Taxonomy and Conservation of Endangered Fish Species: Challenges and Strategies

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Abstract

Regarding the maintenance of biodiversity and the stability of ecosystems, the taxonomy and conservation of endangered fish species are of paramount importance. This paper explores the many difficulties and tactics involved in defending these delicate aquatic species. Taxonomic ambiguity, data gaps, habitat degradation, overfishing, invasive species, pollution, and the overall effects of climate change are obstacles in this endeavor. The conservation and restoration of critical ecosystems are crucial for the survival of these species, and accurate species identification and thorough data are fundamental. Strategies for invasive species control, climate adaptability, and sustainable fisheries management are important. A comprehensive strategy for conservation must include money for research, international cooperation, and public education. In order to successfully solve these issues, scientists, policymakers, communities, and organizations must work together. We can ensure a more resilient and balanced aquatic environment for future generations by putting the suggested ideas into practice. By doing so, we can work towards protecting endangered fish species and the complex web of life they sustain.

Keywords: biodiversity (BD), Taxonomy (T), conservation ©, fish Species (FS), SPSS software.

Introduction

About 2 million species of different kinds are present on the Earth. They all have their body structures and mechanisms different from each other. Among them are the different kinds of fish species that are thoroughly present in different water bodies all over the world. But in last past years, many of the fish species have started to decrease in number in their respective population. As those fish species are an important part of the ecosystem, it is advised to devise some ways to prevent their extinction. For this purpose, one must need to have a deeper appearance to understand what fish species come under this category. Fishes of different kinds are present in the highest streams to the deepest oceans. They vary from each other in the body morphology and functioning. Some of them are now considered endangered. They belong to different classes and they also differ in their environmental background. It ranges from the smallest fishes to the largest sharks in the oceans. In the northern Atlantic Ocean many different kinds of fish species were affected by the natural changes and now are close to extinction. Most of the endangered species specifically belong to that ocean. This includes one of the fastest fish that can travel to double its body length and in the same way, it is the most endangered fish type in its surroundings.

The main reason for the extinction and endangerment of fish species is overfishing. As we know the human population is tremendously increasing day by day, so there is a need to create more ways to fulfil the food requirements in them. One of these is fishing and in many countries, fish is the main source of food for them. This includes some of the islands and the places near the seas and lakes that are bound to eat those fishes. So it's obvious that when a large number of people are present in a specific area they will ultimately eat more food which will decrease the number of fish in those areas. The fish present in these areas are mostly endangered

because they are a source of food for a large number of the population. Fish is a major source of protein and is considered an important source of nutrients. It is most likely to be eaten in China and some other developing countries. Apart from food fish also provide a large amount of useful products to humans. So for those products fish hunting is also done and due to this, there has been a visible decrease in several fish species. Different kinds of sharks are considered to be endangered. This is because in some areas the shark is also eaten and medically it is proven that eating shark meat is very beneficial for human health. It is seen that some kinds of sharks and rays are near extinction because they reproduce at a very slow rate. Due to this reason, the natural increase of them is very slow and ultimately they face the problem of becoming extinct (Ryan & Deepak, 2022).

So the need of the hour is to save these species and to restrict their hunting because if it goes like this the species will ultimately fall extinct. As this thing can only be done on an international level, only the government of those respective areas can help to minimize the fear of extinction. There should be a proper strategy for this purpose because there are multiple reasons for the endangerment of the species. The climatic changes are a major challenge to the fish species because, in case of any change, their habitat is affected they will face major life problems which will cause them to have a life-threatening issue. Currently, for the fishes that are in more threat, their hunting or fishing is strictly banned because the only way to minimize their extinction is the limit fishing. One other cause of the decrease in respective fish species is the water pollution in those areas where the fish are already declining in number. Increase in the human activities has caused a severe threat to the species living in the oceans and lakes. For example, every year due to oil spills, thousands of fish species lose their life as oil enters the water and block the oxygen supply for the species that are present inside the water. When the species inside the water are unable to get oxygen, they ultimately die because of suffocation. Research has shown that water pollution can also affect fish gills which ultimately cause specific diseases in them.

Some natural changes are also a great challenge in saving the species from becoming extinct. Acid rain is an example of this, when acid rain water touches the surface of fish bodies it causes severe bleeding in them. So when one is trying to control the decrease in their number, this can be a great threat to them. Some other challenges make it difficult for the workers of the organizations to have controlled. Many organizations are working all over the world to control the rate of extinction and to save the specific fish species whose life is in danger. They are working together to devise some ways and methods by which species are saved. Endangered species no matter what habitat they belong to are moved to freshwater for reproduction if possible. This is done by aquaculture, endangered species are going through the process of breeding so that the decrease in their population can be fulfilled by this. Special treatment is given to those areas where different kinds of fish species are present. Conservation of these fish species is possible if proper management is there to restore the habitats.

With the proper management and effective steps, it is possible to save the endangered species. Scientists must derive ways in which modern technology can help to save these species. Improvement in conservation strategies can only lead to saving these species in times of serious challenges such as climate change, and natural disasters. With these things the endangered fish species present all over the world can be saved including the species from the highest streams to the deepest oceans.

Literature Review:

This review is based on the overview of those studies that are related to the Taxonomy of fish species along with the strategies and challenges related to the conservation of endangered species of fish population. The word Taxonomy means the process of naming and classification of a living organism, If we are saying Taxonomy of fishes, it means that it is naming and classification of fish species. The word conservation means regaining endangered or threatened species of any population such as fishes(Nogueira et al., 2010). As the time in recent years has been advanced to much extent by the revolution of industry and economy. This industrial revolution

has also contributed to different types of pollution such as water pollution, land pollution, air pollution, and others. Recent studies have diverted much attention of orioles towards the effect of this pollution on the population of fish across the world(Mouillot et al., 2011). If we describe about Taxonomy of fish species, fishes are divided into three types depending upon the type of skeleton they have. These categories are jawless fishes, cartilaginous fishes, and bony fishes(Lermen et al., 2009). All of these types of fishes are given specific names such as jawless fishes are called Agnatha, the cartilaginous fishes are called Chondrichthyes, and bony fishes are called Osteichthyes(Boni & Gunn, 2021; Gippoliti, Cotterill, Groves, & Zinner, 2018; Szaro, 2008).

    All of these kinds of fish have different characters depending on the structure of the body. For example, Agnatha has characteristics like the absence of jaws and paired fins not present(Xing, Zhang, Fan, & Zhao, 2016). They have bony skeletons but such species are not living these days, Some fishes in this category have cartilaginous skeletons as well, and they have such embryonic notochord that persists in adults also(Doremus, 2010). They have seven pairs of gills that are used for respiration in them(Mijkherjee, Praharaj, & Das, 2002). Just like this, Chondrichthyes have also specific characteristics such as they have paired fins, they have hard scales on the body, they have a two-chambered heart for pumping blood in the body, they have a pair of nostrils also, they have a special type of spectrum gill slits on lateral sides of the body, they have such reproductive system that they give birth to young ones(Akhilesh et al., 2023; Mace, 2004). Most of the species of this class have become extinct these days or they are near extinction, which means they have become endangered(Cooke, Paukert, & Hogan, 2012). Along with it, they have paired jaws and appendages like terrestrial vertebrates, their electro-receptive system is well developed to respond to different kinds of stimuli underwater, and they have an endoskeleton that is entirely made up of cartilage(Alagona, 2016; Olden et al., 2010).

    They have no specific kind of swim bladder or lungs in them. The third category of fish is Osteichthyes, they also have a variety of characteristics that are distinguishable from other categories(McQuatters-Gollop et al., 2017). They have entire endoskeletons made up of bone, therefore, they are called bony fishes, they have different kinds of paired fins, they mostly have only one opening for gills, they have such skin that is embedded with dermal scales and mucous glands, they have such variety that some types are having teeth, others are toothless, they have operculum which covers gills which is unique property of this category(Lima, Ramos, da Silva, & de Souza Rosa, 2017; Pinder et al., 2019). But most of the species of this category are living nowadays, only a few have become endangered and extinct. The second part of the review is the conservation of endangered species of fish, as we all know that the best way to conserve any kind of living organism is to protect its habitat as well, for example When fishes have having habitat of water, we should take different steps to improve quality of water so that the species of fishes may not become extinct or endangered(Avise, 1989). Nowadays water pollution has exceeded to such a level that clean water is less available in many parts of the world even for drinking. In such circumstances, where we do not have enough water for drinking, the quality of water for aquatic life has become very pathetic as well(Society, 2016). As we have seen industrial waste is directly thrown into water bodies without any treatment to reduce its toxicity, It heavily affects the quality of water, such industrial effluents make the quantity of soluble oxygen very low to such a level that most of the aquatic life die because of suffocation(Lysne, Perez, Brown, Minton, & Sides, 2008). Recent studies also revealed that acidic rain is increasing the acidic level of water bodies which is making it difficult for aquatic life to live there.

    The acidic rain is also responsible for washing away minerals and metals from soil to water bodies(Haig et al., 2006). The increasing level of metals can cause metal poisoning to fish such as high levels of aluminum clogs in gills because of which most of the fish die thus becoming endangered and extinct. The other factor that contributes to the poor quality of water bodies is agricultural effluents such as the use of pesticides and fertilizers(Sarkar, Pathak, & Lakra, 2008). These pesticides and fertilizers increase the level of phosphate ions in water bodies that can cause eutrophication thus leading to the death of fishes because of less availability of

soluble oxygen to them. The only best strategy for endangered species of fish is to improve the quality of water including freshwater and Marine water as well(Christodoulou, Anastasiadou, Jugovic, & Tzomos, 2016). The quality of water bodies can only be improved if we take stringent steps to avoid the pollution of water by industrial effluent, agricultural effluent, and acidic rain. The toxicity caused by industrial wastes can be mitigated by treatment of industrial waste before dumping it into water bodies. These treatments will lower the toxicity level of industrial effluents(Gurung, 2012). However, this step needs much funding to use such machinery that can be used to reduce the toxicity of industrial waste before dumping it into water bodies. The second strategy can be less flow of agricultural effluents to water bodies. The agricultural effluent is because of the overuse of pesticides and fertilizers that results in damaging the quality of Freshwater such as river water(Strecker, Olden, Whittier, & Paukert, 2011). This problem can be solved by using bio-fertilizers in substitute to artificial fertilizers because natural fertilizers have less toxicity to water bodies.

However, this strategy can only be used if there are proper methods for using natural fertilizers. There should also be awareness among farmers about the harmful impacts of pesticides and fertilizers on water bodies that ultimately affect the species of fish(Geist, 2010). After reviewing all of these studies related to Taxonomy and conservation of endangered species of fish, we know that there is a stringent need to apply a few steps to conserve endangered species of fish otherwise it would be harmful to species of fish in the near future(Reid, Contreras MacBeath, & Csatádi, 2013).

Methodology:

The research determines that taxonomy and conservation strategies of fish species. The research based on some theory and some portion represent that numerical analysis related to them. for determine the research used SPSS software and generate informative results related to them. the correlation coefficient and variance analysis between them for measuring the results.

Taxonomy and conservation strategies:

1. Invest in taxonomic research to correctly identify and categories fish species. Molecular methods and DNA barcoding can help clear up taxonomic ambiguities.

2. Support extensive data gathering initiatives, including as population estimates, habitat mapping, and genetic research. Planning for conservation effectively requires this information.

3. Habitat protection: To maintain essential fish habitats, establish and enforce protected areas and conservation reserves. Projects to restore habitat can also aid in restoring deteriorated regions.

4. Sustainable Fisheries Management: To avoid overfishing and lower bycatch, put in place science-based fisheries management practices such catch limits and seasonal closures.

5. Management of Invasive Fish Species: Create and put into practice management and control methods for invasive fish species. This might involve efforts to remove the substance and regulatory actions to stop new launches.

6. Protection of Water Quality: Enforce laws to lessen pollution and safeguard water quality. Encourage environmentally friendly land use to reduce runoff and pollution.

7. Climate Adaptation: To assist fish species adapt to shifting environmental conditions, develop climate-adaptive management practices. This might entail establishing chilly refuges or reestablishing natural migratory paths.

8. Public Awareness and Education: Increase public understanding of the value of fish conservation and the part that each person can play in it. Participate the neighborhood in conservation initiatives.

9. International Cooperation: Work together to safeguard migratory fish species that pass through several different legal jurisdictions.

10. Funding for Research: Allocate funds to support research and conservation projects as well as monitoring and enforcement actions. Fish species conservation is a complex issue that calls for cooperation between scientists, decision-makers, conservation groups, and local populations. We may work towards protecting these essential elements of aquatic ecosystems by addressing these issues and putting forth sensible solutions.

Endangered Fish Species and their Taxonomy:

Throughout the world, water networks are fronting serious fears about their biodiversity and the stability of the ecosystem. Pressure caused by anthropogenic activities like urbanization, logging, abstraction of water for power generation, irrigation, pollution, and dam construction has imposed serious negative effects on fish biodiversity, genetics, and taxonomy. Different strategies are being initiated but the change in the relative abundance of fish species in a waterbody not only affects species richness and food web but also the biomass of the ecosystem. Due to this, current strategies proposed by researchers are lacking effectiveness and are increasing the risks of endangerment for fish species. Out of these freshwater fish species comprise 48% and marine fish species constitute about 52% of the total fish population. Various threats drive both the freshwater and marine fish species towards endangerment.

Threats towards Marine and Freshwater Fish Species:

Both marine and freshwater fish groups face the effects of human activities but freshwater species have been severely influenced by human concentration that has processed more than 83% of the land surrounding freshwater bodies. Common practices involve dam water divergence, excessive catchments, deforestation, and engineering at river corridors. These factors bring negative outcomes that lead fish species toward endangerment. Habitat loss and destruction is one of the major effects faced by freshwater species. The construction of dam walls causes the separation of downstream species from upstream fish species, inducing the separation of migrating populations.

The second major threat is caused by invasive species. These species when enter the freshwater regime they disturb the native fish species by predation, rivalry, habitat changes, and by spreading disease-causing parasites. The introduction of new plants like *Urochloa mutica* in water can cause changes in the habitat for fish.

Next comes the water pollution factor that affects fish's environment and pushes them toward a red list of

endangered species. That pollution is coming from mining, industries, atmospheric deposition, and run-off water from agriculture. Inland aquatic reservoirs are considered more susceptible to water pollution as they lack the space to dilute pollutants and reduce their effect. A minimum of eight of the thirteen world's extinct freshwater fish had been victimized by pollutants i.e., through eutrophication.

Overfishing is also one of the driving factors for endangered fish species. To fulfill the demand for food or their catchment as ornamental fish for aquariums, the fish population is being disrupted. With overfishing, the remaining fish population faces a depressed environment which can erase the entire fish assemblage.

Climate changes also impact fish assemblages as the major shifts in climate cause either conditions like droughts or extra runoff water in the form of floods. Both of these conditions disturb hydrological and thermal regimes and in turn affect species richness. The taxonomy of fish species and their protection are important components of maintaining biodiversity and the health of ecosystems. Due to habitat degradation, overfishing, pollution, and climate change, fish are among the most endangered vertebrate species on the planet. There we'll go over the issues and solutions surrounding the taxonomy and preservation of fish species that are in risk of extinction:

Challenges:

1. Taxonomic Disambiguation: Due to morphological differences and cryptic species complexes, it can be difficult to accurately identify and classify fish species. Taxonomic ambiguity might impede conservation efforts since it is crucial to identify the precise species at issue.

2. Data Deficit: It is challenging to appropriately determine the conservation status of many fish species due to a lack of complete biological and ecological data. Planning and management for conservation might be hampered by this knowledge gap.

3. Habitat Degradation: Fish species face serious challenges from habitat loss and degradation brought on by things like urbanisation, agriculture, and dam development. An essential problem in fish conservation is the preservation of appropriate habitats.

4. Overfishing: Unsustainable fishing methods such as bycatch and overfishing can push fish species to the verge of extinction. It's essential to control fishing pressure for their preservation.

5. invading Species: The introduction of invading fish species has the potential to outcompete and supplant native fish, which might result in the deterioration of endangered species. The management of invasive species is a difficult task.

6. Pollution: Pollution from urban, industrial, and agricultural regions can impair fish populations and deteriorate water quality. It can also interfere with developmental and reproductive functions.

7. Climate Change: Fish habitats and migratory patterns may be impacted by rising temperatures and changed precipitation patterns. Infection outbreaks are one hazard that climate change might make worse.

Strategies for Dealing with Fish Endangerment:
For dealing with the increasing endangered population of fish, different strategies need to be accessed according to the needs and taxonomic characteristics of the fish group.

Firstly, a strategy for risk assessment can be applied. In this strategy, the taxonomic data from different sources is used to first categorize the type of fish species present in marine and freshwater bodies. After that, the fish richness data needs to be retrieved, to group the data of species according to their extinction and

endangerment levels. This method allows to separate the regimes that need no attention and undivided consideration can be given to endangered fish.

Next, comes the correlation of extinction risks. This strategy is mostly applied to marine environments where fish groups are peculiar about living in large water reservoirs. Therefore, correlation of risk assessment for these species is necessary, especially for the mature marine fish that have spent most of their life in marine water and even mere changes in their habitat can lead them to extinction.

Likewise, another practical strategy that can be implemented for fish conservation is to introduce conservation reserves. These reserves can help in securing species that are endangered by providing them with the environment, food, resources, and suitable conditions for lowering their risk of extinction. These recovery programs can range from a single species of fish to the entire water basin full of diverse species.

Finally, the restoration and management of environmental stressors that move the fish population towards endangerment can help in the practical application of other conservation strategies. The proper method for integrated catchment management, removal of environmental degraders, and restoration of flood plains can help in regulating the other conservation strategies and can ensure their sustainability.
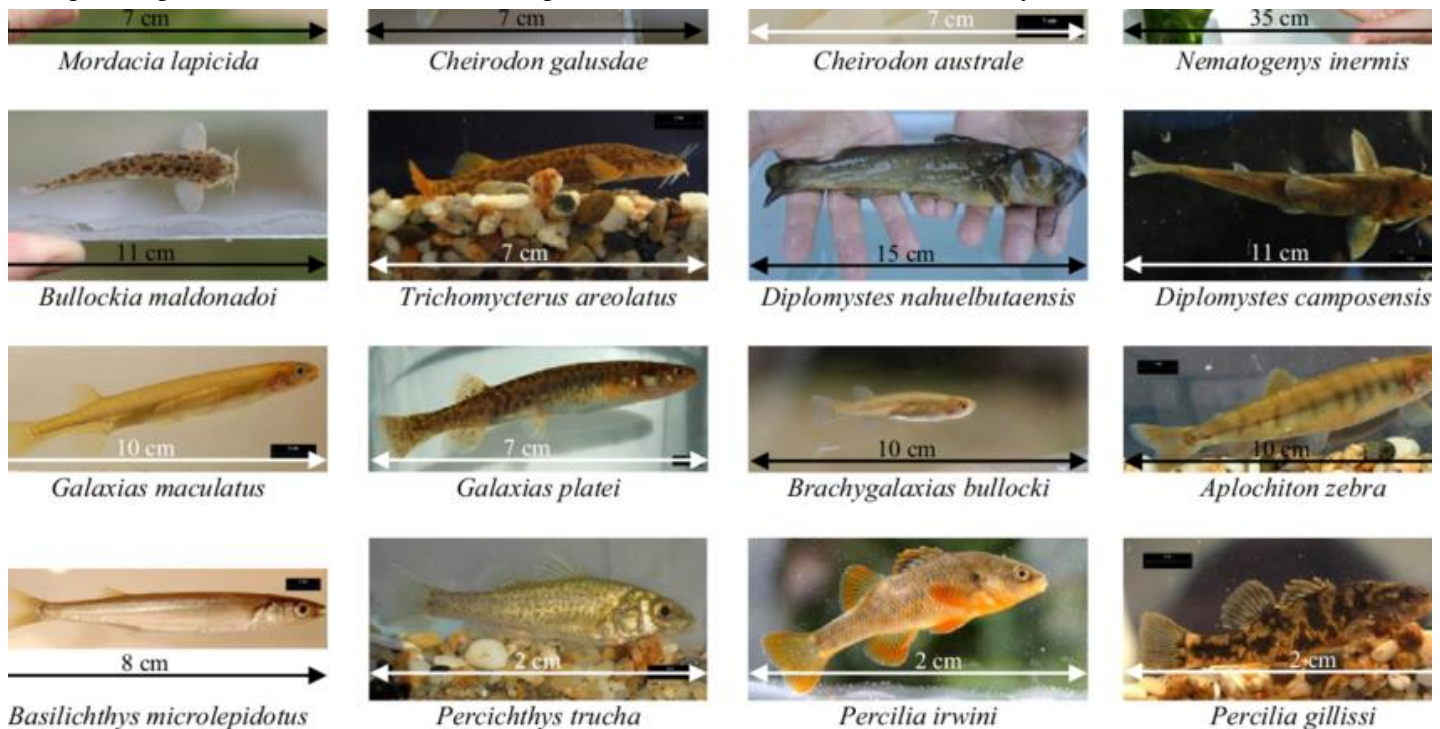
Challenges Hindering the Conservation of Fish Population:

Different challenging factors are hindering the conservation strategies of the fish population. The most important one of these challenges is limited information on the taxonomy and life history of fish populations. Although new advancements have been made by introducing fish databases and block chain strategies, these methods are still under development. Similarly, the lack of information regarding different spatial scales towards which fish migrate is another challenge. Also, the data on the fish-flow relationship, relative to different regimes and their flow magnitudes is lacking and becomes an interruption for conservation.

The seasonal aspects of different fish groups are also limited, which in turn limits the study of fish biology of a certain location in a water body. The prediction of responses of fish and their ecosystem towards different environmental changes and management actions needed to be taken for conservation are also lacking and need immediate consideration.

The data on ecosystem services provided by fish is present only for a general level and needs specifications according to fish taxa and the habitat they own to predict the importance of the conservation of that species. River-fish habitats and the fish species they inhabit are more difficult to understand and study as the rivers are aquatic bodies of diverse flow, different variables, and unknown depths. Therefore, predicting the complete availability of species in river water cannot be assured, and new techniques to reach a depth of water and discover the species resting there. Also, the efforts that are focused only on one species of an aquatic system fail the broader viewpoint and need to conserve the diverse fish species.

Result and descriptions:

Correlations

		Taxonomy 1	Taxonomy 2	conservation 1	conservation 2	endangered fish species 1	endangered fish species 2
Taxonomy 1	Pearson Correlation	1	-.116	.490**	-.208	.675**	-.074
	Sig. (2-tailed)		.421	.000	.148	.000	.612
	N	50	50	50	50	50	50
Taxonomy 2	Pearson Correlation	-.116	1	-.082	.277	.059	.149
	Sig. (2-tailed)	.421		.571	.051	.683	.302
	N	50	50	50	50	50	50
conservation 1	Pearson Correlation	.490**	-.082	1	-.103	.272	-.031
	Sig. (2-tailed)	.000	.571		.476	.056	.833
	N	50	50	50	50	50	50
conservation 2	Pearson Correlation	-.208	.277	-.103	1	-.128	-.029
	Sig. (2-tailed)	.148	.051	.476		.376	.841
	N	50	50	50	50	50	50
endangered fish species 1	Pearson Correlation	.675**	.059	.272	-.128	1	.006
	Sig. (2-tailed)	.000	.683	.056	.376		.967
	N	50	50	50	50	50	50
endangered fish species 2	Pearson Correlation	-.074	.149	-.031	-.029	.006	1
	Sig. (2-tailed)	.612	.302	.833	.841	.967	
	N	50	50	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

Table-1

The above result describes that correlation between independent and dependent variable the endangered fish species 1,2 is dependent variables according to the result its correlation rate is 0.675, 0.059, 0.272 also that 0.006 shows that positive and significantly level between them. the overall result shows significantly relation between the independent and dependent variables.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.068	34.463	34.463	2.068	34.463	34.463
2	1.253	20.887	55.350	1.253	20.887	55.350
3	1.021	17.009	72.360	1.021	17.009	72.360
4	.765	12.753	85.113			
5	.630	10.501	95.614			
6	.263	4.386	100.000			
Extraction Method: Principal Component Analysis.						

Table-2

The above result describes that total variance analysis result present that initial eigenvalues also that cumulative percentage and % of variance. The result describes that extraction sums of squared analysis of each component. According to the result the total values are 2.068 1.253, 1.021, 0.765 also that 0.263 all values shows that positive total values of each variables. the result represent that % of variance are 34.46, 20.887, 17.009, 12.753 and 4.386 respectively. The cumulative percentage present that positive rates are 55.350 72.360, 95.614 also that 100.000 respectively shows that positive rates between them. the result also describe that extraction sums values are 34.463, 20.887 also that 17.009 the result also describes the cumulative percentage its rates are 34.46, 55.350 and 72.360 respectively.

Conclusion:

In conclusion, a crucial frontier in the larger struggle to protect biodiversity and uphold the health of our planet's aquatic ecosystems is the taxonomy and conservation of endangered fish species. Numerous issues affect these species, such as taxonomic uncertainty, data gaps, habitat damage, overfishing, invasive species, pollution, and the looming threat of climate change. However, it is feasible to effectively address these issues by combining scientific rigor with policy efforts and community involvement. Advanced molecular methods like DNA barcoding can be used to improve taxonomic clarity and establish the groundwork for precise conservation measures. The gathering of thorough data, which offers the essential understandings into population dynamics, environmental needs, and genetic diversity, is equally important.

Fish conservation is based on preserving and restoring habitat. For endangered animals to have secure breeding and feeding grounds, protected areas and conservation reserves must be established and enforced alongside actions to minimize pollution and safeguard water quality. In addition, measures for climate adaptation must be created to assist these species in adjusting to the ongoing effects of climate change. To avoid overfishing and bycatch, fisheries must be managed sustainably. To guarantee that fish stocks may recover, it is crucial to put into place rules based on scientific data, such as catch limits and seasonal closures. Effective management strategies are needed to deal with invasive species, which provide a constant danger to native fish populations. Collaboration is necessary on both a national and international scale, particularly for migratory fish species that move between different legal systems. Campaigns for public awareness and education are essential in encouraging a feeling of stewardship and accountability among communities. The long-term viability of conservation activities may be greatly impacted by including local communities in conservation efforts and encouraging ethical fishing methods. Finally, sufficient research money is essential for the accomplishment of conservation programs, as well as for the implementation of laws and monitoring activities. These crucial actions may be continued over time if there are enough financial resources available. In conclusion, there are enormous obstacles confronting endangered fish species, but we have the tools and tactics to lessen these dangers with a coordinated effort and a diversified approach. In addition to being morally required, the preservation of these

distinctive and frequently keystone species is crucial for the general resilience and health of aquatic ecosystems. We can strive to ensure the continuing survival and recovery of endangered fish species by putting the techniques described in this article into practice and encouraging collaboration at all levels, which will help to preserve our natural world for future generations.

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