How Environmental Policy Shapes the Aquarium Trade:

Aquaculture of the Hawaiian Endemic Potter's Angelfish (*Centropyge potteri)*

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INTRODUCTION

- Marine ornamental aquaculture (MOA) addresses ecological concerns related to extracting fish for the $2.15 billion yearly global marine aquarium trade.
- Around 20-30 million marine ornamental fish are harvested yearly, threatening reef ecosystems, especially in regions like Hawai'i.
- Hawai'i banned commercial aquarium fish collection in 2021, increasing the focus on MOA as an ecologically friendly alternative to wild collection.
- MOA helps reduce pressure on wild populations and provides insights for developing sustainable aquarium trade practices.

KEY FACTS

- Culturing marine ornamental fish is extremely challenging due to their tiny pelagic eggs and larvae.
- Successful larval rearing requires continuous cultivation of live feeds: copepods, algae, rotifers, and *Artemia* along with consistent water parameters.
- Increased knowledge of larval growth and complex life histories can improve survival rates and aid future fisheries management.

Figure 1. Marine ornamental fish collected from reefs in Indonesia. Photo: Mikayla Wujec

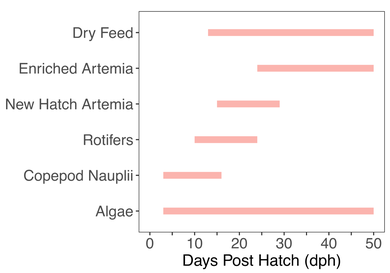

Figure 2. Feeding schedule first used to raise Potter's angelfish at Oceanic Institute (OI). Algae (*T. lutea*) added to 300,000 cells/mL twice daily. Copepod nauplii fed at 1-5/mL, rotifers at 15/mL, and *Artemia* 0.025-0.3/mL.

OBJECTIVES

- Document and describe larval development of the Potter's angelfish (*C. potteri*).
- Investigate rearing protocols for *C. potteri* larvae, enhancing survival rates using an iterative approach to increase efficiency.
- Analyze how environmental policy regarding the collection of Hawaiian reef fish impacts the aquarium trade.

RESULTS

- **Spawning Patterns:** Spawning occurred daily exhibiting lunar and seasonal periodicity, peaking in late winter with an average of 6,728 eggs and 54.9% fertility.
- **Larval Development:** Larvae began exogenous feeding at 3 days post hatch (dph), flexion at 14-22 dph, settlement at ~60 dph with metamorphosis by 90 dph.
- **Mortality Events:** Significant mortality occurred when starting *Artemia* and dry feeds suggesting developmental sensitivity or introduction of pathogens.
- **Protocol Optimization:** Iterative adjustments to feeding regimes in response to mortality events resulted in the first cohort of *C. potteri* available for consumers. Further trials increased efficiency by using 75,000-150,000 cells/mL live algae (*T. lutea*), achieving similar or better survival compared to 300,000 cells/mL.

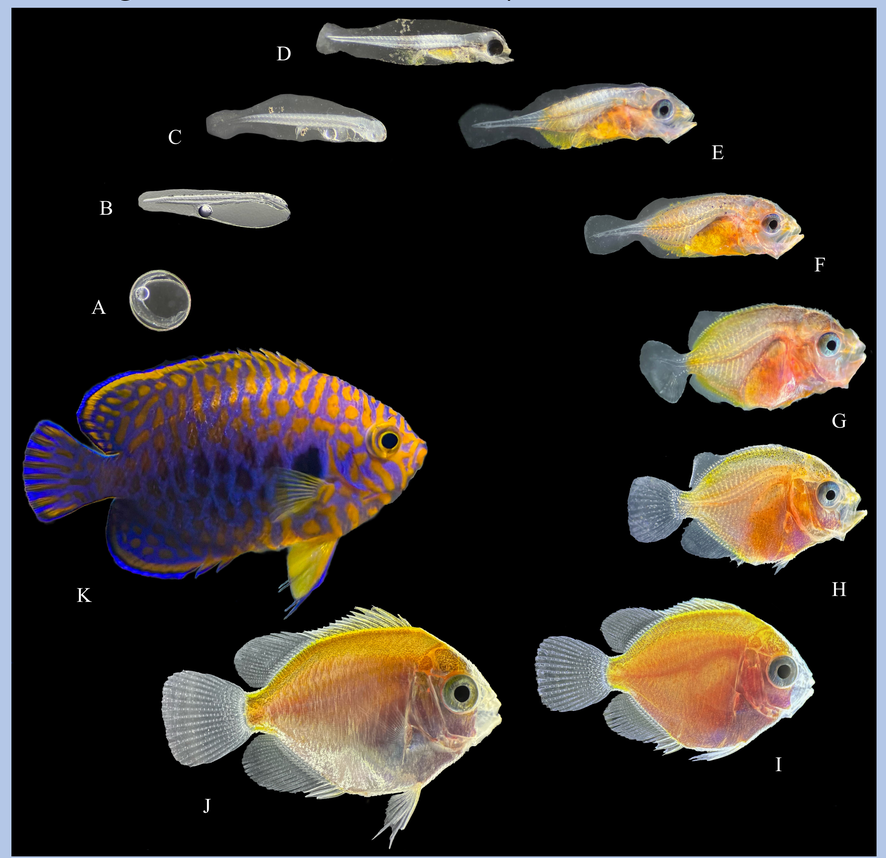

Figure 3. Photographs of representative egg and larvae at (A) embryo, Diameter = 0.68 mm, (B) 0 dph, Body Length = 1.49 mm, (C) 2 dph, BL = 2.47 mm, (D) 5 dph, BL = 2.56 mm, (E) 9 dph, BL = 3.15 mm, (F) 14 dph, BL = 3.94 mm, (G) 21 dph, BL = 4.53 mm, (H) 24 dph, BL = 4.73 mm, (I) 30 dph, BL = 5.93 mm, (J) 60 dph, BL = 13.30 mm, and (K) 140 dph, BL = ~4 cm.

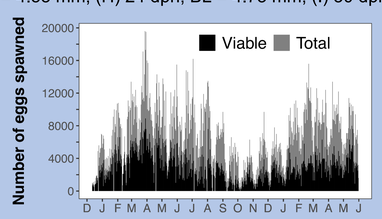

Figure 4. Daily egg output from six pairs (1M:1F), one trio (1M:2F), and one quad (1M:3F) of Potter's angelfish broodstock over a period from December 2022 through May 2024.

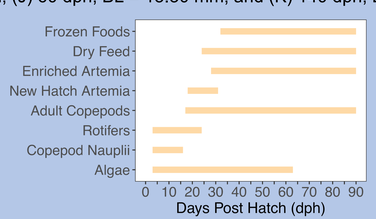

Figure 5. Feeding schedule tailored for Potter's angelfish at OI. Algae added to 150,000 cells/mL daily. Copepod nauplii fed at 1-5/mL, rotifers at 5-10/mL, and *Artemia* 0.025-0.3/mL.

METHODS

- Potter's angelfish broodstock were collected, then quarantined and housed at OI. Eggs were collected and reared in tanks with varying feeding regimens.
- Larval growth, development, and survival were tracked through periodic measurements and photographs, evaluating effects of feeding regimes.
- Impacts of Hawai'i's collection ban on the aquarium industry were assessed through price data and stakeholder interviews, and a policy scenario with state investment in MOA was proposed to evaluate its effects on stakeholders.

ENVIRONMENTAL POLICY

HOW DID HAWAII'S COLLECTION BAN IMPACT THE MARINE AQUARIUM TRADE?

- The supply of Hawaiian native and endemic species decreased while demand remained steady.
- Prices for captive-bred alternatives are 2-4 times higher than wild-caught fish, reflecting market factors plus the costs of research & production.
- Policy changes increased investment in research, leading to commercial aquaculture of Hawaiian species like the Yellow tang and Potter's angelfish.

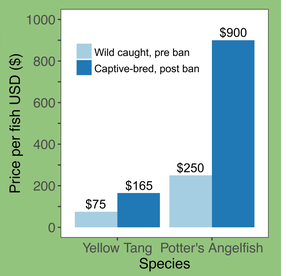

Figure 6. Consumer price of wild caught Yellow tang and Potter's angelfish specimens pre collection ban compared to captive-bred specimens post collection ban.

CONCLUSIONS

- Findings underscore MOA as the key to a sustainable aquarium industry, with effective policy implementation.
- As anthropogenic impacts increase, stricter regulations in Hawai'i have driven investment in sustainable alternatives, promoting a transition to captive-bred options for Hawaiian reef fish species.
- This study marks the first detailed documentation of Potter's angelfish larval development and rearing along with the first large cohort ever produced.
- Further optimization of feeding regimes for Potter's angelfish will allow for commercial production of this endemic species and may be applied to other species.

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