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REGIONAL NOTES

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

Aquaculture at NELHA: a sampling of tenants

Much of the aquaculture in Hawai`i happens at the Natural Energy Laboratory of Hawai`i Authority (NELHA) at the Big Island's Keahole Point near Kailua-Kona. No coastal location in the United States gets more sunlight. And NELHA's pipelines of warm surface water and cold, deep seawater—the deepest with an intake from 3,000 feet below the ocean surface—are unique.

"NELHA is one of the reasons I moved to this island," says Syd Kraul of NELHA tenant Pacific Planktonics. "Not too many places offer a private company access to quality seawater and affordable, government land."

Jim Wyban, founder and president of shrimp broodstock leader High Health Aquaculture Inc., appreciates the knowledge sharing that goes on between the cluster of businesses and talent at NELHA. Proximity to the Kona International Airport at Keahole is another benefit, he says.

Every tenant interviewed for this story says the advantages of a location at NELHA are essential to their businesses. Yet, some of them say rising costs, particularly water rates, give them pause. "Hawai`i is one of the most expensive places in the world to do business," says Suzy Horemans, general manager of tenant Moana Technolgies LLC, "and any added financial burden implemented by NELHA simply makes the continuing presence of many of the aquaculture tenants at NELHA more difficult to justify."

For now, increases to the rates NELHA charges to supply water to aquaculture tenants are on hold. A resolution, pushed through the state legislature last March, requests that the state auditor conduct an audit of NELHA; rate increases are not to happen until an audit is completed. "We pushed back a little this year," says Wyban, noting past frustration in negotiating with the NELHA board of directors. "We want to open a correct dialogue."

NELHA at this time has about 17 aquaculture tenants. One of the newest tenants is Pacific Aquaculture and Biotechnology LLC. Joe Tabrah, manager and president, says the firm's plan is to continue development of an ongoing selective breeding program for "several different species" of specific-pathogen-free (SPF) and specific-pathogen-resistant shrimp broodstock. The five-year-old outfit has been leasing land at Campbell Industrial Park.

Tabrah had hoped to stay on Oahu, but the availability of land at NELHA was "fortuitous," he says. The NELHA board of directors in May ratified transfer of the lease assigned to Sunrise Capital Inc. (formerly Kona Bay Marine Resources Inc.) to Pacific Aquaculture.

Photos courtesy of Taylor Shellfish Farms

*Taylor Shellfish Farms produces about 400 million Manila clam (*Ruditapes philippinarum*, top) seed per year via its hatchery and nursery facilities at NELHA, shown under construction above.*

To get a picture of the state of aquaculture at NELHA, consider these snapshots of four tenants:

Troutlodge Marine Farms of Kona LLC, formed in July 2007 when Sumner, Wash.-based Troutlodge Inc. bought Unlimited Aquaculture LLC, is the first move into commercial marine aquaculture for the 63-year-old company better known for the culture of freshwater species, trout and salmon.

The subsidiary in June introduced its trademarked Big Island Butterfish and is selling it in limited numbers, says general manager Jackie Zimmerman. The butterfish (*Anoplopoma fimbria*), also known as sablefish and black cod, is normally found in the cold waters of the North Pacific Ocean.

A key production constraint is the limited supply of fingerlings, Zimmerman says. Currently, the company purchases fingerlings at a size of 1 g from a hatchery in Canada and grows them to market size in a land-based system using the deep seawater available at NELHA.

What is market size? Wild-caught sablefish are typically two feet long and weigh 10 pounds, a size much larger than the range

Continued on Page 3

Letter from the director

In mid-July, what the *Saipan Tribune* called "a landmark aquaculture workshop" took important steps to advance the aquaculture industry in the Marianas. This multi-institutional effort—with lecturers from the CNMI, Guam, and Hawai`i—was supported by the Northern Marianas College and CTSA to encourage the start of more successful aquafarms like Tony Pelligrino's Saipan SyAqua, which will soon complete construction of facilities that could triple the farm's shrimp production.

Projects that attract and truly engage industry stakeholders are essential because they will have the greatest impact, especially if stakeholders are willing and able to make their own investments. The Oceanic Institute's Dustin Moss, also under CTSA support, is leading a shrimp production demonstration project in Saipan with Saipan SyAqua.

Future issues will highlight this project and other cases where industry commitment is making a difference.

Cheng-Sheng Lee

REGIONAL NOTES

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AQUA CLIPS

UH study aims to turn ethanol waste into feed

The Associated Press, June 23, 2008

HONOLULU (AP) — University of Hawai`i researchers are studying whether they can turn a byproduct of ethanol into feed for fish or cattle.

Hawai`ian Commercial and Sugar Co., which supports the research, says the results could determine whether the company produces ethanol in the islands. The company doesn't currently have a good solution for what to do with vinasse, the waste byproduct of ethanol fermentation, says Lee Jakeway, the company's director of energy development.

Rising transportation costs present "a pressing need" to develop a locally available low-cost substitute for imported fishmeal and other imported protein, says Samir Khanal, a UH-Manoa molecular biosciences and bioengineering professor leading the research.

"Right now, it is still efficient because fishmeal is one of the most inexpensive sources of protein," says Clyde Tamaru, UH Sea Grant agriculture extension specialist and co-investigator on the project. "Eventually that is going to change."

UH co-investigators include Harry Ako, Jon-Paul Bingham, and James Carpenter. Also, Warren Dominy of the Oceanic Institute is joining the research.

Fish farm plans irk Lanai anglers

By Gary T. Kubota, Honolulu Star-Bulletin, June 29, 2008

WAILUKU — A new aquaculture business wants to raise fish in the open ocean off the leeward side of Lanai. But some Lanai fishermen say they're opposed to it.

"We don't want it," says fisherman Allen Kaiaokamalie. "It's our best fishing grounds."

Maui Fresh Fish LLC is developing a hatchery for opakapaka on coastal land at Kahakuloa in north Maui and wants to transfer the stock to aquaculture pens off Lanai where they can grow to adult size.

Ed Cichon, a co-founder and managing member of Maui Fresh Fish, says the business is in its early stages and is holding public meetings as part of its development of an environmental assessment, before applying to the state for an ocean lease.

He says his business has formed a working group to discuss the concerns of the fishermen and see if a site there or elsewhere can be found. "We want to work with them," Cichon says. "We can do a lot of good for the people of Hawai`i and the people of Lanai."

ASCC Marine Science internships facilitate hands-on learning

By ASCC Staff, Samoa Observer, July 21, 2008

At the American Samoa Community College (ASCC), the Marine Science program seeks to close the gap between theory and practice through internship programs. Recent graduate Francis Leiato is a prime example of a student who turned his intern experiences and his educational goals into a professional career, says Ephraim Temple, junior extension agent with the University of Hawai`i Sea Grant College Program.

Leiato graduated last June with a double major in marine science and liberal arts, and he now has a job in his area of interest: aquaculture. Leiato participated in several internships during his years at ASCC. He participated in a 2006 aquaculture internship sponsored by a NOAA grant awarded to the Pacific Islands Educational Partnership Consortium (PIEPC) to develop faisua farming in American Samoa.

In the most recent internship, he and four other students studied marine invertebrates at HIMB, and then put their training to work at home by conducting surveys of reef flats in Auto, Asili, and Tisa's Cove. Their findings form the basis of a booklet that describes native Samoan sea cucumbers and is due for publication later this year.

Today Leiato has a job with the Land Grant/CNR division at ASCC developing an aquaculture demonstration facility for the culture of tilapia and aquarium fish. He works directly with Temple on several projects, and local tilapia farmers now use the knowledge passed along by Leiato to produce their own feeds using locally produced products.

NELHA continued from Page 1

that Troutlodge Marine is targeting with input from chefs: 2 to 3 pounds, explains Zimmerman. The fish was featured at the 27th Annual Kapalua Wine & Food Festival in June and by chef Alan Wong as part of his Farmer Series Dinner in July.

Troutlodge Marine plans to produce sablefish fingerlings of its own, a move critical to increasing production and cutting operating costs. Sablefish broodstock are on site, but the fish only now are mature enough to produce eggs, says Zimmerman. She expects fingerlings within a year. Troutlodge now rents two lots, in addition to the original one-acre Unlimited Aquaculture lot, where it is boosting growout capacity and building a second hatchery.

Eventually, growth will also come from diversity. The firm wants to rear multiple species, cold and warm water, in its hatchery, says Zimmerman, noting that Troutlodge will not grow out all the fingerlings it produces and instead will sell them.

For now, the only other species available from the company is Atlantic halibut (*Hippoglossus hippoglossus*), as it sells off an existing inventory. "Halibut is not a fish that we will continue to do," Zimmerman says. The fish grows slowly, unlike the "very promising" sablefish, she says: "The sablefish does have potential for aquaculture use, since it is a fast grower for a cold water species and has adapted to temperature increases."

*Syd Kraul of Pacific Planktonics not only works with marine ornamentals like the flame angelfish but also produces fingerlings of food fish, such as ono (*Acanthocybium solandri*, Day 14 larvae below) and opakapaka.*

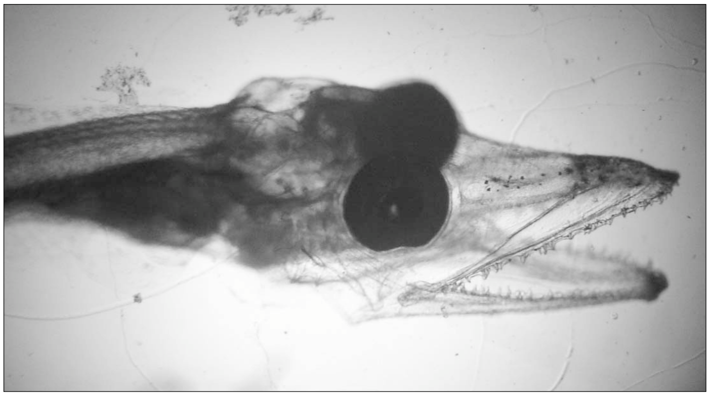


Photo by Syd Kraul

On a half-acre site right next to the ocean, Syd Kraul, as owner of **Pacific Planktonics**, produces "small things," he says: marine ornamental fish, like the harlequin shrimp (*Hymenocera picta*) and flame angelfish (*Centropyge loriculus*), as well as fingerlings of food fish, such as kahala (*Seriola rivoliana*) and opakapaka (*Pristipomoides filamentosus*), all native species.

His biggest challenges are technical. Reef fish are difficult to rear, given the requirement to find the right size food for the small larvae. Kraul proudly explains that he's gotten over that feed hurdle to achieve a 50 percent survival rate. He's got other issues, however, primarily egg suppy and site-specific bacterial diseases, he says.

Financially, the company is "still surviving," says Kraul, who says his clients want him to stay in the fingerling business. "When I solve the technical problems, I'll solve the financial problems."

He does expect to solve them. By the end of the year, Kraul hopes to be selling flame angelfish at an initial rate of 6,000 fish per month. Kahala fingerling sales will come sooner, in early fall, at a rate ranging from 10,000 to 30,000 fish per month, Kraul projects.

After almost a decade of research, **Moana Technologies Inc.** this year began test marketing black tiger shrimp (*Penaeus monodon*) post larvae that are SPF and improved through selective breeding. "At this time, more people want to stock Moana PLs than we can supply," says Suzy Horemans, general manager of the company's arm at NELHA.

Founded in Belgium and headquartered in Hong Kong, the company at NELHA produces broodstock in a biosecure facility. Post larvae are grown in ponds in Asia. The growth rate of PLs has been good and harvests are expected in October, Horemans says. "By switching to Moana seed, [farmers] will be able to greatly reduce the risks and uncertainties they face today," she says.

"We expect to be a small player in the seed market this year but aim to gain market share in 2009," Horemans says. Moana's genetic selection program continues to address farmers' production concerns, such as growth, survival, and feed conversion rates, she says.

Taylor Shellfish Farms Inc., a family-run business based in Shelton, Wash. that had its start in the 1880s, began at NELHA with a quarter acre almost 15 years ago. Today, hatchery and nursery facilities span five acres at NELHA and produce about 400 million clam seed per year, the Manila clam (*Ruditapes philippinarum*), and 100 million oyster seed, primarily the Pacific oyster (*Crassostrea gigas)* with some Kumamoto (*C. sikamea*) and *C. virginica*.

"Demand is strong, but a constraint is getting enough seed to make business go further," says CEO Bill Taylor. The need for more seed was the impetus for the company coming to Hawai`i in the first place. "We couldn't grow seed to the size we needed in Washington. There was not enough sunlight," he says, noting that the cost of heating water to grow microalgae, the main feed for clams and oysters, in the Pacific Northwest was prohibitive.

Of the seed it produces, the outfit uses 70 percent to 80 percent at its Washington farms and sells the rest to other growers. "Our NELHA facility is extremely critical to the success of our farms in Washington and the farms of many other shellfish growers on the West Coast and throughout the world," says Taylor. —*KD*

UPDATE

FY 2007 Plan of Work Support. The following seven projects have been approved by the USDA as part of the CTSA Fiscal Year 2007 Plan of Work:

- Alternative Methods for Marine Copepod Production in Hawai`i, Years 1 and 2
- Pacific Regional Aquaculture Information Service for Education (PRAISE) and Publications, Year 3
- Sea Cucumber Hatchery Production Technology Transfer in Pohnpei, the Federated States of Micronesia, Years 1 and 2
- Promoting Health Management of Shrimp Aquaculture on Guam and the Commonwealth of the Northern Mariana Islands (CNMI)
- Improving the Hatchery Output of the Hawai`ian Pink Snapper (*Pristipomoides filamentosus*), Years 1 and 2
- Improving Outputs in Commercial-Scale Production of Swordtails in Hawai`i, Year 3
- Determining Aquaculture Bottlenecks of Pacific Threadfin (*Polydactylus sexfilis*): Increasing Fry Survival, Growth, and Quality, Years 1 and 2

AQUA TIPS

Development of aquaculture technology for the flame angelfish (*Centropyge loriculus*)

Charles W. Laidley, Chatham K. Callan, Andrew Burnell, Kenneth K. M. Liu, Christina J. Bradley, Martin Bou Mira, and Robin J. Shields

Finfish Department, Oceanic Institute

This article was written as part of the work for the project titled, "Marine Ornamentals Phase II: Mass Culture Techniques for Pygmy Angelfish," which was funded in part by the Center for Tropical and Subtropical Aquaculture under a grant from the U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service.

The marine aquarium trade exposes hundreds of millions of people around the world to the wonders of the undersea world, bringing a new appreciation of the beauty and complexity of the fragile coral reef ecosystem. However, the current reliance on wild-collection of specimens has created concern for long-term industry sustainability, leading many to advocate for the development of captive production technologies as a more sustainable approach to meeting industry needs while protecting our coral reef ecosystems. The development of aquaculture technology for coral reef species could also create new economic opportunities for many struggling island economies. Unfortunately, captive production of most of the coral reef species has proven challenging, mainly due to the small size of newly hatched larvae and lack of success in adapting available rotifer and *Artemia*-based hatchery technologies for rearing of these larvae (Ostrowski and Laidley 2001). Thus, this project was undertaken to develop suitable broodstock, live feeds and larval rearing technologies for the flame angelfish (*Centropyge loriculus*) as a model species for the captive rearing of other high-value ornamental reef fish.

Acquisition and quarantine of broodstock. Flame angelfish broodstock were relatively easy to obtain through commercial transhippers. However, the transfer of fish through common holding systems exposes animals to a wide range of pathogens, including *Cryptocaryon irritans* and other ectoparasites. Therefore, fish were quarantined prior to stocking in broodstock holding systems. The quarantine process begins with a prophylactic freshwater dip (3–5 min.) prior to stocking in quarantine tanks and is followed by a rigorous protocol of hydrogen peroxide treatments (20 min at 100 ppm) three times/week for four weeks, with fish transferred to new quarantine tanks after each treatment. Also showing success is an alternative protocol that includes a four week hyposalinity treatment (~12 ppt), which is more effective in eliminating *Cryptocaryon*.

Broodstock husbandry and holding system. After completing quarantine, flame angelfish stocks were paired, male and female, and stocked in relatively large (1,000 L) broodstock holding tanks. Stocking in harems with multiple females provided little benefit. Tank size had significant effects on reproductive performance, with egg output increasing along with tank size, leading us to adopt relatively large tanks for this small fish.

Photos courtesy of the Oceanic Institute

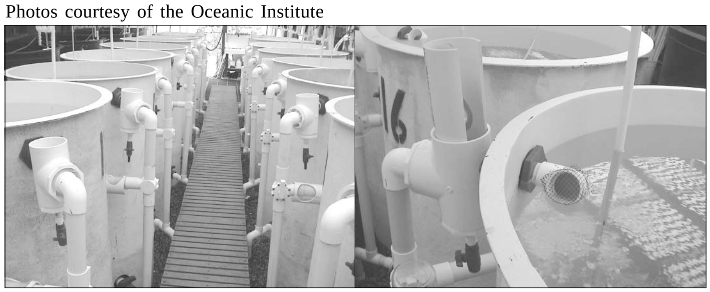


Figure 1. *The above replicated, 19-tank marine ornamental broodstock holding system has a surface egg collector system that allows for gentle collection of small floating eggs from pelagic spawning reef species.*

Despite impressive egg production (> 2,000 eggs/female/day) from this small fish (Laidley et al. 2004), a significant scale-up of broodstock holding capacity was necessary to generate sufficient numbers of eggs for marine ornamental hatchery operations. For example, roughly 20 broodstock pairs are required to supply sufficient numbers of eggs to stock just one 1,000-L larval rearing tank at typical stocking densities of 40 eggs/L. So, we designed and built a replicated broodstock holding system outfitted with individual surface egg collection systems (Figure 1). The system includes both flow-through and recirculating water sources to maintain high-quality water for long-term broodstock health and egg production.

After broodstock expansion, we began experiencing egg quality issues that, after substantial trial-and-error, led us to identify water quality/source as a major factor affecting stock health, reproductive performance, and egg quality. This ornamental reef

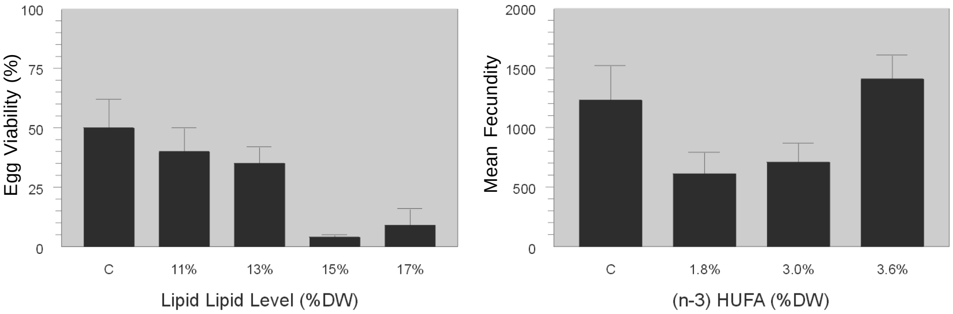


Figure 2. *Broodstock diet effects on reproductive performance and egg quality of flame angelfish broodstock: The left graph demonstrates negative effects of high lipid levels on egg viability, while the right graph shows improvements in fecundity with high dietary n-3 HUFA levels.*

species appears to loose condition when maintained on well water, with improved egg output and quality when maintained on sterilized ocean water. The adoption of a recirculation aquaculture system not only allowed for greater control over water quality but also provided for improved system biosecurity (less new water/less discharge) and for tighter control of environmental parameters, including temperature and salinity.

Efforts were also focused on developing biosecure broodstock diets for maintaining broodstock health and viable egg supplies. Although work remains to fully identify the dietary requirements for the flame angelfish, broodstock diet was shown to impact long-term stock health, reproduction, and egg quality. An initial "mixed diet"—composed of high-quality *Spirulina*-based flake food combined with frozen ground shrimp, krill, fish eggs, *Artemia*, spinach, peas, broccoli, and dried seaweed—proved effective in supporting broodstock. Tested commercial diets proved inferior. Biochemical analysis of these diets and subsequent diet trials demonstrated a critical role for dietary lipid levels (Bou Mira 2008.) and in particular the n-3 highly unsaturated fatty acids (Callan 2007) on reproductive output and egg quality (Figure 2).

We were able to expand the broodstock to 18 mated flame angelfish pairs, which allowed us to generate baseline data for expected reproductive performance. Expected egg output for this species is in the range of 1,000 to 2,000 eggs/day for a period of several years. Broodstock egg output continually increased over time with egg production peaking at more than 45,000 eggs/day (Figure 3). Toward the end of this project, we began to see periodicity in egg production, with peak egg output observed during the dark phase of the lunar cycle.

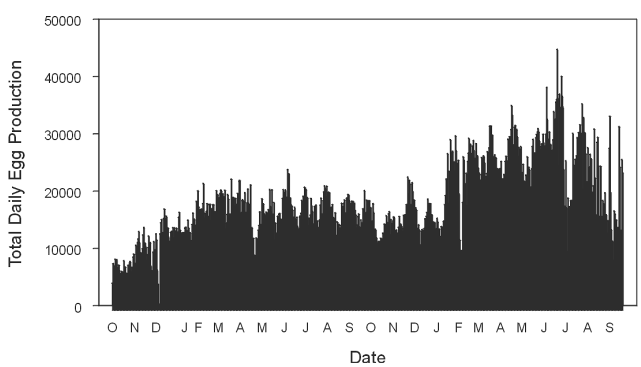


Figure 3. *Daily total egg output from 18 pairs of flame angelfish broodstock peaked at 45,000 eggs in the period from October 2005 to September 2007.*

Identification of suitable first-feed. Initial trials examining conventional rotifer- and *Artemia*-based feeding protocols confirmed previously reported (Holt and Riley 2000, 33–38) challenges in rearing small ornamental reef species. In this project's early stages, we explored a range of potential diet sources for first-feeding larvae, including the use of pond water, sea urchin eggs, ciliates (*Euplotes*), oyster trochophores, and harpacticoid nauplii with little success. The larvae did consume oyster trochophores and harpacticoid nauplii but failed to gain condition or survive past yolk depletion.

Limited success with pond water indicated that locally available marine plankton offered prospects, leading to isolation of a range of calanoid copepods from Kaneohe Bay waters. Using isolated copepod cultures, we quickly focused efforts on a single calanoid species identified as *Parvocalanus* sp. This species was shown to produce relatively small eggs (~ 62 µm) and early nauplii (~ 69 µm), which were easily consumed by flame angelfish larvae. This finding, then, resulted in the first-ever rearing of flame angelfish in captivity (Shields and Laidley 2003; Shields et al. 2005), which we presented at the "Marine Ornamentals 2001" conference in Florida (Laidley et al. 2001). Also, it should be noted that at the same time another Hawai`i researcher successfully reared both Fisher's and lemonpeel angelfish (*Centropyge fisheri* and *C. flavissima*) using wild zooplankton from Kaneohe Bay (Baensch 2002).

Copepod culture. After identifying *Parvocalanus* as suitable feed item for rearing difficult-to-rear species such as flame angelfish, snapper and omilu, we worked to optimize culture conditions and develop a pilot-scale copepod production system to meet larval feed demands. Although copepods provide an excellent nutrient source for the early developing larvae, they are much more difficult to culture than rotifers. Rotifers can be maintained on paste and other commercially available feeds, have rapid life cycles, and are easy to culture at high densities (typically around 1,000/mL in batch systems, with densities greater than 20,000/mL achieved in high-density systems). Still, *Parvocalanus* cultures were maintained relatively easily for periods of years on mixed diets of live *Isochrysis* and *Chaetoceros* algae. We were not successful in utilizing commercially available algae pastes for rearing copepods. Females mature and initiate egg production over a period of about one week and generate eggs for another two weeks. Although adults may be matured at high density (> 100/mL), reproductive activity is inherently density-limited requiring the lowering of adult density at to ~ 1 adult/mL. Cultures usually peak at densities of 10–20 nauplii/mL (Figure 4), although we have achieved densities greater than 70 nauplii/mL. It is important to note that actual daily nauplii output from continuously running production units currently range from 5–10 nauplii/mL/day. We are continuing to refine culture conditions, having optimized feed density (~ 300,000 cells/mL), temperature (~ 25ºC), photoperiod (little effect), salinity (22 ppt) and culture density (~ 1/mL).

Rearing flame angelfish larvae. With the establishment of a reliable egg supply and a source of copepod nauplii, we began developing hatchery methods for rearing flame angelfish larvae.

Continued on Page 6

Angelfish continued from Page 5

Early larval rearing attempts faced extremely low survival rates (< 5%) during the pre-feeding period, explained by the very delicate nature of the newly hatchery larvae. These newly hatched larvae lack developed eyes and functional mouths and are significantly smaller (1.2 mm) than any other species being reared today.

Larval development through the first three days is extremely rapid, as the larvae exhaust yolk supplies and switch to exogenous feeding (Figure 5). Through a combination of improved water quality and reduced turbulence in the larval rearing system, we are now able to achieve Day 3 survival nearing 70%. Starting on Day 2, we maintain *Parvocalanus* copepod nauplii at densities of 5–10 nauplii/mL. By 5 to 7 days post-hatch, larvae begin to assume red coloration and inflate their swim bladders.

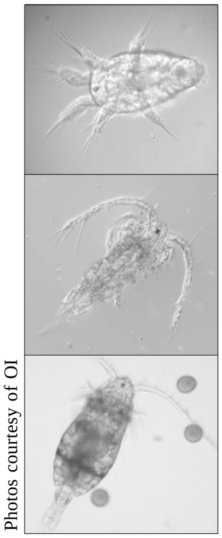
From Day 7 onward, flame angelfish aggressively consume copepod nauplii resulting in rapid growth and major body transformations as larvae transition to a more laterally compressed body shape (Figure 6). Unfortunately, around Day 14, we begin seeing increasing mortalities, lasting until Day 20. In part, we suspect that copepod nauplii may not be meeting larval nutritional requirements through the later larval period, as mortality rates remain high until the larvae are weaned onto newly hatched *Artemia* (Day 18–20).

Efforts to identify a transitional live prey remain, since we were not able to transition flame angelfish larvae onto rotifers, and it is challenging to maintain sufficient numbers of large copepodites.

Also, metamorphosing late stage larvae appear to have swim bladder hyperinflation problems (in our facilities) resulting in a loss buoyancy control, leading to erratic swimming behavior and eventual settlement on the surface, shortly before dying. Ongoing efforts are focused on upgrading both flow-through and recirculating water supplies with degassing systems to lower total gas pressure and reduce this source of mortality. Despite such challenges, flame angelfish larval rearing protocols have now been scaled to 1,000-L larval rearing tank systems for the successful generation of large numbers (thousands) of larvae through the early larval period out to Day 14 (Figure 6).

After weaning onto *Artemia*, mortality rates declined substantially as post-larvae transition through a rather prolonged terminal hatchery phase (~ Day 50) when juveniles can be transferred to nursery tanks. The relatively small numbers (dozens) of surviving fish appeared well adapted to handling and were integrated into a number of mixed ornamental tank systems with good results (Figure 7). Captive-reared flame angelfish appear physically normal, although their overall coloration is not as intense as wild-collected specimens. Recent trials show that this pale coloration and common occurrence of head-and-lateral line erosion disease in captive specimens may be caused by low light levels in research holding systems, a relatively easy issue to address. Captive-cultured fish appear relatively hardy and, by 90 days, can be easily handled and integrated into communal tanks system for hobbyists to enjoy.

Key accomplishments of our work with the flame angelfish include the development of broodstock methods for reliably generating large numbers of high-quality eggs on a daily basis year-round, the identification of and development of culture technology for *Parvocalanus* copepod nauplii as the key first-feed item for small-mouthed pelagic larvae, and the development of rearing methods for getting large numbers of fragile larvae through the critical early larval stages for the first-ever rearing of this key marine ornamental species. Further work, now in progress, is examining methods to increase survival through late hatchery and early juvenile stages with the ultimate goal of producing this species not only to market size but also at commercial scale.



Photos courtesy of OI

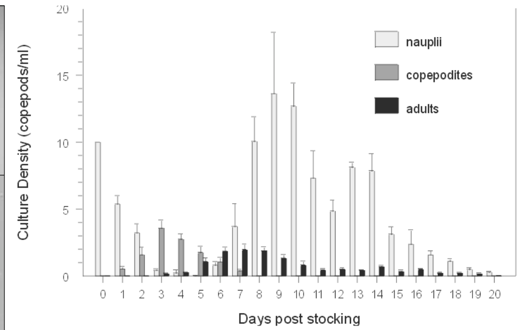


Figure 4. Parvocalanus*, more difficult to rear than rotifers, has three life stages: nauplius, copepodite, and adult (photomicrographs left, top to bottom). A typical copepod production cycle (graph above) involved stocking nauplii at 10/mL on Day 0 followed by maturation to the adult phase and subsequent nauplii production until culture senescence.*

Photos courtesy of the Oceanic Institute

Figure 5. *In early development, flame angelfish larvae hatch lacking mouth or functional eyes (top) and survive on yolk supplies until the initiation of exogenous feeding on Day 3 (center). Successfully feeding larvae (bottom) assume red coloration with inflation of swim bladders by the end of the first week.*

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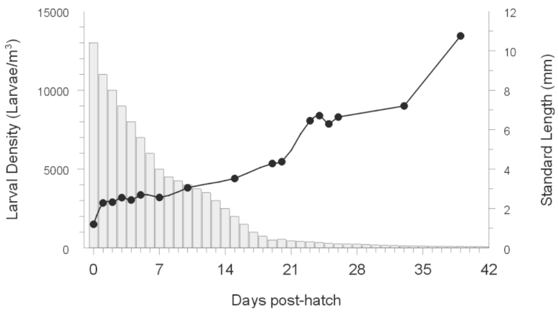

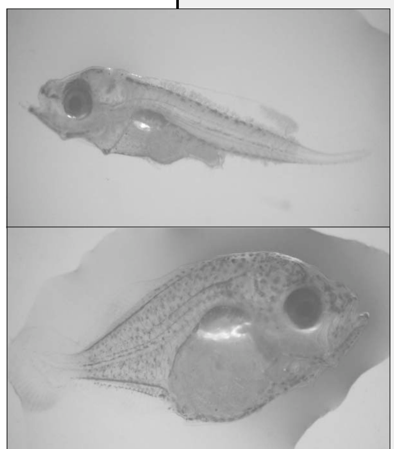

Photos courtesy of OI

Figure 6. *Flame angelfish larval survival and growth in 1,000-L larval rearing system (graph above). Larvae are fed* Parvocalanus *copepod nauplii at a density of 5 to 10 nauplii/mL from Day 2 onward. Note the appearance of hyper-inflated swimbladders in Day 15 and 23 larvae (photos at right).*

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Around the Pacific

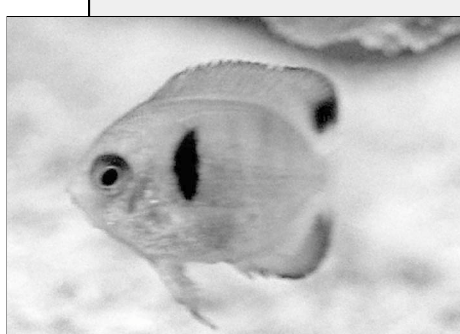
From Majuro, the capital and largest city of the Republic of the Marshall Islands, Manoj Nair, Ph.D., of the College of the Marshall Island's Land Grant Program reports that a successful larval rearing trial has produced juveniles of the surf red fish (*Actinopyga mauritiana*). By October, the hatchery at the Arrak Campus will be expanded, and Nair plans "full-fledged" trials with this and other valuable sea cucumber species on the island, he says.

"Maybe we'll even think of importing the very expensive sand fish *Holothuria scabr*a for mass production for the community to grow out and also reseed the reefs," says Nair.

Note: the *H. scabra* is the focus of a project approved last spring as part of the CTSA Fiscal Year 2007 Plan of Work. Designed by principal investigator Masahiro Ito of the College of Micronesia to transfer sea cucumber technology to technicians in Pohnpei, this project will likely start in the next few months.

Back at the Arrak research facility, pearl oyster experiments involving live feed reduction and elimination in hatchery runs with microalgal concentrates show promise, but further trials are underway in the name of replication, says Nair. The CMI Land Grant Program gave away 5,000 spat, which were a byproduct of this research project, to the commercial pearling company Ebon Pearl Farm.

Sweet Sorrow. This column will be my last, as my final day at CTSA will be Friday, Aug. 29. I am taking a post as a scientific editor for the Coral Reef Ecosystem Division of the National Marine Fisheries Service's Pacific Islands Fisheries Science Center in Honolulu. I have enjoyed getting to know and will miss working with the aquaculture community in Hawai`i and the American Insular Pacific. Mahalo to all the folks who gave me their time, support, and kindness over the last three years. I'd say, "Farewell," but I'm not going far. —*KD* L



Photos courtesy of OI

Figure 7. *Dozens of captive-reared flame angelfish juveniles reared at the Oceanic Institute, such as those shown at left at Day 90 (top) and Day 145 (bottom), have been integrated into mixed ornamental tank systems with successful results.*

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

INSIDE

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The Center for Tropical and Subtropical Aquaculture (CTSA) is one of five regional aquaculture centers in the United States established by Congress in 1986 to support research, development, demonstration, and extension education to enhance viable and profitable U.S. aquaculture. Funded by an annual grant from the U.S. Department of Agriculture's Cooperative State Research, Education, and Extension Service, CTSA integrates individual and institutional expertise and resources in support of commercial aquaculture development.

CTSA currently assists aquaculture development in the region that includes Hawai`i and the U.S.-affiliated Pacific islands (American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Republic of Palau, and Republic of the Marshall Islands).

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Each year, the center works closely with industry representatives to identify priorities that reflect the needs of the aquaculture industry in its region. Then, after consulting with technical experts, CTSA develops a program of directed research that makes these priorities the focus of project objectives. CTSA's board of directors is responsible for overseeing programmatic functions. The center disseminates project results through its print publications, hands-on training workshops, and Web site.

CTSA is jointly administered by the Oceanic Institute and the University of Hawai`i. The main office is located at the Oceanic Institute's Makapuu Point site on the island of Oahu in Hawai`i.

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