

# REGIONAL NOTES

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

## First of Its Kind Aquaculture Workshop held on Saipan, CNMI

**Claus Bier, Mike Ogo, and Dustin Moss**  
**Northern Marianas College**  
**and Oceanic Institute**

Over 80 local farmers, business leaders, government representatives, and interested members of the general public participated in the first Opportunities in Aquaculture Workshop, at the World Resort Saipan on July 10-11, 2008. The workshop, the first of its kind on Saipan, was conducted by Oceanic Institute (OI) and the Northern Marianas College Cooperative Research, Extension & Education Service (NMC-CREES), with funding from CTSA. The goal of the workshop was to educate residents of the Commonwealth of the Northern Mariana Islands (CNMI) and Guam about the potential of aquaculture in the region. In addition, the workshop provided residents with information about region-specific concerns and aquaculture-related regulation and permitting issues.

Scientists from OI, the University of Hawaii Sea Grant, and the University of Guam, as well as local business leaders and regulatory agency representatives gave presentations at the workshop. Topics included shrimp maturation and hatchery techniques, high-intensity shrimp growout using technologies appropriate for Pacific islands, opportunities for shrimp aquaculture in the CNMI and Guam, aquaculture biosecurity, propagation of marine finfish, culture of marine ornamental fish, offshore cage culture of marine finfish, aquaculture development and extension activities in Hawaii, aquaculture extension activities in the

CNMI, aquaculture permitting issues in the CNMI, and CNMI import and export regulations for marine species. In all of the presentations, speakers emphasized the unique geographical advantages of the region, such as the relative isolation of CNMI and Guam from major aquaculture centers, which allows them to implement strict biosecurity procedures. Their proximity by air (3 to 4 hour flights) to Asia and its major potential export markets for aquaculture products is another advantage.

could be used as tanks to grow out shrimp. Pellegrino started a small farm with the help of NMC-CREES. After several successful crops, accompanied by market acceptance and steady local demand for his shrimp, Pellegrino expanded the farm. Currently, Saipan SyAqua has the capacity to produce 10,000 lbs. of shrimp per month. In his presentation, Pellegrino shared his experiences of starting a successful farm and overcoming the various obstacles he has faced during this endeavor.



Photo courtesy of NMC-CREES

Participants at the Opportunities in Aquaculture Workshop.

The CNMI, and, to a lesser extent, Guam, is experiencing economic hardships, due to the closure of garment factories and a downturn in tourism. Workshop attendees were eager to learn about aquaculture, which has been proposed as an alternative industry to help "kick start" the local economy.

Tony Pellegrino's presentation of his shrimp farm, Saipan SyAqua, was a highlight of the workshop, because the farm is such a positive example of aquaculture development in the region. Pellegrino became interested in shrimp farming in 2004, after watching an interview about shrimp production on a local TV station. At the time, he was looking for a way to recycle plastic containers from a former business venture, and thought that they

The most positive result of the workshop to date is the establishment of the first shrimp farm on Tinian, just south of Saipan. Melvin Crisostomo contacted Mike Ogo, NMC-CREES Aquaculture Specialist, shortly after the workshop and expressed an interest in establishing a small shrimp farm on Tinian. With Ogo's help, Crisostomo stocked the first 2,000 juvenile shrimp on his farm in early October. At the time of this report, Crisostomo stated that he was just trying to "get his toes wet" by supplying the very small local market on Tinian, but, if successful, he plans to extend his business throughout the entire CNMI (See related story on page 5).

Ogo reported an increase in calls to NMC-CREES after the workshop from people interested in starting up their own aquaculture farms. Based on the turnout and favorable response to the Opportunities in Aquaculture Workshop, NMC-CREES expressed an interest in organizing a follow-up workshop in the near future to nurture the seed that was planted by the July workshop for developing a prosperous aquaculture industry in the CNMI. ☺

## Letter from the director



The purpose of the *Regional Notes* is to update our readers about CTSA activities and to disseminate valuable aquaculture information to you in a timely fashion. After a thorough evaluation of the best way to accomplish this goal, I am considering a switch to an online-only format for the *Regional Notes* in 2009. Moving the *Regional Notes* online will achieve the intended purposes of the newsletter, in addition to making the news and information available to you faster and help us to “green” our activities. We will be modifying the CTSA website ([www.ctsa.org](http://www.ctsa.org)) to accommodate the new online format. Please bear with us while the website is modified to allow us to produce a more dynamic and informative newsletter and reduce our ecological footprint. Comments? Suggestions? We’d like to know what you think about the change.

*Cheng-Sheng Lee*



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# AQUACLIPS

## *Farming Better Fish*

*By Jonathan Fahey, Forbes.com, September 24, 2008*

Hawaii Oceanic Technology, Inc. plans to culture two endemic Hawaiian species of tuna, yellowfin ahi (*Thunnus albacares*) and bigeye ahi (*T. obesus*), in 82,500 cubic meter offshore cages off the Kohala coast of the Big Island. The tetherless cages, called “oceanspheres™,” would be large enough to hold 1,000 tons of 100-pound ahi. The huge cages would be kept in place 60 feet below the surface of the ocean by motors powered by heat exchangers that use the temperature difference between deep water and shallow water to generate electricity.

The company is trying to secure permits for the operations, a process that is known to be time consuming, because no U.S. regulatory framework for offshore aquaculture currently exists. When the company secures its permits, it aims for six harvests a year from cages spread out over its 120-acre site.

## *Top Leaders Share Concern for Our Oceans*

*By Howard Dashefsky, KHNL, October 1, 2008*

Togiola Tulafono, Governor of American Samoa, and Sebastian Anefal, Governor of Yap, the Federated States of Micronesia, met in Hawaii to discuss the health of the world’s coral reefs with three top U.S. policy makers: Dan Basta, of the National Marine Sanctuaries, Jim Connaughton, of the White House Council on Environmental Quality, and Lyle Laverty, Assistant U.S. Interior Secretary.

On a dive trip off the Big Island’s Kona Coast to get a firsthand look at Hawaii’s reefs and marine life, the leaders shared their concerns about changes that are taking place in the oceans, particularly in areas outside the marine sanctuaries, where the overall health of ocean and coastal environments has undergone a baseline shift towards degradation.

They also exchanged their ideas about priorities for getting people to understand the problems facing our oceans, solving the problems, and sustainably managing ocean resources for a better outlook in the future.

## *Kona Blue to Spawn Kampachi in Mexico*

*By Nina Wu, Honolulu Star Bulletin, October 14, 2008*

Kona Blue Water Farms is planning to spawn its Hawaiian amberjack (“kampachi”) in the Sea of Cortez off the coast of Mexico. The new location will make it easier to ship the fish around the country.

Co-founder and President Neil Anthony Sims said Kona Blue has been looking for expansion opportunities for some time. Mexico was ideal, he said, with its warm waters close to the U.S. market. “We want to grow our fish in the cleanest, deepest water that we can,” said Sims, “removed from the risks of runoffs or other things that might impact fish health and quality.”

Sims said that producing the fish in the Sea of Cortez, also known as the Gulf of California, would also reduce the company’s carbon footprint. Instead of flying the fish from Hawaii, Kona Blue can transport its fish by truck from Mexico to California.

But Sims dismissed any ideas that the company might eventually move from Hawaii. “I’m still here in Kona,” he said. “We see Kona as being a very important part of the equation of pushing the sustainability quotient here.”

The Mexico hatchery, which is expected to reap its first harvest in a year, could boost production fivefold by 2012. Sims said Kona Blue plans to start with four cages, and eventually to increase the number to 12. ♻️

## Fun, Learning, and Food at Hawaii Fishing and Seafood Festival

The Pacific Islands Fisheries Group welcomed the public to a day of fun, learning, and eating seafood at the Third Annual Hawaii Fishing and Seafood Festival on Sunday, October 12, at Pier 38 in Honolulu Harbor.

Members of the science and fishing communities, local shore- and boat-based fishing clubs, and representatives of state and federal agencies, organizations, and academic programs staffed more than 40 booths, answering questions, offering samples, and providing take-home pamphlets and flyers for people to browse at leisure.

At the Aquaculture Development Program booth, one visitor found all sorts of information about aquaculture in Hawaii, how to get started in an aquaculture industry, and where to find farm-raised fish, shellfish, and limu seaweed when shopping for seafood in local markets. The State of Hawaii's Division of Aquatic Resources provided colorful and informative pamphlets about the moi (Pacific threadfin) and ulua tagging projects, and how anglers can participate in these fisheries management programs. Tom Iwai, of Anuenue Fisheries Research Center, demonstrated moi tagging and release. The National Oceanic and Atmospheric Administration (NOAA) staffed three booths, with lots of information about their efforts to restore coastal and marine habitats and how we can all contribute

to the solution of marine debris.

There was something for everyone at the event. Workshops on squid jigging, akule fly tying, constructing a casting rod, and other skills of special interest to fishermen were offered at the festival. Prospective students found out about marine education programs at booths for Honolulu Community College and the University of Hawaii and got on-the-spot answers to their questions about the programs. Landlubbers and experienced seafarers alike had a chance to tour fishing boats and a U.S. Coast Guard cutter docked at the end of the pier. The Keiki Game Corner, with games like Ice Fishing and Duck Pond, entertained children with fun activities and the chance to win prizes. Grownups could bid on fresh "gyotaku" fish prints by artist Naoki and on other items, including a wide selection of reels, spear guns, and other fishing gear, at the Silent Auction booth.

Taking a break from the afternoon sun was another chance to learn something new. During the hottest parts of the day, Brooks Takenaka, from United Fishing Agency, Ltd., gave his slide presentation, "Tuna Quality and Safety, What Do Buyers Look For?" in the ice-cooled Auction House. Takenaka said that quality was related to the end use of the product, and that buyers look at the fishing method used and adjust

their bids accordingly. For example, fish that will be grilled or smoked do not have to match the quality characteristics expected for sashimi. Trolling is best for high quality mahimahi, but longline fishing is preferred for the highest quality tuna, because it avoids stressing the fish, which raises its body temperature and causes lactic acid to build up in the flesh. "The open auction works because it encourages fishermen to choose the best fishing spots, when to go there, and the best crew to take care of the fish after they are caught," he added.

More than 50 vendor and food booths displayed and sold fishing equipment, provided product information, and sold cold beverages and a delicious variety of seafood prepared in different ways during the 9 a.m. to 4 p.m. event. The medical and dental insurance company, HMSA, co-sponsored this year's festival as part of their continuing efforts to raise public awareness of the importance of a healthy lifestyle and the benefits of fishing as a physical activity and of eating fresh seafood that were a main theme of this year's festival.

This well-organized and well-attended community event is sure to earn people's continued support in the years to come. Be on the lookout for announcements of next year's Hawaii Fishing and Seafood Festival—you won't want to miss it!—PO'B



### FAO Glossary of Aquaculture Now Available as Book with CD-ROM

The FAO Glossary of Aquaculture, previously available only online as a PDF version on the FAO website, is now available from the FAO as a book (+ CD-ROM) to reach a wider audience, particularly those who do not have convenient access to the Internet. The 424-page glossary provides definitions of more than 2,500 terms, including information sources, synonyms, related terms, and where available, images, to serve as a valuable reference to readers in the worldwide aquaculture community. Terms and definitions are available in five FAO official languages (English, French, Spanish, Arabic, and Chinese).

### AIP Seafood Quality and Aquaculture Workshop Presentations Available Online

PowerPoint presentations from the Aquaculture Interchange Program (AIP) workshop, "Seafood Quality and Aquaculture," are available for viewing and downloading at the CTSa website, <http://www.ctsa.org>. Click on the Publications .link, and you'll find the workshop listed on the left panel. The 18 presentations given by international experts are available as pdf files, which you can read with free, downloadable Adobe Reader software. ☞

# AQUA TIPS

## Development of DNA-Based Testing for Pacific Threadfin Parentage Assignment

Jinzeng Yang, Heng Wang, Thomas Iwai, Jr., Baoping Zhao, and Cheng-Sheng Lee

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This article was written as part of the work for the project titled, "Development of DNA Markers for Pacific Threadfin Aquaculture," which was funded 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.

Pacific threadfin (*Polydactylus sexfilis*), locally known as moi, the food of Hawaiian royalty, because of its delicate flavor and texture, is becoming an important marine species for the Hawaii aquaculture industry. The wild population of Pacific threadfin along the coastal shoreline has declined significantly due to overfishing, and offshore cage-reared production is expanding on a large scale.

Pacific threadfin reproduces by a way of communal spawning consisting of a group of male and female broodstock fishes. It is not possible to get information about the genetic makeup of the spawning female and sperm donor male at a given spawning event. There is also a pattern of consecutive spawning events in the broodstock tank. To secure the sustainability of Pacific threadfin aquaculture, as well as the genetic diversity of the wild population through stock enhancement, it is necessary to develop a genetic testing tool for pedigree recording and broodstock selection.

A DNA-based genetic testing using microsatellite DNA markers has proved very successful for assigning animal parentage. Microsatellite DNA markers or simple sequence repeats in the form of 2 to 6 nucleotides are very common in the genome and follow a simple Mendelian pattern of inheritance to the next generation. They have been used as genetic tools for gene mapping, parental assignment, and genetic management of broodstock and wild populations in aquaculture. The goal of this project is to identify DNA microsatellite markers of Pacific threadfin, then to employ them for parental assignment and compare the genetic diversity of captive populations to the natural population.

To identify Pacific threadfin microsatellite DNA markers, we initially employed direct DNA sequencing of inserted DNA fragments after they were cloned to plasmids (circular, double-stranded units of DNA that replicate within a cell independently of the chromosomal DNA). Genomic DNA was extracted from the abdominal muscle of Pacific threadfin, followed by electrophoresis and digestions by restriction enzymes. After purification of the digested genomic DNA fragments (about 300-1,500 bp long), these short DNA sequences were inserted to plasmids. After transformation, a total of 3,000 colonies were achieved with more than 60% of recombinant clones. A total of 196 plasmids were sequenced on an ABI 3730 automated sequencer (Applied Biosystems, Foster City, CA) using M13 forward and reverse primers. A total of 132 microsatellite loci were identified, in which



Figure 1. Broodstock Pacific threadfin swimming in a tank

23 clones were observed to contain two or three microsatellite loci in a single fragment. A great number of microsatellites were too close to the linker to allow the primer design and were discarded. Of the suitable colonies, we first designed 73 pairs of PCR primers employing Primer Premier 5.0 software (Applied Biosystems, Foster City, CA). After initial PCR amplifications, 32 microsatellite loci were successfully amplified.

An initial screening of the 32 loci was performed with polyacrylamide gel electrophoresis (PAGE) and silver staining using DNA samples from 18 individuals randomly selected from different locations. Eighteen microsatellite loci displayed polymorphism (at least two alleles) in these individuals, another 16 loci seemed homozygous among them. Ten microsatellite loci, i.e., Pse8, Pse9, Pse24, Pse27, Pse34, Pse35, Pse52, Pse65, Pse82, and Pse98, showed great varieties in band patterns. Preliminary analysis of these ten microsatellite loci was carried out in fish samples collected from wild populations of moi collected from locations around the south shore of Oahu (Sand Island, Waikiki, and Diamond Head) and one captive broodstock population (Fig. 1). All ten microsatellite loci showed polymorphism in these populations, with 3 to 8 alleles per loci across the population (Table 1).

The average allele richness values were higher in the wild population compared to the captive broodstock population. Average expected heterozygosity ( $H_{exp}$ ) and observed heterozygosity ( $H_{obs}$ ) values, however, were similar across the populations. Two loci, Pse65 and Pse82, exhibited significant departures from the Hardy-Weinberg equilibrium expectations for genotype ratio in the fish samples obtained from the Waikiki and Diamond Head areas, respectively. The analysis for linkage disequilibrium of each pair of loci for each of the populations separately indicated

## Workshop Spurs Tinian Aquaculture Project

Reprinted with permission from the *Saipan Tribune*, October 11, 2008

Only several weeks ago did Tinian resident Melvin Crisostomo first approach Michael Ogo, aquaculture specialist at the Northern Marianas College-Cooperative Research Extension and Education Service, to inquire about farming shrimp during the Opportunities in Aquaculture workshop held on Saipan in July.

Just three months later, he and his partners, Gerald Crisostomo and Hiromitsu Iwashita, have released the first 2,000 post larvae shrimp into his tanks Friday, Oct. 3. The shrimp, which came from the University of Guam's Aquaculture Development & Training Center, will be ready for harvest in March 2009.

In addition to the shrimp, Crisostomo and his partners are planning to raise different varieties of tilapia. They have already released the first batch of about 50 tilapia. The tilapia are expected to lay their eggs after about three months and are expected to reach a marketable size within four to six months. A second batch of 200-300 pieces is projected to be released soon.

To spur the tilapia's growth, Crisostomo and his partners grow kangkung, a semi-aquatic leafy vegetable, in the same aquaponic setting. The kangkung will act as a filter, as it takes the waste from the tilapia and converts that into nutrients. The vegetable will also, of course, make a great side dish for the tilapia.

At the moment, the partners plan to grow the shrimp and tilapia for their own consumption. For now, they see their endeavor as a pilot project, but hope to be expanding their operations to include the production of value and brood stock for local markets and possibly providing fresh delicacies at their own restaurant, the Island Garden Restaurant in Tinian's San Jose Village.

The operation has three tanks available—two 6 ft. x 7 ft. and one 16 ft. x 9 ft.—which were all converted from pigpens. All that had to be done was to plaster the walls and fit in all the required piping and filters. This strategy helped to keep their start-up costs low.

"This experience has been both challenging and enjoyable, and we are looking forward to harvest time when we can truly appreciate the fruits of our labor," said Melvin Crisostomo. "This project may not have been a success without the support and guidance of the NMC-CREES."

The aquaculture farmers had guidance from NMC-CREES extension agent Lawrence Duponcheel on Tinian who consulted them on the construction of their tanks. The scientific background and consultation on managing the fish farm came from aquaculture specialist Ogo.

"This is a great example of how NMC and CREES are transferring research-based knowledge to help develop practical and even profitable business opportunities in the CNMI," said NMC president Dr. Carmen Fernandez.

Ogo pointed out that Crisostomo's enterprise is already the fourth aquaculture venture in the CNMI. He is glad that this highly profitable industry is finally getting a foothold on our islands and hopes to see more farmers starting in aquaculture.

For more information on this project, or aquaculture in general, visit the website <http://crees.org/>. —NMC

**Table 1. Characterization of 10 microsatellite loci**

Micro-satellite Locus	Repeat motif	Size (base pairs, bp)	No of Al-les	Hobs	Hexp	PIC	HW p-value
Pse8	(AC)26	194	5	0.712	0.764	0.703	0.108
Pse9	(CA)19	264	5	0.705	0.723	0.682	0.32
Pse24	(GT)5+(TG)3+(GT)10	220	4	0.681	0.705	0.612	0.188
Pse27	(GT)26	229	5	0.72	0.759	0.724	0.457
Pse34	(GT)13	141	4	0.612	0.657	0.586	0.113
Pse35	(AC)23	298	4	0.626	0.663	0.584	0.212
Pse52	(AC)26	181	8	0.732	0.787	0.743	0.365
Pse65	(AC)10+(CA)10	260	3	0.593	0.629	0.542	0.082
Pse82	(ACGC)8	268	4	0.647	0.679	0.549	0.096
Pse98	(AC)24	310	4	0.619	0.654	0.513	0.194

Notes. Hobs: observed heterozygosity; Hexp: expected heterozygosity; PIC: polymorphic information content;

HW p-value: Hardy-Weinberg exact p-value.

**Table 2. Parentage analysis of offspring from three different spawnings**

Parents	Number of fish (n) and percentages			
	36	24	24	Total = 84
Single parental couple	(31) 86%	(24) 100%	(21) 88%	(76) 90%
Two or more parental couples	(5) 14%	0	(3) 12%	(10) 10%
Mating	(9) 27%	(5) 15%	(8) 24%	(11) 33%
Contributors:				
Female	(3) 100%	(2) 67%	(2) 67%	(3) 100%
Male	(6) 75%	(4) 50%	(6) 75%	(6) 75%

that none of the loci exhibited noticeable linkage, indicating that all of them could be used as independent genetic markers. These ten loci and additional DNA makers in expanded DNA samples have been undergoing further analysis in the laboratory.

Based on the results of heterozygosity of the microsatellite loci, five highly polymorphic microsatellite loci, i.e., Pse8, Pse9, Pse27, Pse52, and Pse82, were selected to develop a PCR panel for a parentage assignment study. Parental assignment performed in one small broodstock population through three spawning events showed that 90% of the offspring were successfully assigned to a single broodstock pair under the statistical likelihood of 99.5% (Table 2).

The identified DNA makers are important tools for better management of genetic resources of Pacific threadfin in the captive and wild populations, and the research is currently ongoing at the University of Hawaii at Manoa. The next-step in this project is to further verify and expand microsatellite DNA-based parental assignment, and characterize the genetic diversities of captive and wild Pacific threadfin populations by these microsatellite loci.

It is expected that this project will provide a DNA-based testing for monitoring Pacific threadfin genetic resources. For example, as we acquire the genotypes of tested DNA markers for all the broodstock fishes in a communal tank, we can collect larval samples from consecutive spawning events. By genotyping the larval samples, we should be able to figure out their parents, their associated mating patterns, and the productive females and males in the broodstock population. In addition, the DNA-based microsatellite analysis will allow us to compare genetic differences between different population and genetic diversity or heterozygosity. The obtained genetic characteristics of different populations will provide valuable references to improve the performance of Pacific threadfin aquaculture in Hawaii. 🐟

# Update on the Artificial Propagation of the Feather Duster Worm (*Sabellastarte spectabilis*)

Clyde S. Tamaru, David R. Bybee, and Karen Brittain

University of Hawaii Sea Grant College Program, Brigham Young University-Hawaii, and Hawaii Institute of Marine Biology

This article was written as part of the work for the project titled, "Artificially Propagating the Feather-Duster Worm (*Sabellastarte spectabilis*) for the Marine Ornamental Trade," which was funded 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.

Recently, the marine aquarium industry has attracted much controversy. Opponents focus on the dependence of wild caught stocks of invertebrates and fishes that supply the industry. As with the freshwater ornamentals, culturing the organisms that make up the industry is recognized as being the best solution to minimize harvesting from the wild and sustain the aquarium industry. The feather-duster worm, *Sabellastarte spectabilis*, is one of the most collected invertebrates that make up Hawaii's tropical marine ornamental trade, making it a suitable candidate for developing culture techniques. Supported by the Center for Tropical and Subtropical Aquaculture, Sea Grant College Program, and the Aquaculture Development Program, local researchers have focused on developing techniques for the artificial propagation of the feather-duster worm. Highlights of the research results form the basis for this report.

Understanding the maturation of the sexes and controlling the spawning of a target species is a primary goal in the development of technologies for artificially propagating a commercial product. Stages of sexual maturity were described by Bybee et al. (2007) and used in combination with a technique for the induction of spawning of these worms (Bybee 2005; 2006) to define the spawning season in Hawaii. Worms at the appropriate stage of maturation were placed together in 60-L aquaria equipped with filtered seawater and continuous aeration.

A successful spawning results in fertilized eggs and hatched larvae. Spawning is not successful if only gametes of one sex

are expelled into the water column. Several years of spawning attempts are summarized in Figure 1.

Induction of spawning was attempted between the months of May through January. Although there were intermittent successful spawns obtained over the course of the reporting period, a significant ( $P < 0.05$ , Chi Square) increase in spawning success (e.g., 75%) was achieved only during the month of October. Interestingly, the increase in spawning success was found to be coincident with the time of year when there was the most dramatic change in water temperatures. Thus, a major milestone in controlling reproduction was achieved.

The source of sexually mature individuals, however, remains from the wild, and maturation of brood stock under culture conditions is an area that requires further investigation. Successful spawning translates into the availability of larvae, so defining hatchery techniques becomes the next obvious area that is in need of investigation. Larval development through settlement has been described previously (Bybee et al. 2006) and is not reviewed here.

Earlier work demonstrated that air stones were a preferred substrate for settling larvae. Although the results with the air stones were very appealing, the cost of a single 3" long x 1" wide air stone was \$4.60, and obviously cost prohibitive if the culture process were to be done at commercial scale. Likewise, previous experience showed that removing young worms from the stones was very time consuming and would not be practical. For these reasons, the focus of the next phase of the research would utilize coral chips and substrates of a similar nature that were easily obtainable as well as reasonably priced. A 1,500-L grow out tank was filled with filtered seawater and equipped with continuous aeration. Coral chips were placed on the bottoms of 16" x 16" plastic trays (Fig. 2a) and were placed on the bottoms of the tanks. Red cinder was obtained from Koolau

Farms, Kailua branch, and also stocked into the same plastic trays (Fig. 2b) and placed on the bottoms of the tanks. A total of three trays of each substrate were used per tank. The entire treatment was repeated with two additional 1,500-L tanks, resulting in a total of three tanks. The larvae were allowed to settle on

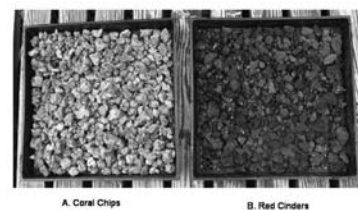


Figure 2

Photograph of the substrate types used in the settlement preference experiment.

the various substrates over the course of the seventh day after hatching. Each tank was then provided *Chaetoceros* spp., resulting in a final cell density of approximately 1,000 cells/ml twice a week. The experiment was allowed to run over the course of six months, after which time all of the trays were removed from each tank and the number of worms present in each tray recorded.

The results of the experiment are summarized in Figure 3. A significantly ( $P < 0.05$ ) higher density of worms per square inch was obtained using coral chips over cinders. The results indicated that coral chips may be a cost-effective substrate for use

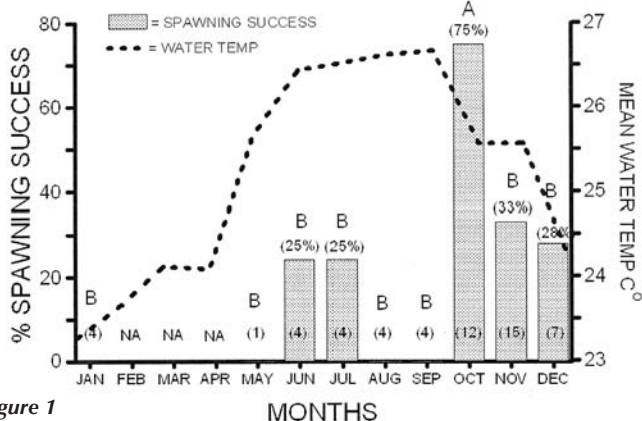
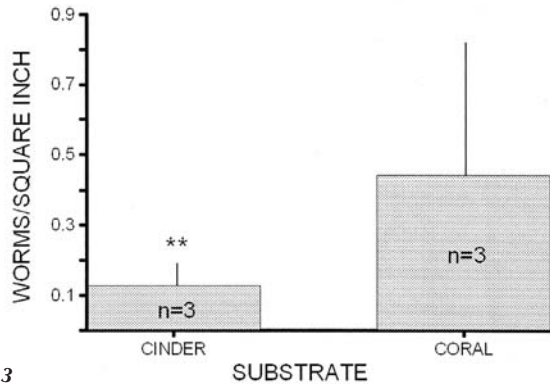


Figure 1

Summary of induction of spawning trials over the course of three years. Numbers in parentheses indicate the number of attempts and percentages indicate spawning success. Bars that do not share a letter of the alphabet are significantly different ( $P < 0.05$ ).

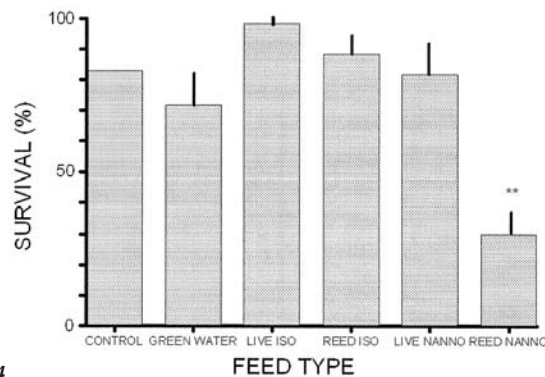
in the artificial propagation of this species, as the cost for the coral is approximately \$200/ton.

Defining what would be an appropriate feed was an important question that needed to be answered in the development of the culture process. A grow out trial using various live and preserved



**Figure 3**  
Summary of density of feather duster worms in response to two different media.

algal forms was investigated. Growth and survival were used as indicators of the effectiveness of a particular feed. Fifteen 60-L glass aquaria were each stocked with 20 juvenile worms obtained from the settlement experiments just described. Each aquarium was filled with filtered seawater, operated as a closed system, and provided with a continuous source of aeration. Live *Isochrysis galbana* (Tahitian strain), live *Nannochloropsis oculata*, tilapia greenwater, *Isochrysis* and *Nannochloropsis* (Instant Algae, Reed Mariculture San Diego California) were the five test diets investigated. With the exception of the control group, a final cell density of approximately 1 million cells per ml was provided twice a week. Two trays (12 inch diameter) were each stocked with 30 worms and placed in a water table that was continuously supplied with raw seawater from Kaneohe Bay

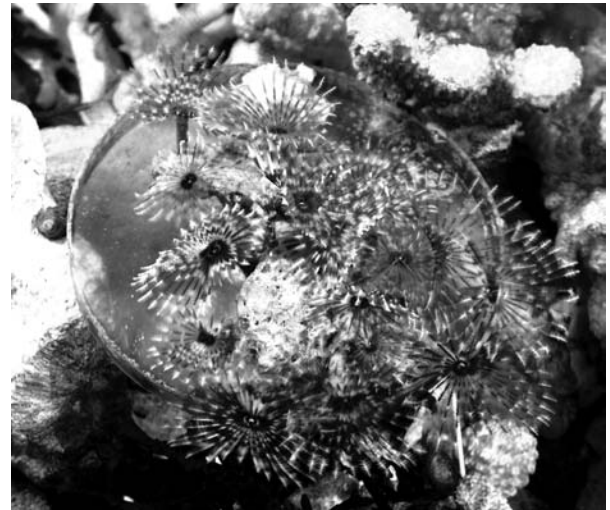


**Figure 4**  
Summary of percent survival of cultured feather duster worms in response to various live or preserved phytoplankton.

to serve as a control. The experiment was initiated in January 2008. After 100 days, with the exception of the Reed Mariculture *Nannochloropsis* algal paste, all of the treatments were found to support growth and survival of the worms. The live *Isochrysis* treatment resulted in the highest rate of growth and survival, while the preserved *Nannochloropsis oculata* treatment resulted in little to no growth and was also significantly ( $P < 0.05$ ) lower in survival (Fig. 4). In contrast, the Reed Mariculture preserved *Isochrysis* was found to support growth and survival of the young worms throughout the testing period.

The research results that have been obtained to date are extremely encouraging and suggest that another marine ornamental commodity that has been exclusively from the wild may be artificially propagated (Fig. 5). Expectations, however, need to be tempered, because the results that have been obtained are still at laboratory-scale. Clearly, a pilot-scale demonstration project is warranted, to provide the kind of reality check needed to determine the economic feasibility of a production technology and where it can be fully assessed.

Surveys that have been conducted during the current project indicate that wild caught adult worms (6-7 inches long) cost between \$1.15 and \$1.25 apiece. The average wholesale price



**Figure 5**  
Bouquet of cultured feather duster worms on coral chips.

of wild caught worms for the trade coming out of Hawaii range between \$2.00 and \$3.00. After going through a second wholesaler, the retail price ranges between \$10 and \$15 per worm. A best estimate of the demand is approximately 10,000 worms per month. Efforts by the project working group are currently underway to take the project results to the demonstration level.

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# CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

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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.

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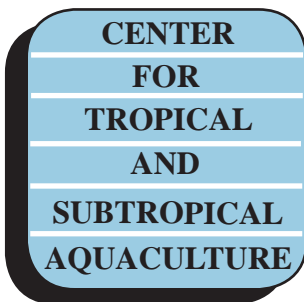
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