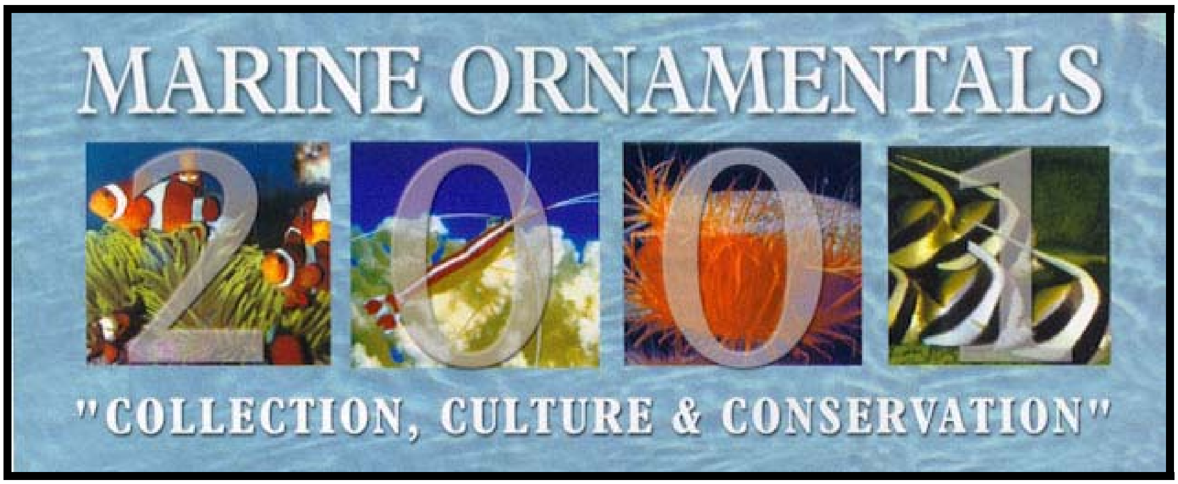
Program & Abstracts



November 26-December 1, 2001

Lake Buena Vista, Florida, USA

UNIVERSITY OF FLORIDA
Institute of Food and Agricultural Sciences

Sea Grant
Florida – and – National

Florida Department of Agriculture and Consumer Services
DIVISION OF AQUACULTURE
Charles H. Bronson, Commissioner

UNIVERSITY OF FLORIDA

Florida Sea Grant College Program
The State University System Program for Coastal Research, Education & Extension

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Welcome to Marine Ornamentals 2001: Collection, Culture & Conservation

Marine Ornamentals '99, held in Hawaii, was the first international conference to focus entirely on the collection, culture and conservation of marine ornamental species. Industry representatives, scientists, students, agency representatives and interested citizens attended. Our appreciation goes to Hawaii Sea Grant for taking the lead in organizing MO '99. Our thanks also go to the sponsors of that conference. The proceedings were recently sent to all attendees and a special issue of *Aquarium Sciences and Conservation* has been published, containing many of the papers from MO '99.

Marine Ornamentals 2001 builds on MO '99 by continuing the conference focus on the collection, culture and conservation of marine ornamental species. Florida Sea Grant assumed the lead role in organizing MO '01. I co-chaired the 21 person Organizing Committee, along with John Corbin, Hawaii Aquaculture Development Program, and Sherman Wilhelm, Division of Aquaculture, Florida Department of Agriculture and Consumer Services. The success of the conference can be traced directly to the strong support of this committee and our sponsors. Ms. Beth Miller-Tipton, UF/IFAS Office of Conferences and Institutes, and her staff did a superb job as conference organizers. This conference would also not have occurred without the financial support of the many sponsors listed in the program.

For MO '01, keynote and plenary speakers come from six countries. Contributed paper presenters come from 13 countries. Within the U.S., speakers come from 19 states. One month prior to the conference, attendees had registered from 21 countries and 31 states of the U.S. Trade show participants come from six states. We really appreciate your interest and attendance.

Now, a challenge to all of you! Hawaii Sea Grant and Florida Sea Grant have led the organization of the first two international conferences. A hosting organization is needed for MO '03, in 2003, for the conference to continue. To be truly international, we hope a host from outside the U.S. steps forward to assume leadership for MO '03. We will all do our part to assist.

Finally, the conference is located in the heart of Florida. Please enjoy our natural and created attractions while you are in our state. Please let me or any member of the organizing committee be of assistance, and thanks again for attending.

James C. Cato
Co-Chair and Conference Organizer
Director, Florida Sea Grant

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Conference Sponsors

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- FAO/Rome Italy/Fishery Industries Division
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- Hawaii Aquaculture
- Louisiana Sea Grant College Program
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Organizing Committee

Ilze Berzins, The Florida Aquarium, Tampa, FL, USA

Chris Brown, Florida International University, Marine Biology Program, North Miami, FL, USA

Jim Cato, **Co-Chair & Conference Organizer**, Florida Sea Grant, University of Florida, Gainesville, FL, USA

John Corbin, **Co-Chair**, Hawaii Aquaculture Development Program, Honolulu, HI, USA

LeRoy Creswell, Florida Sea Grant and St. Lucie County Extension Agent, University of Florida/IFAS, Gainesville, FL, USA

Ruth Francis-Floyd, Department of Fisheries & Aquatic Sciences, University of Florida/IFAS, Gainesville, FL, USA

Edmund Green, World Conservation Monitoring Centre, Cambridge, UK

Joan Holt, University of Texas, Port Aransas, TX, USA

Paul Holthus, Marine Aquarium Council, Honolulu, HI, USA

Steve Kearl, Florida Sea Grant, Gainesville, FL, USA

Audun Lem, Fishery Industries Division, Fish Utilization and Marketing Service, U.N. Food and Agriculture Organization, Rome, Italy

Junda Lin, Florida Institute of Technology, Melbourne, FL, USA

Kevan Main, Mote Marine Laboratory, Sarasota, FL, USA

Nancy Marcus, Florida State University, Tallahassee, FL, USA

Karen Metcalf, Division of Aquaculture, Florida Department of Agriculture & Consumer Services, Tallahassee, FL, USA

Martin Moe, Green Turtle Publications, Islamorada, FL, USA

Steve Olson, American Zoo and Aquarium Association, Silver Spring, MD, USA

Craig Osenberg, Department of Zoology, University of Florida, Gainesville, FL, USA

Jay Rasmussen, Oregon Sea Grant College Program, Newport, OR, USA

Jim Robinett, John G. Shedd Aquarium, Chicago, IL, USA

Bill Seaman, Florida Sea Grant, Gainesville, FL, USA

Craig Watson, Tropical Aquaculture Laboratory, University of Florida/IFAS, Gainesville, FL, USA

Sherman Wilhelm, **Co-Chair**, Division of Aquaculture, Florida Department of Agriculture & Consumer Services, Tallahassee, FL, USA

Program Agenda

Tuesday, November 27, 2001

9:00am – 5:30pm	Conference Registration Office Open
	Keynote Plenary Session – *Ireland Room*
1:00pm – 1:10pm	**Opening Remarks** **Moderator: *James C. Cato***, Director, Florida Sea Grant and Professor, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, USA;
1:10pm – 1:30pm	**Welcome and Florida's Role in Advancing the Ornamental Species Industry — *Michael V. Martin***, Vice President for Agriculture and Natural Resources, University of Florida, Institute of Food and Agricultural Sciences, Gainesville, FL, USA;
1:30pm – 2:15pm	**Keynote Speaker: CONSERVATION** **Buy a Fish, Buy a Coral, Save a Reef: The Importance of Economic Incentives to Sustain Conservation — *Bruce Bunting*,** Vice President, Center for Conservation Finance, World Wildlife Fund US, Washington, DC, USA;
2:15pm – 2:30pm	Question and Answer Session with *Bruce Bunting*
2:30pm – 3:15pm	**Keynote Speaker: CULTURE** **Culture of Marine Ornamentals: For Love, For Money and For Science — *Martin Moe,*** Green Turtle Publications, Islamorada, FL, USA;
3:15pm –3:30pm	Question and Answer Session with *Martin Moe*
3:30pm – 3:45pm	**REFRESHMENT BREAK** – *Hampton Court*
3:45pm – 4:30pm	**Keynote Speaker: COLLECTION** **Sustainability in the Global Marine Ornamentals Trade: A Win/Win Linking Coral Reefs, Collectors and Consumers — *Malcolm I. Sarmiento, Jr.,*** Director, Bureau of Fisheries and Aquatic Resources Republic of the Philippines, Quezon City, Philippines;
4:30pm – 4:45pm	Question and Answer Session with *Malcolm I. Sarmiento, Jr.*
4:45pm – 5:15pm	**Balancing Marine Ornamentals Industry Growth and Sustainable Reef Ecosystems: A View from Congress — *The Honorable Eni F. H. Faleomavaega***, Member of Congress, American Samoa, Delegate, Washington, DC, USA;
5:15pm	OPENING SESSION CONCLUDES
5:15pm – 7:00pm	Poster Presenters to set up displays in Exhibit Area
7:00pm – 9:00pm	**WELCOME RECEPTION** – *Scotland Room*

Wednesday, November 28, 2001

7:30am – 5:30pm	Conference Registration Office Open
7:30am – 8:30am	**MORNING REFRESHMENTS** – *Scotland Room*

Plenary Session – *Ireland Room*

	Moderator: ***Sherman Wilhelm***, Director, Division of Aquaculture, Florida Department of Agriculture and Consumer Services, Tallahassee, FL, USA;
8:30am – 9:00am	**Wild Caught Marine Species and the Ornamental Aquatic Industry —** *John Dawes*, Secretary General, Ornamental Fish International, Manilva Málaga, Spain; ***Svein A. Fossa***, Chairman of the Conservation Committee of Ornamental Fish International, and European Liaison Director in Marine Aquarium Council;
9:00am – 9:30am	**Supplying the Demand for Sustainability: Stories from the Field — *Ferdinand Cruz***, International Marinelife Alliance, Metro Manila, Philippines;
9:30am – 10:00am	**From Reef to Retail: Marine Ornamental Certification for Sustainability is here — *Paul Holthus***, Marine Aquarium Council, Honolulu, HI, USA;
10:00am – 10:30am	**REFRESHMENT BREAK** – *Exhibit Hall*
10:30am – 5:00pm	**THREE CONCURRENT SESSIONS (A, B, C)**

Concurrent Session A: Seahorse Culture – *Ireland Room*

	Moderator: ***Jay Rasmussen***, Sea Grant Extension Program Leader, Oregon State University, Newport, OR, USA;
10:30am – 11:00am	**Factors Affecting Successful Culture of the Seahorse *Hippocampus abdominalis* Leeson, 1827 — *Chris Woods***, National Institute of Water & Atmospheric Research, Wellington, New Zealand;
11:00am – 11:30am	**Rearing the Coral Seahorse, *Hippocampus barbouri*, on Inert Prey — *Michael F. Payne***, Good Fins, Perth, Western Australia;
11:30am – 12noon	**The Copepod/*Artemia* Tradeoff in the Captive Culture of *Hippocampus erectus* (Syngnathidae) — *Todd Gardner*,** Hofstra University Aquaculture Laboratory, Hempstead, NY, USA;
12noon – 1:30pm	**LUNCH** – *Exhibit Hall*

Wednesday, November 28, 2001 *(continued)*

	Concurrent Session B: Live Rock Culture – *Emerald Room*
	Moderator: ***William Rickards***, Director, Virginia Sea Grant, University of Virginia, Charlottesville, VA, USA;
10:30am – 11:00am	**Florida Aquacultured Live Rock as an Alternative to Imported Wild Harvested Live Rock: An Update — *William W. Falls*** and *J. N. Ehringer*, Hillsborough Community College, Tampa, FL, USA; *Roy and Teresa Herndon*, Sea Critters, Dover, FL, USA; *Michael Nichols and Sandy Nettles*, Triton Marine, Ozone, FL, USA; *Cynthia Armstrong and Darlene Haverkamp*, Florida Marine Research Institute, St. Petersburg, FL, USA & Port Manatee, FL, USA; *Michael Robinson,* Nova Southeast University, Boca Raton, FL, USA;
11:00am – 11:30am	**Live Rock Farming Using Sand Molded Substrate — *LeRoy Headlee*** and *Sally Jo. Headlee*, Geothermal Aquaculture Research Foundation, Boise, Idaho, USA;
11:30am – 12noon	**Producing Sps Coral Fragments Using Escape Size and Fragment Orientation — *Sally Jo Headlee*** and *LeRoy Headlee*, Geothermal Aquaculture Research Foundation, Boise, ID, USA;
12noon - 1:30pm	**LUNCH** – *Exhibit Hall*

	Concurrent Session C: Certification Demand – *Diamond Room*
	Moderator: ***John Corbin***, Director, Hawaii Aquaculture Development Program, Honolulu, HI, USA;
10:30am – 11:00am	**Certification for Marine Ornamentals: What it is and How it Works — *Peter Scott*** and *David Vosseler*, Marine Aquarium Council, Honolulu, HI, USA;
11:00am – 11:30am	**Value and Demand for MAC-Certification —** *Sherry Larkin*, ***Wendy Rubinstein*** and *Robert Degner*, University of Florida, Gainesville, FL, USA;
11:30am – 12noon	**Creating Consumer Demand for MAC Certified Marine Ornamentals — *Sylvia Spalding*,** Marine Aquarium Council, Honolulu, HI, USA;
12noon - 1:30pm	**LUNCH** – *Exhibit Hall*

Wednesday, November 28, 2001 *(continued)*

	Concurrent Session A: Feeding and Health – *Emerald Room*
	Moderator: ***Ilze Berzins***, Director of Research and Conservation Programs, Florida Aquarium, Tampa, FL, USA;
1:30pm – 2:00pm	**Delay Feeding and Feeding Regimes Effect Survival of Young Seahorse, *Hippocampus kuda* Bleeker — *V. Muthuwan*,** *N. Luang-Oon, S. Sawatpeera, S. Chalad-Kid, T. Noiraksa*, and *J. Teeramaethee*, Institute of Marine Science, Burapha University, Chonburi Province, Thailand;
2:00pm – 2:30pm	**An Overview of Common Syngnathid Health Problems — *Ilze K. Berzins***, The Florida Aquarium, Tampa, FL, USA; *Martin Greenwell*, John G. Shedd Aquarium, Chicago, IL, USA;
2:30pm – 3:00pm	**The Use of Ovaprim ® as a Treatment for an "Egg-bound" Frogfish (*Antennarius striatus*) — *Roy P. E. Yanong***, *Craig A. Watson* and *Eric W. Curtis,* Tropical Aquaculture Laboratory, Department of Fisheries and Aquatic Sciences, University of Florida, Ruskin, FL, USA; *Harry J. Grier,* Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, Stock Enhancement Research Facility, Palmetto, FL, USA; *Sarah L. Carson,* Oklahoma State University College of Veterinary Medicine, Stillwater, OK, USA; *Gail Case,* Mote Marine Laboratory Aquarium, Sarasota, FL, USA;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

	Concurrent Session B: Live Rock/Urchins/Cyanide – *Ireland Room*
	Moderator: ***William Rickards***, Director, Virginia Sea Grant, University of Virginia, Charlottesville, VA, USA;
1:30pm – 2:00pm	**The Economics of Live Rock and Live Coral Aquaculture — *Robert Pomeroy*** and *John Parks*, World Resources Institute, Washington, DC, USA;
2:00pm – 2:30pm	**Spontaneous Spawning of *Diadema antillarum* Under Photo-thermal Control: An Essential Step for Year-round Laboratory Culture — *Thomas Capo***, *Albert Boyd* and *John Bauer*, University of Miami, Key Biscayne, FL, USA; *Debra Cole*, Coral Gables High School, Coral Gables, FL, USA; *Margaret W. Miller*, Southeast Fisheries Center, Key Biscayne, FL, USA; *Alina M. Szmant*, University of North Carolina, Wilmington, NC, USA;
2:30pm – 3:00pm	**Non-Implementation of Anti-Cyanide Measures in Poor Coastal Areas — *Howard A. Latin***, Rutgers University School of Law, Newark, NJ, USA;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

Wednesday, November 28, 2001 *(continued)*

Concurrent Session C: Sustainability/Habitat – *Diamond Room*

Moderator: ***Robert Stickney***, Director, Texas Sea Grant, Texas A&M University, College Station, TX, USA;

1:30pm – 2:00pm **The Philippine Ornamental Fish Industry Reinvents Itself —** ***Aquilino Alvarez,*** Marine Aquarium Council - Philippines, Manila, Philippines;

2:00pm – 2:30pm **Survival of Targeted Corals Collected for the Marine Aquarium Trade Depends on Requirements for Habitat and Collection Locale —** ***Eric H. Borneman,*** Microcosm, Ltd., Shelburne, VT, USA;

2:30pm – 3:00pm **Development of Sustainable Management Guidelines for the Stony Coral Trade —** ***Andrew W. Bruckner,*** NOAA/NMFS, Silver Spring, MD, USA;

3:00pm – 3:30pm **REFRESHMENT BREAK** – *Exhibit Hall*

Concurrent Session A: Population Status – *Diamond Room*

Moderator: ***Craig Watson***, Director, Tropical Aquaculture Laboratory, Fisheries and Aquatic Sciences Department, Institute of Food and Agricultural Sciences, University of Florida, Ruskin, FL, USA;

3:30pm – 4:00pm **Population Status of Marine Ornamental Fish and Invertebrates in Sri Lanka and Development of Management Strategies for the Industry —** ***Elizabeth Wood*** and *Arjan Rajasuriya*, Marine Conservation Society, Ross-on-Wye, Herefordshire UK;

4:00pm – 4:30pm **Population Structure of the Cortez Rainbow Wrasse (Thalassoma lucasanum) in an Exploited Area in the Pacific Coast of Costa Rica —** *Arturo Dominici-Arosemena*[1], ***Helena Molina-Ureña***[2], *Jorge Cortés-Núñez*[2], *and Ernesto Brugnoli-Olivera*[3], [1]Smithsonian Tropical Research Institute, Balboa, Ancón, Panamá; [2]CIMAR, Universidad de Costa Rica, San José, Costa Rica, [3]Universidad de la República Oriental del Uruguay, Montevideo, Uruguay;

Concurrent Session B: Coral Culture – *Ireland Room*

Moderator: ***Ron Hodson***, Director, North Carolina Sea Grant, North Carolina State University, Raleigh, NC, USA;

3:30pm – 4:00pm **Coral Culture - Possible Future Trends and Directions —** ***Michael Arvedlund,*** DANAQ CONSULT Ltd., Kalundborg, Denmark; *Jamie Cragg* and *Joe Pecorelli*, London Aquarium, County Hall, London, UK;

Wednesday, November 28, 2001 *(continued)*

4:00pm – 4:30pm	**Enhancing Growth of Caribbean Sea Fan Corals in Closed-Cycle Systems — *Kevin E. Gaines***, Harbor Branch Oceanographic Institution, Fort Pierce, FL, USA and *Kevan L. Main*, Mote Marine Laboratory, Sarasota, FL, USA;
	Concurrent Session C: Sustainability – *Emerald Room*
	Moderator: *Robert Stickney*, Director, Texas Sea Grant, Texas A&M University, College Station, TX, USA;
3:30pm – 4:00pm	**Twenty Years of Sustainable Fish Collecting in Mexico in a Baja Fishing Village — *Steve B. Robinson*,** Cortez Marine, Loreto, Baja California Sur, Mexico;
4:00pm – 4:30pm	**Marine Ornamentals in Indonesia: Challenges and Opportunities for Sustainability — *Rezal Kusumaatmadja*** and *Gayatri Lilley,* Marine Aquarium Council, Honolulu, HI, USA;
	Plenary Session – *Ireland Room*
4:30pm – 5:00pm	**Preview of Research and Education Priority Setting — *John Corbin,*** Hawaii Aquaculture Development Program, Honolulu, HI, USA;
5:00pm – 7:00pm	Poster Session Social in Exhibit Area

Thursday, November 29, 2001

7:30am – 5:30pm	Conference Registration Office Open
7:30am – 8:30am	**MORNING REFRESHMENTS** – *Scotland Room*
	Plenary Session – *Ireland Room*
	Moderator: *James McVey*, Aquaculture Program Specialist, National Sea Grant Office, NOAA, Silver Spring, MD, USA;
8:30am – 9:00am	**Current Issues in Disease Control in Marine Ornamentals — *Michael K. Stoskopf, DVM***, College of Veterinary Medicine, North Carolina State University, Raleigh, NC, USA;
9:00am – 9:30am	**The Role of Public Aquaria in the Conservation and Sustainability of the Marine Ornamentals Trade — *Heather Hall, DVM,*** Curator of Lower Vertebrates, London Zoo, Regent's Park, London United Kingdom;
9:30am – 10:00am	**World Trade in Ornamental Species — *Audun Lem,*** Fish Utilization and Marketing Service, FAO, Rome, Italy;
10:00am – 10:30am	**REFRESHMENT BREAK** – *Exhibit Hall*

Thursday, November 29, 2001 *(continued)*

10:30am – 5:00pm **THREE CONCURRENT SESSIONS (A, B, C)**

Concurrent Session A: Nutrition and Disease – *Emerald Room*

Moderator: *Craig Osenberg*, Professor, Department of Zoology, University of Florida, Gainesville, FL, USA;

10:30am – 11:00am **Captive Nutritional Management of Herbivorous Reef Fish Using Atlantic Surgeonfish (*Acanthurus* spp.) as a Model —** *Ruth Francis-Floyd* , University of Florida, College of Veterinary Medicine, Department of Fisheries and Aquatic Sciences, Gainesville, FL, USA and ***G. Christopher Tilghman*****,** University of Florida, Department of Fisheries and Aquatic Sciences, Gainesville, FL, USA;

11:00am – 11:30am **Copper Resistant Amyloodininosis and Possible Immunosuppression in Marine Fish — *RuthEllen Klinger*,** *Ruth Francis-Floyd* and *Allen Riggs,* University of Florida, Gainesville, FL, USA;

11:30am – 12noon **Atypical Presentation of Mycobacteriosis in a Collection of Frogfish *(Antennarius striatus)* — *Roy P. E. Yanong*** and *Eric W. Curtis*, Tropical Aquaculture Laboratory, Department of Fisheries and Aquatic Sciences, University of Florida/IFAS, Ruskin, FL, USA; *Scott P.Terrell*, Walt Disney World Animal Programs, Disney's Animal Kingdom, Bay Lake, FL and University of Florida, Department of Pathobiology, Gainesville, FL, USA; *Gail Case,* Mote Marine Laboratory Aquarium, Sarasota, FL, USA;

12noon - 1:30pm **LUNCH** – *Exhibit Hall*

Concurrent Session B: Aquaria Ecosystems/Cyanide – *Ireland Room*

Moderator: *John Stevely*, Florida Sea Grant and Manatee County Extension Agent, University of Florida, Institute of Food and Agricultural Sciences, Palmetto, FL, USA;

10:30am – 11:00am **The Effects of Sulfur on Nitrate Levels in a Closed Saltwater Ecosystem — *Valerie K. Rule*,** *William Longmore* and *Leonard Sonnenschein,* St. Louis Children's Aquarium, Brentwood, MO, USA;

11:00am – 11:30am **The Evolution of Marine Aquaria: A Pictorial Display of the Past, Present and Future** — ***Jeff A. Turner***, Reef Aquaria Design, Parkland, FL, USA;

11:30am – 12noon **Trends Determined by Cyanide Testing on Marine Aquarium Fish in the Philippines — *Peter J. Rubec*,** *Vaughan R. Pratt* and *Brian McCullough,* International Marinelife Alliance, Honolulu, HI, USA; *Benita Manipula,* and *Emma R. Suplido,* International Marinelife Alliance, Manila, Philippines;

Thursday, November 29, 2001 *(continued)*

12noon - 1:30pm	**LUNCH** – *Exhibit Hall*
	Concurrent Session C: Sustainability/Marketing – *Diamond Room*
	Moderator: ***Charles Adams***, Professor, Marine Economics Specialist, Florida Sea Grant and Food Resource Economics Department, University of Florida, Institute of Food and Agricultural Sciences, Gainesville, FL, USA;
10:30am – 11:00am	**An International Reef Monitoring Program for the Marine Aquarium Trade —** ***Jennifer Liebeler*** and Gregor Hodgson, Reef Check Institute of the Environment, UCLA, Los Angeles, CA, USA;
11:00am – 11:30am	**Coral Farming in the Philippines: Reef Restoration and Sustainable Use by the Aquarium Trade —** ***Joey Gatus***, International Marinelife Alliance, Manila, Philippines; *Vaughan R. Pratt* and *Peter J. Rubec*, International Marinelife Alliance, Honolulu, HI, USA;
11:30am – 12noon	**Perceptions and Market Opinions of U.S. Marine Ornamental Wholesalers** — ***Sherry Larkin***, *Robert Degner, Donna Lee* and *Charles Adams,* University of Florida, Gainesville, FL, USA;
12noon - 1:30pm	**LUNCH** – *Exhibit Hall*
	Concurrent Session A: Disease Diagnosis – *Emerald Room*
	Moderator: ***Ruth Francis-Floyd***, Associate Professor, Department of Fisheries and Aquatic Sciences, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, USA;
1:30pm – 2:00pm	**Disease Diagnosis in Ornamental Marine Fish: A Retrospective Analysis, 1987-2001 —** ***Ruth Francis-Floyd***, University of Florida, Gainesville, FL, USA;
2:00pm – 2:30pm	**Sampling for Success: Getting the Most from Your Diagnostic Laboratory —** ***Jerry R. Heidel*****,** Oregon State University Veterinary Diagnostic Laboratory, Corvallis, OR, USA;
2:30pm – 3:00pm	**The Risks and the Reality: Bacterial Diseases, Marine Ornamentals and Human Health —** ***Timothy J. Miller-Morgan,*** Oregon Sea Grant, Hatfield Marine Science Center, Newport, OR, USA;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

Thursday, November 29, 2001 *(continued)*

Concurrent Session B: Management/Alien Species – *Diamond Room*

Moderator: *John Stevely*, Florida Sea Grant and Manatee County Extension Agent, University of Florida, Institute of Food and Agricultural Sciences, Palmetto, FL, USA;

1:30pm – 2:00pm	**Future of Marine Ornamental Fish Culture — *Frank Hoff***, Florida Aqua Farms Inc., Dade City, FL, USA;
2:00pm – 2:30pm	**Florida's Aquaculture Best Management Practices Program — *Karen Metcalf,*** Division of Aquaculture, Florida Department of Agriculture and Consumer Services, Tallahassee, FL, USA;
2:30pm – 3:00pm	**Alien Species, Hawaiian Coral Reefs and the Potential Impact of the Marine Aquarium Trade: A Natural Resource Manager's Nightmare… — *Dave Gulko,*** Division of Aquatic Resources, Hawaii Department of Land and Natural Resources, Honolulu, HI, USA;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

Concurrent Session C: Trade – *Ireland Room*

Moderator: *LaDon Swann*, Interim Director, Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS, USA;

1:30pm – 2:00pm	**Responsibilities for Collection and Opportunities in Aquaculture for Developing Countries through the Marine Aquarium Trade — *Walt Smith*,** Walt Smith International, Fiji;
2:00pm – 2:30pm	**Current Status of the Wild Marine Ornamental Fish Trade in Puerto Rico — *Edgardo Ojeda-Serrano*** and *Alfonso Aguilar-Perera,* University of Puerto Rico-Sea Grant Program; *Daniel Matos-Caraballo,* Department of Natural and Environmental Resources of Puerto Rico;
2:30pm – 3:00pm	**The United States' Consumption of Marine Ornamentals: A Description from U.S. Import Data — *Cristina Balboa,*** World Resources Institute, Washington DC, USA;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

Concurrent Session A: Education/Urchin/Artificial Reefs – *Ireland Room*

Moderator: *Karen Metcalf*, Biological Administrator, Division of Aquaculture, Florida Department of Agriculture and Consumer Services, Tallahassee, FL, USA;

3:30pm – 4:00pm	**MicroReef Aquariums, Educational Tools for the Classroom — *Thomas Frakes*,** Aquarium Systems, Mentor, OH, USA;

Thursday, November 29, 2001 *(continued)*

4:00pm – 4:30pm **Cultivation techniques for the Variegated Urchin *Lytechinus variegatus* — *Richard Hubbard*,** *Ray Wolcott* and *Bart Baca***,** Nova Southeastern University Oceanographic Center, Dania Beach, FL, USA;

Concurrent Session B: Coral Propagation – *Emerald Room*

Moderator: *John Stevely*, Florida Sea Grant and Manatee County Extension Agent, University of Florida, Institute of Food and Agricultural Sciences, Palmetto, FL, USA;

3:30pm – 4:00pm Part I of II – Presentation of Paper: **Asexual Coral Propagation for the Aquarium Trade and for Reef Restoration Work Using Reef Balls ™** — *Michael R. King*, Coalition Of Reef Lovers (C.O.R.L.) Grand Rapids, MI, USA; ***Todd R. Barber***, Reef Ball Development Group, Ltd and *John Walch,* with a case presentation by Coral Life of Malaysia;

4:00pm – 4:30pm Part II of II – Presentation of Case Study: **Commercialization of Coral Propagation – a Malaysian Experience —** *Sarala Aikanathan***,** Coral Life Sdn Bhd, Kuala Lumpur, Malaysia; ***Todd R. Barber***, Reef Ball Foundation, Inc, Bradenton, FL, USA;

Concurrent Session C: Species Composition – *Diamond Room*

Moderator: *LaDon Swann*, Interim Director, Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS, USA;

3:30pm – 4:00pm ***The Use of Live-Rock Sites and Artificial Substrates for the Collection of Ornamental Fishes —*** *Ken Nedimyer*, Sea Life Inc., Tavernier, FL, USA; *Craig A. Watson*, Department of Fisheries and Aquatic Sciences, Tropical Aquaculture Laboratory, University of Florida, Institute of Food and Agricultural Sciences, Ruskin, FL, USA; ***Craig W. Osenberg*** and *Colette M. St. Mary*, Department of Zoology, University of Florida, Gainesville, FL, USA;

4:00pm – 4:30pm **Intestinal Flagellates in Cultured Clown Fish (*Amphiprion* sp.): Clinical Presentation and Management - *Ruth Francis-Floyd,*** University of Florida, College of Veterinary Medicine, Department of Large Animal Clinical Sciences, Gainesville, FL, USA;

Plenary Session – *Ireland Room*

4:30pm – 5:30pm **Research and Education Priorities for the Future: Discussion of 2001 Priorities — *John Corbin,*** Hawaii Aquaculture Development Program, Honolulu, HI, USA;

Thursday, November 29, 2001 *(continued)*

6:30pm – 10:00pm **Island Reception at Sea World of Florida**

***** SEA WORLD ITINERARY *****

6:30pm	**Group to board buses** (outside Great Hall Assembly Foyer)
6:45pm	**Buses depart for Sea World**
7:00pm – 9:30pm	**Reception and Sea World Entertainment**
9:30pm	**Group to board buses for return to hotel**
10:00pm	**Arrive at hotel**

Friday, November 30, 2001

7:30am – 5:30pm Conference Registration Office Open

7:30am – 8:30am **MORNING REFRESHMENTS** – *Scotland Room*

Plenary Session – *Ireland Room*

Moderator: ***William Seaman***, Associate Director, Florida Sea Grant, and Professor, Fisheries and Aquatic Sciences Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, USA;

8:30am – 9:00am **The Status of the World Conservation Monitoring Centre Marine Aquarium Database — *Edmund Green,*** World Conservation Monitoring Centre, Cambridge, United Kingdom;

9:00am – 9:30am **Balancing Collection and Conservation of Marine Ornamental Species in the Florida Keys National Marine Sanctuary — *Billy Causey,*** Superintendent, Florida Keys National Marine Sanctuary, Marathon, FL, USA;

9:30am – 10:00am **Perspectives in Coral Culture: Science, Medicine and Aquatic Hobby Medicines — *Jean M. Jaubert,*** Director, Scientific (European Oceanographic) Centre of Monaco, Saint Martin, Monaco – *and* – Professor of Marine Biology, University of Nice, Faculty of Sciences, Campus Valrose, Nice, France;

10:00am – 10:30am **REFRESHMENT BREAK** – *Exhibit Hall*

Friday, November 30, 2001 *(continued)*

10:30am – 3:00pm	**THREE CONCURRENT SESSIONS (A, B, C)**

	Concurrent Session A: Culture Techniques – *Ireland Room*
	Moderator: ***Nancy Marcus***, Robert O. Lawton Distinguished Professor and Mary Sears Professor of Oceanography, Department of Oceanography, Florida State University, Tallahassee, FL, USA;
10:30am – 11:00am	**Captive Reproduction of Yellow Tang and Pygmy Angelfishes at the Oceanic Institute in Hawaii — *Charles W. Laidley***, *Andrew F. Burnell* and *Anthony C. Ostrowski,* The Oceanic Institute, Waimanalo, HI, USA;
11:00am – 11:30am	**Breeding and Larval Rearing of the Saddleback Anemonefish, *Amphiprion polymnus* Linneaus — *V. Muthuwan***, *S. Sawatpeera, N. Luang-Oon, S. Munkongsomboon* and *A. Chomrung,* Institute of Marine Science, Burapha University, Chonburi Province, Thailand;
11:30am – 12noon	**Spawning and Larval Rearing of Jackknife (*Equetus lanceolatus*), a Marine Ornamental Fish — *Matt Palmtag*** and *G.J. Holt,* University of Texas at Austin Marine Science Institute, Port Aransas, TX, USA;
12noon - 1:30pm	**LUNCH** – *Exhibit Hall*

	Concurrent Session B: Shrimp Culture – *Emerald Room*
	Moderator: ***LeRoy Creswell***, Florida Sea Grant and St. Lucie County Extension Agent, Institute of Food and Agricultural Sciences, University of Florida, Ft. Pierce, FL, USA;
10:30am – 11:00am	**Overview of Marine Ornamental Shrimp Aquaculture — *Junda Lin,*** Florida Institute of Technology, Melbourne, FL, USA;
11:00am – 11:30am	**Small Scale Mysid Shrimp Culture — *Jay F. Hemdal,*** The Toledo Zoo, Toledo, OH, USA;
11:30am – 12noon	**Control of Pest Anemone *Aiptasia pallida* by Ornamental Shrimp *Lysmata rathbunae* and *L. wurdemanni* — *Andrew L. Rhyne*,** *J. Li,* and *V. Maxwell,* Florida Institute of Technology, Melbourne, FL, USA;
12noon - 1:30pm	**LUNCH** – *Exhibit Hall*

Friday, November 30, 2001 *(continued)*

Concurrent Session C: Coral Culture – *Diamond Room*

Moderator: ***Mike Spranger***, Assistant Sea Grant Director for Extension and Assistant Extension Dean for Aquatic, Coastal and Aquaculture Programs, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, USA;

10:30am – 11:00am	**Propagation of Scleractinian Corals from Wild-captured Gametes: Mass-culture from Mass-spawning —** *Alina M. Szmant,* University of North Carolina at Wilmington, Wilmington, NC, USA; ***Margaret W. Miller,*** NOAA Southeast Fisheries Center, Miami, FL; USA; and Tom Capo, University of Miami, Miami, FL, USA;
11:00am – 11:30am	**A Study of Coral Diet Supplements in a Closed Ecosystem —** ***Jennifer L. Bryan,*** *William Longmore* and *Leonard Sonnenschein,* St. Louis Children's Aquarium, Brentwood, MO, USA;
11:30am – 12noon	**Nubbin-size Dependent Budding and Survival in Corals of *Pachyclavularia violacea* and *Galaxea fasciculari* Under Natural and Artificial Environments? —** ***Ta-Yu Lin*** and *Li-Lian Liu*, Institute of Marine Biology National Sun Yat-sen University, Kaohsiung, Taiwan;
12noon - 1:30pm	**LUNCH** – *Exhibit Hall*

Concurrent Session A: Fish Culture – *Ireland Room*

Moderator: ***Kevan Main***, Director, Center for Aquaculture Research and Development, Mote Marine Laboratory, Sarasota, FL, USA;

1:30pm – 2:00pm	**Development of Prey Capture Mechanics and Kinematics in Marine Fish Larvae: A Novel Approach to Identifying a Major Bottleneck in Ornamental Fish Larviculture — *Ralph G. Turingan,*** Florida Institute of Technology, Melbourne, FL, USA;
2:00pm – 2:30pm	**Induced Spawning of False Percula Clownfish *Amphiprion ocellaris* by Hormone Injection — *Scott E. Clement*** and *Christopher C. Kohler,* Fisheries and Illinois Aquaculture Center, Carbondale, IL, USA;
2:30pm – 3:00pm	**The Developmental Stages of the Saddleback Anemonefish, *Amphiprion polymnus* Linnaeus — *S. Sawatpeera*,** *V. Muthuwan, P. Sonchang* and *N. Keawgunha,* Institute of Marine Science, Burapha University, Chonburi Province, Thailand; and *N. Thareemuk,* Department of Aquatic Science, Burapha University, Chonburi Province, Thailand;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

Friday, November 30, 2001 *(continued)*

	Concurrent Session B: Shrimp Culture – *Emerald Room*
	Moderator: *Junda Lin*, Chair of Aquaculture Programs and Associate Professor, Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL, USA;
1:30pm – 2:00pm	**Small Scale *Mysidopsis bahia* Production — *Mark A. Schick,*** John G. Shedd Aquarium, Chicago, IL, USA;
2:00pm – 2:30pm	**Temperate Shrimps: Perspective Use as Ornamental Species — *Ricardo Calado,*** *Sofia Morais*and *Luís Narciso*, Laboratório Marítimo da Guia – IMAR, Cascais, Portugal;
2:30pm – 3:00pm	**Improvements in Marine Ornamentals Shrimp Culture: High-speed Video Analysis of Feeding Kinematics in Dietary Study — *Andrew Rhyne*,** *J. Lin, R. Calado* and *R. Turingan,* Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL, USA;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

	Concurrent Session C: Management – *Diamond Room*
	Moderator: *Mike Spranger*, Assistant Sea Grant Director for Extension and Assistant Extension Dean for Aquatic, Coastal and Aquaculture Programs, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, USA;
1:30pm – 2:00pm	**"Blueprint for Reform": Transforming the Reef Fish Industry —** *Andreas Merkl*, CoreResources, San Francisco, CA, USA; *John D. Claussen* and ***Darcy L. Wheeles,*** Conservation and Community Investment Forum, San Francisco, CA, USA;
2:00pm – 2:30pm	**Changes in Zooxanthellae Density, Morphology, and Mitotic Index in Hermatypic Corals and Anemones Exposed to Cyanide — *James M. Cervino***, University of South Carolina, Columbia SC, USA; *Raymond L. Hayes*, Howard University, Washington DC, USA; *Marinella Honovitch*, Binghampton University, Binghampton NY, USA; *Thomas J. Goreau,* Global Coral Reef Alliance, New York, NY, USA; *Sam Jones,* New York Aquarium for Conservation, New York NY, USA; *Peter J. Rubec,* International Marinelife Alliance, St. Petersburg, FL, USA;
2:30pm – 3:00pm	**Community-based Management of Coral Reefs: An Essential Requisite for Certification of Marine Aquarium Products Harvested from Reefs Under Customary Marine Tenure — *Austin Bowden-Kerby,*** Foundation of the Peoples of the South Pacific/ Counterpart International, Coral Gardens Initiative, Suva, Fiji Islands;
3:00pm – 3:30pm	**REFRESHMENT BREAK** – *Exhibit Hall*

Friday, November 30, 2001 *(continued)*

3:30pm – 5:00pm	**CLOSING PLENARY SESSION** – *Ireland Room*
	Moderator: ***Chris Brown***, Professor and Director of Marine Biology Programs, Department of Biological Sciences, Florida International University, North Miami, FL, USA;
3:30pm – 4:00pm	**Research on Culturing the Early Life Stages of Marine Ornamental Species — *Joan Holt,*** University of Texas, Marine Science Institute, Port Aransas, TX, USA;
4:00pm – 4:50pm	**Setting Research and Education Priorities for the Future - Group Electronic Survey — *John Corbin,*** Hawaii Aquaculture Development Program, Honolulu, HI, USA;
4:50pm—5:00pm	**Closing Remarks — *James C. Cato***, Director, Florida Sea Grant and Professor, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, USA;

Saturday, December 1, 2001

7:30am – 8:00am	**MORNING REFRESHMENTS** *(for Optional Post-Conference Field Trips)*
7:50am	**Board Buses** *(Outside Great Hall Assembly Foyer)*
8:00am	**Buses depart for East and West Coast Field Trips** *(two separate tours)*
4:30pm	**West Coast Florida Tour returns to hotel**
5:00pm	**East Coast Florida Tour returns to hotel**
5:00pm	**Conference Concludes**

Poster Session Directory

1) **Fatty Acid Profile of Mediterranean Cleaner Shrimp (*Lysmata seticaudata*) (Decapoda: Hippolytidae) Eggs During Embryonic Development — *Ricardo Calado,*** *Sofia Morais* and *Luís Narciso,* Laboratório Marítimo da Guia – IMAR, Cascais, Portugal;

2) **Fatty Acids and Phospholipids in Eggs and Larvae of a Clownfish —** *Melissa Dominguez* and *Pamela J. Seaton,* Department of Chemistry, University of North Carolina at Wilmington, Wilmington, NC, USA; and ***Ileana E. Clavijo,*** Department of Biological Sciences and Center for Marine Sciences, University of North Carolina at Wilmington, Wilmington, NC, USA;

3) **Histological Atlas of the Common Clownfish — *Caroline Dudkowski*** and *Douglas E. Conklin,* University of California at Davis, Department of Animal Science, Davis, CA, USA;

4) **Production Rates of the Rotifers *Brachionus plicatilis* and *Brachionus rotundiformis* Fed a Variety of Algal Species — *Richard Hubbard*** and *Bart Baca*, Nova Southeastern University Oceanographic Center, Dania Beach, Florida, USA;

5) **Characteristics of Fifty-four Marine Algae with a Potential for Mariculture of Marine Organisms** — ***Richard Hubbard*** and *Bart Baca, Nova Southeastern University Oceanographic Center, Dania Beach, Florida, USA**;***

6) **Developmental Stages of *Lytechinus variegatus* From Egg through Settlement — *Richard Hubbard*,** *Ray Wolcot* and *Bart Baca*, Nova Southeastern University Oceanographic Center, Dania Beach, Florida, USA;

7) **Coral Farming as a Cottage Industry - A Viable Adjunct to Wild Harvesting? — *Joseph S. Jones,*** Mountain Corals, Ogden, UT, USA;

8) **Reducing the Risk of Introduction and Damage of Aquatic Nonindigenous Species through Outreach and Education —** *Edwin D. Grosholz* and ***Erin M. Williams,*** Department of Environmental Science and Policy, University of California, Davis, CA, USA;

9) **The Responsible Marine Aquarist Guide — *Elizabeth Wood*** and *Nick Dakin,* Marine Conservation Society, Ross-on-Rye, Herefordshire, UK;

10) **The Use of Cultured and Wild Caught Neon Gobies, *Gobisoma oceanops,* as an Effective Control of Ectoparasites on Mutton Snapper, *Lutjanus analis*, and Greater Amberjack, *Seriola dumerili*, Broodstock in Recirculating Systems — *Scott E. Zimmerman*,** *Federico Rotman, Jorge Alarcon, Daniel D. Benetti* and *Owen Stevens,* University of Miami, Rosenstiel School of Marine and Atmospheric Science (RSMAS), Division of Marine Affairs and Policy Aquaculture Program, Virginia Key, FL, USA;

Invited Speaker Abstracts

Buy a Fish, Buy a Coral, Save a Reef: The Importance of Economic Incentives to Sustain Conservation

Bruce Bunting
World Wildlife Fund, Washington, DC

Coral reefs are in trouble worldwide. These areas of rich biodiversity are important as a source of food, coastal protection, medical products and recreation. Communities and governments are dependent on them for jobs, products and revenue. They are also areas under increasing threat due to global warming, coastal development, destructive fishing practices and other human-related activities.

For the past 40 years, the World Wildlife Fund has been working to protect nature, including coral reefs, around the world. During this time WWF has learned that conservation requires more than protecting individual species and their habitats if it is to be successful for the long term.

First, conservation must be linked with development. Protected areas cannot be separated from their social, economic and political contexts, and they cannot survive indefinitely in a sea of human need. To this end, WWF created programs, such as the Wildlands and Human Needs program established in 1985, to address the needs of people living in and around the world's most precious habitats. Model projects throughout Latin America, Africa and Asia demonstrate that the economic circumstances of rural people who share their land with wild animals can be improved without degrading the natural habitat.

Second, conservation must address the global market and consumer forces that dramatically affect the environment and the economic incentives that underlie these forces. Therefore, WWF has supported the efforts of the Forest Stewardship Council (FSC) and the Marine Stewardship Council (MSC) to create markets for environmentally sound forest and food fish products.

It is clear from the lessons learned by WWF that a sustainable marine ornamental industry will provide critical incentives for the conservation of coral reefs. When communities derive economic benefits from a resource, they will work toward its conservation and sustainable use. This is an especially important factor for coral reefs, as many countries lack the capacity to successfully undertake resource management and enforcement efforts in the remote areas where many coral reefs are found.

A sustainable marine ornamental industry can keep individuals from pursuing livelihoods that could be more environmentally and/or socially damaging, such as destructive fishing using explosives or relocation of people to over-populated urban areas. Furthermore, the public and private marine aquariums that depend on wild-caught marine aquarium organisms for 98 percent of the reef animals in their tanks create increased knowledge of and conservation ethics for coral reef organisms and ecosystems in developed countries.

The key to the solution of using economic incentives to effect coral reef conservation is changing consumer behavior so they buy the right marine aquarium organismsthose that have been harvested using environmentally sound practices from reefs managed to maintain productivity and biodiversity. To identify the right product, it is necessary to know how that animal was caught and handled and how the reef it came from is managed. The Marine Aquarium Council Certification for marine ornamentals covers the entire chain of custody - from "reef to retail". A consumer who buys a MAC labeled organism from a MAC Certified store can be confident that his or her purchase is consistent with the long-term conservation and sustainability of that coral reef and its adjacent community.

MAC has developed the certification system by working with stakeholders around the world. Now, the challenge - and the opportunity - rests with those buy and sell marine ornamentals. Hobbyists and public aquariums must seek out and buy MAC Certified marine ornamentals. Industry operators must choose to stock and offer MAC Certified marine ornamentals as they become available. Governments and non-government organizations must choose to support the certified environmentally sound marine aquarium industry in policies and programs, as they have supported environmentally sound seafood industries, such as dolphin-safe tuna and turtle-safe shrimp.

The MAC Certification harnesses economic forces for positive environmental change globally. The challenge and opportunity are now over to the consumers that buy marine ornamentals, the industry that trades in them and the coastal communities that make use of coral reefs to supply them to be a part of a sustainable "win-win" solution that allows us to say: " Buy a Fish, Buy a Coral, Save a Reef".

Bruce Bunting, World Wildlife Fund, 1250 24th Street, N.W., Washington, DC, 20037-1193, USA, Phone: 202- 778-9676, Fax: 801 - 858-5949, Email: bruce.bunting@wwfus.org

Balancing Collection and Conservation of Marine Ornamental Species in the Florida Keys National Marine Sanctuary

Billy D. Causey
Florida Keys National Marine Sanctuary

Background

The coral reefs of the Florida Keys have been the focus of fishing and collecting activities since before the invention of SCUBA in the 1940's. These activities have increased in intensity over the past few decades, and today many Keys residents simply talk about what it used to be like in the "old days." Stories of beds of queen conch, rafts of sea turtles, huge schools of grouper, snapper, abundant tropical reef fishes and so many lobster all you had to do was wade out from shore to catch them are common.

The collection of marine ornamental species has a long history in the Florida Keys. Commercial collecting began in the mid to late 1950's as public aquaria were stocking their display tanks for public viewing. Collecting activities included the taking of truckloads of living coral and other marinelife from the coral reefs of the Upper Keys. It was, in part, a result of this and other pressures on the coral reefs that prompted a group of conservationists and environmentalists to meet at Everglades National Park in 1957 to consider what actions should be taken to mitigate for these human impacts. This effort eventually led to the designation of the John Pennekamp Coral Reef State Park in December 1960.

With academic backgrounds in marine biology and a strong attraction to coral reefs, my wife, Laura, and I were lured into the "applied" side of coral reef biology and opened *Aplysia* Aquarium, an exclusively salt-water retail store, in Tampa, Florida in 1971. In 1973, we opened a wholesale business, *Aplysia* Aquarium Collecting and Research Center, on Big Pine Key in the Florida Keys. At the time there were over 25 marinelife collectors on Big Pine Key alone.

It wasn't long after we opened our wholesale business in the Keys that we began to experience some negative sentiment from the environmental and conservation community. This seemed ironic because we had always considered ourselves to be conservationists and environmentalists. We soon learned that as long as marine ornamentals have been collected in the Florida Keys, there has been a philosophical debate between conservationists and collectors over the value of the removal of marinelife for the use in marine aquaria. While it was probably not the feeling of the majority of Keys residents, many questioned the value of the business with its perceived impacts to the marine environment. Interestingly, few people have questioned the value of catching sport and food fish in Keys waters. In response to these growing concerns, a group of marinelife collectors, including Laura and I, began meeting in 1974 and soon organized into the Florida Keys Marinelife Association. Our intent was to be proactive in initiating management actions that would help maintain a sustainable marinelife fishery in the Florida Keys. The group also served in a "watch dog" role to some extent, but our primary purpose was to ensure sustainability of the industry.

Personal Transition

Although the career of a marinelife collector had its rewards, it was a difficult way to make a living. The hours were long and physical demands high. Following a massive cold-water fish die-off in 1977 and a warm water fish die-off in June and July of 1980, Laura and I began to realize that many stressors were affecting the health of the marine environment in the Florida Keys. Besides these natural impacts, wire fish traps were introduced into the Keys in the mid-1970's, and within months their impacts on non-target species such as butterflyfishes, surgeonfishes, angelfishes, and others was incredibly obvious. Thankfully, the State of Florida took quick action to ban these overly efficient and deadly devices; however, other fisheries management actions were not so quickly implemented. Additionally, rapid development in the Keys was destroying marine habitats, nutrients from wastewater and stormwater runoff were affecting nearshore water quality, and global warming was impacting the coral reef environment. Laura and I became concerned about these changes and discouraged over the long-term future of the marinelife industry in the Florida Keys.

In May 1983, I was hired as the Manager of the Looe Key National Marine Sanctuary (LKNMS), a 5.3 square nautical mile marine protected area that surrounded the popular spur and groove reef formation of Looe Key Reef, located off Big Pine Key, Florida. Among the regulations at the LKNMS and the previously designated Key Largo National Marine Sanctuary (1975), located offshore and adjacent to Pennekamp Park, was a prohibition on the collecting of all marinelife by divers, except spiny lobster. Suddenly, I found myself in a very different role, that of a protector instead of a consumer. While my position as Sanctuary Manager was more fulfilling and closely aligned with what I had prepared for academically and professionally all my life, the benefits and knowledge that I gained while working alongside other commercial fishers and marinelife collectors in the marine ornamental trade was immeasurable. Working in this field for more than a decade better prepared me for my new role as a marine protected area manager.

Balancing Collection with Conservation

In November 1990, the 2900 square nautical mile Florida Keys National Marine Sanctuary (FKNMS) was designated. The Sanctuary boundary extended around all of the Florida Keys islands, beginning at the mean high tide mark. With the designation of the larger FKNMS, marinelife collectors were concerned that their activities would be prohibited throughout the Sanctuary as they had been in Pennekamp Park and the Key Largo and Looe Key National Marine Sanctuaries. Members of the Florida Keys Marinelife Association were already in the process of working with state fisheries managers to develop size limits, bag limits and gear restrictions for the collection of the diverse marinelife that sustained their industry. The philosophical debate over the conservation value of removing marine ornamentals from their natural environment and shipping them hundreds or thousands of miles to landlocked destinations continued, and concerned those whose livelihoods were dependent on the trade.

Over the years, I have had little doubt in my mind about the value of public and private marine aquaria in promoting marine conservation values and ethics. It is understandable that people learn to care about marine organisms through intimate contact with them. For example, Laura and I had customers in St. Louis, Chicago, and any one of a dozen land-locked cities in "middle America" who knew the scientific name of every species on our 400 plus critter price list, but that had never seen the ocean. We found this to be an incredible testimony to the educational value of living marine organisms. Today, it's those very people, many who have a small piece of the coral reef environment in their living rooms, that we are attempting to reach with the message of marine conservation and a new ocean ethic. Over 40% of North America's watershed drains into the Gulf of Mexico, eventually making its way past the coral reefs of the Florida Keys. People who live at the source of some of our regional impacts can relate to the problems affecting the health of our oceans and coral reef. Therefore, it is critical that we address broad scale water quality problems beginning at this source.

Despite the arguable educational and conservation influence of live marine species, I have had concerns about many issues and practices in the business of collecting marine ornamentals. The use of chemicals, especially cyanide and bleach (which are not used in the Florida Keys), the physical destruction of coral reef habitat during collection operations, and the manner in which fish and invertebrates are held during collection and transit between locations are significant problems in the industry. Good management practices must be used in every step of the marine ornamental trade, from capture, through multiple handlers, to their final destination.

Most important is the sustainability and conservation of marinelife species themselves. Marine ornamental collectors in the Florida Keys capture and ship hundreds of species of fishes, invertebrates and plants. These organisms have very complex life cycles and specific ecological and physiological requirements to reproduce and simply survive in their natural habitats. While I do not have major concerns over the numbers of plants collected and shipped from the Florida Keys, the sustainability of some of the highly desired species of fishes and invertebrates, whose complex life cycles we know very little about, is questionable.

The State of Florida responded to one of these concerns when they prohibited the collection of the long-spined sea urchin (*Diadema antillarum)* through passage of the Marine Life Rule. This action was taken following the massive die-off of the urchin throughout its range in the wider Caribbean in 1983. While marinelife collecting was not responsible for the disappearance of 90-95% of the individuals of this species, the die-off did speak to our lack of understanding regarding the physiology, biology and ecology of some of these complex organisms. Today we are working with marinelife collector Ken Nedimyer and marine expert and author Martin Moe to experiment with restoration techniques that might enhance re-establishment of wild populations of *Diadema* urchins. Their knowledge of the biology of these urchins and vast field expertise is being put to good use in the Sanctuary.

Unlike other commercial fisheries, there is little known about the reproductive survivorship of many of the targeted marinelife species. How many adult, spawning individuals in the population does it take to guarantee that some spawn or juveniles will survive to reproductive age? How many juvenile fish of a certain species does it take to assure survivorship of a single reproductively viable adult? Where do these fish spawn and how far are the larvae broadcasted? What are the environmental factors that affect the survivorship of annual spawn? These questions can be asked about nearly every species of fish collected.

At a minimum, we do know the number of marinelife collectors in the Florida Keys and the landings they have reported to the state, thanks to the efforts of the Florida Keys Marinelife Association and the State of Florida. These data show various trends, but with so many questions about the complex life cycles of hundreds of species, it remains difficult to scientifically respond with traditional fisheries management solutions. If the landings for a species of angelfish are showing a decline, how do we separate the environmental impacts on these species that have very precise physiological requirements from the impacts of over-fishing? It becomes very complicated to tease out species decline due to water quality degradation compared to species decline due to the number of fish being removed from the marine environment.

There are far more questions than answers regarding the complex biology and physiology of the diverse marinelife of the coral reef environment. Until investigations aimed at these and other questions are undertaken, management solutions must err on the side of conservation if we are to be successful in sustaining these populations for the use and enjoyment of future generations. More importantly, we must sustain these species so that they may fulfill their critical ecological role in maintaining a healthy coral reef community.

Conservation Tools

Traditional fisheries management measures such as gear types, seasons, bag limits, size limits and other management measures have demonstrated limited success in the coastal waters of the United States, with many fisheries, such as snapper and grouper in the Florida Keys, showing steep declines in landings. Many fisheries are serially overfished and continually face more stringent management actions despite our considerable knowledge of life histories, biology, ecology and landings statistics. As discussed above, no comparable data exists for angelfishes, butterflyfishes, surgeonfishes, jawfishes, anemones, or mollusks. Therefore, how can we guarantee or even surmise that marine ornamental collecting is occurring in a sustainable manner?

In order to address concerns about the health of all 6000 species of fishes, invertebrates, and plants that inhabit the Florida Keys National Marine Sanctuary, a comprehensive management plan for the Sanctuary was developed. The Management Plan contains some of the most innovative tools available for protecting America's coral reef and its surrounding marine communities for the use and enjoyment of future generations, and balances common sense and practical solutions. The Sanctuary Management Plan represents the most inclusive approach ever attempted at protecting a marine community as diverse and a socio-economic setting as complex as that found in the Florida Keys.

A major component of the Management Plan has been the implementation this nation's first broad-scale marine zoning plan. Among other objectives, marine zoning is designed to protect the biodiversity of Sanctuary resources, including the habitats and food sources for all of the 6000 marine species found here. Much like zoning on land, marine zoning is the setting aside of areas for specific activities, which balances commercial and recreational interests with resource protection and conservation. This reduces user conflicts and focuses management activities in critical and threatened marine habitats. Marine zoning is being used in the Sanctuary to protect biological diversity and reduce human pressures on important natural resources. Five separate zone types have been established in the Sanctuary to achieve these goals: Sanctuary Preservation Areas, Ecological Reserves, Special Use Areas, Wildlife Management Areas and Existing Management Areas. A description of each of these zone types follows.

Sanctuary Preservation Areas (SPAs). Sanctuary Preservation Areas have been established to protect shallow, heavily used reefs where conflicts occur between user groups, and where concentrated visitor activity leads to resource degradation. These zones encompass discrete, biologically important areas and are designed to both reduce user conflicts in high-use areas and sustain critical marine species and habitats. Regulations for Sanctuary Preservation Areas are designed to meet the objectives of these zones by limiting consumptive activities while continuing to allow activities that do not threaten resource protection. SPAs therefore restrict consumptive activities, with two exceptions. The first exception is that catch and release fishing by trolling is allowed in four SPAs, and the second is that the taking of ballyhoo (baitfish) by net is currently allowed by permit in all SPAs. Non-consumptive activities such as snorkeling and SCUBA diving are allowed in all of these zones. There are currently 18 Sanctuary Preservation Areas in the Sanctuary.

Ecological Reserves (ERs). Ecological Reserves are areas of high habitat and species diversity that are representative of the Florida Keys marine ecosystem. These reserves have been established in the Sanctuary to protect biodiversity by setting aside areas with minimal human disturbance. Ecological Reserves encompass large, contiguous diverse habitats, and by doing so they protect and enhance natural spawning, nursery, and permanent residence areas for the replenishment and genetic protection of fish and other marine life. Allowing certain areas to evolve in or return to a natural state preserves the full range of diversity of resources and habitats found throughout the Sanctuary. Ecological Reserves protect the food and home of commercially and recreationally important species, as well as the hundreds of marine organisms not protected by fishery management regulations. Regulations for Ecological Reserves are designed to meet the objectives of these zones by limiting consumptive activities while continuing to allow activities that do not threaten resource protection. Ecological Reserves therefore restrict all consumptive activities and allow non-consumptive activities in some zones where such activities have been determined to be compatible with resource protection. There are currently two Ecological Reserves in the Sanctuary, the Western Sambo Ecological Reserve and the Tortugas Ecological Reserve, totaling approximately 160 square nautical miles (548 square kilometers).

Special Use Areas (SUAs). Special Use Areas are zones that set aside areas for scientific research and educational purposes or to provide for the recovery or restoration of injured or degraded Sanctuary resources. SUAs may also be established to facilitate access or use of Sanctuary resources, or to prevent user conflicts. Because Special Use Areas are designated to facilitate special Sanctuary management programs such as habitat recovery, restoration, and research, or to minimize impacts on sensitive habitats, access to these areas is restricted to entry by permit only. There are currently four permanent Special Use Areas in the Sanctuary, all have been designated for scientific research and monitoring.

Wildlife Management Areas (WMAs). Wildlife Management Areas have been established in the Sanctuary to minimize disturbance to especially sensitive or endangered wildlife populations and their habitats. These zones typically include bird nesting, resting, or feeding areas, turtle nesting beaches, and other sensitive habitats. Regulations governing access are designed to protect endangered or threatened species or their habitats, while providing opportunities for public use. Access restrictions include no-access buffer zones, no-motor zones, idle speed only/no wake zones, and closed zones. Some restrictions specify time periods when use is prohibited. There are currently twenty-seven WMAs in the Sanctuary. Twenty of these WMAs are under joint management between the Sanctuary and the U.S. Fish and Wildlife Service as part of their plan for managing backcountry portions of the Key West, Key Deer, Great White Heron, and Crocodile Lake National Wildlife Refuges.

Existing Management Areas (EMAs). This zone type simply delineates areas that are managed by other agencies where restrictions already exist, such as State parks, aquatic preserves, sanctuaries, and other restricted areas. Their purpose is to recognize established management areas, complement these existing programs, and ensure cooperation and coordination with other agencies in the Florida Keys. Because Existing Management Areas are currently managed by other agencies, regulations already exist under those authorities. Sanctuary regulations supplement these authorities for comprehensive protection of resources. There are currently twenty-one Existing Management Areas within the Sanctuary.

Other Conservation Solutions

Another conservation solution related to the marinelife trade in the Sanctuary came on the heels of the prohibition against the collection of "live rock" in state and federal waters of Florida. These prohibitions were due to the early recognition that the collection of live rock, pieces of living coral reef substrate, was not only unsustainable but was extremely detrimental to the marine habitats of the region. Early after the prohibition went into effect, the Sanctuary began working with marinelife collectors in the Keys to establish live rock aquaculture sites, areas where quarried rock could be placed on the sea floor to receive natural growth and settlement of marine life before being sold. This alternative to the collection of wild live rock has met with mixed success, largely due to storms and hurricanes affecting some of these areas. For the most part marinelife collectors who have invested time and energy in maintaining stock at their sites have had good success and now have a valuable product for sale on the market.

The skills of professionals in the marinelife industry and the strong educational value of local public aquaria are assets the Sanctuary is relying upon to implement another important conservation program in the Florida Keys, called Reef Medics. Reef Medics was initiated to respond to the over 600 boat groundings that occur on living marine habitats of the Sanctuary annually. The majority of these groundings are in seagrass habitats, but a significant number occur on living coral reefs. Reef Medics is working with volunteers, marinelife collectors, and public aquaria in the immediate response to small boat groundings. Trained volunteers will stabilize corals that can be restored on site, marinelife experts may assist in collecting and shipping the smaller fragments to a public aquarium or holding facility, and the aquaria or educational institutions will work to stabilize the fragments. The ultimate goal is for coral pieces to be returned to the area of reef that was impacted by the boat grounding. The multi-phase coral restoration operation of Reef Medics will achieve many objectives, including scientific and educational goals, while increasing the public's awareness of the scope of the boat grounding problem in the Florida Keys National Marine Sanctuary.

Conclusion

Conserving marine species and habitats through the extraordinary pressures and multiple stresses that our coastal communities face today is a challenge for any resource manager. Pollution, habitat degradation, massive algal blooms, serial over-fishing and global warming are killing coral reef communities around the world. Effective management of human impacts, including marine ornamental collecting, is therefore necessary for long-term sustainability.

In the Florida Keys National Marine Sanctuary, we have achieved success by using a variety of tools, such as education and outreach, water quality management, research and monitoring, and enforcement to protect resources. As with other marine protected areas around the world, the Sanctuary relies on marine zoning as an important strategy for protecting and conserving critical marine habitats and species. Fully protected areas, such as the Ecological Reserves in the Sanctuary, take the guesswork out of answering complicated resource management questions. We don't have to understand the complex and intricate biology of the marine organisms that live and reproduce in these areas in order to ensure their survivorship. By setting marine areas aside where human intervention is reduced as much as possible, the full diversity of marine life has a chance to survive and flourish.

Balancing the collection of marine ornamentals with marine conservation can be achieved. However, our long-term success and the sustainability of marinelife species depend on how successful we are at tackling some of the enormous issues affecting our global tropical environment. Impacts to coral reefs and their inhabitants are occurring at the local, regional and global levels. Now is the time to focus our combined strengths and abilities at dealing with these serious threats at every level. The marine ornamental industry can be a powerful influence at promoting the tool of fully protected reserves around the world to in order to address some of the challenges that face the industry today. The increased collaboration between marinelife collectors and Sanctuary managers in the Florida Keys has been critical in striking the balance between collection and conservation. This kind of collaboration and communication between marine protected area managers and marine ornamental collectors around the world may be the key to the long-term sustainability of the inhabitants of the marine environment that we all seek.

Marine Ornamental Industry Development Priorities for a Sustainable Future, Conference Survey Results

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Both the Marine Ornamentals 2001 Conference and its predecessor, Marine Ornamentals 99, were designed to contribute to the broad goal of creating an economically and environmentally viable future for all stakeholders in the marine ornamentals industry. The previous conference took full advantage of the breadth and depth of the expertise in the more than 300 attendees and through an interactive process developed and voted on a set of priority recommendations to guide sustainable development of the marine ornamentals industry in the 21st Century. These 20 Priority Recommendations from Marine Ornamentals 99 were later published with papers from the Conference.

Marine Ornamentals 2001 will continue to facilitate this valuable dialogue among all stakeholders using a three-part survey of attendees. The purpose will be to generate an updated list of priority recommendations to guide future industry decisions and actions on important issues. Part 1 of the survey provides some background on respondents. Part 2 revisits the 20 Priority Recommendations from Marine Ornamentals 99 and gives an opportunity to reaffirm important issues. Part 3 gives Marine Ornamentals 2001 attendees a chance to suggest new priority issues and recommendations.

All registered attendees will be given an opportunity to vote on the new set of Priority Recommendations, combined from the issues listed in Part 2 and Part 3. Voting will be electronic and results will be reported on the last day of the Conference.

Marine Ornamentals 2001, Collection, Culture and Conservation again brings together the diverse international interests of the marine aquarium industry to comprehensively assess progress made in the last two years and consider the future. Organizers believe that providing an effective forum for exchange of information and ideas and developing consensus on key issues, are important benefits from this Conference.

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Supplying the Demand for Sustainability: Stories from the Field

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Indo-Pacific ornamental fish species is a major part of the demand of the marine ornamental market in the western world. The main market is US. Unfortunately exotic animals coming from this part of the world, live fish and corals do not survive well as expected. A major part of the problem is cause by the method of extraction in these countries. It has endangered the ecological integrity of the coastal and isolated reef areas of coastal communities. It has greatly affected their coastal neighbors even in far-flung corners of the country where they sail into to collect ornamental fish threatening the entire livelihood of other people that are highly dependent on the ability of the marine eco-system to supply these resources continuously. In the Philippines a total ban has been considered several times and is still being considered. It has exposed the marine ornamental industry dependent on the Indo-Pacific supply to a lot of understandable criticism for its irresponsibility for causing more environmental destruction and livelihood displacement of innocent people not connected to the trade.

Hundreds of thousands of dollars has been spent in the Philippines by private and country donors such us USAid into reforming the collectors in the ornamental fish industry. People and organizations actively involve in transforming the collectors from their destructive fishing practices to an environmentally friendly method of collecting have often asked themselves a lot of questions and a few of them were "did we succeed? Can waste or over collection of resources be avoided? Can trained collectors supply the demand of the market continuously and not destroy the balance of the marine eco-system? Have ornamental fish reform programs uplifted even a fraction the quality of life of these collectors? Have we created a social and environmental impact in these coastal villages? Are there a lot of backsliders who went back to cyanide? If so why? If it worked, why then are these beautiful exotic animals still dying at the hands of the collectors, export facilities, importers and hobbyists?"

There are several answers to these difficult questions but in a sense yes there is a measure of success. To a certain degree it worked in the Philippines. We have a mass base of collectors that now have the skills to use nets. Those that have not been formally trained have learned from other collectors. What was considered before an uphill battle by organizations is now a level field. The change was brought about by a lot of information drive with Bureau of Fisheries and Aquatic Resources and Local Government Units as partners and net trainings.

For the last three years collectors have tried using nets but fish are still dying. Over collection has not stopped but it is done for different reasons. During their days of cyanide use it was natural for collectors to catch more than what is needed to make up for morality that starts in the field. Collectors using nets now are still force to over collect in the hope that they can breakeven in their cost of operation and mortality cause by bad husbandry and handling. Cost of operation has drastically gone up but the local buying price has remained almost the same for the last decade. This situation is creating a very dangerous condition for a massive backsliding to cyanide and backsliding has started base on our findings during a Marine Aquarium Council (MAC) funded survey.

The result of the survey brought to light problems that were never given time and importance due to funding constraints. Bad husbandry and absence of proper environmental management practices are major issues that have to be address.

MAC has initiated a Feasibility Study in the Philippines to test the industry's capability to comply with its set of standards of best practice, the Philippines being the second largest exporter country. My organization, the International Marinelife Alliance (IMA) was commissioned to undertake the seven-month project with the end in view of empowering collectors to raise their collection and husbandry skills to the level of their counterparts in Australia and Hawaii. It started in April and will end on October.

The question is: "Could these collectors meet the standards set by the Marine Aquarium Council (MAC)? Would they be able to develop and implement environmental management plans and follow them to the letter? Would it make their lives better? Would exporters and importers cooperate and do their part? Would it remove the stigma associated with collecting ornamental fish that in some areas has prompted many Local Government Units to ban the commerce in ornamental fish?"

Standards and best practices guidelines were made to enable certification and labeling methods from ecosystems management, to collection activities, husbandry, transportation, handling up to the importers level. In short a system of tracing the animals is a method of chain of custody.

The Philippines Tropical Fish Exporters Association comments on the standards and best practices and their outlook towards collectors were taken into serious consideration.

The characteristics of collectors/participants in the feasibility study were studied mainly on issues of socio-economic conditions and reactions plus their regard to environmental concerns since all local collectors are living in poverty, ignorance and hunger. A test case in Palawan was undertaken to compare the income of New Busuanga Aquarium Fishers Association (NBAFA) who delivered ornamental fish following the MAC standards to the letter resulting in zero mortality and a delivery having 12.8% mortality. Insights and outlooks of these collectors will be presented on November as we are still closely observing the entire process.

The end of the feasibility study where in 250 net trained collectors participated in different parts of the Philippines will hopefully give answers to a lot of these questions and provide a path for a long lasting solution.

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Wild-caught Marines and the Ornamental Aquatic Industry

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Paper Presented by:
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Although the number of fish and invertebrate species bred or cultured to cater for the international marine aquarium hobby is expanding rapidly, the actual percentage of non-wild-caught species is still very low. Some estimates place the percentage of captive-bred fish species at around 10%, but it is generally accepted within the industry that the actual figure is considerably lower (somewhere between 2-5%). This figure will undoubtedly increase over the coming decade...and probably not in a linear fashion, since major breakthroughs in husbandry and, particularly, larval nutrition are likely to result in periods of significant acceleration.

Despite this, the majority of species within the marine aquarium industry and hobby will continue to be wild-caught for the foreseeable future. This has caused concern in a number of quarters, with accusations of over-exploitation, irreversible reef damage and unethical methods of collecting being aimed at the ornamental marine aquarium industry over the years.

This paper will review and discuss the validity, or otherwise, of some of these beliefs and assumptions and will attempt to place them in some form of perspective with other aspects of marine harvesting, among them the construction and food fish industries.

It will also highlight the philosophies of the modern-day ornamental aquatic industry with regard to collecting and handling methods, the conservation of reef systems, participation in - and support for - sustainable and ethical harvesting programs, the need for education and correct information (as opposed to current levels of misinformation)...and the importance of maintaining a well-monitored (certified) sector of the industry specializing in wild-caught marines.

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Separating Fish Facts From Fishy Fiction (Not Forgetting Invertebrates)

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Coral reefs are critical habitat for an unparalleled diversity of marine life that provides important resources for both local sustenance and commerce: collecting marine ornamental organisms provides one of the few potentially sustainable local industries in many coastal communities with limited resources and few other options for generating income. The fish, corals and other invertebrates may pass through a network of middlemen but ultimately are shipped from the countries of origin by a relatively small number of wholesale exporters and received by a similar number wholesale importers in the market nations who, in turn, supply networks of retail outlets.

The Convention on International Trade in Endangered Species of Flora and Fauna (CITES) attempts to assess the trade in species, listed in Appendix II of the Convention, which are believed to be vulnerable to exploitation but not yet at risk of extinction. All species of hard coral and giant clams are listed under Appendix II of CITES and parties to CITES are then obliged to produce annual reports specifying the quantity of trade that has taken place in each listed species. The magnitude and taxonomic composition of the international trade can then be calculated. This allows any debate on the trade in corals and clams to be based on global data which, despite its faults, is standardised.

By contrast no marine ornamental fish, or invertebrates other than clams or corals, are listed under CITES. Therefore existing calculations of 15-30 million fish from approximately 1000 species (Wood, 2001) are estimates based on a number of assumptions which mean that these figures must be used with caution. The trade in individual species of fish, and invertebrates other than corals and clams, is unknown.

The marine aquarium trade continues to receive the attention of politicians and conservation organisations alike, attracted by accounts of destructive collection practices, alien species, over-exploitation and the threat of extinction of target species. Some regulation has already been established, and more may follow; yet the arguments for and against these measures have taken place in a near vacuum of information on the extent, and therefore impact, of the aquarium trade. The debate at times has been vociferous and contentious but progress remains constrained by the lack of quantitative and unbiased information. At stake is the employment of thousands of people, especially in source nations, and the high incentives for coral reef stewardship which the marine aquarium trade is capable of providing.

Since April 2000 the UNEP-World Conservation Monitoring Centre (UNEP-WCMC) and the Marine Aquarium Council (MAC) have been collaborating with members of trade associations such as AKKII, PTFEA, SAFEA, OFI and OATA to establish a Global Marine Aquarium Database (GMAD) as a freely available source of information on the global aquarium industry. Our common objective is to centralise, standardise and provide fast and easy access to information on the aquarium trade.

The core data in GMAD are the sales records of wholesale import and export companies, specifically:

- Species traded (fish, corals, invertebrates)
- Quantity traded (numbers)
- Country of export
- Country of import
- Date (year)

This is information which is recorded on every invoice for every single transaction within the global aquarium industry. As of September 2001 a total of 33 wholesale export and import companies including many industry leaders, and 4 national management authorities, have provided these data to GMAD.

Further data collection will continue throughout September and October 2001, with the first analysis scheduled in November. My presentation at MO '01 will be based on this analysis, and will coincide with the public release of the first version of GMAD. Topics I will discuss include:

- principal species in trade
- trade links between export and import nations
- descriptions of major markets (e.g. the USA and EU)
- descriptions of lesser known markets (e.g. in SE Asia)
- descriptions of the trade from major and minor exporting nations
- a comparison of GMAD coral data and CITES data

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The Role of Public Aquaria in the Conservation and Sustainability of the Marine Ornamentals Trade

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Worldwide, public aquaria and zoos enjoy immense popularity with a collective annual attendance estimated in excess of 600 million visitors, representing approximately 10% of the world's population. These organizations are experienced in using this popularity to educate and influence their visitors, local communities and other target groups about wildlife conservation concepts and issues. Increasingly, the direct and indirect participation of public aquaria in field conservation programs has become an integral component of institutional missions.

Over the past ten years, specialized taxonomic advisory groups have been formed in European, North American and, most recently, Australian zoos and aquaria to establish a collective approach towards the conservation of marine resources. Programs have been developed that target flagship marine species, such as sharks and seahorses, but also threatened habitats, such as coral reefs. The remit of these initiatives encompasses advancing husbandry techniques and biological knowledge to taking an active role in field conservation efforts, such as Project Seahorse.

Public aquaria recognize that they are one, highly visible component of the aquarium trade. As such, they have a responsibility to encourage and support the sustainable use of marine ornamental species and associated conservation of habitats. Current initiatives range from individual institutional projects towards sustainable trade, to global programs such as the Marine Aquarium Council's certification scheme.

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Research on Culturing the Early Life Stages of Marine Ornamental Species

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The number of marine ornamental species that can be economically produced on commercial farms today is extremely limited. The future of marine ornamental fish farming, like marine food fish culture, depends on the ability to reliably produce eggs, raise large numbers of larvae and transition them to juveniles.

A large number of ornamental species have been spawned in captivity. Some species spawn naturally in large aquaria and others have been conditioned to spawn by photoperiod and temperature cycles (Holt and Riley 2001). Among the priority issues in hatchery technology are designing rearing systems that provide acceptable environmental conditions and proper prey for different stages during development. The environmental conditions for raising the delicate larvae should mimic their natural planktonic habitat. This means very stable conditions of high salinity and oxygen concentration, low nutrients, basic pH, and warm temperatures. Such conditions are difficult to maintain once feeding is initiated because dense concentrations of life prey change the quality of the water. New system designs have overcome many of these problems. For example, algae scrubbers, mesocosoms, and flow-through systems work well depending on the location.

A critical bottleneck continues to occur at first feeding when larvae changeover from internal yolk stores to exogenous feeds. Many ornamental fish spawn tiny pelagic eggs that hatch into larvae with small mouth gapes. Rotifers and *Artemia* are the most widely used live food items in marine fish culture but they are not always acceptable food. Copepod eggs and nauplii are the natural food source of marine fish larvae but they have not generally been used as extensively in aquaculture because they vary in abundance and nutrition, and are difficult to culture on a continuous basis.

The nutritional requirements for long-chain n-3 polyunsaturated fatty acids (PUFA) for the normal growth and development for marine fish larvae are well established (Watanabe 1982). Marine copepods typically have high levels of n-3 PUFAs that reflects the fatty acid composition of their diet. There is a fundamental need for new and more nutritious prey species for rearing marine larvae. A recent breakthrough was the development of a protocol for producing resting stage or diapause eggs of the copepod *Centropages hamatus* (Marcus and Murray 2001). Initial tests as food for marine fish larvae were encouraging. Larval comet *Calloplesiops altivelis* that were fed the copepod nauplii grew larger and survived better than larvae fed rotifers and artemia. Copepod nauplii hatched from *Centropages hamatus* diapause eggs hold promise as an alternative live food for tropical ornamental fish. The next step needed is to develop a large-scale production protocol for these copepods.

Fig 1. Standard length and standard deviation of comet larvae *Calloplesiops altivelis* raised on rotifers and artemia, copepod nauplii, or a mixture of wild zooplankton, rotifers and artemia.

Age	**Rotifers/Artemia**	**Copepods**	**Zooplankton & Rotifers/Artemia**
Day 3	3.5	3.5	3.5
Day 7	3.97 (.177)	4.792 (.115)	No data
Day 14	3.83 *	5.05 (.297)	4.22 (.469)

* Larvae survived to day 14 in only 1 of the 2 enclosures

Worldwide research emphasis on culturing marine ornamentals bodes well for future success in this area. Culturing marine ornamentals in tropical regions by native islanders is a developing scenario that could be successful in conserving coral reef resources while providing ideal culture conditions.

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From Reef to Retail: Marine Ornamental Certification for Sustainability is Here

Paul Holthus
Marine Aquarium Council

The future of the marine ornamentals hobby and industry depends on ensuring that the trade is sustainable, responsible and environmentally sound. The demand from informed consumers for this will create an incentive for industry to provide products and practices that are sustainable. International certification harnesses this market demand for sustainability by:

- Establishing standards for quality products and practices;
- Providing a mechanism to verify compliance with these standards;
- Labeling the results of certification for quality assurance; and
- Creating consumer demand and confidence for certified organisms and industry practices.

The Marine Aquarium Council (MAC) was established in 1998 as an independent, international non-profit conservation organization to develop certification. To do this, MAC brings together the entire "chain of custody" - i.e. collectors, exporters, importers/wholesalers, retailers and the consumer - as well as other stakeholders, including public aquariums, conservation organizations, and government agencies. MAC is developing certification to ensure the collection, culture and commerce in marine ornamentals, is sustainable and environmentally sound.

From the broad network of stakeholders that constitutes MAC, the Board of Directors is required to have a majority representing conservation or public interests. The board currently includes the following: American Marinelife Dealers Association (AMDA), American Zoo and Aquarium Association (AZA), Foundation for Peoples of the South Pacific International (FSPI), Indonesia Ecolabeling Institute (LEI), Indonesia Coral, Shell and Ornamental Fish Association (AKKII), IUCN (the World Conservation Union), International Marinelife Alliance (IMA), Marine Aquarium Societies of North America (MASNA), Ornamental Aquatic Trade Association (OATA), Ornamental Fish International (PIJAC), Pet Industry Joint Advisory Council (PIJAC), Philippine Tropical Fish Exporters Association (PTFEA), The Nature Conservancy (TNC), World Wildlife Fund (WWF).

MAC Certification has been tested along the entire chain of custody - from "reef to retail" - and is now operational. MAC Certification is based on “Core Standards” that set the basic criteria to address critical and urgent issues related to sustainability, environmental impact, husbandry, transport, etc in three areas: 1) Ecosystem and Fishery Management; 2) Collection, Fishing and Holding; and 3) Handling, Husbandry and Transport.

The standard for Ecosystem and Fishery Management addresses management and conservation of the collection area's habitat, biodiversity and stocks and includes requirements for:

- Defining and describing the Collection Area.
- Outlining the history and volume of harvest in collection in the area.
- Outlining the history of management of the Collection Area.
- Outlining effects of other users, e.g. environmental impacts of other fishing activities.

The standard for Collection, Fishing and Holding verifies that the collection, fishing, and pre-exporter handling, packaging and transport of marine aquarium organisms ensures the ecosystem integrity of the collection area, sustainable use of the marine aquarium fishery, and optimal health of the harvested organisms. The standard includes requirements for:

- Prohibiting the use of any destructive fishing methods.
- Requiring fishers only to collect what has been ordered.
- Ensuring minimal stress of organisms during collection through the use of appropriate equipment and handling methods.
- Verifying that all fishers/collectors can meet, or have been trained in, the standards.
- Ensuring water quality and temperature are maintained from reef to exporter

The standard for Handling, Husbandry and Transport verifies that the care, handling, packing and transport of marine aquarium organisms will ensure the optimal health of the organisms at export, import, and retail. This includes requirements for:

- Acclimatizing all organisms.
- Prohibiting the co-mingling of certified and uncertified organisms.
- Ensuring water quality must be monitored and maintained.
- Verifying that all handlers can meet, or have been trained in, the standards for handling and transport.
- Maintaining the traceability of organisms.
- Shipments staying within a maximum allowable Dead On Arrival mortality rate.

“Best Practice” guidance documents support the MAC Standards by providing advice on actions that will lead to likely compliance. During the two years following the launch of the MAC Certification based on the Core Standards, a more comprehensive set of “Full Standards” will be developed. These will address a more comprehensive range of issues and approaches to ensuring sustainability for the marine aquarium trade, as well as including standards for mariculture and aquaculture.

Certification for sustainability is here - from "reef to retail". The challenge and opportunity is now with those who buy and sell marine ornamentals to be a part of a sustainable "win-win" solution for the future of the industry and hobby. Aquarium keepers must seek out and buy MAC Certified marine ornamentals. Industry operators must choose to stock and offer MAC Certified marine ornamentals as they become available. Governments and non-government organizations must choose to support the certified environmentally sound marine aquarium industry in policies and programs.

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Perspectives in Coral Culture: Science, Medicine and Aquarium Hobby

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Since the early 1980s the development of new aquarium concepts and technologies have enabled hobbyists and scientists to cultivate reef-building corals (e.g. Jaubert, 1981 & 1989; Adey, 1983; Delbeek and Sprung, 1994; Fossa and Nilsen, 1996). Applications of these new concepts and technologies concern as many different fields as: biology, medicine, ecology, environmental management, public awareness and aquarium hobby. Coral mesocosms (miniature models of reef ecosystems) are used to carry out experiments at the ecosystem level and investigate the role of coral reefs in the biogeochemical cycling of elements (Adey, 1983; Jaubert *et al*., 1992 & 1995). Clones of cultivated corals propagated by asexual multiplication and grown in either an attached or unattached state have been developed, as biological models, in the laboratories of the European Oceanographic Centre of Monaco. They are designed to meet experimental requirements needed to investigate the mechanisms that underpin photosynthesis and calcification" (Jaubert *et al*., 1996). On the other hand, several authors (see Guillemin *et al*., 1987 & 1989) have demonstrated that implants, made of the skeleton of reef corals, constitute bone graft substitutes of particular interest. Their porous structure provides a scaffold for rapid ingrowth of bone tissue and they undergo a dissolution process that results in their complete resorption and replacement by a new bone. Implants utilized in human surgery and manufactured from samples collected in the sea (Patat and Guillemin, 1989) and efforts are being made to replace them by cultivated corals. Finally, the conservation of endangered species or varieties of corals as well as the restoration and replenishment of damaged reefs with resistant strains produced and propagated in coral nurseries may be other promising applications of *in vitro* coral culture techniques. This latter prospect is especially important owing to the recent acceleration of the worldwide degradation of coral reefs (see Mumby *et al*., 2001).

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International Trade in Ornamental Fish

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With the increasing popularity of aquariums in households in many parts of the world, ornamental fish has become an important part in international trade. Although available statistics are open to interpretation, as the category is not always well defined in international trade statistics, annual international trades in ornamental fish as reflected in FAO statistics are around US$ 250 million. The total value of wholesale trade represents is estimated at close to US$ 1 billion, and retail trade about US$3000 million (live animals for aquariums only).

The international distribution network for ornamental fish is complex, within which several sub-systems coexist. It is undergoing rapid changes and has evolved significantly over the last two decades. The current tendency is to eliminate intermediaries. The combining of activities is not unusual, but the introduction of transshipping has created certain turmoil in the market.

Asia represents more than 50% of the world supply of ornamental fish. Singapore is by far the largest exporter (25%) followed by the United States (7%), Malaysia (5%), the Czech republic (5%), and Indonesia (5%). Since the 1980's the value of world exports has been in marked progression, from US$40 million to close to US$200 million, although the value has dropped slightly in 1998 and 1999. Further, new players such as the Czech Republic, are now competing with those that were traditionally the dominant ones.

Fishkeeping is a hobby that is practiced mainly in industrialized countries because it is still relatively costly. Thus the main importers are the United States (24%), Japan (14%) and Europe, particularly Germany (9%), France (8%) and the United Kingdom (8%). The value of world imports has been in marked progression too, from US$50 million to US$250 million in 15 years.

In international trade, in value terms, freshwater species represent about 90%, against 10% for marine species. The species that dominate the market are all freshwater species, particularly the poeciliidae, the characidae, cichlidae and cyprinidae. Marine species are becoming more popular (particularly the pomacentridae, acanthuridae, labridae, pomacanthidae, chaetodontidae, balistidae, syngnathidae, and the invertebrates).

According to numerous professionals, the marine aquarium with live coral reefs is the trend for the 21st century. This will also be reflected in species traded internationally.

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Culture of Marine Ornamentals: For Love, for Money and for Science

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The modern marine aquarium hobby is a multifaceted giant. It is a hobby/industry with tendrils that enter and entwine with fisheries in developed and developing countries, tropical world environmental issues, world wide air freight trade, multimillion dollar manufacturing companies, growth of extensive wholesale operations, a fledgling commercial marine aquaculture industry, basic and applied scientific research on aquaculture and systems development, and, of course, the corner aquarium shop. This has not always been so.

The explosive growth of this relatively insignificant hobby/industry in the last 15 years has been fueled for the most part by advances in technology that have made it possible for almost all marine aquarium hobbyists to successfully create, modestly or extravagantly, a representation of a living coral reef within a small aquarium system. This has changed everything. And as this hobby/industry has grown, one of the major innovations has been the development of interest and effort in the culture of marine ornamental organisms. Although propagation has always been a major interest to freshwater aquarists, the difficulties and complexities of cultivation of marine ornamental organisms has restricted this segment of the hobby to the realms of science and industry. And until recently, science and industry have had little interest in the propagation of marine ornamentals, the stepchild of marine food organism aquaculture. This is no longer the case. The expanded market has increased commercial interest in propagation of all ornamental marine organisms, and the relative ease of cultivation of many hard and soft corals has made propagation the major interest of many marine hobbyists.

The motivations and capabilities of those that engage in culture of marine ornamentals; the hobbyists, scientists, and commercial propagators, may differ greatly, but the roots of our endeavors are parallel, and it is important for all of us to know and understand the interests, efforts, successes, failures, and attitudes of others engaged in these same basic pursuits. I have attempted to collect and analyze this basic information through a questionnaire distributed to hobbyists, scientists and commercial breeders all over the world, now possible in this day of the computer internet.

The results are still coming in at this point, mid September, but so far 366 hobbyists, scientists, and commercial breeders have responded to this questionnaire. Although this effort is not scientifically designed, it will provide some insight into the state of culture in the marine hobby/industry at this time. The questions were developed to identify the organisms that have been cultured successfully and those whose culture has been attempted and failed. Also, to identify the organisms that provide the best return in commercial culture, and those whose successful culture is most desired but not possible at this time. Hobbyists report on the organisms that they most frequently propagate and what they do with these home bred marine ornamentals. The attitudes of hobbyists toward culture and the hobby itself are also explored. Commercial breeders report on how well, or how difficult, things are with their endeavors and also on their greatest difficulties and the organisms with which they are most financially successful. Scientists report on their sources of funding, the organisms they are working on now and have worked on in the past, those that they have successfully propagated and those where propagation has failed, and they also report on the basic purpose of their research. I think all of us that are engaged in the culture of marine ornamental organisms will find something of interest in the results of this survey.

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Improvements in Marine Ornamentals Shrimp Culture: High-speed Video Analysis of Feeding Kinematics in Dietary Study

Andrew Rhyne, *J. Lin, R. Calado* and *R. Turingan*

Currently, only a handful of species are cultured for the marine aquarium trade. Only one shrimp species is available in commercial quantity, *Lysmata wurdemanni*, a caridean shrimp used to control pest anemones (*Aiptasia* sp.) in the reef aquarium. With a larval duration of more than 90 days *L. wurdemanni* is expensive to culture. Because of a growing demand for captive raised aquarium animals as well as the decline of the world's reefs, research is needed to develop methods for culturing marine ornamentals. Improvements in the nutrition of live feeds have been demonstrated to increase the survival of and shorten larval duration of cultured organisms. Nutrition content of the diet of larval fish and invertebrates has shown a significant correlation with growth and survival. While the importance of the nutritional quality of larval diets is well documented, the manner in which larvae prey on different diets is not. The behavior displayed by both the prey and the predator is an important factor in the growth, development and/or survival of larvae. The ability for the larval predator to feed on the commercially developed prey is a function of physical and chemical qualities of the prey. Commercially developed diets must be nutritionally sound and digestible, must attract the predator and induce their feeding response.

The ability to document the feeding events of larvae is a relatively new and novel approach. Fisheries biologists have used high-speed videography (Fig. 1) in investigating the feeding kinematics involved in prey capture. These studies have allowed researchers to describe the different feeding mechanisms involved in a single feeding event. The use of high-speed video may lead to the discovery of larval food preferences and allow for the development of appropriate microencapsulated diets. The ability to study specific feeding events with high-speed video allows researchers to target a specific larval stage with a specific prey type.

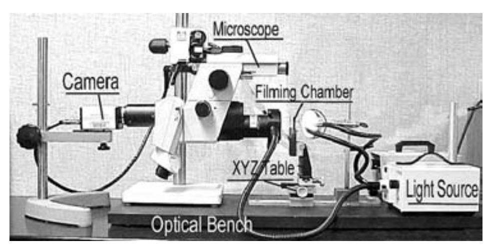

Fig. 1 High-speed video camera system.

Preliminary results of the larvae feeding kinematics indicate that commercial prepared diets are more readily consumed when live preys are also available (Fig 2). These early results suggest that a feeding response on inert diets maybe induced by live prey organisms (newly hatched *Artemia* nauplii and metanauplii). Additional studies on inert diets, in association with live prey organisms, with high-speed video analysis will allow for a more complete understanding of the feeding preferences during the larval development of ornamental shrimps.

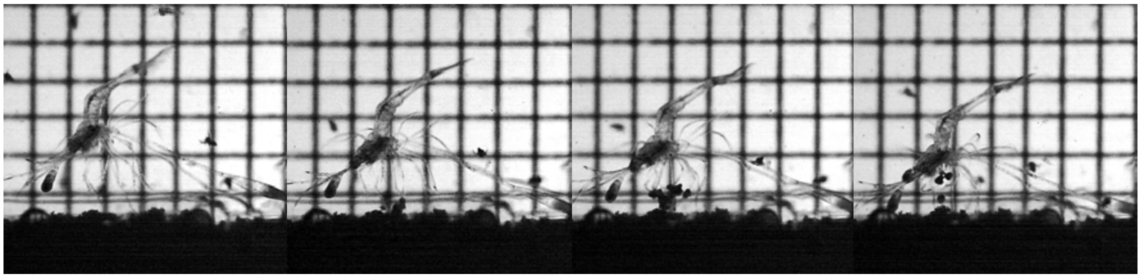

Fig. 2 A larvae of *Lysmata wurdemanni* feeding on a prepared diet.

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Current Issues in Disease Control in Marine Ornamentals

Michael K. Stoskopf
North Carolina State University

This presentation will discuss important recent and upcoming developments in the key components of disease control; husbandry, vaccination, diagnostics, therapeutics and disinfection, with particular emphasis on how they can impact the health of captive marine ornamental fish. Advances in water management and nutrition, vaccine development, and molecular and immunodiagnostics will be examined. Newer therapeutic agents with strong potential for use with ornamental marine fish will be discussed along with how to properly apply our increased knowledge of drug kinetics and dynamics of antimicrobial drugs in marine ornamental fish will be discussed in relation to their potential to ensure better therapeutic response to proper dosing. Current thoughts on system disinfection and isolation will also be discussed.

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Aquaculture Oral Abstracts

A Study of Coral Diet Supplements in a Closed Ecosystem

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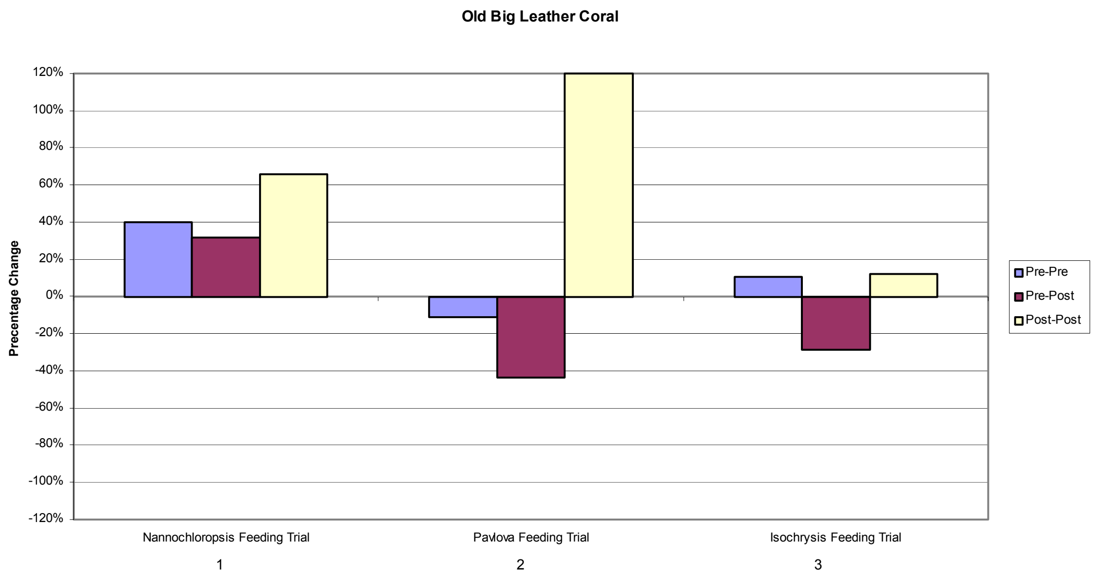
Diet supplementation for corals in a closed ecosystem is not well defined. Previous research conducted at St. Louis Children's Aquarium has yielded data to indicate preferential feeding on certain algae types by particular species of corals. This research reported herein was also conducted at the St. Louis Children's Aquarium over a 6 month period on a 600 gallon Indo-Pacific Living Coral Reef Exhibit and has opened up a new understanding of this complex ecosystem. This study centers on three algaes: Nanno (*Nannochloropsis oculata*), Pavlova (*Pavlova dicryteria*), and T-ISO (*Isochrysis sp.*) used without preservatives and generously supplied by Reed Mariculture. *Plerogyra sinuosa* (Big Bubble and Bubble-S); *Sarcphyton sp.* (Old Big Leather, New Big Leather, and Small Leather); *Aleyonium sp.* (Colt Coral) were chosen at random and were fed three separate algae feeding trials (Nanno, Pavlova, and T-ISO), each feeding trial was repeated several times in succession and coral changes were evaluated using both photographic and physical measurements. Assessments were made before feeding (Pre-) and after feeding (Post-) measuring mantle volume (length x width x height) calculation.

Specifically, by sheer ordinal volume change there were significant negative differences in colt coral for Nanno to Pavlova to T-ISO in the order from greatest to least changed. The bubble coral was likewise affected with the greatest negative change from Nanno followed by Pavlova to T-ISO. The leather corals were affected similarly with Nanno and Pavlova, however not affected by T-ISO. When changes were studied by percentage change in coral mantle size there were several surprising results that led the investigating team to hypothesize that changes in coral mantle size might be segregated into immediate or short-term and long-term changes (see graphs). Long-term positive growth is noted for colt coral by Nanno and Pavlova with a preference for Pavlova and little to no effect by T-ISO. Short-term, however, with all applications, the colt coral mantle decreased greatest with Nanno, less with Pavlova and least with T-ISO, indicating a lack of requirement of the T-ISO for the colt species. Bubble corals, overall, show a preference for Nanno in long-term and short-term positive growth with little effect by T-ISO to negative effect by Pavlova, especially indicating a negative effect, short term by both the Pavlova and T-ISO feeding. The leather corals seemed to experience the greatest positive long-term growth by the Pavlova feeding though in the short-term; the Pavlova decreased the size of the mantle. Nanno also seems to have a beneficial effect both in the short term and long term however lesser than that of the changes created by feeding the Pavlova.

More studies are now underway toward identifying coral feeding and growth with the hope of suggesting metabolic pathways and essential nutrients which may factor into further understanding for cultured and natural living reef systems.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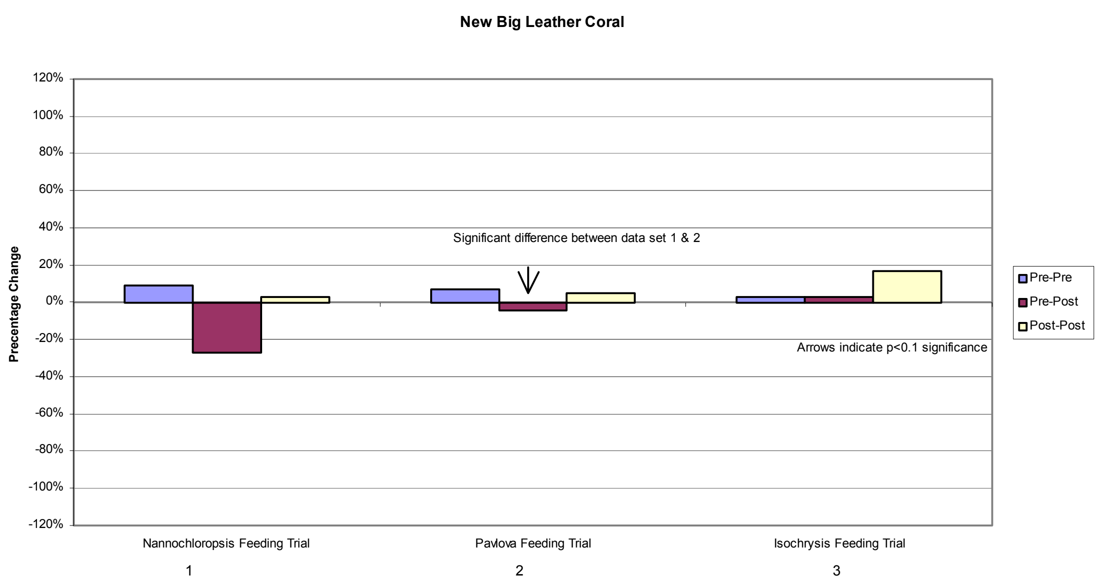
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Arrows indicate p<0.1 significance
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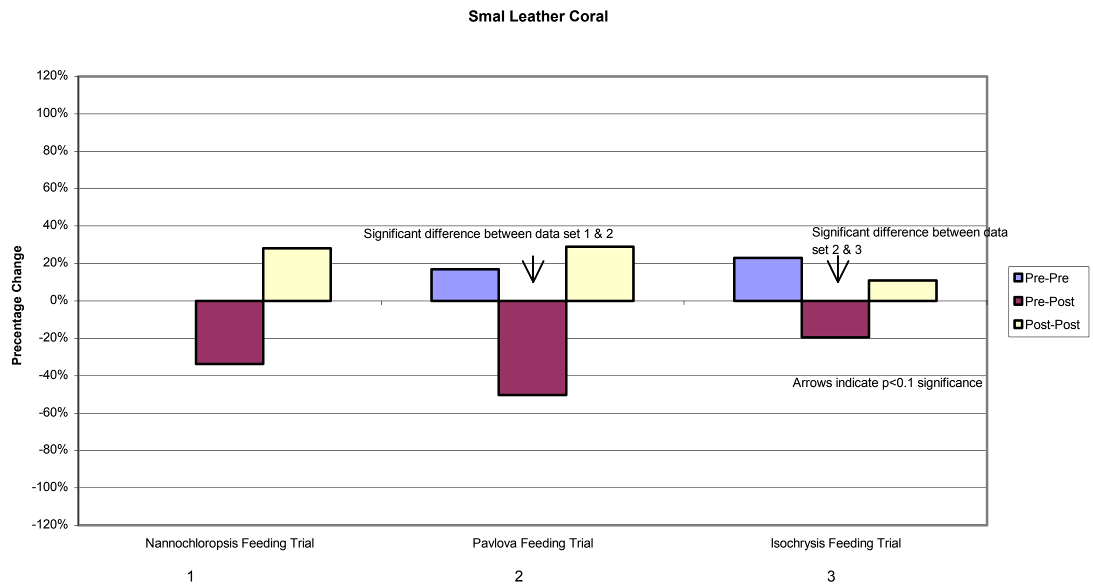
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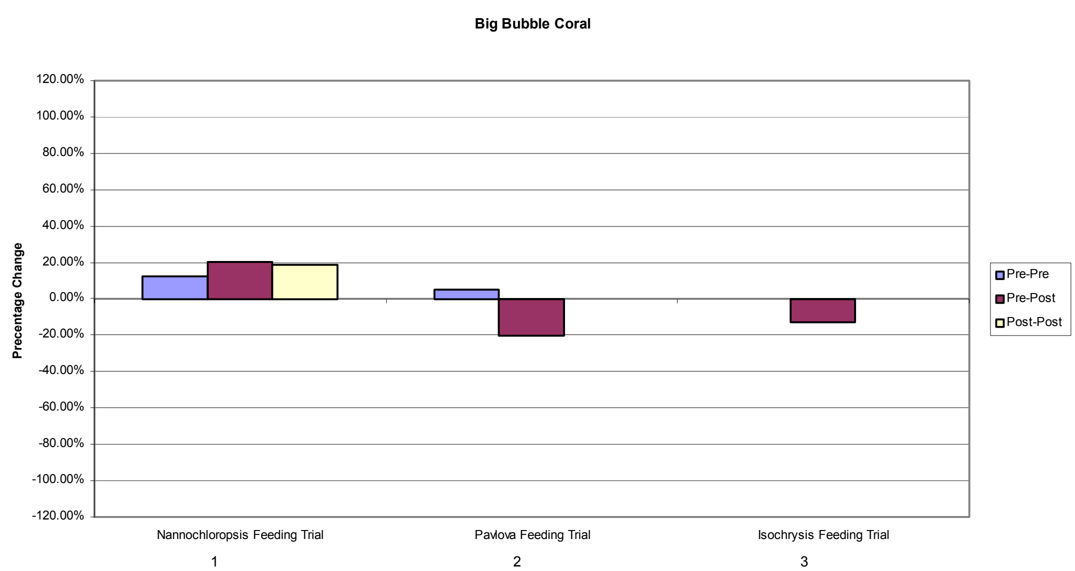
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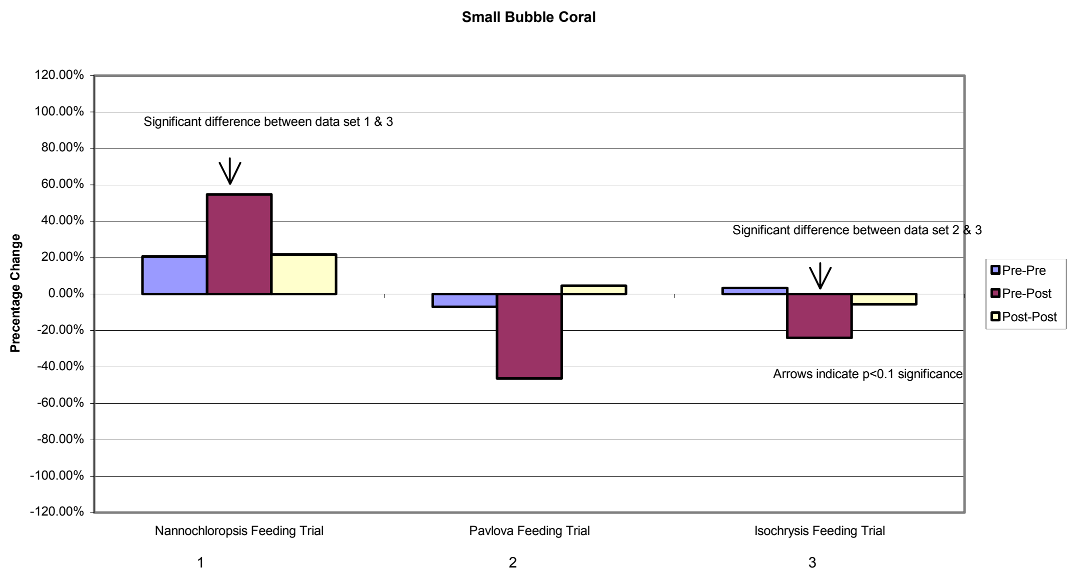

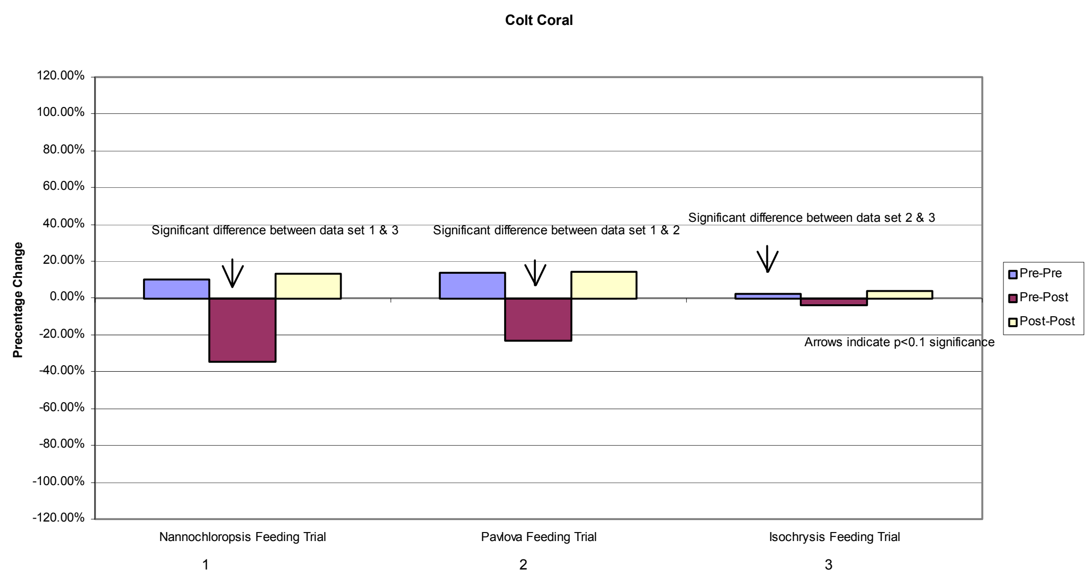

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Spontaneous Spawning of *Diadema antillarum* under Photo-Thermal Control: An Essential Step for Year-round Laboratory Culture

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Debra Cole
Coral Gables High School, Coral Gables, FL

Margaret W. Miller
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Alina M. Szmant
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Diadema antillarum, once abundant throughout the Western Caribbean basin, suffered extensive mortality in the early 80's due to a poorly described epizootic episode (Bauer and Agerter, 1987; Lessios, 1983). Subsequent efforts to culture the long-spined black sea urchin for reintroduction, the ornamental trade, Coral-*Diadema* interaction research, and isolation of the disease causing vector(s) have been hampered by their limited numbers and threatened status in State of Florida. Until now, echinoid gametes have been invasively obtained by dissection, chemical injection, rapid changes in temperature, and low voltage electrical shock (Strathman, 1987). While successful, all have related levels of parental mortality and questionable larval viability.

To ensure broodstock survival and demonstrate their potential for year-round gamete production, two cohorts of 22 animals (> 45 mm) and 27 animals (>55 mm) were collected in the Florida Keys and relocated to University of Miami Experimental Hatchery. Both groups were quarantined, acclimated and housed in Temperature Controlled Rooms (TRC). The recirculating systems consisted of 12,000 l fiberglass tanks with computer controlled lighting, titanium heat exchangers, packed column biological filters and continuous egg collectors (Wisner *et al*, 1996). Photoperiod was set at 13 h light: 11 h dark and temperatures adjusted to 24 ° and 26 °C. Weekly, fresh mixtures of the laboratory cultured red seaweeds *Gracilaria* and *Agardhiella* (Capo *et al*, 1999) and the green algae *Ulva* were supplied *ad libitum.* Supplemental nutrition was obtained from assorted filamentous algae, diatoms and bacterial mats associated with the tank walls. Each system received 2-4 l/min of ambient 25µ filtered seawater to fill the tank after backwashing and provide excess water to overflow through the 40µ nylon filter bags in which the eggs/larvae were retained. Daily, water quality data (temperature, salinity, and pH) was recorded and the contents of the egg collectors checked for the presence of eggs and/or early echinopleuteus larvae. When present, eggs and larvae were concentrated, fixed with 5% formalin-seawater, and stained with Rose Bengal for ease of identification. The total number of eggs and larvae collected per spawning episode were calculated from triplicate 1ml aliquots of the concentrated samples.

Temperature, salinity and pH varied minimally and remained within acceptable limits throughout the experimental period for both temperature control systems. Adult survival was greater than 95% after the relocation and acclimation to their respective temperature. Broodstock held at 24 °C spawned on 28 occasions (a spawning episode involves an indiscernible number of parents) and between 5,000-400,000 eggs were collected per episode**.** The second cohort maintained from February 2000 through May 2001 and held at 26 °C spawned on 6 occasions. Combined, the 2 broodstock cohorts provided a minimum of 2 spontaneous spawning episodes per month between November and May with the maximum of 8 occurring in November (see chart below). To date spawning events have not correlated with a particular lunar phase but signs of pre-spawning aggregate behavior have been observed.

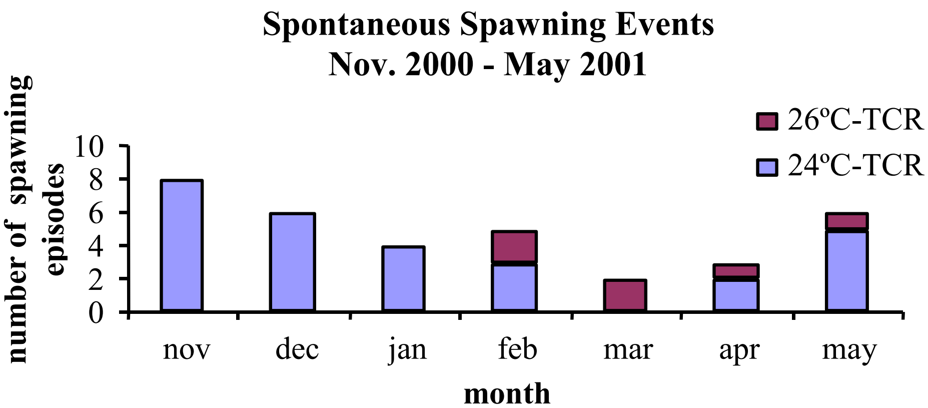

Photo-thermal manipulation of captive broodstock has spontaneously and consistently provided viable spawns throughout the test period. Eggs from six spawning episodes are presently in larviculture. The consistent availability of quality eggs and larvae has proven essential to resolving larval mass rearing techniques for the species.

Acknowledgements: We greatly appreciate the efforts of Nikki Fogarty and Brian Keller for collecting the broodstock. This work is supported by Sea Grant #155-NSGP-UNCW1998-0

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Induced Spawning of False Percula Clownfish *Amphiprion ocellaris* by Hormone Injection

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Newly paired clownfish (presumed females and males) take several months of conditioning before they will begin spawning, and may take several years. Some pairs may court for years but never spawn (Joe Lichtenbert, pers. comm.). An attempt was made to induce spawning in *Amphiprion ocellaris* clownfish by injection with carp pituitary extract.

Methods

Eight pairs of false percula clownfish (*Amphiprion ocellaris*) were divided into three treatment groups. Each of the pairs had been together for at least three months, but none of the pairs had spawned before. Six pairs were placed in three replicate 30 gallon aquara. Each of the 30 gallon aquaria was divided in half and two pairs were added, one pair to a side. One female in each of these tanks received a hormone injection, the other female received a sham injection. The two remaining pairs were placed in a divided 45 gallon aquarium and received no injections. Each pair was provided with a clay flower pot placed on its side and a clay tile placed at a 45 angle between the flower pot and the side glass of the aquarium.

All tanks were illuminated 12 hours a day with a single 20 watt fluorescent lamp, and a single 20 watt actinic lamp was illuminated 24 hours and placed in view of all four tanks to simulate a full moon. Additional light was provided by overhead fluorescent lights during a normal work day. Water temperature was maintained in all tanks at 27 C, salinity at 29 ppt, ammonia and nitrite at 0, and nitrate ranged from 0 to 50 ppt between tanks. The diet consisted of lumpfish roe, frozen artemia, and bloodworms fed twice a day.

Crude carp pituitary extract (Aquaculture Supply, New Orleans, LA) was pulverized with a mortar and pestle and mixed with physiological saline. Injections were made with a 1cc tuberculin syringe and 26 gauge needle. The three females receiving the extract were injected intraperitoneally, just behind the left pelvic fin, with a concentration of 2 mg extract/kg BW. The other three females from the 30 gallon tanks received an intraperitoneal sham injection of saline alone. The two females in the 45 gallon tank were not injected. The tank origin of each female was blind to the researcher.

Results

None of the clownfish pairs in the experiment spawned. It was decided that subsequent daily injections would not be in the best interest of future research with these particular fish. The quantities of fluid introduced to the bellies of the fish produced dramatic swelling. After injection, one of the females stopped gilling and rolled belly up. Fortunately, she recovered after several minutes of gentle ram ventilation by the researcher. This had occurred with another clownfish that received a test injection, however that fish did not recover.

Discussion and Future Research

It is presumed that the surface area to volume ratio for clownfish is too small for intraperitoneal injections, and the introduced fluid produced pulmonary arrest in the two aforementioned females. Data will be presented on dorsal injections made with hCG and GnRH.

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Florida Aquacultured Live Rock as an Alternative to Imported Wild Harvested Live Rock: An Update

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Since 1997, the wild harvest of live rock has been banned in Florida in both state and federal waters. Immediately after this ban, wild rock imports from Fiji and Indonesia skyrocketed (Robinson et al. 2000).

Hillsborough Community College received a three-year research grant from the National Science Foundation to conduct research with private companies on aquaculture methods of live rock. The research encompassed testing five different substrates: 1) Suwanee limestone, 2) Bahama limestone, 3) Miami limestone, 4) pottery clay, and 5) concrete with Styrofoam® beads as live rock hosts. Each of the five substrates were placed on the ocean floor at five sites (Tarpon Springs, Clearwater, Charlotte Harbor, Islamorada, and Marathon) and at four depths (14.63, 9.45, 6.40, and 3.66 meters). The five sites were monitored quarterly with a Hydrolab® and water samples were taken for laboratory testing with a Hach® kit for ammonia, nitrite, nitrate, pH, salinity, oxygen, temperature, light, and turbidity. An Onset® Sensor at each site monitored the temperature every hour. The Florida Keys sites have been assessed since March 1999. The Gulf sites have been monitored since August 1998. The environmental conditions will be presented here along with the first results of biological recruitment on the five substrates. The two locations (Gulf versus Keys) are too different to compare. However we can compare Gulf sites to one other and also the Keys sites to one other as separate entities. The Gulf sites differ from one other by distance from shore, depth, and latitude, whereas the Keys sites differ only by latitude. Bottom time at the Keys sites was shortened due to the destruction of the sites by Hurricanes Georges and Mitch in 1998. Each site showed remarkable habitation by fish and invertebrates (Falls et al. 2001).

Comparison of substrates in the Summer of 2000 showed good growth of organisms at all Gulf and Keys sites. The natural rocks (Suwanee, Bahama, and Miami) and concrete had the most growth. The least amount of growth was seen on the pottery. The inshore site at 3.66 meter (Charlotte Harbor) is the least favorable habitat for an artificial reef. The rock from the Gulf sites showed initial secession of barnacles that were later replaced by coralline algae, filamentous algae (green, brown, and red), encrusting sponges, bryozoans, sipunculid worms, and clams. Later stages show the beginning growth of hard corals. Barnacles were not found on Keys rocks but all other organisms found on Gulf sites were present. The growth rate in the Keys rock developed faster than the Gulf rock by approximately six months. The depths of 14.63, 9.45, and 6.40 meters were all commercially acceptable. The evaluation of quality of the product as commercially acceptable by the ornamental trade was subjective. Customers of the two commercial co-researchers in this study found the aquacultured live rock to be superior to wild imported rock. They describe aquacultured rock as having more life and more color. In addition, it lives longer in their systems. These qualities bring repeat satisfied customers.

Comparison of Florida aquacultured live rock to Fiji rock showed that Fiji rock contains more phosphates than Florida rock. Gulf of Mexico live sand was shown to contain approximately the same level of phosphates as Fiji rock. Table 1 shows the complete comparison of all five substrates, sand, and Fiji rock.

(ppm)	Concrete/ Styrofoam	Clay	Miami Limestone	Suwannee Limestone	Bahama Limestone	Fiji	Gulf Sand
Nitrogen	30	5	5	5	5	30	5
Phosphorus	50	75	12.5	37.5	5	37.5	37.5
pH	11.5	7.5	8.5	7.5	8	8	8
Potassium	200	50	50	70	45	200	200

Table 1. Chemical analysis of substrates.

This study will be completed at the end of July 2001 and the final results will be shown at this meeting. The 2000 annual report is available on the HCC web site at www.hcc.cc.fl.us/services/departments/aquaculture/aquacul.html for viewing or downloading.

Florida aquacultured live rock has continued to grow since the ban in 1997. In 2001, there are eight state and fifteen federal lease sites. This year, the Florida Aquaculture Association will vote on live rock as an official new commodity and elect a representative for this new industry to the Board of Directors.

Finally, enterprising live rock aquaculturists have developed techniques to enhance aquacultured live rock by propagating and attaching various different organisms to small pieces of rock. One such example is “Eco-gorgonians.” Clippings of wild gorgonians are attached to aquacultured live rock. The wild parent gorgonian is left in the sea to continue grow without harvesting the whole animal. The clipping will attach itself to the rock and continue to grow in a reef tank. Research continues on “Eco-gorgonians” in Florida to develop methods to commercial rear this new environmentally friendly product which enhances the reef tank and can be used to seed damaged natural reefs.

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Intestinal Flagellates in Cultured Clown Fish (*Amphiprion* sp.): Clinical Presentation and Management

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Eggs and larvae of commercially cultured percula clown fish were submitted to the fish disease diagnostic laboratory at the University of Florida with a complaint of poor hatch (<50%) and high larval mortality (90%). Eggs were completely covered with a flagellated protozoan that resembled the freshwater parasite *Spironucleus* sp. Adult fish were submitted for examination to determine whether eggs might have become infected from the adult fish, as has been suggested in freshwater angelfish. Flagellates were not found in the intestine of the single female that was submitted for necropsy, however the decision was made to treat all adult fish with metronidazole medicated feed (1.0 g of active drug per 100 grams of food) for five days. Initially, there was a positive response to therapy, however, one month later there was a complaint that the adult fish had completely stopped spawning. A telephone interview with the owner indicated that the fish had been treated with metronidazole at a dose that was substantially higher than the recommendation, and that the daily feeding of the medication had been continuous (≥ 30 days). Reproductive failure has been associated with metronidazole toxicity in dogs. A similar toxic response was hypothesized to have occurred in these fish. A review of the ecology of intestinal parasites, and appropriate use of metronidazole in ornamental fish will be presented as part of this case discussion. Other problems were found on these fish and these will be discussed briefly as well.

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Enhancing Growth of Caribbean Sea Fan Corals in Closed-Cycle Systems

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Advances in reef tank technology have increased the interest from ornamental hobbyists in the availability of corals for their marine aquarium systems. At the same time, many coral reef species are declining because of a lack of suitable habitat, disease, predation and catastrophic events. Photosynthetic soft corals, such as the Caribbean Sea Fan *Gorgonia ventalina*, are found throughout the Florida Keys. Recent reports have documented declines in certain habitats resulting from boat groundings and fungal disease infections.

At this time, there are no commercially cultured gorgonians available in the U.S. aquarium market. Efforts are underway at Harbor Branch Oceanographic Institution to develop the culture technology to produce sea fan colonies. These colonies will be used to replenish depleted natural stocks and provide coral colonies for the marine aquarium industry. Sea fan corals are ideal home aquarium species when the proper lighting is provided to support photosynthesis because they require little to no food.

Efforts to develop the culture and husbandry techniques to economically produce, grow and maintain sea fan corals is currently underway. Production trials have included experiments to determine if the addition of feeds enhances coral growth. Experimental trials were conducted in fall 2000 to determine if the addition of live and liquid feeds increased growth. Feeding trials were conducted in replicated ten-gallon tanks that were filled with seawater. Three coral colonies were placed in each tank for feeding trials. Live and liquid feeds (microalgae– *Nanochloropsis* sp.; enriched rotifers; Marine Snow – a mixture of *Artemia* and photoplankton) were provided to tanks containing individually numbered colonies and growth was compared to control (no feed) colonies. Although growth was not significantly different between the treatments, the greatest increase in mean growth was seen in the enriched rotifer treatment.

Based on these results a new feed trial was initiated in fall 2001 targeting the preferred particle size using dry microparticulate feeds. The test feeds have a much higher protein content than the earlier water-based feeds. Three treatment diets (Golden Pearls – enriched brine shrimp, Salmon starter diet - 52% protein, Revolution - a high-protein) are provided and growth is being compared to Control (no feed) colonies. The culture system design and results of the growth trials will be presented.

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The Copepod/*Artemia* Tradeoff in the Captive Culture of *Hippocampus erectus* (Syngnathidae)

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More than 20 million seahorses are traded worldwide each year and there is every indication that seahorse consumption is on the rise. Although the vast majority of seahorse landings are destined for use in Chinese traditional medicine and shell shops, substantial numbers are also taken for the aquarium trade. Seahorses' low fecundity, monogamous mating behavior and limited species ranges place them in a precarious ecological position. The sustainability of this fishery has not yet been determined, but it is very likely being exceeded for many species (Vincent, 1996).

Although seahorses have been spawned and reared in captivity for many years, a simple, effective and reliable culture protocol is yet to be developed (Forteath, 1996; Scarratt, 1995; Vincent, 1996). At the Hofstra University Aquaculture Laboratory, an effort is underway to solve some of the problems preventing efficient seahorse culture. Two of the major stumbling blocks encountered in the rearing stage are: the inability to provide a sufficiently nutritious first food, and an apparent gas bladder problem which can afflict up to 50% of a brood within the first few days. The affected juveniles become trapped at the surface and eventually die.

In preliminary rearing trials with *Hippocampus erectus,* a tank design was developed which effectively prevented newly hatched seahorses from becoming trapped at the surface. In trials where enriched *Artemia* nauplii were fed to seahorses as an exclusive food, 100% mortality was observed after 2 weeks. In successive trials, wild-caught copepods were substituted for *Artemia* as a first food. After a varying number of days on copepods, the diet was abruptly switched to enriched *Artemia* nauplii. In each of these trials more than 100 juveniles per brood survived to day 60. No difference in survival was observed between juveniles offered copepods for 3, 14 and 24 days, respectively. An experiment has been designed and will be carried out during the summer 2001, in which broods of newborn *H. erectus* will be divided into 6 identical tanks and offered wild-caught copepods for 0-5 days, followed by enriched *Artemia*. Growth and survival of the seahorses will be compared. The results of this experiment will be reported on and the copepod/*Artemia* tradeoff will be discussed.

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Coral Farming In the Philippines: Reef Restoration and Sustainable Use By The Aquarium Trade

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The International Marinelife Alliance (IMA) presently manages two coral farms situated in the Central Visayas, off the Island of Cebu, in the Philippines. The first coral farm was set up on Olango Island in the village of Caw-oy during 1999, by Dr. James Heeger of the University of San Carlos, and now is managed by the IMA. The IMA transported cultured corals from the first farm to start a second farm on Camotes Island during 2000. Local fishermen from villages near both coral farms have been trained in the techniques of coral fragmentation, mounting corals on concrete substrates, and the placement of the coral fragments for grow-out in concrete frames in designated areas. Research is being conducted on coral growth rates. The Olango Island coral farm has a building (shaped like a fish) that is being used as a regional teaching facility. Training in mariculture techniques such as coral farming provides an alternative livelihood for fishermen presently involved in destructive fishing. Reef restoration using coral fragments is planned tied with the placement of artificial reefs. The coral farming needs to be integrated with community-based zonal management strategies, wherein the community allocates lease sites for mariculture, fishing, and/or marine protected areas.

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Live Rock Farming Using Sand Molded Substrate

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Live Rock Aquaculture can be conducted in close systems and in an ocean based project. One of the problems that need to be solved during the planning phase of live rock aquaculture is the acquisition of proper substrate that will be used as base rock. Geothermal Aquaculture Research Foundation has been testing cement-based concrete as a structure for live rock aquaculture. Starting in 1994 Geothermal Aquaculture Research Foundation has developed several recipes and molding methods that can be used by live rock farmers to produce a valuable light weight, porous live rock.

There are several problems inherent to using naturally occurring limestone and aragonite rocks. A final live rock product depends on the type of base rock utilized, and if this base rock does not have a desirable shape and density the finished live rock will not be valuable in the marketplace. By using aragonite gravel and a few simple tools the live rock farmer can control the quality of the finished product. Geothermal Aquaculture Research Foundation has developed a test marketing program that has been researched using the sample trade name Aragocrete™. Several ocean based rock farmers in Fiji and Hawaii are now using sand molded live rocks in their aquaculture program.

In 1994 Geothermal Aquaculture Research Foundation decided to develop a program to supply information to the marine hobby trade about the use of man-made substrate in live rock production. Geothermal Aquaculture Research Foundation has made and marketed tons of dry base rock to hobbyists in the United States. Our marketing research shows that people are willing to pay a premium price for certain types and shapes of artificially created live rock.

The ingredients used by Geothermal Aquaculture Research Foundation to create sand molded live rock are available worldwide. The basic recipe used in the Aragocrete consists of five parts calcium based gravel and one part white cement. This mixture is combined with a small amount of fresh water to create a dry slurry.

The tools needed for production of sand molded live rock consists of a wheelbarrow, five gallon plastic buckets, and several small shovels. The simple tools can be used to create thousands of pounds of base rock each day. The entire live rock production can be done in less-developed areas using the simple tools because they are available worldwide.

Sand molded live rock can be formed into various shapes that are desirable in the aquarium hobby. By creating lightweight porous sculptures that have holes through them this product can be identified easily at the time of harvest. Geothermal aquaculture Research Foundation has developed several methods to identify the man made live rock years after it has been encrusted with organisms.

Curing the Aragocrete Sculptures consists of a simple process of soaking them in warm fresh water for a period of six weeks. This curing process is needed before the base rock is used in closed system aquaculture.

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Producing Sps Coral Fragments Using Escape Size and Fragment Orientation

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Geothermal aquaculture Research Foundation has been able to collect, maintain, and propagate several hundred different strains of sps corals. During the last two years we have been researching production techniques that include symbiont recombination and axial corallite -growth tips- initiation. The growth tips of SPS corals in the genus *Acropora* are very important in the commercial propagation of fragments. By manipulating the brood stock corals we have been able to increase the number of salable frags. Many times a fragment from a small colony of coral will outgrow the colony it came from.

In commercial coral production and in coral research it is often necessary to produce a large number of identical clones of certain small polyp stony corals. At Geothermal Aquaculture Research Foundation when we are working with a new strain of *Acropora* we conduct a series of experiments to determine the optimum growth conditions that will produce the largest number of salable fragments in the shortest time. Analyzing digital photographs taken over a period of several weeks it is easy to determine the optimum escape size and fragment orientation for each strain of coral. The use of super glue reduces the time needed to attach a series of small fragments for observation.

Escape Size

There is a well-known process in marine biology called escape size. During evolution any coral that was broken into small pieces and was able to initiate a rapid early growth was able to survive to produce offspring. It is easy to understand that escape size for sps corals may well be just below the size that is large enough so that something will be left if a Parrot Fish takes a bite.

Each distinct body type of *Acropora* has its own different optimum escape size. Cuttings that are below this size do not have enough polyps to start rapid growth. When too large a branch is used as the cutting the coral often does not go into accelerated growth.

We have chosen a beautiful blue tip *Acropora* for a series of slides that document the production of growing tips, axial corallites. Fragment orientation and controlled pruning are two of the methods that have produced the best results. The Blue tip *Acropora* that we are using in these experiments has an important growth characteristic that has made this work very easy to document. When we received this stag horn coral it was a dull green color. This strain of *Acropora* took about one year to start growing and when it did we noticed that each of the growth tips turned a beautiful florescent blue.

Because this coral has two distinct colors it makes it very easy to document axial corallite production. As soon as the Polyp has started to grow into an axial corallite it turns bright blue. Other types of coral grow very fast, but the axial corallites are the same color as the brood stock.

Fragment Orientation

The blue tip *Acropora* has medium branch size and it has tubular corallites. I will now explain the method that we use to produce multi tip colonies of this coral in the shortest possible time. The cutting is taken of this coral that is approximately 1 in. long. This cutting is mounted very close to the original colony with the growth tip pointed slightly down at what would be 08:00 on a clock face. Super glue is used to attach a group of these corals to a clean Aragocrete rock. During the last year we have been able to mount hundreds of these cuttings in our brood stock tanks. The cuttings that are glued with a growth tip pointed down soon produces several axial corallites on the fragment. These fragments grow most rapidly if they are mounted closer to the light than the parent colony.

Each distinct body type of *Acropora* has its own different optimum Escape Size. Cuttings that are below this size do not have enough polyps to start rapid growth. When too large a branch is used as the cutting the coral often does not go into accelerated growth. At GARF we have over three hundred strains of ornamental corals, and we are researching the proper size of cuttings for each of these strains.

This blue tip *Acropora* has morphed into a rapidly growing commercial coral and the new branches grow to about three-quarters of an inch in twelve weeks. The original fragment is carefully removed from the super glue that is holding it. Super glue allows you to attach fragments in a few seconds, but more importantly unlike epoxy putty is very easy to remove the fragment

The small broken branches can be glued to another rock. The original fragment with the branches removed is then mounted in the same location. When this fragment is glued it is mounted upside down so the branches are pointing toward the bottom of the aquarium. On this fast-growing blue tip *Acropora* the bottom of the branches are much lighter colored, and there are very few radial corallites.

Break *Acropora* Branches

It is important to get into the habit of snapping *Acropora* branches instead of cutting them. By breaking the branches with a pair of needle nose pliers you produce a clean break. When *Acropora* branches are broken you often find that several of the corallites at the break have been split in two leaving the polyp exposed. On this strain of Blue Tip *Acropora* the surviving polyps first look like black dots set back slightly from the edge of the white skeleton. The broken corallites that contain living polyps will often produce a new axial corallite. By using small pliers to break the harvested branches it is possible to double the number of new axial corallites that grow from the harvested base.

For several years we have been studying thousands of *Acropora* cuttings to learn what initiates axial corallite production. A major part of our research is the collection of over one hundred thousand digital pictures of our reef aquariums. We are now able to go back several years and watch cuttings as they grow into colonies.

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Small Scale Mysid Shrimp Culture

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Various species of mysid shrimp (also known as opossum shrimp) have been collected or cultured as a live food for aquatic animals that prefer living foods, such as seadragons, seahorses and pipefish. Some newly imported marine fish that initially refuse to eat typical aquarium fare begin feeding readily when offered live mysids, and then soon adapt to less expensive foods. Many other hardier species of fish also relish the addition of Mysids to their diet, but difficulty in producing these crustaceans in sufficient quantity generally relegates their use to only these most critical cases.

Not all public aquariums utilize live mysids as a food source for the animals in their collections, but extensive displays of seahorses, pipefish and seadragons usually mandates that an adequate supply of live mysids be available. Some coastal aquariums are able to collect their own mysids, but most purchase them from collectors. Of these, one aquarium in particular reported spending over $25,000 in one year for this food. Most aquariums utilizing wild mysids spend much less than this, but it is estimated that on average, they still spend $5000 to $12000 per year for these shrimp. Problems that have been reported by virtually every facility purchasing wild caught mysids have included shipping mortalities, “short counts” and metazoan contaminants such as larval fish, crabs and hydroids. Cultured mysids do not have any of these associated problems. In addition, in-house mysid cultures allow aquarists to select different sizes of mysids to use for special fish rearing projects whereas wild mysids are usually all adult size. Two aquariums, one in the United States and one in Germany have reported chronic *Uronema*-like protozoan infections in their mysid cultures. This has only been seen to cause health problems when these mysids are subsequently fed to seadragons without a prophylactic anti-protozoan treatment.

Last year, a survey of public aquariums in North America showed that only four facilities were raising their own mysids in sustainable cultures at a production rate greater than 2000 shrimp per week, and of these, only two relied exclusively on in-house cultured mysids. Of the aquariums purchasing mysids from commercial collectors, the estimated cost they reported was between .017 cents and .16 cents each, with most indicating a cost of around .025 cents each.

The culture method described can produce over 2000 *Mysidopsis bahia* per week with a time investment of less than 30 minutes per day. Equipment cost is minimal, and the only operational cost of note for this system is the substantial use of artificial seawater and the utilization of *Artemia* nauplii and frozen cyclops as a food source. Using 100 square feet of floor space, and small aquariums with individual air driven filters, the larval mysids are separated from the broodstock by either individually siphoning them, or using the “differential mesh” method. Originally, the average cost for these cultured mysids at the Toledo Zoo was .06 cents each. Refinements made to the technique during the past year has lowered the costs associated with this method to between .028 cents and .042 cents each, very similar to the expense of wild collected mysids.

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Future of Marine Ornamental Fish Culture

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Marine tropicals virtually represent an unlimited, untapped field coupled to a constantly diminishing wild-caught supply. In 1996, 54 million households (58%) in the USA owned at least one pet of which 10% had freshwater fish and 0.8% had saltwater fish. Within the USA it is estimated that 89 million freshwater fish are maintained in 12.1 million aquaria while 5.6 million marine tropical fish are maintained in 1.1 million aquaria. It was estimated that 80% of the freshwater fish are cultured from farms in Florida and Southeast Asia. Whereas, virtually 99.8% of the marine fish, invertebrates and algae are collected from the wild. Worldwide it has been estimated that the aquarium industry is a $4 to $15 billion industry.

Current demand and direction of future marine tropical fish culture endeavors is mainly dependent on nurturing mass customer acceptance of higher price fish and invertebrates. The freshwater aquarium market is well established and has survived by offering very competitive priced livestock. However, in order for cultured marine tropical fish and invertebrates to survive initially we must be able to entice customers to accept higher priced cultured livestock. As this industry matures and competition becomes better developed, prices on the more common cultured species will become very competitive and be more attractive to a larger number of customers.

The goal of this presentation is to cover past and future endeavors and outline some of the reasons for failure of past ventures. I hope to provide insight into why, where and how future investments in marine tropical aquaculture ventures should consider. Of extreme importance is how interest and management of such a venture may make or break the possible success.

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Cultivation Techniques for the Variegated Urchin *Lytechinus variegatus*

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The marine ornamental industry is moving toward self-sustainability. To further this goal, larval food sources and techniques for culture must be developed because standard techniques and food types from commercial aquaculture are not always directly applicable to target organisms in the marine ornamental industry. This study investigates four algal species rarely or never before used in marine ornamental aquaculture: *Micromonas pusilla*, *Pavlova pinguis, Porphyridium cruentum*, and *Rhodomonas lens*. These species were selected as genera or representatives of classes (divisions) because they possess unique and/or abundant fatty acids, polysaccharides, and vitamins. The sea urchin *Lytechinus variegatus* was chosen as a representative of the Echinodermata to establish protocols for future research of this and other classes of Echinoderms with similar larval stages and with potential commercial viability for the marine ornamental industry.

Sexually mature (5-9 cm) *Lytechinus variegatus* were collected from near-shore seagrass beds in Biscayne Bay (Miami, Florida USA) during July, 2001. Spawning was induced by injection of potassium chloride (3cc at 0.55M) through the perioral membrane. The eggs from a single female were rinsed three times with U.V. sterilized offshore seawater (35ppm, used throughout this research) to remove debris and organisms, allowing the eggs to settle (30 minutes) after each rinse. Sperm from a single male was collected dry (no water added) and kept refrigerated until egg rinsing was complete. Seven drops of sperm were placed in 200ml sterile seawater, stirred, and allowed to sit for fifteen minutes for debris to settle and to activate the sperm before mixing with the eggs. After the final rinse, the eggs were placed in a 1 liter beaker and enough sterile sea water was added to increase the volume to 500ml. Then 10ml of the diluted sperm was added and stirred. Fertilization was confirmed by observation of the fertilization membrane under compound ocular microscopy. After the eggs had settled, they were rinsed twice to remove excess sperm and to prevent polyspermy. The clean eggs were placed in a 20cm diameter glass dish (to prevent egg layering), filled to a depth of 3cm with sterile seawater and covered with a paper towel to prevent the introduction of airborne debris (no aeration or water motion).

Free-swimming blastulas were present in the water column within 24 hours and these were poured into a 3.8 liter (1 gallon) glass jar, and sterile seawater was added to a total volume of 3 liters to reduce the density and facilitate the transfer of appropriate numbers of organisms to the culture jars. Blastulas were added at a concentration of 600/liter, to sixteen 3.8liter jars (four replicates per algal species) each containing 3.0 liters sterile seawater. *M. pusilla* was added at a concentration of $3x10^4$ cells /ml and the other three algae at $1x10^4$ cells/ml; these levels were maintained throughout larval development. Aeration and water motion were supplied by a paddle system (Sthrathmann 1987), as modified by Wolcott (unpublished). Every two days, seventy-five percent of the water was siphoned out of the culture jars and replaced with sterile seawater. A 125 micron mesh cloth was used to prevent the loss of larvae during this process.

Nine days after fertilization, the larvae that were fed *Rhodomonas lens* had either settled and begun metamorphosis or remained in the water column, but had developed rudiments. The experiment was terminated at this point and all 16 replicates were examined to determine the larval development stages attained. Larvae fed *Pavlova pinguis* had reached the fully developed pluteus stage. Those fed *Porphyridium cruentum* were slightly less developed, but had reached the eight-arm pluteus stage. Larvae fed *M. pusilla* were about evenly divided between the six-arm and early eight-arm stages. At the algal concentrations used in this research *R. lens* produced superior results, larvae had developed rudiments and/or had begun to metamorphose.

The rate of larval development was directly correlated with algal cell volume (*R. lens* largest to *M. pusilla* smallest) even considering the increased number of *M. pusilla* cells that were fed to the larvae. Further research is needed to determine if larval development may also be correlated with total available biomass and/or the nutritional profile of the algae.

The paddle aeration technique used in this research may be appropriate for other marine larvae that are adversely affected by air bubbles commonly used for aeration and/or water motion.

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Copper Resistant Amyloodininosis and Possible Immunosuppression in Marine Fish

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Amyloodiniosis can be a devastating parasitic disease for captive marine fish, infecting many species (Noga and Levy, 1995). Within 48 hours, 100% mortalities are known to occur. Like the ciliated protozoan, *Cryptocaryon multifilliis*, the dinoflagellate *Amyloodinium ocellatum* has a complex life cycle. Therefore, treatment is difficult; only the dinospore stage is affected by chemotherapy. Prolonged immersion with copper has been the treatment of choice (Cardeilhac and Whitaker, 1988).

Over the last year, a retailer has submitted multiple marine reef species to our University of Florida Fish Diagnostic Laboratory. On three separate visits, heavy infestations of *Amyloodinium ocellatum* were observed on the gills, skin, and fins. All incoming fish are exposed to a ten-minute freshwater dip, followed by a 250 ppm formalin dip before being placed into the store's 1400 gallon (multi-aquaria) display system. This system is also equipped with 250 Watt UV sterilizer, protein skimmer, two biofiltration systems, and kept at maintenance level of chelated copper of 2.0 – 2.5 ppm.

A recommendation was given on each occasion to treat the entire system with the antimalarial drug, Chloroquine diphosphate (Lewis, et al, 1988; Noga, 1996) at a dosage of 10 ppm. Fish appeared to respond quickly and a recheck on survivors three to five days post treatment were Amyloodinium-free.

The resistance of *Amyloodinium* to a constant copper level was a concern. Although the copper was in the chelated form, measurements of free copper levels were also 2.0 – 2.5 ppm, a ten-fold increase over the recommended 0.1 – 0.2 ppm levels. Since copper has been indicated as a immunosuppressant in fish (O'Neill, 1981; Anderson et al, 1989; Zelikoff, 1993; Austin et al, 1999), our laboratory was concerned that the retailer's fish may becoming immunosuppressive from present copper levels, making them susceptible to *Amyloodinium*. Furthermore, it was demonstrated that the ten-fold level of copper may have played a role in another outbreak in the same facility. After a complete breakdown and restart of the system, with a fresh dose of 2.5 ppm chelated copper, acute mortalities occurred within 48 hours of introduction of new fish. The etiologic agent in that case was the bacteria, *Aeromonas salmonicida*. It was suggested to remove the copper with a 100% water change and activated carbon. Fish examined five days later were clean from parasites and bacterial infection.

Because of the complexity of chelated copper and the unknown efficacy (Noga and Levy, 1995, and in this case), we recommended the standard 0.1 – 0.2 ppm free copper maintenance level and ultraviolet sterilization for the retailer's system. Further studies with chelated copper, immunosuppression, and infectious agents will need to be addressed.

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Captive Reproduction of Yellow Tang and Pygmy Angelfishes at the Oceanic Institute in Hawaii

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Hawaii is a major supplier of wild-collected marine ornamental fish to the worldwide aquarium trade. At present, only about 30 of the more than 800 traded marine ornamental species can be reared in captivity. In order to meet the future demands of a growing ornamental industry, it is important that researchers provide suitable alternatives to this reliance on wild-collection practices. However, significant scientific breakthroughs are required to expand the number of cultivatable species.

In general, the two major bottlenecks preventing captive production of many marine ornamental species are (1) the reliable control of reproduction in captive broodstock, and (2) the identification of suitable feeds for early larval rearing (reviewed by Ostrowski and Laidley, in press). The Oceanic Institute (OI) recently began efforts to resolve these bottlenecks in order to spawn and propagate three commonly traded species in Hawaii: the flame angelfish (*Centropyge loriculus*), Potter's angelfish (*Centropyge potteri*), and yellow tang (*Zebrasoma flavescens*).

Broodstock populations of flame angelfish were successfully established at the Oceanic Institute in October 1999, based on the work of Lobel (1978) and Bauer and Bauer (1981). Natural spawns were obtained within one month of stocking in spawning tanks. These pygmy angelfish have continued to spawn daily at dusk without interruption for over 18 months. Similar efforts with the related Potter's angelfish have also yielded rapid success. Over time, broodstock flame angelfish populations have substantially increased egg output (Fig. 1), with the egg output of individual tanks containing one to three females, increasing from several hundred to over 3,000 eggs/day.

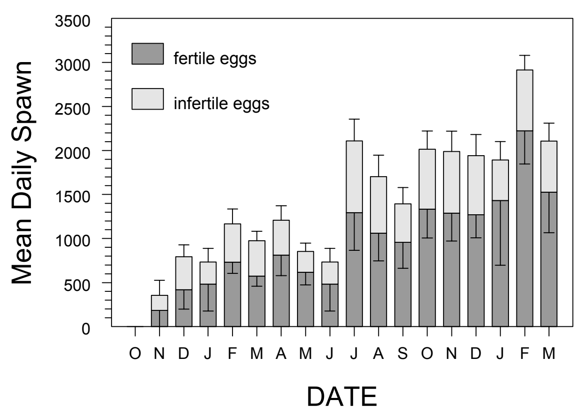

Figure 1. Mean daily egg production for flame angelfish (*Centropyge loriculus*) broodstock tanks at the Oceanic Institute in Hawaii.

In addition to success with angelfish species, OI has also successfully spawned yellow tang, the signature species for Hawaii. These efforts began with field studies into the reproductive biology of natural yellow tang populations, and culminated with the successful spawning of captive broodstock this spring. Field studies allowed us to identify and separate the sexes based on external characteristics that include size dimorphism and bristle patch characteristics. Under a monthly sampling regime, we have characterized the natural reproductive cycle of the yellow tang. These findings correspond to earlier reports (Thresher 1984, Lobel 1989) and show that a low percentage of females spawn year-round while the majority of the natural stocks display a seasonal pattern of reproductive activity. Seasonal changes in female yellow tang include increases in gonad and liver weights, and corresponding increases in the frequency of yolk globular and hydrating stage oocytes, in late spring and extending into early summer. Males appear less seasonal with fully developed testes throughout the year.

On-shore culture tanks were subsequently stocked with equal numbers of males and female yellow tang and tank effluents monitored daily for egg releases. Captive populations began spawning in January, with a peak in spawning activity from multiple tanks throughout the spring and early summer.

The timing of captive spawning corresponds well with gonadal development of natural yellow tang populations in Hawaii. Initial spawns from captive broodstock were relatively small (only a few hundred eggs/tank) and infertile. Spawning activity has continued in a cyclical pattern, with the release of the first fertile natural spawns recorded this March. Although fertility rates remain low (peaking at only 22%), tank fecundity has increased over a hundred-fold to peak spawns of over 13,000 eggs/tank this April.

Yellow tang eggs obtained from both wild spawns and captive spawns were similar, producing eggs with a mean egg diameter of 708 μm and the presence of a 163 μm diameter yellow-colored oil droplet. Embryonic and early larval development appears similar to other difficult-to-rear pelagic spawning reef species.

Considerable work remains to identify the appropriate larval feeds required to sustain these tiny yellow tang through the remaining stages of larval growth and development (bottleneck 2), but just getting these fish to spawn fertile eggs under captive conditions has been a major breakthrough.

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Acknowledgements: The authors appreciate support from the Center for Tropical and Subtropical Aquaculture and the Cooperative State Research, Education, and Extension Service of the U.S. Department of Agriculture Award No. 99-38500-7399; and the National Marine Fisheries Service Award No. NA96FV0282.

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Overview of Marine Ornamental Shrimp Aquaculture

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Many species of marine shrimp, belonging to different taxonmic groups, are collected from wild for the aquarium trade. These species are strikingly colorful and relatively easy to maintain as adults in an aquarium environment. Several of these species have developed close symbiotic relationship with a variety of other animals. For example, some *Lysmata* species are facultative or obligatory cleaners of fish parasites and some (e.g., *L. grabhami*) live symbiotically with sea anemones. Direct and indirect impacts of collecting these shrimp have caused concerns. In recent years efforts have been made to understand the biology of these shrimp and develop cultivation technology to reduce wild collection while sustaining the aquarium trade industry.

Periclimenes petersoni and *P. yucanicus* are very small (therefore less popular in the aquarium trade) and their broodstocks are difficult to maintain (Creswell and Lin, 1997).

The research and development have largely concentrated on the species of cleaner shrimp *Lysmata* and banded coral shrimp *Stenopus* and complete life cycle culture has been achieved for several species (Table 1). *Lysmata rathbunae* and *L. wurdemanni*, two very similar species (often marketed together), have the additional value in controlling the glass anemone *Aiptasia padilla*. The anemone can proliferate quickly through asexual reproduction in an aquarium. They possess both spirocysts and nematocysts that used in self- defense and prey capture and therefore are harmful to other tank inhabitants.

Like in penaeid shrimp, eyestalk ablation can be used to shorten molt interval and to stimulate gonad development in *Stenopus hispidus* (Zhang et al., 1997a), and maybe in other species as well. For *Stenopus* species, sex is difficult to identify. The paring can be challenging at times as each shrimp has a pair of ferocious claws and may attack other shrimp, including a prospective mate. The female is generally the aggressor and sometimes a male may have to be introduced when a female molts. Mating in *S. hispidus* (Zhang et al. 1998a) and *S. scutellatus* can be divided into five steps and the copulation lasts for only five to 10 seconds.

Spawning of *Lysmata* and *Stenopus* shrimp in captivity is relatively easy, especially for the *Lysmata* species, as they are simultaneous hermaphrodites, a unique reproductive system among the decapod crustaceans (Bauer and Holt, 1998; Lin and Zhang, in press). A female can produce several hundred to a couple of thousand eggs during each spawning and carries the embryos under her abdomen until the larvae hatch 10 to 20 days later (Fletcher et al., 1995; Zhang et al. 1998c). The color of the egg mass gradually change and the eyespots appear four to five days before the larvae hatch. Within several to 48 hours after hatching, the female molts, be receptive to mating, and spawn (with or without mating) again. Females can only mate and have their eggs fertilized during the post-molt period when they are soft. Males, at least for *Lysmata wurdemanni*, on the other hand, can fertilize eggs successfully during inter-molt stage (except for those that mated within a day), even with egg mass underneath the abdomen (Lin and Zhang, in press).

In *Lysmata*, larvae are composed of zoea and mysis, each with several stages (Fletcher et al., 1995; Zhang et al., 1998b). In *Stenopus*, newly hatched larvae resemble the mysis larvae of penaeid shrimp and the larvae go through many stages. The biggest challenge for commercial culture of marine ornamental shrimp is the long larval duration (Table 1). *L. rathbunae* has the shortest larval cycle among the species studied, but 25-35 days are still considerably longer than those of penaeid shrimp. Even with considerably higher unit value than food species, shortening larval cycle is the key for successful commercial production of these ornamental shrimp species.

Improving diets of broodstock, and especially of larvae, may accelerate the rates of larval development and increase the potential of commercial aquaculture. For *Lysmata debelius*, average (±s.d.) number of larvae produced decreased from those fed with live *Artemia* nauplii (1,766±391), to frozen enriched *Artemia* nauplii (1,553±224), to frozen *Artemia* nauplii (1,019±276), to fresh mussel and polychaete (486±254) (Simoes et al. 1998). For *L. amboinensis*, however, the shrimp produced similar brood size (mean±s.d.) between those fed with mussel and polychaete (497±251) and those fed with frozen enriched Artemia nauplii (496±120) (Simoes et al. 1998). Broodstocks of *L. wurdemanni* fed with frozen enriched adult *Artemia*, frozen regular adult *Artemia*, and frozen clams produce similar quantity and quality eggs (Lin and Zhang, 2001).

Live *Artemia* nauplii, rotifers, and/or microalgae have been used as live feed for shrimp larvae. *Moina*, freshwater cladoceran that extensively used for marine fish culture in Asia, and copepod nauplii should be tested as alternative live feed for shrimp larvae.

Table 1. Attempts to cultivate various marine ornamental shrimp

Species	Larval Duration	References
Hymenocera picta	28-56 days	Kraul 1999
Lysmata amboinensis	140 days	Fletcher et al., 1995
Lysmata debelius	75-158 days	Fletcher et al., 1995; Palmtag and Holt, 2001
Lysmata grabhami	?	Zhang et al., unpublished
Lysmata rathbunae	25-35 days	Zhang et al. 1998c
Lysmata wurdemanni	90-110 days	Zhang et al., unpublished
Periclimenes pedersoni	?	Creswell and Lin 1997
Periclimenes yucatanicus	?	Creswell and Lin 1997
Stenopus hispidus	120-210 days	Fletcher et al., 1995
Stenopus scutellatus	43-77 days	Zhang et al., 1997b

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Nubbin-size Dependent Budding and Survival in Corals of *Pachyclavularia violacea* and *Galaxea fasciculari* under Natural and Artificial Environments?

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Although land-based and sea-based farms for coral culture are well developed, information on growth comparison between natural and artificial environments are still needed. In the present study, the growth of corals *P. violacea* and *G. fasciculari*, with different nubbin sizes, were compared in the aquarium and field. In *P. violacea*, with nubbin sizes of 6, 12 and 24, a positive correlation between nubbin size and the number of new buds was observed (y =026x+1.41, p<0.03). With nubbin sizes of 1, 3, and 6, a positive correlation between nubbin size and the number of new buds was also observed in *G. fasciculari*. (y =2.44x+6.81, p<0.01). Partial death in the nubbins of *P. violacea* and *G. fasciculari* varied in the range of 10 - 30% and 0 – 10%, respectively. There was no significant difference in the partial death among nubbin sizes in both *P. violacea* and *G. fasciculari*. By comparison, new bud formation of *P. violacea* in natural environment was 0.4 per week that was slower than the artificial group (2.0 per week). The same trend was also observed in *G. fasciculari*, i.e. 2.7 vs. 1.7 per week. Our results indicate that budding of *P. violacea* and *G. fascicularis* are nubbin-size dependent and survival is not.

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Florida's Aquaculture Best Management Practices Program

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Florida is the third leading producer of aquaculture products in the United States. While the commercial production of marine ornamentals is in its infancy, a well-developed regulatory infrastructure exists. During the 1998 legislative session, environmental permitting and regulatory functions for aquaculture were consolidated within the Florida Department of Agriculture and Consumer Services (FDACS). The Department was directed to register and certify (using on-farm visits, a farmer affidavit and confirmation through the appropriate agency) that Florida aquaculture facilities were fully permitted by federal, state and local agencies. In addition, the Department was directed to develop a program of aquaculture Best Management Practices (BMPs) to replace most water management, storage and discharge permits while ensuring the environmental protection goals of the State of Florida are satisfied. The Department was also directed to offer one-on-one assistance to acquire all other environmental permits from the federal to local level and for the outright acquisition of certain fish and shellfish culture permits that were transferred to the Department in recognition that these were farm-raised, domesticated species.

The primary objective of the Certification Program and Best Management Practices is to allow aquaculturists to design and operate their individual facility without harm to the environment and without undue regulation. The BMPs have been drafted to protect environmental quality while allowing the aquafarmer to be innovative in his/her approach to production. The Best Management Practices have been incorporated into Administrative Rule, allowing for the addition and revision of criteria as conditions and technology warrant. Aquaculturists, certified through the Department's Certification Program and following the Best Management Practices, are presumed to be in compliance with State groundwater and surface water standards and do not need additional environmental permits through other state agencies.

Florida's Best Management Practices are found in the *Aquaculture Best Management Practices Manual* (FDACS, 2000) and apply to all types of production and at all phases of operation. Specific management practices are discussed in the BMPs for federal permitting, construction, effluent treatment, wetlands protection, non-native species, health management and many other areas related to aquaculture production. Certain BMP manual chapters apply only to particular products for which there are specific concerns such as non-native species, live rock, marine shrimp and marine bivalves.

The Best Management Practices require that aquacultural products be identified with the Aquaculture Certification Number from the point of harvest to the point of sale. This is necessary to ensure that farm-raised products are not mistaken for wild-harvested products, which have harvesting seasons, catch limits or prohibitions regulated by State and Federal natural resource management agencies. The BMPs also require that records be kept for all live sales, transfers, and purchases of restricted species, marine shrimp, and marine bivalves. It is important for containment of restricted species, and for the health of marine bivalves and shrimp, that records are kept documenting the transfer and location of these animals.

Florida's *Aquaculture Best Management Practices Manual* is a living document which is under constant flux as new techniques are developed, new species cultured and as industry needs warrant. The Department of Agriculture, through the Aquaculture Certification Program and the Best Management Practices, is now the "one stop" agency regulating the aquaculture industry in Florida.

With this new environment for regulation of the industry, the Department intends to encourage growth in marine ornamental production as well as growth and continued success of all other forms of aquaculture in Florida.

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Propagation of Scleractinian Corals from Wild-Captured Gametes: Mass-Culture from Mass-Spawning

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Live hard-corals (as well as their dead skeletons) are a popular component of reef tanks. Their major source to the aquarium trade is the collection of fragments from wild colonies. As coral reefs and coral cover have declined world-wide in recent years, it has become more difficult to obtain permits to collect wild corals; the practice of propagating corals in aquaria from a few wild-collected pieces is now more common. This is a slow process, and produces small numbers of coral for re-sale. Corals propagated by fragmentation are also used for restoration of damaged coral reefs (Rinkevich 1994; Edwards et al 1998;), but this approach has its limitations because, especially in the Caribbean, there are few places with sufficiently lush coral cover to serve as donor sites.

An alternative method of propagating corals for both the ornamental trade and for coral reef restoration is the mass-propagation of corals from the gametes collected from spawning corals. Over the past two decades, detailed information on the reproductive and spawning cycles of a large number of reef corals from both the Pacific and Caribbean has been discovered (Harrison et al 1984; Szmant 1986, 1991; Harrison and Wallace 1990), and can be used to target the collection of gametes as they are released in the field or temporary holding systems.

Most of the major reef-building corals studied to date have short spawning cycles that last two to three days, and are timed by the phase of the moon and sunset. The timing for each species is consistent over large geographic areas. Most species studied are hermaphrodites, where both eggs and sperm are released together packaged into small buoyant bundles that rise up into the water column as they are released. A smaller number of species have separate sexes (gonochoric) and release eggs or sperm in clouds of gametes. The hermaphroditic species that release bundles are the most amenable to the type of mass culture from spawn as described here.

Once the exact timing of spawning for a group of species is known (spawning periods for a given species last ca. 30 to 45 min), groups of divers equipped with collecting nets can be deployed on a reef where the target species are abundant. A major inconvenience and hazard is that most corals spawn late at night and thus more experienced divers and logistic preparation is required than normal diving. For certain species, colonies can be brought into the laboratory or spawned in aquaria on the decks of boats, and then re-cemented on the reef after spawning, thus avoiding the hazards of night-time diving. For species that naturally propagate by fragmentation, spawn needs to be collected from widely separated colonies, since most corals tested do not self-fertilize, and it is difficult to discern the boundaries of a given clonal population without molecular testing.

Individual polyps release a single bundle per night but may release bundles on more than one night. Each bundle contains 6 to >100 eggs and ca. 2 million sperm, depending on the species. The buoyant bundles will rise and accumulate into collecting cups fastened into the upper end of conical nets suspended vertically over the colonies, which divers can retrieve after spawning is over. Gamete bundles do not break down for ca. 30 minutes, and it is critical to retrieve the cups before the bundles break down and the sperm are lost. Contents of the cups from numerous colonies are then combined for fertilization into large containers with filtered seawater. A concentration for fertilization of 2×10^6 sperm per ml is desirable, and thus the volume of water to use for fertilization can be adjusted based on the number of bundles collected. After one hour, excess sperm need to be removed if the embryos will be cultured in the laboratory. In the laboratory, embryos can be raised in containers at a density of about 1 embryo per ml of filtered seawater. Water must be changed every 6-8 hours at first to prevent fouling from the numerous gametes that don't fertilize or develop, and the process is thus very labor intensive for the first 48 hours. Planula larvae are competent to settle after 3-5 days of culture. At this time they can be presented with pre-conditioned tiles or large pieces of reef rubble that have crustose coralline algal (CCA) cover to induce settlement (Morse and Morse 1996).

We have begun to use a field mass-culture system developed by Dr. Andrew Heyward and colleagues, at the Australian Institute of Marine Science, which consists of a large floating bag (1 m x 1 m area and 0.5 m deep) with fine-meshed screen windows, and an automated water pumping system, to raise the larvae out in the field. Degenerating gametes and embryos are flushed out of the bags with intermittent pumping of fresh seawater into the bags, but healthy developing embryos and larvae are retained. After 3-5 days the planulae can be harvested and settled for either aquarium culture or coral reef restoration.

The quality of the substrate used to settle the planulae is critical. If raised in the laboratory, it is important to use field-conditioned substrates for settlement to provide a source of zooxanthellae for the newly settled corals. In addition, high cover by CCA and low cover by thick turf and fleshy algae are important. Especially in aquaria, newly settled corals can be quickly overgrown by algae. Grazing sea urchins, such as *Diadema antillarum* in the Caribbean, graze the substrate making it more suitable for coral settlement and post-settlement survival. We are working on culturing *D. antillarum* for re-introduction to Florida reefs where it has not returned on it's own (see Capo et al, this meeting), as well as a way to increase survivorship of laboratory cultured coral spat. Simultaneous efforts to re-introduce *Diadema* and re-seed the reefs with mass-cultured coral larvae is a novel form of ecological restoration that we hope will help damaged Florida reefs recover more quickly, and that also has potential to be applied to culture of corals and sea urchins for the aquarium trade.

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Breeding and Larval Rearing of the Saddleback Anemonefish, *Amphiprion polymnus* Linneaus

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Four pairs of *Amphiprion polymnus* were obtained from Samae-Sarn district, Chonburi province and reared in 120-liter glass tanks equipped with undergravel filters. The first spawning occurred after 3 months and repeated spawning occurred every 6-28 days all year round (n=20). The larvae hatched out 2-3 hours after darkness on day 6-7 after spawning. The number of hatchling ranged between 134 to 1991 larvae per batch (n = 13). After hatch, the larvae were removed from breeding tank to 30-liter tank at stocking density of 10 larvae per liter. The larvae were fed with rotifer (5 rotifers per ml) and *Isochrysis* sp. from day 1 to day 22. A small amount of artemia nauplii was added on day 14 and gradually increased while the number of rotifer decreased and totally replaced by artemia nauplii on day 22. The larvae started to metamorphose on day 13 and completed on day 27. The highest mortality was occurred during the first week (50%) and then declined. The average survival rate of the saddleback anemonefish after metamorphosis was 11.6 percent.

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Delay Feeding and Feeding Regimes Effect Survival of Young Seahorse, *Hippocampus kuda* Bleeker

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Pregnant male seahorses, *Hippocampus kuda*, were obtained from coastal area of Sean-Suk district, Chonburi province and held in a 120-liter glass aquarium with undergravel filter. The animals were fed with mysid shrimp during the incubation period. After the male released their young, the young seahorses were removed from the aquarium for the experiments.

The aim of the first experiment was to determine the effect of delay feeding on survival rate of young seahorses. The young seahorses from the same batch were stocked into twelve 10-liter aquaria at a density of 10/L. The aquaria were divided into 4 treatments with 3 replicates. The experimental animals were fed with rotifer at 5/mL and *Artemia* nauplii at 1/mL in all treatments but the time of first feeding was varied from 0, 24, 48 and 72 hours after hatch. The experimental period was 2 weeks and numbers of survival were recorded everyday. The water was changed 50-80% daily and new foods were introduced after changing water. The result showed that delay feeding was significantly effect on the survival of the animals. Feeding the young seahorses immediately after hatch gave the highest survival rate at 88.1% while delay feeding to 24, 48, and 72 hours reduced survival rate of young seahorses to 43.5%, 6.0%, and 0.0%, respectively.

The aim of the second experiment was to investigate the effect of feeding regimes on survival rate of the young seahorses. The experimental animals of the same batch were stocked at a density of 10/L in fifteen 30-liter aquaria. The experimental aquaria were divided into 5 treatments with 3 replicates. The young seahorses were subjected to one of the following feeding regimes from first feeding (day 0) to the end of the experiment: (1) *Artemia* nauplii (2) rotifer and *Artemia* nauplii (3) rotifer from day 0 and *Artemia* nauplii were added on day 3 to the end of the experiment (4) the same as the third treatment but *Artemia* nauplii were added on day 5 (5) the same as the third treatment but *Artemia* nauplii were added on day 8. The experimental period was 4 weeks and numbers of survival were recorded everyday. The result showed that the survival rate of young seahorses was significantly difference among the treatments. The highest survival rate was found when the young seahorses were fed with rotifer from day 0 onward and *Artemia* nauplii were added on day 3 or 5. The lowest survival rate was 5.5% when the experimental animals were fed with rotifer and added *Artemia* nauplii were delay to day 8. The survival rates of the animals fed only *Artemia* nauplii or rotifer and *Artemia* nauplii since first feeding were10.5% and 10.3%, respectively.

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Spawning and Larval Rearing of Jackknife (*Equetus lanceolatus*), a Marine Ornamental Fish

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Jackknife are a common species in the marine ornamental trade. Wild collection of marine ornamental fish, such as jackknife, contributes to pressures on natural populations of coral reef organisms. Development of culture techniques is necessary for growth of marine ornamental aquaculture technology and could help safeguard coral reefs. This research presents findings on adult spawning, aquaculture techniques, and early life history of jackknife. Adults spawned at 24 – 29 C and at day lengths of 12 – 15 hours. Groups of 2-5 adult fish in 8000L recirculating tanks have released more than 300,000 eggs over a 3-year span. Mean egg diameter was1.03mm (SE0.02) and newly hatched larvae averaged 2.68mm standard length (SE0.01). Fertilized eggs had a mean hatch rate of 86% (SE12%). Larvae were successfully raised on diets of rotifers enriched with *Isochrysis galbana*, rotifers enriched with Algamac 2000, or copepod nauplii (*Centrophages hammatus*) for the first 8 days of feeding (day 2 – 9). The ratio of DHA - EPA in larvae fed rotifers enriched with Algamac 2000 or copepod nauplii were 7.75 and 6.67, respectively, and total HUFAs were 29.67% of total fatty acids and 37.36% of total fatty acids, respectively. Larvae consumed *Artemia* nauplii enriched with Algamac 2000 after 9 days post-hatching, and began feeding on commercial diet (Kyowa 400-700m) on day 19. Survival to the juvenile stage ranged from 0 – 20%, and fish reached a marketable size of 30mm standard length (SE0.8) by day 35 (Fig.1).

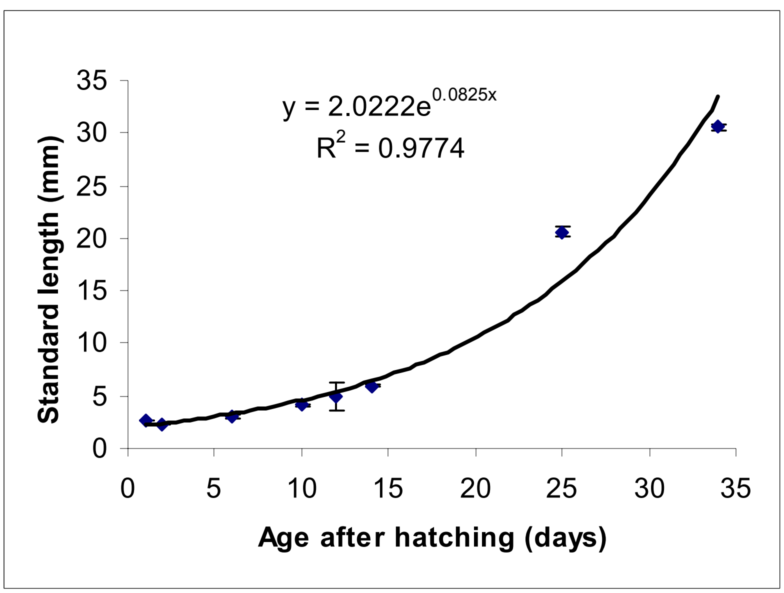

Figure 1. Growth rates of Jackknife (*Equetus lanceolatus*) from hatching until 35 days post-hatching.

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Rearing the Coral Seahorse, *Hippocampus barbouri*, on Inert Prey

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Of all the seahorse species, the Coral seahorse, *Hippocampus barbouri*, is one of the easiest to keep in aquaria, primarily because adults readily accept dead prey and have voracious appetites. In addition, they are unusual amongst seahorses as they regularly use hard corals and other solid substrates as attachment sites, and are reported to be less prone to cnidarian stings than other species. This makes them suitable for display in reef tanks.

Coral seahorses give birth to relatively large young that attach themselves to substrate soon after birth. Juveniles will readily feed on *Artemia* nauplii and when these nauplii are suitably enriched, survival of juveniles is sufficiently high to enable viable commercial production. However, hatching and preparation of *Artemia* nauplii is very time consuming, and enrichment media are invariably expensive. Cultured algae can be used for enrichment, although this too is very time consuming. Development of an inert diet for rearing juvenile seahorses may result in considerable savings in time and may also be more cost effective.

This study compares the growth and survival of newborn Coral seahorses on diets of enriched *Artemia* nauplii and copepods collected from intensive culture and stored frozen. *Artemia* nauplii were enriched with Algamac 2000 and the microalga *Tetraselmis suecica*, while copepods were collected from a 5,000 l culture that had been fed the microalga *Isochrysis galbana* for a prolonged period. Three separate batches of seahorse juveniles were separated into two groups that were fed the treatment diets. Length and wet weight of four seahorses from each experimental unit were recorded weekly for four weeks. Growth and survival data, along with the fatty acid profiles of each diet, are presented.

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The Economics of Live Rock and Live Coral Aquaculture

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Aquaculture is being increasingly cited as a priority solution for reducing the pressures on coral reefs arising from over- and destructive fishing associated with the trade in marine ornamentals. It is seen as an alternative or supplemental livelihood option for those needing an alternative for exit from over- and destructive harvesting of marine ornamentals, especially in developing countries in Asia. Two of the most important marine ornamental invertebrates are live rock and live coral. Experimental and commercial production of live rock and live coral is now underway in Florida, Hawaii, Philippines, Fiji, and Indonesia.

The purpose of this paper is to present results of a bioeconomic analysis of the aquaculture of live rock and live coral in Southeast Asia. This analysis has been conducted to determine the technical and economic feasibility of live rock and live coral culture as an economic alternative for current harvesters of these marine invertebrates, many of whom use unsustainable harvest methods. The bioeconomic production analysis will evaluate the costs and returns of culture, cash flow analysis, and financial ratios. Separate analyses will examine the costs and returns at various stages of the culture process, at various scales of production, and sensitivity to price, grow-out period and survival rates. The paper will conclude with a discussion of the feasibility of culturing live rock and live coral in rural coastal communities in Southeast Asia.

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Control of Pest Anemone *Aiptasia pallida* by Ornamental Shrimp *Lysmata rathbunae* and *L. wurdemanni*

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Shrimp in the genus *Lysmata* are widely traded in the aquarium hobby. The shrimp have a close relationship with other marine animals. They are facultative or obligatory cleaner shrimp feeding on external parasites of fish, or live symbiotically with sea anemones. *Lysmata wurdemanni* has also been used to control the pest glass anemone *Aiptasia padilla.* Once established, the glass anemone will proliferate quickly through asexual reproduction and take over a tank (Clayton and Lasker 1985). The anemone also possess both spirocysts and nematocysts that aid in capturing and immobilizing both hard and soft prey (Thorington and Hessinger 1990), therefore harmful to the animals living in the tank. Aquarist and hobbyist use a variety of methods to remove the anemone. Manual control can be difficult if not impossible. Injecting hot water or chemicals into each anemone can be effective if anemone numbers are low (Hauter and Hauter 2001). However, the use of chemicals (e.g. sodium hydroxide, calcium hydroxide, bleach, or copper sulfate) may harm other tank inhabitants. Biological control has proven effective. Fish such as copper banded butterfly fish have been used to control *Aiptasia*. But these fish have proven hard to maintain and have low survival rate for inexperienced hobbyists. *Lysmata wrudemanni* have been used for many years to control *Aiptasia* and has been an important factor for the shrimp's popularity in the aquarium market.

Recently the technology of culturing *L. wurdemanni* and its closely related species *L. rathbunae* through complete life cycle has been developed (e.g., Zhang et al. 1998a, b; Lin et al. 1999). Aquaculture of the two species is very similar, except that *L. wurdemanni* has much longer larval duration (over 90 days) than that of *L. rathbunae* (25-35 days). With an extended larval cycle, food and labor costs and lower survivorship keep market prices of cultured *L. wurdemanni* higher than wild collected specimens. *L. rathbunae* shrimp are very similar to and are often sold as *L. wurdemanni* and has a promising potential for commercial production.

Hobbyists have speculated that *L. rathbunae* lacks the ability to control *Aiptasia* and therefore has less market value. The present study was designed to test if *L. rathbunae* is capable of preying upon *Aiptasia pallida* and if so, compare the effectiveness of control between *L. wurdemanni* and *L. rathbunae*.

Both *L. rathbunae* and *L. wrudemanni* were maintained in experimental tanks. *A. pallida* were cultured on ceramic plates. Once significant numbers of *A. pallida* were present, the plates were transferred to experimental tanks and allowed to acclimate. Shrimp were then introduced. The size (total length for shrimp and oral disc diameter for anemone) and number of shrimp and anemone in each tank were recorded.

Both *L. rathbunae* and *L. wrudemanni* were found to prey on *A. pallida* and there was no significant difference in effectiveness between the two species. Large anemones were able to defend themselves against a small single shrimp. However, a group of three small shrimp or a large single shrimp was able to consume large *A. pallida*.

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The Effects of Sulfur on Nitrate Levels in a Closed Saltwater Ecosystem

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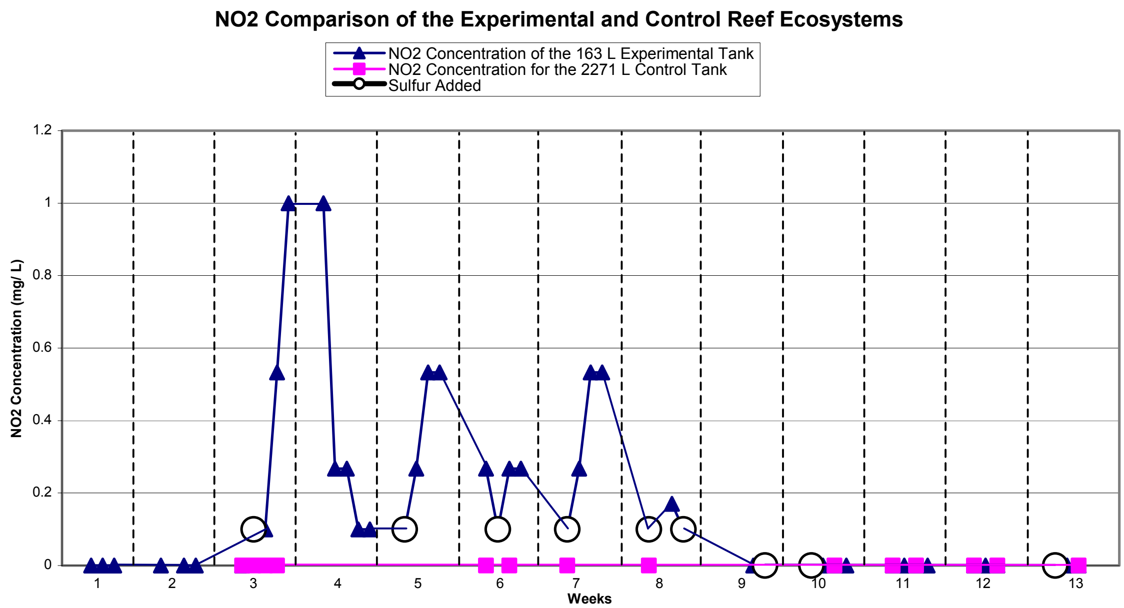
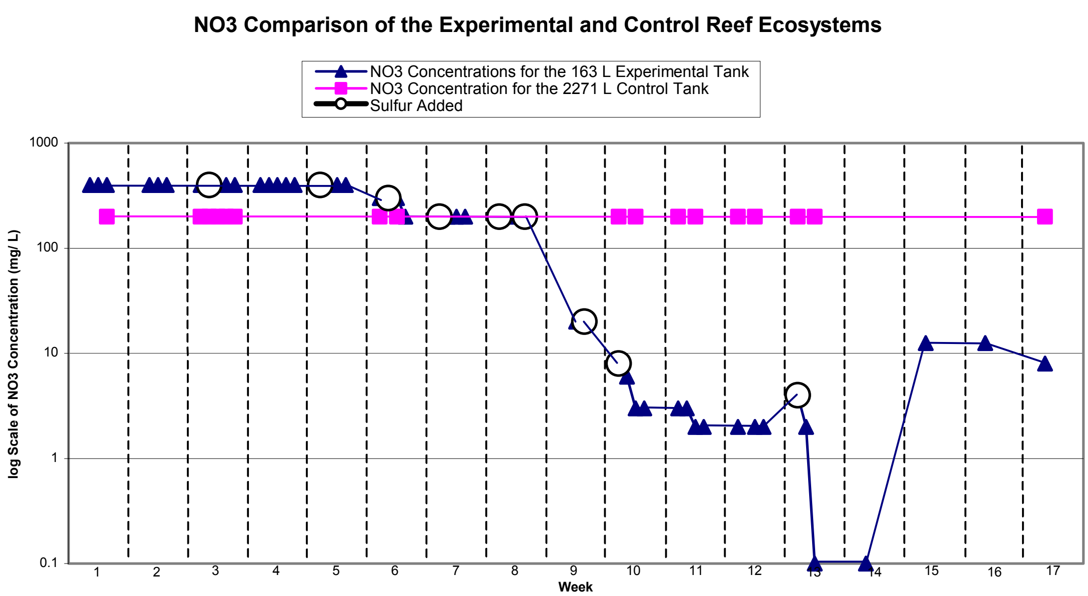
Residual nitrate levels in the open ocean can cause many problems, but natural processes can eventually eliminate these nitrates. In a closed saltwater ecosystem, one of the most problematic maintenance concerns is keeping residual nitrate concentrations at an acceptable level before the build up becomes detrimental to the organisms living in the system. One way to eliminate residual nitrates is to make sure that the nitrogen continues on in its cycling to the denitrification process to produce nitrogen (N) or nitrous oxide (N O) gas. In a poster presentation report, Hignette & Delaporte (2000), from Aquarium du Musee des Arts Africains et Oceanicus (Paris, France), suggested that sulfur can be added to closed saltwater systems to lower nitrate levels. Our study was carried out to determine the effectiveness of sulfur addition and to establish a protocol for sulfur usage.

Twenty-five grams of sulfur was initially added once a week to the 163-liter closed saltwater system, and then increased it to twice a week until levels of nitrates decreased. The nitrogen cycling occurring in the system was observed by doing regular chemistries using colorimetric tests for determining the levels of nitrates, nitrites, ammonia, and ammonium. Further tests were conducted to be sure that a variety of other chemistries were being maintained at appropriate levels. At St. Louis Children's Aquarium, we have successfully lowered and maintained low nitrate concentrations with the addition of sulfur to one of our saltwater tanks and ascertained approximately how much sulfur it takes to achieve this goal and the time necessary to lower nitrate concentrations to near zero. The control for this experiment was done in a nearby closed system coral display.

Our theory behind why the nitrate levels were affected with the addition of sulfur hypothesizes that the denitrifying bacteria that are present in the substratum of the tank use the sulfur in anaerobic processes to convert the nitrates into further broken down non-toxic components, perhaps even elemental in nature. This activity was apparent by a build up of gas bubbles found when the bottom material was disturbed, and the detection of a "rotten egg" sulfur smelling gas. In comparison with our other saltwater tanks, this sort of activity in the form of increased gas production has not been seen in the control environments at St. Louis Children's Aquarium. It is known that certain bacteria can carry out the process of denitrification and some of these bacteria utilize sulfur and nitrates for their metabolic needs while improving the closed system living environment.

The use of sulfur to maintain very low nitrate levels in saltwater aquariums is an important finding in that it allows a simple and inexpensive method of improving water quality in closed ecosystems. (Comparative nitrite and nitrate study graphs are attached.)





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The Developmental Stages of the Saddleback Anemonefish, *Amphiprion polymnus* Linnaeus

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The embryonic development of the saddleback anemonefish, *Amphiprion polymnus* was studied at the Institute of Marine Science, Burapha University, Thailand. The breeding pair was collected from natural and maintained in a 120-liter tank equipped with undergravel filter. A giant clam shell was used as substrate for the saddleback anemonefish to deposit their eggs. Once after spawning, 10-15 egg capsules were taken and incubated in a 1,000 ml beaker that filled with seawater (32-33 ppt). The temperature during incubation period was 29.0-31.5 degree Celsius. The embryonic stages were observed under stereo-microscope and recorded every 10 minutes during the first 3 hours, then every 30 minutes until hatching. The larvae hatched on day 7 after spawning. After hatching the larvae was observed daily until metamorphosis. The 26 stages of development were selected for discussion in detail.

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Small Scale *Mysidopsis bahia* Production

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The opossum shrimp, *Mysidopsis bahia,* has become a popular food item for the ornamental fish trade and is often used to entice fish to begin feeding. While several companies offer wild-caught mysis as feeders, reliance on wild-caught animals has several drawbacks: 1) high cost, 2) the introduction of disease organisms such as *Vibrio spp.* 3) the introduction of undesirable species, 3) high mortality rate of wild caught mysids, 5) problems with supply due to shipping and weather conditions, 6) destruction of natural habitat due to collection techniques. A new propagation method developed at Shedd Aquarium eliminates the limitations caused by using wild-caught animals.

Several authors have previously presented methods for the captive propagation of mysids. By modifying techniques in feeding, larval collection and breeding times, Shedd Aquarium has eliminated the need to purchase wild-caught *M. bahia*. The mysis breeding unit at this facility has a centralized filter, 12 breeding chambers (with the ability and space to add six more), and takes less than 2m^2 of floor space. Each day, 15-20 minutes are spent servicing the unit; every five days it takes 30 minutes to harvest mysids to be used as feeders and re-establish a grow-out chamber.

Current protocols for the system call for two feedings each day. The morning feed is 3-3.5g of frozen copepods to all but the youngest animals (youngest animals range in age from one to five days old—these animals receive rotifers). In the afternoon, all animals receive 24-hour-old Selco enriched brine shrimp nauplii (7-8g wet weight per feed). Current production for the unit is more than 1,300 animals every five days, at an estimated cost of 0.023 cents per animal. If preliminary work of the last year holds up and with the addition of the six breeding chambers, harvest should increase to more than 2,000 *bahia* every five days.

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Captive Nutritional Management of Herbivorous Reef Fish Using Atlantic Surgeonfish (*Acanthurus* spp.) as a Model

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Wild-caught juvenile (<10g) surgeonfish will be fed three diets consisting of a commercially-available ornamental fish feed, a diet similar to a piscivorous diet prepared in many public aquaria (Andrews and Saligson, 1988, Hashey, 1998), and an algae-based formula. Fish will be maintained for four months in three 360l flow-through aquariums at the Whitney Marine Lab in Marineland, Florida. Weight and length data will be collected monthly as per Carlander (1977). Diets will be evaluated by corresponding survivability and pathology, which may be of dietary origin. Photographs will be taken monthly of each fish to document the development of skin lesions or other visible deformities, which may be suggestive of nutritional disease (Stoskopf, 1993).

At the completion of the experiment, the fish will be humanely euthanized using buffered MS-222 (tricaine methanesulfonate). Tissues will be sectioned, stained, and compared to normal acanthurid histology to determine if there are correlations between diet and pathology.

Data obtained from the proposed study can be applied to improve the management, health, and longevity of these fish in captivity.

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Development of Prey Capture Mechanics and Kinematics in Marine Fish Larvae: A Novel Approach to Identifying a Major Bottleneck in Ornamental Fish Larviculture

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A critical period, marked by mass mortality, occurs immediately following yolk-absorption during the larval phase of marine teleosts. Biotic and abiotic factors associated with mortality during this critical period have been identified, but the causal link between these factors and mortality is not clearly understood. This study explores the link between development of the feeding mechanism, kinematics and prey-capture performance in marine fish larvae using high-speed videography . Lower-jaw depression in larvae developed from a simple mechanism around first-feeding, driven by the hyoid-mandible linkage (i.e., the hyoid stage), to a more complex mechanism around metamorphosis, driven by the hyoid- and opercular series-mandible linkages (i.e., the hyoid-opercular stage). This two-stage development of the feeding mechanism was associated with differences in feeding performance: (1) less than 50% of larvae fed during the hyoid (first-feeding) stage whereas almost all larvae at the hyoid-opercular (post-first-feeding) stage consumed prey; and (2) first-feeding larvae preferred small and less elusive prey relative to conspecifics at metamorphosis, which preferred larger and more elusive prey. Understanding the functional relationship between development of the feeding mechanism and prey-capture performance enhances our ability to understand the underlying causes of mortality, particularly during the first-feeding stage of larval marine ornamental fishes. Consequently, our increased understanding of the development of feeding mechanism, prey-capture kinematics and performance in marine fish larvae enhances our ability to formulate feeding quidelines that will minimize mortality, thus economic loses, during the larviculture of marine ornamental fishes.

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Factors Affecting Successful Culture of the Seahorse *Hippocampus abdominalis* Leeson, 1827

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In Australia and New Zealand there is interest in the commercial culture of the temperate seahorse *Hippocampus abdominalis* for supply to the ornamental aquarium and traditional medicinal trades, and there are now several commercial ventures culturing this species. NIWA has been conducting research into successful culture techniques for *H. abdominalis* since 1997 with public dissemination of the knowledge gained. Using standard hatchery techniques, *H. abdominalis* can be successfully reared through multiple captive generations with high survival rates (e.g. 80+% survival to sexual maturity) and good growth (e.g. 11cm+ in length within 1 year).

Using enriched *Artemia* as a food, survival in the most vulnerable stages, 0-2 months of age, is dramatically improved by blacking off glass aquaria from the top to the waterline (i.e. from 18% survival at 2 months of age in normal aquaria to 80+% at 2 months of age in blacked-off aquaria). In newborn juveniles, feeding strike rates are greater in clear culture vessels compared to black or white culture vessels, but at 1 month of age this effect reduces and juveniles can feed better in non-clear culture vessels.

Juveniles 1-2 months of age can be successfully weaned onto frozen (Cyclop-eeze copepods) and artificial foods (Brine Shrimp Direct Golden Pearls) over 30-day periods with *Artemia* as a live food control, with 0-, 5-, 10-, and 20-day co-feeding periods, although growth and survival may be affected depending upon the age of the seahorses and the food offered. For example, 2 month-old juveniles could be weaned onto Golden Pearls with no effect on survival (67-87% mean survival) compared with the control (93% mean survival), but with lower growth (mean final lengths and weight 61.4-65.2 mm and 0.36-0.42 g respectively) compared to the control (mean final length and weight 67.8 mm and 0.53 g respectively).

In terms of optimal rearing temperature, there is no difference between 18 and 21°C for either growth and survival, but these two higher temperatures give greater growth than 12 and 15°C. As an alternative to on-growing seahorses to adult size in the hatchery, juveniles 80mm+ in length can be successfully on-grown in sea-cages suspended from commercial mussel longlines with minimal maintenance and cost as the seahorses obtain nutrition from fouling assemblages (mainly amphipods) growing on the cages.

Results from current experiments examining the effects of stocking density on juvenile growth and survival, the effect of gender segregation on sexually mature seahorse growth, and aspects of the ecology of *H. abdominalis* in the wild that relate to aquaculture (e.g. natural reproductive cycles and diet) will also be presented at the conference.

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The Use of Ovaprim® As a Treatment for an "Egg-Bound" Frogfish (*Antennarius striatus*)

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In mid-May, 2000, one female frogfish *(Antennarius striatus)* exhibited spawning behavior for the first time since her arrival six months earlier. The female was one of 2.1 frogfish housed in a 180-gallon tank with undergravel filtration. She had difficulty releasing the egg mass, and one inch of the egg mass was observed protruding from her vent. The following day, the eggs were removed manually, and hemorrhages were evident around the prolapsed vent. Eggs were nonviable. The female was separated from the males by a divider and placed on enrofloxacin (Baytril®, Bayer Corporation, Shawnee Mission, KS). She recovered uneventfully. A few weeks later, this same female again appeared conditioned and ready to spawn. After two days, a small portion of eggs was seen in the tank. These eggs were poor in consistency and beginning to degrade. At this time, the female exhibited some minor buoyancy control problems. The fish was transported to the Tropical Aquaculture Laboratory for evaluation and treatment. The female weighed 210 grams and was approximately 16 cm TL. Fins had minor erosions on their tips, and eyes were mildly opaque. The left half of the maxillary portion of the mouth was dark. One lesion near the vent was darkened and slightly ulcerated. Attempts to obtain an ovarian biopsy were unsuccessful. Ovaprim® (Syndel Laboratories, Vancouver, British Columbia, Canada), a gonadotropin releasing hormone analogue (GnRHa) with domperidone, a dopamine inhibitor, was administered at the rate of 0.5 mL/kg. The following day, the remaining egg mass was expressed using gentle pressure. A total of 60 grams of eggs (approximately 90 mL volume) was collected. Prolapsed gonadal tissue was gently reinserted and temporary sutures were placed around the vent. The fish was placed on enrofloxacin (Baytril, 5 mg/kg q 48 hours), and the sutures removed after two days. Although the fish outwardly appeared to have recovered, she was found dead two weeks later.

Discussion

Problems with a previous spawn and possible concurrent systemic infections appear to have contributed to her egg-binding. Ovaprim facilitated expression of the remaining eggs. Use of Ovaprim and other hormones to induce ovulation may be an effective treatment modality for egg-binding. An accurate diagnosis of the problem is key to success. A good history of the problem, including evidence of spawning activity and conditioning of the female is critical. An ovarian biopsy should be attempted to stage the maturity of the eggs. Immature eggs may indicate another problem, and will not respond to hormonal treatment.

Hormone-Induced Spawning

In nature, sexually mature, conditioned fish undergo final maturation and spawn after exposure to specific stimuli, including photoperiod, water quality (such as temperature, pH, hardness, salinity, total dissolved solids, alkalinity), flooding, tides, barometric pressure, spawning substrates, or the presence of other species.[4]

In the aquaculture of more difficult species, these triggers may not be easily mimicked. Induction of final maturation and spawning can be stimulated by hormonal injection. Although, theoretically, hormones that act anywhere along the brain-hypothalamic-pituitary-gonadal axis can be used, most spawning hormones available act directly on the pituitary or the gonads.

Ovaprim® is a gonadotropin releasing hormone (GnRH) analogue, based upon the salmon GnRH (sGnRH), found within the brains of many teleosts, and active in most. [2,5] In addition, Ovaprim contains the dopamine blocker domperidone. In later stages of gonadal maturation, Ovaprim causes the release of GTH-II from the pituitary. GTH-II acts upon the gonads, stimulating final maturation of oocytes and ovulation in females, and spermiation in males, via gonadal steroid hormones. Domperidone acts as a dopamine receptor antagonist, blocking the inhibitory effects of dopamine on GTH-II release. In some species, such as many of the cyprinids, this inhibition by dopamine is an important spawning hurdle to overcome. [5] Dosing regimens may vary, but are typically 0.5 mL/kg given in a single dose or divided over two doses, with the initial dose a smaller priming dose.

What is Egg-Binding?

Although egg-binding in birds and reptiles is well-documented,[1,3] by comparison, egg binding in fish is poorly understood. Major differences in egg production and reproduction between birds, reptiles, and fish make any analogies difficult if not altogether incorrect. The terms “egg-binding” and “egg-bound” are frequently used in reference to mature, conditioned female fish that do not spawn normally. Although the terms are used by both professionals and lay persons (e.g., aquarium hobbyists), it is likely that inexperienced hobbyists may be using the term much more loosely and incorrectly. Despite this casual use of terminology, no major work has been done in this area. In fact, there is presently no good definition for egg-binding in fish.

Factors that may determine a fish species’ or individual fish’s predisposition to egg-binding include: status as synchronous vs. group synchronous spawners; complete vs. partial spawning; temperature; age of fish; presence of infectious disease; susceptibility to handling stresses; nutrition; photoperiod, and failure to respond to other spawning triggers.

A better understanding of the germinal epithelium, folliculogenesis, and natural regression, are important prerequisites to tackling the question of egg-binding in fish. PAS-positive granulocytes appear to play an important role in natural regression of gonadal tissue.

The following may be examples of "egg-binding" in different species observed by the authors:

- A group of high-fin black tetras *(Gymnocorymbus ternetzi)* spawned once and then allowed to condition for over one month did not spawn again.
- A group of long-finned rosey barbs *(Barbus conchonius)*, when spawned continuously, alternated between 60% and 100% spawns over time.
- Red drum *(Sciaenops ocellatus)* that were induce-spawned could not be stripped of eggs completely. The following day, following catheterization, remaining eggs were observed to have formed into a gelatinous mass.
- In black sea bass *(Centripristis striatus)* black masses observed in the posterior ovarian lumen are believed to be degenerated egg masses.
- Injection of snook *(Centropomus undecimalis)* with human chorionic gonadotropin (HCG) resulted in an apparent collapse of the ovary followed by infiltration of granulocytes into all vitellogenic oocytes.

Unanswered Questions

There are many unanswered questions. Here are just a few. How do we define "egg-binding" in fish? What factors lead to a species' or an individual fish's susceptibility to becoming egg-bound? How common is egg-binding in nature? What percentage of a spawn can be resorbed and then regress naturally without major interruption of the reproductive cycle? How much of an interruption in the cycle will egg-binding cause, and what are dependent factors? What "level(s)" or "category(ies)" of egg-binding lead to sterility? Exactly what role do PAS positive granulocytes play in natural regression and how may they contribute to egg-binding? Hopefully future work will begin to shed light on this topic.

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Atypical Presentation of Mycobacteriosis in a Collection of Frogfish *(Antennarius striatus)*

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History

A shipment of six striated frogfish *(Antennarius striatus),* approximately 5 to 7.5 cm total length (TL), were shipped 1999 November from Brazil to a wholesaler and sold to Mote Marine Laboratory Aquarium for display. For quarantine, the fish were placed into two groups (sexes were unknown at this time but determined several months later at maturity). 1.2 fish were placed in a 40-gallon tank and 2.1 fish were placed in a 180-gallon tank, each with undergravel filtration. Fish were fed a diet of shrimp, squids, and silversides. After quarantine, fish remained in their respective tanks for grow out.

Beginning in April, the fish in the 40-gallon tank began spawning, without any apparent difficulty, every three weeks. In August, one group of eggs hatched after 48 hours, although larvae did not survive. In mid May, spawning behavior was observed for the first time in the female in the 180-gallon tank but she could not release the egg mass. One inch of the egg mass was observed protruding from the vent. The following day, the eggs were removed manually, and hemorrhages were evident around the prolapsed vent. Eggs were nonviable. The female was separated from the males by a divider and placed on enrofloxacin (Baytril®, Bayer Corporation, Shawnee Mission, KS). She recovered uneventfully. Spawning behavior was observed again several weeks later, but complications arose resulting in incomplete evacuation of her eggs. She was brought to the Tropical Aquaculture Laboratory for treatment with GnRHa (Ovaprim®, Syndel Laboratories, Vancouver, BC, Canada). Her eggs were manually expressed, and she was given a course of Baytril. She appeared to have recovered uneventfully, but was found dead two weeks later. Although significant autolysis had occurred prior to presentation to our laboratory, histopathological examination revealed a massive fungal infection, with colonization of the coelomic cavity, reproductive organs, and gastrointestinal tract, and widespread necrosis of coelomic connective tissue with fibrin deposition, necrotic debris, mixed degenerate inflammatory cells, and numerous fungal hyphae.

Over the next several months, other frogfish from this collection were submitted for evaluation. Several fish exhibit poor buoyancy control, and several had pigmented lesions on their skin. No lesions were noted that could easily explain these mortalities. Significant hepatic lipidosis was seen in many of these fish, so improper nutrition for this species was suspected as a contributing factor. Other rule outs included bacterial disease and viral disease. Cultures results were inconclusive. Finally, during examination of hematoxylin and eosin stained histopathological samples from one of these fish, a very small "granuloma-like" area in the spleen of one fish was noted. In addition, gill pathology observed in wet mount preparations of at least two fish resembled immune reactive, possible granulomatous lesions. Acid fast bacteria (AFB-Kinyoun) stains were run on this specimen to rule out mycobacteriosis. Results were dramatic. Numerous tissues stained AFB positive. AFB stains run on all four previously examined fish also came back AFB positive, with several fish positive in multiple organs, including liver, kidney, ovary, intestinal tract, spleen, and gill.

The last fish brought for necropsy was also cultured for mycobacteriosis. Coelomic saline washes and blood were streaked onto Lowenstein-Jensen slants. Cultures were also run of spleen, kidney, and liver. L-J slants were incubated at 30 degrees C for approximately two months, with no apparent growth, and then moved to room temperature (23-25 degree C) for roughly 2-4 weeks. Yellow colonies, typical for mycobacteria, were observed on culture from the liver. This culture has been submitted for identification. Histopathological examination revealed numerous acid fast bacteria present in multiple organs, including the liver.

Mycobacteriosis in Fish

Clinical signs of mycobacteriosis in a population of fish include chronic, low level mortalities; inappetance; lethargy; abnormal swimming behavior; isolation; ulcerations or erosions; ascites; reduced growth; and exophthalmia. Typical necropsy findings include nodules present on multiple organs, especially kidney, liver, and spleen, and evidence of granulomatous disease on histopathology. Acid fast bacterial stains are generally positive and supportive of infection by mycobacteria. Although *Nocardia spp*. also are acid fast and cause granuloma formation, they are much less common in fish. Culture positive results and identification are desirable. Clinical signs in these fish, although non-specific, did support the finding of mycobacteriosis in this collection. These signs included loss of buoyancy control and pigmented skin lesions, in addition to chronic mortality and problems with spawning.

This case was very atypical in both gross and histological findings. Mycobacteriosis is typically a granulomatous disease. Wet mount examination of tissues, in addition to most of the histopathologic samples demonstrated few, if any granulomas, especially given the massive numbers of acid fast staining organisms present.

Mycobacterial Ecology and Disinfection

Nontuberculous mycobacteria are ubiquitous[1], and have been found in swimming pools, drinking water supplies, coastal waters, as well as in aquaculture facilities and public aquaria. The two most common mycobacterial fish pathogens are *Mycobacterium marinum* and *M. fortuitum*[2] , although other species, including *M. abscessus* have been isolated from diseased fish. In coastal areas, one study correlated high numbers of bacteria with warmer temperatures, low dissolved oxygen, low pH, high soluble zinc, high fulvic acid, and high humic acid.[1] Many similar conditions are found in aquaculture and in aquarium systems.

Disinfection of tanks, nets, and other equipment following depopulation is best achieved using 65-90% isopropyl alcohol or ethanol. Chlorine is not 100% effective, and in one report, as much as 10,000 ppm available chlorine was required to kill mycobacteria. [3]

Caveats for Marine Ornamental Fish Breeders

Mycobacteriosis is commonly observed in older, captive broodfish and is generally considered not responsive to treatment. The details of mycobacterial epidemiology are not well understood. The slow growth rate of mycobacteria is a factor in its late onset and chronic effects. Immunosuppression is believed to play a significant role in the development of disease. Broodfish that have been spawned numerous times are under significant stress, and potentially more predisposed to infection or more significant disease. The source of mycobacteria was not determined in these cases, but because mycobacteria are fairly ubiquitous, a possible source may be: quarantine system; water; food; or the frogfish themselves.

By the time clinical signs and low-level mortality are observed, the disease may already be entrenched in a population. Because mycobacteria usually cause significant granuloma formation, in later stages of the disease, affected organs often contain very little normal tissue. Because treatment is considered ineffective, and because there is potential for vertical transmission (transmission from broodfish to offspring), depopulation is the standard recommendation for a population of broodfish with the disease. Our recommendation to breeders is to always have young broodfish available, and to avoid using older broodfish.

Different species of fish vary in their response to acid fast organisms, but most develop some degree of granulomatous disease. It can only be surmised that mycobacteria did not affect the immune systems of this captive population of *A. striatus* in the typical manner. Other groups of fish may have a similar "non-response" to mycobacteria. Therefore, acid-fast staining and mycobacterial culture are recommended as a general procedure for evaluation of any sample of broodfish with a history of chronic, low level mortalities and spawning difficulties.

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Aquaculture Poster Abstracts

Fatty Acid Profile of Mediterranean Cleaner Shrimp (*Lysmata seticaudata*) (Decapoda: Hippolytidae) Eggs during Embryonic Development

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Introduction

Marine ornamental shrimps of the genus *Lysmata* are some of the most popular and heavily traded species in the marine aquarium industry. In order to face the growing market demand, a great effort is being conducted in the development of rearing methodologies for these species. The rearing potential of ornamental shrimp species from temperate and sub-tropical Eastern Atlantic waters is also being evaluated. The Mediterranean cleaner shrimp (*Lysmata seticaudata*) is certainly one of the most interesting candidates from temperate waters. Besides its beautiful coloration, it also presents associative cleaning behavior and can be easily kept in an aquarium environment.

One of the most important aspects in the rearing success of any marine species is egg quality. Since lipids represent the most important energy source during embryonic development of most crustaceans (Wehrtmann and Graeve, 1998), special attention must be paid to the egg lipid composition, namely its fatty acid profile. Therefore, the main objective of the present work is to study the fatty acid composition of *Lysmata seticaudata* eggs during embryonic development, in order to assess the lipid nutritional requirements of the first larval stages. Additionally, possible differences in the fatty acid profile of eggs from different sized females (small, medium and large) are investigated.

Materials and Methods

Lysmata seticaudata egg-bearing females were collected during May 2001 using baited traps at Cape Raso, 30 Km West of Lisbon, and were transported to the nearby laboratory (Laboratório Marítimo da Guía). Female's carapace length (CL) was measured, from the posterior orbital edge to the middorsal posterior edge of the carapace. Females presenting a CL smaller than 9 mm were classed as small females, while the ones presenting CL's between 10.5 and 11 mm and greater than 12 mm were classified as medium and large females, respectively. Egg mass was removed from the females and eggs were classified according to the following criteria: stage I- uniform yolk and no embryonic development visible; stage II- eyes clearly visible with ½ yolk consumed; stage III- almost no yolk and embryo fully developed. Egg samples from each female size class and embryonic stage of development were stored in liquid nitrogen for posterior analysis. The fatty acid analyses were conducted as described in Narciso and Morais (2001).

Results and discussion

The fatty acid analysis of *Lysmata seticaudata* eggs revealed that the most important fatty acids are, by decreasing order of magnitude, 20:5(n-3), 16:0, 22:6(n-3), 18:1(n-9), 16:1(n-7), 20:4(n-6), 18:0 and 18:1(n-7). These have been found to be the major fatty acids in eggs of other caridean shrimps (Wehrtmann and Graeve, 1998; Wehrtmann and Kattner, 1998)

When analyzing the changes in the egg fatty acid profile during embryonic development, a steady decrease in total FAME is observed, mainly as a result of the decline in total lipid content (data not shown). However, the most pronounced reduction occurs from stage II to stage III (Figure 1), which leads to the conclusion that the highest consumption of energetic reserves in *L. seticaudata* eggs occurs during the latest stages of embryonic development. The same trend was found by Wehrtmann and Kattner (1998) in *Nauticaris megellanica* eggs.

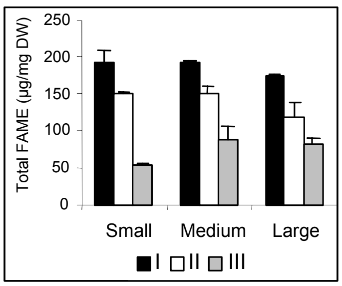

Figure 1. Egg total FAME content in stages I, II and III, in small, medium and large females.

Table I – Fatty acid utilization (%) between stages I and III, in small (S), medium (M) and large (L) females.

Fatty acids (μg/mg DW)	S	M	L
Saturated	67	49	50
Unsaturated	73	56	55
Monounsaturated	76	58	55
Polyunsaturated	71	55	55
(n-3)	70	54	54
(n-6)	72	56	57

Looking at the utilization of fatty acids during development (Table I), it can also be noted that the unsaturated fatty acids are used up at a higher rate than saturated fatty acids; within the unsaturated fatty acids, monounsaturated are more consumed than polyunsaturated fatty acids. Eggs from *Macrobrachium rosenbergii* were also shown to conserve saturated fatty acids but, in this case, polyunsaturated fatty acids were more utilized than the monounsaturated ones (Clarke *et al*., 1990). There was no major difference in the consumption rates of (n-3) and (n-6) fatty acids, although a slight preferential use of (n-6) fatty acids during development was detected. As for individual fatty acids, the results point to a preferential consumption of 16:1(n-7), 18:1(n-9), 20:4(n-6), 20:5(n-3) and 22:6(n-3). Again, these results agree with data from Wehrtmann and Kattner (1998), who studied another hippolytid shrimp.

Finally, when comparing the fatty acid profile of eggs produced by females with a different size, it can be seen that there is a higher reduction in total FAME during embryonic development in small females. This is probably the result of the lower lipid content of these eggs at the start of development (31 % of dry weight *vs*. 38% and 34% in medium and large females, respectively). Another interesting difference between different sized females was found in the consumption patterns of the essential fatty acids 20:5(n-3) and 22:6(n-3) - in eggs produced by small females, 20:5(n-3) was more consumed during embryonic development than 22:6(n-3), while the contrary was observed in medium and large females. No major differences were found in the fatty acid composition during development in medium and large females eggs. Egg size has been correlated with maternal investment in caridean decapods (Clarke, 1993; Wehrtmann and

Graeve, 1998). However, the differences found in the egg fatty acid profile of small and medium/large females were not caused by differences in the egg diameter, given that this parameter did not vary significantly (data not shown). In this case, the age of the female was probably one of the determinant factors of egg fatty acid composition.

Acknowledgements:

The authors would like to thank the Fundação para a Ciência e a Tecnologia (scholarship SFRH/BD/983/2000) from the Portuguese government for the financial support of this research

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Fatty Acids and Phospholipids in Eggs and Larvae of a Clownfish

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Introduction

The clownfish, *Amphiprion clarkii*, is a valuable ornamental fish and optimizing the nutrition of early developmental stages is an important goal in their culture. The viability of larvae is partially dependent on the nutritional composition of the developing eggs. Lipids play an important role in cell membranes and energy storage in egg and larval stages of marine fish. Phospholipids make up approximately 40% of the total lipids found in cell membranes (1). Triacylglycerols serve as a major source of energy for developing eggs and larvae before they can capture food for themselves (2). Thus, the quantity and quality of phospholipids and tryacylglycerols in eggs may play and important role in the development and viability of eggs and larvae.

In this study, we evaluated the fatty acid profiles of developing *A clarkii* eggs by GC/MS. We also identified major phospholipid classes of the developing eggs by ^{31}P-NMR. NMR evaluation of egg lipids is nondestructive and will allow us to further fractionate and investigate changes in individual lipid classes to try to further understand the role of lipids and the development and health of *A. clarkii* eggs and larvae.

Methods

Viable eggs were obtained from a mated pair of *A clarkii* that had been spawning regularly in an aquarium for more than a year. Eggs were harvested 2 hours after egg-laying was completed and again at 9 days, i.e., one day before hatching. Eggs were blotted dry, weighed and stored in 1:1 chloroform : methanol at –20° C. For extraction of lipids the eggs and solvent were homogenized in a hand held, glass homogenizer. The suspension was filtered and the filtrate was concentrated to an oil.

The lipid extract was analyzed by ^{1}H-NMR and ^{31}P-NMR in 0.60 mL $CDCl_3$, 0.09mL CD_3OD and 0.025 mL of aq. Na-EDTA (3). Peaks corresponding to individual phospholipid classes were identified by comparison with authentic phospholipid standards (from Sigma). The percentages of phospholipid classes were determined from their integral areas.

Fatty acid composition was determined by converting the fatty acids of a very small portion of the lipid extract into their fatty acid methyl esters (1). The lipid extract (0.001-0.010g) was refluxed in 1M KOH/methanol for 30 min. then BF_3-methanol for 30 minutes. The FAMEs were extracted into hexane, purified through a “mini” silica column, concentrated and finally redissolved in hexane (1 mL) for GC/MS analysis.

FAMEs were identified by comparison with standards and their % area determined from integration (Figure 2).

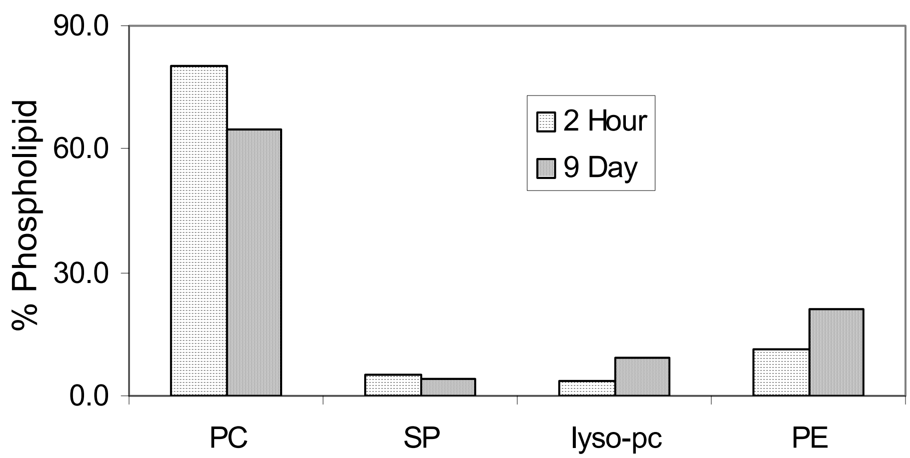
Results

The major phospholipids present in *A clarkii* eggs are phosphatidyl choline and phosphatidyl ethanolamine . As the eggs develop, the total concentration of phospholipids decreases, as determined from ratios of total phospholipid to internal standard ^{31}P-NMR integral areas. Additionally, the overall percent of phospatidyl choline decreases as the percents of phosphatidyl ethanolamine and lyso-phosphatidyl choline increase (Table 1 and Figure 1). Thus, as the eggs develop, phosphatidyl choline is utilized as a source of energy. Concurrently, the other essential phospholipids are synthesized as the embryo develops. The NMR data also shows the presence of several other minor phospholipids, but the signal to noise ratio makes integration difficult.

Table 1. Percent of each Phospholipid class in 2 hour (n=3) vs. 9 day eggs (n=3).

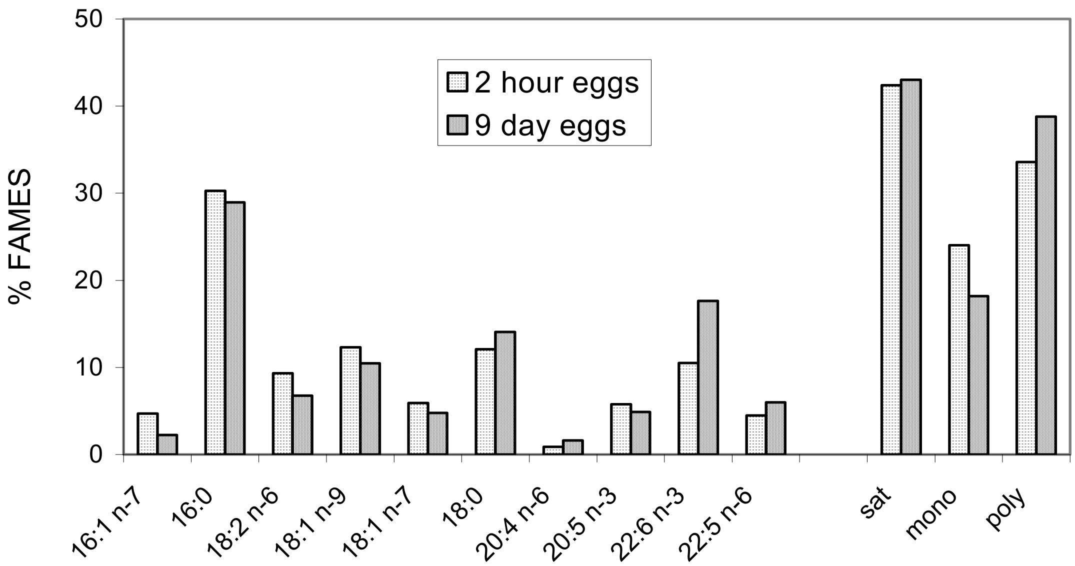
Phospholipid	**2 Hour**		**9 Day**	
	% Area	**%RSD**	**% Area**	**%RSD**
Phosphatidyl choline	80.2	0.3	64.9	2.0
Sphingomyelin	5.1	17.6	4.3	8.6
lyso-Phosphatidyl choline	3.4	22.6	9.4	12.2
Phosphatidyl ethanolamine	11.2	2.8	20.9	9.4

Figure 1. Percent of each phospholipid class in 2 hour vs. 9 day eggs (PC = phasphatidyl choline, SP = sphingomyelin, lyso-pc = lyso-phosphatidyl choline and PE = phosphatidyl ethanolamine).



There are also changes in the fatty acid profiles of the developing eggs (Figure 2). Saturated fatty acids are the major fatty acids in both 2 hour and 9 day eggs, but the percentage of polyunsaturated fatty acids increases slightly, while the monounsaturated fatty acids decrease over the 9 day period. DHA, a polyunsaturated, ω-3 fatty acid, shows the greatest change over time, increasing from ~10% at 2 hours to ~18% at 9 days. This increase in DHA may be significant for the development of the eggs and survivability of the larvae.

Figure 2. Fatty acid profiles of 2 hour vs. 9 day eggs.



Future investigations will incorporate a combination of NMR and GC/MS analysis of individual lipid classes in developing eggs and larvae. These data will hopefully allow us to better understand the role of triacylglycerols vs. phospholipids in the early development of *A clarkii.*

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Production Rates of the Rotifers *Brachionus plicatilis* and *Brachionus rotundiformis* Fed a Variety of Algal Species

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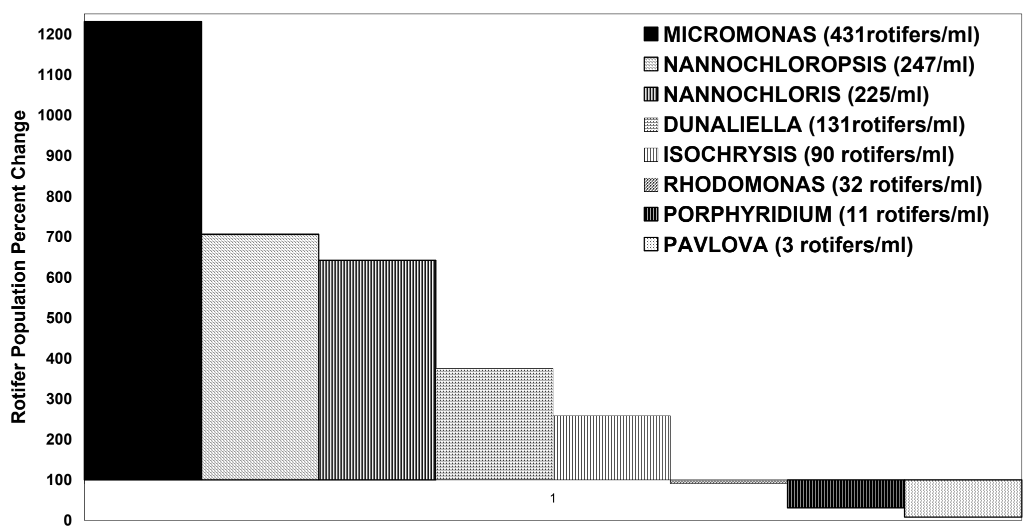
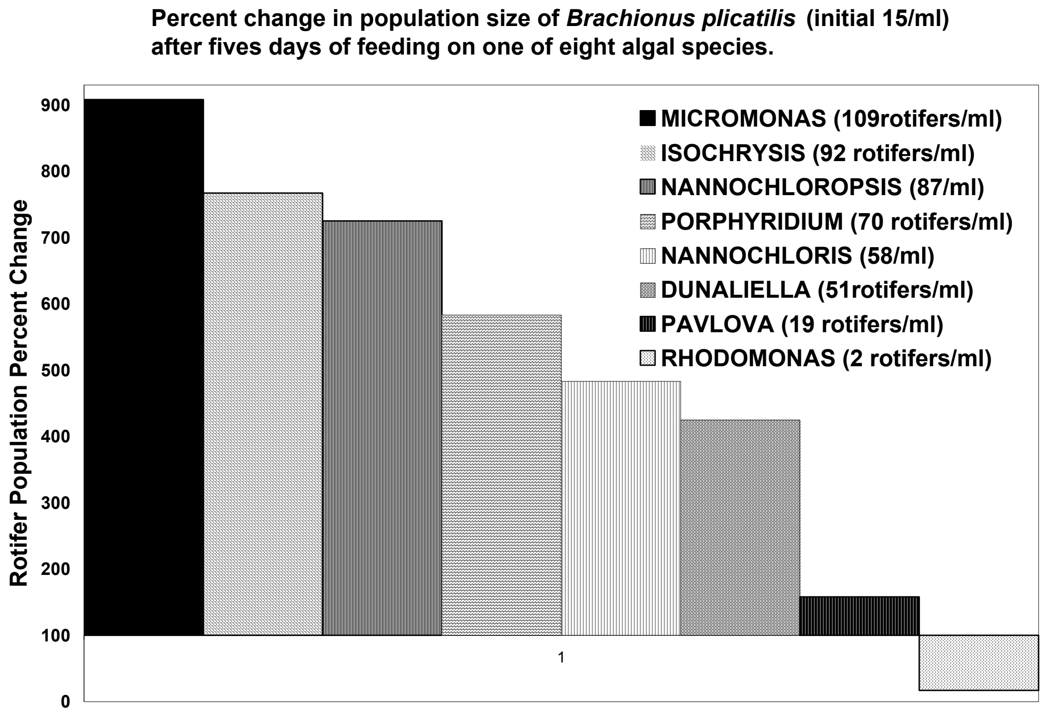
Recent research into the production of marine fish and invertebrates for food, stock enhancement, and the ornamental trade, has lead to the need for initial live foods smaller than the historically used *Artemia* nauplii. This need is currently being fulfilled by the use of *Brachionus plicatilis* l-type (250um) and the smaller rotifer *Brachionus rotundiformis,* specifically the ss-type (160um). The aim of this study was to find easily cultured algal species that would produce optimal population growth rates for *B. plicatilis* and *B. rotundiformis*.

In this experiment *B. plicatilis* and *B. rotundiformis* were raised separately in two liter bottles, at initial stocking densities of 15*B. plicatilis*/ml or

35*B. rotundiformis*/ml, for five days, on eight easily cultured and readily available algal species (*Micromonas pusilla*, *Nannochloropsis salina*, *Nannochloris* sp., *Dunaliella* sp., *Isochrysis* sp., *Rhodomonas lens*, *Porphyridium cruentum*, and *Pavlova pinguis*), to investigate population growth. Cultures were obtained from The Culture Collection of Algae at the Univ. of Texas or Provasoli - Guillard National Center for Culture of Marine Phytoplankton.

Percent change in population size of *Brachionus rotundriformis* (initial 35/ml) after fives days of feeding on one of eight algal species.





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Coral Farming as a Cottage Industry - A Viable Adjunct to Wild Harvesting?

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There are many people that have the idea that the saltwater and in particular the reef hobby is the primary source of problems for the world's reefs. I won't deny that we have contributed to the problems. However, I would like to present what I feel is an important movement within the reef aquarium hobby. This is the growth of coral farming by numerous hobbyists. Untold numbers of individual hobbyists have begun to trim their corals and trade them either with other hobbyists or with their local pet store. Each time this happens there is one less wild coral sold. Many hobbyists have become so proficient at the propagation of corals that they have actually started their own business. This is what I call a **Coral Farmer, when the intent is to produce income.** Of course there are many non-hobbyists that are coral farmers also. In particular are the islanders of Fiji and the Solomons and elsewhere who are cultivating wild corals in their lagoons. I believe that even those individuals that harvest the wild corals in a sustainable manner could properly be called coral farmers. But, what I wish to address are the smaller individual farmers in the U.S. and elsewhere that are pursuing this as a cottage industry.

If you look up the definition of a farmer in Webster's Dictionary it says that a farmer is someone that operates a farm or cultivates land. In the context of my presentation I would like to expand that definition to include anyone who conducts animal husbandry of marine wildlife, particularly within a specified limited non-natural environment.

There have been a number of large scale coral farming entities started with millions of dollars invested and with varying degrees of success. Coral farming as a cottage industry on the other hand only requires a moderate capital investment for the reef hobbyist. Many coral farmers in fact only have their original tank and sell only the trimmings from their established corals. Steve Tyree has established a network of this type of coral farmer into a very viable business - Dynamic Ecomorphology - and sells most of his corals over the internet.

Many others have multiple tanks and propagate several to many types of corals.

The Capital investment varies greatly from coral farm to coral farm depending on number of systems and type of material used. Manufactured tanks, either glass or acrylic are the most common, but, some farmers use Rubber-maid tubs also. The lighting for the systems is probably the greatest initial expense. If the prospective farmer doesn't have sufficient adult livestock, he or she will have to acquire brood stock, which will vary greatly as to cost. Water, salt and electricity are of course the largest continuing expenses. Another key requirement is the experience of the reef hobbyist to be able to maintain all the systems involved in keeping the corals in a healthy state. And, as with any business especially a farm, one must first determine who and where his/her market is.

Many varieties of corals are able to be propagated at this time, mostly the soft corals and SPS corals, although many farmers are experimenting with ways to propagate other corals. At present the most common way to propagate corals is to make clones of the original by breaking or cutting. Then you fix the cutting or fragment, (Commonly called frag) to some form of substrate. Many kinds of substrate have been used - pieces of arragonite rock, either clean or live rock, artificial substrate such as arragacrete (TM), arraga-rock, plastic faucet pieces, eggcrate or other plastic items, or PVC fittings. Actually the limiting feature is the imagination of the farmer and what is readily available. What is commonly used to affix the cutting or frag can be any of a number of items, - rubber bands, cyanoacrylic glues in many different thicknesses, bridal veil mesh, or natural attachment.

Some of the reasons that I feel that coral farming as a cottage industry is a viable option are: most captive grown corals tend to have brighter colors; most tend to be healthier and stronger than their wild cousins due to having lived in an artificial environment all their lives; many hobbyists really want to help prevent reef rape; and the cost of most captive grown corals is significantly lower than a wild specimen; and finally the amount of investment will not require the same amount of return as a multimillion dollar facility.

Coral farming will never totally replace the wild harvesting unless Governments arbitrarily decide to stop all wild harvesting. In which case coral farming will be the only legal option available to the hobby. Coral farmers will always need brood stock, some of which will invariably be newly harvested wild specimens. Also, there will always be a segment of the hobby who will not want anything but wild harvested corals.

There is a need to establish a system of commonly accepted standards for this segment of marine aquaculture. LeRoy Headlee of G.A.R.F. has proposed a system of identifying coral farmed animals that I support wholeheartedly. That is there should be three levels of farmed animals - **PAQ**: this is a propagated coral that has been taken from a recently harvested wild coral but has been **Propagated, Acclimated** to life in an artificial environment, i.e., an aquarium and **Quarantined** so that it is obviously healthy**; Tank Raised:** This is a **PAQ** specimen that has been retained in the farmer's facility until it has at least doubled in size**;** and **Captive Grown:** this is a specimen that is at least the second generation from the wild parent. Also, something that is needed is for all governments to recognize coral farmed animals versus wild caught ones. I suggest a separate CITES classification which would allow farmed animals to be sold or traded internationally. Something else that I feel is needed is for a certification similar to what **AMDA** has for store owners, but, for coral farmers so that customers may know that they are receiving the best product possible. I truly believe that Coral Farming as a cottage industry is not only a viable adjunct to Marine Aquaculture in general but will prove to be a necessary part of the industry's future.

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The Use of Cultured and Wild Caught Neon Gobies, *Gobisoma oceanops,* As an Effective Control of Ectoparasites on Mutton Snapper, *Lutjanus analis*, and Greater Amberjack, *Seriola dumerili*, Broodstock in Recirculating Systems

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Build up of infectious organisms in maturation systems is known to increase stress levels of several species of marine finfish. The use of cultured and wild caught neon gobies, *Gobisoma oceanops*, is described as an alternative and effective control of skin, mouth and gill parasites on mutton snapper, *Lutjanus analis*, and greater amberjack, *Seriola dumerili*, broodstock in recirculating systems. *G. oceanops* acclimated to the maturation tanks and established cleaning stations in custom-built artificial poly-vinyl-chloride (PVC) habitats, and Aquamats (substrate providing bio-filtration and natural food production).

G. oceanops was observed servicing broodstock as early as thirty minutes post-introduction. Various behaviors including the exhibition of the 'invitation pose' (entire body kept virtually motionless and cocked 45), frequent 'cues' of individuals waiting for cleaner fish attention, and active competition for space over cleaner habitats regularly took place throughout the study period. In addition to visual observations, the effectiveness of this symbiotic relationship was shown in several other ways. Prior to cleaner fish introduction, ectoparasites were found accumulated in recirculating system bag filters. The number of parasites in the bag filters decreased precluding the introduction of *G. oceanops*. Video recordings were collected for a seven-day period. Observations regarding visits to habitat, cleaning events, approximate number of *G. oceanops* per broodfish, length of cleaning event, intervals between cleaning events, and aggression/competition were compiled and evaluated.

Broodstock were examined for ectoparasites before and after cleaner fish introduction. Observations of parasite removal were conveniently made during periodic sampling, handling and prophylactic treatments. The introduction of *G. oceanops* resulted in both *L. analis* and *S. dumerili* displaying a decreased amount of parasites after 4-5 weeks of exposure to *G. oceanops.* The use of *G. oceanops* in broodstock maturation tanks as a form of parasite control has proven to be an effective supplement or alternative to current marine finfish prophylactic treatments.

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Export/Import Oral Abstracts

Current Status of the Wild Marine Ornamental Fish Trade in Puerto Rico

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Official custom declaration export documents of several fish trade exporters corresponding to January 1998 through July 2000 were collected from the Department of Natural Resources (DNR-PR). This study aims to provide the most complete and reliable information on the marine ornamental fish trade industry in Puerto Rico. A total of 92 species were identified representing 27 families and 82,290 fish individuals, having a total gross trading value of $275,170.41USD. Grammatidae, Opistognathidae, and Pomacentridae were the three most abundant families, which in turns represent 47,078 (57.2%) fish collected. *Gramma loreto* (42.7 %), *Opistognathus aurifrons* (10.2 %), *Chromis cyanea* (4.13 %), *Holacanthus tricolor* (3.63 %) and *Ophioblennius atlanticus* (3.5 %) were the five top ranking species. *G. loreto* represents by far the most abundant species collected and is considered to be the industry key species. Eight fish trade exporters were identified during the study period, but only three showed a consistency during the last two years. Data on fish species by months, year and export values are discussed in detail. The main US State recipient of Puerto Rico fish trade is California, receiving 53% of the total fish exported.

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Global/Cross-Cutting Oral Abstracts

Coral Culture - Possible Future Trends and Directions

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Techniques of captive asexual reproduction of Hexa- and Octocorallia have been developed in the last decade amongst private aquarists (e.g. Sprung and Delbeek 1997), public aquariums (e.g. Carlson 1992), and a few professional researchers (e.g. Heeger et al. 1999). However, more than 95% of these techniques exists presently only as popular un-edited text mainly accessible by the Internet - if published at all (Arvedlund pers. obs.). In addition, aquarium technicians in public aquariums have acquired a tremendous amount of technical knowledge within this area. Again, this knowledge remains obscured simply because it is never, or at the best very rarely, published (Arvedlund pers. obs.). This situation does not help the promising area of coral culture at all. If we label the first promising decade of coral culture as phase one, whith the majority of techniques having been developed by aquarists and public aquarium technicians, whom may not posses the necessary knowledge of how to publish these results in peer-reviewed journals, the second phase of coral culture should definitely concentrate on changing this situation.

Coral culture comprise an important future potential, not only to secure a stable large-scale production of marine ornamentals for the keen international aquarist and public aquariums, but it will most likely also provide an important contribution to the current methods of restocking local depleted reefs, i.e. international conservation. It is therefore important to bring captive coral culture into a more widely accepted field of applied science, including designed experiments with both controls and tests, in sufficient replicas, with the additional statistical data treatment, analysis, discussion and submission of results to a peer-reviewed journal. This will help this field gain a significantly better global acceptance, much better possibilities of funding, and enhanced prospects of solving difficult problems, e.g. with coral species presently impossible - or at least very difficult - to culture, e.g. corals as *Dendronephtyia* spp.

This presentation is a cross-cutting attempt to bridge the practise of peer-reviewed high-profile published applied science, with the important work of dedicated aquarists and dedicated professional aquarium technicians with their highly valuable observations. DANAQ CONSULT Ltd, a Danish aquaculture company, and London aquarium, have therefore together established "Project Coral". This project is thought as a service, firstly for anybody interested in getting their results published in a peer-reviewed life science journal, secondly as a service helping with the proper design, execution, and analysis of experiments in this field. We present 25 research projects at MO'01, as a suggestion for a possible future scientific direction in coral culture, with a discussion of possible design, statistical treatment, analysis and how and where to publish the acquired data in the peer-reviewed literature. The authors of this abstract will therefore remain available for anybody interested, should you desire, acquiring help getting your coral culture results published in a peer-reviewed journal.

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The United States' Consumption of Marine Ornamentals: A Description from U.S. Import Data

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Recognizing that the marine ornamental trade can have both adverse and beneficial effects on the reef ecosystems, as well as on the fishing communities that depend upon it, industry, conservation organizations, government and hobbyists all have an interest in measuring the trade's social and ecological impact. Reflecting this, U.S. Coral Reef Task Force lists as one of its activities, to "ensure that the international trade in coral reef species for use in U.S. aquariums does not threaten the sustainability of coral reef species and ecosystems" (USCRTF 2000). Without determining a baseline of consumption, however, it is impossible to determine the effects of the trade on coral reef species and ecosystems. This paper is a first step at a comprehensive examination of the United States' consumption of live marine ornamental fish. Through an immense trail of paperwork, the United States Fish and Wildlife Service documents all live ornamental imports into the United Sates. By taking this information and entering it into a workable database, this paper makes this information more useable by industry, conservation organizations, government and hobbyists. Looking at the import data from one representative month in the year 2000, this paper will describe the U.S.'s consumption of marine ornamentals by species imported, volume, value, and country of origin. Since the United States is the number one importer of live coral and marine fish for the ornamental trade, this paper will give some insight into the trade as a whole. The import data, as well as the lessons-learned from the data-collection process, shape policy recommendations about the ornamental fish trade and the United States' documentation of this trade.

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Commercialization of Coral Propagation – A Malaysian Experience

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Marine resources have been harvested for generations throughout Malaysia for food, building material and other commercial uses. Coastal construction projects, collection of marine fauna and flora, and other unregulated coastal activities have drastically decreased the biodiversity of the Malaysian waters.

Fish, seaweed and many invertebrates are being cultured in Malaysian farms to supplement the demands placed on these marine resources. Corals, both hard and soft even though protected by the local laws, are harvested illegally for aquarium trade and the building industry. Until recently there has been no venture to commercial propagation of corals in Malaysia.

Coral Life Sdn. Bhd is a Malaysian owned company incorporated in Kuala Lumpur in 1996, has established to undertake marine and environmental research in Malaysia. Coral Life now operates a marine laboratory in a commercial center in Kuala Lumpur and its main function is to develop coral propagation as a commercial venture and improve propagation biotechnology in Malaysia. Coral Life is being developed from a government funded laboratory at the present moment to a commercially viable center for coral production. It also plays an advisory role to the Ministry of Science, Technology and Environment, Malaysia on marine related matters.

Coral Life has now 40 fully functioning marine aquariums, propagating both hard and soft corals found from the Malaysian waters. They include 5 species of hard corals and three species of soft corals. The coral broodstocks have been collected from Pulau Singa, an island in the Straits of Malacca and Pulau Tioman, an island in the South China Sea. The laboratory is well equipped with good lighting system depicting natural sunlight, biological filters, UV filters and other necessary apparatus to enable the corals to grow.

The main problems encountered through out the setting of the laboratory has been:

- Bad weather at the islands, making collection not possible or difficult.
- Very high temperature in the laboratory due to many aquariums and artificial lights in operation.
- Lack of water pressure and interruption in water supply from the local pipeline.
- Lack of local expert or counterparts in Malaysia and South-East Asia to advise and contribute to the development of this laboratory.

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An Overview of Common Syngnathid Health Problems

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Seahorses and related species in the family Syngnathidae are becoming increasingly popular in the pet trade as well as in the public aquarium industry. The traditional use of these animals by certain medical practices also adds to the demand for these animals. As a result, many wild populations are in danger of overharvesting. The development of successful culture techniques will help reduce collecting pressures. Proper disease diagnosis and appropriate medical treatments will further assist in reducing losses. Common clinical problems encountered include bacterial diseases, gas/air entrapment and parasitic infections.

Vibriosis is the most commonly diagnosed bacterial species affecting captive syngnathids and often results in high mortalities. Common clinical signs encountered include erosive and ulcerative lesions on the skin, sudden death with no visible problems, and edema (swelling) of the tissue around the eye and snout. Culture and sensitivity tests are recommended for appropriate antibiotic treatment. Infections with *Mycobacterium sp.* and *Nocardia sp.* have recently been reported, both conditions are very difficult to resolve.

Gas/air entrapment can affect the skin, brood pouch, and swim bladder. The etiology of these conditions is still in debate. Infectious agents have not been identified. Low level, chronic supersaturation has been proposed but remains unproven. Improper air shipment resulted in the overinflation of the swim bladder in two weedy seadragons (*Phyllopteryx taeniolatus*). Fine needle aspiration or pressure equilibration of the gas/air is often successful in acute (very recent) onset cases. Reoccurrence is common.

Two protozoal ectoparasites, *Amyloodinium ocellatum* and *Uronema marinum*, have been the most commonly diagnosed. Treatment response for *Amyloodinium* infections has been successful using chloroquine diphosphate. *Uronema* infestations, however, are usually difficult to eradicate. The organism often invades the skin and underlying tissues. Endoparasites reported include intestinal coccidiosis, trematodes (flukes), nematodes (roundworms), cestodes (tapeworms) and the microsporidian *Glugea sp.* (has complex life cycle often with dermal manifestations). Admininstration of praziquantel (flukes, tapeworms), fenbendazole (nematodes) and sulfa-trimethoprim (coccidian) varies in treatment effectiveness. No current treatment is available for microsporidian infections. Eradication of affected populations is recommended.

Preventative medicine is encouraged at all steps of the acquisition process (collecting, wholesaler, client/recipient, breeder). Proper handling and shipping procedures, appropriate water parameters, the establishment of a quarantine protocol, and adequate nutrition are essential.

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Temperate Shrimps: Perspective Use as Ornamental Species

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Ornamental species are normally chosen for a variety of reasons such as, their beautiful or strange appearance, their mimetic capacity, symbiotic behavior or even for their rarity (live collections). In contrast to aquaculture, ornamental species are sold in a unit or couple basis, at high prices, which makes their trade a very appealing activity.

Marine tropical shrimps are amongst the most popular species in the aquarium trade industry. This great popularity is mainly due to their striking coloration, mimetic adaptations and unusual associative behavior with fishes and other marine organisms. However, the price that tropical ornamental shrimps had to pay for this success was a remarkable increase on wild specimens collection and, consequently, a growing pressure on natural populations.

In recent years, the artificial rearing of these species has been regarded as the best alternative to wild specimens collection (Zhang *et al.*, 2001). This approach certainly seems to be the best solution to minimize the pressures on the natural populations and habitats of these animals and the only way to achieve a sustainable exploitation of these highly valued resources. Despite all efforts and improvements in the rearing of tropical ornamental shrimps (Zhang *et al.,* 1998a, b; Palmtag and Holt, 2001), artificially reared species are still far from fulfilling the growing market demand. Therefore, any serious conservation policy can be severely threatened, as long as reared shrimps do not satisfy completely the needs of the aquarium trade industry.

The decrease of captures of wild tropical ornamental shrimps may only be achieved if new solutions are considered. One example would be the evaluation of the rearing potential of several shrimp species from temperate and sub-tropical waters, which could fulfill the requirements of the ornamental species trade. Besides their delicacy, the coloration presented by some of these species is able to rival that of tropical ornamental shrimps. Just as tropical species, several temperate shrimps also display remarkable mimetic adaptations, as well as interesting associative behaviors, namely fish cleaning. Another important characteristic presented by the majority of these species is their non-territorial behavior, allowing several specimens to be easily clutched in the same aquarium, without inducing any agonistic behavior.

Some of the possible candidates, from the Mediterranean Sea and the temperate-subtropical Eastern Atlantic, to the ornamental species trade are the mimetic seagrass shrimp (*Hippolyte varians*), the Mediterranean cleaner shrimp (*Lysmata seticaudata*), the feather star shrimp (*Hippolyte prideauxiana*), the blue-white partner shrimp (*Periclimenes sagittifer*) and the golden shrimp (*Stenopus spinosus*). *Cinetorhynchus rigens* and *Lysmata grabhami*, which occur in Madeira and Canary Islands, have also good experimental rearing perspectives.

It must be kept in mind that the minimization of the pressure on the natural populations of tropical shrimps should not be the cause of a future problem: to endanger the natural populations of temperate shrimps. Therefore, the trade of any temperate ornamental species should be entirely dependent on artificial rearing. This principle will ensure that the overfishing problems that are now being faced in coral reef areas will not happen in temperate and sub-tropical waters in the future. However, such an achievement will only be possible if the life cycle of all candidate species is well-known, particularly larval development and reproductive patterns. Although there are still some bottlenecks to be solved, the large amount of scientific work published on Mediterranean and temperate-subtropical Eastern Atlantic shrimps biology will be a valuable contribution for the successful rearing on a commercial scale of temperate ornamental shrimps.

Experimental rearing of *Lysmata seticaudata* has been attempted in our laboratory, with promising results, indicating that this species may be reared on a commercial basis in a near future. Progress has been made in the maintenance and incubation of gravid females, leading to the production of good quality hatchlings. Some abiotic parameters (temperature, light intensity, air and water flow) have been studied and optimized in small and large scale larval rearing. Additionally, larval fatty acid requirements have been examined and different enrichment strategies investigated. By applying the acquired "know how", larval rearing has been achieved with success and post-larval settlement behaviors, as well as juvenile nutritive requirements, are now being studied.

In conclusion, researchers, traders and marine aquarium hobbyists need to realize that a point of no return can easily be reached if the actual pressure on natural populations of tropical shrimps remains. Since Europe is one of the main importers of tropical ornamental shrimps, the commercial rearing of European temperate ornamental shrimp species can result on the production of less expensive animals and contribute to the reduction of the aquarium market pressure on such endangered habitats as coral reefs.

Acknowledgements:

The authors would like to thank the Fundação para a Ciência e a Tecnologia (scholarship SFRH/BD/983/2000) from the Portuguese government for their financial support.

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MicroReef Aquariums, Educational Tools for the Classroom

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Coral reef ecosystems and reef conservation are popular topics for educators but many students will never have the chance to visit a coral reef. The recently developed complete aquarium systems make an ideal learning tool to explore the complexities of the marine reef ecosystem. By combining all the essential components into a complete aquarium package, classroom teachers with little or no aquarium experience can successfully set up and maintain a micro-reef aquarium.

For this to succeed, partnerships with coral culture facilities were required. These companies can provide hardy aquacultured corals, cultured or sustainably harvested live rock and sand, plus other necessary organisms direct to the classroom. The use of a carefully selected livestock practice drastically reduces initial losses due to new tank syndrome.

These small systems, 7 to 10 gallons can be delivered to the school by surface delivery services with all necessary drygoods and complete instructions for set-up. Once the tank is ready with circulating saltwater, the livestock package is delivered by overnight service. The inert sand in the tank is inoculated with live sand and live rocks are placed into the tank followed by the carefully selected group of soft and hard corals. Finally the grazers are added. The teacher can place a single order through a biological supply house, which greatly simplifies the process and keeps costs reasonable, under $500.

This paper will outline the components of these systems, how they are delivered, simplicity of set-up, proposed educational programs to go along with them, and the benefits to the aquarium trade for supporting this project. By placing a few thousand of these aquariums in schools across the country, hundreds of thousands of students can be exposed to coral reef ecosystems fostering an interest in both reef ecology and aquarium keeping. These students could form the nucleus of the next generation of reef keeper.

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Disease Diagnosis In Ornamental Marine Fish: A Retrospective Analysis, 1987-2001

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The University of Florida has had fish diagnostic services available to aquaculturists and others since 1987. The service is operated through the cooperative extension service and involves close cooperation between the College of Veterinary Medicine and the Department of Fisheries and Aquatic Sciences. Because the primary aquaculture industry in the state is ornamental fish, the laboratory has had a significant number of case presentations of ornamental marine species.

In the past 5 years the annual submission of ornamental marine species has ranged from 5-15% of all submissions. Although a diverse range of species have been presented for disease diagnosis, the most frequent marine submissions have been of surgeonfish, clown fish and varieties of angelfish. Clientele is varied, but includes wholesalers/ collectors, pet stores, pet owners, researhers, commercial exhibits, and breeders.

Bacteria have been isolated from most fish that die, but have been from a range of genera including *Vibrio*, *Aeromonas*, *Pseudomonas* and others. In most cases, multiple problems have been identified in sick and dying marine fish. Therefore although bacteria may have caused the death of an animal, it was rarely considered the primary problem. Common problems have included external ciliates, monogenes, internal parasites and husbandry problems including copper toxicity and severe nutritional disease. The frequency of these findings suggest that health management of marine fish is lagging behind advances that have been made in the freshwater industries.

Data collected from medical records of these submissions will be analyzed and presented. Particular attention will be directed to the identification of common and repeatedly encountered health problems that may be appropriate for future research. In addition, an effort will be made to determine whether certain problems are more frequently encountered in some settings but not in others. Suggestions for improved health care and related research, both short and long term, will be presented.

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Sampling for Success: Getting the Most from Your Diagnostic Laboratory

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Monitoring and maintaining the health of marine fish and invertebrates is essential for the successful propagation and conservation of these animals. The identification and treatment of disease in the culture environment and monitoring the presence and effects of disease on wild populations not only assure the well-being of the animals, but also help us understand the impact disease can have on individuals and populations.

Crucial to the success of any disease monitoring program is making an accurate and timely diagnosis. It isn't enough to recognize that an animal is ill. To be of benefit, the nature of the illness as well as its cause must be identified, and for maximum benefit, must be done before the animal succumbs. The veterinary diagnostic laboratory provides the fish health specialist, culturist, and biologist with the testing capabilities needed to make a rapid, definitive diagnosis. The success of this relationship depends upon the collection and submission of appropriate and useful samples.

Collecting samples that will be most useful for diagnostic testing requires care and attention not only during the collection process, but also during packing and transport to the laboratory. Even the best diagnostic specimens can become worthless if time, temperature, or carelessness is allowed to interfere. Failure to follow standard operating procedures for sample collection and submission can delay diagnosis and treatment, resulting in animal, environmental, and financial losses.

Suggestions for a systematic and logical approach to sample collection and safe transport, together with examples of sampling mistakes hampering diagnostic testing, will provide the background needed for you to maximize the benefits of diagnostic laboratory services.

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Marine Ornamentals in Indonesia: Challenges and Opportunities for Sustainabilty

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Indonesia is one of the main source countries of marine ornamentals. Currently with an annual quota of 950,000 pieces of corals and 450 metric tons of live rock, it is the world's largest exporter of coral and, along with the Philippines, it is among the largest exporters of marine aquarium fish.

Efforts to achieve sustainability in marine ornamental trade in Indonesia face great challenges. The vast geographic span of the country, covering 80,000 kilometers of coastline and 3.1 million square kilometers of territorial waters, limits the government capacity to implement effective coral reef conservation measures. Sustainable marine ornamentals trade presents economic and conservation opportunities to rural low-income coastal communities in Indonesia. Collectors of marine ornamentals, and their communities, can become active reef stewards, guarding these valuable resources against destructive uses and often creating de facto management or conservation areas.

The Marine Aquarium Council is currently working with industry operators, government and conservation organizations to implement MAC Certification in Indonesia. This paper will present the most recent development in Indonesia listing the challenges and the opportunities in our efforts to achieve coral reef conservation through MAC Certification.

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Perceptions and Market Opinions of U.S. Marine Ornamental Wholesalers

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Overview

A survey of marine life wholesalers was initiated in 1999 as a first step towards understanding the nature of Florida's marine life industry and the marine aquarium industry in general. The wholesaler survey was designed to tract the flow of product through marketing channels and geographically. We also sought information on the dominance of Florida products both nationally and internationally. As such, this work represents the first study to document the economics of the marine life industry in Florida. Survey questions were written to provide information on the total quantity and value of products purchased and sold in 1998. We asked dealers about product prices, quantities sold, and how Florida compared to imported species. We queried wholesalers on their annual sales volume by species type, collection points, distribution outlets, and expectations about industry trends. We asked firms to describe their market channels (supply and demand side) and solicited their opinions about the state of the industry. We requested information about firm demographics to distinguish between types of market groups.

The survey questions were pre-tested during several personal and telephone interviews of Florida wholesalers conducted in March and April 1999. To increase the response rate, all firms were mailed a personalized letter with a description of the project and a request for cooperation during telephone survey.

Our contact list included all Florida wholesalers licensed to purchase marine life and having reported landed product in either 1997 or 1998 (i.e., firms with active marine life endorsements), a total of 90 firms. Next, we identified dealers located outside of Florida using the trade magazine *Pet Supplies Marketing Directory* (Fancy Publications Inc.) on the suggestion of the president of the American Marinelife Dealers Association. In this manner, 84 domestic firms dealing in "saltwater livestock" were added to our contact list for a total of 174 firms.

Response Rate

Of the 174 firms initially identified as marine life wholesalers, 54 firms (31%) were removed from the list because they did not participate in the market in 1999 or had their telephone disconnected and left no forwarding number. Of the remaining 120 firms, 52 firms (43%) completed the survey, 7 explicitly refused to answer, and 61 provided incomplete responses. Every attempt was made to gather the survey information including contacting some firms up to eleven times. Several surveys were interrupted and never completed. Some firms promised to call back but never did. In many cases, the interviewer was forwarded to another individual within the organization to complete part of the survey and the other individual could not be contacted. Using multiple individuals within a firm to complete the survey was expected given the depth and scope of the subject matter. Of the 52 completed surveys, 25 firms (48%) are licensed wholesalers in Florida and 27 firms were from other States.

"Target firms" in Florida include all dealers licensed by the State to purchase live marine aquarium species. Of the top 25 firms in Florida (firms collectively accounting for 75 percent of sales in 1998), 40 percent completed our survey. Similar information was not available for firms located in other States.

Issue Areas

Respondents were asked a series of open-ended opinion-oriented questions. The questions were intended to assess opinions regarding industry strengths and weaknesses that could ultimately be used to aid marketing campaigns and establish consensus regarding the effectiveness of regulatory measures in Florida. The questions concerned: (1) the advantages and disadvantages of Florida-caught products relative to imports, (2) explanations for observed trends in the collection of fish and invertebrates in Florida, (3) expected changes in the wholesale market within five years, and (4) factors limiting sales of Florida species. The questions and responses, ranked beginning with "1" (where the number 1 response is the mode, i.e., the most commonly cited response) for the Florida wholesalers (i.e., the responses are ordered by share for Florida firms).

Summary of Opinions

When asked to state the unique advantage, if any, that Florida marine species have over imports, the most prevalent response (accounting for approximately 46% of responses) indicated that wholesalers believe Florida products are of higher quality. Respondents defined quality by survival rates and overall health. Higher quality products had higher survival rates and were "less stressed" in general. Wholesalers in other states also indicated that direct contact with collectors was a unique advantage of products obtained from Florida; this response accounted for 38% of the total number of responses. In terms of the disadvantages, respondents cited the lack of sufficient volume (both seasonally and in total) and relatively high price (due to higher collection costs, especially for labor) of Florida products. These two responses accounted for 54% and 47% of those cited by wholesalers located in Florida and other states, respectively.

The stated reasons for the observed decline in fish landings in Florida varied by wholesaler location. Florida wholesalers primarily cited a reduction in water quality (29% of responses). Wholesalers in other states believe that a decline in demand for fish and poor economic conditions for small firms are to blame (62% of responses). In regards to explanations for the observed increase in invertebrate landings in Florida, 60% of the responses cited an improvement in the knowledge and care of keeping invertebrate species or that collecting invertebrates is easier than collecting fish. Wholesalers in other states most frequently cited (in addition to the improved invertebrate knowledge) the increasing popularity of reef tanks (these reasons accounted for 70% of responses).

The question concerning the anticipated changes in the wholesale market for marine aquarium species received the fewest number of distinct responses, which may indicate a greater degree of consensus within the industry. Florida wholesalers expect an increase in the quantity of cultured products. This response could reflect an increase in sales of live rock due to the recent addition of lease sites. Alternatively, it could reflect knowledge of research projects conducted at the University of Florida that are concerned with developing culture techniques for new species. Among the responses cited by wholesalers located outside of Florida, increasing consolidation within the industry (reflecting small firms being displaced or purchased by larger chains) was most frequently mentioned.

The question eliciting the factors that limit the sales of Florida species received the highest number of distinct responses, which may indicate a lesser degree of consensus within the industry regarding this issue. Florida wholesalers perceived import competition, regulatory issues, and illegal market participation within Florida to be the most pressing factors. Wholesalers located in other states cited the lack of natural species diversity as the most limiting factor since a wide selection is desired at the retail level.

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The Risks and the Reality: Bacterial Diseases, Marine Ornamentals, and Human Health

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Bacterial zoonotic diseases are caused by bacteria that are adapted to an animal host but can cause disease in humans. Marine ornamental fish and invertebrates and their holding water may harbor a number of bacterial species with known or suspected zoonotic potential (Table 1).

Table I. Marine and estuarine bacterial agents with confirmed or suspected zoonotic potential

Gram negative bacteria	**Gram positive bacteria**
Aeromonas sp.	*Clostridium botulinum*
Escherichia coli	*Erysipelothrix rhusiopathiae*
Flavobacterium sp.	*Lactobacillus sp.*
Pseudomonas sp.	*Mycobacterium sp.*
Plesiomonas shigelloides	*Norcardia asteroides*
Salmonella sp.	*Staphylococcus aureus*
Vibrio sp.	*Streptococcus sp.*

In general, the risk of animal husbandry staff contracting a bacterial zoonotic disease is relatively low. Those persons at greatest risk are immunosupressed individuals such as the very young, pregnant women, the elderly, individuals with immunosuppressive diseases, and persons on immunosuppressive drugs. However, there are several diseases that can cause problems in healthy individuals. In addition, inadequate sanitation procedures, poor personal hygiene, improper animal handling and disposal of dead animals may also increase the risk of contracting a zoonotic disease.

The most common route of infection in the marine ornamental industry is via the skin through abrasions, cuts, penetrating wounds, or bites. In most cases infections are localized to the injured area.

Marine ornamental fish and invertebrates are exposed to numerous stresses along the chain of custody from the collector or farm to the retail store or hobbyist. Stressed aquatic animals become immunocompromised often resulting in increased bacterial loads and a predisposition to developing disease. Diseased animals are more likely to have increased bacterial loads and subsequently transmit infection to humans. Further, inappropriate use of antibiotics may lead to the development of antibiotic resistance within bacterial populations, potentially increasing the risk to human health.

Table II lists some of the basic preventive strategies that should be employed to reduce the risk of zoonotic infections.

Common sense, excellent animal husbandry, and rigorous health management are the best approaches to reduce risk and prevent infection from zoonotic pathogens.

Table II. Preventive strategies to reduce the risk of zoonotic infection

Some basic principles of preventive health
-Reduce crowding.
-Separate systems for general holding, quarantine, and medical.
-Separate equipment available for each system.
-Disinfectant baths for equipment in each area, baths should be changed daily.
-Equipment should be soaked in disinfectant for at least 20 minutes and allowed to air dry.
-Tanks should be kept clean of organic debris and uneaten food.
-Ill or dead animals removed immediately.
-Footbaths placed at the entrance to general holding areas, food preparation, quarantine and medical areas.
-Disinfectant in the footbaths should be changed daily or more frequently if necessary.
-Veterinarian or aquatic animal health professional carries out regular health monitoring of animals throughout the chain of custody.
-Detailed records should be kept of all findings.
Individuals working with animals, tank or transport water
-Open wounds are covered, preferably by using a bandage or watertight gloves.
-Hand washing after contact with animals or their water.
-Wear latex powder-free gloves when handling animals or working in their environment.
-No eating or drinking in the in animal holding or laboratory areas.
-Food should not be stored in the same refrigerator as biologic samples.
-All staff should receive an annual physical examination.
-Immunosupressed individuals should minimize their exposure to animals and tank water.
-Ill employees should not come in contact with animals or animal environments.
-Proper first aid should be administered immediately if injury occurs.
-Staff must be informed of possible zoonotic diseases as they are identified.
-Any wounds should be observed for signs of infection: painfulness, reddening, heat around the wound, joint pain, a fever, lack of healing, or other signs of general illness.
-Consult a physician if signs of infection occur.

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Value and Demand for MAC-Certification

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Efforts to collect live specimens and to culture marine ornamental fish and invertebrates are increasing due to the growing popularity of aquariums worldwide (Pet Industry Joint Advisory Council, 1999), especially those showcasing “mini-reefs” (Larkin and Degner, in press). This increasing trend has brought attention to the collecting industry in the form of concerns for the long-run sustainability of the resources and quality of the marine environments (World Resources Institute, 1998). Thus, culturing is often cited as a viable alternative production practice, especially for the relatively high-valued species (Sea Grant Association, 1999). Whether culturing is feasible in light of the demand for species variety and the quantity needed to ensure profitability is unknown. However, there is general agreement that culturing efforts and attention to sustainability will continue.

The collection industry is international, easily including over 500 species (there are over 320 species harvested in Florida alone; Adams, Larkin and Lee, in press). Species are harvested/collected from nearly every region in the world, some more remote and or sensitive than others. Currently, there is an international effort underway to design a certification process that would ultimately convince buyers (e.g., home aquarists) that certain species have been collected with the utmost care to the resource, ecosystem, and transport of the animal.

In early 2001, the Marine Aquarium council (MAC) proposed an independent certification process for those in the industry that meet best practice standards. MAC is a non-profit organization that is promoting the “certification for quality and sustainability in the collection, culture, and commerce of marine ornamentals” (*MAC News*, 2001). The certification would be international in scope, voluntary, and be identified through labeling. The certification would be based on the “core standards” and “best practice” guidelines identified in six documents that cover the following areas: (1) handling and transportation, (2) collection and fishing, and (3) ecosystem management.

The number of cultured ornamental marine species is small compared to the number of harvested marine ornamental species. At the commercial production level, finding success at breeding, rearing, raising, and selling marine ornamentals has been challenging. Thus, cultured species are likely to be rewarded with a market premium; such species are commonly referred to as being ‘tank-raised’ for marketing purposes. Aside from promoting the sustainability of tank-raised species, reliance on culturing can provide a consistent source of supply (which is valued by sellers) and a measure of quality (e.g., cultured species may be ‘less stressed’ upon arrival and thereby have a higher survival rate).

To ascertain the value of MAC certification in the marketplace, a conjoint survey is being administered to wholesalers and trans-shippers in the summer of 2001. Conjoint surveys consist of market experiments that ask respondents to evaluate a group of products. The evaluations are typically in the form of assigning a rating to each product. Products are defined using different attributes. In this study, five attributes are used to create the products, namely: source (tank-raised, collected, or collected and MAC-certified), survival rate, size, price, and species. Six "products" are created for each species. The following species are examined:

- Peppermint Shrimp (Lysmata wurdemanni)
- Queen Angelfish (Holacanthus cilaris)
- Cuban (Spotfin) Hogfish (Bodiamus pulchellus)
- Orange Skunk Clownfish (Amphiprion sandaracinos)

For example, one of the six peppermint shrimp products could be defined as being tank-raised, guaranteed live upon arrival, 1-2 inches in length, and priced at $0.79 each.

The conjoint evaluations will be able to identify the value of and demand for MAC-certified products and ascertain whether it varies by species or animal size or is affected by a survival guarantee. The value of the certification can also be determined for firms located in different regions, that specialize in different product forms, or that differ by size. For suppliers of marine ornamentals, results can be compared to costs in order to determine the feasibility of implementing a MAC-certification program. In general, the results can be compared with those pertaining to food fish in terms of whether certification would be expected to command higher prices, which is the ultimate incentive for producers (Holland and Wessells, 1998).

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Certification for Marine Ornamentals: What It Is and How It Works

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Certification standards are used all over the world to define the preferred attributes of a high quality service or product. An assessment of compliance to those standards by independent third party certification companies provides objective evidence that the requirements of a particular standard have been met. Over the last 5 years or so certification schemes have become established to deal with the sustainability issues of the use and harvesting of natural resources. These schemes are underpinned by eco-labeling schemes that encourage consumers to make a positive choice and discriminate in favor of, for example, timber and food fish that are harvested in a sustainable manner.

The Marine Aquarium Council has reviewed the advantages and disadvantages of these certification schemes and worked closely with stakeholders in the Marine Aquarium Industry to produce certification standards and certification scheme for the collection and handling of Marine Organisms. In order to meet the immediate need for certification, MAC has split its Standard's development and implementation process into two phases as follows:

1 - Core Standards. These Standards are contained in three stand-alone MAC Standards documents, Ecosystem Management Standard, Collection and Fishing Standard, and Handling and Transport Standard. Accompanying these Standards documents are MAC Best Practices guidance documents that set the baseline for future MAC accredited certification. These are interim documents and will be used until the series of Full MAC Standards and Best Practices guidance are completed in Phase 2. Practical implementation of these Core Standards will contribute to development of the Full Standards and Best Practices Guidance documents and certification methodology. These Core MAC Standards will come into effect 1 July 2001 and be in effect until at least June 30, 2003.

The scope of the Phase 1 Standards are:

- Ecosystem Management Standard: including collection area ecosystem and fishery management and conservation;
- Collection and Fishing Standard: including fish, coral, live rock, other coral reef organisms, and associated harvesting and related activities, e.g. field handling and holding practices;
- Handling and Transport Standard: including holding, husbandry, packing, transport etc. at wholesale, retail and all other branches of the marine aquarium industry.

2 - Full Standards. The full standards will consist of four MAC Standards documents containing the Ecosystem Management Standard, Collection and Fishing Standard, Handling and Transport Standard, and Mariculture and Aquaculture Standard and four accompanying stand-alone MAC Best Practices guidance documents.

Our presentation will describe the phased introduction of the MAC Certification Scheme for Marine Organisms; its basis on sustainable collection of those organisms using non-destructive methods of fishing; how the scheme works and how it will be applied to each part of the industry.

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Creating Consumer Demand for MAC Certified Marine Ornamentals

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Transforming the marine ornamentals industry by harnessing market forces through a certification and labeling scheme requires a demand for the certified products and practices. This demand is being created through multiple public and consumer awareness initiatives, focusing on aquarium trade issues and the opportunities to make a difference through responsible purchasing practices.

Although the hobbyist audience is demographically scattered, MAC has identified the routes and vehicles to reach them. Some of these involve communicating through the general public. MAC is undertaking outreach and education campaign targeting hobbyists in the key market countries, especially the United States and Western Europe. International efforts to educate consumers and the general public continue with the development of working relationships with industry and conservation partners, writers and publications worldwide.

The MAC brochure has been widely distributed, and the MAC network of interested stakeholders has grown to 2,600 individuals in 60 countries. Each receives the MAC quarterly newsletter by e-mail. Other outreach activities include an information kit for aquarium hobby clubs, articles for aquarium magazines and Web sites, a MAC Web page for consumers and communication materials to include with aquarium retail products in partnership with product manufacturers.

The U.S. hobbyists make up 1 million of the 1.5 million marine aquarium hobbyists worldwide. Consequently, MAC has formed, and found funding for, a partnership with American Zoos and Aquarium Association (AZA), the Ocean Project coalition and SeaWeb to create outreach and awareness raising materials and displays for public aquariums. This partnership project commenced in late 2000. MAC has also formed a partnership with Environmental Media Services (EMS), a nonprofit communications organization dedicated to improving media coverage of environmental issues. EMS is raising public awareness of MAC's certification program and how MAC's efforts to improve marine aquarium collection practices and industry operations will benefit coral reefs. The EMS work with MAC includes consumer focus groups of hobbyists to determine which messages resonate, press kits, press conferences, media tour and encouraging editorial coverage of MAC and certification.

The critical period for hobbyists outreach is immediately before, and for about a year after, certified marine aquarium animals begin to be available in the marketplace. Therefore, launching of the certification system in the 4th quarter of 2001 has made these consumer awareness initiatives high priority items.

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"Blueprint for Reform": Transforming the Reef Fish Industry

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Context

The reefs of Indonesia, the Philippines, and the Western Pacific constitute one of the world's richest genetic storehouses. The region contains over 2000 species of fish and coral, a biomass of 33 metric tons per acre, and an overall range of over 150,000 square miles. This is "ground zero" for marine biodiversity – the habitat from which virtually all tropical fish and coral speciation developed. Unfortunately, the aquarium and live fish trade is contributing significantly to the destruction of these reefs with rampant overfishing and highly damaging fishing methods – employing sodium cyanide and explosives.

What's more alarming, the reefs of the Indo-Pacific region are being wiped out for minimal economic gain. For example, Indonesian fishermen collecting aquarium fish collectively net less than $5 million per year; total aquarium fish exporter revenues are estimated at less than $50 million per year. And yet, because the destructive poison fishing practices are so widespread and damaging, these small dollar amounts threaten the existence of the entire reef ecosystem. In addition, inefficiencies in the current distribution model account for tremendous costs and fish mortality at every step of the supply chain - from reef to the hobbyist's tank furthering the destruction.

This unfortunate situation exists because the current industry business model relies on a condition of negative economic incentives and inefficient distribution practices. Under this model, the exporters and importers realize sizeable profits, while the reef, the local community, and even the consumer (who ends up with poor quality fish) suffer.

The problem of unsustainable reef fish harvesting has been known for some time and a number of multi-laterals and NGOs, such as USAID and COREMAP, have invested heavily in reform efforts. Programs include training fishermen in sustainable practices, resource mapping and monitoring, captive breeding, etc. While these programs are worthwhile, the underlying fundamental economics must also be addressed in order to solve the problem; local fishermen must be able make a living through reef preservation, rather than reef destruction. In addition, the industry must adopt better management practices: net-collecting, appropriate handling, shipping, and husbandry techniques, to name a few. The Marine Aquarium Council (MAC) has launched a comprehensive effort to develop these sustainable practices and will be introducing the first set of standards in late 2001 for industry certification.

The Role of Private Equity: An Investigation

With the need to better understand the underlying fundamental economics of the industry in mind, the Conservation & Community Investment Forum[1] (CCIF) was commissioned by the Packard Foundation and the International Finance Corporation (IFC) to determine if an innovative, private sector-led reform of the ornamental fish trade in the Indo-Pacific region could be implemented.

The goals of this initiative are to: 1) outline how to best implement sustainable methods of collecting, handling, transporting, and holding of ornamental fish for trade, thereby reducing the high mortality rates typical under the current business model, and 2) provide incentives for fishermen to replace cyanide fishing practices with far more benign methods. The basic premise of the latter goal is to dramatically increase the economic value of coral reefs to local communities by creating an international distribution channel for sustainably harvested high-quality marine ornamental fish.

"Blueprint" for Industry Reform

The objective of the CCIF initiative is to create a new economic model that will encourage all industry participants to promote the long-term health of coral reefs in the Indo-Pacific region. This new model for doing business will be described in two documents. The first will be a detailed, investable business plan used to syndicate investors to implement a for-profit business that imports only sustainably caught, certified fish and other reef products. The second document will be an industry roadmap or "blueprint" based on the CCIF business plan that articulates the steps industry can take to make itself more sustainable . This "blueprint" will outline our recommendations for promoting a sustainable industry; from establishing new business models for sustainable, community-based collecting in source countries to initiating a broad branding and marketing scheme in both U.S. and European markets for sustainably caught ornamental fish. The "blueprint" will be informed by our field research and input from the leading industry practitioners and scientists, to ensure that scientifically sound and practical methodologies are employed to increase understanding on actual sustainability of harvesting aquarium fish from source reefs.

A. Results

The CCIF team conducted six weeks of fieldwork in April/May 2001. The team is now developing the business plan and "blueprint" that will serve as models for industry transformation. These documents will be released in late summer 2001. CCIF has coordinated the release and implementation of these documents with interested importers and exporters, retailers and NGOs. By late 2001 the business model and "blueprint"

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[1] CCIF, a project of the Tides Center, is a 501(c)(3) non-profit organization. Support for this project comes from the Packard Foundation and the IFC. CCIF researches and identifies specific opportunities where targeted private investment can effectively stop destructive or natural resource extraction practices, address major social problems, and do so profitably. CCIF focuses on small, targeted equity investments. Activities include developing new business models, coordinating non-profit and for-profit capital investors, conducting research and analysis (due diligence) on organizations who will lead local efforts, and facilitating initiation of international projects.

recommendations will already have been rigorously evaluated and tested in practice at numerous levels.

It is key to our work that an effective communication campaign is implemented to disseminate our findings and promote industry transformation to all stakeholders (industry, investors, hobbyists, communities, etc.) Making a case for industry transformation through a broad communication campaign is critical to encourage adoption of best practices as laid out by the Marine Aquarium Council, to demonstrate the viability of the industry as a catalyst for sustained collection and reef preservation, and to raise the awareness of US and European consumers.

Our presentation will summarize our fieldwork and development of the business plan and the "blueprint for reform." We will discuss our upcoming publication and promotion of these documents and the predicted effect on the industry. The presentation of our work is timely, given the recent, coordinated efforts to transform the industry and the increased effort to educate retailers and hobbyists on the value and benefit of purchasing sustainably collected reef products.

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Global/Cross-cutting Poster Abstracts

Histological Atlas of the Common Clownfish

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There are more home aquaria than cats and dogs, however, very little published scientific data is available on aquaria species. The normal histology of the common clownfish, *Amphiprion ocellaris*, which is considered the ‘goldfish’ of marine aquaria, will be presented. The specimens that are used are small enough that the whole specimen fits on a single slide. The specimens are from aquaria maintained at a normal temperature range, 25-33 °C, and have demonstrated no physical or behavior abnormalities. Slides are prepared for both cross and longitudinal sections. All five types of tissue: epithelial, supporting, muscular, nervous, and liquid are examined and presented. Once the histology in a ‘normal’ fish is understood, pathological changes will be more easily recognized and shown.

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Reducing the Risk of Introduction and Damage of Aquatic Nonindigenous Species through Outreach and Education

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Introduced non-native species in coastal habitats cost the United States billions of dollars every year. The most effective strategy, either from the point of view of minimizing costs or maximizing ecosystem health is to prevent introductions from the start. It is this goal, preventing future introductions of aquatic non-native species in California's San Francisco Bay-Delta that is at the heart of the "Reducing the Introduction and Damage of Aquatic Nonindigenous Species" (RIDNIS) project. One part of our project is to facilitate communication and education among industry members, agencies and academia about the current damage by aquatic non-native invasive species in the San Francisco Bay-Delta as well as future risks associated with the importation, sale, and distribution of live exotic plants and animals. Target industries include aquarium and pet dealers, aquatic plant dealers, landscape and "aquascape" contractors, nursery owners, live seafood importers, aquaculturists, live bait dealers and others involved in the importation, sales, and distribution of live plants and animals. These industries deal with numerous non-native species that have the potential to become pest species in the Bay-Delta ecosystem. A second part of our project is to educate the consumers of live plants and animals about the risks posed by introduced aquatic species. To reach consumers we need industry cooperation to distribute educational materials concerning the disposal of unwanted plants or animals. Project outcomes include 1) hosting workshops in the region to gather industry input in the development of new methods to reduce introductions; 2) developing a full-color brochure highlighting pest species of concern, impacts of these non-native species on native taxa, pathways of dispersal, and methods for preventing dispersal; 3) producing a video to provide information about the mechanisms of aquatic non-native species introductions as well as management solutions specific to the target industries; and 4) a project website (http://www.ridnis.ucdavis.edu) highlighting non-native invasive species in the San Francisco Bay-Delta, pathways of potential introduction, and tips for preventing new introductions. The RIDNIS project is funded by the CALFED Bay-Delta program.

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The Responsible Marine Aquarist Guide

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With numerous supplying countries and thousands of species involved in the marine aquarium trade, how can the buyer - whether an importer, retailer or hobbyist - know what to look for? What is safe to buy in environmental terms? Is it coming from a managed and sustainable fishery? Is it rare in the wild and perhaps at risk from over-collecting? Has it been collected and transported carefully to avoid stress? Will it survive in the long term?

These and other questions are addressed in this guide. The aim of the *Responsible Marine Aquarist* is to raise awareness of conservation and management issues associated the trade, provide information on species suitability and summarise the ways that different countries monitor and control their ornamental fisheries. Hopefully this will encourage consumers to ask questions and make more informed choices about what they buy, and so will promote better practice within the trade.

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Habitat, Fisheries & Collection Oral Abstracts

The Philippine Ornamental Fish Industry Reinvents Itself

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The Philippines may have been the birthplace of cyanide fishing but it is also the first country where the antidote to the cyanide menace was developed. Once the most dominant supplier of marine ornamental fish, satisfying as much as 85% of demand in North America, the Philippines found its comparative advantages eroded by the sodium cyanide stigma.

The stream of negative publicity and the subsequent explosion of consumer protest caused the Philippines to lose much of its market share to other supplier countries. The Philippine tropical fish industry has took the positive view and proceeded to regard the setback as a wake up call. Abandoning their policy of denial that the cyanide problem existed at all, the industry players began to take cognizance of how much the aquarium business had contributed to the destruction of Philippines reefs and what the industry must do to correct their sins of omission and commission.

Aided by enlightened government policies and interventions of non-government organizations, the aquarium industry found the impetus to ride the engine of reform towards environmental and business sustainability. The full support and unconditional cooperation given to the Marine Aquarium Council by the full range of stakeholders in the Philippines is a solid indication of the commitment to ensure the marine aquarium trade is reinvented as an environmentally and economically sustainable part of the country's future.

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Asexual Coral Propagation for the Aquarium Trade and for Reef Restoration Work Using Reef Balls™

Michael R. King, ***Todd R. Barber*** and *John Walch*
with a case presentation by Coral Life of Malaysia

The Coalition of Reef Lovers (CORL), The Reef Ball Development Group, and various scientists and marine aquarists have developed an environmentally friendly and sustainable coral propagation method. This method can be used to produce both soft and hard corals for both reef repair and for the marine ornamental aquarium trade.

This paper is an introduction to improved coral farming methods. Included are recommendations on how to establish, manage and maintain coral farming systems, as well as common definitions of terms. These methods have the ability to supply the growing demand for coral species used in the Marine Ornamental Industry (MOI) and reef restoration work and comply within the "Standards of Practice" being established by the Marine Aquarium Councils (MAC) for maricultured corals.

Keywords: Reef Ball, Reef Balls, Artificial Reefs, Designed Reefs, Coral, Reef restoration, propagation, cultivation, transplantation, aquaculture, CORL,

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Survival of Targeted Corals Collected for the Marine Aquarium Trade Depends on Requirements for Habitat and Collection Locale

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For many years, it has been possible to keep the vast majority of zooxanthellate corals in aquariums alive with relative ease. The techniques and equipment to provide zooxanthellate corals with their requirements for survival, growth and reproduction are largely available. However, the mortality rates for corals remains quite high for many aquarists. One of the primary reasons for mortality in aquarium corals is the lack of knowledge as to the specific environmental parameters or habitat in which they are found.

Different species of corals may have relatively narrow to widely diverse ecological ranges than can span numerous reef zones and geographical areas. Many of the most popular targeted corals are species for which little is known of their abundance, life history, habitat, or collection locale. Furthermore, there is no source of information readily available to aquarists that can be used in emulating natural conditions of collected corals in the aquarium other than estimates of known ecological ranges. Thus, the conditions in which corals may be subjected in individual aquariums are often divergent enough from their natural environment as to cause extensive mortality from a variety of stressors.

Following a workshop in Jakarta, Indonesia, surveys were conducted in the primary coral collecting areas of the Spermonde Archipelago of southwestern Sulawesi, Indonesia. A majority of popular large-polyped corals for the aquarium trade are collected from these waters and are species for which little is known of their collection locale, abundance, or habitat. Numerous transects were conducted, along with manta tows, to gather data to assess ecologically sustainable development of the coral fishery. Data was also collected as to the habitat and environmental conditions of the specific areas in which targeted species are collected, as well as an assessment of the collection and holding facilities.

Based on the surveys, it is found that the current knowledge used to provide corals with appropriate aquarium conditions that allow for their survival is found to be inadequate and the mortality rates for many of these targeted species may be directly linked to this insufficiency. The data accumulated during this study are presented here, and this is the first report of its kind for many of the targeted species for the aquarium trade. In the future, collection of data and reports that provide the location and conditions where collection takes place should be mandatory to ensure higher survival at all post-collection stages. Furthermore, such information will be important in ensuring the proper monitoring and management of coral fisheries, and in preventing continued resource loss resulting from harvest pressures required to replace corals lost to mortality.

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Community-Based Management of Coral Reefs: An Essential Requisite for Certification of Marine Aquarium Products Harvested from Reefs under Customary Marine Tenure

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A fundamental link in the chain of "green certification" for a sustainable marine aquarium trade is site certification. Effective management of the particular collection site, plus regular monitoring for potential negative impacts of collection are proposed as minimum standards for site certification. This paper examines the basis for developing minimum standards for site certification based on the realities of traditional societies, wherever the ownership of reefs and customary rights to communal fisheries resources remain intact.

In many countries of the South Pacific, customary marine tenure continues to give resource ownership and fishing rights of each particular reef area to a specific clan or community. For these customary marine tenure areas, collection activities must involve community approval. However, community approval is not enough, effective community-based management plans and regular monitoring of fishing activities also needs to be operational.

Superimposed on the traditional reef ownership concept, governments of the region have often inherited a western concept and legal framework of state ownership of all resources in the sub-tidal zone. Presently in Fiji the system gives recognition for both governmental and community control over marine resources. A "custodial chief", normally the high chief of each coastal district (*Tikina),* has authority to issue licenses for commercial fishing in the "*qoliqoli*" or customary tenure area, on behalf of the reef owning clans (*matagali* or *tokatoka*). Custodianship may or may not carry monitoring responsibilities, and fees for licenses are arbitrary and are paid directly to the custodian, and may range into the thousands of dollars. The government of Fiji supports the process of conservation by training individuals from fishing communities as "fish wardens", whereby the trainees serve as unpaid educators and enforcers of government conservation laws. Unfortunately most of the coastal villages in Fiji have yet to go through the fish warden training program. Government fisheries officers can be called on by the Custodial Chief for advice before granting licenses for collection corals, fish, or live rock within the qoliqoli, and this sometimes takes place.

FSP/Counterpart has found that the weaknesses of the present system are strengthened when the people actually fishing on the reefs participate in the making of management plans that are approved by the chiefly "Tikina Council" and in consultation with government stakeholders and which then guide the decisions the Custodial Chief. In the primary Coral Gardens site, the eight coastal villages of Cuvu Tikina has formed an environment committee to oversee the implementation of the management plans fish warden training, etc.

The comprehensive management plans of Cuvu Tikina involve the setting aside of some 30% of the Tikina's reefs as well as some adjacent mangrove and seagrass habitats as no-fishing marine protected areas (MPAs). A ban on destructive fishing methods, minimum size limits, and other measures are essential components of the community based management plans as well. The Coral Gardens team will train village youth in reef monitoring and in hands-on habitat enhancement and reef restoration activities to accelerate the resource recovery processes on reefs: coral planting, crown-of-thorns starfish removal, creation of giant clam and beche-de-mer spawning aggregations, mangrove replanting, etc. Project incentives in the developmental stages involve ecotourism within the MPAs, associated with the adjacent Shangri-La Fijian Resort, and commercial coral and *Tridacna* clam aquaculture. Sustainable live rock extraction is another potential activity, now that the management plans and community-based monitoring are in force. The focus of the live rock harvest, if it is to progress beyond the experimental stage, would be to target areas of the reef flat that dry during extreme low tides, and to create tidal pools of higher biodiversity and enhanced fisheries habitat. Live rock would thus be a by-product of habitat enhancement rather than an end in itself.

Community-based management is proving effective in reversing the prevailing trend of coral reef degradation in several sites in the region, and the marine aquarium industry is viewed as a vehicle to stimulate a wider application of effective grass-roots management of coral reefs. The requirement of effective community-based management as a basis for site certification would provide impetus and hopefully resources for the processes required to develop and carry out such management plans. The marine aquarium industry would thus begin working more closely with governmental departments and with non-governmental community development organizations towards the common goal of community-based marine resource conservation and environmental restoration, with the sustainable marine aquarium trades serving as a direct incentive for conservation within customary marine tenure areas that. The goal would be to empower resource-owning communities to take full responsibility for the wise utilization of their own marine resources, and in accordance with existing traditional and governmental structures, stimulating the establishment of no-fishing MPAs and other conservation measures in all areas where the marine aquarium industry operates.

The participatory workshop methods used by the Foundation for the Peoples of the South Pacific/Counterpart International to facilitate the development of community-based management plans in our Coral Gardens sites are discussed in more detail in this presentation. The project began as a small pilot in January 1999, with funding from the Pacific Development and Conservation Trust. On the receipt of funding from the Packard and MacArthur foundations and NZODA, the project was expanded into a full three-year project in June 2000. FSP/CI is in the process of establishing sites in Fiji that are representative of and model adequately the major environmental conditions of the IndoPacific region: atolls, fringing reefs and barrier reefs. A training of trainers will take place in Fiji towards the end of the project to encourage a regionalization of the concepts through the FSP/CI network.

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Development of Sustainable Management Guidelines for the Stony Coral Trade

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As the world's largest importer of coral reef organisms for curios, jewelry, and aquariums, the United States has become concerned that the demand for these organisms may be a major force driving overexploitation and destructive collection practices. As one step to address these concerns, the U.S. sponsored the International Coral Trade Workshop in Jakarta, Indonesia in April 2001 to develop recommendations for the sustainable harvest of stony corals. The workshop brought together over 130 experts from Southeast Asia, the South Pacific, Australia, Europe and the U.S., and included government representatives (Ministries of Fisheries, Trade, Environment and CITES agencies), NGOs (TRAFFIC, WWF, IMA and MAC), scientists, coral collectors and exporters. One day was devoted to presentations on the current state of knowledge of the coral trade, including the status and trends, environmental concerns, existing management approaches, international obligations, mariculture alternatives, certification schemes, and individual country reports. With this background, three working groups were established to develop guidelines for sustainable management strategies, best collection practices, and monitoring approaches.

The major task of the Management Working Group (MWG) was to discuss the types of issues a sustainable management approach for a coral collection fishery in each country would need to address. The MWG recognized that coral fishery management needs to occur at all levels. This includes restrictions on activities that can occur within the ecosystem, as well as specific regulations that affect the coral fisher, the middleman and the exporter, to achieve conservative management approaches that can be validated and enforced. A holistic (ecosystem management) approach is optimal, with consideration of 1) target species, their role in the ecosystem and sustainability issues arising from collection activities in areas severely impacted by other factors; 2) other species and interactions with the ecosystem; and 3) other natural or anthropogenic stressors causing reef degradation. In addition, zoning is necessary to spatially or temporally separate uses and user groups; this can minimize conflicts, while having a beneficial effect on exploited and unexploited organisms and the preservation of biodiversity. Zoning can best be achieved by establishing defined coral collection areas and areas where collection is permanently prohibited, and by limiting the number of coral collectors allowed to operate in a given area. In addition, managers should limit the amount of coral that can be collected in each area, based on the ecological carrying capacity and social objectives for the collection area and the community. If a quota is used as the primary management restriction, this must be set at the level of a geographically defined collection area for each target species, in accordance with ecologically sustainable limits with regards to the abundance, population dynamics and life history characteristics of that species. Overall, the objectives of a management plan for a coral fishery must ensure that exploitation of corals for domestic use and international trade is undertaken without detriment to the ecosystem or its component species. The management approach should be flexible to take into account other impacts. It must also include a precautionary approach due to the current practical limits on implementing an ecosystem approach, including insufficient scientific information on a target species and knowledge of their interactions. The development of a sustainable management plan must be undertaken with participation and consultation of all stakeholders, with equitable distribution of benefits arising from resource utilization.

The Collection Working Group (CWG) examined four main issues: 1) collection techniques that minimize collateral damage to non-target organisms and the surrounding reef environment; 2) optimal locations of collection; 3) preferred target species; and 4) proper handling techniques to maximize survivorship. The CWG proposed a maximum size limit for corals, depending on their growth form. Collectors should preferentially target species with high local abundance, fast growth rate, or high rates of reproductive replenishment. Collection should occur, where possible, in areas of dense coral growth or where competition threatens the existence of a given target species. The number of corals collected from any one area should be low enough to ensure the potential for replacement and regeneration. Specific collection and handling techniques are necessary for target species to minimize stress and to maximize their health and survival. This includes limiting the distance between the collection site and the holding facility, minimizing exposure to direct sunlight, and ensuring sufficient water changes to maintain ambient temperature and salinity and prevent the build-up of toxic metabolites. The group did not recommend prohibiting the collection of any particular coral species at this time. However, a number of species were identified that have a high rate of mortality resulting from collection and/or transport and a low survival in home aquaria, or that may be particularly vulnerable to overexploitation based on their abundance or biology. The CWG suggested that further investigation on these species is necessary to ascertain the nature of the problems, and that a limitation or prohibition on the take of particularly vulnerable taxa may be necessary in the future.

The Monitoring Working Group was tasked with identifying an approach to monitor coral reef resources that could address management needs and also assess ecosystem impacts associated with coral harvest. Effective monitoring requires a tiered approach conducted at different spatial and temporal scales. It should include 1) a baseline assessment of the abundance and size frequency of target stocks and the extent (aerial coverage) of their habitats and that portion of the total habitat where collection occurs; 2) periodic monitoring to detect changes in the resource associated with collection or other impacts; and 3) an analysis of fisheries data and trade statistics to verify compliance with management measures. The group recognized that few stock assessment models are available for stony corals, and additional research on the biology of the target species, and the development of an appropriate fishery model is necessary for setting sustainable harvest quotas. The ultimate goals of a monitoring approach for the stony coral trade are to determine the total allowable catch that a particular management area can sustain without detriment, and to provide feedback that allows a refinement of the quota in response to natural or anthropogenic changes.

The development of a sustainable coral fishery in coral exporting countries will require the development of management plans at the local (community) level, and training throughout the entire chain of custody to ensure compliance. Collectors, middlemen and exporters need training in species identification, proper harvesting and handling procedures, and record keeping, to achieve a sustainable management approach that can be validated and enforced. Furthermore, exporting countries would benefit from additional technical and financial assistance to assist in the development of appropriate management measures, and the implementation of monitoring programs for the stony coral fishery. Any management measures established by government agencies can benefit from independent, third-party certification such as that proposed by the Marine Aquarium Council. This can help ensure that coral species in international trade are harvested in an ecologically sound manner, and those corals have a high potential for survivorship from the reef to the hobbyist.

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Changes in Zooxanthellae Density, Morphology, and Mitotic Index in Hermatypic Corals and Anemones Exposed to Cyanide

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Sodium cyanide (NaCN) is widely used for the capture of reef fish throughout Southeast Asia. The corals *Acropora millepora, Goniopora sp., Favites abdita, Scolymia sp., Plerogyra sp., Heliofungia actinformis, Euphyllia divisa, Scarophyton sp*., and the Caribbean sea anemone species *Aiptasia pallida* were used in the present study. The coral species were exposed to 50, 100, 300, and 600 mg/L of cyanide ion (CN^-) for 1 to 2 minutes. Concentrations of CN^- used were much lower than those used by marine fish collectors. Exposed corals and anemones immediately retracted their tentacles and mesenterial filaments and discharged copious mucus containing zooxanthellae. Changes in protein expression were found in both zooxanthellae and host tissue using gel electrophoresis. Corals and anemones exposed to cyanide showed an immediate increase in zooxanthellae mitotic cell division, and decrease in zooxanthellae density. In contrast, zooxanthellae cell division and density remained constant in controls. Histopathological changes included gastrodermal disruption, mesogleal degradation, and increased mucus in coral tissues. Zooxanthellae show pigment loss, swelling, and deformation. Mortality occurred at all exposure levels. Exposed specimens has a significant increase in the ratio of gram-negative to gram-positive bacteria on the coral surface. The results demonstrate that exposure to lower levels of cyanide than used by fish collectors causes mortality to corals and anemones. Even brief exposure causes slow acting and long term damage to corals and their zooxanthellae.

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Alien Species, Hawaiian Coral Reefs and the Potential Impact of the Marine Aquarium Trade: A Natural Resource Manager's Nightmare…

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Approximately 85% of all U. S. coral reef areas occurs within the Hawaiian Archipelago. These Hawaiian coral reefs are characterized by their isolation from other Pacific reefs and the extremely high endemism across most marine phyla. This high endemism results in a spectacular array of unique coral reef organisms, many of which are sought after for the marine ornamental trade; it also results in an extremely high susceptibility to the impacts of alien species introductions. Organisms which are commonly found on coral reefs elsewhere in the world can be devastating if accidentally released in Hawai‘i, causing habitat shifts and trophic displacement. In most island areas, destructive alien species are accidentally introduced through ballast water and other shipping activities. In Hawai‘i, concern has been raised recently regarding the potential for marine alien species introductions through activities associated with the marine ornamental trade or research into marine ornamental propagation. Such introductions can be classified into three types:

1). Direct Introduction. Introduction of an alien organism via accidental release of that individual organism directly into marine waters.

2). Symbiotic Introduction. Introduction of an alien organism which is a symbiont to a marine ornamental (which itself may be an alien or indigenous, but is characterized as having been brought into the State from outside). The said symbiont is than released to marine waters either via discharge of holding waters or through release of the host organism.

3). Facilitated Introduction. Introduction of an alien organism via viable passage through the digestive system of a marine ornamental; examples may include propagules and fragments of marine plants and algae. The said organism is than released to marine waters either via discharge of holding waters or through release of the host organism itself.

The focus of this talk will be to raise awareness within the marine ornamental community in regards to this issue by looking at three recent examples that may have involved the marine ornamental trade in the spread of alien species. Ecological implications will be discussed along with ways that the industry can be directly involved such that resource management concerns can be mitigated prior to environmental impact occurring.

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Non-Implementation of Anti-Cyanide Measures in Poor Coastal Areas

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For more than 25 years, the author has studied a broad variety of environmental implementation practices, constraints, and problems.[1] Creating workable marine conservation measures requires more than idealized goals and benign intent: It requires a realistic, detailed understanding of many critical ecological conditions, economic and social circumstances, and human motivations that invariably shape how environmental programs actually function or more often fail to produce any tangible improvements. This paper applies the lens of implementation realism to the familiar but thus far intractable problem of cyanide use to collect ornamental fish for the aquarium industry. The main conclusion is that the conditions and incentives necessary to curtail cyanide use in poor coastal areas clearly do not exist. Indeed, the most prominent current NGO supplier-side initiatives are so implausible from an implementation perspective that it is difficult to believe they were ever intended to succeed.

Cyanide use became prevalent in the Philippines, then by far the largest exporter, in the early 1980s, and NGO efforts to reduce cyanide use began several years later. Seven years ago, the author published a critique of the Haribon Foundation and Ocean Voice International anti-cyanide program, which entailed net training for fish collectors, community education and organization efforts, creation of fishermen collectives to increase the income they received, and closer contacts with law-enforcement officials. It is unfortunate but not surprising that current NGO efforts are extremely similar to the failed efforts undertaken more than a decade ago. The 1994 paper predicted positive measures to train collectors in the use of better fishing methods would fail absent corresponding negative measures to reduce the profitability of continued cyanide use.[2]

This is a classic "Tragedy of the Commons" situation in which fish collectors have little incentive to sacrifice income or convenience when their sacrifices will not ensure any conservation as long as other collectors are free to continue to use destructive methods. As long as some collectors continued to use cyanide in a way that was more profitable and less difficult, many net-trained fishermen would become "backsliders" and many others would not choose to participate. This is precisely what has happened in the past decade, but current anti-cyanide programs are to a large extent based on net-training, education, and *voluntary compliance* with good fishing practices. I predicted failure in 1994 and predict comparable failure for current NGO efforts that have not remedied any of the fundamental social and economic problems in poor coastal regions.

It has become clear that no effective anti-cyanide program can be implemented in developing countries as long as large industry firms in major consumer nations continue to tolerate or encourage cyanide use. In other words, any really effective solution requires changing the market demand for cyanide-contaminated fish in a way that fundamentally reverses the economic incentives for fish collectors to use cyanide. As long as importing and retailing practices remain the same in the U.S., by far the largest market for aquarium fish, nothing that could be done in the poor supplier nations has a realistic chance to overcome the many systemic collection practices, attitudes, and economic incentives that support continued cyanide use.

Most collectors are poor people with little education and no income-generating alternatives that will yield comparable or higher returns. In the Philippines and Indonesia, cyanide is often sold by middlemen or exporters who will not furnish boats to the fish collectors and will not buy their fish unless they use cyanide purchased from these entrepreneurs. How will the fish collectors reach the better reef areas and whom will they sell the fish to if they try to cut out the middlemen who *want to sell* cyanide? In both supplier countries, many fish collectors are migrants who are not rooted in particular coastal communities. When one reef area gets fished out, they move on to another region. Under these conditions, why should we expect them to be concerned with localized ecological degradation, and who will implement, monitor, and enforce any chain-of-custody procedures for net-caught fish?

Both major exporting nations are now contending against social anarchy in many areas and open rebellion in some. Who can be expected to enforce the laws or to implement a chain-of-custody paper trail that may result in lost income for some collectors under these anarchic and dangerous conditions? In both nations there is a tradition of deference by poor people to "land barons" and other wealthy people who flaunt the law with impunity, and law enforcement is extremely weak in both states. Many cultures in both exporting nations have traditions of "telling people what they want to hear." If fish collectors or middlemen are faced with a possible loss of income from non-compliance with anti-cyanide laws or a proposed chain-of-custody approach, there is no reason to believe that the collectors will reveal the reality of continued cyanide use. And there is no more reason to believe that net users will risk social conflicts by identifying other collectors who continue to use destructive methods. Another consideration is that many people consider government officials in these nations among the most corrupt in the world.[3]

In light of these circumstances, NGO programs that seek to impose sustainable fishing practices in poor coastal areas without substantially changing the market incentives in the consumer nations surely have very little chance to succeed. The recent Marine Aquarium Council standards and "best practices" guidelines are a good example of a program virtually certain to fail at the implementation level. The MAC has issued dozens of standards for sustainable fish collection and more dozens of "best practices" ostensibly intended to meet these standards.[4] A number of the standards and best practices will be evaluated when the paper is presented, but consider these few examples: (1) "All those involved [in] collection, fishing, husbandry and transport, e.g., collectors, fishers, boat handlers, etc. shall be able to demonstrate how they maintain up to date information on the marine organisms they collect. . . ." (2) "Collectors and fishers should be able to demonstrate they are fully conversant with the requirements of the Collection Area Management Plan." (3) "Collectors and fishers should be able to demonstrate or document how organisms from certified and uncertified collection areas are not mixed. It should be possible at all times following collection to attribute the collected organism or batch or organisms to a particular collector or fisher and the certified collection area from where it was collected." (4) "The term '*chain of custody*' means the sequence of commercial operations or people responsible for the collection and trade in marine organisms. This begins with the collectors and extends to the retailer-sale and to the end buyer. For a retailer to be able to offer certified marine organisms, all components of the chain of custody handling the organisms must be certified."

I do not believe these MAC standards and guidelines, and many others, could or will be implemented by uneducated fish collectors whose overwhelming priority is to increase their incomes. Who will meet all these requirements in developing countries? How about middlemen and exporters who have been selling cyanide-contaminated fish for decades? I do not think so. It strains credulity to believe they will change their behavior in expensive, time-consuming ways unless strong pressures are applied from importers and retailers who create the market demand in the U.S. for cyanide-contaminated fish and cyanide-free fish. If there is any feasible way to reduce cyanide use and marine degradation, the solution must come from U.S. aquarium industry firms or from U.S. government regulations.

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[1] For a complete list of the author's publications, see: **www.ecovitality.org/halcv.htm**

[2] A copy is available at:
www.ias.unu.edu/vfellow/foo/ecotec/ecotech94/Paper-28.htm

[3] For a recent ranking of perceived government corruption, see: **www.transparency.org**

[4] A copy of the MAC standards is available at: **www.aquariumcouncil.org**

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An International Reef Monitoring Program for the Marine Aquarium Trade

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Reef Check, the global coral reef education, monitoring, and management program, was founded in 1997 as a volunteer initiative to help local communities learn how to monitor coral reef health using a standard and scientifically rigorous method. Since then, Reef Check has expanded to include teams of volunteer SCUBA divers and snorkelers in over 60 countries. By providing an annual, synoptic view of coral reef health, Reef Check provides crucial data to scientists and resource managers. One of the impacts to coral reef health is the marine aquarium trade, which involves the capture and removal of living reef organisms, including fish, corals, other macro-invertebrates and live rock. These activities can have a negative impact on reefs, depending on the methods used and the numbers and age/size classes of organisms removed. The Marine Aquarium Council (MAC) has created certification standards to educate and certify those engaged in the collection and care of ornamental marine life. Reef Check has developed a method to monitor reef animal populations in MAC collection areas. The monitoring program will answer three fundamental questions: (1) are population reductions from collection ecologically significant when compared to natural background variations (e.g. natural variability in recruitment)? (2) do the collection methods used and/or the removal of the populations harvested damage the reef ecosystem? (3) does the removal of organisms affect the ability of the populations of harvested species to replace themselves? The new Marine Aquarium Trade Field monitoring will provide timely scientific data to MAC, collectors, and resource managers—an important step towards ensuring the sustainability of healthy reef ecosystems.

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Population Structure of the Cortez Rainbow Wrasse (*Thalassoma lucasanum*) in an Exploited Area in the Pacific Coast of Costa Rica

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The eastern Pacific lacks of many reef-building coral species, which renders a reduced reef habitat diversity, and impoverished inshore fish fauna, in comparison with the Caribbean, and the Indo-Pacific regions. Anthropogenic factors affecting the naturally scarce coral communities include the extraction of both corals (e.g. *Pocillopora* spp), and ornamental reef fish. In Costa Rica, most of the ornamental fish are taken from the coastal areas of the Gulf of Papagayo, where the top exploited species are, in descending order: the Cortez rainbow wrasse (*Thalassoma lucasanum*), King angelfish (*Holacanthus passer*), and the Cortez angelfish (*Pomacanthus zonipectus*). This study is the first report on population structure of a Costa Rican reef fish in an exploited area. We present preliminary data on the relative abundance of the rainbow wrasse (a.k.a. lollipop wrasse, paddlefin wrasse), a sequential hermaphroditic fish with distinctive sexual coloration patterns at certain phases, as well as its relation with physical parameters and habitat in Culebra Bay, Gulf of Papagayo, Costa Rica. We also discuss current and potential management actions for this species.

Four sites at two localities 3 Km apart were chosen: at Pelonas Islands, sites A and B were located 75 m from each other. Site A depicts the deepest (mean sampled depth = 19.8 m) point, while site B was the shallowest (mean depth=8.2 m) point. At the second locality, Viradores Islands, sites C and D were 150 m apart, and were sampled at intermediate depths (mean=10.5 and 9.5 m, respectively). Temperature and visibility were correlated, both varying significantly among months due to seasonal coastal upwelling. The predominant substrates at sites B, C, and D were medium-sized rocks, and rock-sand, while *Pocillopora* spp (3 to 90%) was the most common of the live coral cover. The deep site, A, was characterized by the presence of the soft coral *Carijoa* (mean cover=27.7%), and the orange cup coral *Tubastrea coccinea* (mean cover=10.3%).

Over nine months (February to October 1997), we conducted visual point censuses on 6-m radius circular plots, counting and measuring all fish observed during 10 minutes. Lollipop wrasses were classified into 4 life stages based on total body length (TL) and coloration patterns: juvenile (<2 cm TL), initial phase (>2 cm TL, either males or females), transitional male (>4 cm TL, intermediate between initial and terminal phases), and terminal phase male (>4 cm TL). Terminal phase males (a.k.a. Paddlefin wrasse) have a higher value for the aquarium, while the females and initial males (a.k.a. Mexicana wrasse) sell for less. Rainbow wrasse abundances for the different phases were calculated as total numbers per plot. We found higher mean numbers of juveniles and initial phases of *T. lucasanum* at the shallow sites (site D mean=67 fish/plot, site C mean=53 fish/plot, site B mean=37 fish/plot), which had higher cover of the branching coral *Pocillopora* spp, than at the deep site A (mean=11 fish/plot). The relative abundances of the life stages were significantly different. Not surprisingly, initial phase males and adult females were more abundant than terminal males. Only the behaviorally most dominant individuals of this species transform into the terminal phase, and these latter, in turn, are intolerant to other terminal males, thus self limiting their densities.

Our data show evidence of year round recruitment, increasing during the rainy season (May-November). Numbers of of juveniles and initial phases were low from February through June, increasing consistently between July and October. The smallest size class is more abundant in May, and it remains the dominant size class for the wet season (August through October). The early stages show a significant correlation with the percent cover of *Pocillopora* sp., suggesting that the juvenile stage may use the corals for shelter. Wet season conditions may improve the survival of the post recruits.

If absence of terminal males triggers the sex transformation of females into terminal phase males, then a higher proportion of transitional males should follow high extraction rates of terminal phases. Massive extraction of the terminal phase, in contrast to natural mortality, may cause disruption of the dominance hierarchy and the transformation of far more individuals than the necessary to compensate for losses (i.e., overcompensation). Our observations suggest temporal variations in the sex reversal rates, also taking place at relatively small sizes. Transitional males were more abundant in February at all the shallow sites, and furthermore, a few ~4-cm TL fish were already in their terminal phase. No geographic or depth patterns were apparent for the abundances of terminal phase males, since the highest (28 fish/plot) and lowest (3 fish/plot) mean abundances of this phase were found in the same locality, Viradores Islands, at intermediate depths. At the three shallow sites, we found decreased abundances of terminal phase males from May to October. The deep site might be less exploited because of the low densities and logistic difficulties.

Additionally, habitat degradation in the Gulf of Papagayo resulting from diverse human activities is expected to have a negative effect on *Pocillopora* sp., as well as the rainbow wrasse, that recruits among this coral's branches.

Current regulations are based on license and monthly Total Allowable Catch (TAC) systems, but they disregard the population dynamics of the different species. For example, until 1998, local fishermen considered the initial and terminal phases as different species, due to misinformation by the fisheries institution that regulates the ornamental fish extraction. This, of course, has an effect on the regulation enforcement by the authorities. We suggest to establish TACs based on new knowledge gathered from research projects such as ours, and to closely monitor the changes in population structure of the most exploited species.

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The Use of Live-Rock Sites and Artificial Substrates for the Collection of Ornamental Fishes

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Artificial reefs may provide a useful tool to enhance production of marine ornamentals and to divert detrimental harvesting activities from sensitive natural habitat. One form of artificial reef that is already available to marine ornamental collectors involved in live rock cultivation is live-rock boulder mounds. These live-rock sites not only serve as production sites for corals and other invertebrates but they also provide habitat and shelter for small fishes. During the summer of 2001, we deployed six limestone boulder piles in the upper Florida Keys. We also deployed six concrete/pvc modules designed to facilitate the collection of marine ornamentals. We planned to monitor these sites (as well as six natural reefs) as they were colonized by fishes, and to compare collection efficiency and economic return among the three habitat types. Due to summer and fall storms, however, we were unable to sample the experiment.

As a result, in this talk, we: 1) present our study design and rationale; 2) discuss the overall scientific goals of our research program, which is aimed at evaluating the use of live-rock sites (and other types of artificial reefs) for fish production; 3) examine the environmental costs (e.g., redistribution of fishes) and benefits (e.g., redirection of harvesting) associated with using artificial reefs for marine ornamental collection; and 4) present the results of a mathematical model (parameterized with field data) designed to evaluate the sustainability of harvesting from lease sites.

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Twenty Years of Sustainable Fish Collecting in Mexico in a Baja Fishing Village

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Marine tropical fish and invertebrates have been collected using fine-mesh nets for over twenty years on a commercial level in the village of Ensenada Blanca, South of Loreto, Baja California Sur, Mexico. The collecting is done using ¼" monofilament hand nets and barrier nets. The fisherman's association is a village enterprise employing only local divers and packers. Since 1998, collecting permits were allocated to local collectors for areas comprising about 100 km of shoreline; which exclude fishermen from outside the community. Airport wildlife authorities enforce quotas on the number of each species exported. Federal fishery authorities require underwater surveys of reef populations and monitor collecting through the imposition of 'monitors' in the boats, who report back to Mexico City. Each year's annual quotas are determined from underwater surveys conducted during the previous year. In Ensenada Blanca, monitoring was conducted monthly by a survey team led by a biologist, Sergio Morales, under guidelines set forth by the Mexican National Fisheries Institute.

Last year (2000), net collecting yielded the largest harvest ever in terms of the number of specimens caught, boxes shipped, and income to the fishermen. Not only did fish and invertebrate population numbers hold steady for the 80 species being monitored, they were noted to increase in a number of geographic areas. Since drugs like cyanide are not used, there is little or no damage to habitats such as coral reefs and fish recruitment can occur unfettered. The fact that target species have not declined, and that the same species are present every year despite ongoing collecting, suggests that commercial collecting using nets is sustainable. Consequently, the quotas were increased for the year 2001-2002. The Mexican experience has something to offer in the debate concerning the defensibility of tropical fish collecting as a legitimate and positive form of employment for village fishermen.

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Trends Determined by Cyanide Testing on Marine Aquarium Fish in the Philippines

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Cyanide has been demonstrated to kill corals and there is scientific evidence that it contributes to the high delayed mortality of marine fish in the aquarium trade (Jones, 1997, Jones and Steven 1997, Jones and Hoegh-Guldberg 1999, Jones et al. 1999, Cervino et al. In Press, Hall and Bellwood 1995, Hanawa et al. 1998, Rubec et al. In Press). The International Marinelife Alliance (IMA) has been conducting cyanide detection testing (CDT) of marine aquarium and food fish in the Philippines since 1992. The testing is conducted under contract with the Philippine Bureau of Fisheries and Aquatic Resources. A network consisting of six CDT laboratories and three regional Marine Inspection and Sampling offices has been established. The CDT network conducts random sampling from fish collectors, middlemen, and exporters. Samples also are collected by law enforcement personnel and voluntarily submitted by fish exporters to determine whether or not the fish are cyanide-free. Over 40,000 aquarium and food fish specimens have been tested since 1993. The CDT laboratories in conjunction with law enforcement efforts are acting to deter cyanide fishing in the Philippines. The proportion of fish tested with cyanide present has dropped from 43% in 1996 to 8% in 1999. Trends with the cyanide testing by size of fish, by fish species, and area of collection will be presented.

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Responsibilities for Collection and Opportunities in Aquaculture for Developing Countries through the Marine Aquarium Trade

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In the rapidly expanding marine ornamental trade there are many economic and educational opportunities available to developing countries throughout the South Pacific region. As advances in technology become more readily available to the average hobbyist it is now possible to maintain and control a miniature version of the coral reef in their home or office. Developing countries have the potential to maximize their involvement in the marine aquarium industry while learning sustainable collection technique, proper husbandry, shipping, and handling procedures. Exporters that have been successful in establishing collection stations in these countries can contribute greatly to the local economy in export dollars and in their large-scale use of local goods and services. The exporters provide an economic rationale for keeping the reefs alive and healthy because it provides a sustainable source of livelihood for the local communities involved. It is the responsibility of the exporter to investigate and utilize appropriate monitoring procedures when instructing their divers. Once trained the local divers should be able to stay within the prescribed guidelines to achieve responsible, sustainable harvest levels. If all facets are done correctly, the marine aquarium industry can be instrumental in creating international public awareness to the fragile and threatened coral reefs of the world.

Recently our industry has made it possible for local villagers to become involved in the relatively new field of marine aquaculture and coral farming. Coral farming can create many benefits for the countries involved. These benefits range from economic to educational as well as benefiting the future of the marine ecosystem itself. The "Walt Smith International" coral farm in Fiji has created new employment, public awareness, economic incentives, tourist attractions and a reasonable alternative to wild harvest. Our coral farm has also been host to several post-graduate students to learn and share in this exciting new field. Working closely with the University of the South Pacific Marine Studies program our results are shared to advance the learning process and bring the future of coral farming forward through practical and profitable applications. In addition, there is great potential of utilizing this technology to replace or repair damaged reef areas subjected to heavy storms or recent bleaching events. By analyzing the results of various experiments conducted on the farm sites both local divers and the scientist are able to determine a multitude of factors together. There are still many things that can be learned about coral growth that include temperature growth rates, sunlight exposure, placement on the reef, predators, water movement and natural settlement. Such information can be extremely useful to science as well as the enthusiastic marine aquarist. The marine aquarium industry is the perfect platform to provide a viable and practical application in coral farming. The activities of sustainable collection and marine aquaculture can easily co-exist while placing only minimal financial burden on the collector or exporter sponsoring the farm. They are now able to carry out experimentation and analyze the results at the same time their collection operation continues to earn an income to support this activity. Once the farm becomes a financially viable operation it should be possible to replace up to 60% of the wild harvest with species grown on the farm. After a few seasons the farming operation could be totally reliant on second-generation brood stock. Another advantage to coral farming is that it allows for selective harvesting as only the desired species and colors will be chosen for the market by controlling the brood stock selection.

In conclusion, it should be the goal of the marine aquarium trade to evolve into the practice of steady, positive marine aquaculture of all forms while more concise monitoring and sustainable harvest procedures are strictly followed. This should insure a healthy and sustainable future of our industry and the planet.

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Population Status of Marine Ornamental Fish and Invertebrates in Sri Lanka and Development of Management Strategies for the Industry

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The aquarium fishery in Sri Lanka began as long ago as the 1930s, but it was not until the 1950s that it was firmly established and began to expand. There are now at least 750 collectors, and exports go to around 45 countries. It is high value industry, with viability dependent on a healthy resource base. Prior to the 1990s, there were no records kept of catch, no controls on collecting activity and no management in operation. In the early 1990s, protective legislation for corals and a number of rare species was introduced, and some protected areas were also established. In 1996, a Marine Aquarium Fishery project began in 1996, with collaboration between collectors and traders to investigate resource use and availability, and to formulate management strategies.

Underwater surveys were carried out at representative sites around a 350km stretch of coastline in the south-west of Sri Lanka. Habitats investigated included coral reefs, limestone (old coral) reefs, sandstone reefs and sand/rubble habitats, at depths ranging from the 1m - 30 metres. Over 400 data sets were obtained from a range of sites including some subjected to high collecting pressure and others less often or seldom visited by collectors. The surveys concentrated on species of interest to the ornamental trade, and were based on standard visual census methodology using 50m transects.

Results were discussed with collectors and exporters and their collective input sought so that a more comprehensive assessment of conservation status could be made. A socio-economic survey was also carried out, which included a questionnaire about management strategies. Interviews were held with 321 out of a total of 742 registered collectors, and various potential management strategies explained and discussed. The collectors were asked their opinion on the list of species already selected for protection (55% agreed with the list; 29% disagreed); on the idea of bringing in quotas (30% agreed with the idea; 51% disagreed) and whether they believed protected areas might be beneficial (58% thought they would be beneficial, 7% thought they might be, and 29% thought they would not be).

The underwater surveys provided useful data but have shortcomings and require significant research resources if they are to be continued. Experienced collectors undoubtedly have the best knowledge of resource availability and fluctuations, and this information needs to be harnessed in collaborative efforts to manage the fishery. As a result of the surveys, about 100 species were put forward as needing quotas or protection. However, consensus may be difficult. In practical terms, probably the most effective way of ensuring that representative habitats and their constituent communities are conserved is to establish fishery reserves where collecting is not permitted. The concept of no-take areas is accepted by the ornamental industry, but enforcement will not necessarily be easy.

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