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The Oceanic Institute and the University of Hawaii
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REGIONAL NOTES

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

The hazards of hydrogen sulfide

Check out our new website to be launched on September 17th!!!
www.ctsa.org

Hydrogen sulfide can result from mixtures of saltwater, oils, sewage and chemicals containing sulfur. It is capable of causing death when inhaled in sufficient concentration. Earlier this year an aquaculturist cleaning a tank died due to inhalation of hydrogen sulfide, probably created by the anaerobic decay of organic matter such as fish waste. The tank was the size of one that many aquaculturists routinely enter to perform maintenance. Even with its extreme level of toxicity, the smell of the hydrogen sulfide has generally been thought of as its most negative feature despite a general awareness of its dangers by most workers exposed to it. However, hydrogen sulfide is not something to take lightly. In recent years, the occupational hazards of hydrogen sulfide have been increasingly publicized as the number of accidental deaths due to hydrogen sulfide inhalation has risen. Did you know that after a certain amount of high-level exposure, it destroys your sense of smell, deceiving you into thinking that it's gone and causing you to underestimate your level of exposure? Or that you can only smell it at low-levels?

In this issue, CTSA has provided some information regarding hydrogen sulfide and how those exposed to it can protect themselves.

What is hydrogen sulfide?

Hydrogen sulfide occurs naturally in crude petroleum, natural gas, volcanic gases, and hot springs. It can also result from bacterial breakdown of organic matter. It is also produced by human and animal wastes.

Hydrogen sulfide is a colorless, flammable gas under normal conditions. It is commonly known as hydrosulfuric acid, stink damp, and sewer gas. It smells like rotten eggs. People can smell it at low levels.

It is heavier than air and can reach high concentrations in poorly ventilated spaces, depressions and wells. It is flammable and explosive within the range 4.3% - 46% when mixed with air.

What happens to hydrogen sulfide when it enters the environment?

Hydrogen sulfide is released primarily as a gas and will spread in the air. When released as a gas, it will form sulfur dioxide and sulfuric acid in the atmosphere. Sulfur dioxide can be broken down further and is a major component in acid rain. Hydrogen sulfide remains in the atmosphere for about 18 hours.

What are the effects of hydrogen sulfide?

The effects of varying concentration of hydrogen sulfide are shown below:

PPM	Effect
0.05	Detectable by odor
0.1	Irritation of eye and upper respiratory tract
1.0	Threshold Limit Value (8 hours exposure)
15	Short Term Exposure Limit (15 minutes exposure only)
30	Very strong smell, but not unbearable
50	Eye irritation, seeing a halo around lights, headache, loss of sense of smell, nausea, rawness in the throat, cough and respiratory difficulties. Central nervous system irritation manifesting as irritability and insomnia, progresses to symptoms of depression (i.e. fatigue, lethargy, giddiness and then coma at about 300 ppm). Pulmonaty odema may occur up to 24 to 72 hours after exposure.
150	Rapid olfactory fatigues occurs
300	Unconsciousness after a few minutes of exposure
500	Rapid onset of unconsciousness after a few breaths, respiratory center stimulation and rapid breathing.
600-1000	Single breath causes immediate respiratory arrest and unconsciousness.

Hydrogen sulfide is considered a broad-spectrum poison, meaning it can poison several different systems in the body.

Breathing very high levels of hydrogen sulfide can cause death within just a few breaths. There could be loss of consciousness after one or more breaths.

Exposure to lower concentrations can result in eye irritation, a sore throat and cough, shortness of breath, and fluid in the lungs. These symptoms usually go away in a few weeks. Long-term, low-level exposure may result in fatigue, loss of appetite, headaches, irritability, poor memory, and dizziness.

Animal studies showed that pigs that ate food containing hydrogen sulfide had diarrhea after a few days and weight loss after

Continued on page 7

Letter from the director

As we finish our second year under the new proposal development process, I feel we are moving closer to achieving CTSA's goal of assisting industry development while helping to reduce the administrative workload on project working group members. This new process may not be perfect and I realize that it still needs some fine tuning. I have always emphasized my desire for suggestions from all of you. So far, I have received several suggestions, particularly on creating problem statements with a multi-institutional approach that would address our wide geographic region. Again, I ask for your comments and suggestions. I would like to discuss this further and hear from anyone interested in participating. A meeting will be held prior to the next IAC meeting, which is held in February 2003. If you are interested, please contact me (cslee@oceanicinstitute.org) and I will include you in future correspondence regarding the meeting.

Cheng-Sheng Lee

REGIONAL NOTES

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AQUA CLIPS

PBCP assist in Waianae Coast development

Pacific Business Center News, Spring/Summer 2002

For the past nine months, the [Pacific Business Center Program] has been working on identifying products and services needed in Hawaii and having export potential. The Center then prepared business plans for business ventures having the best potential for success on the Waianae Coast on economically depressed area of Oahu. [The PBCP staff] identified three best potential businesses for the Waianae area: (1) seed-crop production, (2) moi production in deep ocean cages, and (3) marketing of arts and crafts produced in Waianae.

Ocean fish farm thriving

By Scott Ishikawa, Honolulu Advertiser and July 31, 2002

Cates International [is] now harvesting about 5,000 pounds of [moi] each week for fish dealers. The company, which leases about 28 acres of Hawaii waters, was the first to be issued an ocean lease in the United States to operate an ocean farm "We're seeing a demand for the fish now by Mainland chefs," said [Virginia Enos, a business partner with Cates International], "We'd like to double our production and those fish would most likely go to the Mainland." Enos said about 65 percent of their harvest goes to the local fish market, with the remainder sent to the Mainland. The company received nationwide exposure this month when one of its raised fish was highlighted on NBC's morning show "Today" -- before being cooked by Hawaii chef Roy Yamaguchi.

Hawaii Pacesetters

Pacific Business News, August 2, 2002

Robin Shields was promoted to fin fish program manager. He will manage the institute's pioneering research on the aquacutlture of marine food fish. *Editor's Note: Dr. Shields replaces Dr. Anthony Ostrowski (see below) as the Program Manager and also as the Principal Investigator for several CTSA projects.*

Director of U.S. Marine Shrimp Farming Program Appointed

The Oceanic Institute press release

Dr. Anthony C. Ostrowski has been appointed Director of the United States Marine Shrimp Farming Program. In this role Dr. Ostrowski will coordinate the activities of a consortium of research institutions to advance the U.S. shrimp farming industry's competitiveness in the global marketplace. Dr. Ostrowski succeeds Dr. Robert Bullis. The U.S. Marine Shrimp Farming Consortium, funded by the U.S. Department of Agriculture, Cooperative State Research, Education, and Extension Service, was formed to identify and solve problems that constrain the sustainability and expansion of the U.S. marine shrimp farming industry. The Constortium has provided U.S. shrmip producers with direct access to reliable, captive supplies of high health, selectively bred, improved shrimp stocks, and advanced disease diagnosis and treatment methods, nutrition formulation, and production technologies.

Ocean farm to raise ahi

By Andrew Gomes, The Honolulu Advertiser, Friday, August 9, 2002

[A Big Island] company has applied for an ocean lease to raise ahi for export primarily to Japan. [Ahi Nui Tuna Farming LLC] plans to capture low-value juvenile bigeye and yellowfin tuna and raise them in special net cages until double or triple in size. Ahi Nui hopes that the state will grant a lese for about 200 acres of subsurface ocean along the Kohala coast north of [Kawaihae]. Aquaculture experts said the catch-and-feed method of raising ahi can benefit local fishermen and does not significantly affect wild stocks.Ahi Nui plans to operate up to 18 cages and export primarily to [Japan where prices are higher].

The National Aquaculture Association would like member input in identifying critical issues or problems that should be addressed by the USDA ARS/CSREES Aquaculture Programs. NAA, along with other national and species associations, has been invited to participate in a joint ARS/CSREES National Aquaculture Program Planning Workshop being held on November 20 and 21, 2002. The two-day workshop is part of a strategy designed to facilitate the update of the ARS 5-year Aquaculture Action Plan and plans for the CSREES Aquaculture Program. The workshop will be used to: 1) identify research needs of the U.S. aquaculture industry; 2) prioritize these research needs for the USDA's National Aquaculture Programs; 3) aid in developing a coordinated research program which will address the aquaculture industry; 4) strengthen the integration of USDA's research, technology transfer, and extension programs in aquaculture and 5) strengthen the working dialogue among USDA's partners, professional organizations, the aquaculture industry, other interested stakeholders, and USDA program leaders and scientists to help address relevant issues in aquaculture. The Action Plan for the ARS Nation al Program 106, Aquaculture is found on the ARS web page http://www.nps.ars.usda.gov. A description of the CSREES Aquaculture Program is available at http://www.reeusda.gov/pas/aquaculture/csrees_aquaculture_home/index.htm. NAA members are asked to submit through e-mail (naa@intrepid.net) or fax (304-726-2196) three to five critical issues or problems facing the aquaculture industry that they would like addressed by the USDA ARS/CSREES Aquaculture Programs. The information will be incorporated into a 20-minute presentation by NAA at the Workshop. A report highlighting the program priorities and summaries of the various association presentations will be posted on respective agency websites following the workshop.

Gonsalves appointed Director of PBARC

A native of the Island of Hawaii, Dr. Dennis Gonsalves was appointed as the Center Director for the Pacific Basin Agricultural Research Center (PBARC) on Hawaii's "Big Island" in May 2002.

In early July Dr. Gonsalves visited the Oceanic Institute to familiarize himself with its facilities and the ongoing research activities of OI's Aquatic Feeds and Nutrition Program. The Feeds Program is administered at the local level by PBARC, which is part of the Pacific West Area of the USDA Agricultural Research Service (ARS). As Center Director, Dr. Gonsalves is responsible for the scientific and administrative management of PBARC, and provides leadership for the scientific quality, relevance and impact of the center's research programs. The PBARC office works in concert with the ARS Pacific West Area headquarters located in Albany, California, to oversee the research progress and future initiatives of OI's Feeds Program, reviewing its reports and proposals, and approving its annual research plans and budgets.

Dr. Gonsalves is a well known plant pathologist, and recently moved back to Hawaii after serving for 25 years at Cornell University's New York State Agricultural Experiment Station. His research at the Cornell facility focused on plant virology, with the goal of controlling virus diseases in fruits and vegetables. As a member of the team, which included University of Hawaii members, and developed and commercialized a transgenic papaya resistant to the papaya ringspot virus, Dr. Gonsalves' research has been extremely beneficial to the papaya industry in Hawaii and elsewhere. He also has several patents to his credit. Although he has not been living in Hawaii for the past 35 years, Hawaii was never far from his heart and Dr. Gonsalves is happy to return home. Born and raised on a sugar plantation in Kohala, Hawaii, Dennis Gonsalves graduated from Kamehameha Schools in 1961 and earned his B.S. in Horticulture in 1965 and M.S. in Plant Pathology in 1968, both from the University of Hawaii. He then moved to California to attend the University of California at Davis, where he obtained his PhD in Plant Pathology in 1972. Florida, was his next home, as he worked on viruses that affect citrus at the University of Florida, where he was a professor. Dr. Gonsalves joined Cornell University's research faculty in 1977.

CTSA received approval for its Year 15 Plan of Work on June 11, 2002. The projects approved thus far are:

Aquaculture of Hawaiian Marine Invertebrates for the Marine Ornamental Trade, Year 1
Reproduction and Selective Breeding of Pacific Threadfin, Year 1
Aquaculture of Marine Ornamental Species, Year 3
Disease Management and Virology for Hawaiian Aquaculture, Year 9
Library Aquaculture Workstation, Year 15
National Aquaculture Extension Conference
Transitioning Hawaii's Freshwater Ornamental Aquaculture Industry, Year 3
Publications, Year 12

Together the projects comprise a powerful workforce dedicated to further developing and supporting aquaculture in the region. The above listed projects have either already begun or will commence by October of this year.

AQUA TIPS

A Practical Method for Rotifer Culture Using Concentrated Microalgae

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This article was written as part of the work for the project titled "Marine Food Fish Production, Year 3," 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 rotifer (Brachionus sp) has long been an indispensable dietary component for the production of both freshwater and marine fish larvae. The purpose of this article is to describe a simple, reliable method for culturing rotifers using commercial microalgae products that can be easily applied to large or small hatchery operations.

Introduction

Following the pioneering larviculture studies of Japanese researchers in the 1960s, basic rotifer production methods were established using live microalgae and/or yeast as feed. Increasingly sophisticated yeast-based artificial diets or rotifers later became available, incorporating essential nutrients and offering 100% replacement of microalgae. Despite these diet developments it is still very common for hatcheries to use live microalgae rather than "replacement" diets for rotifer production. This is partly due to the more complex procedures required to maintain stable production using artificial diets and also because of feed costs.

Although live microalgae (commonly *Nannochloropsis* sp or *Tetraselmis* sp) offers simplicity in terms of rotifer system design, operators are all-too-frequently faced with the sense of frustration/impending disaster when algae production falters or collapses during peak demand. Substantial time and operator skill are required for proper maintenance of microalgae stocks and to manage the large culture volumes required. Space availability may also be a serious limiting factor for hatcheries because of the low algae and rotifer densities achievable.

There is clearly a case for algae replacement diets if they can be made to work simply and effectively, and concentrated microalgae products have been receiving increasing interest for this purpose. Freshwater *Chlorella* was the first such commercial product available. This product was initially developed in Japan as a human nutritional supplement, but has also revolutionized high-density rotifer production methods in that country. However, it has not been feasible to adopt freshwater *Chlorella* in the U.S., due to a combination of import restrictions, shipping charges and short shelf life.

More recently, a range of stable concentrated microalgae products has become available from California-based Reed Mariculture Inc., sold under the brand name Instant Algae®. Several species of microalgae are offered to meet the different nutritional needs of the target zooplankton, fish and shellfish species. To our knowledge these are the only such concentrated microalgae products available commercially in the U.S. The Oceanic Institute began trials with Instant Algae® in 1999 and has since adopted the product for routine rotifer production, removing the need for large-scale microalgae culture. The 3-day rotifer batch culture method described below is simple and reproducible. It does not incorporate the more sophisticated water treatment steps (pH control, automatic feeding, oxygenation), or blending of algae species needed to achieve very high rotifer densities, but this simplicity makes the method suitable for a wide range of hatchery conditions.

Culture Method

System Configuration: We have used Instant Algae® for rotifer culture in a variety of different-shaped tanks, including tall and cylindrical with a conical base and shallow and cylindrical with a flat base. It is important to prevent algae from settling on the base of the tank and tall and narrow tanks are more amenable in this respect. Exact tank dimensions do not appear to be critical provided aeration is adjusted to suit. For flat-bottomed tanks 5' in diameter by 15" deep, we place five square air stones evenly around the tank floor. A

water temperature of 28-30ºC and salinity of 25 ppt are used. The correct salinity is obtained by mixing full strength seawater with freshwater (at the Oceanic Institute this equates to approximately one-third freshwater and two-thirds saltwater)

Regular removal of particulates is essential and this is achieved by suspending filter material in the water column. For large-scale rotifer production in 5' diameter tanks, we use a white matting supplied by Aquatic Ecosystems Inc. (product code PF2). The matting is cut into squares approximately 12" by 18" and at least two of these squares are suspended from the side of each tank using stainless steel wire hooks. For smaller culture volumes (~100-200 L), green "scrubby pads" from the hardware store work satisfactorily for particle removal. In either case, it is important to remove and thoroughly rinse the filter material every day. Ideally, each culture tank should be equipped with a replacement set of filters, so that the newly-rinsed filters can be fully air-dried before reuse.

Husbandry Protocol: Reed Mariculture Inc. supplies concentrated *Nannochloropsis* at a standard density of 68 billion cells/ml. For simplicity, all feeding calculations can be based on this stated algae cell density, however it is useful to verify the actual density for each new batch received. At each feeding the concentrated algae should be mixed well with a small volume of water before dispensing into the rotifer culture tank. It is OK to prepare the full day's algae requirements in one morning session, and then store it in the refrigerator until required.

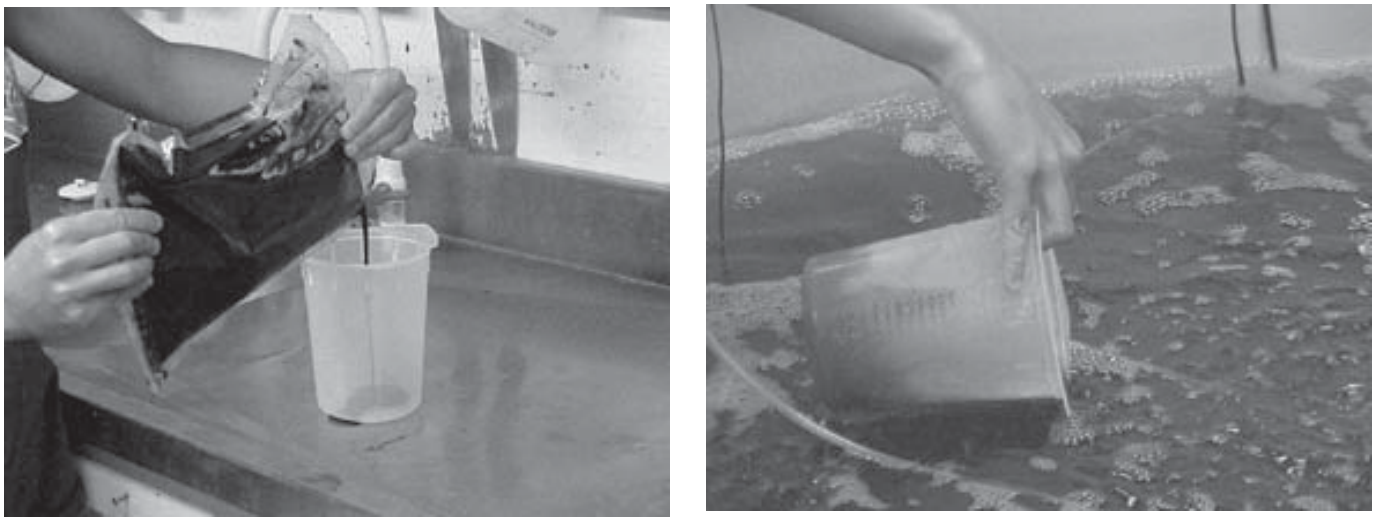

Figure 1. *The algae concentrate is simply measured (A), mixed with water and then dispensed into the rotifer culture tank (B).*

Step-by-step procedures for a 200L culture tank are described below:

- **Day 0 (Setup)**
  - Mix freshwater and saltwater to the 200L level.
  - Switch on air supply and water heaters.
  - Inoculate tank at a density of 100 rotifers/ml (= 20 million rotifers).
  - Calculate amount of Instant Algae required for a working concentration of **18 million** cells/ml (= **53 ml** for a 200L culture tank). Offer this in 4 equal rations (i.e., 13 ml per ration), spaced evenly throughout the day (7am-5pm).
- **Day 1**
  - Remove filter matting, rinse and replace with clean matting.
  - Calculate amount of Instant Algae required for a working concentration of **36 million** cells/ml (= **106 ml** for a 200L culture tank). Offer this in 4 equal rations (i.e., **26.5 ml** per ration), spaced evenly throughout the day (7am-5pm).
- **Day 2 (Harvest)**
  - Switch off air supply and water heaters.
  - Remove filter matting and gently drain the contents of the tank into a submerged nylon mesh bag. The preferred mesh size depends on which rotifer strain is being used: 70mm for s-type rotifers, 38mm for ss-type rotifers. The harvest bag should be equipped with an airstone and continuously flushed with saltwater.
  - Transfer the harvested rotifers to a well aerated bucked and count a volumetric sub-sample. Return 20 million rotifers to a clean culture tank (= day 0) and enrich the remainder in preparation for feeding to fish larvae.

This method reliably yields a four-fold increase in population density over the culture cycle, i.e., approximately 80 million rotifers harvested from 20 million inoculated. Higher yields can be obtained by increasing rotifer stocking density, feeding rate or culture

Marketing your product locally and nationally

The last issue of Regional Notes reported on the Hawaii Aquaculture Association's annual conference. One of the speakers, Mary Maunupau of Tropic Fish and Vegetable, a wholesale, export, import, retail and distribution company in Honolulu, was of particular interest to many of the participants. Following is a summary of her presentation with Glenn Tanoue, president of Tropic Fish and Vegetable, as well as some extra hints she provided later.

If farmers thought that raising a great tasting product was all that needed to be done to turn a profit – think again. Mary Maunupau told participants of the HAA conference that while a high-quality product is important, other factors can play as great, if not greater, a role in actual sales. Although being a distributor of seafood is different than being a farmer and direct seller of seafood, much of what distributors have to know comes from the farmers themselves. Being able to market your seafood product means knowing the strengths and the limitations of your product, especially compared to those of your competitors. Quality assurance, consistency, organization, and of course, cost, are some of the key elements for farmers to consider when trying to establish relationships with buyers.

These days, buyers are becoming more and more demanding in terms of quality assurance. Buyers want to know exactly how and where the product has been raised, including environmental conditions, types of feed and chemical purity. Some buyers even want paper trails. So when asked about the effectiveness of co-ops, Mary felt that although co-ops would enable small farms to sell to larger markets and to help promise consistency, it would complicate the ability to demonstrate the chain of custody to a potential buyer. Sanitation is of utmost importance, but handling, packing and processing procedures are also key issues. An implemented Hazard Analysis Critical Control Point (HACCP) plan is critical to large buyers. The use of no preservatives, additives and sulfites is ideal, but long shelf-life while maintaining the integrity of the product is also essential.

Consistency in product and supply is imperative and cannot be emphasized enough. Do everything possible to avoid establishing a bad reputation with a buyer, which may mean that some months you have a surplus that will have to be sold elsewhere. The reputation of the restaurants and retailers you sell to lies in their ability to supply what they promise as does yours. However, while quantity is important, quality of the product is equally vital. One small or poor shipment can destroy your relationship with a buyer, especially in the beginning.

The importance of knowing the product you are trying to sell cannot be stressed enough. Mary emphasized cutting, cooking, eating and testing your own product to know what will and will not work in cooking procedures. This will help in discussions with buyers and sometimes you can suggest something that perhaps they had not thought of. Many buyers will also request samples. This can be expensive, but sometimes this may be the only way to get a buyer, so don't be too miserly. But also remember that no one will deny a free product, therefore see if they will pay for the shipping so that both of you have a vested interest and you can see if they truly are serious about your product. Without samples, there is also no way to estimate an agreeable price for both parties.

Although the products that come out of Hawaii are of high quality and can fetch a fairly high price in the islands, once you tack on the costs of packing and air freight to the mainland, it makes it very difficult to market your product – even if it is "fresh from Hawaii." For example, Mary pointed out that although certain species can go for high prices locally purely based on its reputation as an *ono* or delicious fish, there may be a species already established in the mainland with many suppliers that has a similar taste and texture and is larger and cheaper than the local favorite. So, do your research. A species that is economically feasible and even profitable in Hawaii does not necessarily need to be cultured in larger quantities to make it a viable product for the mainland.

It doesn't make good business sense to raise something no one wants to buy and the inverse is also true – It makes good business sense to raise something that everyone wants to buy. Several of the participants wanted to know for what types of seafood distributors like Tropic Fish receive. According to Mary, bottomfish is a hot item. There are always requests for bottomfish, but do your research if you are thinking about going in that direction on your farm because buyers can get it for $4/lb from Samoa. However, sometimes sellers can get a better return for aquacultured fish because the fat level can be controlled and the products generally look better. Glenn Tanoue, president of Tropic Fish, also added that the size of the fish is important. Ideal weights for whole snappers are one pound, but opakapaka and onaga filets should be between five and six pounds.

Moi are best for sales at ¾-1 lb. Another hot ticket item is bluefin tuna, which goes for $15-17/lb headed and gutted (60 lbs and up is the preferred size). Glenn estimated that a 100 lb bluefin tuna yields around 80-82 lbs of saleable fish.

Although there are several factors to consider before deciding to culture a certain species, cost is always the main deciding aspect. Some things to consider that are not obvious to those investigating cost-effectiveness are: the costs of shipping and handling, the risk of delays of the flights and the labor costs to ensure that all quality assurance requirements are met, making all the shipping arrangements and tracking all costs. Shipping and handling is a particularly tricky situation. There are several different costs associated with the packaging alone. The costs of the packaging are fairly minimal, but the weight it adds to the shipment is considerable. You may be sending 30 lbs of fish but you will actually be paying to ship 45 lbs of net weight. It is a known fact that airline flights are often delayed. Because shipping fresh products from Hawaii or any other of the island nations, means putting your shipment on a plane, you have to be aware that your shipment may not get to where it needs to be before it spoils. If packed properly, most fresh fish can withstand 48 hours without refrigeration, but airlines will not allow you to file a claim to recover some of your costs unless your shipment gets pushed back over 48 hours from the original time. This means that any delays under 48 hours are losses that you have to eat.

We all know that some of the best seafood comes from our region, but sometimes that reputation is not enough. Marketing and research are essential components to any successful business plan.

Rotifer culture cont'd

from page 5

duration. For example, our standard 4-day culture procedure for ss-type rotifers yields a 7- to 10-fold population increase. However, this higher density approach requires more stringent husbandry methods to account for the increased biological loading of the system.

Using August 2002 prices of $45-72 per 1L bag of *Nannochloropsis* (depending on quantity ordered), the feed cost per million rotifers is approximately 12-19¢ using the simple culture technique described here. Hatchery operators can judge for themselves whether or not this is economically justified when compared to live algae-based culture methods. At the Oceanic Institute, our use of concentrated microalgae has freed up valuable staff time for research studies that would otherwise be spent on algae husbandry for rotifer production. At the very least, concentrated microalgae can be considered a good insurance policy against those all-too-familiar shortfalls in algae production.

The methods described in this article were developed within grants awarded to the Oceanic Institute by the USDA's Center for Tropical and Subtropical Aquaculture ("Marine Foodfish Seedstock Production") and by the National Oceanic and Atmospheric Administration ("Hawaiian Fisheries Development").

Reference to a specific product or manufacturer does not constitute its endorsement by the Oceanic Institute. The Institute has not conducted an exhaustive search or comprehensive evaluation of concentrated microalgae products from all manufacturers or suppliers.

Hydrogen sulfide cont'd

from page 1

about 105 days.

Where would hydrogen sulfide be found in an aquaculture facility?

Possible sources of hydrogen sulfide in aquaculture facilities are sludge tanks, sedimentation/settling tanks, biofilters, wells, sumps or basins etc., their associated piping and stagnant seawater in any part of a system.

It may be retained in solution, in potentially high concentrations, in salt water covered by an oily layer through which the hydrogen sulfide cannot easily diffuse, but is released by agitation of the mixture.

What can I do to eliminate the hazards of hydrogen sulfide?

In working areas, hazards arising from hydrogen sulfide can be eliminated by the usual good housekeeping practices of cleanliness and good ventilation. Good design of systems where dead spaces are eliminated will also help avoid problems associated with hydrogen sulfide production. Entry into tanks or confined spaces where hydrogen sulfide may be present should only be made in accordance with safe working practices.

Has the federal government made recommendations to protect human health?

EPA has established that hydrogen sulfide is a regulated toxic substance and is a hazardous substance as defined under the Federal Water Pollution Control Act.

The Occupational Safety and Health Administration (OSHA) has established an acceptable ceiling concentration of 20 parts per million (20 ppm) in the workplace, with a maximum level of 50 ppm allowed for 10 minutes if no other measurable exposure occurs.

The National Institute of Occupational Safety and Health (NIOSH) recommends a maximum exposure level of **10 ppm**.

Sources of Information:

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for hydrogen sulfide. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

For more information:

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. Or contact your community or state health or environmental quality department if you have any more questions or concerns.

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333
Phone: 1-888-422-8737
http://www.atsdr.cdc.gov/tfacts114.html)

You can also get information on hydrogen chloride specific to aquaculture from http://www.lib.noaa.gov/docaqua/safety.html.

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 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 (USDA/CSREES), the centers integrate individual and institutional expertise and resources in support of commercial aquaculture development.

CTSA currently assists aquaculture development in the region that includes Hawaii and the U.S. Affiliated Pacific Islands (American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Republic of Belau [Palau] and the Republic of the Marshall Islands.)

In its thirteen years of operation, CTSA has distributed $7 million to fund more than 130 projects addressing a variety of national aquaculture priorities.

Each year, the Center works closely with industry representatives to identify priorities that reflect the needs of the aquaculture industry. After consultation with appropriate technical experts, CTSA responds with a program of directed research with objectives that focus on these industry priorities.

FAST FACT

Aquaculture was first practiced in China, more than 2000 years ago.

A Board of Directors is responsible for overseeing the programmatic functions of CTSA. Results of CTSA projects are disseminated through its print publications, hands- on training workshops, and Web site.

CTSA is jointly administered by The Oceanic Institute and the University of Hawaii and is located at The Oceanic Institute's Makapu'u Point site on the island of Oahu in Hawaii.

For further information on the CTSA program, contact Cheng-Sheng Lee, Ph.D., Director, by phone (808-259-3107), fax (808-259-8395) or by email at cslee@oceanicinstitute.org.

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