chao, Mohammad Mukhlis Kamal, Zeehan Jaafar, Helen Larson, Daniel Lumbantobing, Kelvin Lim, Daniel Mokodongan, Jihad Sulfani Udin, Frank Van Veen.

5.1.1 SITES AND SPECIES

From a total of 20 Sulawesi species assessed during the workshop, 11 were categorised as threatened. These 11 species and the five sites where they occur (Table 3 and Figure 2), were the focus of A2P discussions on the first day of the Red List workshop. The main points and recommendations from these discussions are captured below.

Table 3. Sulawesi species categorised as threatened at the 2019 Sunda Freshwater Fishes Red List Review Workshop in Singapore, showing threat category and the site where they occur.

Site	No. of species	Species name and category
1. Lake Poso	6	*Adrianichthys kruyti* (CR - PE); *Adrianichthys roseni* (CR - PE); *Mugilogobius amadi* (CR - PE); *Nomorhamphus celebensis* (EN); *Mugilogobius sarasinorum* (EN); *Xenopoecilus poptae* (EN)
2. Lake Lindu	2	*Xenopoecilus sarasinorum* (CR); *Xenopoecilus bonneorum* (EN)
3. Lake Tiu	1	*Oryzias soerotoi* (CR)
4. Asinua District, Konawe Regency	1	*Oryzias asinua* (EN)
5. Muna Island	1	*Oryzias woworae* (EN)

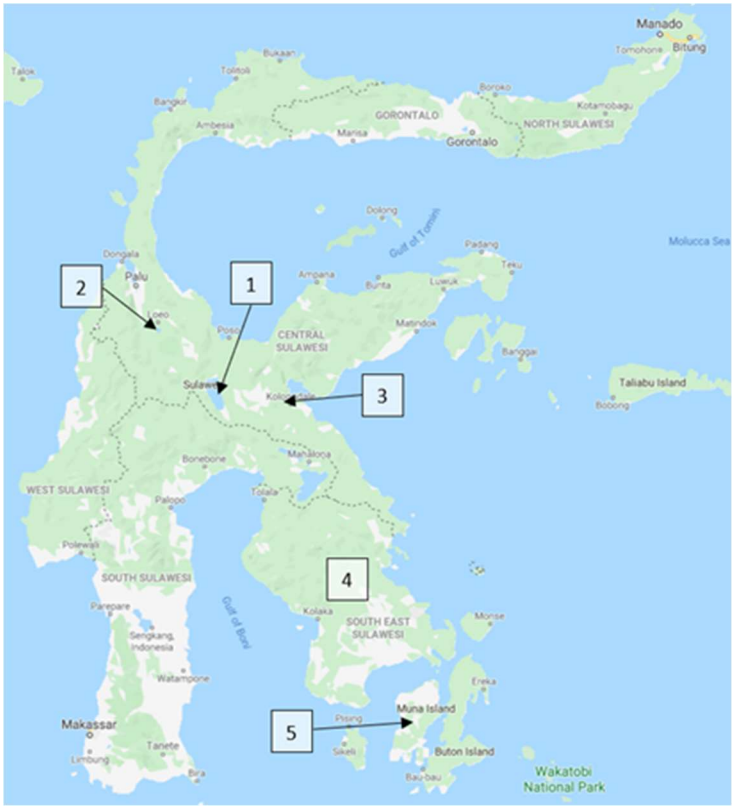


Figure 2. Map illustrating the distribution of the 11 threatened Sulawesi endemics, across five sites. 1= Lake Poso (6 species); 2= Lake Lindu (2 species); 3= Lake Tiu (1 species); 4= Asinua District, Konawe Regency (1 species); 5= Muna Island (1 species)

5.1.2 SULAWESI: SITE-SPECIFIC THREATS

1. LAKE POSO

The coded threats assigned to these species through the Red List assessment suggested species-specific differences in vulnerability to the threats associated with the Lake. When discussed in detail with the group of species experts, a picture of the Lake's history emerged that explained these differences.

A volcanic eruption in the sea off Sulawesi in 1983 caused tectonic effects in the Lake, possibly giving rise to the release of toxic gases in its deepest parts (Larson, H. pers. comm., 2019). It is assumed that this affected all fish in the lake (mass die-offs were observed at that time) but that it had a particularly big impact on the larger, pelagic fish such as *A. kruyti, A. roseni and M. amadi*. Smaller fish inhabiting the shallower edges of the lake (such as *N. celebensis, X. poptae* and *M. sarasinorum*), are thought to have been less affected.

Subsequently, invasive species, such as common carp *Cyprinus carpio*, Nile tilapia *Oreochromis niloticus,* climbing perch *Anabas testudineus*, airbreathing catfish *Clarias* species, and striped snakehead *Channa striata* (Harder *et al.,* 2012; Mokodongan 2019*a*; Jaafar 2019) were introduced, some as food fish as part of government-driven food security initiatives, others as discards from ornamental fish hobbyists and breeders. Agriculture and other human activities around the lake have also increased in the years since the tectonic impacts, reducing water quality. Pesticide and herbicide run-off, sedimentation and nutrient overload are all considered threats. Domestic waste and sewage are assumed to be smaller problems here than in other areas but are expected to increase as the human population expands. A combination of these threats is assumed to have led to the decline of *N. celebensis, X. poptae* and *M. sarasinorum* (and to other species native or endemic to the lake). The pelagic species, *A. kruyti, A. roseni and M. amadi*, may be less affected by pollution emanating from the lake's edge, but invasive species would be expected to limit their recovery, assuming that they are not already extinct.

A dam is situated in the vicinity of Lake Poso. Following discussion, it was agreed that as the dam is not directly connected to the lake, turbidity effects are unlikely, and no reports were known of water levels being affected. The dam is a known threat to migratory fish such as eels but was not considered a risk to these lake endemics.

Mugilogobius amadi used to be a staple fish in the lake. *Adrianichthys kruyti* and *A. roseni* would also have been fished. These fish are now extremely rare (possibly extinct) and fishing is now largely for the introduced invasive species. If these threatened species were to recover it is assumed that they would be fished again for food. It was noted that *X. poptae* is still fished for food.

Some of these fish are harvested for the ornamental trade. *Mugilogobius amadi* has been falsely identified in trade (due to misidentification of species). *Mugilogobius sarasinorum* has been confirmed as present in the aquarium trade, and *N. celebensis* is known to be collected from the wild for the ornamental pet trade.

The impact of volcanic activity remains a risk for the future, to all endemic species in Lake Poso as the lake floor straddles two tectonic plates.

It was considered unlikely that current threats could be mitigated in time to allow recovery of those species that are already considered possibly extinct.

2. LAKE LINDU

Xenopeocilus bonneorum is endemic to Lake Lindu, which is situated near to but not in, a protected area. As the lake is relatively shallow it is assumed to be more vulnerable than Lake Poso to the impacts of human activities around its shores. There is expanding agriculture around Lake Lindu, as well as livestock grazing and forestry, which create water quality issues. Three species of introduced fish are known to occur in the lake, (Mozambique Tilapia *Oreochromis mossambicus*, the Common Carp *Cyprinus carpio* and the Walking Catfish *Clarias batrachus*). These were first introduced into the lake in the 1950's to increase commercial fish production but have now become the most common fish species in the lake. Although their impact on *Xenopeocilus bonneorum* is unknown, it is assumed to be negative.

3. LAKE TIU

Oryzias soerotoi is endemic to Lake Tiu, which is located in central Sulawesi about 65 km east of Lake Poso and 50 km from the Malili Lakes. It is a narrow lake that extends 2 km from north to south (Mokodongan *et al.* 2014, Mokodongan and Yamahira 2015). Lake Tiu has established fisheries and invasive fish species such as tilapias (*Oreochromis* species), snakehead (family Channidae), and goldfish (carp) have become established, however it is not known how large an effect this has had on the native fish in the lake, including *Oryzias soerotoi*. Another threat comes from oil palm plantations which are reclaiming areas surrounding the lake, especially the eastern coastal area (Mokodongan *et al*. 2014). These plantations could increase run off and change turbidity and nutrient levels within the lake (Mokodongan 2019b).

4. ASINUA DISTRICT, KONAWE REGENCY

Oryzias asinua occurs in a single body of water where there is large-scale sand-mining by local people. This may impact the species' spawning habitat and reduce or prevent breeding, but this is not known. At present local communities are not aware of this problem.

5. MUNA ISLAND

Oryzias woworae was previously known from one location but has since been recorded at five more localities. Expeditions in 2014-2015 failed to record this species at one of the locations (Waleale River) and so it may have become extinct here. Water levels at this site are low due to the presence of a dam. It is assumed that this may have contributed to the decline or loss of the species from tis location.

There are invasive species at all sites, but their impact on *O. woworae* is not understood. There is also fishing at all sites. It is not known whether *O. woworae* is a food fish, but it is sought after in the aquarium trade and so may be affected by harvesting.

5.1.3 SULAWESI: CONSERVATION NEEDS AND OPPORTUNITIES

Invasive species and **declining water quality** were agreed to be the main threats to the recovery and conservation of threatened freshwater fish in Sulawesi. Over-harvesting, particularly for the **ornamental trade** but also for **food,** was considered an ongoing issue for several species and **sand-mining** is a localised problem affecting a single species. The following section captures the group's discussion on the challenges and opportunities for mitigating and managing these and other threats over the next 5 – 10 years.

MANAGING INVASIVE SPECIES

The removal of invasive species from these water bodies was considered neither feasible nor affordable. The active introduction of invasive fish has been part of government-driven food security programmes, as well as the result of careless introductions from the aquaculture industry. Though preventing further introductions was considered sensible, invasive stocks were thought to be too well-established for this to make much difference. There are initiatives in other places that encourage the commercial fishing of invasive species as a stock-reduction strategy, but it was not known whether this could work in Sulawesi. It was agreed that though the presence of invasive species is assumed to be a barrier to recovery of threatened species, it is not understood how this works. Competition for resources and disease transmission are assumed to be the main risks but the details of this are not well-understood. It was agreed that it might be possible to identify ways of supporting these species if more was understood about their interaction with invasive species, though this would be difficult, given that some have not been seen for many years. In general, it was agreed that focusing on building resilience of local species by improving water and habitat quality, would be a more achievable short-term strategy for mitigating the threat of invasive species, while more research and engagement with government and aquaculture would be sensible longer-term strategies.

MANAGING OVER-HARVEST FOR FOOD OR TRADE

The 11 species assessed as threatened may now be eligible for protection under sub-national or national laws or decrees. It was noted that there is a "freshwater species gap" in the national species protection list. Engaging with relevant government agencies on this would be a useful first step to formalising protection at the appropriate level. For any species currently or potentially impacted by international trade, CITES listing may be considered.

In some cases (depending on the type of fishing), it may be possible to work with fisherman to substitute threatened species for more common species. *Xenopoecilus poptae* was a suggested candidate for this.

CONSERVATION-DIRECTED RESEARCH

For *Oryzias asinua*, more information on sand-mining and on the species spawning habits and critical habitat may facilitate protection or management at some key sites. For other species, developing a greater understanding of threats, including but not limited to the interaction with invasive species, may help inform mitigating action.

COLLABORATING ON SHARED GOALS

Lake Poso and Lake Lindu are tourist destinations, providing economic incentives for good environmental stewardship. Lakes in Sulawesi (including Lake Poso) have been described as "the Galapagos Islands of the fish world". Local communities rely on clean water for their health and well-being and on fish for food. Where there are dams, the dam turbines rely on clean water and are negatively affected by turbidity. These shared goals around clean water, fish abundance and general environmental quality may provide opportunities for productive engagement with both local communities and the private sector.

Management improvements at the broader site level would be beneficial at all sites, not only for wildlife but for the local communities that rely on fresh water and on fish stocks for their well-being, and for others whose livelihoods benefit from the quality and productivity of these areas. Site-level planning for this was recommended with attention to the management of domestic, agricultural and recreational activities considered important targets. Burung Indonesia is involved in a project with

communities around Lake Poso to raise awareness of biodiversity values and to engage them in programmes to limit pesticide and herbicide run-off. Approximately 5% of the communities around Lake Poso have been engaged to date. There may be similar initiatives at other sites and further support for this work could expand its reach.

AWARENESS AND COMMUNICATION

Few people are aware of the plight of these threatened species. Raising awareness of this as a problem and encouraging actions aimed at supporting recovery may be a valuable conservation activity. **However, awareness and communication work must be carefully targeted, and the risks evaluated.** Many endemic fish from Sulawesi are beautiful and popular in the ornamental trade. There is a risk of increasing the level of interest in catching and trading them.

EX SITU SUPPORT

Some species are already present in trade and are thought to be easily bred in captivity (e.g. *Oryzias woworae)*. It is possible that others could be successfully bred if brood stock was available. Well-targeted conservation breeding programmes at an appropriate scale, carried out *ex situ* in Sulawesi, could be used to buy time for species while the results of mitigation take effect and to increase numbers rapidly to restock areas where threats have been adequately mitigated. Establishing the need for this in individual cases, and the feasibility of achieving it, was considered a valuable exercise for all threatened species and especially for those threatened by trade.

GENOME RESOURCE BANKING

Genome resource banking is broadly defined as the storage of gametes, testes, or embryos. Threatened populations are targeted for genome banking to preserve genetic diversity. Cells stored in liquid nitrogen; a process known as cryopreservation. Cryopreserved cells are frozen but alive, and the genetic material remains unaltered. These frozen banks store genomic material of extant species that may seed shrinking populations, maintain genomic material of rare and threatened species, and sustain genomic material of extant species to secure genetic diversity. Select cell types, for example testicular or embryonic cells, can regenerate new individuals under correct treatment, and potentially counter species extinction (Hagedorn et al. 2018). It was recommended that all 11 species be targeted for genome resource banking. [Note that though some have not been found by researchers for many years, it is possible that local people still find them.]

The recommended conservation action priorities for threatened freshwater fish species endemic to Sulawesi are summarised in section 5.1.4. below.

5.1.4. RECOMMENDED CONSERVATION ACTION PRIORITIES FOR SULAWESI ENDEMICS

Threat	Recommended action
Invasive species	**Short-term:** Raise awareness among target audiences and particularly within the aquaculture industry, to prevent more releases. Increase understanding of the specific impact of invasive species on endemic species to help identify feasible mitigation options. **Long-term:** Research and trial a range of mitigation options.
Pollution/water quality issues	**Short-term:** Work with communities to reduce pollution from domestic waste, agriculture and forestry. Engage with the private sector (e.g. tourism, the hydro-electric company) to pursue shared interests in maintaining lake water quality. **Long-term:** Develop community-driven area/site management plans that include biodiversity conservation provisions (e.g. management of agriculture, forestry and domestic effluent, recreational activities, and of harvesting).
Fishing for food or the ornamental trade	Assessment of trade impact for all species threatened by trade, to establish what level of legal protection would be useful (e.g. sub-national, national or international) and whether a harvest management plan is needed. Targeted awareness and communication to encourage substitution of threatened species still caught for food (*X. poptae*) and to discourage harvesting for trade.
Stochastic risks (e.g. tectonic activity, small population effects)	Feasibility study for ***ex situ* management** within Sulawesi, of all 11 species categorised as threatened, and a resulting action plan if considered feasible. Genome resource banking for all 11 threatened species.
Information gaps	Surveys to confirm whether three of these species are extant (*A. kruyti*; *A. roseni*; *M. amadi*) Gather more information on sand-mining, species spawning habits and critical habitat. Gather more information on threats to taxa, directed towards designing mitigating action.
Multiple threats	Develop a multi-species conservation action plan for the six species in Lake Poso.

5.2 BORNEO, SUMATRA, PENINSULAR MALAYSIA

Contributors: Amirrudin B. Ahmad, Mike Baltzer, Kenny Chua Wei Jie, Jonathan Ho, Zeehan Jaafar, Daniel Lumbantobing, Mohammed Mukhlis Kamal, Kelvin Lim, Daniel Frikli Mokodongon, Heok Hee Ng, Bi Wei Low, Heok Hui Tan, Sara Thornton, Jihad Sulfani Udin, Frank Van Veen, Clare Wilkinson, Yulintine.

5.2.1 SUMMARY REVIEW OF THREATENED SPECIES

BORNEO ENDEMICS

A total of 45 freshwater fish species assessed as threatened during the workshop are endemic to Borneo. Of these, 19 were categorised as Vulnerable, 20 as Endangered, and six as Critically Endangered (see complete list of species assessed in Appendix I). The map in figure 3 below provides an indication of the geographic spread of these 45 threatened species across the island. A large proportion (82%) of these species are located towards the south and west part of the island, in Kalimantan and southern Sarawak. Only one of the Bornean threatened species occurs in Brunei Darussalam; two occur at the northern most part of the island in Sabah and one species in northern Kalimantan. The Kapuas River basin in West Kalimantan, and the Sadong River basin in Sarawak appear to be key areas for threatened freshwater fish species and 34 species are endemic to or reliant on peat swamp forests and black water habitats for their existence.

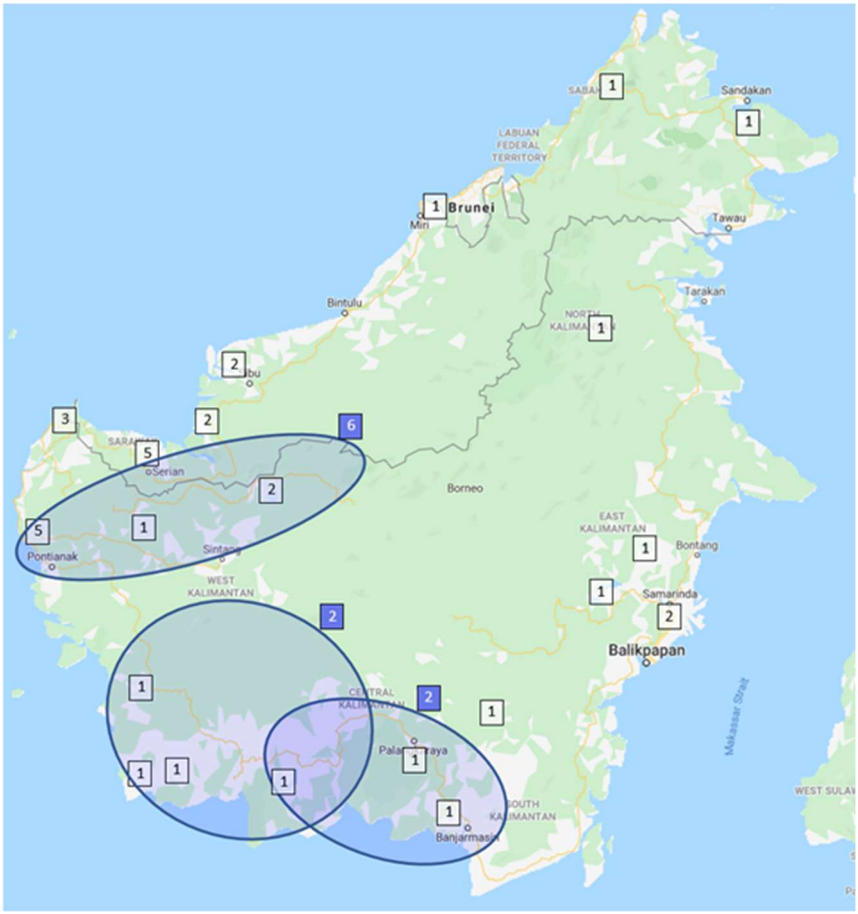


Figure 3. Map illustrating the distribution of the 45 threatened freshwater fish species endemic to Borneo. The white squares refer to the number of species found (approximately*) in that localised area. The three large blue ovals indicate wider areas for which species are found at multiple locations throughout that area (the numbers of species for which this applies are provided in the adjacent blue squares).

**Please refer to individual species assessments on the IUCN Red List website for an accurate distribution map of each species.*

SUMATRA ENDEMICS

Thirty of the species categorised as threatened at the workshop are endemic to Sumatra. Of these, nine were categorised as Vulnerable, 12 as Endangered and nine as Critically Endangered with one of the latter considered possibly extinct. Nineteen of the 30 species are spread across locations on mainland Sumatra and the other eleven are confined to one or more of the six associated islands. A total of 24 species are endemic to or reliant on peat swamp forests and black water habitats. The map in Figure 4 below illustrates the distribution of species. For further information on the locations of individual species see the Sumatra A2P Matrix (Appendix 2.3) of this report and the individual species assessments on the Red List website.

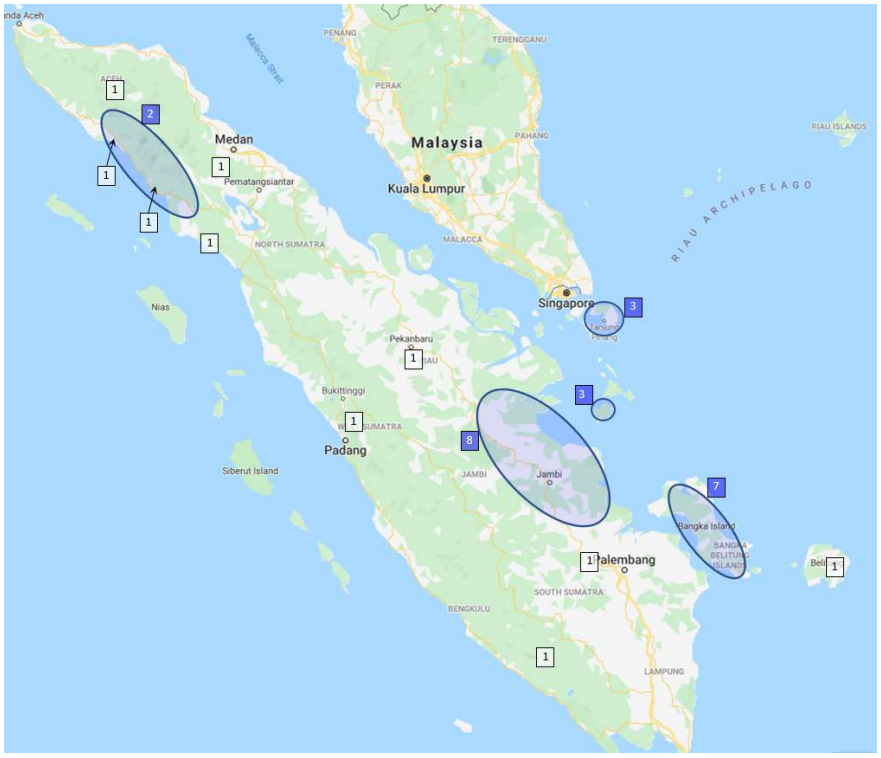


Figure 4. Map illustrating the distribution of the 30 threatened freshwater fish species endemic to Sumatra. The white squares refer to species found (approximately*) in that particularly localised area. The large blue ovals indicate wider areas for which species are found at multiple locations throughout that area. The numbers of species found within these wider areas are provided in the adjacent blue squares. (N.B. Three of the 11 species that are confined to offshore occur on more than one island).

**Please refer to individual species assessments on the IUCN Red List website for an accurate distribution map of each species.*

PENINSULAR MALAYSIA ENDEMICS

Eighteen of the species categorised as threatened are endemic to Peninsular Malaysia. Of these, one was categorised as Vulnerable, 10 Endangered and seven as Critically Endangered with two of the latter considered possibly extinct. The map in Figure 5 below illustrates the distribution of species.

For further information on the locations of individual species see the Peninsular Malaysia A2P Matrix (Appendix 2.3) of this report and the individual species assessments on the Red List website.

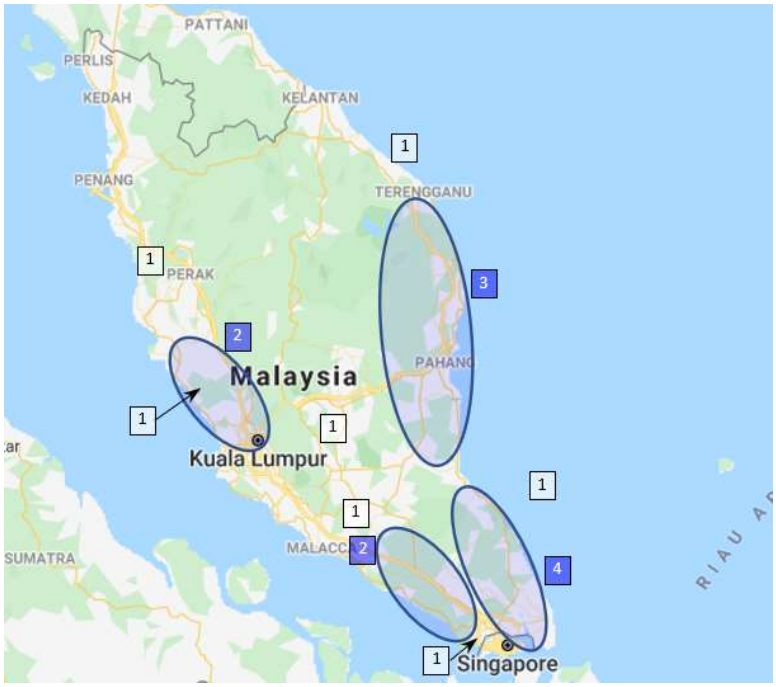


Figure 5. Map illustrating the distribution of the 18 threatened freshwater fish species endemic to Peninsular Malaysia. The white squares refer to species found (approximately*) in that particularly localised area. The large blue ovals indicate wider areas for which species are found at multiple locations throughout that area. The numbers of species found within these wider areas are provided in the adjacent blue squares.

**Please refer to individual species assessments on the IUCN Red List website for an accurate distribution map of each species.*

OTHER THREATENED SPECIES FROM INDONESIA AND MALAYSIA

A further 29 species categorised as threatened occur in Indonesia and Malaysia. Eleven of these are endemic to Sulawesi and discussed in the "Sulawesi" section. Five are endemic to Java, two are found in Java and Sumatra, four in Sumatra and Peninsular Malaysia, four in Peninsular Malaysia and Thailand, one in Timor and one occurs in Cambodia, Lao PDR, Peninsular Malaysia, Thailand and Vietnam. These are all discussed in the "Sunda region-wide" section.

5.2.2 REVIEW OF THREATS AND OPPORTUNITIES

Habitat loss and degradation due to peat swamp forest conversion (for industrial scale forestry and monoculture plantations and smallholder agriculture) and fires are the most significant threats, affecting 72 threatened species. Unsustainable collection for the aquarium trade is another significant known, or potential threat to 31 of the 93 species.

SPECIES ENDEMIC TO OR FOUND IN PEAT SWAMP FORESTS OR BLACK WATER HABITATS

Borneo - 34 threatened species:

Critically Endangered: *Betta hendra, Betta pinguis, Betta rutilans, Parosphromenus ornaticauda, Parosphromenus quindecim, Parakysis notialis*; **Endangered:** *Betta channoides, Betta chini, Betta foerschi, Betta mandor, Parosphromenus anjunganensis, Parosphromenus filamentosus, Parosphromenus linkei, Parosphromenus opallios, Parosphromenus pahuensis, Sphaerichthys vaillanti, Parakysis anomalopteryx, Encheloclarias baculum, Encheloclarias prolatus, Clarias kapuasensis, Clarias pseudonieuhofii;* **Vulnerable:** *Paedocypris micromegethes, Betta brownorum, Betta dimidiata, Betta ibanorum, Betta lehi, Betta midas, Betta uberis, Parosphromenus allani, Parosphromenus parvulus, Sphaerichthys acrostoma, Stigmatogobius signifier, Encheloclarias medialis, Sundadanio echinus.*

Sumatra - 24 threatened species:

Critically Endangered*: Betta burdigala, Betta chloropharynx, Betta cracens, Betta miniopinna, Betta pardalotos, Parosphromenus gunawani, Parosphromenus phoenicurus;* **Endangered:** *Betta rubra, Betta schalleri, Betta spilotogena, Clarias microspilus, Luciocephalus aura, Parakysis hystriculus, Sundadanio atomus, Sundadanio goblinus; Parosphromenus deissneri;* **Vulnerable:** *Betta dennisyongi, Betta simorum, Betta renata, Encheloclarias tapeinopterus, Encheloclarias velatus, Parosphromenus bintan, Sundadanio axelrodi, Sundadanio gargula.*

Peninsular Malaysia – 12 species:

Critically Endangered*: Encheloclarias kelioides (PE), Parosphromenus alfredi;* **Endangered:** *Betta persephone, Betta livida, Betta tomi, Betta tussyae, Betta waseri, Encheloclarias curtisoma, Parosphromenus harveyi, Parosphromenus rubrimontis, Parosphromenus tweediei;* **Vulnerable:** *Parosphromenus nagyi.*

There has been a dramatic loss of peat swamp forest habitat across Indonesia and Malaysia due to the development of industrial scale forestry and conversion to monoculture (particularly oil palm plantations); as well as logging; water diversion and drainage and conversion to small-holder agricultural areas.

Additionally, peatland fires have become an annual phenomenon across Kalimantan and Sumatra, having significant negative impacts on wildlife, the global climate and human health (Page *et al.,* 2002; Tacconi, 2003; Tacconi, 2016; Harrison *et al.,* 2016). In Malaysia the peat areas are less prone to fire due to the replacement of peat swamp forest with oil palm. Very little peat swamp forest remains in Peninsular Malaysia. Undisturbed peat-swamp forests are generally resistant to fire. However, peat degradation resulting from drainage of peat swamps, combined with prolonged droughts cause peatlands to dry out and become highly vulnerable to fire (Turetsky *et al.*, 2015). Peat-swamp forests are drained through the construction of drainage canals which lower the water table of the peatland. Drainage canals are built for plantation development, logging and agriculture. Currently at least half of all peatland areas across Indonesia are drained with varying intensity (Miettinen *et al.,* 2017). Peat-swamp forest loss is expected to continue and is predominantly driven by agricultural development and fire (Miettinen *et al.,* 2012). The development of lowland peat-swamps in Borneo has come about due to increasing scarcity of agricultural land, and a persistent demand for forest and agricultural products locally as well as globally (Miettinen *et al.,* 2012b; Ritzema *et al.,* 2014). This has catalysed movements into marginal land, such as peatland, to increase food production (Nursyamsi *et al.,* 2016).

Peatland fires are a consequence of human activity (land-use change, increased human access and increased risk of anthropic ignitions) and of the absence of strong policy initiatives and effective policy implementation (Page and Hooijer, 2016). Fires are predominantly started by people; either deliberately or accidentally (Cattau *et al.,* 2016). Their reasons for ignition are diverse, resulting from complex underlying causes (Dennis *et al.,* 2005; Cattau *et al.,* 2016). Slash and burn agricultural techniques have a long history in Borneo, and the livelihoods of small farmers generally still depend upon fire as the only affordable way to rapidly clear land (Cochrane, 2003; Rieley and Page, 2005; Page and Hooijer, 2016). Fires are also started through arson, from cooking fires, to create better access to valuable timber and to hunt animals, including fish (Dennis *et al.,* 2005; Tacconi and Vayda, 2005; Medrilzam *et al.,* 2014; Thornton *et al.,* 2017). In many situations fire is a useful, effective and efficient tool for communities (Chokkalingam *et al.,* 2005; Tacconi and Ruchiat, 2006). However, once ignited, fires on peatlands can quickly spread out of control. In degraded peatland areas, these fires persist in

the subterranean, and the substrate continue to smoulder. These fires are especially difficult to extinguish despite extensive rains or firefighting attempts. Fires can linger for weeks, months and occasionally longer (Harrison *et al.,* 2009; Turetsky *et al.,* 2015; Page and Hooijer, 2016).

If solutions are not found to counter the problematic fires in Kalimantan (and peatland habitats across Indonesia) and Sarawak, Malaysia, as well as the underlying socioeconomic factors driving the drainage and clearance of peat-swamp forests, the remaining peat-swamp forests will be lost along with threatened fish species that are found in these unique habitats.

Although Indonesia has placed a moratorium on new development in peat swamps, there is a lack of enforcement of this and the moratorium does not cover already designated concessions.

Heath forest, known as 'Kerangas' or 'Sundaland heath forest', is a less understood and less studied habitat compared to peat swamp forest habitat. Heath forest areas are characterised by sandy, fast draining low nutrient soils. They are mostly found in a band in Southern Kalimantan between the low-lying coastal peatlands and the tall Dipterocarp forest in the hills and mountains of Borneo's interior, and further also in Brunei as well as Bangka and Belitung Islands (which are included in the Sumatra section of this report). The aquatic habitats in kerangas contain low pH 'black water' (similar to peat swamps) and mostly consist of small streams in relatively steep valleys with permanent pools connected by transient riffles, feeding larger permanently flowing streams. Limited, ad-hoc sampling of these habitats has shown their potential importance for 'Endangered' *Betta foerschi* and 'Vulnerable' *Encheloclarias medialis* as well as the presence of yet undescribed taxa that appear to be confined to these habitats. Currently, most of the remaining intact Kerangas forest is situated in Central Kalimantan and is destined for either commercial logging or conversion to plantations (oil palm and *Acacia*) in land-use destination planning. None of it is included in protected areas. Outside the logging and plantation concessions the major threats are illegal logging with the use of heavy machinery that destroy the small streams, and unregulated gold mining that severely impacts the larger permanently flowing streams (Figure 6), and the larger rivers they flow into, by dramatically changing the river bed, increasing turbidity and through pollution with mercury. Studies of aquatic biodiversity in "Kerangas" and the impact thereon of land-use change and other threats are urgently required.

Figure 6. The impact of unregulated gold mining on aquatic Kerangas habitats. © Frank Van Veen

Badan Restorasi Gambut (BRG) is an agency within the Indonesian government that provides oversight and some funding for peatland restoration, operating mainly in West Papua, Kalimantan and Sumatra. They have a three-pronged approach:

- re-wetting (blocking canals).
- re-vegetating (with plants conducive to restoring peatlands).
- re-vitalising livelihoods (agro-forestry and aquaculture).

This initiative was instigated by presidential decree following the devastating 2015 peatland fires with a 5-year term which ends December 2020. The future of the BRG beyond this date is currently unknown but the hope is that, following the re-election of President Widodo in 2019, its term will be extended. Restoring peatland is a difficult and lengthy process and not possible in all cases, however there are opportunities to make positive changes, especially in areas only recently damaged. Further multi-disciplinary research is required to aid this initiative.

Further peat-swamp forest conversion to agricultural land (and other land uses) must be further halted. In addition to increasing vulnerability to fire, peatland drainage also causes peat decomposition, leading to land surface subsidence. High rates of land subsidence are inevitable consequences of conversion of forested tropical peatlands to other land uses (Hooijer *et al.,* 2012). It has been estimated that drained peatlands in the tropics can lose between 3 to 5 cm in height per year. As a result, and within only a few decades, ongoing subsidence will likely threaten the long-term agricultural and economic productivity of drained coastal tropical peatlands. As drainage also increases the risk of fire, along with the significant negative impacts from these on global climate and human health, high water levels in peatland areas must be restored and maintained. In managed areas of peatlands (e.g. industrial plantations), the highest possible water table levels tolerated by the plantation species need to be kept (Page and Hooijer, 2016). There are opportunities to engage with companies on this. There are also precedents in Sumatra, where companies have set-aside and protected peat-swamp forest areas (e.g. APRIL Group: https://www.aprilasia.com/en/sustainability/peatland-management).

Engaging with the Roundtable on Sustainable Palm Oil (RSPO) may help to get freshwater and freshwater fish conservation issues factored into their certification scheme (the mechanisms for this are through the Indonesian Sustainable Palm Oil (ISPO) system and Malaysian Sustainable Palm Oil (MSPO) system. Certification is partly based on no loss of high conservation value (HCV) sites in Malaysia. Information from researchers can also be supplied to update best practices (e.g. Barclay et al 2017), that feed into the guidelines for certification. For example: road development, width/ design of riparian buffers, how land is cleared, application of pesticides/fertilisers. For example Sabah is leading efforts in the region with regards to aims for all oil palm to be certified (however, currently this is often not enforced) (https://www.theedgemarkets.com/article/sabah-reaffirms-pledge-full-rspocertification-2025; https://www.theborneopost.com/2018/11/17/cm-sabah-palm-oil-100-rspo-certified-by-2025/).

Opportunities to connect with local communities on the benefits of protecting peat swamp forests to sustain the fish populations, as well as on protecting important freshwater sources from the impacts of gold mining (which causes mercury pollution, silts up rivers and destroys riverbeds) should be explored and followed up whenever possible. Most rural communities across Borneo rely on freshwater fish as a main source of protein. For those living around peat-swamp forest habitats there is certainly an opportunity to engage with them about the importance of intact peat-swamp forests

and sustaining local fish populations. This engagement should involve local communities (who know the importance of the forest to their livelihoods), local government officials, local NGOs and local and international conservation organisations.

There are many opportunities for conservation-directed research. For example, it would be helpful to have more precise information on the distribution of these threatened species to help focus conservation activities and to identify agencies who may be able to assist.

There are some existing ichthyology networks focused on fish research (for example, members of the Asian Society of Ichthyologists (ASI) are working on peat swamp fishes). Increased attendance and presentations at conferences and symposia, by freshwater fish experts, could elevate interest in freshwater fish, particularly conservation of threatened species. Considering that peat swamp forest conversion is impacting approximately 76 threatened species, the establishment of a peat-swamp forest fish network is considered timely and has been recommended.

SPECIES KNOWN TO BE, OR POTENTIALLY THREATENED BY OVERHARVESTING FOR THE ORNAMENTAL AQUARIUM TRADE

Borneo - 20 threatened species:

Critically Endangered: *Betta hendra, Betta rutilans, Parosphromenus ornaticauda:* **Endangered:** *Betta albimarginata, Betta channoides, Betta foerschi, Betta patoti, Osphronemus laticlavius, Parosphromenus linkei, Parosphromenus opallios, Sphaerichthys vaillanti:* **Vulnerable:** *Gastromyzon crenastus, Gastromyzon farragus, Gastromyzon scitulus, Paedocypris micromegethes, Betta breviobesa, Betta dimidiata, Betta macrostoma, Betta uberis, Sundadanio echinus.*

Sumatra – 7 species

Endangered: *Betta rubra, Sundadanio atomus, Sundadanio goblinus;* **Vulnerable:** *Betta dennisyongi, Betta simorum, Sundadanio axelrodi, Sundadanio gargula.*

Peninsular Malaysia – 2 species

Endangered: *Barbodes dunckeri, Parosphromenus tweediei.*

SPECIES IN TRADE	SCALE OF THREAT
Betta macrostoma	Occasionally found in the international aquarium trade, where it commands a high price of USD 150–180 per pair
Betta channoides *Betta albimarginata* ***Betta simorum*** ***Betta uberis*** *Betta patoti*	Highly sought after in the international aquarium trade
Sphaerichthys vaillanti ***Betta dimidiata***	Increasingly prominent in the aquarium trade at a national and international scale. Both species are available seasonally
Paedocypris micromegethes ***Sundadanio echinus***	Specimens have been recorded as being sold in the international aquarium trade, although with seemingly sporadic availability.
Gastromyzon farragus *Gastromyzon crenastus*	*Gastromyzon* species are readily available in the aquarium trade but are often misidentified, therefore it is difficult to

SPECIES IN TRADE	SCALE OF THREAT
Gastromyzon scitulus	know how abundant each species is within the trade. It is considered that the three threatened *Gastromyzon* species considered as part of this study are seldomly encountered, whereas *G. ctenocephalus* (Near Threatened), *G. ocellatus* and *G. zebrinus* are the most commonly encountered species in trade (H.H. Tan pers. comm., 2020). G*astromyzon* species are also caught and eaten locally (Tan 2006).
Barbodes dunckeri ***Betta dennisyongi*** *Betta rubra* ***Parosphromenus tweediei*** ***Sundadanio atomus*** ***Sundadanio axelrodi*** ***Sundadanio gargula*** ***Sundadanio goblinus***	Known to be in trade, but at uncertain levels. *P. tweediei*, a peat swamp species is now found only in concrete drainage tunnels.
Betta hendra ***Betta rutilans*** ***Parosphromenus ornaticauda*** ***Betta foerschi*** ***Parosphromenus linkei*** **Parosphromenus opallios** *Betta breviobesa*	Occasionally seen in the ornamental fish trade, however the impact of this on their wild populations is not known. *Betta breviobesa* is often misidentified in trade as *Betta enisae*
Osphronemus laticlavius	Juveniles are regularly encountered in the ornamental trade, which suggests that this species has been bred commercially outside of Sabah (H.H. Tan pers. comm. 2019).

Eighteen of the 29 species for which overharvesting is considered a known or possible threat, are also threatened by peat swamp forest conversion. These species are indicated in **bold** in the table above.

Research into the characteristics and extent of trade in these 29 species could help identify the kinds of support needed (e.g. local, national or international legal protection and enforcement, and/or *ex situ* breeding support (see below) to alleviate pressure on wild populations). An additional 12 species are uncommonly found in the ornamental trade, which is not currently considered a threat to these species. However, monitoring harvest levels may be useful to detect if this situation changes in the future.

Social media platforms have been used to communicate on freshwater fish conservation through habitat monitoring and control of collection of wild fish. However, this is done on voluntarily basis. Several social media groups are actively promoting interest and sharing information and expertise on freshwater fish fauna in Malaysia and Indonesia (e.g. Ikan Air Tawar Malaysia and Indonesia Freshwater Fish). Additionally, whilst these groups promote interest in freshwater fishes and their conservation, sharing of information such as habitat geo-locations might inadvertently expose populations to greater risk of harvesting for ornamental trade purposes (Chua, K. pers. comm. 2020).

SPECIES SUBJECT TO OTHER THREATS

In Sumatra, *Rasbora tawarensis* is endemic to Lake Laut Tawar in Aceh. Threats to this species include drying of feeder rivers and invasive species. It is an important food source for local communities and as far as is known, there is currently no plan in place to secure the future of this species.

Barbodes dunckeri was originally described from the island state of Singapore, where it is now extinct. In Peninsular Malaysia (Johor), *Barbodes dunckeri* is known only from a few sites, some in protected areas (Gunung Arong and Gunung Panti Forest Reserve are priority areas for the species), though specimens can still be collected from those places. Local people collect it for their personal aquariums. It has been bred successfully in captivity in Europe. If the species (and its habitat) could be protected at these key sites it should recover and persist (Ahmad, A. pers. Comm., 2019) but it is expected to be lost at other sites as a result of pending development.

Several threatened species inhabit smaller islands where a range of threats related to habitat conversion, mining, increasing tourism and water abstraction are putting pressure on freshwater systems. More research is needed towards effective mitigation to protect these systems both for fish and for local communities. More research is needed into the impacts of mining effluent on Bangka and Biliton / Belitung Islands, which are home to the Endangered *Parosphromenus deissneri*. In Peninsular Malaysia, *Clarias batu* is endemic to Tioman Island where it is now only known from a few streams. The species seems to be less tolerant of low oxygen content, requiring faster flowing waters. The local community does not favour freshwater fish and tourists are mainly interested in marine species. However more recently, recreational fishing has increased (both for food and for collection) and water abstraction has increased (Ahmad, A. pers. Comm., 2019). More needs to be known about the distribution and threats to this species, which may warrant its own recovery plan. Also, part of Peninsular Malaysia, Redang Island is home to *Clarias sulcatus*. There is only one stream on the island and an airport development is expected to affect the catchment. Water abstraction to support increasing tourism will put further pressure on freshwater systems. This species, which is thought to number as few as 100 specimens (Ahmad, A. pers. Comm., 2019), would also benefit from more research into the nature and impact of threats to its survival and potentially its own recovery plan.

EX SITU NEEDS

Genome resource banking should be considered for all threatened species as the route to their effective conservation is not secure.

Alleviating threats in the wild may not be achieved quickly enough to prevent extinction of some of the species identified as threatened. For others, a well-protected source for wild supplementation may be an important conservation or recovery strategy. The IUCN/SSC Guidelines on the Use of *Ex Situ* Management for Species Conservation (IUCN/SSC (2014) is a useful resource for clarifying goals and assessing feasibility of applying *ex situ* management of living populations, before making recommendations to proceed.

5.2.3 RECOMMENDED CONSERVATION ACTION PRIORITIES FOR BORNEO, SUMATRA AND PENINSULAR MALAYSIA ENDEMICS

Threat	Actions
Peat swamp forest (PSF) conversion	**Stop further conversion of Peat Swamp Forest (PSF):** • Engage directly with plantation companies to encourage set-aside for remaining PSF within concessions (through the Indonesian Sustainable Palm Oil (ISPO) Standard in Indonesia and the Malaysian Sustainable Palm Oil Standard in Malaysia, with certification based on High Conservation Value (HCV) sites). • Connect with local communities on the benefits of protecting PSF to sustain fish populations and support alternative livelihoods. • Support enforcement of current moratorium on peat swamp conversion (Indonesia only). • Engage with and support the work of Indonesia's peatland restoration agency: Badan Restorasi Gambut (BRG). **Connect with NGOs and other agencies on the ground able to support conservation work for individual threatened species:** • Overlay distribution maps of each threatened fish species (in one map) and connect with conservation NGOs working in those areas, not necessarily on fishes but potentially able to assist in the conservation of fish species. • Overlay threatened fish distribution with other threatened aquatic species, e.g. plants, crustaceans to investigate if there is a strong correlation between threatened fish and other threatened species. Potentially identify key sites for protection / management with high number of threatened species. **Increase studies on heathland habitat or "Kerangas":** • Establish whether this provides important habitat for the threatened species identified.
Over-harvesting for trade	• Investigate the nature and scale of trade in affected species. • Identify and monitor species for which this may be problem in future. • Consider either national or international protection, and a trade management plan, for all threatened species affected by trade. • Identify potential targets for *ex situ* breeding support (see below).

Threat	Actions
Mining effluent (Bangka & Biliton / Belitung Islands)	• Investigate the status and impact of this on threatened species on these islands and recommend possible mitigation.
Species recovery planning or species-focused site protection planning	The following are potential candidates for species-focused planning: • *Barbodes dunckeri* (require site-based protection to prevent over-harvest). • *Rasbora tawarensis* (Lake Laut Tawar, Sumatra. Threats include drying of feeder rivers and invasive species. An important food source for local communities). • *Clarias batu* (Tioman Island, Peninsular Malaysia. Several sites with multiple threats). • *Clarias sulcatus* (Redang Island, P. Malaysia. Potentially multiple threats about which little is known)

***Ex situ* conservation**	• Genome resource banking should be considered for all threatened species, as the route to their effective conservation is not secure.
	• Explore the potential value and feasibility conservation-directed *ex situ* management for threatened species:
	  ○ identify species for which other measures are unlikely to be sufficient to prevent extinction.
	  ○ apply IUCN SSC *Ex situ* Guidelines to clarify the goals of *ex situ* management (given known threats to the species), and to assess the feasibility of running an *ex situ* management programme able to meet those goals.
	  ○ Recommend priority species for *ex situ* management.

Raise awareness and profile of threatened freshwater fishes	• Use ichthyology network to elevate interest among the academic community for work on freshwater fishes. • Establish peat swamp forest fish network. • Raise awareness at the policy level, of these threatened fish species and the importance of protecting them. • Connect where possible with water quality initiatives that focus on providing clean water for people (e.g. UN SDG related initiatives) to capitalise on shared goals. • Connect with NGOs interested in PSF protection/restoration and encourage inclusion of consideration of importance of freshwater habitat for threatened fish species (and people) in their work.

5.3 SUNDA REGION-WIDE

Contributors: Amirrudin B. Ahmad, Mike Baltzer, Jonathan Ho, Zeehan Jaafar, Daniel Lumbantobing, Mohammed Mukhlis Kamal, Kelvin Lim, Daniel Frikli Mokodongon, Heok Hee Ng, Bi Wei Low, Heok Hui Tan, Sara Thornton, Jihad Sulfani Udin, Frank Van Veen, Clare Wilkinson, Yulintine.

5.3.1 SUMMARY REVIEW OF THREATENED SPECIES

Sunda region-wide - 18 threatened species:

Critically Endangered: *Barbonymus platysoma (PE), Hemileiocassis panjang (PE), Oryzias timorensis (PE), Probarbus jullieni;* **Endangered:** *Betta hipposideros, Betta pi, Brevibora dorsiocellata Discherodontus halei, Parosphromenus paludicola;* **Vulnerable:** *Balitoropsis ophiolepis, Betta coccina, Hemibagrus planiceps, Homaloptera ocellata, Homalopteroides wassinkii, Lobocheilos falcifer, Neolissochilus hendersoni, Parakysis verrucosus, Rasbora lateristriata.*

The 18 freshwater fish included in this "Sunda region-wide" section include: five species endemic to Java, two found in Java and Sumatra, four in Sumatra and Peninsular Malaysia, four in Peninsular Malaysia and Thailand, one in Timor and one through Cambodia, Lao PDR, Peninsular Malaysia, Thailand and Vietnam.

5.3.2 REVIEW OF THREATS AND OPPORTUNITIES

SPECIES-FOCUSED RECOVERY PLANNING

Probabarbus julieni (CR) is a high-profile Mekong River fish. During the recent past, the natural stocks of *P. jullieni* have been decreased severely due to habitat degradation and man-induced hazards in the aquatic ecosystem (Zakaria *et al.,* 2012). It is particularly vulnerable to over-exploitation as adults from spawning aggregations are targeted by fishermen at spawning grounds. Other threats include habitat destruction and large dams, which pose a threat because the species cannot pass through them and does not thrive in reservoirs. It is currently listed on Appendix I of CITES and could benefit from its own fisheries management and conservation plan. For further details about threats and conservation, see Zakaria *et al.* (2012).

JAVA ENDEMICS

Many species in Java are under intense pressure from human activities. The larger rivers are degraded and there are few remaining freshwater swamps (though there may be some where the Javan rhino is being protected). It is likely that some of the Javan endemics are already extinct or close to it and species that may be common elsewhere within the Sunda region are considered to be possibly extinct (Ng H.H. pers. comm, 2020). Both *Hemileiocassis panjang* and *Barbonymus platysoma* are considered possibly extinct. Surveys are required to determine whether they still exist.

Rasbora lateristriata and *Lobocheilos falcifer* used to be important food source. It is still possible to catch both species, but only in the more preserved areas. There are no current attempts to protect them, but they occur in existing national parks and there are often enclaves within these parks where people live and fish. Protected area managers do not usually consider the fishes, but these species should be considered in any protected area management plans. Note that the national parks are mostly at higher altitudes where the habitat is more pristine and there are good opportunities for recovery where habitat is maintained. *Lobocheilos falcifer*, which is distributed more widely, may also need conservation attention elsewhere. New records for this species have been made from Central Java--namely in the upper reaches of Tuntang basin draining northward to Java Sea and of the Wawar

basin draining southward to Indian Ocean--during recent ichthyological field surveys (Hasan *et al.*, 2019a; Hasan *et al.*, 2019b), which highlight the importance of conducting more inventory studies in river basins or tributaries previously undocumented yet potential given their condition being relatively less impacted by human activities. At lower altitudes its populations are likely to be fragmented and subject to considerable habitat degradation and so may be a candidate for supportive breeding as part of any recovery effort (D. Lumbantobing pers. obs.; H.H. Tan pers. comm.).

SUMATRA, PENINSULAR MALAYSIA AND THAILAND

Surveys failed to find *Brevibora dorsiocellata* in Peninsular Malaysia and it could be extinct there. This species is found in trade in large numbers, but it is commercially bred in several countries. Volume of wild take is not known. *Betta coccina* and *B. hipposideros* are peat swamp forest species found in the aquarium trade. *Betta pi* is also in the aquarium trade but is not as popular as other *Betta* species. It is not clear whether it is harvested from the wild. As far as is known, *Parosphronemus paludicola* occurs in a protected area but on the outskirts, in an area that can be easily accessed. Anyone can fish this area and there are also people with traditional rights to the protected area who live permanently within it. At present harvesting is thought to be small-scale. *B. dorsiocellata* is found in trade. What is in trade originates from Sumatra and it may be extinct from Peninsular Malaysia, but this is not yet certain. Harvesting for trade is a threat in Sumatra, where it still occurs. This is a schooling species; therefore, many are caught at a time. *Parakysis verrucosus* is possibly extinct on an island off Sumatra where it previously occurred but is still found in Peninsular Malaysia. This species is not considered a charismatic / high profile species (it is a tiny brown catfish with skin covered in bumps), so it is more challenging to get people interested in its conservation, however it could benefit from habitat enhancements targeting other species.

The following table records the conservation actions recommended for species in this group. Not all species are covered due to time constraints.

5.3.3 RECOMMENDED CONSERVATION ACTION PRIORITIES FOR SPECIES IN THE "SUNDA REGION-WIDE" GROUP

Action	Details
Single species planning	For *Probabarbus julieni*, to include fisheries management planning as well as wider recovery and conservation.
Survey to establish whether extant	*Barbonymus platysoma* (PE), *Hemileiocassis panjang* (PE), *Oryzias timorensis* (PE), *Brevibora dorsiocellata* (check whether extinct in Malaysia),
Include within protected area management plans	*Rasbora lateristriata* and *Lobocheilos falcifer* (Java), *Balitoropsis ophiolepis* (Java and Sumatra)
Protect or where possible restore peat swamp forest and other black water habitats (see Indonesia and Malaysia action table for details)	*Brevibora dorsiocellata, Betta coccina, B. hipposideros, Parakysis verrucosus*
Establish impact of trade and recommend action where needed	*Betta coccina, B. hipposideros, Betta pi, Brevibora dorsiocellata*

***Ex situ* conservation**	• Genome resource banking should be considered for **all** threatened species, as the route to their effective conservation is not secure.
	• Explore the potential value and feasibility conservation-directed *ex situ* management for threatened species:
	  ○ identify species for which other measures are unlikely to be sufficient to prevent extinction.
	  ○ apply IUCN SSC *Ex situ* Guidelines to clarify the goals of *ex situ* management (given known threats to the species), and to assess the feasibility of running an *ex situ* management programme able to meet those goals.
	• Recommend priority species for *ex situ* management.

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APPENDIX I

Participants of the IUCN Red List review and Assess to Plan workshop for freshwater fishes of the Sunda region, Singapore, 29 Jan – 1 Feb 2019

NAME	ORGANISATION
Amirrudin B. Ahmad	Universiti Malaysia Terengganu
Amy Palmer-Newton	Freshwater Biodiversity Unit, IUCN Global Species Programme
Bi Wei Low	National University of Singapore
Caroline Lees	IUCN SSC Conservation Planning Specialist Group
Catherine Sayer	Freshwater Biodiversity Unit, IUCN Global Species Programme
Clare Wilkinson	Imperial College London/NUS
Claudine Gibson	IUCN SSC Conservation Planning Specialist Group
Daniel N. Lumbantobing	Division of Fishes, Smithsonian National Museum of Natural History
Daniel Frikli Mokodongan	University Haluoleo (UNHALU)
Frank Van Veen	University of Exeter
Helen Larson	Museum and Art Gallery of the Northern Territory
Heok Hee Ng	Independent
Heok Hui Tan	Lee Kong Chian Natural History Museum, NUS
Jihad Sulfani Udin	Burung
Jonathan Ho	National University of Singapore
Kelvin Lim	Lee Kong Chian Natural History Museum, NUS
Kenny Wei Jie Chua	National University of Singapore
Kevin Johnson	Amphibian Ark
Mike Baltzer	Shoal
Mohammad Mukhlis Kamal	Bogor Agricultural University
Nerissa Chao	IUCN SSC Asian Species Action Partnership
Roopali Raghavan	Wildlife Reserves Singapore
Sara Thornton	University of Leicester
Timothy Lyons	BioPark
Yulintine	University of Palangka Raya
Zeehan Jaafar	National University of Singapore

APPENDIX II

List of the 400 freshwater fish species and Red List category assigned during the Sunda Freshwater Fishes Red List Review workshop. *Please refer to the IUCN Red List website (www.iucnredlist.org) for the most up-to-date assessment information.*[2]

REGION	FAMILY	SPECIES NAME	RL CAT.	
SULAWESI	ADRIANICHTHYIDAE	*Adrianichthys kruyti*	CR	PE
		Adrianichthys roseni	CR	PE
		Oryzias soerotoi	CR	
		Xenopoecilus sarasinorum	CR	
	GOBIIDAE	*Mugilogobius amadi*	CR	PE
	ADRIANICHTHYIDAE	*Oryzias asinua*	EN	
		Oryzias woworae	EN	
		Xenopoecilus bonneorum	EN	
		Xenopoecilus poptae	EN	
	GOBIIDAE	*Mugilogobius sarasinorum*	EN	
	ZENARCHOPTERIDAE	*Nomorhamphus celebensis*	EN	
	ADRIANICHTHYIDAE	*Oryzias eversi*	NT	
		Oryzias nebulosus	NT	
		Oryzias nigrimas	NT	
		Oryzias orthognathus	NT	
		Xenopoecilus oophorus	LC	
		Oryzias wolasi	DD	
	GOBIIDAE	*Lentipes mekonggaensis*	DD	
	ZENARCHOPTERIDAE	*Nomorhamphus brembachi*	DD	
		Nomorhamphus ebrardtii	DD	
BORNEO	AKYSIDAE	*Parakysis notialis*	CR	
	OSPHRONEMIDAE	*Betta hendra*	CR	
		Betta pinguis	CR	
		Betta rutilans	CR	
		Parosphromenus ornaticauda	CR	
		Parosphromenus quindecim	CR	
	AKYSIDAE	*Parakysis anomalopteryx*	EN	
	BAGRIDAE	*Pseudomystus myersi*	EN	
	CLARIIDAE	*Clarias kapuasensis*	EN	
		Clarias pseudonieuhofii	EN	
		Encheloclarias baculum	EN	
		Encheloclarias prolatus	EN	
	OSPHRONEMIDAE	*Betta albimarginata*	EN	
		Betta antoni	EN	
		Betta channoides	EN	
		Betta chini	EN	
		Betta foerschi	EN	
		Betta mandor	EN	
		Betta patoti	EN	
		Osphronemus laticlavius	EN	

[2] *The Family names Gastromyzontidae and Zenarchopteridae used in this report are correct, however currently deviate from the taxonomy published on the current IUCN Red List (2020-1).*

REGION	FAMILY	SPECIES NAME	RL CAT.	
		Parosphromenus anjunganensis	EN	
		Parosphromenus filamentosus	EN	
		Parosphromenus linkei	EN	
		Parosphromenus opallios	EN	
		Parosphromenus pahuensis	EN	
		Sphaerichthys vaillanti	EN	
	GASTROMYZONTIDAE	*Gastromyzon crenastus*	VU	
		Gastromyzon farragus	VU	
		Gastromyzon scitulus	VU	
	CLARIIDAE	*Encheloclarias medialis*	VU	
	CYPRINIDAE	*Barbodes bunau*	VU	
		Paedocypris micromegethes	VU	
		Sundadanio echinus	VU	
	GOBIIDAE	*Stigmatogobius signifer*	VU	
	OSPHRONEMIDAE	*Betta breviobesa*	VU	
		Betta brownorum	VU	
		Betta dimidiata	VU	
		Betta ibanorum	VU	
		Betta lehi	VU	
		Betta macrostoma	VU	
		Betta midas	VU	
		Betta uberis	VU	
		Parosphromenus allani	VU	
		Parosphromenus parvulus	VU	
		Sphaerichthys acrostoma	VU	
	GASTROMYZONTIDAE	*Gastromyzon aequabilis*	NT	
		Gastromyzon auronigrus	NT	
		Gastromyzon borneensis	NT	
		Gastromyzon cornusaccus	NT	
		Gastromyzon ctenocephalus	NT	
		Gastromyzon extrorsus	NT	
		Gastromyzon ingeri	NT	
		Gastromyzon ocellatus	NT	
		Gastromyzon pariclavis	NT	
		Gastromyzon spectabilis	NT	
		Gastromyzon umbrus	NT	
		Gastromyzon zebrinus	NT	
		Hypergastromyzon eubranchus	NT	
		Neogastromyzon crassiobex	NT	
		Neogastromyzon pauciradiatus	NT	
		Protomyzon borneensis	NT	
	CYPRINIDAE	*Leptobarbus melanopterus*	NT	
		Osteochilus partilineatus	NT	
		Parachela cyanea	NT	
		Rasbora calliura	NT	
		Rasbora ennealepis	NT	
		Rasbora patrickyapi	NT	

REGION	FAMILY	SPECIES NAME	RL CAT.	
		Sundadanio margarition	NT	
		Sundadanio rubellus	NT	
	GOBIIDAE	*Pseudogobiopsis festiva*	NT	
	OSPHRONEMIDAE	*Sphaerichthys selatanensis*	NT	
	BAGRIDAE	*Hemibagrus baramensis*	LC	
		Hemibagrus bongan	LC	
		Hemibagrus fortis	LC	
	GASTROMYZONTIDAE	*Gastromyzon contractus*	LC	
		Gastromyzon venustus	LC	
		Glaniopsis denudata	LC	
		Glaniopsis gossei	LC	
		Glaniopsis hanitschi	LC	
		Homaloptera orthogoniata	LC	
		Homalopteroides avii	LC	
		Katibasia insidiosa	LC	
		Parhomaloptera microstoma	LC	
		Protomyzon whiteheadi	LC	
	CLARIIDAE	*Clarias anfractus*	LC	
		Clarias planiceps	LC	
	CYPRINIDAE	*Crossocheilus nigriloba*	LC	
		Crossocheilus oblongus	LC	
		Cyclocheilichthys janthochir	LC	
		Rasbora kottelati	LC	
		Rasbora sarawakensis	LC	
		Sundadanio retiarius	LC	
	OSPHRONEMIDAE	*Betta anabatoides*	LC	
		Betta gladiator	LC	
		Betta ocellata	LC	
		Osphronemus septemfasciatus	LC	
	AKYSIDAE	*Acrochordonichthys chamaeleon*	DD	
		Acrochordonichthys falcifer	DD	
		Acrochordonichthys guttatus	DD	
		Acrochordonichthys mahakamensis	DD	
		Acrochordonichthys pachyderma	DD	
		Acrochordonichthys strigosus	DD	
		Breitensteinia hypselurus	DD	
		Breitensteinia insignis	DD	
		Pseudobagarius baramensis	DD	
		Pseudobagarius fuscus	DD	
		Pseudobagarius meridionalis	DD	
		Pseudobagarius pseudobagarius	DD	
	BAGRIDAE	*Bagrichthys micranodus*	DD	
		Bagrichthys vaillantii	DD	
	BALITORIDAE	*Homalopteroides weberi*	DD	
		Homalopteroides yuwonoi	DD	
		Pseudohomaloptera batek	DD	

REGION	FAMILY	SPECIES NAME	RL CAT.	
		Pseudohomaloptera tatereganii	DD	
	CLARIIDAE	*Clarias insolitus*	DD	
		Clarias intermedius	DD	
		Clarias microstomus	DD	
		Clarias nigricans	DD	
		Clarias pseudoleiacanthus	DD	
	CYPRINIDAE	*Barbodes xouthos*	DD	
		Crossocheilus elegans	DD	
		Labiobarbus lamellifer	DD	
		Leptobarbus hosii	DD	
		Osteochilus sarawakensis	DD	
		Rasbora atranus	DD	
		Rasbora cryptica	DD	
		Rasbora dies	DD	
		Rasbora lacrimula	DD	
		Rasbora rutteni	DD	
		Rasbora semilineata	DD	
		Rasbora trifasciata	DD	
		Rasbora tuberculata	DD	
	ELEOTRIDAE	*Pogoneleotris heterolepis*	DD	
	GASTROMYZONTIDAE	*Glaniopsis multiradiata*	DD	
		Hypergastromyzon humilis	DD	
	GOBIIDAE	*Parawaous megacephalus*	DD	
		Pseudapocryptes borneensis	DD	
		Stenogobius ingeri	DD	
		Stigmatogobius borneensis	DD	
	OSPHRONEMIDAE	*Betta akarensis*	DD	
		Betta balunga	DD	
		Betta compuncta	DD	
		Betta enisae	DD	
		Betta ideii	DD	
		Betta krataios	DD	
		Betta obscura	DD	
		Betta pallifina	DD	
		Betta taeniata	DD	
		Betta unimaculata	DD	
		Trichopodus poptae	DD	
SUMATRA	CYPRINIDAE	*Rasbora tawarensis*	CR	
	OSPHRONEMIDAE	*Betta burdigala*	CR	
		Betta chloropharynx	CR	
		Betta cracens	CR	
		Betta fusca	CR	
		Betta miniopinna	CR	
		Betta pardalotos	CR	
		Parosphromenus gunawani	CR	
		Parosphromenus phoenicurus	CR	
	AKYSIDAE	*Parakysis hystriculus*	EN	

REGION	FAMILY	SPECIES NAME	RL CAT.	
	BAGRIDAE	*Hemibagrus lacustrinus*	EN	
		Sundolyra latebrosa	EN	
	CLARIIDAE	*Clarias microspilus*	EN	
	CYPRINIDAE	*Sundadanio atomus*	EN	
		Sundadanio goblinus	EN	
	OSPHRONEMIDAE	*Betta rubra*	EN	
		Betta schalleri	EN	
		Betta spilotogena	EN	
		Luciocephalus aura	EN	
		Parosphromenus deissneri	EN	
	SILURIDAE	*Ompok brevirictus*	EN	
	CLARIIDAE	*Encheloclarias tapeinopterus*	VU	
		Encheloclarias velatus	VU	
	CYPRINIDAE	*Rasbora leptosoma*	VU	
		Sundadanio axelrodi	VU	
		Sundadanio gargula	VU	
	OSPHRONEMIDAE	*Betta dennisyongi*	VU	
		Betta renata	VU	
		Betta simorum	VU	
		Parosphromenus bintan	VU	
	BAGRIDAE	*Hemibagrus caveatus*	NT	
	BALITORIDAE	*Homalopterula heterolepis*	NT	
	CYPRINIDAE	*Paedocypris progenetica*	NT	
		Pectenocypris micromysticetus	NT	
	OSPHRONEMIDAE	*Parosphromenus sumatranus*	NT	
		Betta falx	LC	
		Betta raja	LC	
	AKYSIDAE	*Akysis fontaneus*	DD	
		Akysis galeatus	DD	
		Akysis heterurus	DD	
		Akysis scorteus	DD	
		Pseudobagarius macronema	DD	
	BALITORIDAE	*Homalopterula amphisquamata*	DD	
		Homalopterula modiglianii	DD	
		Homalopterula vanderbilti	DD	
	CLARIIDAE	*Clarias olivaceus*	DD	
	CYPRINIDAE	*Barbonymus belinka*	DD	
		Osteochilus serokan	DD	
		Rasbora sumatrana	DD	
	GOBIIDAE	*Sicyopterus macrostetholepis*	DD	
		Stiphodon carisa	DD	
		Stiphodon maculidorsalis	DD	
		Stiphodon ornatus	DD	
PENINSULAR MALAYSIA	BAGRIDAE	*Hyalobagrus ornatus*	CR	PE
	CLARIIDAE	*Clarias batu*	CR	
		Clarias sulcatus	CR	
		Encheloclarias kelioides	CR	PE

REGION	FAMILY	SPECIES NAME	RL CAT.	
	COBITIDAE	*Lepidocephalus pahangensis*	CR	
	OSPHRONEMIDAE	*Betta omega*	CR	
		Parosphromenus alfredi	CR	
	CLARIIDAE	*Encheloclarias curtisoma*	EN	
	CYPRINIDAE	*Barbodes dunckeri*	EN	
	OSPHRONEMIDAE	*Betta livida*	EN	
		Betta persephone	EN	
		Betta tomi	EN	
		Betta tussyae	EN	
		Betta waseri	EN	
		Parosphromenus harveyi	EN	
		Parosphromenus rubrimontis	EN	
		Parosphromenus tweediei	EN	
		Parosphromenus nagyi	VU	
	AKYSIDAE	*Parakysis longirostris*	NT	
	BAGRIDAE	*Hemibagrus gracilis*	LC	
	COBITIDAE	*Pangio filinaris*	LC	
	CYPRINIDAE	*Rasbora notura*	LC	
	OSPHRONEMIDAE	*Betta pugnax*	LC	
	AKYSIDAE	*Akysis microps*	DD	
		Pseudobagarius alfredi	DD	
	BAGRIDAE	*Hemibagrus divaricatus*	DD	
	GOBIIDAE	*Gobiopterus birtwistlei*	DD	
	MASTACEMBELIDAE	*Macrognathus perakensis*	DD	
	OSPHRONEMIDAE	*Betta stigmosa*	DD	
SUNDA REGION-WIDE	ADRIANICHTHYIDAE	*Oryzias timorensis*	CR	PE
	BAGRIDAE	*Hemileiocassis panjang*	CR	PE
	CYPRINIDAE	*Barbonymus platysoma*	CR	PE
		Probarbus jullieni	CR	
		Brevibora dorsiocellata	EN	
		Discherodontus halei	EN	
	OSPHRONEMIDAE	*Betta hipposideros*	EN	
		Betta pi	EN	
		Parosphromenus paludicola	EN	
	AKYSIDAE	*Parakysis verrucosus*	VU	
	BAGRIDAE	*Hemibagrus planiceps*	VU	
	BALITORIDAE	*Balitoropsis ophiolepis*	VU	
		Homaloptera ocellata	VU	
		Homalopteroides wassinkii	VU	
	CYPRINIDAE	*Lobocheilos falcifer*	VU	
		Neolissochilus hendersoni	VU	
		Rasbora lateristriata	VU	
	OSPHRONEMIDAE	*Betta coccina*	VU	
	ADRIANICHTHYIDAE	*Oryzias hubbsi*	NT	
	OSPHRONEMIDAE	*Betta picta*	NT	
		Trichopodus leerii	NT	
	ADRIANICHTHYIDAE	*Oryzias javanicus*	LC	

REGION	FAMILY	SPECIES NAME	RL CAT.	
	AKYSIDAE	*Acrochordonichthys rugosus*	LC	
		Akysis hendricksoni	LC	
	BAGRIDAE	*Bagrichthys hypselopterus*	LC	
		Bagrichthys macracanthus	LC	
		Bagrichthys macropterus	LC	
		Bagroides melapterus	LC	
	BALITORIDAE	*Balitoropsis zollingeri*	LC	
		Homaloptera parclitella	LC	
		Homalopteroides nebulosus	LC	
		Neohomaloptera johorensis	LC	
	BARBUCCIDAE	*Barbucca diabolica*	LC	
	BOTIIDAE	*Syncrossus hymenophysa*	LC	
	CLARIIDAE	*Clarias batrachus*	LC	
		Clarias leiacanthus	LC	
		Clarias meladerma	LC	
		Clarias nieuhofii	LC	
	COBITIDAE	*Kottelatlimia katik*	LC	
		Pangio malayana	LC	
		Pangio muraeniformis	LC	
		Pangio oblonga	LC	
		Pangio piperata	LC	
	CYPRINIDAE	*Amblyrhynchichthys truncatus*	LC	
		Barbodes binotatus	LC	
		Barbodes lateristriga	LC	
		Barbodes rhombeus	LC	
		Boraras maculatus	LC	
		Brevibora cheeya	LC	
		Devario regina	LC	
		Eirmotus furvus	LC	
		Eirmotus insignis	LC	
		Epalzeorhynchos kalopterum	LC	
		Garra cambodgiensis	LC	
		Hampala macrolepidota	LC	
		Labiobarbus fasciatus	LC	
		Labiobarbus ocellatus	LC	
		Luciosoma setigerum	LC	
		Macrochirichthys macrochirus	LC	
		Neolissochilus soroides	LC	
		Osteochilus flavicauda	LC	
		Poropuntius normani	LC	
		Puntioplites bulu	LC	
		Rasbora bankanensis	LC	
		Rasbora cephalotaenia	LC	
		Rasbora kalbarensis	LC	
	ELEOTRIDAE	*Bostrychus sinensis*	LC	
		Bunaka gyrinoides	LC	
		Butis amboinensis	LC	

REGION	FAMILY	SPECIES NAME	RL CAT.	
		Butis gymnopomus	LC	
		Eleotris fusca	LC	
		Eleotris melanosoma	LC	
		Giuris margaritacea	LC	
	GOBIIDAE	*Brachygobius doriae*	LC	
		Brachygobius sabanus	LC	
		Caragobius urolepis	LC	
		Eugnathogobius siamensis	LC	
		Glossogobius aureus	LC	
		Glossogobius bicirrhosus	LC	
		Glossogobius circumspectus	LC	
		Mugilogobius cavifrons	LC	
		Periophthalmodon septemradiatus	LC	
		Pseudogobiopsis oligactis	LC	
		Sicyopterus cynocephalus	LC	
		Sicyopterus longifilis	LC	
		Sicyopterus microcephalus	LC	
		Sicyopus zosterophorus	LC	
		Stiphodon atropurpureus	LC	
		Stiphodon pelewensis	LC	
		Stiphodon semoni	LC	
		Stiphodon surrufus	LC	
	OSPHRONEMIDAE	*Belontia hasselti*	LC	
		Betta bellica	LC	
		Betta edithae	LC	
		Betta imbellis	LC	
		Luciocephalus pulcher	LC	
		Osphronemus goramy	LC	
		Trichopodus trichopterus	LC	
		Trichopsis vittata	LC	
	SILURIDAE	*Ompok fumidus*	LC	
	AKYSIDAE	*Acrochordonichthys ischnosoma*	DD	
		Akysis variegatus	DD	
		Breitensteinia cessator	DD	
		Parakysis grandis	DD	
	COBITIDAE	*Pangio alcoides*	DD	
	CYPRINIDAE	*Crossocheilus langei*	DD	
		Crossocheilus obscurus	DD	
		Cyclocheilichthys schoppeae	DD	
		Eirmotus isthmus	DD	
		Esomus malayensis	DD	
		Hypsibarbus birtwistlei	DD	
		Labiobarbus festivus	DD	
		Neobarynotus microlepis	DD	
		Osteochilus schlegelii	DD	
		Rasbora chrysotaenia	DD	

REGION	FAMILY	SPECIES NAME	RL CAT.	
		Rasbora everetti	DD	
		Rasbora philippina	DD	
		Rasbora taytayensis	DD	
		Systomus rubripinnis	DD	
	ELEOTRIDAE	*Hypseleotris cyprinoides*	DD	
		Oxyeleotris urophthalmoides	DD	
		Oxyeleotris urophthalmus	DD	
		Prionobutis dasyrhynchus	DD	
	GOBIIDAE	*Awaous litturatus*	DD	
		Awaous personatus	DD	
		Brachygobius aggregatus	DD	
		Brachygobius xanthomelas	DD	
		Brachygobius xanthozonus	DD	
		Gobiopterus brachypterus	DD	
		Lentipes adelphizonus	DD	
		Lentipes whittenorum	DD	
		Sicyopterus micrurus	DD	
		Sicyopterus parvei	DD	
		Sicyopus auxilimentus	DD	
		Sicyopus multisquamatus	DD	
		Stenogobius blokzeyli	DD	
		Stenogobius gymnopomus	DD	
		Stiphodon multisquamus	DD	
		Stiphodon zebrinus	DD	
		Trypauchenichthys sumatrensis	DD	
		Trypauchenichthys typus	DD	
	OSPHRONEMIDAE	*Betta apollon*	DD	
		Betta aurigans	DD	
		Betta ferox	DD	
		Betta kuehnei	DD	
		Betta pulchra	DD	
		Sphaerichthys osphromenoides	DD	
	RHYACICHTHYIDAE	*Rhyacichthys aspro*	DD	