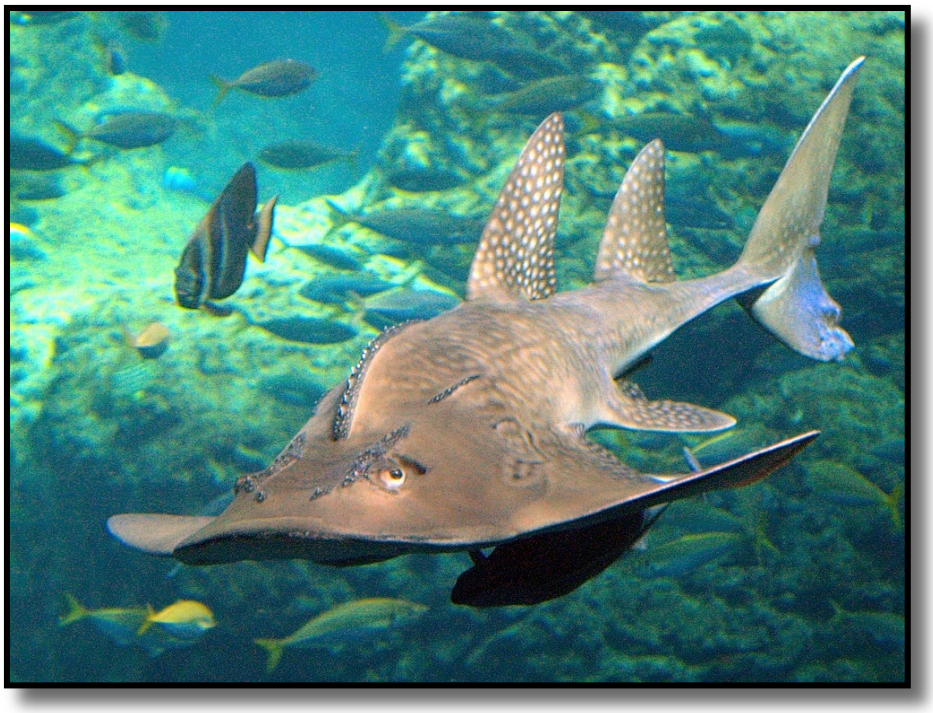
Bowmouth Guitarfish (*Rhina ancylostomus*):
An Ex Situ Conservation Assessment



SAFE SAVING ANIMALS FROM EXTINCTION SHARK AND RAY

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NEWPORT AQUARIUM

Bowmouth Guitarfish (*Rhina ancylostomus*)

An Ex Situ Conservation Assessment

Report from a workshop conducted on:
14 – 16 November 2023
Shedd Aquarium
Chicago, Illinois, USA

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Cover photo: Heidi Zeiger, Shedd Aquarium

A contribution of the IUCN/SSC Conservation Planning Specialist Group, in collaboration with Shedd, Seattle, Georgia, and Newport Aquariums, AZA SAFE: Sharks & Rays, and workshop participants.

Workshop host: Shedd Aquarium
Workshop sponsors: Shedd Aquarium, Seattle Aquarium, Georgia Aquarium, Newport Aquarium, Fred Fan Aquatics and AZA SAFE Sharks & Rays.

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Suggested Citation:
Abel, G., K. Feldheim, L. Hoopes, S. Kessel, L. Penfold, R. Pollom, P. Sloan, and P.S. Miller. 2024. Bowmouth Guitarfish (*Rhina ancylostomus*): An ex situ conservation assessment. Apple Valley, MN: IUCN SSC Conservation Planning Specialist Group.

This report can be downloaded from www.cpsg.org.

Bowmouth Guitarfish (*Rhina ancylostomus*)
An Ex Situ Conservation Assessment

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A 2019 Red List of Threatened Species update published through the International Union for the Conservation of Nature (IUCN) Species Survival Commission (SSC) Shark Specialist Group (SSG), assessed the Bowmouth Guitarfish *Rhina ancylostomus* Critically Endangered. In November 2022, a diverse group of stakeholders came together in a workshop facilitated by the IUCN SSC Conservation Planning Specialist Group (CPSG) for an ex situ conservation assessment of the species. The resulting report examines the role of aquariums, in collaboration with other stakeholders, in filling existing gaps in conservation actions for the Bowmouth Guitarfish.

Dr. Lisa Hoopes
Chair, Aquarium Working Group
IUCN Species Survival Commission Shark Specialist Group

Executive Summary

The Bowmouth Guitarfish (*Rhina ancylostomus*) is an Indo-Pacific shark-like ray that inhabits coastal waters of East Africa and the Red Sea, the northern Indian Ocean rim to Southeast Asia, north to Japan, south to Australia across the north of the continent, and east to the Solomon Islands, and New Caledonia. The genetic structure of regional populations of the genus *Rhina* is not well understood and individuals being managed within aquariums may represent more than one species. The species is listed as Critically Endangered (CR) on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species due to being at an extremely high risk of extinction and Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Association of Zoos and Aquariums (AZA) and other regional zoological associations maintain population management plans and studbooks of individual Guitarfish within their regional member institutions. The AZA studbook (as of July 2022) identifies 17 individuals (7 males and 10 females, designated as 7.10) within nine accredited institutions in North America, Europe, Middle East and Asia. The species has been maintained by AZA accredited facilities since 2005, with the first North American aquarium birth event occurring at the Newport Aquarium in 2014.

In November 2022, Fred Fan Aquatics (FFA) purchased 12 (4.8) Bowmouth Guitarfish of various age classes from commercial fishing cooperative organizations based in the Yilan and Penghu regions of Taiwan. The species is caught within near-shore permanent set-nets located around Taiwan and consumed in the region. The live purchases by FFA were made for the express purpose of donating the animals to a consortium of international aquariums, building upon an ex situ management program that FFA and Newport Aquarium began in 2005.

The potential donation of the Guitarfish from FFA for an ex situ conservation management program prompted a core group of aquaria in North America and Asia, together with other wildlife conservation institutions, to begin developing an integrated conservation plan approach, as part of a broader One Plan approach (Traylor-Holzer et al. 2019) for this species. The goal of the approach was to inform whether management of the species in human care (ex situ) environments could help improve long-term viability and promote recovery of the Bowmouth Guitarfish across its historic natural (in situ) range. In order to develop a realistic integrated conservation action plan, the Ex Situ Conservation Assessment workshop for the Bowmouth Guitarfish was held 14 – 16 November 2023 at the Shedd Aquarium in Chicago, Illinois (USA). The Conservation Planning Specialist Group (CPSG), part of the IUCN's Species Survival Commission (SSC), was invited to design and facilitate the multi-stakeholder workshop. The overall goal of the workshop was to assess the potential role(s), if any, that ex situ management could play in contributing to species recovery in the wild.

Experts in both in situ and ex situ conservation of Bowmouth Guitarfish presented background information on the species' status in nature, population genetic structure (where known) in both in situ and ex situ environments, the current ex situ metapopulation and animal care practices. Based on the information presented, workshop participants were able to characterize several primary threats and conservation challenges to Bowmouth Guitarfish conservation, which would set the context for determining which and how ex situ management options, if any, could help improve the status of the species in the wild.

The workshop was structured around the IUCN SSC Guidelines on the Use of Ex situ Management for Species Conservation, which utilizes a five-step decision process to determine whether any ex situ activities might be appropriate for inclusion within a conservation strategy or action plan for the species (IUCN 2014; McGowan et al. 2017).

Participants identified six potential conservation roles for ex situ activities that could address conservation challenges and/or priority knowledge gaps for effective management of the species within the context of a conservation action plan. Once these roles were identified, three working groups were formed to discuss the relative conservation benefits of three broad strategies that included these potential roles:

- Preventing species extinction – Insurance population/long-term ark; rescue
- Supporting existing populations – demographic/genetic reinforcement; demographic manipulation
- Addressing key conservation knowledge gaps – Research and/or training; conservation education

The three strategies involve explicit ex situ management of Bowmouth Guitarfish throughout the full life cycle of the species. Feasibility of implementing each of the three strategies was also considered in the context of whether acquiring additional individuals from the wild was necessary to improve genetic representation and ex situ management options of the species, including reproduction for release of live pups when and where appropriate. Each working group engaged in detailed discussions of the relative benefits, challenges, and feasibility of advancing the potential roles, and generated recommended actions to facilitate implementation of the strategies. Another key outcome was a synthesis of husbandry information across four aquaria with extensive experience caring for Bowmouth Guitarfish, Osaka Aquarium, Kaiyukan (Japan), Georgia Aquarium (U.S.), Newport Aquarium (U.S.), and Resorts World Sentosa (RWS), S.E.A. Aquarium (Singapore).

The workshop concluded with a consensus recommendation to create a governing body, titled Shark Ray 360, with a steering committee to coordinate and oversee implementation of the recommended actions. A preliminary set of working groups was identified to carry this process forward, and Grant Abel from Seattle Aquarium was nominated to be the coordinator, tasked with identifying working group Leads, establishing a Steering Committee and advancing the Coalition's recommended actions.

Proposed logo for the new Shark Ray 360 Coalition.

Introduction: Overview of Species Status and Workshop Presentations

The Bowmouth Guitarfish (*Rhina ancylostomus*) has a discontinuous distribution in warm-temperate and tropical waters of the Indo-West Pacific region. They are found primarily in shallow coastal and estuarine waters and in shallow reef complexes from South Africa through the western Indian Ocean, including in the Red Sea and Arabian/Persian Gulf, the northern Indian Ocean rim to Southeast Asia, extending north to China, Japan and Korea, south to Australia across the nSorth of the continent, and east to the Solomon Islands and New Caledonia (Last and Stevens 2009, Last et al. 2016) (Figure 1). The genetic structure of regional subpopulations of the genus *Rhina* is not well understood and individuals being managed within aquariums globally, may represent more than one species. The Bowmouth Guitarfish is listed as Critically Endangered (CR) on the IUCN Red List of Threatened Species and is listed in Appendix II of CITES. The Association of Zoos & Aquariums (AZA) and other regional zoological associations maintain population management plans and studbooks of individual Guitarfish within their regional populations. The AZA studbook (as of July 2022) consists of 17 individuals (7 male, 10 female) managed within nine accredited institutions in North America, Europe, the Middle East and Asia. The species has been maintained by AZA accredited facilities since 2005, with the first documented aquarium birth event in North America occurring at the Newport Aquarium in 2014.

Figure 1. Distribution map of the Bowmouth Guitarfish, *Rhina ancylostomus*. Retrieved from the IUCN Red List assessment of the species (www.iucnredlist.org; Kyne et al. 2019).

The Ex Situ Conservation Assessment workshop for the Bowmouth Guitarfish was held 14 – 16 November 2023 at the Shedd Aquarium in Chicago, Illinois (USA). The workshop included a series of presentations designed to provide updated information on the status of the species in the wild (in situ) and in human care (ex situ) environments. Brief summaries of these presentations are given below.

Bowmouth Guitarfish natural history, threats, and conservation priorities
Rima Jabado, IUCN SSC Shark Specialist Group; Cassie Rigby, James Cook University, Australia

Dr. Jabado provided an overview of Rhino Ray species, natural history, primary threats and extinction risk. She emphasized the status of Rhino Ray as the most threatened marine taxa in the world.

Initiating the ex situ population: Origin, destination, and handling in situ
Fred Fan, Founder and CEO, Fred Fan Aquatics

Overview of set net fishing in Taiwan, capture, handling, and transport of Bowmouth Guitarfish in set net fisheries, where they are captured as by-catch. Mr. Fan emphasized the acclimation and care given during quarantine of Bowmouth, and sophisticated transport techniques, leading to good welfare and high survivability during and post-transport.

In situ population genetics of *Rhina ancylostomus*
Emily Humble, Research Fellow in Conservation Genomics, University of Edinburgh, Scotland

Dr. Humble provided an overview of her genetic sampling techniques, results, and most pressing questions generated from her work. Her results suggest geographically isolated populations are likely connected and show the Red Sea population has the lowest levels of genetic diversity. Primary questions include: 1. What is the unsampled range? 2. How is genetic variation represented in aquariums? 3. Are there bio-banked samples? 4. What do the genetic patterns mean for potential reintroduction/restoration planning?

A review of knowledge of ex situ care
Lisa Hoopes, Senior Director of Research and Conservation, IUCN Center for Species Survival, Georgia Aquarium, USA

Dr. Hoopes reported on the ex situ care of Bowmouth Guitarfish, emphasizing what aquariums do well, and where we have knowledge gaps. She shared the need to better understand breeding seasonality, timing, pre-natal nutrition, and other factors necessary to improve survivability of aquarium bred animals.

AZA studbook update
Jen Hazeres, Senior Biologist, Newport Aquarium, USA

Jen Hazeres, AZA's studbook keeper for *Rhina ancylostomus*, gave an overview of 11 aquarium populations, two more than those documented in the 2022 AZA studbook. This included updated collective ex situ population size, age structure, and reproductive history.

Ex situ population status in Europe
Oliver Walenciak, Curator, Sea Life Deutschland, Germany, EAZA studbook keeper

Oliver Walenciak, EAZA's studbook keeper for *Rhina ancylostomus*, gave an overview of European aquariums caring for the species.

Genetics in captive elasmobranchs
Kevin Feldheim, A. Watson Armour III Manager of the Pritzker Laboratory for Molecular Systematics and Evolution, Field Museum, USA

Dr. Feldheim provided a summary of know genetic relationships in Bowmouth Guitarfish in aquarium care. He shared genetic considerations for ex situ breeding with a focus on genetic drift, unequal family sizes, sex ratio of breeding adults, and inbreeding.

Based on this full body of information, workshop participants developed an assessment of the primary threats impacting long-term viability of the Bowmouth Guitarfish in the wild, as well as the challenges to successfully implementing effective conservation measures to improve the species status in the wild. The result of this assessment is found in Figure 2. Note that this exercise is not meant to generate a quantitatively rigorous analysis of the demographic impacts of different threats to wild Bowmouth populations, nor is it an exhaustive representation of the full suite of biological, sociological and/or economic challenges to successful management of in situ and ex situ populations. The intent of this participatory exercise was to create a shared understanding of the reasons why ex situ management of Bowmouth Guitarfish may be considered as a valued component of its conservation and recovery.

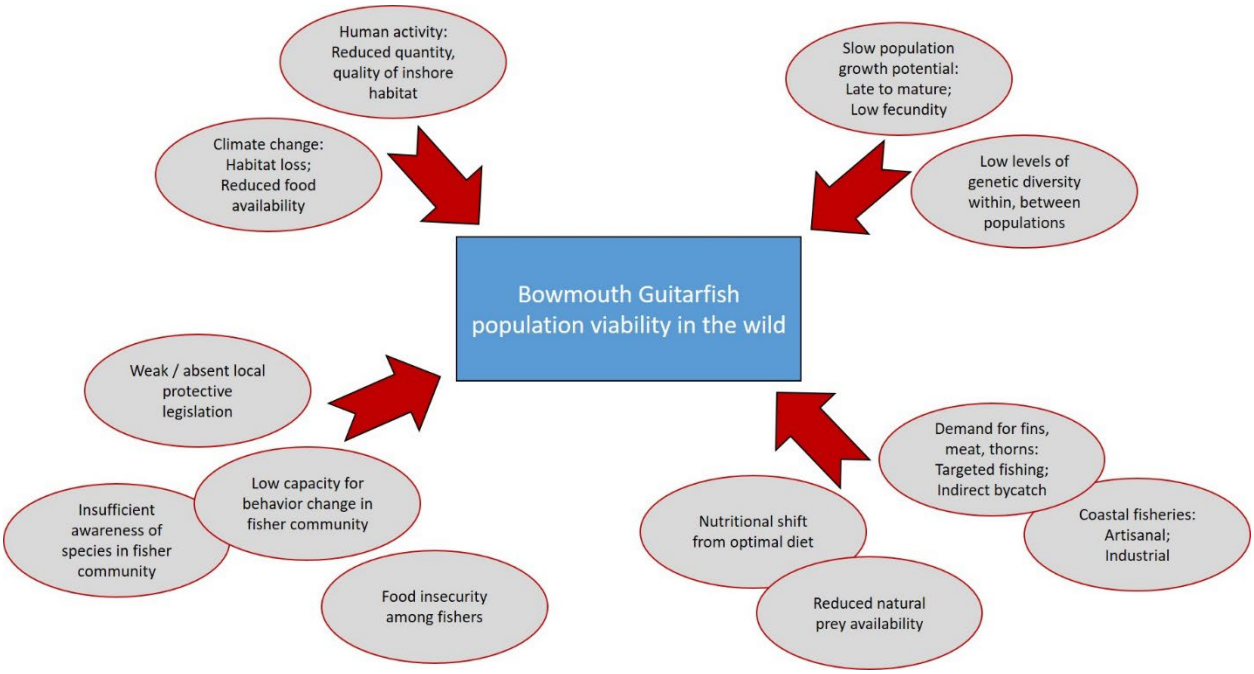

Figure 2. Graphical depiction of primary threats to continued persistence of Bowmouth Guitarfish populations in their wild habitats, and important challenges to effective species conservation management. Overlapping text "bubbles" indicate broad causal relationships among identified variables / processes. These threats primarily fall within the IUCN Threats Classification Scheme of Biological resource use, specifically 5.4 - Fishing & harvesting aquatic resources.

The Ex Situ Assessment Process

Successful examples of an integrated conservation action plan developed using the One Plan Approach demonstrate how those plans help to mitigate species extinctions (Pramuk et al., 2013; Miller, 2017; Traylor-Holzer et al., 2018). These and other examples emphasize the need for extensive information, lead-time preparation, capacity building and collaboration between a wide range of stakeholders and adequate long-term funding to be effective conservation action plans. Species conservation planning considers all options when assessing actions to address the pressures facing a threatened species. In addition to actions directed at reducing or eliminating a particular threat that impact Bowmouth Guitarfish populations in the wild, such as mitigating habitat loss or fishing mortality, other ex situ strategies may be needed to prevent population declines or extinction. Identifying and addressing important knowledge gaps can also lead to effective conservation outcomes by informing questions and ensuring confidence in future decisions. Ex situ management is also a potential option that contributes to the conservation of other aquatic and terrestrial threatened species (Traylor-Holzer, 2021). The range of ex situ scenarios and

tools is diverse and can target different conservation needs and roles and, therefore, serve various purposes.

Ex situ conservation activities can support species conservation, prevent extinction, and promote recovery in a variety of ways (Traylor-Holzer *et al*. 2019), including:

- Offsetting the impact of threats. Ex situ activities can improve the demographic and/or genetic viability of a wild population by counteracting the impacts of primary or stochastic threats on the population, such as reduced survival, low reproduction rates, and genetic isolation – for example, through head-start programs that bring juveniles from the wild into ex situ management and return them to their place of origin once they are less vulnerable, or through releases to genetically augment isolated populations.
- Addressing the causes of primary threats. Ex situ activities can help reduce primary threats such as habitat loss, exploitation, invasive species, or disease through specifically designed research, training, or conservation education activities that directly and effectively impact the causes of these threats – for example, through ex situ research to detect, combat or treat disease.
- Buying time. Establishment of a genetically diverse and sustainable ex situ rescue or insurance population may also be critical in preventing species extinction when the wild population is declining and primary threats are not able to be ameliorated – for example, populations facing widespread disease epidemics or decimation by invasive species or uncontrollable fishing practices (Rojas-Bracho, L. *et al*. 2019).
- Restoring wild populations. Once the primary threats have been sufficiently addressed, ex situ populations can be used to re-establish wild populations.

This workshop focused on the assessment of ex situ activities for the Bowmouth Guitarfish and the ability of such activities to contribute effectively to the species' conservation and recovery in the wild. The assessment was developed as part of a One Plan approach to conservation of this species (Traylor-Holzer *et al*. 2019). The workshop was structured around the IUCN SSC *Guidelines on the Use of Ex situ Management for Species Conservation*, which utilizes a five-step decision process to determine if and which ex situ activities might be appropriate to be included in the overall conservation strategy for the species (IUCN 2014; McGowan *et al*. 2017). Those steps include:

1. Conduct a thorough status assessment (of both in situ and any known ex situ populations) and threat analysis.
2. Identify potential roles that ex situ management can support in the overall conservation of the species.
3. Define the characteristics and dimensions of the conservation strategy needed to fulfill the identified potential ex situ conservation role(s).
4. Define the resources and expertise needed for the ex situ management program to meet its role(s) and appraise the feasibility and risks.
5. Make an informed and transparent decision as to which ex situ roles and activities (if any) to retain within the overall conservation strategy for the species.

This evaluative process was applied during the workshop through plenary and small group discussions. An essential element of this process involved both in situ and ex situ species experts in all stages of the assessment to fully evaluate conservation needs and potential opportunities.

Workshop process overview

In advance of the November 2023 workshop, participants were provided with the IUCN's Red List assessment of the species (Kyne et al. 2019) and other key online informational resources as briefing materials. The workshop's first day featured a series of presentations providing additional updated background information on the species' status in both in situ and ex situ environments. With this common base of knowledge, participants discussed the impact of threats across the various stages of the species' life cycle and identified important knowledge gaps in species biology, ecology, threats and their impacts, and ex situ population management.

Participants reviewed a list of potential conservation roles for ex situ activities (see Appendix III for the full list of options) to identify those roles that might address known conservation challenges and/or priority knowledge gaps. In total, six distinct ex situ conservation roles were ultimately identified as potentially applicable for the species, and therefore to be the subject of additional discussion during the workshop. Three concurrent working groups were established to discuss the relative conservation benefit(s) of these potential roles, as follows:

- Working group #1: Preventing population / species extinction – Insurance population/long-term ark; rescue.
- Working group #2: Reinforce existing populations – demographic/genetic reinforcement; demographic manipulation.
- Working group #3: Address knowledge gaps – Research and/or training; conservation education.

The three broad sets of strategies used above to define the working groups evolved into mutually supporting ex situ conservation actions that included short-term and/or long-term care of individuals across multiple participating Aquariums and life stages of the metapopulation. Discussions in these groups focused on the benefits of implementing these roles for improving the status of Bowmouth Guitarfish populations in their native habitats, weighed against the risks of their implementation. In the latter stages of the workshop, working groups developed detailed action steps designed to begin implementation of the three ex situ strategies identified above. These action steps were presented to the full plenary body of participants and subject to discussion. This report is the written record of those discussions and the conservation actions recommended to be advanced collectively by the group.

Ex Situ Roles to Support In Situ Conservation of Bowmouth Guitarfish

Workshop participants identified six ex situ conservation roles as potentially applicable for supporting in situ conservation of Bowmouth Guitarfish. These roles can be grouped into three broad, integrated conservation strategies based on their focal activities and conservation impact.

Preventing population / species extinction

1. Insurance Population/Long Term Ark: Maintenance of a long-term ex situ metapopulation to serve as a genetic backup to the wild population to prevent local, regional or global species extinction and to preserve options for future reintroduction efforts where populations of the species are under intense anthropogenic pressures or have been extirpated from all or a part of its range.
2. Rescue: Temporary removal of a colony or population that is under imminent threat of extinction. Conservation value may depend upon the uniqueness of the population based on its location, size, local adaptations, and genetic diversity. Rescued populations may be relocated to other natural or

historical habitats or retained within ex situ environments to support an insurance population and/or other ex situ conservation roles.

Reinforce existing populations

3. Population Reinforcement: An ex situ insurance population that provides healthy, genetically relevant individuals to supplement an extant wild population, thereby improving its demographic and/or genetic viability.
4. Demographic Manipulation: Similar role to reinforcement, but releases are targeted to improve a vulnerable demographic rate (e.g., early survival) or status (e.g., adult sex ratio) in the wild.

Address knowledge gaps

5. Research/Training: Use of an ex situ population or activities for research and/or training that will directly benefit conservation of the species, or a similar species, in the wild (e.g., genetics, disease, sensitivity to threats, husbandry methods, release and monitoring, methods).
6. Conservation Education: Use of an ex situ population or activities to support educational and awareness programs that addresses specific threats or constraints to conservation of the species or protection of its habitat (e.g., promote buy-in by fishing communities, regional governments and other stakeholders).

A simple graphical representation of these roles and their relationship within a broader integrated population management strategy is shown in Figure 3.

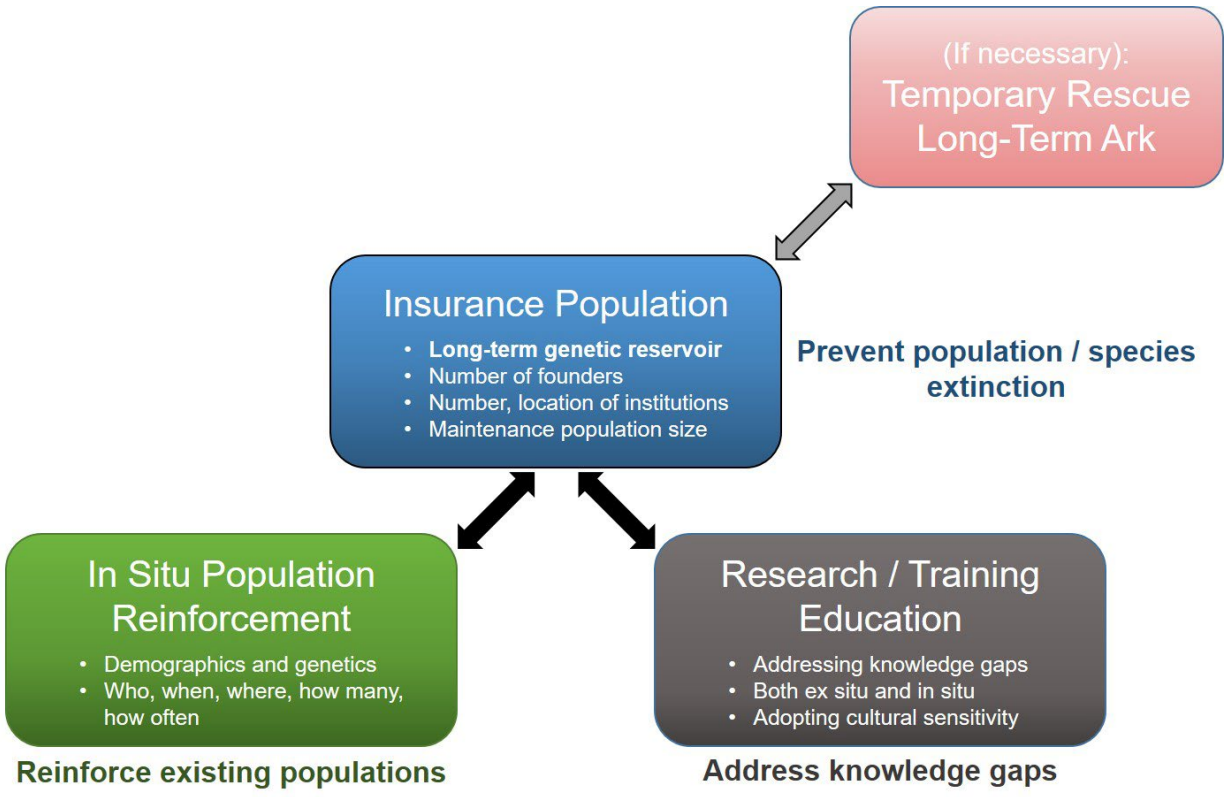

Figure 3. Diagram outlining the essential ex situ elements of an integrated conservation strategy for the Bowmouth Guitarfish, *Rhina ancylostomus*.

Working Group: Preventing Population/ Species Extinction

Participants: Grant Abel, Anthony Chang, Jack Jewel, Ashley Kwok, Leah Neal, Linda Penfold, Cassie Rigby, Peggy Sloan, Carlos Taura, Oliver Walenciak

In its broadest sense, maintaining a Bowmouth Guitarfish metapopulation as an insurance population within ex situ environments can help prevent species extinction should threats to a wild population(s) lead to the extirpation of the population.

The overall goal of an ex situ insurance population is to maintain a healthy, self-sustaining metapopulation of Bowmouth Guitarfish that represents the genetic and demographic structure of the in situ population. The ex situ metapopulation can then be managed to produce individuals for release back into the wild to support recovery of the wild population, while also retaining healthy levels of genetic diversity and demographic performance. The ex situ environment would provide conditions necessary to manage, grow and reproduce individuals to achieve long-term potentialities.

The insurance population role will contribute quantifiable benefits to in situ conservation when genetic characteristics of the ex situ population are representative of the genetics of the in situ population throughout the range of the population, which may differ from the range of the species; whilst managed breeding is producing healthy, genetically diverse pups able to be released into a series of well- managed marine protected areas within its natural range. The geographic and taxonomic scope of an insurance population strategy needs to be guided by genetic analysis of the wild population that it seeks to represent and of the existing ex situ population to determine if there are multiple species or genetically different populations, which would inform breeding recommendations within the metapopulation.

The temporary rescue and long-term ark roles that are linked to an insurance population are considered second-tier roles that are not required in the immediate future but may be implemented over a longer timeframe. In order to develop a longer-term ark, it is important to establish the genetic structure of the ex situ populations, such as the extent of relatedness among founder individuals.

Defining success of an ex situ insurance population

A successful insurance population for Bowmouth Guitarfish will be measured by:

- Successful application of reproduction technologies, including promotion of natural breeding and survival of >75% offspring beyond one year of age.
- Viable levels of genetic diversity retention within the metapopulation.
- An established global collaborative network of institutions with a commitment to participate in managing a healthy, genetically relevant ex situ metapopulation.
- Selected offspring from founder Bowmouth Guitarfish living to reproduce successfully.
- Establishment of marine reserves dedicated to protecting the species by mitigating fishing mortality in its native environment. The presence of viable release areas helps to justify the efforts require to develop and manage the ex situ population for subsequent release activities.
- Establishment of sustainable fisheries with practices that minimize catch and mortality of Bowmouth populations. Again, having this security in place provides justification for ex situ activities designed to promote future population integration.

The group recognized the value of conducting a population viability analysis (PVA) to identify quantitative management targets for both ex situ and in situ populations, and to explore management alternatives in support of maintaining demographic viability and genetic viability in the ex situ

metapopulation. It is also important for aquariums managing for conservation recovery to maintain a species studbook so that the population of individuals distributed across multiple institutions can be managed effectively as a metapopulation retaining high levels of genetic diversity. This would also support a long-term breeding program that is scalable, which could become a multi-jurisdictional Species Survival Plan.

General characteristics of a successful insurance population program include:

a) A generational approach to the duration of the program – maintaining the program for at least 45 years, with offspring thriving from F1 (& higher) generations.

b) Calculation of the required number of founders and population size based on guidance from population genetics principles and PVA.

c) Ex situ environmental variables necessary to successfully reproduce and manage individuals throughout all their natural life stages.

d) Bio banking:
   - Preserving genetic material from individuals.
   - Supporting research advancements in this emerging science.
   - Acknowledging regional differences in what some countries will allow (i.e. Europe restrictive with blood draws) may affect participation of some partners in the program.
   - Assessing the feasibility of bio-banking as a contribution to species conservation

e) Eventual readiness for release of individuals bred from the metapopulation.

f) Well-informed in situ governance supported by local stakeholders that enables the release of ex situ bred conspecifics into a wild population.

Feasibility and Risks

Feasibility:

1. Survey to know where Bowmouth Guitarfish are being managed, including a census of the current population in each country.
   - Establish which institutions that can manage *Rhina* throughout their life stages and whether they are able to reproduce through natural behavior and institutions that can artificial reproductive technologies for breeding.
   - Establish a global studbook for the species. Acknowledging that regional zoological Associations (e.g. AZA) maintain regional studbooks for the individuals being managed within participating institutions, a global studbook and records management platform, while requiring oversight and data management, would facilitate effective data acquisition.
2. Spatial: Understanding the spatial conditions in which Bowmouth Guitarfish are being managed and determine what optimum conditions support reproduction or management of single or same-sex individuals.
3. Reproduce viable offspring with a survival rate to age 1 of 0.75 or greater.
   - Increasing post-natal survivorship of individuals born within the metapopulation.
4. Functional pairings that reproduce naturally.
   - Currently there are a small number of institutions that have established functional parings, which are breeding naturally. Additional questions to be answered include:
     - How many institutions can develop a breeding program?
     - Do we need to start moving animals to establish more functional pairings?

- Understanding what makes successful breeding.
    - There are four Bowmouth Guitarfish that were born under human care that are now nearing breeding age. These individuals are currently being managed at RWS S.E.A. Aquarium in Singapore and Disney's Living Seas in Florida, demonstrating that the species can survive through the first stages of life under human care.
    - Need to determine the higher priority between reproduction among any breeding pairs, and restricting breeding to genetically viable/valuable pairs.

5. Manuals and standard operating procedures that document handling, nutrition, response to therapeutics and other management practices that support animal wellness under human care and facilitate effective use of artificial reproduction technologies.

Risks:

1. Genetic bottleneck: To avoid this risk, consideration will be needed for recruitment into the ex situ metapopulation that will establish a long-term founder population.
2. Need to understand connectivity between geographically distant populations in order to assess the importance of population structure and, by extension, the ability of released individuals to contribute to metapopulation stability if populations are connected demographically.
3. Long term care and animal wellness
    - Disease risks, demographics, and density of Bowmouth Guitarfish within each participating Aquarium, general husbandry and veterinary issues.
    - Optimum facility design and animal management. It was noted that separation of male and female Bowmouth Guitarfish may be important during mating and when space needed to raise young animals.
4. Transport of live pups.
    - The cost and logistic details necessary for moving live Bowmouth Guitarfish was identified as a high risk.

Recommended actions for creating an ex situ insurance population

1. Determine the current number and demographics of founder Bowmouth Guitarfish in the ex situ metapopulation, their geographic origins, and the number and location of institutions managing the animals.

   Statement: To understand the number of founders that can be managed within participating institutions, which in turn could potentially participate in a managed reproduction program guidance for making recommendations by genetic/demographic information through a global studbook and census could inform a breeding transfer plan. Currently, we do not know the number of founders in all institutions in North America, Europe, Middle East, Africa, and Asia respectively.

   Actions:
    - Survey of the various ex situ habitats of partner institutions managing, and planning to manage, this species.
    - Global survey of current institutions, whether a partner Aquarium in Shark Ray 360 or not, that are breeding.

- Advance the genetic work of other working groups looking to understand the genetic profile(s) of the species in the wild

Responsibility: South-East Zoo Alliance for Reproduction and Conservation (SEZARC)

Time: 6 months- June 2024

Cost: $10,000-$50,000

Collaborators: Global Aquariums managing and breeding Bowmouth Guitarfish and regional studbook keepers.

Metric: Accessible database with survey results that help inform successful ex situ management and transfers, if needed, to advance reproduction.

2. Data Mining

Statement: To understand and synthesize animal care practices across multiple institutions to inform best-practices with respect to environmental, diet and nutritional needs for normal post-natal ontogeny of live births and throughout the life stages of the species.

Actions:

- Dedicated staff and funding will be needed to identify and accomplish data mining tasks.
- Output to inform Shark Ray 360 partners and Aquariums managing the species writ large with respect to best management practices. This may take the form of a publication, similar to a species husbandry manual.
- Surveys that seek to encompass all ex situ management practices being applied today, to help determine the common denominators for successful Bowmouth Guitarfish management. Denominators may include, but not be limited to the following:
    - Diet and Nutrition during all life stages.
    - Environmental elements including water quality, spatial needs, other species being managed within the ex situ environment that Bowmouth Guitarfish would interact with.
    - Health issues and responses to therapeutics and veterinary procedures.
    - Population structure to understand sex ratios and reproductive age for successful breeding.

3. Creating a forum for participants to communicate effectively.

Statement: Effective communications among Shark Ray 360 partners managing Bowmouth Guitarfish will help reinforce communication of ideas, events and topics of mutual interest/concern related to ex situ management.

Actions:

- Communication amongst stakeholder institutions should be effective.
- Knowledge sharing of results will help institutional management provide increased support to institutional representatives involved in the project.
- A dedicated person or organization to establish and or manage a communication platform will be needed to ensure consistent long-term commitments.

4. Acquire additional founder animals.

Statement: Reinforcing the ex situ metapopulation to for the purpose of expanding the genetic profile and potential for successful reproduction.

Actions:

- Additional Bowmouth Guitarfish acquired by participating institutions should be unrelated to conspecifics.
- FFA indicated that the company had purchased four juvenile Bowmouth Guitarfish from commercial fishery cooperatives in Taiwan to donate to the project. Also, the RWS S.E.A. Aquarium indicated they have two surplus Bowmouth Guitarfish that were born at the Aquarium that could be relocated to another facility for the program.
- The coordinator and members of the workshop steering committee to work with FFA and RWS S.E.A. Aquarium to help coordinate relocation of the six animals.

5. Retain and recruit genetic diversity within the ex situ metapopulation.

Statement: Partners will need to manage the ex situ population to retain 90% - 95% of in situ genetic diversity sampled by the founders.

Explanation:
Proportion of total wild population gene diversity at the onset of an ex situ management program (GD_0) that is sampled within a group of unrelated founders to that ex situ population (N_{FND}) can be estimate from

$$GD_0 = 1 / 2N_{FND}$$

Over time, the future proportion of the original gene diversity is retained in the ex situ population according to the relationship

$$GD_t = GD_0 * [1 – 1/2N_e]^t$$

where N_e is the effective population size, itself a function of the breeding structure of the population and the sex ratio of adults.

Action:

- The species is classified as Critically Endangered in the wild and a lack of intervention could further accelerate the process of extinction for the specie. A population viability analysis can be valuable in this situation to help determine the required number of founders and the long-term census and effective population size to achieve the long-term genetic diversity goal. The Shark Ray 360 partners to review and recommend when to coordinate a population viability analysis (PVA) for advancing the conservation action plan.

Risks:

a. Financial commitments to receive new founders, albeit at no cost for the animals, and commit to the long-term goals of the program may outweigh the resources of well-intentioned partners.
b. Feasibility of long-term bio-banking should be explored to begin accommodating samples for future research.

Important considerations for future discussion

Ex situ

- Safe handling techniques – collate videos of handling, ultrasound, blood collection and other procedures and manage these resources on a platform for Partners to share. Techniques should include considerations for animal welfare during the procedures.
- Behavior Management – examples of animal training protocols for safe handling, feeding and other activities that promote agency and inform the animals how to participate in the activities without undue stress to animals or staff involved.
- Include link on the communications platform to SAFE shark & ray blood collection initiative and other relevant sites.
- Health assessments – establish and communicate criteria that defines a healthy animal fit for the purposes of transfer or release.
- Communications – via the communications platform and other means such as this report, create awareness of the One Plan approach, recognizing regional needs for cultural language and topics related to the Shark Ray 360 program.
- Funding – develop a clear funding strategy for all aspects of the One Plan approach to be successfully undertaken by all participants involved.
- Capacity Building - Cross-train with range country partners to ensure safe and effective ex situ management practices.

In situ

- Acquire movement data, including prime habitat data and home range size for juveniles, sub-adults, and adults.
- Acquire data on wild diets of pups, juveniles, and adults.
- Acquire ecological and life history information from the wild to help inform potential release options and ex situ management practices.)
- Identify appropriate marine reserves for releasing pups and young adults.
- Establish a dialogue and avenues for collaboration and capacity building with the local communities at potential release sites where the species is utilized as a resource, including fisheries management authorities.
- Identify students and scientists, including social scientists, in range countries that support the program activities.
- Engage local, regional, and national governments to support the project and would be stakeholders in release activities.

Working Group: Reinforcing Existing Populations

Participants: Nick Derbyshire, Fred Fan, Kevin Feldheim, Lisa Hoopes, Emily Humble, Riley Pollom, Andrew Pulver

An ex situ management program for Bowmouth Guitarfish can strengthen the viability of existing in situ populations through breeding and release of individuals into suitable in situ sites within the historic range of the species. This form of augmentation or recruitment into the in situ population can increase abundance in wild populations, or to target an increase in a particular age/sex-class that may be reduced through one or more threats to long-term population stability.

General characteristics of this integrated management option include:

- Characteristics and dimensions of the ex situ management program required to fulfill a specific ecological role.
- The goal is to help recover the in situ Bowmouth Guitarfish population.
- Consider focusing on demographics over genetics in the short-term phases of the program. The PVA recommended above will help to understand how many animals to release for reinforcement of a designated population, how often to conduct releases, and how long to maintain the reinforcement effort.
- Marine Protected Areas that mitigate or ameliorate anthropogenic threats for novel pups and juveniles to acclimate to the natural environment and live to reproductive ages.
- Attention to ex situ management practices that ensure a healthy, self-sustaining ex situ population.
- Genetic population segments to be determined.
- Transport logistics, complexities, required resources, to be determined.
- International non-government organizations, local government and local community partners are essential for supporting these activities.
- Tagging and translocation of wild-caught individuals considered in addition to release of pups and juveniles bred within ex situ management environments.

Defining success of population reinforcement

A successful reinforcement effort using the ex situ population of Bowmouth Guitarfish will be measured by:

- Successful tracking of the release program efficacy through individual tagging and post-release monitoring.
- Resighting through post-release monitoring that demonstrate Bowmouth Guitarfish population abundance increases over time towards a fully recovered status.
- Creation of MPAs supporting Bowmouth Guitarfish populations that are conserved through effective integrated population management.

Key ex situ population management research gaps

- Identifying optimal age/size class(es) for release.
- Identifying and agreeing on best practices for transport techniques and logistics.
- Transfer of knowledge and cross-training programs are implemented.
- Participating organizations commit to the long-term goals of the program.
- Pup holding space (space requirements/sea pens) are developed and deployed with a series of appropriate MPAs.
- Artificial reproduction technologies are developed and applied to the species in ex situ management, potentially eliminating some disease and special risks.
- Diet, feeding, and nutritional needs are determined and applied by all participating institutions.
- Knowledge of diseases and disease risks in the wild are understood and appropriate prophylactic recommendations are developed.
- Behavior management of animals and staff trained in the application of operant conditioning enable procedures to be conducted with minimum stress.
- Ex situ management involving natural breeding and/or use of artificial reproduction technologies are identified and result in healthy, genetically appropriate pups for release.
- Advancements in artificial reproduction technology
- Breeding in sea pens adjacent to release location as an ex situ management option to be determined.
- Identifying locations in the wild where pups are born and consider whether a head starting option may be helpful to the long-term goals of the program.

Feasibility and risks

Feasibility:

- High feasibility and immediate need – prioritize and coordinate both in situ and ex situ research and animal care knowledge gaps, including use of artificial reproduction technologies, and tracking growth and sexual maturity of pups across institutions. This has started and is a high priority.
- Genetics data from the existing ex-situ metapopulation is needed to understand where there's an opportunity to geographically target collection of additional founder individuals.
- A global studbook and taxon advisory group would assist with decision making and animal transfers from regions other than Taiwan and Indonesia where most animals in ex situ management have originated. Geneticists suggest representatives from the entire geographic range to represent haplotypes.
- Understanding when pups can be safely transported.
- Development of artificial reproduction technologies
- Staffing – who will be dedicated to exchange and training from pup rearing all the way through reintroduction. Can there be a project manager? Funds?
- The controlled environment in an aquarium habitat provides access to husbandry, research, and educational opportunities.

Risks:

- Limited genetics of current ex situ metapopulation compared across the geographic range of the species.
- Potential for close relatedness within the ex situ metapopulation.
- Not having a release location/protected area available in time for when ex situ breeding is successful.

- Creating conflicts among institutions between the desire for retaining display animals and moving those individuals out for release
- Aquariums resistance to releasing pups when born due to the cost to move animals from aquariums to introduction locations.
- Natural disaster or other event that catastrophic event that damages the holding and release infrastructure established for the project.
- What facilities are needed to have successful reintroduction efforts across the species' range?

Recommended actions for implementing a population reinforcement program

1. Conduct a population viability analysis (PVA) to determine the required conditions of a successful in situ population reinforcement program.

   Statement: Key elements of a successful program include the frequency of reinforcement events, how many individuals of a given age/sex-class to release into the wild, the duration of a sustained release effort, etc.

   Responsibility: Riley Pollom

   Time: 6 months

   Cost: $18,000 + workshop costs

   Collaborators: CPSG; *Rhina* holders; *in-situ* researchers

   Metric: Completed PVA available to answer management questions

2. Identify candidate habitat areas for release of ex situ bred individuals into wild habitats

   Statement: Key considerations include:
   - Defining the species-specific attributes of appropriate marine protected areas that would serve as release sites for pups bred in ex situ conditions. This may be needed in addition to a clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. See IUCN WCPA's Best Practice Protected Area Guidelines Series

   Responsibility: Fred Fan, Nick Derbyshire, Lisa Hoopes + others TBD

   Time: 2-3 years

   Cost: $100,000 (primarily travel)

   Collaborators: Regional Aquariums, stakeholders including management authorities, researchers,

   Metric: Sites identified and connections with local authorities and stakeholders are engaged to advance work for establishing release site infrastructure.

3. Design an appropriate and effective in situ holding facility (i.e., sea pen/sanctuary) for individuals to acclimate and be managed prior to release.

   Statement: Key considerations include:
   - Sea pen design and spatial dimensions
   - Support staff facilities, staff training in animal care and maintenance of the facility.
   - Diet and nutritional needs readily available. This includes live feed for natural foraging.

   Responsibility: Chris Coco, Fred Fan, Grant Abel, others TBC

   Time: 6 months - year

Cost: Unknown, but depends on the type of facility and the location of materials

Collaborators: regional and partner aquariums; aquaculture industry, manufacturer of sea pens, local communities for supply of live feed.

Metric: Pen(s) built

4. Develop a post-release monitoring plan and implementation, including details of tagging methodologies to be used.

   Responsibility: Kevin Feldheim, Steve Kessel, others TBC

   Time: ongoing monitoring for project lifetime

   Cost: Unknown, determined by how many animals are tagged and the tagging method

   Collaborators: researchers

   Metric: successful tag implantation, acoustic array established in release locations, data being received indicating survival of released animals.

5. Identify animal transport logistics, and those for overall release effort.

   Statement: Key considerations include:
   - Trained staff and transport equipment
   - Animal handling equipment and standard operating procedures in place for moving pups form the sea pens to release sites.
   - Regional government support for permitting throughout all stages of moving pups from the aquariums to release sites. *Responsibility*: Andy Sim, Fred Fan, Grant Abel, others TBC

   Time: 1 year

   Cost: Unknown, depends on the origin / destination and the method of transport

   Collaborators: local aquariums, freight, airlines, local chamber of commerce and local support

   Metric: Transport and handling SOP

6. Identify regional Project Manager(s) or Point(s) of Contact

   Responsibility: Hap Fatzinger, Lisa Hoopes

   Time: Project lifetime

   Cost: Unknown, depend on the region

   Collaborators: Existing in situ conservation organizations/representatives, working group leads, regional community supporters

   Metric: Hired individual(s) with contract

7. Create training and knowledge transfer protocols for in situ staff.

   Responsibility: Project Manager, Nick Derbyshire, Jen Hazeres, Leah Neal, ex-situ collaborators

   Time: Lifetime of project

   Cost: Location dependent

   Collaborators: Shark Ray 360 working groups

   Metric: SOPs developed and agreed among stakeholders

Working Group: Addressing Knowledge Gaps

Participants: Jolene Hanna, Jen Hazeres, Akane Kato, Steve Kessel, Hiroyuki Murakami, Megan Strobel, Yoshii Yusuke, Paula Carlson, Connie Blowe, Kady Lyons

A comprehensive integrated conservation action plan for Bowmouth Guitarfish can directly benefit conservation of the species in the wild. This can be achieved through detailed research efforts designed to answer knowledge gaps about the species, including its natural ecology, threats to the species in the wild, population genetics structure, sensitivity to disease processes, therapeutics, appropriate methods, and equipment for handling and transporting animals, husbandry and veterinary procedures, and effective monitoring and release protocols. In addition, an ex situ management program can support education and awareness efforts that can help identify change to specific threats in the wild or constraints to conserving the species in its native habitats.

A review of knowledge gaps related to conservation of the Bowmouth Guitarfish

General

- What is the value of Bowmouth fisheries in each region? They are found in 46 countries.
- Financial incentives for people catching Bowmouth Guitarfish or other protected species. There will be a need to make it appealing for them to comply.
    - E.g., Gov. incentives if fisheries can tag/release.
    - E.g., In situ conservation groups already working towards this to make financial goals more feasible.
- Will there be data on Bowmouth fisheries from local markets and are they able to identify these species?
- To get these data – there will need to be a local student who is studying this and can be with local fisheries to conduct surveys on this data.
- Are there general incentives for releasing other protected species?
    - This varies by region and by the local market.
- In Hong Kong, they are educating the younger generation about shark fin soup. It is tradition in the older generation. So, the same messages will not transfer well from United States to Asian countries.
    - It might be beneficial to educate the consumer rather than the fishermen. In the example of shark fin soup, the people eating it do not necessarily associate it with the actual shark. So, educating this population that sharks are harmed for this soup.
    - An example of this was on Tuna Fish in Japan. As their population decreased, Gov. enacted policies that restricted the amount able to catch and lowered the amount markets are able to sell. This helped bring back their population, but this only succeeded because they were able to work with the people and the market for this common goal.
    - This tuna fish example could be difficult to apply to the topic of shark fin soup because the Bowmouth in general is very high quality for shark fin soup. Would we need regulation or a hard stop collecting?
    - This would also depend greatly regionally by market and the way they sell their fish, is it sold together mixed or separate?
- What is the chain of command in each fishery on how the fish get to these markets?
    - Depends on the local nature of the market – social science studies can apply to this.

Research (ex situ)

- Data on fisheries (High importance, less feasible)
- Husbandry practices (High importance, High feasibility)
  - Temperature, habitat, nutrition (health parameters), surveys
  - Disease susceptibility – broad survey on what Bowmouth are dying from, we can dive into records (This could also be something as a future goal for this project)
- Reproductive Biology (High importance, feasibility of this depends on the ability to keep Bowmouth alive)
  - Nothing else can be conducted if we do not know their reproductive physiology – needs to be a multi-institutional effort.
  - This will need to be conducted monthly at a minimum like in the Stegostoma tigrinum Augmentation and Recovery (StAR) Project, (a collaborative effort to introduce viable eggs from *Stegostoma tigrinum* reproduced within participating aquariums into the wild), rather than looking through records for this information because it is more data than just blood value levels and chemistry levels.
    - This can also blend into the training category – StAR Project had SOAP (Subjective, Objective, Assessment and Plan methodology). Biggest problem this initiative ran into was getting facilities to fully commit. Only sending in 1 sample vs. 10 samples needed.
  - Other aspects to think about – Who is managing the initiative, who is paying for it – will there be a grant?
  - We will need a lead + funding. Typically, organizations who are part of these initiatives will pay for their own diagnostic testing to give results to the research projects.
  - Look into other Elasmobranch data, like SAFE. Do not do what has already been done before, we can tap into where data already exists.
  - SAFE is trying to establish normal parameters for CBC/Chem (need to spell out), while this is not reproductive research, it can put us in contact with the people who can help and are interested.
  - To make this feasible on an international level, a SOAP and training will need to be established. So, all institutions have the same machines conducting the tests with the same sample preparation methods.
- Literature Review (High importance, high feasibility)
  - Due to amount that is out there, this should be able to be done in a short time frame. Lit Review not included in red list.
- Spatial Ecology (High important, low feasibility)
  - What does an MPA for Bowmouth look like? Where are there nurseries?
  - We will need expertise, get data out/equipment in, hard to do in certain locations.
  - Other thoughts – Marine Megafauna when tagging Guitarfish will also tag Bowmouth in some circumstances.
  - Training for this will be key/important because it will be opportunistic.
- Diet (High importance, low feasibility)
  - Will need efforts from fisheries. Size of the individuals matters at the fish markets, both in situ and ex situ will benefit from this information.
  - Data from wild may not be accurate – Should Bowmouth be eating this diet, or is this is all that is available to them?
  - Need dedicated people in these fisheries/markets to fully conduct this work.
  - Genetics (Less important, high feasibility)
    (A genetics catalogue exists for a portion of Bowmouth currently in aquarium care.)

- Fisheries data (High Important, Less Feasibility)
  - Once data and reviews are published, we will be in touch with the right people and feasibility will increase. Need to identify partners.
- Feasibility on ex situ research, in general, will be highly variable depending on country (for example, Japan is legally required to share everything caught and must be listed by species with number)

Training (Ex situ)

- SOAP (High importance, low feasibility)
  - Husbandry manual surveys - Product of these surveys will get "Best Practice".
  - Some things to keep in mind – some facilities do not ever handle their Bowmouth.
    - Would there need to be a workshop where we physically handle them to train other institutions on an international level?
  - Variation between organizations – Who is illustrating best practices and how are these measured?
- Reproduction Assessment SOAP (High importance, low feasibility)
  - Not all facilities know how to handle, need to have expertise to run CBC/Chemistries, specialized equipment like ultrasounds.

Training (in situ)

- Narrators/docents (high importance, high feasibility)
  - Will be able to "hit key points", signs on exhibits for the public from "fact sheet".
  - Institutions can train these employees from the same fact sheet.
  - Will this work on international level? – Yes, if we just stick to the facts
- Training for fisheries in handling (High importance, low feasibility)
  - High variable by country/region
  - Will need to spend the time to form relationships with fishermen.
  - Training governing bodies/ policy makers as well
  - Need funding and multiple dedicated personnel.

Education (ex situ)

- Create portfolio for messaging (High importance, high feasibility)
  - Can be created over a series of zoom calls from all people in initiative to create a series of 7-10 talking points that will be presented.
  - Will create a consistent message across organizations.
- Awareness Day (High importance, low feasibility)
  - Need someone that has time, dedication and wants to spearhead this initiative.
    - In general, educate staff on what is being done → this can also fall under training.

Education (in situ)

- Fisheries and Gov. Personnel (High important, low feasibility)
  - Different information due to a different skill base but they are similar.
- Materials for policy (high importance, feasibility is variable)
  - Depends on countries and education programs in schools.
  - Can we create connections through public engagement like merchandise?
  - "Mr. Leatherback" was an educational example brought up during the discussion.

Recommended actions for addressing knowledge gaps

1. Conduct a literature review of available information.

   Statement: Develop a comprehensive review/synthesis of the state of knowledge (including formal literature review as well as gray literature, conference notes, interviews, etc.)

   Responsibility: Steve Kessel

   Time: 6 months (reviewable draft)

   Cost: Time – low cost

   Collaborators: All workshop participants and other organizations/individuals to be identified

   Metric: Published review

2. Conduct research program on spatial ecology needs of the species in wild habitats.

   Statement: Defining spatial ecology of Bowmouth Guitarfish across multiple life stages and regions (juveniles and nurseries, mature individuals, home range size, migration patterns)

   Responsibility: Georgia Aquarium, Shedd Aquarium(?)

   Time: 6 months to 10 years

   Cost: Unknown but significant

   Collaborators: Kevin Weng, Georgia Aquarium, Fred Fan, Ocean Tracking Network? Marine Megafauna Foundation?

   Metric: Number of tagged animals. Ten individuals per age class per region (four regions total) with adequate sex distribution, telemetry data

3. Conduct research on reproduction in the ex situ environment.

   Statement: Quantify reproductive life history of adult Bowmouth Guitarfish in ex situ facilities

   Responsibility: To be determined (need a leader)

   Time: At least five years to conduct monthly exams across all participating institutions

   Cost: Unknown but significant – staff time and sample processing

   Collaborators: Willing aquariums with a commitment to perform monthly exams

   Metric: Publication(s) and addition of data to database

4. Conduct research on in situ population genetics of Bowmouth Guitarfish.

   Statement: In situ population genetic assessment can help to improve geographic representation in the ex situ population.

   Responsibility: Emily Humble

   Time: Approximately 1-2 years

   Cost: Unknown but significant – staff time and sample processing

   Collaborators: To be determined

   Metric: Publication(s) and addition of data to database

5. Assess genetics in the ex situ population of Bowmouth Guitarfish

   Statement: We must characterize the genetic composition of the complete ex situ population in order to improve our ability to maximize genetic variation through long-term management.

   Responsibility: Linda Penfold, Kevin Feldheim

   Time: 1-3 years

   Cost: Unknown but significant

   Collaborators: All institutions holding Bowmouth Guitarfish for procuring samples

   Metric: Completed database of genetic information

6. Conduct research into the dietary composition of Bowmouth Guitarfish in wild habitats

   Statement: Describe the in situ dietary nice of various life stages of Bowmouth Guitarfish throughout various regions of their natural geographic range.

   Responsibility: To be determined – will require previous knowledge gained through a literature review and networking with field researchers and colleagues working with the species.

   Time: 1-3 years for baseline analysis

   Cost: Unknown but significant. Based upon time in terms of salary costs of individuals conducting the research. Cost of analysis will be based on the labs to be utilized. Also, may need to include the cost of metabarcoding if there is a desire to move beyond simpler analysis of stomach content.

   Collaborators: In-country universities, governmental agencies, fishers, funders from public aquarium community

   Metric: Published data shared with stakeholders

7. Develop consistent messaging materials among institutions holding Bowmouth Guitarfish

   Statement: Create a standardized compilation /portfolio of facts from which organizations can choose message for their public.

   Responsibility: Cassie Rigby (IUCN), SAFE representative(?)

   Time: 4 months

   Cost: Unknown

   Collaborators: Anyone interested within the IUCN and SAFE communities

   Metric: Portfolio of messaging materials

8. Generate materials on ex situ husbandry practices for Bowmouth Guitarfish

   Statement: Compile data on husbandry, animal health practices (nutrition, habitat animal health care, and training / handling) and life-support management.

   Responsibility: Linda Penfold (SEZARC)

   Time: Unknown

   Cost: Unknown but manageable

   Collaborators: All institutions with Bowmouth in their care

   Metric: Interactive database

9. Plan for a Bowmouth Awareness Day

   Statement: Foster appreciation and bring attention the plight of the Bowmouth Guitarfish to the general public through an education campaign.

   Responsibility: SAFE

   Time: 1 year

   Cost: Unknown but manageable, depending on the level of in-kind support from institutions

   Collaborators: Other AZA and associated members, IUCN Shark Specialist Group

   Metric: Number of mentions / hits / shares on social media; number of dedicated celebrations, amount of money raised in support of Bowmouth Guitarfish conservation

10. Create a portfolio of potential funding sources and partners to support Bowmouth Guitarfish conservation

    Statement: Identify suitable partners, sponsors, and grant foundations who support conservation of Bowmouth Guitarfish.

    Responsibility: Shark Ray 360 members

    Time: Unknown

    Cost: Salary / time of dedicates staff, in-kind support from facilities

    Collaborators: Willing organizations with development / fundraising capacity

    Metric: Amount of funding secured to support other conservation activities

Other actions not yet fully characterized: Training / education projects

The following items were identified as high importance but with lower feasibility or dependent on the collection of information from other recommended projects.

- Husbandry practice guidelines and health assessment guidelines/training
  - Dependent on the survey previously mentioned
  - Reproductive assessment training relies on consistency between facilities as manifested by the StAR project
- Public Education, reducing demand to control the market
  - Critical. Discussed that focusing on youth is more likely to induce change over time in Asia. Very location-dependent
  - Engagement through merchandise?
  - Timeline 10+ years
- Public education, materials for fishermen
  - Training on tag placement, morphometrics, population data
- Public education, materials for policy making
  - Need research data to make a better point.
- Public education, here in the USA
  - Engagement through merchandise?
- Capacity building for data collection and research

Next Steps in the Development of an Ex Situ Program for the Bowmouth Guitarfish

Statement of Purpose for the Shark Ray 360 initiative

Near the end of the workshop, the following statement was brought forward as a summary of the motivation behind and intended outcome of the assessment workshop. It is reproduced here for reference and to serve as a guiding statement for the partner organizations and working groups tasked with undertaking elements of the final conservation action plan. See Taylor et al. (2023) for general background information related to this statement.

> The **Shark Ray 360** team assembled to this Bowmouth Guitarfish recovery plan was formed in response to its Critically Endangered status. Noting that integrated conservation action plans explicitly consider all tools that may be needed to save a species or population from extinction. This report of the workshop held at Shedd Aquarium in 2023 recommends *inter alia*, that "**elasmobranch conservationists around the world work together and act with urgency to consider critically needed conservation measures both in wild environments within the species' geographic range (*in situ*) and in protected or modified environments within or outside that range (*ex situ*)**". Many of the threatened Rhina subpopulations most vulnerable to extinction or extirpation range within shallow coastal waters that overlap areas used intensively by people. Most are declining due, at least in part, to fishing activities and extinction is considered imminent in some regions without coordinated actions to save them.
>
> Serious conservation issues in countries with poor governance coupled with corruption, make it difficult to implement timely solutions to reduce or eliminate fisheries mortality. Such cases require *ex situ* interventions to bridge the time-gap between when the species/population could become extinct in the wild and when meaningful management actions allowing recovery would be applied. The intention is to avoid conservation actions being too little and coming too late, and of not having all the necessary tools ready for dealing with emergencies.

Discussion: Governance of implementing recommended actions from this workshop

A proposal was brought to the group concerning the formation of an organizing body to oversee progress on implementing the actions developed at this workshop. The organization would be called The Shark Ray 360 Coalition, with a proposed logo designed by Fred Fan of Fred Fan Aquatics (see page ii). Grant Abel (Seattle Aquarium) was nominated as Coordinator of the Coalition. The position would be funded, providing the resources necessary to devote the proper time and energy that is required for advancing the recommendations in this report.

The Shark Ray 360 Coalition will include a series of working groups, focusing on specific topics of critical importance to the creation of the ex situ conservation program. The working groups proposed at the workshop are listed below but may change as leads are confirmed and the roles are further developed. Leaders of these working groups will be encouraged to form regional or, where appropriate, national groups to determine appropriate activities and governance structures at a finer geographic scale.

The Shark Ray 360 Coalition: Initial Working Groups

1. Husbandry / Studbook Management
2. Veterinary
3. Research – may include genetics monitoring and tracking
4. Communications / Marketing
5. Fundraising
6. Regional in situ activities (likely to be multiple groups here, depending on the regions chosen for detailed work)
7. Outreach and training / capacity-building

Grant Abel would work with other Coalition members to identify Leads for each of the proposed working groups, who would then represent their groups at the Steering Committee.

A priority action for this effort is to identify all interested individuals and organizations interested in participating in the Coalition. This can include animal holding facilities that are able to continue research on ex situ diet/nutrition, husbandry, life history, etc. but may not be able to display the animals.

Ad hoc working group activity: Compiling ex situ husbandry data across institutions

On the morning of the workshop's last day, a group of participants with specific expertise in ex situ elasmobranch management gathered to exchange information describing how Bowmouth Guitarfish are managed at their institutions. This critical information will be reviewed and ultimately incorporated into the evolving database of Bowmouth Guitarfish information and data currently administered by the South-East Zoo Alliance for Reproduction and Conservation. The data compiled in this discussion are summarized below in Table 1.

Table 1. Summary of husbandry data compiled by ad hoc working group at Bowmouth Guitarfish workshop, 16 November 2023.

Management Variable	Kaiyukan, Osaka	Georgia Aquarium	Newport Aquarium	S.E.A. Aquarium
Sex ratio	1.1.0	1.2.0	2.2.0	1.2.0
				2.4.0
Habitat (mil L)	5.4	24	1.5	10
				5
Depth (m)	9	9.5	3 and 6	12
Diet (%)	10 crustacean 20 squid / invert 70 teleost	75 crustacean 25 invert / teleost	65 crustacean 35 teleost	25 crustacean 75 teleost
Fresh / frozen	Frozen	Frozen	Frozen	50:50
Seawater type / salinity (%)	Natural: 34%	Instant Ocean: 32%	Manmade: 30-32%	Natural: 32%
Water temp (˚C)	23.0	24.5	23.6	25.0
Photoperiod / light	12/12	10/6	12/12	18/6
Moonlight	Y	Y	N	Y
Supplements	None	Mazuri (no cobalt)	Mazuri	Mazuri
	None	Vit C with surgeries	Vit C	?
Handling neonates?	N/A	Daily up to 5x	Daily 3x	Daily 1x
Handling duration	N/A	2 months	3 weeks	4 months
First food items	N/A	Superba krill	Shrimp (frozen)	Shrimp (live)
Food items refused	N/A	Salmon	Fish	Garlic
Tube feed?	N/A	Y	Y	Y
Tube feed when?	N/A	24h post-birth	24hr post-birth	2-3days post-birth
# confirmed pregnancy	Copulation only	3	2 or 3	Many
Pups / litter	N/A	1 – 7	1 – 9	1 – 14
Pup weight (kg)	N/A	0.8 – 1.0	0.9 – 1.1	
Pup length (cm)	N/A	47 – 50	48 – 51	40
When is female moved to birth?	N/A	4 weeks prior	2 – 4 weeks prior	When confirmed pregnant
Pregnancy frequency	N/A	Annually	Younger: Annually; Older, biannually	Annually
Age of breeding female				
Length of breeding female				
Weight of breeding females				

References

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Appendix I: Workshop participant list

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Appendix II: Workshop agenda

Bowmouth Guitarfish (*Rhina ancylostomus*): An *Ex Situ* Assessment and Planning Workshop

14 – 16 November, 2023
Shedd Aquarium, Chicago, Illinois, USA

WORKSHOP AGENDA

Note: All times listed as Central U.S. time zone

DAY ONE: 14 NOVEMBER 2023

9:00 Workshop opening, logistics: *Peggy Sloan*

9:15 Introduction to CPSG, overview of agenda, and participant introductions: *Onnie Byers*

9:45 Overview of the *IUCN SSC Guidelines on the Use of Ex-Situ Management for Species Conservation* as part of the One Plan approach to conservation: *Phil Miller*

10:15 Background presentations Part 1

1. Review: Status of Rhinidae ***in situ***
   - Natural history, threats, priorities: *Rima Jabado* (virtual), *Cassie Rigby*
   - Origin, destination, and handling *in situ*: *Fred Fan*
   - Population genetics: *Emily Humble*

Issue generation and evaluating *in situ* threats and vulnerabilities to the species (threat diagramming)

11:30 Coffee / tea break

11:45 Background presentations Part 2

2. Review: State of the science for ***ex situ*** management of Rhinidae
   - Consolidated knowledge of *ex situ* care: *Lisa Hoopes*
   - *Ex situ* population status in Asia, North America and Europe: *Kelly Sowers, Oliver Walenciak*
   - Affiliations among *ex situ* populations in collaborating aquariums: *Kevin Feldheim*

12:15 Plenary discussion: Defining potential *ex situ* conservation roles for Bowmouth Guitarfish

1:00 Lunch (provided)

2:00 Plenary discussion: Identifying the potential role(s) for *ex situ* activities and how they can support a healthy *ex situ* population while improving viability of Bowmouth Guitarfish in the wild.
(Coffee / tea available during this session)

4:00 Introduction to working group dynamics; working group formation

5:00 Adjourn

5:15 Icebreaker: Informal information sharing

DAY TWO: 15 NOVEMBER 2023

9:00 Working Group Session I: Defining the goal and the characteristics of an *ex situ* population of Bowmouth Guitarfish that would be required to fulfill each potential role. Include factors such as:

- Number and source of any wild-caught individuals
- Population size and structure to be maintained for demographic and genetic viability
- Type of management to employ (group management?)
- Type of facilities needed
- Capture, transport and release techniques
- Anticipated duration of program to achieve program goals

(Coffee / tea break available during working group session)

11:00 Plenary Session I: Presentation of characteristics of each potential *ex situ* program

12:00 Lunch (provided)

1:00 Working Group Session II: Define the resources and expertise needed for the *ex situ* program to meet its role(s) and assess feasibility and risks. Develop recommendations regarding management decision for *ex situ* programs based on evaluation of benefits, risks, and feasibility Include factors such as:

- Biological feasibility:
  - Founder source and availability
  - Existing expertise (capture, transport, release, *ex situ* management)
- Social feasibility:
  - Existing species plans and governing agencies at the global scale
  - Other stakeholder issues (general public, indigenous groups, etc.)
  - Organizational aspects (among multiple partners)
- Regulatory compliance
- Resource availability:
  - Staffing needs (number, expertise)
  - Availability of resources
- Likelihood of success
- Risk assessment:
  - Risk to source population viability
  - Risk to recipient population and site
  - Disease and parasite risks
  - Socio-economic and political risks
  - Financial risk
  - Likely future for wild population in absence of *ex situ* activities (risk of no action)

(Coffee / tea break available during Working Group Session)

4:00 Plenary Session II: Presentation of needs, risks, and feasibility of each potential program, group's recommendation regarding *ex situ* activities, and the identified goal and recommended program structure for any recommended program

Consensus decision on whether or not to pursue each recommended *ex situ* program.

5:00 Adjourn

DAY THREE: 16 NOVEMBER 2023

7:30 Bowmouth Guitarfish feeding session with Shedd Animal Care staff

8:00 Breakfast (provided)

9:00 Working Group Session III: Preliminary action planning for each agreed upon *ex situ* program, including monitoring and exit strategy considerations, collaborating partners, timelines, and costs
(Coffee / tea break available during Working Group Session)

11:00 Plenary Session III: Presentation of action plan

12:30 Lunch (provided)

1:30 Plenary Session IV: Next steps and timeline for action

3:00 Workshop closing

Appendix III: Potential ex situ roles and descriptions

COMMON EX SITU AND POPULATION MANAGEMENT CONSERVATION ROLES

Based on a combination of the role descriptions in the IUCN SSC Guidelines on the Use of Ex Situ Management for Species Conservation, IUCN SSC Guidelines for Reintroductions and Other Conservation Translocations, and Appendix I of the Amphibian Ark Conservation Needs Assessment Process

In essence, *ex situ* management can support species conservation and prevent extinction by:

1) addressing primary threats and/or their causes;
2) counteracting the impacts of primary or stochastic threats on the population (such as reduced survival, poor reproduction and genetic isolation);
3) using *ex situ* populations for population restoration or conservation introduction; and/or
4) preventing extinction by gaining time in situations where threats are not under control or mitigation is not successful (enough).

This list of ten potential conservation roles for *ex situ* (or other population management) activities are the most common roles that address these four functions.

Ark

Maintain a long-term *ex situ* population after extinction of all known wild populations and as a preparation for reintroduction or assisted colonization if and when feasible.

Insurance population

Maintain a long-term viable *ex situ* population of the species to prevent predicted local, regional or global species extinction and preserve options for future conservation strategies. These are typically species that are threatened and/or declining and for which it is unsure whether *in situ* threat mitigation will have the sufficient effect in a sufficient timeframe to prevent the extinction of the species or to prevent a dramatic decline in the numbers, populations and/or genetic diversity of the species. An *ex situ* population may be desired as an insurance population from which individuals can be taken for genetic and/or demographic supplementation or other conservation translocations as required, but these are not yet actively planned the foreseeable future.

Rescue (temporary or long-term)

Establish an *ex situ* population for a species that is in imminent danger of extinction (locally or globally) and requires *ex situ* management, as part of an integrated program, to ensure its survival. The species may be in imminent danger because the threats cannot/will not be reversed in time to prevent likely species extinction, or the threats have no current remedy. The rescue may need to be long term or temporary (for example, to protect from catastrophes or predicted imminent threats that are limited in time, e.g. extreme weather, disease, oil spill).

Demographic manipulation

Improve a demographic rate (survival or reproduction) or status (e.g. skewed sex ratio) in the wild, often of a particular age, sex, or life stage. An example is a head-start program that removes individuals from the wild to reduce high mortality during a specific life stage and then subsequently returns them to the wild.

Population restoration: Reintroduction

Serve as a source of individuals for population restoration to re-establish the species to part of its former range from which it has been extirpated.

Population restoration: Reinforcement

Serve as a source of individuals for population restoration to supplement an existing population (e.g. for demographic, behavioral or genetic purposes).

Conservation introduction: Ecological replacement

Introduce the species outside of its indigenous range to re-establish a lost ecological function and/or modify habitats. This may involve species that are not themselves threatened but that contribute to the conservation of other taxa through their ecological role.

Conservation introduction: Assisted colonization

Introduce the species outside of its indigenous range to avoid extinction of populations of the species.

Ex situ research and/or training

Use an *ex situ* population for research and/or training that will directly benefit conservation of the species, or a similar species, in the wild (e.g. develop monitoring methods; address data gaps in disease transmission or treatment). The research or training must address specific questions essential for success of the overall conservation strategy for the species. This can include non-threatened species serving as a model for threatened species, or establishing *ex situ* populations of a threatened species to gain important species-specific husbandry and breeding expertise that is likely to be needed in the future to conserve the species.

Conservation education

Forms the basis for an education and awareness program that addresses specific threats or constraints to the conservation of the species or its habitat. Education should address specific human behavioral changes that are essential for the success, and an integral part of, the overall conservation strategy for the species. This primarily involves *ex situ* locations visited by the intended human audience.