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The Oceanic Institute and the University of Hawaii
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REGIONAL NOTES

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

CTSA project tackles marine ornamentals

A new CTSA project will use a multi-institutional approach in an attempt to resolve the barriers to cultivating several popular marine ornamental species.

Approved by the USDA as part of the CTSA Year 13 Plan of Work, the project titled *Aquaculture of Marine Ornamental Species - Year One* will tap into the talents of researchers from The Oceanic Institute (OI), the Guam Aquaculture Development and Training Center (GADTC), the University of Hawaii (UH) and the University of Hawaii Sea Grant Extension Service (UHSGES).

The growing popularity of marine aquariums creates exciting potential for expanding this segment of the aquaculture industry. Although advances in marine hatchery technologies have helped to increase the number of species commercially produced, attempts to culture higher-value species have been more difficult. The first challenge is to spawn these desirable species. Once larvae are produced, the next problem stems from the small mouths of these marine creatures, which creates challenges in identifying and mass culturing appropriate live feeds for larval rearing.

Currently, only five percent of tropical marine organisms traded are produced through aquaculture.

Using several approaches, the project participants will work to identify appropriate first feeds and refine culture techniques for the following species: the Clown coris (*Coris gaimard*), yellow tang *(Zebrasoma flavescens*), flame angelfish (*Centropyge loriculus*), and feather-duster worm (*Sabellastarte sanctijosephi)*.

Dr. Anthony Ostrowski of The Oceanic Institute will serve as the project director and coordinator for the various activities of the project. "Currently, only five percent of tropical marine organisms traded are produced through aquaculture," he said. "The CTSA project will help identify and resolve bottlenecks in rearing marine ornamentals, helping to pave the way to expanding aquaculture's stake in the marine ornamental industry."

The Oceanic Institute's portion of the project will focus on maturation and spawning techniques for the yellow tang and the flame angelfish and examine a variety of novel first feed items and approaches to rearing the larvae. Stocking yellow tangs began in November 1999 for future spawning and larval rearing research.

The first challenge is to establish reproductively active broodstock. A few of the tangs are quite large and tests have shown at least one of them is mature and ready to spawn. Once larvae are obtained, the project will focus on resolving the elusive question of what to feed them. The Oceanic Institute's work with the flame angelfish is moving closer to that stage. Flame angels at OI have been spawning daily since December 1999, producing an average 120,000 larvae each month.

Andrew Burnell, OI research assistant, examines flame angel eggs collected from spawning tanks.

The research conducted by the University of Hawaii and UHSGES will focus on invertebrates as well as finfish. Efforts include establishing colonies of feather-duster worms at chosen farm

(See Marine ornamental, page 2)

Letter from the director

At the 2000 World Aquaculture Society conference, I had the opportunity to visit with many of my colleagues from our region and from around the world.

While we enjoyed sharing the latest research findings, it was clear that for aquaculture to be successful, the industry must go beyond the emphasis on technical challenges and profitable operations. Aquaculture operations must be environmentally sound and socially acceptable as well. These are important considerations to keep in mind as we develop aquaculture in our region. Success will be ours if we work together and encourage open communication among researchers, farmers, and government officials.

We enjoyed feedback from many of you on the new *Regional Notes* and encourage those who haven't to take a minute to send us your thoughts. You may use the form on page 7 or send an email to me at *cslee@oceanicinstitute.org.* With help from our many readers, we will work to make each issue of *Regional Notes* worth fitting into your busy day.

REGIONAL NOTES

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Marine ornamental project begins

(continued from page 1)

facilities. Studies will be conducted on these colonies and detailed descriptions will be developed to include husbandry and egg collection methods, the worm's larval stages, preliminary growth estimates, and comparisons of various substrates for settlement.

One-day-old flame angel larvae are 1.3 mm.
Photo by Andrew Burnell

The UHSGES project activities will focus on the use of standard rotifer/algae production systems in an effort to identify species that can be cultured using currently available methods. By using this complementary approach, more species can be identified to initiate the transfer of technology to the commercial sector.

The project extends across the CTSA region to include researchers at GADTC. The GADTC is a multi-species tropical hatchery and research facility operated by the Guam Department of Commerce since 1986. GADTC already has several other research efforts underway involving the culture of marine ornamental fish, including the lyretail blenny (*Meiacanthus atrodorsalis*) being cultured for the first time by GADTC staff.

Research conducted at the GADTC will focus on establishing broodstock populations of the Clown coris, a highly prized ornamental wrasse. The GADTC approach will also collect wild zooplankton from nearshore areas. This collected zooplankton will be used to conduct short-term feeding trials of spawned Clown coris larvae and help identify the food these species eat in the wild.

With the combined talents and experience of the researchers at OI, GADTC, UH, and UHSGES, the chances are very good that the objectives of this project will be met. The successful cultivation of these popular marine species will not only create exciting growth opportunities for the aquaculture industry, it will also reduce pressures on wild populations by providing a more sustainable alternative to collection practices. This will help ensure that these beautiful ocean creatures will be enjoyed in their native habitat — as well as aquariums — for generations to come.

CTSA director plans site visits

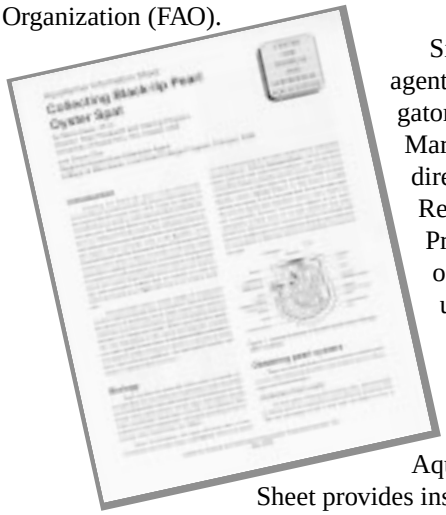
To facilitate communication and solicit suggestions from industry, CTSA director Dr. Cheng-Sheng Lee will visit aquaculture farms throughout the region. He will coordinate his visiting schedule with the extension agent in your area.

Dr. Lee recently met with some Industry Advisory Council (IAC) members on the Kona side of the Big Island of Hawaii where he also had an opportunity to tour the Hawaii Ocean Science and Technology (HOST) Park operated by the National Energy Laboratory of Hawaii Authority (NELHA). Their current tenants are producing an amazing diversity of aquaculture products including microalgae, black pearls, and several marine invertebrate species popular in the aquarium industry. These are just some of the examples of the exciting things happening in aquaculture today. Dr. Lee appreciated the suggestions on how to strengthen the aquaculture industry and its profitability.

CTSA's industry-driven efforts are fueled by the contributions of its IAC members and others. By strengthening the lines of communication with all individuals concerned about aquaculture and staying in touch with current needs and concerns, CTSA strives to provide support to make the most significant contribution to the long-term growth of the aquaculture industry.

New publications focus on bivalves

The Giant Clam and the Black-lip pearl oyster are the focus of two new publications produced as part of the CTSA project titled *Aquaculture Extension and Training Support for the U.S. Affiliated Pacific Islands*. Since 1989, this project has provided aquaculture information and assistance to residents throughout the U.S. Affiliated Pacific Islands. Over the years, this multi-institutional effort has received additional funding support from the University of Hawaii Sea Grant Extension Service, Pacific Aquaculture Development Program, the Federated States of Micronesia government, the College of Micronesia, the Pacific Island Network, and the United Nations Food and Agriculture Organization (FAO).



Simon Ellis, extension agent and principal investigator for the project, and Maria Haws, Ph.D., director of the Pearl Research and Training Program at the University of Hawaii - Hilo teamed up to write CTSA publication #144, *Collecting Black-lip Pearl Oyster Spat*. This eight page Aquafarmer Information Sheet provides instructions for collecting spat, the juvenile pearl oysters that are cultivated and then seeded to produce the valuable black pearls. Spat collection offers an environmentally sensitive alternative to collecting adult oysters directly from their reef habitat and may be more economical than purchasing from spat hatcheries, which often do not produce the quantities needed to meet demand.

The second publication focuses on another bivalve, the giant clam. CTSA publication #143, *Nursery and Grow-out Techniques for Giant Clams (Bivalvia: Tridacnidae)* is a 100-page manual with detailed, step-by-step instructions on how to cultivate this fascinating species. Giant clams are a truly versatile aquaculture product and can be cultivated for their delicious meat, their decorative shell, and even as an ornamental species for the marine aquarium trade. The publication continues where another CTSA manual left off. The earlier manual, CTSA publication #130, *Spawning and Early Larval Rearing of Giant Clams* (still available) was designed to guide an inexperienced culturist through all the basic steps of clam spawning and larval rearing while still offering new and alternative information to the experienced farmer.

Giant clams being reared at the RRE clam farm, Majuro, RMI.
Photo by Matt Harris

CTSA publications can be obtained (while supplies last) by contacting Alcian Clegg at the CTSA Administrative Center by phone (808) 259-3168, by fax (808) 259-8395, or by email at aclegg@oceanicinstitute.org. For a complete list of CTSA publications and their availability, visit our website at http://library.kcc.hawaii.edu/CTSA.

Thanks to PRAISE

When you're trying to find something, isn't it always in the last place you look? For Joe Tabrah of The Oceanic Institute, the "last place" was the CTSA-funded Library Aquaculture Workstation, known as the *Pacific Regional Aquaculture Information Service for Education* (PRAISE).

Mr. Tabrah had trouble locating a particular research paper on the Hawaiian limpet, *Opihi (Cellana exarata)* until CTSA suggested he contact PRAISE. He requested the search via email and soon received a list of citations and abstracts. He then made his selection and emailed his request for the full paper. The requested document was emailed to him in *Ariel* format. *Ariel* files can be read by any program that can read TIFFS (such as *CorelDraw*, *PhotoPaint* or *Photoshop*). Or you can download a copy of *DocView*, a free program that can also read *Ariel* files. The Web address to download *DocView* is http://archive.nlm.nih.gov/proj/docview/project.htm.

Researchers, farmers, and students alike have discovered that PRAISE is a valuable information resource for a wide variety of aquaculture topics. By subscribing to a number of databases, PRAISE is able to locate articles on aquaculture topics from hundreds of scientific journals.

The next time you are trying to find aquaculture information, make PRAISE the *first* place you look!

How to contact *PRAISE*

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AQUA TIPS

Effects of three maturation diets on spawning of the armored catfish (*Corydoras aeneus*)

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This article was written as part of the work for the projects titled "Transitioning Hawaii's Freshwater Ornamental Fish Industry, Year One" and "Expansion and Diversification of Freshwater Tropical Fish Culture, Year Two," 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.

Corydoras aeneus

Introduction

A previous investigation described the fatty acid profiles of a number of prepared and live feeds commonly used by Hawaii's tropical fish breeders in conditioning their broodstock (Tamaru et al., 1997). The essential fatty acids for the various live and prepared feeds were summarized in an unconventional means (percent composition) and then ranked from the highest to lowest (Table 1). An interesting similarity in all of the conditioning feeds was the presence of two essential fatty acids (linoleic acid C18:2n6 and arachidonic acid C20:4n6) in relatively high quantities. Both of these fatty acids are related to each other as linoleic acid is the precursor molecule for arachidonic acid and it is not surprising that they are intimately linked with regard to their relative abundance in a particular maturation feed. What is most intriguing is their relationship with the reproductive process in fishes. Both of these fatty acids are precursor molecules for a group of biochemical agents collectively known as eicosanoids that have been shown to be crucial in a variety of physiological functions (Bell et al., 1994). An example of an eicosanoid is prostaglandins, which in fish have been shown to stimulate ovulation (Goetz 1983) as well as serve as a chemical messenger or pheromone in the mating process (Stacey, 1984). Arachidonic acid is the precursor molecule for the synthesis of prostaglandins in trout (Goetz et al., 1989). Arachidonic acid has been shown to participate in gonadotropin-releasing hormone stimulation of gonadotropin in goldfish (Chang et al., 1989). Based on the fatty acid results of the prepared and live feeds examined, it was proposed that further investigations were warranted.

A maturation diet (beef heart mixed with an assortment of seafood products) routinely used as a conditioning feed for discus (*Symphysodon discus*) and other freshwater ornamental broodstock by Hawaii's tropical fish breeders was found to be consistent in relative high amounts of the two essential fatty acids. Using the armored catfish *(Corydoras aeneus)* as a model, this study investigated the effects of these conditioning feeds on spawning.

Table 1. Summary of essential fatty acids found in maturation feeds ranked by percent composition. *From Tamaru et al., 1997.*

Ranking	Beef Heart Diet	Beef Liver	Black Tubifex Worms	Red Tubifex Worms	*Moina sp.*	Earth worms	Mosquito Larvae
1	18:2n6	18:2n6	18:2n6	18:2n6	20:4n6	20:4n6	18:2n6
2	20:4n6	20:4n6	20:4n6	20:4n6	18:2n6	18:2n6	20:4n6
3	22:6n3	18:3n3	20:5n3	20:5n3	20:5n3	18:3n3	18:3n3
4	18:3n3	20:5n3	18:3n3	18:3n3	18:3n3	20:5n3	20:5n3
5	20:5n3	22:6n3	22:6n3	22:6n3	22:6n3	22:6n3	22:6n3

Material and Methods

Three 15-gallon tanks were each stocked with a trio of fishes consisting of two males and one female *C. aeneus*. The tanks shared a single recirculating system so that water quality parameters would be equivalent in all three tanks. Three one-month trials were conducted in which fish in each tank were fed each of the following treatment diets (beef heart/seafood mix, beef heart only, and Nutrafry). For example, for the first trial, Tank 1, Tank 2, and Tank 3 received the beef heart/seafood mix, beef heart, and Nutrafry, respectively. For the second trial, fish in Tank 1, Tank 2, and Tank 3 received beef

heart, Nutrafry and beef heart/seafood mix, respectively. Feed for each tank was rotated again after a month's duration so that all trios had an opportunity to be fed a particular diet. Fish in each treatment group were fed equal weights of each of the diets. This meant that they were fed equal amounts of Nutrafry and wet weights of the beef heart and beef heart/seafood diets. During the experiment, the dates spawning occurred and the number of eggs spawned were determined for each tank.

Results

The fatty acid profiles of the three treatment diets are presented in Table 2. The commercial pellet, Nutrafry, was found to contain the highest amount of all of the fatty acids. A summary of the spawning activities of the fish fed the various treatment feeds is presented in Table 3.

The total number of eggs spawned by individuals that were fed the beef heart/seafood mix was significantly higher than those fed the other diets. The number of spawning events, however, did not differ statistically. Egg production per spawning event is a more accurate portrayal of the spawning results and although it appears that there may be a trend in the number of eggs per spawn, no statistical difference could be detected between fish fed beef heart/seafood mix and beef heart. The only statistical difference occurred with the lower number of eggs per spawning produced by individuals being fed Nutrafry. Although percent hatching for each spawning was not measured, hatching did occur in all nests that were set aside for observation. In addition, the armored catfish fed the beef heart/seafood mix produced larger eggs, although the biological significance of this characteristic remains to be determined. In subsequent experiments, a more thorough investigation will have to include an assessment of egg quality.

It is rather surprising that the reproductive performance of the armored catfish was so poor when fed Nutrafry in comparison to the other diets tested. Nutrafry has been found to be a highly palatable food for freshwater ornamental fish and results in superior growth for angelfish (Ako and Tamaru, 2000). It is clear that the essential fatty acids EPA (C20:5n3), DHA (C22:6n3), and the total fatty acids are not correlated with the observed reproductive performance of the armored catfish. This is quite a contrast to what has been reported for marine fishes where these fatty acids have been found to be crucial for reproduction. Arachidonic acid (ADA, C20:4n6), however, is still correlated with the observed reproductive performance but only in a relative sense as summarized in Figures 1 and 2.

The only significant correlations observed were between the ratio of ADA to total fatty acids with the number of eggs/spawn as well as for the ratio of ADA to EPA and the number of eggs/spawn. This observed correlation between the ratio of ADA/EPA and spawning is consistent with what is currently known about the metabolic pathway of eicosanoids. ADA is the major precursor of eicosanoids in mammals (Johnston et al., 1983) and fish (Tocher and Sargent, 1987). Although EPA is also a precursor molecule for eicosanoid synthesis, the EPA-derived class of compounds generally has a much lower biological activity than the ADA-derived eicosanoids (Lands, 1989). It is interesting to

Table 2. Fatty acid profiles of three maturation diets used for *C. aeneus*.
(*Values are reported in mg/100 mg as fed).*

Fatty Acid	Beef Heart/ Seafood	Beef Heart	Nutrafry
14:0	0.01	0.03	1.83
16:0	0.20	0.33	4.48
16:1n7	0.01	0.05	1.77
18:0	0.20	0.29	0.82
18:1n9	0.17	0.62	1.76
18:2n6	0.51	0.30	0.90
18:3n3	0.06	0.03	0.27
18:4n3	N.D.	0.00	0.42
20:1n9	0.00	0.02	0.29
20:4n6	0.15	0.11	0.23
20:5n3	0.03	0.03	2.41
22:1n11	N.D.	0.01	0.08
22:6n3	0.10	0.00	2.05
Total Fatty Acids	1.46	1.82	17.30

N.D. = not detectable

Table 3. Summary of spawnings for *C. aeneus* fed three different maturation diets.

Treatments	Total Number of Eggs Spawned	Number of Spawns	Average Number of Eggs/Spawn
Trial #1			
Nutrafry	331	9	37
Beef Heart	457	6	76
Beef Heart/ Seafood	1127	7	161
Trial #2			
Nutrafry	56	1	56
Beef Heart	996	4	249
Beef Heart/ Seafood	1750	6	292
Trial #3			
Nutrafry	57	1	57
Beef Heart	244	1	244
Beef Heart/ Seafood	666	2	333

Aqua Tips

(continued from page 5)

note that Nutrafry actually has the highest of all of the fatty acids examined for the diets used in the current investigation and one would have expected Nutrafry to result in the best performance if you are a believer in the adage that more is better. This clearly is not the case and the correlations that were observed indicate that reproductive performance decreases with increasing amounts of EPA or total fatty acids in relation to ADA.

There are two means by which this observation can come about. The first is by competitive inhibition in which the enzymes involved with eicosanoid synthesis are inhibited in their activity by an excessive amount of a precursor molecule (e.g., EPA). Alternatively, there is a shift in the formation of EPA-derived products as a result of an imbalance in the amount of

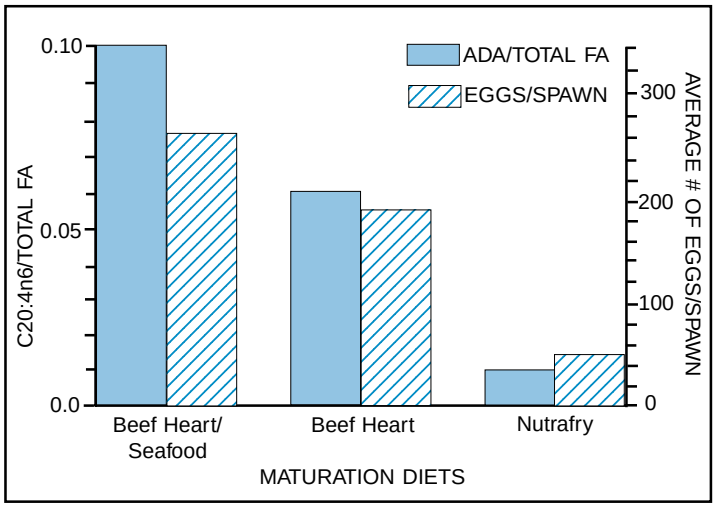

Figure 1. Relationship between ratio of ADA and total fatty acids and average number of eggs spawned.

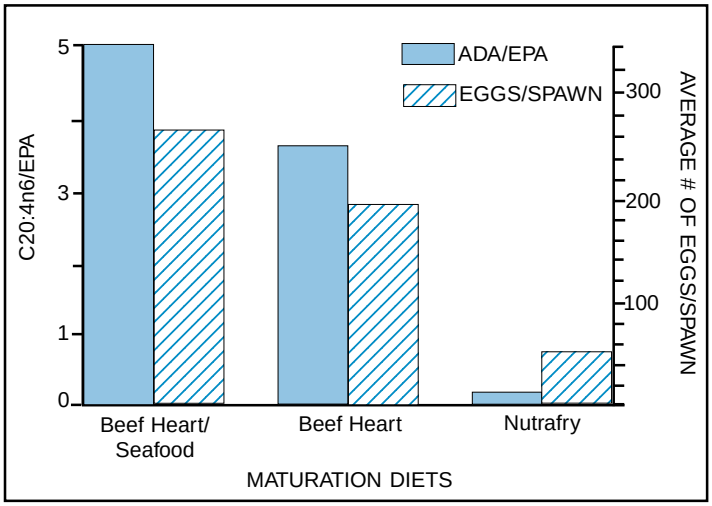

Figure 2. Relationship between ratio of ADA and EPA and average number of eggs spawned.

ADA relative to EPA or total fatty acids. The results of the current investigation provide two benchmarks in that a ratio of ADA/EPA that is greater than 3 or a ratio of ADA/Total fatty acids greater than 0.05 appear to be values that may have biological significance. Further investigation is needed to validate this initial finding.

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IAC and TC elect officers

Elections were held at the February 2000 CTSA Industry Advisory Council (IAC) and Technical Committee (TC) annual meetings to select officers for the coming year.

Dr. Rick Spencer was re-elected to a seventh term as IAC chairman. A member of the IAC since 1988, Dr. Spencer has a strong academic as well as industry background that has proven valuable to the IAC. Dr. Spencer has a doctorate in Oceanography from the University of Hawaii and is a limited partner in Hawaiian Marine Enterprises, a Kahuku-based firm that cultures and markets edible seaweed, clams, and freshwater ornamental fish.

Richard Croft was re-elected as vice-chairman of the IAC. An IAC member since 1990, Mr. Croft lives in Pohnpei and is owner of Pohnpei Natural Products, an aquaculture business that cultivates and markets sea sponges and locally made soaps and shell products.

The TC members elected Dr. Harry Ako as their chairman. Dr. Ako replaces Dr. Christopher Brown, who had served one term before accepting a position as professor and director of the Marine Biology Program at Florida International University. Dr. Ako earned his doctorate in Biochemistry from Washington State University. His research has focused primarily on aquaculture feeds.

Simon Ellis was re-elected as TC vice-chairman. A TC member since 1997, Mr. Ellis is also the regional extension agent for the U.S. Affiliated Pacific Islands. He earned a master of science degree in Fisheries and Aquaculture from Louisiana State University.

Aquaculture Websites

If you're an avid *Web-surfer*, then you know there are thousands of aquaculture-related sites out there — and new ones being launched every day! Here's a few of our favorites that you'll want to visit on your next trip to cyberspace.

AquaNIC (Aquaculture Network Information Center)
http://aquanic.org/
AquaNIC houses or provides links to thousands of state, national, and international aquaculture publications, newsletters, visual media, calendars, job services, directories, and specialty sections for species and production systems.

USDA Animal & Plant Health Inspection Service (APHIS)
http://www.aphis.usda.gov/vs/aqua/aquaphis.html
APHIS provides agricultural producers with a broad range of cooperative programs for protecting the health of animals and plants.

American Tilapia Association
http://ag.arizona.edu/azaqua/ata.html
This Web page provides access to information about tilapia, the fastest growing aquaculture crop in the United States and around the world.

World Aquaculture Society (WAS)
http://www.was.org/
An international nonprofit society with over 4,000 members in 94 countries. Founded in 1970, its primary focus is to improve communication and information exchange within the diverse global aquaculture community.

CTSA wants to hear from you!

Regional Notes benefits greatly from feedback from its readers. We welcome your ideas and suggestions on articles you would like to see in future issues. You may use this form or email Cheng-Sheng Lee at

If you are a new reader and would like to be added to our mailing list or if you are aware of others who would benefit from our publication, please complete and mail the form below. Please also let us know if you are receiving duplicate copies or if you had a change in address. If you prefer, you may email the information to *jmcauliffe@oceanicinstitute.org.*

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CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

The Center for Tropical and Subtropical Aquaculture (CTSA) is one of five regional aquaculture centers in the United States. Established by the U.S. Department of Agriculture, the centers integrate individual and institutional expertise and resources in support of commercial aquaculture development. CTSA was established in 1986 and is jointly administered by The Oceanic Institute and the University of Hawaii. The CTSA offices and staff are located at The Oceanic Institute's Makapu'u Point site on windward Oahu. A Board of Directors is responsible for overseeing the programmatic functions of CTSA.

The mission of CTSA is to support aquaculture research, development, demonstration and extension education to enhance viable and profitable U.S. aquaculture. Unlike the other centers, which work within a defined geographical region, the CTSA "region" encompasses tropical and subtropical species wherever they are cultured. Research projects span the American Insular Pacific, using its extensive resource base to meet the needs and concerns of the tropical aquaculture industry.

Each year's program is developed by CTSA's Industry Advisory Council and Technical Committee, reflecting the Center's mix of commercial and scientific expertise. Council members represent financial institutions, aquaculture and agriculture enterprises, government agencies, and other business concerns. The Technical Committee includes researchers, extension agents, and fisheries officers. Both committees include representatives from American Samoa, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, Guam, Hawaii, the Republic of Belau, and the Republic of the Marshall Islands. For further information on the CTSA program, contact Cheng-Sheng Lee, Ph.D., Executive Director, by phone (808) 259-3107, by fax at (808) 259-8395 or by email at cslee@oceanicinstitute.org.

FAST FACT

In 1998, there were 345 ornamental fish growers in the U.S. with $69 million in total sales.

1998 Census of Aquaculture
National Agriculture Statistics Service
U.S. Department of Agriculture

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

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