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**REPORT ON THE WORLD AQUACULTURE SOCIETY 19TH ANNUAL
CONFERENCE AND EXPOSITION HONOLULU, HAWAII, U.S.A., 4-10
JANUARY 1988**

by

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**ASEAN/UNDP/FAO Regional Small-Scale Coastal Fisheries Development
Project
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1988**

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FOREWORD

The report on the latest meeting of the World Aquaculture Society held in Honolulu, Hawaii in January 1988 was rendered by Dr. Herminio R. Rabanal. Although the report is a very brief summary of the results of that meeting, the attached Appendices A, B and C can serve as very useful recent information in aquaculture. In particular, Appendix C which records the abstracts of contributed papers and posters that are relevant to the Asian region gives valuable information for aquaculture operators and aqua-culturists in the region.

We have requested Dr. Rabanal to contribute this as a technical paper to this Project and we are grateful that he has consented to this proposal.

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REPORT ON THE WORLD AQUACULTURE SOCIETY 19TH ANNUAL CONFERENCE
AND EXPOSITION, HONOLULU, HAWAII, U.S.A.

4-10 JANUARY 1988 AND
SOME NOTES ON AQUACULTURE IN HAWAII

by

Herminio R. Rabanal¹

I. INTRODUCTION

1. The 19th Annual Conference and Exposition of the World Aquaculture Society was held in Honolulu, Hawaii in 4-10 January 1988. It was attended by some 1 000 participants from 50 countries, mainly of 2 500 registered members and other individuals interested in the work of the Society. Three hundred fifteen papers were submitted for presentation in the technical sessions as well as posters. The meeting sessions were divided into plenary and review sessions, special sessions, and technical sessions.

II. THE CONFERENCE

2. The main theme of this 19th Annual Conference of the Society was "East Meets West". It was opened by an opening plenary session on the morning of Tuesday, 5 January 1988 with Dr. John Glude, former president of the Society as moderator. The opening plenary session consisted of an invocation, welcome addresses by Dr. J. Corbin, representing the Society in Hawaii and by Senator Chang, representing the State of Hawaii; presidential address by Dr. David Aiken, incumbent president of the Society; and keynote addresses by Dr. I-ChiuLiao of Taiwan for the East and Dr. Paul Sandifer for the west.

3. The plenary and review sessions dealt on: (a) Status of world aquaculture reviewed by Dr. Colin Nash of FAO, Rome; (b) Genetic improvements in cultured stocks, reviewed by Dr. Graham Gall, University of California, Davis; and (c) Advances in shrimp disease and diagnosis and treatment reviewed by Dr. James Brock of the State of Hawaii, Department of Land and Natural Resources.

4. Four special sessions were organized in this conference. These are: (a) Recent advances in shrimp culture, moderated by Dr. Gary Pruder of the Oceanic Institute, Hawaii; (b) Aquaculture in Asia and the Pacific, moderated by Dr. Robert Brick of the University of Hawaii; (c) Marketing strategies and tactics for aquaculture products, moderated by Mr. Raymond Rhodes of the South Carolina Wildlife and Marine Resources Department; and (d) Aquaculture products: implication for human health, organized by Dr. John D. Castell of Canada and Dr. Lorena E. Barck of the University of Hawaii.

5. The bases of technical exchanges during the conference were highlighted in 23 technical sessions on the following subjects: (1) crawfish; (2) water quality; (3) shrimp diet and nutrition; (4) pond culture; (5) shrimp larvae; (6) live feeds; (7) Crustacea; (8) shrimp culture I; (9) tilapia; (10) poly- culture; (11) aquaculture development/technology transfer; (12) pond dynamics; (13) diet and nutrition; (14) shrimp reproduction; (15) finfish I; (16) shrimp culture II; (17) genetics; (18) finfish reproduction; (19) mollusks; (20) aquaculture in developing countries; (21) processed feeds; (22) finfish II; and (23) economics and marketing. These technical sessions were held in different venues and many of them were simultaneously conducted in order to accommodate the numerous papers which were submitted in this conference.

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6. Some 97 papers were presented in the poster session. These were of diverse interests and attracted a lot of attention from the conference participants. This arrangement was also a means to accommodate the overflowing number of papers in this conference. The abstracts of presented and poster technical papers that are relevant to

aquaculture development in Asia and the Pacific are presented as Appendix C.

7. The conference tours which were also regular features of this conference consisted of those that catered to cultural and touristic purposes for accompanying family members of the conference attendees. There were, however, two major aquaculture tours, one within the island of Oahu which included visits to Amorient Farms, the largest aquafarm on Oahu; the Marine Research and Training Center of the University of Hawaii (shrimp, prawns, Chinese cat-fish, carp and tilapia); Unisyn (hydroponics, microalgae), and the Oceanic Institute (shrimp, milkfish research and various training programs). The second tour is the big island (Hawaii Island) aquaculture tour which consisted of a visit to the National Energy Research Laboratory of Hawaii (NERLH) in Kona, where the Ocean Thermal Energy Conversion (OTEC) project utilizes cold, deep ocean water, for aquaculture projects. Cultured on site are abalone, microalgae, seaweed, American lobster and salmon; and also a visit to the Aquatic Culture and Design Farm (Chinese catfish, prawns).

8. Of the numerous technical papers submitted in this conference, there are a number that are of interest and relevance to Philippine and Asian aquaculture. The authors, titles and abstracts of these papers are copied as Appendix C.

9. Many personalities and stalwarts in various fields of aquaculture were met during this conference. Although, due to the large attendance, it was not possible to meet even those with whom some reactions or exchanges should be undertaken. A list of the personalities and other individuals met in this conference are listed in Appendix A,

III. THE EXPOSITION

10. The exposition was a major feature of this annual affair of the Society. Fifty-five exhibitors displayed aquaculture equipments, feeds, drugs and chemicals, publications and other informative materials, marketing services, aquaculture management equipment such as pumps, environmental quality monitoring equipments, nets, and investment prospect services. The basis for future business relations of these exhibitors with people in the industry were established in some instances during this conference and some sales were also accomplished. The list of exhibitors in this conference is included as Appendix B.

IV. NOTES ON AQUACULTURE IN HAWAII

11. Aquaculture in Hawaii is being accelerated through aggressive research and development programmes of government and government-supported institutions. Hawaii is one of the states of that country that has put up and maintains an office called Hawaii Aquaculture Development Program (ADP). Established over 10 years ago, this agency promotes development, renders extension services and funds research in aquaculture. In the field of research, two institutions stand out as leaders in this field: University of Hawaii and the Oceanic Institute. The University of Hawaii has acquired the former research station of the Aquatic Farms (a private consulting firm) and now maintains it as a Marine Research and Training Center (MRTC) for active research and training work in aquaculture. The Oceanic Institute, a private, non-profit organization supported by federal, state and private sources, has been engaged in marine research with emphasis in aquaculture. It has four major programs at present including: (a) finfish, biology and culture (e.g. mullet, milkfish, mahimahi); (b) crustacean culture, specially penaeid shrimp (*Penaeus vannamei*) and *P. monodon*; (c) study and formulation of feeds for cultured species; and (d) oceanographic studies.

12. There are a number of private aquaculture enterprises of which the two major ones in the State of Hawaii are (1) Amorient Aquafarm, Inc. and (2) Marine Culture Enterprises (MCE). The Amorient Aquafarm is the largest operating about 100 ha area of farm for penaeid shrimp, hatchery and intensive grow-out and the culture of some finfish species. Of the shrimps, *Penaeus vannamei* and *P. monodon* are the cultivated species in about 40 ha of this farm.

13. The Marine Culture Enterprises, which has been reported to be the most

intensive shrimp farm in the world, makes use of shallow raceways in enclosed greenhouses to raise the introduced blue shrimp, Penaeus stylirostris. Built on a two-ha area, it is designed to be Capable of producing up to 200 tons (400 000 lbs) of shrimp tails per year. Unfortunately, during the initial year of its operation (1986/87), it suffered a disease problem necessitating total disinfection and setting'back the schedule of production operations.

14. The National Energy Research Laboratory of Hawaii (NERLH) with its Ocean Thermal Energy Conversion (OTEC) project, located in Kona, Hawaii Island, utilizes pumped, nutrient-rich deep ocean water (from over 600 m deep) for aquaculture. Culture of abalone, microalgae, seaweed, lobster and the coho salmon have been experimented using this water. Results in some of these experiments are now being piloted by interested private firms using a reserved land adjacent to this Laboratory.

15. Utilization of organic wastes such as animal manure for the culture of economic species of microalgae is another recent trend observed in Hawaii. The Unisyn Company utilizes animal manure for its practice of hydroponics in agriculture using greenhouses and the culture of economic microalgae especially Spirulina. Likewise, the Natural Energy Research Laboratory of Hawaii in Kona through interested private firms has started producing Spirulina and Dunaliella species. Both these microalgae are high in nutrient value and are utilized as ingredients of valuable human food products.

16. The culture of the giant freshwater prawn, Macrobrachium rosenbergii which had a headstart during the early 80's in Hawaii is observed to have declined considerably. Previous prawn farms are now being converted for *the* culture of other finfish of more economic importance. The introduced Chinese catfish, Clarias fuscus, and hybrid red tilapia have good market in Hawaii and are now cultivated in freshwater farms. In saltwater, mullet culture, milkfish culture and the possible culture of mahimahi (Corephaena), a very valuable species in the state, have good prospects. Both the grey mullet and the milkfish have been experimentally hatched in Hawaii laboratories (Oceanic Institute). The hatching of mahimahi, which is a very valuable food species in this state has recently been accomplished also by the Oceanic Institute. Overall at present, aquaculture development in the state of Hawaii is mainly focused in the production of penaeid shrimp through high technology aimed at filling the high market need for this product in the American market.

V. OTHER ACTIVITIES

17. In addition to attendance to the WAS Annual Conference, this writer was invited to participate in the-annual meeting of the global USAID—supported Pond Dynamics/Aquaculture, Collaborative Research Support Programme (CRSP) held in Kona, Hawaii, 11-15 January 1988, specifically to be member of the External Evaluation Panel (EEP) of this Program for the period starting January 1988. This Program has field experimental projects in Indonesia, Philippines and Thailand in Asia; Honduras and Panama in Latin America; and Rwanda in Africa. The objective of the Program is to undertake experiments in field projects in this listed developing countries using uniform treatments with standard chemical, physical and biological monitoring of the environments of these aquaculture projects matched against the production obtained of fish or shrimp resulting from the conditions used in the culture. The idea is to get a thorough understanding of the dynamics of production through aqua-culture in these sites so that proper production models can be developed to be used to effect increase in food production which is much needed in many developing countries of the world. The experiment started in 1983 and is scheduled to terminate about 1990. Three production cycles have been completed so far (1983-1987), and forward planning for experiments for 1988 to 1990 were discussed in this meeting.

**APPENDIX A
LIST OF PERSONALITIES MET**

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APPENDIX C
ABSTRACTS OF SELECTED PAPERS OF INTEREST TO
PHILIPPINE AND ASIAN AQUACULTURE

1. RESPONSE TO PENAEUS INDICUS POSTLARVAE TO VARIOUS FEEDS.
Veronica R. Alava*, Aquaculture Department, Southeast Asian Fisheries Development Center, P.O. Box 256 Iloilo City, Philippines.

Penaeus indicus postlarvae 5 (9 mm mean total length, 3 mg mean wet body weight) were fed with five dry artificial diets (commercial feed A, B, C, experimental diets PL-P and 2S) and a control (fish muscle). The shrimps were reared under the following conditions: feeding level, 30% of the body weight/ day (dry matter basis); feeding frequency, three times a day; particle size of diets, 425 urn; stocking density, 200 individuals/30 liters of water; salinity, 32-34 ppt; water temperature 28-29°C. On day 30, shrimps attained mean total lengths of 13 to 22 mm. The mean wet body weight of shrimps fed PL-P (57 mg) was significantly higher ($P < 0.01$) than those of shrimps fed Diets A, B, 2S and fish muscle but not with those red Diet C. The survival rate of shrimps fed PL-P was the highest (92%), significantly higher ($P < 0.01$) than those fed Diet B (69%) and fish muscle (14%). Results showed the feasibility of rearing P. indicus postlarvae with PL-P formulated diet,

2. A TENTATIVE YIELD-DENSITY MODEL FOR MACROBRACHIUM ROSENBERGII REARED UNDER DISCONTINUOUS CULTURE CONDITIONS.
AQUACOP and Loic Antoine, IFREMER, Centre Oceanologique du Pacifique, BP 7 004 Taravao, Tahiti, French Polynesia.

A simple model has been imagined to give the evolution of the individual mean weight (g) and yield (t/ha/year) with initial densities varying from 1 to 21 individuals/m². The mean initial weight is 1 g, supposing an initial rearing from PL to 1 g not included in the model.

Data for growth and mortality have been found AQUACOP experiments in Tahiti, IFREMER experiments in Martinique and from literature. The model can be used as a forecasting tool for farmers rearing Macrobrachium under discontinuous culture system.

3. A BIOTECHNICAL MICROCOMPUTERIZED MANAGEMENT PROGRAM FOR A TROPICAL SHRIMP FARM (MACROBRACHIUM OR PENAEIDS).
AQUACOP, Regis, F. Bador and Jean-Nicolas R. Bazin IFREMER Centre Oceanologique de Pacifique, BP 7 004 Taravao, Tahiti, French Polynesia.

Operating a commercial shrimp farm implies the integration of various and biological, technical and financial data. A microcomputerized program can greatly alleviate such a management. The proposed program concerns as a Macrobrachium or Penaeid shrimp farm working under a discontinuous culture system. The data management system used is Knowledge-Man (2.01 Version) working through MS-DOS. Survival and feeding rates, estimated from IFREMER/COP results, are entered as biological hypothesis and can be adjusted to peculiar local conditions.

* Presenting author

At pond scale, physicochemical parameters are recorded daily, whereas fertilizer and food quantities, sampling data and harvest results are entered every two weeks. At farm scale, purchases and sales are entered every two weeks.

From the latest data input, the farmer is proposed an estimation of the growing biomass and the daily rations for each pond and for the next two weeks. The farmer can modify these proposed figures according to special observations or events.

A biotechnical synthesis for each grow-out pond, along with a cash-flow and book-keeping summary are printed once a month. An end-of-rearing analysis sheet is printed after the final harvest, and presents all the calculated results necessary to estimate the performance of the grow-out.

This program will be improved from experiences in farms which use it. A special version for Macrobrachium continuous culture farms will be soon realized.

4. EFFECTS OF DISSOLVED OXYGEN CONCENTRATION ON SURVIVAL AND GROWTH OF PENAEUS VANNAMEI AND PENAEUS STYLIROSTRIS.
AQUACOP, Edouard Bedier and Claude Soyez, IFREMER Centre Oceanologique du Pacifique, BP 7 004 Taravao Tahiti, French Polynesia.

The water dissolved oxygen concentration (DO; is one of the most important parameters of pond management. If lethal values of DO are fairly well known, there are few data on long term effects of sub-lethal values on survival and growth of penaeid shrimps. A profitable management of ponds (water renewal, use of aeration devices, etc.) largely depends on these data.

A DO continuous monitoring system allowed us to submit Penaeus vannamei and P. stylirostris individually tagged to the following conditions: saturation of DO as reference, continuous level of 3 ppm, continuous level of. 1.5 ppm and diurnal like 6 h-18 h cycle at respectively. 1.5 ppm and saturation.

No significant survival and growth difference occurred for P. vannamei submitted to a continuous concentration of 3 ppm, but mortality occurred as early as the fourth day at a continuous concentration of. 1.5 ppm. Survival and growth of P. vannamei and P. stylirostris were significantly lowered under diurnal-like cycle condition; the molting cycle of these shrimps was modified in comparison to the cycle of those maintained at a constant level of 3 ppm and higher.

As a consequence, it is very likely that in grow-out conditions, an important decrease of the dissolved oxygen concentration during the night time affects the growth of shrimps even if diurnal conditions are adequate.

5. MAINTENANCE OF WATER QUALITY BY BACTERIAL SYSTEMS IN INTENSIVE TROPICAL PENAEID SHRIMP CULTURE: PRELIMINARY RESULTS.
AQUACOP and Edouardo Bedier, IFREMER, Centre Oceanologique du Pacifique, BP 7 004 Taravao, Tahiti, French Polynesia. Micheline Bianchi, CNRS ER223, Campus de Luminy Case 907 70 route Leon Lachamp 13 288 Marseille Cedex 9, France.

The "Centre Oceanologique du Pacifique" in Tahiti has investigated for

several years the tropical penaeid shrimp intensive culture. Extrapolated yields up to 27 metric tons/ha/year have been obtained in aerated ponds with low water renewal rates. Considering the high biomass reached in these ponds, the maintenance of a suitable water quality constitutes a critical point, mainly for the elimination of nitrogenous wastes; the development in the pond water itself of planktonic and bacterial populations, insures the mineralization of organic matter and the nitrification of wastes.

The experiments conducted in 1 and 10 cubic meter circular tanks showed that the nitrification process occurred systematically and that only the duration of each step of the process was influenced by initial biomass and water quality. The establishment of this process was studied for 200, 400, 560, 600 and 800 g/m² biomasses, and the respective ammonification and ammonium oxidation rates (K1 and K2) were calculated. Reference tanks without animals fed at the same rate as the ones with a shrimp biomass exhibited the same ammonification rate, which suggests that this process is independent from animal biomass and must be related to food only.

With a biomass of 560 g/m², and with water initially inoculated from an intensive grow-out pond, ammonia disappeared within 30 days and nitrite within 50 days; counts of total bacteria fluctuated around 1 million/ml, and those of heterotrophic bacteria around 10,000/ml. Evolution of microorganism populations (bacteria and predatory protozoa) was studied.

The results presented in this paper are a first step towards a better understanding of this particular kind of intensive culture system, and towards its modelization.^c

6 PRELIMINARY NUTRITIONAL STUDIES OF SEABASS LATES CALCARIFER (BLOCH): PROTEIN AND LIPIN REQUIREMENTS. AQUACOP, Gerard Cuzon and Jacques Fuchs, IFREMER Centre Oceanologique du Pacifique,, BP 7 004 Taravao Tahiti, French Polynesia.

Some dietary requirements of seabass fry imported from Singapore were studied at the Centre Oceanologique du Pacifique.

In a first experiment, four diets ranging from 35 to 55% protein content mainly from Norway fish meal were compared to a control diet at 52% protein including fish meal plus fish protein concentrate. Protein/energy ratio was fixed around 140 mg protein/kcal. Juveniles weighing 35 grams were randomized and distributed at 35 to 38 fish per tank in two replicates. The preliminary results from the four experimental diets revealed an optimum of protein requirement ranging from 45 to 55%. The highest growth rate was obtained with the 52% protein reference diet, a result that can be related to the protein quality of this formula.

In a second experiment, three diets at 6, 10 and 14% lipid and 52% protein content were allocated in three blocks of 21 fish per tank (average initial weight: 20, 25 and 30 grams). No significant difference of growth and survival rates were recorded. The sparing action of the dietary lipid was not proved in the studied range of 6 to 14% of the diet. From these results, it can be estimated that the digestible energy requirement could be reduced around 6.7 kcal per gram of diet for Seabass juveniles. The formulation of a commercial fish feed for Seabass is still under progress, studying energy-ratio and protein source quality.

7. MONITORING OF DISSOLVED OXYGEN LEVEL IN PENAEID INTENSIVE

GROW-OUT PONDS.

AQUACOP and Alan Febvre, IFREMER, Centre Oceanologique du Pacifique, BP 7 004, Taravao, Tahiti, French Polynesia.

Intensive grow-out ponds of Penaeid shrimps undergo great variations of dissolved oxygen (DO) concentration related to changes in culture conditions (phytoplankton density biomass, water renewal, bottom condition, ...). Culture methods are briefly discussed, considering mainly their impact on DO level, which was monitored continuously over the rearing period. The selection of oxygen transfer systems, and the optimization of their use are particularly studied.

An analysis procedure of the DO concentration variations in pond water is proposed, with respect to the usually recorded physicochemical and biological parameters. This procedure is utilized to evaluate the performances of the different aeration devices in conditions close to the intensive culture ones.

The changes and incidents observed during the grow-out period are correlated to the DO concentration variations; this enables to classify these changes, and select the appropriate measures to recover adequate culture conditions. This study further allows one to make an objective evaluation of the commonly used intensive pond management strategies, and to propose new types of interventions.

8. REPRODUCTION OF GROUPE EPINEPHELUS MICRODON IN FRENCH POLYNESIA. NATURAL CYCLE CHARACTERISTICS AND FIRST RESULTS IN CAPTIVITY.

AQUACOP, Jacques Fuchs and Laurent Debas, IFREMER, Centre Oceanologique du Pacifique, BP 7 004 Taravao, Tahiti, French Polynesia. Bernard Jalabert, INRA, Laboratoire de Physiologie des Poissons, Campus de Beaulieu, 35 042 Rennes Cedex, France. Eric Morize, ORSTOM BP 529 Papeete, Tahiti, French Polynesia.

Little basic information is available on Epinephelus microdon, a candidate species for aquaculture in French Polynesia. Researches were therefore, conducted in 1985-1986 on the reproduction cycle and the sexual dimorphism of this species in the wild and its propagation in captivity.

Regular collection of fish in Tikehau atoll (Tuamotu Islands) clearly showed the seasonal characteristic of the reproduction in the wild, with a maximum sexual activity in March, although some mature individuals were observed all over the year. First maturations were noticed on 0.4-0.5 kg mean weight fish, and the sex reversal of this protandric hermaphroditic species appeared from 1 kg on. Studies to identify sex by morphometric variations were not statistically conclusive (24% error) when compared to the mean weight criteria (26% error).

In captivity, the grouper has been observed to spawn naturally, from November to April, according to lunar cycle, with a peak of activity in February. Nineteen natural spawnings and 16 million eggs (860 µm diameter; 95% fertilization rate) were obtained in 1986, each female depositing 0.8 to 1 million eggs per kg. In 1985 comparative studies were carried out using hormone injections (LHRH and HCG): few females correctly responded to the treatment, but produced good quality eggs.

Preliminary larval rearing trials showed a peak of mortality on days 4-5 corresponding to the first feeding period, and on days 10-15, with a total mortality after day 20. An inadequate food frequency was suspected to be the major reason for these strong mortalities. Further research has to be conducted both on the

control of maturation and the larval rearing of this promising species for aquaculture.

9. A COMPUTER MANAGEMENT INFORMATION SYSTEM FOR A COMMERCIAL SHRIMP CULTURE OPERATION.

Sidney B. Ashmore*, Amorient quafarm, Inc.
P.O. Box 131, Kahuku, Hawaii 96731 USA.

A menu driven computer management information system was set up at the Amorient Aquafarm, Inc. Kahuku operation. The system stores data and generates weekly and monthly production reports for both the hatchery and farm operations. The system consists of an IBM PC "AT class" clone that runs at 4.77 or 8 mhz with DOS 3.1 and 760 Kb RAM. A 45 Mb fixed disk, 360 Kb floppy and a 20 Mb tape back-up provide ample disk space. A battery back-up and line conditioner are on line to collectively supply enough power to save all open files and bring the system down during a blackout and prevent any damaging voltage spikes or surges.

10. NAUPLII PRODUCTION RESULTS FROM A COMMERCIAL PENAEUS VANNAMEI MATURATION FACILITY IN HAWAII.

Sidney B. Ashmore*, Amorient Aquafarm, Inc. P.O. Box
131, Kahuku, Hawaii 96731 U.S.A.

Amorient Aquafarm, Inc., in Kahuku, Hawaii constructed and stocked three 4.6 meter diameter maturation tanks in September of 1986. Two F2 and one F3 Penaeus vannamei generations were stocked at 5.5 broodstocks/m². The F3 generation was stocked at a 1.6:1 female:male ratio while the F2 generations were stocked at 1:1 and 1.6:1 female:male ratios. Mean size at stocking was 49 g, 40 g and 37 g for the F3, F2 1:1 ratio and F2 1.6:1 ratio populations, respectively. Approximately two months elapsed before the three populations reached average monthly nauplii production levels for the 7.5 month production period. Total nauplii production from September 1986 to the middle of May 1987 was 27.4 million, 19.4 million and 13.9 million for the F3, F2 (1:1 ratio) and F2 (1.6:1 ratio) populations, respectively. The F3 population recorded 417 fertile spawns while the F2 populations recorded 313 (1:1 ratio) and 263 (1.6:1 ratio) fertile spawns. Differences in average nauplii per spawn and percent hatch rate were less dramatic between the three tanks, ranging from 53K to 66K nauplii per spawn while the average percent hatch rate ranged from 39% to 46%. Individual spawning histories of female broodstock from all three maturation populations were recorded. The results suggest that manipulation of stocking ratios and monitoring of individual female performance may lead to a maximization of nauplii produced under the present system.

11. AMMONIA-AMMONIUM NITROGEN UPTAKE BY CHAETOCEROS GRACILIS WITH APPLICATIONS IN SHRIMP MARICULTURE.

Daniel J. Avery, Texas A & M University Galveston Galveston, TX 77553.
David V. Aldrich, Department of Marine Biology, Texas A & M University Galveston Galveston, Texas 77551.

Water quality control is of major importance in high density shrimp rearing operations. The microalgae Chaetoceros gracilis, which is a common larval shrimp food source, was tested for its ability to utilize ammonia-ammonium nitrogen (NH₃/NH₄-N).

Each of three uniform log phase cultures of Chaetoceros gracilis was divided into three treatments per experiment; 1) culture medium with added NH₃/NH₄-N and without Chaetoceros, 2) culture medium with added NH₃/NH₄-N and with Chaetoceros, 3) culture medium with added NH₃/NH₄-N and with Chaetoceros. Two

light intensities (106.1 and 3.2uE) were also tested to simulate different environmental conditions. At the higher level the original amount of NH₃/NH₄-N (.375 mg/1) was reduced by approximately 69% after one hour, and by about 99% after three hours. Reductions of slightly less magnitude were observed at the lower light intensity (68% and 90%, respectively). This data indicates that Chaetoceros gracilis reduces NH₃/NH₄-N levels at a rapid rate under experimental conditions, and may be useful in this role in shrimp hatchery operations,

12. SELECTION INDEX FOR COMPARATIVE EVALUATION OF OREOCHROMIS NILOTICUS STRAINS DURING EARLY DEVELOPMENT. Zubaida U. Basiao*, Southeast Asian Fisheries Development Center, Binangonan Freshwater Biology Station, Binangonan Rizal, Philippines. Roger W. Doyle, Department of Biology Dalhousie University, Halifax, NS B3H 4J1, Canada.

Several strains of Oreochromis niloticus, O. mossambicus and their hybrids occur in the Philippines and others are likely to be introduced or developed locally in the near future. There is a tendency towards genetic deterioration of strains under commercial cultivation owing to inbreeding, population bottlenecks, uncontrolled hybridization and reverse selection.

The objective of the project is to develop an "index" for between-strain monitoring, comparison and selection that is usable at the young juvenile stage. The methodology is to measure variables relating to early growth and stress resistance, and associate them, (by multivariate techniques) with the grow-out performance and quality of the same strains in commercial environments.

The paper reports on 3 aspects of the work on young fish: 1) the use of a control population of "red" genotypes to provide internal statistical control over among replicate variability in growth; 2) the use of size-specific growth estimators to reduce non-genetic maternal effects; and 3) the use of micro-developmental abnormalities in scale morphology to measure stress responses individually and non-destructively, without resorting to LD-50 or similar population-level responses. Used together, the procedures reduce environmental error while greatly increasing the degrees of freedom available for statistical hypothesis testing in experiments of modest size.

(Note: For oral presentation at the 1988 meeting of the World Aquaculture Society).

13. SELECTED SECTIONS FROM A HANDBOOK OF NORMAL PENAEID SHRIMP HISTOLOGY. T.A. Bell*, D.V. Lightner and W.C. Randall, University of Arizona Environmental Research Laboratory 2601 E. Airport Drive, Tucson, AZ 85706.

The presented poster depicts excerpts from an upcoming publication. The excerpts illustrate selected micrographs from several representative chapters. In addition to the micrographs, the poster contains a pictorial representation of the macroscopic location of the selected micrographs.

The forthcoming publication will be a definitive handbook of B&W, and color light micrographs, characterizing the complete histology of a typical penaeid shrimp. The handbook will include limited text, consisting of chapters covering: techniques, nomenclature, bibliography and index. The majority of the handbook is composed of

micrographic plates with facing pages of expanded captions. The micrographs are arranged in chapters, each of which describes the normal histology of a particular anatomical system. Color micrographs supplement the B&W in those sections where relevant information can only be visualized with tissue-specific histochemical stains.

14. MICROBIAL PRODUCTION OF NUTRITIONAL PROTEIN FOR AQUACULTURE SYSTEMS.

J.A. Bender, I. Ekpo, Y. Vatcharapuan and E.R. Archibold Department of Biology, Morehouse College, Atlanta, GA 30314.

The objective of this research was to develop a low-cost, high quality protein for application in aquaculture systems. Since the intent was to develop a method which is easily transferred to developing countries, only available waste biomass and low-technology processes were used. Grass clippings were anaerobically digested by a simple silaging process, then used as a feed-stock for nitrogen fixing, asymbiotic bacteria and cyanobacteria in simulated laboratory ponds. Protein levels increased from 10-15% in the silage to 20-30% in the final microbial biomass in 7.-10 days. The microbes attached to the silage forming a buoyant gelatinous mat which was easily harvested by raking the surface of the pond. Outside ponds in Santiago, Dominican Republic, showed productivity similar but somewhat lower in protein to that of the simulated laboratory ponds. Results from digestion studies with T. nilotica and H. molitrix (Silver carp) indicated that the silage/microbe product competed favorably with commercial cat-fish feed in percent digestibility.

15. ENHANCED GROWTH OF THE NEMATODE, PANAGRELLUS REDIVIVUS. BY FATTY ACID MANIPULATION AND THE EFFECT OF THAT MANIPULATION ON THE GROWTH OF LARVAL PENAEUS VANNAMEI.

James M. Biedenbach*, Linda L. Smith and Addison L. Lawrence Shrimp Mariculture Project, Texas Agricultural Experiment Station, Texas, A&M University System, P.O. Drawer Q Port Aransas, TX 78373.

Corn oil, menhaden oil and yeast were added in varying combinations to culture media of Paragrellus redivivus to effect a change in growth and fatty acid content. The addition of corn oil, menhaden oil or yeast to cultures increased nematode growth by 13%, 32% and 36%, respectively over standard media. Combinations of corn oil + yeast and menhaden oil + yeast increased nematode growth 68% and 63%, respectively.

Fatty acid content was altered in nematodes cultured on media containing oils. Significant increases in fatty acids 18:0 and 18:2 were observed in those nematodes cultured in the presence of corn oil, while significant increases in fatty acids 14:0, 16:0, 16:1, 20:5 and 22:6 were found in those nematode cultured on media containing menhaden oil.

Experiments with Penaeus vannamei larvae fed standard, yeast modified, corn yeast modified, and menhaden-yeast modified nematodes resulted in no significant differences in survival and metamorphosis between any of the nematode-algae fed treatments and the standard algae Artemia control. Significant differences in growth (dry weight) were observed between larvae fed nematodes modified by yeast or menhaden-yeast and those fed nematodes modified with corn oil suggesting a lack of essential fatty acids in the corn oil modified nematodes. Although nematodes cultured with menhaden oil accumulated high amounts of highly unsaturated fatty acids, these levels did not improve growth of P. vannamei over unmodified nematode controls.

16. IMPROVED ACUTE TOXICITY TESTS WITH PENAEID POSTLARVAE. Patrick W. Borthwick, U.S. Environmental Protection Agency, Environmental Research Laboratory, Gulf Breeze FL 32561. John E. Bente and Christopher D. Howell Continental Fisheries Ltd., 4104 West 23rd Street Panama City, FL 32405.

Contamination of water sources for shrimp farming facilities may reduce the quality of the marketable shrimp. A simple bioassay and toxicity test for water quality was developed which uses early postlarvae of penaeid shrimp. This test procedure is based on existing static acute toxicity tests for mysids. Seven day old postlarvae (PL-7) of penaeid shrimp are recommended for testing because PL 14-21-28 jumped out of the test media. Tests with PL-7 gave acceptable survival and concentration/effect relationships. Sensitivity to toxic compounds was similar to that of mysids and other estuarine crustaceans. The added advantage of the penaeid shrimp test is that it directly relates to industry needs. Data are presented that show sensitivity of Penaeus vannamei in comparison to mysis and other crustaceans. Recommendations are made for incorporation of the penaeid test as a screening method for adequate water quality in shrimp culture.

- 17 SMALL SCALE COMMERCIAL SHRIMP FARMING IN THE CARIBBEAN-FACT OR FANTASY?
Nigel L. Bowers, Leeward Islands Shrimp Company Ltd. P.O. Box 284, St. Kitts, West Indies.

Profitable commercial shrimp farming on any scale in the Caribbean has yet to become a reality. The purpose of this paper is to discuss some of the major reasons for this failure and to demonstrate ways in which many of these obstacles can be overcome. The paper focuses primarily on the systems developed over the last four years by Leeward Islands Shrimp Company Ltd., a small totally integrated commercial farm on St. Kitts. The results of three years of commercial maturation, hatchery and grow-out operations are discussed in terms of maximizing system efficiency under sub-optimal culture conditions.

Particular attention is given to pond production data for small ponds at high salinities (greater than 40 ppt) and the effects on growth rates using post larvae from pond raised broodstock and from wild caught ones. Preliminary observations suggest that the FI generation from shrimp raised in high salinity ponds exhibits superior grow-out performance to either their parents or their offspring.

18. EVALUATION OF SURFACE AERATORS FOR USE IN AQUACULTURE PONDS.
Claude E. Boyd, Department of Fisheries and Allied Aquaculture, Auburn University, Alabama 36849 USA.

Thirty-two aerators representing all basic types of surface aerators were tested for standard oxygen transfer rate (SOTR) and standard aeration efficiency (SAE). Electric paddle wheel aerators were more efficient than other types of aerators in transferring oxygen. Specifications for construction of electric paddle wheel aerators that have SAE values of around 4.5 lb O₂/hp.hr under standard conditions are presented. Methods for estimating oxygen transfer under actual pond conditions and calculating cost of operation are provided. Paddle wheel aerators also may be driven by diesel or gasoline engines. Strategies for optimum use of aeration in ponds is discussed and supported with results of recent studies.

19. DEVELOPMENTS IN GIANT CLAM MARICULTURE IN AUSTRALIA.

R.D. Braley, Zoology Department, James Cook University Townsville, Queensland 4811, Australia.

Studies of methods for farming giant clams have resulted from the awareness of the rapid decline of natural populations from overfishing in the Pacific region and the clams' intrinsic peculiarity of autotrophy, which obviates the need for feeding. An international research program funded by the Australian Centre for International Agricultural Research (ACIAR) is based at James Cook University and Orpheus Island with affiliated programs in the Philippines, Fiji and Papua New Guinea. There is also a high level of communication between this program and the Giant Clam program at the MMDC in Palau. Contrary to the culture of Tridacna derasa in Palau, the ACIAR program has focused on the largest and fastest growing species, Tridacna gigas, with less emphasis on Hippopus hippopus and Tridacna squamosa. Selection of broodstock utilizing a biopsy technique and spawning induction by serotonin are used routinely. The larvae have been reared successfully using modified temperate intensive bivalve hatchery techniques. Semi-intensive methods of culture have yielded about 10-fold lower survival from eggs to 5 month old seed than intensive methods. Nevertheless, mortality of post-settled to metamorphosing larvae remains high and requires further research. In a comparison of four positions of holding juvenile clams during the ocean-nursery phase (floating, subtidal rack, benthic and intertidal benthic), the intertidal position resulted in high survival, near maximum growth rates, and tolerance of clams to considerable periods of intertidal exposure without negative effects. Protected fringing reefs resulted in better growth than exposed fringing reefs. Culture in the intertidal zone is more economical in construction and maintenance. Large-scale systems using 30 m x 1 m x 0.2 m 'Lines' (rectangular boxes) and mesh 'Covers' directly over the clams on the natural substrate are now being tested for ocean nursery of Tridacna gigas. Private enterprise has shown an interest in T. gigas farming in North Queensland with the establishment of two operations near Cairns using semi-intensive land-based and extensive ocean-based larval and seed culture.

20. INFLUENCE OF DIETARY FATTY ACIDS ON REPRODUCTION OF PENAEUS STYLIROSTRIS.

William A. Bray* and Addison L. Lawrence, Shrimp Maricultural Experiment Station, Texas A&M University System, 4301 Waldron Road, Corpus Christi, TX 78418.

Fatty acid profiles of gonad, hepatopancreas and muscle tissues of female Penaeus stylirostris were compared after animals were fed various diets for 90 days. Treatments consisted of an all fresh-frozen diet (squid, bloodworms, shrimp and brine shrimp in a 4:2:2:1 ratio) and three combination diets of 40% squid and 60% prepared dry feed. The combination diets were similar in composition, but varied in total dietary lipid.

Fatty acid composition of tissues in the combination diet treatments differed strongly from the fresh-frozen diet treatment. Treatments containing 50% prepared diet components showed increased C14 and C16 fatty acids, and decreased levels were increased in combination diet treatments 200-800% over the tissue levels found in the fresh-frozen diet treatments. Gonad tissue long chain fatty acid levels in the fresh-frozen treatment were most similar to those of control females (wild matured), with the following levels (mean \pm SD): 18:2, 1.23 \pm 0.55%; 20:4, 2.33 \pm 0.45%; 20:5, 9.33 \pm 0.9%; 22:6, 14.83 \pm 1.50%. Reproductive performance, evaluated by number of eggs per spawn, percent hatch, number of nauplii per spawn, and protozoa 1 length, was significantly better in the all fresh-frozen diet.

21. SUCCESSFUL REPRODUCTION OF PENAEUS MONODON AETER, CULTURE UNDER HYPERSALINE CONDITIONS, William A. Bray*, Addison L. Lawrence and Joanna R. Leung-Trujillo, Shrimp Mariculture Project, Texas Agricultural Experiment Station, Texas A&M University System, 4301 Waldron Road, Corpus Christi, TX 78418.

Penaeus monodon postlarvae (Malaysian origin, N = 100) were cultured to adulthood, with the final six months of grow-out under salinity levels ranging from 42-52 ppt. Upon transfer from a hypersaline earthen pond, broodstock were olive drab in appearance and exhibited no ovarian development. Adults were acclimated to oceanic salinity (35 ppt) in a laboratory recirculating system and ablated after two days. For two weeks, all shed exoskeletons of females were dissected to determine presence of spermatophores. Results of dissections and light microscope evaluation of sperm indicated all females (N = 20) had mated under the hypersaline pond conditions prior to placement in the laboratory. Sperm appeared morphologically normal.

After three to four weeks of exposure to oceanic salinity in laboratory conditions, strong brown and black markings on the exoskeleton were exhibited by the broodstock, and ovarian development followed. The first mature female was isolated for spawning five weeks after eyestalk ablation, and then reproductive performance was evaluated for 80 days. Mean spawn size was $315,000 \pm 28,920$ (SE) eggs, with $195,000 \pm 24,400$ nauplii per spawn and 59.6 ± 5.61 percent hatch (N = 60). Mean weights were 146.6 and 104.5 g for females and males, respectively.

22. THE USE OF EDTA IN AQUACULTURE: A POSSIBLE MECHANISM OF BROAD-SPECTRUM TOXICITY REDUCTION. David E. Brune, Agricultural Engineering Department Clemson University, Clemson, SC 296340357. Albert Garcia, Agricultural Engineering Department Texas A&M University, College Station, TX 77843. Herschel A. Elliott, Agricultural Engineering Penn State University, University Park, PA 16802.

Disodium ethylenediamine tetracetate (EDTA) is routinely used in aquaculture as a broad-spectrum "cure-all" in preventing metal toxicity to aquatic organisms. On the other hand, it is routinely used to keep certain essential metals in solution when needed for phytoplankton culture. The reaction of EDTA in multi-metal solutions is complex and not surprisingly the outcome of blind addition of EDTA to culture water produces highly variable results. Recently, the authors reported on the ability of EDTA to catalyze the oxidation of soluble Mn^{++} to insoluble MnO_2 under certain conditions. This paper offers evidence to suggest that higher than expected levels of Mn^{++} are often times observed in aquaculture water supply, as a result of stabilization by inorganic and organic sequestering agents. Furthermore, it is demonstrated that chelation of Mn^{++} by phosphate may be counteracted by the addition of low levels of EDTA. Once the metal ligand is competitively bound by EDTA, it is then possible to oxidize the EDTA-metal complex to insoluble MnO_2 . This mechanism is proposed as the basis of a possible technique for the removal of stabilized heavy metals from aquaculture water supply when they appear at concentrations higher than expected, based on predictions from chemical equilibrium relationships.

23. MICROBIAL ACTIVITY AND GROWTH IN A BRACKISHWATER SHRIMP POND: SOME CURRENT METHODS COMPARED. Jeff M. Burgett¹, Shaun M. Moss¹ and David M. Karl² ¹Department of Zoology, ²Department of Oceanography University of Hawaii at Manoa.

Bacteria and algae dominate the metabolism of semi-intensive aquaculture ponds, but few techniques have been developed to measure their activity and growth

rates. Using water samples from a Hawaiian shrimp pond, we compared several current methods used to measure microbial growth rates, biomass and amino acid uptake.

Water column samples from early, middle and late stages of grow-out were separated into <1, <20 and <335 μm . size fractions before each analysis. Growth rates and microbial carbon production were calculated from the rate of incorporation of ^3H -adenine into nucleic acids. These results were compared to rates obtained using three concentrations of ^3H -thymidine. Particulate ATP content was used to calculate total microbial biomass. The ratio of ATP and non-ATP luminescence was assessed as a possible index of growth rate. Algal biomass was measured by Chl a fluorescence. The uptake and respiration of ^{14}C -glutamate provided an estimate of heterotrophic potential within each size fraction. The uptake of ^3H -glutamate gave an independent measure of the metabolism of this substrate.

The measured dependence of ^3H -thymidine uptake on concentration, and its incorporation into RNA and protein as well as DNA, suggests that the established protocol for this technique could lead to substantial errors in estimates of heterotrophic growth rates. Bacteria and algae smaller than 1 μm were at times the dominant planktonic organisms in the study pond. Essentially all glutamate was taken up by organisms < 1 μm implying that most active bacteria were not attached to particles. Microbial growth rates were inversely proportional to size. The relative reliability of the techniques and their potential in aqua-culture research are discussed.

24. THE INCIDENCE AND EFFECTS OF THE VIRUS BACULOVIRUS PENAEI (BVP) ON THE PERFORMANCE OF PENAEUS VANNAMEI NURSERY PONDS.

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A field analysis for the presence of the virus Baculovirus Penaei (BVP) inclusion bodies was conducted on Penaeus vannamei juveniles at the Acuespecies S.A. nursery ponds in Ecuador. The study was conducted on 24 nursery ponds of 0.6 hectares over a period of four months. Three 30 shrimp samples per pond were taken on seven-day intervals until harvest. Twenty wet-mount examinations were taken from hepatopancreas of each shrimp. The weight of the shrimp were recorded. The production data will demonstrate that the presence of virus Baculovirus in the nursery phase is not a significant factor.

25. CHINESE INTEGRATED AGRICULTURE AND AQUACULTURE: AN ECONOMICALLY AND ECOLOGICALLY EFFICIENT SYSTEM. W.Y.B. Chang, Great Lakes Research Division University of Michigan, Ann Arbor, Michigan.

Aquaculture practice in China dates back more than 3,000 years with the first document on the culture of common carp (Cyprinus carpio) assembled in 500 B.C. by Fan Li, who described widely used culture methods of the time. This document showed that even this early in human history Chinese fish culture had been integrated with agricultural production. Since then many improvements have been made; the Chinese have perfected culture practice and led the world in per unit pond fish production (exceeding 10,000 kg/ha in 1985). Two main types of integrated agriculture/aquaculture practices are found in China today. Integrated pond aquaculture, which turns the wastes from animal husbandry and the by-products

from fields into food and feed and uses a high fish stocking density and rotation in harvesting to achieve high rates of fish growth and production, is the principal method used. This is an efficient ecological system since the agricultural wastes are used to produce fish while the aquaculture wastes such as pond soil are used for crop production. Integrated lake farming systems have further improved 'this operational efficiency by reducing the problem of low dissolved oxygen and increasing the production of aquatic plants which have higher growth rate and are more efficient as fish feed than phytoplankton. My presentation will cover the basic ecological concept of Chinese integrated aquaculture, various operational models used in Chinese integrated aquaculture, and the economical benefits of the integrated culture systems.

26. ACCUMULATION OF INORGANIC NITROGEN COMPOUNDS IN THE PRAWN PONDS.

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Inorganic nitrogen compounds were monitored both in the hatchery and grow-out ponds of Penaeus monodon in Taiwan. The newly hatched P. monodon nauplii were reared in the ponds (4 x 7 m) with a stocking density of 100 nauplii/L until they reached the 10-12th day of the postlarva stage. The P. monodon postlarvae (PL23-25) were cultured in the ponds (45 x 31 m) about four months with a stocking density of 143 postlarvae/m². There were changes in 0.021-0.650 mg/L ammonia-N, 0.003-0.031 mg/L NH₃-N, 0.001-0.078 mg/L NO₂-N, 0.013-0.184 mg/L NO₃-N and 0.010-1.281 mg/L ammonia-N, 0.001-0.133 mg/L NH₃-N, 0.002-0.069 mg/L NO₂-N, 0.003-0.112 mg/L NO₃-N at the first and second trials in the hatchery ponds. There were changes in 0.002-6.598 mg/L ammonia-N, 0.002-0.136 mg/L NH₃-N, 0.013-4.543 mg/L NO₂-N and 0.018-0.520 mg/L NO₃-N in the grow-out ponds. Nitrate rather than ammonia contributes to the survival rate of larvae in the hatchery ponds. Higher concentrations of ammonia and nitrate affected the growth and survival in the grow-out ponds. Besides providing oxygenation, water replacement is suggested.

27. INTENSIVE GROW-OUT TRIALS OF TIGER PRAWN AND RED-TAILED PRAWN IN TAIWAN.

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One grow-out trial of the tiger prawn Penaeus monodon and two continuous trials of the red-tailed prawn P. penicillatus were operated in a highly intensive system in Taiwan. The P. monodon postlarvae (PL 25-27) of 600,000 were reared in six 0.14 ha ponds and the P. penicillatus postlarvae (PL 8-12) of 720,000 and 1,200,000 were reared in three 0.14 ha ponds, respectively. Each pond is 2.2 m depth and is installed with two 1-Hp paddlewheels. Both species of the prawns were only fed with commercially formulated feed four times a day. Yield obtained for P. monodon was 848-1,500 kg/0.14 ha with an average of 1,212 kg/0.14 ha. Whereas, yield was 4,650 kg/0.42 ha and 5,160 kg/0.42 ha for P. penicillatus at first trial. The production were also compared with those reported before and a survey from conventional grow-out farms. The productivity of this system producing P. monodon and P. penicillatus was 8.7-21 tonnes/ha/crop and 11-12 tonnes/ha/crop, respectively. The studies indicated that increasing stocking as well as air supply,

controlling inlet and drainage of water flow and deepening water level are capable of elevating the production in a small impounding area.

28. STUDY ON THE ELIMINATION OF AMMONIA AND NITRATE IN THE LAVICULTURE OF PRAWN,
Jiann-Chu Chen*, Ping-Chung Liu and Yao-Tsu Lin Department of Aquaculture, National Taiwan College of Marine Science and Technology, Keelung, Taiwan, 20224 Republic of China.

Since ammonia and nitrite, the most common toxicants, increased exponentially both in the hatchery and grow-out ponds many efforts have been made to eliminate or reduce the concentration of these chemicals. Besides water replacement, a well balanced ecosystem is considered for the ponds having microorganisms, algae, Artemia nauplii, artificial feed and prawn larvae. Tiger prawn, Penaeus monodon postlarvae were cultured in the holding tanks with and without adding nitrifying bacteria solution, respectively. Parameters of ammonia, nitrite, nitrate, sulfide and chemical oxygen demand (COD), etc. and growth and survival of the animals were monitored. The results indicated that an appropriate use of nitrifying bacteria could help reduce the ammonia and nitrite concentrations in both closed and recirculated systems. The postlarvae reared in the recirculated system has better growth and survival than those in the closed system. A new hatchery system with recirculated water developed for commercial use is suggested.

29. QUALITATIVE LIPID REQUIREMENTS OF MILKFISH (CHANOS CHANOS) JUVENILES FED PURIFIED DIETS,
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Five purified diets, differing only in their lipid source, were fed to juvenile milkfish (Chanos chanos). Dietary lipids were selected to cover a wide range of omega 3: omega 6 fatty acid ratios, and to provide different degrees of unsaturation. The control diet was lipid free, and the four remaining diets contained one of the following oils, added at a 10% inclusion level: coconut oil, soybean oil, menhaden oil and mixture composed of 3 parts menhaden to 7 parts soybean oil.

After 21 days, the best growth performance (85% increase in body weight) was observed in fish receiving the diet supplemented with the 3:7 mixture of menhaden and soybean oil, followed by those receiving the diet supplemented with coconut oil (69.3% increase). Growth performance of fish receiving the diets supplemented with menhaden oil and soybean oil was virtually identical (61.5%). Growth was poorest (47.3%) in milkfish receiving the lipid-free control diet. Survival rate was 100% for milkfish receiving the diets supplemented with 10% lipid, and 96% for those receiving the lipid-free survival, and feed conversion, the diet supplemented with a 3:7 mixture of menhaden and soybean oil came closest to providing an adequate source of dietary lipids for juvenile milkfish.

30. THE EFFECTS OF AGED SEDIMENT AND STOCKING DENSITIES ON FRESHWATER PRAWN MACROBRACHIUM ROSENBERGII CULTURE.
Yew-Hu Chien*, Department of Aquaculture Hong-Tsu Lai, Institute of Fisheries, National Taiwan College of Marine Science and Technology, Keelung Taiwan, R.O.C.

Excess feed and metabolites from intensive culture system always cause deterioration of the sediment and water quality. To assess the effects of aged

sediment and stocking densities on the freshwater prawn Macrobrachium rosenbergii culture, 32 tanks were assigned to 16 treatments in a 4 x 4 factorial arrangement; 4 stocking densities: 0, 16, 23, 31/m² by sediment of 0 ooze content: 0, 25, 50, 100%. Survival and growth of prawn were recorded routinely, water and sediment were analyzed. Besides the density factor, increase of NH₃, NO₂⁻, and NO₃⁻ in surface sediment was the reason which caused the growth retardation when stocking density increased. Constant aeration might keep the toxic substance under lethal level and result in insignificant difference in mortality among treatments. The increase of ooze content enhanced the drop of Eh (redox potential), the increase of TN (total N), NH₃ and S²⁻ in the sediment. Crawling activity of prawn and constant aeration kept the Eh above highly reduced level and minimized the differences of sulfide among treatments of various stocking densities. Along with the increase of stocking density, NO₃⁻ and NH₃ in water, surface and subsurface sediment, TN in surface sediment, TN, NO₂⁻ and sulfide in subsurface sediment increased.

31. CHOLESTEROL REQUIREMENT OF POSTLARVAL PENAEUS VANNAMEI.
Ann E. Clark* and Addison Lawrence, Shrimp Mariculture Project, Texas Agricultural Experiment Station, Texas A&M University System, P.O. Drawer Q, Port Aransas Texas 78373.

A purified diet was used within an innovative experimental system to determine the cholesterol requirement of Penaeus vannamei. Cholesterol is a dietary essential due to its inability to be synthesized de novo. Post-larval shrimp averaging 63 ± 14 mg and 58 ± 7 mg were fed casein-gelatin based purified diets containing varying levels of cholesterol. The levels tested were 0%, .5%, 1%, 2%, and 4%. Data suggests that the minimum requirement for good growth is .5%. Growth at this level after 14 days averaged 679 ± 64% and 672 ± 103%, survival averaged 93 ± 5% and 92 ± 12%.

32. LECITHIN REQUIREMENT OF POSTLARVAL PENAEUS VANNAMEI,
Ann E. Clark* and Addison Lawrence, Shrimp Mariculture Project, Texas Agricultural Experiment Station Texas A&M University System, P.O. Drawer Q Port Aransas, Texas 78373.

The lecithin requirement of Penaeus vannamei was evaluated using a casein-gelatin based purified diet. Lecithin is a questionable essential lipid in shrimp diets, especially because of its varying fatty acid composition. Post-larval shrimp averaging 63 ± 14 mg and 58 ± 7 mg were fed diets containing different levels of soy lecithin. The levels tested were 0%, .5%, 1%, 2%, 4% and 8%. Results suggest that the requirement is between 2% and 8%. Growth at these levels after 14 days ranged from 596 ± 120% to 688 ± 126%. Survival ranged from 68 ± 4% to 91 ± 9%.

33. A NEW SYSTEM FOR DOUBLE CROPPING SHRIMP.
Harry L. Cook*, Richard A. Creelman and Ed Cook Ocean Ventures, Inc., Port Lavaca, TX 77979, USA.

The purpose of this research was to investigate the feasibility of a method of managing ponds to produce more than one crop of shrimp per year along the Gulf of Mexico. The culture unit was comprised of three growing ponds of 2.2 acres each which are inter-connected by sluice gates. The two exterior ponds were stocked in May with shrimp which had been head-started in a covered nursery. Stocking density was about 28,000 per acre. At about the same time 660,000 postlarvae (5-6 mm) were stocked in the middle pond. The two outside ponds were harvested in late July. These ponds were then refilled and restocked by opening the sluice gates connecting them to the middle pond. Large juveniles from the middle pond swam into the newly

refilled ponds. All three ponds were harvested in early November.

34. POLYCHAETE BIOMASS AS AN INDICATOR OF NATURAL PRODUCTIVITY IN PENAEID SHRIMP CULTURE PONDS. Jack Crockett*, Leslie Sturmer, Addison Lawrence and John Whitson, Shrimp Mariculture Project, Texas Agricultural Experiment Station, Texas A&M University System, 4301 Waldron Road Corpus Christi, Texas 78418.

Benthic polychaete worms contribute significantly to the nutritional requirements of penaeid shrimp cultured in ponds. There exists a complex relationship between feed, polychaete population and shrimp population. To facilitate the study of this dynamic interaction, a practical method of monitoring polychaete population was developed.

Core samples were taken on a weekly basis from six 0.1 ha ponds stocked with 10.13 juvenile Penaeus vannamei per m². The samples were washed in a benthos bucket. Material retained on a 500 µ screen was immersed in 10% buffered formalin solution containing rose bengal stain for 24 hours. A second washing through a 2 mm screen supported over a 500 µ screen separated polychaetes from detritus and compacted substrate. Polychaetes were isolated from any remaining material with forces and counted. They were dried at 95°C for 75 minutes and weighed to the nearest 0.01 mg,

Biomass of dried polychaetes ranged from 0.119 to 3.870 g per m² while polychaete density varied from 1,919 to 22,311 organisms per m². The average individual weight of dried polychaetes fluctuated from 0.02 mg to 0.55 mg.

Biomass measurements provided a more accurate indication of the nutritional potential of a polychaete population, as variation of average individual weight caused numbers of polychaetes to be misleading. The relationships between polychaete biomass, shrimp biomass and feed are discussed.

35. OPTIMAL DIETARY PROTEIN LEVEL FOR JUVENILE FRESHWATER PRAWN MACROBRACHIUM ROSENBERGII. Louis R. D'Abramo and Laurieann Reed, Department of Wildlife and Fisheries, Mississippi State University Mississippi State MS 39762 USA.

Juvenile freshwater prawn Macrobrachium rosenbergii were fed purified isoenergetic diets containing protein levels of 15, 20, 25, 30 and 35%. Purified crab protein served almost exclusively as the protein source. After 90 days and at least 12 molts survival and weight gain was determined. The mean wet weight increased with increasing protein levels. Significant differences in wet weight existed between all groups except those that were fed the 25 and 30% protein levels. The observed significant reductions in weight gain were the result of decreases in wet weight increase/molt rather than a protraction of the time interval between each successive molt. The optimal dietary protein level for juvenile freshwater prawn is estimated to be between 33 and 35% (dry weight).

36. PREDATION RATE OF TIGER SHRIMP (PENAEUS MONODON) LARVAE ON ROTIFER (BRACHIONUS PLICATILIS). Edward Danakusumah, Bojonegara Research Station for Coastal Aquaculture, P.O. Box 01, Bojonegara Cilegon-42454, Indonesia. Dadi Koswara, Faculty of Fisheries, Bogor Agricultural University Darmaga, Bogor, Indonesia.

Experiments on the predation rate of tiger shrimp (Penaeus monodon) larvae

on rotifer (Brachionus plicatilis) had been conducted under laboratory conditions. The study was aimed to understand the rotifer requirement of P. monodon larvae. The larvae were cultured in beakers of 1,000 ml capacity. They were fed with rotifers at different densities of 10, 20 and 30 individuals per ml.

Result showed linear relationship between density of rotifer and predation rate. To some extent, the higher rotifer density, the higher predation rate. Relationship between larval substage and predation rate showed quadratic curve. Most active predation was found between Mysis-1 and Mysis-2.

37. AN INTEGRATED DISSOLVED OXYGEN MONITORING AND CONTROL SYSTEM, INCLUDING TOTAL DATA MANAGEMENT CAPABILITY, FOR A COMMERCIAL AQUACULTURE OPERATION.

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Dissolved oxygen (DO) monitoring has become one of the most important operational criteria in commercial aquaculture operations. Natural environmental conditions often tend to change the DO holding capacity of water, sometimes in very short periods of time. These changes require excessive manpower usage and often cause increased expenses due to the "overuse" of aeration equipment of oxygen generating equipment.

Continuous monitoring DO instrumentation can now be combined with automatic paging systems, alarms, and/or computer control and data management systems for the purposes of saving the aquaculturist money and allowing him to work smarter in controlling this very important parameter. With new monitoring technologies like self-cleaning DO sensors, proportional control capabilities, etc. the grower acquires the necessary control of the water conditions that are so important for the well-being of his stock. Existing continuous monitoring systems, with various levels of automation, are shown and discussed. Financial considerations are explored and cost justifications defined.

38. EFFECTS OF FERTILIZATION RATE ON PRIMARY PRODUCTION AND YIELD OF TILAPIA IN PONDS.

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Carrying capacity in extensive fish culture ponds is constituted by the quality and quantity of food stuff, as well as water quality. These are influenced primarily by the nature and quantity of the fertilizers applied. We conducted a series of fertilization experiments in earthen ponds in Thailand to determine the carrying capacity for optimal tilapia (Oreochromis niloticus) production. The experiments involved applications of: 1) inorganic phosphate; 2) phosphate and urea; and 3) organic fertilizer. Each experiment was run in 3-4 replicates for a 5-month period. Fish yield, production of potential food organisms (plankton and benthos) and water quality were determined in response to respective fertilizer application. The results show that the pond carrying capacity ranged 'below the poverty line' to 'excessively wasteful' situations. Based on equal amount of P and N fertility, the organic fertilizer (chicken manure) created greater pond carrying capacity than the inorganic fertilizer. An optimal carrying capacity was established in ponds receiving chicken manure at a rate of 500 kg/ha/week, which produced average organic carbon at 100 kg/ha/day and fish yield at 24 kg/ha/day, The indirect food conversion ratio of chicken manure was 3 and the net organic carbon conversion ratio was approximately 5.

39. CHARACTERIZATION OF LEACHING RATE IN SHRIMP FEEDS: MEASUREMENTS OF LOSS IN WEIGHT AND ORGANIC MATTER.
S. Divakaran* and Eirik O. Duerr, The Oceanic Institute Makapuu Point, Waimanalo, HI 96795 USA.

The rate of leaching and consequent loss of macronutrients from five commercial shrimp feeds was determined by measuring their loss in weight and non-volatile organic matter. Weight loss and leaching of organic matter from the feed material into water containing 32 ppt sodium chloride was measured at eight time intervals (from 4 to 48 hours). Loss of non-volatile organic matter was measured by colorimetry as the amount of dichromate reduced from a 5% solution of potassium dichromate in 95% sulfuric acid. A close correlation was observed between weight loss (which included the loss of both organic and water-soluble inorganic constituents) and the loss of organic matter. The method described above can be useful in determining the total loss of water-soluble organic macronutrients (e.g. soluble proteins, crystalline amino acids, soluble carbohydrates, vitamins) from shrimp feeds.

40. BIOCHEMICAL COMPARISON BETWEEN DIPLOID AND TRIPLOID PACIFIC OYSTERS (CRASSOSTREA GIGAS).
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Diploid and triploid cohort oysters, Crassostrea gigas, were sampled at various times during their reproductive cycle, and their biochemical components quantified. A majority of the sampling was carried out in the summer when triploid Pacific oysters devote 60-75% less effort to reproduction than diploids. Proximate analysis was done using the kjeldahl method for protein a phosphosul-phovanillin method for lipids, and anthrone method for glycogen (carbohydrates) and a muffle furnace to determine ash.

Diploid and triploids have a significantly different biochemical patterns. Glycogen levels decreased in diploids from winter values of 30% (dw) to a minimum of 6% at the peak of gametogenesis. Protein in diploids rose from 30% to 80% in midsummer; it appears to be the major component of gametes. Diploid lipid values increased at the start of gametogenesis, but then slowly declined. The annual biochemical patterns for triploids were more consistent. Although delayed and less extreme, the same inverse relationship between glycogen and protein is observed during gametogenesis. Spawning seems to have been detrimental to diploids as the triploid percentage significantly changed between the pre- and post-spawning samples. After spawning, diploid and triploid composition patterns paralleled each other as they slowly return to winter levels when oysters contain similar amounts of the biochemical components. The implications of the different biochemical patterns for marketing triploid oysters will be discussed.

41. OPTIMAL DEPTH AND CULTURE DENSITY FOR PRODUCTION OF SPIRULINA PLATENSIS IN OUTDOOR CIRCULATING ALGAL RACEWAYS.
Eirik O. Duerr*, The Oceanic Institute, Makapuu Point Waimanalo HI 96795 USA.

Donald W, Freeman, USDA-ARS Tropical Aquaculture Research Unit The Oceanic Institute, Makapuu Point, Waimanalo HI 96795 USA. Paul K. Bienfang, The Oceanic Institute, Makapuu Point Waimanalo, HI 96795 USA.

Optimization of the light regimen to which an algal culture is exposed is a

critical consideration in the design and operation of an algal production system. Artificial light supplementation is not cost-effective for large-scale outdoor cultures; methods of optimizing available solar radiation in the culture are therefore required. The bluegreen alga Spirulina platensis was cultured in outdoor circulating algal raceways (5.9 m² each) which were managed at three depths (10, 15 or 20 cm) at a given culture density. A total of four densities (0.2, 0.4, 0.6 or 0.8 O.D._{680 nm}) were examined at each depth. Productivity was determined daily before culture conditions were reestablished by harvesting back the net biomass increase. At the lower densities and depths, growth was inhibited by excess light; at the higher densities and depths, it was inhibited due to insufficient light. Results suggested that a depth of 10-15 cm, combined with a harvesting schedule that kept the culture density close to 0.6 O.D._{680 nm}, provided an optimal algal culture regimen.

42. STATUS AND PROBLEMS OF MASS PRODUCTION OF GREY MULLET, MUGIL CEPEALUS.

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Progress in artificial propagation of grey mullet (Mugil cephalus) has been impeded by the lack of reliable hatchery techniques. In this study, hatchery procedures used in Japan for culturing red sea bream were tested on mullet larvae.

Fertilized eggs were obtained from hormonally induced spawns during the 1986 mullet spawning season (Dec-Mar.). These eggs were hatched in 1,000-liter, open system incubation tanks. Newly hatched larvae were divided into 5,000-liter tanks (N = 8) at a density of 20 individuals per liter. Mullet larvae initially feed 65 hours after hatching at 24°C and average 3.3 mm in total length.

The feeding program was initiated by the introduction at first feeding of s-type rotifers at a density of 5-20 individuals/ml. Chlorella sp. was also stocked at a density of 500 x 10³ cells/ml. Chlorella and rotifer densities are maintained until day 30 and 70, respectively. From day 30, artificial feed (ground shrimp food at 42% protein) was supplemented. Newly hatched Artemia were also utilized between days 30-50. During this period, Artemia densities increased from 0.1 to 2 individuals per ml. Survival rates among the 100,000 mullet juveniles produced during a 6 man-month period ranged between 9 and 25%. The apparent key to larval rearing success is the availability of a sufficient quantity of food.

43. EVALUATION OF VARIOUS GROWTH ENHANCEMENT FACTORS, MEDIA FORMULATIONS, AND SUPPORT MATRICES FOR THE DEVELOPMENT OF PRIMARY AND ESTABLISHED CELL LINES FROM PENAEUS HEPATOPANCREAS.

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The development of diagnostic methods to detect baculovirus penaei (BP) in cultured shrimp populations has been hampered by a lack of sufficient anti-genic material. Cells liberated from hepatopancreatic tissue (HP) of Penaeus vannamei by mechanical treatment were evaluated as source material for development of cell lines suitable for BP virus replication.

HP cells were released from caecae by mechanical agitation; they attached to Cytodex 2 beads and to agar but not the 6 other matrices. The buoyant density of HP cells was determined by Ficoll centrifugation to vary from 1.016 to 1.033 g/ml. HP

suspended cell populations could be subcultivated 4 x (during 2-1/2 mts) in L-15 containing 10% fetal bovine serum and 1% L-glutamine. Cells formed epithelial monolayers on agar surfaces and could be maintained for at least one month exposed to the atmosphere of the flask. BP virus replication was evident in infected, primary cells and demonstrated by the formation of polyhedra.

Mixed HP cell cultures were also established in several growth media (Schneider's drosophila medium, Grace's insect medium, RPMI 1640, MEM, Bulbecco's modified MEM) supplemented with 15% FBS along with various combinations of mammalian cell growth factors. In these studies, best results were obtained using RPMI 1640 or DMEM supplemented with a combinations of growth factors have produced indications of enhanced cell survival. Three subcultivations have been made over a period of 2 months. Poor culture survival was obtained using Grace's or Schneider's media.

44. AN ECONOMICAL COMPARISON OF AERATION DEVICES FOR AQUACULTURE PONDS.

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The physical efficiency of aeration devices has been tested, but the economic efficiency of aerators used in aquaculture ponds has not been determined. Fixed and variable costs were determined and compared for 25 types of aeration devices that included: floating, electric and tractor-powered versions of paddlewheel, pump sprayer, vertical pump, propeller-aspirator pump and diffuser aerators. A linear programming computer model was developed to minimize total annual cost of aeration given different pond sizes, different aeration strategies and different farm sizes.

Fixed costs varied from \$125 to \$1,233 per horse-power per year and comprised from 60 to 90% of total annual cost per aerator depending on the aeration strategy. A farmer's choice of an aerator should be based primarily on the quality of construction, maintenance and repair requirements as well as its operating efficiency. Fiberglass and metal floatation devices and frames will have significantly lower annual depreciation costs than styrofoam floats and plastic frames while those with simpler designs will have lower maintenance and repair costs.

The LP model selected optimal systems for different farm resource situations based on minimum total annual cost. The most cost-efficient aeration systems were determined for: 1) 0.4, 1, 2, 4, 8 and 20-hectare ponds; 2) Watershed versus seine-through ponds; 3) 8, 20, 40, 80, 200 and 280-hectare farms. Economic trade-offs between emergency and continuous aeration were discussed. The additional production needed to justify the additional expense of aeration was calculated for the alternatives considered.

45. DESCRIPTION OF A MEDIUM SCALE PENAEID MATURATION SYSTEM IN THE PHILIPPINES.

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An 8-tank maturation unit was established to supply year round viable nauplii for a Penaeus monodon hatchery whose target production was 2 million postlarvae 15 per month. No broodstock was maintained. Spawners came from

either an estuarine or the open sea. All females are tagged to monitor individual spawning performance. Daily checking is accomplished to lessen the possibility of spawns occurring inside the tank. No spawning tanks are utilized. Gravid females are transferred directly to larval tanks in batches of 3 to 4 per tank. No egg counts, fertility or hatching rates are determined. All unhatched eggs and weak nauplii are siphoned out for two consecutive mornings after the spawn, leaving only healthy, phototactic nauplii in the larval tank. Count at N4 is used as a measure of total viable nauplii. Survival from nauplii to the first protozoal stage is recorded. Daily nauplii production ranged from .5 to .6 million. Materials and methods are discussed in detail as well as production results and observations.

46. PRODUCTION OF FLORIDA RED HYBRID TILAPIA (FEMALE Oreochromis urolepis hornorum X MALE O. mossambicus IN FED AND MANURED SEAWATER POOLS.

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Florida red hybrid tilapia (Oreochromis urolepis hornorum female x O. mossambicus male) were reared in seawater pools in the central Bahamas. Fish (1.3 g mean weight) were stocked in eight plastic-lined pools (23 m³) at a density of 25/m³ (250,000/ha). Fish in four pools received floating pelletized feed (30% protein) three times per day to appetite satiation and four pools received daily application of chicken manure at 105 kg/ha/day (dry weight). All pools received continuous diffused aeration at 57 lpm and flow-through seawater providing a daily exchange of a 4.0 and 0.1 times for fed and manured pools, respectively. Water temperature averaged 27°C and salinity averaged 37 ppt.

In fed pools, mean fish weight was 114 g after 80 days at a survival rate of 92%. After 170 days, mean fish weight was 467 g at a survival rate of 89%. Over the 170 day period, fish productivity increased to 806 kg/ha/day and the food conversion ratio (dry weight: wet weight) was 1.7. Expressed in logarithmic (natural) form, growth rate (% weight/day) and feeding rate (% weight/day) were linear functions of fish weight.

In manured pools, mean fish weight was 19 g after 80 days at a survival rate of 70%. Mean fish productivity increased to 80 kg/ha/day over the first 20 days, as in fed pools, but declined over the remaining 60 days to less than 10 kg/ha/day. Mean productivity over 80 days was 32 kg/ha/day for manured pools and 270 kg/ha/day for fed pools.

Water quality, bacterial productivity, phytoplankton and macroalgae productivity and plankton density and composition were also measured and their relationship to fish productivity examined.

47. RICE-CRUSTACEAN CULTURE: POTENTIAL IN SOUTHEAST ASIA.

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Rice, the dominant cereal crop in Asia, is cultured on 21 million ha and annually produced a by-product of over 1,000 million tons of straw, leaf, bran and hull in Asia. These represent a potential resource for aquaculture which except for a small percentage of the area (=1%) used for rice-fish culture, remains practically an untapped resource. Interest in rice-fish culture in Asia declined with the increased use of pesticides during the Green Revolution, but with the recent development of new high-yielding resistant rice varieties and natural pest control agents, there has been renewed interest. Any species which could directly utilize the nongrain parts of rice or the microcommunity colonizing the nongrain parts should integrate well in a rice based aquaculture system.

The thesis of this presentation is to explore the role of a crustacean in a rice culture system reviewing the advantages (e.g. increased yield/ha) and constraints (e.g. pesticide use). The methods of rice-crawfish culture in the United States are discussed with comparisons to the few studies of rice-crustacean culture in Southeast Asia. The prospectus of adding income to the producer is evaluated and recommendations are made for considering future development.

48. A DESCRIPTION OF MARINE SHRIMP CULTURE IN TAIWAN AND ITS SIMULATED TRANSFER TO HAWAII.

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Eleven intensive style marine shrimp farms were surveyed in southern Taiwan and descriptions of these farms are presented. Based on these descriptions, we constructed a model of a well-run Taiwan shrimp farm. We then conducted an economic analysis of this hypothetical farm in Taiwan and its simulated transfer to Hawaii. Comparisons are made.

49. THE NUTRITIONAL RESPONSES OF THREE SPECIES OF POSTLARVAL PENAEID SHRIMP TO COTTONSEED MEAL.

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This study investigates the use of cottonseed meal, a low-cost high protein source, in the diets of postlarvae for three penaeid shrimp species, *Penaeus setiferus*, *P. stylirostris* and *P. vannamei*. Four cottonseed meal levels, 0%, 5%, 10% and 20%, for two protein levels, 20% and 30%, were evaluated using 19 liter tanks in the laboratory. Survival ranged from 91-100% for *P. setiferus*, 84-95% for *P. stylirostris* and 98-100% for *P. vannamei*. For all three shrimp species tested, shrimp fed the higher protein level of 30% exhibited significantly higher final mean weights, average weight gains and present weight gains than those fed the lower protein level of 20%. For feeds containing 30% protein, both *P. vannamei* and *P. stylirostris* showed no significant differences in final weights for all cottonseed meal levels tested. However, *P. setiferus* showed a significant decrease in growth when fed diets containing 20% cottonseed meal at 30% protein. For feeds containing 20% protein, up to 10% cottonseed meal may be added to *P. vannamei* and *P. stylirostris* feeds without significantly affecting growth. Adding 5% or higher levels of cottonseed to 20% protein diets for *P. setiferus* causes a significant decrease in weight gain. The

data indicate that different levels of cottonseed meal can be used in the diet of penaeid shrimp depending upon the shrimp species and protein level in the diet.

50. NUTRITIONAL RESPONSE OF POSTLARVAL PENAEUS VANNAMEI TO DIFFERENT SOYBEAN LEVELS.

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This paper investigates the nutritional response of 0.04 g Penaeus vannamei to different levels of soybean meal using 19 liter tanks in the laboratory. At 25% and 35% protein levels, 15%, 25%, 45% and 53% and 30%, 45%, 60% and 75% soybean levels were tested, respectively. Survival at the 25% protein level was significantly better than survival at 35% protein. Survival of shrimp fed 25% and 35% protein diets was 76-95% and 86-96%, respectively. Differences in survival between soybean levels within each of the two protein levels tested were not significant. Growth, in terms of final mean weight, over a 14 day experimental period was not significantly different for the two protein levels tested. Comparisons of the various diets tested on P. vannamei suggest that in diets containing soybean meal, feeding at a lower protein level (25%) gives better survival with no significant decrease in growth. Furthermore, for 35% protein diets, 45% to 60% soybean meal can be added without significantly affecting growth. Adding 75% soybean meal causes a slight decrease in weight. The presence of 25-53% soybean meal is advantageous in feeds containing 25% protein. This study complements previous studies done on juvenile and subadult penaeid shrimp.

51. WATER QUALITY MODEL FOR SHRIMP POND MANAGEMENT.

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One of the key factors in aquaculture is water quality management, the creating and maintaining of a high quality environment for the cultured animals. Within this study we developed a general algorithm describing the interrelationship between the different parts of the ecosystem and their influence on the water quality by using SLAM II, a Fortran based simulation language. The objectives of the algorithm are: 1) determine which phenomena dominate the pond water quality dynamics; 2) devise management suggestions which will reliably improve or stabilize the environment quality of the pond at a reasonable cost; 3) indicate which areas require further scientific investigation based on sensitivity analysis.

52. ARGULID PARASITES OF IMPORTANCE TO INDIAN MAJOR CARPS.

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The fish lice (Argulus spp.) are probably of economic importance since heavy infestations of lice may destroy the entire fish populations in confined environment. The problem of parasitism and its attendant degeneration are among the most interesting features in the whole realm of ecology and evolution. The grade of parasitism and the resultant effects in the habits, morphology and biology of the branchiuran parasites are studied. Argulids are the most widespread crustacean

ectoparasites of both fresh and saltwater fishes of the world. Altogether 540 fish were examined and the degree of infestation (30%) together with numerical abundance of Argulus raychoudhuriin, sp. on its hosts (540) has been highlighted. A range from 14% to 71% of Indian major carps had argulid infestation.. In lieu of host specificity, host preference by this parasite has been discussed. Statistical analysis reveals an association between host species and infestation level. The largest extents of infestation with argulid are shown by Catla catla (31.8%), Labeo rohita (40%) and Cirrhinus mrigala (12.5%). A simple correlation coefficient (r) between the rate of infestation and environmental parameters in the sampling pond was determined. It reveals that both water temperature and CO₂ play positive roles while pH and dissolved oxygen play negative correlation towards increase and decrease of infestation level. To protect the fish from parasitic affliction, the manipulation of the environmental parameters may help so as to avoid the indiscriminate use of pesticides.

53. INFLUENCE OF DAILY WATER CHANGE ON MEDIUM QUALITY AND GROWTH OF PENAEUS STYLIROSTRIS IN SEMI-INTENSIVE CULTURE CONDITION IN NEW CALEDONIA.

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Three experiments were conducted to examine the effect of daily water change on the semi-intensive grow-out with P. stylirostris in the Station d' Aquaculture de Saint Vincent (a joined project between Ifremer, France-Aqua-culture and the territory of New Caledonia). Three daily water changes were applied (initially 5, 10 and 20%) in 1,000 m² earthen ponds, stocked with 12 juveniles/m² (initial mean weight: 1.4 g).

After 129 days, final mean weights were respectively: 20.8 g, 21.6 g and 23 g and extrapolated yields: 4.9, 5.2 and 5.8 T/ha/year, survival rates ranging from 79 to 81%.

Daily water change has affected environmental parameters as soon as the beginning of the rearing, but growth has only been affected beyond 10 g mean weight 5% water change has induced, when the load reach 100 g/m², important risks of mortality (drop of oxygen level-deterioration of the soil) that needed massive water changes.

The most important daily flow (25% in final) has allowed the obtainment of the best growth, a higher yield and an easier rearing control.

54. SHRIMP FARMING IN TEXAS: CAN IT BE DONE?

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Four different types of shrimp farms utilizing 655 acres of land were evaluated for the mid coast of Texas. Type I stocked postlarvae directly into grow-out ponds and produced one crop of edible shrimp per year. Type II utilized intensive nurseries and produced two crops per year. Types III and IV used large nurseries ponds and produced two and three crops per year, respectively. Investment cost ranged from \$2.08 million for Type I to \$2.64 million for Types III and IV. Type II farm had the greatest production level followed by Types IV, III and then I. Type IV had the greatest annual cost of production whereas Type I had the least. Types I and II had

almost a 25% internal rate of return on investment before income taxes whereas Types III and IV had less than 5%.

55 THE EFFECTIVENESS OF FOUR PRIMER/RESOLVER REGIMENS OF CPH AND LHRH-A ON THE INDUCED SPAWNING OF GREY MULLET, MUGIL CEPHALUS.

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Two hormone injections (i.e. a primer and resolver) were used to induce spawning in the grey mullet, Mugil cephalus, during the 1985-1986 spawning season. Four combinations of carp pituitary homogenate (CPH) and LHRH-analogue (CPH/CPH, CPH/LHRH-a, LHRH-a/CPH, LHRH-a/LHRH-a) were tested in 41 spawning attempts. Another four fish received saline injections and served as sham controls. The effectiveness of each hormonal therapy was evaluated in terms of spawning success, fecundity, fertilization rate and the time elapsed from initial and secondary injections to spawning time.

The results demonstrate that a hormonal therapy was required for inducing mullet to spawn. No significant differences existed among the four regimens in terms of spawning success, fecundity, or the time intervals between the injections and the spawns. Multiple contrasts showed that the CPH/CPH regimen had a significantly lower rate of fertilization compared to the other regimens being tested.

56. INTENSIVE CULTURE OF UDANG WINDU (PENAEUS MONODON FAB.) IN KARAWANG REGION.

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Intensive cultures for Udang Windu (Penaeus monodon) have been conducted in the brackishwater pond at Karawang region. The Udang Windu have been cultured in various densities and conditions, to get more information to improvement for culture techniques and grow-out management, especially for Karawang region. Varied production was obtained depending on the season of the year.

57. THE RELATIONSHIP BETWEEN WATER CHEMISTRY AND GROWTH OF TILAPIA NILOTICA IN RWANDAN (CENTRAL AFRICA) FISH PONDS FERTILIZED WITH CHICKEN MANURE.

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Richard A. Tubb and Wayne Seim, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97311 USA.

Water chemistry and growth of Tilapia nilotica were examined in ponds at the fish culture station of the Universitie National du Rwanda, located at an altitude of 1,700 meters (5,600 feet). Chicken manure was broadcast onto the ponds at one of three levels: 125, 250 and 500 kg/ha/wk. Experiments were conducted for 150 day repetitions. Minimum water temperatures (surface) in the experimental ponds ranged from 17°C to 22°C during the experiment and maximum pond temperatures (surface) ranged from 25°C to 29°C.

Fish growth and net productivity were significantly higher in both repetitions in ponds receiving the highest inputs and in those receiving the lowest levels. In the second repetition, growth averaged 0.8 g/day in the highest treatment and 0.4 g/day in the lowest; net productivity averaged 26 kg/are/yr and 12 kg/are/yr, respectively.

Total phosphorus, not filterable orthophosphate and total nitrogen levels, as well as pH, and chlorophyll a, were significantly higher in ponds receiving the highest inputs.

58. VITAMIN REQUIREMENTS OF FRESHWATER PRAWNS,
MACROBRACHIUM ROSENBERGII.

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Postlarval Macrobrachium rosenbergii were reared on purified diets for 12 weeks in individual cages. Deletion of fat-soluble vitamins did not significantly affect growth rates. Deletion of trace minerals significantly reduced growth rates, but the effect was small. Deletion of water-soluble vitamins caused great mortality. Ten water-soluble vitamins were individually deleted in subsequent experiments and deletion of vitamin C was found to be responsible for the mortality. Other symptoms of vitamin C deficiency were a somewhat higher incidence of small subcuticular black or dark brown lesions, molting of only the abdomen (or only the posterior part of it) for prawns dying while trying to molt, and the presence of subcuticular blotches in the rostrums and in other parts of non-molting animals, these blotches usually being white in living animals and brown in dead ones. Deletion of pyridoxine was found to significantly reduce growth rates. Deletion of riboflavin significantly increased growth rates, indicating that riboflavin was present at a detrimentally high level.

59. GIANT CLAM CULTIVATION IN THE PACIFIC ISLANDS.

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Giant tridacnid clams were historically an important seafood in the Pacific Islands, but in many areas natural stocks have been reduced to biological or economic extinction by subsistence and commercial harvesting. During the past five years the Pacific Fisheries Development Foundation (NMFS/NOAA), the US Department of the Interior, the UN/FAO and other international agencies have funded a giant clam research and development program based at the MMDC laboratory in Palau.

The MMDC has pioneered the development of a low-cost, low-technology system for giant clam spawning larval culture, juvenile culture and grow-out in shallow coral reef waters. Clam growth rates under cultivation have been shown to be relatively rapid, even in the absence of food or fertilizer inputs. Techniques have been developed for control of pests, predators and algal fouling. The use of direct-drive diesel pumps has eliminated dependence on municipal power grids, formerly a serious constraint in Micronesia.

MMDC personnel have raised six of the seven tridacnid species, producing over one million seed clams and some 75,000 pounds of biomass. Several Tridacna derasa cohorts have been raised to full sexual maturity at age five years and production of second-generation cohorts is now practiced routinely, giving independence from wild broodstock. Techniques have been developed for air-

freighting seed clams abroad, and to date more than 45 international shipments have been made. In 1987, revenues from sales of seed clams at the MMDC were invested in reconstruction of the hatchery, doubling its size and production capacity.

Low-technology methods for giant clam hatchery culture and grow-out are now being transferred with demonstrable success, to a number of other countries in the region. Some 12 nations or nation-states in the tropical Pacific have undertaken personnel training and stock enhancement programs using seed clams produced and marketed by the MMDC. Ocean-based cultivation of giant clams is proving to be technically and socially feasible in some very remote Pacific Island settings, where other kinds of marine and terrestrial farming are clearly impractical.

60. SEEDLING PRODUCTION OF PRAWN PENAEUS JAPONICUS FOR RELEASING CONDUCTED BY FISHERMEN'S COOPERATIVE.
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Seedling production of prawn Penaeus japonicus has been rapidly developed during the last 20 years. Now fishermen's cooperative produce the larvae in their own hatchery and release them to their section of the sea. One of the typical examples of such system is the Yatsushiro Fishermen's Cooperative Association located in the Yatsushiro Bay, Kumamoto Prefecture, southern Japan. They have 10 concrete tanks (about 1,000 m³ in total volume) in the hatchery. Annual seedling production is about 7 or 8 million prawn juveniles. All of them have been released for propagating the prawn resources in the natural waters.

In this paper, the seedling techniques in the hatchery and methods of the releasing are introduced. During the last five years, statistic analyses of prawn catching are also discussed.

61. OPTIMAL HARVESTING AGE OF CULTURED MARINE SHRIMP.
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A dynamic decision model is developed to determine the optimal harvesting policy of a shrimp-producing firm. The model incorporates uncertainty in market price and biological growth of shrimp. It also takes into account the effect of seasonality in both price and growth. It provides a set of cut-off prices, weights and revenues as simple managerial decision rules. Results of applying the model using the Oceanic Institute's experimental round pond data and also a commercial shrimp farm in Hawaii will be discussed.

62. ECONOMIC PROGRAMMING MODEL FOR OPTIMAL INTENSIFICATION OF AQUACULTURAL PRODUCTION SYSTEMS.
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Aquacultural farm managers face critical decisions on the appropriate level of intensification. An economic programming model was developed to demonstrate the impact of resource endowments, market situations and biological parameters on intensification decisions. Optimal intensification will vary based on the producer's physical and market environment. By varying critical factors in the "environment", the model indicates changes in the production system that will result. Penaeid shrimp production is used to demonstrate the models' capabilities.

Alternative production intensifications ranged from extensive systems based on natural carrying capacity to intensive pond systems. Use of extensive systems is limited by the availability of unique physical endowments including intertidal land, wild fry and water quality. As these limitations increase, production systems must be based on greater intensification with use of nutrient inputs, higher stocking, and controlled water exchange. Further intensification involves increased rates of input use and the additional inputs of aeration and greater technical skills. The most intensive systems included in this study were restricted to ponds that did not utilize controlled environment aqua-cultural techniques.

Resource endowment effects investigated in the model include land, seed, nutrients and technical skills. Availability of intertidal land, wild or hatchery post-larvae, local feedstuffs, formulated feeds and management expertise are important factors in intensification decisions. Market situation effects investigated are prices of land, seed, feed and shrimp. Results of the model will indicate the operator's appropriate reaction to changes in relative prices among inputs and outputs. Biological parameters investigated include feed conversion and survival. These production coefficients may vary substantially as a result of lack of research data or the individual operator's inability to achieve research production levels.

The model can be expanded to address other effects dependent on the critical factors in the environment faced by the decision maker. Thus, the model will be useful to farm managers and planners who can adjust its parameters to address their individual circumstances and critical concerns.

63. INDUCED MATURATION OF POND-REARED ABLATED PENAEUS MONODON.

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The effect of tank color and eyestalk tags on reproduction of ablated pond-reared Penaeus monodon in a 12 m³ circular flowthrough tank was tested. In the first experiment, 8-mo-old (9 mo from spawning) females in the black painted tank gave higher nauplii production (6.3×10^6) and hatch rates (54.0%) than in unpainted tanks (1.4 to 3.5×10^6 nauplii, 22.8 to 51.7% hatching). In the second study using 6-mo-old broodstock, the painted tanks gave higher nauplii production but not hatch rates. Average larval production per tank was lower (1.1 to 2.3×10^6 nauplii) compared to the first study. In both experiments, tagging of the (unablated) eyestalk did not appear to affect mating behavior and fertilization rates. Average daily number of spawns, hatch rates, eggs and nauplii produced per tank over a 12-week period are given.

64. IMPACTS OF INTENSIVE SHRIMP PRODUCTION ON THE CULTURE POND ECOSYSTEM.

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Pacific white shrimp, Penaeus vannamei, were cultured in three replicate 0.25 ha ponds at each of three densities, 20, 40 and 60 shrimp/m². The ponds were continuously aerated and water was exchanged at a rate which generally increased over the production cycle. Instantaneous aeration and water exchange rates were similar for all ponds. Various aspects of the pond water chemistry and biota were monitored over the course of the production cycle. Comparisons are made between and within density treatments. Spatial differences within ponds were determined for the various parameters. Both long term and diurnal temporal differences within ponds were also determined. The primary parameters measured were temperature, salinity, dissolved oxygen, biochemical oxygen demand, ammonia, nitrite, phosphate, turbidity, hydrogen sulfide, pH, chloro-phyll-a, primary productivity, phytoplankton species composition, zooplankton concentration and species composition, coliform bacteria, benthos density and species composition. In addition, shrimp growth was regularly monitored.

Correlations were noted between shrimp density and the level of dissolved oxygen, nutrients, BOD, chlorophyll-a, primary productivity and various aspects of the biota. Long term temporal differences were noted for these parameters as well. As supplemental aeration was begun, spatial differences within ponds disappeared as a result of the rapid mixing of the water column. Diurnal fluctuations were noted in the dissolved oxygen, pH, and chlorophyll-a. Chlorophyll-a levels dropped rapidly at dusk and rose rapidly in the morning while levels were nearly stable through the night and through midday. The benthic population, primarily polychaetes and the aquatic insect population was high early in the production cycle, yet disappeared abruptly after several weeks.

65. THE EFFECT OF SALINITY ON GROWTH OF OREOCHROMIS AUREUS.
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Oreochromis aureus fry, seven days after hatching were reared at salinity levels of 1, 10 and 20 ppt for four weeks. Thirty fingerlings were stocked in circular fiberglass reinforced plastic tanks holding 2,000 l of water of 1, 10 and 20 ppt. Five replicates were used for 1 and 10 ppt and one for 1 and 20 ppt. Growth tests lasted for twenty weeks for the former and seven months for the latter.

The results showed that initially growth was faster at 1 ppt than at 10 and 20 ppt. Four weeks after stocking, however, body weight and body length of fingerlings were significantly higher at 10 ppt than at 1 ppt and after three months, growth was also significantly faster at 20 ppt than at 1 ppt. There were no injuries to the fish due to frequent measurement and no significant difference in survival rate, indicating that O. aureus has a good potential for culture in brackishwater.

66. A STATUS REPORT ON SHRIMP FARMING IN INDONESIA.
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The data presented in this report were mostly collected from the survey during the author's extensive travels around the country from January to May 1987. Official data were adopted only when it was verifiable.

Indonesia contributed 31,600 tons of shrimp, a total value of 259 million U.S. dollars to the world's seafood market. About half of them, 15,000 tons, were from

aquaculture. There are approximately 150,000 hectares of coastal land available and already developed for shrimp culture. Due to insufficient supply of postlarvae, only half of them were utilized for shrimp culture in 1986.

Up to May 1987, there were only 400 hectares in semi-intensive operation and the rest were extensive ponds. Production from extensive ponds was 100-200 kg/ha/crop while it is 2-6 tons/ha/crop from semi-intensive ponds. Two crops can be achieved in each year.

The number of wild-caught postlarvae amounted to 500 million in 1986 and is on the decline while 270 million were produced from hatcheries. Among 130 licensed hatcheries, only about 60 are in operation and less than ten are in consistent production of more than three million of postlarvae per month. Demand for 1987 is estimated to be two billion.

Shrimp culture has caught national attention for its high profitability and short payback term. Net return for extensive ponds can reach as high as US\$1,600 per hectare per year. A farm with ten hectares of semi-intensive ponds can gain more than US\$500,000 each year. A hatchery which costs US\$150,000 to build can produce up to 30 million of postlarvae and is capable of making US\$300,000 profit. Payback requires two to three years for a semi-intensive farm without experiencing major problems and one to two years for a well-run hatchery.

67. NATURAL SPAWNING AND LARVAL REARING OF GOLDEN-RABBITFISH, SIGANUS GUTTATUS (BLOCH).

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In Indonesia, Golden-Rabbitfish, Siganus guttatus (Bloch) is considered as potential candidate for mariculture because of its fast growth and high price. In order to promote the Golden-Rabbitfish mariculture, especially the seed production, attempts of breeding and larval rearing had been conducted at Bojonegara Research Station for Coastal Aquaculture, Indonesia.

Eight pairs of broodstock were selected and captured in a 10-ton concrete tank. The fish were fed with minced fish or shrimp mixed with aquatic-plant Ipomoea reptans. Spontaneous spawning occurred every month (3-7 days after new moon) between March and October 1985. The spawning time was between 8 and 10 PM.

The hatching time was varied between 20-24 hours at water temperature of 26-29°C. The hatching rate was 90-95%. Average total length of newly hatched larvae was 1.7 mm. The critical age was at day-3. The larvae metamorphosed to be juvenile at day-32 when the average total length reached 26.15 mm.

68. COST OF PENAEID JUVENILES IN INTENSIVE RACEWAY SYSTEM.

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This analysis compared the use of intensive nursery raceway system with

direct stocking of pls into grow-out ponds. The intensive raceway system allows two crops to be produced in Texas whereas only one crop is feasible with direct stocking. Both investment and operational cost are analyzed for three types of greenhouses and three types of raceways where the types vary in price and lengths of life. Three grow-out pond stocking densities and two size farms were evaluated for each combination of greenhouse and raceway type. Investment cost ranged from 142 thousand dollars for the small farm using the least expensive type greenhouse and raceway and utilizing the lowest stocking density to about 2.3 million dollars for the large farm using the most expensive greenhouse and raceway and the highest stocking density per hectare in the grow-out ponds. The operational cost was 7.60 and 9.71 dollars, respectively per 1,000 one gram juveniles produced. Generally, the raceway compared favourably with direct stocking for growth was 1.1 gram per week and survival was less than 35% in the grow-out ponds.

69. COMPARISON OF GENETIC VARIATION IN SIZE-SPECIFIC SELECTION OF TILAPIA HYBRIDS UNDER TWO FEEDING REGIMES.

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Genetic parameters of size-specific-growth were estimated in tilapia hybrids (Oreochromis mossambicus/O. hornorum) under two different feeding regimes, namely 'point feeding' and 'broadcast feeding'. The latter reduced within-group competition while the former increased the competition. A scale circulus spacing (CIRC) technique was used as a size-specific-growth estimator. The results showed higher sire-component heritability estimates in the non-competitive than in the competitive treatments. The pattern was reversed for the dam component. The results suggested that maternal effects (i.e., variation in egg size and duration of mouth brooding), which normally the result of genetic parameters estimates, are reduced when growth is measured on size-specific basis.

The higher heritability estimate for size-specific-growth in non-competitive treatment coupled with the very high genetic correlation among sequential estimates suggested that selection for size-specific-growth in non-competitive environments is a promising technique for selective stock improvement in aquaculture.

70 MATURATION PRODUCTION FROM BACULO VIRUS PENAEI (BVP) SHEDDING VERSUS NON-SHEDDING PENAEUS VANNAMEI.

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The virus, Baculovirus penaei (BVP) exists in feral populations of Penaeus vannamei along the coast of Ecuador. At Acusemillas S. A., microscopic fecal examinations for the presence of polyhedral inclusion bodies were conducted on P. vannamei broodstock to determine the reproductive performance from BVP shedding versus non-shedding spawners.

Two thousand three hundred naturally mated spawners were monitored for BVP over a four month period. Comparison in fecundity and nauplii production between 1,100 BVP positive and 1,200 BVP negative spawners resulted in no significant differences.

The data demonstrate that Baculovirus penaei infection in a P. vannamei

maturation system does not have a negative effect on maturation production.

71. PROPERTIES OF EXTRUSION COOKED SHRIMP FEEDS CONTAINING VARIOUS COMMERCIAL BINDERS.

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Shrimp feeds were prepared by extrusion cooking using various commercial binders to check improvement of product stability. Three test diets were utilized in conjunction with the inclusion of low levels of binders. The three diets were based on various formulation strategies: 1) diets containing high levels of marine protein; 2) diets containing low levels of marine protein; and 3) an Oceanic Institute standard test diet.

The extruded shrimp feeds were evaluated for water stability at six intervals over a 24-hour period by measuring the physical integrity of the feeds. The testing system was designed to closely approximate actual feeding trial studies. Results showed that a variance in water stability occurred with the use of different binders in the same formulation. A variance in the pellet water stability was also seen when using various formulations containing the same binders. Conclusions are drawn with regard to binders used in the different formulation strategies .

72. THE ANNUAL REPRODUCTIVE CYCLE OF CAPTIVE MILKFISH, (CHANOS CHANOS) IN HAWAII.

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Three parameters (percent of fish maturing, state of maturity and steroid profiles) were used to study the annual reproductive cycle of captive milkfish in Hawaii. The percentage of fish undergoing maturation and the state of gonadal maturation (oocyte diameter in females and milt volume in males) were obtained monthly between April and November 1985 and again between March 1986 and September 1987. Serum steroid levels (testosterone, 11-ketotestosterone and estradiol) was obtained via monthly blood sampling between April 1986 and March 1987. All three parameters were consistent and indicated that gonadal maturation takes place between the months of April and October. This contrasts with the most restricted spawning season described for wild milkfish. Naturally occurring milkfish larvae have reportedly been found in Hawaiian waters only between the months of June through August.

Data obtained in 1987 on sexually segregated groups suggest that gonadal maturation takes place in segregated males, but is inhibited in segregated females. The sex ratio in maturation tanks can therefore be of potential importance to milkfish culture.

73. THE CORRELATION OF SERUM TESTOSTERONE, 11-KETOTESTOSTERONE, AND ESTRADIOL LEVELS WITH THE ANNUAL REPRODUCTIVE SEASON IN THE MILKFISH, CHANOS CHANOS FORSSKAL.

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In this study, the annual reproductive activity of milkfish, Chanos chanos, was investigated in captive fish held at the Oceanic Institute, Hawaii, USA. Nine female and 11 male milkfish, each over seven years of age, were maintained in two 30,000-liter tanks. From the beginning of March 1986 to the beginning of March 1987, the fish were captured and anesthetized on a monthly basis. Ovaries were biopsied via intraovarian cannulation. Males were subjected to abdominal pressure and the quantity of extruded milt was rated between 0 and 3. Three ml of blood was obtained from half of the fish for radioimmunoassay (RIA) of serum 11-ketotestosterone (males only), testosterone (T), and 17-estradiol (females only). There was a significant increase in the percentage of maturing males and females in April 1986. This number remained high through August. The number of females starting maturation dropped off in September, while the number of males continued through October and dropped off sharply in November. From November through February, the number of maturing fish of both sexes remained low. In March 1987, the number of maturing males began to rise again. Serum steroid levels mirrored these results showing the greatest activity between April and September. Of particular interest is the relatively early rise of 11-ketotestosterone as compared to testosterone in males. This steroid is suspected of playing a role in spermatogenesis in fishes. Its appearance in March, prior to an increase in testosterone may be related to the development of the gonad from its immature off-season state. Although naturally occurring milkfish larvae can only be found between June and August, gonadal maturation may be starting several months earlier.

74. COMPARATIVE SURVIVAL BETWEEN DIPLOID AND TRIPLOID GRASS CARP LARVAE REARED IN PONDS.

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Concerns have been expressed by producers of grass carp (Ctenopharyngodon idella) that triploids are not as competitive as diploids and that survival of triploid fry is reduced in mixed populations. We used a new batch sampling technique (developed by the North Carolina Cooperative Fishery Research Unit) that estimates the percentage of triploidy in larval fish samples to compare relative survival between triploid and diploid larvae reared to fingerlings and/or subadults.

Female grass carp were induced to ovulate using human chorionic gonadotropin and carp pituitary. Triploidy was induced by employing temperature or hydrostatic shock treatments to ova at two to four minute intervals after fertilization. Batch samples of 100 four-day-old larvae were examined using flow cytometry and percent triploidy was estimated for each treatment. Larvae from each treatment were stocked in separate ponds. At harvest, individual blood samples from 120 fingerlings (50-75 mm long) from each pond were examined using a coulter counter to determine percent triploidy. Ponds were restocked and later blood samples from 120 subadults (200-275 mm) were again tested using the coulter counter. In almost all tests, percentages of triploid fingerlings and/or sub-adults were very similar to initial estimates of percentages of larval triploids provided by the batch analysis technique. These results indicate that there were no significant differences in relative survival between diploids and triploids to either the fingerling or subadult stage.

75 BIOMASS EVALUATION OF MACROBRACHIUM ROSENBERGII PONDS IN A CONTINUOUS STOCKING SYSTEM, ON A 27-HA FARM IN FRENCH GUIANA.

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Stock data are a key point for pond and financial management. The proposed biomass evaluation method is integrated into normal fishing activities; it is based on the knowledge of three notions:

a) the fishing efficiency (F.E.) calculable through two successive fishings across the complete surface of the pond:

$$\frac{F_1 - F_2}{F_1} \times 100 = \text{F.E.}$$

b) the net selectivity which is an estimation of the size classes totally and partially caught by the net.

c) the pond population structure by size classes (histogram). The efficiency of the successive fishings and the harvested amount enabled us to calculate the fraction of the pond population reached according to the net selectivity; the relation of this fraction in the population histogram gives the pond biomass.

Reliability is based on a similar fishing efficiency in the two seinings. In fact for more accuracy it is better to use a slightly smaller mesh net than the one used for commercial fishing; three or four biomass evaluations per year can be carried out in a pond. Comparison helps to test an eventual lack of precision. Various calculations are possible and comparable through a computer program. The few draindowns that have had to be done confirmed the reliability of this method.

76 CAGE CULTURE EVALUATION OF TILAPIA HYBRIDS.

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Two cage culture studies were conducted simultaneously from June 3 to August 26, 1987. Study I compared the growth and yield of two hybrid tilapia strains while Study II compared 32 percent (AT32) and 36 percent (AT36) crude-protein floating feeds as cage rations. The studies were conducted in replicate 0.5 m³ floating cages stocked with equal numbers of red- and normal-colored phenotypes at 300/m³. The two strains, similar genetically to Oreochromis aureus (AT) or O. niloticus (NT), were developed via hybridization and five generations of backcrossing. Weight and specific growth (SG) were measured every 15 days.

In Study I, red- and normal-colored AT fingerlings were 45.6 and 53.0 g, respectively, and NT fingerlings were 45.6 and 45.8 g, respectively, at stocking. After 86 days, AT hybrids averaged 193.5 g (SG = 1.68) and 189.5 g (SG = 1.48) and NT hybrids averaged 224.5 g (SG = 1.85) and 215.7 g (SG = 1.80) for red- and normal-colored phenotypes, respectively.

In Study II, red- and normal-colored AT32 and AT36 fingerlings were stocked at 39.5 and 38.4 g and 45.6 and 53.0 g, respectively. After 86 days, red- and normal-colored AT32 tilapia averaged 193.5 g (SG = 1.68) and 189.5 g (SG = 1.48), respectively, while AT36 tilapia averaged 175.0 g (SG = 1.73) and 154.6 g (SG = 1.61) for red- and normal-colored phenotypes, respectively.

77. NITRATE AND AMMONIA DEPLETION IN INDONESIAN AQUACULTURE PONDS FERTILIZED WITH CHICKEN MANURE.

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Twelve 0.2 ha aquaculture ponds for Nile tilapia production in West Java were fertilized weekly with 4 levels of chicken manure: 12.5, 25, 50, and 100 g m⁻². During a 150 day grow out period, weekly ammonia-N and nitrate-N concentrations often exceeded 0.05 mg L⁻¹ in the ponds fertilized with 12.5 and 25 g m⁻² wk⁻¹, but were usually less than 0.05 mg L⁻¹ in ponds fertilized with 50 and 100 g m⁻² wk⁻¹. These differences between treatments in dissolved inorganic nitrogen (DIN), and apparent nitrogen limitation of algal productivity at higher loading rates, were examined through daily and diurnal measurements of ammonia-N and nitrate-N. Data suggest that algal production was limited by a shortage of CO₂ at lower fertilization rates and by a shortage of DIN at higher fertilization rates. At higher fertilization rates, CO₂ for algae was additionally supplied through microbial respiration of organic carbon in chicken manure. Laboratory experiments measuring the release of ammonia-N and nitrate-N from chicken manure and urea were conducted to evaluate nitrogen transfer rates from these materials. An economic analysis is presented which relates appropriate application rates to fish yields and the cost of fertilizers in West Java.

78. THE EFFECTS OF VARIOUS BINDERS ON THE GROWTH AND SURVIVAL OF LARVAL KURUMA SHRIMP, PENAEUS JAPONICUS. FED MICRO-PARTICULATE DIETS BASED ON CRAB PROTEIN.

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Nutritional values of crab protein as a dietary protein source have been recognized suitable for juvenile crustaceans. However, those for larvae are not fully understood. Therefore, the availability of crab protein for micro-particulate diets to larval Penaeus japonicus was examined in this study.

Six binders such as carrageenan, glutens (Gluten M and activated gluten), zein, gelatin, CMC were mixed with microparticulate diet. None of the groups showed good growth and survival compared with the groups fed control diets, indicating the leaching of nutrients due to poor bindings and/or insufficient nutritional values of crab protein for larval shrimps. The next experiment was, therefore, conducted to examine the effect of casein supplement to crab protein and leaching by employing the microcoated diets.

The good performance was obtained from the diet which has 20 and 40% supplement of casein, and there was no effect of coating in those groups. We can conclude that although crab protein is not a superior single protein source for larval P. japonicus, it will be better when other protein source such as casein is supplemented. In such a case, carrageenan is one of the best binders for microparticulate diet.

79. HATCHERY CULTURE OF MAHIMAHU, CORYPHAENA HIPPIURUS; NUTRITION AND DISEASE FACTORS.

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Successful mass production of mahimahi fingerlings requires large quantities of living plankton. As larvae grow, their diet for optimum survival changes from rotifers to copepods and progressively larger plankton species. Artemia salina is not an adequate diet for successful mahimahi culture. Although mortality correlates with diet, significant mortality occurs at all hatchery stages, regardless of diet. Larval mortality patterns are variable, but symptomatic of disease.

High densities of marine bacteria, including *Vibrios* and other classically pathogenic bacterial species, are not necessarily lethal to mahimahi larvae. Antibiotic treatment of plankton can adversely affect larval survival. Detection and avoidance of lethal bacteria species are described.

80. PENAEUS MONODON NAUPLIUS TO JUVENILE ON THE SAME ARTIFICIAL DIET.

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Penaeus monodon larvae have been successfully reared using microencapsulated diets (Frippak Feeds) from late nauplius stage VI to early juvenile stages with an average survival of 60%. Development and growth were dependent on capsule size and feed concentration.

81. PRELIMINARY CALCULATIONS ON THE ENERGETIC REQUIREMENTS OF PENAEUS MONODON LARVAE USING ENCAPSULATED DIETS.

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Ingestion rates for Penaeus monodon larval stages have been measured using algae, Artemia and microencapsulated diets. Respiration rates have also been measured for different larval stages over a range of temperatures. These data have been used together with assimilation and growth rates to calculate preliminary energetic requirements for the larvae.

82. FRESHWATER PRAWN MACROBRACHIUM ROSENBERGII (DE MAN) REARING IN FRENCH GUIANA: MEAN OF PRODUCTION CONTROL IN THE CONTINUOUS GROW-OUT SYSTEM.

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The application of freshwater prawn continuous grow-out system follows a theoretical model based upon a steady progression of different size classes formed by periodic stockings of post-larvae. This progression is kept in motion by culling permanently large market-sized animals. The theoretical model species stocking sequence (number of PL and frequency) and harvesting characteristics (retained size and fishing frequency) in order to get a yield of homogeneous size prawns ranging from 2.5 to 3 metric tons/ha/year.

In practice, several factors can interfere with this steady advance leading to a significant lowering of production. A technical assistance team set up in the early 80's as part of development plans in French Guiana, systematically analyses size histograms to diagnose low production ponds. Most of the time, an over representation of sub-harvestable size classes due to a slowing down of their growth,

is responsible for a general blockade of the production system. The origin of this slow growth is sought into environmental conditions or in population management, especially harvesting.

Over a long period of time, control of a population reared with the continuous grow-out system is effective.

83. ESTIMATION OF ESSENTIAL AMINO ACID REQUIREMENTS FOR PENAEUS VANNAMEI.

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The essential amino acid requirements for Penaeus vannamei were estimated by two experimental methods. One, they were estimated by determining the dietary requirement of one essential amino acid using a purified diet and extrapolating the dietary requirements for the remaining essential amino acids using the essential amino acid profile of tail muscle. The second method used to estimate the essential amino acid requirements will allow increase use for cheaper feedstuffs in the shrimp feeds. The resulting cheaper feeds would significantly reduce the cost for producing marketable size shrimp in ponds.

84. THE NUTRITIONAL RESPONSE OF POSTLARVAL PENAEUS VANNAMEI TO MEAT AND BONE MEAL.

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Nutritional response of postlarval Penaeus vannamei to meat and bone meal was evaluated. There was no significant reduction in survival for the four week test period for shrimp fed diets containing 27.6% and 40% protein (dry weight basis) as percent meat and bone meal in the diets was increased from 0% to 20% and 0% to 40%, respectively. Regression of growth in terms of percent weight gain per animal onto percentage of meat and bone meal indicated that growth is decreased as percentage of meat and bone meal in the diet is increased from 0% to 20% and 0% to 40% in 27.6% and 40% protein diets, respectively. Percent reduction of growth for 27.6% protein diets containing 10% and 20% meat and bone meal versus 0% was 8.8% and 42.9%, respectively. The 8.8% decrease in growth was not but the 42.9% was significantly less than growth of shrimp fed diets not containing meat and bone meal as determined by Student-Newman-Kuels test. Percent reduction of growth for 40% protein diets containing 10%, 20%, 30% and 40% meat and bone meal versus 0% was 6.4%, 14.8%, 34.0% and 56.7%, respectively. The 6.4% and 14.8% were not but the 34.0% and 56.7% decreases in growth were significantly less than growth of shrimp fed diets not containing meat and bone meal. Data indicate that meat and bone meal could be cost-effectively used in diets for Penaeus vannamei depending upon the relative costs of meat and bone meal versus the more expensive marine animal meals.

85. SHRIMP FEEDING RESPONSES TO FOOD WEB MANIPULATIONS IN EXPERIMENTAL GROWOUT PONDS.

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Although penaeid shrimp have long been considered opportunistic omnivores, data from field studies indicate that these shrimp are primarily carnivores. In

their natural habitats, penaeids typically prey upon copepods, amphipods, small shrimp and crabs, and polychaete worms. The foraging habits of Penaeus vannamei marine shrimp were examined in eight 200 m² earthen ponds during a manipulative field experiment designed to examine shrimp growth under simple detrital-based and phytoplankton-based food webs. Results from unmanipulated control ponds were compared to those from ponds receiving organic and inorganic inputs designed to stimulate primary and secondary productivity. Although prey groups normally consumed by penaeids in their natural habitats were rare, shrimp growth in these experimental ponds rivaled growth rates in nature and those in semi-intensive growout ponds receiving applied commercial feeds. These experiments document extreme flexibility in prey-size requirements and trophic level position for Penaeus vannamei. Penaeid growth rates in semi-intensive growout ponds appear to be greatly affected by natural prey availability.

86. USING EXPERIMENTAL MICROCOSMS IN SHRIMP RESEARCH: THE GROWTH-ENHANCING EFFECT OF SHRIMP POND WATER.
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Progress in agricultural research is accelerating at a rapid pace and great strides have already been made in the past 30 years. The influence of ecological theory upon this progress is clear; from the impact of population ecology upon integrated pest management to the effects of ecosystem dynamics upon optimized harvesting, ecological principles have provided major advances. In contrast, progress in aquaculture has only recently begun to accelerate, and the impact of ecological principles is just beginning to emerge. Research on shrimp culture has recently begun to focus upon the impact of natural food webs as a direct food source for shrimp, the influence of shrimp feeding behavior on their uptake of applied feeds, primary productivity and its role in oxygen balance and nutrient cycling and effects of microbial interactions upon oxidation-reduction processes in sediments. Research in these areas involves expensive, labor-intensive field experiments in experimental ponds or small-scale farm ponds. We believe that microcosm laboratories can be appropriate arenas for testing hypotheses concerning pond environmental effects upon feed conversion rates, growth, yields and survival. In pond microcosms, shrimp can be subjected to physical, chemical and biological conditions that in many ways approximate growout-pond conditions. These conditions appear to have tremendous effects upon growth potential. Recent microcosm experiments reveal that, even under intensive growout conditions, shrimp-pond water alone can sustain growth and survival for at least six weeks. Research is now under-way in microcosm laboratories to determine the mechanisms behind the growth-enhancing effect of pond water.

87. AN ANALYSIS OF THE INFLUENCE OF DIETARY AND OTHER REARING CONDITION VARIABLES ON GROWTH AND SURVIVAL RATES OF LARVAL PENAEUS VANNAMEI IN A COMMERCIAL HATCHERY.
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Growth rates, survival rates and data on feeding levels for larval Penaeus vannamei were recorded in 62 independent larval rearings. A total of 76.0 million nauplii were stocked over a period of 4 months and reared for an average of 21 days to reach a 10 day-old postlarvae (P10). Overall survival was 60.9% with mean growth of 0.239 mm/day to reach an average body length of 5.29 mm at harvest. The temperature was 28.2°C ± 1°C and the salinity 35%.

The following factors were analyzed to reveal relationships with growth and/or survival rates; concentrations of algal feeds during the protozoa and early mysis larval substages; total number of live Artemia nauplii fed; total weight of microencapsulated artificial diet "Frippak" fed as an algae and/or an artemia supplement; shrimp nauplii stocking density and postlarval harvest density.

Regression analysis revealed a significant positive correlation between the two variables growth and survival. The value of these two factors as measures of quality is discussed.

88. SALINITY TOLERANCE OF FERTILIZED EGGS AND YOLK-SAC LARVAE IN MILKFISH (CHANOS CHANOS FORSSKAL).

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The tolerance of milkfish embryos and larvae to direct salinity change was investigated. Embryos (blastomere and gastrulae) and one- and two-day-old larvae were obtained from milkfish hormonally induced to mature and spawn in captivity. Specimens were transferred directly from 32‰ to 5, 10, 15, 20, 25, 30, 35 and 40‰. Larval hatching and survival rates up to six days were determined.

Hatching was observed in all salinities tested regardless of the stage at which transfer occurred. Normal larvae hatched from eggs transferred at blastomere and gastrula stages between 10-40 and 15-40‰, respectively. Highest values of normal or viable hatch were found between 20-40‰.

One-day-old larvae could not tolerate direct transfer into 5‰. Two-day-old larvae survived direct transfer to all test salinities. On Day 6, higher larval survival rates were found between 15 and 30‰ for larvae transferred at one-day-old between 5 and 25‰ for larvae transferred at two-day-old.

This study clearly demonstrated the euryhaline capability of milkfish and their ability to tolerate salinity fluxes very early in life.

89. AN ECONOMIC COMPARISON OF EXTENSIVE, SEMI-INTENSIVE AND INTENSIVE SHRIMP CULTURE TECHNOLOGIES IN HAWAII AND GUAM. Kendrick Lee, Robert Cantre^{11*}, Ping Sun Leung, Yung C. Shang and Jaw-Kai Wang, Department of Agricultural and Resource Economics Gilmore Hall 112, University of Hawaii-Manoa Hawaii 96822, USA.

Although Hawaii and Guam are considered favourable areas to culture marine shrimp, the optimal farm system has not been identified. A previously developed spreadsheet model was modified for this research. Three technologies will be examined for transferability to Hawaii and Guam: extensive, semi-intensive and intensive. Insufficient data from existing commercial farms (in Hawaii and Guam) was lacking, so data from literature and other shrimp farming regions and assumptions were used to provide a reasonable data range for analysis.

90. THE ECONOMICS OF TECHNOLOGICAL INNOVATION IN TAIWANESE AQUACULTURE DEVELOPMENT, 1953-1985.

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Taiwanese aquaculture development was analyzed from an agricultural deve-

lopment economics perspective focusing on the role of technology. The temporal patterns of area, output per area and real prices, for six species groups: milkfish, carp, oyster, tilapia, eel and shrimp; were analyzed, utilizing the theory of an "innovation cycle", providing evidence that technology was related to aquaculture development. In an "innovation cycle", new technology (either new species or new culture techniques) will first be reflected in an increase in output per area (learning effect), followed by a decline in real prices (market effect) . Examination of general economic and social conditions over time helps identify the conditions which should exist to make successful aqua-culture development possible. Implications for future of the Taiwanese aqua-culture sector and the transferability of aquaculture as a development tool for other third world countries were derived from this research.

91. THE EFFECT OF ASCORBIC ACID ON SPERM AND SPERMATOPHORE QUALITY IN PENAEUS VANNAMEI MALES FED PREPARED DIETS.
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The effect of ascorbid acid (AsA) on sperm and spermatophore quality was studied in Penaeus vannamei. Adult P. vannamei were stocked at a 1:1 male: female ratio in indoor 3.7 m diameter fiberglass tanks and maintained on a recirculating seawater system. Mean weights \pm SD were 50.99 ± 9.2 and 40.46 ± 5.2 g for females and males, respectively. Three 3-tank replicates were fed the following experimental diets: 1) Diet A - 60% prepared dry diets supplemented with 10 g/kg of encapsulated Vitamin C, 40% marine polychaetes; 2) Diet B - 60% prepared dry diet without Vitamin C supplement, 40% marine polychaetes; and 3) Control - 40% squid, 20% shrimp, 20% marine polychaetes and 20% adult brine shrimp.

Reproductive response of the males were evaluated by comparing mating rate among treatments and by evaluating overall morphology of the reproductive tract (testes, vas deferens, terminal ampoules). Sperm quality parameters were also determined through spermatophore morphology, sperm counts, trypan blue dye exclusion and sperm cell morphology.

92. THE APPLICATION OF ARTIFICIAL PLANKTON B.P. IN PENAEUS MONODON LARVAL PRODUCTION.
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Penaeus monodon is the major culture species in Southeast Asia. Conventional larval rearing methods rely heavily on live foods, primarily Skeletonema, rotifers and Artemia. for the various stages of growth. However, the culture of live foods is subject to such unpredictable factors as weather. Furthermore, Artemia is not indigenous everywhere. Therefore, an ideal food substitute for the future is artificial feed. This study explores the applications of artificial plankton B.P. in P. monodon larval rearing.

Half ton fiberglass reinforced plastic tanks containing 450 l of water and constantly aerated were used to culture P. monodon from nauplius to PL 1. Water temperature and salinity were maintained at $30 \pm 1^\circ\text{C}$ and 31 ± 3 ppt, respectively and pH ranged from 8.0 to 8.4; the tanks were covered with black orchid net and the larvae were fed every 6 hours. The optimal larval density and combinations of B.P. and live food were studied. Results of this study show that the initial stocking density of 80 to 100 nauplii/l, and 1.0 to 1.5 g B.P./450 l/feeding combined with 2,000

cells/ml of Skeletonema given once a day, produced the best result. Although Skeletonema was found: to be still essential, results are encouraging.

93. FEASIBILITY STUDY FOR ALTERNATIVE CULTURE SPECIES IN TAIWAN-PENAEUS PENICILLATUS.

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Penaeus monodon is almost synonymous with aquaculture in Taiwan indicating the level of success the culture of this species has attained over the past two decades. However, other species are being considered for future culture to diversify an industry heavily dependent on one product as well as provide the market with an alternative commodity. This paper explores the feasibility of P. penicillatus as an alternative culture species in Taiwan.

Penaeus penicillatus has five major merits considered ideal for aquaculture:

1. Induced maturation of spawners in captivity is possible even without eyestalk ablation.
2. Larval rearing is comparatively easy.
3. Penaeus penicillatus is relatively disease resistant and may be cultured in grow-out ponds at high densities (1-1.2 million/ha).
4. This species still grows at low temperatures (about 20°C) and can be fed a low-protein diet (as low as 22%).
5. The "white shrimp", P. penicillatus is readily acceptable in the international market.

This paper also discusses some difficulties in the culture of this prawn.

94. PRODUCTION AND CONSUMPTION OF FRESHWATER PRAWNS -THE THAI WAY.

C. Kwei Lin, Agricultural & Food Engineering Division Asian Institute of Technology, Bangkok, Thailand.

Production of farmed freshwater prawns (Maerobrachium rosenbergii de Man) in Thailand has increased exponentially during the recent 10 years. The present production, involving more than 2,000 farms over about 4,000 ha of pond area, reaches 4,000 tons annually. Most production farms practice intensive monoculture, applying appropriate technology developed locally. Vertically integrated management style is adopted by medium and large size farmers, who produce their own post larvae, manufacture supplemental feed, manage ponds, harvest and wholesale the products. Year-round favorable temperature, abundant surface water, relatively inexpensive feed and labor force, and innovative local technology have been main factors contributing to profitable and thriving prawn farming in Thailand. The domestic consumption has been the major market for farmed prawns. As prawns being native to Thai waters many traditional Thai ways of preparing prawn dishes were developed. Undoubtedly, the success of prawn farming enterprise, has been associated with the anthropological background unique to Thailand.

95. NUTRITION STUDY ON CHINESE PRAWN (PENAEUS ORIENTALIS): PROTEIN.

H.W. Liu and B.S. Wu, Shandong Mariculture Institute Qingdao, China.

Fifteen *Penaeus orientalis* juveniles (average weight = 1.5 ± 0.3 g) were kept in each of the fifteen 150-L glass aquaria supplied with seawater (33 ppt) through a sand-gravel filter. Five diets were prepared containing 23-60% protein and fed at 10% of body weight/day for the first two weeks and 8% for the succeeding two weeks.

Prawns fed the 40% protein diet produced the best growth, food conversion ratio (FCR) and survival rate. Growth depressions occurred among the prawns fed 47% and 60% protein.

96. COMPARISON OF PHYTOPLANKTON COUNTS AND GROWTH OF PENAEUS VANNAMEI IN PONDS UNDER DIFFERENT ENVIRONMENTAL CONDITIONS.

Jairo Llanos, Diana Marin and Jeffrey Peterson Acuespecies, S.A., Guayaquil, Ecuador.

Data were analyzed from 40 10.9 hectare shrimp production ponds at Acuespecies S.A., a 500 hectare shrimp farm in Guayas Province, Ecuador.

Comparison were made between average monthly shrimp growth rates (grams/month) versus average monthly phytoplankton counts (cells/ml). The study was conducted over a 12-month period during which climatic conditions varied widely.

The Guayas basin, where the ponds are located is characterized by wide variations in salinity due to seasonal rainfall. Salinities during the study period ranged between 0.0 and 24.0 parts per thousand. Temperatures varied between 24.0 and 30.0°C.

Results correlate higher growth rates with higher phytoplankton populations.

97. AUTOMATED WATER QUALITY DATA ACQUISITION IN AQUACULTURE SYSTEMS.

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An automated water quality data acquisition system has been developed by the Aquacultural Engineering program at the University of California at Davis (UCD). The self-contained computer based system consists of a Campbell Scientific "micrologger", a weather station and a unique water sampling raft. The system can monitor and record the following information on a routine basis: a) weather data including solar irradiance, photosynthetically active radiation, wind speed, wind direction, air temperature, relative humidity and rainfall; b) pond environmental data taken at 20 cm intervals (to a maximum depth of 175 cm) including dissolved oxygen, temperature, pH and photosynthetically active radiation.

This poster describes the data acquisition system, its uses in aquaculture research, and possible modifications for use in commercial aquaculture system monitoring.

98. AN ANALYSIS OF THE SURVIVAL AND THE GROWTH IN PONDS OF HATCHERY REARED PENAEUS VANNAMEI LARVAE.

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The survival and the growth of Penaeus vannamei juveniles originating from the same hatchery are analyzed in several Ecuadorian shrimp farms. The object of this paper is to establish an eventual relationship between farm results and the hatchery techniques employed with special attention to:

- a) nauplii origin, wild caught gravid females versus artificially matured and inseminated females;
- b) preventive antibiotic usage;
- c) use of supplementary artificial microencapsulated feeds; and
- d) age of postlarvae at the time of stocking in ponds.

The analysis deals with the two types of grow-out technology most used in Ecuador. In the first system postlarvae are stocked in a separate nursery ponds prior to on-growing. In the second, the postlarvae are stocked directly into the grow-out ponds. In the first instance, the analysis considers only the nursery stage.

99. STOCKING DENSITY AND FEED LEVEL EFFECTS ON GROWTH AND SURVIVAL OF JUVENILE PENAEUS VANNAMEI AND P. STYLIROSTRIS IN POND CAGES.

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A formulated shrimp feed containing 30% protein was tested on juvenile Penaeus vannamei and P. stylirostris held in bottomless cages. Desired feed levels ranging from 0 to 15% wet body weight per day were used for stocking densities of 10, 20 and 40 per m². Further experiments used desired feed levels ranging from 0 to 5% wet body weight per day with stocking densities of 20, 40 and 60 per m². Growth of P. vannamei and P. stylirostris was inversely related to stocking density. In addition, growth of shrimp fed the 30% protein feed was better than that of unfed shrimp. No significant differences in growth of P. vannamei occurred between desired feed levels ranging from 5 to 15% or between desired feed levels ranging from 1.25 to 5%. Growth of P. stylirostris was better at desired feed levels of 2.5% when compared to 1.25% and did not differ from that of shrimp fed at 5%. The results suggest (1) that in ponds, low feed levels can increase the growth of 1 to 5 g shrimp; (2) that feed rates above 2.5% do not give any additional benefit; and (3) that supplemental feeding may be more important to p. stylirostris than to P. vannamei.

100. POLYUNSATURATED FATTY ACIDS IN THE DIET OF PENAEUS VANNAMEI.

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Studies have suggested that bloodworms provide nutritional components in diets of tank-reared shrimp that are essential for maturation and cannot be provided by conventional diets. Omega-3 fatty acids have been implicated as target compounds needed to trigger maturation. Because the link between fatty acids and shrimp maturation has not been firmly established, an investigation was undertaken to characterize fatty acids in bloodworms and contrast levels and distributions with those in other food materials used in shrimp rearing. Included were pellet foods, live foods such as squid, oysters, algae and brine shrimp; live foods enriched with the

PUFA boosters, Marila^T or Selco^T; and two species of bloodworms, one from the Maine coast and one from Panama. Because bloodworms are usually purchased from a limited supply, other worms which might be grown locally have also been analyzed for fatty acids. Wide variations in fatty acids were observed among tested foods. Variables derived from this fatty acid data provide information for future investigations of dietary factors essential to shrimp maturation. Several food materials proved to equal or exceeded bloodworms in absolute quantities of PUFAs and may offer an alternative to the bloodworm diet.

Bloodworms typically are frozen for prolonged use. Fatty acid analyses made of worms stored for one year indicated little degradation in fatty acids as long as food remained frozen at 4°C until use. Seasonal variations in fatty acid content for bloodworms purchased in January and in August have also been assessed.

101. SEMI-INTENSIFICATION OF EXTENSIVE MARINE SHRIMP CULTURE IN ECUADOR: PLANNING AND IMPLEMENTATION.

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Historically, most of the marine shrimp, Penaeus vannamei pond culture in Ecuador has been extensive with production averaging 300-500 kg/ha/yr. In the last few years natural seed supply has been unpredictable, and the once inexpensive coastal land areas are no longer available. On the surface, this situation mandates an intensification of production using hatchery reared stock, feeding, water management, etc. In theory, intensification should bring greater net profits. However, there are many problems in intensifying an existing operation. Our company has been attempting to intensify in a joint venture with the Ecuadorian hatchery and grow-out firms, Ecualarvae S.A. and Prexamar C.A. Although designing, building and starting up the hatchery, de novo pre-sented many challenges. The greatest problem involved "retrofitting" the 200 hectare grow-out farm from an extensive operation to a semi-extensive one. Our strategy, which gives a potentially economic favorable return is to only slightly intensify (500-1,000 kg/ha/yr) the grow-out operation for the first two years. This paper discusses our overall strategic planning, most prominent general management problems, planning and integration of hatchery and pond stocking phases, theory behind calculation of critical standing crop values for a minimum feed level application, long range financial and cash flow planning using computer based spread sheet models, practical considerations of growth management, and finally the importance of the stochasticity associated with production and survival in hatchery and ponds.

102. DEVELOPMENTAL CHANGES IN PROTEIN-NUCLEIC ACID LEVELS OF PENAEUS VANNAMEI TAIL MUSCLE.

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Marine shrimp (Penaeus vannamei) were raised in Taiwanese-type grow-out ponds at the Oceanic Institute in Hawaii. Samplings of animals were made at weekly intervals for four consecutive weeks, starting from the estimated age of

approximately 16 weeks. A total of 20 animals per week were randomly selected for the determination of tail weights and tail muscle weights to study allo-metric growth of tail muscle in marine shrimp. Animals were sexed to study sexual dimorphism, as well as variations within a population regarding body weights and muscle development.

In addition to gross measurements of body weights, tail weights and tail muscle weights, tail muscle samples were subjected to tissue fractionation by a modified method of Wannemacher et al. to determine protein, RNA and DNA contents. Protein and nucleic acid contents were then used to estimate physiological changes associated with age and sex in the course of muscle growth. Physiological changes are discussed in terms of accumulation of muscle nuclei protein accretion, DNA space and translational capacity of nuclei for protein synthesis.

103. INSTANTANEOUS GROWTH RATE OF TILAPIA GENOTYPES IN UNDISTURBED AQUACULTURE SYSTEMS. I. "RED" AND "GREY" MORPHS IN INDONESIA.

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Genetic improvements of growth rate is a potential method of increasing fish production. Tests of genetic variability are often limited to laboratory environments quite different than the environment from which the studied fish originate. Strain, family or even individual variation in growth rate may be partially masked by genotype-environment interactions. Conclusions from such studies may bear little resemblance to true differences under natural conditions. The objectives of this study were: 1) to compare the growth rate of different strains of Tilapia; and 2) to determine the amount of variation in growth rate among traditional farming systems in Indonesia. We used spacing of circular on scales (CIRC) to estimate size-specific growth rates. This technique allows growth rate to be quantified from a single sample. Growth of fish from 7 farms and 2 colour morphs were compared, at 2 standard fish sizes.

Repeatability of CIRC is high under the present farming conditions. Overall, gray morphs grew faster than reds, but a significant interaction between colour morph and farm makes farm-wise comparison necessary. Growth rates were significantly greater for gray tilapia on 2 farms but never greater for red. Growth between farms differed significantly. The body length/scale radius allometry varied significantly between farms and colour morphs, indicating genetic variability in this trait. This data 1) confirms that the gray colour morph is faster growing under natural conditions and 2) allows management practice to be directly related to growth, from which adjustments in density, feeding levels and other growth-related factors can be made.

104. MANAGEMENT STRATEGIES FOR PENAEUS VANNAMEI BROODSTOCK. Kathleen M. McGovern*.

Data collected from earlier trials at Amoriant Aquafarm showed that individual Penaeus vannamei do not contribute equally to the nauplii production of a maturation population. Impregnation of individual females did not occur at random but favored a select group of females in each maturation population. Using this information trials were conducted using female selection in an attempt to increase the nauplii production from a maturation population.

Females in each maturation tank were tagged and their nauplii production recorded. In two trials females producing few or no nauplii were replaced. In two other trials, the highest producing females from two maturation populations were combined into one population.

Results suggest that culling and selective replacement of females, based on records of individual performance in the maturation system, can result in improved yields of nauplii.

105. CARBON LIMITATION IN FERTILIZED FISHPONDS IN JAVA.

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The backbone of Java consists of a chain at some 25 major volcanic peaks. Among the peaks are ridges of uplifted limestone reefs. Groundwater and runoff from volcanic regions were mineral poor carbonate-bicarbonate alkalinity was on the order of 20 mg L⁻¹. By contrast, water emerging from limestone regions had alkalinity near 160 mg L⁻¹. When phosphorus and nitrogen fertilizers were added to low alkalinity water in ponds in a volcanic region, the growth of algae and subsequent yield of Nile Tilapia were low: 1.1 g C m⁻² day⁻¹ and 1,080 kg fish ha⁻¹ per 150 day grow-out period, respectively. With low alkalinity, carbon dioxide limited pond production, and phosphorus, and nitrogen remained in pond water unused by the algae. When alkalinity was increased to 50-60 mg L⁻¹ and fertilizer was applied at the same rate, algae productivity and fish yield increased to 1.5 g C m⁻² day⁻¹ and 1,475 kg fish ha⁻¹ per 150 day grow-out period. With increased abundance of CO₂ and increased growth of algae, phosphorus and nitrogen uptake from pond water increased, thus improving fertilizer efficiency. CO₂ continued to be in short supply at the highest levels of pond production obtained in the experiment. Fertilizer applied at the same rate to ponds in limestone drainage systems of Java with greater alkalinity would likely support pond productivity in excess of that obtained here. This work shows that CO₂ availability needs to be assessed during design of fertilizer application schemes in order to use fertilizers economically and to obtain consistent fertilizer-based yields from site to site in Java.

106 USE OF SCALE CIRCULUS SPACING TO DETECT GROWTH- RATE DIFFERENCES BETWEEN CARP (CYPRINUS CARPIO) IN FARMING SYSTEMS IN INDONESIA.

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Methods for determination of short-term individual growth rates in fish are desirable for aquacultural stock improvement, and for comparisons of response to various management regimes and to environmental conditions. The direct determination of growth rate of individually identified fish by repeated measurement of length is impractical in most aquacultural situations, because of problems arising from management practices (frequent addition of new stock, large numbers, labour costs, unreliable marking). This is especially so in extensive production systems in the Third World.

Significant positive linear relationships were demonstrated between growth rate and scale circulus spacing (CIRC) of goldfish (Carassiois auratus) and' of common carp (Cyprinus carpio). Use of this relationship as a simple and inexpensive estimator of mean growth rates in differing carp farming systems in Indonesia is described.

Potential utility of CIRC as a tool for optimizing finfish aquaculture production operations, and as a selection criterion in stock improvement is discussed.

This work is part of a collaborative research project between the Research Institute for Freshwater Fisheries, in Bogor, Indonesia and the Department of Biology of Dalhousie University in Halifax, Canada, part of the Network of Aquaculture Genetics in Asia, funded by the International Research Centre of Canada.

107. INTENSIVE NURSERY REARING OF PENAEUS VANNAMEI IN ROUND PONDS.

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Results of high-density nursery trials currently in progress in a 337 m² round earthen pond at the Oceanic Institute, Waimanalo, HI are reported. Post-larvae are stocked at 1,000/m² and grown to 1 g average weight at harvest. Water quality is controlled by constant exchange and periodic removal of solid wastes through a center drain. Data include water quality parameters, final survival, weekly growth and size distribution at harvest.

108. PRACTICAL FEEDS AND FEEDING SCHEDULES FOR POST-LARVAL FRESHWATER PRAWNS, MACROBRACHIUM ROSENBERGII.

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To achieve profitable pond culture in temperate regions, M. rosenbergii must apparently be stocked as juveniles which have been raised in a temperature-controlled nursery facility. This study investigated some commercially available feeds, feeding schedules, and feed supplements for growing postlarvae to a juvenile size of about 0.5 g. Postlarvae were grown for nine weeks at a density of 2.0/L and a water temperature of 28 ± 0.5°C in 76-L aquaria equipped with outside biological filtration. Feeding rates were adjusted daily so that generally only a little uneaten food remained at the next feeding time. Uneaten food was siphoned out once daily just before a feeding time. There were three or four replicates per treatment. Experiment 1 tested four commercially available feeds; MFC Clover Brand Catfish Fingerling Crumbles (38% protein), Purina Trout Chow No. 2 (50% protein), Silver Cup Fish Feed-Salmon (49% protein), Rangen No. 2 Postlarval Shrimp Diet (45% protein), and a reference diet (EXD-86). Purina No. 2 Trout Chow gave the best survival and yield and was used as the sole or main food in subsequent experiments. Experiment 2 tested four feeding schedules: once per day (at 1600. h), twice per day (at 0800 and 1600 h), twice per day (at 0800 h and 2000 h), and three times per day (at 0800 h, 1600 h, and 2400 h). The once-per-day treatment gave the best growth, survival and yield. Experiment 3 tested the effects of supplementing trout chow with several fresh or frozen foods; no results were available at the time of this writing.

109. KNOW YOUR MARKET POTENTIAL BEFORE YOU BUILD YOUR FARM: EXPERIENCES AT AMORIENT AQUAFARM IN HAWAII.
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A natural progression for aquaculture projects is the development of expertise in raising a particular aquatic species and then the promotion of the development of a facility to mass produce that product. For commercial success, this must be done in conjunction with careful market factor analysis. Among the questions to be considered are:

- 1) Is there a large and knowledgeable consumer population close to the production site?
- 2) How many producers of the product are in commercial operation and how long have they been in business?
- 3) What forms of the product are acceptable to the present consumer group?
- 4) Have product handling, marketing personnel and product transportation costs been adequately budgeted?

The frequent result of failure to consider these and other important marketing factors is the construction of a successful production facility but a failed commercial venture. Proper business planning can reduce the risk of this happening.

110. APPLICATION OF EUCHEUMA CARRAGEENAN PHYCOCOLLOIDS AS BINDERS IN AQUATIC DIETS.
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Cultivation of species of Euclidean comprises a major red seaweed aquaculture industry throughout Asia, especially in Indonesia and in the Philippines. Production of E. cottonii in the latter country alone exceeds 45,000 tons annually. The species E. cottonii and E. spinosum are commercially processed to yield kappa and iota type carrageenan, respectively, which form polysaccharide gels with various textural and setting properties. Pellet texture can be altered with cations and use of synergistic gums. These unique features can be used to produce a variety of water stable diets, including pellets and flake products, utilizing relatively simple processing techniques. Combinations of both dry and wet ingredients can be utilized to produce a well-balanced diet. Extruded gel formulations exhibit good rehydration properties without excessive loss of solids.

Crude Euclidean extracts, as well as appropriate combinations of kappa/ iota type semi-refined carrageenans, have been effective as nutrient "delivery systems" for seabass (Lates calcarifer) and siganids (Signanus spp) as well as providing a water stable digestible matrix for potential delivery of vitamins and specific chemoattractants at various stages of fish growth. Adjustment of the hydrocolloid mixture allows control of physical tactile properties and nutritional composition that directly affect acceptance and feeding response. The Euclidean gel systems lends

itself to a variety of aquatic dietary applications, including possible use in penaeid maturation for feeding of natural and compound food in a composite flexible, soft-textured and stable "worm-like" configuration.

111. AQUACULTURE OF SHRIMP IN MEXICO: SOME ECONOMIC AND SOCIAL CONSIDERATIONS.

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This paper evaluates the current situation which exists in Mexico regarding aquaculture production of shrimp and analyzes how development of this industry could affect U.S.-Mexican fishery relations. Analysis concentrates upon the economic feasibility of the industry in different geographic regions within Mexico. It is based on original data obtained through on-site investigations in several states in Mexico: Sinaloa on the North-Pacific Coast and Campeche on the Gulf Coast.

In addition to economic analysis (cost of land, construction, operation, availability of larvae, etc. ...) social factors are also considered. In Mexico, aquaculture production of shrimp is reserved for the social sector or in other words, for cooperative enterprises instead of private enterprises. Further, the majority of suitable coastal lands for shrimp cultivation are held in ejidos, a type of agrarian cooperative enterprise which by law may not rent or sell the land concession it has received from the federal government. The development of shrimp aquaculture in Mexico must therefore include a study of social organizations, not only economic determinants.

The complex social and economic situation surrounding the shrimp aquaculture industry in Mexico has greatly retarded its development. The result is that Mexico has foregone foreign exchange and job creation opportunities. In the U.S., lack of Mexican aquaculture development has led to a smaller supply of fresh shrimp and therefore, very likely, to higher prices.

Development of shrimp cultivation, however, will require new strategies to encourage private investment and must involve the participation of different social groups. The benefits to both countries from shrimp aquaculture development in Mexico could be great. This paper analyzes the current situation and suggests strategies for binational cooperation in this important industry.

112. MINIMUM EFFECTIVE DOSE OF LHRH-A FOR THE INDUCED SPAWNING OF MILKFISH, CHANOS CHANOS FORSSKAL.

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We investigated the minimum effective dose of LHRH-analogue that will induce milkfish to spawn. In this experiment, the correlation between the dosage of LHRH-a administered to both sexes, the number of fertilized spawns, the number of spawned eggs and spawned egg diameters was also examined.

The milkfish used for spawning had undergone chronic LHRH-a plus 17-methyltestosterone (17-MT) therapy and ranged between seven and nine years of age. Females possessing average egg diameters of ≥ 750 μm were injected with dosages ranging between 1-65 $\mu\text{g}/\text{kg}$ body weight. Running ripe males were given dosages between 20 and 65 $\mu\text{g}/\text{kg}$ body weight. Treated individuals were placed in round, 5,000-liter tanks in a 2:1 male to female sex ratio.

A significantly lower spawning success rate was observed in the 1-5µg/kg dosage range. There was no correlation between the occurrence of fertilized spawns and the dosages tested on both males and females. No dose-related effect was observed on fertilization rates, fecundity or spawned egg diameters. The interval between hormone injection and spawning ranged widely. The interval between fertilized spawns, however, was significantly shorter than between unfertilized spawns.

Though the females responded to the LHRH-a therapy, success with males was limited. The necessity for additional stimuli or alternative therapies is the subject of future studies.

113. BIOENCAPSULATION OF THERAPEUTIC QUANTITIES OF THE ANTIBACTERIAL ROMET-30 IN THE NEMATODE PANAGRELLUS REDIVIVUS AND IN NAUPLII OF ARTEMIA SALINA.

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Nauplii of the brine shrimp, Artemia salina and cultures of the soil nematode, Panagrellus redivivus were fed a suspension of the antibacterial Romet-30 to determine if they could be used as a mechanism for delivery of the water-insoluble drug to larval penaeid shrimp. Two groups of brine shrimp nauplii and nematodes in one liter beakers Romet-30 was added to achieve a suspension concentration of 3 mg of drug per ml of seawater. Animals and antibiotic were kept in suspension by gentle aeration and agitation during the uptake period. After a 4-hour uptake period, samples of nauplii and nematodes were collected with a 100 mesh screen and rinsed with sterile sea-water to remove surface traces of the drug. Predetermined numbers of nauplii and nematodes were placed into stainless steel cylinders on Mueller-Hinton agar plates with 3% salt that had been inoculated with a Romet-sensitive strain of Vibrio alginolyticus. After overnight incubation, the resulting zones of inhibition were compared to that of a standard Kirby-Bauer sensitivity disc containing 25 µg of the drug that was placed on each plate as standard control. Negative controls of equal numbers of nauplii and nematodes that were not exposed to the antibiotic were also included in the tests. Artemia nauplii and nematodes did consume and concentrate the antibiotic from the suspension. They exhibited no signs of toxicity from exposure to the drug, and contained the antibiotic in sufficient quantity to theoretically provide a therapeutic dose of the drug when fed to penaeid larvae.

114 EFFECT OF SALINITY ON GROWTH OF PENAEUS VANNAMEI POSTLARVAE.

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Growth of 22-day-old Penaeus vannamei postlarvae acclimated to four salinities (2, 4, 8 and 16 ppt) was determined after one month. Thirty shrimp were stocked into triplicated 113-liter (30-gallon) aquaria, and fed live Artemia nauplii and freeze-dried calanoid copepods. Although results were variable between studies, best growth occurred at 4 ppt, and highest survival occurred at 8 and 16 ppt.

115. PARALLELS IN THE DEVELOPMENT OF CATFISH AND SHRIMP POND AQUACULTURE.

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Production of an aquatic animal in pond aquaculture is discussed in relation to catfish and a marine shrimp. Parallels in the development of the two industries are presented. A comparison of tangible differences is discussed in terms of the economic, fixed, and variable costs. A number of intangible differences is presented which may account for the success of the catfish farming and lack of success in shrimp farming. Opportunities for technology transfer are pointed out.

116. CAROTENOID PRODUCTION OF SPIRULINA PLATENSIS (UTEX 1928) GROWN UNDER DIFFERENT LIGHT CONDITIONS.
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The effects of variation in quantity and quality of light provided to cultures of Spirulina platensis were investigated in this study. The response in this alga in terms of growth rate and carotenoid production was measured to determine the light regimen which maximizes total carotenoid production. Increasing white light irradiance from 4 to 26 x 10¹⁵ quanta cm⁻² sec⁻¹ produced an increase in growth rates from 0.8 to 2.8 doublings per day (continuous illumination). Total carotenoid content decreased with increasing irradiance from 2.2 to 0.6% of dry weight over the 4 to 40 X 10¹⁵ quanta intensity interval. Growth saturation irradiance levels above 40 X 10¹⁵ quanta did cause increasing amounts of carotenoids to be produced. Individual carotenoids showed different response patterns to changes in irradiance levels and light quality. Spirulina exhibited slower growth under blue light, but identical growth under red light when compared to growth in white light at the same total quanta level. Spectral distribution had little effect on carotenoid content and composition.

Maximum carotenoid production based on growth rate and carotenoid content was measured at 26 X 10¹⁵ quanta. This point represents the onset of light saturation. Daily carotenoid production at this light level equalled 105 mg for each gram Spirulina starting material. It is concluded from this study that maximizing growth rate is the most important factor in determining carotenoid production by Spirulina platensis.

117. EFFECT OF LIGHT SPECTRUM AND INTENSITY ON GROWTH AND SURVIVAL OF LARVAL ENAEUS VANNAMEI.
Paul G. Olin* and Arlo W. Fast Hawaii Institute of Marine Biology P.O. Box 1346, Kaneohe, HI 96744 USA.

Experiments were conducted to determine the effect of light spectrum and intensity on the growth and survival of Penaeus vannamei larvae. Larvae were reared in one liter imhoff cones with 0.2µm filtered seawater at 30 parts per thousand and 27 degrees centigrade. Animals were fed the diatom Chaetoceros gracilis and Artemia nauplii. Treatments included white, blue, red and green light along with complete dark. Survival ranged from a high of 69% to a low of 32%, decreasing in the following sequence: green > red > blue > white > dark. These results are discussed in relation to growth, survival and light intensity.

110; EXPERIMENTAL INFECTIONS WITH BACULOVIRUS PENAEI IN PENAEUS VANNAMEI.

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The virus Baculovirus penaei causes cytopathological alterations and mortality in a few species of penaeids. including Penaeus vannamei. infections impact production in both hatcheries and ponds. When we experimentally fed infected host tissue, either directly or concentrated as food in rotifers, to protozoal or mysis stages of P. vannamei, it produced extensive infections in the hepatopancreas and midgut. Typically, all those shrimp acquired infections, with as many as 80% or more of the hepatopancreatic cells affected. Consequently, the system involving larval stage of P. vannamei serves as a valuable model to assess parameters of infectivity. We will use the model to address questions involving a bioassay to detect infection, pathogenesis of infection, longevity of the infective agent, and methods to control infections. Depending on experimental conditions, the characteristic polyhedral occlusion bodies recognizable with light microscopy appeared abundant in infected nuclei of larvae fed as third stage protozoa by the third to fifth day after being fed the virus. Free enveloped nucleocapsids detected by transmission electron microscopy were associated with hypertrophic nuclei and the appearance of virogenic stroma. The proteinaceous bodies with occluded virions discharged into the lumen of the hepatopancreas tubulae or midgut when the host cell ruptured.

The study was conducted in cooperation with the U.S. Department of Agriculture Grant No. 85-CRSR-2-2438.

119. ALGAL ENRICHMENT AT A PENAEID SHRIMP HATCHERY.

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Carbon dioxide and additional fluorescent lights were used to increase algae production at Amorient Aquafarm's Kahuku shrimp hatchery. Chaetoceros gracilis cell densities were recorded from 200 liter cylinders with and without CO₂ and light additions. Initial cell counts, counts 3 days after inoculation and 6 days after inoculation, averaged 0.3, 2.1 and 2.2 x 10⁶ cells/ml in untreated cylinders and 0.4, 3.8 and 4.4 X 10⁶ cells/ml in treated cylinders, respectively. Cultures were partially harvested and refilled daily after 3 days. Algae cell counts in flasks and carboys with added CO₂ also increased. Dense Chaetoceros cultures severely restricted light penetration into cylinders. Injection with CO₂ and increased illumination lessened required laboratory space and culture volumes for algae, and allowed greater flexibility in algae production schedules.

120. EFFECT OF SUBLETHAL CONCENTRATIONS OF TEXTILE DYE EFFLUENT ON FOOD UTILIZATION, GROWTH AND CONVERSION EFFICIENCY OF A FRESHWATER FISH OREOCHROMIS MOSSAMBICUS.

S. Palanichamy*, M. Ramakrishnan and P. Baskaran P.G. and Research Department of Zoology, A.P.A. College of Arts and Culture, Palani-624602 Tamil Nadu, India.

Oreochromis mossambicus was exposed to different sublethal concentrations of textile dye effluent (0.15 to 0.6%). Mortality, food utilization, growth and conversion efficiency were studied. At a concentration of 0.9%, 100% mortality was observed within 96 h exposure; no mortality occurred at 0.5%; LC₅₀ was 0.75%. Rearing the fish in increasing sublethal concentrations of effluent, it was

found that the feeding rate decreased from 33.8 mg g fish⁻¹ day⁻¹ (fish reared in effluent free-water) to 10.3 mg g fish⁻¹ day⁻¹ at the highest sublethal concentration (0.6%). Absorption and metabolic rates also decreased with increasing concentrations. Growth rate also decreased from 12.2 mg g⁻¹ d⁻¹. Conversion efficiency decreased with increasing concentrations of effluent.

121. THE EMERGENCE OF CHINA AS A WORLD LEADER IN MARINE SHRIMP PRODUCTION.

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The People's Republic of China has the potential to become the largest single producer of marine shrimp due to its extensive exploitable coastline, particularly in the Bohai Gulf (200,000-300,000 hectares), and its established, though rudimentary, infrastructure for processing, feed production and product export. KCM International, Inc. is working with a client firm that has secured joint venture agreements to further develop several ongoing marine shrimp farms. The 650 km, mostly flat, coastline of the Bohai Gulf features uniformly shallow near-shore waters that can be readily enclosed by dike construction out to one kilometer or more from shore for significant additional pond culture area. Typical pond production levels in this region for the China, white marine shrimp, Penaeus orientalis, average 105 catties per mu (787 kg per ha), although more intensive shrimp culture practices at the large Tanghai Shrimp Farm near Tangshan resulted in production levels of 440 catties per mu (3.3 MT per ha) in 1986 from approximately 2 to 3 ha ponds. Experimental 5 mu (0.83 acres) ponds at the Nandagang State Shrimp Farm near Cangzhou have reached production levels of 1,070 catties (8 MT per ha). KCM International expects that a production goal of about 2 MT per ha per year is achievable with appropriate inputs of technology and proper designs. Principal limitations to improved levels of shrimp production in the Bohai Gulf are restrictions limiting availability of seedstock supplies, inadequate feed formulations, pond design and general management for improved product quality. These elements are now being supplied through KCM International and projected shrimp production from the Bohai Gulf alone could reach nearly 400,000 MT of shrimp for export annually.

122. MACROBRACHIUM ROSENBERGII AND NOTEMIGONUS CRYSOLEUCAS POLY CULTURE STUDIES IN LOUISIANA.

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Polyculture studies were conducted in Southwest Louisiana from 1984 to 1986 with Malaysian prawn, Macrobrachium rosenbergii and Golden shiners, Notemigonus crysoleucas. In 1984, stocking of shiners at 24.7/m² with prawn at 4.4/m² resulted in increased average total pond production of 307 kg/ha of the bait fish over the average prawn production of 640 kg/ha. Prawn in monoculture averaged 629 kg/ha. Prawn/shiner polyculture trials in 1985 demonstrated no difference in growth between prawn stocked at 3.7/m² in polyculture with 32.1/m² shiners. Prawn growth, survival and yield were not affected by this density of shiners and averaged 533 kg/ha. Shiner survival was decreased by presence of prawn but difference in yield was not significant (P <0.05). A comparison of increased stocking rates of 24.7/m² and 49.4/m² shiners with 4.9/m² of prawn in 1986 did not seem to decrease prawn production, averaging 631.6 and 840.5 kg/ha, respectively. Increased shiner stocking density resulted in decreased survival and production of this species; averaged 398.3 and 193.1 when stocked at 24.7/m² and 49.4/m²,

respectively.

These results indicate that it is feasible for bait fish producers in the Southeastern United States to stock prawn in combination with shiners.

123. COMPARATIVE PRODUCTION OF COLOSSOMA MACROPOMUM AND TILAPIA NILOTICA IN PANAMA.

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The production of Colossoma macropomum, a relatively little studied fish, was compared with that of Tilapia nilotica, a fish well known for its good production characteristics. Both species were grown simultaneously in a randomized design that was arranged in 2 x 2 factorial with each species being tested at a density of 1 and 0.25 fish/m²; treatments were replicated three times. Fingerlings were stocked into earthen ponds (870 m²), fed a commercial diet (25% protein), and harvested after 126 days of growth. Mean net production (kg/ha) for tilapia at high and low density was 3,361 and 917, respectively and for colossoma was 3,682 and 977, respectively. The production difference between species was not significant (P>0.05) while the difference between densities was highly significant (P < 0.01). Although net production was not

different for the species, colossoma gained significantly more weight per fish than the tilapia gains (g), for the low density of tilapia and colossoma were 379 and 471, respectively. While increasing the stocking density four-fold resulted in an almost four-fold increase in net production for both species, mean weight gains were not significantly affected by density. All other variables being equal, we concluded that the production of a 400 g fish with prepared diets could be achieved equally as efficiently with T. nilotica or C. macropomum. Also, both species should be stocked at a rate of at least 1/m² for high production without a significant loss of mean fish weight.

124. SHRIMP POND SAMPLING FOR GROWTH AND POPULATION: THEORY AND PRACTICE.

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This paper discusses the development of sampling systems at Acuespecies S.A., a 500 hectare shrimp farm in Guayas Province, Ecuador. A theoretical model of shrimp growth and population dynamics was developed to predict weekly growth and mortality. This model was tested using two techniques. The first were weekly cast-net samples to determine growth and the second were monthly samples using an in-pond grid system and cast net to estimate shrimp population.

Several factors were determined as having a significant effect on the confidence of the sampling results. Pond depth and bottom uniformly affected cast net performance and bi-monthly variations in shrimp activity affected distribution. The latter appear to be related to lunar phase.

125. EFFECT OF DIFFERENT MEDIA ON THE PRODUCTION AND CHEMICAL COMPOSITION OF FREE LIVING NEMATODES PANAGRILUS REDIVIVUS.

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Nematodes were cultured in media composed of either wheat flour, oatmeal, or cornmeal. Each growth media was tested with and without yeast as an additive. Total production of nematodes in wheat flour was significantly greater than in oatmeal or cornmeal media. The addition of yeasts prevented fungal contamination of all cultures, but had no effect on nematode yield. Production of nematodes stopped after day 21 in cornmeal, day 35 in oatmeal and day 54 in wheat flour.

A second rearing trial was conducted using media composed of either wheat flour, cottonseed meal or ground shrimp feed. Wheat flour provided a significantly greater average daily production and length of production than either cottonseed meal or shrimp feed meal.

Proximate analysis revealed that the chemical composition of the media affected the chemical composition of the nematodes. Protein content of nematodes cultured in cottonseed meal (64.6%) and shrimp feed meal (57.2%) was significantly higher than protein content of nematodes grown in wheat flour (50.9%). Slight differences in fatty acid profile were also observed in nematodes grown in the different media.

126. LARGE SCALE BREEDING OF INDIAN MAJOR CARPS AND CHINESE CARPS UNDER VARIED HORMONE DOSAGE AND INTERVAL ROUTINES IN BANGLADESH.

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Varied hormone dosage in different times of breeding season and varied time intervals between the preliminary dose and resolving dose were compared against success in ovulation and fertilization in Indian major and Chinese carps. A total of 962 individual females of Labeo rohita, Catla catla, Cirrhina mrigala, Labeo calbasu and Hypophthalmichthys molitrix were used in the experiment. The hormone dosage used was higher at the beginning of the breeding season and lower in the later part of the breeding season. Considering the natural fact the species would give better result in ovulation and fertilization at their optimum breeding season, the varied hormone dosage and time interval between the preliminary dose, and resolving dose appeared to have considerable effect in ovulation and fertilization in all the major carps and Chinese carps.

127. EFFECTS OF DIFFERENT LEVELS OF CRUDE PROTEIN AND FEEDING RATES ON THE GROWTH OF FINGERLINGS OF TILAPIA (OREOCHROMIS AUREA) IN FLOATING CAGES.

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Two tests of feeding were carried out to determine the level of crude protein and the feeding rate optimums in the growth of fingerlings of Tilapia (Oreochromis aurea) in floating cages.

In the first test July of 1986, we evaluated the growth and food conversion of four diets that contained the following levels of crude protein: 25, 30, 35 and 40%. All diets were isocaloric, with 3,815 Kcal/Kg. A commercial diet containing 32% of crude protein was used for control.

For each of the diets three floating cages of 1 m³ were utilized with a density

of 100 fishes/cage. A ration equivalent of 4% of the total weight was offered twice daily for 75 days. The diet with 25% crude protein level and 1.7 food conversion gave the best results. Following the diets, 40, 35 and 30% of crude protein gave food conversions of 1.9, 2.1 and 2.4, respectively. The food conversion for control was 2.7. The water temperature changed from 29°C to 26°C.

A second experiment was carried out in September of 1986. We worked only with 25% crude protein level and changed the feeding rates of 3, 4, 5, 6 and 7%. The test had a duration of 60 days. The best results in the feeding rate of 3% were obtained with a food conversion of 1.5, followed by the rates 4, 5, 6 and 7% for a food conversion of 1.7, 2.1 and 2.9, respectively. The water temperature changed from 25°C to 17°C.

In conclusion Oreochromis aurea can be fed in levels of 25% crude protein at feeding rates 3-4%.

128. **MARKETING STRATEGIES AND TACTICS FOR AQUACULTURE FIRMS: AN OVERVIEW.**

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For the aquaculture entrepreneur, the marketing function can be divided into three basic ongoing tasks: (1) market analysis; (2) setting marketing objectives; and (3) deciding on specific strategies to attain the objectives. These tasks may be performed in an intuitive manner and/or be part of a formal written marketing plan. The marketing "tools" for reaching identified target markets are your aquaculture products in various forms, pricing, promotion and distribution strategies and associated tactics. Unfortunately, some aquaculture entrepreneurs often invest very little time and money into understanding the market situation but prefer to adopt a "trial and error" marketing approach.

Realizing that a small aquaculture firm may lack the resources to cost effectively utilize various marketing tactics, a group of aquaculture firms may have the alternative to pool resources in the form of marketing cooperatives or associations. The cooperative is managed and operated in the interest of its patrons as a jointly owned extension of the members' business compared to a private business concern operated in the interests of the owners as a means of making profits on their capital investment. Historically, agricultural marketing boards or associations in the United States have often concentrated on just generic product promotion for its membership.

129. **PRELIMINARY DESIGN SPECIFICATIONS FOR SHRIMP AND OYSTER CO-PRODUCTION.**

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Production of oysters in the effluent of shrimp ponds has the potential to increase the revenues to shrimp farmers by adding a second crop which feeds on unutilized organic detritus and phytoplankton from shrimp ponds.

The metabolic rates of oysters grown in shrimp pond effluent and the effects on the water quality were studied to determine the preliminary design specifications for co-production of shrimp and oysters.

During the course of the experiment it was found that oxygen supply was a

limiting factor in growth and feeding of oysters in effluent due to the high level of non-oyster respiration in the system.

Feeding rates of two size classes were determined and growth was measured under two conditions. Suspended solids, turbidity and oxygen were removed from effluent waters passing through an oyster tank, while $\text{NO}_3 + \text{NO}_2$, PO_4 , NH_4 were added in predictable quantities. Effluent from highly productive shrimp ponds may require dilution to reduce particle density and increase dissolved oxygen to maximize oyster production.

130. A COMPUTER DATA ACQUISITION SYSTEM FOR AQUACULTURE POND MANAGEMENT.

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Aquaculture pond monitoring, control and management may be performed by microprocessors. A system has been developed as a research tool for monitoring weather and water quality data at a marine shrimp facility. The unit may be easily adapted to control aeration, circulation, feeders, alarms and other devices as well as function as a data logger. The system has broad application in all areas of fresh or brackishwater aquaculture.

The system uses an Apple IIe microcomputer, Leeds and Northrup dissolved oxygen probe, YSI temperature sensors, wind anemometer, Licor solar sensor, analog to digital conversion board, relay switches, chamber for probes, submerged pumps and sample lines. The computer controls relays that turn a sample pump on and cycle to the next pond. Data for each of four ponds is saved to diskette every 10 minutes.

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131. FINGERLING PRODUCTION OF TILAPIA NILOTICA AT THE RWASAVE FISH CULTURE STATION OF THE NATIONAL UNIVERSITY OF RWANDA.

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Rwanda's climate is cooler than its latitude would indicate (2°S), because elevation of most of the country lies between 1,500 and 2,500 meters. For this reason, the suitability of tilapia culture has been questioned. However, in

light of local management constraints, Tilapia nilotica have proven satisfactory when fingerlings were made available.

Production of fingerlings in ponds stocked with T. nilotica brooders has been monitored at the National University of Rwanda's aquaculture research station since 1984, when this species was re-introduced to Rwanda. Finger-ling production is generally very low (usually 10-30 fingerlings per female per month). Age of females at first reproduction was about nine months. Reproduction occurs in every month but is lowest during the dry season (June-August), where minimum air temperatures fall to 4°C to 10°C. Reproduction success has also been attributed to pond design. Brooders stocked in ponds with vertical levees and minimum depths greater than 80 cm did not reproduce. Nesting typically occurs at depths of 20 to 50 cm on gently-sloped sandy substrates.

The low reproductive rate of tilapia in Rwanda may be advantageous and simplify management practices for the rural fish farmers.

132. DETERMINATION OF OPTIMUM STOCKING DENSITY FOR REARING FRY OF ROHU (Labeo rohita HAM.) IN NURSERY PONDS.
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Studies were undertaken in ponds of 400 m² each to determine the optimum stocking density for maximum survival and growth of fry in nursery ponds. The ponds were stocked with 4 days old hatchlings (average length 6 mm) of rohu (Labeo rohita Ham.) . Three stocking densities were tried viz., 6.25, 7.50 and 8.25 million hatchlings per hectare. Each stocking density was replicated in two ponds. All the ponds were fertilized with organic manure (cattle dung) at the rate 10 tons per hectare. The fry were fed daily with a mixture of finely powdered mustard oil cake and rice bran.

The ponds were harvested after 4 weeks rearing and the survival and growth of fry was estimated. The average survival (average of two ponds) was 73.94, 63.40 and 57.41% and the fry reached average lengths of 32.0, 30.2 and 28.2 mm at 6.25, 7.50 and 8.75 million per hectare stocking densities, respectively. This has indicated that at the management level (fertilization and feeding) practiced, the stocking densities can not be exceeded. Further work is in progress to study whether stocking densities could be further increased with changes in quality and quantity of fertilizer and feed.

- 133 EFFECT OF DIFFERENT FERTILIZERS ON THE GROWTH AND SURVIVAL OF SILVER CARP (Hypophthalmichthys molitrix VAL.) FRY.
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For determining the effect of different fertilizers on the survival and growth of fry in nursery ponds, studies were undertaken in 6 nursery ponds of 400 m² each. The ponds were stocked with 4 days old hatchlings (average length 8 mm) of silver carp (Hypophthalmichthys molitrix Val.) at a density of 5 million per hectare. Three types of fertilizers were tried viz., organic manure only-cattle dung at the rate of 10 tons per hectare; inorganic fertilizers only-urea and triple superphosphate at the rate

of 100 and 75 kg per hectare, respectively; and a mixture of both organic and inorganic fertilizers-cattle dung, urea and triple superphosphate at the rate of 5 tons, 50 kg and 38 kg per hectare, respectively. Each fertilizer dose was replicated in two ponds. The fry were fed daily with a mixture of finely powdered mustard oil cake and rice bran (containing about 21% protein). The ponds were harvested after 4 weeks rearing and the survival and growth of fry were estimated.

Ponds fertilized with organic manure only gave the maximum survival of 75.49% (average of two ponds) and the fry attained an average length of 34.36 mm, while the ponds fertilized with inorganic fertilizers only gave the lowest survival of 60.46% and the fry reached an average size of 33.38 mm. Survival of fry was 67.00% in ponds fertilized with a mixture of organic and inorganic fertilizers and the fry reached an average length of 28.83 mm. The study revealed that fertilization of ponds with cattle dung gave not only maximum survival but also optimum growth of fry.

134. STUDIES ON THE COMPARATIVE GROWTH AND SURVIVAL OF SILVER CARP (HYPOPHTHALMICHTHYS MOLITRIX VAL.) IN ONE STAGE AND TWO STAGE NURSING.

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Studies were conducted to evaluate whether one stage nursing or two stage nursing would be appropriate for obtaining maximum production of finger-lings from unit area with optimum growth. In one stage nursing, the ponds were stocked with 4 days old hatchlings (average length 8 mm) or silver carp (Hypophthalmichthys molitrix Val.) at a density of 600,000 per hectare.

At the end of 8 weeks rearing, fry in one stage nursing reached an average length of 41.2 mm to 53.58 mm with a survival range of 69.9 to 84.58%. In two stage nursing, the fry attained a length of 27.46 to 40.30 mm with a survival range of 56.02 to 78.57% in 4 weeks rearing. When the population was thinned out, they reached a length of 50.01 to 60.00 mm with a survival range of 88.59 to 92.60%, indicating that two-stage nursing is better in terms of higher survival and growth and also in terms of economic return.

135. AN ASSESSMENT OF THE EFFICIENCY OF IODINE DISINFECTANT IN THE TREATMENT OF EGGS OF PENAEUS VANNAMEI.

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In aquaculture, iodine is used as an egg disinfectant for some fish species, in order to control the propagation of pathogen organisms (bacteria, virus, fungi). This work assesses its effectiveness in Penaeus vannamei eggs.

Results show a reduction in bacteria counts (gram-negative), also a possible positive effect against Baculovirus penaei.

136. A COMPARATIVE ANALYSIS OF SPERM QUALITY BETWEEN WILD CAUGHT MALES AND UNILATERALLY EYESTALK ABLATED REGENERATED MALES IN A COMMERCIAL PENAEUS VANNAMEI MATURATION FACILITY.

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Lee, MACROBIO S.A. P.O. Box 562, Guayaquil, Ecuador.

Wild caught Penaeus vannamei males were used for insemination and later ablated to compare performances in a commercial maturation facility. The system operates with artificial insemination only, where females artificially mature separately without males.

Males, wild caught and ablated are kept in separate tanks of 4.5 M in diameter at a density of 5.0 to 12.5 animals per M². Temperature was maintained between 27 and 28.5°C with a water exchange of 90 to 100% per day and the animals were fed with a combination of fresh frozen feeds plus maturation pellets (Nippai). Ablated males received bloodworms as a fatty acid booster in their diets. Wild mature males were received, acclimated and used within 8 to 10 days after arrival. These same animals now without spermatophores were ablated using a ligature method and reused after approximately 10 days when spermatophores showed good development.

The tests involved 1,516 wild caught males (A) for the insemination of 1,128 females, 645 males reused after ablation (B) for 483 females, 212 males reused after a second regeneration (C) for 169 females and 103 males reused after a third generation (D) for 94 females.

Results were analyzed in terms of egg fertilization rates, giving for (A) 25.3%, (B) 25.8%, (C) 27.4% and (D) 17.0%. Additional comparative observations on colour, size and consistency are made. The experiment shows that male eyestalk ablation is a viable way of improving male reuse.

137. INTENSIFICATION OF SHRIMP CULTURE IN EARTHEN PONDS IN SOUTH CAROLINA: PROGRESS AND PROSPECTS.

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Experiments on the intensive cultivation of Pacific white shrimp, Penaeus vannamei, in ponds in South Carolina were initiated in 1985 at the Waddell Mariculture Center. The first study involved two 0.1 ha ponds stocked at approximately 40 postlarvae/m², with management practices based on those used in Taiwan for intensive pond culture of P. monodon. Harvest yields averaged 6,757 kg/ha for one crop, demonstrating the technical feasibility of such intensive culture of P. vannamei. In 1986, 2.5 ha of ponds at the Waddell Mariculture Center (six ponds totalling 2.0 ha at 40 PL's/m² and two ponds totalling 0.5 ha at 60 PL's/m²) yielded a total of 13,606 kg (5,442 kg/ha), despite the worst heat wave and drought on record in South Carolina and sub-stantial decreases in aeration and water exchange rates. This serves as a pilot scale, proof-of-concept test. During these studies, no effects of ponds size were noted. Initial implementation of intensification efforts in the embryonic South Carolina shrimp farming industry also occurred during 1986, with approximately 32 ha of private ponds stocked at densities from 10-32 PL's/m². Harvest biomass increased with stocking density, with maximum yields of 3,575 kg/ha. In 1987, our team is investigating effects of high density (20-100 PL's/m²) in pond culture and impacts of intensification on water quality and pond ecology. Despite disappointing growth rates, yields are expected to be high. Technology transfer efforts have continued, with a 100% increase in private pond area under semi-intensive to intensive management. Two small private ponds have already been harvested yielding 3,600 and 5,100 kg/ha. Prospects for further development in the private sector appear excellent; yields of 10,000 kg/ha/crop are anticipated from

private ponds within the next few years. Intensification definitely works in earthen ponds to at least 2 ha in size where the necessary aeration, water exchange, high quality feed and good management are available.

- 138 THE EFFECT OF FORMULATED FEEDS ON THE PLANKTONIC MICROBIAL POPULATIONS OF SHRIMP POND SYSTEMS IN HAWAII.
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Feeds applied to shrimp pond systems are generally selected to provide for the nutritional requirements of the shrimp. There is a recycling of nutrients via the shrimp and the heterotrophic food web which has a secondary effect of stimulating primary productivity. Various commercial shrimp feeds have been shown to leach specific nutrients at varying rates. In this study, growth responses of the algae and protozoans present in shrimp ponds were evaluated to determine how the specific feeds influenced the microbial biota in the water column.

Four commercial shrimp diets (Nippai, Hanaqua, Purina MR-25 and Waldron) and one experimental formulated diet (OIS861) were incubated in water from a shrimp pond under ambient daytime conditions for 9 hours. An additional treatment consisting of a standard inorganic nutrient solution was incubated along with a control. The feed material and pond water were contained in clear plastic tissue culture tubes suspended in the shrimp pond. Changes in the number of microorganisms were noted for each treatment at the end of the incubation period. Diatom species responded similarly to all of the treatments (either increased in biomass in all treatments or in none of the treatments). However, the flagellated algal and protozoan species showed growth responses that varied with the feed treatment. It was concluded that the type of feed applied to aquaculture ponds, at least in the short term will influence the microbial composition of those ponds.

139. THE CULTURE OF PENAEUS SEMISULCATUS IN ISRAEL.
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Growth performance data on Penaeus semisulcatus under semi-intensive pond conditions were collected in Israel between 1984 and 1987. Shrimp were grown from PL to a maximum mean size of 11.3 g realizing a production of 2,057 kg/ha in 1984. In 1985, shrimp growth from PL to market size was separated into nursery and grow-out phases. Final grow-out results gave a maximum yield of 3,610 kg/ha and maximum mean size of 21.5 g. Sample shipments to maximize revenues. Any increase in shrimp size at harvest would require new management practices.

Juvenile shrimp (3.4 to 6.5 g) were held during the winter of 1986 in open ponds and restocked in grow-out ponds in the spring of 1987. Shrimp survivorship during overwintering was low - 10 to 15%. However, a maximum shrimp size of 25.6 g and production of 7,450 kg/ha were obtained using this strategy. It is felt that comparable results, but with higher survivorship could be obtained by headstarting shrimp in hothouses. Two major problems that remain to be solved in Israel are the formulation of a local shrimp diet for and year round maturation of P. semisulcatus.

140. ECONOMICS OF COMMERCIAL PRODUCTION OF FRESHWATER PRAWN IN THAILAND.
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A cost and return analysis was conducted for freshwater prawn farming in Thailand for three different scales of farms: small, medium and large. The stocking rate decreases as the farm size increases, while the survival rate increases as the stocking rate decreases. The results of the analysis revealed that freshwater prawn farming in all scales tested in Thailand proved to be profitable but the best results obtained were from farms in the median range.

141. SOCIO-ECONOMIC IMPACTS AND CONSTRAINTS OF AQUACULTURE DEVELOPMENT IN ASIAN COUNTRIES.

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Aquaculture plays a vital role in Asian countries as a source of animal protein, employment and foreign exchange earnings, as well as a means of improving farm income. However, there are numerous socio-economic constraints that must be addressed by these countries in their development of aquaculture, e.g., inadequate supply and high cost of major inputs (seed, feed, fertilizer, etc.), lack of adequate credit, inefficient marketing infrastructure and socio-cultural problems.

142. THE USE OF DEFATTED AND FULL FAT SOYBEAN MEAL WITH AND WITHOUT EXTRUSION PROCESS AS PARTIAL REPLACEMENT FOR FISHMEAL IN TILAPIA DIET.

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The purpose of the study was to evaluate the nutritional value of different types of soybean meal with and without extrusion process as replacement for fishmeal in tilapia diet. Two types of commercial soybean meal, defatted and full fat were extruded by twin screw extruder at 80°C and 135°C. Each diet contained 24% protein and 11% lipid. All diets were isocaloric. Thirty percent of fishmeal protein was replaced by each type of soybean meal with or without extrusion. Fishmeal group was used as control. There were a total of 7 dietary groups; each was fed to 3 aquariums of fish. The experiment was carried out in a closed circulated filtered rearing system for 2 months. Fish received all the soybean meal replacement diets had similar weight gain percentage, feed conversion ratio, protein digestibility, lipid digestibility and dry matter digestibility as compared to that of fish receiving control group fishmeal. Although fish fed the defatted soybean meal replacement diet had slightly better growth parameters as compared to that of fish fed other replacement groups, the differences were not significant ($P>0.05$). The body compositions of fish were also identical regardless of which diet was received. These data suggest that fishmeal can be replaced partially by either defatted or full fat soybean meal when the dietary protein level was 24%. Extrusion at either 80°C or 135°C did not enhance the nutritional value of soybean meal as partial replacement for fishmeal in tilapia diet.

143. USE OF MG-L-ASCORBYL-2-PHOSPHATE AS VITAMIN C SOURCE IN SHRIMP DIET.

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To meet the instability of Vitamin C compounded in formulated shrimp diet, a trial to substitute APM for L-Ascorbic Acid was made. The APM commercial name of Mg-L-Ascorbyl-2-Phosphate introduced by one of the present authors was examined for its stability during processing and staying in sea-water. Also, groups of juvenile Penaeus japonicus, a penaeid shrimp were subjected to a rearing experiment to know if the APM could be utilized by the shrimp. The HPLC analyses indicated that the APM was stable while processing into dried pelleted food. The recovery rate of the APM after processing ranged from 77% (1,078 mg APM in 1 kg diet) to 20% (43 mg APM in 1 kg diet). The loss may be attributed to absorption by other ingredients while processing. A couple of experiments to see its chemical stability in seawater detected 97.9% and 99.8% of the initial content after 22 and 26 hours, respectively. The rearing experiment fed with five different diets containing varied amounts of APM laster for 101 days and normal growths were observed, in treatments fed diets with 1,078, 430, 215 mg APM in 1 kg, whereas mass mortality occurred in treatments fed diets with 43 and 0 mg APM per kg. The concentration of accumulated APM and the converted L-Ascorbic Acid in the hepatopancreas in the survived animals indicates the optimum level of the APM to be about 215 mg per kg.

144. HISTOLOGIC RESPONSE OF A PENAEID SHRIMP TO DIETARY VITAMIN C.

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This is a report of a study utilizing a purified diet in evaluating Vitamin C effects on histopathology of tissues of postlarval shrimp (Penaeus vannamei). The study was conducted utilizing 20 liter circular tanks in a recirculating system, over a period of four weeks. Vitamin C levels of .071 to 11.31 g/kg were used and the tissue response was evaluated among eight shrimp from each treatment. The animals were fixed in Davidson's solution and evaluated at the light microscopy level. The dietary effects of Vitamin C levels were evaluated in terms of pathologic changes observed in the shrimp tissues. The histology and histopathology of the tissues will be described.

145. THE IMPORTANCE OF FATTY ACIDS IN A DRY FEED USED AS A COMPLETE REPLACEMENT FOR ARTEMIA.

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Two semi-purified experimental feeds were formulated to include 100% menhaden or 100% corn oil as the primary lipid source. Growth of Penaeus vannamei larvae fed each of the dry formulations plus algae was compared to that of larvae fed Artemia plus algae or only algae. All feeding regimes included 100,000 cells/ml Chaetoceros gracilis and 30,000 cells/ml Tetraselmis chunii. Dry feeds were presented in four equal allotments/day at six hour intervals beginning from the third protozoal substage until termination of the fifth postlarval substage. Artemia was presented in a single feeding/day.

The addition of dry feed to an algae regime significantly improved growth and survival of Penaeus vannamei over that obtained on an algae-only regime. Larvae fed the dry feed containing menhaden oil were larger than those fed the feed containing corn oil; however, the difference was not significant at $\alpha = .01$. Growth of larvae fed either formulated feed was inferior to that of larvae fed Artemia.

146. PROTEIN REQUIREMENT OF LARVAL PENAEUS VANNAMEI
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A semi-purified feed was used to examine the protein requirement of Penaeus vannamei. Protein levels examined were: 37.6, 44.6, 51.6 and 58.6%. Lipid was constant at 12.4%. Energy varied between 4,763 and 5,078 KCal/kg. Feeds were presented in four equal allotments/day at six hour intervals from the third protozoal substage until termination at the fifth postlarval substage. Algae (100,000 cells/ml Chaetoceros gracilis and 30,000 cells/ml £. chuii) was added to all dry feed regimes and to the two control regimes (algae-only and algae plus Artemia).

There was no significant difference in survival, rate of metamorphosis or final weight/PL-5 of larvae fed feeds containing any level of protein, suggesting that within this series of formulated feeds, a protein level of 37.6% is sufficient. Final weight of Artemia-fed larvae was equal to that of larvae fed dry feeds.

147. BELIZE'S FIRST COMMERCIAL SHRIMP FARM SET UP.
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Our hatchery and farm are constructed near the mouth of the Sennis River by the sea in southern Belize. The hatchery facility includes maturation, larviculture, algae production, artemia culture, spawning and labwork.

The maturation room consists of 8-12' diameter swimming pools plus spawning tanks with partial artificial lighting. Clear seawater from a large reservoir flows by gravity to the hatchery. Maturation water passes through rapid sand filters and larviculture water through diatomaceous earth filters. The larviculture area consists of 20,000 L rectangular epoxy-coated tanks with four bottom designs. Larvae are stocked at 50 animals per liter and fed on algae and artemia plus artificial diets. The hatchery will produce approximately 6 million PL's per month for stocking 330 plus acres of ponds.

The algae area produces Chaetoceros gracilis and Tetraselmis chuii. Test tube, flask and carboy cultures are raised in a 21°C air conditioned room. The mass production consists of 10 250 L, 10 1,000 L and 8 8,000 L algae tanks covered by a transparent plastic roof.

Penaeus vannamei and P. stylirostris have been raised on site with some work on P. schmitti (local species) .

Stage one, 3 feet deep ponds average 25 acres. The electrical driven 25 cfs vertical 12 foot lift propeller pumps lift double-screened, clear sea-water into a supply canal. Outlet canals discharge water 1.5 miles distant. Harvesting by nets in 12 foot shared concrete discharge silos simplifies operations.

The unique features, advantages and problems of working this site are discussed thoroughly.

148. INTENSIVE PENAEUS MONODON CULTURE ON THE ISLAND OF NEGROS, PHILIPPINES: A COMPARATIVE ANALYSIS OF PRODUCTION ECONOMICS AND CULTURE TECHNIQUES.
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In the Philippines, the cultivation of the tiger prawn, Penaeus monodon, is generally carried out in brackishwater ponds either in monoculture or in polyculture with milkfish. Traditional and extensive culture practices, involving low pond stocking densities, no supplemental feeding and limited water management, have and continue to be the most widely used methods of prawn production in the country. In recent years however, wide spread expansion of the prawn farming industry in the ASEAN region has led to the introduction of semi-intensive and intensive culture practices on a limited number of farms in the Philippines. Although other areas are involved to a limited extent, the highest concentration of semi-intensive and intensive operations is on the island of Negros in the Western Visayas.

This study first examines present day culture practices and the production economics of the prawn farming industry on Negros. Management criteria and production parameters are defined. The economics and technical aspects of prawn farming on Negros are then compared to those commonly associated with the industry in other parts of the Philippines. Data used in this study were collected over the period 1986-87 during two independent studies carried out in the Philippines, one having national scope and the other focusing specifically on the Negros prawn farming sector.

149 FURTHER STUDIES OF DENSITY EFFECTS IN INTENSIVE POND CULTURE OF PERAEUS VANNAMEI.

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Pond grow-out studies have been conducted to examine the intensive culture potential of Penaeus vannamei in South Carolina since 1985. In May 1987, an experiment was initiated to evaluate the effect of density on the growth and survival of P. vannamei reared in intensive grow-out ponds.

Hatchery reared postlarvae were stocked in nine .25 ha ponds at three densities: 20, 40 and 60 shrimp/m². Each pond was equipped with two paddle-wheel aerators (8 hp/ha) and water was exchanged at an average rate of 9%/pond/ day. The shrimp were fed a 40% protein diet twice each day during the study and water quality parameters were monitored daily. Estimates of growth were made by seine samples, which were conducted at 14 day intervals. By grow-out day 154, the shrimp stocked at 20, 40 and 60/m² had reached mean weights of 12.8, 12.3 and 11.2 grams, respectively. At that time, there appeared to be no significant effect on density on the growth rate of the shrimp.

150 COMPARISON OF LIVE AND ARTIFICIAL DIETS FOR REARING THE LARVAE OF PENAEUS VANNAMEI IN A SMALL-SCALE EXPERIMENTAL SYSTEM.

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A series of larval diet studies was conducted with a small-scale rearing system utilizing 1-liter Imhoff settling cones. Each cone was initially stocked with 100 stage I protozoae of Penaeus vannamei and maintained for 11 days. Upon termination of each experiment, growth parameters such as dry weights, survival and stage of development were determined for larvae reared on each diet. Larvae

were reared using 10 combinations of live foods including nematodes, rotifers, brine shrimp and diatoms. There were significant differences in growth between larvae reared on the various diets. It was found that larvae of P. vannamei can be reared from protozoa I through postlarva solely on nematodes and rotifers; however, these larvae had lower survival, lower weight gains and retarded development compared to larvae reared on diets including diatoms and brine shrimp. Best growth was always obtained with diets which included brine shrimp. The greatest weight gains were obtained with a diet which included a combination of diatoms, nematodes and brine shrimp. The highest survival was obtained with a diet consisting only of diatoms and brine shrimp. Larvae reared on live diets were also compared with larvae reared on three commercially available artificial feeds. Although these artificial diets can be used as a partial or total replacement for diatoms, the supplemental use of brine shrimp is required to obtain good growth.

151. FEEDING REGIMES FOR ENHANCED PENAEUS VANNAMEI PRODUCTION IN INTENSIVE NURSERY RACEWAYS.

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The potential of enclosed nursery systems for "headstarting" penaeid postlarvae in temperate climates has been demonstrated in 65 m² raceways. Several feeding experiments were conducted in 1987 to further evaluate these intensive systems and to enhance Penaeus vannamei juvenile production. The effects of continuous feeding, accomplished by six automatic feeders per raceway, versus interval feeding on shrimp growth and survival were compared at stocking densities of 3,000 and 6,000/m² for 45 and 30 days, respectively. Supplementation of the dry diet (50% crude protein) with Artemia nauplii was also tested in replicated raceways at the lower stocking density for 30 days.

Shrimp growth and survival were not significantly influenced by the continuous or interval feeding regimes at either density. A 0.85 g juvenile (overall mean harvest weight) was produced at a harvest density of 1,668/m², whereas a 0.59 g juvenile was produced at a harvest density of 3,324/m². Corresponding harvest yields were 1,418 and 1,960 g/m² for the low and high densities, respectively. Artemia supplementation also did not affect P. vannamei production. Overall mean harvest weight and survival were 0.71 g and 70%, respectively for the 30-day nursery period.

These results coupled with low feed conversion ratios (0.9 to 1.2:1) obtained in each feeding experiment, implied utilization of the high natural productivity associated with artificial habitats installed in the raceways (240 m² of substrate area per raceway). The contribution of these "fouling" communities to P. vannamei production, determined by stable carbon isotope analysis is discussed..

152. SALINITY EFFECTS ON PENAEUS VANNAMEI PRODUCTION IN NURSERY AND GROW-OUT PONDS.

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The effects of two salinity levels, ambient (35-40 ppt) versus a differential of 12-15 ppt maintained by freshwater dilution, were evaluated on Penaeus vannamei production in both nursery and grow-out phases. Four trials were conducted in 1987 to test these treatments in replicated, 0.1-ha earthen ponds:

- 1) postlarvae nursed for 32 days in spring at a stocking density of 250/m²;
- 2) a 26-day nursery period in mid-summer stocked at 225 PL/m²;
- 3) juveniles (mean weight = 0.6 g) stocked at 10/m² for 63 days in the summer; and
- 4) a 70-day grow-out period in fall stocked at 12.5 juveniles/m².

Neither survival rates nor harvest weights were significantly influenced by salinity levels in Trial 1, with respective means (overall) of 60% and 0.74 g obtained. During Trial 2, a significant difference ($P < 0.05$) in survival suggested a possible temperature interaction as mean water temperatures increased from 27°C in the first nursery period to 30°C in the second. Differences in growth (overall harvest weight mean = 0.67 g) were not detected. These trends were repeated in the grow-out trials, indicating that the combination of high salinity and high temperature was not favorable for P. vannamei production.

Differences in other water quality parameters (particularly dissolved oxygen levels), primary productivity (measured by chlorophyll a, b and c concentrations), and secondary productivity (polychaete populations), which may have further influenced these results are discussed.

153. UNEXPECTED RAPID DESTRUCTION OF SPERM IN CAPTIVE PENAEID SHRIMP.

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Male penaeids typically become infertile in captivity. Experiments were conducted to examine the condition of the penaeid reproductive tract as a function of time in captivity. Penaeus setiferus sourced off Corpus Christi were introduced on day 1 into laboratory tanks. At 35 and 48 days after capture, the reproductive tracts of 5 males were compared microscopically to those of day 1 males. The ampoules at both 35 and 48 days lacked turgidity were slightly brown and in general contained little secretory product. Experimental spermatophores exhibited darkening and progressive loss of the wing. The sperm cap which forms a hemicylinder around the sperm mass of the day 1 spermatophore was partially resorbed by day 35 and missing by day 48. The sperm mass of the spermatophore contained numerous bacteria by day 48. Only the glutinous mass of the spermatophore appeared normal at both experimental time points. The vas deferens in most males at 35 and 48 days appeared normal with the dissecting microscope. However, when examined with phase contrast microscopy, the sperm from segment 2B of 48 day males were grossly distorted and the sperm mass contained numerous bacteria. These observations establish that bacteria proliferate in the sperm mass of captive male shrimp and that destruction of penaeid sperm is occurring in regions of the vas deferens that appear normal with the dissecting microscope. Thus, captive males become infertile prior to what would be expected based on external morphology of the vas deferens.

154. THE EFFECT OF VARIOUS COMMERCIAL ARTIFICIAL SEASALTS ON THE GROWTH OF PENAEUS VANNAMEI.

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Eight brands of artificial seasalt mixtures were evaluated with Hawaiian Marine, the standard artificial seawater used in the rearing of penaeid larvae in the experimental Imhoff cone system. Twenty-four hours prior to use, the nine artificial seasalt mixtures were mixed using deionized water and 1 ppm EDTA to a salinity of

30 ppt. Penaeus vannamei larvae were acclimatized as nauplii to the nine mixtures and stocked into the cone system during the first protozoal substage. All treatments were fed algae (100,000 cells/ml Chaeto-ceros gracilis and 30,000 cells/ml Tetraselmis chuii) from the nauplius sub-stage; Artemia was added from the third protozoal substage. The experiment was terminated when at least 90% of the larvae in the Hawaiian Marine control metamorphosed into the PL1 substage. Percent survival, percent metamorphosis and dry weight/PLI were determined.

Mean survival among the nine brands ranged from 85% to 93%, Metamorphosis (62-95%) and dry weight/PLI (99.6-134.6/ig/PLI) varied significantly among the nine brands. Tropic Marin, Sera and Ocean 50 can be used as replacements for Hawaiian Marine without deleterious effects upon survival, metamorphosis and growth to the PL1 substage. The other brands (particularly Marine Environment, Forty Fathoms and Instant Ocean), either due to technical problems such as incomplete dissolution of salt components or poor larval response in comparison to Hawaiian Marine were found to be less suited for penaeid larviculture research.

155. STEROID PROFILES OF NATURAL AND ACCELERATED MATURATION IN FEMALE MULLET (MUGIL CEPHALUS).

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Ten females were subjected to chronic LHRH-a plus testosterone treatment. Therapy was initiated (Nov. 1986) at the onset of vitellogenesis as scored by ovarian biopsy. Average egg diameters, serum estradiol-17 β and testosterone were monitored until March 1987. Twenty control individuals were monitored in the same way from September 1986 through March 1987.

When therapy was initiated females possessed eggs that averaged 220 + 42 μ m. The treated individuals exhibited an acceleration in the rate of egg growth. After 22 days of therapy, average egg diameters of 490 \pm 122 μ m were obtained in the treated group versus 304 \pm 52 μ m in the placebo group.

Steroid profiles of treated females also reflect the acceleration of ovarian maturation. Peaks in serum E₂ and testosterone were observed a month prior to the control group's peak. The E₂ levels found in treated fish are significantly lower than the control fish when compared at the same stage of maturation. No difference can be observed in testosterone values.

Three of the treated fish were induced to spawn in December. They then rematured and were spawned a second time by March 1987. This is a significant achievement because this species is considered an annual spawner.

156. USE OF DRIED TETRASELMIS CHUII AS BOTH A COMPLETE AND PARTIAL REPLACEMENT FOR LIVE ALGAE IN THE FEEDING REGIME OF LARVAL PENAEUS VANNAMEI.

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Spray dried Tetraselmis chuii was examined as both a complete (100%) and a partial (33% and 67%) replacement for live algae fed to Penaeus vannamei larvae

(N5 to PL). The two live algae regimes were 130,000 cells/ml Tetraselmis chuii and a combination of 100,000 cells/ml Chaetoceros gracilis + 30,000 cells/ml T. chuii. The live algae was grown under unialgal (non-axenic) batch conditions in natural seawater enriched with Guillard's f/2 strength nutrients. Experimentation was conducted in the Imhoff cone system at a stocking density of 100 larvae/liter.

Final survival and dry weight of larvae fed 100% dried T. chuii was equal to that of larvae fed either of the two live algae regimes. Rate of metamorphosis of larvae fed the dried algae was significantly slower than that of larvae fed the live algae, but only by a matter of hours.

Replacing 33% of the live C. gracilis + T. chuii regime (on a cell number basis) with dried T. chuii increased the metamorphic rate of Penaeus vannamei but did not significantly improve growth. A 67% replacement significantly improved both growth and metamorphic rates over that of the 100% live combination regime and equalled that obtained with the 100% live T. chuii regime.

The use of dried algae in the larval feeding regime offers several practical advantages over that of live algae. This particular dried algal product has excellent potential for use in penaeid larviculture.

157. SEX-REVERSAL OF OREOCHROMIS AUREAUS WITH MIBOLERONE, A NEW SYNTHETIC STEROID, USING BOTH IMMERSION AND FEED TREATMENTS.

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Mibolerone (MI), a new synthetic steroid was used to sex-reserve undifferentiated Oreochromis aureus fry. Fry were exposed to 0.0 ppm, 0.3 ppm, 0.6 ppm or 1.0 ppm MI in static-water solutions for five weeks (immersion treatments), or were fed a diet containing 1.0 ppm MI for four weeks in a flow-through system. After hormonal treatments, the fish were grown to 60 mm minimum total length prior to sex determination using gonadal squash examination of 50 fish per treatment replication. Data were also collected on the MI concentrations in immersion-treated fish and on the loss of MI from static-water systems.

Fish exposed to 1.0 ppm, 0.6 ppm or 0.3 ppm MI had average tissue MI concentrations of 14.3 ppm, 5.6 ppm and 3.3 ppm, respectively over the five weeks immersion treatment. Exposure to 1.0 ppm or 0.6 ppm MI for five weeks resulted in an average of 82% males and 18% ovo-testicular fish (non-functional females), with no functional females being produced. Exposure to 0.3 ppm resulted in 78.7% males, 20.7% ovo-testicular fish, and 0.7% females. Control treatments approximated a 50:50 male:female sex ratio. Fry growth and survival was reduced in all MI immersion treatments. Feeding a diet containing 1.0 ppm MI resulted in 85% males, 11% ovo-testicular fish and 4% females.

The MI concentration in aerated static-water without fish present was reduced by 42% after seven days, while the MI concentration in aerated static-water of aquaria stocked with fish was reduced by 67% over the same time period. These results indicate that substantial bio-degradation of MI occurred, since the amount of MI loss from the water was approximately five times greater than was previously found as residue in fish tissues in the immersion treatment study after a comparable exposure.

Exposing tilapia fry to static-water solutions of 0.6 ppm MI for five weeks appears to be a feasible method of eliminating the production of functional females. Immersion solutions should be changed weekly to maintain an effective hormone concentration.

158. ORGAN CULTURE ASSAY OF THE EFFECTS OF PUTATIVE REPRODUCTIVE HORMONES ON IMMATURE PENAEUS VANNAMEI OVARIES.

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The vertebrate-type steroid hormones, progesterone, 17 α -hydroxyprogesterone (17-OHP) and estradiol-17 β (E₂) and insect juvenile hormone III (JHIII) were assayed to determine the effects on oocyte growth of Penaeus vannamei. Immature ovarian pieces (2-4 mm) were cultured in 600 μ l Medium 199, with salt concentrations adjusted to Homarus saline, plus 100 μ l hormone solution. The steroids and terpenoid were dissolved in 100% EtOH to produce 7.0 mM solution, which was then serially diluted with saline to produce concentrations of 700 nM, 70 nM, 7 nM, 700 pM, 70 pM and 7 pM hormone solutions. Controls received 100 μ l saline. Samples assaying EtOH in saline (1:10,000) showed no significant difference from controls. Tissues were fixed in Kahle's solution, dehydrated in an EtOH/butanol mixture, embedded in paraplast-plus and stained with hematoxylin and eosin. Twenty oocytes were measured for each animal at each concentration for each 24 hour period. When compared to controls, 17-OHP and JHIII caused highly significant increases in oocyte diameter after 24 hours of culture. Progesterone and E₂ did not produce any significant effects on cell diameter.

159. SELECTION IN THAI OREOCHROMIS NILOTICUS; CORRELATED RESPONSE BETWEEN AGE AND SIZE AT MATURATION AND JUVENILE GROWTH.

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Two generations of divergent selection for age at maturity of Oreochromis niloticus were studied at the National Inland Fisheries Institute (NIFI) and Bangsai, Thailand. The study indirectly resulted in a genetic growth gain. The early-maturity selected line was significantly larger and grew faster than the late-maturity selected line (size 19-26% larger and growth 5-9% faster). Phenotypic correlation coefficients between age and size at maturity range between 0.5 to 0.9. Juvenile growth rates of the selected and unselected lines were also compared. There were no differences in pre-maturity growth rates between the selected and unselected lines.

160. EFFECTS OF VARYING STOCKING DENSITIES OF MACROBRACHIUM ROSENBERGII IN A POLYCULTURE SYSTEM WITH TILAPIA NILOTICA.

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Tilapia nilotica were stocked at a rate of 6 000/ha with three different densities of Macrobrachium rosenbergii nursed post-larvae (15, 30, 45 thousand/ ha). A seven day feeding regime was used for a grow-out period of 180 days. The prawns were not fed intentionally during the course of the study and the fish were fed with 32% protein sinking pellets at a rate adjusted to the average weight of the fish and divided into two equal portions per day. Tilapia fingerlings averaged 34 g at stocking and 524 g at harvest. Post-larvae averaged 0.03 g at stocking and 26.4 g at harvest. Fish yield averaged 2 612 kg/ha and 86% survival. Prawn yield averaged 587 kg/ha and 84% survival. Results showed that the growth and survival of fish were independent of prawn stocking densities ($P < 0.05$). Prawns were influenced by their own stocking rate. Individual prawn growth weights and stocking densities are negative correlated while yield is positively correlated ($P < 0.05$) with stocking densities. Survival of the prawns was different ($P > 0.05$) with the three treatments used in this experiment. Survival was 91% at the low stocking rate and 74% at the higher stocking rate. Fish attained an average weight of 450 g around day 155; a higher stocking density for the fish could have been employed.

161. STUDIES OF OFF-FLAVOR IN AQUACULTURE: GEOSMIN PRODUCTION BY BLUE-GREEN ALGAE.

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Geosmin concentration and phytoplankton were monitored in 43 ponds that received either feed or fertilizer. Ponds were located at the Auburn University Research Unit and sampled from April to October in 1986 and 1987. Six ponds were sampled over a period of 4 to 8 weeks to describe geosmin production dynamics. In all ponds geosmin could be detected; concentrations ranged from less than 0.05 $\mu\text{g/l}$ to 10.0 $\mu\text{g/l}$. Twenty ponds were dominated by Micro-cystis blooms and had geosmin concentrations lower than 0.05 $\mu\text{g/l}$, except for one pond with 0.8 $\mu\text{g/l}$. The ponds containing Soirulina had 2.5 $\mu\text{g/l}$ geosmin. From five ponds with Aphanizomenon blooms only one pond had a geosmin concentration higher than 0.2 $\mu\text{g/l}$, i.e. 9.8 $\mu\text{g/l}$. Geosmin concentrations were high (2.9 to 10.0 $\mu\text{g/l}$) in ponds where Anabaena variabilis was abundant, but lower (less than 0.05 $\mu\text{g/l}$ to 0.3 $\mu\text{g/l}$) in ponds with other Anabaena species.

Comparison of geosmin concentrations of raw and cell free water showed that 90 to 99% of the geosmin is contained in the algal cells. When the geosmin producing algae are abundant, the geosmin concentration is correlated with the chlorophyll a content of the water.

162. TEMPERATURE AND SALINITY EFFECTS ON METAMORPHOSIS AND SURVIVAL OF PENAEUS STYLIROSTRIS NAUPLII.

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Effects of temperature, salinity and temperature-salinity interactions on Penaeus stylirostris naupliar survival and metamorphosis were evaluated. Newly hatched nauplii from three different maternal shrimp were exposed to three temperature and five salinity levels, 23°C, 28°C, 33°C and 23 ppt, 28 ppt, 33 ppt, 38

ppt, 43 ppt, respectively. Survival and metamorphich rates of nauplii to protozoa were determined by microscopic examination of each individual larva at 24 h, 48 h, 72 h and 96 h. Results were analyzed by ANOVA.

Differences in mean percent survival and metamorphosis among temperature and salinity levels were highly significant ($P = .0001$). Metamorphosis was a more sensitive measure of temperature and salinity preference than survival. Greatest percent metamorphosis was 96% at 28°C and 33 ppt with 100% survival. Salinities below and above 33 ppt at 28°C yielded lower rates of survival and metamorphosis. Temperature and salinity interactions with respect to larvi-culture production and pelagic larval ecology are discussed.

163. CONSTRAINTS ON THE USE OF AQUACULTURE FEEDS IN DEVELOPING COUNTRIES WITH SPECIAL REFERENCE TO AFRICA.
Michael M.J. Vincke and Michael B. New Aquaculture Development and Coordination Programme Fisheries Department, FAO, 00100 Rome, Italy.

After providing background information on the current and potential scale of aquaculture in the developing world and the production techniques utilized there, constraints on the use of feed are examined. Examples of results from the use of simple feeding strategies in Africa are provided and the needs for applied research and development in the manufacture and use of supplemental feeds are identified.

164. SHRIMP FORAGING EFFECTS UPON MICROBIAL COMMUNITIES IN EXPERIMENTAL MICROCOSMS.
Pieter, T. Visscher, Kenneth M. Leber and Shaun Moss The Oceanic Institute, Makapuu Point Waimanalo, HI 96795 USA.

Foraging effects of Penaeus vannamei were experimentally examined in 30-gallon round flow-through microcosm tanks containing grow-out pond water, well water and sediments. Shrimp were stocked at a density level of 50 ani-mals/m². We manipulated: 1) feed availability (presence or absence of a Taiwanese feed), 2) feeding frequency, 3) water source, and 4) grazing pressure from P. vannamei. Natural prey densities and prey colonization rates in sediments and in the water column were then monitored. Effects of shrimp predation on microbes and meiofauna were intense. Availability of commercial feed greatly affected rates of shrimp predation on microbial and meiofaunal prey. These experiments suggest that even under intensive grow-out conditions, natural productivity in pond water has tremendous impact on p. vannamei growth rates.

165. PROCESS AUTOMATIZATION IN AQUACULTURE: REALITY OR UTOPIA?
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In order to remain economically feasible aquaculture in tropical countries has usually had to minimize on technology out of pure necessity. The need for pure and heated waters in great quantities for special aquaculture systems such hatcheries, recirculated water systems or intensive rearing units in moderate regions, where water is very precious, often leads to the question of whether process technology in aquaculture may be a practical undertaking.

When our project began in 1983, we had to cope with an inadequate measure-ment technology, notably lacking in "on-line" electrodes for oxygen monitoring' (probably the most important parameter for determining water quality).

There were also no appropriate electrodes for detecting nitrogen containing substances, such as ammoniac, ammonia, nitrate and nitrite. At that time, measurement technology and the relatively high prices for computers hindered the introduction of process automatization in aquaculture outside our laboratory. Nevertheless, we were still able to monitor most of the essential water quality parameters accurately and to use them for process regulation. Since specialized manpower can be well economized and insurance fees kept substantially low, the introduction of automatic measurement and control systems became a possibility even in the days of low technology aquaculture facilities.

We developed a computerized modular monitor and regulation system in our department designed to meet the needs of the aquaculture industry. The process controller registers data from various sources and offers appropriate alarms capable of monitoring water quality, external environment, equipment control, feeding schemes and production planning. In the event of operational problems in aquaculture facilities, it is possible to pinpoint errors and introduce appropriate corrective measures to effectively counteract these irregularities .

In particular we could monitor retrospectively in order to systematically analyze the chain of events and thereby enable correct future adjustments. Changes in the input parameters can be simulated and transferred to the process.

The development promotes a scheme with which critical levels of various water parameters may be avoided, employing automated adaption of the feeding regime and of the overall management procedures.

166 TROPHIC STATUS OF POND AQUACULTURE SYSTEMS: MASS BALANCE EVIDENCED FOR NET ORGANIC MATTER PRODUCTION IN SITU.

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Aquaculture ponds which receive large allochthonous organic inputs (feed) might be expected to be net consumers of organic matter. This hypothesis has been tested in a semi-extensive Macrobrachium rosenbergii pond for eight days and in four semi-intensive Penaeus vannamei ponds for two months. Mass balances for carbon have been constructed in order to quantify the trophic status of these systems. The ponds were sampled hourly with data loggers for pH and water temperature. Alkalinity and salinity were sampled at least weekly. The concentration and distribution of dissolved inorganic carbon (DIC) species was calculated with carbonate equilibrium equations for every hour during the deployments. CO₂ partial pressures and climatic data were used to estimate CO₂ transfer between the ponds and the atmosphere. DIC fluxes due to water inflow and seepage were calculated. Mass balances indicated that some of the sampled ponds were net consumers of CO₂ during the investigation. Since the concentration of DIC in the water did not increase substantially during the study periods, inputs of inorganic carbon to these systems must be accounted for by autotrophic carbon fixation.

167. INFLUENCE OF BIOLOGICAL AND ENVIRONMENTAL FACTORS ON SHRIMP FOND PRODUCTION AS PREDICTED BY STOCHASTIC MODEL.

John Whitson*¹, Addison Lawrence¹ and William Grant² ¹Shrimp Mariculture Project, Texas Agricultural Experiment Station, Texas A&M University System P.O. Drawer Q, Port Aransas, TX 78373. ²Department of Wildlife and Fisheries Sciences Texas A&M University, College Station TX 77843.

A stochastic model of shrimp pond production is constructed based on new findings about shrimp dietary habits and present understandings of shrimp pond and other marine environments.

A baseline run of the model is discussed and a series of variations of stocking densities, feeding rates and stocking dates are examined. Attention is drawn to implications of over- and underfeeding and the effects on the planktonic and benthic ecosystems of the shrimp pond.

The behavior of the model is compared to existing data from the ponds at the Texas Agricultural Experiment Station Shrimp Mariculture Project, and its usefulness as a management tool is evaluated.

168. INDUCED SPAWNING, LARVAL CULTURE AND JUVENILE GROWTH OF PAPHLA UNDULATA (MOLLUSCA: VENERIDAE) IN THE LABORATORY. T.M. Wong, Shamsuddin Salleh and T.G. Lim School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia.

Induced spawning of Paphia undulata was studied using various techniques developed for bivalve molluscs. Injection of 0.5 ml of 2 mM/L serotonin into the food consistently induced spawning between 0.5 to 2 hours after the injection.

Mature eggs measured 61 μm in diameter. Mobile early trochophore larvae were seen after 4 hours and the straight-hinged stage reached 10-14 hours later (Shell length = 65 μm). Reared on a diet of Isochrysis sp., 2-day old D-stage veligers measured 95.0 μm in shell length. Early umbo larvae were seen by the 6th day (S.L. = 120 μm). The pediveliger appeared by the 12th day (S.L. = 232 μm). Settlement was completed by the 15th day. Mean shell length of settled spats measured 324 μm .

Juvenile growth was rapid when cultured in an upwelling system and mean shell length of 17.9 mm was reached 104 days after spawning. The implications of these findings in the commercial culture of P. undulata are discussed.

169. SHRIMP YIELDS AND ECONOMIC POTENTIAL OF INTENSIVE ROUND POND SYSTEMS. James A. Wyban*, J.N. Sweeney, R.A. Karma and E.S. McSweeney Oceanic Institute, Makapuu Point Waimanalo, HI 96795 USA.

A 337 m² round pond system for intensive shrimp culture was designed and built in 1985. In 1986, three grow-out trials at shrimp densities of 45 shrimp/m² were completed in the pond (Wyban and Sweeney, 1987). In 1987, two grow-out trials at shrimp densities of 100 shrimp/m² were completed. In 1987, a commercial prototype, 2,000 m² round ponds was designed and constructed. One grow-out trial at shrimp densities of 75/m² was completed in the prototype. This paper summarizes the results of these six grow-out trials. Pond design and management of feeding, water quality and sedimentation are discussed. Shrimp growth rates, survival, feed conversion ratio, shrimp production and crop value are reported. Financial projections based on pond construction costs, operating costs and crop value are reviewed.

170. INDUCED OVARIAN MATURATION AND SPAWNING OF PENAEUS VANNAMEI.

Isao Yano*, Department of Medical Zoology School of Medicine, Mie University Tsu, Mei 514 Japan. James A. Wyban, The Oceanic Institute Makapuu Point, Waimanalo, HI 96795 USA.

The effect of implantation of American lobster's ganglion on ovarian maturation and spawning was investigated in Penaeus vannamei. Females with undeveloped ovaries were used for the present study. Females implanted with ganglion and males were housed in a 10 m³ tank with flowing, filtered sea-water. Water temperature was 24-26°C and photoperiod was 14L:10D. Salinity ranged from 35-36‰. More advanced ovarian development stages were observed in the females implanted with ganglion. Many eggs were spawned by the ganglion implanted females. These results indicate that implantation of lobster's ganglion is effective in inducing ovarian maturation and spawning in P. vannamei.

171. THE ECONOMICS OF ENGINEERING ASPECTS OF POND AQUACULTURE IN TEXAS.

M.E. Yates* and W.L. Griffin Department of Agricultural Economics Texas A&M University, College Station Texas 77843 USA.

The items of capital cost involved in aquaculture pond grow-out facilities were grouped into nine categories. These are: surveying, engineering design, earthwork, road construction, piping, channels, outlet structures, pumps and aerators. The quantitative relationship of each category to the scale of the operation was calculated, based upon their intrinsic relationship. Three models were built for a 100, 200 and 1 000 acre farm, respectively, reflecting these relationships. The costs of different materials and methods of construction were introduced into the models and that which was optimal was chosen in each size category.

Comparisons were made between the capital cost per acre of the three models. Sensitivity analyses were run, showing the response of the total capital costs to changes in the component inputs. The capital cost models were integrated into an existing overall budgetary model for Texas shrimp farms. The sensitivity of the total cost of each sized unit to changes in the capital cost components was thereby ascertained.

172. ROBOT AQUA-FEEDER.

Kao Yi-Tung*, Fang Min-Ting and Hu Shun-Chih Nan Rong Fishing Machinery Co., Ltd. 75-10, I-Chou Li, Yiang Hsuei Cheng Tainen Hsiang, Taiwan, Republic of China.

This totally brand-new feeder has been designed and made to perform the long sought-after job of self-guiding, auto-moving, spray feed work inside the pond. It leaves the positioned 'harbor' according to scheduled timetable, cruises the entire pond 4 meters away from the edge while spray-feeding. After a cycle it enters the harbor for re-charging.

This robot feeder is now put on field test, with satisfactory results so far.

173. EFFECTS OF TEMPERATURE AND FEED RATE ON GROWTH IN THE CHINESE CATFISH, CLARIAS FUSCUS.

Michael J.A. Young* and Arlo W. Fast Hawaii Institute of Marine Biology Kaneohe, HI 96744 USA.

Growth of Chinese catfish was evaluated under four temperature regimes: 20, 25, 30 and 35°C. Within each temperature treatment, three feed rates: 2, 4 and

6% body weight per day were tested. Fish were stocked into each temperature-feed treatment at 2 months old; approximately 1-4 grams in weight. Stocking density for each treatment was 100 fish/m². Growth and survival was monitored biweekly for one year.

Growth was significantly depressed at 20 and 35°C, and survival poor, 54 and 0%, respectively. Maximal growth and survival was obtained at 30°C for animals between 1 and 119 grams in weight, and at 25°C for animals above 120 grams. Best overall feed conversion was obtained at the 2% feeding level at all temperatures.

**PUBLICATIONS AND DOCUMENTS OF THE
ASEAN/UNDP/FAO REGIONAL SMALL-SCALE COASTAL FISHERIES
DEVELOPMENT PROJECT
(RAS/84/016)**

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