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Fenced and Feral: Farming and Spread of Flowerhorn (Amphilophus spp.) in Lake Sampaloc, Philippines

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CRAWLING BATTLES:
ANTHROPOGENIC THREATS TO THE
CRUSTACEANS OF SASMUAN PAMPANGA
COASTAL WETLANDS, PHILIPPINES

FENCED AND FERAL: FARMING AND SPREAD OF FLOWERHORN (*AMPHILOPHUS* SPP.) IN LAKE SAMPALOC, PHILIPPINES

HANNAH NICOLE C. GASMEN AND JANICE A. RAGA ZA

Flowerhorns are hybrids within the *Amphilophus* group known for their vivid coloration, large body size, and high value in the aquarium trade (Figure 1). However, once introduced into natural ecosystems, they exhibit traits that promote ecological dominance (Nasution *et al.*, 2022). These fish are notably aggressive, often monopolizing shelters, feeding sites, and breeding grounds (Herder *et al.*, 2012). In closed systems such as Lake Sampaloc, this dominance has contributed to alterations in native fish assemblages, with small-bodied and endemic species experiencing marked population declines (Yan, 2023). Flowerhorns outcompete native species primarily through resource competition and territorial aggression, especially during spawning periods. Like many other members of the Cichlidae family, they demonstrate exceptional adaptability to a wide range of environmental conditions, including degraded or polluted habitats, which enhances their capacity to survive, reproduce, and establish thriving populations. Consequently, their invasive potential poses a substantial threat to native fish communities (Nasution *et al.*, 2022).

In addition, the Flowerhorn cichlid (*Amphilophus* spp.), being freshwater and benthopelagic, has also contributed to ecological pressures in invaded systems. In Lake Sampaloc, these fishes can reach a maximum length of 24.4 cm and are characterized by their bright orange or golden coloration in adults (from *A. citrinellus* ancestry), with mature males being larger, exhibiting elongated fins, and developing a distinct nuchal hump (Conkel, 1993). Flowerhorn cichlids are predominantly found



FIGURE 1. A detailed view of a Flowerhorn cichlid highlights its vibrant gold coloration derived from Midas cichlid inheritance, a trait prized in the aquarium trade but impactful in the wild. Photo: H.N. Gasmén.



FIGURE 2. A view of Lake Sampaloc providing context for the distribution of fish pen aquaculture. Photo: H.N. Gasmén.

in lakes and are omnivorous, feeding mainly on snails and small fishes, along with insect larvae, worms, and other benthic organisms (Yamamoto and Tagawa, 2000). Originally native to Central America, particularly Nicaragua and Costa Rica, they were introduced through the aquarium trade and subsequently escaped into natural waters (Nico *et al.*, 2007).

Lake Sampaloc is an inactive volcanic maar located at approximately 14°04'42" N, 121°20'03" E in San Pablo City, Laguna, Philippines (Figure 2). It is the largest among the seven crater lakes in the city, spanning approximately 104 hectares with a maximum width of 1.2 kilometers, a surface area of 1.04 km², and a maximum depth reaching 27 meters (LLDA, 2005; Duka *et al.*, 2024). The lake's relatively small catchment area of 26 hectares contributes to a prolonged water residence time of up to four years, fostering stable stratification and unique limnological dynamics. Hydrologically, Lake Sampaloc receives water inputs primarily from precipitation, subsurface springs, and surface runoff, while outflows occur via seepage, evaporation, and discharge through Sabang Creek (Duka *et al.*, 2024). Located within a tropical

monsoonal zone, it experiences distinct wet and dry seasons that drive seasonal changes in temperature, nutrient concentration, and aquatic productivity (Tamayo-Zafaralla *et al.*, 2013).

Biologically, Lake Sampaloc supports a moderately diverse fish assemblage, with twelve recorded species representing three orders and eight families (Briones *et al.*, 2016). This community comprises

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both native and introduced taxa. Native species such as *Leiopotherapon plumbeus* (Ayungin), *Giuris margaritacea* (Bakuli), and *Glossogobius* spp. (Biya) persist but are increasingly outnumbered by non-native fishes like the most commercially farmed *Oreochromis* spp. (Tilapia) (Figure 3), ornamental fishes such as *Amphilophus* spp. (Flowerhorn cichlids) and *Parachromis managuensis* (Jaguar cichlids). Notably, Briones *et al.* (2016) reported significant trophic overlap between these groups, suggesting strong competition for limited resources.

The presence of Flowerhorn cichlids in Lake Sampaloc raises particular concern. According to local accounts, these ornamental fishes escaped from aquaria breeding facilities during a major typhoon, and subsequent fish assemblage surveys as early as 2016 have already documented their establishment in the lake. This is corroborated by observations during the present on-the-ground survey, which revealed that Flowerhorn cichlids are not only persisting in the wild but are also being actively farmed within the lake (Figure 4). This is particularly interesting and concerning because it indicates both accidental introduction and intentional cultivation, amplifying their ecological foothold.

The proliferation of Flowerhorns, facilitated by both ornamental cage escapes and local aquaculture practices, poses significant ecological risks. Their aggressive behavior and high reproductive potential threatens native ichthyofauna and destabilizes existing food web dynamics (Nasution *et al.*, 2022). Collectively, these factors highlight the growing ecological stress on Lake Sampaloc's native fish populations and the urgent need for integrated management



FIGURE 3. A monument to tilapia, symbolizing the lake's primary aquaculture species and its central role in the livelihood and culinary identity of Lake Sampaloc's communities. Photo: H.N. Gasmen.



FIGURE 4. A caretaker tending to a fish pen, showcasing a hands-on management practice. Photo: H.N. Gasmen.

strategies that address both unintentional introductions and deliberate aquaculture of invasive ornamental species.

PHENOTYPIC PLASTICITY AND ADAPTIVE SUCCESS OF FLOWERHORN CICHLIDS IN POLLUTED ENVIRONMENTS

Flowerhorn hybrids show marked phenotypic plasticity, tolerating eutrophic and contaminated conditions (Nasution *et al.*, 2022). This adaptability underscores the importance of examining pollution dynamics in Lake Sampaloc as a key ecological factor. Recent research emphasizes the mounting pollution burden within the lake, where chemical and synthetic contaminants interact with biological stressors, undermining overall ecosystem health.

Dimzon *et al.* (2018) conducted targeted and non-targeted chemical analyses across the lakes of San Pablo City, including Lake Sampaloc, and identified a variety of trace organic pollutants, such as pharmaceuticals, plasticizers, and industrial compounds, primarily originating from untreated sewage, household

runoff, and aquaculture practices. Due to the lake's limited outflow and prolonged water retention, these contaminants continue to persist and exert chronic sublethal effects on aquatic organisms.

Similarly, Natuel *et al.* (2023) documented the occurrence of microplastics in both rural and urban lakes of San Pablo City, including Lake Sampaloc, reporting higher concentrations in urban-influenced waters. These microplastic fibers and fragments, derived mainly from synthetic textiles and packaging, are likely linked to domestic wastewater and urban surface runoff. Field observations

THE PRESENCE OF FLOWERHORN CICHLIDS IN LAKE SAMPALOC RAISES PARTICULAR CONCERN.

ACCORDING TO LOCAL ACCOUNTS, THESE ORNAMENTAL FISHES ESCAPED FROM AQUARIA BREEDING FACILITIES DURING A MAJOR TYPHOON, AND SUBSEQUENT FISH ASSEMBLAGE SURVEYS AS EARLY AS 2016 HAVE ALREADY DOCUMENTED THEIR ESTABLISHMENT IN THE LAKE. THIS IS CORROBORATED BY OBSERVATIONS DURING THE PRESENT ON-THE-GROUND SURVEY, WHICH REVEALED THAT FLOWERHORN CICHLIDS ARE NOT ONLY PERSISTING IN THE WILD BUT ARE ALSO BEING ACTIVELY FARMED WITHIN THE LAKE. THIS IS PARTICULARLY INTERESTING AND CONCERNING BECAUSE IT INDICATES BOTH ACCIDENTAL INTRODUCTION AND INTENTIONAL CULTIVATION, AMPLIFYING THEIR ECOLOGICAL FOOTHOLD.

further corroborate these findings, revealing significant amounts of plastic waste and visible contaminants within Lake Sampaloc's waters, as well as open dumpsites situated near its shores. This localized waste mismanagement compounds pollutant influx and degradation of water quality. Literature suggests that chronic exposure to such contaminants may compromise fish immunity and increase susceptibility to parasitic infections; degraded water quality coupled with invasive dominance could facilitate the persistence and transmission of parasites in local aquatic systems.

Hydrological disturbances compound these issues by enhancing pollutant transport and nutrient dynamics. Casim *et al.* (2023) reported significant fluctuations in chlorophyll-a and nutrient concentrations following tropical storms, demonstrating how episodic weather events drive eutrophication, algal blooms, and contaminant redistribution. These dynamic conditions not only destabilize the native biota but also strengthen the competitive advantage of Flowerhorn cichlids, whose phenotypic plasticity and physiological tolerance enable survival and dominance under anthropogenically stressed environments.

FISH PEN FARMING OF FLOWERHORN CICHLIDS

Flowerhorn are now intentionally penned alongside tilapia for ornamental sales in Lake Sampaloc. Field observations during an on-site survey revealed that Flowerhorn cichlids (*Amphilophus* spp.), originally introduced as ornamental fish, are now being incorporated into local aquaculture practices. A caretaker managing fish pens in Barangay IV-A explained that their primary focus remains on farming *Oreochromis* species (*O. niloticus* and *O. aureus*) (Figure 5), which are highly valued for food and commercial purposes. However, wild Flowerhorn entering tilapia pens (Figure 6) are retained and on-sold as ornamentals, and some pens now stock them intentionally. According to the caretaker, this practice stems from the species' remarkable resilience, comparable to that of tilapia, and their dominance within the lake. Rather than discarding them as an ecological nuisance, a fish farm has adapted by capitalizing on their abundance and hardy nature. The cichlids are primarily sold for the



FIGURE 5. *Tilapia* (*Oreochromis niloticus* and *O. aureus*) placed in a plastic basin prior to selling. Photo: H.N. Gasmen.



FIGURE 6. A caretaker manages Flowerhorns in a fish pen, showcasing a fish farm's role in harvesting and maintaining the species for aquaculture and ornamental sale. Photo: H.N. Gasmen.

ornamental pet trade, with larger specimens priced at approximately \$0.50 per fish, and the smaller ones at around \$0.35 per fish (Caretaker interview, August 2025).

While residents of Barangay IV-A do not consume the fish, visiting locals from Laguna Province and nearby areas were observed catching Flowerhorn cichlids during recreational fishing and incorporating them into home-cooked meals. These individuals depicted the taste and texture of the fish as fatter and oilier than tilapia, giving it a distinct culinary profile (Figure 7). We do not recommend consumption pending risk assessment for helminths and contaminants; if consumed, fish must be thoroughly cooked.

Recent research from India reports the first confirmed case of *Paracapillaria philippinensis*, a parasitic nematode with zoonotic potential, infecting Flowerhorn cichlids in ornamental fish facilities. The study confirmed the presence of adult worms, larvae, and eggs, establishing Flowerhorn cichlids as competent hosts for this parasite (Arumugam *et*

al., 2024). This raises significant public health concerns; if invasive Flowerhorns in natural systems such as Lake Sampaloc harbor this parasite, they could act as persistent reservoirs of infection. Therefore, promoting the consumption of Flowerhorns as a control strategy cannot proceed without rigorous risk assessment and food safety evaluation.

This adaptive utilization exemplifies a pragmatic human response to an invasive species, turning an ecological threat into an economic opportunity. However, the intentional propagation and commercialization of Flowerhorn cichlids risks sustaining or even expanding their invasive population in Lake Sampaloc, thereby exacerbating ecological pressures on native biodiversity.

If farming Flowerhorns remains a practice, implementing stricter aquaculture biosecurity protocols can significantly mitigate the risk of invasive species proliferation in Lake Sampaloc. Pens should be constructed with durable, stable, and HACCP-compliant materials to withstand environmental stress while minimizing ecological impact. Frames should be fabricated from rust-free and

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long-lasting materials such as galvanized iron, polyvinyl chloride, or virgin-grade high-density polyethylene for pontoons or runners, as these ensure structural integrity during storms and flood events. Bamboo frames should be avoided due to their poor strength and low longevity under turbulent conditions. Small-mesh netting is recommended to prevent the escape of juveniles (FAO, n.d.; NFDB, 2016). Over-top netting should also be installed as an added layer of containment to prevent fish from jumping or being displaced by predators or strong winds.

To further reduce escape risks during extreme weather, flood-overflow baffles or reinforced barriers should be integrated into the pen design (FAO, n.d.; NFDB, 2016). Operational biosecurity measures include the use of dedicated harvest socks or totes during fish handling to minimize accidental releases, as well as quarantining broodstock for at least seven days prior to stocking to ensure only healthy individuals enter culture systems (FAO, n.d.). Daily pen integrity inspections must be logged, and an escape or incident reporting system should be in place to enable early detection and rapid response in case of breaches. Finally, comprehensive record-keeping for stocking, transfers, and harvests ensures accountability and traceability, which are critical for biosecurity management in open-water aquaculture (NFDB, 2016; FAO, n.d.). We recommend confirming BFAR/LLDA permitting for any culture, transport, or processing of invasive ornamentals, and clarifying whether special authorization is required for Flowerhorn penning.

COEXISTENCE AND POPULATION EXPANSION OF INVASIVE CICHLIDS

Field observations and local reports indicate that Flowerhorns (*Amphilophus* hybrids) and Jaguar cichlids (*Parachromis managuensis*) are both present and thriving in Lake Sampaloc (Figure 8). While Jaguars are described as an aggressive piscivorous species (Dadiono and Murti, 2023), the continued presence of robust Flowerhorn populations based on local observation suggests these hybrids remain well established. This observation depicts their apparent resilience and adaptability, though it does not establish a causal relationship regarding interspecific competition or coexistence mechanisms. A rapid creel and shoreline transect (n≈20 interviews;



FIGURE 7. Recreational fishing by visiting Laguna locals demonstrates human interaction with the lake ecosystem and opportunistic harvesting of *Midas cichlid* hybrids. Photo: H.N. Gasmen.



FIGURE 8. Jaguar cichlid (*Parachromis managuensis*) collected by visiting fisher-folk for consumption. Photo: H.N. Gasmen.

10 transects) would establish relative encounter rates of Flowerhorn vs. Jaguar within one season.

Both species are frequently caught by the fishing community and are commonly observed in shallow, vegetated zones around the lake's periphery (Figure 9). These habitats provide abundant resources and potential breeding sites, which may contribute to the observed overlap in their distribution. Similar to Flowerhorns, Jaguar cichlids are also harvested by visiting fisher-folk for consumption.

However, their dominance has severe implications for native biodiversity. The native Ayungin (*Leiopotherapon plumbeus*) (Figure 10), once a common catch for local fishers, is now rarely encountered and has been classified as endangered by the IUCN (2023). The aggressive spread of multiple invasive species reflects their ecological plasticity and poses a compounded threat to the lake's native fish populations, accelerating the decline of this ecologically and economically important species.

AQUACULTURE MANAGEMENT AND COMMUNITY ENGAGEMENT

Community education and aquaculture management are pivotal for addressing Lake Sampaloc's ecological challenges. Encouraging responsible cage culture, such as wildlife-proof designs, can help prevent further accidental introductions of invasive Flowerhorn cichlids.

The lakeside community in Barangay IV-A practices intensive tilapia (*Oreochromis* spp.) farming. Runoff from these fish pens, rich in nutrients and potential chemical residues, contributes to eutrophication, algal blooms, and overall water quality degradation (Figure 11). While such conditions significantly stress sensitive native species like Ayungin, Flowerhorns continue to thrive. Their remarkable phenotypic plasticity and resilience enable them to survive and even dominate in polluted or altered habitats, stressing the urgent need for integrated aquaculture and invasive species management (Nasution *et al.*, 2022).

Successful community-based environmental monitoring initiatives, such as the Coastal Resource Management (CRM) Project in Apo Island, illustrate the effectiveness of engaging fisher-folk in ecological monitoring, fisheries law enforcement, and participatory

governance (Green *et al.*, 2003). Adapting similar strategies in Lake Sampaloc would involve training fisher-folk to monitor invasive Flowerhorn cichlids, evaluate water quality and pollutant inputs including runoff from tilapia pens, and document trends in native fish populations. Institutional mechanisms such as Barangay Fisheries and Aquatic Resource Management Councils (BFARMCs) and local CRM offices already exist in lakeside communities, creating a foundation for integrating traditional ecological knowledge with systematic monitoring approaches.

To operationalize this framework, practical components could include weekly Catch Per Unit Effort (CPUE) logbooks maintained by fisher-folk to track Flowerhorn and Jaguar cichlid abundance in open waters, monthly 50 m x 5 m shoreline litter transects at fixed points to assess waste accumulation and its impact on water quality, and quarterly pen biosecurity audits using standardized checklists to ensure containment measures, such as mesh integrity, over-top netting, and overflow barriers, are effective. Incentivizing and empowering fisher-folk participation through recognition programs, livelihood benefits, or co-management arrangements can strengthen regulatory compliance, promote stewardship, and enhance enforcement of sustainable aquaculture and invasive species control measures.

INVASIVE ALIEN FISH SPECIES MANAGEMENT STRATEGIES

The restoration of Yellowstone Lake provides a compelling model for managing invasive fish populations and mitigating their ecological impacts (Koel *et al.*, 2020). In this case study, systematic interventions, including targeted removal of invasive lake trout,

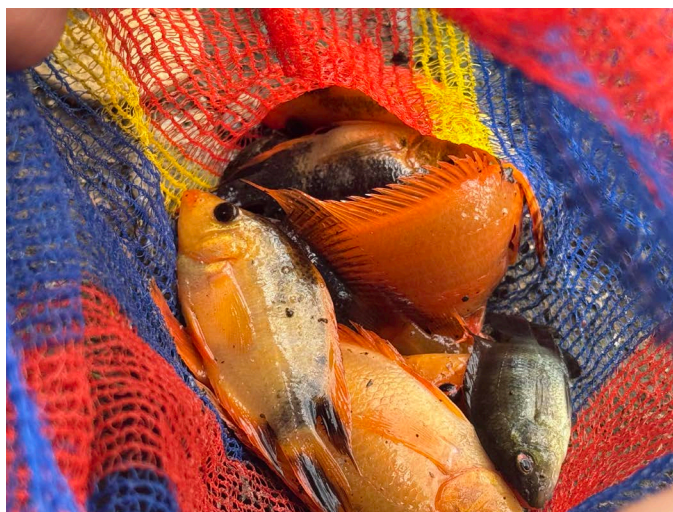


FIGURE 9. Juveniles of Flowerhorn cichlid (*Amphilophus* spp.) and Jaguar cichlid (*Parachromis managuensis*) harvested by a visiting Laguna local, reflecting the coexistence of the two species. Photo: H.N. Gasmén.



FIGURE 10. Despite its endangered status, Ayungin (*Leipotherapon plumbeus*) continues to be caught for market sale. Photo: H.N. Gasmén.

habitat monitoring, and community engagement, were employed to protect native Yellowstone cutthroat trout and restore ecosystem balance. The study focused on the effectiveness of combining scientific monitoring with adaptive management strategies, such as prioritizing high-risk areas for removal and continuously evaluating population responses. Importantly, Koel *et al.* (2020) emphasize that invasive fish control requires sustained effort over multiple years, with integrated approaches that balance ecological goals, stakeholder involvement, and long-term monitoring.

For Lake Sampaloc, these lessons are particularly relevant. Flowerhorn cichlids together with Jaguar cichlids, like lake trout in Yellowstone, dominate certain habitats and disrupt native species. The Yellowstone experience urges the need for coordinated, long-term, and evidence-based management strategies, ranging from community-based harvesting to aquaculture regulation, pollution mitigation, and ongoing ecological monitoring, to curb the proliferation of Flowerhorn

cichlids while supporting local livelihoods. Applying these principles could enhance the resilience of Lake Sampaloc's ecosystem and ensure the persistence of its native fish assemblages.

UTILIZING INVASIVE BIOMASS AS ECONOMY-BASED AQUAFEED

The practical harvesting and utilization of Flowerhorn cichlids alongside Jaguars in Lake Sampaloc offers a strategic opportunity to mitigate ecological harm while supporting sustainable aquaculture

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WITH INSTITUTIONAL BACKING, STRATEGIC COORDINATION, AND CONTINUED ECOLOGICAL MONITORING, THIS FRAMEWORK COULD DELIVER MULTIPLE BENEFITS: REDUCED INVASIVE FISH DENSITY, ECONOMIC STIMULATION, IMPROVED FEED SUSTAINABILITY, AND INDIRECT SUPPORT FOR NATIVE BIODIVERSITY RECOVERY.

OVER TIME, SUCH INTERVENTIONS, WHEN COMBINED WITH RESPONSIBLE AQUACULTURE PRACTICES, CAN STRENGTHEN BOTH THE RESILIENCE OF LAKE SAMPALOC'S ECOSYSTEM AND THE ECONOMIC SECURITY OF SURROUNDING COMMUNITIES, EVEN UNDER PERSISTENT INVASIVE FISH DOMINANCE.

practices. Flowerhorn cichlids often aggregate near fish cages and shallow vegetated zones, making them accessible for removal through community-level interventions. Targeted harvesting can reduce their competitive pressure on native species while simultaneously providing biomass for fishmeal production (Ragaza *et al.*, 2022). The rendered fishmeal can then be integrated into feed formulations for cultured species. However, ensuring fishmeal safety is paramount. Each batch should undergo testing for moisture, crude protein, total viable count (TVC) of Enterobacteriaceae (Béké *et al.*, 2025), and heavy metals such as lead and cadmium (Sabbir *et al.* 2018).

Furthermore, microplastic contamination should also be evaluated, isolated, and identified visually, through microscopy and periodic Fourier transform infrared (FTIR) spectroscopy, as previous studies have reported microplastics in fishmeal products from major producing countries (Wang *et al.*, 2021), and Natuel *et al.* (2023) reported the presence of microplastics in Lake Sampaloc.

While transforming an invasive species into a valuable resource presents logistical and economic challenges, including the establishment of organized collection points, accessible processing facilities, and structured market chains, a circular economy model offers long-term benefits. Studies such as Ragaza *et al.* (2022) confirm that fishmeal derived from invasive species can serve as a nutritionally comparable and viable substitute for conventional protein sources in aquafeeds.

With institutional backing, strategic coordination, and continued ecological monitoring, this framework could deliver multiple benefits: reduced invasive fish density, economic stimulation, improved feed sustainability, and indirect support for native biodiversity recovery. Over time, such interventions, when combined with responsible aquaculture practices, can strengthen both the resilience of Lake Sampaloc's ecosystem and the economic security of surrounding communities, even under persistent invasive fish dominance.

CONCLUSION

In the Lower Tapajós River in Brazil, fisher-folk directly recorded CPUE, spawning observations, and habitat changes. This type of participation not only generated scientifically valuable data but also improved compliance with conservation regulations



FIGURE II. A lakeside community fishpen in Lake Sampaloc, a common aquaculture setup that, while supporting livelihoods, contributes to nutrient runoff and alters the lake's ecological balance. Photo: H.N. Gasmén.

by aligning science with local practices (Silvano and Hallwass, 2020). A similar approach is highly feasible in the Philippines, where the deep-rooted “bayanihan” communal cooperation spirit and strong social cohesion within fishing communities provide a natural foundation for collective environmental stewardship. In Lake Sampaloc, many fisher-folk have already observed and responded to seasonal patterns, fish behavior, and habitat changes, often passing this knowledge down through generations. Institutionalizing these practices into structured community-based monitoring

systems, supported by agencies such as BFAR CALABARZON and LLDA, could create a powerful synergy between traditional ecological knowledge and scientific data collection. Educational campaigns should emphasize the ecological risks associated with releasing Flowerhorns into open waters (Yan, 2023).

Ultimately, restoring balance in Lake Sampaloc requires an integrated strategy that aligns science with community, enforcement with education, and policy with practice. Aquaculture can ease pressure only with strict biosecurity, regulated utilization, and continuous removals.

Notes

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ULTIMATELY, RESTORING BALANCE IN LAKE SAMPALOC REQUIRES AN INTEGRATED STRATEGY THAT ALIGNS SCIENCE WITH COMMUNITY, ENFORCEMENT WITH EDUCATION, AND POLICY WITH PRACTICE. AQUACULTURE CAN EASE PRESSURE ONLY WITH STRICT BIOSECURITY, REGULATED UTILIZATION, AND CONTINUOUS REMOVALS.

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